# Stellaris® LM3S1960 Microcontroller

## DATA SHEET

DS-LM3S1960-11108

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# Revision History

The revision history table notes changes made between the indicated revisions of the LM3S1960 data sheet.

**Table 1. Revision History**

| Date | Revision | Description |
|---|---|---|
| November 2011 | 11108 | ■ Added module-specific pin tables to each chapter in the new Signal Description sections.<br>■ In Hibernation chapter:<br>– Changed terminology from non-volatile memory to battery-backed memory.<br>– Clarified Hibernation module register reset conditions.<br>■ In Timer chapter, clarified that in 16-Bit Input Edge Time Mode, the timer is capable of capturing three types of events: rising edge, falling edge, or both.<br>■ In UART chapter, clarified interrupt behavior.<br>■ In SSI chapter, corrected SSIClk in the figure "Synchronous Serial Frame Format (Single Transfer)".<br>■ In Signal Tables chapter:<br>– Corrected pin numbers in table "Connections for Unused Signals" (other pin tables were correct).<br>– Corrected buffer type for PWMn signals in pin tables.<br>■ In Electrical Characteristics chapter:<br>– Added parameter "Input voltage for a GPIO configured as an analog input" to the "Maximum Ratings" table.<br>– Corrected Nom values for parameters "TCK clock Low time" and "TCK clock High time" in "JTAG Characteristics" table.<br>■ Additional minor data sheet clarifications and corrections. |

**Table 1. Revision History *(continued)***

| Date | Revision | Description |
|---|---|---|
| January 2011 | 9102 | ■ In **Application Interrupt and Reset Control (APINT)** register, changed bit name from SYSRESETREQ to SYSRESREQ.<br>■ Added DEBUG (Debug Priority) bit field to **System Handler Priority 3 (SYSPRI3)** register.<br>■ Added "Reset Sources" table to System Control chapter.<br>■ Corrected GPIOAMSEL bit field in GPIO Analog Mode Select (**GPIOAMSEL**) register to be four-bits wide, bits[7:4].<br>■ Removed mention of false-start bit detection in the UART chapter. This feature is not supported.<br>■ Added note that specific module clocks must be enabled before that module's registers can be programmed. There must be a delay of 3 system clocks after the module clock is enabled before any of that module's registers are accessed.<br>■ Changed $I^2C$ slave register base addresses and offsets to be relative to the $I^2C$ module base address of 0x4002.0000 and 0x4002.1000, so register bases and offsets were changed for all $I^2C$ slave registers. Note that the hw_i2c.h file in the StellarisWare® Driver Library uses a base address of 0x4002.0800 and 0x4002.1800 for the $I^2C$ slave registers. Be aware when using registers with offsets between 0x800 and 0x818 that StellarisWare uses the old slave base address for these offsets.<br>■ Added GNDPHY and VCCPHY to Connections for Unused Signals tables.<br>■ Added specification for maximum input voltage on a non-power pin when the microcontroller is unpowered ($V_{NON}$ parameter in Maximum Ratings table).<br>■ Additional minor data sheet clarifications and corrections. |
| September 2010 | 7787 | ■ Reorganized ARM Cortex-M3 Processor Core, Memory Map and Interrupts chapters, creating two new chapters, The Cortex-M3 Processor and Cortex-M3 Peripherals. Much additional content was added, including all the Cortex-M3 registers.<br>■ Changed register names to be consistent with StellarisWare names: the Cortex-M3 **Interrupt Control and Status (ICSR)** register to the **Interrupt Control and State (INTCTRL)** register, and the Cortex-M3 **Interrupt Set Enable (SETNA)** register to the **Interrupt 0-31 Set Enable (EN0)** register.<br>■ Added clarification of instruction execution during Flash operations.<br>■ Modified Figure 8-1 on page 288 to clarify operation of the GPIO inputs when used as an alternate function.<br>■ Corrected GPIOAMSEL bit field in **GPIO Analog Mode Select (GPIOAMSEL)** register to be eight-bits wide, bits[7:0].<br>■ Added caution not to apply a Low value to PB7 when debugging; a Low value on the pin causes the JTAG controller to be reset, resulting in a loss of JTAG communication.<br>■ In General-Purpose Timers chapter, clarified operation of the 32-bit RTC mode.<br>■ In Electrical Characteristics chapter:<br>– Added $I_{LKG}$ parameter (GPIO input leakage current) to Table 20-4 on page 610.<br>– Corrected values for $t_{CLKRF}$ parameter (SSIClk rise/fall time) in Table 20-17 on page 618.<br>■ Added dimensions for Tray and Tape and Reel shipping mediums. |

**Table 1. Revision History *(continued)***

| Date | Revision | Description |
|---|---|---|
| June 2010 | 7393 | ■ Corrected base address for SRAM in architectural overview chapter.<br>■ Clarified system clock operation, adding content to “Clock Control” on page 172.<br>■ In Signal Tables chapter, added table "Connections for Unused Signals."<br>■ In "Thermal Characteristics" table, corrected thermal resistance value from 34 to 32.<br>■ In "Reset Characteristics" table, corrected value for supply voltage (VDD) rise time.<br>■ Additional minor data sheet clarifications and corrections. |
| April 2010 | 7007 | ■ Added caution note to the **I²C Master Timer Period (I2CMTPR)** register description and changed field width to 7 bits.<br>■ Removed erroneous text about restoring the Flash Protection registers.<br>■ Added note about $\overline{\text{RST}}$ signal routing.<br>■ Clarified the function of the TnSTALL bit in the **GPTMCTL** register.<br>■ Additional minor data sheet clarifications and corrections. |
| January 2010 | 6712 | ■ In "System Control" section, clarified Debug Access Port operation after Sleep modes.<br>■ Clarified wording on Flash memory access errors.<br>■ Added section on Flash interrupts.<br>■ Clarified operation of SSI transmit FIFO.<br>■ Made these changes to the Operating Characteristics chapter:<br>– Added storage temperature ratings to "Temperature Characteristics" table<br>– Added "ESD Absolute Maximum Ratings" table<br>■ Made these changes to the Electrical Characteristics chapter:<br>– In "Flash Memory Characteristics" table, corrected Mass erase time<br>– Added sleep and deep-sleep wake-up times ("Sleep Modes AC Characteristics" table)<br>– In "Reset Characteristics" table, corrected units for supply voltage (VDD) rise time |
| October 2009 | 6462 | ■ Removed erroneous reference to the WRC bit in the Hibernation chapter.<br>■ Deleted reset value for 16-bit mode from **GPTMTAILR**, **GPTMTAMATCHR**, and **GPTMTAR** registers because the module resets in 32-bit mode.<br>■ Made these changes to the Electrical Characteristics chapter:<br>– Removed $V_{SIH}$ and $V_{SIL}$ parameters from Operating Conditions table.<br>– Added table showing actual PLL frequency depending on input crystal.<br>– Changed the name of the $t_{HIB_REG_WRITE}$ parameter to $t_{HIB_REG_ACCESS}$.<br>– Changed SSI set up and hold times to be expressed in system clocks, not ns. |
| July 2009 | 5920 | Corrected ordering numbers. |

**Table 1. Revision History *(continued)***

| Date | Revision | Description |
|---|---|---|
| July 2009 | 5902 | ■ Clarified Power-on reset and RST pin operation; added new diagrams.<br>■ Corrected the reset value of the **Hibernation Data (HIBDATA)** and **Hibernation Control (HIBCTL)** registers.<br>■ Clarified explanation of nonvolatile register programming in Internal Memory chapter.<br>■ Added explanation of reset value to **FMPRE0/1/2/3**, **FMPPE0/1/2/3**, **USER_DBG**, and **USER_REG0/1** registers.<br>■ Changed buffer type for WAKE pin to TTL and HIB pin to OD.<br>■ In ADC characteristics table, changed Max value for GAIN parameter from ±1 to ±3 and added $E_{IR}$ (Internal voltage reference error) parameter.<br>■ Additional minor data sheet clarifications and corrections. |
| April 2009 | 5367 | ■ Added JTAG/SWD clarification (see “Communication with JTAG/SWD” on page 160).<br>■ Added clarification that the PLL operates at 400 MHz, but is divided by two prior to the application of the output divisor.<br>■ Added "GPIO Module DC Characteristics" table (see Table 20-4 on page 610).<br>■ Additional minor data sheet clarifications and corrections. |
| January 2009 | 4660 | ■ Corrected bit type for RELOAD bit field in SysTick Reload Value register; changed to R/W.<br>■ Clarification added as to what happens when the SSI in slave mode is required to transmit but there is no data in the TX FIFO.<br>■ Additional minor data sheet clarifications and corrections. |
| November 2008 | 4283 | ■ Revised High-Level Block Diagram.<br>■ Additional minor data sheet clarifications and corrections were made. |
| October 2008 | 4149 | ■ Corrected values for DSOSCSRC bit field in **Deep Sleep Clock Configuration (DSLPCLKCFG)** register.<br>■ The FMA value for the **FMPRE3** register was incorrect in the Flash Resident Registers table in the Internal Memory chapter. The correct value is 0x0000.0006.<br>■ Incorrect Comparator Operating Modes tables were removed from the Analog Comparators chapter. |
| August 2008 | 3447 | ■ Added note on clearing interrupts to Interrupts chapter.<br>■ Added Power Architecture diagram to System Control chapter.<br>■ Additional minor data sheet clarifications and corrections. |
| July 2008 | 3108 | ■ Additional minor data sheet clarifications and corrections. |
| May 2008 | 2972 | ■ As noted in the PCN, the option to provide VDD25 power from external sources was removed. Use the LDO output as the source of VDD25 input.<br>■ Additional minor data sheet clarifications and corrections. |
| April 2008 | 2881 | ■ The $\Theta_{JA}$ value was changed from 55.3 to 34 in the "Thermal Characteristics" table in the Operating Characteristics chapter. |

**Table 1. Revision History *(continued)***

| Date | Revision | Description |
|---|---|---|
| | | ■ Bit 31 of the **DC3** register was incorrectly described in prior versions of the data sheet. A reset of 1 indicates that an even CCP pin is present and can be used as a 32-KHz input clock.<br>■ Values for $I_{DD_HIBERNATE}$ were added to the "Detailed Power Specifications" table in the "Electrical Characteristics" chapter.<br>■ The "Hibernation Module DC Electricals" table was added to the "Electrical Characteristics" chapter.<br>■ The $T_{VDDRISE}$ parameter in the "Reset Characteristics" table in the "Electrical Characteristics" chapter was changed from a max of 100 to 250.<br>■ The maximum value on Core supply voltage ($V_{DD25}$) in the "Maximum Ratings" table in the "Electrical Characteristics" chapter was changed from 4 to 3.<br>■ The operational frequency of the internal 30-kHz oscillator clock source is 30 kHz ± 50% (prior data sheets incorrectly noted it as 30 kHz ± 30%).<br>■ A value of 0x3 in bits 5:4 of the **MISC** register (OSCSRC) indicates the 30-KHz internal oscillator is the input source for the oscillator. Prior data sheets incorrectly noted 0x3 as a reserved value.<br>■ The reset for bits 6:4 of the **RCC2** register (OSCSRC2) is 0x1 (IOSC). Prior data sheets incorrectly noted the reset was 0x0 (MOSC).<br>■ Two figures on clock source were added to the "Hibernation Module":<br>– Clock Source Using Crystal<br>– Clock Source Using Dedicated Oscillator<br>■ The following notes on battery management were added to the "Hibernation Module" chapter:<br>– Battery voltage is not measured while in Hibernate mode.<br>– System level factors may affect the accuracy of the low battery detect circuit. The designer should consider battery type, discharge characteristics, and a test load during battery voltage measurements.<br>■ A note on high-current applications was added to the GPIO chapter:<br>For special high-current applications, the GPIO output buffers may be used with the following restrictions. With the GPIO pins configured as 8-mA output drivers, a total of four GPIO outputs may be used to sink current loads up to 18 mA each. At 18-mA sink current loading, the VOL value is specified as 1.2 V. The high-current GPIO package pins must be selected such that there are only a maximum of two per side of the physical package or BGA pin group with the total number of high-current GPIO outputs not exceeding four for the entire package.<br>■ A note on Schmitt inputs was added to the GPIO chapter:<br>Pins configured as digital inputs are Schmitt-triggered.<br>■ The Buffer type on the WAKE pin changed from OD to - in the Signal Tables.<br>■ The "Differential Sampling Range" figures in the ADC chapter were clarified.<br>■ The last revision of the data sheet (revision 2550) introduced two errors that have now been corrected:<br>– The LQFP pin diagrams and pin tables were missing the comparator positive and negative input pins.<br>– The base address was listed incorrectly in the **FMPRE0** and **FMPPE0** register bit diagrams.<br>■ Additional minor data sheet clarifications and corrections. |
| March 2008 | 2550 | Started tracking revision history. |

# About This Document

This data sheet provides reference information for the LM3S1960 microcontroller, describing the functional blocks of the system-on-chip (SoC) device designed around the ARM® Cortex™-M3 core.

## Audience

This manual is intended for system software developers, hardware designers, and application developers.

## About This Manual

This document is organized into sections that correspond to each major feature.

## Related Documents

The following related documents are available on the Stellaris® web site at www.ti.com/stellaris:

- *Stellaris® Errata*
- *ARM® Cortex™-M3 Errata*
- *Cortex™-M3/M4 Instruction Set Technical User's Manual*
- *Stellaris® Graphics Library User's Guide*
- *Stellaris® Peripheral Driver Library User's Guide*

The following related documents are also referenced:

- *ARM® Debug Interface V5 Architecture Specification*
- *ARM® Embedded Trace Macrocell Architecture Specification*
- *IEEE Standard 1149.1-Test Access Port and Boundary-Scan Architecture*

This documentation list was current as of publication date. Please check the web site for additional documentation, including application notes and white papers.

# Documentation Conventions

This document uses the conventions shown in Table 2 on page 29.

**Table 2. Documentation Conventions**

| Notation | Meaning |
|---|---|
| **General Register Notation** | |
| **REGISTER** | APB registers are indicated in uppercase bold. For example, **PBORCTL** is the Power-On and Brown-Out Reset Control register. If a register name contains a lowercase n, it represents more than one register. For example, **SRCRn** represents any (or all) of the three Software Reset Control registers: **SRCR0, SRCR1** , and **SRCR2**. |
| bit | A single bit in a register. |
| bit field | Two or more consecutive and related bits. |
| offset 0x*nnn* | A hexadecimal increment to a register's address, relative to that module's base address as specified in Table 2-4 on page 66. |
| Register *N* | Registers are numbered consecutively throughout the document to aid in referencing them. The register number has no meaning to software. |
| reserved | Register bits marked *reserved* are reserved for future use. In most cases, reserved bits are set to 0; however, user software should not rely on the value of a reserved bit. To provide software compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| *yy:xx* | The range of register bits inclusive from xx to yy. For example, 31:15 means bits 15 through 31 in that register. |
| **Register Bit/Field Types** | This value in the register bit diagram indicates whether software running on the controller can change the value of the bit field. |
| RC | Software can read this field. The bit or field is cleared by hardware after reading the bit/field. |
| RO | Software can read this field. Always write the chip reset value. |
| R/W | Software can read or write this field. |
| R/WC | Software can read or write this field. Writing to it with any value clears the register. |
| R/W1C | Software can read or write this field. A write of a 0 to a W1C bit does not affect the bit value in the register. A write of a 1 clears the value of the bit in the register; the remaining bits remain unchanged.<br>This register type is primarily used for clearing interrupt status bits where the read operation provides the interrupt status and the write of the read value clears only the interrupts being reported at the time the register was read. |
| R/W1S | Software can read or write a 1 to this field. A write of a 0 to a R/W1S bit does not affect the bit value in the register. |
| W1C | Software can write this field. A write of a 0 to a W1C bit does not affect the bit value in the register. A write of a 1 clears the value of the bit in the register; the remaining bits remain unchanged. A read of the register returns no meaningful data.<br>This register is typically used to clear the corresponding bit in an interrupt register. |
| WO | Only a write by software is valid; a read of the register returns no meaningful data. |
| **Register Bit/Field Reset Value** | This value in the register bit diagram shows the bit/field value after any reset, unless noted. |
| 0 | Bit cleared to 0 on chip reset. |
| 1 | Bit set to 1 on chip reset. |
| - | Nondeterministic. |
| **Pin/Signal Notation** | |
| [ ] | Pin alternate function; a pin defaults to the signal without the brackets. |
| pin | Refers to the physical connection on the package. |
| signal | Refers to the electrical signal encoding of a pin. |

**Table 2. Documentation Conventions *(continued)***

| Notation | Meaning |
|---|---|
| assert a signal | Change the value of the signal from the logically False state to the logically True state. For active High signals, the asserted signal value is 1 (High); for active Low signals, the asserted signal value is 0 (Low). The active polarity (High or Low) is defined by the signal name (see SIGNAL and $\overline{\text{SIGNAL}}$ below). |
| deassert a signal | Change the value of the signal from the logically True state to the logically False state. |
| $\overline{\text{SIGNAL}}$ | Signal names are in uppercase and in the Courier font. An overbar on a signal name indicates that it is active Low. To assert $\overline{\text{SIGNAL}}$ is to drive it Low; to deassert $\overline{\text{SIGNAL}}$ is to drive it High. |
| SIGNAL | Signal names are in uppercase and in the Courier font. An active High signal has no overbar. To assert SIGNAL is to drive it High; to deassert SIGNAL is to drive it Low. |
| **Numbers** | |
| X | An uppercase X indicates any of several values is allowed, where X can be any legal pattern. For example, a binary value of 0X00 can be either 0100 or 0000, a hex value of 0xX is 0x0 or 0x1, and so on. |
| 0x | Hexadecimal numbers have a prefix of 0x. For example, 0x00FF is the hexadecimal number FF.<br>All other numbers within register tables are assumed to be binary. Within conceptual information, binary numbers are indicated with a b suffix, for example, 1011b, and decimal numbers are written without a prefix or suffix. |

# 1 Architectural Overview

The Stellaris® family of microcontrollers—the first ARM® Cortex™-M3 based controllers—brings high-performance 32-bit computing to cost-sensitive embedded microcontroller applications. These pioneering parts deliver customers 32-bit performance at a cost equivalent to legacy 8- and 16-bit devices, all in a package with a small footprint.

The Stellaris family offers efficient performance and extensive integration, favorably positioning the device into cost-conscious applications requiring significant control-processing and connectivity capabilities. The Stellaris LM3S1000 series extends the Stellaris family with larger on-chip memories, enhanced power management, and expanded I/O and control capabilities.

The LM3S1960 microcontroller is targeted for industrial applications, including remote monitoring, electronic point-of-sale machines, test and measurement equipment, network appliances and switches, factory automation, HVAC and building control, gaming equipment, motion control, medical instrumentation, and fire and security.

For applications requiring extreme conservation of power, the LM3S1960 microcontroller features a battery-backed Hibernation module to efficiently power down the LM3S1960 to a low-power state during extended periods of inactivity. With a power-up/power-down sequencer, a continuous time counter (RTC), a pair of match registers, an APB interface to the system bus, and dedicated non-volatile memory, the Hibernation module positions the LM3S1960 microcontroller perfectly for battery applications.

In addition, the LM3S1960 microcontroller offers the advantages of ARM's widely available development tools, System-on-Chip (SoC) infrastructure IP applications, and a large user community. Additionally, the microcontroller uses ARM's Thumb®-compatible Thumb-2 instruction set to reduce memory requirements and, thereby, cost. Finally, the LM3S1960 microcontroller is code-compatible to all members of the extensive Stellaris family; providing flexibility to fit our customers' precise needs.

Texas Instruments offers a complete solution to get to market quickly, with evaluation and development boards, white papers and application notes, an easy-to-use peripheral driver library, and a strong support, sales, and distributor network. See “Ordering and Contact Information” on page 648 for ordering information for Stellaris family devices.

## 1.1 Product Features

The LM3S1960 microcontroller includes the following product features:

- 32-Bit RISC Performance
  - 32-bit ARM® Cortex™-M3 v7M architecture optimized for small-footprint embedded applications
  - System timer (SysTick), providing a simple, 24-bit clear-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism
  - Thumb®-compatible Thumb-2-only instruction set processor core for high code density
  - 50-MHz operation
  - Hardware-division and single-cycle-multiplication

  - Integrated Nested Vectored Interrupt Controller (NVIC) providing deterministic interrupt handling
  - 36 interrupts with eight priority levels
  - Memory protection unit (MPU), providing a privileged mode for protected operating system functionality
  - Unaligned data access, enabling data to be efficiently packed into memory
  - Atomic bit manipulation (bit-banding), delivering maximum memory utilization and streamlined peripheral control

- ARM® Cortex™-M3 Processor Core
  - Compact core.
  - Thumb-2 instruction set, delivering the high-performance expected of an ARM core in the memory size usually associated with 8- and 16-bit devices; typically in the range of a few kilobytes of memory for microcontroller class applications.
  - Rapid application execution through Harvard architecture characterized by separate buses for instruction and data.
  - Exceptional interrupt handling, by implementing the register manipulations required for handling an interrupt in hardware.
  - Deterministic, fast interrupt processing: always 12 cycles, or just 6 cycles with tail-chaining
  - Memory protection unit (MPU) to provide a privileged mode of operation for complex applications.
  - Migration from the ARM7™ processor family for better performance and power efficiency.
  - Full-featured debug solution
    - Serial Wire JTAG Debug Port (SWJ-DP)
    - Flash Patch and Breakpoint (FPB) unit for implementing breakpoints
    - Data Watchpoint and Trigger (DWT) unit for implementing watchpoints, trigger resources, and system profiling
    - Instrumentation Trace Macrocell (ITM) for support of printf style debugging
    - Trace Port Interface Unit (TPIU) for bridging to a Trace Port Analyzer
  - Optimized for single-cycle flash usage
  - Three sleep modes with clock gating for low power
  - Single-cycle multiply instruction and hardware divide
  - Atomic operations
  - ARM Thumb2 mixed 16-/32-bit instruction set

  - 1.25 DMIPS/MHz
- JTAG
  - IEEE 1149.1-1990 compatible Test Access Port (TAP) controller
  - Four-bit Instruction Register (IR) chain for storing JTAG instructions
  - IEEE standard instructions: BYPASS, IDCODE, SAMPLE/PRELOAD, EXTEST and INTEST
  - ARM additional instructions: APACC, DPACC and ABORT
  - Integrated ARM Serial Wire Debug (SWD)
- Hibernation
  - System power control using discrete external regulator
  - Dedicated pin for waking from an external signal
  - Low-battery detection, signaling, and interrupt generation
  - 32-bit real-time clock (RTC)
  - Two 32-bit RTC match registers for timed wake-up and interrupt generation
  - Clock source from a 32.768-kHz external oscillator or a 4.194304-MHz crystal
  - RTC predivider trim for making fine adjustments to the clock rate
  - 64 32-bit words of non-volatile memory
  - Programmable interrupts for RTC match, external wake, and low battery events
- Internal Memory
  - 256 KB single-cycle flash
    - User-managed flash block protection on a 2-KB block basis
    - User-managed flash data programming
    - User-defined and managed flash-protection block
  - 64 KB single-cycle SRAM
- GPIOs
  - 7-60 GPIOs, depending on configuration
  - 5-V-tolerant in input configuration
  - Fast toggle capable of a change every two clock cycles
  - Programmable control for GPIO interrupts
    - Interrupt generation masking

- Edge-triggered on rising, falling, or both
- Level-sensitive on High or Low values

– Bit masking in both read and write operations through address lines

– Pins configured as digital inputs are Schmitt-triggered.

– Programmable control for GPIO pad configuration

- Weak pull-up or pull-down resistors
- 2-mA, 4-mA, and 8-mA pad drive for digital communication; up to four pads can be configured with an 18-mA pad drive for high-current applications
- Slew rate control for the 8-mA drive
- Open drain enables
- Digital input enables

■ General-Purpose Timers

– Four General-Purpose Timer Modules (GPTM), each of which provides two 16-bit timers/counters. Each GPTM can be configured to operate independently:

- As a single 32-bit timer
- As one 32-bit Real-Time Clock (RTC) to event capture
- For Pulse Width Modulation (PWM)

– 32-bit Timer modes

- Programmable one-shot timer
- Programmable periodic timer
- Real-Time Clock when using an external 32.768-KHz clock as the input
- User-enabled stalling when the controller asserts CPU Halt flag during debug

– 16-bit Timer modes

- General-purpose timer function with an 8-bit prescaler (for one-shot and periodic modes only)
- Programmable one-shot timer
- Programmable periodic timer
- User-enabled stalling when the controller asserts CPU Halt flag during debug

– 16-bit Input Capture modes

- Input edge count capture

        - Input edge time capture
    - 16-bit PWM mode
        - Simple PWM mode with software-programmable output inversion of the PWM signal
- ARM FiRM-compliant Watchdog Timer
    - 32-bit down counter with a programmable load register
    - Separate watchdog clock with an enable
    - Programmable interrupt generation logic with interrupt masking
    - Lock register protection from runaway software
    - Reset generation logic with an enable/disable
    - User-enabled stalling when the controller asserts the CPU Halt flag during debug
- UART
    - Three fully programmable 16C550-type UARTs with IrDA support
    - Separate 16x8 transmit (TX) and receive (RX) FIFOs to reduce CPU interrupt service loading
    - Programmable baud-rate generator allowing speeds up to 3.125 Mbps
    - Programmable FIFO length, including 1-byte deep operation providing conventional double-buffered interface
    - FIFO trigger levels of 1/8, 1/4, 1/2, 3/4, and 7/8
    - Standard asynchronous communication bits for start, stop, and parity
    - Line-break generation and detection
    - Fully programmable serial interface characteristics
        - 5, 6, 7, or 8 data bits
        - Even, odd, stick, or no-parity bit generation/detection
        - 1 or 2 stop bit generation
    - IrDA serial-IR (SIR) encoder/decoder providing
        - Programmable use of IrDA Serial Infrared (SIR) or UART input/output
        - Support of IrDA SIR encoder/decoder functions for data rates up to 115.2 Kbps half-duplex
        - Support of normal 3/16 and low-power (1.41-2.23 µs) bit durations
        - Programmable internal clock generator enabling division of reference clock by 1 to 256 for low-power mode bit duration
- Synchronous Serial Interface (SSI)

  - Two SSI modules, each with the following features:
  - Master or slave operation
  - Programmable clock bit rate and prescale
  - Separate transmit and receive FIFOs, 16 bits wide, 8 locations deep
  - Programmable interface operation for Freescale SPI, MICROWIRE, or Texas Instruments synchronous serial interfaces
  - Programmable data frame size from 4 to 16 bits
  - Internal loopback test mode for diagnostic/debug testing

- $I^2C$
  - Two $I^2C$ modules, each with the following features:
  - Devices on the $I^2C$ bus can be designated as either a master or a slave
    - Supports both sending and receiving data as either a master or a slave
    - Supports simultaneous master and slave operation
  - Four $I^2C$ modes
    - Master transmit
    - Master receive
    - Slave transmit
    - Slave receive
  - Two transmission speeds: Standard (100 Kbps) and Fast (400 Kbps)
  - Master and slave interrupt generation
    - Master generates interrupts when a transmit or receive operation completes (or aborts due to an error)
    - Slave generates interrupts when data has been sent or requested by a master
  - Master with arbitration and clock synchronization, multimaster support, and 7-bit addressing mode

- Analog Comparators
  - Three independent integrated analog comparators
  - Configurable for output to drive an output pin or generate an interrupt
  - Compare external pin input to external pin input or to internal programmable voltage reference
  - Compare a test voltage against any one of these voltages

    - An individual external reference voltage
    - A shared single external reference voltage
    - A shared internal reference voltage

- PWM
  - Three PWM generator blocks, each with one 16-bit counter, two PWM comparators, a PWM signal generator, a dead-band generator, and an interrupt selector
  - One fault input in hardware to promote low-latency shutdown
  - One 16-bit counter
    - Runs in Down or Up/Down mode
    - Output frequency controlled by a 16-bit load value
    - Load value updates can be synchronized
    - Produces output signals at zero and load value
  - Two PWM comparators
    - Comparator value updates can be synchronized
    - Produces output signals on match
  - PWM generator
    - Output PWM signal is constructed based on actions taken as a result of the counter and PWM comparator output signals
    - Produces two independent PWM signals
  - Dead-band generator
    - Produces two PWM signals with programmable dead-band delays suitable for driving a half-H bridge
    - Can be bypassed, leaving input PWM signals unmodified
  - Flexible output control block with PWM output enable of each PWM signal
    - PWM output enable of each PWM signal
    - Optional output inversion of each PWM signal (polarity control)
    - Optional fault handling for each PWM signal
    - Synchronization of timers in the PWM generator blocks
    - Interrupt status summary of the PWM generator blocks
- QEI

  - Two QEI modules, each with the following features:
  - Position integrator that tracks the encoder position
  - Velocity capture using built-in timer
  - The input frequency of the QEI inputs may be as high as 1/4 of the processor frequency (for example, 12.5 MHz for a 50-MHz system)
  - Interrupt generation on:
    - Index pulse
    - Velocity-timer expiration
    - Direction change
    - Quadrature error detection
- Power
  - On-chip Low Drop-Out (LDO) voltage regulator, with programmable output user-adjustable from 2.25 V to 2.75 V
  - Hibernation module handles the power-up/down 3.3 V sequencing and control for the core digital logic and analog circuits
  - Low-power options on controller: Sleep and Deep-sleep modes
  - Low-power options for peripherals: software controls shutdown of individual peripherals
  - 3.3-V supply brown-out detection and reporting via interrupt or reset
- Flexible Reset Sources
  - Power-on reset (POR)
  - Reset pin assertion
  - Brown-out (BOR) detector alerts to system power drops
  - Software reset
  - Watchdog timer reset
  - Internal low drop-out (LDO) regulator output goes unregulated
- Industrial and extended temperature 100-pin RoHS-compliant LQFP package
- Industrial-range 108-ball RoHS-compliant BGA package

## 1.2 Target Applications

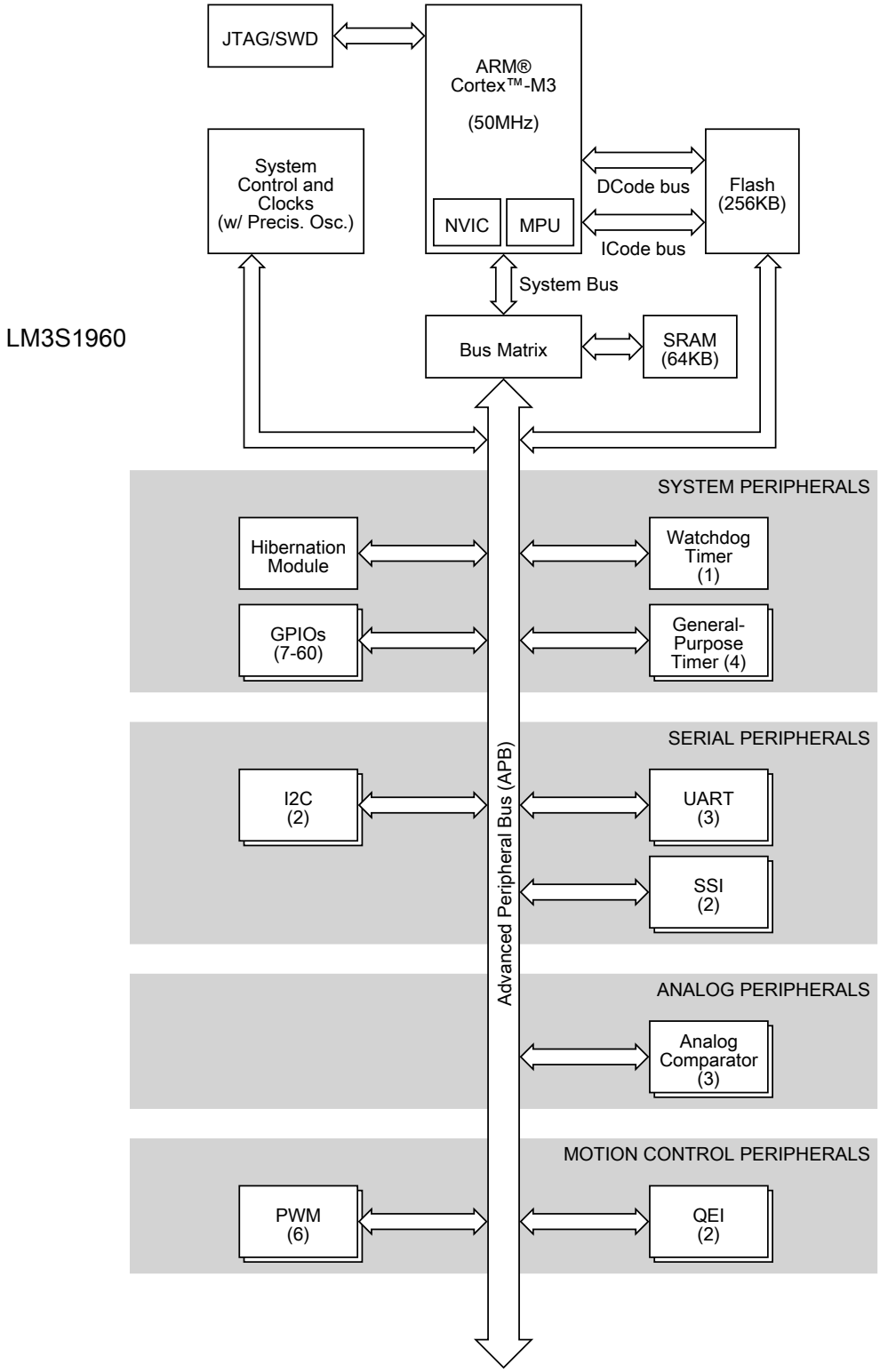
- Remote monitoring
- Electronic point-of-sale (POS) machines

- Test and measurement equipment
- Network appliances and switches
- Factory automation
- HVAC and building control
- Gaming equipment
- Motion control
- Medical instrumentation
- Fire and security
- Power and energy
- Transportation

## 1.3 High-Level Block Diagram

Figure 1-1 on page 40 depicts the features on the Stellaris LM3S1960 microcontroller.

**Figure 1-1. Stellaris LM3S1960 Microcontroller High-Level Block Diagram**



# 1.4 Functional Overview

The following sections provide an overview of the features of the LM3S1960 microcontroller. The page number in parenthesis indicates where that feature is discussed in detail. Ordering and support information can be found in “Ordering and Contact Information” on page 648.

## 1.4.1 ARM Cortex™-M3

### 1.4.1.1 Processor Core (see page 47)

All members of the Stellaris product family, including the LM3S1960 microcontroller, are designed around an ARM Cortex™-M3 processor core. The ARM Cortex-M3 processor provides the core for a high-performance, low-cost platform that meets the needs of minimal memory implementation, reduced pin count, and low-power consumption, while delivering outstanding computational performance and exceptional system response to interrupts.

### 1.4.1.2 Memory Map (see page 66)

A memory map lists the location of instructions and data in memory. The memory map for the LM3S1960 controller can be found in Table 2-4 on page 66. Register addresses are given as a hexadecimal increment, relative to the module's base address as shown in the memory map.

### 1.4.1.3 System Timer (SysTick) (see page 89)

Cortex-M3 includes an integrated system timer, SysTick. SysTick provides a simple, 24-bit clear-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism. The counter can be used in several different ways, for example:

- An RTOS tick timer which fires at a programmable rate (for example, 100 Hz) and invokes a SysTick routine.
- A high-speed alarm timer using the system clock.
- A variable rate alarm or signal timer—the duration is range-dependent on the reference clock used and the dynamic range of the counter.
- A simple counter. Software can use this to measure time to completion and time used.
- An internal clock source control based on missing/meeting durations. The COUNTFLAG bit-field in the control and status register can be used to determine if an action completed within a set duration, as part of a dynamic clock management control loop.

### 1.4.1.4 Nested Vectored Interrupt Controller (NVIC) (see page 90)

The LM3S1960 controller includes the ARM Nested Vectored Interrupt Controller (NVIC) on the ARM® Cortex™-M3 core. The NVIC and Cortex-M3 prioritize and handle all exceptions. All exceptions are handled in Handler Mode. The processor state is automatically stored to the stack on an exception, and automatically restored from the stack at the end of the Interrupt Service Routine (ISR). The vector is fetched in parallel to the state saving, which enables efficient interrupt entry. The processor supports tail-chaining, which enables back-to-back interrupts to be performed without the overhead of state saving and restoration. Software can set eight priority levels on 7 exceptions (system handlers) and 36 interrupts.

#### 1.4.1.5 System Control Block (SCB) (see page 92)

The SCB provides system implementation information and system control, including configuration, control, and reporting of system exceptions.

#### 1.4.1.6 Memory Protection Unit (MPU) (see page 92)

The MPU supports the standard ARMv7 Protected Memory System Architecture (PMSA) model. The MPU provides full support for protection regions, overlapping protection regions, access permissions, and exporting memory attributes to the system.

### 1.4.2 Motor Control Peripherals

To enhance motor control, the LM3S1960 controller features Pulse Width Modulation (PWM) outputs and the Quadrature Encoder Interface (QEI).

#### 1.4.2.1 PWM

Pulse width modulation (PWM) is a powerful technique for digitally encoding analog signal levels. High-resolution counters are used to generate a square wave, and the duty cycle of the square wave is modulated to encode an analog signal. Typical applications include switching power supplies and motor control.

On the LM3S1960, PWM motion control functionality can be achieved through:

- Dedicated, flexible motion control hardware using the PWM pins
- The motion control features of the general-purpose timers using the CCP pins

***PWM Pins (see page 520)***

The LM3S1960 PWM module consists of three PWM generator blocks and a control block. Each PWM generator block contains one timer (16-bit down or up/down counter), two comparators, a PWM signal generator, a dead-band generator, and an interrupt. The control block determines the polarity of the PWM signals, and which signals are passed through to the pins.

Each PWM generator block produces two PWM signals that can either be independent signals or a single pair of complementary signals with dead-band delays inserted. The output of the PWM generation blocks are managed by the output control block before being passed to the device pins.

***CCP Pins (see page 335)***

The General-Purpose Timer Module's CCP (Capture Compare PWM) pins are software programmable to support a simple PWM mode with a software-programmable output inversion of the PWM signal.

***Fault Pin (see page 526)***

The LM3S1960 PWM module includes one fault-condition handling input to quickly provide low-latency shutdown and prevent damage to the motor being controlled.

#### 1.4.2.2 QEI (see page 558)

A quadrature encoder, also known as a 2-channel incremental encoder, converts linear displacement into a pulse signal. By monitoring both the number of pulses and the relative phase of the two signals, you can track the position, direction of rotation, and speed. In addition, a third channel, or index signal, can be used to reset the position counter.

The Stellaris quadrature encoder with index (QEI) module interprets the code produced by a quadrature encoder wheel to integrate position over time and determine direction of rotation. In

addition, it can capture a running estimate of the velocity of the encoder wheel. The LM3S1960 microcontroller includes two QEI modules, which enables control of two motors at the same time.

## 1.4.3 Analog Peripherals

For support of analog signals, the LM3S1960 microcontroller offers three analog comparators.

### 1.4.3.1 Analog Comparators (see page 507)

An analog comparator is a peripheral that compares two analog voltages, and provides a logical output that signals the comparison result.

The LM3S1960 microcontroller provides three independent integrated analog comparators that can be configured to drive an output or generate an interrupt .

A comparator can compare a test voltage against any one of these voltages:

- An individual external reference voltage
- A shared single external reference voltage
- A shared internal reference voltage

The comparator can provide its output to a device pin, acting as a replacement for an analog comparator on the board, or it can be used to signal the application via interrupts to cause it to start capturing a sample sequence.

## 1.4.4 Serial Communications Peripherals

The LM3S1960 controller supports both asynchronous and synchronous serial communications with:

- Three fully programmable 16C550-type UARTs
- Two SSI modules
- Two $I^2C$ modules

### 1.4.4.1 UART (see page 389)

A Universal Asynchronous Receiver/Transmitter (UART) is an integrated circuit used for RS-232C serial communications, containing a transmitter (parallel-to-serial converter) and a receiver (serial-to-parallel converter), each clocked separately.

The LM3S1960 controller includes three fully programmable 16C550-type UARTs that support data transfer speeds up to 3.125 Mbps. (Although similar in functionality to a 16C550 UART, it is not register-compatible.) In addition, each UART is capable of supporting IrDA.

Separate 16x8 transmit (TX) and receive (RX) FIFOs reduce CPU interrupt service loading. The UART can generate individually masked interrupts from the RX, TX, modem status, and error conditions. The module provides a single combined interrupt when any of the interrupts are asserted and are unmasked.

### 1.4.4.2 SSI (see page 432)

Synchronous Serial Interface (SSI) is a four-wire bi-directional full and low-speed communications interface.

The LM3S1960 controller includes two SSI modules that provide the functionality for synchronous serial communications with peripheral devices, and can be configured to use the Freescale SPI, MICROWIRE, or TI synchronous serial interface frame formats. The size of the data frame is also configurable, and can be set between 4 and 16 bits, inclusive.

Each SSI module performs serial-to-parallel conversion on data received from a peripheral device, and parallel-to-serial conversion on data transmitted to a peripheral device. The TX and RX paths are buffered with internal FIFOs, allowing up to eight 16-bit values to be stored independently.

Each SSI module can be configured as either a master or slave device. As a slave device, the SSI module can also be configured to disable its output, which allows a master device to be coupled with multiple slave devices.

Each SSI module also includes a programmable bit rate clock divider and prescaler to generate the output serial clock derived from the SSI module's input clock. Bit rates are generated based on the input clock and the maximum bit rate is determined by the connected peripheral.

#### 1.4.4.3 $I^2C$ (see page 470)

The Inter-Integrated Circuit ($I^2C$) bus provides bi-directional data transfer through a two-wire design (a serial data line SDA and a serial clock line SCL).

The $I^2C$ bus interfaces to external $I^2C$ devices such as serial memory (RAMs and ROMs), networking devices, LCDs, tone generators, and so on. The $I^2C$ bus may also be used for system testing and diagnostic purposes in product development and manufacture.

The LM3S1960 controller includes two $I^2C$ modules that provide the ability to communicate to other IC devices over an $I^2C$ bus. The $I^2C$ bus supports devices that can both transmit and receive (write and read) data.

Devices on the $I^2C$ bus can be designated as either a master or a slave. Each $I^2C$ module supports both sending and receiving data as either a master or a slave, and also supports the simultaneous operation as both a master and a slave. The four $I^2C$ modes are: Master Transmit, Master Receive, Slave Transmit, and Slave Receive.

A Stellaris $I^2C$ module can operate at two speeds: Standard (100 Kbps) and Fast (400 Kbps).

Both the $I^2C$ master and slave can generate interrupts. The $I^2C$ master generates interrupts when a transmit or receive operation completes (or aborts due to an error). The $I^2C$ slave generates interrupts when data has been sent or requested by a master.

### 1.4.5 System Peripherals

#### 1.4.5.1 Programmable GPIOs (see page 280)

General-purpose input/output (GPIO) pins offer flexibility for a variety of connections.

The Stellaris GPIO module is comprised of eight physical GPIO blocks, each corresponding to an individual GPIO port. The GPIO module is FiRM-compliant (compliant to the ARM Foundation IP for Real-Time Microcontrollers specification) and supports 7-60 programmable input/output pins. The number of GPIOs available depends on the peripherals being used (see “Signal Tables” on page 578 for the signals available to each GPIO pin).

The GPIO module features programmable interrupt generation as either edge-triggered or level-sensitive on all pins, programmable control for GPIO pad configuration, and bit masking in both read and write operations through address lines. Pins configured as digital inputs are Schmitt-triggered.

#### 1.4.5.2 Four Programmable Timers (see page 328)

Programmable timers can be used to count or time external events that drive the Timer input pins.

The Stellaris General-Purpose Timer Module (GPTM) contains four GPTM blocks. Each GPTM block provides two 16-bit timers/counters that can be configured to operate independently as timers or event counters, or configured to operate as one 32-bit timer or one 32-bit Real-Time Clock (RTC).

When configured in 32-bit mode, a timer can run as a Real-Time Clock (RTC), one-shot timer or periodic timer. When in 16-bit mode, a timer can run as a one-shot timer or periodic timer, and can extend its precision by using an 8-bit prescaler. A 16-bit timer can also be configured for event capture or Pulse Width Modulation (PWM) generation.

#### 1.4.5.3 Watchdog Timer (see page 365)

A watchdog timer can generate an interrupt or a reset when a time-out value is reached. The watchdog timer is used to regain control when a system has failed due to a software error or to the failure of an external device to respond in the expected way.

The Stellaris Watchdog Timer module consists of a 32-bit down counter, a programmable load register, interrupt generation logic, and a locking register.

The Watchdog Timer can be configured to generate an interrupt to the controller on its first time-out, and to generate a reset signal on its second time-out. Once the Watchdog Timer has been configured, the lock register can be written to prevent the timer configuration from being inadvertently altered.

### 1.4.6 Memory Peripherals

The LM3S1960 controller offers both single-cycle SRAM and single-cycle Flash memory.

#### 1.4.6.1 SRAM (see page 254)

The LM3S1960 static random access memory (SRAM) controller supports 64 KB SRAM. The internal SRAM of the Stellaris devices starts at base address 0x2000.0000 of the device memory map. To reduce the number of time-consuming read-modify-write (RMW) operations, ARM has introduced *bit-banding* technology in the new Cortex-M3 processor. With a bit-band-enabled processor, certain regions in the memory map (SRAM and peripheral space) can use address aliases to access individual bits in a single, atomic operation.

#### 1.4.6.2 Flash (see page 255)

The LM3S1960 Flash controller supports 256 KB of flash memory. The flash is organized as a set of 1-KB blocks that can be individually erased. Erasing a block causes the entire contents of the block to be reset to all 1s. These blocks are paired into a set of 2-KB blocks that can be individually protected. The blocks can be marked as read-only or execute-only, providing different levels of code protection. Read-only blocks cannot be erased or programmed, protecting the contents of those blocks from being modified. Execute-only blocks cannot be erased or programmed, and can only be read by the controller instruction fetch mechanism, protecting the contents of those blocks from being read by either the controller or by a debugger.

### 1.4.7 Additional Features

#### 1.4.7.1 JTAG TAP Controller (see page 153)

The Joint Test Action Group (JTAG) port is an IEEE standard that defines a Test Access Port and Boundary Scan Architecture for digital integrated circuits and provides a standardized serial interface for controlling the associated test logic. The TAP, Instruction Register (IR), and Data Registers (DR) can be used to test the interconnections of assembled printed circuit boards and obtain manufacturing

information on the components. The JTAG Port also provides a means of accessing and controlling design-for-test features such as I/O pin observation and control, scan testing, and debugging.

The JTAG port is composed of the standard five pins: TRST, TCK, TMS, TDI, and TDO. Data is transmitted serially into the controller on TDI and out of the controller on TDO. The interpretation of this data is dependent on the current state of the TAP controller. For detailed information on the operation of the JTAG port and TAP controller, please refer to the *IEEE Standard 1149.1-Test Access Port and Boundary-Scan Architecture*.

The Stellaris JTAG controller works with the ARM JTAG controller built into the Cortex-M3 core. This is implemented by multiplexing the TDO outputs from both JTAG controllers. ARM JTAG instructions select the ARM TDO output while Stellaris JTAG instructions select the Stellaris TDO outputs. The multiplexer is controlled by the Stellaris JTAG controller, which has comprehensive programming for the ARM, Stellaris, and unimplemented JTAG instructions.

#### 1.4.7.2 System Control and Clocks (see page 166)

System control determines the overall operation of the device. It provides information about the device, controls the clocking of the device and individual peripherals, and handles reset detection and reporting.

#### 1.4.7.3 Hibernation Module (see page 233)

The Hibernation module provides logic to switch power off to the main processor and peripherals, and to wake on external or time-based events. The Hibernation module includes power-sequencing logic, a real-time clock with a pair of match registers, low-battery detection circuitry, and interrupt signalling to the processor. It also includes 64 32-bit words of non-volatile memory that can be used for saving state during hibernation.

### 1.4.8 Hardware Details

Details on the pins and package can be found in the following sections:

- “Pin Diagram” on page 576
- “Signal Tables” on page 578
- “Operating Characteristics” on page 608
- “Electrical Characteristics” on page 609
- “Package Information” on page 650

# 2 The Cortex-M3 Processor

The ARM® Cortex™-M3 processor provides a high-performance, low-cost platform that meets the system requirements of minimal memory implementation, reduced pin count, and low power consumption, while delivering outstanding computational performance and exceptional system response to interrupts. Features include:

- Compact core.
- Thumb-2 instruction set, delivering the high-performance expected of an ARM core in the memory size usually associated with 8- and 16-bit devices; typically in the range of a few kilobytes of memory for microcontroller class applications.
- Rapid application execution through Harvard architecture characterized by separate buses for instruction and data.
- Exceptional interrupt handling, by implementing the register manipulations required for handling an interrupt in hardware.
- Deterministic, fast interrupt processing: always 12 cycles, or just 6 cycles with tail-chaining
- Memory protection unit (MPU) to provide a privileged mode of operation for complex applications.
- Migration from the ARM7™ processor family for better performance and power efficiency.
- Full-featured debug solution
  - Serial Wire JTAG Debug Port (SWJ-DP)
  - Flash Patch and Breakpoint (FPB) unit for implementing breakpoints
  - Data Watchpoint and Trigger (DWT) unit for implementing watchpoints, trigger resources, and system profiling
  - Instrumentation Trace Macrocell (ITM) for support of printf style debugging
  - Trace Port Interface Unit (TPIU) for bridging to a Trace Port Analyzer
- Optimized for single-cycle flash usage
- Three sleep modes with clock gating for low power
- Single-cycle multiply instruction and hardware divide
- Atomic operations
- ARM Thumb2 mixed 16-/32-bit instruction set
- 1.25 DMIPS/MHz

The Stellaris® family of microcontrollers builds on this core to bring high-performance 32-bit computing to cost-sensitive embedded microcontroller applications, such as factory automation and control, industrial control power devices, building and home automation, and stepper motor control.

This chapter provides information on the Stellaris implementation of the Cortex-M3 processor, including the programming model, the memory model, the exception model, fault handling, and power management.

For technical details on the instruction set, see the *Cortex™-M3/M4 Instruction Set Technical User's Manual*.

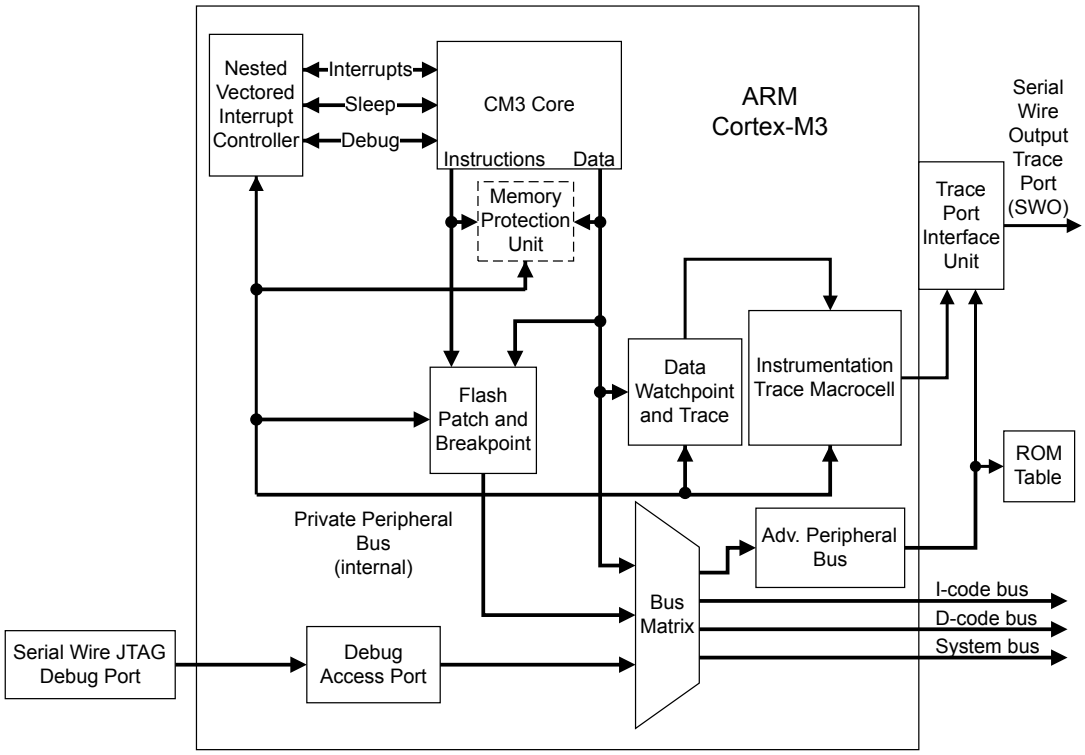
## 2.1 Block Diagram

The Cortex-M3 processor is built on a high-performance processor core, with a 3-stage pipeline Harvard architecture, making it ideal for demanding embedded applications. The processor delivers exceptional power efficiency through an efficient instruction set and extensively optimized design, providing high-end processing hardware including a range of single-cycle and SIMD multiplication and multiply-with-accumulate capabilities, saturating arithmetic and dedicated hardware division.

To facilitate the design of cost-sensitive devices, the Cortex-M3 processor implements tightly coupled system components that reduce processor area while significantly improving interrupt handling and system debug capabilities. The Cortex-M3 processor implements a version of the Thumb® instruction set based on Thumb-2 technology, ensuring high code density and reduced program memory requirements. The Cortex-M3 instruction set provides the exceptional performance expected of a modern 32-bit architecture, with the high code density of 8-bit and 16-bit microcontrollers.

The Cortex-M3 processor closely integrates a nested interrupt controller (NVIC), to deliver industry-leading interrupt performance. The Stellaris NVIC includes a non-maskable interrupt (NMI) and provides eight interrupt priority levels. The tight integration of the processor core and NVIC provides fast execution of interrupt service routines (ISRs), dramatically reducing interrupt latency. The hardware stacking of registers and the ability to suspend load-multiple and store-multiple operations further reduce interrupt latency. Interrupt handlers do not require any assembler stubs which removes code overhead from the ISRs. Tail-chaining optimization also significantly reduces the overhead when switching from one ISR to another. To optimize low-power designs, the NVIC integrates with the sleep modes, including Deep-sleep mode, which enables the entire device to be rapidly powered down.

**Figure 2-1. CPU Block Diagram**




## 2.2 Overview

### 2.2.1 System-Level Interface

The Cortex-M3 processor provides multiple interfaces using AMBA® technology to provide high-speed, low-latency memory accesses. The core supports unaligned data accesses and implements atomic bit manipulation that enables faster peripheral controls, system spinlocks, and thread-safe Boolean data handling.

The Cortex-M3 processor has a memory protection unit (MPU) that provides fine-grain memory control, enabling applications to implement security privilege levels and separate code, data and stack on a task-by-task basis.

### 2.2.2 Integrated Configurable Debug

The Cortex-M3 processor implements a complete hardware debug solution, providing high system visibility of the processor and memory through either a traditional JTAG port or a 2-pin Serial Wire Debug (SWD) port that is ideal for microcontrollers and other small package devices. The Stellaris implementation replaces the ARM SW-DP and JTAG-DP with the ARM CoreSight™-compliant Serial Wire JTAG Debug Port (SWJ-DP) interface. The SWJ-DP interface combines the SWD and JTAG debug ports into one module. See the *ARM® Debug Interface V5 Architecture Specification* for details on SWJ-DP.

For system trace, the processor integrates an Instrumentation Trace Macrocell (ITM) alongside data watchpoints and a profiling unit. To enable simple and cost-effective profiling of the system trace events, a Serial Wire Viewer (SWV) can export a stream of software-generated messages, data trace, and profiling information through a single pin.

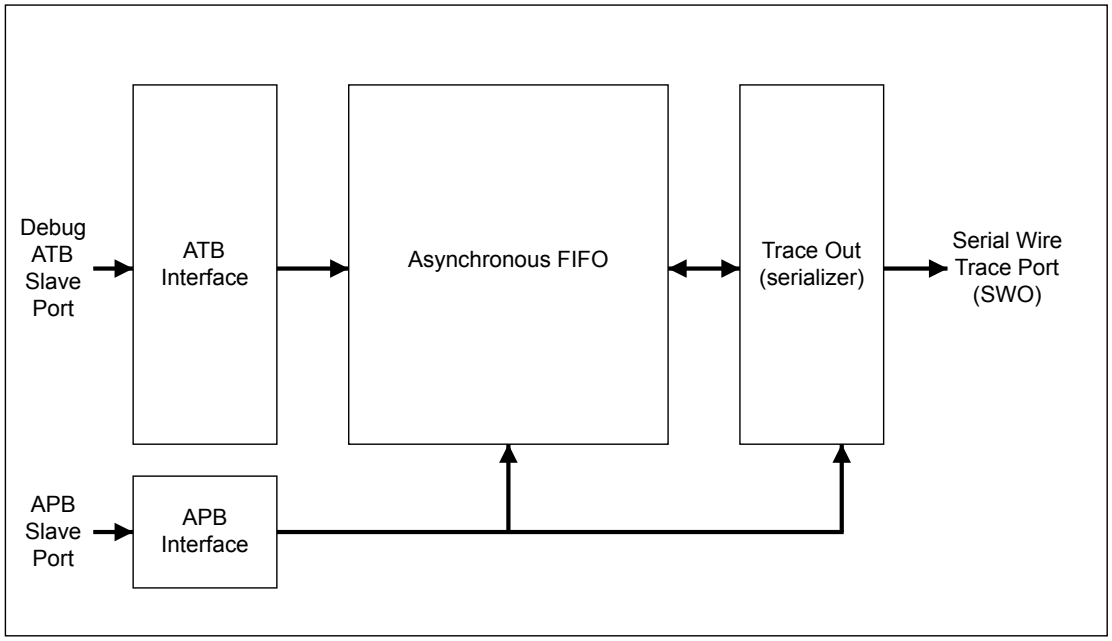
The Flash Patch and Breakpoint Unit (FPB) provides up to eight hardware breakpoint comparators that debuggers can use. The comparators in the FPB also provide remap functions of up to eight words in the program code in the CODE memory region. This enables applications stored in a read-only area of Flash memory to be patched in another area of on-chip SRAM or Flash memory. If a patch is required, the application programs the FPB to remap a number of addresses. When those addresses are accessed, the accesses are redirected to a remap table specified in the FPB configuration.

For more information on the Cortex-M3 debug capabilities, see the*ARM® Debug Interface V5 Architecture Specification*.

### 2.2.3 Trace Port Interface Unit (TPIU)

The TPIU acts as a bridge between the Cortex-M3 trace data from the ITM, and an off-chip Trace Port Analyzer, as shown in Figure 2-2 on page 50.

**Figure 2-2. TPIU Block Diagram**




### 2.2.4 Cortex-M3 System Component Details

The Cortex-M3 includes the following system components:

- SysTick

  A 24-bit count-down timer that can be used as a Real-Time Operating System (RTOS) tick timer or as a simple counter (see “System Timer (SysTick)” on page 89).

- Nested Vectored Interrupt Controller (NVIC)

  An embedded interrupt controller that supports low latency interrupt processing (see “Nested Vectored Interrupt Controller (NVIC)” on page 90).

- System Control Block (SCB)

The programming model interface to the processor. The SCB provides system implementation information and system control, including configuration, control, and reporting of system exceptions (see “System Control Block (SCB)” on page 92).

- Memory Protection Unit (MPU)

  Improves system reliability by defining the memory attributes for different memory regions. The MPU provides up to eight different regions and an optional predefined background region (see “Memory Protection Unit (MPU)” on page 92).

## 2.3 Programming Model

This section describes the Cortex-M3 programming model. In addition to the individual core register descriptions, information about the processor modes and privilege levels for software execution and stacks is included.

### 2.3.1 Processor Mode and Privilege Levels for Software Execution

The Cortex-M3 has two modes of operation:

- Thread mode

  Used to execute application software. The processor enters Thread mode when it comes out of reset.

- Handler mode

  Used to handle exceptions. When the processor has finished exception processing, it returns to Thread mode.

In addition, the Cortex-M3 has two privilege levels:

- Unprivileged

  In this mode, software has the following restrictions:

  – Limited access to the MSR and MRS instructions and no use of the CPS instruction

  – No access to the system timer, NVIC, or system control block

  – Possibly restricted access to memory or peripherals

- Privileged

  In this mode, software can use all the instructions and has access to all resources.

In Thread mode, the **CONTROL** register (see page 65) controls whether software execution is privileged or unprivileged. In Handler mode, software execution is always privileged.

Only privileged software can write to the **CONTROL** register to change the privilege level for software execution in Thread mode. Unprivileged software can use the SVC instruction to make a supervisor call to transfer control to privileged software.

### 2.3.2 Stacks

The processor uses a full descending stack, meaning that the stack pointer indicates the last stacked item on the memory. When the processor pushes a new item onto the stack, it decrements the stack pointer and then writes the item to the new memory location. The processor implements two stacks:

the main stack and the process stack, with a pointer for each held in independent registers (see the **SP** register on page 55).

In Thread mode, the **CONTROL** register (see page 65) controls whether the processor uses the main stack or the process stack. In Handler mode, the processor always uses the main stack. The options for processor operations are shown in Table 2-1 on page 52.

**Table 2-1. Summary of Processor Mode, Privilege Level, and Stack Use**

| Processor Mode | Use | Privilege Level | Stack Used |
|---|---|---|---|
| Thread | Applications | Privileged or unprivileged [a] | Main stack or process stack [a] |
| Handler | Exception handlers | Always privileged | Main stack |

a. See **CONTROL** (page 65).

## 2.3.3 Register Map

Figure 2-3 on page 52 shows the Cortex-M3 register set. Table 2-2 on page 53 lists the Core registers. The core registers are not memory mapped and are accessed by register name, so the base address is n/a (not applicable) and there is no offset.

**Figure 2-3. Cortex-M3 Register Set**

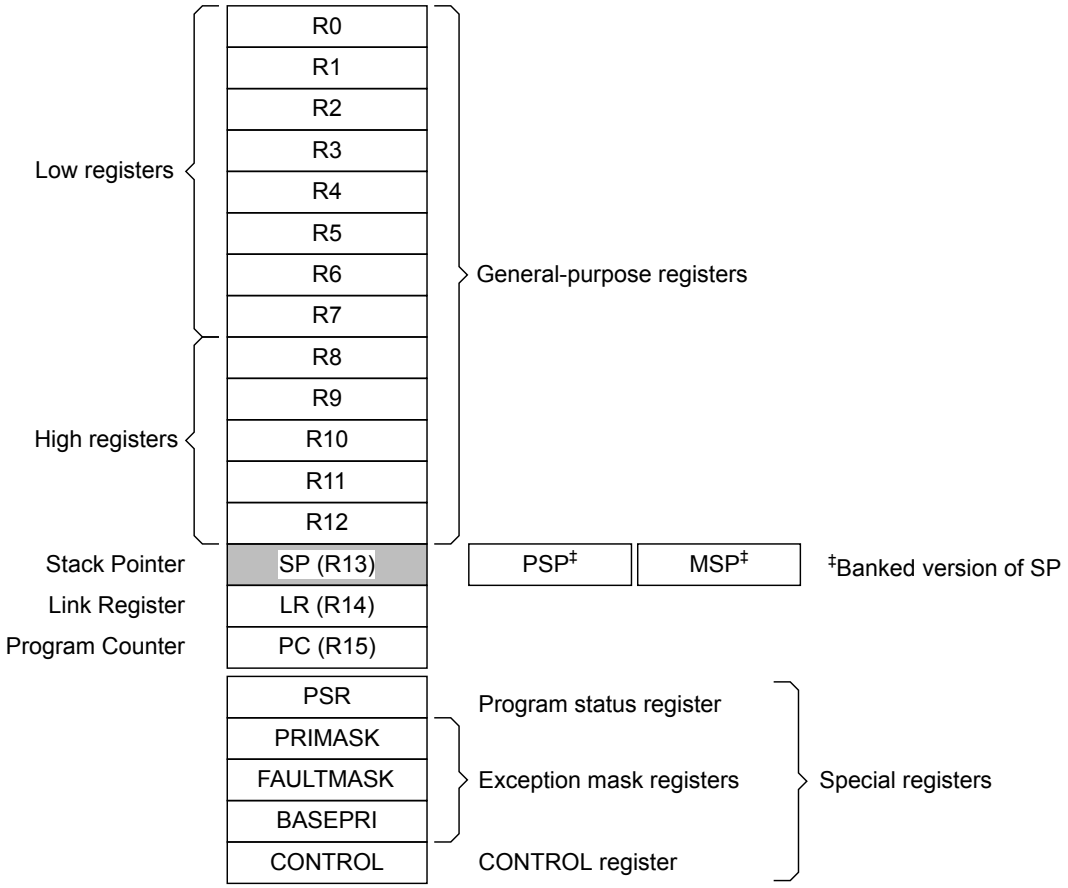


**Table 2-2. Processor Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| - | R0 | R/W | - | Cortex General-Purpose Register 0 | 54 |
| - | R1 | R/W | - | Cortex General-Purpose Register 1 | 54 |
| - | R2 | R/W | - | Cortex General-Purpose Register 2 | 54 |
| - | R3 | R/W | - | Cortex General-Purpose Register 3 | 54 |
| - | R4 | R/W | - | Cortex General-Purpose Register 4 | 54 |
| - | R5 | R/W | - | Cortex General-Purpose Register 5 | 54 |
| - | R6 | R/W | - | Cortex General-Purpose Register 6 | 54 |
| - | R7 | R/W | - | Cortex General-Purpose Register 7 | 54 |
| - | R8 | R/W | - | Cortex General-Purpose Register 8 | 54 |
| - | R9 | R/W | - | Cortex General-Purpose Register 9 | 54 |
| - | R10 | R/W | - | Cortex General-Purpose Register 10 | 54 |
| - | R11 | R/W | - | Cortex General-Purpose Register 11 | 54 |
| - | R12 | R/W | - | Cortex General-Purpose Register 12 | 54 |
| - | SP | R/W | - | Stack Pointer | 55 |
| - | LR | R/W | 0xFFFF.FFFF | Link Register | 56 |
| - | PC | R/W | - | Program Counter | 57 |
| - | PSR | R/W | 0x0100.0000 | Program Status Register | 58 |
| - | PRIMASK | R/W | 0x0000.0000 | Priority Mask Register | 62 |
| - | FAULTMASK | R/W | 0x0000.0000 | Fault Mask Register | 63 |
| - | BASEPRI | R/W | 0x0000.0000 | Base Priority Mask Register | 64 |
| - | CONTROL | R/W | 0x0000.0000 | Control Register | 65 |

### 2.3.4 Register Descriptions

This section lists and describes the Cortex-M3 registers, in the order shown in Figure 2-3 on page 52. The core registers are not memory mapped and are accessed by register name rather than offset.

**Note:** The register type shown in the register descriptions refers to type during program execution in Thread mode and Handler mode. Debug access can differ.

### Register 1: Cortex General-Purpose Register 0 (R0)

### Register 2: Cortex General-Purpose Register 1 (R1)

### Register 3: Cortex General-Purpose Register 2 (R2)

### Register 4: Cortex General-Purpose Register 3 (R3)

### Register 5: Cortex General-Purpose Register 4 (R4)

### Register 6: Cortex General-Purpose Register 5 (R5)

### Register 7: Cortex General-Purpose Register 6 (R6)

### Register 8: Cortex General-Purpose Register 7 (R7)

### Register 9: Cortex General-Purpose Register 8 (R8)

### Register 10: Cortex General-Purpose Register 9 (R9)

### Register 11: Cortex General-Purpose Register 10 (R10)

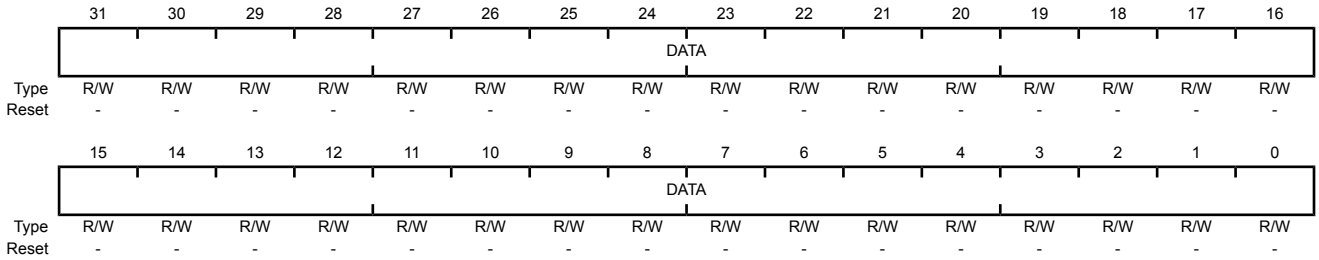
### Register 12: Cortex General-Purpose Register 11 (R11)

### Register 13: Cortex General-Purpose Register 12 (R12)

The **Rn** registers are 32-bit general-purpose registers for data operations and can be accessed from either privileged or unprivileged mode.

Cortex General-Purpose Register 0 (R0)

Type R/W, reset -



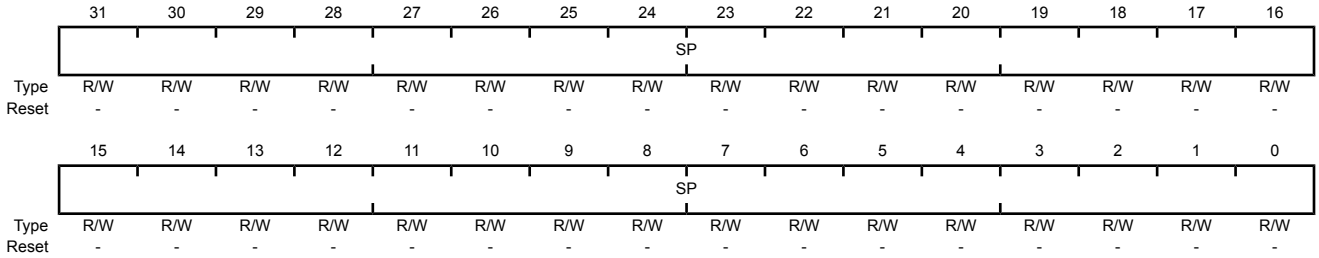

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | DATA | R/W | - | Register data. |

### Register 14: Stack Pointer (SP)

The **Stack Pointer (SP)** is register R13. In Thread mode, the function of this register changes depending on the ASP bit in the **Control Register (CONTROL)** register. When the ASP bit is clear, this register is the **Main Stack Pointer (MSP)**. When the ASP bit is set, this register is the **Process Stack Pointer (PSP)**. On reset, the ASP bit is clear, and the processor loads the **MSP** with the value from address 0x0000.0000. The **MSP** can only be accessed in privileged mode; the **PSP** can be accessed in either privileged or unprivileged mode.

Stack Pointer (SP)

Type R/W, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | SP | R/W | - | This field is the address of the stack pointer. |

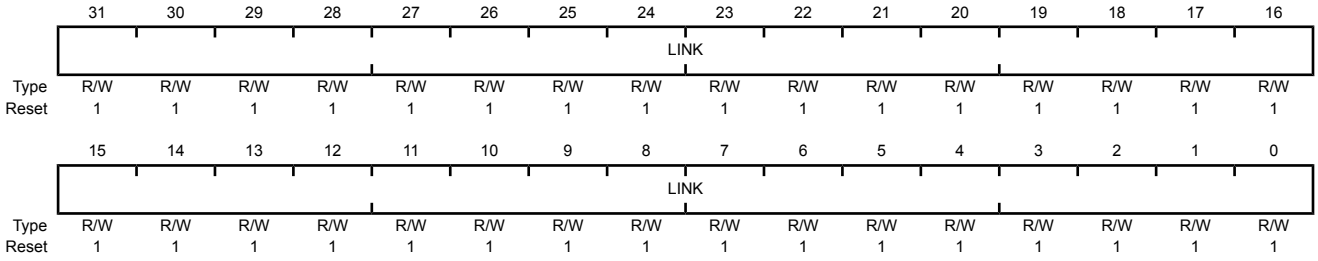
### Register 15: Link Register (LR)

The **Link Register (LR)** is register R14, and it stores the return information for subroutines, function calls, and exceptions. **LR** can be accessed from either privileged or unprivileged mode.

EXC_RETURN is loaded into **LR** on exception entry. See Table 2-10 on page 82 for the values and description.

Link Register (LR)

Type R/W, reset 0xFFFF.FFFF



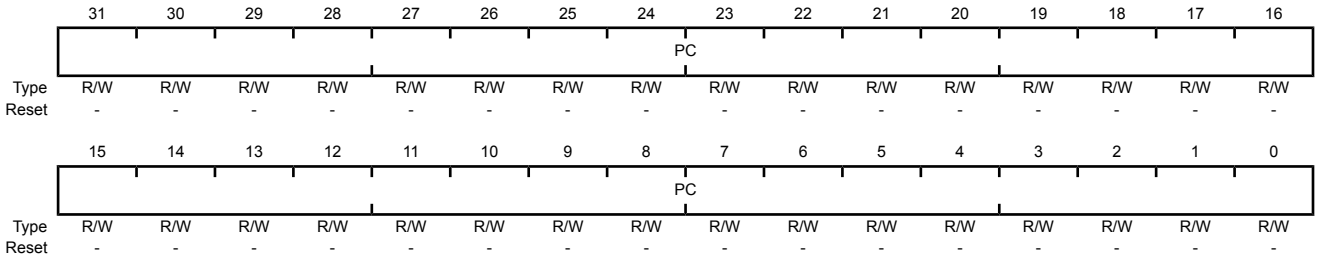

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | LINK | R/W | 0xFFFF.FFFF | This field is the return address. |

### Register 16: Program Counter (PC)

The **Program Counter (PC)** is register R15, and it contains the current program address. On reset, the processor loads the **PC** with the value of the reset vector, which is at address 0x0000.0004. Bit 0 of the reset vector is loaded into the THUMB bit of the **EPSR** at reset and must be 1. The **PC** register can be accessed in either privileged or unprivileged mode.

Program Counter (PC)

Type R/W, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | PC | R/W | - | This field is the current program address. |

### Register 17: Program Status Register (PSR)

**Note:** This register is also referred to as **xPSR**.

The **Program Status Register (PSR)** has three functions, and the register bits are assigned to the different functions:

- **Application Program Status Register (APSR)**, bits 31:27,
- **Execution Program Status Register (EPSR)**, bits 26:24, 15:10
- **Interrupt Program Status Register (IPSR)**, bits 5:0

The **PSR**, **IPSR**, and **EPSR** registers can only be accessed in privileged mode; the **APSR** register can be accessed in either privileged or unprivileged mode.

**APSR** contains the current state of the condition flags from previous instruction executions.

**EPSR** contains the Thumb state bit and the execution state bits for the If-Then (`IT`) instruction or the Interruptible-Continuable Instruction (`ICI`) field for an interrupted load multiple or store multiple instruction. Attempts to read the **EPSR** directly through application software using the `MSR` instruction always return zero. Attempts to write the **EPSR** using the `MSR` instruction in application software are always ignored. Fault handlers can examine the **EPSR** value in the stacked **PSR** to determine the operation that faulted (see “Exception Entry and Return” on page 80).

**IPSR** contains the exception type number of the current Interrupt Service Routine (ISR).

These registers can be accessed individually or as a combination of any two or all three registers, using the register name as an argument to the `MSR` or `MRS` instructions. For example, all of the registers can be read using **PSR** with the `MRS` instruction, or **APSR** only can be written to using **APSR** with the `MSR` instruction. page 58 shows the possible register combinations for the **PSR**. See the `MRS` and `MSR` instruction descriptions in the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information about how to access the program status registers.

**Table 2-3. PSR Register Combinations**

| Register | Type | Combination |
|---|---|---|
| **PSR** | R/W[a, b] | **APSR**, **EPSR**, and **IPSR** |
| **IEPSR** | RO | **EPSR** and **IPSR** |
| **IAPSR** | R/W[a] | **APSR** and **IPSR** |
| **EAPSR** | R/W[b] | **APSR** and **EPSR** |

a. The processor ignores writes to the **IPSR** bits.

b. Reads of the **EPSR** bits return zero, and the processor ignores writes to these bits.

Program Status Register (PSR)

Type R/W, reset 0x0100.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Z | C | V | Q | ICI / IT | | THUMB | reserved | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ICI / IT | | | | | | reserved | | | | ISRNUM | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | N | R/W | 0 | **APSR** Negative or Less Flag<br><br>Value Description<br>1 The previous operation result was negative or less than.<br>0 The previous operation result was positive, zero, greater than, or equal.<br><br>The value of this bit is only meaningful when accessing **PSR** or **APSR**. |
| 30 | Z | R/W | 0 | **APSR** Zero Flag<br><br>Value Description<br>1 The previous operation result was zero.<br>0 The previous operation result was non-zero.<br><br>The value of this bit is only meaningful when accessing **PSR** or **APSR**. |
| 29 | C | R/W | 0 | **APSR** Carry or Borrow Flag<br><br>Value Description<br>1 The previous add operation resulted in a carry bit or the previous subtract operation did not result in a borrow bit.<br>0 The previous add operation did not result in a carry bit or the previous subtract operation resulted in a borrow bit.<br><br>The value of this bit is only meaningful when accessing **PSR** or **APSR**. |
| 28 | V | R/W | 0 | **APSR** Overflow Flag<br><br>Value Description<br>1 The previous operation resulted in an overflow.<br>0 The previous operation did not result in an overflow.<br><br>The value of this bit is only meaningful when accessing **PSR** or **APSR**. |
| 27 | Q | R/W | 0 | **APSR** DSP Overflow and Saturation Flag<br><br>Value Description<br>1 DSP Overflow or saturation has occurred.<br>0 DSP overflow or saturation has not occurred since reset or since the bit was last cleared.<br><br>The value of this bit is only meaningful when accessing **PSR** or **APSR**.<br>This bit is cleared by software using an `MRS` instruction. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 26:25 | ICI / IT | RO | 0x0 | **EPSR** ICI / IT status<br>These bits, along with bits 15:10, contain the Interruptible-Continuable Instruction (ICI) field for an interrupted load multiple or store multiple instruction or the execution state bits of the IT instruction.<br>When **EPSR** holds the ICI execution state, bits 26:25 are zero.<br>The If-Then block contains up to four instructions following an IT instruction. Each instruction in the block is conditional. The conditions for the instructions are either all the same, or some can be the inverse of others. See the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information.<br>The value of this field is only meaningful when accessing **PSR** or **EPSR**. |
| 24 | THUMB | RO | 1 | **EPSR** Thumb State<br>This bit indicates the Thumb state and should always be set.<br>The following can clear the THUMB bit:<br>■ The BLX, BX and POP{PC} instructions<br>■ Restoration from the stacked **xPSR** value on an exception return<br>■ Bit 0 of the vector value on an exception entry or reset<br>Attempting to execute instructions when this bit is clear results in a fault or lockup. See “Lockup” on page 84 for more information.<br>The value of this bit is only meaningful when accessing **PSR** or **EPSR**. |
| 23:16 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:10 | ICI / IT | RO | 0x0 | **EPSR** ICI / IT status<br>These bits, along with bits 26:25, contain the Interruptible-Continuable Instruction (ICI) field for an interrupted load multiple or store multiple instruction or the execution state bits of the IT instruction.<br>When an interrupt occurs during the execution of an LDM, STM, PUSH or POP instruction, the processor stops the load multiple or store multiple instruction operation temporarily and stores the next register operand in the multiple operation to bits 15:12. After servicing the interrupt, the processor returns to the register pointed to by bits 15:12 and resumes execution of the multiple load or store instruction. When **EPSR** holds the ICI execution state, bits 11:10 are zero.<br>The If-Then block contains up to four instructions following a 16-bit IT instruction. Each instruction in the block is conditional. The conditions for the instructions are either all the same, or some can be the inverse of others. See the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information.<br>The value of this field is only meaningful when accessing **PSR** or **EPSR**. |
| 9:6 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

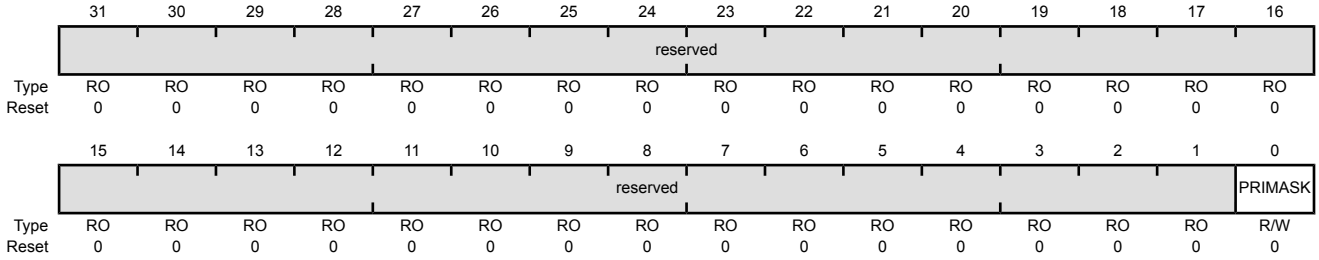
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 5:0 | ISRNUM | RO | 0x00 | **IPSR** ISR Number<br>This field contains the exception type number of the current Interrupt Service Routine (ISR).<br><br>Value — Description<br>0x00 — Thread mode<br>0x01 — Reserved<br>0x02 — NMI<br>0x03 — Hard fault<br>0x04 — Memory management fault<br>0x05 — Bus fault<br>0x06 — Usage fault<br>0x07-0x0A — Reserved<br>0x0B — SVCall<br>0x0C — Reserved for Debug<br>0x0D — Reserved<br>0x0E — PendSV<br>0x0F — SysTick<br>0x10 — Interrupt Vector 0<br>0x11 — Interrupt Vector 1<br>... — ...<br>0x3B — Interrupt Vector 43<br>0x3C-0x3F — Reserved<br><br>See “Exception Types” on page 75 for more information.<br>The value of this field is only meaningful when accessing **PSR** or **IPSR**. |

### Register 18: Priority Mask Register (PRIMASK)

The **PRIMASK** register prevents activation of all exceptions with programmable priority. Reset, non-maskable interrupt (NMI), and hard fault are the only exceptions with fixed priority. Exceptions should be disabled when they might impact the timing of critical tasks. This register is only accessible in privileged mode. The MSR and MRS instructions are used to access the **PRIMASK** register, and the CPS instruction may be used to change the value of the **PRIMASK** register. See the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information on these instructions. For more information on exception priority levels, see “Exception Types” on page 75.

Priority Mask Register (PRIMASK)

Type R/W, reset 0x0000.0000



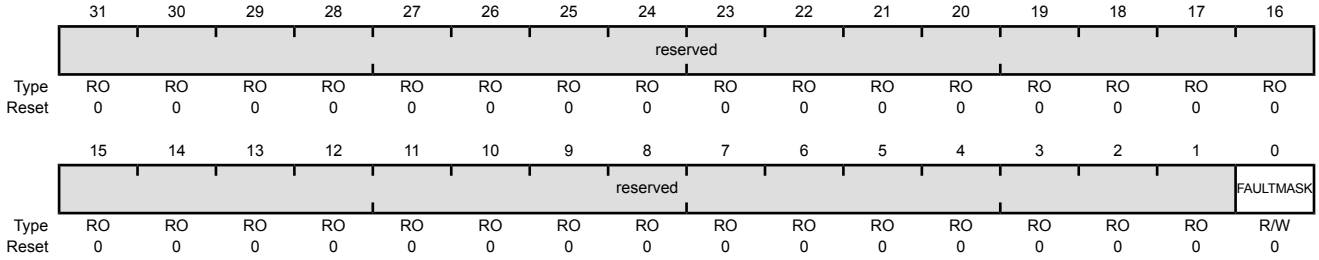

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x0000.000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | PRIMASK | R/W | 0 | Priority Mask<br>Value Description<br>1 Prevents the activation of all exceptions with configurable priority.<br>0 No effect. |

### Register 19: Fault Mask Register (FAULTMASK)

The **FAULTMASK** register prevents activation of all exceptions except for the Non-Maskable Interrupt (NMI). Exceptions should be disabled when they might impact the timing of critical tasks. This register is only accessible in privileged mode. The MSR and MRS instructions are used to access the **FAULTMASK** register, and the CPS instruction may be used to change the value of the **FAULTMASK** register. See the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information on these instructions. For more information on exception priority levels, see “Exception Types” on page 75.

Fault Mask Register (FAULTMASK)

Type R/W, reset 0x0000.0000



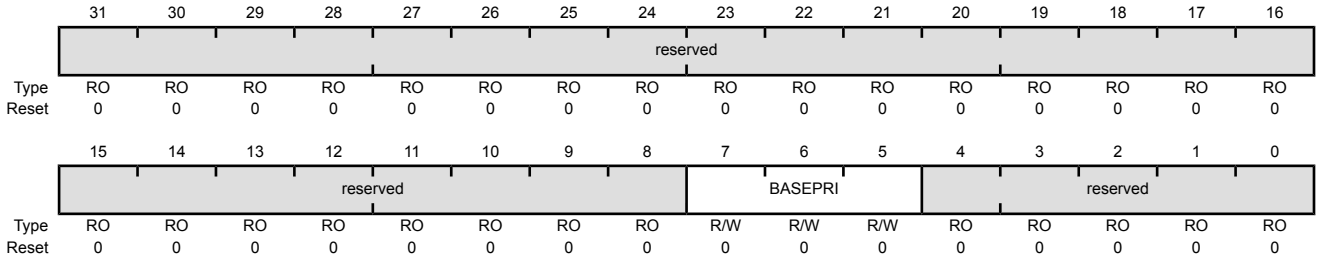

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x0000.000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | FAULTMASK | R/W | 0 | Fault Mask<br><br>Value Description<br>1 Prevents the activation of all exceptions except for NMI.<br>0 No effect.<br><br>The processor clears the FAULTMASK bit on exit from any exception handler except the NMI handler. |

### Register 20: Base Priority Mask Register (BASEPRI)

The **BASEPRI** register defines the minimum priority for exception processing. When **BASEPRI** is set to a nonzero value, it prevents the activation of all exceptions with the same or lower priority level as the **BASEPRI** value. Exceptions should be disabled when they might impact the timing of critical tasks. This register is only accessible in privileged mode. For more information on exception priority levels, see “Exception Types” on page 75.

Base Priority Mask Register (BASEPRI)

Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x0000.00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:5 | BASEPRI | R/W | 0x0 | Base Priority<br>Any exception that has a programmable priority level with the same or lower priority as the value of this field is masked. The **PRIMASK** register can be used to mask all exceptions with programmable priority levels. Higher priority exceptions have lower priority levels.<br><br>Value Description<br>0x0 All exceptions are unmasked.<br>0x1 All exceptions with priority level 1-7 are masked.<br>0x2 All exceptions with priority level 2-7 are masked.<br>0x3 All exceptions with priority level 3-7 are masked.<br>0x4 All exceptions with priority level 4-7 are masked.<br>0x5 All exceptions with priority level 5-7 are masked.<br>0x6 All exceptions with priority level 6-7 are masked.<br>0x7 All exceptions with priority level 7 are masked. |
| 4:0 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

### Register 21: Control Register (CONTROL)

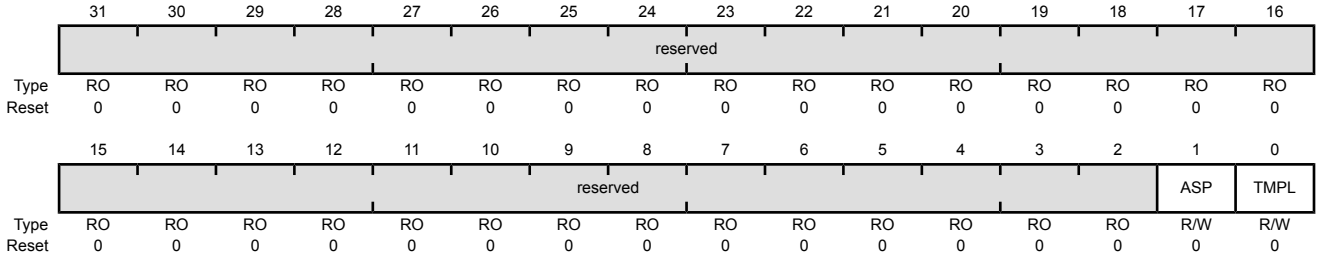
The **CONTROL** register controls the stack used and the privilege level for software execution when the processor is in Thread mode. This register is only accessible in privileged mode.

Handler mode always uses **MSP**, so the processor ignores explicit writes to the ASP bit of the **CONTROL** register when in Handler mode. The exception entry and return mechanisms automatically update the **CONTROL** register based on the EXC_RETURN value (see Table 2-10 on page 82). In an OS environment, threads running in Thread mode should use the process stack and the kernel and exception handlers should use the main stack. By default, Thread mode uses **MSP**. To switch the stack pointer used in Thread mode to **PSP**, either use the MSR instruction to set the ASP bit, as detailed in the *Cortex™-M3/M4 Instruction Set Technical User's Manual*, or perform an exception return to Thread mode with the appropriate EXC_RETURN value, as shown in Table 2-10 on page 82.

**Note:** When changing the stack pointer, software must use an ISB instruction immediately after the MSR instruction, ensuring that instructions after the ISB execute use the new stack pointer. See the *Cortex™-M3/M4 Instruction Set Technical User's Manual*.

Control Register (CONTROL)

Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x0000.000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | ASP | R/W | 0 | Active Stack Pointer<br><br>Value Description<br>1 **PSP** is the current stack pointer.<br>0 **MSP** is the current stack pointer<br><br>In Handler mode, this bit reads as zero and ignores writes. The Cortex-M3 updates this bit automatically on exception return. |
| 0 | TMPL | R/W | 0 | Thread Mode Privilege Level<br><br>Value Description<br>1 Unprivileged software can be executed in Thread mode.<br>0 Only privileged software can be executed in Thread mode. |

### 2.3.5 Exceptions and Interrupts

The Cortex-M3 processor supports interrupts and system exceptions. The processor and the Nested Vectored Interrupt Controller (NVIC) prioritize and handle all exceptions. An exception changes the normal flow of software control. The processor uses Handler mode to handle all exceptions except for reset. See “Exception Entry and Return” on page 80 for more information.

The NVIC registers control interrupt handling. See “Nested Vectored Interrupt Controller (NVIC)” on page 90 for more information.

### 2.3.6 Data Types

The Cortex-M3 supports 32-bit words, 16-bit halfwords, and 8-bit bytes. The processor also supports 64-bit data transfer instructions. All instruction and data memory accesses are little endian. See “Memory Regions, Types and Attributes” on page 68 for more information.

## 2.4 Memory Model

This section describes the processor memory map, the behavior of memory accesses, and the bit-banding features. The processor has a fixed memory map that provides up to 4 GB of addressable memory.

The memory map for the LM3S1960 controller is provided in Table 2-4 on page 66. In this manual, register addresses are given as a hexadecimal increment, relative to the module’s base address as shown in the memory map.

The regions for SRAM and peripherals include bit-band regions. Bit-banding provides atomic operations to bit data (see “Bit-Banding” on page 70).

The processor reserves regions of the Private peripheral bus (PPB) address range for core peripheral registers (see “Cortex-M3 Peripherals” on page 89).

**Note:** Within the memory map, all reserved space returns a bus fault when read or written.

**Table 2-4. Memory Map**

| Start | End | Description | For details, see page ... |
|---|---|---|---|
| **Memory** | | | |
| 0x0000.0000 | 0x0003.FFFF | On-chip Flash | 255 |
| 0x0004.0000 | 0x1FFF.FFFF | Reserved | - |
| 0x2000.0000 | 0x2000.FFFF | Bit-banded on-chip SRAM | 254 |
| 0x2001.0000 | 0x21FF.FFFF | Reserved | - |
| 0x2200.0000 | 0x221F.FFFF | Bit-band alias of bit-banded on-chip SRAM starting at 0x2000.0000 | 254 |
| 0x2220.0000 | 0x3FFF.FFFF | Reserved | - |
| **FiRM Peripherals** | | | |
| 0x4000.0000 | 0x4000.0FFF | Watchdog timer 0 | 368 |
| 0x4000.1000 | 0x4000.3FFF | Reserved | - |
| 0x4000.4000 | 0x4000.4FFF | GPIO Port A | 293 |
| 0x4000.5000 | 0x4000.5FFF | GPIO Port B | 293 |
| 0x4000.6000 | 0x4000.6FFF | GPIO Port C | 293 |
| 0x4000.7000 | 0x4000.7FFF | GPIO Port D | 293 |
| 0x4000.8000 | 0x4000.8FFF | SSI0 | 444 |

**Table 2-4. Memory Map *(continued)***

| Start | End | Description | For details, see page ... |
|---|---|---|---|
| 0x4000.9000 | 0x4000.9FFF | SSI1 | 444 |
| 0x4000.A000 | 0x4000.BFFF | Reserved | - |
| 0x4000.C000 | 0x4000.CFFF | UART0 | 398 |
| 0x4000.D000 | 0x4000.DFFF | UART1 | 398 |
| 0x4000.E000 | 0x4000.EFFF | UART2 | 398 |
| 0x4000.F000 | 0x4001.FFFF | Reserved | - |
| **Peripherals** | | | |
| 0x4002.0000 | 0x4002.0FFF | $I^2C$ 0 | 485 |
| 0x4002.1000 | 0x4002.1FFF | $I^2C$ 1 | 485 |
| 0x4002.2000 | 0x4002.3FFF | Reserved | - |
| 0x4002.4000 | 0x4002.4FFF | GPIO Port E | 293 |
| 0x4002.5000 | 0x4002.5FFF | GPIO Port F | 293 |
| 0x4002.6000 | 0x4002.6FFF | GPIO Port G | 293 |
| 0x4002.7000 | 0x4002.7FFF | GPIO Port H | 293 |
| 0x4002.8000 | 0x4002.8FFF | PWM | 529 |
| 0x4002.9000 | 0x4002.BFFF | Reserved | - |
| 0x4002.C000 | 0x4002.CFFF | QEI0 | 563 |
| 0x4002.D000 | 0x4002.DFFF | QEI1 | 563 |
| 0x4002.E000 | 0x4002.FFFF | Reserved | - |
| 0x4003.0000 | 0x4003.0FFF | Timer 0 | 340 |
| 0x4003.1000 | 0x4003.1FFF | Timer 1 | 340 |
| 0x4003.2000 | 0x4003.2FFF | Timer 2 | 340 |
| 0x4003.3000 | 0x4003.3FFF | Timer 3 | 340 |
| 0x4003.4000 | 0x4003.BFFF | Reserved | - |
| 0x4003.C000 | 0x4003.CFFF | Analog Comparators | 507 |
| 0x4003.D000 | 0x400F.BFFF | Reserved | - |
| 0x400F.C000 | 0x400F.CFFF | Hibernation Module | 241 |
| 0x400F.D000 | 0x400F.DFFF | Flash memory control | 259 |
| 0x400F.E000 | 0x400F.EFFF | System control | 180 |
| 0x400F.F000 | 0x41FF.FFFF | Reserved | - |
| 0x4200.0000 | 0x43FF.FFFF | Bit-banded alias of 0x4000.0000 through 0x400F.FFFF | - |
| 0x4400.0000 | 0xDFFF.FFFF | Reserved | - |
| **Private Peripheral Bus** | | | |
| 0xE000.0000 | 0xE000.0FFF | Instrumentation Trace Macrocell (ITM) | 49 |
| 0xE000.1000 | 0xE000.1FFF | Data Watchpoint and Trace (DWT) | 49 |
| 0xE000.2000 | 0xE000.2FFF | Flash Patch and Breakpoint (FPB) | 49 |
| 0xE000.3000 | 0xE000.DFFF | Reserved | - |
| 0xE000.E000 | 0xE000.EFFF | Cortex-M3 Peripherals (SysTick, NVIC, MPU and SCB) | 97 |
| 0xE000.F000 | 0xE003.FFFF | Reserved | - |
| 0xE004.0000 | 0xE004.0FFF | Trace Port Interface Unit (TPIU) | 50 |
| 0xE004.1000 | 0xFFFF.FFFF | Reserved | - |

### 2.4.1 Memory Regions, Types and Attributes

The memory map and the programming of the MPU split the memory map into regions. Each region has a defined memory type, and some regions have additional memory attributes. The memory type and attributes determine the behavior of accesses to the region.

The memory types are:

- Normal: The processor can re-order transactions for efficiency and perform speculative reads.
- Device: The processor preserves transaction order relative to other transactions to Device or Strongly Ordered memory.
- Strongly Ordered: The processor preserves transaction order relative to all other transactions.

The different ordering requirements for Device and Strongly Ordered memory mean that the memory system can buffer a write to Device memory but must not buffer a write to Strongly Ordered memory.

An additional memory attribute is Execute Never (XN), which means the processor prevents instruction accesses. A fault exception is generated only on execution of an instruction executed from an XN region.

### 2.4.2 Memory System Ordering of Memory Accesses

For most memory accesses caused by explicit memory access instructions, the memory system does not guarantee that the order in which the accesses complete matches the program order of the instructions, providing the order does not affect the behavior of the instruction sequence. Normally, if correct program execution depends on two memory accesses completing in program order, software must insert a memory barrier instruction between the memory access instructions (see “Software Ordering of Memory Accesses” on page 69).

However, the memory system does guarantee ordering of accesses to Device and Strongly Ordered memory. For two memory access instructions A1 and A2, if both A1 and A2 are accesses to either Device or Strongly Ordered memory, and if A1 occurs before A2 in program order, A1 is always observed before A2.

### 2.4.3 Behavior of Memory Accesses

Table 2-5 on page 68 shows the behavior of accesses to each region in the memory map. See “Memory Regions, Types and Attributes” on page 68 for more information on memory types and the XN attribute. Stellaris devices may have reserved memory areas within the address ranges shown below (refer to Table 2-4 on page 66 for more information).

**Table 2-5. Memory Access Behavior**

| Address Range | Memory Region | Memory Type | Execute Never (XN) | Description |
|---|---|---|---|---|
| 0x0000.0000 - 0x1FFF.FFFF | Code | Normal | - | This executable region is for program code. Data can also be stored here. |
| 0x2000.0000 - 0x3FFF.FFFF | SRAM | Normal | - | This executable region is for data. Code can also be stored here. This region includes bit band and bit band alias areas (see Table 2-6 on page 70). |
| 0x4000.0000 - 0x5FFF.FFFF | Peripheral | Device | XN | This region includes bit band and bit band alias areas (see Table 2-7 on page 71). |
| 0x6000.0000 - 0x9FFF.FFFF | External RAM | Normal | - | This executable region is for data. |

**Table 2-5. Memory Access Behavior *(continued)***

| Address Range | Memory Region | Memory Type | Execute Never (XN) | Description |
|---|---|---|---|---|
| 0xA000.0000 - 0xDFFF.FFFF | External device | Device | XN | This region is for external device memory. |
| 0xE000.0000- 0xE00F.FFFF | Private peripheral bus | Strongly Ordered | XN | This region includes the NVIC, system timer, and system control block. |
| 0xE010.0000- 0xFFFF.FFFF | Reserved | - | - | - |

The Code, SRAM, and external RAM regions can hold programs. However, it is recommended that programs always use the Code region because the Cortex-M3 has separate buses that can perform instruction fetches and data accesses simultaneously.

The MPU can override the default memory access behavior described in this section. For more information, see “Memory Protection Unit (MPU)” on page 92.

The Cortex-M3 prefetches instructions ahead of execution and speculatively prefetches from branch target addresses.

### 2.4.4 Software Ordering of Memory Accesses

The order of instructions in the program flow does not always guarantee the order of the corresponding memory transactions for the following reasons:

- The processor can reorder some memory accesses to improve efficiency, providing this does not affect the behavior of the instruction sequence.
- The processor has multiple bus interfaces.
- Memory or devices in the memory map have different wait states.
- Some memory accesses are buffered or speculative.

“Memory System Ordering of Memory Accesses” on page 68 describes the cases where the memory system guarantees the order of memory accesses. Otherwise, if the order of memory accesses is critical, software must include memory barrier instructions to force that ordering. The Cortex-M3 has the following memory barrier instructions:

- The Data Memory Barrier (`DMB`) instruction ensures that outstanding memory transactions complete before subsequent memory transactions.
- The Data Synchronization Barrier (`DSB`) instruction ensures that outstanding memory transactions complete before subsequent instructions execute.
- The Instruction Synchronization Barrier (`ISB`) instruction ensures that the effect of all completed memory transactions is recognizable by subsequent instructions.

Memory barrier instructions can be used in the following situations:

- MPU programming
  - If the MPU settings are changed and the change must be effective on the very next instruction, use a `DSB` instruction to ensure the effect of the MPU takes place immediately at the end of context switching.

– Use an ISB instruction to ensure the new MPU setting takes effect immediately after programming the MPU region or regions, if the MPU configuration code was accessed using a branch or call. If the MPU configuration code is entered using exception mechanisms, then an ISB instruction is not required.

- Vector table

  If the program changes an entry in the vector table and then enables the corresponding exception, use a DMB instruction between the operations. The DMB instruction ensures that if the exception is taken immediately after being enabled, the processor uses the new exception vector.

- Self-modifying code

  If a program contains self-modifying code, use an ISB instruction immediately after the code modification in the program. The ISB instruction ensures subsequent instruction execution uses the updated program.

- Memory map switching

  If the system contains a memory map switching mechanism, use a DSB instruction after switching the memory map in the program. The DSB instruction ensures subsequent instruction execution uses the updated memory map.

- Dynamic exception priority change

  When an exception priority has to change when the exception is pending or active, use DSB instructions after the change. The change then takes effect on completion of the DSB instruction.

Memory accesses to Strongly Ordered memory, such as the System Control Block, do not require the use of DMB instructions.

For more information on the memory barrier instructions, see the *Cortex™-M3/M4 Instruction Set Technical User's Manual*.

### 2.4.5 Bit-Banding

A bit-band region maps each word in a bit-band alias region to a single bit in the bit-band region. The bit-band regions occupy the lowest 1 MB of the SRAM and peripheral memory regions. Accesses to the 32-MB SRAM alias region map to the 1-MB SRAM bit-band region, as shown in Table 2-6 on page 70. Accesses to the 32-MB peripheral alias region map to the 1-MB peripheral bit-band region, as shown in Table 2-7 on page 71. For the specific address range of the bit-band regions, see Table 2-4 on page 66.

**Note:** A word access to the SRAM or the peripheral bit-band alias region maps to a single bit in the SRAM or peripheral bit-band region.

A word access to a bit band address results in a word access to the underlying memory, and similarly for halfword and byte accesses. This allows bit band accesses to match the access requirements of the underlying peripheral.

**Table 2-6. SRAM Memory Bit-Banding Regions**

| Address Range | Memory Region | Instruction and Data Accesses |
|---|---|---|
| 0x2000.0000 - 0x200F.FFFF | SRAM bit-band region | Direct accesses to this memory range behave as SRAM memory accesses, but this region is also bit addressable through bit-band alias. |

**Table 2-6. SRAM Memory Bit-Banding Regions *(continued)***

| Address Range | Memory Region | Instruction and Data Accesses |
|---|---|---|
| 0x2200.0000 - 0x23FF.FFFF | SRAM bit-band alias | Data accesses to this region are remapped to bit band region. A write operation is performed as read-modify-write. Instruction accesses are not remapped. |

**Table 2-7. Peripheral Memory Bit-Banding Regions**

| Address Range | Memory Region | Instruction and Data Accesses |
|---|---|---|
| 0x4000.0000 - 0x400F.FFFF | Peripheral bit-band region | Direct accesses to this memory range behave as peripheral memory accesses, but this region is also bit addressable through bit-band alias. |
| 0x4200.0000 - 0x43FF.FFFF | Peripheral bit-band alias | Data accesses to this region are remapped to bit band region. A write operation is performed as read-modify-write. Instruction accesses are not permitted. |

The following formula shows how the alias region maps onto the bit-band region:

```
bit_word_offset = (byte_offset x 32) + (bit_number x 4)
```

```
bit_word_addr = bit_band_base + bit_word_offset
```

where:

bit_word_offset
The position of the target bit in the bit-band memory region.

bit_word_addr
The address of the word in the alias memory region that maps to the targeted bit.

bit_band_base
The starting address of the alias region.

byte_offset
The number of the byte in the bit-band region that contains the targeted bit.

bit_number
The bit position, 0-7, of the targeted bit.

Figure 2-4 on page 72 shows examples of bit-band mapping between the SRAM bit-band alias region and the SRAM bit-band region:

- The alias word at 0x23FF.FFE0 maps to bit 0 of the bit-band byte at 0x200F.FFFF:

  ```
  0x23FF.FFE0 = 0x2200.0000 + (0x000F.FFFF*32) + (0*4)
  ```

- The alias word at 0x23FF.FFFC maps to bit 7 of the bit-band byte at 0x200F.FFFF:

  ```
  0x23FF.FFFC = 0x2200.0000 + (0x000F.FFFF*32) + (7*4)
  ```

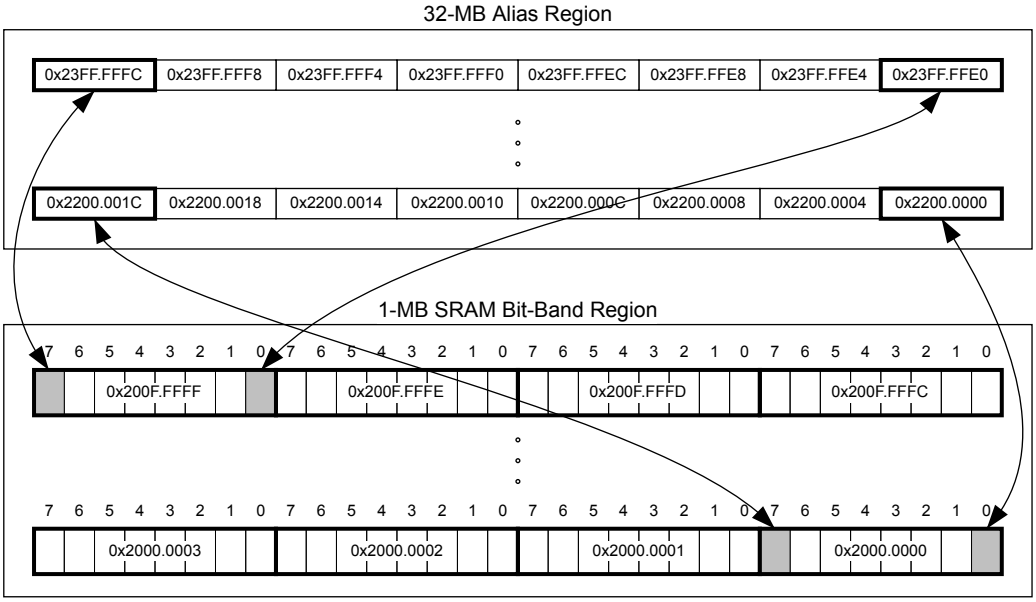
- The alias word at 0x2200.0000 maps to bit 0 of the bit-band byte at 0x2000.0000:

  ```
  0x2200.0000 = 0x2200.0000 + (0*32) + (0*4)
  ```

- The alias word at 0x2200.001C maps to bit 7 of the bit-band byte at 0x2000.0000:

```
0x2200.001C = 0x2200.0000+ (0*32) + (7*4)
```

**Figure 2-4. Bit-Band Mapping**




### 2.4.5.1 Directly Accessing an Alias Region

Writing to a word in the alias region updates a single bit in the bit-band region.

Bit 0 of the value written to a word in the alias region determines the value written to the targeted bit in the bit-band region. Writing a value with bit 0 set writes a 1 to the bit-band bit, and writing a value with bit 0 clear writes a 0 to the bit-band bit.

Bits 31:1 of the alias word have no effect on the bit-band bit. Writing 0x01 has the same effect as writing 0xFF. Writing 0x00 has the same effect as writing 0x0E.

When reading a word in the alias region, 0x0000.0000 indicates that the targeted bit in the bit-band region is clear and 0x0000.0001 indicates that the targeted bit in the bit-band region is set.

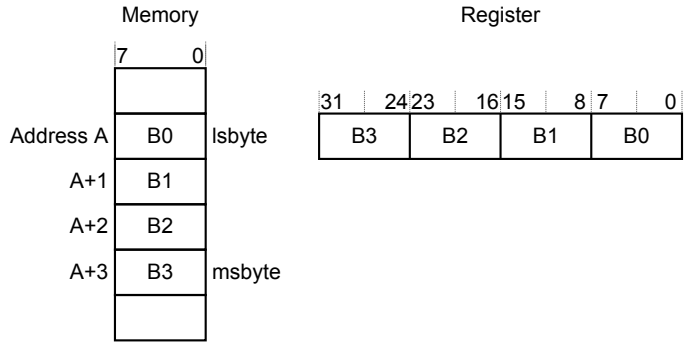
### 2.4.5.2 Directly Accessing a Bit-Band Region

"Behavior of Memory Accesses" on page 68 describes the behavior of direct byte, halfword, or word accesses to the bit-band regions.

## 2.4.6 Data Storage

The processor views memory as a linear collection of bytes numbered in ascending order from zero. For example, bytes 0-3 hold the first stored word, and bytes 4-7 hold the second stored word. Data is stored in little-endian format, with the least-significant byte (lsbyte) of a word stored at the lowest-numbered byte, and the most-significant byte (msbyte) stored at the highest-numbered byte. Figure 2-5 on page 73 illustrates how data is stored.

**Figure 2-5. Data Storage**




## 2.4.7 Synchronization Primitives

The Cortex-M3 instruction set includes pairs of synchronization primitives which provide a non-blocking mechanism that a thread or process can use to obtain exclusive access to a memory location. Software can use these primitives to perform a guaranteed read-modify-write memory update sequence or for a semaphore mechanism.

A pair of synchronization primitives consists of:

- A Load-Exclusive instruction, which is used to read the value of a memory location and requests exclusive access to that location.
- A Store-Exclusive instruction, which is used to attempt to write to the same memory location and returns a status bit to a register. If this status bit is clear, it indicates that the thread or process gained exclusive access to the memory and the write succeeds; if this status bit is set, it indicates that the thread or process did not gain exclusive access to the memory and no write was performed.

The pairs of Load-Exclusive and Store-Exclusive instructions are:

- The word instructions `LDREX` and `STREX`
- The halfword instructions `LDREXH` and `STREXH`
- The byte instructions `LDREXB` and `STREXB`

Software must use a Load-Exclusive instruction with the corresponding Store-Exclusive instruction.

To perform an exclusive read-modify-write of a memory location, software must:

1. Use a Load-Exclusive instruction to read the value of the location.
2. Modify the value, as required.
3. Use a Store-Exclusive instruction to attempt to write the new value back to the memory location.
4. Test the returned status bit.

   If the status bit is clear, the read-modify-write completed successfully. If the status bit is set, no write was performed, which indicates that the value returned at step 1 might be out of date. The software must retry the entire read-modify-write sequence.

Software can use the synchronization primitives to implement a semaphore as follows:

1. Use a Load-Exclusive instruction to read from the semaphore address to check whether the semaphore is free.
2. If the semaphore is free, use a Store-Exclusive to write the claim value to the semaphore address.
3. If the returned status bit from step 2 indicates that the Store-Exclusive succeeded, then the software has claimed the semaphore. However, if the Store-Exclusive failed, another process might have claimed the semaphore after the software performed step 1.

The Cortex-M3 includes an exclusive access monitor that tags the fact that the processor has executed a Load-Exclusive instruction. The processor removes its exclusive access tag if:

- It executes a CLREX instruction.
- It executes a Store-Exclusive instruction, regardless of whether the write succeeds.
- An exception occurs, which means the processor can resolve semaphore conflicts between different threads.

For more information about the synchronization primitive instructions, see the *Cortex™-M3/M4 Instruction Set Technical User's Manual*.

## 2.5 Exception Model

The ARM Cortex-M3 processor and the Nested Vectored Interrupt Controller (NVIC) prioritize and handle all exceptions in Handler Mode. The processor state is automatically stored to the stack on an exception and automatically restored from the stack at the end of the Interrupt Service Routine (ISR). The vector is fetched in parallel to the state saving, enabling efficient interrupt entry. The processor supports tail-chaining, which enables back-to-back interrupts to be performed without the overhead of state saving and restoration.

Table 2-8 on page 76 lists all exception types. Software can set eight priority levels on seven of these exceptions (system handlers) as well as on 36 interrupts (listed in Table 2-9 on page 77).

Priorities on the system handlers are set with the NVIC **System Handler Priority n (SYSPRIn)** registers. Interrupts are enabled through the NVIC **Interrupt Set Enable n (ENn)** register and prioritized with the NVIC **Interrupt Priority n (PRIn)** registers. Priorities can be grouped by splitting priority levels into preemption priorities and subpriorities. All the interrupt registers are described in “Nested Vectored Interrupt Controller (NVIC)” on page 90.

Internally, the highest user-programmable priority (0) is treated as fourth priority, after a Reset, Non-Maskable Interrupt (NMI), and a Hard Fault, in that order. Note that 0 is the default priority for all the programmable priorities.

**Important:** After a write to clear an interrupt source, it may take several processor cycles for the NVIC to see the interrupt source de-assert. Thus if the interrupt clear is done as the last action in an interrupt handler, it is possible for the interrupt handler to complete while the NVIC sees the interrupt as still asserted, causing the interrupt handler to be re-entered errantly. This situation can be avoided by either clearing the interrupt source at the beginning of the interrupt handler or by performing a read or write after the write to clear the interrupt source (and flush the write buffer).

See “Nested Vectored Interrupt Controller (NVIC)” on page 90 for more information on exceptions and interrupts.

### 2.5.1 Exception States

Each exception is in one of the following states:

- **Inactive.** The exception is not active and not pending.
- **Pending.** The exception is waiting to be serviced by the processor. An interrupt request from a peripheral or from software can change the state of the corresponding interrupt to pending.
- **Active.** An exception that is being serviced by the processor but has not completed.

  **Note:** An exception handler can interrupt the execution of another exception handler. In this case, both exceptions are in the active state.

- **Active and Pending.** The exception is being serviced by the processor, and there is a pending exception from the same source.

### 2.5.2 Exception Types

The exception types are:

- **Reset.** Reset is invoked on power up or a warm reset. The exception model treats reset as a special form of exception. When reset is asserted, the operation of the processor stops, potentially at any point in an instruction. When reset is deasserted, execution restarts from the address provided by the reset entry in the vector table. Execution restarts as privileged execution in Thread mode.
- **NMI.** A non-maskable Interrupt (NMI) can be signaled using the NMI signal or triggered by software using the **Interrupt Control and State (INTCTRL)** register. This exception has the highest priority other than reset. NMI is permanently enabled and has a fixed priority of -2. NMIs cannot be masked or prevented from activation by any other exception or preempted by any exception other than reset.
- **Hard Fault.** A hard fault is an exception that occurs because of an error during exception processing, or because an exception cannot be managed by any other exception mechanism. Hard faults have a fixed priority of -1, meaning they have higher priority than any exception with configurable priority.
- **Memory Management Fault.** A memory management fault is an exception that occurs because of a memory protection related fault, including access violation and no match. The MPU or the fixed memory protection constraints determine this fault, for both instruction and data memory transactions. This fault is used to abort instruction accesses to Execute Never (XN) memory regions, even if the MPU is disabled.
- **Bus Fault.** A bus fault is an exception that occurs because of a memory-related fault for an instruction or data memory transaction such as a prefetch fault or a memory access fault. This fault can be enabled or disabled.
- **Usage Fault.** A usage fault is an exception that occurs because of a fault related to instruction execution, such as:
  - An undefined instruction
  - An illegal unaligned access
  - Invalid state on instruction execution

– An error on exception return
An unaligned address on a word or halfword memory access or division by zero can cause a usage fault when the core is properly configured.

- **SVCall.** A supervisor call (SVC) is an exception that is triggered by the SVC instruction. In an OS environment, applications can use SVC instructions to access OS kernel functions and device drivers.
- **Debug Monitor.** This exception is caused by the debug monitor (when not halting). This exception is only active when enabled. This exception does not activate if it is a lower priority than the current activation.
- **PendSV.** PendSV is a pendable, interrupt-driven request for system-level service. In an OS environment, use PendSV for context switching when no other exception is active. PendSV is triggered using the **Interrupt Control and State (INTCTRL)** register.
- **SysTick.** A SysTick exception is an exception that the system timer generates when it reaches zero when it is enabled to generate an interrupt. Software can also generate a SysTick exception using the **Interrupt Control and State (INTCTRL)** register. In an OS environment, the processor can use this exception as system tick.
- **Interrupt (IRQ).** An interrupt, or IRQ, is an exception signaled by a peripheral or generated by a software request and fed through the NVIC (prioritized). All interrupts are asynchronous to instruction execution. In the system, peripherals use interrupts to communicate with the processor. Table 2-9 on page 77 lists the interrupts on the LM3S1960 controller.

For an asynchronous exception, other than reset, the processor can execute another instruction between when the exception is triggered and when the processor enters the exception handler.

Privileged software can disable the exceptions that Table 2-8 on page 76 shows as having configurable priority (see the **SYSHNDCTRL** register on page 131 and the **DIS0** register on page 106).

For more information about hard faults, memory management faults, bus faults, and usage faults, see “Fault Handling” on page 82.

**Table 2-8. Exception Types**

| Exception Type | Vector Number | Priority[a] | Vector Address or Offset[b] | Activation |
|---|---|---|---|---|
| - | 0 | - | 0x0000.0000 | Stack top is loaded from the first entry of the vector table on reset. |
| Reset | 1 | -3 (highest) | 0x0000.0004 | Asynchronous |
| Non-Maskable Interrupt (NMI) | 2 | -2 | 0x0000.0008 | Asynchronous |
| Hard Fault | 3 | -1 | 0x0000.000C | - |
| Memory Management | 4 | programmable[c] | 0x0000.0010 | Synchronous |
| Bus Fault | 5 | programmable[c] | 0x0000.0014 | Synchronous when precise and asynchronous when imprecise |
| Usage Fault | 6 | programmable[c] | 0x0000.0018 | Synchronous |
| - | 7-10 | - | - | Reserved |
| SVCall | 11 | programmable[c] | 0x0000.002C | Synchronous |
| Debug Monitor | 12 | programmable[c] | 0x0000.0030 | Synchronous |
| - | 13 | - | - | Reserved |

**Table 2-8. Exception Types *(continued)***

| Exception Type | Vector Number | Priority[a] | Vector Address or Offset[b] | Activation |
|---|---|---|---|---|
| PendSV | 14 | programmable[c] | 0x0000.0038 | Asynchronous |
| SysTick | 15 | programmable[c] | 0x0000.003C | Asynchronous |
| Interrupts | 16 and above | programmable[d] | 0x0000.0040 and above | Asynchronous |

a. 0 is the default priority for all the programmable priorities.

b. See “Vector Table” on page 78.

c. See **SYSPRI1** on page 128.

d. See **PRIn** registers on page 114.

**Table 2-9. Interrupts**

| Vector Number | Interrupt Number (Bit in Interrupt Registers) | Vector Address or Offset | Description |
|---|---|---|---|
| 0-15 | - | 0x0000.0000 - 0x0000.003C | Processor exceptions |
| 16 | 0 | 0x0000.0040 | GPIO Port A |
| 17 | 1 | 0x0000.0044 | GPIO Port B |
| 18 | 2 | 0x0000.0048 | GPIO Port C |
| 19 | 3 | 0x0000.004C | GPIO Port D |
| 20 | 4 | 0x0000.0050 | GPIO Port E |
| 21 | 5 | 0x0000.0054 | UART0 |
| 22 | 6 | 0x0000.0058 | UART1 |
| 23 | 7 | 0x0000.005C | SSI0 |
| 24 | 8 | 0x0000.0060 | $I^2C0$ |
| 25 | 9 | - | Reserved |
| 26 | 10 | 0x0000.0068 | PWM Generator 0 |
| 27 | 11 | 0x0000.006C | PWM Generator 1 |
| 28 | 12 | 0x0000.0070 | PWM Generator 2 |
| 29 | 13 | 0x0000.0074 | QEI0 |
| 30-33 | 14-17 | - | Reserved |
| 34 | 18 | 0x0000.0088 | Watchdog Timer 0 |
| 35 | 19 | 0x0000.008C | Timer 0A |
| 36 | 20 | 0x0000.0090 | Timer 0B |
| 37 | 21 | 0x0000.0094 | Timer 1A |
| 38 | 22 | 0x0000.0098 | Timer 1B |
| 39 | 23 | 0x0000.009C | Timer 2A |
| 40 | 24 | 0x0000.00A0 | Timer 2B |
| 41 | 25 | 0x0000.00A4 | Analog Comparator 0 |
| 42 | 26 | 0x0000.00A8 | Analog Comparator 1 |
| 43 | 27 | 0x0000.00AC | Analog Comparator 2 |
| 44 | 28 | 0x0000.00B0 | System Control |
| 45 | 29 | 0x0000.00B4 | Flash Memory Control |
| 46 | 30 | 0x0000.00B8 | GPIO Port F |
| 47 | 31 | 0x0000.00BC | GPIO Port G |

**Table 2-9. Interrupts *(continued)***

| Vector Number | Interrupt Number (Bit in Interrupt Registers) | Vector Address or Offset | Description |
|---|---|---|---|
| 48 | 32 | 0x0000.00C0 | GPIO Port H |
| 49 | 33 | 0x0000.00C4 | UART2 |
| 50 | 34 | 0x0000.00C8 | SSI1 |
| 51 | 35 | 0x0000.00CC | Timer 3A |
| 52 | 36 | 0x0000.00D0 | Timer 3B |
| 53 | 37 | 0x0000.00D4 | $I^2C1$ |
| 54 | 38 | 0x0000.00D8 | QEI1 |
| 55-58 | 39-42 | - | Reserved |
| 59 | 43 | 0x0000.00EC | Hibernation Module |

### 2.5.3 Exception Handlers

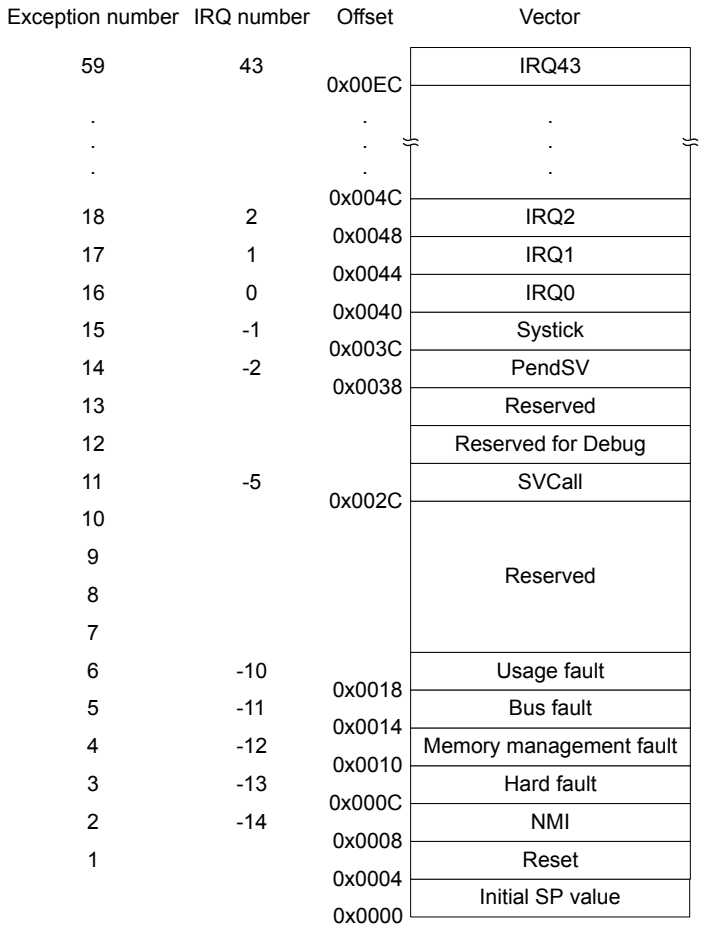
The processor handles exceptions using:

- **Interrupt Service Routines (ISRs).** Interrupts (IRQx) are the exceptions handled by ISRs.
- **Fault Handlers.** Hard fault, memory management fault, usage fault, and bus fault are fault exceptions handled by the fault handlers.
- **System Handlers.** NMI, PendSV, SVCall, SysTick, and the fault exceptions are all system exceptions that are handled by system handlers.

### 2.5.4 Vector Table

The vector table contains the reset value of the stack pointer and the start addresses, also called exception vectors, for all exception handlers. The vector table is constructed using the vector address or offset shown in Table 2-8 on page 76. Figure 2-6 on page 79 shows the order of the exception vectors in the vector table. The least-significant bit of each vector must be 1, indicating that the exception handler is Thumb code

**Figure 2-6. Vector Table**




On system reset, the vector table is fixed at address 0x0000.0000. Privileged software can write to the **Vector Table Offset (VTABLE)** register to relocate the vector table start address to a different memory location, in the range 0x0000.0100 to 0x3FFF.FF00 (see "Vector Table" on page 78). Note that when configuring the **VTABLE** register, the offset must be aligned on a 256-byte boundary.

## 2.5.5 Exception Priorities

As Table 2-8 on page 76 shows, all exceptions have an associated priority, with a lower priority value indicating a higher priority and configurable priorities for all exceptions except Reset, Hard fault, and NMI. If software does not configure any priorities, then all exceptions with a configurable priority have a priority of 0. For information about configuring exception priorities, see page 128 and page 114.

**Note:** Configurable priority values for the Stellaris implementation are in the range 0-7. This means that the Reset, Hard fault, and NMI exceptions, with fixed negative priority values, always have higher priority than any other exception.

For example, assigning a higher priority value to IRQ[0] and a lower priority value to IRQ[1] means that IRQ[1] has higher priority than IRQ[0]. If both IRQ[1] and IRQ[0] are asserted, IRQ[1] is processed before IRQ[0].

If multiple pending exceptions have the same priority, the pending exception with the lowest exception number takes precedence. For example, if both IRQ[0] and IRQ[1] are pending and have the same priority, then IRQ[0] is processed before IRQ[1].

When the processor is executing an exception handler, the exception handler is preempted if a higher priority exception occurs. If an exception occurs with the same priority as the exception being handled, the handler is not preempted, irrespective of the exception number. However, the status of the new interrupt changes to pending.

### 2.5.6 Interrupt Priority Grouping

To increase priority control in systems with interrupts, the NVIC supports priority grouping. This grouping divides each interrupt priority register entry into two fields:

- An upper field that defines the group priority
- A lower field that defines a subpriority within the group

Only the group priority determines preemption of interrupt exceptions. When the processor is executing an interrupt exception handler, another interrupt with the same group priority as the interrupt being handled does not preempt the handler.

If multiple pending interrupts have the same group priority, the subpriority field determines the order in which they are processed. If multiple pending interrupts have the same group priority and subpriority, the interrupt with the lowest IRQ number is processed first.

For information about splitting the interrupt priority fields into group priority and subpriority, see page 122.

### 2.5.7 Exception Entry and Return

Descriptions of exception handling use the following terms:

- **Preemption.** When the processor is executing an exception handler, an exception can preempt the exception handler if its priority is higher than the priority of the exception being handled. See “Interrupt Priority Grouping” on page 80 for more information about preemption by an interrupt. When one exception preempts another, the exceptions are called nested exceptions. See “Exception Entry” on page 81 more information.
- **Return.** Return occurs when the exception handler is completed, and there is no pending exception with sufficient priority to be serviced and the completed exception handler was not handling a late-arriving exception. The processor pops the stack and restores the processor state to the state it had before the interrupt occurred. See “Exception Return” on page 82 for more information.
- **Tail-Chaining.** This mechanism speeds up exception servicing. On completion of an exception handler, if there is a pending exception that meets the requirements for exception entry, the stack pop is skipped and control transfers to the new exception handler.
- **Late-Arriving.** This mechanism speeds up preemption. If a higher priority exception occurs during state saving for a previous exception, the processor switches to handle the higher priority exception and initiates the vector fetch for that exception. State saving is not affected by late arrival because the state saved is the same for both exceptions. Therefore, the state saving continues uninterrupted. The processor can accept a late arriving exception until the first instruction of the exception handler of the original exception enters the execute stage of the processor. On

return from the exception handler of the late-arriving exception, the normal tail-chaining rules apply.

### 2.5.7.1 Exception Entry

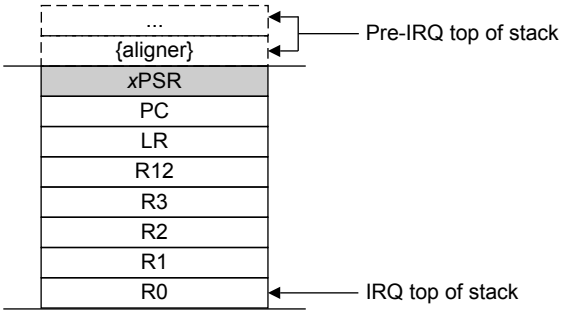
Exception entry occurs when there is a pending exception with sufficient priority and either the processor is in Thread mode or the new exception is of higher priority than the exception being handled, in which case the new exception preempts the original exception.

When one exception preempts another, the exceptions are nested.

Sufficient priority means the exception has more priority than any limits set by the mask registers (see **PRIMASK** on page 62, **FAULTMASK** on page 63, and **BASEPRI** on page 64). An exception with less priority than this is pending but is not handled by the processor.

When the processor takes an exception, unless the exception is a tail-chained or a late-arriving exception, the processor pushes information onto the current stack. This operation is referred to as *stacking* and the structure of eight data words is referred to as *stack frame*.

**Figure 2-7. Exception Stack Frame**




Immediately after stacking, the stack pointer indicates the lowest address in the stack frame. Unless stack alignment is disabled, the stack frame is aligned to a double-word address. If the STKALIGN bit of the **Configuration Control (CCR)** register is set, stack align adjustment is performed during stacking.

The stack frame includes the return address, which is the address of the next instruction in the interrupted program. This value is restored to the **PC** at exception return so that the interrupted program resumes.

In parallel to the stacking operation, the processor performs a vector fetch that reads the exception handler start address from the vector table. When stacking is complete, the processor starts executing the exception handler. At the same time, the processor writes an EXC_RETURN value to the **LR**, indicating which stack pointer corresponds to the stack frame and what operation mode the processor was in before the entry occurred.

If no higher-priority exception occurs during exception entry, the processor starts executing the exception handler and automatically changes the status of the corresponding pending interrupt to active.

If another higher-priority exception occurs during exception entry, known as late arrival, the processor starts executing the exception handler for this exception and does not change the pending status of the earlier exception.

### 2.5.7.2 Exception Return

Exception return occurs when the processor is in Handler mode and executes one of the following instructions to load the EXC_RETURN value into the **PC**:

- An LDM or POP instruction that loads the **PC**
- A BX instruction using any register
- An LDR instruction with the **PC** as the destination

EXC_RETURN is the value loaded into the **LR** on exception entry. The exception mechanism relies on this value to detect when the processor has completed an exception handler. The lowest four bits of this value provide information on the return stack and processor mode. Table 2-10 on page 82 shows the EXC_RETURN values with a description of the exception return behavior.

EXC_RETURN bits 31:4 are all set. When this value is loaded into the **PC**, it indicates to the processor that the exception is complete, and the processor initiates the appropriate exception return sequence.

**Table 2-10. Exception Return Behavior**

| EXC_RETURN[31:0] | Description |
|---|---|
| 0xFFFF.FFF0 | Reserved |
| 0xFFFF.FFF1 | Return to Handler mode.<br>Exception return uses state from **MSP**.<br>Execution uses **MSP** after return. |
| 0xFFFF.FFF2 - 0xFFFF.FFF8 | Reserved |
| 0xFFFF.FFF9 | Return to Thread mode.<br>Exception return uses state from **MSP**.<br>Execution uses **MSP** after return. |
| 0xFFFF.FFFA - 0xFFFF.FFFC | Reserved |
| 0xFFFF.FFFD | Return to Thread mode.<br>Exception return uses state from **PSP**.<br>Execution uses **PSP** after return. |
| 0xFFFF.FFFE - 0xFFFF.FFFF | Reserved |

## 2.6 Fault Handling

Faults are a subset of the exceptions (see “Exception Model” on page 74). The following conditions generate a fault:

- A bus error on an instruction fetch or vector table load or a data access.
- An internally detected error such as an undefined instruction or an attempt to change state with a BX instruction.
- Attempting to execute an instruction from a memory region marked as Non-Executable (XN).
- An MPU fault because of a privilege violation or an attempt to access an unmanaged region.

### 2.6.1 Fault Types

Table 2-11 on page 83 shows the types of fault, the handler used for the fault, the corresponding fault status register, and the register bit that indicates the fault has occurred. See page 135 for more information about the fault status registers.

**Table 2-11. Faults**

| Fault | Handler | Fault Status Register | Bit Name |
|---|---|---|---|
| Bus error on a vector read | Hard fault | **Hard Fault Status (HFAULTSTAT)** | VECT |
| Fault escalated to a hard fault | Hard fault | **Hard Fault Status (HFAULTSTAT)** | FORCED |
| MPU or default memory mismatch on instruction access | Memory management fault | **Memory Management Fault Status (MFAULTSTAT)** | IERR [a] |
| MPU or default memory mismatch on data access | Memory management fault | **Memory Management Fault Status (MFAULTSTAT)** | DERR |
| MPU or default memory mismatch on exception stacking | Memory management fault | **Memory Management Fault Status (MFAULTSTAT)** | MSTKE |
| MPU or default memory mismatch on exception unstacking | Memory management fault | **Memory Management Fault Status (MFAULTSTAT)** | MUSTKE |
| Bus error during exception stacking | Bus fault | **Bus Fault Status (BFAULTSTAT)** | BSTKE |
| Bus error during exception unstacking | Bus fault | **Bus Fault Status (BFAULTSTAT)** | BUSTKE |
| Bus error during instruction prefetch | Bus fault | **Bus Fault Status (BFAULTSTAT)** | IBUS |
| Precise data bus error | Bus fault | **Bus Fault Status (BFAULTSTAT)** | PRECISE |
| Imprecise data bus error | Bus fault | **Bus Fault Status (BFAULTSTAT)** | IMPRE |
| Attempt to access a coprocessor | Usage fault | **Usage Fault Status (UFAULTSTAT)** | NOCP |
| Undefined instruction | Usage fault | **Usage Fault Status (UFAULTSTAT)** | UNDEF |
| Attempt to enter an invalid instruction set state [b] | Usage fault | **Usage Fault Status (UFAULTSTAT)** | INVSTAT |
| Invalid EXC_RETURN value | Usage fault | **Usage Fault Status (UFAULTSTAT)** | INVPC |
| Illegal unaligned load or store | Usage fault | **Usage Fault Status (UFAULTSTAT)** | UNALIGN |
| Divide by 0 | Usage fault | **Usage Fault Status (UFAULTSTAT)** | DIV0 |

a. Occurs on an access to an XN region even if the MPU is disabled.

b. Attempting to use an instruction set other than the Thumb instruction set, or returning to a non load-store-multiple instruction with ICI continuation.

### 2.6.2 Fault Escalation and Hard Faults

All fault exceptions except for hard fault have configurable exception priority (see **SYSPRI1** on page 128). Software can disable execution of the handlers for these faults (see **SYSHNDCTRL** on page 131).

Usually, the exception priority, together with the values of the exception mask registers, determines whether the processor enters the fault handler, and whether a fault handler can preempt another fault handler as described in “Exception Model” on page 74.

In some situations, a fault with configurable priority is treated as a hard fault. This process is called priority escalation, and the fault is described as *escalated to hard fault*. Escalation to hard fault occurs when:

- A fault handler causes the same kind of fault as the one it is servicing. This escalation to hard fault occurs because a fault handler cannot preempt itself because it must have the same priority as the current priority level.

- A fault handler causes a fault with the same or lower priority as the fault it is servicing. This situation happens because the handler for the new fault cannot preempt the currently executing fault handler.
- An exception handler causes a fault for which the priority is the same as or lower than the currently executing exception.
- A fault occurs and the handler for that fault is not enabled.

If a bus fault occurs during a stack push when entering a bus fault handler, the bus fault does not escalate to a hard fault. Thus if a corrupted stack causes a fault, the fault handler executes even though the stack push for the handler failed. The fault handler operates but the stack contents are corrupted.

**Note:** Only Reset and NMI can preempt the fixed priority hard fault. A hard fault can preempt any exception other than Reset, NMI, or another hard fault.

### 2.6.3 Fault Status Registers and Fault Address Registers

The fault status registers indicate the cause of a fault. For bus faults and memory management faults, the fault address register indicates the address accessed by the operation that caused the fault, as shown in Table 2-12 on page 84.

**Table 2-12. Fault Status and Fault Address Registers**

| Handler | Status Register Name | Address Register Name | Register Description |
|---|---|---|---|
| Hard fault | **Hard Fault Status (HFAULTSTAT)** | - | page 141 |
| Memory management fault | **Memory Management Fault Status (MFAULTSTAT)** | **Memory Management Fault Address (MMADDR)** | page 135<br>page 142 |
| Bus fault | **Bus Fault Status (BFAULTSTAT)** | **Bus Fault Address (FAULTADDR)** | page 135<br>page 143 |
| Usage fault | **Usage Fault Status (UFAULTSTAT)** | - | page 135 |

### 2.6.4 Lockup

The processor enters a lockup state if a hard fault occurs when executing the NMI or hard fault handlers. When the processor is in the lockup state, it does not execute any instructions. The processor remains in lockup state until it is reset, an NMI occurs, or it is halted by a debugger.

**Note:** If the lockup state occurs from the NMI handler, a subsequent NMI does not cause the processor to leave the lockup state.

## 2.7 Power Management

The Cortex-M3 processor sleep modes reduce power consumption:

- Sleep mode stops the processor clock.
- Deep-sleep mode stops the system clock and switches off the PLL and Flash memory.

The SLEEPDEEP bit of the **System Control (SYSCTRL)** register selects which sleep mode is used (see page 124). For more information about the behavior of the sleep modes, see “System Control” on page 177.

This section describes the mechanisms for entering sleep mode and the conditions for waking up from sleep mode, both of which apply to Sleep mode and Deep-sleep mode.

## 2.7.1 Entering Sleep Modes

This section describes the mechanisms software can use to put the processor into one of the sleep modes.

The system can generate spurious wake-up events, for example a debug operation wakes up the processor. Therefore, software must be able to put the processor back into sleep mode after such an event. A program might have an idle loop to put the processor back to sleep mode.

### 2.7.1.1 Wait for Interrupt

The wait for interrupt instruction, WFI, causes immediate entry to sleep mode unless the wake-up condition is true (see “Wake Up from WFI or Sleep-on-Exit” on page 85). When the processor executes a WFI instruction, it stops executing instructions and enters sleep mode. See the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information.

### 2.7.1.2 Wait for Event

The wait for event instruction, WFE, causes entry to sleep mode conditional on the value of a one-bit event register. When the processor executes a WFE instruction, it checks the event register. If the register is 0, the processor stops executing instructions and enters sleep mode. If the register is 1, the processor clears the register and continues executing instructions without entering sleep mode.

If the event register is 1, the processor must not enter sleep mode on execution of a WFE instruction. Typically, this situation occurs if an SEV instruction has been executed. Software cannot access this register directly.

See the *Cortex™-M3/M4 Instruction Set Technical User's Manual* for more information.

### 2.7.1.3 Sleep-on-Exit

If the SLEEPEXIT bit of the **SYSCTRL** register is set, when the processor completes the execution of all exception handlers, it returns to Thread mode and immediately enters sleep mode. This mechanism can be used in applications that only require the processor to run when an exception occurs.

## 2.7.2 Wake Up from Sleep Mode

The conditions for the processor to wake up depend on the mechanism that cause it to enter sleep mode.

### 2.7.2.1 Wake Up from WFI or Sleep-on-Exit

Normally, the processor wakes up only when the NVIC detects an exception with sufficient priority to cause exception entry. Some embedded systems might have to execute system restore tasks after the processor wakes up and before executing an interrupt handler. Entry to the interrupt handler can be delayed by setting the PRIMASK bit and clearing the FAULTMASK bit. If an interrupt arrives that is enabled and has a higher priority than current exception priority, the processor wakes up but does not execute the interrupt handler until the processor clears PRIMASK. For more information about **PRIMASK** and **FAULTMASK**, see page 62 and page 63.

### 2.7.2.2 Wake Up from WFE

The processor wakes up if it detects an exception with sufficient priority to cause exception entry.

In addition, if the SEVONPEND bit in the **SYSCTRL** register is set, any new pending interrupt triggers an event and wakes up the processor, even if the interrupt is disabled or has insufficient priority to cause exception entry. For more information about **SYSCTRL**, see page 124.

## 2.8 Instruction Set Summary

The processor implements a version of the Thumb instruction set. Table 2-13 on page 86 lists the supported instructions.

**Note:** In Table 2-13 on page 86:

- Angle brackets, <>, enclose alternative forms of the operand
- Braces, {}, enclose optional operands
- The Operands column is not exhaustive
- Op2 is a flexible second operand that can be either a register or a constant
- Most instructions can use an optional condition code suffix

For more information on the instructions and operands, see the instruction descriptions in the *Cortex™-M3/M4 Instruction Set Technical User's Manual*.

**Table 2-13. Cortex-M3 Instruction Summary**

| Mnemonic | Operands | Brief Description | Flags |
|---|---|---|---|
| ADC, ADCS | {Rd,} Rn, Op2 | Add with carry | N,Z,C,V |
| ADD, ADDS | {Rd,} Rn, Op2 | Add | N,Z,C,V |
| ADD, ADDW | {Rd,} Rn , #imm12 | Add | N,Z,C,V |
| ADR | Rd, label | Load PC-relative address | - |
| AND, ANDS | {Rd,} Rn, Op2 | Logical AND | N,Z,C |
| ASR, ASRS | Rd, Rm, <Rs\|#n> | Arithmetic shift right | N,Z,C |
| B | label | Branch | - |
| BFC | Rd, #lsb, #width | Bit field clear | - |
| BFI | Rd, Rn, #lsb, #width | Bit field insert | - |
| BIC, BICS | {Rd,} Rn, Op2 | Bit clear | N,Z,C |
| BKPT | #imm | Breakpoint | - |
| BL | label | Branch with link | - |
| BLX | Rm | Branch indirect with link | - |
| BX | Rm | Branch indirect | - |
| CBNZ | Rn, label | Compare and branch if non-zero | - |
| CBZ | Rn, label | Compare and branch if zero | - |
| CLREX | - | Clear exclusive | - |
| CLZ | Rd, Rm | Count leading zeros | - |
| CMN | Rn, Op2 | Compare negative | N,Z,C,V |
| CMP | Rn, Op2 | Compare | N,Z,C,V |
| CPSID | i | Change processor state, disable interrupts | - |
| CPSIE | i | Change processor state, enable interrupts | - |
| DMB | - | Data memory barrier | - |
| DSB | - | Data synchronization barrier | - |

**Table 2-13. Cortex-M3 Instruction Summary *(continued)***

| Mnemonic | Operands | Brief Description | Flags |
|---|---|---|---|
| EOR, EORS | {Rd,} Rn, Op2 | Exclusive OR | N,Z,C |
| ISB | - | Instruction synchronization barrier | - |
| IT | - | If-Then condition block | - |
| LDM | Rn{!}, reglist | Load multiple registers, increment after | - |
| LDMDB, LDMEA | Rn{!}, reglist | Load multiple registers, decrement before | - |
| LDMFD, LDMIA | Rn{!}, reglist | Load multiple registers, increment after | - |
| LDR | Rt, [Rn, #offset] | Load register with word | - |
| LDRB, LDRBT | Rt, [Rn, #offset] | Load register with byte | - |
| LDRD | Rt, Rt2, [Rn, #offset] | Load register with two bytes | - |
| LDREX | Rt, [Rn, #offset] | Load register exclusive | - |
| LDREXB | Rt, [Rn] | Load register exclusive with byte | - |
| LDREXH | Rt, [Rn] | Load register exclusive with halfword | - |
| LDRH, LDRHT | Rt, [Rn, #offset] | Load register with halfword | - |
| LDRSB, LDRSBT | Rt, [Rn, #offset] | Load register with signed byte | - |
| LDRSH, LDRSHT | Rt, [Rn, #offset] | Load register with signed halfword | - |
| LDRT | Rt, [Rn, #offset] | Load register with word | - |
| LSL, LSLS | Rd, Rm, <Rs\|#n> | Logical shift left | N,Z,C |
| LSR, LSRS | Rd, Rm, <Rs\|#n> | Logical shift right | N,Z,C |
| MLA | Rd, Rn, Rm, Ra | Multiply with accumulate, 32-bit result | - |
| MLS | Rd, Rn, Rm, Ra | Multiply and subtract, 32-bit result | - |
| MOV, MOVS | Rd, Op2 | Move | N,Z,C |
| MOV, MOVW | Rd, #imm16 | Move 16-bit constant | N,Z,C |
| MOVT | Rd, #imm16 | Move top | - |
| MRS | Rd, spec_reg | Move from special register to general register | - |
| MSR | spec_reg, Rm | Move from general register to special register | N,Z,C,V |
| MUL, MULS | {Rd,} Rn, Rm | Multiply, 32-bit result | N,Z |
| MVN, MVNS | Rd, Op2 | Move NOT | N,Z,C |
| NOP | - | No operation | - |
| ORN, ORNS | {Rd,} Rn, Op2 | Logical OR NOT | N,Z,C |
| ORR, ORRS | {Rd,} Rn, Op2 | Logical OR | N,Z,C |
| POP | reglist | Pop registers from stack | - |
| PUSH | reglist | Push registers onto stack | - |
| RBIT | Rd, Rn | Reverse bits | - |
| REV | Rd, Rn | Reverse byte order in a word | - |
| REV16 | Rd, Rn | Reverse byte order in each halfword | - |
| REVSH | Rd, Rn | Reverse byte order in bottom halfword and sign extend | - |
| ROR, RORS | Rd, Rm, <Rs\|#n> | Rotate right | N,Z,C |
| RRX, RRXS | Rd, Rm | Rotate right with extend | N,Z,C |

**Table 2-13. Cortex-M3 Instruction Summary *(continued)***

| Mnemonic | Operands | Brief Description | Flags |
|---|---|---|---|
| RSB, RSBS | {Rd,} Rn, Op2 | Reverse subtract | N,Z,C,V |
| SBC, SBCS | {Rd,} Rn, Op2 | Subtract with carry | N,Z,C,V |
| SBFX | Rd, Rn, #lsb, #width | Signed bit field extract | - |
| SDIV | {Rd,} Rn, Rm | Signed divide | - |
| SEV | - | Send event | - |
| SMLAL | RdLo, RdHi, Rn, Rm | Signed multiply with accumulate (32x32+64), 64-bit result | - |
| SMULL | RdLo, RdHi, Rn, Rm | Signed multiply (32x32), 64-bit result | - |
| SSAT | Rd, #n, Rm {,shift #s} | Signed saturate | Q |
| STM | Rn{!}, reglist | Store multiple registers, increment after | - |
| STMDB, STMEA | Rn{!}, reglist | Store multiple registers, decrement before | - |
| STMFD, STMIA | Rn{!}, reglist | Store multiple registers, increment after | - |
| STR | Rt, [Rn {, #offset}] | Store register word | - |
| STRB, STRBT | Rt, [Rn {, #offset}] | Store register byte | - |
| STRD | Rt, Rt2, [Rn {, #offset}] | Store register two words | - |
| STREX | Rt, Rt, [Rn {, #offset}] | Store register exclusive | - |
| STREXB | Rd, Rt, [Rn] | Store register exclusive byte | - |
| STREXH | Rd, Rt, [Rn] | Store register exclusive halfword | - |
| STRH, STRHT | Rt, [Rn {, #offset}] | Store register halfword | - |
| STRSB, STRSBT | Rt, [Rn {, #offset}] | Store register signed byte | - |
| STRSH, STRSHT | Rt, [Rn {, #offset}] | Store register signed halfword | - |
| STRT | Rt, [Rn {, #offset}] | Store register word | - |
| SUB, SUBS | {Rd,} Rn, Op2 | Subtract | N,Z,C,V |
| SUB, SUBW | {Rd,} Rn, #imm12 | Subtract 12-bit constant | N,Z,C,V |
| SVC | #imm | Supervisor call | - |
| SXTB | {Rd,} Rm {,ROR #n} | Sign extend a byte | - |
| SXTH | {Rd,} Rm {,ROR #n} | Sign extend a halfword | - |
| TBB | [Rn, Rm] | Table branch byte | - |
| TBH | [Rn, Rm, LSL #1] | Table branch halfword | - |
| TEQ | Rn, Op2 | Test equivalence | N,Z,C |
| TST | Rn, Op2 | Test | N,Z,C |
| UBFX | Rd, Rn, #lsb, #width | Unsigned bit field extract | - |
| UDIV | {Rd,} Rn, Rm | Unsigned divide | - |
| UMLAL | RdLo, RdHi, Rn, Rm | Unsigned multiply with accumulate (32x32+32+32), 64-bit result | - |
| UMULL | RdLo, RdHi, Rn, Rm | Unsigned multiply (32x 2), 64-bit result | - |
| USAT | Rd, #n, Rm {,shift #s} | Unsigned Saturate | Q |
| UXTB | {Rd,} Rm, {,ROR #n} | Zero extend a Byte | - |
| UXTH | {Rd,} Rm, {,ROR #n} | Zero extend a Halfword | - |
| WFE | - | Wait for event | - |
| WFI | - | Wait for interrupt | - |

# 3 Cortex-M3 Peripherals

This chapter provides information on the Stellaris® implementation of the Cortex-M3 processor peripherals, including:

- SysTick (see page 89)

  Provides a simple, 24-bit clear-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism.

- Nested Vectored Interrupt Controller (NVIC) (see page 90)
  - Facilitates low-latency exception and interrupt handling
  - Controls power management
  - Implements system control registers

- System Control Block (SCB) (see page 92)

  Provides system implementation information and system control, including configuration, control, and reporting of system exceptions.

- Memory Protection Unit (MPU) (see page 92)

  Supports the standard ARMv7 Protected Memory System Architecture (PMSA) model. The MPU provides full support for protection regions, overlapping protection regions, access permissions, and exporting memory attributes to the system.

Table 3-1 on page 89 shows the address map of the Private Peripheral Bus (PPB). Some peripheral register regions are split into two address regions, as indicated by two addresses listed.

**Table 3-1. Core Peripheral Register Regions**

| Address | Core Peripheral | Description (see page ...) |
|---|---|---|
| 0xE000.E010-0xE000.E01F | System Timer | 89 |
| 0xE000.E100-0xE000.E4EF<br>0xE000.EF00-0xE000.EF03 | Nested Vectored Interrupt Controller | 90 |
| 0xE000.ED00-0xE000.ED3F | System Control Block | 92 |
| 0xE000.ED90-0xE000.EDB8 | Memory Protection Unit | 92 |

## 3.1 Functional Description

This chapter provides information on the Stellaris implementation of the Cortex-M3 processor peripherals: SysTick, NVIC, SCB and MPU.

### 3.1.1 System Timer (SysTick)

Cortex-M3 includes an integrated system timer, SysTick, which provides a simple, 24-bit clear-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism. The counter can be used in several different ways, for example as:

- An RTOS tick timer that fires at a programmable rate (for example, 100 Hz) and invokes a SysTick routine.

- A high-speed alarm timer using the system clock.

- A variable rate alarm or signal timer—the duration is range-dependent on the reference clock used and the dynamic range of the counter.
- A simple counter used to measure time to completion and time used.
- An internal clock source control based on missing/meeting durations. The COUNT bit in the **STCTRL** control and status register can be used to determine if an action completed within a set duration, as part of a dynamic clock management control loop.

The timer consists of three registers:

- **SysTick Control and Status (STCTRL)**: A control and status counter to configure its clock, enable the counter, enable the SysTick interrupt, and determine counter status.
- **SysTick Reload Value (STRELOAD)**: The reload value for the counter, used to provide the counter's wrap value.
- **SysTick Current Value (STCURRENT)**: The current value of the counter.

When enabled, the timer counts down on each clock from the reload value to zero, reloads (wraps) to the value in the **STRELOAD** register on the next clock edge, then decrements on subsequent clocks. Clearing the **STRELOAD** register disables the counter on the next wrap. When the counter reaches zero, the COUNT status bit is set. The COUNT bit clears on reads.

Writing to the **STCURRENT** register clears the register and the COUNT status bit. The write does not trigger the SysTick exception logic. On a read, the current value is the value of the register at the time the register is accessed.

The SysTick counter runs on the system clock. If this clock signal is stopped for low power mode, the SysTick counter stops. Ensure software uses aligned word accesses to access the SysTick registers.

**Note:** When the processor is halted for debugging, the counter does not decrement.

### 3.1.2 Nested Vectored Interrupt Controller (NVIC)

This section describes the Nested Vectored Interrupt Controller (NVIC) and the registers it uses. The NVIC supports:

- 36 interrupts.
- A programmable priority level of 0-7 for each interrupt. A higher level corresponds to a lower priority, so level 0 is the highest interrupt priority.
- Low-latency exception and interrupt handling.
- Level and pulse detection of interrupt signals.
- Dynamic reprioritization of interrupts.
- Grouping of priority values into group priority and subpriority fields.
- Interrupt tail-chaining.
- An external Non-maskable interrupt (NMI).

The processor automatically stacks its state on exception entry and unstacks this state on exception exit, with no instruction overhead, providing low latency exception handling.

#### 3.1.2.1 Level-Sensitive and Pulse Interrupts

The processor supports both level-sensitive and pulse interrupts. Pulse interrupts are also described as edge-triggered interrupts.

A level-sensitive interrupt is held asserted until the peripheral deasserts the interrupt signal. Typically this happens because the ISR accesses the peripheral, causing it to clear the interrupt request. A pulse interrupt is an interrupt signal sampled synchronously on the rising edge of the processor clock. To ensure the NVIC detects the interrupt, the peripheral must assert the interrupt signal for at least one clock cycle, during which the NVIC detects the pulse and latches the interrupt.

When the processor enters the ISR, it automatically removes the pending state from the interrupt (see “Hardware and Software Control of Interrupts” on page 91 for more information). For a level-sensitive interrupt, if the signal is not deasserted before the processor returns from the ISR, the interrupt becomes pending again, and the processor must execute its ISR again. As a result, the peripheral can hold the interrupt signal asserted until it no longer needs servicing.

#### 3.1.2.2 Hardware and Software Control of Interrupts

The Cortex-M3 latches all interrupts. A peripheral interrupt becomes pending for one of the following reasons:

- The NVIC detects that the interrupt signal is High and the interrupt is not active.
- The NVIC detects a rising edge on the interrupt signal.
- Software writes to the corresponding interrupt set-pending register bit, or to the **Software Trigger Interrupt (SWTRIG)** register to make a Software-Generated Interrupt pending. See the `INT` bit in the **PEND0** register on page 108 or **SWTRIG** on page 116.

A pending interrupt remains pending until one of the following:

- The processor enters the ISR for the interrupt, changing the state of the interrupt from pending to active. Then:
  - For a level-sensitive interrupt, when the processor returns from the ISR, the NVIC samples the interrupt signal. If the signal is asserted, the state of the interrupt changes to pending, which might cause the processor to immediately re-enter the ISR. Otherwise, the state of the interrupt changes to inactive.
  - For a pulse interrupt, the NVIC continues to monitor the interrupt signal, and if this is pulsed the state of the interrupt changes to pending and active. In this case, when the processor returns from the ISR the state of the interrupt changes to pending, which might cause the processor to immediately re-enter the ISR.

    If the interrupt signal is not pulsed while the processor is in the ISR, when the processor returns from the ISR the state of the interrupt changes to inactive.
- Software writes to the corresponding interrupt clear-pending register bit
  - For a level-sensitive interrupt, if the interrupt signal is still asserted, the state of the interrupt does not change. Otherwise, the state of the interrupt changes to inactive.

– For a pulse interrupt, the state of the interrupt changes to inactive, if the state was pending or to active, if the state was active and pending.

### 3.1.3 System Control Block (SCB)

The System Control Block (SCB) provides system implementation information and system control, including configuration, control, and reporting of the system exceptions.

### 3.1.4 Memory Protection Unit (MPU)

This section describes the Memory protection unit (MPU). The MPU divides the memory map into a number of regions and defines the location, size, access permissions, and memory attributes of each region. The MPU supports independent attribute settings for each region, overlapping regions, and export of memory attributes to the system.

The memory attributes affect the behavior of memory accesses to the region. The Cortex-M3 MPU defines eight separate memory regions, 0-7, and a background region.

When memory regions overlap, a memory access is affected by the attributes of the region with the highest number. For example, the attributes for region 7 take precedence over the attributes of any region that overlaps region 7.

The background region has the same memory access attributes as the default memory map, but is accessible from privileged software only.

The Cortex-M3 MPU memory map is unified, meaning that instruction accesses and data accesses have the same region settings.

If a program accesses a memory location that is prohibited by the MPU, the processor generates a memory management fault, causing a fault exception and possibly causing termination of the process in an OS environment. In an OS environment, the kernel can update the MPU region setting dynamically based on the process to be executed. Typically, an embedded OS uses the MPU for memory protection.

Configuration of MPU regions is based on memory types (see “Memory Regions, Types and Attributes” on page 68 for more information).

Table 3-2 on page 92 shows the possible MPU region attributes. See the section called “MPU Configuration for a Stellaris Microcontroller” on page 96 for guidelines for programming a microcontroller implementation.

**Table 3-2. Memory Attributes Summary**

| Memory Type | Description |
|---|---|
| Strongly Ordered | All accesses to Strongly Ordered memory occur in program order. |
| Device | Memory-mapped peripherals |
| Normal | Normal memory |

To avoid unexpected behavior, disable the interrupts before updating the attributes of a region that the interrupt handlers might access.

Ensure software uses aligned accesses of the correct size to access MPU registers:

- Except for the **MPU Region Attribute and Size (MPUATTR)** register, all MPU registers must be accessed with aligned word accesses.
- The **MPUATTR** register can be accessed with byte or aligned halfword or word accesses.

The processor does not support unaligned accesses to MPU registers.

When setting up the MPU, and if the MPU has previously been programmed, disable unused regions to prevent any previous region settings from affecting the new MPU setup.

#### 3.1.4.1 Updating an MPU Region

To update the attributes for an MPU region, the **MPU Region Number (MPUNUMBER)**, **MPU Region Base Address (MPUBASE)** and **MPUATTR** registers must be updated. Each register can be programmed separately or with a multiple-word write to program all of these registers. You can use the **MPUBASEx** and **MPUATTRx** aliases to program up to four regions simultaneously using an STM instruction.

***Updating an MPU Region Using Separate Words***

This example simple code configures one region:

```
; R1 = region number
; R2 = size/enable
; R3 = attributes
; R4 = address
LDR R0,=MPUNUMBER        ; 0xE000ED98, MPU region number register
STR R1, [R0, #0x0]       ; Region Number
STR R4, [R0, #0x4]       ; Region Base Address
STRH R2, [R0, #0x8]      ; Region Size and Enable
STRH R3, [R0, #0xA]      ; Region Attribute
```

Disable a region before writing new region settings to the MPU if you have previously enabled the region being changed. For example:

```
; R1 = region number
; R2 = size/enable
; R3 = attributes
; R4 = address
LDR R0,=MPUNUMBER         ; 0xE000ED98, MPU region number register
STR R1, [R0, #0x0]        ; Region Number
BIC R2, R2, #1            ; Disable
STRH R2, [R0, #0x8]       ; Region Size and Enable
STR R4, [R0, #0x4]        ; Region Base Address
STRH R3, [R0, #0xA]       ; Region Attribute
ORR R2, #1                ; Enable
STRH R2, [R0, #0x8]       ; Region Size and Enable
```

Software must use memory barrier instructions:

- Before MPU setup, if there might be outstanding memory transfers, such as buffered writes, that might be affected by the change in MPU settings.
- After MPU setup, if it includes memory transfers that must use the new MPU settings.

However, memory barrier instructions are not required if the MPU setup process starts by entering an exception handler, or is followed by an exception return, because the exception entry and exception return mechanism cause memory barrier behavior.

Software does not need any memory barrier instructions during MPU setup, because it accesses the MPU through the Private Peripheral Bus (PPB), which is a Strongly Ordered memory region.

For example, if all of the memory access behavior is intended to take effect immediately after the programming sequence, then a DSB instruction and an ISB instruction should be used. A DSB is required after changing MPU settings, such as at the end of context switch. An ISB is required if the code that programs the MPU region or regions is entered using a branch or call. If the programming sequence is entered using a return from exception, or by taking an exception, then an ISB is not required.

### *Updating an MPU Region Using Multi-Word Writes*

The MPU can be programmed directly using multi-word writes, depending how the information is divided. Consider the following reprogramming:

```
; R1 = region number
; R2 = address
; R3 = size, attributes in one
LDR R0, =MPUNUMBER  ; 0xE000ED98, MPU region number register
STR R1, [R0, #0x0]  ; Region Number
STR R2, [R0, #0x4]  ; Region Base Address
STR R3, [R0, #0x8]  ; Region Attribute, Size and Enable
```

An STM instruction can be used to optimize this:

```
; R1 = region number
; R2 = address
; R3 = size, attributes in one
LDR R0, =MPUNUMBER  ; 0xE000ED98, MPU region number register
STM R0, {R1-R3}     ; Region number, address, attribute, size and enable
```

This operation can be done in two words for pre-packed information, meaning that the **MPU Region Base Address (MPUBASE)** register (see page 148) contains the required region number and has the VALID bit set. This method can be used when the data is statically packed, for example in a boot loader:

```
; R1 = address and region number in one
; R2 = size and attributes in one
LDR R0, =MPUBASE    ; 0xE000ED9C, MPU Region Base register
STR R1, [R0, #0x0]  ; Region base address and region number combined
                    ; with VALID (bit 4) set
STR R2, [R0, #0x4]  ; Region Attribute, Size and Enable
```

### *Subregions*

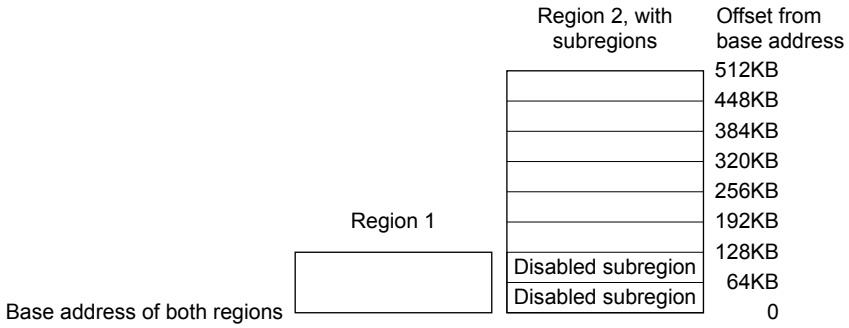
Regions of 256 bytes or more are divided into eight equal-sized subregions. Set the corresponding bit in the SRD field of the **MPU Region Attribute and Size (MPUATTR)** register (see page 150) to disable a subregion. The least-significant bit of the SRD field controls the first subregion, and the most-significant bit controls the last subregion. Disabling a subregion means another region overlapping the disabled range matches instead. If no other enabled region overlaps the disabled subregion, the MPU issues a fault.

Regions of 32, 64, and 128 bytes do not support subregions. With regions of these sizes, the SRD field must be configured to 0x00, otherwise the MPU behavior is unpredictable.

***Example of SRD Use***

Two regions with the same base address overlap. Region one is 128 KB, and region two is 512 KB. To ensure the attributes from region one apply to the first 128 KB region, configure the SRD field for region two to 0x03 to disable the first two subregions, as Figure 3-1 on page 95 shows.

**Figure 3-1. SRD Use Example**




### 3.1.4.2 MPU Access Permission Attributes

The access permission bits, TEX, S, C, B, AP, and XN of the **MPUATTR** register, control access to the corresponding memory region. If an access is made to an area of memory without the required permissions, then the MPU generates a permission fault.

Table 3-3 on page 95 shows the encodings for the TEX, C, B, and S access permission bits. All encodings are shown for completeness, however the current implementation of the Cortex-M3 does not support the concept of cacheability or shareability. Refer to the section called “MPU Configuration for a Stellaris Microcontroller” on page 96 for information on programming the MPU for Stellaris implementations.

**Table 3-3. TEX, S, C, and B Bit Field Encoding**

| TEX | S | C | B | Memory Type | Shareability | Other Attributes |
|---|---|---|---|---|---|---|
| 000b | x[a] | 0 | 0 | Strongly Ordered | Shareable | - |
| 000 | x[a] | 0 | 1 | Device | Shareable | - |
| 000 | 0 | 1 | 0 | Normal | Not shareable | Outer and inner write-through. No write allocate. |
| 000 | 1 | 1 | 0 | Normal | Shareable | |
| 000 | 0 | 1 | 1 | Normal | Not shareable | |
| 000 | 1 | 1 | 1 | Normal | Shareable | |
| 001 | 0 | 0 | 0 | Normal | Not shareable | Outer and inner noncacheable. |
| 001 | 1 | 0 | 0 | Normal | Shareable | |
| 001 | x[a] | 0 | 1 | Reserved encoding | - | - |
| 001 | x[a] | 1 | 0 | Reserved encoding | - | - |
| 001 | 0 | 1 | 1 | Normal | Not shareable | Outer and inner write-back. Write and read allocate. |
| 001 | 1 | 1 | 1 | Normal | Shareable | |
| 010 | x[a] | 0 | 0 | Device | Not shareable | Nonshared Device. |
| 010 | x[a] | 0 | 1 | Reserved encoding | - | - |
| 010 | x[a] | 1 | x[a] | Reserved encoding | - | - |

**Table 3-3. TEX, S, C, and B Bit Field Encoding *(continued)***

| TEX | S | C | B | Memory Type | Shareability | Other Attributes |
|---|---|---|---|---|---|---|
| 1BB | 0 | A | A | Normal | Not shareable | Cached memory (BB = outer policy, AA = inner policy).<br>See Table 3-4 for the encoding of the AA and BB bits. |
| 1BB | 1 | A | A | Normal | Shareable | |

a. The MPU ignores the value of this bit.

Table 3-4 on page 96 shows the cache policy for memory attribute encodings with a TEX value in the range of 0x4-0x7.

**Table 3-4. Cache Policy for Memory Attribute Encoding**

| Encoding, AA or BB | Corresponding Cache Policy |
|---|---|
| 00 | Non-cacheable |
| 01 | Write back, write and read allocate |
| 10 | Write through, no write allocate |
| 11 | Write back, no write allocate |

Table 3-5 on page 96 shows the AP encodings in the **MPUATTR** register that define the access permissions for privileged and unprivileged software.

**Table 3-5. AP Bit Field Encoding**

| AP Bit Field | Privileged Permissions | Unprivileged Permissions | Description |
|---|---|---|---|
| 000 | No access | No access | All accesses generate a permission fault. |
| 001 | R/W | No access | Access from privileged software only. |
| 010 | R/W | RO | Writes by unprivileged software generate a permission fault. |
| 011 | R/W | R/W | Full access. |
| 100 | Unpredictable | Unpredictable | Reserved. |
| 101 | RO | No access | Reads by privileged software only. |
| 110 | RO | RO | Read-only, by privileged or unprivileged software. |
| 111 | RO | RO | Read-only, by privileged or unprivileged software. |

### *MPU Configuration for a Stellaris Microcontroller*

Stellaris microcontrollers have only a single processor and no caches. As a result, the MPU should be programmed as shown in Table 3-6 on page 96.

**Table 3-6. Memory Region Attributes for Stellaris Microcontrollers**

| Memory Region | TEX | S | C | B | Memory Type and Attributes |
|---|---|---|---|---|---|
| Flash memory | 000b | 0 | 1 | 0 | Normal memory, non-shareable, write-through |
| Internal SRAM | 000b | 1 | 1 | 0 | Normal memory, shareable, write-through |
| External SRAM | 000b | 1 | 1 | 1 | Normal memory, shareable, write-back, write-allocate |
| Peripherals | 000b | 1 | 0 | 1 | Device memory, shareable |

In current Stellaris microcontroller implementations, the shareability and cache policy attributes do not affect the system behavior. However, using these settings for the MPU regions can make the application code more portable. The values given are for typical situations.

#### 3.1.4.3 MPU Mismatch

When an access violates the MPU permissions, the processor generates a memory management fault (see “Exceptions and Interrupts” on page 66 for more information). The **MFAULTSTAT** register indicates the cause of the fault. See page 135 for more information.

## 3.2 Register Map

Table 3-7 on page 97 lists the Cortex-M3 Peripheral SysTick, NVIC, MPU and SCB registers. The offset listed is a hexadecimal increment to the register's address, relative to the Core Peripherals base address of 0xE000.E000.

**Note:** Register spaces that are not used are reserved for future or internal use. Software should not modify any reserved memory address.

**Table 3-7. Peripherals Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| **System Timer (SysTick) Registers** | | | | | |
| 0x010 | STCTRL | R/W | 0x0000.0000 | SysTick Control and Status Register | 100 |
| 0x014 | STRELOAD | R/W | 0x0000.0000 | SysTick Reload Value Register | 102 |
| 0x018 | STCURRENT | R/WC | 0x0000.0000 | SysTick Current Value Register | 103 |
| **Nested Vectored Interrupt Controller (NVIC) Registers** | | | | | |
| 0x100 | EN0 | R/W | 0x0000.0000 | Interrupt 0-31 Set Enable | 104 |
| 0x104 | EN1 | R/W | 0x0000.0000 | Interrupt 32-43 Set Enable | 105 |
| 0x180 | DIS0 | R/W | 0x0000.0000 | Interrupt 0-31 Clear Enable | 106 |
| 0x184 | DIS1 | R/W | 0x0000.0000 | Interrupt 32-43 Clear Enable | 107 |
| 0x200 | PEND0 | R/W | 0x0000.0000 | Interrupt 0-31 Set Pending | 108 |
| 0x204 | PEND1 | R/W | 0x0000.0000 | Interrupt 32-43 Set Pending | 109 |
| 0x280 | UNPEND0 | R/W | 0x0000.0000 | Interrupt 0-31 Clear Pending | 110 |
| 0x284 | UNPEND1 | R/W | 0x0000.0000 | Interrupt 32-43 Clear Pending | 111 |
| 0x300 | ACTIVE0 | RO | 0x0000.0000 | Interrupt 0-31 Active Bit | 112 |
| 0x304 | ACTIVE1 | RO | 0x0000.0000 | Interrupt 32-43 Active Bit | 113 |
| 0x400 | PRI0 | R/W | 0x0000.0000 | Interrupt 0-3 Priority | 114 |
| 0x404 | PRI1 | R/W | 0x0000.0000 | Interrupt 4-7 Priority | 114 |
| 0x408 | PRI2 | R/W | 0x0000.0000 | Interrupt 8-11 Priority | 114 |
| 0x40C | PRI3 | R/W | 0x0000.0000 | Interrupt 12-15 Priority | 114 |
| 0x410 | PRI4 | R/W | 0x0000.0000 | Interrupt 16-19 Priority | 114 |

**Table 3-7. Peripherals Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x414 | PRI5 | R/W | 0x0000.0000 | Interrupt 20-23 Priority | 114 |
| 0x418 | PRI6 | R/W | 0x0000.0000 | Interrupt 24-27 Priority | 114 |
| 0x41C | PRI7 | R/W | 0x0000.0000 | Interrupt 28-31 Priority | 114 |
| 0x420 | PRI8 | R/W | 0x0000.0000 | Interrupt 32-35 Priority | 114 |
| 0x424 | PRI9 | R/W | 0x0000.0000 | Interrupt 36-39 Priority | 114 |
| 0x428 | PRI10 | R/W | 0x0000.0000 | Interrupt 40-43 Priority | 114 |
| 0xF00 | SWTRIG | WO | 0x0000.0000 | Software Trigger Interrupt | 116 |
| **System Control Block (SCB) Registers** | | | | | |
| 0xD00 | CPUID | RO | 0x411F.C231 | CPU ID Base | 117 |
| 0xD04 | INTCTRL | R/W | 0x0000.0000 | Interrupt Control and State | 118 |
| 0xD08 | VTABLE | R/W | 0x0000.0000 | Vector Table Offset | 121 |
| 0xD0C | APINT | R/W | 0xFA05.0000 | Application Interrupt and Reset Control | 122 |
| 0xD10 | SYSCTRL | R/W | 0x0000.0000 | System Control | 124 |
| 0xD14 | CFGCTRL | R/W | 0x0000.0000 | Configuration and Control | 126 |
| 0xD18 | SYSPRI1 | R/W | 0x0000.0000 | System Handler Priority 1 | 128 |
| 0xD1C | SYSPRI2 | R/W | 0x0000.0000 | System Handler Priority 2 | 129 |
| 0xD20 | SYSPRI3 | R/W | 0x0000.0000 | System Handler Priority 3 | 130 |
| 0xD24 | SYSHNDCTRL | R/W | 0x0000.0000 | System Handler Control and State | 131 |
| 0xD28 | FAULTSTAT | R/W1C | 0x0000.0000 | Configurable Fault Status | 135 |
| 0xD2C | HFAULTSTAT | R/W1C | 0x0000.0000 | Hard Fault Status | 141 |
| 0xD34 | MMADDR | R/W | - | Memory Management Fault Address | 142 |
| 0xD38 | FAULTADDR | R/W | - | Bus Fault Address | 143 |
| **Memory Protection Unit (MPU) Registers** | | | | | |
| 0xD90 | MPUTYPE | RO | 0x0000.0800 | MPU Type | 144 |
| 0xD94 | MPUCTRL | R/W | 0x0000.0000 | MPU Control | 145 |
| 0xD98 | MPUNUMBER | R/W | 0x0000.0000 | MPU Region Number | 147 |
| 0xD9C | MPUBASE | R/W | 0x0000.0000 | MPU Region Base Address | 148 |
| 0xDA0 | MPUATTR | R/W | 0x0000.0000 | MPU Region Attribute and Size | 150 |
| 0xDA4 | MPUBASE1 | R/W | 0x0000.0000 | MPU Region Base Address Alias 1 | 148 |
| 0xDA8 | MPUATTR1 | R/W | 0x0000.0000 | MPU Region Attribute and Size Alias 1 | 150 |
| 0xDAC | MPUBASE2 | R/W | 0x0000.0000 | MPU Region Base Address Alias 2 | 148 |
| 0xDB0 | MPUATTR2 | R/W | 0x0000.0000 | MPU Region Attribute and Size Alias 2 | 150 |

**Table 3-7. Peripherals Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0xDB4 | MPUBASE3 | R/W | 0x0000.0000 | MPU Region Base Address Alias 3 | 148 |
| 0xDB8 | MPUATTR3 | R/W | 0x0000.0000 | MPU Region Attribute and Size Alias 3 | 150 |

## 3.3 System Timer (SysTick) Register Descriptions

This section lists and describes the System Timer registers, in numerical order by address offset.

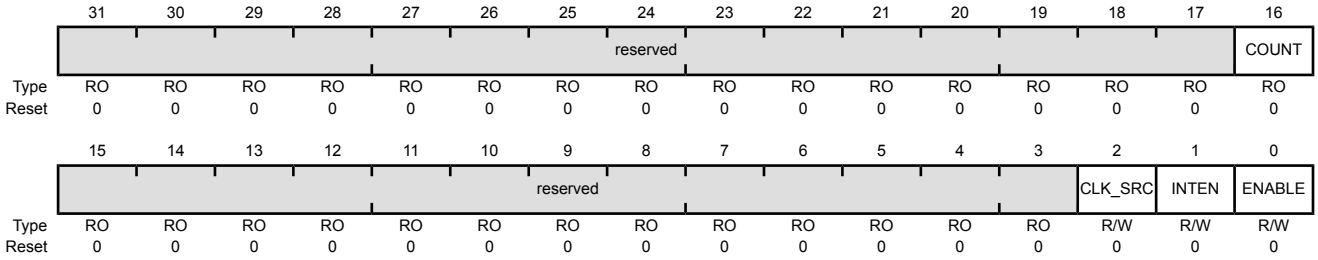
## Register 1: SysTick Control and Status Register (STCTRL), offset 0x010

**Note:** This register can only be accessed from privileged mode.

The SysTick **STCTRL** register enables the SysTick features.

SysTick Control and Status Register (STCTRL)

Base 0xE000.E000
Offset 0x010
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:17 | reserved | RO | 0x000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 16 | COUNT | RO | 0 | Count Flag<br><br>Value Description<br>0 The SysTick timer has not counted to 0 since the last time this bit was read.<br>1 The SysTick timer has counted to 0 since the last time this bit was read.<br><br>This bit is cleared by a read of the register or if the **STCURRENT** register is written with any value.<br><br>If read by the debugger using the DAP, this bit is cleared only if the `MasterType` bit in the **AHB-AP Control Register** is clear. Otherwise, the `COUNT` bit is not changed by the debugger read. See the *ARM® Debug Interface V5 Architecture Specification* for more information on `MasterType`. |
| 15:3 | reserved | RO | 0x000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | CLK_SRC | R/W | 0 | Clock Source<br><br>Value Description<br>0 External reference clock. (Not implemented for most Stellaris microcontrollers.)<br>1 System clock<br><br>Because an external reference clock is not implemented, this bit must be set in order for SysTick to operate. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | INTEN | R/W | 0 | Interrupt Enable |

| Value | Description |
|---|---|
| 0 | Interrupt generation is disabled. Software can use the COUNT bit to determine if the counter has ever reached 0. |
| 1 | An interrupt is generated to the NVIC when SysTick counts to 0. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | ENABLE | R/W | 0 | Enable |

| Value | Description |
|---|---|
| 0 | The counter is disabled. |
| 1 | Enables SysTick to operate in a multi-shot way. That is, the counter loads the RELOAD value and begins counting down. On reaching 0, the COUNT bit is set and an interrupt is generated if enabled by INTEN. The counter then loads the RELOAD value again and begins counting. |

## Register 2: SysTick Reload Value Register (STRELOAD), offset 0x014

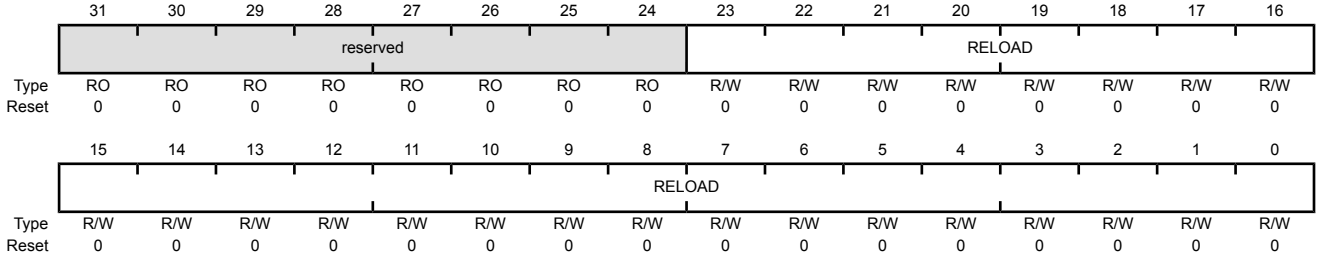
**Note:** This register can only be accessed from privileged mode.

The **STRELOAD** register specifies the start value to load into the **SysTick Current Value (STCURRENT)** register when the counter reaches 0. The start value can be between 0x1 and 0x00FF.FFFF. A start value of 0 is possible but has no effect because the SysTick interrupt and the COUNT bit are activated when counting from 1 to 0.

SysTick can be configured as a multi-shot timer, repeated over and over, firing every N+1 clock pulses, where N is any value from 1 to 0x00FF.FFFF. For example, if a tick interrupt is required every 100 clock pulses, 99 must be written into the RELOAD field.

SysTick Reload Value Register (STRELOAD)

Base 0xE000.E000
Offset 0x014
Type R/W, reset 0x0000.0000



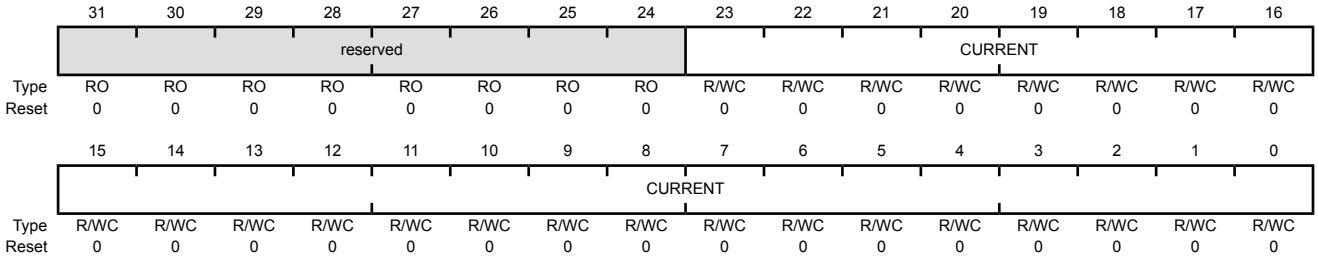

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:24 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:0 | RELOAD | R/W | 0x00.0000 | Reload Value<br>Value to load into the **SysTick Current Value (STCURRENT)** register when the counter reaches 0. |

### Register 3: SysTick Current Value Register (STCURRENT), offset 0x018

**Note:** This register can only be accessed from privileged mode.

The **STCURRENT** register contains the current value of the SysTick counter.

SysTick Current Value Register (STCURRENT)
Base 0xE000.E000
Offset 0x018
Type R/WC, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:24 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:0 | CURRENT | R/WC | 0x00.0000 | Current Value<br>This field contains the current value at the time the register is accessed. No read-modify-write protection is provided, so change with care.<br>This register is write-clear. Writing to it with any value clears the register. Clearing this register also clears the COUNT bit of the **STCTRL** register. |

## 3.4 NVIC Register Descriptions

This section lists and describes the NVIC registers, in numerical order by address offset.

The NVIC registers can only be fully accessed from privileged mode, but interrupts can be pended while in unprivileged mode by enabling the **Configuration and Control (CFGCTRL)** register. Any other unprivileged mode access causes a bus fault.

Ensure software uses correctly aligned register accesses. The processor does not support unaligned accesses to NVIC registers.

An interrupt can enter the pending state even if it is disabled.

Before programming the **VTABLE** register to relocate the vector table, ensure the vector table entries of the new vector table are set up for fault handlers, NMI, and all enabled exceptions such as interrupts. For more information, see page 121.

## Register 4: Interrupt 0-31 Set Enable (EN0), offset 0x100

**Note:** This register can only be accessed from privileged mode.

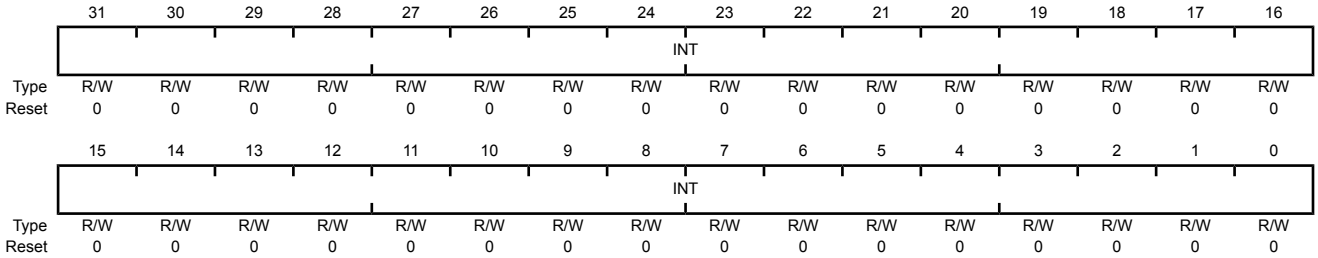
The **EN0** register enables interrupts and shows which interrupts are enabled. Bit 0 corresponds to Interrupt 0; bit 31 corresponds to Interrupt 31.

See Table 2-9 on page 77 for interrupt assignments.

If a pending interrupt is enabled, the NVIC activates the interrupt based on its priority. If an interrupt is not enabled, asserting its interrupt signal changes the interrupt state to pending, but the NVIC never activates the interrupt, regardless of its priority.

Interrupt 0-31 Set Enable (EN0)

Base 0xE000.E000
Offset 0x100
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | INT | R/W | 0x0000.0000 | Interrupt Enable |

| Value | Description |
|---|---|
| 0 | On a read, indicates the interrupt is disabled.<br>On a write, no effect. |
| 1 | On a read, indicates the interrupt is enabled.<br>On a write, enables the interrupt. |

A bit can only be cleared by setting the corresponding `INT[n]` bit in the **DISn** register.

## Register 5: Interrupt 32-43 Set Enable (EN1), offset 0x104

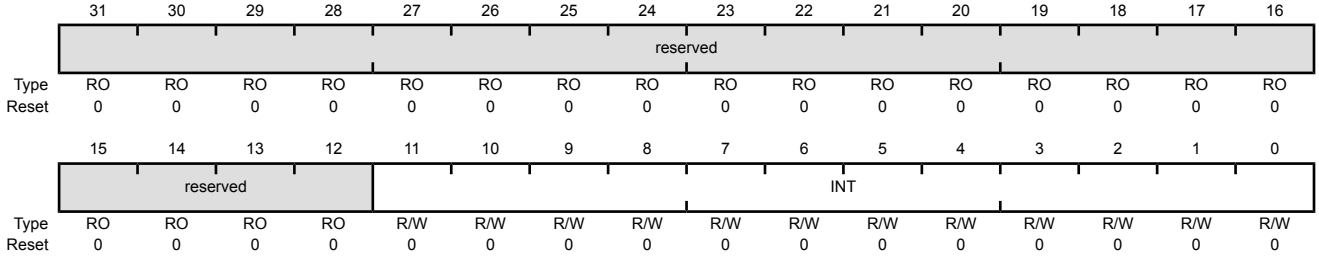
**Note:** This register can only be accessed from privileged mode.

The **EN1** register enables interrupts and shows which interrupts are enabled. Bit 0 corresponds to Interrupt 32; bit 11 corresponds to Interrupt 43. See Table 2-9 on page 77 for interrupt assignments.

If a pending interrupt is enabled, the NVIC activates the interrupt based on its priority. If an interrupt is not enabled, asserting its interrupt signal changes the interrupt state to pending, but the NVIC never activates the interrupt, regardless of its priority.

Interrupt 32-43 Set Enable (EN1)

Base 0xE000.E000
Offset 0x104
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x0000.0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | INT | R/W | 0x000 | Interrupt Enable |

| Value | Description |
|---|---|
| 0 | On a read, indicates the interrupt is disabled. |
| | On a write, no effect. |
| 1 | On a read, indicates the interrupt is enabled. |
| | On a write, enables the interrupt. |

A bit can only be cleared by setting the corresponding `INT[n]` bit in the **DIS1** register.

## Register 6: Interrupt 0-31 Clear Enable (DIS0), offset 0x180

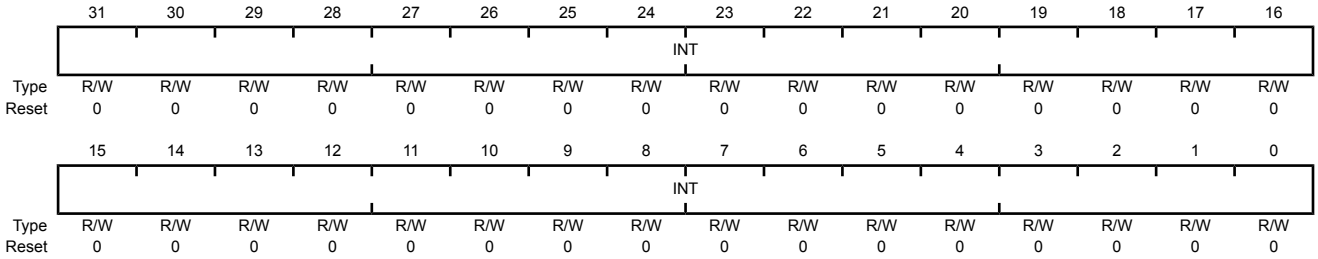
**Note:** This register can only be accessed from privileged mode.

The **DIS0** register disables interrupts. Bit 0 corresponds to Interrupt 0; bit 31 corresponds to Interrupt 31.

See Table 2-9 on page 77 for interrupt assignments.

Interrupt 0-31 Clear Enable (DIS0)

Base 0xE000.E000
Offset 0x180
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | INT | R/W | 0x0000.0000 | Interrupt Disable |

| Value | Description |
|---|---|
| 0 | On a read, indicates the interrupt is disabled.<br>On a write, no effect. |
| 1 | On a read, indicates the interrupt is enabled.<br>On a write, clears the corresponding `INT[n]` bit in the **EN0** register, disabling interrupt [n]. |

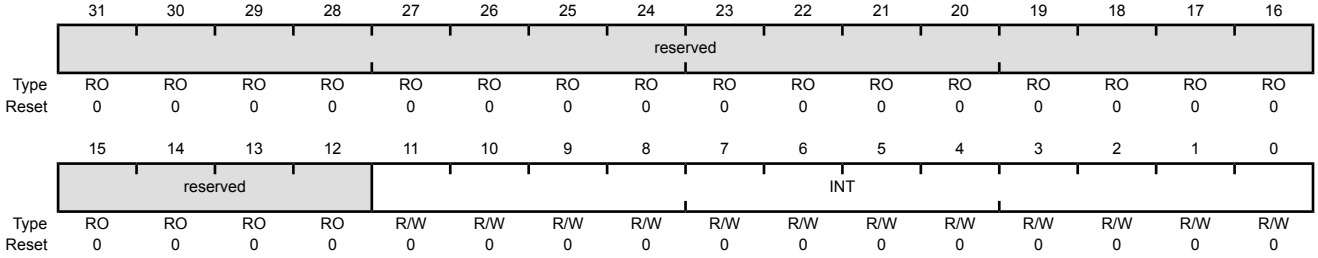
## Register 7: Interrupt 32-43 Clear Enable (DIS1), offset 0x184

**Note:** This register can only be accessed from privileged mode.

The **DIS1** register disables interrupts. Bit 0 corresponds to Interrupt 32; bit 11 corresponds to Interrupt 43. See Table 2-9 on page 77 for interrupt assignments.

Interrupt 32-43 Clear Enable (DIS1)

Base 0xE000.E000
Offset 0x184
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x0000.0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | INT | R/W | 0x000 | Interrupt Disable |

| Value | Description |
|---|---|
| 0 | On a read, indicates the interrupt is disabled.<br>On a write, no effect. |
| 1 | On a read, indicates the interrupt is enabled.<br>On a write, clears the corresponding `INT[n]` bit in the **EN1** register, disabling interrupt [n]. |

## Register 8: Interrupt 0-31 Set Pending (PEND0), offset 0x200

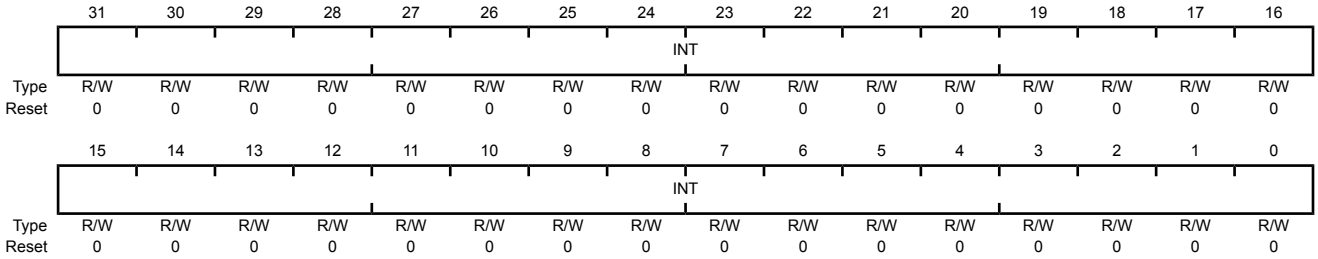
**Note:** This register can only be accessed from privileged mode.

The **PEND0** register forces interrupts into the pending state and shows which interrupts are pending. Bit 0 corresponds to Interrupt 0; bit 31 corresponds to Interrupt 31.

See Table 2-9 on page 77 for interrupt assignments.

Interrupt 0-31 Set Pending (PEND0)

Base 0xE000.E000
Offset 0x200
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | INT | R/W | 0x0000.0000 | Interrupt Set Pending |

| Value | Description |
|---|---|
| 0 | On a read, indicates that the interrupt is not pending.<br>On a write, no effect. |
| 1 | On a read, indicates that the interrupt is pending.<br>On a write, the corresponding interrupt is set to pending even if it is disabled. |

If the corresponding interrupt is already pending, setting a bit has no effect.

A bit can only be cleared by setting the corresponding `INT[n]` bit in the **UNPEND0** register.

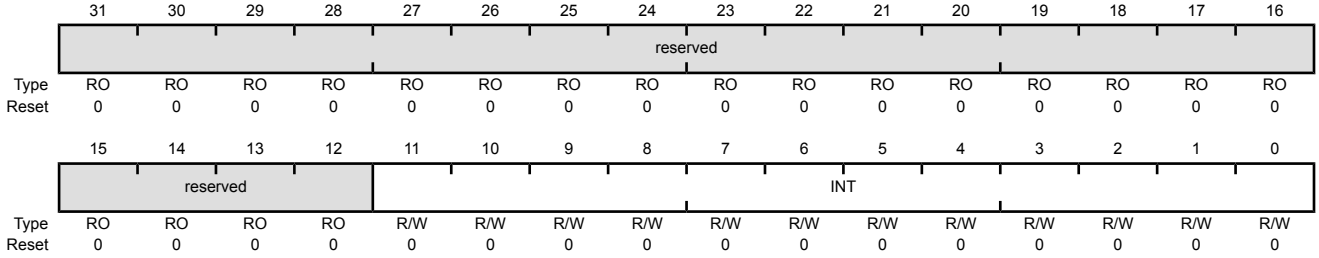
## Register 9: Interrupt 32-43 Set Pending (PEND1), offset 0x204

**Note:** This register can only be accessed from privileged mode.

The **PEND1** register forces interrupts into the pending state and shows which interrupts are pending. Bit 0 corresponds to Interrupt 32; bit 11 corresponds to Interrupt 43. See Table 2-9 on page 77 for interrupt assignments.

Interrupt 32-43 Set Pending (PEND1)

Base 0xE000.E000
Offset 0x204
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x0000.0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | INT | R/W | 0x000 | Interrupt Set Pending |

| Value | Description |
|---|---|
| 0 | On a read, indicates that the interrupt is not pending.<br>On a write, no effect. |
| 1 | On a read, indicates that the interrupt is pending.<br>On a write, the corresponding interrupt is set to pending even if it is disabled. |

If the corresponding interrupt is already pending, setting a bit has no effect.

A bit can only be cleared by setting the corresponding `INT[n]` bit in the **UNPEND1** register.

## Register 10: Interrupt 0-31 Clear Pending (UNPEND0), offset 0x280

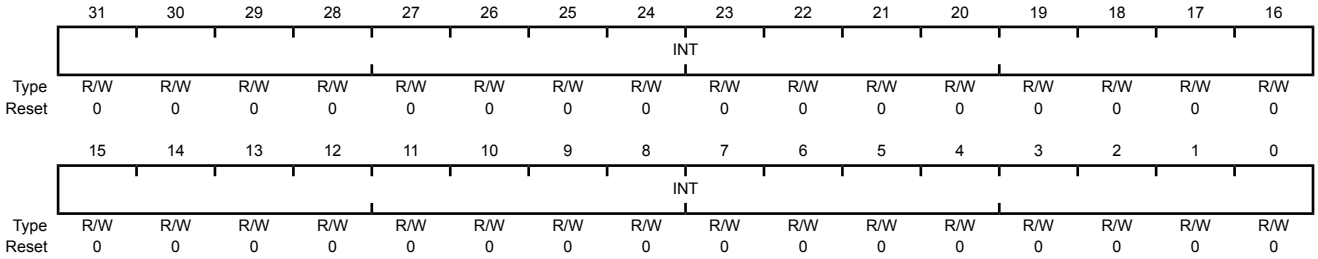
**Note:** This register can only be accessed from privileged mode.

The **UNPEND0** register shows which interrupts are pending and removes the pending state from interrupts. Bit 0 corresponds to Interrupt 0; bit 31 corresponds to Interrupt 31.

See Table 2-9 on page 77 for interrupt assignments.

Interrupt 0-31 Clear Pending (UNPEND0)

Base 0xE000.E000
Offset 0x280
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | INT | R/W | 0x0000.0000 | Interrupt Clear Pending |

| Value | Description |
|---|---|
| 0 | On a read, indicates that the interrupt is not pending.<br>On a write, no effect. |
| 1 | On a read, indicates that the interrupt is pending.<br>On a write, clears the corresponding `INT[n]` bit in the **PEND0** register, so that interrupt [n] is no longer pending.<br>Setting a bit does not affect the active state of the corresponding interrupt. |

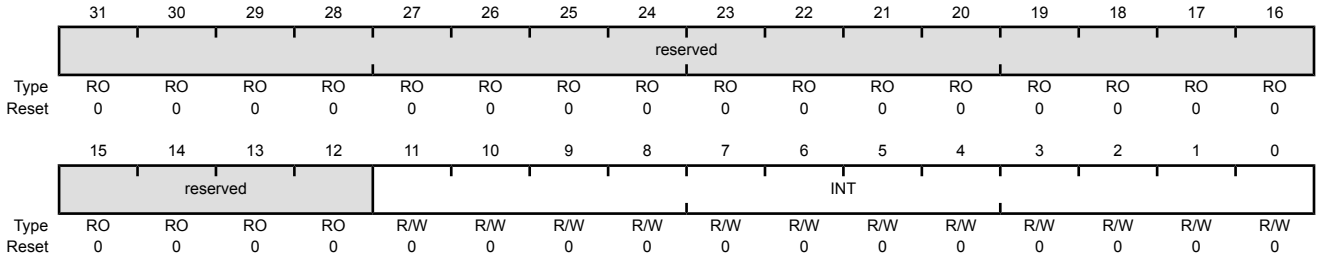
## Register 11: Interrupt 32-43 Clear Pending (UNPEND1), offset 0x284

**Note:** This register can only be accessed from privileged mode.

The **UNPEND1** register shows which interrupts are pending and removes the pending state from interrupts. Bit 0 corresponds to Interrupt 32; bit 11 corresponds to Interrupt 43. See Table 2-9 on page 77 for interrupt assignments.

Interrupt 32-43 Clear Pending (UNPEND1)

Base 0xE000.E000
Offset 0x284
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x0000.0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | INT | R/W | 0x000 | Interrupt Clear Pending |

| Value | Description |
|---|---|
| 0 | On a read, indicates that the interrupt is not pending.<br>On a write, no effect. |
| 1 | On a read, indicates that the interrupt is pending.<br>On a write, clears the corresponding `INT[n]` bit in the **PEND1** register, so that interrupt [n] is no longer pending.<br>Setting a bit does not affect the active state of the corresponding interrupt. |

## Register 12: Interrupt 0-31 Active Bit (ACTIVE0), offset 0x300

**Note:** This register can only be accessed from privileged mode.

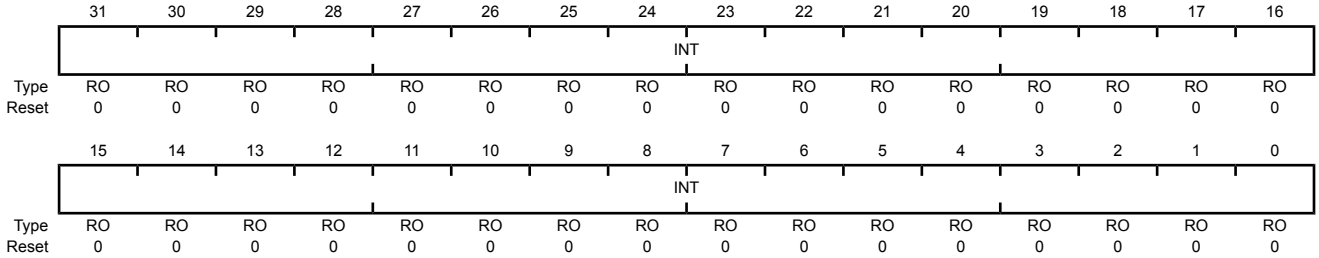
The **ACTIVE0** register indicates which interrupts are active. Bit 0 corresponds to Interrupt 0; bit 31 corresponds to Interrupt 31.

See Table 2-9 on page 77 for interrupt assignments.

**Caution – Do not manually set or clear the bits in this register.**

Interrupt 0-31 Active Bit (ACTIVE0)

Base 0xE000.E000
Offset 0x300
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | INT | RO | 0x0000.0000 | Interrupt Active |

| Value | Description |
|---|---|
| 0 | The corresponding interrupt is not active. |
| 1 | The corresponding interrupt is active, or active and pending. |

## Register 13: Interrupt 32-43 Active Bit (ACTIVE1), offset 0x304

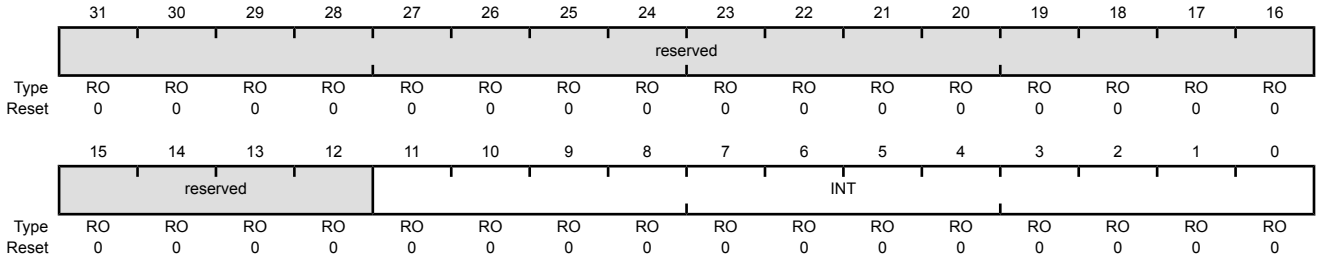
**Note:** This register can only be accessed from privileged mode.

The **ACTIVE1** register indicates which interrupts are active. Bit 0 corresponds to Interrupt 32; bit 11 corresponds to Interrupt 43. See Table 2-9 on page 77 for interrupt assignments.

**Caution – Do not manually set or clear the bits in this register.**

Interrupt 32-43 Active Bit (ACTIVE1)

Base 0xE000.E000
Offset 0x304
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x0000.0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | INT | RO | 0x000 | Interrupt Active<br>Value Description<br>0 The corresponding interrupt is not active.<br>1 The corresponding interrupt is active, or active and pending. |

### Register 14: Interrupt 0-3 Priority (PRI0), offset 0x400

### Register 15: Interrupt 4-7 Priority (PRI1), offset 0x404

### Register 16: Interrupt 8-11 Priority (PRI2), offset 0x408

### Register 17: Interrupt 12-15 Priority (PRI3), offset 0x40C

### Register 18: Interrupt 16-19 Priority (PRI4), offset 0x410

### Register 19: Interrupt 20-23 Priority (PRI5), offset 0x414

### Register 20: Interrupt 24-27 Priority (PRI6), offset 0x418

### Register 21: Interrupt 28-31 Priority (PRI7), offset 0x41C

### Register 22: Interrupt 32-35 Priority (PRI8), offset 0x420

### Register 23: Interrupt 36-39 Priority (PRI9), offset 0x424

### Register 24: Interrupt 40-43 Priority (PRI10), offset 0x428

**Note:** This register can only be accessed from privileged mode.

The **PRIn** registers provide 3-bit priority fields for each interrupt. These registers are byte accessible. Each register holds four priority fields that are assigned to interrupts as follows:

| PRIn Register Bit Field | Interrupt |
|---|---|
| Bits 31:29 | Interrupt [4n+3] |
| Bits 23:21 | Interrupt [4n+2] |
| Bits 15:13 | Interrupt [4n+1] |
| Bits 7:5 | Interrupt [4n] |

See Table 2-9 on page 77 for interrupt assignments.

Each priority level can be split into separate group priority and subpriority fields. The PRIGROUP field in the **Application Interrupt and Reset Control (APINT)** register (see page 122) indicates the position of the binary point that splits the priority and subpriority fields.

These registers can only be accessed from privileged mode.

Interrupt 0-3 Priority (PRI0)

Base 0xE000.E000
Offset 0x400
Type R/W, reset 0x0000.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | INTD | | | reserved | | | | | INTC | | | reserved | | | | |
| Type | R/W | R/W | R/W | RO | RO | RO | RO | RO | R/W | R/W | R/W | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | INTB | | | reserved | | | | | INTA | | | reserved | | | | |
| Type | R/W | R/W | R/W | RO | RO | RO | RO | RO | R/W | R/W | R/W | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:29 | INTD | R/W | 0x0 | Interrupt Priority for Interrupt [4n+3]<br>This field holds a priority value, 0-7, for the interrupt with the number [4n+3], where n is the number of the **Interrupt Priority** register (n=0 for **PRI0**, and so on). The lower the value, the greater the priority of the corresponding interrupt. |
| 28:24 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:21 | INTC | R/W | 0x0 | Interrupt Priority for Interrupt [4n+2]<br>This field holds a priority value, 0-7, for the interrupt with the number [4n+2], where n is the number of the **Interrupt Priority** register (n=0 for **PRI0**, and so on). The lower the value, the greater the priority of the corresponding interrupt. |
| 20:16 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:13 | INTB | R/W | 0x0 | Interrupt Priority for Interrupt [4n+1]<br>This field holds a priority value, 0-7, for the interrupt with the number [4n+1], where n is the number of the **Interrupt Priority** register (n=0 for **PRI0**, and so on). The lower the value, the greater the priority of the corresponding interrupt. |
| 12:8 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:5 | INTA | R/W | 0x0 | Interrupt Priority for Interrupt [4n]<br>This field holds a priority value, 0-7, for the interrupt with the number [4n], where n is the number of the **Interrupt Priority** register (n=0 for **PRI0**, and so on). The lower the value, the greater the priority of the corresponding interrupt. |
| 4:0 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

### Register 25: Software Trigger Interrupt (SWTRIG), offset 0xF00

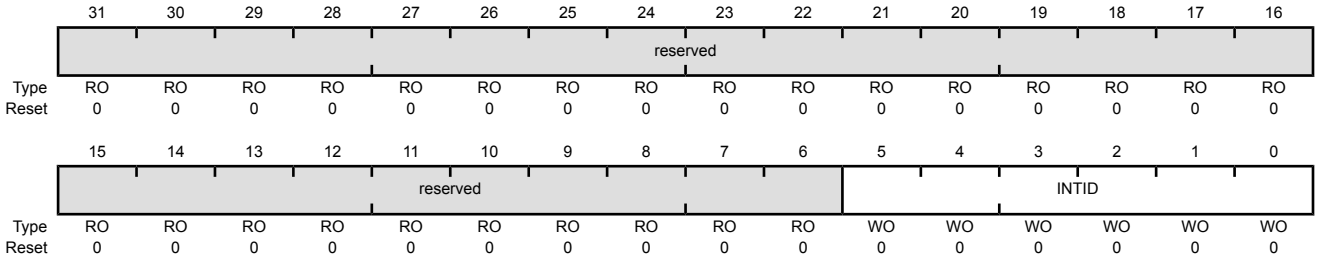
**Note:** Only privileged software can enable unprivileged access to the **SWTRIG** register.

Writing an interrupt number to the **SWTRIG** register generates a Software Generated Interrupt (SGI). See Table 2-9 on page 77 for interrupt assignments.

When the MAINPEND bit in the **Configuration and Control (CFGCTRL)** register (see page 126) is set, unprivileged software can access the **SWTRIG** register.

Software Trigger Interrupt (SWTRIG)

Base 0xE000.E000
Offset 0xF00
Type WO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x0000.00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5:0 | INTID | WO | 0x00 | Interrupt ID<br>This field holds the interrupt ID of the required SGI. For example, a value of 0x3 generates an interrupt on IRQ3. |

## 3.5 System Control Block (SCB) Register Descriptions

This section lists and describes the System Control Block (SCB) registers, in numerical order by address offset. The SCB registers can only be accessed from privileged mode.

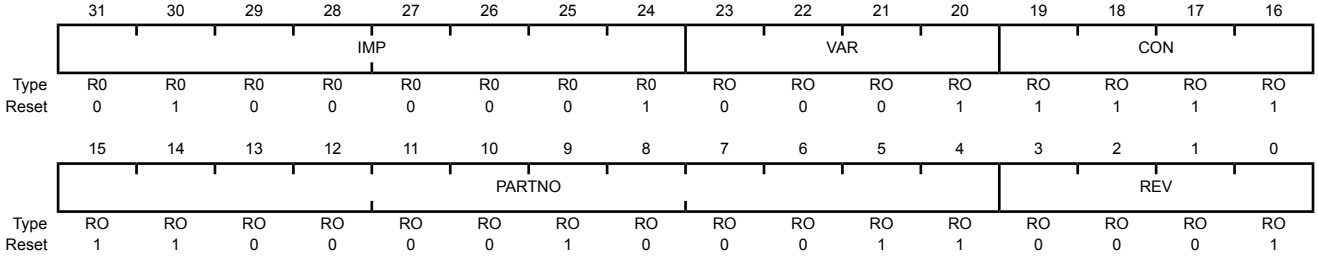
All registers must be accessed with aligned word accesses except for the **FAULTSTAT** and **SYSPRI1**-**SYSPRI3** registers, which can be accessed with byte or aligned halfword or word accesses. The processor does not support unaligned accesses to system control block registers.

## Register 26: CPU ID Base (CPUID), offset 0xD00

**Note:** This register can only be accessed from privileged mode.

The **CPUID** register contains the ARM® Cortex™-M3 processor part number, version, and implementation information.

CPU ID Base (CPUID)
Base 0xE000.E000
Offset 0xD00
Type RO, reset 0x411F.C231




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:24 | IMP | R0 | 0x41 | Implementer Code<br><br>Value Description<br>0x41 ARM |
| 23:20 | VAR | RO | 0x1 | Variant Number<br><br>Value Description<br>0x1 The rn value in the rnpn product revision identifier, for example, the 1 in r1p1. |
| 19:16 | CON | RO | 0xF | Constant<br><br>Value Description<br>0xF Always reads as 0xF. |
| 15:4 | PARTNO | RO | 0xC23 | Part Number<br><br>Value Description<br>0xC23 Cortex-M3 processor. |
| 3:0 | REV | RO | 0x1 | Revision Number<br><br>Value Description<br>0x1 The pn value in the rnpn product revision identifier, for example, the 1 in r1p1. |

## Register 27: Interrupt Control and State (INTCTRL), offset 0xD04

**Note:** This register can only be accessed from privileged mode.

The **INCTRL** register provides a set-pending bit for the NMI exception, and set-pending and clear-pending bits for the PendSV and SysTick exceptions. In addition, bits in this register indicate the exception number of the exception being processed, whether there are preempted active exceptions, the exception number of the highest priority pending exception, and whether any interrupts are pending.

When writing to **INCTRL**, the effect is unpredictable when writing a 1 to both the PENDSV and UNPENDSV bits, or writing a 1 to both the PENDSTSET and PENDSTCLR bits.

Interrupt Control and State (INTCTRL)

Base 0xE000.E000
Offset 0xD04
Type R/W, reset 0x0000.0000

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMISET | reserved | | PENDSV | UNPENDSV | PENDSTSET | PENDSTCLR | reserved | ISRPRE | ISRPEND | reserved | | | | VECPEND | |
| Type R/W | RO | RO | R/W | WO | R/W | WO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VECPEND | | | | RETBASE | reserved | | | | | VECACT | | | | | |
| Type RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | NMISET | R/W | 0 | NMI Set Pending |

| Value | Description |
|---|---|
| 0 | On a read, indicates an NMI exception is not pending.<br>On a write, no effect. |
| 1 | On a read, indicates an NMI exception is pending.<br>On a write, changes the NMI exception state to pending. |

Because NMI is the highest-priority exception, normally the processor enters the NMI exception handler as soon as it registers the setting of this bit, and clears this bit on entering the interrupt handler. A read of this bit by the NMI exception handler returns 1 only if the NMI signal is reasserted while the processor is executing that handler.

| | | | | |
|---|---|---|---|---|
| 30:29 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 28 | PENDSV | R/W | 0 | PendSV Set Pending |

| Value | Description |
|---|---|
| 0 | On a read, indicates a PendSV exception is not pending.<br>On a write, no effect. |
| 1 | On a read, indicates a PendSV exception is pending.<br>On a write, changes the PendSV exception state to pending. |

Setting this bit is the only way to set the PendSV exception state to pending. This bit is cleared by writing a 1 to the UNPENDSV bit.

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 27 | UNPENDSV | WO | 0 | PendSV Clear Pending<br><br>Value Description<br>0 On a write, no effect.<br>1 On a write, removes the pending state from the PendSV exception.<br><br>This bit is write only; on a register read, its value is unknown. |
| 26 | PENDSTSET | R/W | 0 | SysTick Set Pending<br><br>Value Description<br>0 On a read, indicates a SysTick exception is not pending.<br>On a write, no effect.<br>1 On a read, indicates a SysTick exception is pending.<br>On a write, changes the SysTick exception state to pending.<br><br>This bit is cleared by writing a 1 to the PENDSTCLR bit. |
| 25 | PENDSTCLR | WO | 0 | SysTick Clear Pending<br><br>Value Description<br>0 On a write, no effect.<br>1 On a write, removes the pending state from the SysTick exception.<br><br>This bit is write only; on a register read, its value is unknown. |
| 24 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23 | ISRPRE | RO | 0 | Debug Interrupt Handling<br><br>Value Description<br>0 The release from halt does not take an interrupt.<br>1 The release from halt takes an interrupt.<br><br>This bit is only meaningful in Debug mode and reads as zero when the processor is not in Debug mode. |
| 22 | ISRPEND | RO | 0 | Interrupt Pending<br><br>Value Description<br>0 No interrupt is pending.<br>1 An interrupt is pending.<br><br>This bit provides status for all interrupts excluding NMI and Faults. |
| 21:18 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 17:12 | VECPEND | RO | 0x00 | Interrupt Pending Vector Number<br>This field contains the exception number of the highest priority pending enabled exception. The value indicated by this field includes the effect of the **BASEPRI** and **FAULTMASK** registers, but not any effect of the **PRIMASK** register.<br>Value / Description<br>0x00 No exceptions are pending<br>0x01 Reserved<br>0x02 NMI<br>0x03 Hard fault<br>0x04 Memory management fault<br>0x05 Bus fault<br>0x06 Usage fault<br>0x07-0x0A Reserved<br>0x0B SVCall<br>0x0C Reserved for Debug<br>0x0D Reserved<br>0x0E PendSV<br>0x0F SysTick<br>0x10 Interrupt Vector 0<br>0x11 Interrupt Vector 1<br>... ...<br>0x3B Interrupt Vector 43<br>0x3C-0x3F Reserved |
| 11 | RETBASE | RO | 0 | Return to Base<br>Value / Description<br>0 There are preempted active exceptions to execute.<br>1 There are no active exceptions, or the currently executing exception is the only active exception.<br>This bit provides status for all interrupts excluding NMI and Faults. This bit only has meaning if the processor is currently executing an ISR (the **Interrupt Program Status (IPSR)** register is non-zero). |
| 10:6 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5:0 | VECACT | RO | 0x00 | Interrupt Pending Vector Number<br>This field contains the active exception number. The exception numbers can be found in the description for the VECPEND field. If this field is clear, the processor is in Thread mode. This field contains the same value as the ISRNUM field in the **IPSR** register.<br>Subtract 16 from this value to obtain the IRQ number required to index into the **Interrupt Set Enable (ENn)**, **Interrupt Clear Enable (DISn**), **Interrupt Set Pending (PENDn)**, **Interrupt Clear Pending (UNPENDn)**, and **Interrupt Priority (PRIn)** registers (see page 58). |

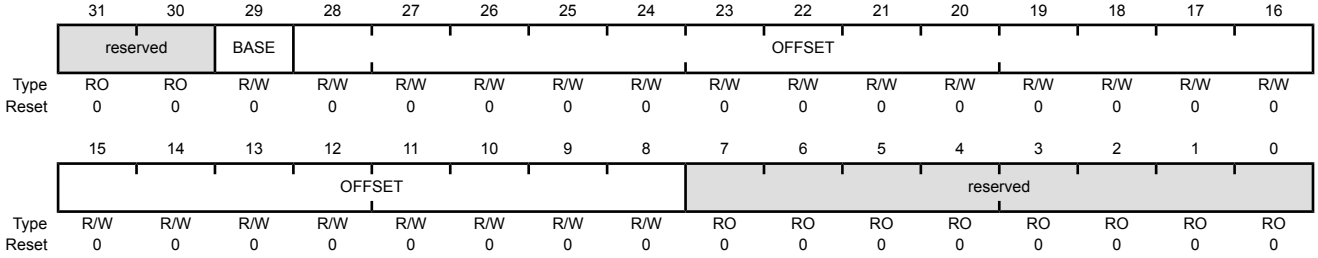
## Register 28: Vector Table Offset (VTABLE), offset 0xD08

**Note:** This register can only be accessed from privileged mode.

The **VTABLE** register indicates the offset of the vector table base address from memory address 0x0000.0000.

Vector Table Offset (VTABLE)

Base 0xE000.E000
Offset 0xD08
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:30 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 29 | BASE | R/W | 0 | Vector Table Base<br>Value Description<br>0 The vector table is in the code memory region.<br>1 The vector table is in the SRAM memory region. |
| 28:8 | OFFSET | R/W | 0x000.00 | Vector Table Offset<br>When configuring the OFFSET field, the offset must be aligned to the number of exception entries in the vector table. Because there are 43 interrupts, the offset must be aligned on a 256-byte boundary. |
| 7:0 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 29: Application Interrupt and Reset Control (APINT), offset 0xD0C

**Note:** This register can only be accessed from privileged mode.

The **APINT** register provides priority grouping control for the exception model, endian status for data accesses, and reset control of the system. To write to this register, 0x05FA must be written to the VECTKEY field, otherwise the write is ignored.

The PRIGROUP field indicates the position of the binary point that splits the INTx fields in the **Interrupt Priority (PRIx)** registers into separate group priority and subpriority fields. Table 3-8 on page 122 shows how the PRIGROUP value controls this split. The bit numbers in the Group Priority Field and Subpriority Field columns in the table refer to the bits in the INTA field. For the INTB field, the corresponding bits are 15:13; for INTC, 23:21; and for INTD, 31:29.

**Note:** Determining preemption of an exception uses only the group priority field.

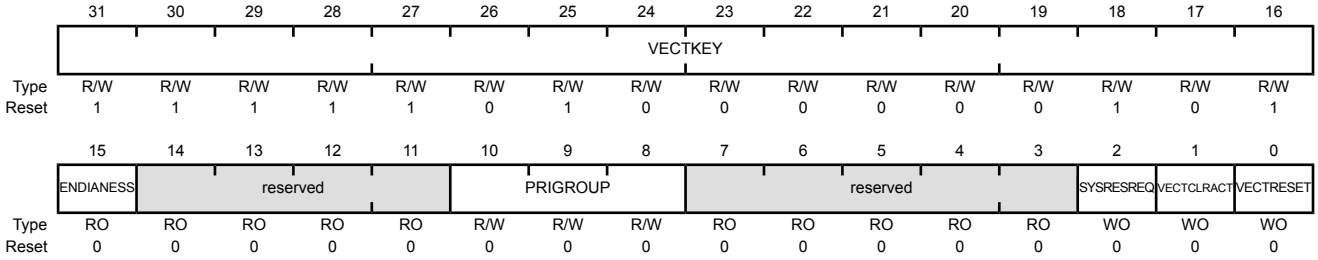
**Table 3-8. Interrupt Priority Levels**

| PRIGROUP Bit Field | Binary Point[a] | Group Priority Field | Subpriority Field | Group Priorities | Subpriorities |
|---|---|---|---|---|---|
| 0x0 - 0x4 | bxxx. | [7:5] | None | 8 | 1 |
| 0x5 | bxx.y | [7:6] | [5] | 4 | 2 |
| 0x6 | bx.yy | [7] | [6:5] | 2 | 4 |
| 0x7 | b.yyy | None | [7:5] | 1 | 8 |

a. INTx field showing the binary point. An x denotes a group priority field bit, and a y denotes a subpriority field bit.

Application Interrupt and Reset Control (APINT)

Base 0xE000.E000
Offset 0xD0C
Type R/W, reset 0xFA05.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | VECTKEY | R/W | 0xFA05 | Register Key<br>This field is used to guard against accidental writes to this register. 0x05FA must be written to this field in order to change the bits in this register. On a read, 0xFA05 is returned. |
| 15 | ENDIANESS | RO | 0 | Data Endianess<br>The Stellaris implementation uses only little-endian mode so this is cleared to 0. |
| 14:11 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 10:8 | PRIGROUP | R/W | 0x0 | Interrupt Priority Grouping<br>This field determines the split of group priority from subpriority (see Table 3-8 on page 122 for more information). |
| 7:3 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | SYSRESREQ | WO | 0 | System Reset Request<br>Value Description<br>0 No effect.<br>1 Resets the core and all on-chip peripherals except the Debug interface.<br>This bit is automatically cleared during the reset of the core and reads as 0. |
| 1 | VECTCLRACT | WO | 0 | Clear Active NMI / Fault<br>This bit is reserved for Debug use and reads as 0. This bit must be written as a 0, otherwise behavior is unpredictable. |
| 0 | VECTRESET | WO | 0 | System Reset<br>This bit is reserved for Debug use and reads as 0. This bit must be written as a 0, otherwise behavior is unpredictable. |

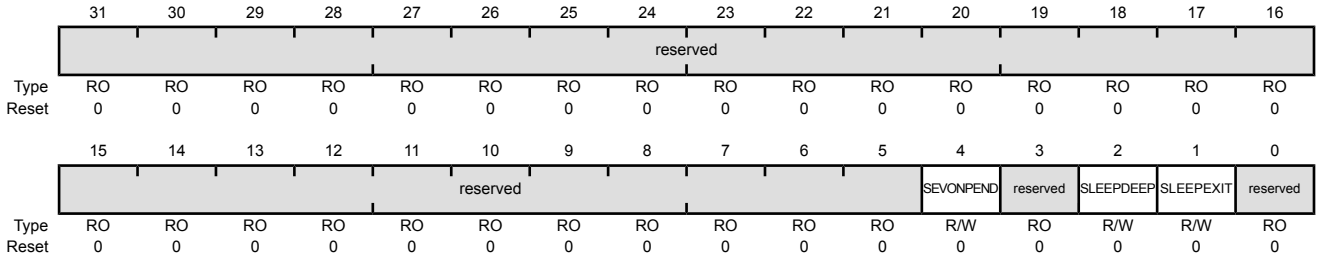
## Register 30: System Control (SYSCTRL), offset 0xD10

**Note:** This register can only be accessed from privileged mode.

The **SYSCTRL** register controls features of entry to and exit from low-power state.

System Control (SYSCTRL)

Base 0xE000.E000
Offset 0xD10
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:5 | reserved | RO | 0x0000.00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | SEVONPEND | R/W | 0 | Wake Up on Pending<br><br>Value Description<br>0 Only enabled interrupts or events can wake up the processor; disabled interrupts are excluded.<br>1 Enabled events and all interrupts, including disabled interrupts, can wake up the processor.<br><br>When an event or interrupt enters the pending state, the event signal wakes up the processor from WFE. If the processor is not waiting for an event, the event is registered and affects the next WFE.<br>The processor also wakes up on execution of a SEV instruction or an external event. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | SLEEPDEEP | R/W | 0 | Deep Sleep Enable<br><br>Value Description<br>0 Use Sleep mode as the low power mode.<br>1 Use Deep-sleep mode as the low power mode. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | SLEEPEXIT | R/W | 0 | Sleep on ISR Exit<br><br>Value Description<br>0 When returning from Handler mode to Thread mode, do not sleep when returning to Thread mode.<br>1 When returning from Handler mode to Thread mode, enter sleep or deep sleep on return from an ISR.<br><br>Setting this bit enables an interrupt-driven application to avoid returning to an empty main application. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

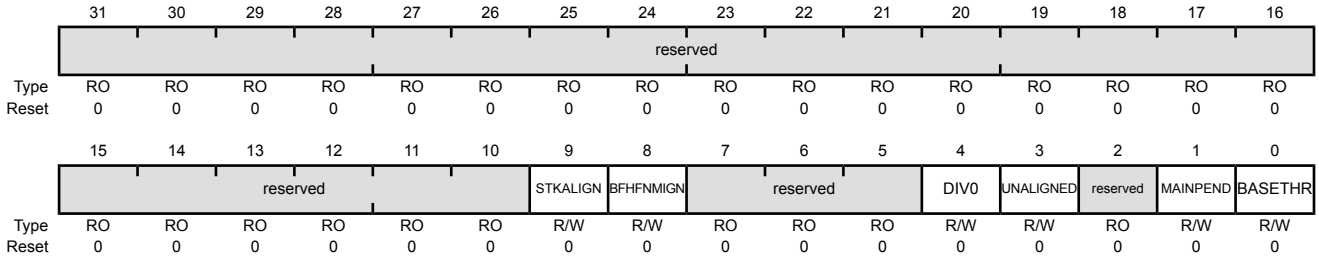
## Register 31: Configuration and Control (CFGCTRL), offset 0xD14

**Note:** This register can only be accessed from privileged mode.

The **CFGCTRL** register controls entry to Thread mode and enables: the handlers for NMI, hard fault and faults escalated by the **FAULTMASK** register to ignore bus faults; trapping of divide by zero and unaligned accesses; and access to the **SWTRIG** register by unprivileged software (see page 116).

Configuration and Control (CFGCTRL)

Base 0xE000.E000
Offset 0xD14
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:10 | reserved | RO | 0x0000.00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | STKALIGN | R/W | 0 | Stack Alignment on Exception Entry<br><br>Value Description<br>0 The stack is 4-byte aligned.<br>1 The stack is 8-byte aligned.<br><br>On exception entry, the processor uses bit 9 of the stacked **PSR** to indicate the stack alignment. On return from the exception, it uses this stacked bit to restore the correct stack alignment. |
| 8 | BFHFNMIGN | R/W | 0 | Ignore Bus Fault in NMI and Fault<br>This bit enables handlers with priority -1 or -2 to ignore data bus faults caused by load and store instructions. The setting of this bit applies to the hard fault, NMI, and **FAULTMASK** escalated handlers.<br><br>Value Description<br>0 Data bus faults caused by load and store instructions cause a lock-up.<br>1 Handlers running at priority -1 and -2 ignore data bus faults caused by load and store instructions.<br><br>Set this bit only when the handler and its data are in absolutely safe memory. The normal use of this bit is to probe system devices and bridges to detect control path problems and fix them. |
| 7:5 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 4 | DIV0 | R/W | 0 | Trap on Divide by 0<br>This bit enables faulting or halting when the processor executes an SDIV or UDIV instruction with a divisor of 0.<br><br>Value Description<br>0 Do not trap on divide by 0. A divide by zero returns a quotient of 0.<br>1 Trap on divide by 0. |
| 3 | UNALIGNED | R/W | 0 | Trap on Unaligned Access<br><br>Value Description<br>0 Do not trap on unaligned halfword and word accesses.<br>1 Trap on unaligned halfword and word accesses. An unaligned access generates a usage fault.<br><br>Unaligned LDM, STM, LDRD, and STRD instructions always fault regardless of whether UNALIGNED is set. |
| 2 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | MAINPEND | R/W | 0 | Allow Main Interrupt Trigger<br><br>Value Description<br>0 Disables unprivileged software access to the **SWTRIG** register.<br>1 Enables unprivileged software access to the **SWTRIG** register (see page 116). |
| 0 | BASETHR | R/W | 0 | Thread State Control<br><br>Value Description<br>0 The processor can enter Thread mode only when no exception is active.<br>1 The processor can enter Thread mode from any level under the control of an EXC_RETURN value (see “Exception Return” on page 82 for more information). |

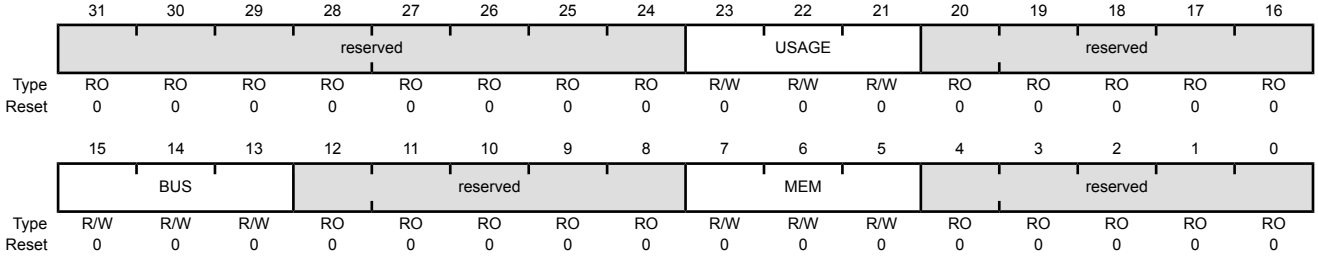
## Register 32: System Handler Priority 1 (SYSPRI1), offset 0xD18

**Note:** This register can only be accessed from privileged mode.

The **SYSPRI1** register configures the priority level, 0 to 7 of the usage fault, bus fault, and memory management fault exception handlers. This register is byte-accessible.

System Handler Priority 1 (SYSPRI1)

Base 0xE000.E000
Offset 0xD18
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:24 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:21 | USAGE | R/W | 0x0 | Usage Fault Priority<br>This field configures the priority level of the usage fault. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 20:16 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:13 | BUS | R/W | 0x0 | Bus Fault Priority<br>This field configures the priority level of the bus fault. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 12:8 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:5 | MEM | R/W | 0x0 | Memory Management Fault Priority<br>This field configures the priority level of the memory management fault. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 4:0 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

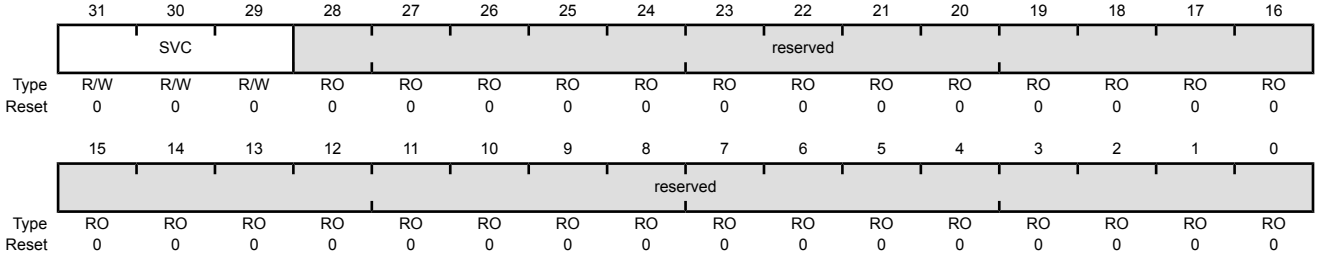
## Register 33: System Handler Priority 2 (SYSPRI2), offset 0xD1C

**Note:** This register can only be accessed from privileged mode.

The **SYSPRI2** register configures the priority level, 0 to 7 of the SVCall handler. This register is byte-accessible.

System Handler Priority 2 (SYSPRI2)

Base 0xE000.E000
Offset 0xD1C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:29 | SVC | R/W | 0x0 | SVCall Priority<br>This field configures the priority level of SVCall. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 28:0 | reserved | RO | 0x000.0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

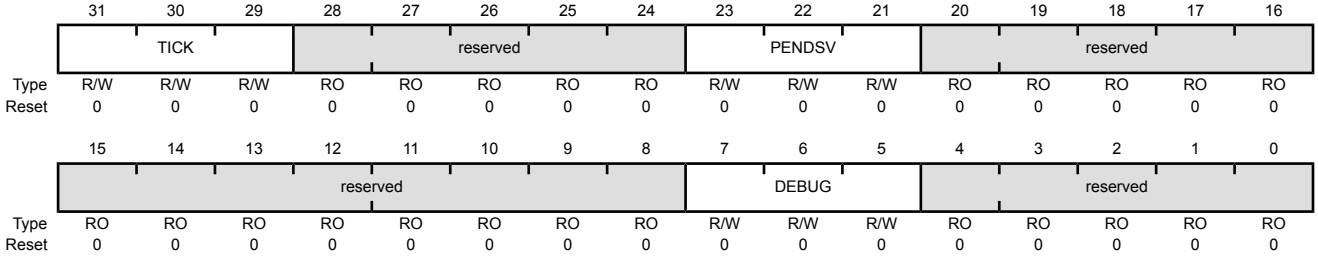
## Register 34: System Handler Priority 3 (SYSPRI3), offset 0xD20

**Note:** This register can only be accessed from privileged mode.

The **SYSPRI3** register configures the priority level, 0 to 7 of the SysTick exception and PendSV handlers. This register is byte-accessible.

System Handler Priority 3 (SYSPRI3)

Base 0xE000.E000
Offset 0xD20
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:29 | TICK | R/W | 0x0 | SysTick Exception Priority<br>This field configures the priority level of the SysTick exception. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 28:24 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:21 | PENDSV | R/W | 0x0 | PendSV Priority<br>This field configures the priority level of PendSV. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 20:8 | reserved | RO | 0x000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:5 | DEBUG | R/W | 0x0 | Debug Priority<br>This field configures the priority level of Debug. Configurable priority values are in the range 0-7, with lower values having higher priority. |
| 4:0 | reserved | RO | 0x0.0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 35: System Handler Control and State (SYSHNDCTRL), offset 0xD24

**Note:** This register can only be accessed from privileged mode.

The **SYSHNDCTRL** register enables the system handlers, and indicates the pending status of the usage fault, bus fault, memory management fault, and SVC exceptions as well as the active status of the system handlers.

If a system handler is disabled and the corresponding fault occurs, the processor treats the fault as a hard fault.

This register can be modified to change the pending or active status of system exceptions. An OS kernel can write to the active bits to perform a context switch that changes the current exception type.

**Caution – Software that changes the value of an active bit in this register without correct adjustment to the stacked content can cause the processor to generate a fault exception. Ensure software that writes to this register retains and subsequently restores the current active status.**

**If the value of a bit in this register must be modified after enabling the system handlers, a read-modify-write procedure must be used to ensure that only the required bit is modified.**

System Handler Control and State (SYSHNDCTRL)

Base 0xE000.E000
Offset 0xD24
Type R/W, reset 0x0000.0000

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| reserved | | | | | | | | | | | | | USAGE | BUS | MEM |
| Type RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | R/W | R/W | R/W |
| Reset 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SVC | BUSP | MEMP | USAGEP | TICK | PNDSV | reserved | MON | SVCA | reserved | | | USGA | reserved | BUSA | MEMA |
| Type R/W | R/W | R/W | R/W | R/W | R/W | RO | R/W | R/W | RO | RO | RO | R/W | RO | R/W | R/W |
| Reset 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:19 | reserved | RO | 0x000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 18 | USAGE | R/W | 0 | Usage Fault Enable<br>Value Description<br>0 Disables the usage fault exception.<br>1 Enables the usage fault exception. |
| 17 | BUS | R/W | 0 | Bus Fault Enable<br>Value Description<br>0 Disables the bus fault exception.<br>1 Enables the bus fault exception. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 16 | MEM | R/W | 0 | Memory Management Fault Enable<br><br>Value Description<br>0 Disables the memory management fault exception.<br>1 Enables the memory management fault exception. |
| 15 | SVC | R/W | 0 | SVC Call Pending<br><br>Value Description<br>0 An SVC call exception is not pending.<br>1 An SVC call exception is pending.<br><br>This bit can be modified to change the pending status of the SVC call exception. |
| 14 | BUSP | R/W | 0 | Bus Fault Pending<br><br>Value Description<br>0 A bus fault exception is not pending.<br>1 A bus fault exception is pending.<br><br>This bit can be modified to change the pending status of the bus fault exception. |
| 13 | MEMP | R/W | 0 | Memory Management Fault Pending<br><br>Value Description<br>0 A memory management fault exception is not pending.<br>1 A memory management fault exception is pending.<br><br>This bit can be modified to change the pending status of the memory management fault exception. |
| 12 | USAGEP | R/W | 0 | Usage Fault Pending<br><br>Value Description<br>0 A usage fault exception is not pending.<br>1 A usage fault exception is pending.<br><br>This bit can be modified to change the pending status of the usage fault exception. |
| 11 | TICK | R/W | 0 | SysTick Exception Active<br><br>Value Description<br>0 A SysTick exception is not active.<br>1 A SysTick exception is active.<br><br>This bit can be modified to change the active status of the SysTick exception, however, see the Caution above before setting this bit. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 10 | PNDSV | R/W | 0 | PendSV Exception Active<br><br>Value Description<br>0 A PendSV exception is not active.<br>1 A PendSV exception is active.<br><br>This bit can be modified to change the active status of the PendSV exception, however, see the Caution above before setting this bit. |
| 9 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 8 | MON | R/W | 0 | Debug Monitor Active<br><br>Value Description<br>0 The Debug monitor is not active.<br>1 The Debug monitor is active. |
| 7 | SVCA | R/W | 0 | SVC Call Active<br><br>Value Description<br>0 SVC call is not active.<br>1 SVC call is active.<br><br>This bit can be modified to change the active status of the SVC call exception, however, see the Caution above before setting this bit. |
| 6:4 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | USGA | R/W | 0 | Usage Fault Active<br><br>Value Description<br>0 Usage fault is not active.<br>1 Usage fault is active.<br><br>This bit can be modified to change the active status of the usage fault exception, however, see the Caution above before setting this bit. |
| 2 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | BUSA | R/W | 0 | Bus Fault Active<br><br>Value Description<br>0 Bus fault is not active.<br>1 Bus fault is active.<br><br>This bit can be modified to change the active status of the bus fault exception, however, see the Caution above before setting this bit. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | MEMA | R/W | 0 | Memory Management Fault Active |

| Value | Description |
|---|---|
| 0 | Memory management fault is not active. |
| 1 | Memory management fault is active. |

This bit can be modified to change the active status of the memory management fault exception, however, see the Caution above before setting this bit.

## Register 36: Configurable Fault Status (FAULTSTAT), offset 0xD28

**Note:** This register can only be accessed from privileged mode.

The **FAULTSTAT** register indicates the cause of a memory management fault, bus fault, or usage fault. Each of these functions is assigned to a subregister as follows:

- **Usage Fault Status (UFAULTSTAT)**, bits 31:16
- **Bus Fault Status (BFAULTSTAT)**, bits 15:8
- **Memory Management Fault Status (MFAULTSTAT)**, bits 7:0

**FAULTSTAT** is byte accessible. **FAULTSTAT** or its subregisters can be accessed as follows:

- The complete **FAULTSTAT** register, with a word access to offset 0xD28
- The **MFAULTSTAT**, with a byte access to offset 0xD28
- The **MFAULTSTAT** and **BFAULTSTAT**, with a halfword access to offset 0xD28
- The **BFAULTSTAT**, with a byte access to offset 0xD29
- The **UFAULTSTAT**, with a halfword access to offset 0xD2A

Bits are cleared by writing a 1 to them.

In a fault handler, the true faulting address can be determined by:

1. Read and save the **Memory Management Fault Address (MMADDR)** or **Bus Fault Address (FAULTADDR)** value.
2. Read the MMARV bit in **MFAULTSTAT**, or the BFARV bit in **BFAULTSTAT** to determine if the **MMADDR** or **FAULTADDR** contents are valid.

Software must follow this sequence because another higher priority exception might change the **MMADDR** or **FAULTADDR** value. For example, if a higher priority handler preempts the current fault handler, the other fault might change the **MMADDR** or **FAULTADDR** value.

Configurable Fault Status (FAULTSTAT)
Base 0xE000.E000
Offset 0xD28
Type R/W1C, reset 0x0000.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | DIV0 | UNALIGN | reserved | | | | NOCP | INVPC | INVSTAT | UNDEF |
| Type | RO | RO | RO | RO | RO | RO | R/W1C | R/W1C | RO | RO | RO | RO | R/W1C | R/W1C | R/W1C | R/W1C |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BFARV | reserved | | BSTKE | BUSTKE | IMPRE | PRECISE | IBUS | MMARV | reserved | | MSTKE | MUSTKE | reserved | DERR | IERR |
| Type | R/W1C | RO | RO | R/W1C | R/W1C | R/W1C | R/W1C | R/W1C | R/W1C | RO | RO | R/W1C | R/W1C | RO | R/W1C | R/W1C |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:26 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 25 | DIV0 | R/W1C | 0 | Divide-by-Zero Usage Fault<br><br>Value Description<br>0 No divide-by-zero fault has occurred, or divide-by-zero trapping is not enabled.<br>1 The processor has executed an SDIV or UDIV instruction with a divisor of 0.<br><br>When this bit is set, the **PC** value stacked for the exception return points to the instruction that performed the divide by zero.<br>Trapping on divide-by-zero is enabled by setting the DIV0 bit in the **Configuration and Control (CFGCTRL)** register (see page 126).<br>This bit is cleared by writing a 1 to it. |
| 24 | UNALIGN | R/W1C | 0 | Unaligned Access Usage Fault<br><br>Value Description<br>0 No unaligned access fault has occurred, or unaligned access trapping is not enabled.<br>1 The processor has made an unaligned memory access.<br><br>Unaligned LDM, STM, LDRD, and STRD instructions always fault regardless of the configuration of this bit.<br>Trapping on unaligned access is enabled by setting the UNALIGNED bit in the **CFGCTRL** register (see page 126).<br>This bit is cleared by writing a 1 to it. |
| 23:20 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 19 | NOCP | R/W1C | 0 | No Coprocessor Usage Fault<br><br>Value Description<br>0 A usage fault has not been caused by attempting to access a coprocessor.<br>1 The processor has attempted to access a coprocessor.<br><br>This bit is cleared by writing a 1 to it. |
| 18 | INVPC | R/W1C | 0 | Invalid PC Load Usage Fault<br><br>Value Description<br>0 A usage fault has not been caused by attempting to load an invalid **PC** value.<br>1 The processor has attempted an illegal load of EXC_RETURN to the **PC** as a result of an invalid context or an invalid EXC_RETURN value.<br><br>When this bit is set, the **PC** value stacked for the exception return points to the instruction that tried to perform the illegal load of the **PC**.<br>This bit is cleared by writing a 1 to it. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 17 | INVSTAT | R/W1C | 0 | Invalid State Usage Fault<br><br>Value Description<br>0 A usage fault has not been caused by an invalid state.<br>1 The processor has attempted to execute an instruction that makes illegal use of the **EPSR** register.<br><br>When this bit is set, the **PC** value stacked for the exception return points to the instruction that attempted the illegal use of the **Execution Program Status Register (EPSR)** register.<br>This bit is not set if an undefined instruction uses the **EPSR** register.<br>This bit is cleared by writing a 1 to it. |
| 16 | UNDEF | R/W1C | 0 | Undefined Instruction Usage Fault<br><br>Value Description<br>0 A usage fault has not been caused by an undefined instruction.<br>1 The processor has attempted to execute an undefined instruction.<br><br>When this bit is set, the **PC** value stacked for the exception return points to the undefined instruction.<br>An undefined instruction is an instruction that the processor cannot decode.<br>This bit is cleared by writing a 1 to it. |
| 15 | BFARV | R/W1C | 0 | Bus Fault Address Register Valid<br><br>Value Description<br>0 The value in the **Bus Fault Address (FAULTADDR)** register is not a valid fault address.<br>1 The **FAULTADDR** register is holding a valid fault address.<br><br>This bit is set after a bus fault, where the address is known. Other faults can clear this bit, such as a memory management fault occurring later.<br>If a bus fault occurs and is escalated to a hard fault because of priority, the hard fault handler must clear this bit. This action prevents problems if returning to a stacked active bus fault handler whose **FAULTADDR** register value has been overwritten.<br>This bit is cleared by writing a 1 to it. |
| 14:13 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 12 | BSTKE | R/W1C | 0 | Stack Bus Fault<br><br>Value Description<br>0 No bus fault has occurred on stacking for exception entry.<br>1 Stacking for an exception entry has caused one or more bus faults.<br><br>When this bit is set, the **SP** is still adjusted but the values in the context area on the stack might be incorrect. A fault address is not written to the **FAULTADDR** register.<br>This bit is cleared by writing a 1 to it. |
| 11 | BUSTKE | R/W1C | 0 | Unstack Bus Fault<br><br>Value Description<br>0 No bus fault has occurred on unstacking for a return from exception.<br>1 Unstacking for a return from exception has caused one or more bus faults.<br><br>This fault is chained to the handler. Thus, when this bit is set, the original return stack is still present. The **SP** is not adjusted from the failing return, a new save is not performed, and a fault address is not written to the **FAULTADDR** register.<br>This bit is cleared by writing a 1 to it. |
| 10 | IMPRE | R/W1C | 0 | Imprecise Data Bus Error<br><br>Value Description<br>0 An imprecise data bus error has not occurred.<br>1 A data bus error has occurred, but the return address in the stack frame is not related to the instruction that caused the error.<br><br>When this bit is set, a fault address is not written to the **FAULTADDR** register.<br>This fault is asynchronous. Therefore, if the fault is detected when the priority of the current process is higher than the bus fault priority, the bus fault becomes pending and becomes active only when the processor returns from all higher-priority processes. If a precise fault occurs before the processor enters the handler for the imprecise bus fault, the handler detects that both the IMPRE bit is set and one of the precise fault status bits is set.<br>This bit is cleared by writing a 1 to it. |
| 9 | PRECISE | R/W1C | 0 | Precise Data Bus Error<br><br>Value Description<br>0 A precise data bus error has not occurred.<br>1 A data bus error has occurred, and the **PC** value stacked for the exception return points to the instruction that caused the fault.<br><br>When this bit is set, the fault address is written to the **FAULTADDR** register.<br>This bit is cleared by writing a 1 to it. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 8 | IBUS | R/W1C | 0 | Instruction Bus Error<br><br>Value Description<br>0 An instruction bus error has not occurred.<br>1 An instruction bus error has occurred.<br><br>The processor detects the instruction bus error on prefetching an instruction, but sets this bit only if it attempts to issue the faulting instruction.<br>When this bit is set, a fault address is not written to the **FAULTADDR** register.<br>This bit is cleared by writing a 1 to it. |
| 7 | MMARV | R/W1C | 0 | Memory Management Fault Address Register Valid<br><br>Value Description<br>0 The value in the **Memory Management Fault Address (MMADDR)** register is not a valid fault address.<br>1 The **MMADDR** register is holding a valid fault address.<br><br>If a memory management fault occurs and is escalated to a hard fault because of priority, the hard fault handler must clear this bit. This action prevents problems if returning to a stacked active memory management fault handler whose **MMADDR** register value has been overwritten.<br>This bit is cleared by writing a 1 to it. |
| 6:5 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | MSTKE | R/W1C | 0 | Stack Access Violation<br><br>Value Description<br>0 No memory management fault has occurred on stacking for exception entry.<br>1 Stacking for an exception entry has caused one or more access violations.<br><br>When this bit is set, the **SP** is still adjusted but the values in the context area on the stack might be incorrect. A fault address is not written to the **MMADDR** register.<br>This bit is cleared by writing a 1 to it. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | MUSTKE | R/W1C | 0 | Unstack Access Violation<br><br>Value Description<br>0 No memory management fault has occurred on unstacking for a return from exception.<br>1 Unstacking for a return from exception has caused one or more access violations.<br><br>This fault is chained to the handler. Thus, when this bit is set, the original return stack is still present. The **SP** is not adjusted from the failing return, a new save is not performed, and a fault address is not written to the **MMADDR** register.<br>This bit is cleared by writing a 1 to it. |
| 2 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | DERR | R/W1C | 0 | Data Access Violation<br><br>Value Description<br>0 A data access violation has not occurred.<br>1 The processor attempted a load or store at a location that does not permit the operation.<br><br>When this bit is set, the **PC** value stacked for the exception return points to the faulting instruction and the address of the attempted access is written to the **MMADDR** register.<br>This bit is cleared by writing a 1 to it. |
| 0 | IERR | R/W1C | 0 | Instruction Access Violation<br><br>Value Description<br>0 An instruction access violation has not occurred.<br>1 The processor attempted an instruction fetch from a location that does not permit execution.<br><br>This fault occurs on any access to an XN region, even when the MPU is disabled or not present.<br>When this bit is set, the **PC** value stacked for the exception return points to the faulting instruction and the address of the attempted access is not written to the **MMADDR** register.<br>This bit is cleared by writing a 1 to it. |

## Register 37: Hard Fault Status (HFAULTSTAT), offset 0xD2C

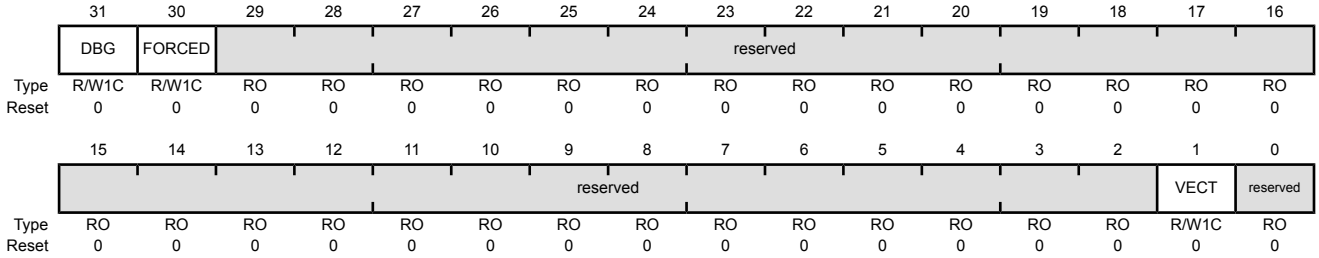
**Note:** This register can only be accessed from privileged mode.

The **HFAULTSTAT** register gives information about events that activate the hard fault handler.

Bits are cleared by writing a 1 to them.

Hard Fault Status (HFAULTSTAT)

Base 0xE000.E000
Offset 0xD2C
Type R/W1C, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | DBG | R/W1C | 0 | Debug Event<br>This bit is reserved for Debug use. This bit must be written as a 0, otherwise behavior is unpredictable. |
| 30 | FORCED | R/W1C | 0 | Forced Hard Fault<br>Value Description<br>0 No forced hard fault has occurred.<br>1 A forced hard fault has been generated by escalation of a fault with configurable priority that cannot be handled, either because of priority or because it is disabled.<br>When this bit is set, the hard fault handler must read the other fault status registers to find the cause of the fault.<br>This bit is cleared by writing a 1 to it. |
| 29:2 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | VECT | R/W1C | 0 | Vector Table Read Fault<br>Value Description<br>0 No bus fault has occurred on a vector table read.<br>1 A bus fault occurred on a vector table read.<br>This error is always handled by the hard fault handler.<br>When this bit is set, the **PC** value stacked for the exception return points to the instruction that was preempted by the exception.<br>This bit is cleared by writing a 1 to it. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

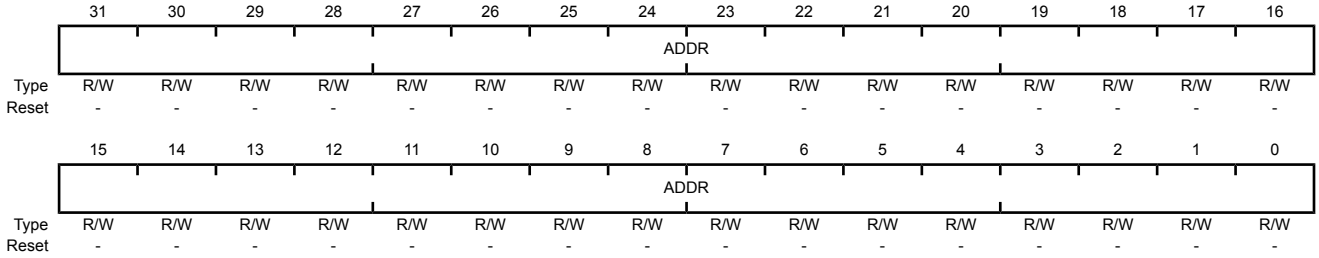
## Register 38: Memory Management Fault Address (MMADDR), offset 0xD34

**Note:** This register can only be accessed from privileged mode.

The **MMADDR** register contains the address of the location that generated a memory management fault. When an unaligned access faults, the address in the **MMADDR** register is the actual address that faulted. Because a single read or write instruction can be split into multiple aligned accesses, the fault address can be any address in the range of the requested access size. Bits in the **Memory Management Fault Status (MFAULTSTAT)** register indicate the cause of the fault and whether the value in the **MMADDR** register is valid (see page 135).

Memory Management Fault Address (MMADDR)

Base 0xE000.E000
Offset 0xD34
Type R/W, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | ADDR | R/W | - | Fault Address<br>When the MMARV bit of **MFAULTSTAT** is set, this field holds the address of the location that generated the memory management fault. |

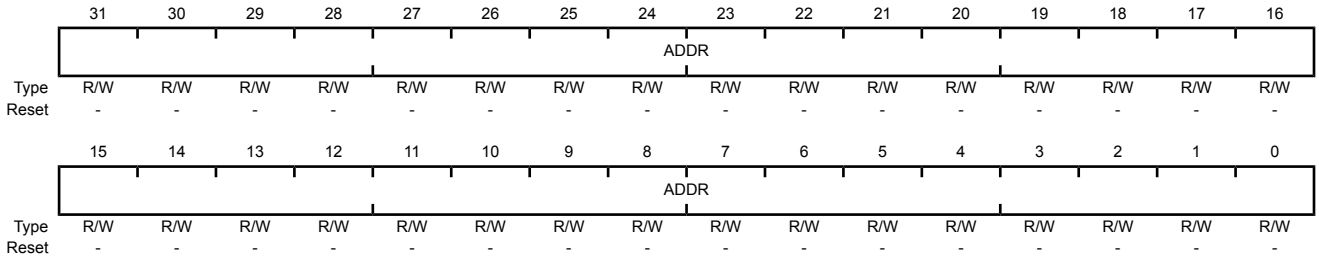
### Register 39: Bus Fault Address (FAULTADDR), offset 0xD38

**Note:** This register can only be accessed from privileged mode.

The **FAULTADDR** register contains the address of the location that generated a bus fault. When an unaligned access faults, the address in the **FAULTADDR** register is the one requested by the instruction, even if it is not the address of the fault. Bits in the **Bus Fault Status (BFAULTSTAT)** register indicate the cause of the fault and whether the value in the **FAULTADDR** register is valid (see page 135).

Bus Fault Address (FAULTADDR)

Base 0xE000.E000
Offset 0xD38
Type R/W, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | ADDR | R/W | - | Fault Address<br>When the FAULTADDRV bit of **BFAULTSTAT** is set, this field holds the address of the location that generated the bus fault. |

## 3.6 Memory Protection Unit (MPU) Register Descriptions

This section lists and describes the Memory Protection Unit (MPU) registers, in numerical order by address offset.

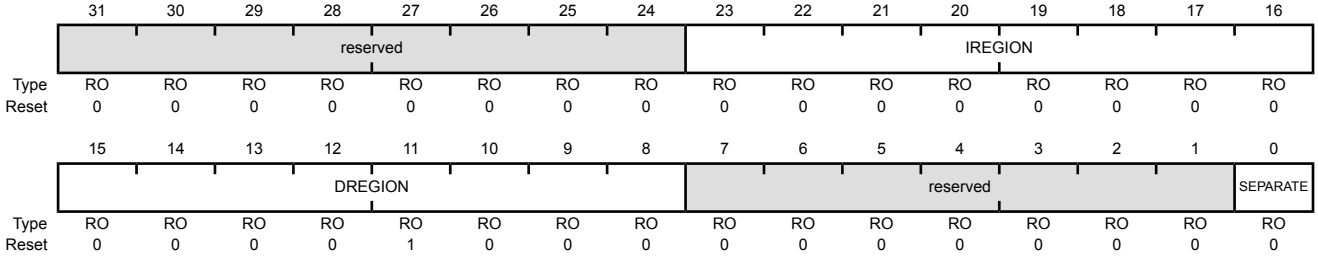
The MPU registers can only be accessed from privileged mode.

## Register 40: MPU Type (MPUTYPE), offset 0xD90

**Note:** This register can only be accessed from privileged mode.

The **MPUTYPE** register indicates whether the MPU is present, and if so, how many regions it supports.

MPU Type (MPUTYPE)
Base 0xE000.E000
Offset 0xD90
Type RO, reset 0x0000.0800




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:24 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:16 | IREGION | RO | 0x00 | Number of I Regions<br>This field indicates the number of supported MPU instruction regions. This field always contains 0x00. The MPU memory map is unified and is described by the `DREGION` field. |
| 15:8 | DREGION | RO | 0x08 | Number of D Regions<br>Value Description<br>0x08 Indicates there are eight supported MPU data regions. |
| 7:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | SEPARATE | RO | 0 | Separate or Unified MPU<br>Value Description<br>0 Indicates the MPU is unified. |

## Register 41: MPU Control (MPUCTRL), offset 0xD94

**Note:** This register can only be accessed from privileged mode.

The **MPUCTRL** register enables the MPU, enables the default memory map background region, and enables use of the MPU when in the hard fault, Non-maskable Interrupt (NMI), and **Fault Mask Register (FAULTMASK)** escalated handlers.

When the ENABLE and PRIVDEFEN bits are both set:

- For privileged accesses, the default memory map is as described in "Memory Model" on page 66. Any access by privileged software that does not address an enabled memory region behaves as defined by the default memory map.
- Any access by unprivileged software that does not address an enabled memory region causes a memory management fault.

Execute Never (XN) and Strongly Ordered rules always apply to the System Control Space regardless of the value of the ENABLE bit.

When the ENABLE bit is set, at least one region of the memory map must be enabled for the system to function unless the PRIVDEFEN bit is set. If the PRIVDEFEN bit is set and no regions are enabled, then only privileged software can operate.

When the ENABLE bit is clear, the system uses the default memory map, which has the same memory attributes as if the MPU is not implemented (see Table 2-5 on page 68 for more information). The default memory map applies to accesses from both privileged and unprivileged software.

When the MPU is enabled, accesses to the System Control Space and vector table are always permitted. Other areas are accessible based on regions and whether PRIVDEFEN is set.

Unless HFNMIENA is set, the MPU is not enabled when the processor is executing the handler for an exception with priority –1 or –2. These priorities are only possible when handling a hard fault or NMI exception or when **FAULTMASK** is enabled. Setting the HFNMIENA bit enables the MPU when operating with these two priorities.

MPU Control (MPUCTRL)

Base 0xE000.E000
Offset 0xD94
Type R/W, reset 0x0000.0000

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| reserved | | | | | | | | | | | | | | | |
| RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| reserved | | | | | | | | | | | | | PRIVDEFEN | HFNMIENA | ENABLE |
| RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | R/W | R/W | R/W |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x0000.000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2 | PRIVDEFEN | R/W | 0 | MPU Default Region<br>This bit enables privileged software access to the default memory map.<br><br>Value Description<br>0 If the MPU is enabled, this bit disables use of the default memory map. Any memory access to a location not covered by any enabled region causes a fault.<br>1 If the MPU is enabled, this bit enables use of the default memory map as a background region for privileged software accesses.<br><br>When this bit is set, the background region acts as if it is region number -1. Any region that is defined and enabled has priority over this default map.<br>If the MPU is disabled, the processor ignores this bit. |
| 1 | HFNMIENA | R/W | 0 | MPU Enabled During Faults<br>This bit controls the operation of the MPU during hard fault, NMI, and **FAULTMASK** handlers.<br><br>Value Description<br>0 The MPU is disabled during hard fault, NMI, and **FAULTMASK** handlers, regardless of the value of the ENABLE bit.<br>1 The MPU is enabled during hard fault, NMI, and **FAULTMASK** handlers.<br><br>When the MPU is disabled and this bit is set, the resulting behavior is unpredictable. |
| 0 | ENABLE | R/W | 0 | MPU Enable<br><br>Value Description<br>0 The MPU is disabled.<br>1 The MPU is enabled.<br><br>When the MPU is disabled and the HFNMIENA bit is set, the resulting behavior is unpredictable. |

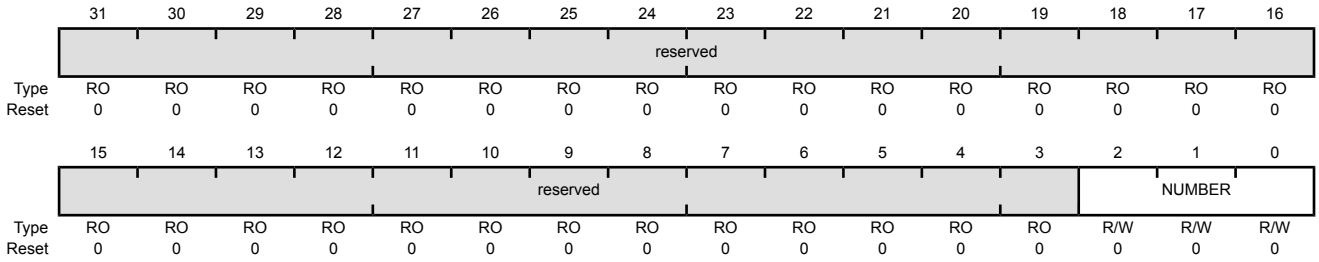
## Register 42: MPU Region Number (MPUNUMBER), offset 0xD98

**Note:** This register can only be accessed from privileged mode.

The **MPUNUMBER** register selects which memory region is referenced by the **MPU Region Base Address (MPUBASE)** and **MPU Region Attribute and Size (MPUATTR)** registers. Normally, the required region number should be written to this register before accessing the **MPUBASE** or the **MPUATTR** register. However, the region number can be changed by writing to the **MPUBASE** register with the VALID bit set (see page 148). This write updates the value of the REGION field.

MPU Region Number (MPUNUMBER)

Base 0xE000.E000
Offset 0xD98
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x0000.000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2:0 | NUMBER | R/W | 0x0 | MPU Region to Access<br>This field indicates the MPU region referenced by the **MPUBASE** and **MPUATTR** registers. The MPU supports eight memory regions. |

## Register 43: MPU Region Base Address (MPUBASE), offset 0xD9C

## Register 44: MPU Region Base Address Alias 1 (MPUBASE1), offset 0xDA4

## Register 45: MPU Region Base Address Alias 2 (MPUBASE2), offset 0xDAC

## Register 46: MPU Region Base Address Alias 3 (MPUBASE3), offset 0xDB4

**Note:** This register can only be accessed from privileged mode.

The **MPUBASE** register defines the base address of the MPU region selected by the **MPU Region Number (MPUNUMBER)** register and can update the value of the **MPUNUMBER** register. To change the current region number and update the **MPUNUMBER** register, write the **MPUBASE** register with the VALID bit set.

The ADDR field is bits 31:*N* of the **MPUBASE** register. Bits (*N*-1):5 are reserved. The region size, as specified by the SIZE field in the **MPU Region Attribute and Size (MPUATTR)** register, defines the value of *N* where:

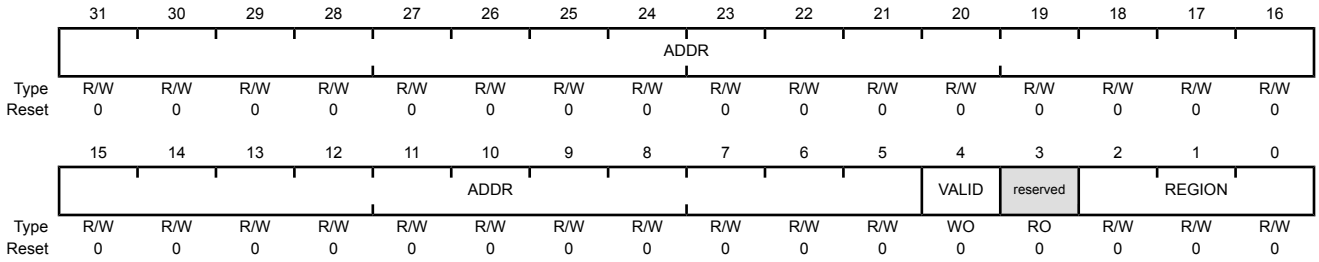
$N = Log_2(\text{Region size in bytes})$

If the region size is configured to 4 GB in the **MPUATTR** register, there is no valid ADDR field. In this case, the region occupies the complete memory map, and the base address is 0x0000.0000.

The base address is aligned to the size of the region. For example, a 64-KB region must be aligned on a multiple of 64 KB, for example, at 0x0001.0000 or 0x0002.0000.

MPU Region Base Address (MPUBASE)

Base 0xE000.E000
Offset 0xD9C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:5 | ADDR | R/W | 0x0000.000 | Base Address Mask<br>Bits 31:*N* in this field contain the region base address. The value of *N* depends on the region size, as shown above. The remaining bits (*N*-1):5 are reserved.<br>Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 4 | VALID | WO | 0 | Region Number Valid<br><br>Value Description<br>0 The **MPUNUMBER** register is not changed and the processor updates the base address for the region specified in the **MPUNUMBER** register and ignores the value of the REGION field.<br>1 The **MPUNUMBER** register is updated with the value of the REGION field and the base address is updated for the region specified in the REGION field.<br><br>This bit is always read as 0. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2:0 | REGION | R/W | 0x0 | Region Number<br><br>On a write, contains the value to be written to the **MPUNUMBER** register. On a read, returns the current region number in the **MPUNUMBER** register. |

## Register 47: MPU Region Attribute and Size (MPUATTR), offset 0xDA0

## Register 48: MPU Region Attribute and Size Alias 1 (MPUATTR1), offset 0xDA8

## Register 49: MPU Region Attribute and Size Alias 2 (MPUATTR2), offset 0xDB0

## Register 50: MPU Region Attribute and Size Alias 3 (MPUATTR3), offset 0xDB8

**Note:** This register can only be accessed from privileged mode.

The **MPUATTR** register defines the region size and memory attributes of the MPU region specified by the **MPU Region Number (MPUNUMBER)** register and enables that region and any subregions.

The **MPUATTR** register is accessible using word or halfword accesses with the most-significant halfword holding the region attributes and the least-significant halfword holds the region size and the region and subregion enable bits.

The MPU access permission attribute bits, XN, AP, TEX, S, C, and B, control access to the corresponding memory region. If an access is made to an area of memory without the required permissions, then the MPU generates a permission fault.

The SIZE field defines the size of the MPU memory region specified by the **MPUNUMBER** register as follows:

(Region size in bytes) = $2^{(SIZE+1)}$

The smallest permitted region size is 32 bytes, corresponding to a SIZE value of 4. Table 3-9 on page 150 gives example SIZE values with the corresponding region size and value of N in the **MPU Region Base Address (MPUBASE)** register.

**Table 3-9. Example SIZE Field Values**

| SIZE Encoding | Region Size | Value of N[a] | Note |
|---|---|---|---|
| 00100b (0x4) | 32 B | 5 | Minimum permitted size |
| 01001b (0x9) | 1 KB | 10 | - |
| 10011b (0x13) | 1 MB | 20 | - |
| 11101b (0x1D) | 1 GB | 30 | - |
| 11111b (0x1F) | 4 GB | No valid ADDR field in **MPUBASE**; the region occupies the complete memory map. | Maximum possible size |

a. Refers to the N parameter in the **MPUBASE** register (see page 148).

MPU Region Attribute and Size (MPUATTR)

Base 0xE000.E000
Offset 0xDA0
Type R/W, reset 0x0000.0000

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| reserved | | | XN | reserved | AP | | | reserved | | TEX | | | S | C | B |
| Type | RO | RO | RO | R/W | RO | R/W | R/W | R/W | RO | RO | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SRD | | | | | | | | reserved | | SIZE | | | | | ENABLE |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | RO | RO | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:29 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 28 | XN | R/W | 0 | Instruction Access Disable<br>Value Description<br>0 Instruction fetches are enabled.<br>1 Instruction fetches are disabled. |
| 27 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 26:24 | AP | R/W | 0 | Access Privilege<br>For information on using this bit field, see Table 3-5 on page 96. |
| 23:22 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 21:19 | TEX | R/W | 0x0 | Type Extension Mask<br>For information on using this bit field, see Table 3-3 on page 95. |
| 18 | S | R/W | 0 | Shareable<br>For information on using this bit, see Table 3-3 on page 95. |
| 17 | C | R/W | 0 | Cacheable<br>For information on using this bit, see Table 3-3 on page 95. |
| 16 | B | R/W | 0 | Bufferable<br>For information on using this bit, see Table 3-3 on page 95. |
| 15:8 | SRD | R/W | 0x00 | Subregion Disable Bits<br>Value Description<br>0 The corresponding subregion is enabled.<br>1 The corresponding subregion is disabled.<br>Region sizes of 128 bytes and less do not support subregions. When writing the attributes for such a region, configure the SRD field as 0x00. See the section called “Subregions” on page 94 for more information. |
| 7:6 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5:1 | SIZE | R/W | 0x0 | Region Size Mask<br>The SIZE field defines the size of the MPU memory region specified by the **MPUNUMBER** register. Refer to Table 3-9 on page 150 for more information. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | ENABLE | R/W | 0 | Region Enable |

| Value | Description |
|---|---|
| 0 | The region is disabled. |
| 1 | The region is enabled. |

# 4 JTAG Interface

The Joint Test Action Group (JTAG) port is an IEEE standard that defines a Test Access Port and Boundary Scan Architecture for digital integrated circuits and provides a standardized serial interface for controlling the associated test logic. The TAP, Instruction Register (IR), and Data Registers (DR) can be used to test the interconnections of assembled printed circuit boards and obtain manufacturing information on the components. The JTAG Port also provides a means of accessing and controlling design-for-test features such as I/O pin observation and control, scan testing, and debugging.

The JTAG port is comprised of five pins: $\overline{\text{TRST}}$, TCK, TMS, TDI, and TDO. Data is transmitted serially into the controller on TDI and out of the controller on TDO. The interpretation of this data is dependent on the current state of the TAP controller. For detailed information on the operation of the JTAG port and TAP controller, please refer to the *IEEE Standard 1149.1-Test Access Port and Boundary-Scan Architecture*.

The Stellaris® JTAG controller works with the ARM JTAG controller built into the Cortex-M3 core. This is implemented by multiplexing the TDO outputs from both JTAG controllers. ARM JTAG instructions select the ARM TDO output while Stellaris JTAG instructions select the Stellaris TDO outputs. The multiplexer is controlled by the Stellaris JTAG controller, which has comprehensive programming for the ARM, Stellaris, and unimplemented JTAG instructions.

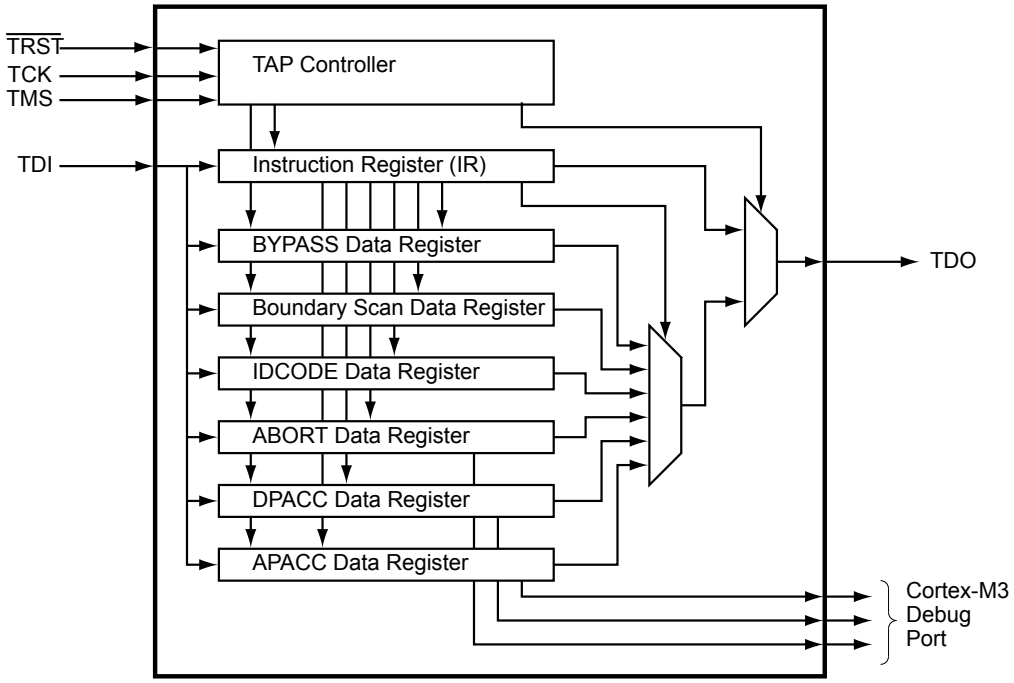
The Stellaris JTAG module has the following features:

- IEEE 1149.1-1990 compatible Test Access Port (TAP) controller
- Four-bit Instruction Register (IR) chain for storing JTAG instructions
- IEEE standard instructions: BYPASS, IDCODE, SAMPLE/PRELOAD, EXTEST and INTEST
- ARM additional instructions: APACC, DPACC and ABORT
- Integrated ARM Serial Wire Debug (SWD)

See the *ARM® Debug Interface V5 Architecture Specification* for more information on the ARM JTAG controller.

## 4.1 Block Diagram

**Figure 4-1. JTAG Module Block Diagram**




## 4.2 Signal Description

Table 4-1 on page 154 and Table 4-2 on page 155 list the external signals of the JTAG/SWD controller and describe the function of each. The JTAG/SWD controller signals are alternate functions for some GPIO signals, however note that the reset state of the pins is for the JTAG/SWD function. The JTAG/SWD controller signals are under commit protection and require a special process to be configured as GPIOs, see “Commit Control” on page 290. The column in the table below titled "Pin Assignment" lists the GPIO pin placement for the JTAG/SWD controller signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) is set to choose the JTAG/SWD function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 4-1. JTAG_SWD_SWO Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| SWCLK | 80 | I | TTL | JTAG/SWD CLK. |
| SWDIO | 79 | I/O | TTL | JTAG TMS and SWDIO. |
| SWO | 77 | O | TTL | JTAG TDO and SWO. |
| TCK | 80 | I | TTL | JTAG/SWD CLK. |
| TDI | 78 | I | TTL | JTAG TDI. |
| TDO | 77 | O | TTL | JTAG TDO and SWO. |
| TMS | 79 | I/O | TTL | JTAG TMS and SWDIO. |
| TRST | 89 | I | TTL | JTAG TRST. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 4-2. JTAG_SWD_SWO Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| SWCLK | A9 | I | TTL | JTAG/SWD CLK. |
| SWDIO | B9 | I/O | TTL | JTAG TMS and SWDIO. |
| SWO | A10 | O | TTL | JTAG TDO and SWO. |
| TCK | A9 | I | TTL | JTAG/SWD CLK. |
| TDI | B8 | I | TTL | JTAG TDI. |
| TDO | A10 | O | TTL | JTAG TDO and SWO. |
| TMS | B9 | I/O | TTL | JTAG TMS and SWDIO. |
| TRST | A8 | I | TTL | JTAG TRST. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 4.3 Functional Description

A high-level conceptual drawing of the JTAG module is shown in Figure 4-1 on page 154. The JTAG module is composed of the Test Access Port (TAP) controller and serial shift chains with parallel update registers. The TAP controller is a simple state machine controlled by the TRST, TCK and TMS inputs. The current state of the TAP controller depends on the current value of TRST and the sequence of values captured on TMS at the rising edge of TCK. The TAP controller determines when the serial shift chains capture new data, shift data from TDI towards TDO, and update the parallel load registers. The current state of the TAP controller also determines whether the Instruction Register (IR) chain or one of the Data Register (DR) chains is being accessed.

The serial shift chains with parallel load registers are comprised of a single Instruction Register (IR) chain and multiple Data Register (DR) chains. The current instruction loaded in the parallel load register determines which DR chain is captured, shifted, or updated during the sequencing of the TAP controller.

Some instructions, like EXTEST and INTEST, operate on data currently in a DR chain and do not capture, shift, or update any of the chains. Instructions that are not implemented decode to the BYPASS instruction to ensure that the serial path between TDI and TDO is always connected (see Table 4-4 on page 161 for a list of implemented instructions).

See “JTAG and Boundary Scan” on page 614 for JTAG timing diagrams.

### 4.3.1 JTAG Interface Pins

The JTAG interface consists of five standard pins: TRST,TCK, TMS, TDI, and TDO. These pins and their associated reset state are given in Table 4-3 on page 155. Detailed information on each pin follows.

**Table 4-3. JTAG Port Pins Reset State**

| Pin Name | Data Direction | Internal Pull-Up | Internal Pull-Down | Drive Strength | Drive Value |
|---|---|---|---|---|---|
| TRST | Input | Enabled | Disabled | N/A | N/A |
| TCK | Input | Enabled | Disabled | N/A | N/A |
| TMS | Input | Enabled | Disabled | N/A | N/A |
| TDI | Input | Enabled | Disabled | N/A | N/A |
| TDO | Output | Enabled | Disabled | 2-mA driver | High-Z |

#### 4.3.1.1 Test Reset Input (TRST)

The TRST pin is an asynchronous active Low input signal for initializing and resetting the JTAG TAP controller and associated JTAG circuitry. When TRST is asserted, the TAP controller resets to the Test-Logic-Reset state and remains there while TRST is asserted. When the TAP controller enters the Test-Logic-Reset state, the JTAG Instruction Register (IR) resets to the default instruction, IDCODE.

By default, the internal pull-up resistor on the TRST pin is enabled after reset. Changes to the pull-up resistor settings on GPIO Port B should ensure that the internal pull-up resistor remains enabled on PB7/TRST; otherwise JTAG communication could be lost.

#### 4.3.1.2 Test Clock Input (TCK)

The TCK pin is the clock for the JTAG module. This clock is provided so the test logic can operate independently of any other system clocks. In addition, it ensures that multiple JTAG TAP controllers that are daisy-chained together can synchronously communicate serial test data between components. During normal operation, TCK is driven by a free-running clock with a nominal 50% duty cycle. When necessary, TCK can be stopped at 0 or 1 for extended periods of time. While TCK is stopped at 0 or 1, the state of the TAP controller does not change and data in the JTAG Instruction and Data Registers is not lost.

By default, the internal pull-up resistor on the TCK pin is enabled after reset. This assures that no clocking occurs if the pin is not driven from an external source. The internal pull-up and pull-down resistors can be turned off to save internal power as long as the TCK pin is constantly being driven by an external source.

#### 4.3.1.3 Test Mode Select (TMS)

The TMS pin selects the next state of the JTAG TAP controller. TMS is sampled on the rising edge of TCK. Depending on the current TAP state and the sampled value of TMS, the next state is entered. Because the TMS pin is sampled on the rising edge of TCK, the *IEEE Standard 1149.1* expects the value on TMS to change on the falling edge of TCK.

Holding TMS high for five consecutive TCK cycles drives the TAP controller state machine to the Test-Logic-Reset state. When the TAP controller enters the Test-Logic-Reset state, the JTAG Instruction Register (IR) resets to the default instruction, IDCODE. Therefore, this sequence can be used as a reset mechanism, similar to asserting TRST. The JTAG Test Access Port state machine can be seen in its entirety in Figure 4-2 on page 158.

By default, the internal pull-up resistor on the TMS pin is enabled after reset. Changes to the pull-up resistor settings on GPIO Port C should ensure that the internal pull-up resistor remains enabled on PC1/TMS; otherwise JTAG communication could be lost.

#### 4.3.1.4 Test Data Input (TDI)

The TDI pin provides a stream of serial information to the IR chain and the DR chains. TDI is sampled on the rising edge of TCK and, depending on the current TAP state and the current instruction, presents this data to the proper shift register chain. Because the TDI pin is sampled on the rising edge of TCK, the *IEEE Standard 1149.1* expects the value on TDI to change on the falling edge of TCK.

By default, the internal pull-up resistor on the TDI pin is enabled after reset. Changes to the pull-up resistor settings on GPIO Port C should ensure that the internal pull-up resistor remains enabled on PC2/TDI; otherwise JTAG communication could be lost.

#### 4.3.1.5 Test Data Output (TDO)

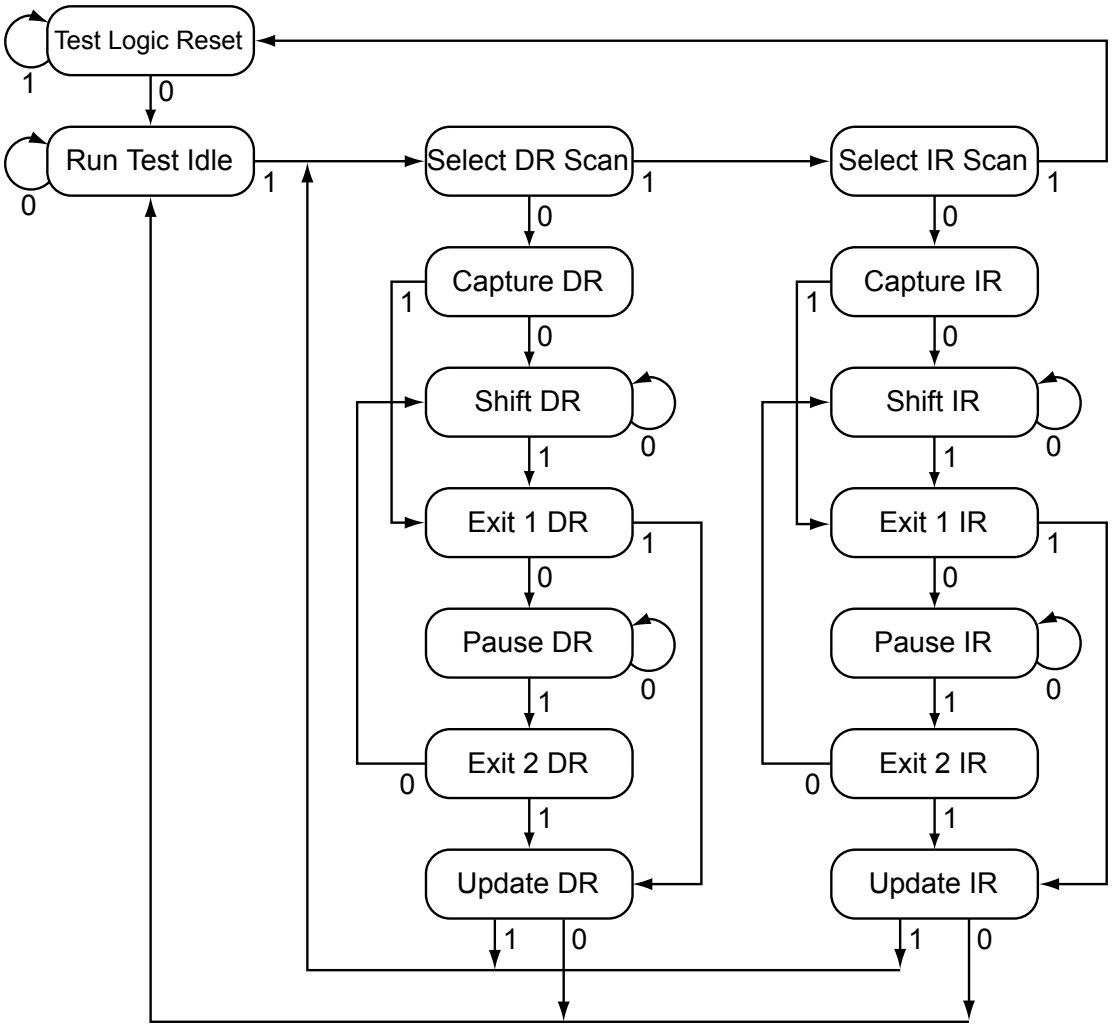
The TDO pin provides an output stream of serial information from the IR chain or the DR chains. The value of TDO depends on the current TAP state, the current instruction, and the data in the chain being accessed. In order to save power when the JTAG port is not being used, the TDO pin is placed in an inactive drive state when not actively shifting out data. Because TDO can be connected to the TDI of another controller in a daisy-chain configuration, the *IEEE Standard 1149.1* expects the value on TDO to change on the falling edge of TCK.

By default, the internal pull-up resistor on the TDO pin is enabled after reset. This assures that the pin remains at a constant logic level when the JTAG port is not being used. The internal pull-up and pull-down resistors can be turned off to save internal power if a High-Z output value is acceptable during certain TAP controller states.

### 4.3.2 JTAG TAP Controller

The JTAG TAP controller state machine is shown in Figure 4-2 on page 158. The TAP controller state machine is reset to the Test-Logic-Reset state on the assertion of a Power-On-Reset (POR) or the assertion of $\overline{\text{TRST}}$. Asserting the correct sequence on the TMS pin allows the JTAG module to shift in new instructions, shift in data, or idle during extended testing sequences. For detailed information on the function of the TAP controller and the operations that occur in each state, please refer to *IEEE Standard 1149.1*.

**Figure 4-2. Test Access Port State Machine**




### 4.3.3 Shift Registers

The Shift Registers consist of a serial shift register chain and a parallel load register. The serial shift register chain samples specific information during the TAP controller's CAPTURE states and allows this information to be shifted out of TDO during the TAP controller's SHIFT states. While the sampled data is being shifted out of the chain on TDO, new data is being shifted into the serial shift register on TDI. This new data is stored in the parallel load register during the TAP controller's UPDATE states. Each of the shift registers is discussed in detail in "Register Descriptions" on page 161.

### 4.3.4 Operational Considerations

There are certain operational considerations when using the JTAG module. Because the JTAG pins can be programmed to be GPIOs, board configuration and reset conditions on these pins must be considered. In addition, because the JTAG module has integrated ARM Serial Wire Debug, the method for switching between these two operational modes is described below.

#### 4.3.4.1 GPIO Functionality

When the controller is reset with either a POR or RST, the JTAG/SWD port pins default to their JTAG/SWD configurations. The default configuration includes enabling digital functionality (setting **GPIODEN** to 1), enabling the pull-up resistors (setting **GPIOPUR** to 1), and enabling the alternate hardware function (setting **GPIOAFSEL** to 1) for the PB7 and PC[3:0] JTAG/SWD pins.

It is possible for software to configure these pins as GPIOs after reset by writing 0s to PB7 and PC[3:0] in the **GPIOAFSEL** register. If the user does not require the JTAG/SWD port for debugging or board-level testing, this provides five more GPIOs for use in the design.

---

**Caution – It is possible to create a software sequence that prevents the debugger from connecting to the Stellaris microcontroller. If the program code loaded into flash immediately changes the JTAG pins to their GPIO functionality, the debugger may not have enough time to connect and halt the controller before the JTAG pin functionality switches. This may lock the debugger out of the part. This can be avoided with a software routine that restores JTAG functionality based on an external or software trigger.**

---

The GPIO commit control registers provide a layer of protection against accidental programming of critical hardware peripherals. Protection is currently provided for the five JTAG/SWD pins (PB7 and PC[3:0]). Writes to protected bits of the **GPIO Alternate Function Select (GPIOAFSEL)** register (see page 303) are not committed to storage unless the **GPIO Lock (GPIOLOCK)** register (see page 313) has been unlocked and the appropriate bits of the **GPIO Commit (GPIOCR)** register (see page 314) have been set to 1.

***Recovering a "Locked" Device***

**Note:** The mass erase of the flash memory caused by the below sequence erases the entire flash memory, regardless of the settings in the **Flash Memory Protection Program Enable n (FMPPEn)** registers. Performing the sequence below does not affect the nonvolatile registers discussed in “Nonvolatile Register Programming” on page 257.

If software configures any of the JTAG/SWD pins as GPIO and loses the ability to communicate with the debugger, there is a debug sequence that can be used to recover the device. Performing a total of ten JTAG-to-SWD and SWD-to-JTAG switch sequences while holding the device in reset mass erases the flash memory. The sequence to recover the device is:

1. Assert and hold the RST signal.
2. Perform the JTAG-to-SWD switch sequence.
3. Perform the SWD-to-JTAG switch sequence.
4. Perform the JTAG-to-SWD switch sequence.
5. Perform the SWD-to-JTAG switch sequence.
6. Perform the JTAG-to-SWD switch sequence.
7. Perform the SWD-to-JTAG switch sequence.
8. Perform the JTAG-to-SWD switch sequence.
9. Perform the SWD-to-JTAG switch sequence.
10. Perform the JTAG-to-SWD switch sequence.

11. Perform the SWD-to-JTAG switch sequence.

12. Release the $\overline{\text{RST}}$ signal.

13. Wait 400 ms.

14. Power-cycle the device.

The JTAG-to-SWD and SWD-to-JTAG switch sequences are described in "ARM Serial Wire Debug (SWD)" on page 160. When performing switch sequences for the purpose of recovering the debug capabilities of the device, only steps 1 and 2 of the switch sequence in the section called "JTAG-to-SWD Switching" on page 160 must be performed.

#### 4.3.4.2 Communication with JTAG/SWD

Because the debug clock and the system clock can be running at different frequencies, care must be taken to maintain reliable communication with the JTAG/SWD interface. In the Capture-DR state, the result of the previous transaction, if any, is returned, together with a 3-bit ACK response. Software should check the ACK response to see if the previous operation has completed before initiating a new transaction. Alternatively, if the system clock is at least 8 times faster than the debug clock (TCK or SWCLK), the previous operation has enough time to complete and the ACK bits do not have to be checked.

#### 4.3.4.3 ARM Serial Wire Debug (SWD)

In order to seamlessly integrate the ARM Serial Wire Debug (SWD) functionality, a serial-wire debugger must be able to connect to the Cortex-M3 core without having to perform, or have any knowledge of, JTAG cycles. This is accomplished with a SWD preamble that is issued before the SWD session begins.

The switching preamble used to enable the SWD interface of the SWJ-DP module starts with the TAP controller in the Test-Logic-Reset state. From here, the preamble sequences the TAP controller through the following states: Run Test Idle, Select DR, Select IR, Test Logic Reset, Test Logic Reset, Run Test Idle, Run Test Idle, Select DR, Select IR, Test Logic Reset, Test Logic Reset, Run Test Idle, Run Test Idle, Select DR, Select IR, and Test Logic Reset states.

Stepping through this sequences of the TAP state machine enables the SWD interface and disables the JTAG interface. For more information on this operation and the SWD interface, see the *ARM® Debug Interface V5 Architecture Specification*.

Because this sequence is a valid series of JTAG operations that could be issued, the ARM JTAG TAP controller is not fully compliant to the *IEEE Standard 1149.1*. This is the only instance where the ARM JTAG TAP controller does not meet full compliance with the specification. Due to the low probability of this sequence occurring during normal operation of the TAP controller, it should not affect normal performance of the JTAG interface.

##### *JTAG-to-SWD Switching*

To switch the operating mode of the Debug Access Port (DAP) from JTAG to SWD mode, the external debug hardware must send the switching preamble to the device. The 16-bit switch sequence for switching to SWD mode is defined as b1110011110011110, transmitted LSB first. This can also be represented as 16'hE79E when transmitted LSB first. The complete switch sequence should consist of the following transactions on the TCK/SWCLK and TMS/SWDIO signals:

1. Send at least 50 TCK/SWCLK cycles with TMS/SWDIO set to 1. This ensures that both JTAG and SWD are in their reset/idle states.

2. Send the 16-bit JTAG-to-SWD switch sequence, 16'hE79E.

3. Send at least 50 TCK/SWCLK cycles with TMS/SWDIO set to 1. This ensures that if SWJ-DP was already in SWD mode, before sending the switch sequence, the SWD goes into the line reset state.

***SWD-to-JTAG Switching***

To switch the operating mode of the Debug Access Port (DAP) from SWD to JTAG mode, the external debug hardware must send a switch sequence to the device. The 16-bit switch sequence for switching to JTAG mode is defined as b1110011100111100, transmitted LSB first. This can also be represented as 16'hE73C when transmitted LSB first. The complete switch sequence should consist of the following transactions on the TCK/SWCLK and TMS/SWDIO signals:

1. Send at least 50 TCK/SWCLK cycles with TMS/SWDIO set to 1. This ensures that both JTAG and SWD are in their reset/idle states.

2. Send the 16-bit SWD-to-JTAG switch sequence, 16'hE73C.

3. Send at least 5 TCK/SWCLK cycles with TMS/SWDIO set to 1. This ensures that if SWJ-DP was already in JTAG mode, before sending the switch sequence, the JTAG goes into the Test Logic Reset state.

## 4.4 Initialization and Configuration

After a Power-On-Reset or an external reset ($\overline{\text{RST}}$), the JTAG pins are automatically configured for JTAG communication. No user-defined initialization or configuration is needed. However, if the user application changes these pins to their GPIO function, they must be configured back to their JTAG functionality before JTAG communication can be restored. This is done by enabling the five JTAG pins (PB7 and PC[3:0]) for their alternate function using the **GPIOAFSEL** register. In addition to enabling the alternate functions, any other changes to the GPIO pad configurations on the five JTAG pins (PB7 andPC[3:0]) should be reverted to their default settings.

## 4.5 Register Descriptions

There are no APB-accessible registers in the JTAG TAP Controller or Shift Register chains. The registers within the JTAG controller are all accessed serially through the TAP Controller. The registers can be broken down into two main categories: Instruction Registers and Data Registers.

### 4.5.1 Instruction Register (IR)

The JTAG TAP Instruction Register (IR) is a four-bit serial scan chain connected between the JTAG TDI and TDO pins with a parallel load register. When the TAP Controller is placed in the correct states, bits can be shifted into the Instruction Register. Once these bits have been shifted into the chain and updated, they are interpreted as the current instruction. The decode of the Instruction Register bits is shown in Table 4-4 on page 161. A detailed explanation of each instruction, along with its associated Data Register, follows.

**Table 4-4. JTAG Instruction Register Commands**

| IR[3:0] | Instruction | Description |
|---|---|---|
| 0000 | EXTEST | Drives the values preloaded into the Boundary Scan Chain by the SAMPLE/PRELOAD instruction onto the pads. |
| 0001 | INTEST | Drives the values preloaded into the Boundary Scan Chain by the SAMPLE/PRELOAD instruction into the controller. |

**Table 4-4. JTAG Instruction Register Commands *(continued)***

| IR[3:0] | Instruction | Description |
|---|---|---|
| 0010 | SAMPLE / PRELOAD | Captures the current I/O values and shifts the sampled values out of the Boundary Scan Chain while new preload data is shifted in. |
| 1000 | ABORT | Shifts data into the ARM Debug Port Abort Register. |
| 1010 | DPACC | Shifts data into and out of the ARM DP Access Register. |
| 1011 | APACC | Shifts data into and out of the ARM AC Access Register. |
| 1110 | IDCODE | Loads manufacturing information defined by the *IEEE Standard 1149.1* into the IDCODE chain and shifts it out. |
| 1111 | BYPASS | Connects TDI to TDO through a single Shift Register chain. |
| All Others | Reserved | Defaults to the BYPASS instruction to ensure that TDI is always connected to TDO. |

#### 4.5.1.1 EXTEST Instruction

The EXTEST instruction is not associated with its own Data Register chain. The EXTEST instruction uses the data that has been preloaded into the Boundary Scan Data Register using the SAMPLE/PRELOAD instruction. When the EXTEST instruction is present in the Instruction Register, the preloaded data in the Boundary Scan Data Register associated with the outputs and output enables are used to drive the GPIO pads rather than the signals coming from the core. This allows tests to be developed that drive known values out of the controller, which can be used to verify connectivity. While the EXTEST instruction is present in the Instruction Register, the Boundary Scan Data Register can be accessed to sample and shift out the current data and load new data into the Boundary Scan Data Register.

#### 4.5.1.2 INTEST Instruction

The INTEST instruction is not associated with its own Data Register chain. The INTEST instruction uses the data that has been preloaded into the Boundary Scan Data Register using the SAMPLE/PRELOAD instruction. When the INTEST instruction is present in the Instruction Register, the preloaded data in the Boundary Scan Data Register associated with the inputs are used to drive the signals going into the core rather than the signals coming from the GPIO pads. This allows tests to be developed that drive known values into the controller, which can be used for testing. It is important to note that although the $\overline{\text{RST}}$ input pin is on the Boundary Scan Data Register chain, it is only observable. While the INTEXT instruction is present in the Instruction Register, the Boundary Scan Data Register can be accessed to sample and shift out the current data and load new data into the Boundary Scan Data Register.

#### 4.5.1.3 SAMPLE/PRELOAD Instruction

The SAMPLE/PRELOAD instruction connects the Boundary Scan Data Register chain between TDI and TDO. This instruction samples the current state of the pad pins for observation and preloads new test data. Each GPIO pad has an associated input, output, and output enable signal. When the TAP controller enters the Capture DR state during this instruction, the input, output, and output-enable signals to each of the GPIO pads are captured. These samples are serially shifted out of TDO while the TAP controller is in the Shift DR state and can be used for observation or comparison in various tests.

While these samples of the inputs, outputs, and output enables are being shifted out of the Boundary Scan Data Register, new data is being shifted into the Boundary Scan Data Register from TDI. Once the new data has been shifted into the Boundary Scan Data Register, the data is saved in the parallel load registers when the TAP controller enters the Update DR state. This update of the parallel load register preloads data into the Boundary Scan Data Register that is associated with

each input, output, and output enable. This preloaded data can be used with the EXTEST and INTEST instructions to drive data into or out of the controller. Please see “Boundary Scan Data Register” on page 164 for more information.

#### 4.5.1.4 ABORT Instruction

The ABORT instruction connects the associated ABORT Data Register chain between TDI and TDO. This instruction provides read and write access to the ABORT Register of the ARM Debug Access Port (DAP). Shifting the proper data into this Data Register clears various error bits or initiates a DAP abort of a previous request. Please see the “ABORT Data Register” on page 165 for more information.

#### 4.5.1.5 DPACC Instruction

The DPACC instruction connects the associated DPACC Data Register chain between TDI and TDO. This instruction provides read and write access to the DPACC Register of the ARM Debug Access Port (DAP). Shifting the proper data into this register and reading the data output from this register allows read and write access to the ARM debug and status registers. Please see “DPACC Data Register” on page 165 for more information.

#### 4.5.1.6 APACC Instruction

The APACC instruction connects the associated APACC Data Register chain between TDI and TDO. This instruction provides read and write access to the APACC Register of the ARM Debug Access Port (DAP). Shifting the proper data into this register and reading the data output from this register allows read and write access to internal components and buses through the Debug Port. Please see “APACC Data Register” on page 165 for more information.

#### 4.5.1.7 IDCODE Instruction

The IDCODE instruction connects the associated IDCODE Data Register chain between TDI and TDO. This instruction provides information on the manufacturer, part number, and version of the ARM core. This information can be used by testing equipment and debuggers to automatically configure their input and output data streams. IDCODE is the default instruction that is loaded into the JTAG Instruction Register when a Power-On-Reset (POR) is asserted, $\overline{\text{TRST}}$ is asserted, or the Test-Logic-Reset state is entered. Please see “IDCODE Data Register” on page 164 for more information.

#### 4.5.1.8 BYPASS Instruction

The BYPASS instruction connects the associated BYPASS Data Register chain between TDI and TDO. This instruction is used to create a minimum length serial path between the TDI and TDO ports. The BYPASS Data Register is a single-bit shift register. This instruction improves test efficiency by allowing components that are not needed for a specific test to be bypassed in the JTAG scan chain by loading them with the BYPASS instruction. Please see “BYPASS Data Register” on page 164 for more information.

### 4.5.2 Data Registers

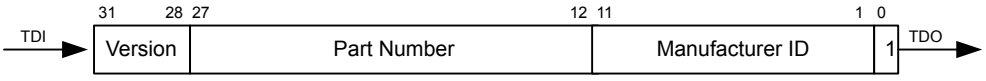
The JTAG module contains six Data Registers. These include: IDCODE, BYPASS, Boundary Scan, APACC, DPACC, and ABORT serial Data Register chains. Each of these Data Registers is discussed in the following sections.

#### 4.5.2.1 IDCODE Data Register

The format for the 32-bit IDCODE Data Register defined by the *IEEE Standard 1149.1* is shown in Figure 4-3 on page 164. The standard requires that every JTAG-compliant device implement either the IDCODE instruction or the BYPASS instruction as the default instruction. The LSB of the IDCODE Data Register is defined to be a 1 to distinguish it from the BYPASS instruction, which has an LSB of 0. This allows auto configuration test tools to determine which instruction is the default instruction.

The major uses of the JTAG port are for manufacturer testing of component assembly, and program development and debug. To facilitate the use of auto-configuration debug tools, the IDCODE instruction outputs a value of 0x3BA0.0477. This allows the debuggers to automatically configure themselves to work correctly with the Cortex-M3 during debug.

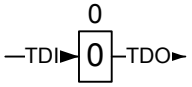
**Figure 4-3. IDCODE Register Format**




#### 4.5.2.2 BYPASS Data Register

The format for the 1-bit BYPASS Data Register defined by the *IEEE Standard 1149.1* is shown in Figure 4-4 on page 164. The standard requires that every JTAG-compliant device implement either the BYPASS instruction or the IDCODE instruction as the default instruction. The LSB of the BYPASS Data Register is defined to be a 0 to distinguish it from the IDCODE instruction, which has an LSB of 1. This allows auto configuration test tools to determine which instruction is the default instruction.

**Figure 4-4. BYPASS Register Format**

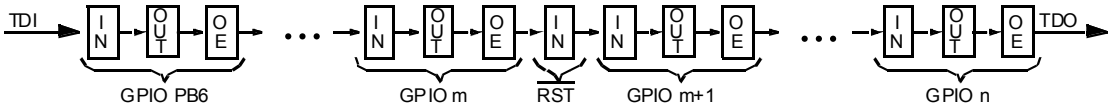



#### 4.5.2.3 Boundary Scan Data Register

The format of the Boundary Scan Data Register is shown in Figure 4-5 on page 165. Each GPIO pin, starting with a GPIO pin next to the JTAG port pins, is included in the Boundary Scan Data Register. Each GPIO pin has three associated digital signals that are included in the chain. These signals are input, output, and output enable, and are arranged in that order as can be seen in the figure.

When the Boundary Scan Data Register is accessed with the SAMPLE/PRELOAD instruction, the input, output, and output enable from each digital pad are sampled and then shifted out of the chain to be verified. The sampling of these values occurs on the rising edge of TCK in the Capture DR state of the TAP controller. While the sampled data is being shifted out of the Boundary Scan chain in the Shift DR state of the TAP controller, new data can be preloaded into the chain for use with the EXTEST and INTEST instructions. These instructions either force data out of the controller, with the EXTEST instruction, or into the controller, with the INTEST instruction.

**Figure 4-5. Boundary Scan Register Format**




#### 4.5.2.4 APACC Data Register

The format for the 35-bit APACC Data Register defined by ARM is described in the *ARM® Debug Interface V5 Architecture Specification*.

#### 4.5.2.5 DPACC Data Register

The format for the 35-bit DPACC Data Register defined by ARM is described in the *ARM® Debug Interface V5 Architecture Specification*.

#### 4.5.2.6 ABORT Data Register

The format for the 35-bit ABORT Data Register defined by ARM is described in the *ARM® Debug Interface V5 Architecture Specification*.

# 5 System Control

System control determines the overall operation of the device. It provides information about the device, controls the clocking to the core and individual peripherals, and handles reset detection and reporting.

## 5.1 Signal Description

Table 5-1 on page 166 and Table 5-2 on page 166 list the external signals of the System Control module and describe the function of each. The NMI signal is the alternate function for and functions as a GPIO after reset. under commit protection and require a special process to be configured as any alternate function or to subsequently return to the GPIO function, see “Commit Control” on page 290. The column in the table below titled "Pin Assignment" lists the GPIO pin placement for the NMI signal. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the NMI function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280. The remaining signals (with the word "fixed" in the Pin Assignment column) have a fixed pin assignment and function.

**Table 5-1. System Control & Clocks Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| CMOD0 | 65 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| CMOD1 | 76 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| OSC0 | 48 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| OSC1 | 49 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| $\overline{\text{RST}}$ | 64 | I | TTL | System reset input. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 5-2. System Control & Clocks Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| CMOD0 | E11 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| CMOD1 | B10 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| OSC0 | L11 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| OSC1 | M11 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| $\overline{\text{RST}}$ | H11 | I | TTL | System reset input. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 5.2 Functional Description

The System Control module provides the following capabilities:

- Device identification (see “Device Identification” on page 167)

- Local control, such as reset (see “Reset Control” on page 167), power (see “Power Control” on page 171) and clock control (see “Clock Control” on page 172)
- System control (Run, Sleep, and Deep-Sleep modes); see “System Control” on page 177

### 5.2.1 Device Identification

Several read-only registers provide software with information on the microcontroller, such as version, part number, SRAM size, flash size, and other features. See the **DID0**, **DID1**, and **DC0**-**DC4** registers.

### 5.2.2 Reset Control

This section discusses aspects of hardware functions during reset as well as system software requirements following the reset sequence.

#### 5.2.2.1 CMOD0 and CMOD1 Test-Mode Control Pins

Two pins, CMOD0 and CMOD1, are defined for internal use for testing the microcontroller during manufacture. They have no end-user function and should not be used. The CMOD pins should be connected to ground.

#### 5.2.2.2 Reset Sources

The controller has five sources of reset:

1. External reset input pin ($\overline{\text{RST}}$) assertion; see “External $\overline{\text{RST}}$ Pin” on page 168.
2. Power-on reset (POR); see “Power-On Reset (POR)” on page 168.
3. Internal brown-out (BOR) detector; see “Brown-Out Reset (BOR)” on page 169.
4. Software-initiated reset (with the software reset registers); see “Software Reset” on page 170.
5. A watchdog timer reset condition violation; see “Watchdog Timer Reset” on page 170.

Table 5-3 provides a summary of results of the various reset operations.

**Table 5-3. Reset Sources**

| Reset Source | Core Reset? | JTAG Reset? | On-Chip Peripherals Reset? |
|---|---|---|---|
| Power-On Reset | Yes | Yes | Yes |
| $\overline{\text{RST}}$ | Yes | Pin Config Only | Yes |
| Brown-Out Reset | Yes | No | Yes |
| Software System Request Reset[a] | Yes | No | Yes |
| Software Peripheral Reset | No | No | Yes[b] |
| Watchdog Reset | Yes | No | Yes |

a. By using the SYSRESREQ bit in the ARM Cortex-M3 **Application Interrupt and Reset Control (APINT)** register

b. Programmable on a module-by-module basis using the Software Reset Control Registers.

After a reset, the **Reset Cause (RESC)** register is set with the reset cause. The bits in this register are sticky and maintain their state across multiple reset sequences, except when an internal POR is the cause, and then all the other bits in the **RESC** register are cleared except for the POR indicator.

#### 5.2.2.3 Power-On Reset (POR)

**Note:** The power-on reset also resets the JTAG controller. An external reset does not.

The internal Power-On Reset (POR) circuit monitors the power supply voltage ($V_{DD}$) and generates a reset signal to all of the internal logic including JTAG when the power supply ramp reaches a threshold value ($V_{TH}$). The microcontroller must be operating within the specified operating parameters when the on-chip power-on reset pulse is complete. The 3.3-V power supply to the microcontroller must reach 3.0 V within 10 msec of $V_{DD}$ crossing 2.0 V to guarantee proper operation. For applications that require the use of an external reset signal to hold the microcontroller in reset longer than the internal POR, the $\overline{RST}$ input may be used as discussed in “External $\overline{RST}$ Pin” on page 168.

The Power-On Reset sequence is as follows:

1. The microcontroller waits for internal POR to go inactive.
2. The internal reset is released and the core loads from memory the initial stack pointer, the initial program counter, and the first instruction designated by the program counter, and then begins execution.

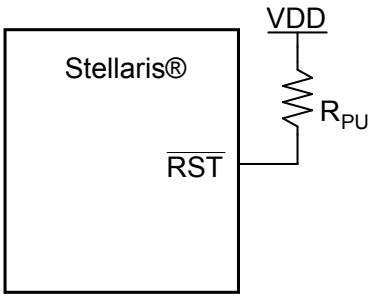
The internal POR is only active on the initial power-up of the microcontroller. The Power-On Reset timing is shown in Figure 20-6 on page 616.

#### 5.2.2.4 External $\overline{RST}$ Pin

**Note:** It is recommended that the trace for the $\overline{RST}$ signal must be kept as short as possible. Be sure to place any components connected to the $\overline{RST}$ signal as close to the microcontroller as possible.

If the application only uses the internal POR circuit, the $\overline{RST}$ input must be connected to the power supply ($V_{DD}$) through an optional pull-up resistor (0 to 100K Ω) as shown in Figure 5-1 on page 168.

**Figure 5-1. Basic $\overline{RST}$ Configuration**



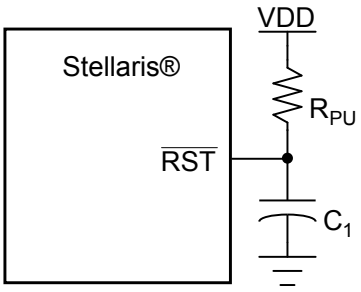

$R_{PU}$ = 0 to 100 kΩ

The external reset pin ($\overline{RST}$) resets the microcontroller including the core and all the on-chip peripherals except the JTAG TAP controller (see “JTAG Interface” on page 153). The external reset sequence is as follows:

1. The external reset pin ($\overline{RST}$) is asserted for the duration specified by $T_{MIN}$ and then de-asserted (see “Reset” on page 615).
2. The internal reset is released and the core loads from memory the initial stack pointer, the initial program counter, and the first instruction designated by the program counter, and then begins execution.

To improve noise immunity and/or to delay reset at power up, the $\overline{RST}$ input may be connected to an RC network as shown in Figure 5-2 on page 169.

**Figure 5-2. External Circuitry to Extend Power-On Reset**

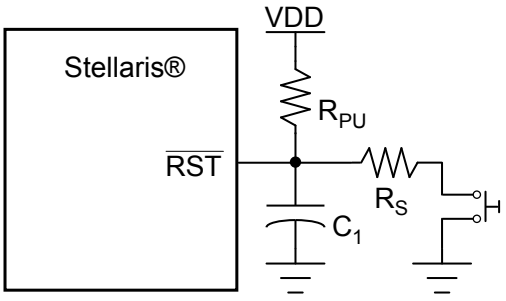



$R_{PU}$ = 1 kΩ to 100 kΩ

$C_1$ = 1 nF to 10 µF

If the application requires the use of an external reset switch, Figure 5-3 on page 169 shows the proper circuitry to use.

**Figure 5-3. Reset Circuit Controlled by Switch**




Typical $R_{PU}$ = 10 kΩ

Typical $R_S$ = 470 Ω

$C_1$ = 10 nF

The $R_{PU}$ and $C_1$ components define the power-on delay.

The external reset timing is shown in Figure 20-5 on page 616.

### 5.2.2.5 Brown-Out Reset (BOR)

A drop in the input voltage resulting in the assertion of the internal brown-out detector can be used to reset the controller. This is initially disabled and may be enabled by software.

The system provides a brown-out detection circuit that triggers if the power supply ($V_{DD}$) drops below a brown-out threshold voltage ($V_{BTH}$). If a brown-out condition is detected, the system may generate a controller interrupt or a system reset.

Brown-out resets are controlled with the **Power-On and Brown-Out Reset Control (PBORCTL)** register. The BORIOR bit in the **PBORCTL** register must be set for a brown-out condition to trigger a reset.

The brown-out reset is equivalent to an assertion of the external RST input and the reset is held active until the proper $V_{DD}$ level is restored. The **RESC** register can be examined in the reset interrupt handler to determine if a Brown-Out condition was the cause of the reset, thus allowing software to determine what actions are required to recover.

The internal Brown-Out Reset timing is shown in Figure 20-7 on page 616.

#### 5.2.2.6 Software Reset

Software can reset a specific peripheral or generate a reset to the entire system .

Peripherals can be individually reset by software via three registers that control reset signals to each peripheral (see the **SRCRn** registers). If the bit position corresponding to a peripheral is set and subsequently cleared, the peripheral is reset. The encoding of the reset registers is consistent with the encoding of the clock gating control for peripherals and on-chip functions (see “System Control” on page 177). Note that all reset signals for all clocks of the specified unit are asserted as a result of a software-initiated reset.

The entire system can be reset by software by setting the SYSRESETREQ bit in the Cortex-M3 Application Interrupt and Reset Control register resets the entire system including the core. The software-initiated system reset sequence is as follows:

1. A software system reset is initiated by writing the SYSRESETREQ bit in the ARM Cortex-M3 Application Interrupt and Reset Control register.
2. An internal reset is asserted.
3. The internal reset is deasserted and the controller loads from memory the initial stack pointer, the initial program counter, and the first instruction designated by the program counter, and then begins execution.

The software-initiated system reset timing is shown in Figure 20-8 on page 617.

#### 5.2.2.7 Watchdog Timer Reset

The watchdog timer module's function is to prevent system hangs. The watchdog timer can be configured to generate an interrupt to the controller on its first time-out, and to generate a reset signal on its second time-out.

After the first time-out event, the 32-bit counter is reloaded with the value of the **Watchdog Timer Load (WDTLOAD)** register, and the timer resumes counting down from that value. If the timer counts down to its zero state again before the first time-out interrupt is cleared, and the reset signal has been enabled, the watchdog timer asserts its reset signal to the system. The watchdog timer reset sequence is as follows:

1. The watchdog timer times out for the second time without being serviced.
2. An internal reset is asserted.
3. The internal reset is released and the controller loads from memory the initial stack pointer, the initial program counter, the first instruction designated by the program counter, and begins execution.

The watchdog reset timing is shown in Figure 20-9 on page 617.

### 5.2.3 Power Control

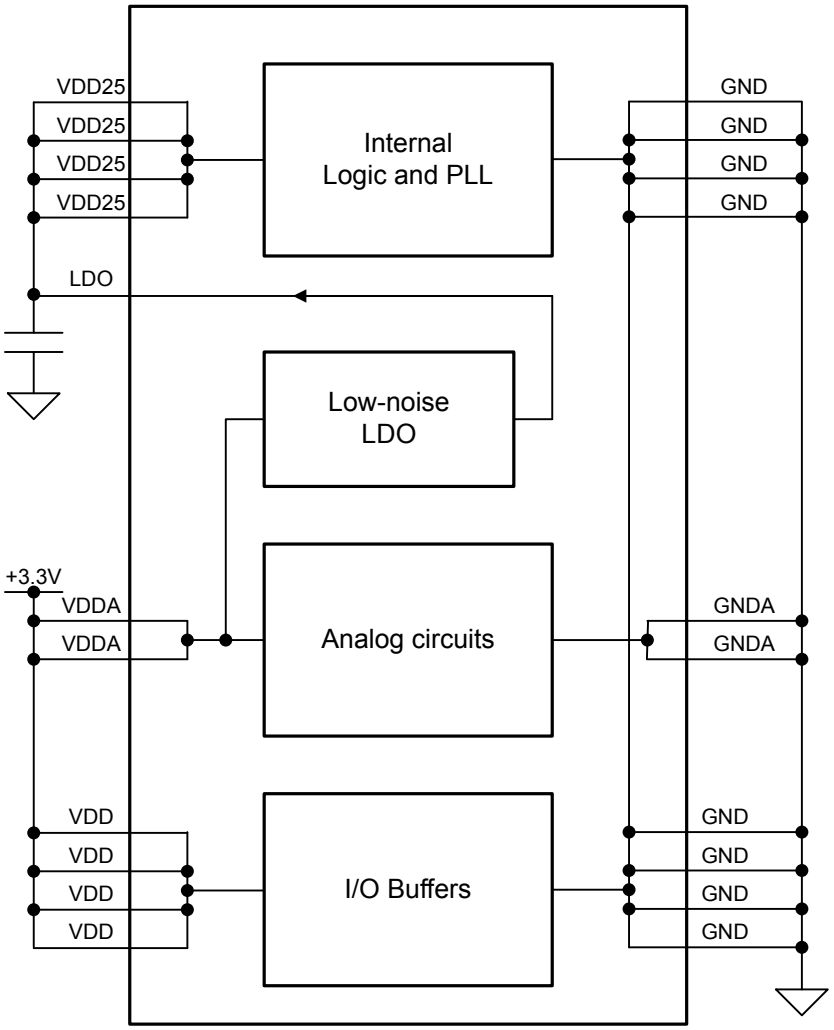
The Stellaris® microcontroller provides an integrated LDO regulator that is used to provide power to the majority of the controller's internal logic. For power reduction, the LDO regulator provides software a mechanism to adjust the regulated value, in small increments (VSTEP), over the range of 2.25 V to 2.75 V (inclusive)—or 2.5 V ± 10%. The adjustment is made by changing the value of the VADJ field in the **LDO Power Control (LDOPCTL)** register.

Figure 5-4 on page 171 shows the power architecture.

**Note:** On the printed circuit board, use the LDO output as the source of VDD25 input. Do not use an external regulator to supply the voltage to VDD25. In addition, the LDO requires decoupling capacitors. See “On-Chip Low Drop-Out (LDO) Regulator Characteristics” on page 610.

VDDA must be supplied with 3.3 V, or the microcontroller does not function properly. VDDA is the supply for all of the analog circuitry on the device, including the LDO and the clock circuitry.

**Figure 5-4. Power Architecture**



## 5.2.4 Clock Control

System control determines the control of clocks in this part.

### 5.2.4.1 Fundamental Clock Sources

There are multiple clock sources for use in the device:

- **Internal Oscillator (IOSC).** The internal oscillator is an on-chip clock source. It does not require the use of any external components. The frequency of the internal oscillator is 12 MHz ± 30%. Applications that do not depend on accurate clock sources may use this clock source to reduce system cost. The internal oscillator is the clock source the device uses during and following POR. If the main oscillator is required, software must enable the main oscillator following reset and allow the main oscillator to stabilize before changing the clock reference.
- **Main Oscillator (MOSC).** The main oscillator provides a frequency-accurate clock source by one of two means: an external single-ended clock source is connected to the OSC0 input pin, or an external crystal is connected across the OSC0 input and OSC1 output pins. If the PLL is being used, the crystal value must be one of the supported frequencies between 3.579545 MHz through 8.192 MHz (inclusive). If the PLL is not being used, the crystal may be any one of the supported frequencies between 1 MHz and 8.192 MHz. The single-ended clock source range is from DC through the specified speed of the device. The supported crystals are listed in the XTAL bit field in the **RCC** register (see page 189).
- **Internal 30-kHz Oscillator.** The internal 30-kHz oscillator is similar to the internal oscillator, except that it provides an operational frequency of 30 kHz ± 50%. It is intended for use during Deep-Sleep power-saving modes. This power-savings mode benefits from reduced internal switching and also allows the main oscillator to be powered down.
- **External Real-Time Oscillator.** The external real-time oscillator provides a low-frequency, accurate clock reference. It is intended to provide the system with a real-time clock source. The real-time oscillator is part of the Hibernation Module (see “Hibernation Module” on page 233) and may also provide an accurate source of Deep-Sleep or Hibernate mode power savings.

The internal system clock (SysClk), is derived from any of the above sources plus two others: the output of the main internal PLL, and the internal oscillator divided by four (3 MHz ± 30%). The frequency of the PLL clock reference must be in the range of 3.579545 MHz to 8.192 MHz (inclusive). Table 5-4 on page 172 shows how the various clock sources can be used in a system.

**Table 5-4. Clock Source Options**

| Clock Source | Drive PLL? | | Used as SysClk? | |
|---|---|---|---|---|
| Internal Oscillator (12 MHz) | No | BYPASS = 1 | Yes | BYPASS = 1, OSCSRC = 0x1 |
| Internal Oscillator divide by 4 (3 MHz) | No | BYPASS = 1 | Yes | BYPASS = 1, OSCSRC = 0x2 |
| Main Oscillator | Yes | BYPASS = 0, OSCSRC = 0x0 | Yes | BYPASS = 1, OSCSRC = 0x0 |
| Internal 30-kHz Oscillator | No | BYPASS = 1 | Yes | BYPASS = 1, OSCSRC = 0x3 |
| External Real-Time Oscillator | No | BYPASS = 1 | Yes | BYPASS = 1, OSCSRC2 = 0x7 |

### 5.2.4.2 Clock Configuration

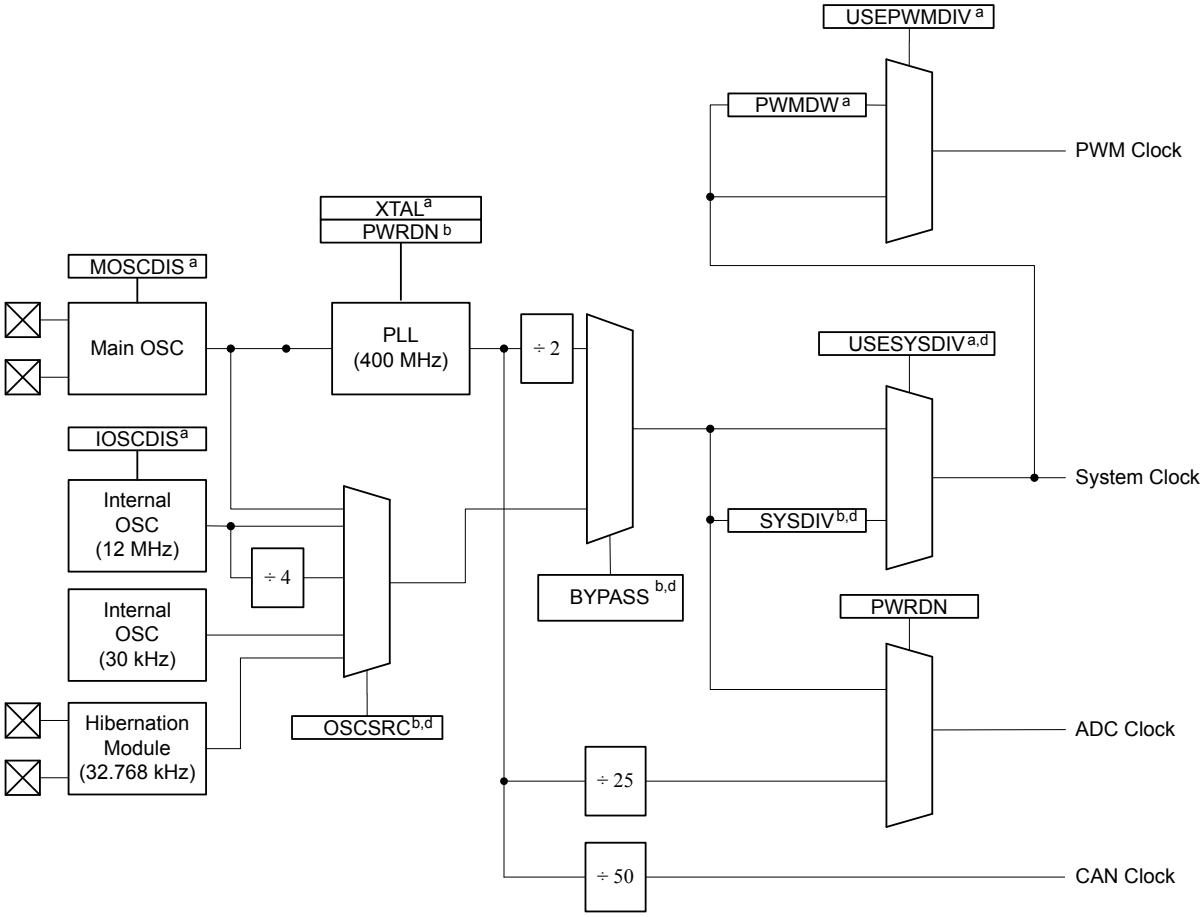
The **Run-Mode Clock Configuration (RCC)** and **Run-Mode Clock Configuration 2 (RCC2)** registers provide control for the system clock. The **RCC2** register is provided to extend fields that

offer additional encodings over the **RCC** register. When used, the **RCC2** register field values are used by the logic over the corresponding field in the **RCC** register. In particular, **RCC2** provides for a larger assortment of clock configuration options. These registers control the following clock functionality:

- Source of clocks in sleep and deep-sleep modes
- System clock derived from PLL or other clock source
- Enabling/disabling of oscillators and PLL
- Clock divisors
- Crystal input selection

Figure 5-5 on page 174 shows the logic for the main clock tree. The peripheral blocks are driven by the system clock signal and can be individually enabled/disabled. The PWM clock signal is a synchronous divide of the system clock to provide the PWM circuit with more range (set with `PWMDIV` in **RCC**).

**Figure 5-5. Main Clock Tree**




a. Control provided by RCC register bit/field.
b. Control provided by RCC register bit/field or RCC2 register bit/field, if overridden with RCC2 register bit USERCC2.
c. Control provided by RCC2 register bit/field.
d. Also may be controlled by DSLPCLKCFG when in deep sleep mode.

**Note:** The figure above shows all features available on all Stellaris® Fury-class devices. Not all peripherals may be available on this device.

In the **RCC** register, the SYSDIV field specifies which divisor is used to generate the system clock from either the PLL output or the oscillator source (depending on how the BYPASS bit in this register is configured). When using the PLL, the VCO frequency of 400 MHz is predivided by 2 before the divisor is applied. Table 5-5 shows how the SYSDIV encoding affects the system clock frequency, depending on whether the PLL is used (BYPASS=0) or another clock source is used (BYPASS=1). The divisor is equivalent to the SYSDIV encoding plus 1. For a list of possible clock sources, see Table 5-4 on page 172.

**Table 5-5. Possible System Clock Frequencies Using the SYSDIV Field**

| SYSDIV | Divisor | Frequency (BYPASS=0) | Frequency (BYPASS=1) | StellarisWare Parameter[a] |
|---|---|---|---|---|
| 0x0 | /1 | reserved | Clock source frequency/2 | SYSCTL_SYSDIV_1[b] |
| 0x1 | /2 | reserved | Clock source frequency/2 | SYSCTL_SYSDIV_2 |
| 0x2 | /3 | reserved | Clock source frequency/3 | SYSCTL_SYSDIV_3 |
| 0x3 | /4 | 50 MHz | Clock source frequency/4 | SYSCTL_SYSDIV_4 |
| 0x4 | /5 | 40 MHz | Clock source frequency/5 | SYSCTL_SYSDIV_5 |
| 0x5 | /6 | 33.33 MHz | Clock source frequency/6 | SYSCTL_SYSDIV_6 |
| 0x6 | /7 | 28.57 MHz | Clock source frequency/7 | SYSCTL_SYSDIV_7 |
| 0x7 | /8 | 25 MHz | Clock source frequency/8 | SYSCTL_SYSDIV_8 |
| 0x8 | /9 | 22.22 MHz | Clock source frequency/9 | SYSCTL_SYSDIV_9 |
| 0x9 | /10 | 20 MHz | Clock source frequency/10 | SYSCTL_SYSDIV_10 |
| 0xA | /11 | 18.18 MHz | Clock source frequency/11 | SYSCTL_SYSDIV_11 |
| 0xB | /12 | 16.67 MHz | Clock source frequency/12 | SYSCTL_SYSDIV_12 |
| 0xC | /13 | 15.38 MHz | Clock source frequency/13 | SYSCTL_SYSDIV_13 |
| 0xD | /14 | 14.29 MHz | Clock source frequency/14 | SYSCTL_SYSDIV_14 |
| 0xE | /15 | 13.33 MHz | Clock source frequency/15 | SYSCTL_SYSDIV_15 |
| 0xF | /16 | 12.5 MHz (default) | Clock source frequency/16 | SYSCTL_SYSDIV_16 |

a. This parameter is used in functions such as SysCtlClockSet() in the Stellaris Peripheral Driver Library.

b. SYSCTL_SYSDIV_1 does not set the USESYSDIV bit. As a result, using this parameter without enabling the PLL results in the system clock having the same frequency as the clock source.

The SYSDIV2 field in the **RCC2** register is 2 bits wider than the SYSDIV field in the **RCC** register so that additional larger divisors up to /64 are possible, allowing a lower system clock frequency for improved Deep Sleep power consumption. When using the PLL, the VCO frequency of 400 MHz is predivided by 2 before the divisor is applied. The divisor is equivalent to the SYSDIV2 encoding plus 1. Table 5-6 shows how the SYSDIV2 encoding affects the system clock frequency, depending on whether the PLL is used (BYPASS2=0) or another clock source is used (BYPASS2=1). For a list of possible clock sources, see Table 5-4 on page 172.

**Table 5-6. Examples of Possible System Clock Frequencies Using the SYSDIV2 Field**

| SYSDIV2 | Divisor | Frequency (BYPASS2=0) | Frequency (BYPASS2=1) | StellarisWare Parameter[a] |
|---|---|---|---|---|
| 0x00 | /1 | reserved | Clock source frequency/2 | SYSCTL_SYSDIV_1[b] |
| 0x01 | /2 | reserved | Clock source frequency/2 | SYSCTL_SYSDIV_2 |
| 0x02 | /3 | reserved | Clock source frequency/3 | SYSCTL_SYSDIV_3 |
| 0x03 | /4 | 50 MHz | Clock source frequency/4 | SYSCTL_SYSDIV_4 |
| 0x04 | /5 | 40 MHz | Clock source frequency/5 | SYSCTL_SYSDIV_5 |
| 0x05 | /6 | 33.33 MHz | Clock source frequency/6 | SYSCTL_SYSDIV_6 |
| 0x06 | /7 | 28.57 MHz | Clock source frequency/7 | SYSCTL_SYSDIV_7 |
| 0x07 | /8 | 25 MHz | Clock source frequency/8 | SYSCTL_SYSDIV_8 |
| 0x08 | /9 | 22.22 MHz | Clock source frequency/9 | SYSCTL_SYSDIV_9 |
| 0x09 | /10 | 20 MHz | Clock source frequency/10 | SYSCTL_SYSDIV_10 |
| ... | ... | ... | ... | ... |

**Table 5-6. Examples of Possible System Clock Frequencies Using the SYSDIV2 Field *(continued)***

| SYSDIV2 | Divisor | Frequency (BYPASS2=0) | Frequency (BYPASS2=1) | StellarisWare Parameter[a] |
|---|---|---|---|---|
| 0x3F | /64 | 3.125 MHz | Clock source frequency/64 | SYSCTL_SYSDIV_64 |

a. This parameter is used in functions such as SysCtlClockSet() in the Stellaris Peripheral Driver Library.

b. SYSCTL_SYSDIV_1 does not set the USESYSDIV bit. As a result, using this parameter without enabling the PLL results in the system clock having the same frequency as the clock source.

#### 5.2.4.3 Crystal Configuration for the Main Oscillator (MOSC)

The main oscillator supports the use of a select number of crystals. If the main oscillator is used by the PLL as a reference clock, the supported range of crystals is 3.579545 to 8.192 MHz, otherwise, the range of supported crystals is 1 to 8.192 MHz.

The XTAL bit in the **RCC** register (see page 189) describes the available crystal choices and default programming values.

Software configures the **RCC** register XTAL field with the crystal number. If the PLL is used in the design, the XTAL field value is internally translated to the PLL settings.

#### 5.2.4.4 Main PLL Frequency Configuration

The main PLL is disabled by default during power-on reset and is enabled later by software if required. Software specifies the output divisor to set the system clock frequency, and enables the main PLL to drive the output. The PLL operates at 400 MHz, but is divided by two prior to the application of the output divisor.

If the main oscillator provides the clock reference to the main PLL, the translation provided by hardware and used to program the PLL is available for software in the **XTAL to PLL Translation (PLLCFG)** register (see page 193). The internal translation provides a translation within ± 1% of the targeted PLL VCO frequency. Table 20-9 on page 613 shows the actual PLL frequency and error for a given crystal choice.

The Crystal Value field (XTAL) in the **Run-Mode Clock Configuration (RCC)** register (see page 189) describes the available crystal choices and default programming of the **PLLCFG** register. Any time the XTAL field changes, the new settings are translated and the internal PLL settings are updated.

To configure the external 32-kHz real-time oscillator as the PLL input reference, program the OSCRC2 field in the **Run-Mode Clock Configuration 2 (RCC2)** register to be 0x7.

#### 5.2.4.5 PLL Modes

The PLL has two modes of operation: Normal and Power-Down

- Normal: The PLL multiplies the input clock reference and drives the output.
- Power-Down: Most of the PLL internal circuitry is disabled and the PLL does not drive the output.

The modes are programmed using the **RCC**/**RCC2** register fields (see page 189 and page 194).

#### 5.2.4.6 PLL Operation

If a PLL configuration is changed, the PLL output frequency is unstable until it reconverges (relocks) to the new setting. The time between the configuration change and relock is $T_{READY}$ (see Table 20-8 on page 613). During the relock time, the affected PLL is not usable as a clock reference.

PLL is changed by one of the following:

- Change to the XTAL value in the **RCC** register—writes of the same value do not cause a relock.
- Change in the PLL from Power-Down to Normal mode.

A counter is defined to measure the $T_{READY}$ requirement. The counter is clocked by the main oscillator. The range of the main oscillator has been taken into account and the down counter is set to 0x1200 (that is, ~600 µs at an 8.192 MHz external oscillator clock). Hardware is provided to keep the PLL from being used as a system clock until the $T_{READY}$ condition is met after one of the two changes above. It is the user's responsibility to have a stable clock source (like the main oscillator) before the **RCC**/**RCC2** register is switched to use the PLL.

If the main PLL is enabled and the system clock is switched to use the PLL in one step, the system control hardware continues to clock the controller from the oscillator selected by the **RCC**/**RCC2** register until the main PLL is stable ($T_{READY}$ time met), after which it changes to the PLL. Software can use many methods to ensure that the system is clocked from the main PLL, including periodically polling the PLLLRIS bit in the **Raw Interrupt Status (RIS)** register, and enabling the PLL Lock interrupt.

### 5.2.5 System Control

For power-savings purposes, the **RCGCn** , **SCGCn** , and **DCGCn** registers control the clock gating logic for each peripheral or block in the system while the controller is in Run, Sleep, and Deep-Sleep mode, respectively.

There are four levels of operation for the device defined as:

- **Run Mode.** In Run mode, the controller actively executes code. Run mode provides normal operation of the processor and all of the peripherals that are currently enabled by the **RCGCn** registers. The system clock can be any of the available clock sources including the PLL.
- **Sleep Mode.** In Sleep mode, the clock frequency of the active peripherals is unchanged, but the processor and the memory subsystem are not clocked and therefore no longer execute code. Sleep mode is entered by the Cortex-M3 core executing a WFI(Wait for Interrupt) instruction. Any properly configured interrupt event in the system will bring the processor back into Run mode. See “Power Management” on page 84 for more details.

  Peripherals are clocked that are enabled in the **SCGCn** register when auto-clock gating is enabled (see the **RCC** register) or the **RCGCn** register when the auto-clock gating is disabled. The system clock has the same source and frequency as that during Run mode.
- **Deep-Sleep Mode.** In Deep-Sleep mode, the clock frequency of the active peripherals may change (depending on the Run mode clock configuration) in addition to the processor clock being stopped. An interrupt returns the device to Run mode from one of the sleep modes; the sleep modes are entered on request from the code. Deep-Sleep mode is entered by first writing the Deep Sleep Enable bit in the ARM Cortex-M3 NVIC system control register and then executing a WFI instruction. Any properly configured interrupt event in the system will bring the processor back into Run mode. See “Power Management” on page 84 for more details.

  The Cortex-M3 processor core and the memory subsystem are not clocked. Peripherals are clocked that are enabled in the **DCGCn** register when auto-clock gating is enabled (see the **RCC** register) or the **RCGCn** register when auto-clock gating is disabled. The system clock source is the main oscillator by default or the internal oscillator specified in the **DSLPCLKCFG** register if one is enabled. When the **DSLPCLKCFG** register is used, the internal oscillator is powered up, if necessary, and the main oscillator is powered down. If the PLL is running at the time of the

WFI instruction, hardware will power the PLL down and override the SYSDIV field of the active **RCC**/**RCC2** register, to be determined by the DSDIVORIDE setting in the **DSLPCLKCFG** register, up to /16 or /64 respectively. When the Deep-Sleep exit event occurs, hardware brings the system clock back to the source and frequency it had at the onset of Deep-Sleep mode before enabling the clocks that had been stopped during the Deep-Sleep duration.

- **Hibernate Mode.** In this mode, the power supplies are turned off to the main part of the device and only the Hibernation module's circuitry is active. An external wake event or RTC event is required to bring the device back to Run mode. The Cortex-M3 processor and peripherals outside of the Hibernation module see a normal "power on" sequence and the processor starts running code. It can determine that it has been restarted from Hibernate mode by inspecting the Hibernation module registers.

---

**Caution – If the Cortex-M3 Debug Access Port (DAP) has been enabled, and the device wakes from a low power sleep or deep-sleep mode, the core may start executing code before all clocks to peripherals have been restored to their run mode configuration. The DAP is usually enabled by software tools accessing the JTAG or SWD interface when debugging or flash programming. If this condition occurs, a Hard Fault is triggered when software accesses a peripheral with an invalid clock.**

**A software delay loop can be used at the beginning of the interrupt routine that is used to wake up a system from a WFI (Wait For Interrupt) instruction. This stalls the execution of any code that accesses a peripheral register that might cause a fault. This loop can be removed for production software as the DAP is most likely not enabled during normal execution.**

**Because the DAP is disabled by default (power on reset), the user can also power-cycle the device. The DAP is not enabled unless it is enabled through the JTAG or SWD interface.**

---

## 5.3 Initialization and Configuration

The PLL is configured using direct register writes to the **RCC**/**RCC2** register. If the **RCC2** register is being used, the USERCC2 bit must be set and the appropriate **RCC2** bit/field is used. The steps required to successfully change the PLL-based system clock are:

1. Bypass the PLL and system clock divider by setting the BYPASS bit and clearing the USESYS bit in the **RCC** register. This configures the system to run off a “raw” clock source and allows for the new PLL configuration to be validated before switching the system clock to the PLL.
2. Select the crystal value (XTAL) and oscillator source (OSCSRC), and clear the PWRDN bit in **RCC**/**RCC2**. Setting the XTAL field automatically pulls valid PLL configuration data for the appropriate crystal, and clearing the PWRDN bit powers and enables the PLL and its output.
3. Select the desired system divider (SYSDIV) in **RCC**/**RCC2** and set the USESYS bit in **RCC**. The SYSDIV field determines the system frequency for the microcontroller.
4. Wait for the PLL to lock by polling the PLLLRIS bit in the **Raw Interrupt Status (RIS)** register.
5. Enable use of the PLL by clearing the BYPASS bit in **RCC**/**RCC2**.

## 5.4 Register Map

Table 5-7 on page 179 lists the System Control registers, grouped by function. The offset listed is a hexadecimal increment to the register's address, relative to the System Control base address of 0x400F.E000.

**Note:** Spaces in the System Control register space that are not used are reserved for future or internal use. Software should not modify any reserved memory address.

**Table 5-7. System Control Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | DID0 | RO | - | Device Identification 0 | 181 |
| 0x004 | DID1 | RO | - | Device Identification 1 | 197 |
| 0x008 | DC0 | RO | 0x00FF.007F | Device Capabilities 0 | 199 |
| 0x010 | DC1 | RO | 0x0010.30DF | Device Capabilities 1 | 200 |
| 0x014 | DC2 | RO | 0x070F.5337 | Device Capabilities 2 | 202 |
| 0x018 | DC3 | RO | 0xBF00.FFFF | Device Capabilities 3 | 204 |
| 0x01C | DC4 | RO | 0x0000.C0FF | Device Capabilities 4 | 206 |
| 0x030 | PBORCTL | R/W | 0x0000.7FFD | Brown-Out Reset Control | 183 |
| 0x034 | LDOPCTL | R/W | 0x0000.0000 | LDO Power Control | 184 |
| 0x040 | SRCR0 | R/W | 0x00000000 | Software Reset Control 0 | 229 |
| 0x044 | SRCR1 | R/W | 0x00000000 | Software Reset Control 1 | 230 |
| 0x048 | SRCR2 | R/W | 0x00000000 | Software Reset Control 2 | 232 |
| 0x050 | RIS | RO | 0x0000.0000 | Raw Interrupt Status | 185 |
| 0x054 | IMC | R/W | 0x0000.0000 | Interrupt Mask Control | 186 |
| 0x058 | MISC | R/W1C | 0x0000.0000 | Masked Interrupt Status and Clear | 187 |
| 0x05C | RESC | R/W | - | Reset Cause | 188 |
| 0x060 | RCC | R/W | 0x078E.3AD1 | Run-Mode Clock Configuration | 189 |
| 0x064 | PLLCFG | RO | - | XTAL to PLL Translation | 193 |
| 0x070 | RCC2 | R/W | 0x0780.2810 | Run-Mode Clock Configuration 2 | 194 |
| 0x100 | RCGC0 | R/W | 0x00000040 | Run Mode Clock Gating Control Register 0 | 208 |
| 0x104 | RCGC1 | R/W | 0x00000000 | Run Mode Clock Gating Control Register 1 | 214 |
| 0x108 | RCGC2 | R/W | 0x00000000 | Run Mode Clock Gating Control Register 2 | 223 |
| 0x110 | SCGC0 | R/W | 0x00000040 | Sleep Mode Clock Gating Control Register 0 | 210 |
| 0x114 | SCGC1 | R/W | 0x00000000 | Sleep Mode Clock Gating Control Register 1 | 217 |
| 0x118 | SCGC2 | R/W | 0x00000000 | Sleep Mode Clock Gating Control Register 2 | 225 |
| 0x120 | DCGC0 | R/W | 0x00000040 | Deep Sleep Mode Clock Gating Control Register 0 | 212 |
| 0x124 | DCGC1 | R/W | 0x00000000 | Deep Sleep Mode Clock Gating Control Register 1 | 220 |
| 0x128 | DCGC2 | R/W | 0x00000000 | Deep Sleep Mode Clock Gating Control Register 2 | 227 |
| 0x144 | DSLPCLKCFG | R/W | 0x0780.0000 | Deep Sleep Clock Configuration | 196 |

## 5.5 Register Descriptions

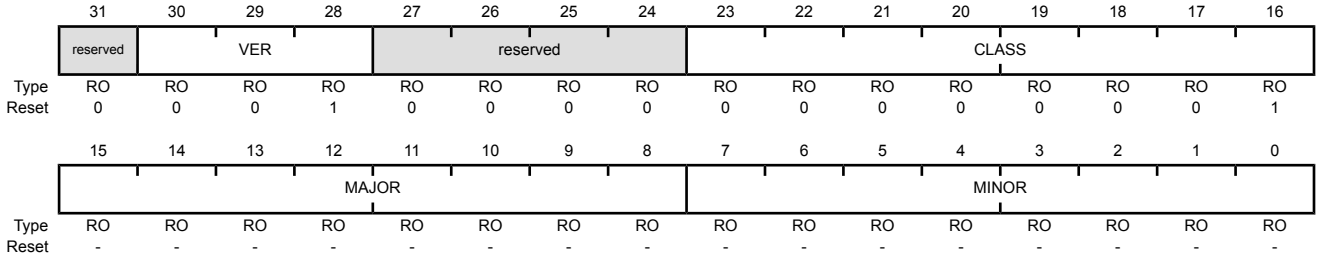
All addresses given are relative to the System Control base address of 0x400F.E000.

## Register 1: Device Identification 0 (DID0), offset 0x000

This register identifies the version of the microcontroller. Each microcontroller is uniquely identified by the combined values of the CLASS field in the **DID0** register and the PARTNO field in the **DID1** register.

Device Identification 0 (DID0)

Base 0x400F.E000
Offset 0x000
Type RO, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 30:28 | VER | RO | 0x1 | DID0 Version<br>This field defines the **DID0** register format version. The version number is numeric. The value of the VER field is encoded as follows:<br>Value Description<br>0x1 Second version of the **DID0** register format. |
| 27:24 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 23:16 | CLASS | RO | 0x1 | Device Class<br>The CLASS field value identifies the internal design from which all mask sets are generated for all devices in a particular product line. The CLASS field value is changed for new product lines, for changes in fab process (for example, a remap or shrink), or any case where the MAJOR or MINOR fields require differentiation from prior devices. The value of the CLASS field is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x1 Stellaris® Fury-class devices. |

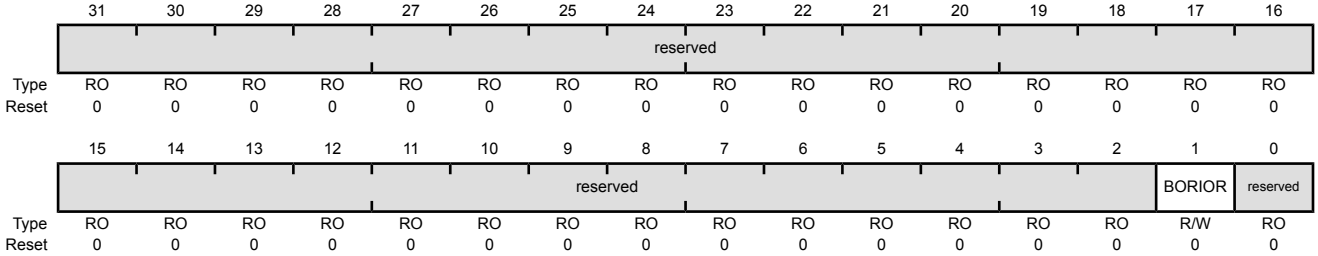
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 15:8 | MAJOR | RO | - | Major Revision<br>This field specifies the major revision number of the device. The major revision reflects changes to base layers of the design. The major revision number is indicated in the part number as a letter (A for first revision, B for second, and so on). This field is encoded as follows:<br><br>Value Description<br>0x0 Revision A (initial device)<br>0x1 Revision B (first base layer revision)<br>0x2 Revision C (second base layer revision)<br><br>and so on. |
| 7:0 | MINOR | RO | - | Minor Revision<br>This field specifies the minor revision number of the device. The minor revision reflects changes to the metal layers of the design. The MINOR field value is reset when the MAJOR field is changed. This field is numeric and is encoded as follows:<br><br>Value Description<br>0x0 Initial device, or a major revision update.<br>0x1 First metal layer change.<br>0x2 Second metal layer change.<br><br>and so on. |

## Register 2: Brown-Out Reset Control (PBORCTL), offset 0x030

This register is responsible for controlling reset conditions after initial power-on reset.

Brown-Out Reset Control (PBORCTL)

Base 0x400F.E000
Offset 0x030
Type R/W, reset 0x0000.7FFD



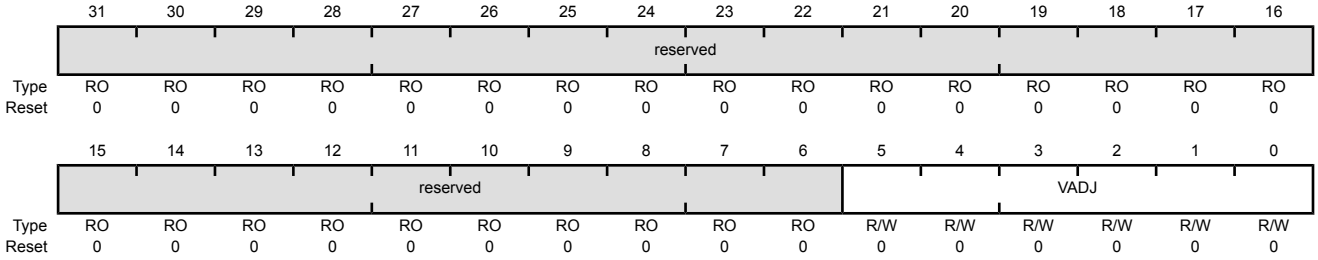

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | BORIOR | R/W | 0 | BOR Interrupt or Reset<br>This bit controls how a BOR event is signaled to the controller. If set, a reset is signaled. Otherwise, an interrupt is signaled. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 3: LDO Power Control (LDOPCTL), offset 0x034

The VADJ field in this register adjusts the on-chip output voltage ($V_{OUT}$).

LDO Power Control (LDOPCTL)

Base 0x400F.E000
Offset 0x034
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5:0 | VADJ | R/W | 0x0 | LDO Output Voltage<br>This field sets the on-chip output voltage. The programming values for the VADJ field are provided below. |

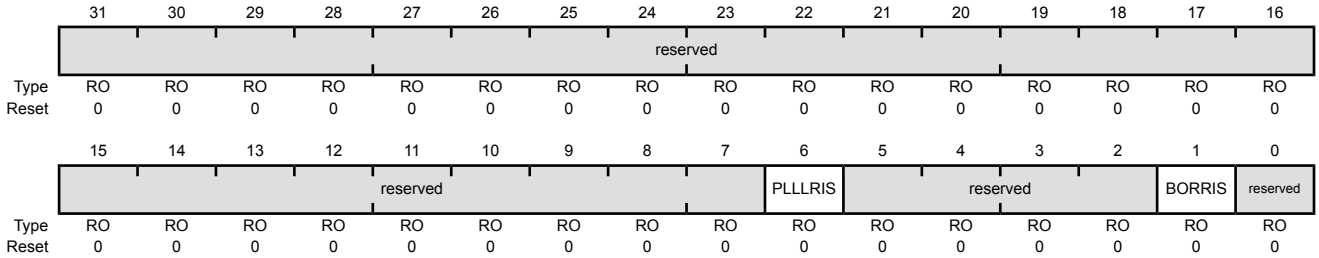
| Value | $V_{OUT}$ (V) |
|---|---|
| 0x00 | 2.50 |
| 0x01 | 2.45 |
| 0x02 | 2.40 |
| 0x03 | 2.35 |
| 0x04 | 2.30 |
| 0x05 | 2.25 |
| 0x06-0x3F | Reserved |
| 0x1B | 2.75 |
| 0x1C | 2.70 |
| 0x1D | 2.65 |
| 0x1E | 2.60 |
| 0x1F | 2.55 |

## Register 4: Raw Interrupt Status (RIS), offset 0x050

Central location for system control raw interrupts. These are set and cleared by hardware.

Raw Interrupt Status (RIS)

Base 0x400F.E000
Offset 0x050
Type RO, reset 0x0000.0000



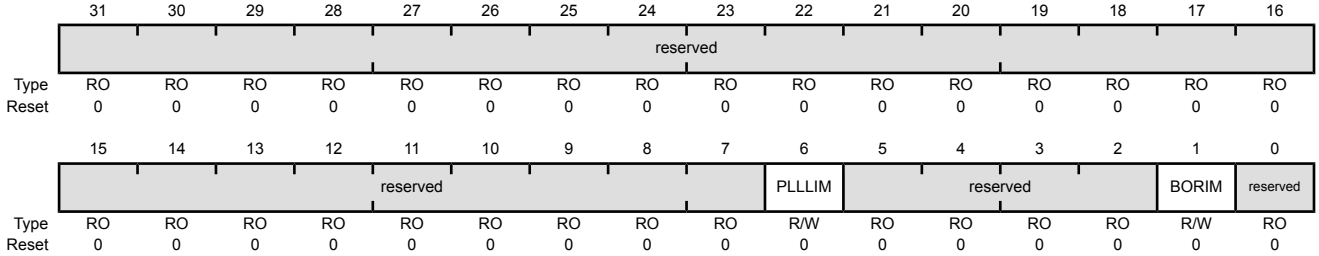

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | PLLLRIS | RO | 0 | PLL Lock Raw Interrupt Status<br>This bit is set when the PLL $T_{READY}$ Timer asserts. |
| 5:2 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | BORRIS | RO | 0 | Brown-Out Reset Raw Interrupt Status<br>This bit is the raw interrupt status for any brown-out conditions. If set, a brown-out condition is currently active. This is an unregistered signal from the brown-out detection circuit. An interrupt is reported if the BORIM bit in the **IMC** register is set and the BORIOR bit in the **PBORCTL** register is cleared. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 5: Interrupt Mask Control (IMC), offset 0x054

Central location for system control interrupt masks.

Interrupt Mask Control (IMC)

Base 0x400F.E000
Offset 0x054
Type R/W, reset 0x0000.0000



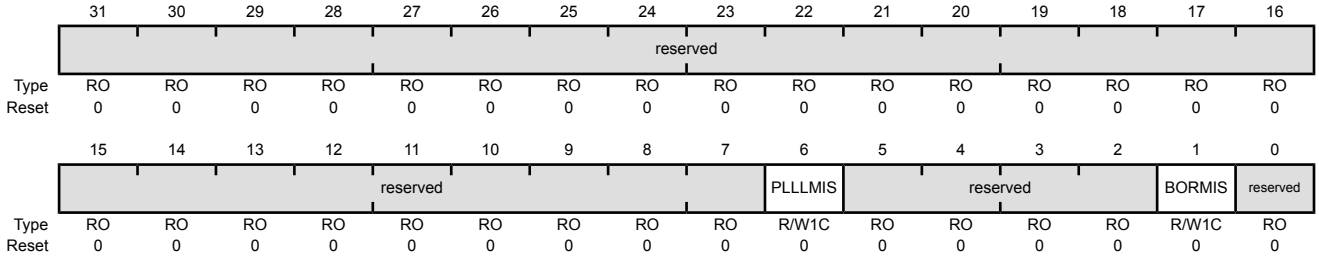

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | PLLLIM | R/W | 0 | PLL Lock Interrupt Mask<br>This bit specifies whether a PLL Lock interrupt is promoted to a controller interrupt. If set, an interrupt is generated if `PLLLRIS` in **RIS** is set; otherwise, an interrupt is not generated. |
| 5:2 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | BORIM | R/W | 0 | Brown-Out Reset Interrupt Mask<br>This bit specifies whether a brown-out condition is promoted to a controller interrupt. If set, an interrupt is generated if `BORRIS` is set; otherwise, an interrupt is not generated. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 6: Masked Interrupt Status and Clear (MISC), offset 0x058

On a read, this register gives the current masked status value of the corresponding interrupt. All of the bits are R/W1C and this action also clears the corresponding raw interrupt bit in the **RIS** register (see page 185).

Masked Interrupt Status and Clear (MISC)

Base 0x400F.E000
Offset 0x058
Type R/W1C, reset 0x0000.0000



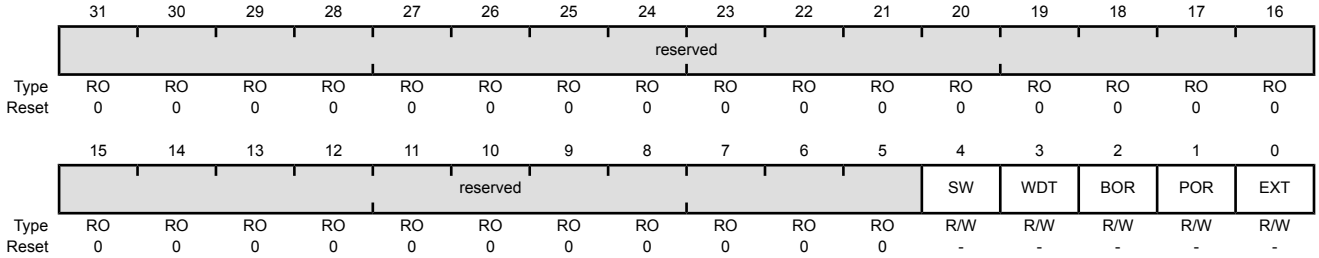

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | PLLLMIS | R/W1C | 0 | PLL Lock Masked Interrupt Status<br>This bit is set when the PLL $T_{READY}$ timer asserts. The interrupt is cleared by writing a 1 to this bit. |
| 5:2 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | BORMIS | R/W1C | 0 | BOR Masked Interrupt Status<br>The `BORMIS` is simply the `BORRIS` ANDed with the mask value, `BORIM`. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 7: Reset Cause (RESC), offset 0x05C

This register is set with the reset cause after reset. The bits in this register are sticky and maintain their state across multiple reset sequences, except when an power-on reset is the cause, in which case, all bits other than POR in the **RESC** register are cleared.

Reset Cause (RESC)

Base 0x400F.E000
Offset 0x05C
Type R/W, reset -



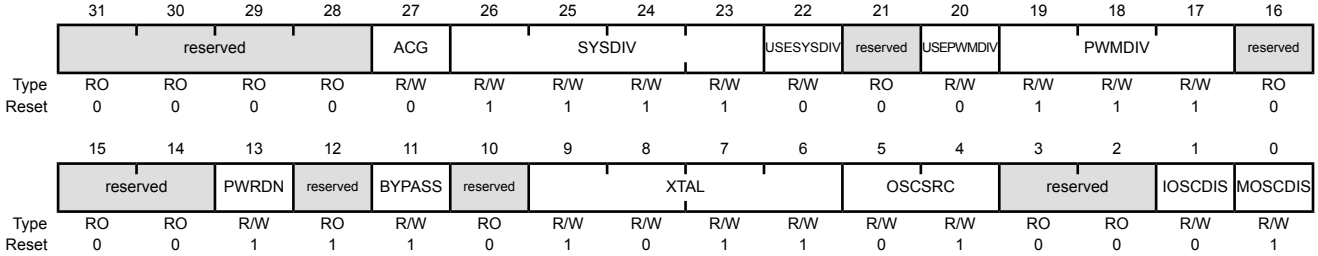

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:5 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | SW | R/W | - | Software Reset<br>When set, indicates a software reset is the cause of the reset event. |
| 3 | WDT | R/W | - | Watchdog Timer Reset<br>When set, indicates a watchdog reset is the cause of the reset event. |
| 2 | BOR | R/W | - | Brown-Out Reset<br>When set, indicates a brown-out reset is the cause of the reset event. |
| 1 | POR | R/W | - | Power-On Reset<br>When set, indicates a power-on reset is the cause of the reset event. |
| 0 | EXT | R/W | - | External Reset<br>When set, indicates an external reset ($\overline{\text{RST}}$ assertion) is the cause of the reset event. |

## Register 8: Run-Mode Clock Configuration (RCC), offset 0x060

This register is defined to provide source control and frequency speed.

Run-Mode Clock Configuration (RCC)

Base 0x400F.E000
Offset 0x060
Type R/W, reset 0x078E.3AD1




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:28 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 27 | ACG | R/W | 0 | Auto Clock Gating<br>This bit specifies whether the system uses the **Sleep-Mode Clock Gating Control (SCGCn)** registers and **Deep-Sleep-Mode Clock Gating Control (DCGCn)** registers if the controller enters a Sleep or Deep-Sleep mode (respectively). If set, the **SCGCn** or **DCGCn** registers are used to control the clocks distributed to the peripherals when the controller is in a sleep mode. Otherwise, the **Run-Mode Clock Gating Control (RCGCn)** registers are used when the controller enters a sleep mode.<br>The **RCGCn** registers are always used to control the clocks in Run mode.<br>This allows peripherals to consume less power when the controller is in a sleep mode and the peripheral is unused. |
| 26:23 | SYSDIV | R/W | 0xF | System Clock Divisor<br>Specifies which divisor is used to generate the system clock from either the PLL output or the oscillator source (depending on how the BYPASS bit in this register is configured). See Table 5-5 on page 175 for bit encodings.<br>If the SYSDIV value is less than MINSYSDIV (see page 200), and the PLL is being used, then the MINSYSDIV value is used as the divisor.<br>If the PLL is not being used, the SYSDIV value can be less than MINSYSDIV. |
| 22 | USESYSDIV | R/W | 0 | Enable System Clock Divider<br>Use the system clock divider as the source for the system clock. The system clock divider is forced to be used when the PLL is selected as the source.<br>If the USERCC2 bit in the **RCC2** register is set, then the SYSDIV2 field in the **RCC2** register is used as the system clock divider rather than the SYSDIV field in this register. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 21 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 20 | USEPWMDIV | R/W | 0 | Enable PWM Clock Divisor<br>Use the PWM clock divider as the source for the PWM clock. |
| 19:17 | PWMDIV | R/W | 0x7 | PWM Unit Clock Divisor<br>This field specifies the binary divisor used to predivide the system clock down for use as the timing reference for the PWM module. This clock is only power 2 divide and rising edge is synchronous without phase shift from the system clock.<br>Value Divisor<br>0x0 /2<br>0x1 /4<br>0x2 /8<br>0x3 /16<br>0x4 /32<br>0x5 /64<br>0x6 /64<br>0x7 /64 (default) |
| 16:14 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 13 | PWRDN | R/W | 1 | PLL Power Down<br>This bit connects to the PLL PWRDN input. The reset value of 1 powers down the PLL. |
| 12 | reserved | RO | 1 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11 | BYPASS | R/W | 1 | PLL Bypass<br>Chooses whether the system clock is derived from the PLL output or the OSC source. If set, the clock that drives the system is the OSC source. Otherwise, the clock that drives the system is the PLL output clock divided by the system divider.<br>See Table 5-5 on page 175 for programming guidelines. |
| 10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 9:6 | XTAL | R/W | 0xB | Crystal Value<br>This field specifies the crystal value attached to the main oscillator. The encoding for this field is provided below. Depending on the crystal used, the PLL frequency may not be exactly 400 MHz (see Table 20-9 on page 613 for more information).<br>Value / Crystal Frequency (MHz) Not Using the PLL / Crystal Frequency (MHz) Using the PLL<br>0x0 — 1.000 — reserved<br>0x1 — 1.8432 — reserved<br>0x2 — 2.000 — reserved<br>0x3 — 2.4576 — reserved<br>0x4 — 3.579545 MHz<br>0x5 — 3.6864 MHz<br>0x6 — 4 MHz<br>0x7 — 4.096 MHz<br>0x8 — 4.9152 MHz<br>0x9 — 5 MHz<br>0xA — 5.12 MHz<br>0xB — 6 MHz (reset value)<br>0xC — 6.144 MHz<br>0xD — 7.3728 MHz<br>0xE — 8 MHz<br>0xF — 8.192 MHz |
| 5:4 | OSCSRC | R/W | 0x1 | Oscillator Source<br>Selects the input source for the OSC. The values are:<br>Value / Input Source<br>0x0 — MOSC — Main oscillator<br>0x1 — IOSC — Internal oscillator (default)<br>0x2 — IOSC/4 — Internal oscillator / 4<br>0x3 — 30 kHz — 30-KHz internal oscillator<br>For additional oscillator sources, see the **RCC2** register. |
| 3:2 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | IOSCDIS | R/W | 0 | Internal Oscillator Disable<br>0: Internal oscillator (IOSC) is enabled.<br>1: Internal oscillator is disabled. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | MOSCDIS | R/W | 1 | Main Oscillator Disable<br>0: Main oscillator is enabled .<br>1: Main oscillator is disabled (default). |

## Register 9: XTAL to PLL Translation (PLLCFG), offset 0x064

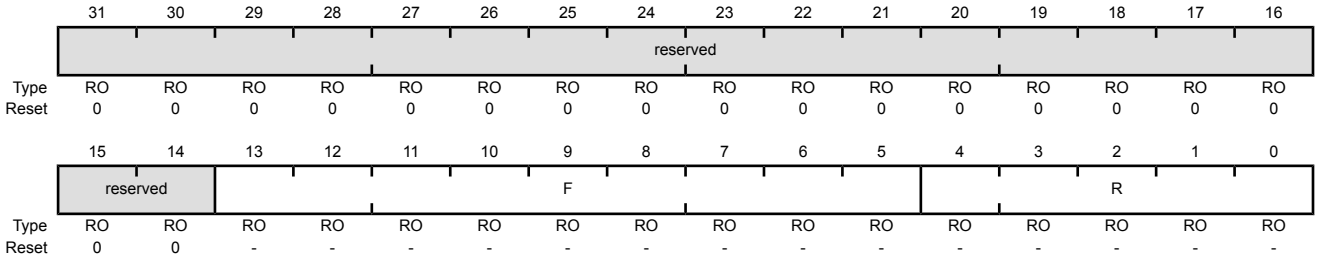
This register provides a means of translating external crystal frequencies into the appropriate PLL settings. This register is initialized during the reset sequence and updated anytime that the XTAL field changes in the **Run-Mode Clock Configuration (RCC)** register (see page 189).

The PLL frequency is calculated using the **PLLCFG** field values, as follows:

```
PLLFreq = OSCFreq * F / (R + 1)
```

XTAL to PLL Translation (PLLCFG)

Base 0x400F.E000
Offset 0x064
Type RO, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:14 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 13:5 | F | RO | - | PLL F Value<br>This field specifies the value supplied to the PLL's F input. |
| 4:0 | R | RO | - | PLL R Value<br>This field specifies the value supplied to the PLL's R input. |

## Register 10: Run-Mode Clock Configuration 2 (RCC2), offset 0x070

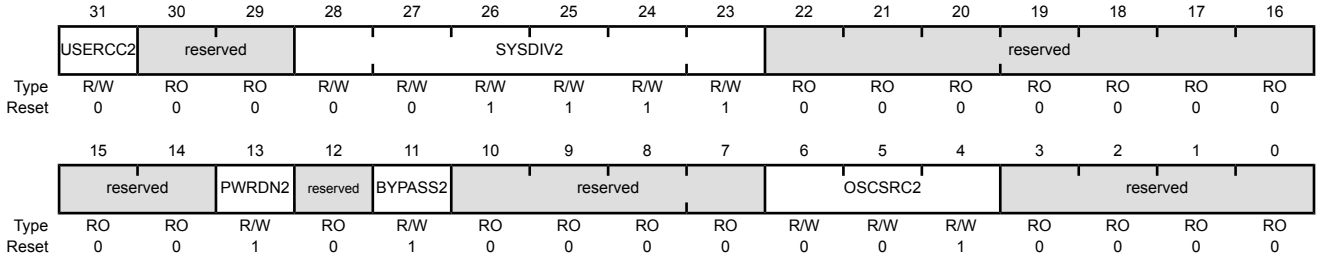
This register overrides the **RCC** equivalent register fields, as shown in Table 5-8, when the USERCC2 bit is set, allowing the extended capabilities of the **RCC2** register to be used while also providing a means to be backward-compatible to previous parts. Each **RCC2** field that supersedes an **RCC** field is located at the same LSB bit position; however, some **RCC2** fields are larger than the corresponding **RCC** field.

**Table 5-8. RCC2 Fields that Override RCC fields**

| RCC2 Field... | Overrides RCC Field |
|---|---|
| SYSDIV2, bits[28:23] | SYSDIV, bits[26:23] |
| PWRDN2, bit[13] | PWRDN, bit[13] |
| BYPASS2, bit[11] | BYPASS, bit[11] |
| OSCSRC2, bits[6:4] | OSCSRC, bits[5:4] |

Run-Mode Clock Configuration 2 (RCC2)

Base 0x400F.E000
Offset 0x070
Type R/W, reset 0x0780.2810




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | USERCC2 | R/W | 0 | Use RCC2<br>When set, overrides the **RCC** register fields. |
| 30:29 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 28:23 | SYSDIV2 | R/W | 0x0F | System Clock Divisor<br>Specifies which divisor is used to generate the system clock from either the PLL output or the oscillator source (depending on how the BYPASS2 bit is configured). SYSDIV2 is used for the divisor when both the USESYSDIV bit in the **RCC** register and the USERCC2 bit in this register are set. See Table 5-6 on page 175 for programming guidelines. |
| 22:14 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 13 | PWRDN2 | R/W | 1 | Power-Down PLL<br>When set, powers down the PLL. |
| 12 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

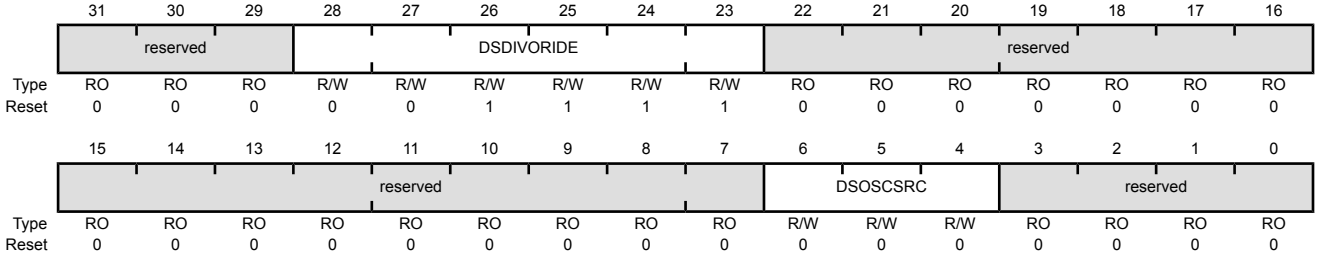
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 11 | BYPASS2 | R/W | 1 | Bypass PLL<br>When set, bypasses the PLL for the clock source.<br>See Table 5-6 on page 175 for programming guidelines. |
| 10:7 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6:4 | OSCSRC2 | R/W | 0x1 | Oscillator Source<br>Selects the input source for the OSC. The values are:<br>Value Description<br>0x0 MOSC<br>Main oscillator<br>0x1 IOSC<br>Internal oscillator<br>0x2 IOSC/4<br>Internal oscillator / 4<br>0x3 30 kHz<br>30-kHz internal oscillator<br>0x4 Reserved<br>0x5 Reserved<br>0x6 Reserved<br>0x7 32 kHz<br>32.768-kHz external oscillator |
| 3:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 11: Deep Sleep Clock Configuration (DSLPCLKCFG), offset 0x144

This register provides configuration information for the hardware control of Deep Sleep Mode.

Deep Sleep Clock Configuration (DSLPCLKCFG)

Base 0x400F.E000
Offset 0x144
Type R/W, reset 0x0780.0000



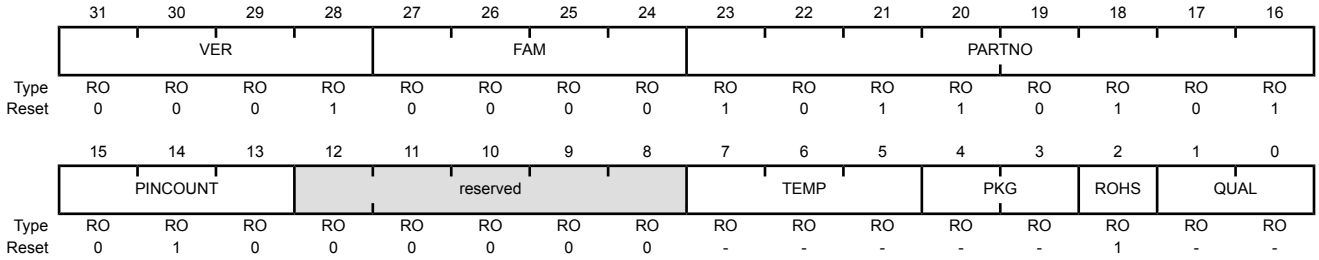

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:29 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 28:23 | DSDIVORIDE | R/W | 0x0F | Divider Field Override<br>6-bit system divider field to override when Deep-Sleep occurs with PLL running. |
| 22:7 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6:4 | DSOSCSRC | R/W | 0x0 | Clock Source<br>Specifies the clock source during Deep-Sleep mode.<br>Value Description<br>0x0 MOSC<br>Use main oscillator as source.<br>0x1 IOSC<br>Use internal 12-MHz oscillator as source.<br>0x2 Reserved<br>0x3 30 kHz<br>Use 30-kHz internal oscillator as source.<br>0x4 Reserved<br>0x5 Reserved<br>0x6 Reserved<br>0x7 32 kHz<br>Use 32.768-kHz external oscillator as source. |
| 3:0 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 12: Device Identification 1 (DID1), offset 0x004

This register identifies the device family, part number, temperature range, pin count, and package type. Each microcontroller is uniquely identified by the combined values of the CLASS field in the **DID0** register and the PARTNO field in the **DID1** register.

Device Identification 1 (DID1)

Base 0x400F.E000
Offset 0x004
Type RO, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:28 | VER | RO | 0x1 | DID1 Version<br>This field defines the **DID1** register format version. The version number is numeric. The value of the VER field is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x1 Second version of the **DID1** register format. |
| 27:24 | FAM | RO | 0x0 | Family<br>This field provides the family identification of the device within the Luminary Micro product portfolio. The value is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x0 Stellaris family of microcontollers, that is, all devices with external part numbers starting with LM3S. |
| 23:16 | PARTNO | RO | 0xB5 | Part Number<br>This field provides the part number of the device within the family. The value is encoded as follows (all other encodings are reserved):<br>Value Description<br>0xB5 LM3S1960 |
| 15:13 | PINCOUNT | RO | 0x2 | Package Pin Count<br>This field specifies the number of pins on the device package. The value is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x2 100-pin or 108-ball package |

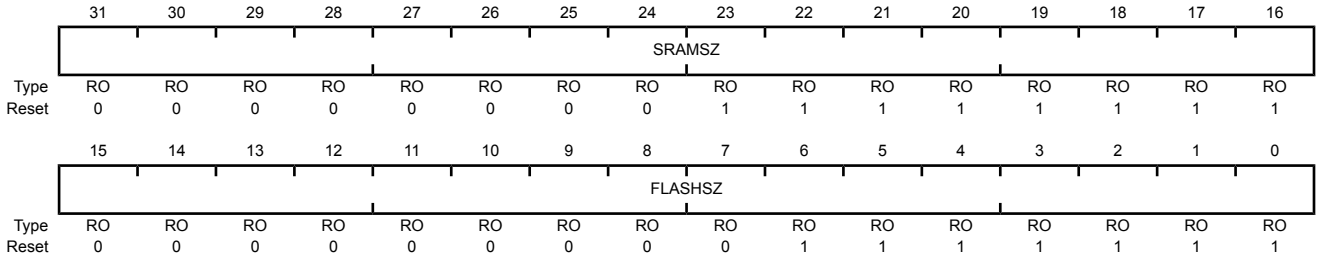
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 12:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:5 | TEMP | RO | - | Temperature Range<br>This field specifies the temperature rating of the device. The value is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x0 Commercial temperature range (0°C to 70°C)<br>0x1 Industrial temperature range (-40°C to 85°C)<br>0x2 Extended temperature range (-40°C to 105°C) |
| 4:3 | PKG | RO | - | Package Type<br>This field specifies the package type. The value is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x0 SOIC package<br>0x1 LQFP package<br>0x2 BGA package |
| 2 | ROHS | RO | 1 | RoHS-Compliance<br>This bit specifies whether the device is RoHS-compliant. A 1 indicates the part is RoHS-compliant. |
| 1:0 | QUAL | RO | - | Qualification Status<br>This field specifies the qualification status of the device. The value is encoded as follows (all other encodings are reserved):<br>Value Description<br>0x0 Engineering Sample (unqualified)<br>0x1 Pilot Production (unqualified)<br>0x2 Fully Qualified |

## Register 13: Device Capabilities 0 (DC0), offset 0x008

This register is predefined by the part and can be used to verify features.

Device Capabilities 0 (DC0)

Base 0x400F.E000
Offset 0x008
Type RO, reset 0x00FF.007F



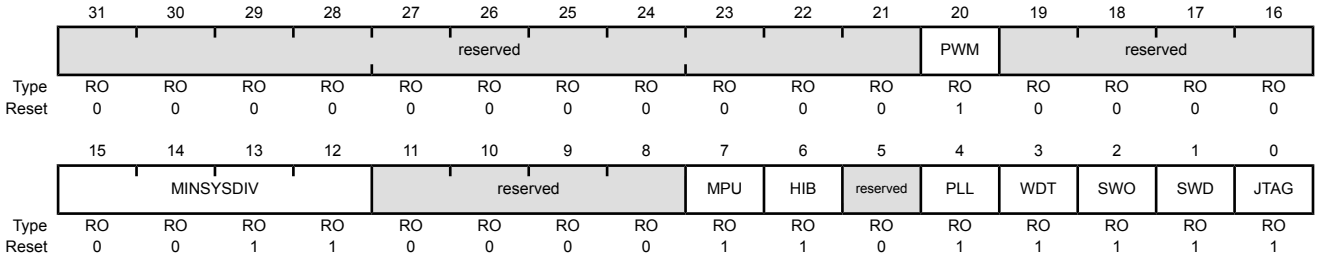

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | SRAMSZ | RO | 0x00FF | SRAM Size<br>Indicates the size of the on-chip SRAM memory.<br><br>Value Description<br>0x00FF 64 KB of SRAM |
| 15:0 | FLASHSZ | RO | 0x007F | Flash Size<br>Indicates the size of the on-chip flash memory.<br><br>Value Description<br>0x007F 256 KB of Flash |

## Register 14: Device Capabilities 1 (DC1), offset 0x010

This register provides a list of features available in the system. The Stellaris family uses this register format to indicate the availability of the following family features in the specific device: CANs, PWM, ADC, Watchdog timer, Hibernation module, and debug capabilities. This register also indicates the maximum clock frequency and maximum ADC sample rate. The format of this register is consistent with the **RCGC0**, **SCGC0**, and **DCGC0** clock control registers and the **SRCR0** software reset control register.

Device Capabilities 1 (DC1)

Base 0x400F.E000
Offset 0x010
Type RO, reset 0x0010.30DF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:21 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 20 | PWM | RO | 1 | PWM Module Present<br>When set, indicates that the PWM module is present. |
| 19:16 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:12 | MINSYSDIV | RO | 0x3 | System Clock Divider<br>Minimum 4-bit divider value for system clock. The reset value is hardware-dependent. See the **RCC** register for how to change the system clock divisor using the SYSDIV bit.<br>Value Description<br>0x3 Specifies a 50-MHz CPU clock with a PLL divider of 4. |
| 11:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | MPU | RO | 1 | MPU Present<br>When set, indicates that the Cortex-M3 Memory Protection Unit (MPU) module is present. See the "Cortex-M3 Peripherals" chapter in the Stellaris Data Sheet for details on the MPU. |
| 6 | HIB | RO | 1 | Hibernation Module Present<br>When set, indicates that the Hibernation module is present. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 5 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | PLL | RO | 1 | PLL Present<br>When set, indicates that the on-chip Phase Locked Loop (PLL) is present. |
| 3 | WDT | RO | 1 | Watchdog Timer Present<br>When set, indicates that a watchdog timer is present. |
| 2 | SWO | RO | 1 | SWO Trace Port Present<br>When set, indicates that the Serial Wire Output (SWO) trace port is present. |
| 1 | SWD | RO | 1 | SWD Present<br>When set, indicates that the Serial Wire Debugger (SWD) is present. |
| 0 | JTAG | RO | 1 | JTAG Present<br>When set, indicates that the JTAG debugger interface is present. |

## Register 15: Device Capabilities 2 (DC2), offset 0x014

This register provides a list of features available in the system. The Stellaris family uses this register format to indicate the availability of the following family features in the specific device: Analog Comparators, General-Purpose Timers, I2Cs, QEIs, SSIs, and UARTs. The format of this register is consistent with the **RCGC1**, **SCGC1**, and **DCGC1** clock control registers and the **SRCR1** software reset control register.

Device Capabilities 2 (DC2)

Base 0x400F.E000
Offset 0x014
Type RO, reset 0x070F.5337

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | COMP2 | COMP1 | COMP0 | reserved | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | I2C1 | reserved | I2C0 | reserved | | QEI1 | QEI0 | reserved | | SSI1 | SSI0 | reserved | UART2 | UART1 | UART0 |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:27 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 26 | COMP2 | RO | 1 | Analog Comparator 2 Present<br>When set, indicates that analog comparator 2 is present. |
| 25 | COMP1 | RO | 1 | Analog Comparator 1 Present<br>When set, indicates that analog comparator 1 is present. |
| 24 | COMP0 | RO | 1 | Analog Comparator 0 Present<br>When set, indicates that analog comparator 0 is present. |
| 23:20 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 19 | TIMER3 | RO | 1 | Timer 3 Present<br>When set, indicates that General-Purpose Timer module 3 is present. |
| 18 | TIMER2 | RO | 1 | Timer 2 Present<br>When set, indicates that General-Purpose Timer module 2 is present. |
| 17 | TIMER1 | RO | 1 | Timer 1 Present<br>When set, indicates that General-Purpose Timer module 1 is present. |
| 16 | TIMER0 | RO | 1 | Timer 0 Present<br>When set, indicates that General-Purpose Timer module 0 is present. |
| 15 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 14 | I2C1 | RO | 1 | I2C Module 1 Present<br>When set, indicates that I2C module 1 is present. |
| 13 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 12 | I2C0 | RO | 1 | I2C Module 0 Present<br>When set, indicates that I2C module 0 is present. |
| 11:10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | QEI1 | RO | 1 | QEI1 Present<br>When set, indicates that QEI module 1 is present. |
| 8 | QEI0 | RO | 1 | QEI0 Present<br>When set, indicates that QEI module 0 is present. |
| 7:6 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | SSI1 | RO | 1 | SSI1 Present<br>When set, indicates that SSI module 1 is present. |
| 4 | SSI0 | RO | 1 | SSI0 Present<br>When set, indicates that SSI module 0 is present. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | UART2 | RO | 1 | UART2 Present<br>When set, indicates that UART module 2 is present. |
| 1 | UART1 | RO | 1 | UART1 Present<br>When set, indicates that UART module 1 is present. |
| 0 | UART0 | RO | 1 | UART0 Present<br>When set, indicates that UART module 0 is present. |

## Register 16: Device Capabilities 3 (DC3), offset 0x018

This register provides a list of features available in the system. The Stellaris family uses this register format to indicate the availability of the following family features in the specific device: Analog Comparator I/Os, CCP I/Os, ADC I/Os, and PWM I/Os.

Device Capabilities 3 (DC3)

Base 0x400F.E000
Offset 0x018
Type RO, reset 0xBF00.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 32KHZ | reserved | CCP5 | CCP4 | CCP3 | CCP2 | CCP1 | CCP0 | reserved | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PWMFAULT | C2O | C2PLUS | C2MINUS | C1O | C1PLUS | C1MINUS | C0O | C0PLUS | C0MINUS | PWM5 | PWM4 | PWM3 | PWM2 | PWM1 | PWM0 |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | 32KHZ | RO | 1 | 32KHz Input Clock Available<br>When set, indicates an even CCP pin is present and can be used as a 32-KHz input clock. |
| 30 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 29 | CCP5 | RO | 1 | CCP5 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 5 is present. |
| 28 | CCP4 | RO | 1 | CCP4 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 4 is present. |
| 27 | CCP3 | RO | 1 | CCP3 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 3 is present. |
| 26 | CCP2 | RO | 1 | CCP2 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 2 is present. |
| 25 | CCP1 | RO | 1 | CCP1 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 1 is present. |
| 24 | CCP0 | RO | 1 | CCP0 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 0 is present. |
| 23:16 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15 | PWMFAULT | RO | 1 | PWM Fault Pin Present<br>When set, indicates that the PWM Fault pin is present. |
| 14 | C2O | RO | 1 | C2o Pin Present<br>When set, indicates that the analog comparator 2 output pin is present. |

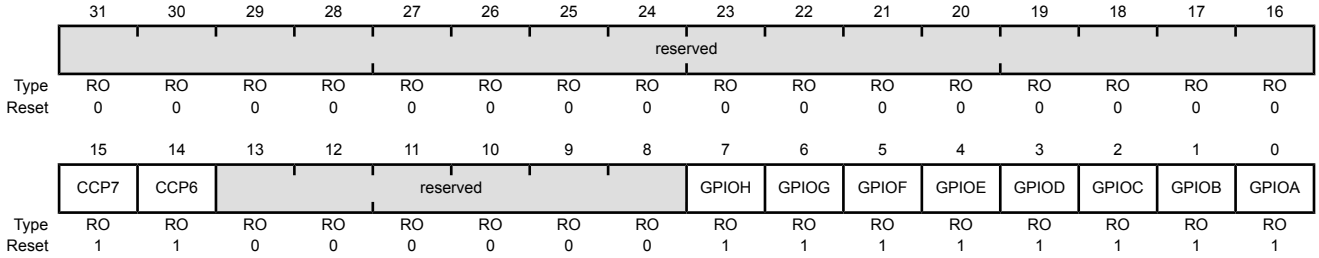
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 13 | C2PLUS | RO | 1 | C2+ Pin Present<br>When set, indicates that the analog comparator 2 (+) input pin is present. |
| 12 | C2MINUS | RO | 1 | C2- Pin Present<br>When set, indicates that the analog comparator 2 (-) input pin is present. |
| 11 | C1O | RO | 1 | C1o Pin Present<br>When set, indicates that the analog comparator 1 output pin is present. |
| 10 | C1PLUS | RO | 1 | C1+ Pin Present<br>When set, indicates that the analog comparator 1 (+) input pin is present. |
| 9 | C1MINUS | RO | 1 | C1- Pin Present<br>When set, indicates that the analog comparator 1 (-) input pin is present. |
| 8 | C0O | RO | 1 | C0o Pin Present<br>When set, indicates that the analog comparator 0 output pin is present. |
| 7 | C0PLUS | RO | 1 | C0+ Pin Present<br>When set, indicates that the analog comparator 0 (+) input pin is present. |
| 6 | C0MINUS | RO | 1 | C0- Pin Present<br>When set, indicates that the analog comparator 0 (-) input pin is present. |
| 5 | PWM5 | RO | 1 | PWM5 Pin Present<br>When set, indicates that the PWM pin 5 is present. |
| 4 | PWM4 | RO | 1 | PWM4 Pin Present<br>When set, indicates that the PWM pin 4 is present. |
| 3 | PWM3 | RO | 1 | PWM3 Pin Present<br>When set, indicates that the PWM pin 3 is present. |
| 2 | PWM2 | RO | 1 | PWM2 Pin Present<br>When set, indicates that the PWM pin 2 is present. |
| 1 | PWM1 | RO | 1 | PWM1 Pin Present<br>When set, indicates that the PWM pin 1 is present. |
| 0 | PWM0 | RO | 1 | PWM0 Pin Present<br>When set, indicates that the PWM pin 0 is present. |

## Register 17: Device Capabilities 4 (DC4), offset 0x01C

This register provides a list of features available in the system. The Stellaris family uses this register format to indicate the availability of the following family features in the specific device: Ethernet MAC and PHY, GPIOs, and CCP I/Os. The format of this register is consistent with the **RCGC2**, **SCGC2**, and **DCGC2** clock control registers and the **SRCR2** software reset control register.

Device Capabilities 4 (DC4)

Base 0x400F.E000
Offset 0x01C
Type RO, reset 0x0000.C0FF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15 | CCP7 | RO | 1 | CCP7 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 7 is present. |
| 14 | CCP6 | RO | 1 | CCP6 Pin Present<br>When set, indicates that Capture/Compare/PWM pin 6 is present. |
| 13:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | GPIOH | RO | 1 | GPIO Port H Present<br>When set, indicates that GPIO Port H is present. |
| 6 | GPIOG | RO | 1 | GPIO Port G Present<br>When set, indicates that GPIO Port G is present. |
| 5 | GPIOF | RO | 1 | GPIO Port F Present<br>When set, indicates that GPIO Port F is present. |
| 4 | GPIOE | RO | 1 | GPIO Port E Present<br>When set, indicates that GPIO Port E is present. |
| 3 | GPIOD | RO | 1 | GPIO Port D Present<br>When set, indicates that GPIO Port D is present. |
| 2 | GPIOC | RO | 1 | GPIO Port C Present<br>When set, indicates that GPIO Port C is present. |
| 1 | GPIOB | RO | 1 | GPIO Port B Present<br>When set, indicates that GPIO Port B is present. |

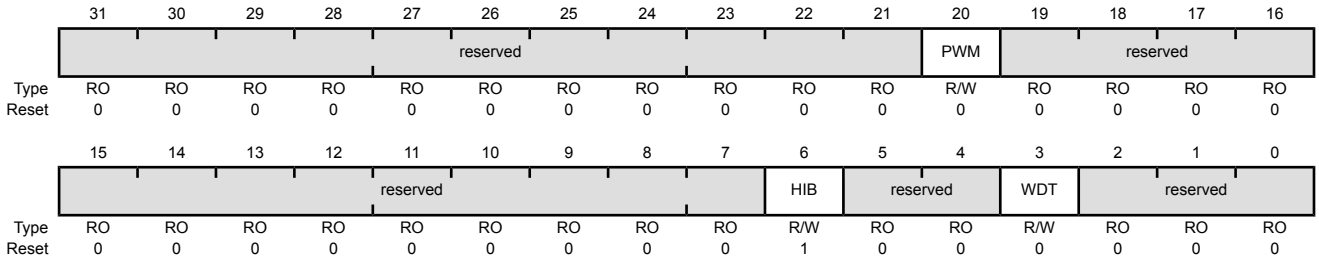
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | GPIOA | RO | 1 | GPIO Port A Present<br>When set, indicates that GPIO Port A is present. |

## Register 18: Run Mode Clock Gating Control Register 0 (RCGC0), offset 0x100

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC0** is the clock configuration register for running operation, **SCGC0** for Sleep operation, and **DCGC0** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Run Mode Clock Gating Control Register 0 (RCGC0)

Base 0x400F.E000
Offset 0x100
Type R/W, reset 0x00000040




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:21 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 20 | PWM | R/W | 0 | PWM Clock Gating Control<br>This bit controls the clock gating for the PWM module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, a read or write to the unit generates a bus fault. |
| 19:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | HIB | R/W | 1 | HIB Clock Gating Control<br>This bit controls the clock gating for the Hibernation module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. |
| 5:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | WDT | R/W | 0 | WDT Clock Gating Control<br>This bit controls the clock gating for the WDT module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, a read or write to the unit generates a bus fault. |

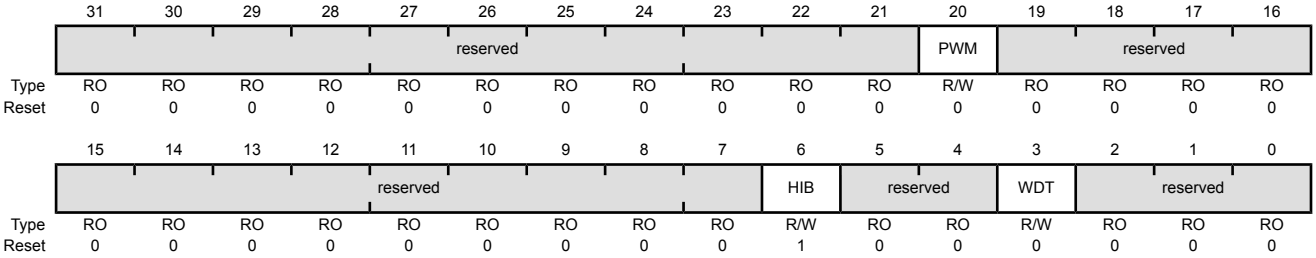
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 19: Sleep Mode Clock Gating Control Register 0 (SCGC0), offset 0x110

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC0** is the clock configuration register for running operation, **SCGC0** for Sleep operation, and **DCGC0** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Sleep Mode Clock Gating Control Register 0 (SCGC0)

Base 0x400F.E000
Offset 0x110
Type R/W, reset 0x00000040




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:21 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 20 | PWM | R/W | 0 | PWM Clock Gating Control<br>This bit controls the clock gating for the PWM module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, a read or write to the unit generates a bus fault. |
| 19:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | HIB | R/W | 1 | HIB Clock Gating Control<br>This bit controls the clock gating for the Hibernation module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. |
| 5:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | WDT | R/W | 0 | WDT Clock Gating Control<br>This bit controls the clock gating for the WDT module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, a read or write to the unit generates a bus fault. |

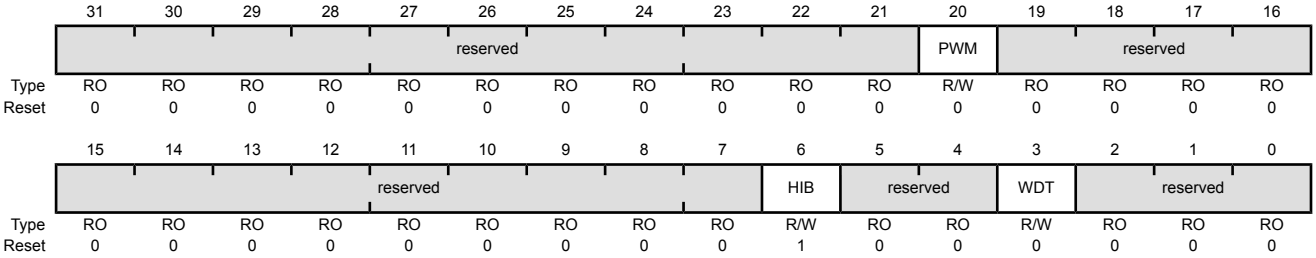
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 20: Deep Sleep Mode Clock Gating Control Register 0 (DCGC0), offset 0x120

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC0** is the clock configuration register for running operation, **SCGC0** for Sleep operation, and **DCGC0** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Deep Sleep Mode Clock Gating Control Register 0 (DCGC0)

Base 0x400F.E000
Offset 0x120
Type R/W, reset 0x00000040




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:21 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 20 | PWM | R/W | 0 | PWM Clock Gating Control<br>This bit controls the clock gating for the PWM module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, a read or write to the unit generates a bus fault. |
| 19:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | HIB | R/W | 1 | HIB Clock Gating Control<br>This bit controls the clock gating for the Hibernation module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. |
| 5:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | WDT | R/W | 0 | WDT Clock Gating Control<br>This bit controls the clock gating for the WDT module. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, a read or write to the unit generates a bus fault. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 21: Run Mode Clock Gating Control Register 1 (RCGC1), offset 0x104

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC1** is the clock configuration register for running operation, **SCGC1** for Sleep operation, and **DCGC1** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Run Mode Clock Gating Control Register 1 (RCGC1)

Base 0x400F.E000
Offset 0x104
Type R/W, reset 0x00000000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | COMP2 | COMP1 | COMP0 | reserved | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| Type | RO | RO | RO | RO | RO | R/W | R/W | R/W | RO | RO | RO | RO | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | I2C1 | reserved | I2C0 | reserved | | QEI1 | QEI0 | reserved | | SSI1 | SSI0 | reserved | UART2 | UART1 | UART0 |
| Type | RO | R/W | RO | R/W | RO | RO | R/W | R/W | RO | RO | R/W | R/W | RO | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:27 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 26 | COMP2 | R/W | 0 | Analog Comparator 2 Clock Gating<br>This bit controls the clock gating for analog comparator 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 25 | COMP1 | R/W | 0 | Analog Comparator 1 Clock Gating<br>This bit controls the clock gating for analog comparator 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 24 | COMP0 | R/W | 0 | Analog Comparator 0 Clock Gating<br>This bit controls the clock gating for analog comparator 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 23:20 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 19 | TIMER3 | R/W | 0 | Timer 3 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 3. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 18 | TIMER2 | R/W | 0 | Timer 2 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 17 | TIMER1 | R/W | 0 | Timer 1 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 16 | TIMER0 | R/W | 0 | Timer 0 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 15 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 14 | I2C1 | R/W | 0 | I2C1 Clock Gating Control<br>This bit controls the clock gating for I2C module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 13 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 12 | I2C0 | R/W | 0 | I2C0 Clock Gating Control<br>This bit controls the clock gating for I2C module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 11:10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | QEI1 | R/W | 0 | QEI1 Clock Gating Control<br>This bit controls the clock gating for QEI module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 8 | QEI0 | R/W | 0 | QEI0 Clock Gating Control<br>This bit controls the clock gating for QEI module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 7:6 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | SSI1 | R/W | 0 | SSI1 Clock Gating Control<br>This bit controls the clock gating for SSI module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 4 | SSI0 | R/W | 0 | SSI0 Clock Gating Control<br>This bit controls the clock gating for SSI module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | UART2 | R/W | 0 | UART2 Clock Gating Control<br>This bit controls the clock gating for UART module 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 1 | UART1 | R/W | 0 | UART1 Clock Gating Control<br>This bit controls the clock gating for UART module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 0 | UART0 | R/W | 0 | UART0 Clock Gating Control<br>This bit controls the clock gating for UART module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

## Register 22: Sleep Mode Clock Gating Control Register 1 (SCGC1), offset 0x114

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC1** is the clock configuration register for running operation, **SCGC1** for Sleep operation, and **DCGC1** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Sleep Mode Clock Gating Control Register 1 (SCGC1)

Base 0x400F.E000
Offset 0x114
Type R/W, reset 0x00000000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | COMP2 | COMP1 | COMP0 | reserved | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| Type | RO | RO | RO | RO | RO | R/W | R/W | R/W | RO | RO | RO | RO | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | I2C1 | reserved | I2C0 | reserved | | QEI1 | QEI0 | reserved | | SSI1 | SSI0 | reserved | UART2 | UART1 | UART0 |
| Type | RO | R/W | RO | R/W | RO | RO | R/W | R/W | RO | RO | R/W | R/W | RO | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:27 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 26 | COMP2 | R/W | 0 | Analog Comparator 2 Clock Gating<br>This bit controls the clock gating for analog comparator 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 25 | COMP1 | R/W | 0 | Analog Comparator 1 Clock Gating<br>This bit controls the clock gating for analog comparator 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 24 | COMP0 | R/W | 0 | Analog Comparator 0 Clock Gating<br>This bit controls the clock gating for analog comparator 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 23:20 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 19 | TIMER3 | R/W | 0 | Timer 3 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 3. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 18 | TIMER2 | R/W | 0 | Timer 2 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 17 | TIMER1 | R/W | 0 | Timer 1 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 16 | TIMER0 | R/W | 0 | Timer 0 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 15 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 14 | I2C1 | R/W | 0 | I2C1 Clock Gating Control<br>This bit controls the clock gating for I2C module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 13 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 12 | I2C0 | R/W | 0 | I2C0 Clock Gating Control<br>This bit controls the clock gating for I2C module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 11:10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | QEI1 | R/W | 0 | QEI1 Clock Gating Control<br>This bit controls the clock gating for QEI module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 8 | QEI0 | R/W | 0 | QEI0 Clock Gating Control<br>This bit controls the clock gating for QEI module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

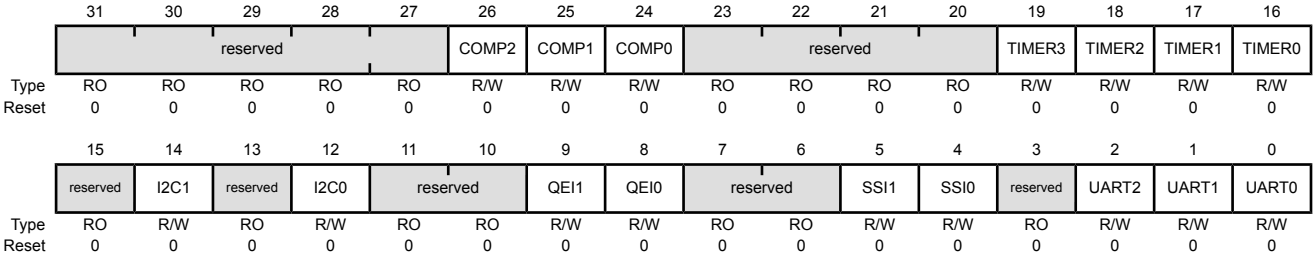
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 7:6 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | SSI1 | R/W | 0 | SSI1 Clock Gating Control<br>This bit controls the clock gating for SSI module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 4 | SSI0 | R/W | 0 | SSI0 Clock Gating Control<br>This bit controls the clock gating for SSI module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | UART2 | R/W | 0 | UART2 Clock Gating Control<br>This bit controls the clock gating for UART module 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 1 | UART1 | R/W | 0 | UART1 Clock Gating Control<br>This bit controls the clock gating for UART module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 0 | UART0 | R/W | 0 | UART0 Clock Gating Control<br>This bit controls the clock gating for UART module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

## Register 23: Deep Sleep Mode Clock Gating Control Register 1 (DCGC1), offset 0x124

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC1** is the clock configuration register for running operation, **SCGC1** for Sleep operation, and **DCGC1** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Deep Sleep Mode Clock Gating Control Register 1 (DCGC1)

Base 0x400F.E000
Offset 0x124
Type R/W, reset 0x00000000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:27 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 26 | COMP2 | R/W | 0 | Analog Comparator 2 Clock Gating<br>This bit controls the clock gating for analog comparator 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 25 | COMP1 | R/W | 0 | Analog Comparator 1 Clock Gating<br>This bit controls the clock gating for analog comparator 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 24 | COMP0 | R/W | 0 | Analog Comparator 0 Clock Gating<br>This bit controls the clock gating for analog comparator 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 23:20 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 19 | TIMER3 | R/W | 0 | Timer 3 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 3. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 18 | TIMER2 | R/W | 0 | Timer 2 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 17 | TIMER1 | R/W | 0 | Timer 1 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 16 | TIMER0 | R/W | 0 | Timer 0 Clock Gating Control<br>This bit controls the clock gating for General-Purpose Timer module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 15 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 14 | I2C1 | R/W | 0 | I2C1 Clock Gating Control<br>This bit controls the clock gating for I2C module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 13 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 12 | I2C0 | R/W | 0 | I2C0 Clock Gating Control<br>This bit controls the clock gating for I2C module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 11:10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | QEI1 | R/W | 0 | QEI1 Clock Gating Control<br>This bit controls the clock gating for QEI module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 8 | QEI0 | R/W | 0 | QEI0 Clock Gating Control<br>This bit controls the clock gating for QEI module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

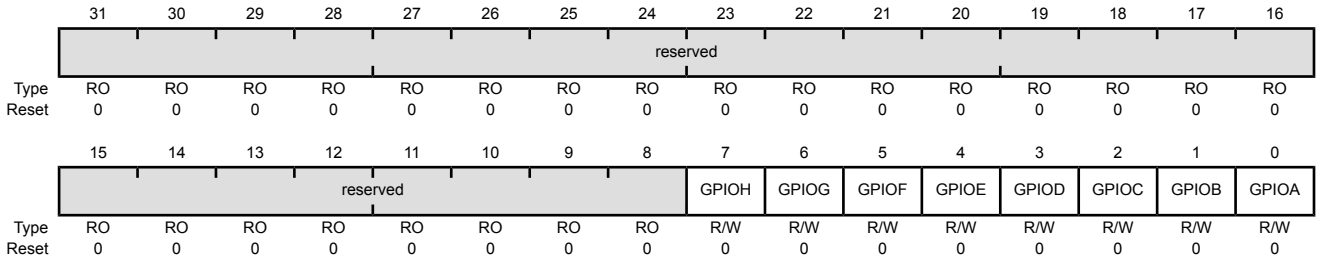
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 7:6 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | SSI1 | R/W | 0 | SSI1 Clock Gating Control<br>This bit controls the clock gating for SSI module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 4 | SSI0 | R/W | 0 | SSI0 Clock Gating Control<br>This bit controls the clock gating for SSI module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | UART2 | R/W | 0 | UART2 Clock Gating Control<br>This bit controls the clock gating for UART module 2. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 1 | UART1 | R/W | 0 | UART1 Clock Gating Control<br>This bit controls the clock gating for UART module 1. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 0 | UART0 | R/W | 0 | UART0 Clock Gating Control<br>This bit controls the clock gating for UART module 0. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

## Register 24: Run Mode Clock Gating Control Register 2 (RCGC2), offset 0x108

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC2** is the clock configuration register for running operation, **SCGC2** for Sleep operation, and **DCGC2** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Run Mode Clock Gating Control Register 2 (RCGC2)

Base 0x400F.E000
Offset 0x108
Type R/W, reset 0x00000000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | GPIOH | R/W | 0 | Port H Clock Gating Control<br>This bit controls the clock gating for Port H. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 6 | GPIOG | R/W | 0 | Port G Clock Gating Control<br>This bit controls the clock gating for Port G. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 5 | GPIOF | R/W | 0 | Port F Clock Gating Control<br>This bit controls the clock gating for Port F. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 4 | GPIOE | R/W | 0 | Port E Clock Gating Control<br>This bit controls the clock gating for Port E. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 3 | GPIOD | R/W | 0 | Port D Clock Gating Control<br>This bit controls the clock gating for Port D. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

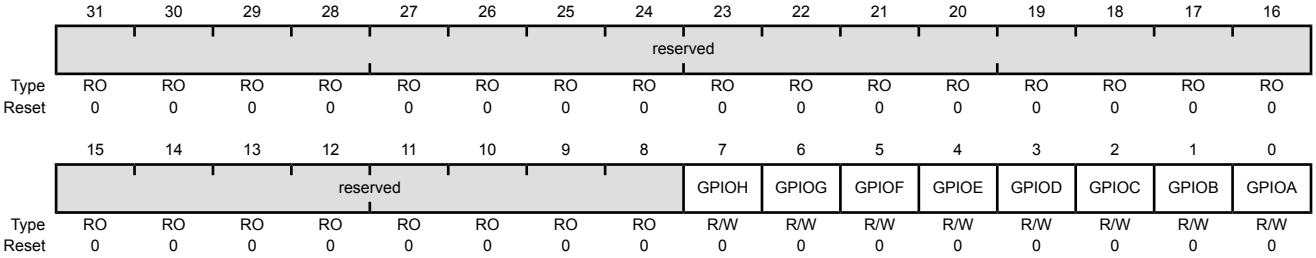
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2 | GPIOC | R/W | 0 | Port C Clock Gating Control<br>This bit controls the clock gating for Port C. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 1 | GPIOB | R/W | 0 | Port B Clock Gating Control<br>This bit controls the clock gating for Port B. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 0 | GPIOA | R/W | 0 | Port A Clock Gating Control<br>This bit controls the clock gating for Port A. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

## Register 25: Sleep Mode Clock Gating Control Register 2 (SCGC2), offset 0x118

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC2** is the clock configuration register for running operation, **SCGC2** for Sleep operation, and **DCGC2** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Sleep Mode Clock Gating Control Register 2 (SCGC2)

Base 0x400F.E000
Offset 0x118
Type R/W, reset 0x00000000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | GPIOH | R/W | 0 | Port H Clock Gating Control<br>This bit controls the clock gating for Port H. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 6 | GPIOG | R/W | 0 | Port G Clock Gating Control<br>This bit controls the clock gating for Port G. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 5 | GPIOF | R/W | 0 | Port F Clock Gating Control<br>This bit controls the clock gating for Port F. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 4 | GPIOE | R/W | 0 | Port E Clock Gating Control<br>This bit controls the clock gating for Port E. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

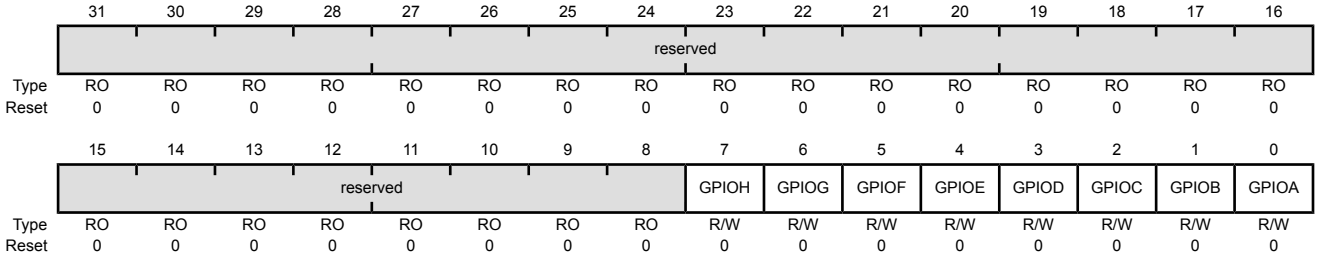
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | GPIOD | R/W | 0 | Port D Clock Gating Control<br>This bit controls the clock gating for Port D. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 2 | GPIOC | R/W | 0 | Port C Clock Gating Control<br>This bit controls the clock gating for Port C. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 1 | GPIOB | R/W | 0 | Port B Clock Gating Control<br>This bit controls the clock gating for Port B. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 0 | GPIOA | R/W | 0 | Port A Clock Gating Control<br>This bit controls the clock gating for Port A. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

## Register 26: Deep Sleep Mode Clock Gating Control Register 2 (DCGC2), offset 0x128

This register controls the clock gating logic. Each bit controls a clock enable for a given interface, function, or unit. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled (saving power). If the unit is unclocked, reads or writes to the unit will generate a bus fault. The reset state of these bits is 0 (unclocked) unless otherwise noted, so that all functional units are disabled. It is the responsibility of software to enable the ports necessary for the application. Note that these registers may contain more bits than there are interfaces, functions, or units to control. This is to assure reasonable code compatibility with other family and future parts. **RCGC2** is the clock configuration register for running operation, **SCGC2** for Sleep operation, and **DCGC2** for Deep-Sleep operation. Setting the ACG bit in the **Run-Mode Clock Configuration (RCC)** register specifies that the system uses sleep modes.

Deep Sleep Mode Clock Gating Control Register 2 (DCGC2)

Base 0x400F.E000
Offset 0x128
Type R/W, reset 0x00000000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | GPIOH | R/W | 0 | Port H Clock Gating Control<br>This bit controls the clock gating for Port H. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 6 | GPIOG | R/W | 0 | Port G Clock Gating Control<br>This bit controls the clock gating for Port G. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 5 | GPIOF | R/W | 0 | Port F Clock Gating Control<br>This bit controls the clock gating for Port F. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 4 | GPIOE | R/W | 0 | Port E Clock Gating Control<br>This bit controls the clock gating for Port E. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

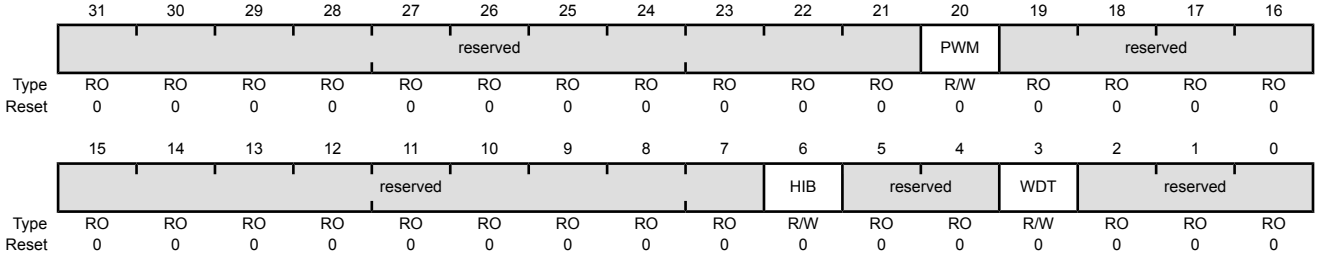
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | GPIOD | R/W | 0 | Port D Clock Gating Control<br>This bit controls the clock gating for Port D. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 2 | GPIOC | R/W | 0 | Port C Clock Gating Control<br>This bit controls the clock gating for Port C. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 1 | GPIOB | R/W | 0 | Port B Clock Gating Control<br>This bit controls the clock gating for Port B. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |
| 0 | GPIOA | R/W | 0 | Port A Clock Gating Control<br>This bit controls the clock gating for Port A. If set, the unit receives a clock and functions. Otherwise, the unit is unclocked and disabled. If the unit is unclocked, reads or writes to the unit will generate a bus fault. |

## Register 27: Software Reset Control 0 (SRCR0), offset 0x040

Writes to this register are masked by the bits in the **Device Capabilities 1 (DC1)** register.

Software Reset Control 0 (SRCR0)

Base 0x400F.E000
Offset 0x040
Type R/W, reset 0x00000000



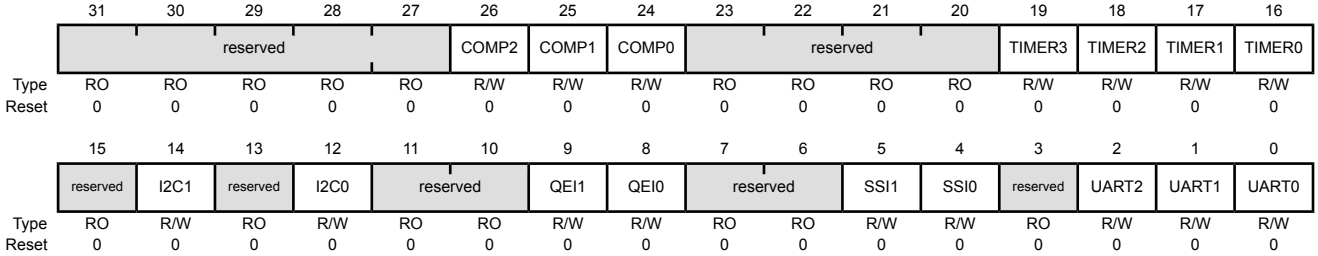

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:21 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 20 | PWM | R/W | 0 | PWM Reset Control<br>Reset control for PWM module. |
| 19:7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | HIB | R/W | 0 | HIB Reset Control<br>Reset control for the Hibernation module. |
| 5:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | WDT | R/W | 0 | WDT Reset Control<br>Reset control for Watchdog unit. |
| 2:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 28: Software Reset Control 1 (SRCR1), offset 0x044

Writes to this register are masked by the bits in the **Device Capabilities 2 (DC2)** register.

Software Reset Control 1 (SRCR1)

Base 0x400F.E000
Offset 0x044
Type R/W, reset 0x00000000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:27 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 26 | COMP2 | R/W | 0 | Analog Comp 2 Reset Control<br>Reset control for analog comparator 2. |
| 25 | COMP1 | R/W | 0 | Analog Comp 1 Reset Control<br>Reset control for analog comparator 1. |
| 24 | COMP0 | R/W | 0 | Analog Comp 0 Reset Control<br>Reset control for analog comparator 0. |
| 23:20 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 19 | TIMER3 | R/W | 0 | Timer 3 Reset Control<br>Reset control for General-Purpose Timer module 3. |
| 18 | TIMER2 | R/W | 0 | Timer 2 Reset Control<br>Reset control for General-Purpose Timer module 2. |
| 17 | TIMER1 | R/W | 0 | Timer 1 Reset Control<br>Reset control for General-Purpose Timer module 1. |
| 16 | TIMER0 | R/W | 0 | Timer 0 Reset Control<br>Reset control for General-Purpose Timer module 0. |
| 15 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 14 | I2C1 | R/W | 0 | I2C1 Reset Control<br>Reset control for I2C unit 1. |

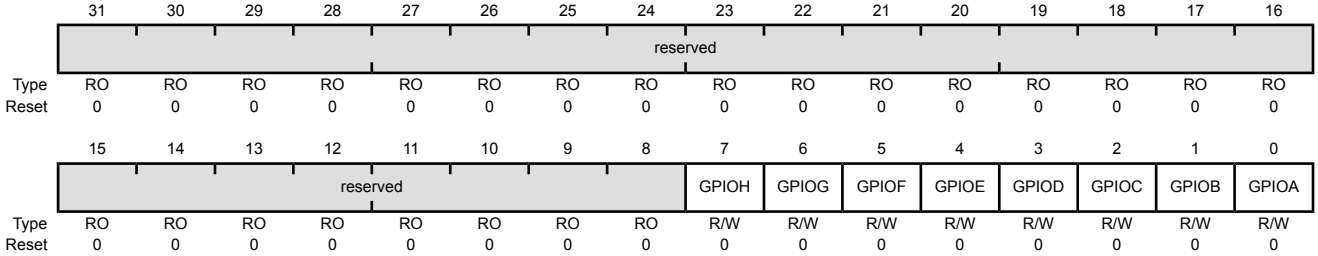
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 13 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 12 | I2C0 | R/W | 0 | I2C0 Reset Control<br>Reset control for I2C unit 0. |
| 11:10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | QEI1 | R/W | 0 | QEI1 Reset Control<br>Reset control for QEI unit 1. |
| 8 | QEI0 | R/W | 0 | QEI0 Reset Control<br>Reset control for QEI unit 0. |
| 7:6 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | SSI1 | R/W | 0 | SSI1 Reset Control<br>Reset control for SSI unit 1. |
| 4 | SSI0 | R/W | 0 | SSI0 Reset Control<br>Reset control for SSI unit 0. |
| 3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | UART2 | R/W | 0 | UART2 Reset Control<br>Reset control for UART unit 2. |
| 1 | UART1 | R/W | 0 | UART1 Reset Control<br>Reset control for UART unit 1. |
| 0 | UART0 | R/W | 0 | UART0 Reset Control<br>Reset control for UART unit 0. |

## Register 29: Software Reset Control 2 (SRCR2), offset 0x048

Writes to this register are masked by the bits in the **Device Capabilities 4 (DC4)** register.

Software Reset Control 2 (SRCR2)

Base 0x400F.E000
Offset 0x048
Type R/W, reset 0x00000000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | GPIOH | R/W | 0 | Port H Reset Control<br>Reset control for GPIO Port H. |
| 6 | GPIOG | R/W | 0 | Port G Reset Control<br>Reset control for GPIO Port G. |
| 5 | GPIOF | R/W | 0 | Port F Reset Control<br>Reset control for GPIO Port F. |
| 4 | GPIOE | R/W | 0 | Port E Reset Control<br>Reset control for GPIO Port E. |
| 3 | GPIOD | R/W | 0 | Port D Reset Control<br>Reset control for GPIO Port D. |
| 2 | GPIOC | R/W | 0 | Port C Reset Control<br>Reset control for GPIO Port C. |
| 1 | GPIOB | R/W | 0 | Port B Reset Control<br>Reset control for GPIO Port B. |
| 0 | GPIOA | R/W | 0 | Port A Reset Control<br>Reset control for GPIO Port A. |

# 6 Hibernation Module

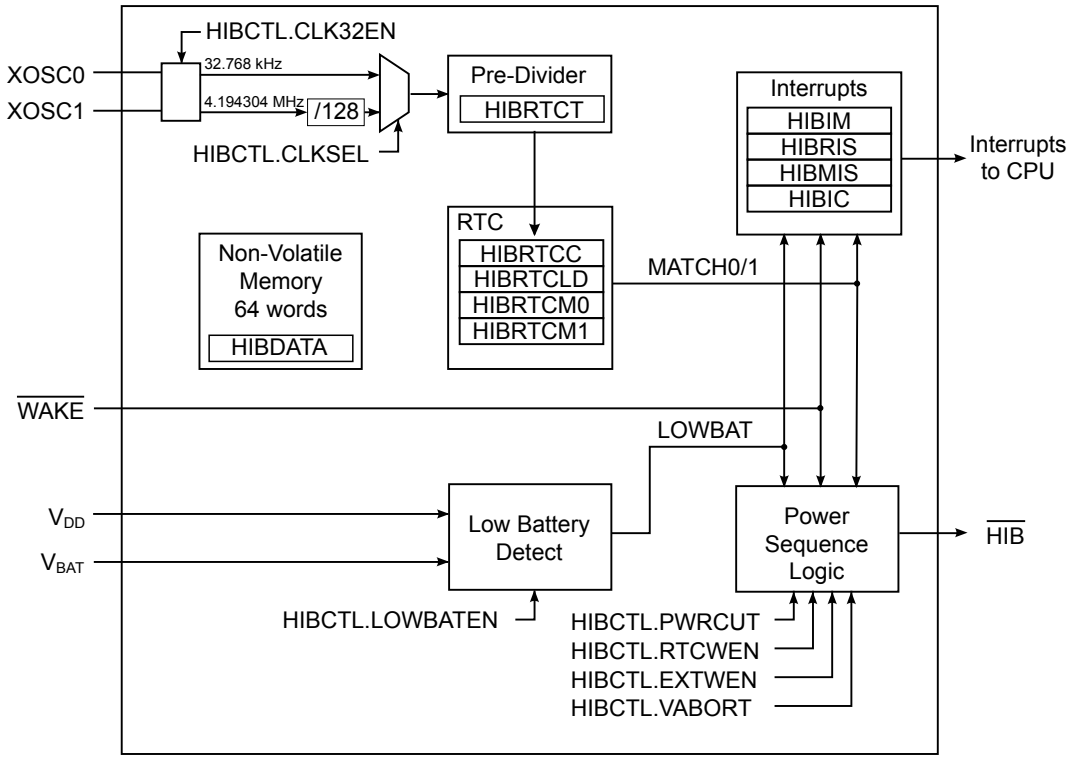
The Hibernation Module manages removal and restoration of power to provide a means for reducing power consumption. When the processor and peripherals are idle, power can be completely removed with only the Hibernation module remaining powered. Power can be restored based on an external signal, or at a certain time using the built-in Real-Time Clock (RTC). The Hibernation module can be independently supplied from a battery or an auxiliary power supply.

The Hibernation module has the following features:

- System power control using discrete external regulator
- Dedicated pin for waking from an external signal
- Low-battery detection, signaling, and interrupt generation
- 32-bit real-time clock (RTC)
- Two 32-bit RTC match registers for timed wake-up and interrupt generation
- Clock source from a 32.768-kHz external oscillator or a 4.194304-MHz crystal
- RTC predivider trim for making fine adjustments to the clock rate
- 64 32-bit words of non-volatile memory
- Programmable interrupts for RTC match, external wake, and low battery events

## 6.1 Block Diagram

**Figure 6-1. Hibernation Module Block Diagram**




## 6.2 Signal Description

Table 6-1 on page 234 and Table 6-2 on page 235 list the external signals of the Hibernation module and describe the function of each. These signals have dedicated functions and are not alternate functions for any GPIO signals.

**Table 6-1. Hibernate Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| HIB | 51 | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| VBAT | 55 | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| WAKE | 50 | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| XOSC0 | 52 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| XOSC1 | 53 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 6-2. Hibernate Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| HIB | M12 | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| VBAT | L12 | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| WAKE | M10 | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| XOSC0 | K11 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| XOSC1 | K12 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

# 6.3 Functional Description

The Hibernation module controls the power to the processor with an enable signal (HIB) that signals an external voltage regulator to turn off.

The Hibernation module power source is determined dynamically. The supply voltage of the Hibernation module is the larger of the main voltage source ($V_{DD}$) or the battery/auxilliary voltage source ($V_{BAT}$). A voting circuit indicates the larger and an internal power switch selects the appropriate voltage source. The Hibernation module also has a separate clock source to maintain a real-time clock (RTC). Once in hibernation, the module signals an external voltage regulator to turn back on the power when an external pin (WAKE) is asserted, or when the internal RTC reaches a certain value. The Hibernation module can also detect when the battery voltage is low, and optionally prevent hibernation when this occurs.

When waking from hibernation, the HIB signal is deasserted. The return of $V_{DD}$ causes a POR to be executed. The time from when the WAKE signal is asserted to when code begins execution is equal to the wake-up time ($t_{WAKE_TO_HIB}$) plus the power-on reset time ($T_{IRPOR}$).

## 6.3.1 Register Access Timing

Because the Hibernation module has an independent clocking domain, certain registers must be written only with a timing gap between accesses. The delay time is $t_{HIB_REG_WRITE}$, therefore software must guarantee that a delay of $t_{HIB_REG_WRITE}$ is inserted between back-to-back writes to certain Hibernation registers, or between a write followed by a read to those same registers. There is no restriction on timing for back-to-back reads from the Hibernation module. The following registers are subject to this timing restriction:

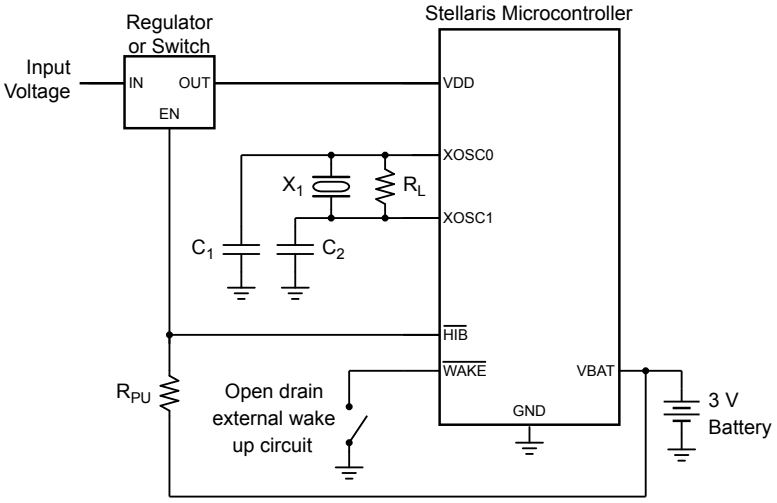
- **Hibernation RTC Counter (HIBRTCC)**
- **Hibernation RTC Match 0 (HIBRTCM0)**
- **Hibernation RTC Match 1 (HIBRTCM1)**
- **Hibernation RTC Load (HIBRTCLD)**
- **Hibernation RTC Trim (HIBRTCT)**
- **Hibernation Data (HIBDATA)**

### 6.3.2 Clock Source

The Hibernation module must be clocked by an external source, even if the RTC feature is not used. An external oscillator or crystal can be used for this purpose. To use a crystal, a 4.194304-MHz crystal is connected to the XOSC0 and XOSC1 pins. This clock signal is divided by 128 internally to produce the 32.768-kHz clock reference. For an alternate clock source, a 32.768-kHz oscillator can be connected to the XOSC0 pin. See Figure 6-2 on page 236 and Figure 6-3 on page 237. Note that these diagrams only show the connection to the Hibernation pins and not to the full system. See "Hibernation Module" on page 617 for specific values.

The clock source is enabled by setting the CLK32EN bit of the **HIBCTL** register. The type of clock source is selected by setting the CLKSEL bit to 0 for a 4.194304-MHz clock source, and to 1 for a 32.768-kHz clock source. If the bit is set to 0, the 4.194304-MHz input clock is divided by 128, resulting in a 32.768-kHz clock source. If a crystal is used for the clock source, the software must leave a delay of $t_{XOSC_SETTLE}$ after setting the CLK32EN bit and before any other accesses to the Hibernation module registers. The delay allows the crystal to power up and stabilize. If an oscillator is used for the clock source, no delay is needed.

**Figure 6-2. Clock Source Using Crystal**




**Note:** $X_1$ = Crystal frequency is $f_{XOSC_XTAL}$.

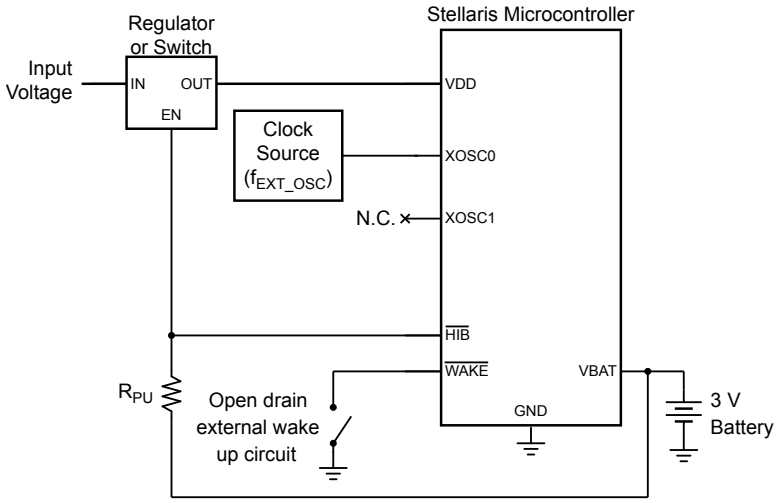
$C_{1,2}$ = Capacitor value derived from crystal vendor load capacitance specifications.

$R_L$ = Load resistor is $R_{XOSC_LOAD}$.

$R_{PU}$ = Pull-up resistor (1 M½).

See "Hibernation Module" on page 617 for specific parameter values.

**Figure 6-3. Clock Source Using Dedicated Oscillator**




**Note:** $R_{PU}$ = Pull-up resistor (1 M½).

## 6.3.3 Battery Management

The Hibernation module can be independently powered by a battery or an auxiliary power source. The module can monitor the voltage level of the battery and detect when the voltage drops below $V_{LOWBAT}$. When this happens, an interrupt can be generated. The module can also be configured so that it will not go into Hibernate mode if the battery voltage drops below this threshold. Battery voltage is not measured while in Hibernate mode.

**Important:** System level factors may affect the accuracy of the low battery detect circuit. The designer should consider battery type, discharge characteristics, and a test load during battery voltage measurements.

Note that the Hibernation module draws power from whichever source ($V_{BAT}$ or $V_{DD}$) has the higher voltage. Therefore, it is important to design the circuit to ensure that $V_{DD}$ is higher that $V_{BAT}$ under nominal conditions or else the Hibernation module draws power from the battery even when $V_{DD}$ is available.

The Hibernation module can be configured to detect a low battery condition by setting the LOWBATEN bit of the **HIBCTL** register. In this configuration, the LOWBAT bit of the **HIBRIS** register will be set when the battery level is low. If the VABORT bit is also set, then the module is prevented from entering Hibernation mode when a low battery is detected. The module can also be configured to generate an interrupt for the low-battery condition (see “Interrupts and Status” on page 239).

## 6.3.4 Real-Time Clock

The Hibernation module includes a 32-bit counter that increments once per second with a proper clock source and configuration (see “Clock Source” on page 236). The 32.768-kHz clock signal is fed into a predivider register which counts down the 32.768-kHz clock ticks to achieve a once per second clock rate for the RTC. The rate can be adjusted to compensate for inaccuracies in the clock source by using the predivider trim register, **HIBRTCT**. This register has a nominal value of 0x7FFF, and is used for one second out of every 64 seconds to divide the input clock. This allows the software to make fine corrections to the clock rate by adjusting the predivider trim register up or down from 0x7FFF. The predivider trim should be adjusted up from 0x7FFF in order to slow down the RTC rate, and down from 0x7FFF in order to speed up the RTC rate.

The Hibernation module includes two 32-bit match registers that are compared to the value of the RTC counter. The match registers can be used to wake the processor from hibernation mode, or to generate an interrupt to the processor if it is not in hibernation.

The RTC must be enabled with the RTCEN bit of the **HIBCTL** register. The value of the RTC can be set at any time by writing to the **HIBRTCLD** register. The predivider trim can be adjusted by reading and writing the **HIBRTCT** register. The predivider uses this register once every 64 seconds to adjust the clock rate. The two match registers can be set by writing to the **HIBRTCM0** and **HIBRTCM1** registers. The RTC can be configured to generate interrupts by using the interrupt registers (see "Interrupts and Status" on page 239). As long as the RTC is enabled and a valid $V_{BAT}$ is present, the RTC continues counting, regardless of whether $V_{DD}$ is present or if the part is in hibernation.

### 6.3.5 Battery-Backed Memory

The Hibernation module contains 64 32-bit words of memory which are retained during hibernation. This memory is powered from the battery or auxiliary power supply during hibernation. The processor software can save state information in this memory prior to hibernation, and can then recover the state upon waking. The battery-backed memory can be accessed through the **HIBDATA** registers.

### 6.3.6 Power Control

**Important:** The Hibernation Module requires special system implementation considerations when using $\overline{\text{HIB}}$ to control power, as it is intended to power-down all other sections of its host device. All system signals and power supplies that connect to the chip must be driven to 0 $V_{DC}$ or powered down with the same regulator controlled by $\overline{\text{HIB}}$. See "Hibernation Module" on page 617 for more details.

The Hibernation module controls power to the microcontroller through the use of the $\overline{\text{HIB}}$ pin. This pin is intended to be connected to the enable signal of the external regulator(s) providing 3.3 V and/or 2.5 V to the microcontroller. When the $\overline{\text{HIB}}$ signal is asserted by the Hibernation module, the external regulator is turned off and no longer powers the system. The Hibernation module remains powered from the $V_{BAT}$ supply (which could be a battery or an auxiliary power source) until a Wake event. Power to the device is restored by deasserting the $\overline{\text{HIB}}$ signal, which causes the external regulator to turn power back on to the chip.

### 6.3.7 Initiating Hibernate

Hibernation mode is initiated by the microcontroller setting the HIBREQ bit of the **HIBCTL** register. Prior to doing this, a wake-up condition must be configured, either from the external WAKE pin, or by using an RTC match.

The Hibernation module is configured to wake from the external $\overline{\text{WAKE}}$ pin by setting the PINWEN bit of the **HIBCTL** register. It is configured to wake from RTC match by setting the RTCWEN bit. Either one or both of these bits can be set prior to going into hibernation. The $\overline{\text{WAKE}}$ pin includes a weak internal pull-up. Note that both the HIB and $\overline{\text{WAKE}}$ pins use the Hibernation module's internal power supply as the logic 1 reference.

When the Hibernation module wakes, the microcontroller will see a normal power-on reset. Software can detect that the power-on was due to a wake from hibernation by examining the raw interrupt status register (see "Interrupts and Status" on page 239) and by looking for state data in the battery-backed memory (see "Battery-Backed Memory" on page 238).

When the $\overline{\text{HIB}}$ signal deasserts, enabling the external regulator, the external regulator must reach the operating voltage within $t_{HIB_TO_VDD}$.

### 6.3.8 Interrupts and Status

The Hibernation module can generate interrupts when the following conditions occur:

- Assertion of $\overline{\text{WAKE}}$ pin
- RTC match
- Low battery detected

All of the interrupts are ORed together before being sent to the interrupt controller, so the Hibernate module can only generate a single interrupt request to the controller at any given time. The software interrupt handler can service multiple interrupt events by reading the **HIBMIS** register. Software can also read the status of the Hibernation module at any time by reading the **HIBRIS** register which shows all of the pending events. This register can be used at power-on to see if a wake condition is pending, which indicates to the software that a hibernation wake occurred.

The events that can trigger an interrupt are configured by setting the appropriate bits in the **HIBIM** register. Pending interrupts can be cleared by writing the corresponding bit in the **HIBIC** register.

## 6.4 Initialization and Configuration

The Hibernation module can be set in several different configurations. The following sections show the recommended programming sequence for various scenarios. The examples below assume that a 32.768-kHz oscillator is used, and thus always show bit 2 (CLKSEL) of the **HIBCTL** register set to 1. If a 4.194304-MHz crystal is used instead, then the CLKSEL bit remains cleared. Because the Hibernation module runs at 32.768 kHz and is asynchronous to the rest of the system, software must allow a delay of $t_{HIB_REG_WRITE}$ after writes to certain registers (see “Register Access Timing” on page 235). The registers that require a delay are listed in a note in “Register Map” on page 240 as well as in each register description.

### 6.4.1 Initialization

The Hibernation module clock source must be enabled first, even if the RTC feature is not used. If a 4.194304-MHz crystal is used, perform the following steps:

1. Write 0x40 to the **HIBCTL** register at offset 0x10 to enable the crystal and select the divide-by-128 input path.
2. Wait for a time of $t_{XOSC_SETTLE}$ for the crystal to power up and stabilize before performing any other operations with the Hibernation module.

If a 32.678-kHz oscillator is used, then perform the following steps:

1. Write 0x44 to the **HIBCTL** register at offset 0x10 to enable the oscillator input.
2. No delay is necessary.

The above is only necessary when the entire system is initialized for the first time. If the processor is powered due to a wake from hibernation, then the Hibernation module has already been powered up and the above steps are not necessary. The software can detect that the Hibernation module and clock are already powered by examining the CLK32EN bit of the **HIBCTL** register.

### 6.4.2 RTC Match Functionality (No Hibernation)

Use the following steps to implement the RTC match functionality of the Hibernation module:

1. Write the required RTC match value to one of the **HIBRTCMn** registers at offset 0x004 or 0x008.
2. Write the required RTC load value to the **HIBRTCLD** register at offset 0x00C.
3. Set the required RTC match interrupt mask in the RTCALT0 and RTCALT1 bits (bits 1:0) in the **HIBIM** register at offset 0x014.
4. Write 0x0000.0041 to the **HIBCTL** register at offset 0x010 to enable the RTC to begin counting.

### 6.4.3 RTC Match/Wake-Up from Hibernation

Use the following steps to implement the RTC match and wake-up functionality of the Hibernation module:

1. Write the required RTC match value to the **HIBRTCMn** registers at offset 0x004 or 0x008.
2. Write the required RTC load value to the **HIBRTCLD** register at offset 0x00C.
3. Write any data to be retained during power cut to the **HIBDATA** register at offsets 0x030-0x12C.
4. Set the RTC Match Wake-Up and start the hibernation sequence by writing 0x0000.004F to the **HIBCTL** register at offset 0x010.

### 6.4.4 External Wake-Up from Hibernation

Use the following steps to implement the Hibernation module with the external $\overline{\text{WAKE}}$ pin as the wake-up source for the microcontroller:

1. Write any data to be retained during power cut to the **HIBDATA** register at offsets 0x030-0x12C.
2. Enable the external wake and start the hibernation sequence by writing 0x0000.0056 to the **HIBCTL** register at offset 0x010.

### 6.4.5 RTC/External Wake-Up from Hibernation

1. Write the required RTC match value to the **HIBRTCMn** registers at offset 0x004 or 0x008.
2. Write the required RTC load value to the **HIBRTCLD** register at offset 0x00C.
3. Write any data to be retained during power cut to the **HIBDATA** register at offsets 0x030-0x12C.
4. Set the RTC Match/External Wake-Up and start the hibernation sequence by writing 0x0000.005F to the **HIBCTL** register at offset 0x010.

## 6.5 Register Map

Table 6-3 on page 241 lists the Hibernation registers. All addresses given are relative to the Hibernation Module base address at 0x400F.C000. Note that the Hibernation module clock must be enabled before the registers can be programmed (see page 208). There must be a delay of 3 system clocks after the Hibernation module clock is enabled before any Hibernation module registers are accessed.

**Important:** The Hibernation module registers are reset under two conditions:

1. A system reset when the RTCEN and the PINWEN bits in the **HIBCTL** register are both cleared.

2. A cold POR, when both the $V_{DD}$ and $V_{BAT}$ supplies are removed.

Any other reset condition is ignored by the Hibernation module.

**Table 6-3. Hibernation Module Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | HIBRTCC | RO | 0x0000.0000 | Hibernation RTC Counter | 242 |
| 0x004 | HIBRTCM0 | R/W | 0xFFFF.FFFF | Hibernation RTC Match 0 | 243 |
| 0x008 | HIBRTCM1 | R/W | 0xFFFF.FFFF | Hibernation RTC Match 1 | 244 |
| 0x00C | HIBRTCLD | R/W | 0xFFFF.FFFF | Hibernation RTC Load | 245 |
| 0x010 | HIBCTL | R/W | 0x8000.0000 | Hibernation Control | 246 |
| 0x014 | HIBIM | R/W | 0x0000.0000 | Hibernation Interrupt Mask | 248 |
| 0x018 | HIBRIS | RO | 0x0000.0000 | Hibernation Raw Interrupt Status | 249 |
| 0x01C | HIBMIS | RO | 0x0000.0000 | Hibernation Masked Interrupt Status | 250 |
| 0x020 | HIBIC | R/W1C | 0x0000.0000 | Hibernation Interrupt Clear | 251 |
| 0x024 | HIBRTCT | R/W | 0x0000.7FFF | Hibernation RTC Trim | 252 |
| 0x030-0x12C | HIBDATA | R/W | - | Hibernation Data | 253 |

## 6.6 Register Descriptions

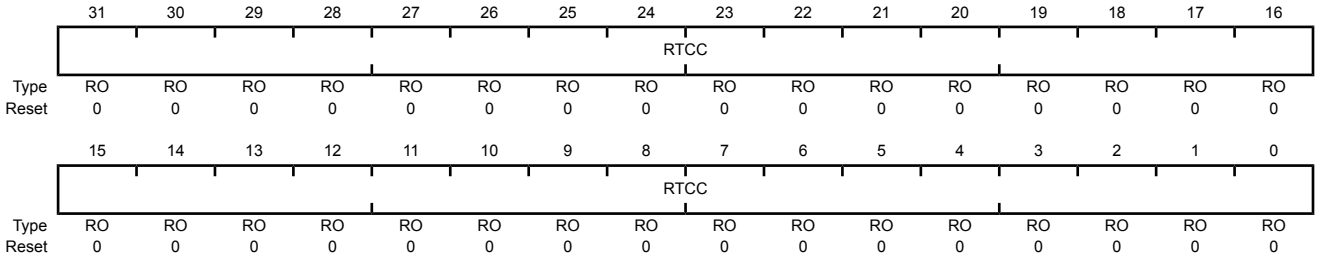
The remainder of this section lists and describes the Hibernation module registers, in numerical order by address offset.

## Register 1: Hibernation RTC Counter (HIBRTCC), offset 0x000

This register is the current 32-bit value of the RTC counter.

Hibernation RTC Counter (HIBRTCC)

Base 0x400F.C000
Offset 0x000
Type RO, reset 0x0000.0000



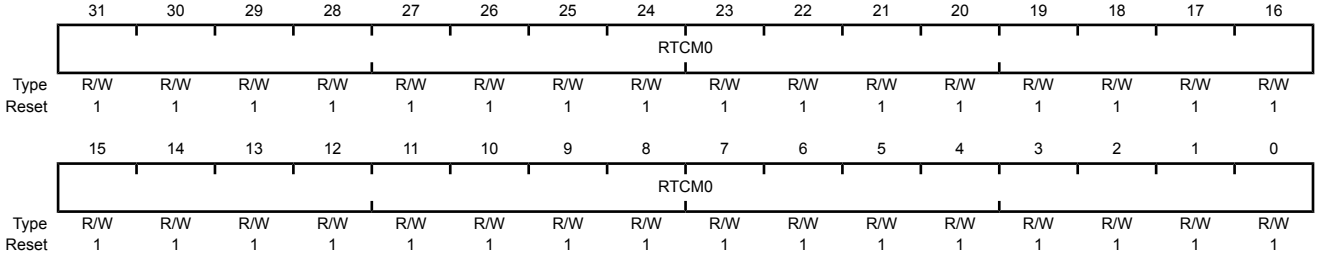

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | RTCC | RO | 0x0000.0000 | RTC Counter<br>A read returns the 32-bit counter value. This register is read-only. To change the value, use the **HIBRTCLD** register. |

## Register 2: Hibernation RTC Match 0 (HIBRTCM0), offset 0x004

This register is the 32-bit match 0 register for the RTC counter.

Hibernation RTC Match 0 (HIBRTCM0)

Base 0x400F.C000
Offset 0x004
Type R/W, reset 0xFFFF.FFFF



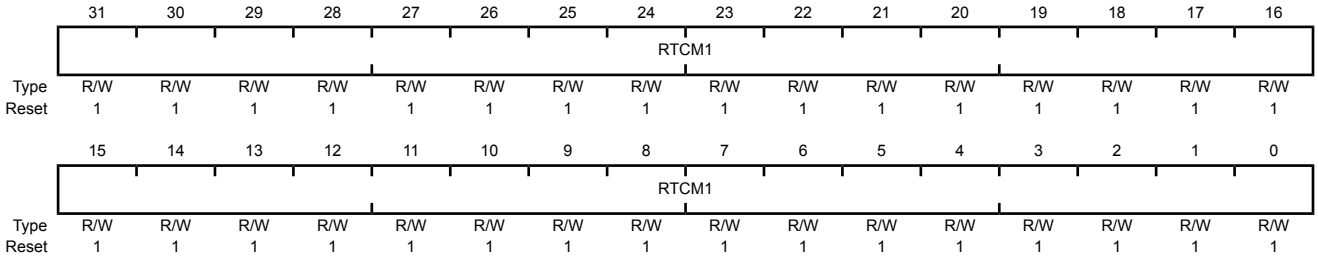

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | RTCM0 | R/W | 0xFFFF.FFFF | RTC Match 0<br>A write loads the value into the RTC match register.<br>A read returns the current match value. |

## Register 3: Hibernation RTC Match 1 (HIBRTCM1), offset 0x008

This register is the 32-bit match 1 register for the RTC counter.

Hibernation RTC Match 1 (HIBRTCM1)

Base 0x400F.C000
Offset 0x008
Type R/W, reset 0xFFFF.FFFF



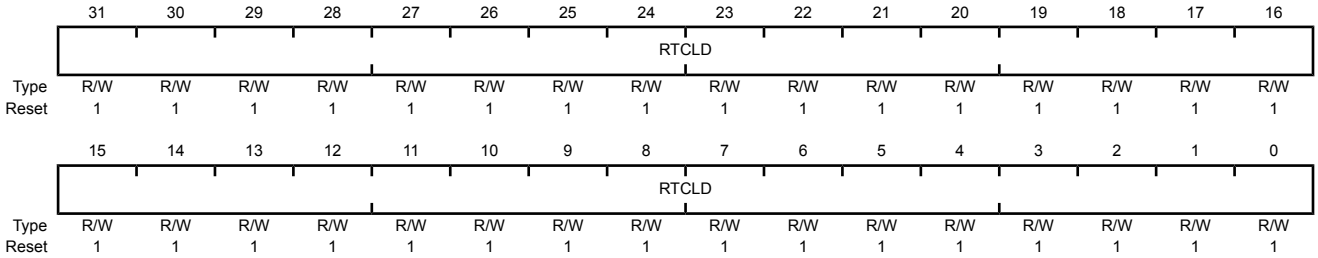

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | RTCM1 | R/W | 0xFFFF.FFFF | RTC Match 1<br>A write loads the value into the RTC match register.<br>A read returns the current match value. |

## Register 4: Hibernation RTC Load (HIBRTCLD), offset 0x00C

This register is the 32-bit value loaded into the RTC counter.

Hibernation RTC Load (HIBRTCLD)

Base 0x400F.C000
Offset 0x00C
Type R/W, reset 0xFFFF.FFFF

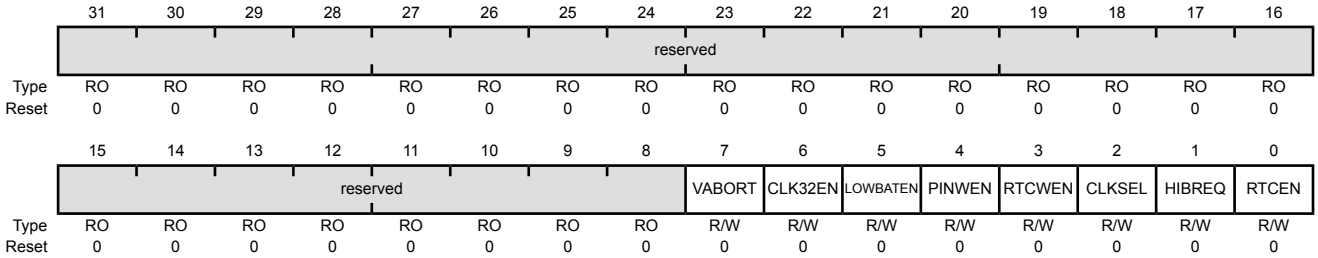



| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | RTCLD | R/W | 0xFFFF.FFFF | RTC Load<br>A write loads the current value into the RTC counter (RTCC).<br>A read returns the 32-bit load value. |

## Register 5: Hibernation Control (HIBCTL), offset 0x010

This register is the control register for the Hibernation module.

Hibernation Control (HIBCTL)
Base 0x400F.C000
Offset 0x010
Type R/W, reset 0x8000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | VABORT | R/W | 0 | Power Cut Abort Enable<br><br>Value Description<br>0 Power cut occurs during a low-battery alert.<br>1 Power cut is aborted. |
| 6 | CLK32EN | R/W | 0 | Clocking Enable<br><br>Value Description<br>0 Disabled<br>1 Enabled<br><br>This bit must be enabled to use the Hibernation module. If a crystal is used, then software should wait 20 ms after setting this bit to allow the crystal to power up and stabilize. |
| 5 | LOWBATEN | R/W | 0 | Low Battery Monitoring Enable<br><br>Value Description<br>0 Disabled<br>1 Enabled<br><br>When set, low battery voltage detection is enabled ($V_{BAT} < V_{LOWBAT}$). |
| 4 | PINWEN | R/W | 0 | External $\overline{WAKE}$ Pin Enable<br><br>Value Description<br>0 Disabled<br>1 Enabled<br><br>When set, an external event on the $\overline{WAKE}$ pin will re-power the device. |

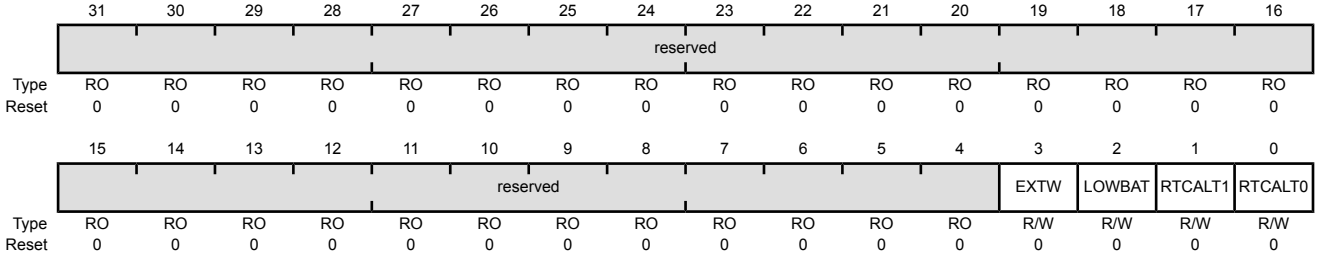
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | RTCWEN | R/W | 0 | RTC Wake-up Enable<br><br>Value: 0 = Disabled; 1 = Enabled<br><br>When set, an RTC match event (RTCM0 or RTCM1) will re-power the device based on the RTC counter value matching the corresponding match register 0 or 1. |
| 2 | CLKSEL | R/W | 0 | Hibernation Module Clock Select<br><br>Value: 0 = Use Divide by 128 output. Use this value for a 4.194304-MHz crystal.; 1 = Use raw output. Use this value for a 32.768-kHz oscillator. |
| 1 | HIBREQ | R/W | 0 | Hibernation Request<br><br>Value: 0 = Disabled; 1 = Hibernation initiated<br><br>After a wake-up event, this bit is cleared by hardware. |
| 0 | RTCEN | R/W | 0 | RTC Timer Enable<br><br>Value: 0 = Disabled; 1 = Enabled |

## Register 6: Hibernation Interrupt Mask (HIBIM), offset 0x014

This register is the interrupt mask register for the Hibernation module interrupt sources.

Hibernation Interrupt Mask (HIBIM)

Base 0x400F.C000
Offset 0x014
Type R/W, reset 0x0000.0000



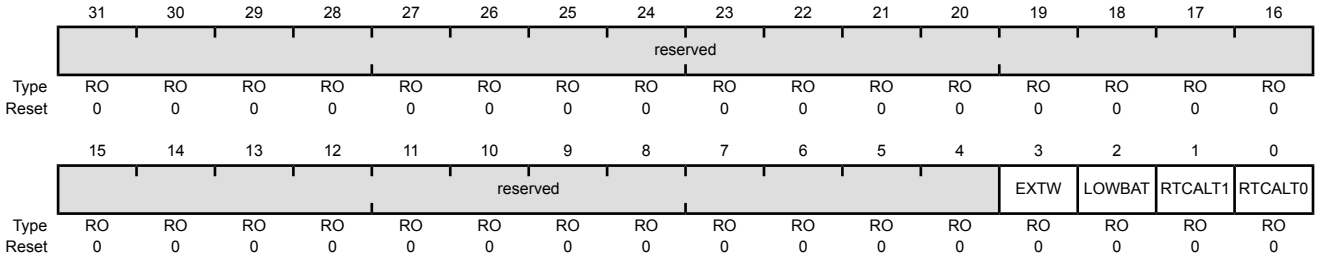

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x000.0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | EXTW | R/W | 0 | External Wake-Up Interrupt Mask<br>Value: 0 = Masked; 1 = Unmasked |
| 2 | LOWBAT | R/W | 0 | Low Battery Voltage Interrupt Mask<br>Value: 0 = Masked; 1 = Unmasked |
| 1 | RTCALT1 | R/W | 0 | RTC Alert1 Interrupt Mask<br>Value: 0 = Masked; 1 = Unmasked |
| 0 | RTCALT0 | R/W | 0 | RTC Alert0 Interrupt Mask<br>Value: 0 = Masked; 1 = Unmasked |

## Register 7: Hibernation Raw Interrupt Status (HIBRIS), offset 0x018

This register is the raw interrupt status for the Hibernation module interrupt sources.

Hibernation Raw Interrupt Status (HIBRIS)

Base 0x400F.C000
Offset 0x018
Type RO, reset 0x0000.0000



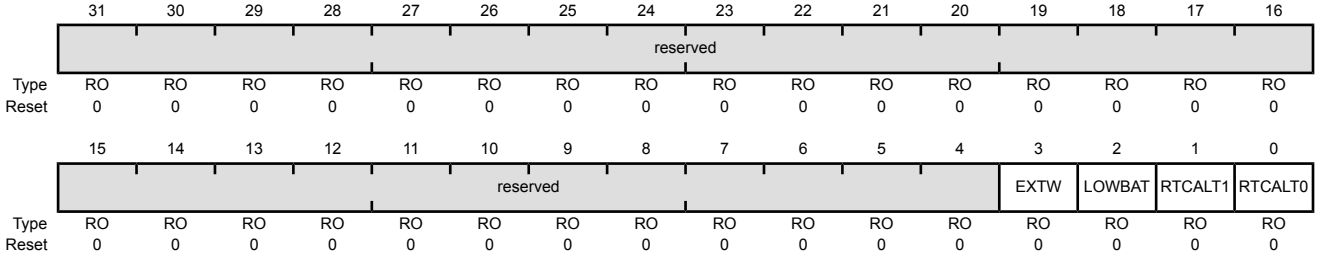

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x000.0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | EXTW | RO | 0 | External Wake-Up Raw Interrupt Status |
| 2 | LOWBAT | RO | 0 | Low Battery Voltage Raw Interrupt Status |
| 1 | RTCALT1 | RO | 0 | RTC Alert1 Raw Interrupt Status |
| 0 | RTCALT0 | RO | 0 | RTC Alert0 Raw Interrupt Status |

## Register 8: Hibernation Masked Interrupt Status (HIBMIS), offset 0x01C

This register is the masked interrupt status for the Hibernation module interrupt sources.

Hibernation Masked Interrupt Status (HIBMIS)

Base 0x400F.C000
Offset 0x01C
Type RO, reset 0x0000.0000



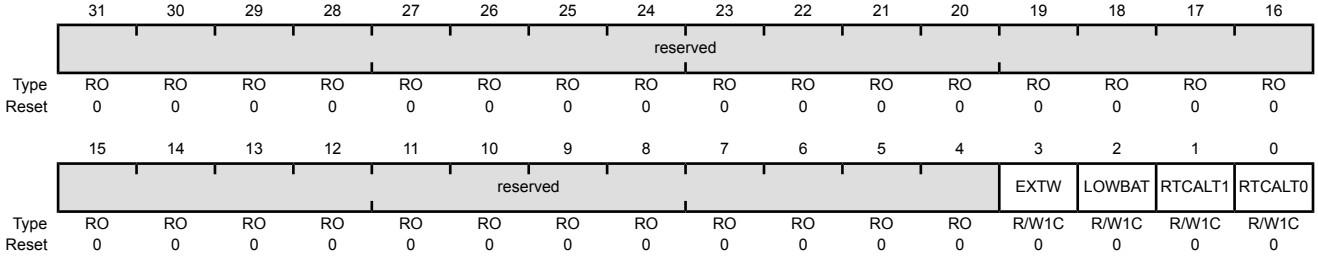

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x000.0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | EXTW | RO | 0 | External Wake-Up Masked Interrupt Status |
| 2 | LOWBAT | RO | 0 | Low Battery Voltage Masked Interrupt Status |
| 1 | RTCALT1 | RO | 0 | RTC Alert1 Masked Interrupt Status |
| 0 | RTCALT0 | RO | 0 | RTC Alert0 Masked Interrupt Status |

## Register 9: Hibernation Interrupt Clear (HIBIC), offset 0x020

This register is the interrupt write-one-to-clear register for the Hibernation module interrupt sources.

Hibernation Interrupt Clear (HIBIC)

Base 0x400F.C000
Offset 0x020
Type R/W1C, reset 0x0000.0000



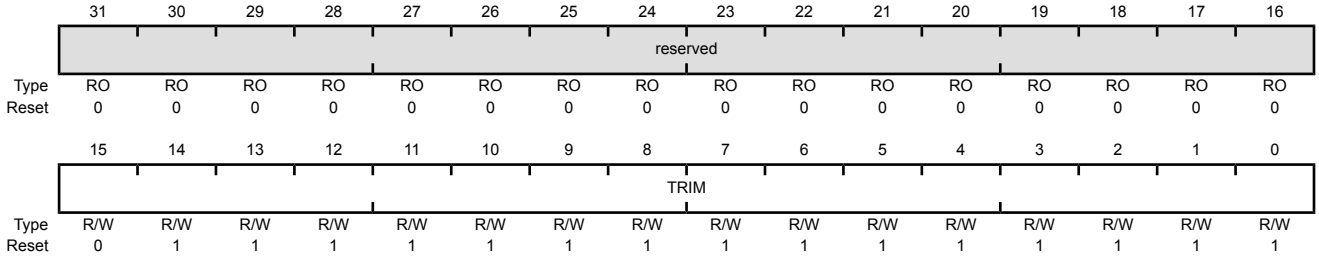

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x000.0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | EXTW | R/W1C | 0 | External Wake-Up Masked Interrupt Clear<br>Reads return an indeterminate value. |
| 2 | LOWBAT | R/W1C | 0 | Low Battery Voltage Masked Interrupt Clear<br>Reads return an indeterminate value. |
| 1 | RTCALT1 | R/W1C | 0 | RTC Alert1 Masked Interrupt Clear<br>Reads return an indeterminate value. |
| 0 | RTCALT0 | R/W1C | 0 | RTC Alert0 Masked Interrupt Clear<br>Reads return an indeterminate value. |

## Register 10: Hibernation RTC Trim (HIBRTCT), offset 0x024

This register contains the value that is used to trim the RTC clock predivider. It represents the computed underflow value that is used during the trim cycle. It is represented as 0x7FFF ± N clock cycles.

Hibernation RTC Trim (HIBRTCT)

Base 0x400F.C000
Offset 0x024
Type R/W, reset 0x0000.7FFF



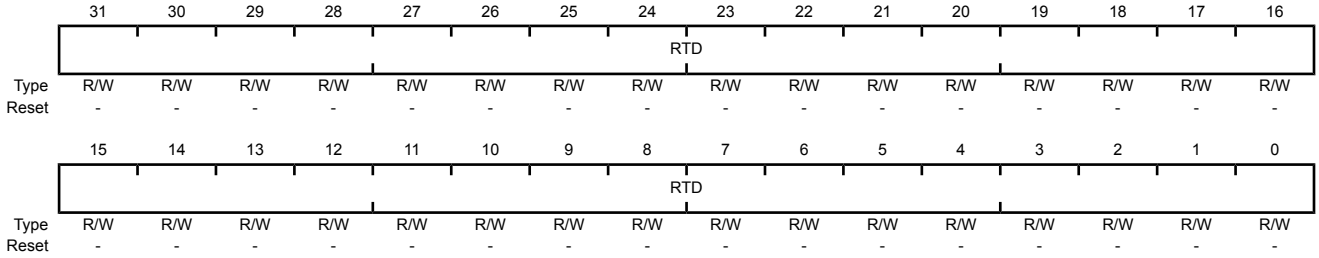

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | TRIM | R/W | 0x7FFF | RTC Trim Value<br>This value is loaded into the RTC predivider every 64 seconds. It is used to adjust the RTC rate to account for drift and inaccuracy in the clock source. The compensation is made by software by adjusting the default value of 0x7FFF up or down. |

## Register 11: Hibernation Data (HIBDATA), offset 0x030-0x12C

This address space is implemented as a 64x32-bit memory (256 bytes). It can be loaded by the system processor in order to store state information and does not lose power during a power-cut operation as long as a battery is present.

Hibernation Data (HIBDATA)

Base 0x400F.C000
Offset 0x030-0x12C
Type R/W, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | RTD | R/W | - | Hibernation Module NV Registers[63:0] |

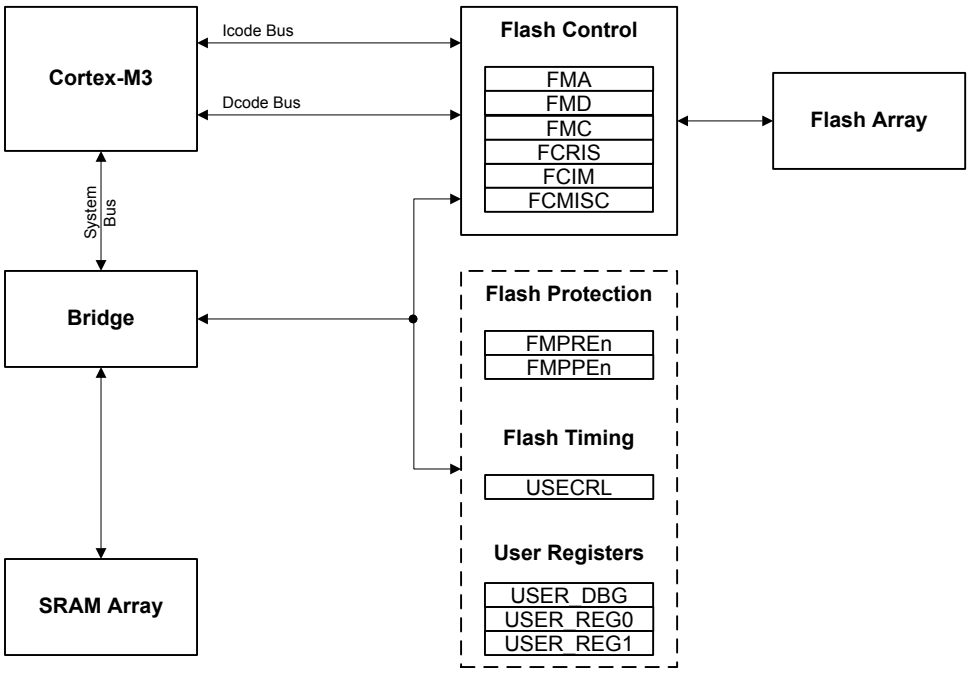
# 7 Internal Memory

The LM3S1960 microcontroller comes with 64 KB of bit-banded SRAM and 256 KB of flash memory. The flash controller provides a user-friendly interface, making flash programming a simple task. Flash protection can be applied to the flash memory on a 2-KB block basis.

## 7.1 Block Diagram

Figure 7-1 on page 254 illustrates the Flash functions. The dashed boxes in the figure indicate registers residing in the System Control module rather than the Flash Control module.

**Figure 7-1. Flash Block Diagram**




## 7.2 Functional Description

This section describes the functionality of the SRAM and Flash memories.

### 7.2.1 SRAM Memory

The internal SRAM of the Stellaris® devices is located at address 0x2000.0000 of the device memory map. To reduce the number of time consuming read-modify-write (RMW) operations, ARM has introduced *bit-banding* technology in the Cortex-M3 processor. With a bit-band-enabled processor, certain regions in the memory map (SRAM and peripheral space) can use address aliases to access individual bits in a single, atomic operation.

The bit-band alias is calculated by using the formula:

```
bit-band alias = bit-band base + (byte offset * 32) + (bit number * 4)
```

For example, if bit 3 at address 0x2000.1000 is to be modified, the bit-band alias is calculated as:

```
0x2200.0000 + (0x1000 * 32) + (3 * 4) = 0x2202.000C
```

With the alias address calculated, an instruction performing a read/write to address 0x2202.000C allows direct access to only bit 3 of the byte at address 0x2000.1000.

For details about bit-banding, see “Bit-Banding” on page 70.

### 7.2.2 Flash Memory

The flash is organized as a set of 1-KB blocks that can be individually erased. Erasing a block causes the entire contents of the block to be reset to all 1s. An individual 32-bit word can be programmed to change bits that are currently 1 to a 0. These blocks are paired into a set of 2-KB blocks that can be individually protected. The protection allows blocks to be marked as read-only or execute-only, providing different levels of code protection. Read-only blocks cannot be erased or programmed, protecting the contents of those blocks from being modified. Execute-only blocks cannot be erased or programmed, and can only be read by the controller instruction fetch mechanism, protecting the contents of those blocks from being read by either the controller or by a debugger.

See also “Serial Flash Loader” on page 622 for a preprogrammed flash-resident utility used to download code to the flash memory of a device without the use of a debug interface.

#### 7.2.2.1 Flash Memory Timing

The timing for the flash is automatically handled by the flash controller. However, in order to do so, it must know the clock rate of the system in order to time its internal signals properly. The number of clock cycles per microsecond must be provided to the flash controller for it to accomplish this timing. It is software's responsibility to keep the flash controller updated with this information via the **USec Reload (USECRL)** register.

On reset, the **USECRL** register is loaded with a value that configures the flash timing so that it works with the maximum clock rate of the part. If software changes the system operating frequency, the new operating frequency minus 1 (in MHz) must be loaded into **USECRL** before any flash modifications are attempted. For example, if the device is operating at a speed of 20 MHz, a value of 0x13 (20-1) must be written to the **USECRL** register.

#### 7.2.2.2 Flash Memory Protection

The user is provided two forms of flash protection per 2-KB flash blocks in four pairs of 32-bit wide registers. The protection policy for each form is controlled by individual bits (per policy per block) in the **FMPPEn** and **FMPREn** registers.

- **Flash Memory Protection Program Enable (FMPPEn)**: If set, the block may be programmed (written) or erased. If cleared, the block may not be changed.
- **Flash Memory Protection Read Enable (FMPREn)**: If a bit is set, the corresponding block may be executed or read by software or debuggers. If a bit is cleared, the corresponding block may only be executed, and contents of the memory block are prohibited from being read as data.

The policies may be combined as shown in Table 7-1 on page 255.

**Table 7-1. Flash Protection Policy Combinations**

| FMPPEn | FMPREn | Protection |
|---|---|---|
| 0 | 0 | Execute-only protection. The block may only be executed and may not be written or erased. This mode is used to protect code. |

**Table 7-1. Flash Protection Policy Combinations *(continued)***

| FMPPEn | FMPREn | Protection |
|---|---|---|
| 1 | 0 | The block may be written, erased or executed, but not read. This combination is unlikely to be used. |
| 0 | 1 | Read-only protection. The block may be read or executed but may not be written or erased. This mode is used to lock the block from further modification while allowing any read or execute access. |
| 1 | 1 | No protection. The block may be written, erased, executed or read. |

A Flash memory access that attempts to read a read-protected block (**FMPREn** bit is set) is prohibited and generates a bus fault. A Flash memory access that attempts to program or erase a program-protected block (**FMPPEn** bit is set) is prohibited and can optionally generate an interrupt (by setting the AMASK bit in the **Flash Controller Interrupt Mask (FCIM)** register) to alert software developers of poorly behaving software during the development and debug phases.

The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. These settings create a policy of open access and programmability. The register bits may be changed by clearing the specific register bit. The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. The changes are committed using the **Flash Memory Control (FMC)** register. Details on programming these bits are discussed in “Nonvolatile Register Programming” on page 257.

#### 7.2.2.3 Interrupts

The Flash memory controller can generate interrupts when the following conditions are observed:

- Programming Interrupt - signals when a program or erase action is complete.
- Access Interrupt - signals when a program or erase action has been attempted on a 2-kB block of memory that is protected by its corresponding **FMPPEn** bit.

The interrupt events that can trigger a controller-level interrupt are defined in the **Flash Controller Masked Interrupt Status (FCMIS)** register (see page 265) by setting the corresponding MASK bits. If interrupts are not used, the raw interrupt status is always visible via the **Flash Controller Raw Interrupt Status (FCRIS)** register (see page 264).

Interrupts are always cleared (for both the **FCMIS** and **FCRIS** registers) by writing a 1 to the corresponding bit in the **Flash Controller Masked Interrupt Status and Clear (FCMISC)** register (see page 266).

## 7.3 Flash Memory Initialization and Configuration

### 7.3.1 Flash Programming

The Stellaris devices provide a user-friendly interface for flash programming. All erase/program operations are handled via three registers: **FMA**, **FMD**, and **FMC**.

During a Flash memory operation (write, page erase, or mass erase) access to the Flash memory is inhibited. As a result, instruction and literal fetches are held off until the Flash memory operation is complete. If instruction execution is required during a Flash memory operation, the code that is executing must be placed in SRAM and executed from there while the flash operation is in progress.

#### 7.3.1.1 To program a 32-bit word

1. Write source data to the **FMD** register.
2. Write the target address to the **FMA** register.
3. Write the flash write key and the WRITE bit (a value of 0xA442.0001) to the **FMC** register.
4. Poll the **FMC** register until the WRITE bit is cleared.

#### 7.3.1.2 To perform an erase of a 1-KB page

1. Write the page address to the **FMA** register.
2. Write the flash write key and the ERASE bit (a value of 0xA442.0002) to the **FMC** register.
3. Poll the **FMC** register until the ERASE bit is cleared.

#### 7.3.1.3 To perform a mass erase of the flash

1. Write the flash write key and the MERASE bit (a value of 0xA442.0004) to the **FMC** register.
2. Poll the **FMC** register until the MERASE bit is cleared.

### 7.3.2 Nonvolatile Register Programming

This section discusses how to update registers that are resident within the Flash memory itself. These registers exist in a separate space from the main Flash memory array and are not affected by an ERASE or MASS ERASE operation. The bits in these registers can be changed from 1 to 0 with a write operation. Prior to being committed, the register contents are unaffected by any reset condition except power-on reset, which returns the register contents to the original value. By committing the register values using the COMT bit in the **FMC** register, the register contents become nonvolatile and are therefore retained following power cycling. Once the register contents are committed, the contents are permanent, and they cannot be restored to their factory default values.

With the exception of the **USER_DBG** register, the settings in these registers can be tested before committing them to Flash memory. For the **USER_DBG** register, the data to be written is loaded into the **FMD** register before it is committed. The **FMD** register is read only and does not allow the **USER_DBG** operation to be tried before committing it to nonvolatile memory.

**Important:** The Flash memory registers can only have bits changed from 1 to 0 by user programming and can only be committed once. After being committed, these registers cannot be restored to their factory default values.

In addition, the **USER_REG0**, **USER_REG1**, **USER_REG2**, **USER_REG3**, and **USER_DBG** registers each use bit 31 (NW) to indicate that they have not been committed and bits in the register may be changed from 1 to 0. These five registers can only be committed once whereas the Flash memory protection registers may be committed multiple times. Table 7-2 on page 258 provides the **FMA** address required for commitment of each of the registers and the source of the data to be written when the **FMC** register is written with a value of 0xA442.0008. After writing the COMT bit, the user may poll the **FMC** register to wait for the commit operation to complete.

**Table 7-2. User-Programmable Flash Memory Resident Registers**

| Register to be Committed | FMA Value | Data Source |
|---|---|---|
| FMPRE0 | 0x0000.0000 | FMPRE0 |
| FMPRE1 | 0x0000.0002 | FMPRE1 |
| FMPRE2 | 0x0000.0004 | FMPRE2 |
| FMPRE3 | 0x0000.0006 | FMPRE3 |
| FMPPE0 | 0x0000.0001 | FMPPE0 |
| FMPPE1 | 0x0000.0003 | FMPPE1 |
| FMPPE2 | 0x0000.0005 | FMPPE2 |
| FMPPE3 | 0x0000.0007 | FMPPE3 |
| USER_REG0 | 0x8000.0000 | USER_REG0 |
| USER_REG1 | 0x8000.0001 | USER_REG1 |
| USER_REG2 | 0x8000.0002 | USER_REG2 |
| USER_REG3 | 0x8000.0003 | USER_REG3 |
| USER_DBG | 0x7510.0000 | FMD |

## 7.4 Register Map

Table 7-3 on page 258 lists the Flash memory and control registers. The offset listed is a hexadecimal increment to the register's address. The **FMA**, **FMD**, **FMC**, **FCRIS**, **FCIM**, and **FCMISC** register offsets are relative to the Flash memory control base address of 0x400F.D000. The Flash memory protection register offsets are relative to the System Control base address of 0x400F.E000.

**Table 7-3. Flash Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| **Flash Memory Control Registers (Flash Control Offset)** | | | | | |
| 0x000 | FMA | R/W | 0x0000.0000 | Flash Memory Address | 260 |
| 0x004 | FMD | R/W | 0x0000.0000 | Flash Memory Data | 261 |
| 0x008 | FMC | R/W | 0x0000.0000 | Flash Memory Control | 262 |
| 0x00C | FCRIS | RO | 0x0000.0000 | Flash Controller Raw Interrupt Status | 264 |
| 0x010 | FCIM | R/W | 0x0000.0000 | Flash Controller Interrupt Mask | 265 |
| 0x014 | FCMISC | R/W1C | 0x0000.0000 | Flash Controller Masked Interrupt Status and Clear | 266 |
| **Flash Memory Protection Registers (System Control Offset)** | | | | | |
| 0x130 | FMPRE0 | R/W | 0xFFFF.FFFF | Flash Memory Protection Read Enable 0 | 269 |
| 0x200 | FMPRE0 | R/W | 0xFFFF.FFFF | Flash Memory Protection Read Enable 0 | 269 |
| 0x134 | FMPPE0 | R/W | 0xFFFF.FFFF | Flash Memory Protection Program Enable 0 | 270 |
| 0x400 | FMPPE0 | R/W | 0xFFFF.FFFF | Flash Memory Protection Program Enable 0 | 270 |
| 0x140 | USECRL | R/W | 0x31 | USec Reload | 268 |
| 0x1D0 | USER_DBG | R/W | 0xFFFF.FFFE | User Debug | 271 |
| 0x1E0 | USER_REG0 | R/W | 0xFFFF.FFFF | User Register 0 | 272 |

**Table 7-3. Flash Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x1E4 | USER_REG1 | R/W | 0xFFFF.FFFF | User Register 1 | 273 |
| 0x204 | FMPRE1 | R/W | 0xFFFF.FFFF | Flash Memory Protection Read Enable 1 | 274 |
| 0x208 | FMPRE2 | R/W | 0xFFFF.FFFF | Flash Memory Protection Read Enable 2 | 275 |
| 0x20C | FMPRE3 | R/W | 0xFFFF.FFFF | Flash Memory Protection Read Enable 3 | 276 |
| 0x404 | FMPPE1 | R/W | 0xFFFF.FFFF | Flash Memory Protection Program Enable 1 | 277 |
| 0x408 | FMPPE2 | R/W | 0xFFFF.FFFF | Flash Memory Protection Program Enable 2 | 278 |
| 0x40C | FMPPE3 | R/W | 0xFFFF.FFFF | Flash Memory Protection Program Enable 3 | 279 |

## 7.5 Flash Register Descriptions (Flash Control Offset)

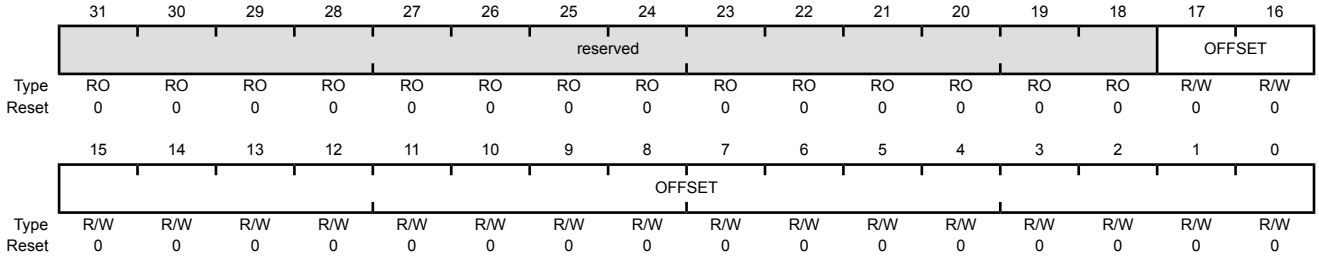
This section lists and describes the Flash Memory registers, in numerical order by address offset. Registers in this section are relative to the Flash control base address of 0x400F.D000.

## Register 1: Flash Memory Address (FMA), offset 0x000

During a write operation, this register contains a 4-byte-aligned address and specifies where the data is written. During erase operations, this register contains a 1 KB-aligned address and specifies which page is erased. Note that the alignment requirements must be met by software or the results of the operation are unpredictable.

Flash Memory Address (FMA)

Base 0x400F.D000
Offset 0x000
Type R/W, reset 0x0000.0000



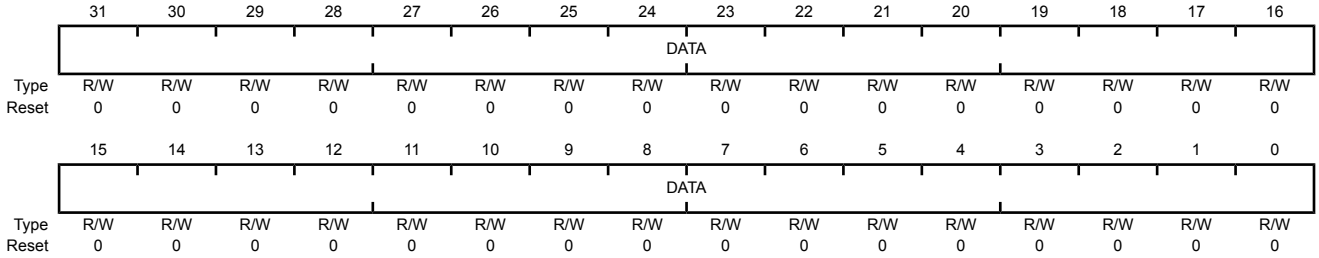

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:18 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 17:0 | OFFSET | R/W | 0x0 | Address Offset<br>Address offset in flash where operation is performed, except for nonvolatile registers (see “Nonvolatile Register Programming” on page 257 for details on values for this field). |

## Register 2: Flash Memory Data (FMD), offset 0x004

This register contains the data to be written during the programming cycle or read during the read cycle. Note that the contents of this register are undefined for a read access of an execute-only block. This register is not used during the erase cycles.

Flash Memory Data (FMD)

Base 0x400F.D000
Offset 0x004
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | DATA | R/W | 0x0 | Data Value<br>Data value for write operation. |

## Register 3: Flash Memory Control (FMC), offset 0x008

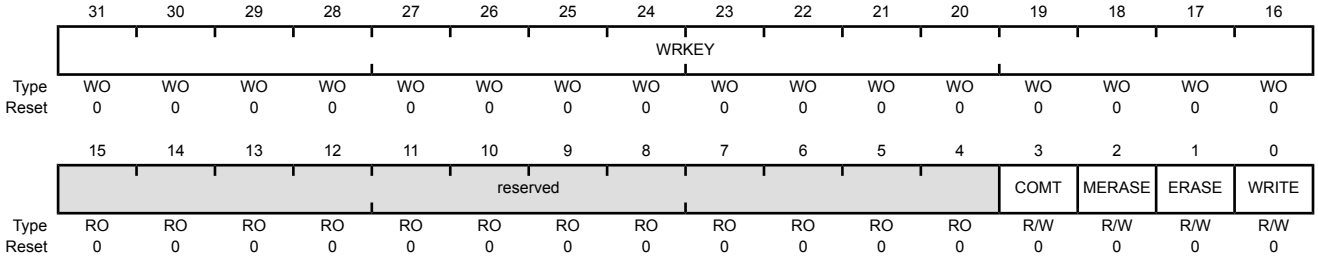
When this register is written, the flash controller initiates the appropriate access cycle for the location specified by the **Flash Memory Address (FMA)** register (see page 260). If the access is a write access, the data contained in the **Flash Memory Data (FMD)** register (see page 261) is written.

This is the final register written and initiates the memory operation. There are four control bits in the lower byte of this register that, when set, initiate the memory operation. The most used of these register bits are the ERASE and WRITE bits.

It is a programming error to write multiple control bits and the results of such an operation are unpredictable.

Flash Memory Control (FMC)

Base 0x400F.D000
Offset 0x008
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | WRKEY | WO | 0x0 | Flash Write Key<br>This field contains a write key, which is used to minimize the incidence of accidental flash writes. The value 0xA442 must be written into this field for a write to occur. Writes to the **FMC** register without this WRKEY value are ignored. A read of this field returns the value 0. |
| 15:4 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | COMT | R/W | 0 | Commit Register Value<br>Commit (write) of register value to nonvolatile storage. A write of 0 has no effect on the state of this bit.<br>If read, the state of the previous commit access is provided. If the previous commit access is complete, a 0 is returned; otherwise, if the commit access is not complete, a 1 is returned.<br>This can take up to 50 µs. |
| 2 | MERASE | R/W | 0 | Mass Erase Flash Memory<br>If this bit is set, the flash main memory of the device is all erased. A write of 0 has no effect on the state of this bit.<br>If read, the state of the previous mass erase access is provided. If the previous mass erase access is complete, a 0 is returned; otherwise, if the previous mass erase access is not complete, a 1 is returned.<br>This can take up to 250 ms. |

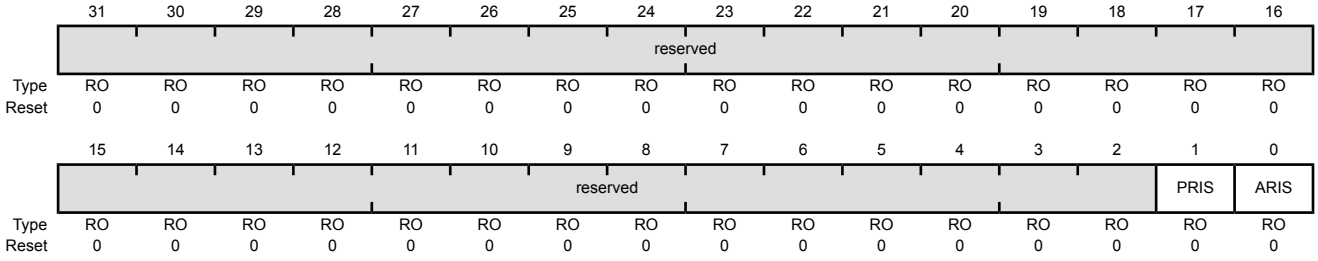
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | ERASE | R/W | 0 | Erase a Page of Flash Memory<br>If this bit is set, the page of flash main memory as specified by the contents of **FMA** is erased. A write of 0 has no effect on the state of this bit.<br>If read, the state of the previous erase access is provided. If the previous erase access is complete, a 0 is returned; otherwise, if the previous erase access is not complete, a 1 is returned.<br>This can take up to 25 ms. |
| 0 | WRITE | R/W | 0 | Write a Word into Flash Memory<br>If this bit is set, the data stored in **FMD** is written into the location as specified by the contents of **FMA**. A write of 0 has no effect on the state of this bit.<br>If read, the state of the previous write update is provided. If the previous write access is complete, a 0 is returned; otherwise, if the write access is not complete, a 1 is returned.<br>This can take up to 50 µs. |

## Register 4: Flash Controller Raw Interrupt Status (FCRIS), offset 0x00C

This register indicates that the flash controller has an interrupt condition. An interrupt is only signaled if the corresponding **FCIM** register bit is set.

Flash Controller Raw Interrupt Status (FCRIS)

Base 0x400F.D000
Offset 0x00C
Type RO, reset 0x0000.0000



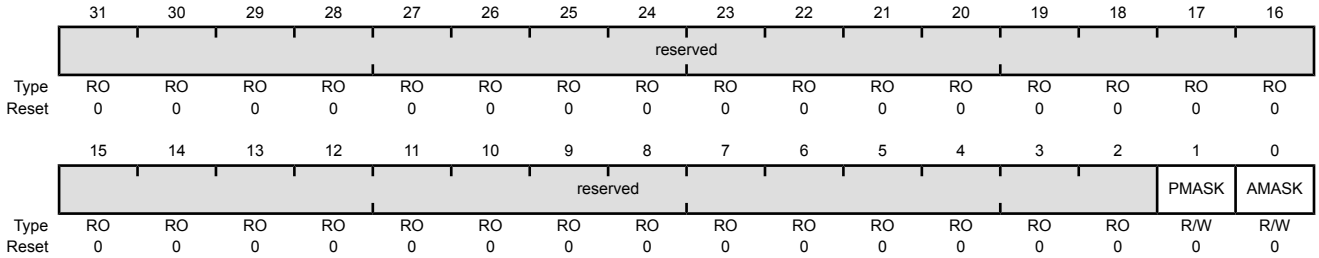

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | PRIS | RO | 0 | Programming Raw Interrupt Status<br>This bit provides status on programming cycles which are write or erase actions generated through the **FMC** register bits (see page 262).<br><br>Value Description<br>1 The programming cycle has completed.<br>0 The programming cycle has not completed.<br><br>This status is sent to the interrupt controller when the PMASK bit in the **FCIM** register is set.<br>This bit is cleared by writing a 1 to the PMISC bit in the **FCMISC** register. |
| 0 | ARIS | RO | 0 | Access Raw Interrupt Status<br><br>Value Description<br>1 A program or erase action was attempted on a block of Flash memory that contradicts the protection policy for that block as set in the **FMPPEn** registers.<br>0 No access has tried to improperly program or erase the Flash memory.<br><br>This status is sent to the interrupt controller when the AMASK bit in the **FCIM** register is set.<br>This bit is cleared by writing a 1 to the AMISC bit in the **FCMISC** register. |

## Register 5: Flash Controller Interrupt Mask (FCIM), offset 0x010

This register controls whether the flash controller generates interrupts to the controller.

Flash Controller Interrupt Mask (FCIM)

Base 0x400F.D000
Offset 0x010
Type R/W, reset 0x0000.0000



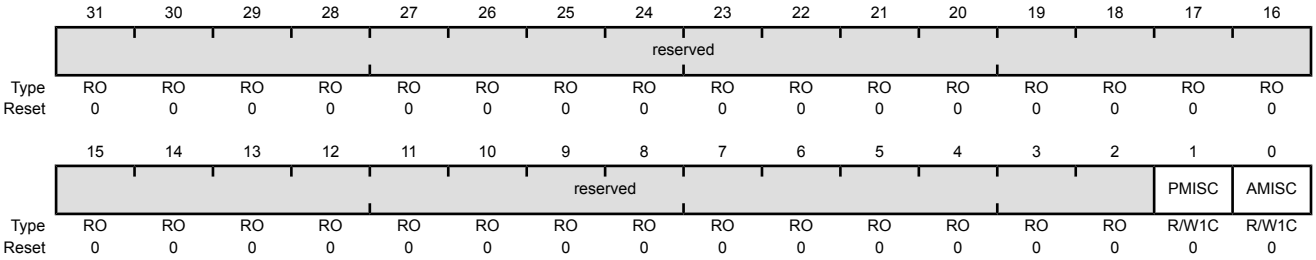

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | PMASK | R/W | 0 | Programming Interrupt Mask<br>This bit controls the reporting of the programming raw interrupt status to the interrupt controller.<br><br>Value Description<br>1 An interrupt is sent to the interrupt controller when the PRIS bit is set.<br>0 The PRIS interrupt is suppressed and not sent to the interrupt controller. |
| 0 | AMASK | R/W | 0 | Access Interrupt Mask<br>This bit controls the reporting of the access raw interrupt status to the interrupt controller.<br><br>Value Description<br>1 An interrupt is sent to the interrupt controller when the ARIS bit is set.<br>0 The ARIS interrupt is suppressed and not sent to the interrupt controller. |

## Register 6: Flash Controller Masked Interrupt Status and Clear (FCMISC), offset 0x014

This register provides two functions. First, it reports the cause of an interrupt by indicating which interrupt source or sources are signalling the interrupt. Second, it serves as the method to clear the interrupt reporting.

Flash Controller Masked Interrupt Status and Clear (FCMISC)

Base 0x400F.D000
Offset 0x014
Type R/W1C, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | PMISC | R/W1C | 0 | Programming Masked Interrupt Status and Clear<br><br>Value Description<br>1 When read, a 1 indicates that an unmasked interrupt was signaled because a programming cycle completed.<br>Writing a 1 to this bit clears `PMISC` and also the `PRIS` bit in the **FCRIS** register (see page 264).<br>0 When read, a 0 indicates that a programming cycle complete interrupt has not occurred.<br>A write of 0 has no effect on the state of this bit. |
| 0 | AMISC | R/W1C | 0 | Access Masked Interrupt Status and Clear<br><br>Value Description<br>1 When read, a 1 indicates that an unmasked interrupt was signaled because a program or erase action was attempted on a block of Flash memory that contradicts the protection policy for that block as set in the **FMPPEn** registers.<br>Writing a 1 to this bit clears `AMISC` and also the `ARIS` bit in the **FCRIS** register (see page 264).<br>0 When read, a 0 indicates that no improper accesses have occurred.<br>A write of 0 has no effect on the state of this bit. |

## 7.6 Flash Register Descriptions (System Control Offset)

The remainder of this section lists and describes the Flash Memory registers, in numerical order by address offset. Registers in this section are relative to the System Control base address of 0x400F.E000.

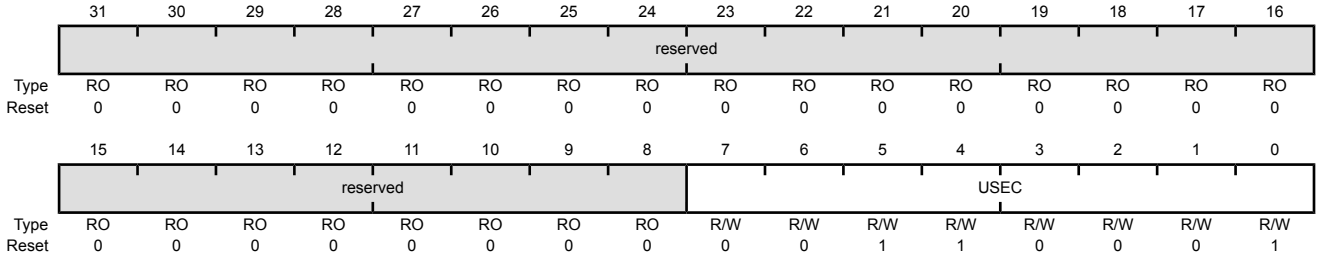
## Register 7: USec Reload (USECRL), offset 0x140

**Note:** Offset is relative to System Control base address of 0x400F.E000

This register is provided as a means of creating a 1-µs tick divider reload value for the flash controller. The internal flash has specific minimum and maximum requirements on the length of time the high voltage write pulse can be applied. It is required that this register contain the operating frequency (in MHz -1) whenever the flash is being erased or programmed. The user is required to change this value if the clocking conditions are changed for a flash erase/program operation.

USec Reload (USECRL)

Base 0x400F.E000
Offset 0x140
Type R/W, reset 0x31




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | USEC | R/W | 0x31 | Microsecond Reload Value<br>MHz -1 of the controller clock when the flash is being erased or programmed.<br>If the maximum system frequency is being used, USEC should be set to 0x31 (50 MHz) whenever the flash is being erased or programmed. |

## Register 8: Flash Memory Protection Read Enable 0 (FMPRE0), offset 0x130 and 0x200

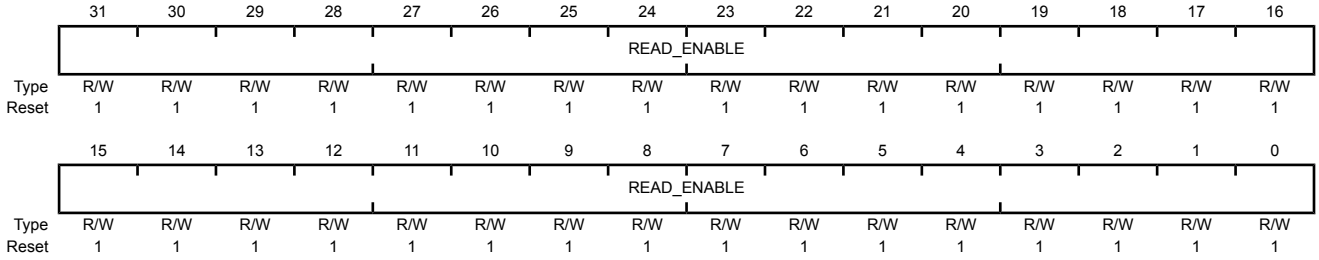
**Note:** This register is aliased for backwards compatability.

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the read-only protection bits for each 2-KB flash block (**FMPPEn** stores the execute-only bits). Flash memory up to a total of 64 KB is controlled by this register. Other **FMPREn** registers (if any) provide protection for other 64K blocks. This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Read Enable 0 (FMPRE0)

Base 0x400F.E000
Offset 0x130 and 0x200
Type R/W, reset 0xFFFF.FFFF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | READ_ENABLE | R/W | 0xFFFFFFFF | Flash Read Enable. Enables 2-KB Flash memory blocks to be executed or read. The policies may be combined as shown in the table “Flash Protection Policy Combinations”. |

| Value | Description |
|---|---|
| 0xFFFFFFFF | Bits [31:0] each enable protection on a 2-KB block of Flash memory up to the total of 64 KB. |

## Register 9: Flash Memory Protection Program Enable 0 (FMPPE0), offset 0x134 and 0x400

**Note:** This register is aliased for backwards compatability.

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the execute-only protection bits for each 2-KB flash block (**FMPREn** stores the execute-only bits). Flash memory up to a total of 64 KB is controlled by this register. Other **FMPPEn** registers (if any) provide protection for other 64K blocks. This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Program Enable 0 (FMPPE0)

Base 0x400F.E000
Offset 0x134 and 0x400
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROG_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROG_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | PROG_ENABLE | R/W | 0xFFFFFFFF | Flash Programming Enable<br>Configures 2-KB flash blocks to be execute only. The policies may be combined as shown in the table “Flash Protection Policy Combinations”.<br><br>Value Description<br>0xFFFFFFFF Bits [31:0] each enable protection on a 2-KB block of Flash memory up to the total of 64 KB. |

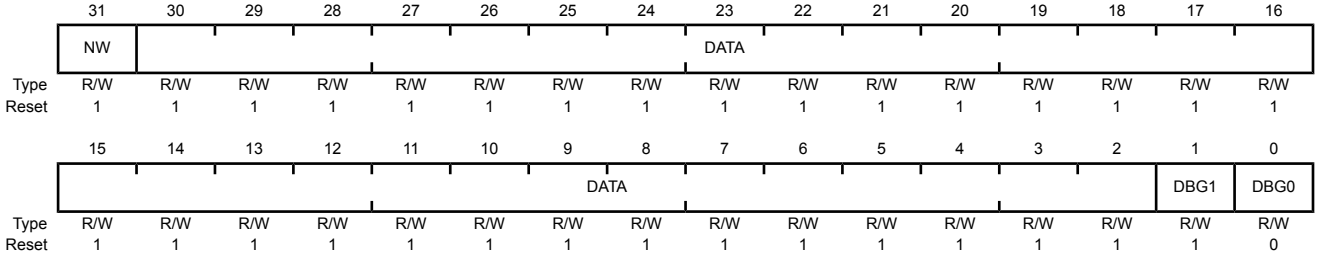
## Register 10: User Debug (USER_DBG), offset 0x1D0

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register provides a write-once mechanism to disable external debugger access to the device in addition to 27 additional bits of user-defined data. The DBG0 bit (bit 0) is set to 0 from the factory and the DBG1 bit (bit 1) is set to 1, which enables external debuggers. Changing the DBG1 bit to 0 disables any external debugger access to the device permanently, starting with the next power-up cycle of the device. The NW bit (bit 31) indicates that the register has not yet been committed and is controlled through hardware to ensure that the register is only committed once. Prior to being committed, bits can only be changed from 1 to 0. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. Once committed, this register cannot be restored to the factory default value.

User Debug (USER_DBG)

Base 0x400F.E000
Offset 0x1D0
Type R/W, reset 0xFFFF.FFFE




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | NW | R/W | 1 | User Debug Not Written<br>When set, this bit indicates that this 32-bit register has not been committed. When clear, this bit specifies that this register has been committed and may not be committed again. |
| 30:2 | DATA | R/W | 0x1FFFFFFF | User Data<br>Contains the user data value. This field is initialized to all 1s and can only be committed once. |
| 1 | DBG1 | R/W | 1 | Debug Control 1<br>The DBG1 bit must be 1 and DBG0 must be 0 for debug to be available. |
| 0 | DBG0 | R/W | 0 | Debug Control 0<br>The DBG1 bit must be 1 and DBG0 must be 0 for debug to be available. |

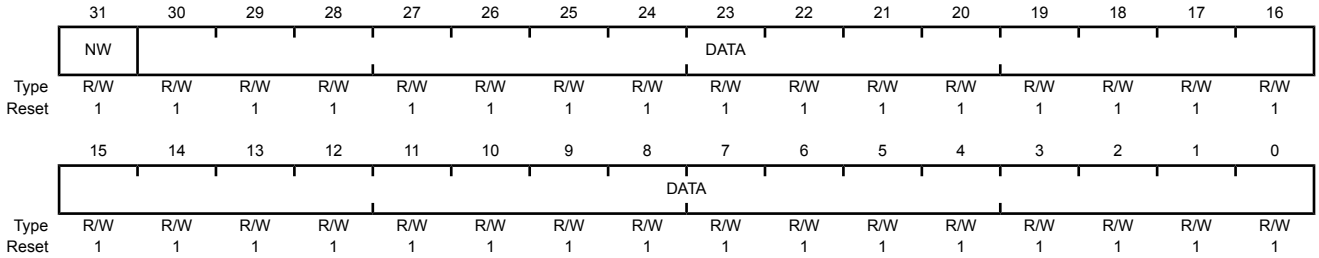
## Register 11: User Register 0 (USER_REG0), offset 0x1E0

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register provides 31 bits of user-defined data that is non-volatile and can only be committed once. Bit 31 indicates that the register is available to be committed and is controlled through hardware to ensure that the register is only committed once. Prior to being committed, bits can only be changed from 1 to 0. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. The write-once characteristics of this register are useful for keeping static information like communication addresses that need to be unique per part and would otherwise require an external EEPROM or other non-volatile device. Once committed, this register cannot be restored to the factory default value.

User Register 0 (USER_REG0)

Base 0x400F.E000
Offset 0x1E0
Type R/W, reset 0xFFFF.FFFF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | NW | R/W | 1 | Not Written<br>When set, this bit indicates that this 32-bit register has not been committed. When clear, this bit specifies that this register has been committed and may not be committed again. |
| 30:0 | DATA | R/W | 0x7FFFFFFF | User Data<br>Contains the user data value. This field is initialized to all 1s and can only be committed once. |

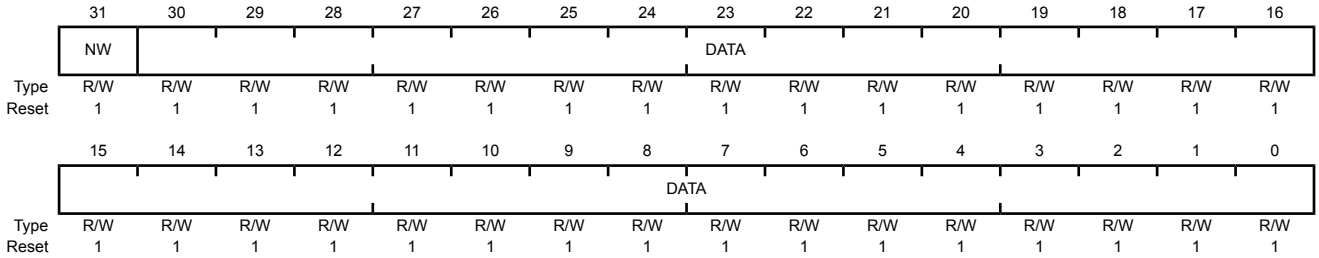
## Register 12: User Register 1 (USER_REG1), offset 0x1E4

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register provides 31 bits of user-defined data that is non-volatile and can only be committed once. Bit 31 indicates that the register is available to be committed and is controlled through hardware to ensure that the register is only committed once. Prior to being committed, bits can only be changed from 1 to 0. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. The write-once characteristics of this register are useful for keeping static information like communication addresses that need to be unique per part and would otherwise require an external EEPROM or other non-volatile device. Once committed, this register cannot be restored to the factory default value.

User Register 1 (USER_REG1)

Base 0x400F.E000
Offset 0x1E4
Type R/W, reset 0xFFFF.FFFF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31 | NW | R/W | 1 | Not Written<br>When set, this bit indicates that this 32-bit register has not been committed. When clear, this bit specifies that this register has been committed and may not be committed again. |
| 30:0 | DATA | R/W | 0x7FFFFFFF | User Data<br>Contains the user data value. This field is initialized to all 1s and can only be committed once. |

## Register 13: Flash Memory Protection Read Enable 1 (FMPRE1), offset 0x204

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the read-only protection bits for each 2-KB flash block (**FMPPEn** stores the execute-only bits). Flash memory up to a total of 64 KB is controlled by this register. Other **FMPREn** registers (if any) provide protection for other 64K blocks. This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. If the Flash memory size on the device is less than 64 KB, this register usually reads as zeroes, but software should not rely on these bits to be zero. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Read Enable 1 (FMPRE1)

Base 0x400F.E000
Offset 0x204
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | READ_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | READ_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | READ_ENABLE | R/W | 0xFFFFFFFF | Flash Read Enable. Enables 2-KB Flash memory blocks to be executed or read. The policies may be combined as shown in the table “Flash Protection Policy Combinations”. |

| Value | Description |
|---|---|
| 0xFFFFFFFF | Bits [31:0] each enable protection on a 2-KB block of Flash memory in memory range from 65 to 128 KB. |

## Register 14: Flash Memory Protection Read Enable 2 (FMPRE2), offset 0x208

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the read-only protection bits for each 2-KB flash block (**FMPPEn** stores the execute-only bits). This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Read Enable 2 (FMPRE2)

Base 0x400F.E000
Offset 0x208
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | READ_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | READ_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | READ_ENABLE | R/W | 0xFFFFFFFF | Flash Read Enable<br>Enables 2-KB flash blocks to be executed or read. The policies may be combined as shown in the table “Flash Protection Policy Combinations”.<br><br>Value Description<br>0xFFFFFFFF Enables 256 KB of flash. |

## Register 15: Flash Memory Protection Read Enable 3 (FMPRE3), offset 0x20C

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the read-only protection bits for each 2-KB flash block (**FMPPEn** stores the execute-only bits). This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Read Enable 3 (FMPRE3)

Base 0x400F.E000
Offset 0x20C
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | READ_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | READ_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | READ_ENABLE | R/W | 0xFFFFFFFF | Flash Read Enable<br>Enables 2-KB flash blocks to be executed or read. The policies may be combined as shown in the table “Flash Protection Policy Combinations”.<br>Value Description<br>0xFFFFFFFF Enables 256 KB of flash. |

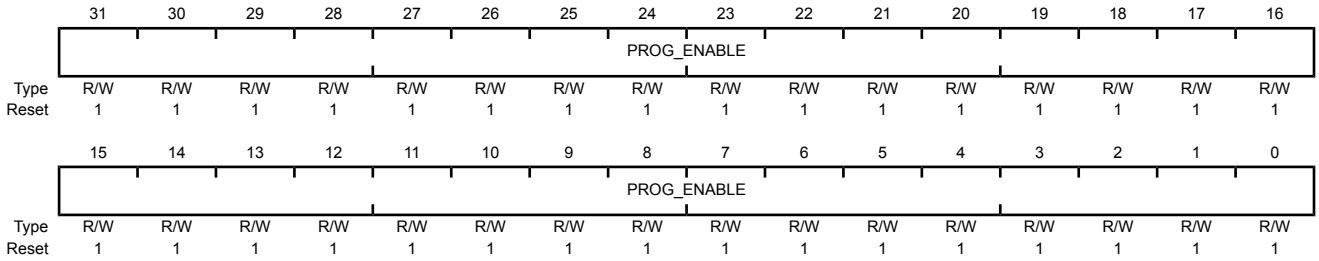
## Register 16: Flash Memory Protection Program Enable 1 (FMPPE1), offset 0x404

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the execute-only protection bits for each 2-KB flash block (**FMPREn** stores the execute-only bits). Flash memory up to a total of 64 KB is controlled by this register. Other **FMPPEn** registers (if any) provide protection for other 64K blocks. This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. The reset value shown only applies to power-on reset; any other type of reset does not affect this register. If the Flash memory size on the device is less than 64 KB, this register usually reads as zeroes, but software should not rely on these bits to be zero. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Program Enable 1 (FMPPE1)

Base 0x400F.E000
Offset 0x404
Type R/W, reset 0xFFFF.FFFF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | PROG_ENABLE | R/W | 0xFFFFFFFF | Flash Programming Enable |

| Value | Description |
|---|---|
| 0xFFFFFFFF | Bits [31:0] each enable protection on a 2-KB block of Flash memory in memory range from 65 to 128 KB. |

## Register 17: Flash Memory Protection Program Enable 2 (FMPPE2), offset 0x408

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the execute-only protection bits for each 2-KB flash block (**FMPREn** stores the execute-only bits). This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Program Enable 2 (FMPPE2)

Base 0x400F.E000
Offset 0x408
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROG_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROG_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | PROG_ENABLE | R/W | 0xFFFFFFFF | Flash Programming Enable<br>Configures 2-KB flash blocks to be execute only. The policies may be combined as shown in the table “Flash Protection Policy Combinations”.<br><br>Value Description<br>0xFFFFFFFF Enables 256 KB of flash. |

## Register 18: Flash Memory Protection Program Enable 3 (FMPPE3), offset 0x40C

**Note:** Offset is relative to System Control base address of 0x400FE000.

This register stores the execute-only protection bits for each 2-KB flash block (**FMPREn** stores the execute-only bits). This register is loaded during the power-on reset sequence. The factory settings for the **FMPREn** and **FMPPEn** registers are a value of 1 for all implemented banks. This achieves a policy of open access and programmability. The register bits may be changed by writing the specific register bit. However, this register is R/W0; the user can only change the protection bit from a 1 to a 0 (and may NOT change a 0 to a 1). The changes are not permanent until the register is committed (saved), at which point the bit change is permanent. If a bit is changed from a 1 to a 0 and not committed, it may be restored by executing a power-on reset sequence. For additional information, see the "Flash Memory Protection" section.

Flash Memory Protection Program Enable 3 (FMPPE3)

Base 0x400F.E000
Offset 0x40C
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROG_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROG_ENABLE | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | PROG_ENABLE | R/W | 0xFFFFFFFF | Flash Programming Enable<br>Configures 2-KB flash blocks to be execute only. The policies may be combined as shown in the table “Flash Protection Policy Combinations”.<br><br>Value Description<br>0xFFFFFFFF Enables 256 KB of flash. |

# 8 General-Purpose Input/Outputs (GPIOs)

The GPIO module is composed of eight physical GPIO blocks, each corresponding to an individual GPIO port (Port A, Port B, Port C, Port D, Port E, Port F, Port G, Port H). The GPIO module supports 7-60 programmable input/output pins, depending on the peripherals being used.

The GPIO module has the following features:

- 7-60 GPIOs, depending on configuration
- 5-V-tolerant in input configuration
- Fast toggle capable of a change every two clock cycles
- Programmable control for GPIO interrupts
  - Interrupt generation masking
  - Edge-triggered on rising, falling, or both
  - Level-sensitive on High or Low values
- Bit masking in both read and write operations through address lines
- Pins configured as digital inputs are Schmitt-triggered.
- Programmable control for GPIO pad configuration
  - Weak pull-up or pull-down resistors
  - 2-mA, 4-mA, and 8-mA pad drive for digital communication; up to four pads can be configured with an 18-mA pad drive for high-current applications
  - Slew rate control for the 8-mA drive
  - Open drain enables
  - Digital input enables

## 8.1 Signal Description

GPIO signals have alternate hardware functions. Table 8-4 on page 284 and Table 8-5 on page 285 list the GPIO pins and the digital alternate functions. Other analog signals are 5-V tolerant and are connected directly to their circuitry (C0-, C0+, C1-, C1+, C2-, C2+). These signals are configured by clearing the DEN bit in the **GPIO Digital Enable (GPIODEN)** register. The digital alternate hardware functions are enabled by setting the appropriate bit in the **GPIO Alternate Function Select (GPIOAFSEL)** and **GPIODEN** registers and configuring the PMCx bit field in the **GPIO Port Control (GPIOPCTL)** register to the numeric enoding shown in the table below. Note that each pin must be programmed individually; no type of grouping is implied by the columns in the table.

**Important:** All GPIO pins are configured as GPIOs and tri-stated by default (**GPIOAFSEL**=0, **GPIODEN**=0, **GPIOPDR**=0, **GPIOPUR**=0, and **GPIOPCTL**=0, with the exception of the four JTAG/SWD pins (shown in the table below). A Power-On-Reset ($\overline{\text{POR}}$) or asserting $\overline{\text{RST}}$ puts the pins back to their default state.

**Table 8-1. GPIO Pins With Non-Zero Reset Values**

| GPIO Pins | Default State | GPIOAFSEL | GPIODEN | GPIOPDR | GPIOPUR | GPIOPCTL |
|---|---|---|---|---|---|---|
| PA[1:0] | UART0 | 1 | 1 | 0 | 0 | 0x1 |
| PA[5:2] | SSI0 | 1 | 1 | 0 | 0 | 0x1 |
| PB[3:2] | $I^2C0$ | 1 | 1 | 0 | 0 | 0x1 |
| PC[3:0] | JTAG/SWD | 1 | 1 | 0 | 1 | 0x3 |

**Table 8-2. GPIO Pins and Alternate Functions (100LQFP)**

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PA0 | 26 | U0Rx | |
| PA1 | 27 | U0Tx | |
| PA2 | 28 | SSI0Clk | |
| PA3 | 29 | SSI0Fss | |
| PA4 | 30 | SSI0Rx | |
| PA5 | 31 | SSI0Tx | |
| PA6 | 34 | I2C1SCL | |
| PA7 | 35 | I2C1SDA | |
| PB0 | 66 | PWM2 | |
| PB1 | 67 | PWM3 | |
| PB2 | 70 | I2C0SCL | |
| PB3 | 71 | I2C0SDA | |
| PB4 | 92 | C0- | |
| PB5 | 91 | C1- | |
| PB6 | 90 | C0+ | |
| PB7 | 89 | TRST | |
| PC0 | 80 | TCK | SWCLK |
| PC1 | 79 | TMS | SWDIO |
| PC2 | 78 | TDI | |
| PC3 | 77 | TDO | SWO |
| PC4 | 25 | CCP5 | |
| PC5 | 24 | C1+ | |
| PC6 | 23 | C2+ | |
| PC7 | 22 | C2- | |
| PD0 | 10 | IDX0 | |
| PD1 | 11 | PhA0 | |
| PD2 | 12 | U1Rx | |
| PD3 | 13 | U1Tx | |
| PD4 | 95 | CCP0 | |
| PD5 | 96 | CCP2 | |
| PD6 | 99 | Fault | |
| PD7 | 100 | CCP1 | |
| PE0 | 72 | SSI1Clk | |

**Table 8-2. GPIO Pins and Alternate Functions (100LQFP) *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PE1 | 73 | SSI1Fss | |
| PE2 | 74 | SSI1Rx | |
| PE3 | 75 | SSI1Tx | |
| PE4 | 6 | CCP3 | |
| PE5 | 5 | | |
| PE6 | 2 | PWM4 | |
| PE7 | 1 | PWM5 | |
| PF0 | 47 | PWM0 | |
| PF1 | 61 | PWM1 | |
| PF2 | 60 | | |
| PF3 | 59 | | |
| PF4 | 58 | C0o | |
| PF5 | 46 | C1o | |
| PF6 | 43 | C2o | |
| PF7 | 42 | CCP4 | |
| PG0 | 19 | U2Rx | |
| PG1 | 18 | U2Tx | |
| PG2 | 17 | | |
| PG3 | 16 | | |
| PG4 | 41 | | |
| PG5 | 40 | | |
| PG6 | 37 | PhA1 | |
| PG7 | 36 | PhB1 | |
| PH0 | 86 | CCP6 | |
| PH1 | 85 | CCP7 | |
| PH2 | 84 | IDX1 | |
| PH3 | 83 | PhB0 | |

**Table 8-3. GPIO Pins and Alternate Functions (108BGA)**

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PA0 | L3 | U0Rx | |
| PA1 | M3 | U0Tx | |
| PA2 | M4 | SSI0Clk | |
| PA3 | L4 | SSI0Fss | |
| PA4 | L5 | SSI0Rx | |
| PA5 | M5 | SSI0Tx | |
| PA6 | L6 | I2C1SCL | |
| PA7 | M6 | I2C1SDA | |
| PB0 | E12 | PWM2 | |
| PB1 | D12 | PWM3 | |
| PB2 | C11 | I2C0SCL | |

**Table 8-3. GPIO Pins and Alternate Functions (108BGA) *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PB3 | C12 | I2C0SDA | |
| PB4 | A6 | C0- | |
| PB5 | B7 | C1- | |
| PB6 | A7 | C0+ | |
| PB7 | A8 | TRST | |
| PC0 | A9 | TCK | SWCLK |
| PC1 | B9 | TMS | SWDIO |
| PC2 | B8 | TDI | |
| PC3 | A10 | TDO | SWO |
| PC4 | L1 | CCP5 | |
| PC5 | M1 | C1+ | |
| PC6 | M2 | C2+ | |
| PC7 | L2 | C2- | |
| PD0 | G1 | IDX0 | |
| PD1 | G2 | PhA0 | |
| PD2 | H2 | U1Rx | |
| PD3 | H1 | U1Tx | |
| PD4 | E1 | CCP0 | |
| PD5 | E2 | CCP2 | |
| PD6 | F2 | Fault | |
| PD7 | F1 | CCP1 | |
| PE0 | A11 | SSI1Clk | |
| PE1 | B12 | SSI1Fss | |
| PE2 | B11 | SSI1Rx | |
| PE3 | A12 | SSI1Tx | |
| PE4 | D1 | CCP3 | |
| PE5 | D2 | | |
| PE6 | C2 | PWM4 | |
| PE7 | C1 | PWM5 | |
| PF0 | M9 | PWM0 | |
| PF1 | H12 | PWM1 | |
| PF2 | J11 | | |
| PF3 | J12 | | |
| PF4 | L9 | C0o | |
| PF5 | L8 | C1o | |
| PF6 | M8 | C2o | |
| PF7 | K4 | CCP4 | |
| PG0 | K1 | U2Rx | |
| PG1 | K2 | U2Tx | |
| PG2 | J1 | | |
| PG3 | J2 | | |

**Table 8-3. GPIO Pins and Alternate Functions (108BGA) *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PG4 | K3 | | |
| PG5 | M7 | | |
| PG6 | L7 | PhA1 | |
| PG7 | C10 | PhB1 | |
| PH0 | C9 | CCP6 | |
| PH1 | C8 | CCP7 | |
| PH2 | D11 | IDX1 | |
| PH3 | D10 | PhB0 | |

**Table 8-4. GPIO Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PA0 | 26 | I/O | TTL | GPIO port A bit 0. |
| PA1 | 27 | I/O | TTL | GPIO port A bit 1. |
| PA2 | 28 | I/O | TTL | GPIO port A bit 2. |
| PA3 | 29 | I/O | TTL | GPIO port A bit 3. |
| PA4 | 30 | I/O | TTL | GPIO port A bit 4. |
| PA5 | 31 | I/O | TTL | GPIO port A bit 5. |
| PA6 | 34 | I/O | TTL | GPIO port A bit 6. |
| PA7 | 35 | I/O | TTL | GPIO port A bit 7. |
| PB0 | 66 | I/O | TTL | GPIO port B bit 0. |
| PB1 | 67 | I/O | TTL | GPIO port B bit 1. |
| PB2 | 70 | I/O | TTL | GPIO port B bit 2. |
| PB3 | 71 | I/O | TTL | GPIO port B bit 3. |
| PB4 | 92 | I/O | TTL | GPIO port B bit 4. |
| PB5 | 91 | I/O | TTL | GPIO port B bit 5. |
| PB6 | 90 | I/O | TTL | GPIO port B bit 6. |
| PB7 | 89 | I/O | TTL | GPIO port B bit 7. |
| PC0 | 80 | I/O | TTL | GPIO port C bit 0. |
| PC1 | 79 | I/O | TTL | GPIO port C bit 1. |
| PC2 | 78 | I/O | TTL | GPIO port C bit 2. |
| PC3 | 77 | I/O | TTL | GPIO port C bit 3. |
| PC4 | 25 | I/O | TTL | GPIO port C bit 4. |
| PC5 | 24 | I/O | TTL | GPIO port C bit 5. |
| PC6 | 23 | I/O | TTL | GPIO port C bit 6. |
| PC7 | 22 | I/O | TTL | GPIO port C bit 7. |
| PD0 | 10 | I/O | TTL | GPIO port D bit 0. |
| PD1 | 11 | I/O | TTL | GPIO port D bit 1. |
| PD2 | 12 | I/O | TTL | GPIO port D bit 2. |
| PD3 | 13 | I/O | TTL | GPIO port D bit 3. |
| PD4 | 95 | I/O | TTL | GPIO port D bit 4. |
| PD5 | 96 | I/O | TTL | GPIO port D bit 5. |

**Table 8-4. GPIO Signals (100LQFP) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PD6 | 99 | I/O | TTL | GPIO port D bit 6. |
| PD7 | 100 | I/O | TTL | GPIO port D bit 7. |
| PE0 | 72 | I/O | TTL | GPIO port E bit 0. |
| PE1 | 73 | I/O | TTL | GPIO port E bit 1. |
| PE2 | 74 | I/O | TTL | GPIO port E bit 2. |
| PE3 | 75 | I/O | TTL | GPIO port E bit 3. |
| PE4 | 6 | I/O | TTL | GPIO port E bit 4. |
| PE5 | 5 | I/O | TTL | GPIO port E bit 5. |
| PE6 | 2 | I/O | TTL | GPIO port E bit 6. |
| PE7 | 1 | I/O | TTL | GPIO port E bit 7. |
| PF0 | 47 | I/O | TTL | GPIO port F bit 0. |
| PF1 | 61 | I/O | TTL | GPIO port F bit 1. |
| PF2 | 60 | I/O | TTL | GPIO port F bit 2. |
| PF3 | 59 | I/O | TTL | GPIO port F bit 3. |
| PF4 | 58 | I/O | TTL | GPIO port F bit 4. |
| PF5 | 46 | I/O | TTL | GPIO port F bit 5. |
| PF6 | 43 | I/O | TTL | GPIO port F bit 6. |
| PF7 | 42 | I/O | TTL | GPIO port F bit 7. |
| PG0 | 19 | I/O | TTL | GPIO port G bit 0. |
| PG1 | 18 | I/O | TTL | GPIO port G bit 1. |
| PG2 | 17 | I/O | TTL | GPIO port G bit 2. |
| PG3 | 16 | I/O | TTL | GPIO port G bit 3. |
| PG4 | 41 | I/O | TTL | GPIO port G bit 4. |
| PG5 | 40 | I/O | TTL | GPIO port G bit 5. |
| PG6 | 37 | I/O | TTL | GPIO port G bit 6. |
| PG7 | 36 | I/O | TTL | GPIO port G bit 7. |
| PH0 | 86 | I/O | TTL | GPIO port H bit 0. |
| PH1 | 85 | I/O | TTL | GPIO port H bit 1. |
| PH2 | 84 | I/O | TTL | GPIO port H bit 2. |
| PH3 | 83 | I/O | TTL | GPIO port H bit 3. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 8-5. GPIO Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PA0 | L3 | I/O | TTL | GPIO port A bit 0. |
| PA1 | M3 | I/O | TTL | GPIO port A bit 1. |
| PA2 | M4 | I/O | TTL | GPIO port A bit 2. |
| PA3 | L4 | I/O | TTL | GPIO port A bit 3. |
| PA4 | L5 | I/O | TTL | GPIO port A bit 4. |
| PA5 | M5 | I/O | TTL | GPIO port A bit 5. |
| PA6 | L6 | I/O | TTL | GPIO port A bit 6. |

**Table 8-5. GPIO Signals (108BGA) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PA7 | M6 | I/O | TTL | GPIO port A bit 7. |
| PB0 | E12 | I/O | TTL | GPIO port B bit 0. |
| PB1 | D12 | I/O | TTL | GPIO port B bit 1. |
| PB2 | C11 | I/O | TTL | GPIO port B bit 2. |
| PB3 | C12 | I/O | TTL | GPIO port B bit 3. |
| PB4 | A6 | I/O | TTL | GPIO port B bit 4. |
| PB5 | B7 | I/O | TTL | GPIO port B bit 5. |
| PB6 | A7 | I/O | TTL | GPIO port B bit 6. |
| PB7 | A8 | I/O | TTL | GPIO port B bit 7. |
| PC0 | A9 | I/O | TTL | GPIO port C bit 0. |
| PC1 | B9 | I/O | TTL | GPIO port C bit 1. |
| PC2 | B8 | I/O | TTL | GPIO port C bit 2. |
| PC3 | A10 | I/O | TTL | GPIO port C bit 3. |
| PC4 | L1 | I/O | TTL | GPIO port C bit 4. |
| PC5 | M1 | I/O | TTL | GPIO port C bit 5. |
| PC6 | M2 | I/O | TTL | GPIO port C bit 6. |
| PC7 | L2 | I/O | TTL | GPIO port C bit 7. |
| PD0 | G1 | I/O | TTL | GPIO port D bit 0. |
| PD1 | G2 | I/O | TTL | GPIO port D bit 1. |
| PD2 | H2 | I/O | TTL | GPIO port D bit 2. |
| PD3 | H1 | I/O | TTL | GPIO port D bit 3. |
| PD4 | E1 | I/O | TTL | GPIO port D bit 4. |
| PD5 | E2 | I/O | TTL | GPIO port D bit 5. |
| PD6 | F2 | I/O | TTL | GPIO port D bit 6. |
| PD7 | F1 | I/O | TTL | GPIO port D bit 7. |
| PE0 | A11 | I/O | TTL | GPIO port E bit 0. |
| PE1 | B12 | I/O | TTL | GPIO port E bit 1. |
| PE2 | B11 | I/O | TTL | GPIO port E bit 2. |
| PE3 | A12 | I/O | TTL | GPIO port E bit 3. |
| PE4 | D1 | I/O | TTL | GPIO port E bit 4. |
| PE5 | D2 | I/O | TTL | GPIO port E bit 5. |
| PE6 | C2 | I/O | TTL | GPIO port E bit 6. |
| PE7 | C1 | I/O | TTL | GPIO port E bit 7. |
| PF0 | M9 | I/O | TTL | GPIO port F bit 0. |
| PF1 | H12 | I/O | TTL | GPIO port F bit 1. |
| PF2 | J11 | I/O | TTL | GPIO port F bit 2. |
| PF3 | J12 | I/O | TTL | GPIO port F bit 3. |
| PF4 | L9 | I/O | TTL | GPIO port F bit 4. |
| PF5 | L8 | I/O | TTL | GPIO port F bit 5. |
| PF6 | M8 | I/O | TTL | GPIO port F bit 6. |
| PF7 | K4 | I/O | TTL | GPIO port F bit 7. |

**Table 8-5. GPIO Signals (108BGA) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PG0 | K1 | I/O | TTL | GPIO port G bit 0. |
| PG1 | K2 | I/O | TTL | GPIO port G bit 1. |
| PG2 | J1 | I/O | TTL | GPIO port G bit 2. |
| PG3 | J2 | I/O | TTL | GPIO port G bit 3. |
| PG4 | K3 | I/O | TTL | GPIO port G bit 4. |
| PG5 | M7 | I/O | TTL | GPIO port G bit 5. |
| PG6 | L7 | I/O | TTL | GPIO port G bit 6. |
| PG7 | C10 | I/O | TTL | GPIO port G bit 7. |
| PH0 | C9 | I/O | TTL | GPIO port H bit 0. |
| PH1 | C8 | I/O | TTL | GPIO port H bit 1. |
| PH2 | D11 | I/O | TTL | GPIO port H bit 2. |
| PH3 | D10 | I/O | TTL | GPIO port H bit 3. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

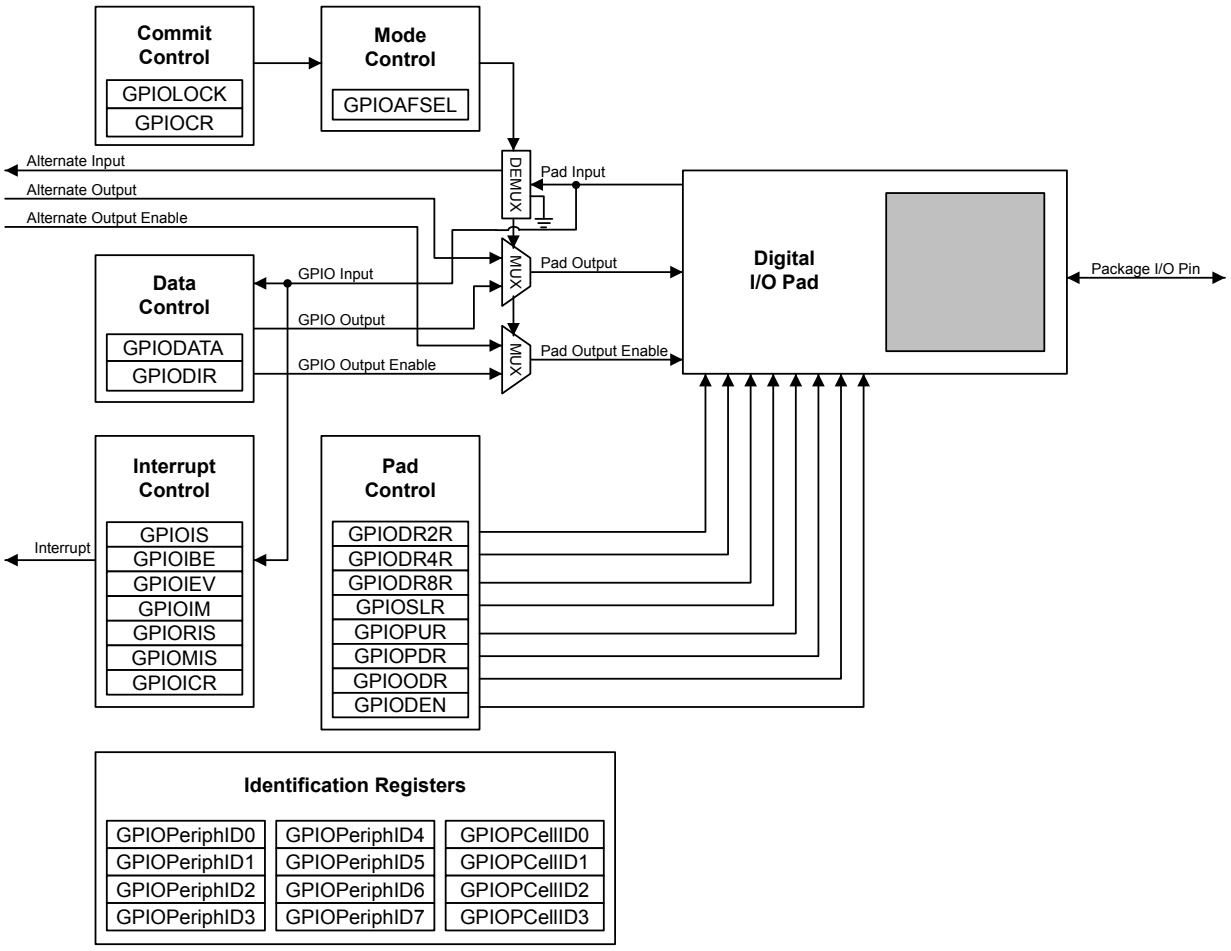
## 8.2 Functional Description

**Important:** All GPIO pins are tri-stated by default (**GPIOAFSEL**=0, **GPIODEN**=0, **GPIOPDR**=0, and **GPIOPUR**=0), with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). The JTAG/SWD pins default to their JTAG/SWD functionality (**GPIOAFSEL**=1, **GPIODEN=1** and **GPIOPUR**=1). A Power-On-Reset ($\overline{\text{POR}}$) or asserting $\overline{\text{RST}}$ puts both groups of pins back to their default state.

While debugging systems where PB7 is being used as a GPIO, care must be taken to ensure that a low value is not applied to the pin when the part is reset. Because PB7 reverts to the $\overline{\text{TRST}}$ function after reset, a Low value on the pin causes the JTAG controller to be reset, resulting in a loss of JTAG communication.

Each GPIO port is a separate hardware instantiation of the same physical block (see Figure 8-1 on page 288). The LM3S1960 microcontroller contains eight ports and thus eight of these physical GPIO blocks.

**Figure 8-1. GPIO Port Block Diagram**




## 8.2.1 Data Control

The data control registers allow software to configure the operational modes of the GPIOs. The data direction register configures the GPIO as an input or an output while the data register either captures incoming data or drives it out to the pads.

### 8.2.1.1 Data Direction Operation

The **GPIO Direction (GPIODIR)** register (see page 295) is used to configure each individual pin as an input or output. When the data direction bit is set to 0, the GPIO is configured as an input and the corresponding data register bit will capture and store the value on the GPIO port. When the data direction bit is set to 1, the GPIO is configured as an output and the corresponding data register bit will be driven out on the GPIO port.

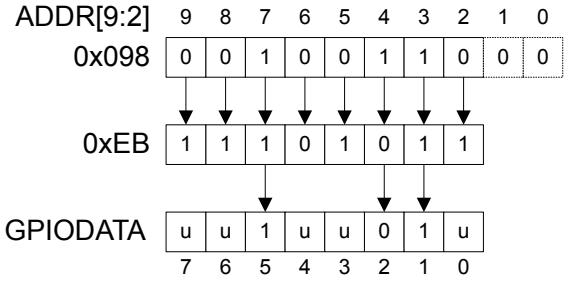
### 8.2.1.2 Data Register Operation

To aid in the efficiency of software, the GPIO ports allow for the modification of individual bits in the **GPIO Data (GPIODATA)** register (see page 294) by using bits [9:2] of the address bus as a mask. This allows software drivers to modify individual GPIO pins in a single instruction, without affecting the state of the other pins. This is in contrast to the "typical" method of doing a read-modify-write operation to set or clear an individual GPIO pin. To accommodate this feature, the **GPIODATA** register covers 256 locations in the memory map.

During a write, if the address bit associated with that data bit is set to 1, the value of the **GPIODATA** register is altered. If it is cleared to 0, it is left unchanged.

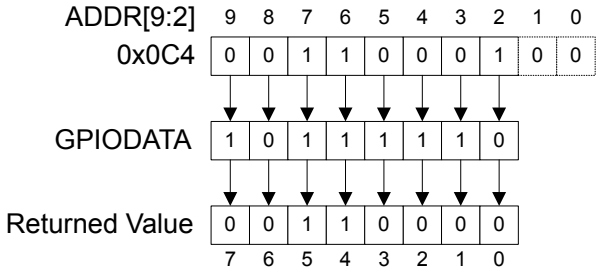
For example, writing a value of 0xEB to the address GPIODATA + 0x098 would yield as shown in Figure 8-2 on page 289, where u is data unchanged by the write.

**Figure 8-2. GPIODATA Write Example**




During a read, if the address bit associated with the data bit is set to 1, the value is read. If the address bit associated with the data bit is set to 0, it is read as a zero, regardless of its actual value. For example, reading address GPIODATA + 0x0C4 yields as shown in Figure 8-3 on page 289.

**Figure 8-3. GPIODATA Read Example**




## 8.2.2 Interrupt Control

The interrupt capabilities of each GPIO port are controlled by a set of seven registers. With these registers, it is possible to select the source of the interrupt, its polarity, and the edge properties. When one or more GPIO inputs cause an interrupt, a single interrupt output is sent to the interrupt controller for the entire GPIO port. For edge-triggered interrupts, software must clear the interrupt to enable any further interrupts. For a level-sensitive interrupt, it is assumed that the external source holds the level constant for the interrupt to be recognized by the controller.

Three registers are required to define the edge or sense that causes interrupts:

- **GPIO Interrupt Sense (GPIOIS)** register (see page 296)
- **GPIO Interrupt Both Edges (GPIOIBE)** register (see page 297)
- **GPIO Interrupt Event (GPIOIEV)** register (see page 298)

Interrupts are enabled/disabled via the **GPIO Interrupt Mask (GPIOIM)** register (see page 299).

When an interrupt condition occurs, the state of the interrupt signal can be viewed in two locations: the **GPIO Raw Interrupt Status (GPIORIS)** and **GPIO Masked Interrupt Status (GPIOMIS)** registers (see page 300 and page 301). As the name implies, the **GPIOMIS** register only shows interrupt

conditions that are allowed to be passed to the controller. The **GPIORIS** register indicates that a GPIO pin meets the conditions for an interrupt, but has not necessarily been sent to the controller.

Interrupts are cleared by writing a 1 to the appropriate bit of the **GPIO Interrupt Clear (GPIOICR)** register (see page 302).

When programming the following interrupt control registers, the interrupts should be masked (**GPIOIM** set to 0). Writing any value to an interrupt control register (**GPIOIS**, **GPIOIBE**, or **GPIOIEV**) can generate a spurious interrupt if the corresponding bits are enabled.

### 8.2.3 Mode Control

The GPIO pins can be controlled by either hardware or software. When hardware control is enabled via the **GPIO Alternate Function Select (GPIOAFSEL)** register (see page 303), the pin state is controlled by its alternate function (that is, the peripheral). Software control corresponds to GPIO mode, where the **GPIODATA** register is used to read/write the corresponding pins.

### 8.2.4 Commit Control

The GPIO commit control registers provide a layer of protection against accidental programming of critical hardware peripherals. Protection is currently provided for the five JTAG/SWD pins (PB7 and PC[3:0]). Writes to protected bits of the **GPIO Alternate Function Select (GPIOAFSEL)** register (see page 303) are not committed to storage unless the **GPIO Lock (GPIOLOCK)** register (see page 313) has been unlocked and the appropriate bits of the **GPIO Commit (GPIOCR)** register (see page 314) have been set to 1.

### 8.2.5 Pad Control

The pad control registers allow for GPIO pad configuration by software based on the application requirements. The pad control registers include the **GPIODR2R**, **GPIODR4R**, **GPIODR8R**, **GPIOODR**, **GPIOPUR**, **GPIOPDR**, **GPIOSLR**, and **GPIODEN** registers. These registers control drive strength, open-drain configuration, pull-up and pull-down resistors, slew-rate control and digital enable.

For special high-current applications, the GPIO output buffers may be used with the following restrictions. With the GPIO pins configured as 8-mA output drivers, a total of four GPIO outputs may be used to sink current loads up to 18 mA each. At 18-mA sink current loading, the $V_{OL}$ value is specified as 1.2 V. The high-current GPIO package pins must be selected such that there are only a maximum of two per side of the physical package or BGA pin group with the total number of high-current GPIO outputs not exceeding four for the entire package.

### 8.2.6 Identification

The identification registers configured at reset allow software to detect and identify the module as a GPIO block. The identification registers include the **GPIOPeriphID0**-**GPIOPeriphID7** registers as well as the **GPIOPCellID0**-**GPIOPCellID3** registers.

## 8.3 Initialization and Configuration

To use the GPIO, the peripheral clock must be enabled by setting the appropriate GPIO Port bit field (GPIOn) in the **RCGC2** register.

On reset, all GPIO pins (except for the five JTAG pins) are configured out of reset to be undriven (tristate): **GPIOAFSEL**=0, **GPIODEN**=0, **GPIOPDR**=0, and **GPIOPUR**=0. Table 8-6 on page 291 shows all possible configurations of the GPIO pads and the control register settings required to achieve them. Table 8-7 on page 291 shows how a rising edge interrupt would be configured for pin 2 of a GPIO port.

### Table 8-6. GPIO Pad Configuration Examples

| Configuration | GPIO Register Bit Value[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AFSEL | DIR | ODR | DEN | PUR | PDR | DR2R | DR4R | DR8R | SLR |
| Digital Input (GPIO) | 0 | 0 | 0 | 1 | ? | ? | X | X | X | X |
| Digital Output (GPIO) | 0 | 1 | 0 | 1 | ? | ? | ? | ? | ? | ? |
| Open Drain Output (GPIO) | 0 | 1 | 1 | 1 | X | X | ? | ? | ? | ? |
| Open Drain Input/Output ($I^2C$) | 1 | X | 1 | 1 | X | X | ? | ? | ? | ? |
| Digital Input (Timer CCP) | 1 | X | 0 | 1 | ? | ? | X | X | X | X |
| Digital Input (QEI) | 1 | X | 0 | 1 | ? | ? | X | X | X | X |
| Digital Output (PWM) | 1 | X | 0 | 1 | ? | ? | ? | ? | ? | ? |
| Digital Output (Timer PWM) | 1 | X | 0 | 1 | ? | ? | ? | ? | ? | ? |
| Digital Input/Output (SSI) | 1 | X | 0 | 1 | ? | ? | ? | ? | ? | ? |
| Digital Input/Output (UART) | 1 | X | 0 | 1 | ? | ? | ? | ? | ? | ? |
| Analog Input (Comparator) | 0 | 0 | 0 | 0 | 0 | 0 | X | X | X | X |
| Digital Output (Comparator) | 1 | X | 0 | 1 | ? | ? | ? | ? | ? | ? |

a. X=Ignored (don't care bit)

?=Can be either 0 or 1, depending on the configuration

### Table 8-7. GPIO Interrupt Configuration Example

| Register | Desired Interrupt Event Trigger | Pin 2 Bit Value[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| GPIOIS | 0=edge<br>1=level | X | X | X | X | X | 0 | X | X |
| GPIOIBE | 0=single edge<br>1=both edges | X | X | X | X | X | 0 | X | X |
| GPIOIEV | 0=Low level, or negative edge<br>1=High level, or positive edge | X | X | X | X | X | 1 | X | X |
| GPIOIM | 0=masked<br>1=not masked | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

a. X=Ignored (don't care bit)

## 8.4 Register Map

Table 8-8 on page 292 lists the GPIO registers. The offset listed is a hexadecimal increment to the register's address, relative to that GPIO port's base address:

- GPIO Port A: 0x4000.4000
- GPIO Port B: 0x4000.5000
- GPIO Port C: 0x4000.6000
- GPIO Port D: 0x4000.7000
- GPIO Port E: 0x4002.4000
- GPIO Port F: 0x4002.5000
- GPIO Port G: 0x4002.6000
- GPIO Port H: 0x4002.7000

Note that the GPIO module clock must be enabled before the registers can be programmed (see page 223). There must be a delay of 3 system clocks after the GPIO module clock is enabled before any GPIO module registers are accessed.

**Important:** The GPIO registers in this chapter are duplicated in each GPIO block; however, depending on the block, all eight bits may not be connected to a GPIO pad. In those cases, writing to those unconnected bits has no effect, and reading those unconnected bits returns no meaningful data.

**Note:** The default reset value for the **GPIOAFSEL**, **GPIOPUR**, and **GPIODEN** registers are 0x0000.0000 for all GPIO pins, with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). These five pins default to JTAG/SWD functionality. Because of this, the default reset value of these registers for GPIO Port B is 0x0000.0080 while the default reset value for Port C is 0x0000.000F.

The default register type for the **GPIOCR** register is RO for all GPIO pins with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). These five pins are currently the only GPIOs that are protected by the **GPIOCR** register. Because of this, the register type for GPIO Port B7 and GPIO Port C[3:0] is R/W.

The default reset value for the **GPIOCR** register is 0x0000.00FF for all GPIO pins, with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). To ensure that the JTAG port is not accidentally programmed as a GPIO, these five pins default to non-committable. Because of this, the default reset value of **GPIOCR** for GPIO Port B is 0x0000.007F while the default reset value of GPIOCR for Port C is 0x0000.00F0.

**Table 8-8. GPIO Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | GPIODATA | R/W | 0x0000.0000 | GPIO Data | 294 |
| 0x400 | GPIODIR | R/W | 0x0000.0000 | GPIO Direction | 295 |
| 0x404 | GPIOIS | R/W | 0x0000.0000 | GPIO Interrupt Sense | 296 |
| 0x408 | GPIOIBE | R/W | 0x0000.0000 | GPIO Interrupt Both Edges | 297 |
| 0x40C | GPIOIEV | R/W | 0x0000.0000 | GPIO Interrupt Event | 298 |
| 0x410 | GPIOIM | R/W | 0x0000.0000 | GPIO Interrupt Mask | 299 |
| 0x414 | GPIORIS | RO | 0x0000.0000 | GPIO Raw Interrupt Status | 300 |

**Table 8-8. GPIO Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x418 | GPIOMIS | RO | 0x0000.0000 | GPIO Masked Interrupt Status | 301 |
| 0x41C | GPIOICR | W1C | 0x0000.0000 | GPIO Interrupt Clear | 302 |
| 0x420 | GPIOAFSEL | R/W | - | GPIO Alternate Function Select | 303 |
| 0x500 | GPIODR2R | R/W | 0x0000.00FF | GPIO 2-mA Drive Select | 305 |
| 0x504 | GPIODR4R | R/W | 0x0000.0000 | GPIO 4-mA Drive Select | 306 |
| 0x508 | GPIODR8R | R/W | 0x0000.0000 | GPIO 8-mA Drive Select | 307 |
| 0x50C | GPIOODR | R/W | 0x0000.0000 | GPIO Open Drain Select | 308 |
| 0x510 | GPIOPUR | R/W | - | GPIO Pull-Up Select | 309 |
| 0x514 | GPIOPDR | R/W | 0x0000.0000 | GPIO Pull-Down Select | 310 |
| 0x518 | GPIOSLR | R/W | 0x0000.0000 | GPIO Slew Rate Control Select | 311 |
| 0x51C | GPIODEN | R/W | - | GPIO Digital Enable | 312 |
| 0x520 | GPIOLOCK | R/W | 0x0000.0001 | GPIO Lock | 313 |
| 0x524 | GPIOCR | - | - | GPIO Commit | 314 |
| 0xFD0 | GPIOPeriphID4 | RO | 0x0000.0000 | GPIO Peripheral Identification 4 | 316 |
| 0xFD4 | GPIOPeriphID5 | RO | 0x0000.0000 | GPIO Peripheral Identification 5 | 317 |
| 0xFD8 | GPIOPeriphID6 | RO | 0x0000.0000 | GPIO Peripheral Identification 6 | 318 |
| 0xFDC | GPIOPeriphID7 | RO | 0x0000.0000 | GPIO Peripheral Identification 7 | 319 |
| 0xFE0 | GPIOPeriphID0 | RO | 0x0000.0061 | GPIO Peripheral Identification 0 | 320 |
| 0xFE4 | GPIOPeriphID1 | RO | 0x0000.0000 | GPIO Peripheral Identification 1 | 321 |
| 0xFE8 | GPIOPeriphID2 | RO | 0x0000.0018 | GPIO Peripheral Identification 2 | 322 |
| 0xFEC | GPIOPeriphID3 | RO | 0x0000.0001 | GPIO Peripheral Identification 3 | 323 |
| 0xFF0 | GPIOPCellID0 | RO | 0x0000.000D | GPIO PrimeCell Identification 0 | 324 |
| 0xFF4 | GPIOPCellID1 | RO | 0x0000.00F0 | GPIO PrimeCell Identification 1 | 325 |
| 0xFF8 | GPIOPCellID2 | RO | 0x0000.0005 | GPIO PrimeCell Identification 2 | 326 |
| 0xFFC | GPIOPCellID3 | RO | 0x0000.00B1 | GPIO PrimeCell Identification 3 | 327 |

## 8.5 Register Descriptions

The remainder of this section lists and describes the GPIO registers, in numerical order by address offset.

## Register 1: GPIO Data (GPIODATA), offset 0x000

The **GPIODATA** register is the data register. In software control mode, values written in the **GPIODATA** register are transferred onto the GPIO port pins if the respective pins have been configured as outputs through the **GPIO Direction (GPIODIR)** register (see page 295).

In order to write to **GPIODATA**, the corresponding bits in the mask, resulting from the address bus bits [9:2], must be High. Otherwise, the bit values remain unchanged by the write.

Similarly, the values read from this register are determined for each bit by the mask bit derived from the address used to access the data register, bits [9:2]. Bits that are 1 in the address mask cause the corresponding bits in **GPIODATA** to be read, and bits that are 0 in the address mask cause the corresponding bits in **GPIODATA** to be read as 0, regardless of their value.

A read from **GPIODATA** returns the last bit value written if the respective pins are configured as outputs, or it returns the value on the corresponding input pin when these are configured as inputs. All bits are cleared by a reset.

GPIO Data (GPIODATA)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x000
Type R/W, reset 0x0000.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | DATA | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

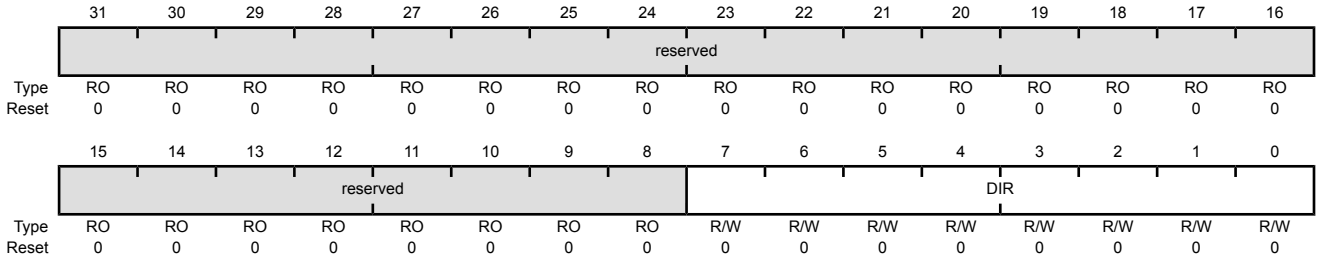
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DATA | R/W | 0x00 | GPIO Data<br>This register is virtually mapped to 256 locations in the address space. To facilitate the reading and writing of data to these registers by independent drivers, the data read from and the data written to the registers are masked by the eight address lines `ipaddr[9:2]`. Reads from this register return its current state. Writes to this register only affect bits that are not masked by `ipaddr[9:2]` and are configured as outputs. See “Data Register Operation” on page 288 for examples of reads and writes. |

## Register 2: GPIO Direction (GPIODIR), offset 0x400

The **GPIODIR** register is the data direction register. Bits set to 1 in the **GPIODIR** register configure the corresponding pin to be an output, while bits set to 0 configure the pins to be inputs. All bits are cleared by a reset, meaning all GPIO pins are inputs by default.

GPIO Direction (GPIODIR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x400
Type R/W, reset 0x0000.0000



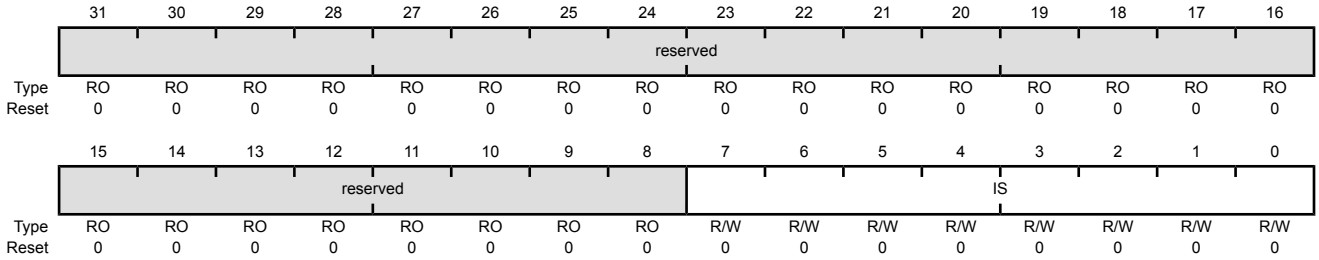

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DIR | R/W | 0x00 | GPIO Data Direction<br>The `DIR` values are defined as follows:<br><br>Value Description<br>0 Pins are inputs.<br>1 Pins are outputs. |

## Register 3: GPIO Interrupt Sense (GPIOIS), offset 0x404

The **GPIOIS** register is the interrupt sense register. Bits set to 1 in **GPIOIS** configure the corresponding pins to detect levels, while bits set to 0 configure the pins to detect edges. All bits are cleared by a reset.

GPIO Interrupt Sense (GPIOIS)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x404
Type R/W, reset 0x0000.0000



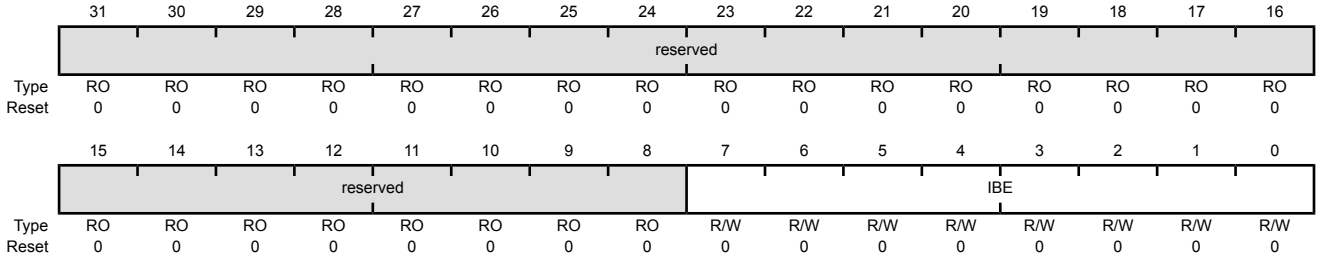

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | IS | R/W | 0x00 | GPIO Interrupt Sense<br>The `IS` values are defined as follows:<br><br>Value Description<br>0 Edge on corresponding pin is detected (edge-sensitive).<br>1 Level on corresponding pin is detected (level-sensitive). |

## Register 4: GPIO Interrupt Both Edges (GPIOIBE), offset 0x408

The **GPIOIBE** register is the interrupt both-edges register. When the corresponding bit in the **GPIO Interrupt Sense (GPIOIS)** register (see page 296) is set to detect edges, bits set to High in **GPIOIBE** configure the corresponding pin to detect both rising and falling edges, regardless of the corresponding bit in the **GPIO Interrupt Event (GPIOIEV)** register (see page 298). Clearing a bit configures the pin to be controlled by **GPIOIEV**. All bits are cleared by a reset.

GPIO Interrupt Both Edges (GPIOIBE)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x408
Type R/W, reset 0x0000.0000



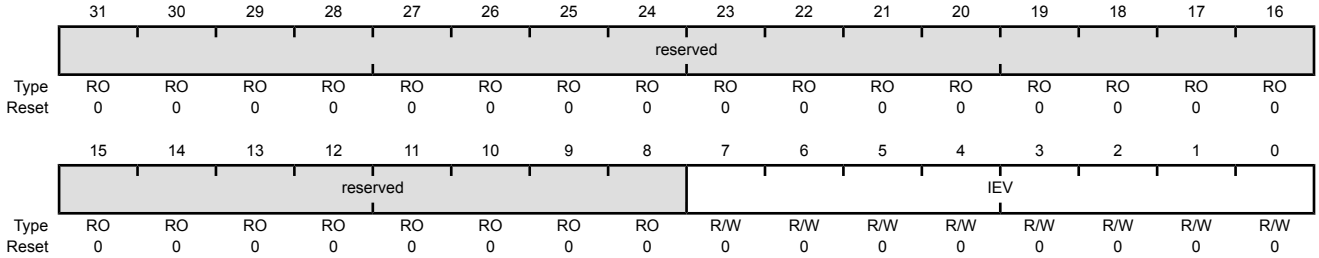

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | IBE | R/W | 0x00 | GPIO Interrupt Both Edges<br>The IBE values are defined as follows:<br><br>Value Description<br>0 Interrupt generation is controlled by the **GPIO Interrupt Event (GPIOIEV)** register (see page 298).<br>1 Both edges on the corresponding pin trigger an interrupt.<br><br>**Note:** Single edge is determined by the corresponding bit in **GPIOIEV**. |

## Register 5: GPIO Interrupt Event (GPIOIEV), offset 0x40C

The **GPIOIEV** register is the interrupt event register. Bits set to High in **GPIOIEV** configure the corresponding pin to detect rising edges or high levels, depending on the corresponding bit value in the **GPIO Interrupt Sense (GPIOIS)** register (see page 296). Clearing a bit configures the pin to detect falling edges or low levels, depending on the corresponding bit value in **GPIOIS**. All bits are cleared by a reset.

GPIO Interrupt Event (GPIOIEV)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x40C
Type R/W, reset 0x0000.0000



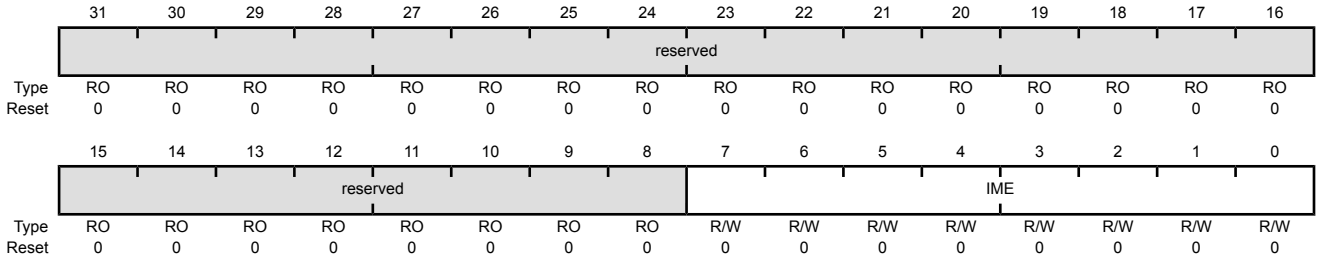

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | IEV | R/W | 0x00 | GPIO Interrupt Event<br>The `IEV` values are defined as follows:<br>Value Description<br>0 Falling edge or Low levels on corresponding pins trigger interrupts.<br>1 Rising edge or High levels on corresponding pins trigger interrupts. |

## Register 6: GPIO Interrupt Mask (GPIOIM), offset 0x410

The **GPIOIM** register is the interrupt mask register. Bits set to High in **GPIOIM** allow the corresponding pins to trigger their individual interrupts and the combined **GPIOINTR** line. Clearing a bit disables interrupt triggering on that pin. All bits are cleared by a reset.

GPIO Interrupt Mask (GPIOIM)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x410
Type R/W, reset 0x0000.0000



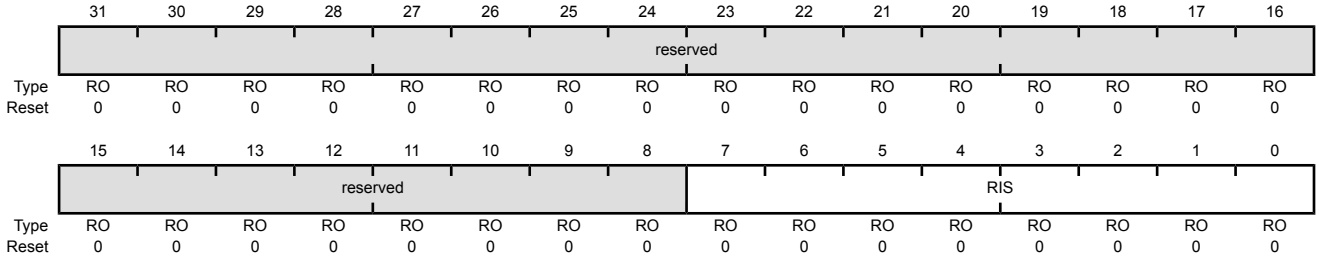

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | IME | R/W | 0x00 | GPIO Interrupt Mask Enable<br>The `IME` values are defined as follows:<br><br>Value Description<br>0 Corresponding pin interrupt is masked.<br>1 Corresponding pin interrupt is not masked. |

## Register 7: GPIO Raw Interrupt Status (GPIORIS), offset 0x414

The **GPIORIS** register is the raw interrupt status register. Bits read High in **GPIORIS** reflect the status of interrupt trigger conditions detected (raw, prior to masking), indicating that all the requirements have been met, before they are finally allowed to trigger by the **GPIO Interrupt Mask (GPIOIM)** register (see page 299). Bits read as zero indicate that corresponding input pins have not initiated an interrupt. All bits are cleared by a reset.

GPIO Raw Interrupt Status (GPIORIS)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x414
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | RIS | RO | 0x00 | GPIO Interrupt Raw Status<br>Reflects the status of interrupt trigger condition detection on pins (raw, prior to masking).<br>The RIS values are defined as follows:<br><br>Value Description<br>0 Corresponding pin interrupt requirements not met.<br>1 Corresponding pin interrupt has met requirements. |

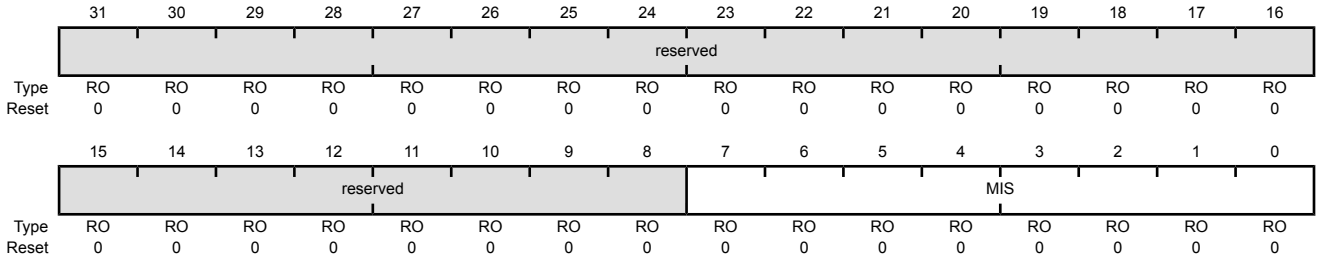
## Register 8: GPIO Masked Interrupt Status (GPIOMIS), offset 0x418

The **GPIOMIS** register is the masked interrupt status register. Bits read High in **GPIOMIS** reflect the status of input lines triggering an interrupt. Bits read as Low indicate that either no interrupt has been generated, or the interrupt is masked.

**GPIOMIS** is the state of the interrupt after masking.

GPIO Masked Interrupt Status (GPIOMIS)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x418
Type RO, reset 0x0000.0000



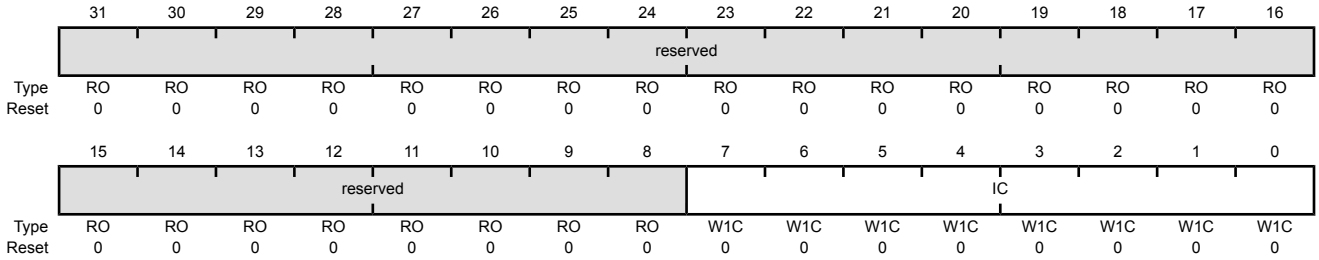

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | MIS | RO | 0x00 | GPIO Masked Interrupt Status<br>Masked value of interrupt due to corresponding pin.<br>The `MIS` values are defined as follows:<br><br>Value Description<br>0 Corresponding GPIO line interrupt not active.<br>1 Corresponding GPIO line asserting interrupt. |

## Register 9: GPIO Interrupt Clear (GPIOICR), offset 0x41C

The **GPIOICR** register is the interrupt clear register. Writing a 1 to a bit in this register clears the corresponding interrupt edge detection logic register. Writing a 0 has no effect.

GPIO Interrupt Clear (GPIOICR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x41C
Type W1C, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | IC | W1C | 0x00 | GPIO Interrupt Clear<br>The `IC` values are defined as follows:<br><br>Value Description<br>0 Corresponding interrupt is unaffected.<br>1 Corresponding interrupt is cleared. |

## Register 10: GPIO Alternate Function Select (GPIOAFSEL), offset 0x420

The **GPIOAFSEL** register is the mode control select register. Writing a 1 to any bit in this register selects the hardware control for the corresponding GPIO line. All bits are cleared by a reset, therefore no GPIO line is set to hardware control by default.

The GPIO commit control registers provide a layer of protection against accidental programming of critical hardware peripherals. Protection is currently provided for the five JTAG/SWD pins (PB7 and PC[3:0]). Writes to protected bits of the **GPIO Alternate Function Select (GPIOAFSEL)** register (see page 303) are not committed to storage unless the **GPIO Lock (GPIOLOCK)** register (see page 313) has been unlocked and the appropriate bits of the **GPIO Commit (GPIOCR)** register (see page 314) have been set to 1.

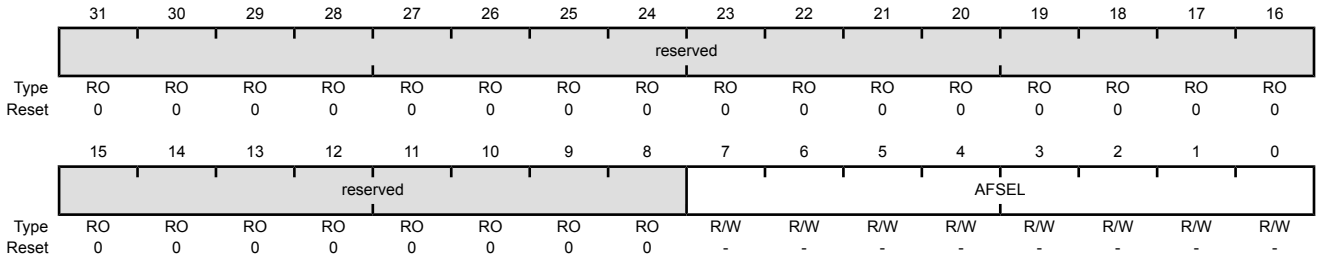
**Important:** All GPIO pins are tri-stated by default (**GPIOAFSEL**=0, **GPIODEN**=0, **GPIOPDR**=0, and **GPIOPUR**=0), with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). The JTAG/SWD pins default to their JTAG/SWD functionality (**GPIOAFSEL**=1, **GPIODEN=1** and **GPIOPUR**=1). A Power-On-Reset (POR) or asserting RST puts both groups of pins back to their default state.

While debugging systems where PB7 is being used as a GPIO, care must be taken to ensure that a low value is not applied to the pin when the part is reset. Because PB7 reverts to the TRST function after reset, a Low value on the pin causes the JTAG controller to be reset, resulting in a loss of JTAG communication.

**Caution – It is possible to create a software sequence that prevents the debugger from connecting to the Stellaris® microcontroller. If the program code loaded into flash immediately changes the JTAG pins to their GPIO functionality, the debugger may not have enough time to connect and halt the controller before the JTAG pin functionality switches. This may lock the debugger out of the part. This can be avoided with a software routine that restores JTAG functionality based on an external or software trigger.**

GPIO Alternate Function Select (GPIOAFSEL)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x420
Type R/W, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

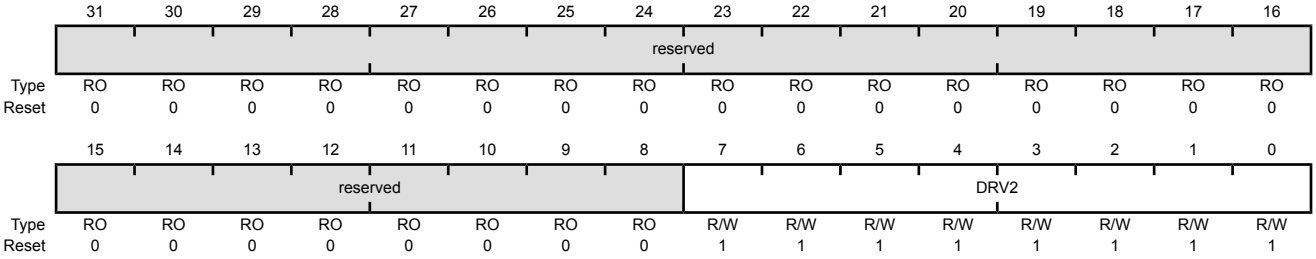
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 7:0 | AFSEL | R/W | - | GPIO Alternate Function Select<br>The AFSEL values are defined as follows:<br><br>Value Description<br>0 Software control of corresponding GPIO line (GPIO mode).<br>1 Hardware control of corresponding GPIO line (alternate hardware function).<br><br>**Note:** The default reset value for the **GPIOAFSEL**, **GPIOPUR**, and **GPIODEN** registers are 0x0000.0000 for all GPIO pins, with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). These five pins default to JTAG/SWD functionality. Because of this, the default reset value of these registers for GPIO Port B is 0x0000.0080 while the default reset value for Port C is 0x0000.000F. |

## Register 11: GPIO 2-mA Drive Select (GPIODR2R), offset 0x500

The **GPIODR2R** register is the 2-mA drive control register. It allows for each GPIO signal in the port to be individually configured without affecting the other pads. When writing a DRV2 bit for a GPIO signal, the corresponding DRV4 bit in the **GPIODR4R** register and the DRV8 bit in the **GPIODR8R** register are automatically cleared by hardware.

GPIO 2-mA Drive Select (GPIODR2R)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x500
Type R/W, reset 0x0000.00FF



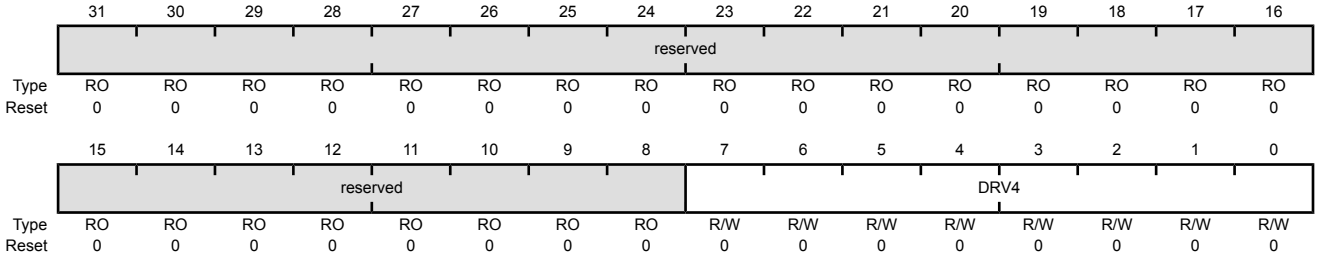

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DRV2 | R/W | 0xFF | Output Pad 2-mA Drive Enable<br>A write of 1 to either **GPIODR4[n]** or **GPIODR8[n]** clears the corresponding 2-mA enable bit. The change is effective on the second clock cycle after the write. |

## Register 12: GPIO 4-mA Drive Select (GPIODR4R), offset 0x504

The **GPIODR4R** register is the 4-mA drive control register. It allows for each GPIO signal in the port to be individually configured without affecting the other pads. When writing the DRV4 bit for a GPIO signal, the corresponding DRV2 bit in the **GPIODR2R** register and the DRV8 bit in the **GPIODR8R** register are automatically cleared by hardware.

GPIO 4-mA Drive Select (GPIODR4R)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x504
Type R/W, reset 0x0000.0000



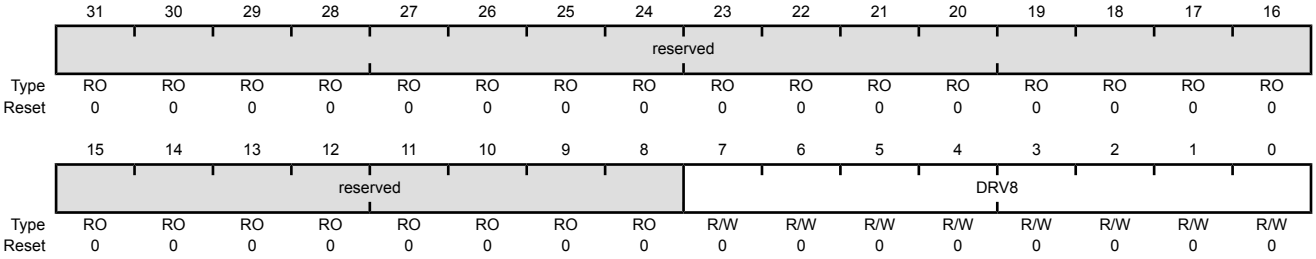

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DRV4 | R/W | 0x00 | Output Pad 4-mA Drive Enable<br>A write of 1 to either **GPIODR2[n]** or **GPIODR8[n]** clears the corresponding 4-mA enable bit. The change is effective on the second clock cycle after the write. |

## Register 13: GPIO 8-mA Drive Select (GPIODR8R), offset 0x508

The **GPIODR8R** register is the 8-mA drive control register. It allows for each GPIO signal in the port to be individually configured without affecting the other pads. When writing the DRV8 bit for a GPIO signal, the corresponding DRV2 bit in the **GPIODR2R** register and the DRV4 bit in the **GPIODR4R** register are automatically cleared by hardware.

GPIO 8-mA Drive Select (GPIODR8R)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x508
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DRV8 | R/W | 0x00 | Output Pad 8-mA Drive Enable<br>A write of 1 to either **GPIODR2[n]** or **GPIODR4[n]** clears the corresponding 8-mA enable bit. The change is effective on the second clock cycle after the write. |

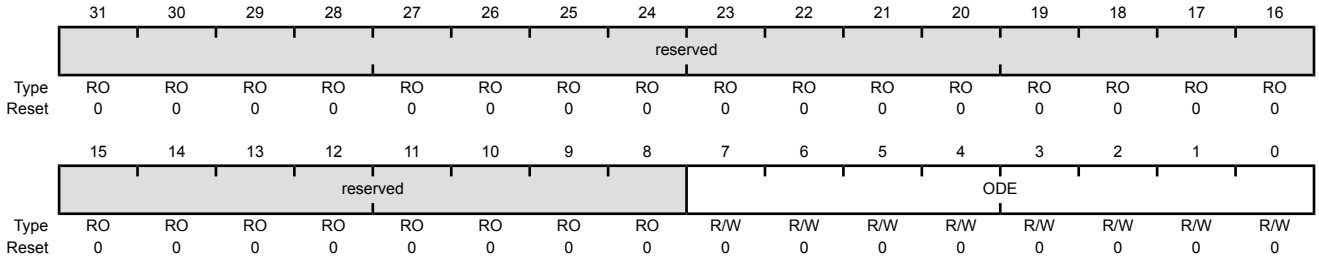
## Register 14: GPIO Open Drain Select (GPIOODR), offset 0x50C

The **GPIOODR** register is the open drain control register. Setting a bit in this register enables the open drain configuration of the corresponding GPIO pad. When open drain mode is enabled, the corresponding bit should also be set in the **GPIO Digital Enable (GPIODEN)** register (see page 312). Corresponding bits in the drive strength registers (**GPIODR2R**, **GPIODR4R**, **GPIODR8R**, and **GPIOSLR** ) can be set to achieve the desired rise and fall times. The GPIO acts as an open-drain input if the corresponding bit in the **GPIODIR** register is cleared. If open drain is selected while the GPIO is configured as an input, the GPIO will remain an input and the open-drain selection has no effect until the GPIO is changed to an output.

When using the $I^2C$ module, in addition to configuring the pin to open drain, the **GPIO Alternate Function Select (GPIOAFSEL)** register bits for the $I^2C$ clock and data pins should be set to 1 (see examples in “Initialization and Configuration” on page 290).

GPIO Open Drain Select (GPIOODR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x50C
Type R/W, reset 0x0000.0000



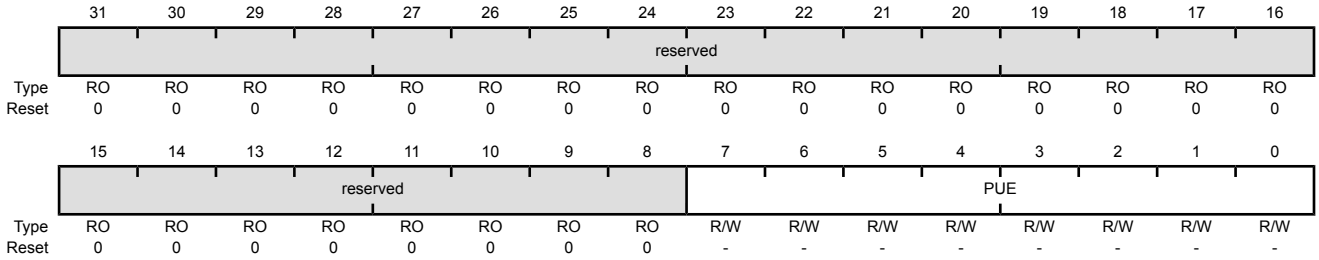

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | ODE | R/W | 0x00 | Output Pad Open Drain Enable<br>The ODE values are defined as follows:<br>Value Description<br>0 Open drain configuration is disabled.<br>1 Open drain configuration is enabled. |

## Register 15: GPIO Pull-Up Select (GPIOPUR), offset 0x510

The **GPIOPUR** register is the pull-up control register. When a bit is set to 1, it enables a weak pull-up resistor on the corresponding GPIO signal. Setting a bit in **GPIOPUR** automatically clears the corresponding bit in the **GPIO Pull-Down Select (GPIOPDR)** register (see page 310).

GPIO Pull-Up Select (GPIOPUR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x510
Type R/W, reset -



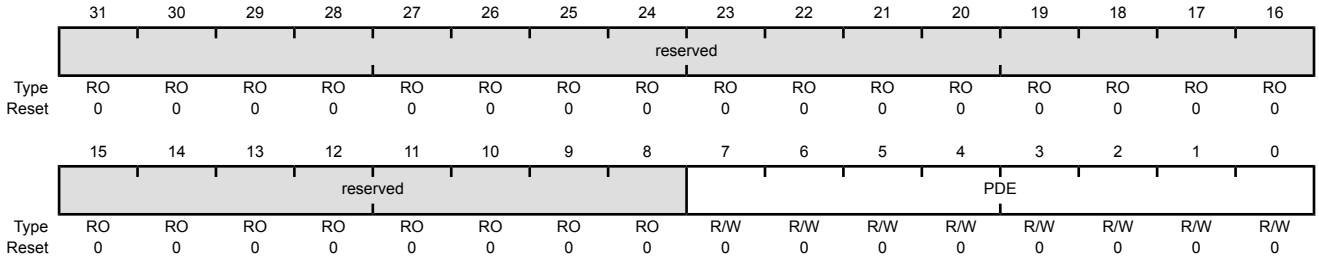

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PUE | R/W | - | Pad Weak Pull-Up Enable<br>A write of 1 to **GPIOPDR[n]** clears the corresponding **GPIOPUR[n]** enables. The change is effective on the second clock cycle after the write.<br>**Note:** The default reset value for the **GPIOAFSEL**, **GPIOPUR**, and **GPIODEN** registers are 0x0000.0000 for all GPIO pins, with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). These five pins default to JTAG/SWD functionality. Because of this, the default reset value of these registers for GPIO Port B is 0x0000.0080 while the default reset value for Port C is 0x0000.000F. |

## Register 16: GPIO Pull-Down Select (GPIOPDR), offset 0x514

The **GPIOPDR** register is the pull-down control register. When a bit is set to 1, it enables a weak pull-down resistor on the corresponding GPIO signal. Setting a bit in **GPIOPDR** automatically clears the corresponding bit in the **GPIO Pull-Up Select (GPIOPUR)** register (see page 309).

GPIO Pull-Down Select (GPIOPDR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x514
Type R/W, reset 0x0000.0000



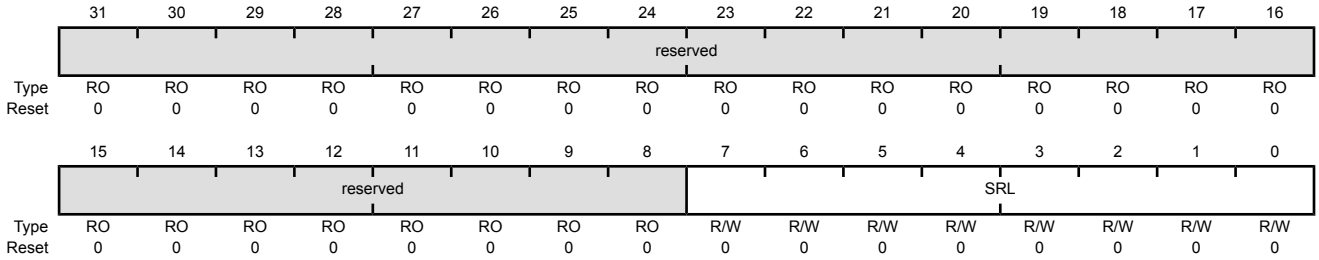

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PDE | R/W | 0x00 | Pad Weak Pull-Down Enable<br>A write of 1 to **GPIOPUR[n]** clears the corresponding **GPIOPDR[n]** enables. The change is effective on the second clock cycle after the write. |

## Register 17: GPIO Slew Rate Control Select (GPIOSLR), offset 0x518

The **GPIOSLR** register is the slew rate control register. Slew rate control is only available when using the 8-mA drive strength option via the **GPIO 8-mA Drive Select (GPIODR8R)** register (see page 307).

GPIO Slew Rate Control Select (GPIOSLR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x518
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | SRL | R/W | 0x00 | Slew Rate Limit Enable (8-mA drive only)<br>The SRL values are defined as follows:<br><br>Value Description<br>0 Slew rate control disabled.<br>1 Slew rate control enabled. |

## Register 18: GPIO Digital Enable (GPIODEN), offset 0x51C

**Note:** Pins configured as digital inputs are Schmitt-triggered.

The **GPIODEN** register is the digital enable register. By default, with the exception of the GPIO signals used for JTAG/SWD function, all other GPIO signals are configured out of reset to be undriven (tristate). Their digital function is disabled; they do not drive a logic value on the pin and they do not allow the pin voltage into the GPIO receiver. To use the pin in a digital function (either GPIO or alternate function), the corresponding GPIODEN bit must be set.

GPIO Digital Enable (GPIODEN)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x51C
Type R/W, reset -

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | DEN | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - | - |

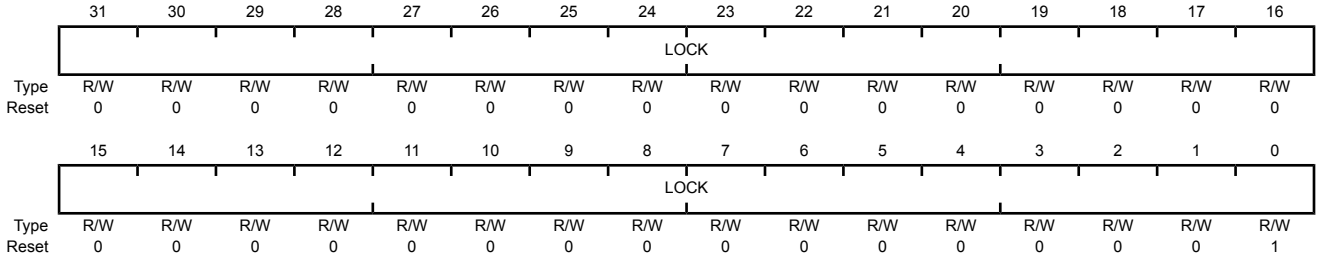
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DEN | R/W | - | Digital Enable<br>The DEN values are defined as follows:<br><br>Value Description<br>0 Digital functions disabled.<br>1 Digital functions enabled.<br><br>**Note:** The default reset value for the **GPIOAFSEL**, **GPIOPUR**, and **GPIODEN** registers are 0x0000.0000 for all GPIO pins, with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). These five pins default to JTAG/SWD functionality. Because of this, the default reset value of these registers for GPIO Port B is 0x0000.0080 while the default reset value for Port C is 0x0000.000F. |

## Register 19: GPIO Lock (GPIOLOCK), offset 0x520

The **GPIOLOCK** register enables write access to the **GPIOCR** register (see page 314). Writing 0x1ACC.E551 to the **GPIOLOCK** register will unlock the **GPIOCR** register. Writing any other value to the **GPIOLOCK** register re-enables the locked state. Reading the **GPIOLOCK** register returns the lock status rather than the 32-bit value that was previously written. Therefore, when write accesses are disabled, or locked, reading the **GPIOLOCK** register returns 0x00000001. When write accesses are enabled, or unlocked, reading the **GPIOLOCK** register returns 0x00000000.

GPIO Lock (GPIOLOCK)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x520
Type R/W, reset 0x0000.0001




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | LOCK | R/W | 0x0000.0001 | GPIO Lock<br>A write of the value 0x1ACC.E551 unlocks the **GPIO Commit (GPIOCR)** register for write access.<br>A write of any other value or a write to the **GPIOCR** register reapplies the lock, preventing any register updates. A read of this register returns the following values:<br>Value Description<br>0x0000.0001 Locked<br>0x0000.0000 Unlocked |

## Register 20: GPIO Commit (GPIOCR), offset 0x524

The **GPIOCR** register is the commit register. The value of the **GPIOCR** register determines which bits of the **GPIOAFSEL** register are committed when a write to the **GPIOAFSEL** register is performed. If a bit in the **GPIOCR** register is a zero, the data being written to the corresponding bit in the **GPIOAFSEL** register will not be committed and will retain its previous value. If a bit in the **GPIOCR** register is a one, the data being written to the corresponding bit of the **GPIOAFSEL** register will be committed to the register and will reflect the new value.

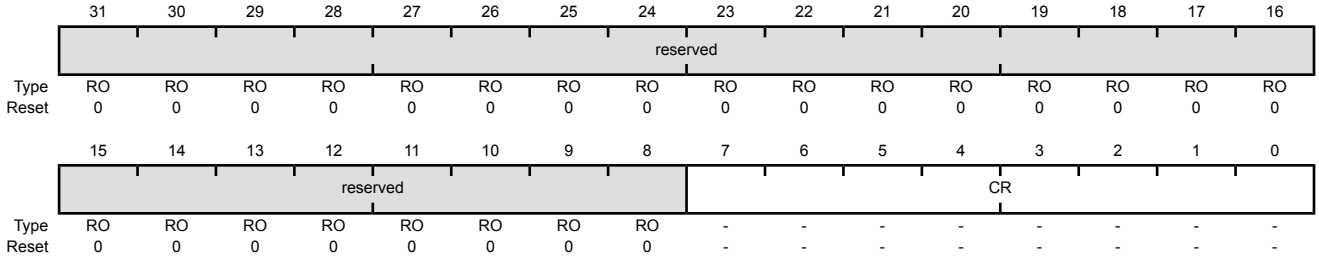
The contents of the **GPIOCR** register can only be modified if the **GPIOLOCK** register is unlocked. Writes to the **GPIOCR** register are ignored if the **GPIOLOCK** register is locked.

**Important:** This register is designed to prevent accidental programming of the registers that control connectivity to the JTAG/SWD debug hardware. By initializing the bits of the **GPIOCR** register to 0 for PB7 and PC[3:0], the JTAG/SWD debug port can only be converted to GPIOs through a deliberate set of writes to the **GPIOLOCK**, **GPIOCR**, and the corresponding registers.

Because this protection is currently only implemented on the JTAG/SWD pins on PB7 and PC[3:0], all of the other bits in the **GPIOCR** registers cannot be written with 0x0. These bits are hardwired to 0x1, ensuring that it is always possible to commit new values to the **GPIOAFSEL**register bits of these other pins.

GPIO Commit (GPIOCR)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0x524
Type -, reset -




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

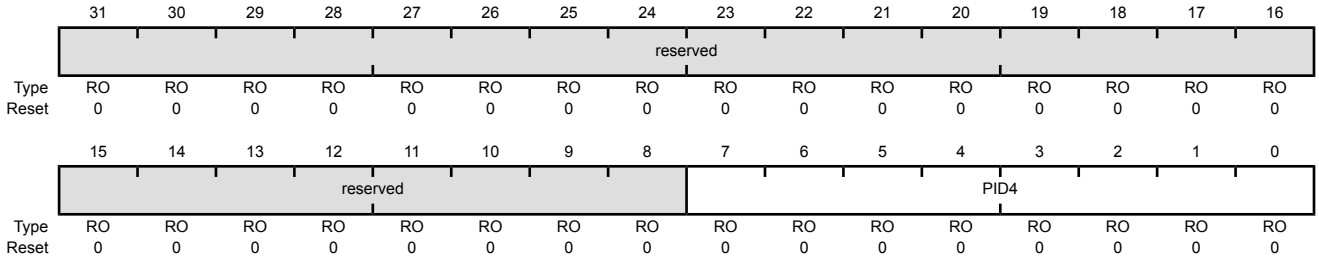
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 7:0 | CR | - | - | GPIO Commit<br>On a bit-wise basis, any bit set allows the corresponding **GPIOAFSEL** bit to be set to its alternate function.<br>**Note:** The default register type for the **GPIOCR** register is RO for all GPIO pins with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). These five pins are currently the only GPIOs that are protected by the **GPIOCR** register. Because of this, the register type for GPIO Port B7 and GPIO Port C[3:0] is R/W.<br>The default reset value for the **GPIOCR** register is 0x0000.00FF for all GPIO pins, with the exception of the five JTAG/SWD pins (PB7 and PC[3:0]). To ensure that the JTAG port is not accidentally programmed as a GPIO, these five pins default to non-committable. Because of this, the default reset value of **GPIOCR** for GPIO Port B is 0x0000.007F while the default reset value of GPIOCR for Port C is 0x0000.00F0. |

## Register 21: GPIO Peripheral Identification 4 (GPIOPeriphID4), offset 0xFD0

The **GPIOPeriphID4**, **GPIOPeriphID5**, **GPIOPeriphID6**, and **GPIOPeriphID7** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 4 (GPIOPeriphID4)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFD0
Type RO, reset 0x0000.0000



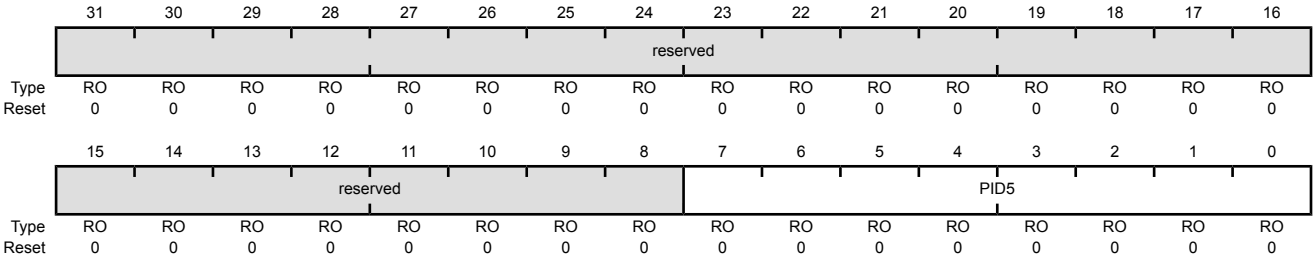

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID4 | RO | 0x00 | GPIO Peripheral ID Register[7:0] |

## Register 22: GPIO Peripheral Identification 5 (GPIOPeriphID5), offset 0xFD4

The **GPIOPeriphID4**, **GPIOPeriphID5**, **GPIOPeriphID6**, and **GPIOPeriphID7** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 5 (GPIOPeriphID5)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFD4
Type RO, reset 0x0000.0000



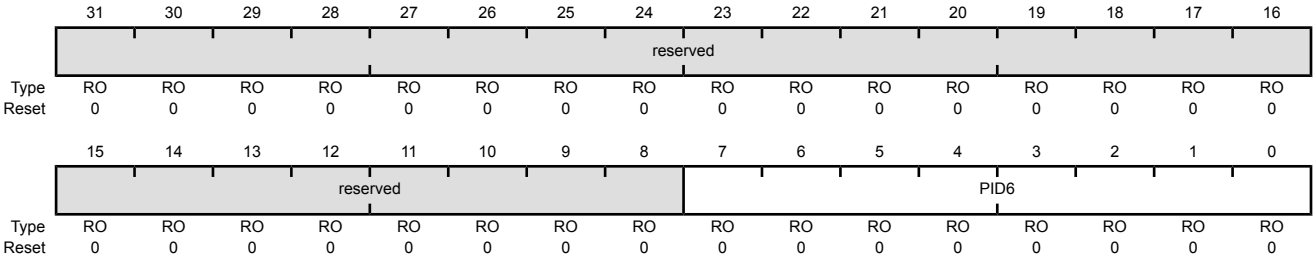

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID5 | RO | 0x00 | GPIO Peripheral ID Register[15:8] |

## Register 23: GPIO Peripheral Identification 6 (GPIOPeriphID6), offset 0xFD8

The **GPIOPeriphID4**, **GPIOPeriphID5**, **GPIOPeriphID6**, and **GPIOPeriphID7** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 6 (GPIOPeriphID6)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFD8
Type RO, reset 0x0000.0000



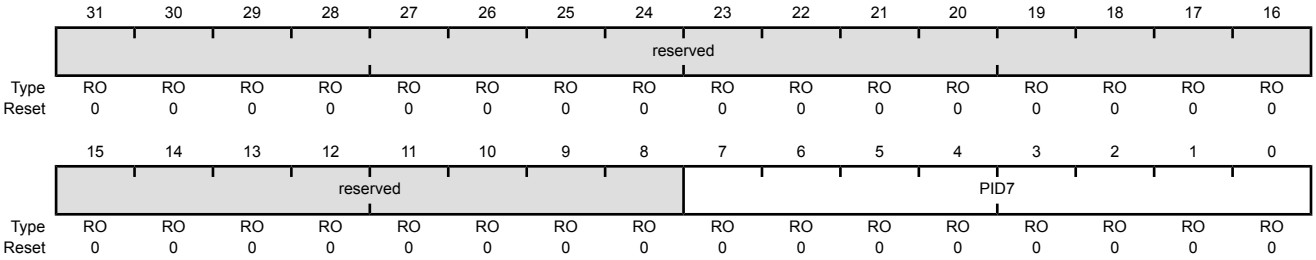

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID6 | RO | 0x00 | GPIO Peripheral ID Register[23:16] |

## Register 24: GPIO Peripheral Identification 7 (GPIOPeriphID7), offset 0xFDC

The **GPIOPeriphID4**, **GPIOPeriphID5**, **GPIOPeriphID6**, and **GPIOPeriphID7** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 7 (GPIOPeriphID7)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFDC
Type RO, reset 0x0000.0000



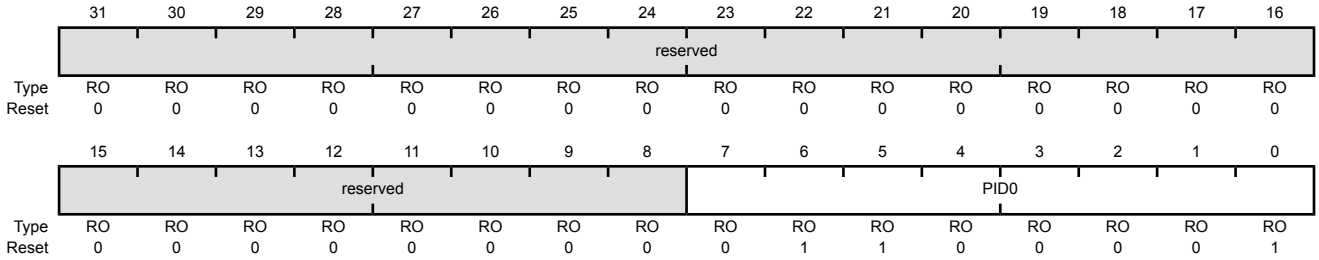

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID7 | RO | 0x00 | GPIO Peripheral ID Register[31:24] |

## Register 25: GPIO Peripheral Identification 0 (GPIOPeriphID0), offset 0xFE0

The **GPIOPeriphID0**, **GPIOPeriphID1**, **GPIOPeriphID2**, and **GPIOPeriphID3** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 0 (GPIOPeriphID0)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFE0
Type RO, reset 0x0000.0061



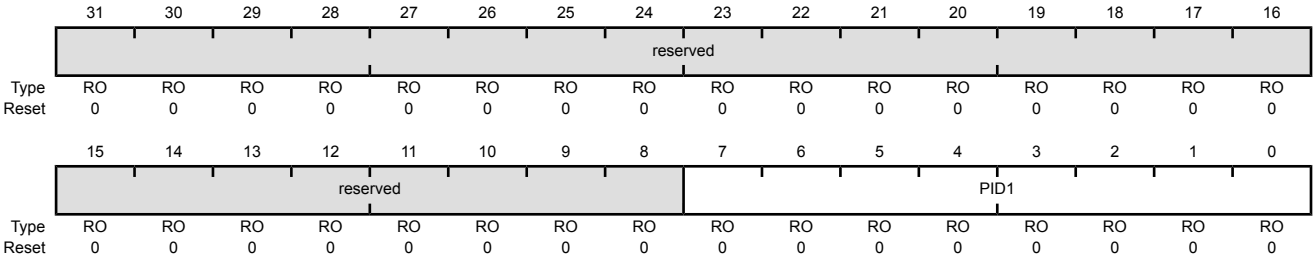

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID0 | RO | 0x61 | GPIO Peripheral ID Register[7:0]<br>Can be used by software to identify the presence of this peripheral. |

## Register 26: GPIO Peripheral Identification 1 (GPIOPeriphID1), offset 0xFE4

The **GPIOPeriphID0**, **GPIOPeriphID1**, **GPIOPeriphID2**, and **GPIOPeriphID3** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 1 (GPIOPeriphID1)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFE4
Type RO, reset 0x0000.0000



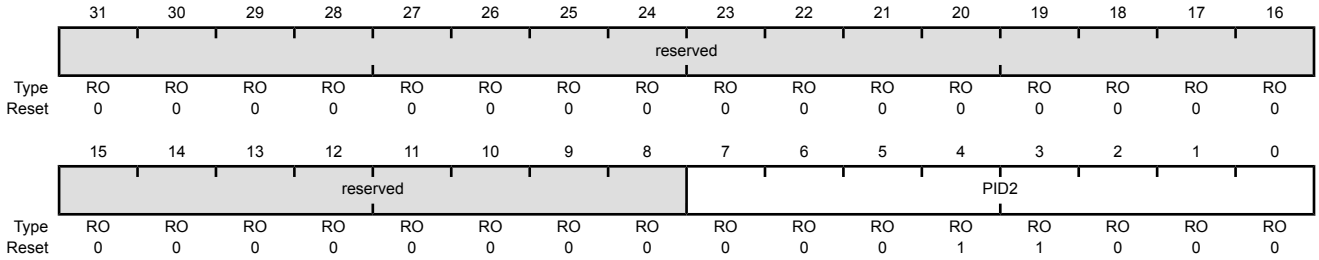

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID1 | RO | 0x00 | GPIO Peripheral ID Register[15:8]<br>Can be used by software to identify the presence of this peripheral. |

## Register 27: GPIO Peripheral Identification 2 (GPIOPeriphID2), offset 0xFE8

The **GPIOPeriphID0**, **GPIOPeriphID1**, **GPIOPeriphID2**, and **GPIOPeriphID3** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 2 (GPIOPeriphID2)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFE8
Type RO, reset 0x0000.0018



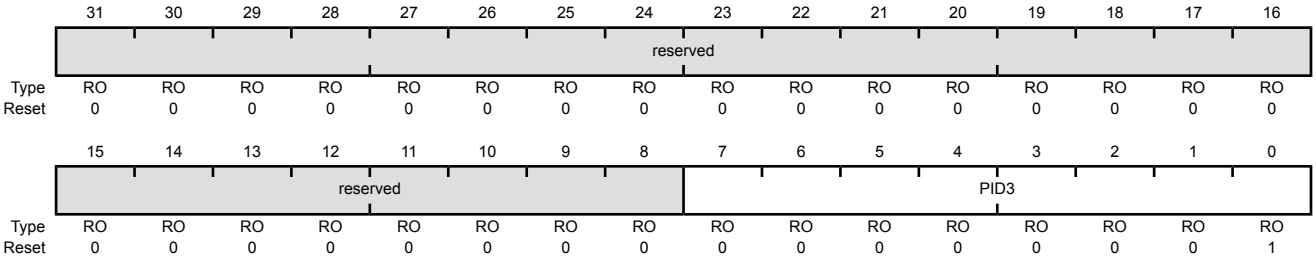

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID2 | RO | 0x18 | GPIO Peripheral ID Register[23:16]<br>Can be used by software to identify the presence of this peripheral. |

## Register 28: GPIO Peripheral Identification 3 (GPIOPeriphID3), offset 0xFEC

The **GPIOPeriphID0**, **GPIOPeriphID1**, **GPIOPeriphID2**, and **GPIOPeriphID3** registers can conceptually be treated as one 32-bit register; each register contains eight bits of the 32-bit register, used by software to identify the peripheral.

GPIO Peripheral Identification 3 (GPIOPeriphID3)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFEC
Type RO, reset 0x0000.0001



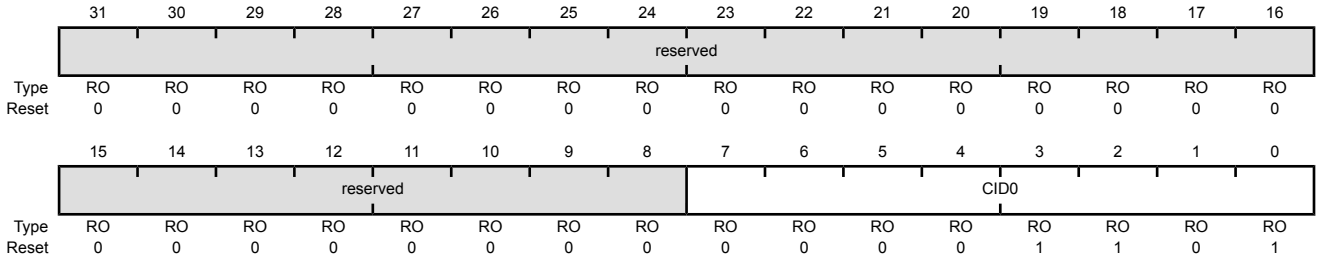

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID3 | RO | 0x01 | GPIO Peripheral ID Register[31:24]<br>Can be used by software to identify the presence of this peripheral. |

## Register 29: GPIO PrimeCell Identification 0 (GPIOPCellID0), offset 0xFF0

The **GPIOPCellID0**, **GPIOPCellID1**, **GPIOPCellID2**, and **GPIOPCellID3** registers are four 8-bit wide registers, that can conceptually be treated as one 32-bit register. The register is used as a standard cross-peripheral identification system.

GPIO PrimeCell Identification 0 (GPIOPCellID0)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFF0
Type RO, reset 0x0000.000D



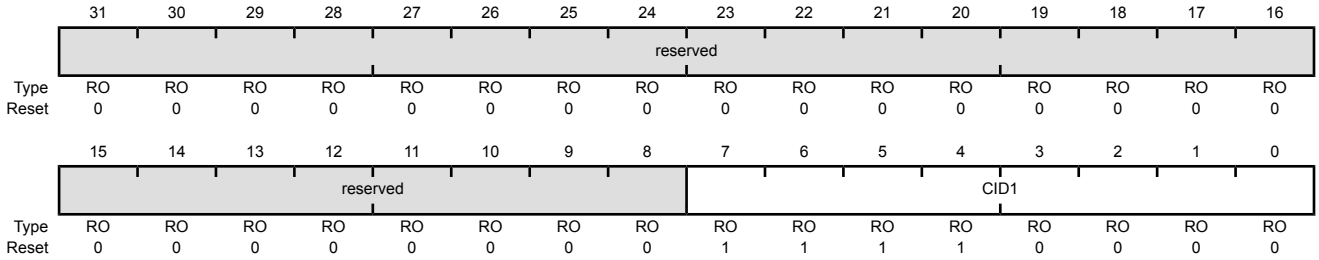

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID0 | RO | 0x0D | GPIO PrimeCell ID Register[7:0]<br>Provides software a standard cross-peripheral identification system. |

## Register 30: GPIO PrimeCell Identification 1 (GPIOPCellID1), offset 0xFF4

The **GPIOPCellID0**, **GPIOPCellID1**, **GPIOPCellID2**, and **GPIOPCellID3** registers are four 8-bit wide registers, that can conceptually be treated as one 32-bit register. The register is used as a standard cross-peripheral identification system.

GPIO PrimeCell Identification 1 (GPIOPCellID1)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFF4
Type RO, reset 0x0000.00F0



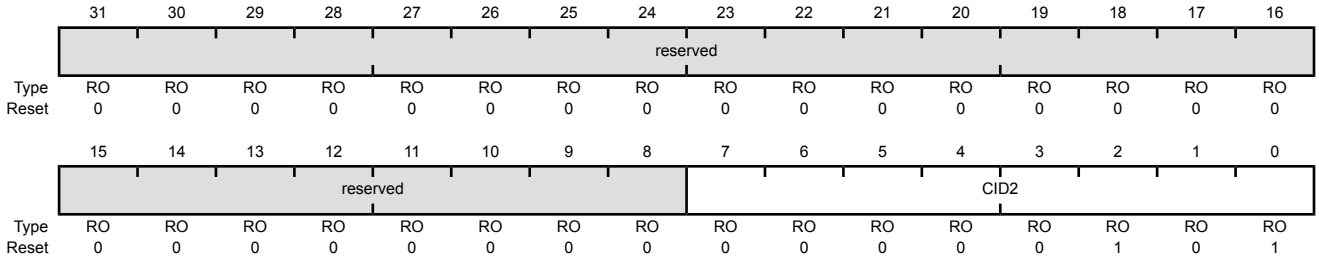

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID1 | RO | 0xF0 | GPIO PrimeCell ID Register[15:8]<br>Provides software a standard cross-peripheral identification system. |

## Register 31: GPIO PrimeCell Identification 2 (GPIOPCellID2), offset 0xFF8

The **GPIOPCellID0**, **GPIOPCellID1**, **GPIOPCellID2**, and **GPIOPCellID3** registers are four 8-bit wide registers, that can conceptually be treated as one 32-bit register. The register is used as a standard cross-peripheral identification system.

GPIO PrimeCell Identification 2 (GPIOPCellID2)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFF8
Type RO, reset 0x0000.0005



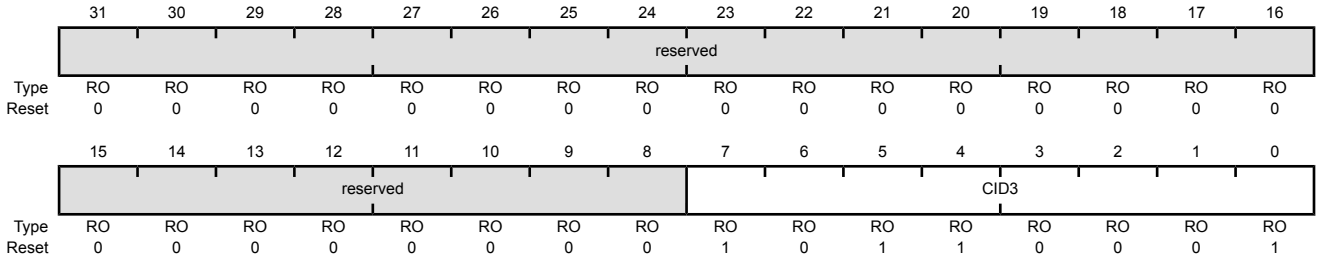

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID2 | RO | 0x05 | GPIO PrimeCell ID Register[23:16]<br>Provides software a standard cross-peripheral identification system. |

## Register 32: GPIO PrimeCell Identification 3 (GPIOPCellID3), offset 0xFFC

The **GPIOPCellID0**, **GPIOPCellID1**, **GPIOPCellID2**, and **GPIOPCellID3** registers are four 8-bit wide registers, that can conceptually be treated as one 32-bit register. The register is used as a standard cross-peripheral identification system.

GPIO PrimeCell Identification 3 (GPIOPCellID3)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000
Offset 0xFFC
Type RO, reset 0x0000.00B1




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID3 | RO | 0xB1 | GPIO PrimeCell ID Register[31:24]<br>Provides software a standard cross-peripheral identification system. |

# 9 General-Purpose Timers

Programmable timers can be used to count or time external events that drive the Timer input pins. The Stellaris® General-Purpose Timer Module (GPTM) contains four GPTM blocks (Timer0, Timer1, Timer 2, and Timer 3). Each GPTM block provides two 16-bit timers/counters (referred to as TimerA and TimerB) that can be configured to operate independently as timers or event counters, or configured to operate as one 32-bit timer or one 32-bit Real-Time Clock (RTC).

The GPT Module is one timing resource available on the Stellaris microcontrollers. Other timer resources include the System Timer (SysTick) (see 89) and the PWM timer in the PWM module (see “PWM Timer” on page 523).

The General-Purpose Timers provide the following features:

- Four General-Purpose Timer Modules (GPTM), each of which provides two 16-bit timers/counters. Each GPTM can be configured to operate independently:
  - As a single 32-bit timer
  - As one 32-bit Real-Time Clock (RTC) to event capture
  - For Pulse Width Modulation (PWM)
- 32-bit Timer modes
  - Programmable one-shot timer
  - Programmable periodic timer
  - Real-Time Clock when using an external 32.768-KHz clock as the input
  - User-enabled stalling when the controller asserts CPU Halt flag during debug
- 16-bit Timer modes
  - General-purpose timer function with an 8-bit prescaler (for one-shot and periodic modes only)
  - Programmable one-shot timer
  - Programmable periodic timer
  - User-enabled stalling when the controller asserts CPU Halt flag during debug
- 16-bit Input Capture modes
  - Input edge count capture
  - Input edge time capture
- 16-bit PWM mode
  - Simple PWM mode with software-programmable output inversion of the PWM signal

## 9.1 Block Diagram

**Note:** In Figure 9-1 on page 329, the specific CCP pins available depend on the Stellaris device. See Table 9-1 on page 329 for the available CCPs.

**Figure 9-1. GPTM Module Block Diagram**

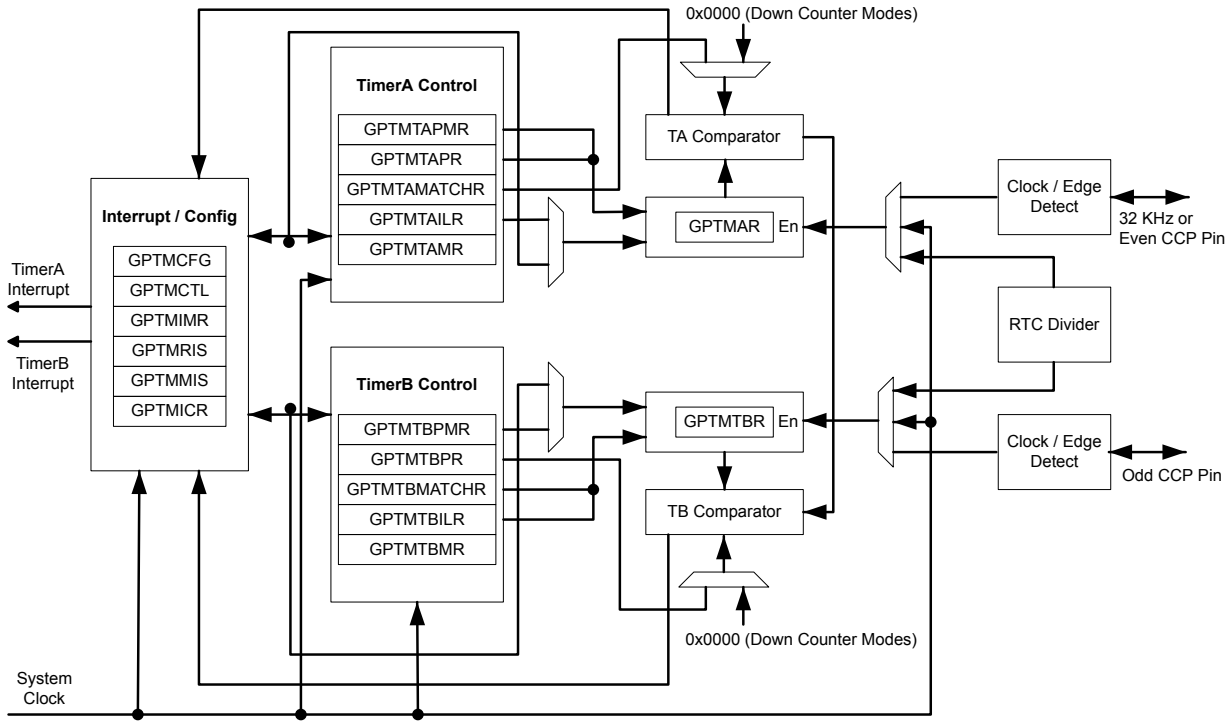



**Table 9-1. Available CCP Pins**

| Timer | 16-Bit Up/Down Counter | Even CCP Pin | Odd CCP Pin |
|---|---|---|---|
| Timer 0 | TimerA | CCP0 | - |
| | TimerB | - | CCP1 |
| Timer 1 | TimerA | CCP2 | - |
| | TimerB | - | CCP3 |
| Timer 2 | TimerA | CCP4 | - |
| | TimerB | - | CCP5 |
| Timer 3 | TimerA | CCP6 | - |
| | TimerB | - | CCP7 |

## 9.2 Signal Description

Table 9-2 on page 330 and Table 9-3 on page 330 list the external signals of the GP Timer module and describe the function of each. The GP Timer signals are alternate functions for some GPIO signals and default to be GPIO signals at reset. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for these GP Timer signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the GP Timer

function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 9-2. General-Purpose Timers Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| CCP0 | 95 | I/O | TTL | Capture/Compare/PWM 0. |
| CCP1 | 100 | I/O | TTL | Capture/Compare/PWM 1. |
| CCP2 | 96 | I/O | TTL | Capture/Compare/PWM 2. |
| CCP3 | 6 | I/O | TTL | Capture/Compare/PWM 3. |
| CCP4 | 42 | I/O | TTL | Capture/Compare/PWM 4. |
| CCP5 | 25 | I/O | TTL | Capture/Compare/PWM 5. |
| CCP6 | 86 | I/O | TTL | Capture/Compare/PWM 6. |
| CCP7 | 85 | I/O | TTL | Capture/Compare/PWM 7. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 9-3. General-Purpose Timers Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| CCP0 | E1 | I/O | TTL | Capture/Compare/PWM 0. |
| CCP1 | F1 | I/O | TTL | Capture/Compare/PWM 1. |
| CCP2 | E2 | I/O | TTL | Capture/Compare/PWM 2. |
| CCP3 | D1 | I/O | TTL | Capture/Compare/PWM 3. |
| CCP4 | K4 | I/O | TTL | Capture/Compare/PWM 4. |
| CCP5 | L1 | I/O | TTL | Capture/Compare/PWM 5. |
| CCP6 | C9 | I/O | TTL | Capture/Compare/PWM 6. |
| CCP7 | C8 | I/O | TTL | Capture/Compare/PWM 7. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 9.3 Functional Description

The main components of each GPTM block are two free-running 16-bit up/down counters (referred to as TimerA and TimerB), two 16-bit match registers, two prescaler match registers, and two 16-bit load/initialization registers and their associated control functions. The exact functionality of each GPTM is controlled by software and configured through the register interface.

Software configures the GPTM using the **GPTM Configuration (GPTMCFG)** register (see page 341), the **GPTM TimerA Mode (GPTMTAMR)** register (see page 342), and the **GPTM TimerB Mode (GPTMTBMR)** register (see page 344). When in one of the 32-bit modes, the timer can only act as a 32-bit timer. However, when configured in 16-bit mode, the GPTM can have its two 16-bit timers configured in any combination of the 16-bit modes.

### 9.3.1 GPTM Reset Conditions

After reset has been applied to the GPTM module, the module is in an inactive state, and all control registers are cleared and in their default states. Counters TimerA and TimerB are initialized to 0xFFFF, along with their corresponding load registers: the **GPTM TimerA Interval Load (GPTMTAILR)** register (see page 355) and the **GPTM TimerB Interval Load (GPTMTBILR)** register (see page 356). The prescale counters are initialized to 0x00: the **GPTM TimerA Prescale (GPTMTAPR)** register (see page 359) and the **GPTM TimerB Prescale (GPTMTBPR)** register (see page 360).

### 9.3.2 32-Bit Timer Operating Modes

This section describes the three GPTM 32-bit timer modes (One-Shot, Periodic, and RTC) and their configuration.

The GPTM is placed into 32-bit mode by writing a 0 (One-Shot/Periodic 32-bit timer mode) or a 1 (RTC mode) to the **GPTM Configuration (GPTMCFG)** register. In both configurations, certain GPTM registers are concatenated to form pseudo 32-bit registers. These registers include:

- **GPTM TimerA Interval Load (GPTMTAILR)** register [15:0], see page 355
- **GPTM TimerB Interval Load (GPTMTBILR)** register [15:0], see page 356
- **GPTM TimerA (GPTMTAR)** register [15:0], see page 363
- **GPTM TimerB (GPTMTBR)** register [15:0], see page 364

In the 32-bit modes, the GPTM translates a 32-bit write access to **GPTMTAILR** into a write access to both **GPTMTAILR** and **GPTMTBILR**. The resulting word ordering for such a write operation is:

```
GPTMTBILR[15:0]:GPTMTAILR[15:0]
```

Likewise, a read access to **GPTMTAR** returns the value:

```
GPTMTBR[15:0]:GPTMTAR[15:0]
```

#### 9.3.2.1 32-Bit One-Shot/Periodic Timer Mode

In 32-bit one-shot and periodic timer modes, the concatenated versions of the TimerA and TimerB registers are configured as a 32-bit down-counter. The selection of one-shot or periodic mode is determined by the value written to the TAMR field of the **GPTM TimerA Mode (GPTMTAMR)** register (see page 342), and there is no need to write to the **GPTM TimerB Mode (GPTMTBMR)** register.

When software writes the TAEN bit in the **GPTM Control (GPTMCTL)** register (see page 346), the timer begins counting down from its preloaded value. Once the 0x0000.0000 state is reached, the timer reloads its start value from the concatenated **GPTMTAILR** on the next cycle. If configured to be a one-shot timer, the timer stops counting and clears the TAEN bit in the **GPTMCTL** register. If configured as a periodic timer, it continues counting.

In addition to reloading the count value, the GPTM generates interrupts and triggers when it reaches the 0x000.0000 state. The GPTM sets the TATORIS bit in the **GPTM Raw Interrupt Status (GPTMRIS)** register (see page 351), and holds it until it is cleared by writing the **GPTM Interrupt Clear (GPTMICR)** register (see page 353). If the time-out interrupt is enabled in the **GPTM Interrupt Mask (GPTMIMR)** register (see page 349), the GPTM also sets the TATOMIS bit in the **GPTM Masked Interrupt Status (GPTMMIS)** register (see page 352).

If software reloads the **GPTMTAILR** register while the counter is running, the counter loads the new value on the next clock cycle and continues counting from the new value.

If the TASTALL bit in the **GPTMCTL** register is set, the timer freezes counting while the processor is halted by the debugger. The timer resumes counting when the processor resumes execution.

#### 9.3.2.2 32-Bit Real-Time Clock Timer Mode

In Real-Time Clock (RTC) mode, the concatenated versions of the TimerA and TimerB registers are configured as a 32-bit up-counter. When RTC mode is selected for the first time, the counter is loaded with a value of 0x0000.0001. All subsequent load values must be written to the **GPTM TimerA Match (GPTMTAMATCHR)** register (see page 357) by the controller.

The input clock on an even CCP input is required to be 32.768 KHz in RTC mode. The clock signal is then divided down to a 1 Hz rate and is passed along to the input of the 32-bit counter.

When software writes the TAEN bit inthe **GPTMCTL** register, the counter starts counting up from its preloaded value of 0x0000.0001. When the current count value matches the preloaded value in the **GPTMTAMATCHR** register, it rolls over to a value of 0x0000.0000 and continues counting until either a hardware reset, or it is disabled by software (clearing the TAEN bit). When a match occurs, the GPTM asserts the RTCRIS bit in **GPTMRIS**. If the RTC interrupt is enabled in **GPTMIMR**, the GPTM also sets the RTCMIS bit in **GPTMMIS** and generates a controller interrupt. The status flags are cleared by writing the RTCCINT bit in **GPTMICR**.

If the TASTALL and/or TBSTALL bits in the **GPTMCTL** register are set, the timer does not freeze if the RTCEN bit is set in **GPTMCTL**.

## 9.3.3 16-Bit Timer Operating Modes

The GPTM is placed into global 16-bit mode by writing a value of 0x4 to the **GPTM Configuration (GPTMCFG)** register (see page 341). This section describes each of the GPTM 16-bit modes of operation. TimerA and TimerB have identical modes, so a single description is given using an **n** to reference both.

### 9.3.3.1 16-Bit One-Shot/Periodic Timer Mode

In 16-bit one-shot and periodic timer modes, the timer is configured as a 16-bit down-counter with an optional 8-bit prescaler that effectively extends the counting range of the timer to 24 bits. The selection of one-shot or periodic mode is determined by the value written to the TnMR field of the **GPTMTnMR** register. The optional prescaler is loaded into the **GPTM Timern Prescale (GPTMTnPR)** register.

When software writes the TnEN bit in the **GPTMCTL** register, the timer begins counting down from its preloaded value. Once the 0x0000 state is reached, the timer reloads its start value from **GPTMTnILR** and **GPTMTnPR** on the next cycle. If configured to be a one-shot timer, the timer stops counting and clears the TnEN bit in the **GPTMCTL** register. If configured as a periodic timer, it continues counting.

In addition to reloading the count value, the timer generates interrupts and triggers when it reaches the 0x0000 state. The GPTM sets the TnTORIS bit in the **GPTMRIS** register, and holds it until it is cleared by writing the **GPTMICR** register. If the time-out interrupt is enabled in **GPTMIMR**, the GPTM also sets the TnTOMIS bit in **GPTMISR** and generates a controller interrupt.

If software reloads the **GPTMTAILR** register while the counter is running, the counter loads the new value on the next clock cycle and continues counting from the new value.

If the TnSTALL bit in the **GPTMCTL** register is set, the timer freezes counting while the processor is halted by the debugger. The timer resumes counting when the processor resumes execution.

The following example shows a variety of configurations for a 16-bit free running timer while using the prescaler. All values assume a 50-MHz clock with Tc=20 ns (clock period).

**Table 9-4. 16-Bit Timer With Prescaler Configurations**

| Prescale | #Clock (T c)[a] | Max Time | Units |
|---|---|---|---|
| 00000000 | 1 | 1.3107 | mS |
| 00000001 | 2 | 2.6214 | mS |
| 00000010 | 3 | 3.9322 | mS |
| ---------- | -- | -- | -- |

**Table 9-4. 16-Bit Timer With Prescaler Configurations *(continued)***

| Prescale | #Clock (T c)[a] | Max Time | Units |
|---|---|---|---|
| 11111101 | 254 | 332.9229 | mS |
| 11111110 | 255 | 334.2336 | mS |
| 11111111 | 256 | 335.5443 | mS |

a. Tc is the clock period.

### 9.3.3.2 16-Bit Input Edge Count Mode

**Note:** For rising-edge detection, the input signal must be High for at least two system clock periods following the rising edge. Similarly, for falling-edge detection, the input signal must be Low for at least two system clock periods following the falling edge. Based on this criteria, the maximum input frequency for edge detection is 1/4 of the system frequency.

**Note:** The prescaler is not available in 16-Bit Input Edge Count mode.

In Edge Count mode, the timer is configured as a down-counter capable of capturing three types of events: rising edge, falling edge, or both. To place the timer in Edge Count mode, the TnCMR bit of the **GPTMTnMR** register must be set to 0. The type of edge that the timer counts is determined by the TnEVENT fields of the **GPTMCTL** register. During initialization, the **GPTM Timern Match (GPTMTnMATCHR)** register is configured so that the difference between the value in the **GPTMTnILR** register and the **GPTMTnMATCHR** register equals the number of edge events that must be counted.

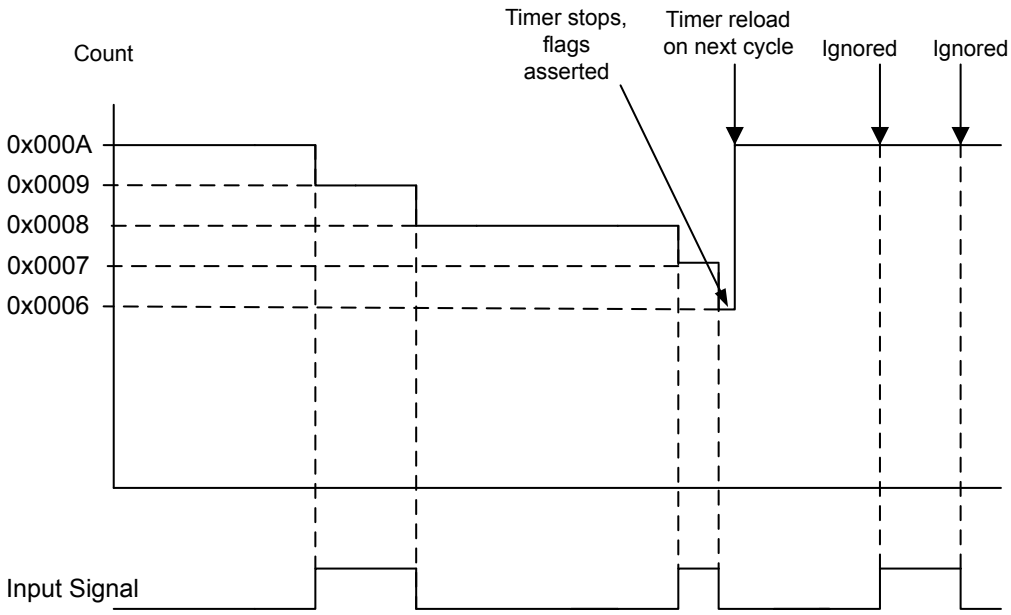
When software writes the TnEN bit in the **GPTM Control (GPTMCTL)** register, the timer is enabled for event capture. Each input event on the CCP pin decrements the counter by 1 until the event count matches **GPTMTnMATCHR**. When the counts match, the GPTM asserts the CnMRIS bit in the **GPTMRIS** register (and the CnMMIS bit, if the interrupt is not masked).

The counter is then reloaded using the value in **GPTMTnILR**, and stopped since the GPTM automatically clears the TnEN bit in the **GPTMCTL** register. Once the event count has been reached, all further events are ignored until TnEN is re-enabled by software.

Figure 9-2 on page 334 shows how input edge count mode works. In this case, the timer start value is set to **GPTMTnILR** =0x000A and the match value is set to **GPTMTnMATCHR** =0x0006 so that four edge events are counted. The counter is configured to detect both edges of the input signal.

Note that the last two edges are not counted since the timer automatically clears the TnEN bit after the current count matches the value in the **GPTMTnMATCHR** register.

**Figure 9-2. 16-Bit Input Edge Count Mode Example**




### 9.3.3.3 16-Bit Input Edge Time Mode

**Note:** For rising-edge detection, the input signal must be High for at least two system clock periods following the rising edge. Similarly, for falling edge detection, the input signal must be Low for at least two system clock periods following the falling edge. Based on this criteria, the maximum input frequency for edge detection is 1/4 of the system frequency.

**Note:** The prescaler is not available in 16-Bit Input Edge Time mode.

In Edge Time mode, the timer is configured as a free-running down-counter initialized to the value loaded in the **GPTMTnILR** register (or 0xFFFF at reset). The timer is capable of capturing three types of events: rising edge, falling edge, or both. The timer is placed into Edge Time mode by setting the TnCMR bit in the **GPTMTnMR** register, and the type of event that the timer captures is determined by the TnEVENT fields of the **GPTMCTL** register.

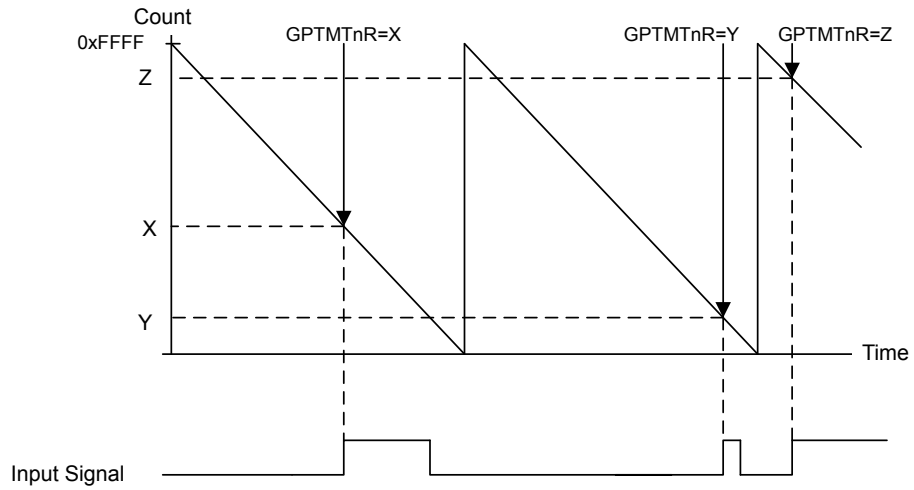
When software writes the TnEN bit in the **GPTMCTL** register, the timer is enabled for event capture. When the selected input event is detected, the current Tn counter value is captured in the **GPTMTnR** register and is available to be read by the controller. The GPTM then asserts the CnERIS bit (and the CnEMIS bit, if the interrupt is not masked).

After an event has been captured, the timer does not stop counting. It continues to count until the TnEN bit is cleared. When the timer reaches the 0x0000 state, it is reloaded with the value from the **GPTMTnILR** register.

Figure 9-3 on page 335 shows how input edge timing mode works. In the diagram, it is assumed that the start value of the timer is the default value of 0xFFFF, and the timer is configured to capture rising edge events.

Each time a rising edge event is detected, the current count value is loaded into the **GPTMTnR** register, and is held there until another rising edge is detected (at which point the new count value is loaded into **GPTMTnR**).

**Figure 9-3. 16-Bit Input Edge Time Mode Example**




### 9.3.3.4 16-Bit PWM Mode

**Note:** The prescaler is not available in 16-Bit PWM mode.

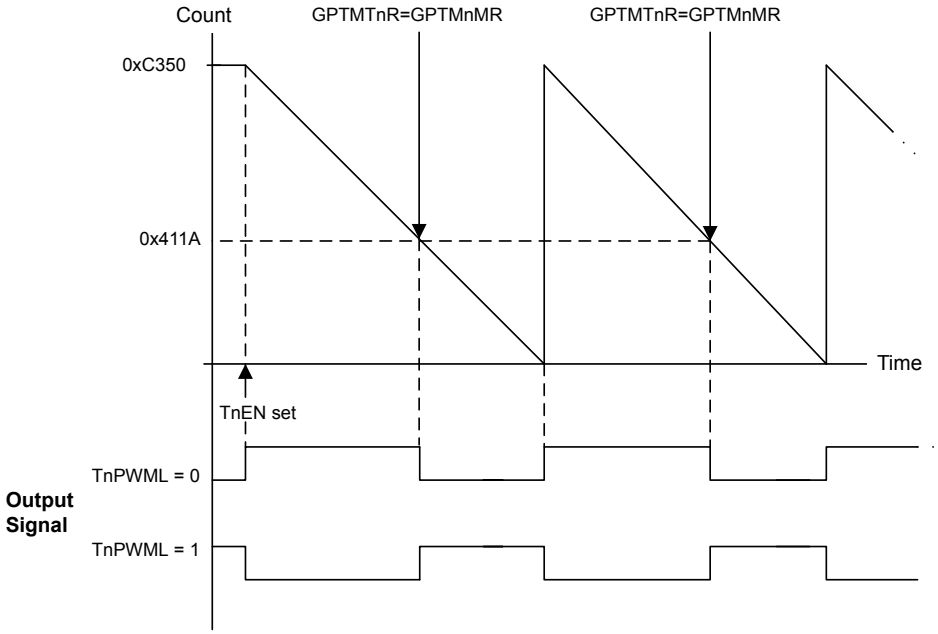
The GPTM supports a simple PWM generation mode. In PWM mode, the timer is configured as a down-counter with a start value (and thus period) defined by **GPTMTnILR**. In this mode, the PWM frequency and period are synchronous events and therefore guaranteed to be glitch free. PWM mode is enabled with the **GPTMTnMR** register by setting the TnAMS bit to 0x1, the TnCMR bit to 0x0, and the TnMR field to 0x2.

When software writes the TnEN bit in the **GPTMCTL** register, the counter begins counting down until it reaches the 0x0000 state. On the next counter cycle, the counter reloads its start value from **GPTMTnILR** and continues counting until disabled by software clearing the TnEN bit in the **GPTMCTL** register. No interrupts or status bits are asserted in PWM mode.

The output PWM signal asserts when the counter is at the value of the **GPTMTnILR** register (its start state), and is deasserted when the counter value equals the value in the **GPTM Timern Match Register (GPTMTnMATCHR)**. Software has the capability of inverting the output PWM signal by setting the TnPWML bit in the **GPTMCTL** register.

Figure 9-4 on page 336 shows how to generate an output PWM with a 1-ms period and a 66% duty cycle assuming a 50-MHz input clock and **TnPWML** =0 (duty cycle would be 33% for the **TnPWML** =1 configuration). For this example, the start value is **GPTMTnIRL**=0xC350 and the match value is **GPTMTnMATCHR**=0x411A.

**Figure 9-4. 16-Bit PWM Mode Example**




## 9.4 Initialization and Configuration

To use the general-purpose timers, the peripheral clock must be enabled by setting the TIMER0, TIMER1, TIMER2, and TIMER3 bits in the **RCGC1** register.

This section shows module initialization and configuration examples for each of the supported timer modes.

### 9.4.1 32-Bit One-Shot/Periodic Timer Mode

The GPTM is configured for 32-bit One-Shot and Periodic modes by the following sequence:

1. Ensure the timer is disabled (the TAEN bit in the **GPTMCTL** register is cleared) before making any changes.
2. Write the **GPTM Configuration Register (GPTMCFG)** with a value of 0x0.
3. Set the TAMR field in the **GPTM TimerA Mode Register (GPTMTAMR)**:
   a. Write a value of 0x1 for One-Shot mode.
   b. Write a value of 0x2 for Periodic mode.
4. Load the start value into the **GPTM TimerA Interval Load Register (GPTMTAILR)**.
5. If interrupts are required, set the TATOIM bit in the **GPTM Interrupt Mask Register (GPTMIMR)**.
6. Set the TAEN bit in the **GPTMCTL** register to enable the timer and start counting.

7. Poll the TATORIS bit in the **GPTMRIS** register or wait for the interrupt to be generated (if enabled). In both cases, the status flags are cleared by writing a 1 to the TATOCINT bit of the **GPTM Interrupt Clear Register (GPTMICR)**.

In One-Shot mode, the timer stops counting after step 7 on page 337. To re-enable the timer, repeat the sequence. A timer configured in Periodic mode does not stop counting after it times out.

### 9.4.2 32-Bit Real-Time Clock (RTC) Mode

To use the RTC mode, the timer must have a 32.768-KHz input signal on an even CCP input. To enable the RTC feature, follow these steps:

1. Ensure the timer is disabled (the TAEN bit is cleared) before making any changes.
2. Write the **GPTM Configuration Register (GPTMCFG)** with a value of 0x1.
3. Write the desired match value to the **GPTM TimerA Match Register (GPTMTAMATCHR)**.
4. Set/clear the RTCEN bit in the **GPTM Control Register (GPTMCTL)** as desired.
5. If interrupts are required, set the RTCIM bit in the **GPTM Interrupt Mask Register (GPTMIMR)**.
6. Set the TAEN bit in the **GPTMCTL** register to enable the timer and start counting.

When the timer count equals the value in the **GPTMTAMATCHR** register, the GPTM asserts the RTCRIS bit in the **GPTMRIS** register and continues counting until Timer A is disabled or a hardware reset. The interrupt is cleared by writing the RTCCINT bit in the **GPTMICR** register.

### 9.4.3 16-Bit One-Shot/Periodic Timer Mode

A timer is configured for 16-bit One-Shot and Periodic modes by the following sequence:

1. Ensure the timer is disabled (the TnEN bit is cleared) before making any changes.
2. Write the **GPTM Configuration Register (GPTMCFG)** with a value of 0x4.
3. Set the TnMR field in the **GPTM Timer Mode (GPTMTnMR)** register:
   a. Write a value of 0x1 for One-Shot mode.
   b. Write a value of 0x2 for Periodic mode.
4. If a prescaler is to be used, write the prescale value to the **GPTM Timern Prescale Register (GPTMTnPR)**.
5. Load the start value into the **GPTM Timer Interval Load Register (GPTMTnILR)**.
6. If interrupts are required, set the TnTOIM bit in the **GPTM Interrupt Mask Register (GPTMIMR)**.
7. Set the TnEN bit in the **GPTM Control Register (GPTMCTL)** to enable the timer and start counting.
8. Poll the TnTORIS bit in the **GPTMRIS** register or wait for the interrupt to be generated (if enabled). In both cases, the status flags are cleared by writing a 1 to the TnTOCINT bit of the **GPTM Interrupt Clear Register (GPTMICR)**.

In One-Shot mode, the timer stops counting after step 8 on page 337. To re-enable the timer, repeat the sequence. A timer configured in Periodic mode does not stop counting after it times out.

### 9.4.4 16-Bit Input Edge Count Mode

A timer is configured to Input Edge Count mode by the following sequence:

1. Ensure the timer is disabled (the TnEN bit is cleared) before making any changes.
2. Write the **GPTM Configuration (GPTMCFG)** register with a value of 0x4.
3. In the **GPTM Timer Mode (GPTMTnMR)** register, write the TnCMR field to 0x0 and the TnMR field to 0x3.
4. Configure the type of event(s) that the timer captures by writing the TnEVENT field of the **GPTM Control (GPTMCTL)** register.
5. Load the timer start value into the **GPTM Timern Interval Load (GPTMTnILR)** register.
6. Load the desired event count into the **GPTM Timern Match (GPTMTnMATCHR)** register.
7. If interrupts are required, set the CnMIM bit in the **GPTM Interrupt Mask (GPTMIMR)** register.
8. Set the TnEN bit in the **GPTMCTL** register to enable the timer and begin waiting for edge events.
9. Poll the CnMRIS bit in the **GPTMRIS** register or wait for the interrupt to be generated (if enabled). In both cases, the status flags are cleared by writing a 1 to the CnMCINT bit of the **GPTM Interrupt Clear (GPTMICR)** register.

In Input Edge Count Mode, the timer stops after the desired number of edge events has been detected. To re-enable the timer, ensure that the TnEN bit is cleared and repeat step 4 on page 338 through step 9 on page 338.

### 9.4.5 16-Bit Input Edge Timing Mode

A timer is configured to Input Edge Timing mode by the following sequence:

1. Ensure the timer is disabled (the TnEN bit is cleared) before making any changes.
2. Write the **GPTM Configuration (GPTMCFG)** register with a value of 0x4.
3. In the **GPTM Timer Mode (GPTMTnMR)** register, write the TnCMR field to 0x1 and the TnMR field to 0x3.
4. Configure the type of event that the timer captures by writing the TnEVENT field of the **GPTM Control (GPTMCTL)** register.
5. Load the timer start value into the **GPTM Timern Interval Load (GPTMTnILR)** register.
6. If interrupts are required, set the CnEIM bit in the **GPTM Interrupt Mask (GPTMIMR)** register.
7. Set the TnEN bit in the **GPTM Control (GPTMCTL)** register to enable the timer and start counting.
8. Poll the CnERIS bit in the **GPTMRIS** register or wait for the interrupt to be generated (if enabled). In both cases, the status flags are cleared by writing a 1 to the CnECINT bit of the **GPTM**

**Interrupt Clear (GPTMICR)** register. The time at which the event happened can be obtained by reading the **GPTM Timern (GPTMTnR)** register.

In Input Edge Timing mode, the timer continues running after an edge event has been detected, but the timer interval can be changed at any time by writing the **GPTMTnILR** register. The change takes effect at the next cycle after the write.

### 9.4.6 16-Bit PWM Mode

A timer is configured to PWM mode using the following sequence:

1. Ensure the timer is disabled (the TnEN bit is cleared) before making any changes.
2. Write the **GPTM Configuration (GPTMCFG)** register with a value of 0x4.
3. In the **GPTM Timer Mode (GPTMTnMR)** register, set the TnAMS bit to 0x1, the TnCMR bit to 0x0, and the TnMR field to 0x2.
4. Configure the output state of the PWM signal (whether or not it is inverted) in the TnPWML field of the **GPTM Control (GPTMCTL)** register.
5. Load the timer start value into the **GPTM Timern Interval Load (GPTMTnILR)** register.
6. Load the **GPTM Timern Match (GPTMTnMATCHR)** register with the desired value.
7. Set the TnEN bit in the **GPTM Control (GPTMCTL)** register to enable the timer and begin generation of the output PWM signal.

In PWM Timing mode, the timer continues running after the PWM signal has been generated. The PWM period can be adjusted at any time by writing the **GPTMTnILR** register, and the change takes effect at the next cycle after the write.

## 9.5 Register Map

Table 9-5 on page 339 lists the GPTM registers. The offset listed is a hexadecimal increment to the register's address, relative to that timer's base address:

- Timer0: 0x4003.0000
- Timer1: 0x4003.1000
- Timer2: 0x4003.2000
- Timer3: 0x4003.3000

Note that the Timer module clock must be enabled before the registers can be programmed (see page 214). There must be a delay of 3 system clocks after the Timer module clock is enabled before any Timer module registers are accessed.

**Table 9-5. Timers Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | GPTMCFG | R/W | 0x0000.0000 | GPTM Configuration | 341 |
| 0x004 | GPTMTAMR | R/W | 0x0000.0000 | GPTM TimerA Mode | 342 |
| 0x008 | GPTMTBMR | R/W | 0x0000.0000 | GPTM TimerB Mode | 344 |

**Table 9-5. Timers Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x00C | GPTMCTL | R/W | 0x0000.0000 | GPTM Control | 346 |
| 0x018 | GPTMIMR | R/W | 0x0000.0000 | GPTM Interrupt Mask | 349 |
| 0x01C | GPTMRIS | RO | 0x0000.0000 | GPTM Raw Interrupt Status | 351 |
| 0x020 | GPTMMIS | RO | 0x0000.0000 | GPTM Masked Interrupt Status | 352 |
| 0x024 | GPTMICR | W1C | 0x0000.0000 | GPTM Interrupt Clear | 353 |
| 0x028 | GPTMTAILR | R/W | 0xFFFF.FFFF | GPTM TimerA Interval Load | 355 |
| 0x02C | GPTMTBILR | R/W | 0x0000.FFFF | GPTM TimerB Interval Load | 356 |
| 0x030 | GPTMTAMATCHR | R/W | 0xFFFF.FFFF | GPTM TimerA Match | 357 |
| 0x034 | GPTMTBMATCHR | R/W | 0x0000.FFFF | GPTM TimerB Match | 358 |
| 0x038 | GPTMTAPR | R/W | 0x0000.0000 | GPTM TimerA Prescale | 359 |
| 0x03C | GPTMTBPR | R/W | 0x0000.0000 | GPTM TimerB Prescale | 360 |
| 0x040 | GPTMTAPMR | R/W | 0x0000.0000 | GPTM TimerA Prescale Match | 361 |
| 0x044 | GPTMTBPMR | R/W | 0x0000.0000 | GPTM TimerB Prescale Match | 362 |
| 0x048 | GPTMTAR | RO | 0xFFFF.FFFF | GPTM TimerA | 363 |
| 0x04C | GPTMTBR | RO | 0x0000.FFFF | GPTM TimerB | 364 |

## 9.6 Register Descriptions

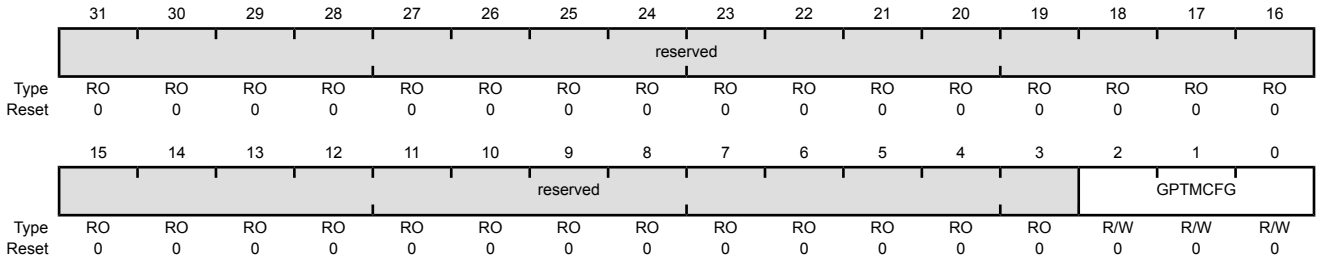
The remainder of this section lists and describes the GPTM registers, in numerical order by address offset.

## Register 1: GPTM Configuration (GPTMCFG), offset 0x000

This register configures the global operation of the GPTM module. The value written to this register determines whether the GPTM is in 32- or 16-bit mode.

GPTM Configuration (GPTMCFG)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x000
Type R/W, reset 0x0000.0000



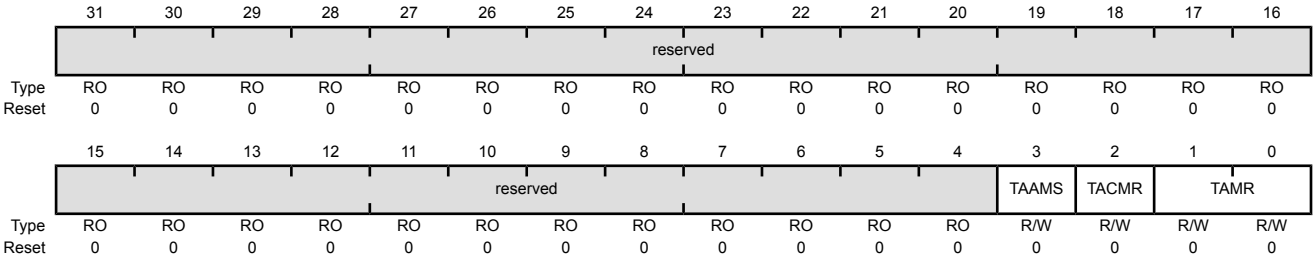

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2:0 | GPTMCFG | R/W | 0x0 | GPTM Configuration<br>The GPTMCFG values are defined as follows:<br>Value Description<br>0x0 32-bit timer configuration.<br>0x1 32-bit real-time clock (RTC) counter configuration.<br>0x2 Reserved<br>0x3 Reserved<br>0x4-0x7 16-bit timer configuration, function is controlled by bits 1:0 of **GPTMTAMR** and **GPTMTBMR**. |

## Register 2: GPTM TimerA Mode (GPTMTAMR), offset 0x004

This register configures the GPTM based on the configuration selected in the **GPTMCFG** register. When in 16-bit PWM mode, set the TAAMS bit to 0x1, the TACMR bit to 0x0, and the TAMR field to 0x2.

GPTM TimerA Mode (GPTMTAMR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x004
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | TAAMS | R/W | 0 | GPTM TimerA Alternate Mode Select<br>The TAAMS values are defined as follows:<br><br>Value Description<br>0 Capture mode is enabled.<br>1 PWM mode is enabled.<br><br>**Note:** To enable PWM mode, you must also clear the TACMR bit and set the TAMR field to 0x2. |
| 2 | TACMR | R/W | 0 | GPTM TimerA Capture Mode<br>The TACMR values are defined as follows:<br><br>Value Description<br>0 Edge-Count mode<br>1 Edge-Time mode |

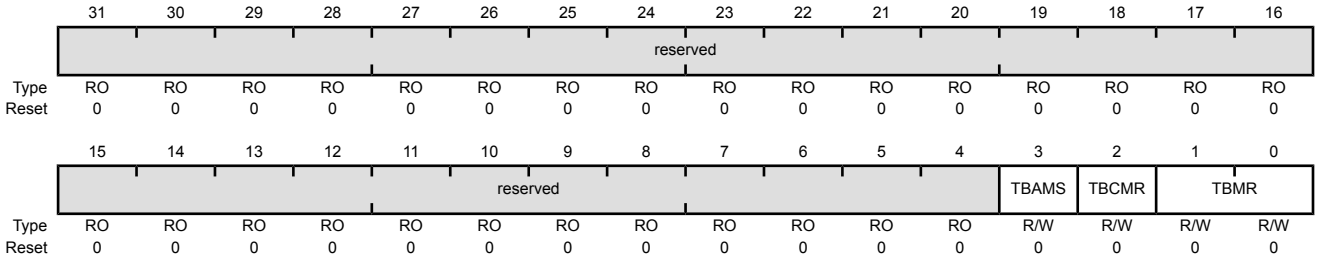
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1:0 | TAMR | R/W | 0x0 | GPTM TimerA Mode<br>The TAMR values are defined as follows:<br><br>Value Description<br>0x0 Reserved<br>0x1 One-Shot Timer mode<br>0x2 Periodic Timer mode<br>0x3 Capture mode<br><br>The Timer mode is based on the timer configuration defined by bits 2:0 in the **GPTMCFG** register (16-or 32-bit).<br>In 16-bit timer configuration, TAMR controls the 16-bit timer modes for TimerA.<br>In 32-bit timer configuration, this register controls the mode and the contents of **GPTMTBMR** are ignored. |

## Register 3: GPTM TimerB Mode (GPTMTBMR), offset 0x008

This register configures the GPTM based on the configuration selected in the **GPTMCFG** register. When in 16-bit PWM mode, set the TBAMS bit to 0x1, the TBCMR bit to 0x0, and the TBMR field to 0x2.

GPTM TimerB Mode (GPTMTBMR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x008
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | TBAMS | R/W | 0 | GPTM TimerB Alternate Mode Select<br>The TBAMS values are defined as follows:<br><br>Value Description<br>0 Capture mode is enabled.<br>1 PWM mode is enabled.<br><br>**Note:** To enable PWM mode, you must also clear the TBCMR bit and set the TBMR field to 0x2. |
| 2 | TBCMR | R/W | 0 | GPTM TimerB Capture Mode<br>The TBCMR values are defined as follows:<br><br>Value Description<br>0 Edge-Count mode<br>1 Edge-Time mode |

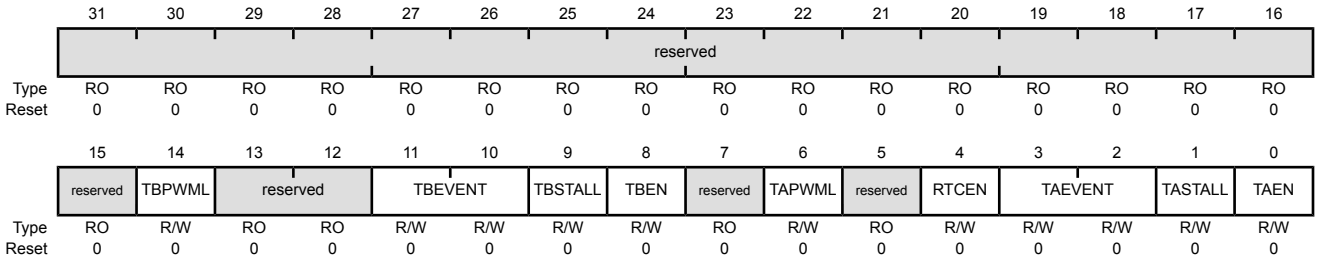
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1:0 | TBMR | R/W | 0x0 | GPTM TimerB Mode<br>The TBMR values are defined as follows:<br><br>Value Description<br>0x0 Reserved<br>0x1 One-Shot Timer mode<br>0x2 Periodic Timer mode<br>0x3 Capture mode<br><br>The timer mode is based on the timer configuration defined by bits 2:0 in the **GPTMCFG** register.<br>In 16-bit timer configuration, these bits control the 16-bit timer modes for TimerB.<br>In 32-bit timer configuration, this register's contents are ignored and **GPTMTAMR** is used. |

## Register 4: GPTM Control (GPTMCTL), offset 0x00C

This register is used alongside the **GPTMCFG** and **GMTMTnMR** registers to fine-tune the timer configuration, and to enable other features such as timer stall.

GPTM Control (GPTMCTL)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x00C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:15 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 14 | TBPWML | R/W | 0 | GPTM TimerB PWM Output Level<br>The TBPWML values are defined as follows:<br><br>Value Description<br>0 Output is unaffected.<br>1 Output is inverted. |
| 13:12 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:10 | TBEVENT | R/W | 0x0 | GPTM TimerB Event Mode<br>The TBEVENT values are defined as follows:<br><br>Value Description<br>0x0 Positive edge<br>0x1 Negative edge<br>0x2 Reserved<br>0x3 Both edges |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 9 | TBSTALL | R/W | 0 | GPTM Timer B Stall Enable<br>The TBSTALL values are defined as follows:<br><br>Value Description<br>0 Timer B continues counting while the processor is halted by the debugger.<br>1 Timer B freezes counting while the processor is halted by the debugger.<br><br>If the processor is executing normally, the TBSTALL bit is ignored. |
| 8 | TBEN | R/W | 0 | GPTM TimerB Enable<br>The TBEN values are defined as follows:<br><br>Value Description<br>0 TimerB is disabled.<br>1 TimerB is enabled and begins counting or the capture logic is enabled based on the **GPTMCFG** register. |
| 7 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | TAPWML | R/W | 0 | GPTM TimerA PWM Output Level<br>The TAPWML values are defined as follows:<br><br>Value Description<br>0 Output is unaffected.<br>1 Output is inverted. |
| 5 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | RTCEN | R/W | 0 | GPTM RTC Enable<br>The RTCEN values are defined as follows:<br><br>Value Description<br>0 RTC counting is disabled.<br>1 RTC counting is enabled. |
| 3:2 | TAEVENT | R/W | 0x0 | GPTM TimerA Event Mode<br>The TAEVENT values are defined as follows:<br><br>Value Description<br>0x0 Positive edge<br>0x1 Negative edge<br>0x2 Reserved<br>0x3 Both edges |

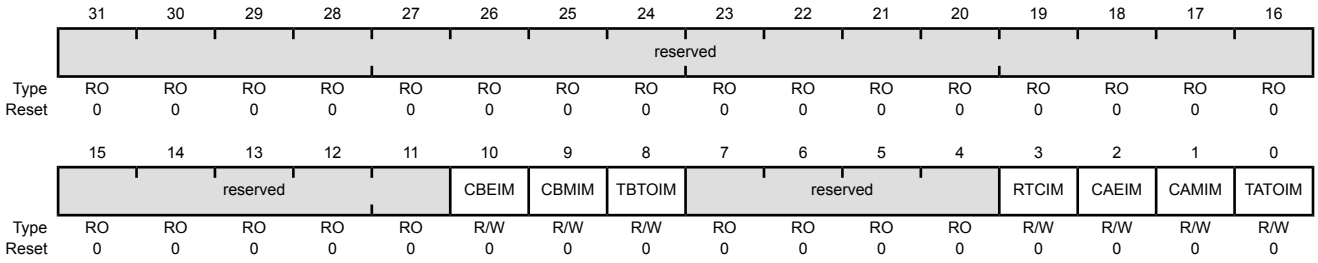
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | TASTALL | R/W | 0 | GPTM Timer A Stall Enable<br>The TASTALL values are defined as follows:<br><br>Value Description<br>0 Timer A continues counting while the processor is halted by the debugger.<br>1 Timer A freezes counting while the processor is halted by the debugger.<br><br>If the processor is executing normally, the TASTALL bit is ignored. |
| 0 | TAEN | R/W | 0 | GPTM TimerA Enable<br>The TAEN values are defined as follows:<br><br>Value Description<br>0 TimerA is disabled.<br>1 TimerA is enabled and begins counting or the capture logic is enabled based on the **GPTMCFG** register. |

## Register 5: GPTM Interrupt Mask (GPTMIMR), offset 0x018

This register allows software to enable/disable GPTM controller-level interrupts. Writing a 1 enables the interrupt, while writing a 0 disables it.

GPTM Interrupt Mask (GPTMIMR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x018
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | CBEIM | R/W | 0 | GPTM CaptureB Event Interrupt Mask<br>The CBEIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |
| 9 | CBMIM | R/W | 0 | GPTM CaptureB Match Interrupt Mask<br>The CBMIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |
| 8 | TBTOIM | R/W | 0 | GPTM TimerB Time-Out Interrupt Mask<br>The TBTOIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |
| 7:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

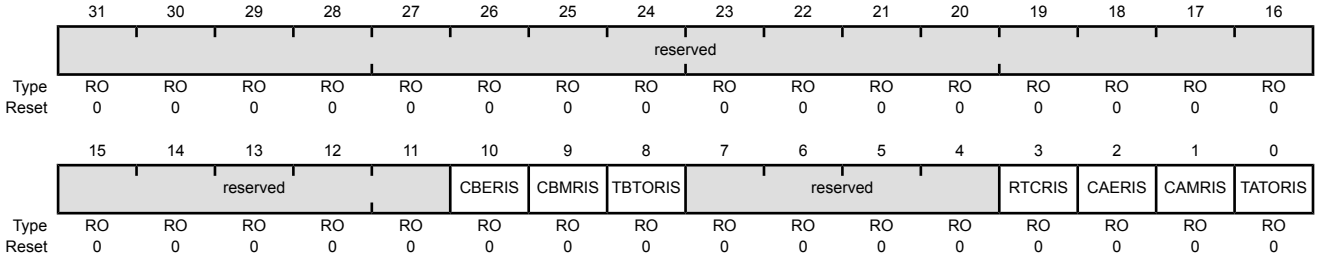
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | RTCIM | R/W | 0 | GPTM RTC Interrupt Mask<br>The RTCIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |
| 2 | CAEIM | R/W | 0 | GPTM CaptureA Event Interrupt Mask<br>The CAEIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |
| 1 | CAMIM | R/W | 0 | GPTM CaptureA Match Interrupt Mask<br>The CAMIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |
| 0 | TATOIM | R/W | 0 | GPTM TimerA Time-Out Interrupt Mask<br>The TATOIM values are defined as follows:<br><br>Value Description<br>0 Interrupt is disabled.<br>1 Interrupt is enabled. |

## Register 6: GPTM Raw Interrupt Status (GPTMRIS), offset 0x01C

This register shows the state of the GPTM's internal interrupt signal. These bits are set whether or not the interrupt is masked in the **GPTMIMR** register. Each bit can be cleared by writing a 1 to its corresponding bit in **GPTMICR**.

GPTM Raw Interrupt Status (GPTMRIS)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x01C
Type RO, reset 0x0000.0000



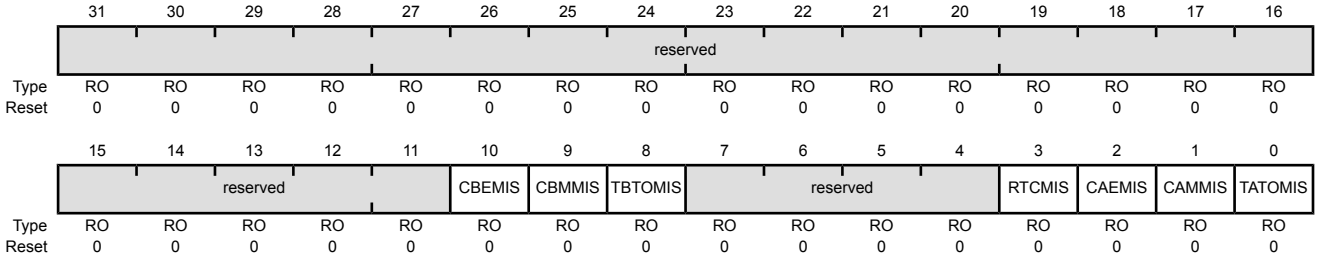

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | CBERIS | RO | 0 | GPTM CaptureB Event Raw Interrupt<br>This is the CaptureB Event interrupt status prior to masking. |
| 9 | CBMRIS | RO | 0 | GPTM CaptureB Match Raw Interrupt<br>This is the CaptureB Match interrupt status prior to masking. |
| 8 | TBTORIS | RO | 0 | GPTM TimerB Time-Out Raw Interrupt<br>This is the TimerB time-out interrupt status prior to masking. |
| 7:4 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | RTCRIS | RO | 0 | GPTM RTC Raw Interrupt<br>This is the RTC Event interrupt status prior to masking. |
| 2 | CAERIS | RO | 0 | GPTM CaptureA Event Raw Interrupt<br>This is the CaptureA Event interrupt status prior to masking. |
| 1 | CAMRIS | RO | 0 | GPTM CaptureA Match Raw Interrupt<br>This is the CaptureA Match interrupt status prior to masking. |
| 0 | TATORIS | RO | 0 | GPTM TimerA Time-Out Raw Interrupt<br>This the TimerA time-out interrupt status prior to masking. |

## Register 7: GPTM Masked Interrupt Status (GPTMMIS), offset 0x020

This register show the state of the GPTM's controller-level interrupt. If an interrupt is unmasked in **GPTMIMR**, and there is an event that causes the interrupt to be asserted, the corresponding bit is set in this register. All bits are cleared by writing a 1 to the corresponding bit in **GPTMICR**.

GPTM Masked Interrupt Status (GPTMMIS)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x020
Type RO, reset 0x0000.0000



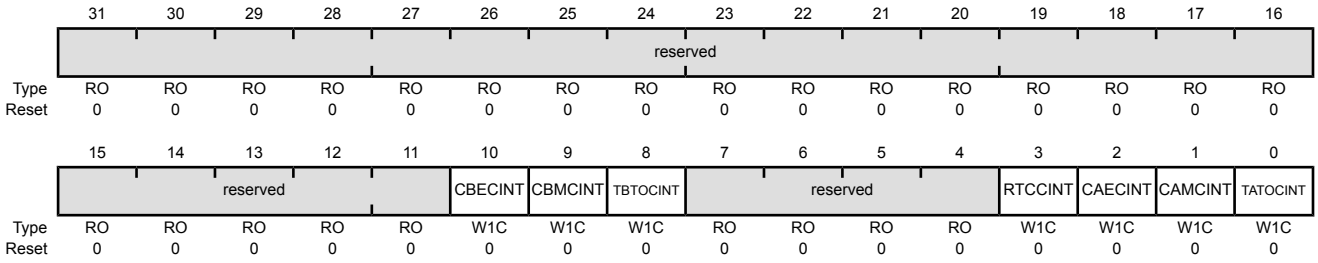

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | CBEMIS | RO | 0 | GPTM CaptureB Event Masked Interrupt<br>This is the CaptureB event interrupt status after masking. |
| 9 | CBMMIS | RO | 0 | GPTM CaptureB Match Masked Interrupt<br>This is the CaptureB match interrupt status after masking. |
| 8 | TBTOMIS | RO | 0 | GPTM TimerB Time-Out Masked Interrupt<br>This is the TimerB time-out interrupt status after masking. |
| 7:4 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | RTCMIS | RO | 0 | GPTM RTC Masked Interrupt<br>This is the RTC event interrupt status after masking. |
| 2 | CAEMIS | RO | 0 | GPTM CaptureA Event Masked Interrupt<br>This is the CaptureA event interrupt status after masking. |
| 1 | CAMMIS | RO | 0 | GPTM CaptureA Match Masked Interrupt<br>This is the CaptureA match interrupt status after masking. |
| 0 | TATOMIS | RO | 0 | GPTM TimerA Time-Out Masked Interrupt<br>This is the TimerA time-out interrupt status after masking. |

## Register 8: GPTM Interrupt Clear (GPTMICR), offset 0x024

This register is used to clear the status bits in the **GPTMRIS** and **GPTMMIS** registers. Writing a 1 to a bit clears the corresponding bit in the **GPTMRIS** and **GPTMMIS** registers.

GPTM Interrupt Clear (GPTMICR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x024
Type W1C, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | CBECINT | W1C | 0 | GPTM CaptureB Event Interrupt Clear<br>The CBECINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |
| 9 | CBMCINT | W1C | 0 | GPTM CaptureB Match Interrupt Clear<br>The CBMCINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |
| 8 | TBTOCINT | W1C | 0 | GPTM TimerB Time-Out Interrupt Clear<br>The TBTOCINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |
| 7:4 | reserved | RO | 0x0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | RTCCINT | W1C | 0 | GPTM RTC Interrupt Clear<br>The RTCCINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |
| 2 | CAECINT | W1C | 0 | GPTM CaptureA Event Interrupt Clear<br>The CAECINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |
| 1 | CAMCINT | W1C | 0 | GPTM CaptureA Match Interrupt Clear<br>The CAMCINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |
| 0 | TATOCINT | W1C | 0 | GPTM TimerA Time-Out Interrupt Clear<br>The TATOCINT values are defined as follows:<br><br>Value Description<br>0 The interrupt is unaffected.<br>1 The interrupt is cleared. |

## Register 9: GPTM TimerA Interval Load (GPTMTAILR), offset 0x028

This register is used to load the starting count value into the timer. When GPTM is configured to one of the 32-bit modes, **GPTMTAILR** appears as a 32-bit register (the upper 16-bits correspond to the contents of the **GPTM TimerB Interval Load (GPTMTBILR)** register). In 16-bit mode, the upper 16 bits of this register read as 0s and have no effect on the state of **GPTMTBILR**.

GPTM TimerA Interval Load (GPTMTAILR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x028
Type R/W, reset 0xFFFF.FFFF

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TAILRH | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TAILRL | | | | | | | | | | | | | | | |
| Type | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

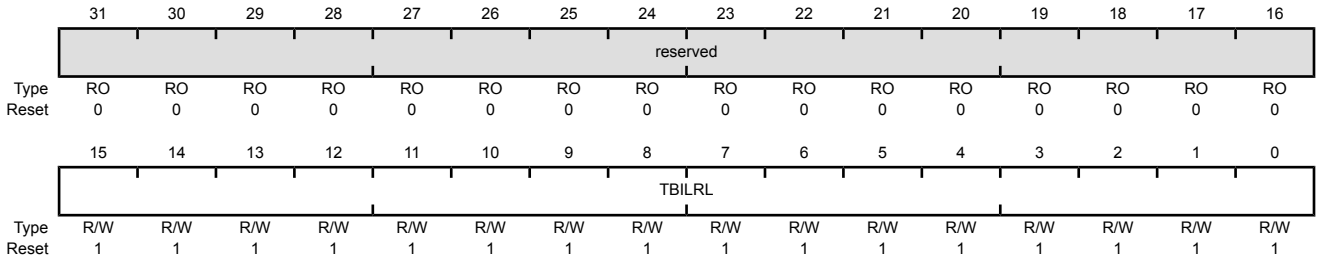
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | TAILRH | R/W | 0xFFFF | GPTM TimerA Interval Load Register High<br>When configured for 32-bit mode via the **GPTMCFG** register, the **GPTM TimerB Interval Load (GPTMTBILR)** register loads this value on a write. A read returns the current value of **GPTMTBILR**.<br>In 16-bit mode, this field reads as 0 and does not have an effect on the state of **GPTMTBILR**. |
| 15:0 | TAILRL | R/W | 0xFFFF | GPTM TimerA Interval Load Register Low<br>For both 16- and 32-bit modes, writing this field loads the counter for TimerA. A read returns the current value of **GPTMTAILR**. |

## Register 10: GPTM TimerB Interval Load (GPTMTBILR), offset 0x02C

This register is used to load the starting count value into TimerB. When the GPTM is configured to a 32-bit mode, **GPTMTBILR** returns the current value of TimerB and ignores writes.

GPTM TimerB Interval Load (GPTMTBILR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x02C
Type R/W, reset 0x0000.FFFF



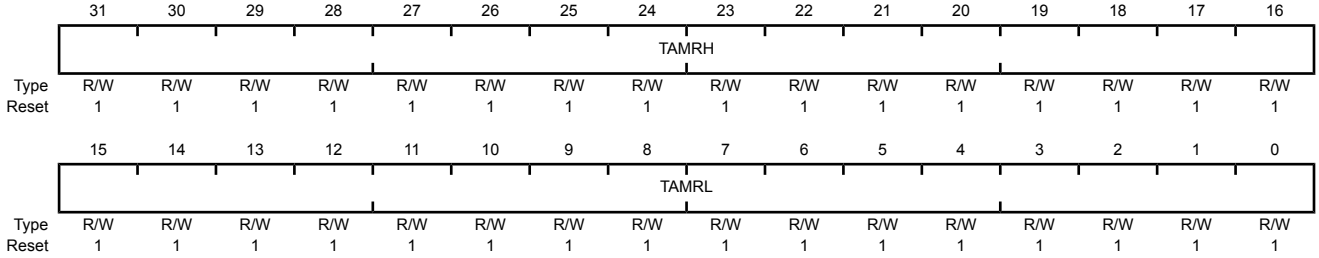

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | TBILRL | R/W | 0xFFFF | GPTM TimerB Interval Load Register<br>When the GPTM is not configured as a 32-bit timer, a write to this field updates **GPTMTBILR**. In 32-bit mode, writes are ignored, and reads return the current value of **GPTMTBILR**. |

## Register 11: GPTM TimerA Match (GPTMTAMATCHR), offset 0x030

This register is used in 32-bit Real-Time Clock mode and 16-bit PWM and Input Edge Count modes.

GPTM TimerA Match (GPTMTAMATCHR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x030
Type R/W, reset 0xFFFF.FFFF



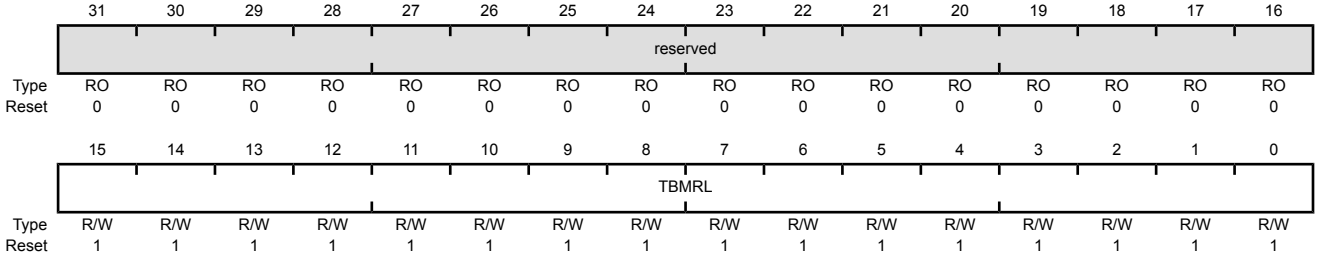

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | TAMRH | R/W | 0xFFFF | GPTM TimerA Match Register High<br>When configured for 32-bit Real-Time Clock (RTC) mode via the **GPTMCFG** register, this value is compared to the upper half of **GPTMTAR**, to determine match events.<br>In 16-bit mode, this field reads as 0 and does not have an effect on the state of **GPTMTBMATCHR**. |
| 15:0 | TAMRL | R/W | 0xFFFF | GPTM TimerA Match Register Low<br>When configured for 32-bit Real-Time Clock (RTC) mode via the **GPTMCFG** register, this value is compared to the lower half of **GPTMTAR**, to determine match events.<br>When configured for PWM mode, this value along with **GPTMTAILR**, determines the duty cycle of the output PWM signal.<br>When configured for Edge Count mode, this value along with **GPTMTAILR**, determines how many edge events are counted. The total number of edge events counted is equal to the value in **GPTMTAILR** minus this value. |

## Register 12: GPTM TimerB Match (GPTMTBMATCHR), offset 0x034

This register is used in 16-bit PWM and Input Edge Count modes.

GPTM TimerB Match (GPTMTBMATCHR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x034
Type R/W, reset 0x0000.FFFF



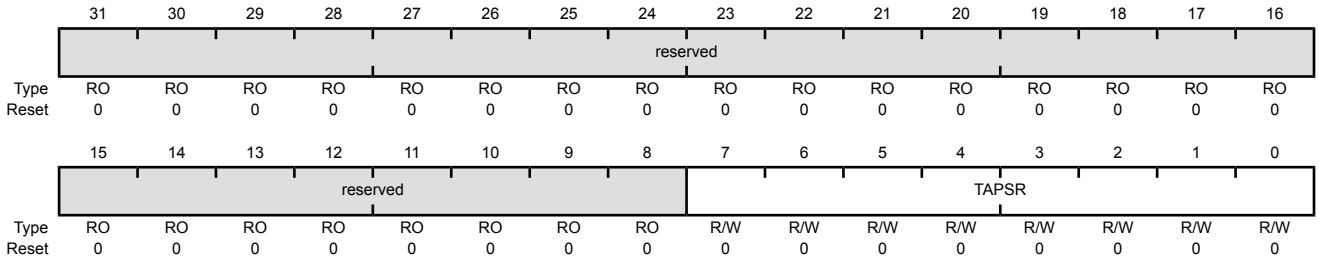

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | TBMRL | R/W | 0xFFFF | GPTM TimerB Match Register Low<br>When configured for PWM mode, this value along with **GPTMTBILR**, determines the duty cycle of the output PWM signal.<br>When configured for Edge Count mode, this value along with **GPTMTBILR**, determines how many edge events are counted. The total number of edge events counted is equal to the value in **GPTMTBILR** minus this value. |

## Register 13: GPTM TimerA Prescale (GPTMTAPR), offset 0x038

This register allows software to extend the range of the 16-bit timers when operating in one-shot or periodic mode.

GPTM TimerA Prescale (GPTMTAPR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x038
Type R/W, reset 0x0000.0000



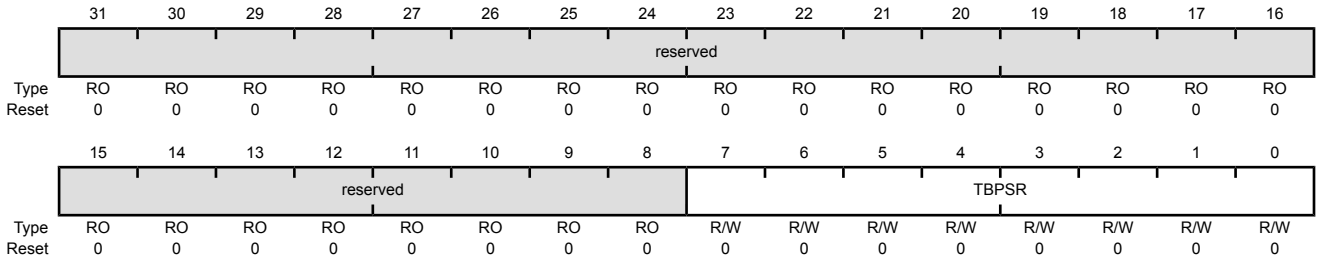

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | TAPSR | R/W | 0x00 | GPTM TimerA Prescale<br>The register loads this value on a write. A read returns the current value of the register.<br>Refer to Table 9-4 on page 332 for more details and an example. |

## Register 14: GPTM TimerB Prescale (GPTMTBPR), offset 0x03C

This register allows software to extend the range of the 16-bit timers when operating in one-shot or periodic mode.

GPTM TimerB Prescale (GPTMTBPR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x03C
Type R/W, reset 0x0000.0000



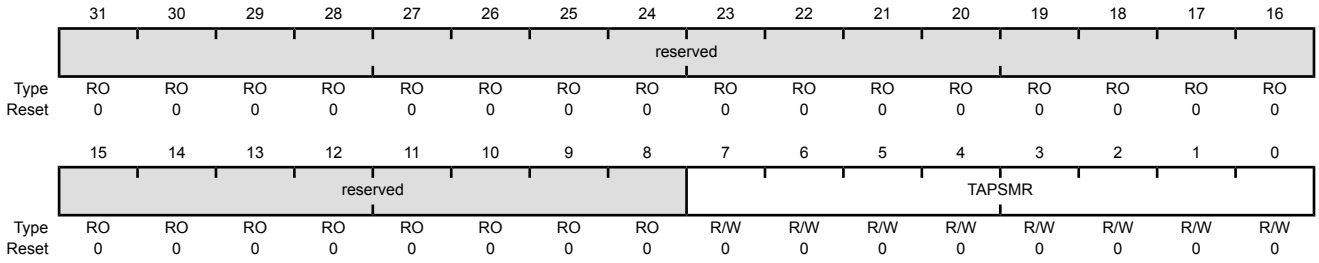

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | TBPSR | R/W | 0x00 | GPTM TimerB Prescale<br>The register loads this value on a write. A read returns the current value of this register.<br>Refer to Table 9-4 on page 332 for more details and an example. |

## Register 15: GPTM TimerA Prescale Match (GPTMTAPMR), offset 0x040

This register effectively extends the range of **GPTMTAMATCHR** to 24 bits when operating in 16-bit one-shot or periodic mode.

GPTM TimerA Prescale Match (GPTMTAPMR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x040
Type R/W, reset 0x0000.0000



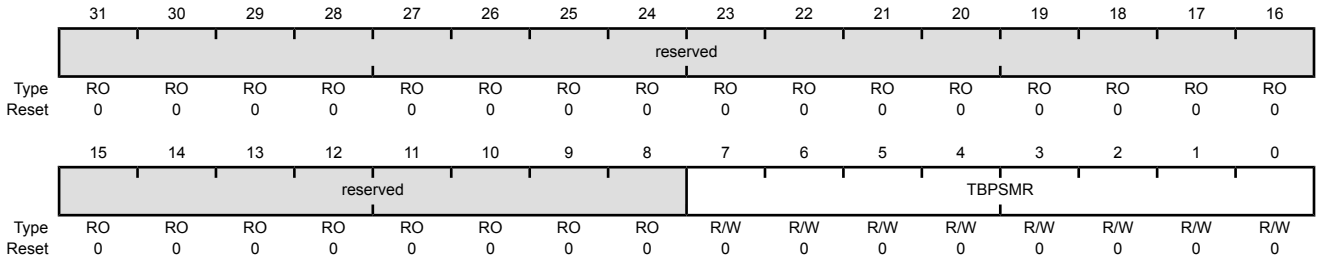

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | TAPSMR | R/W | 0x00 | GPTM TimerA Prescale Match<br>This value is used alongside **GPTMTAMATCHR** to detect timer match events while using a prescaler. |

## Register 16: GPTM TimerB Prescale Match (GPTMTBPMR), offset 0x044

This register effectively extends the range of **GPTMTBMATCHR** to 24 bits when operating in 16-bit one-shot or periodic mode.

GPTM TimerB Prescale Match (GPTMTBPMR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x044
Type R/W, reset 0x0000.0000



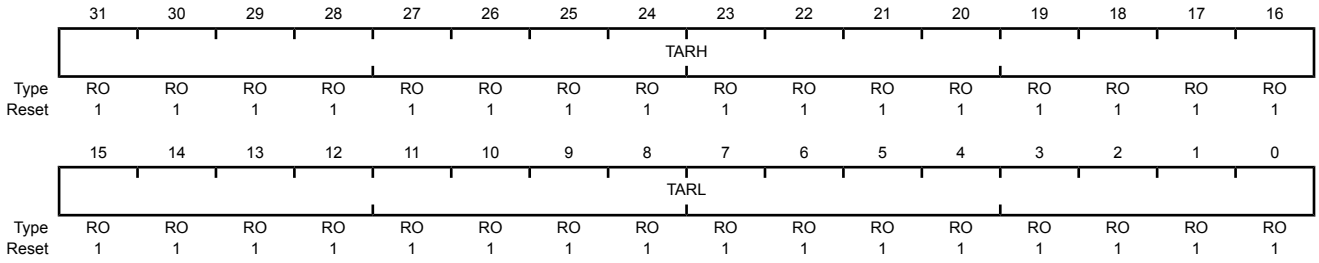

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | TBPSMR | R/W | 0x00 | GPTM TimerB Prescale Match<br>This value is used alongside **GPTMTBMATCHR** to detect timer match events while using a prescaler. |

## Register 17: GPTM TimerA (GPTMTAR), offset 0x048

This register shows the current value of the TimerA counter in all cases except for Input Edge Count mode. When in this mode, this register contains the number of edges that have occurred.

GPTM TimerA (GPTMTAR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x048
Type RO, reset 0xFFFF.FFFF



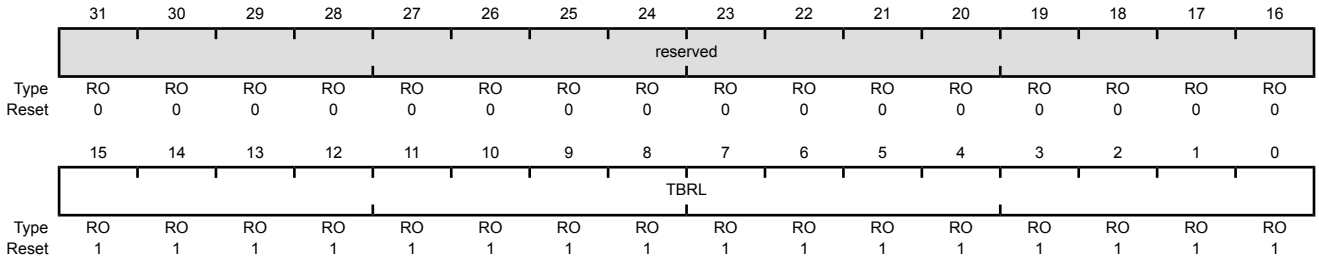

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | TARH | RO | 0xFFFF | GPTM TimerA Register High<br>If the **GPTMCFG** is in a 32-bit mode, TimerB value is read. If the **GPTMCFG** is in a 16-bit mode, this is read as zero. |
| 15:0 | TARL | RO | 0xFFFF | GPTM TimerA Register Low<br>A read returns the current value of the **GPTM TimerA Count Register**, except in Input Edge-Count mode, when it returns the number of edges that have occurred. |

## Register 18: GPTM TimerB (GPTMTBR), offset 0x04C

This register shows the current value of the TimerB counter in all cases except for Input Edge Count mode. When in this mode, this register contains the number of edges that have occurred.

GPTM TimerB (GPTMTBR)

Timer0 base: 0x4003.0000
Timer1 base: 0x4003.1000
Timer2 base: 0x4003.2000
Timer3 base: 0x4003.3000
Offset 0x04C
Type RO, reset 0x0000.FFFF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | TBRL | RO | 0xFFFF | GPTM TimerB<br>A read returns the current value of the **GPTM TimerB Count Register**, except in Input Edge-Count mode, when it returns the number of edges that have occurred. |

# 10 Watchdog Timer

A watchdog timer can generate nonmaskable interrupts (NMIs) or a reset when a time-out value is reached. The watchdog timer is used to regain control when a system has failed due to a software error or due to the failure of an external device to respond in the expected way.

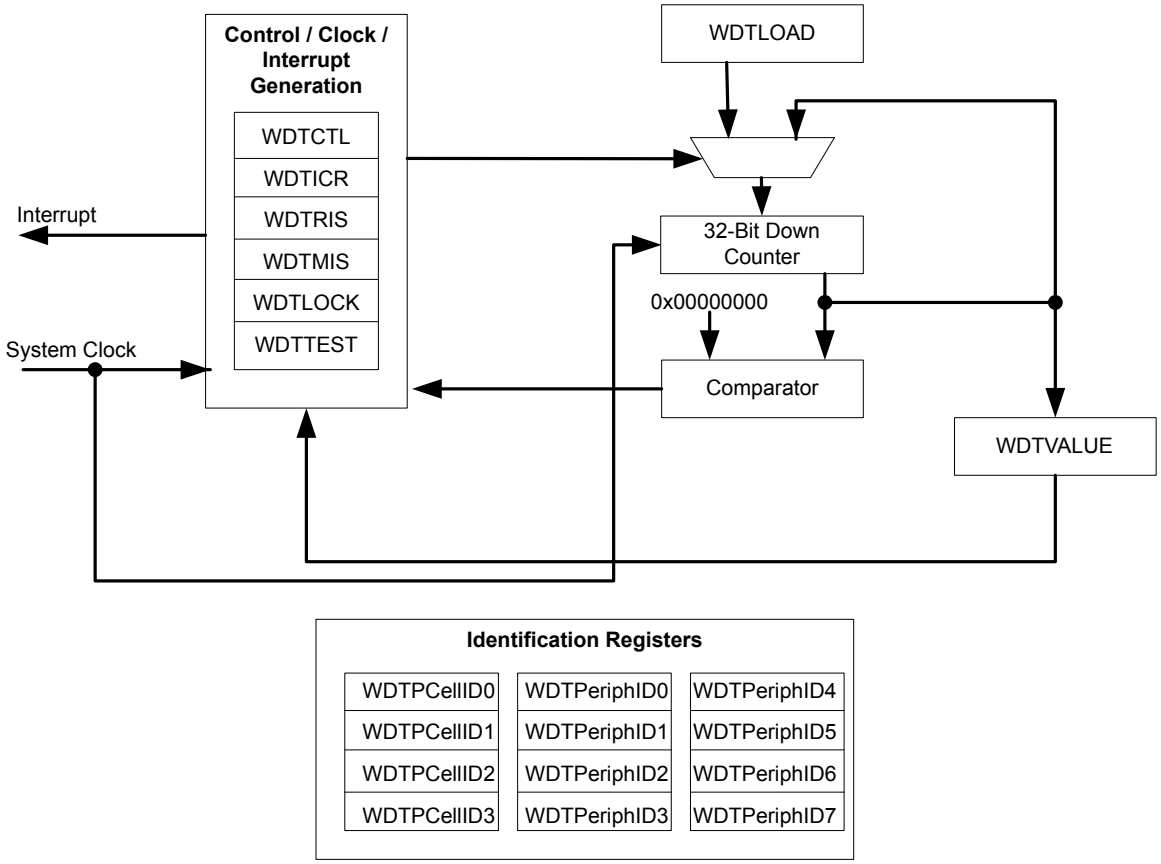
The Stellaris® Watchdog Timer module has the following features:

- 32-bit down counter with a programmable load register
- Separate watchdog clock with an enable
- Programmable interrupt generation logic with interrupt masking
- Lock register protection from runaway software
- Reset generation logic with an enable/disable
- User-enabled stalling when the controller asserts the CPU Halt flag during debug

The Watchdog Timer can be configured to generate an interrupt to the controller on its first time-out, and to generate a reset signal on its second time-out. Once the Watchdog Timer has been configured, the lock register can be written to prevent the timer configuration from being inadvertently altered.

## 10.1 Block Diagram

**Figure 10-1. WDT Module Block Diagram**




## 10.2 Functional Description

The Watchdog Timer module generates the first time-out signal when the 32-bit counter reaches the zero state after being enabled; enabling the counter also enables the watchdog timer interrupt. After the first time-out event, the 32-bit counter is re-loaded with the value of the **Watchdog Timer Load (WDTLOAD)** register, and the timer resumes counting down from that value. Once the Watchdog Timer has been configured, the **Watchdog Timer Lock (WDTLOCK)** register is written, which prevents the timer configuration from being inadvertently altered by software.

If the timer counts down to its zero state again before the first time-out interrupt is cleared, and the reset signal has been enabled (via the `WatchdogResetEnable` function), the Watchdog timer asserts its reset signal to the system. If the interrupt is cleared before the 32-bit counter reaches its second time-out, the 32-bit counter is loaded with the value in the **WDTLOAD** register, and counting resumes from that value.

If **WDTLOAD** is written with a new value while the Watchdog Timer counter is counting, then the counter is loaded with the new value and continues counting.

Writing to **WDTLOAD** does not clear an active interrupt. An interrupt must be specifically cleared by writing to the **Watchdog Interrupt Clear (WDTICR)** register.

The Watchdog module interrupt and reset generation can be enabled or disabled as required. When the interrupt is re-enabled, the 32-bit counter is preloaded with the load register value and not its last state.

## 10.3 Initialization and Configuration

To use the WDT, its peripheral clock must be enabled by setting the WDT bit in the **RCGC0** register. The Watchdog Timer is configured using the following sequence:

1. Load the **WDTLOAD** register with the desired timer load value.
2. If the Watchdog is configured to trigger system resets, set the RESEN bit in the **WDTCTL** register.
3. Set the INTEN bit in the **WDTCTL** register to enable the Watchdog and lock the control register.

If software requires that all of the watchdog registers are locked, the Watchdog Timer module can be fully locked by writing any value to the **WDTLOCK** register. To unlock the Watchdog Timer, write a value of 0x1ACC.E551.

## 10.4 Register Map

Table 10-1 on page 367 lists the Watchdog registers. The offset listed is a hexadecimal increment to the register's address, relative to the Watchdog Timer base address of 0x4000.0000.

**Table 10-1. Watchdog Timer Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | WDTLOAD | R/W | 0xFFFF.FFFF | Watchdog Load | 369 |
| 0x004 | WDTVALUE | RO | 0xFFFF.FFFF | Watchdog Value | 370 |
| 0x008 | WDTCTL | R/W | 0x0000.0000 | Watchdog Control | 371 |
| 0x00C | WDTICR | WO | - | Watchdog Interrupt Clear | 372 |
| 0x010 | WDTRIS | RO | 0x0000.0000 | Watchdog Raw Interrupt Status | 373 |
| 0x014 | WDTMIS | RO | 0x0000.0000 | Watchdog Masked Interrupt Status | 374 |
| 0x418 | WDTTEST | R/W | 0x0000.0000 | Watchdog Test | 375 |
| 0xC00 | WDTLOCK | R/W | 0x0000.0000 | Watchdog Lock | 376 |
| 0xFD0 | WDTPeriphID4 | RO | 0x0000.0000 | Watchdog Peripheral Identification 4 | 377 |
| 0xFD4 | WDTPeriphID5 | RO | 0x0000.0000 | Watchdog Peripheral Identification 5 | 378 |
| 0xFD8 | WDTPeriphID6 | RO | 0x0000.0000 | Watchdog Peripheral Identification 6 | 379 |
| 0xFDC | WDTPeriphID7 | RO | 0x0000.0000 | Watchdog Peripheral Identification 7 | 380 |
| 0xFE0 | WDTPeriphID0 | RO | 0x0000.0005 | Watchdog Peripheral Identification 0 | 381 |
| 0xFE4 | WDTPeriphID1 | RO | 0x0000.0018 | Watchdog Peripheral Identification 1 | 382 |
| 0xFE8 | WDTPeriphID2 | RO | 0x0000.0018 | Watchdog Peripheral Identification 2 | 383 |

**Table 10-1. Watchdog Timer Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0xFEC | WDTPeriphID3 | RO | 0x0000.0001 | Watchdog Peripheral Identification 3 | 384 |
| 0xFF0 | WDTPCellID0 | RO | 0x0000.000D | Watchdog PrimeCell Identification 0 | 385 |
| 0xFF4 | WDTPCellID1 | RO | 0x0000.00F0 | Watchdog PrimeCell Identification 1 | 386 |
| 0xFF8 | WDTPCellID2 | RO | 0x0000.0005 | Watchdog PrimeCell Identification 2 | 387 |
| 0xFFC | WDTPCellID3 | RO | 0x0000.00B1 | Watchdog PrimeCell Identification 3 | 388 |

## 10.5 Register Descriptions

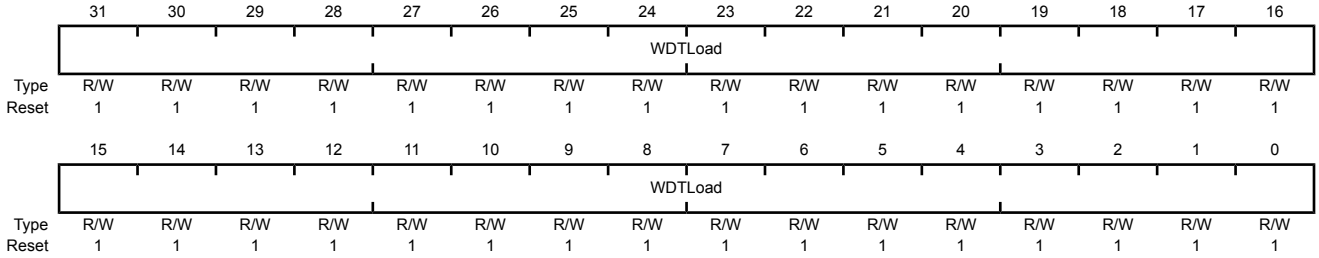
The remainder of this section lists and describes the WDT registers, in numerical order by address offset.

## Register 1: Watchdog Load (WDTLOAD), offset 0x000

This register is the 32-bit interval value used by the 32-bit counter. When this register is written, the value is immediately loaded and the counter restarts counting down from the new value. If the **WDTLOAD** register is loaded with 0x0000.0000, an interrupt is immediately generated.

Watchdog Load (WDTLOAD)

Base 0x4000.0000
Offset 0x000
Type R/W, reset 0xFFFF.FFFF



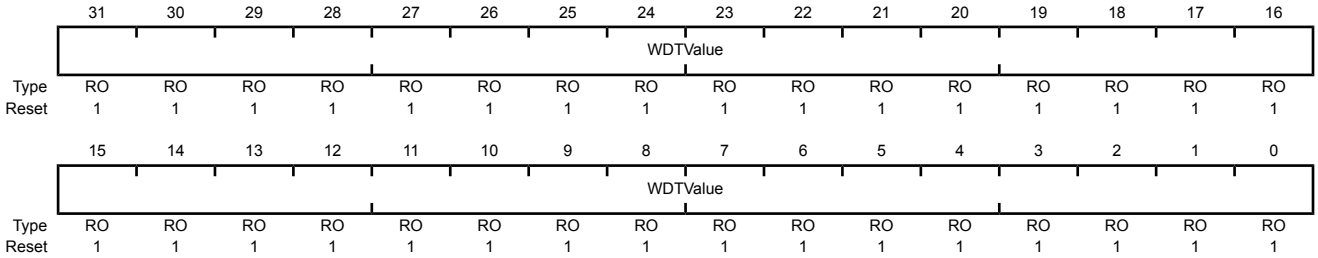

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | WDTLoad | R/W | 0xFFFF.FFFF | Watchdog Load Value |

## Register 2: Watchdog Value (WDTVALUE), offset 0x004

This register contains the current count value of the timer.

Watchdog Value (WDTVALUE)

Base 0x4000.0000
Offset 0x004
Type RO, reset 0xFFFF.FFFF




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | WDTValue | RO | 0xFFFF.FFFF | Watchdog Value<br>Current value of the 32-bit down counter. |

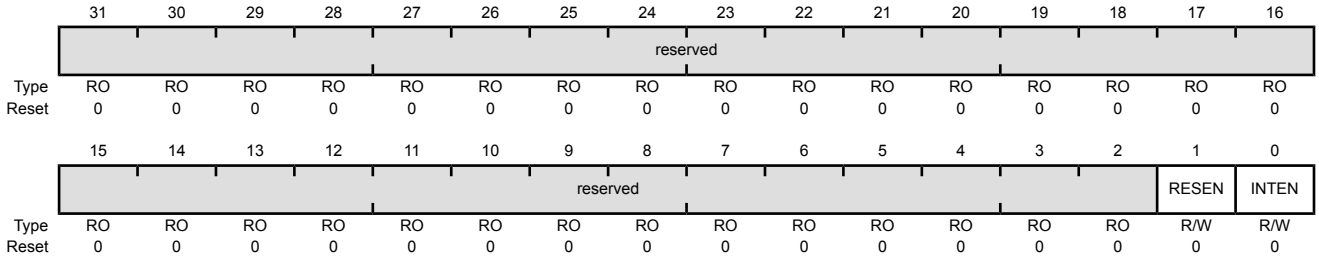
## Register 3: Watchdog Control (WDTCTL), offset 0x008

This register is the watchdog control register. The watchdog timer can be configured to generate a reset signal (on second time-out) or an interrupt on time-out.

When the watchdog interrupt has been enabled, all subsequent writes to the control register are ignored. The only mechanism that can re-enable writes is a hardware reset.

Watchdog Control (WDTCTL)

Base 0x4000.0000
Offset 0x008
Type R/W, reset 0x0000.0000



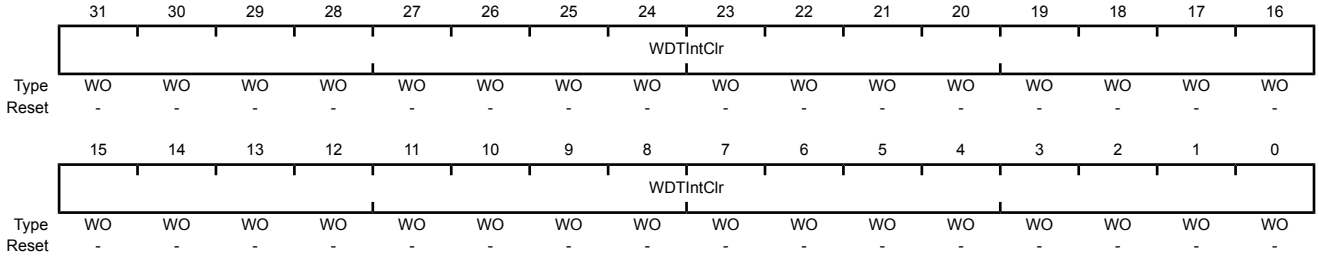

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | RESEN | R/W | 0 | Watchdog Reset Enable<br>The RESEN values are defined as follows:<br><br>Value Description<br>0 Disabled.<br>1 Enable the Watchdog module reset output. |
| 0 | INTEN | R/W | 0 | Watchdog Interrupt Enable<br>The INTEN values are defined as follows:<br><br>Value Description<br>0 Interrupt event disabled (once this bit is set, it can only be cleared by a hardware reset).<br>1 Interrupt event enabled. Once enabled, all writes are ignored. |

## Register 4: Watchdog Interrupt Clear (WDTICR), offset 0x00C

This register is the interrupt clear register. A write of any value to this register clears the Watchdog interrupt and reloads the 32-bit counter from the **WDTLOAD** register. Value for a read or reset is indeterminate.

Watchdog Interrupt Clear (WDTICR)

Base 0x4000.0000
Offset 0x00C
Type WO, reset -



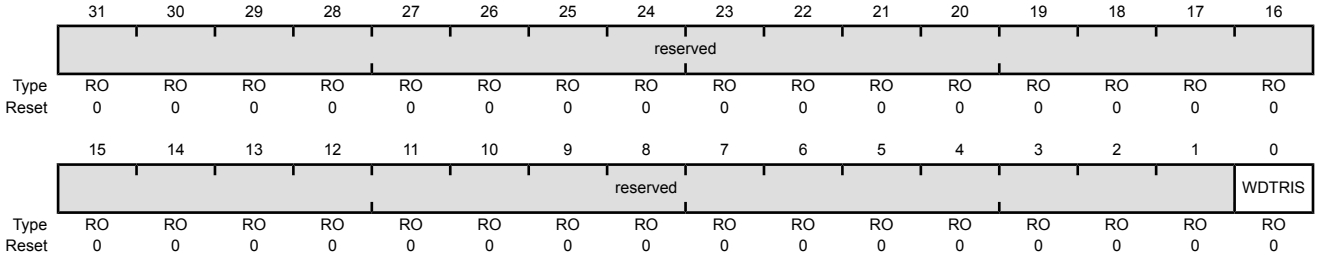

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | WDTIntClr | WO | - | Watchdog Interrupt Clear |

## Register 5: Watchdog Raw Interrupt Status (WDTRIS), offset 0x010

This register is the raw interrupt status register. Watchdog interrupt events can be monitored via this register if the controller interrupt is masked.

Watchdog Raw Interrupt Status (WDTRIS)

Base 0x4000.0000
Offset 0x010
Type RO, reset 0x0000.0000



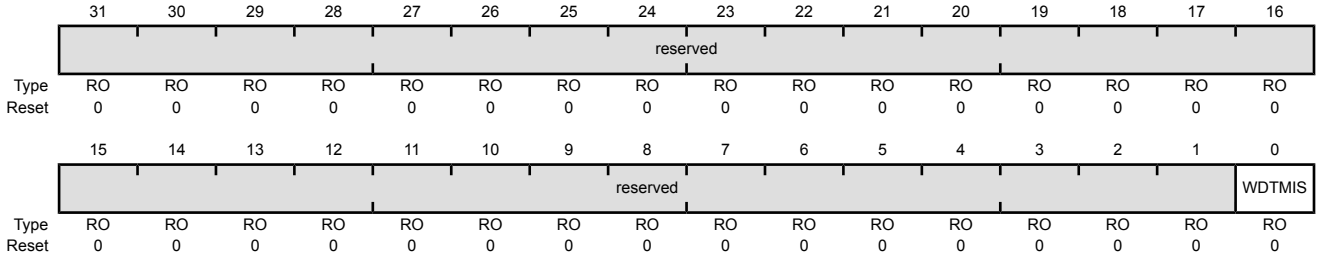

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | WDTRIS | RO | 0 | Watchdog Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of **WDTINTR**. |

## Register 6: Watchdog Masked Interrupt Status (WDTMIS), offset 0x014

This register is the masked interrupt status register. The value of this register is the logical AND of the raw interrupt bit and the Watchdog interrupt enable bit.

Watchdog Masked Interrupt Status (WDTMIS)

Base 0x4000.0000
Offset 0x014
Type RO, reset 0x0000.0000



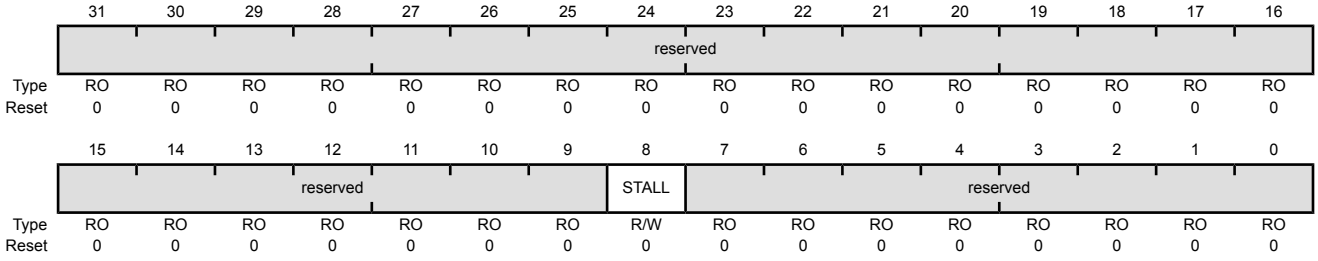

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | WDTMIS | RO | 0 | Watchdog Masked Interrupt Status<br>Gives the masked interrupt state (after masking) of the **WDTINTR** interrupt. |

## Register 7: Watchdog Test (WDTTEST), offset 0x418

This register provides user-enabled stalling when the microcontroller asserts the CPU halt flag during debug.

Watchdog Test (WDTTEST)

Base 0x4000.0000
Offset 0x418
Type R/W, reset 0x0000.0000



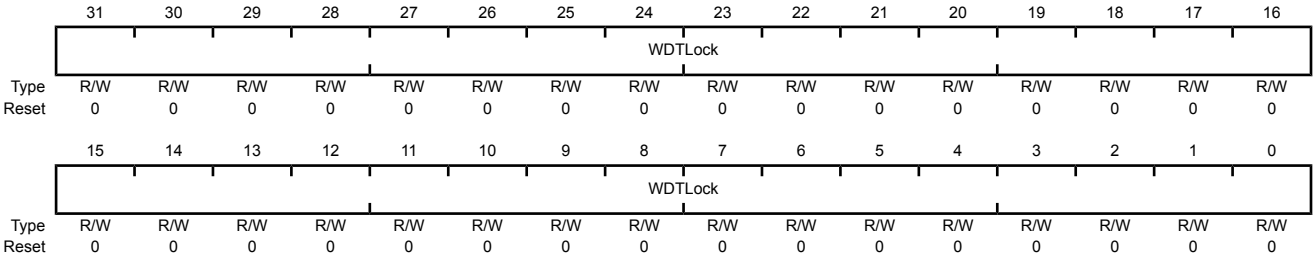

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:9 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 8 | STALL | R/W | 0 | Watchdog Stall Enable<br>When set to 1, if the Stellaris microcontroller is stopped with a debugger, the watchdog timer stops counting. Once the microcontroller is restarted, the watchdog timer resumes counting. |
| 7:0 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 8: Watchdog Lock (WDTLOCK), offset 0xC00

Writing 0x1ACC.E551 to the **WDTLOCK** register enables write access to all other registers. Writing any other value to the **WDTLOCK** register re-enables the locked state for register writes to all the other registers. Reading the **WDTLOCK** register returns the lock status rather than the 32-bit value written. Therefore, when write accesses are disabled, reading the **WDTLOCK** register returns 0x0000.0001 (when locked; otherwise, the returned value is 0x0000.0000 (unlocked)).

Watchdog Lock (WDTLOCK)

Base 0x4000.0000
Offset 0xC00
Type R/W, reset 0x0000.0000



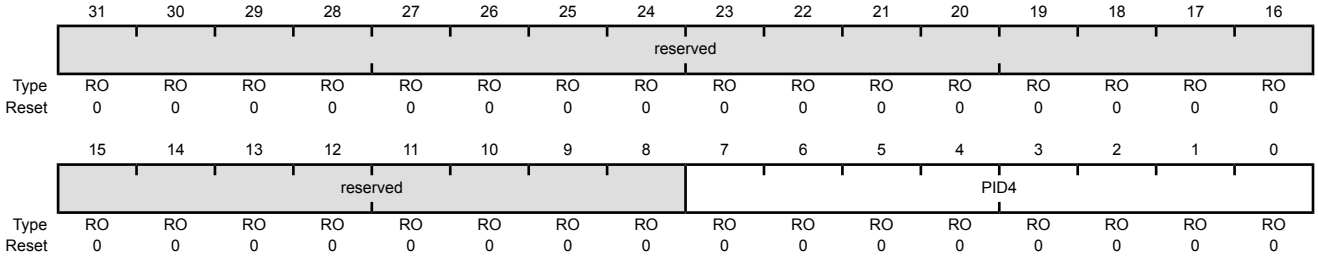

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | WDTLock | R/W | 0x0000 | Watchdog Lock<br>A write of the value 0x1ACC.E551 unlocks the watchdog registers for write access. A write of any other value reapplies the lock, preventing any register updates.<br>A read of this register returns the following values:<br>Value Description<br>0x0000.0001 Locked<br>0x0000.0000 Unlocked |

## Register 9: Watchdog Peripheral Identification 4 (WDTPeriphID4), offset 0xFD0

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 4 (WDTPeriphID4)

Base 0x4000.0000
Offset 0xFD0
Type RO, reset 0x0000.0000



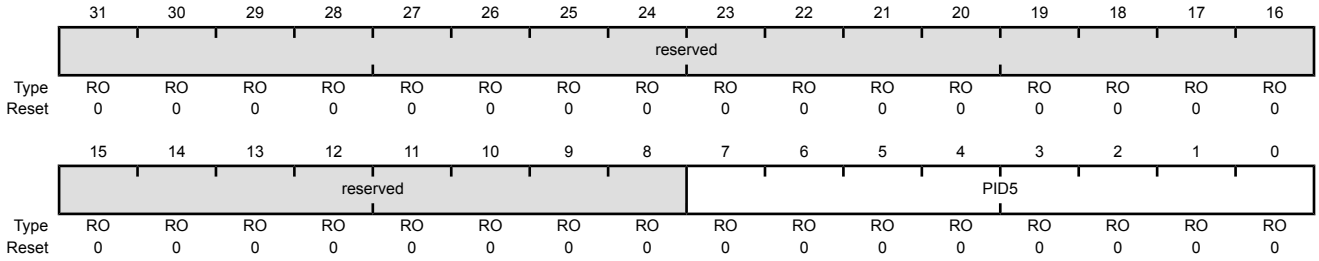

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID4 | RO | 0x00 | WDT Peripheral ID Register[7:0] |

## Register 10: Watchdog Peripheral Identification 5 (WDTPeriphID5), offset 0xFD4

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 5 (WDTPeriphID5)

Base 0x4000.0000
Offset 0xFD4
Type RO, reset 0x0000.0000



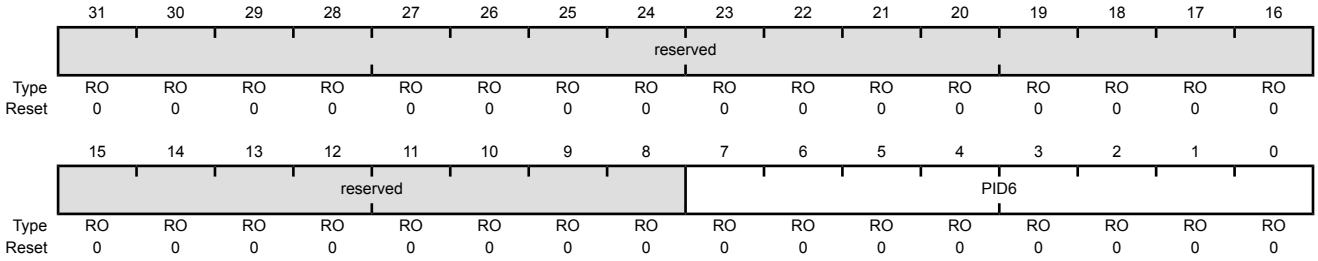

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID5 | RO | 0x00 | WDT Peripheral ID Register[15:8] |

## Register 11: Watchdog Peripheral Identification 6 (WDTPeriphID6), offset 0xFD8

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 6 (WDTPeriphID6)

Base 0x4000.0000
Offset 0xFD8
Type RO, reset 0x0000.0000



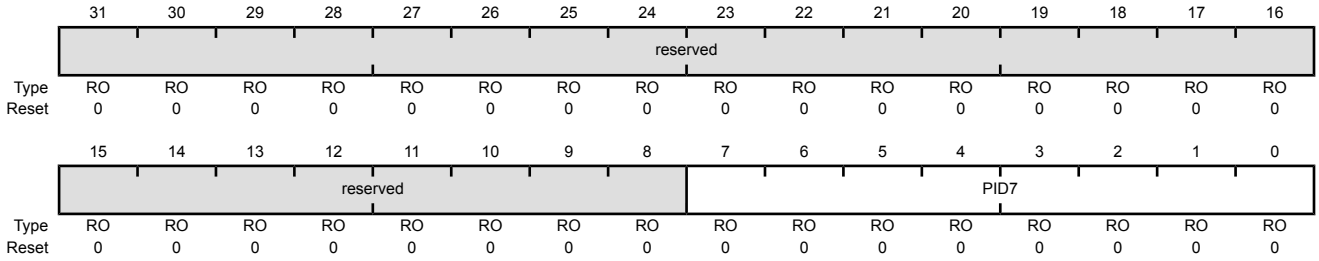

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID6 | RO | 0x00 | WDT Peripheral ID Register[23:16] |

## Register 12: Watchdog Peripheral Identification 7 (WDTPeriphID7), offset 0xFDC

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 7 (WDTPeriphID7)

Base 0x4000.0000
Offset 0xFDC
Type RO, reset 0x0000.0000



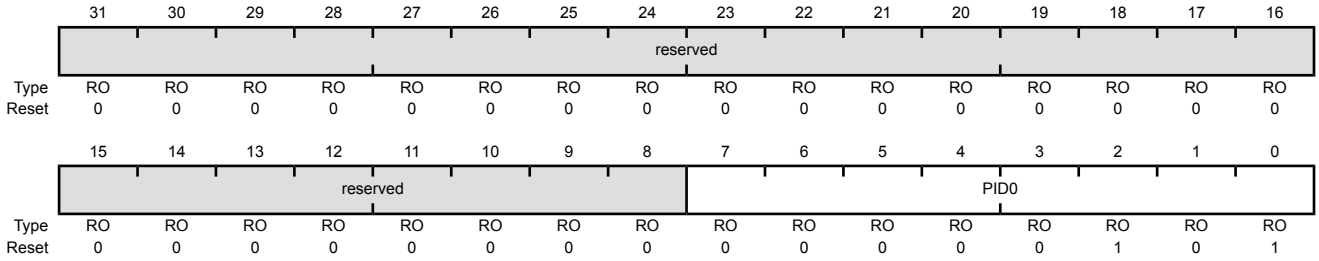

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID7 | RO | 0x00 | WDT Peripheral ID Register[31:24] |

## Register 13: Watchdog Peripheral Identification 0 (WDTPeriphID0), offset 0xFE0

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 0 (WDTPeriphID0)

Base 0x4000.0000
Offset 0xFE0
Type RO, reset 0x0000.0005



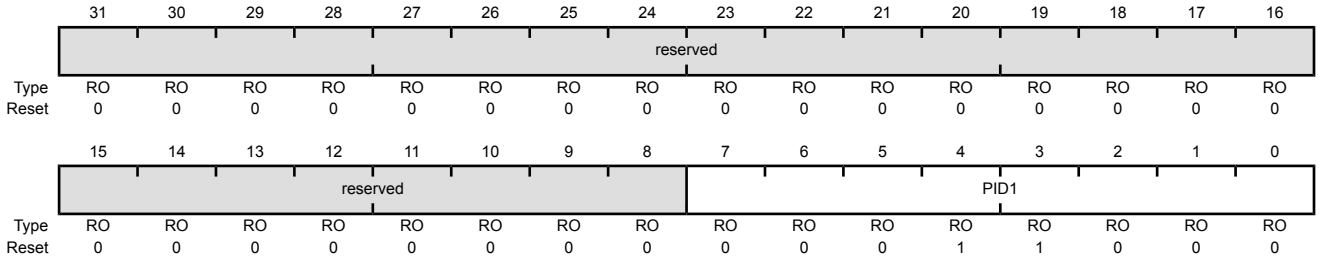

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID0 | RO | 0x05 | Watchdog Peripheral ID Register[7:0] |

## Register 14: Watchdog Peripheral Identification 1 (WDTPeriphID1), offset 0xFE4

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 1 (WDTPeriphID1)

Base 0x4000.0000
Offset 0xFE4
Type RO, reset 0x0000.0018



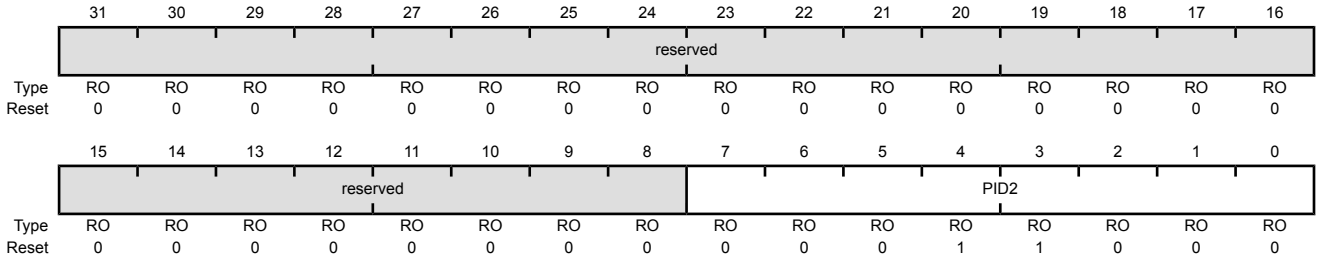

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID1 | RO | 0x18 | Watchdog Peripheral ID Register[15:8] |

## Register 15: Watchdog Peripheral Identification 2 (WDTPeriphID2), offset 0xFE8

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 2 (WDTPeriphID2)

Base 0x4000.0000
Offset 0xFE8
Type RO, reset 0x0000.0018



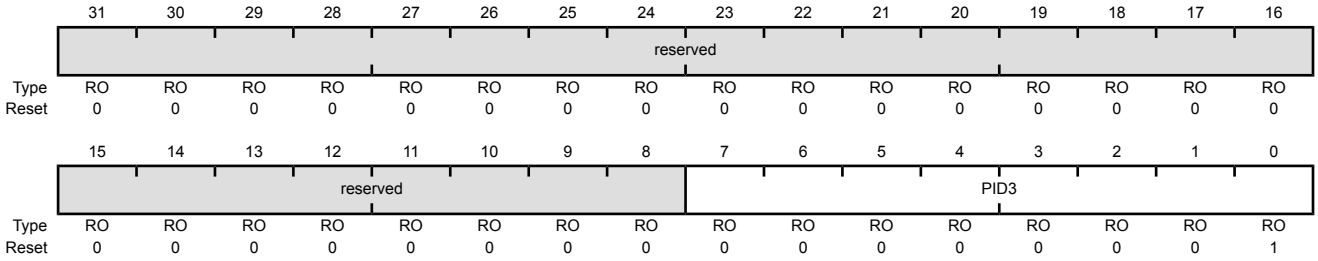

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID2 | RO | 0x18 | Watchdog Peripheral ID Register[23:16] |

## Register 16: Watchdog Peripheral Identification 3 (WDTPeriphID3), offset 0xFEC

The **WDTPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog Peripheral Identification 3 (WDTPeriphID3)

Base 0x4000.0000
Offset 0xFEC
Type RO, reset 0x0000.0001



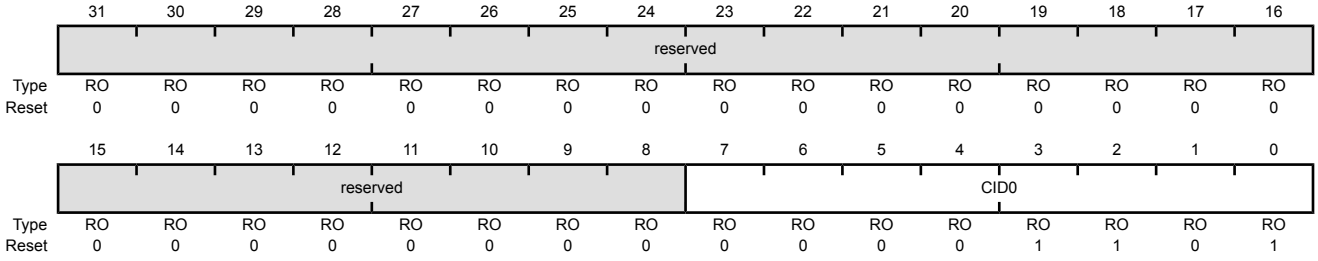

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID3 | RO | 0x01 | Watchdog Peripheral ID Register[31:24] |

## Register 17: Watchdog PrimeCell Identification 0 (WDTPCellID0), offset 0xFF0

The **WDTPCellIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog PrimeCell Identification 0 (WDTPCellID0)

Base 0x4000.0000
Offset 0xFF0
Type RO, reset 0x0000.000D



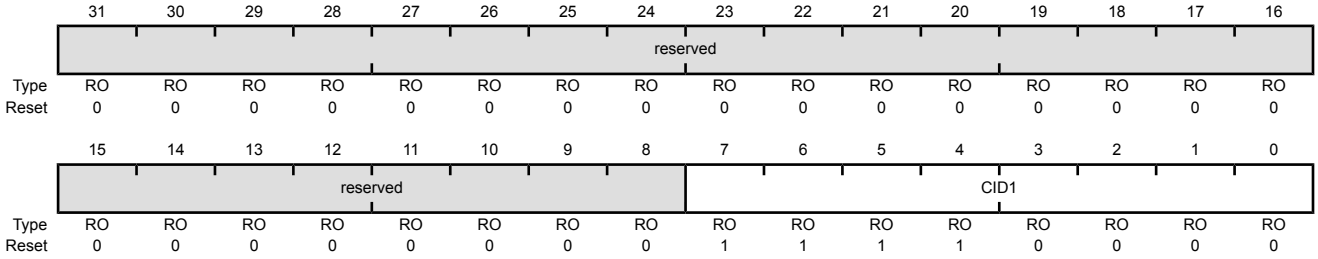

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID0 | RO | 0x0D | Watchdog PrimeCell ID Register[7:0] |

## Register 18: Watchdog PrimeCell Identification 1 (WDTPCellID1), offset 0xFF4

The **WDTPCellIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog PrimeCell Identification 1 (WDTPCellID1)

Base 0x4000.0000
Offset 0xFF4
Type RO, reset 0x0000.00F0



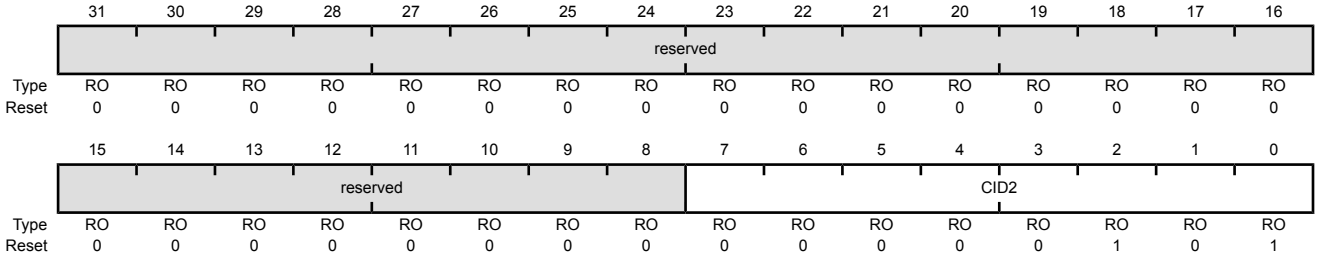

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID1 | RO | 0xF0 | Watchdog PrimeCell ID Register[15:8] |

## Register 19: Watchdog PrimeCell Identification 2 (WDTPCellID2), offset 0xFF8

The **WDTPCellIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog PrimeCell Identification 2 (WDTPCellID2)

Base 0x4000.0000
Offset 0xFF8
Type RO, reset 0x0000.0005



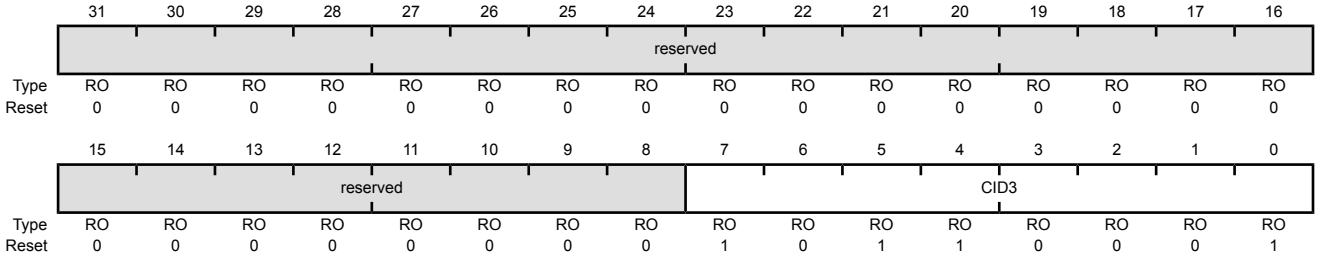

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID2 | RO | 0x05 | Watchdog PrimeCell ID Register[23:16] |

## Register 20: Watchdog PrimeCell Identification 3 (WDTPCellID3 ), offset 0xFFC

The **WDTPCellIDn** registers are hard-coded and the fields within the register determine the reset value.

Watchdog PrimeCell Identification 3 (WDTPCellID3)

Base 0x4000.0000
Offset 0xFFC
Type RO, reset 0x0000.00B1




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID3 | RO | 0xB1 | Watchdog PrimeCell ID Register[31:24] |

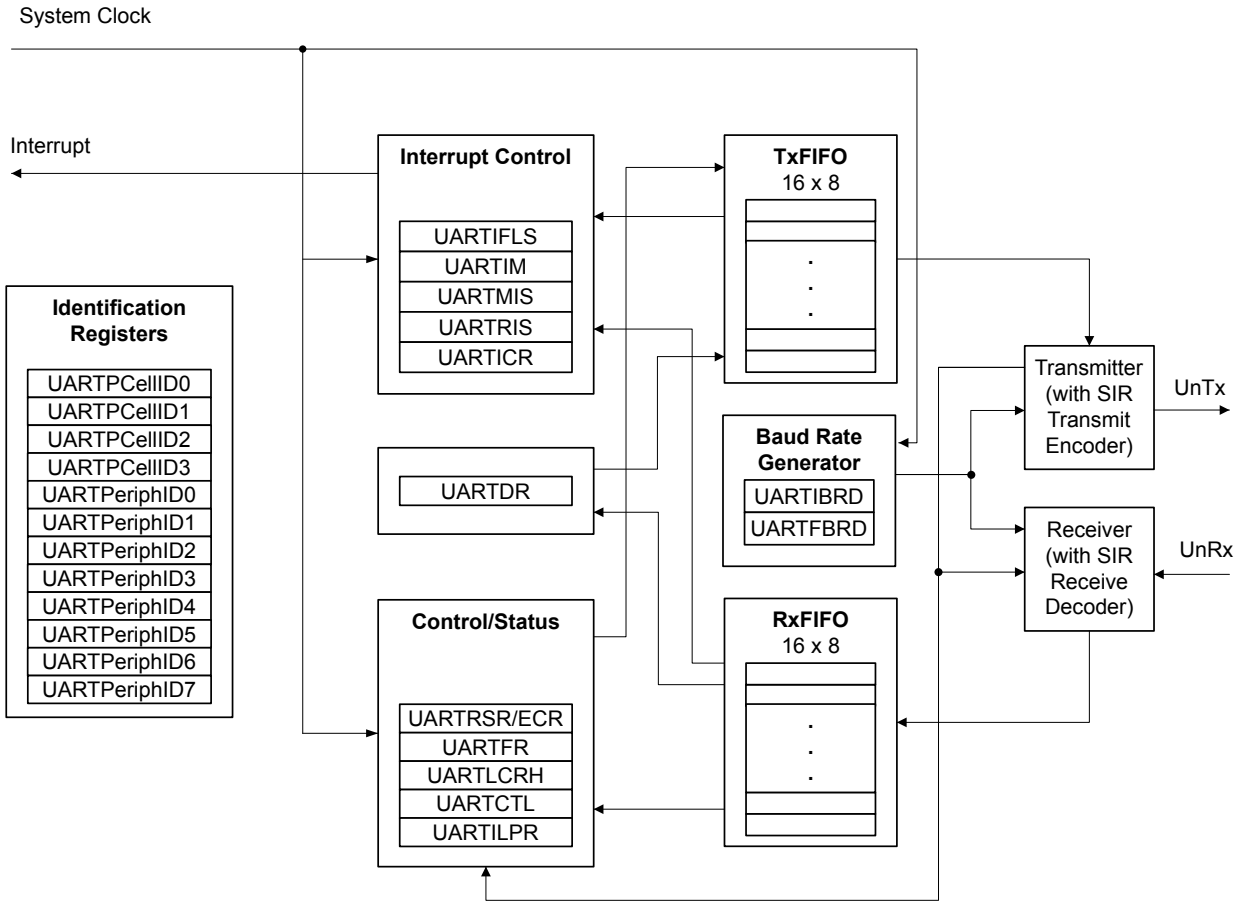
# 11 Universal Asynchronous Receivers/Transmitters (UARTs)

Each Stellaris® Universal Asynchronous Receiver/Transmitter (UART) has the following features:

- Three fully programmable 16C550-type UARTs with IrDA support
- Separate 16x8 transmit (TX) and receive (RX) FIFOs to reduce CPU interrupt service loading
- Programmable baud-rate generator allowing speeds up to 3.125 Mbps
- Programmable FIFO length, including 1-byte deep operation providing conventional double-buffered interface
- FIFO trigger levels of 1/8, 1/4, 1/2, 3/4, and 7/8
- Standard asynchronous communication bits for start, stop, and parity
- Line-break generation and detection
- Fully programmable serial interface characteristics
  - 5, 6, 7, or 8 data bits
  - Even, odd, stick, or no-parity bit generation/detection
  - 1 or 2 stop bit generation
- IrDA serial-IR (SIR) encoder/decoder providing
  - Programmable use of IrDA Serial Infrared (SIR) or UART input/output
  - Support of IrDA SIR encoder/decoder functions for data rates up to 115.2 Kbps half-duplex
  - Support of normal 3/16 and low-power (1.41-2.23 µs) bit durations
  - Programmable internal clock generator enabling division of reference clock by 1 to 256 for low-power mode bit duration

## 11.1 Block Diagram

**Figure 11-1. UART Module Block Diagram**




## 11.2 Signal Description

Table 11-1 on page 390 and Table 11-2 on page 391 list the external signals of the UART module and describe the function of each. The UART signals are alternate functions for some GPIO signals and default to be GPIO signals at reset, with the exception of the U0Rx and U0Tx pins which default to the UART function. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for these UART signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the UART function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 11-1. UART Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| U0Rx | 26 | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| U0Tx | 27 | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U1Rx | 12 | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |

**Table 11-1. UART Signals (100LQFP) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| U1Tx | 13 | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U2Rx | 19 | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| U2Tx | 18 | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 11-2. UART Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| U0Rx | L3 | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| U0Tx | M3 | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U1Rx | H2 | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |
| U1Tx | H1 | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U2Rx | K1 | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| U2Tx | K2 | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 11.3 Functional Description

Each Stellaris UART performs the functions of parallel-to-serial and serial-to-parallel conversions. It is similar in functionality to a 16C550 UART, but is not register compatible.

The UART is configured for transmit and/or receive via the TXE and RXE bits of the **UART Control (UARTCTL)** register (see page 410). Transmit and receive are both enabled out of reset. Before any control registers are programmed, the UART must be disabled by clearing the UARTEN bit in **UARTCTL**. If the UART is disabled during a TX or RX operation, the current transaction is completed prior to the UART stopping.

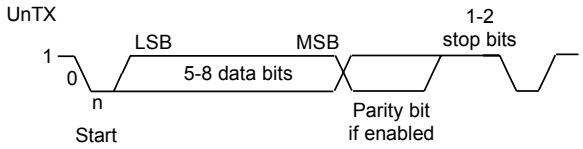
The UART peripheral also includes a serial IR (SIR) encoder/decoder block that can be connected to an infrared transceiver to implement an IrDA SIR physical layer. The SIR function is programmed using the UARTCTL register.

### 11.3.1 Transmit/Receive Logic

The transmit logic performs parallel-to-serial conversion on the data read from the transmit FIFO. The control logic outputs the serial bit stream beginning with a start bit, and followed by the data bits (LSB first), parity bit, and the stop bits according to the programmed configuration in the control registers. See Figure 11-2 on page 392 for details.

The receive logic performs serial-to-parallel conversion on the received bit stream after a valid start pulse has been detected. Overrun, parity, frame error checking, and line-break detection are also performed, and their status accompanies the data that is written to the receive FIFO.

**Figure 11-2. UART Character Frame**




## 11.3.2 Baud-Rate Generation

The baud-rate divisor is a 22-bit number consisting of a 16-bit integer and a 6-bit fractional part. The number formed by these two values is used by the baud-rate generator to determine the bit period. Having a fractional baud-rate divider allows the UART to generate all the standard baud rates.

The 16-bit integer is loaded through the **UART Integer Baud-Rate Divisor (UARTIBRD)** register (see page 406) and the 6-bit fractional part is loaded with the **UART Fractional Baud-Rate Divisor (UARTFBRD)** register (see page 407). The baud-rate divisor (BRD) has the following relationship to the system clock (where *BRDI* is the integer part of the BRD and *BRDF* is the fractional part, separated by a decimal place.)

```
BRD = BRDI + BRDF = UARTSysClk / (16 * Baud Rate)
```

where UARTSysClk is the system clock connected to the UART.

The 6-bit fractional number (that is to be loaded into the DIVFRAC bit field in the **UARTFBRD** register) can be calculated by taking the fractional part of the baud-rate divisor, multiplying it by 64, and adding 0.5 to account for rounding errors:

```
UARTFBRD[DIVFRAC] = integer(BRDF * 64 + 0.5)
```

The UART generates an internal baud-rate reference clock at 16x the baud-rate (referred to as Baud16). This reference clock is divided by 16 to generate the transmit clock, and is used for error detection during receive operations.

Along with the **UART Line Control, High Byte (UARTLCRH)** register (see page 408), the **UARTIBRD** and **UARTFBRD** registers form an internal 30-bit register. This internal register is only updated when a write operation to **UARTLCRH** is performed, so any changes to the baud-rate divisor must be followed by a write to the **UARTLCRH** register for the changes to take effect.

To update the baud-rate registers, there are four possible sequences:

- **UARTIBRD** write, **UARTFBRD** write, and **UARTLCRH** write
- **UARTFBRD** write, **UARTIBRD** write, and **UARTLCRH** write
- **UARTIBRD** write and **UARTLCRH** write
- **UARTFBRD** write and **UARTLCRH** write

## 11.3.3 Data Transmission

Data received or transmitted is stored in two 16-byte FIFOs, though the receive FIFO has an extra four bits per character for status information. For transmission, data is written into the transmit FIFO. If the UART is enabled, it causes a data frame to start transmitting with the parameters indicated in the **UARTLCRH** register. Data continues to be transmitted until there is no data left in the transmit FIFO. The BUSY bit in the **UART Flag (UARTFR)** register (see page 403) is asserted as soon as

data is written to the transmit FIFO (that is, if the FIFO is non-empty) and remains asserted while data is being transmitted. The BUSY bit is negated only when the transmit FIFO is empty, and the last character has been transmitted from the shift register, including the stop bits. The UART can indicate that it is busy even though the UART may no longer be enabled.

When the receiver is idle (the UnRx is continuously 1) and the data input goes Low (a start bit has been received), the receive counter begins running and data is sampled on the eighth cycle of Baud16 (described in "Transmit/Receive Logic" on page 391).

The start bit is valid and recognized if UnRx is still low on the eighth cycle of Baud16, otherwise it is ignored. After a valid start bit is detected, successive data bits are sampled on every 16th cycle of Baud16 (that is, one bit period later) according to the programmed length of the data characters. The parity bit is then checked if parity mode was enabled. Data length and parity are defined in the **UARTLCRH** register.

Lastly, a valid stop bit is confirmed if UnRx is High, otherwise a framing error has occurred. When a full word is received, the data is stored in the receive FIFO, with any error bits associated with that word.

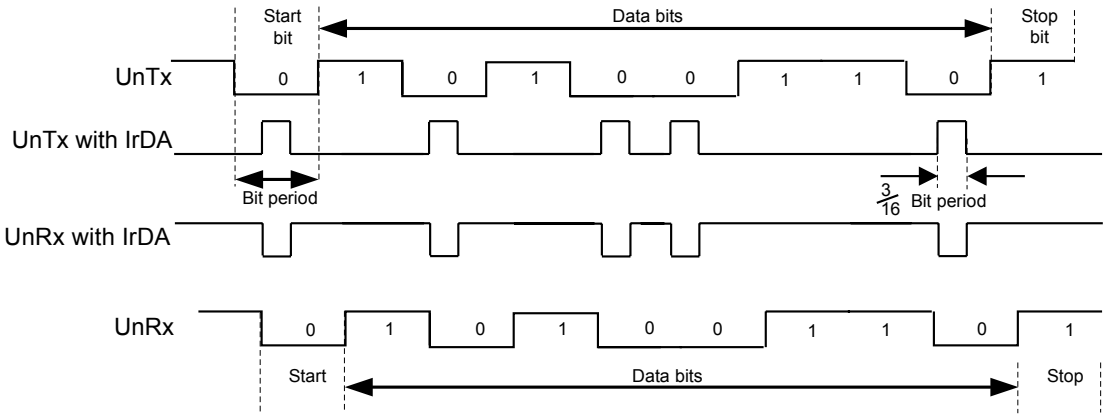
### 11.3.4 Serial IR (SIR)

The UART peripheral includes an IrDA serial-IR (SIR) encoder/decoder block. The IrDA SIR block provides functionality that converts between an asynchronous UART data stream, and half-duplex serial SIR interface. No analog processing is performed on-chip. The role of the SIR block is to provide a digital encoded output and decoded input to the UART. The UART signal pins can be connected to an infrared transceiver to implement an IrDA SIR physical layer link. The SIR block has two modes of operation:

- In normal IrDA mode, a zero logic level is transmitted as high pulse of 3/16th duration of the selected baud rate bit period on the output pin, while logic one levels are transmitted as a static LOW signal. These levels control the driver of an infrared transmitter, sending a pulse of light for each zero. On the reception side, the incoming light pulses energize the photo transistor base of the receiver, pulling its output LOW. This drives the UART input pin LOW.
- In low-power IrDA mode, the width of the transmitted infrared pulse is set to three times the period of the internally generated IrLPBaud16 signal (1.63 µs, assuming a nominal 1.8432 MHz frequency) by changing the appropriate bit in the **UARTCR** register. See page 405 for more information on IrDA low-power pulse-duration configuration.

Figure 11-3 on page 394 shows the UART transmit and receive signals, with and without IrDA modulation.

**Figure 11-3. IrDA Data Modulation**




In both normal and low-power IrDA modes:

- During transmission, the UART data bit is used as the base for encoding
- During reception, the decoded bits are transferred to the UART receive logic

The IrDA SIR physical layer specifies a half-duplex communication link, with a minimum 10 ms delay between transmission and reception. This delay must be generated by software because it is not automatically supported by the UART. The delay is required because the infrared receiver electronics might become biased, or even saturated from the optical power coupled from the adjacent transmitter LED. This delay is known as latency, or receiver setup time.

If the application does not require the use of the UnRx signal, the GPIO pin that has the UnRx signal as an alternate function must be configured as the UnRx signal and pulled High.

### 11.3.5 FIFO Operation

The UART has two 16-entry FIFOs; one for transmit and one for receive. Both FIFOs are accessed via the **UART Data (UARTDR)** register (see page 399). Read operations of the **UARTDR** register return a 12-bit value consisting of 8 data bits and 4 error flags while write operations place 8-bit data in the transmit FIFO.

Out of reset, both FIFOs are disabled and act as 1-byte-deep holding registers. The FIFOs are enabled by setting the FEN bit in **UARTLCRH** (page 408).

FIFO status can be monitored via the **UART Flag (UARTFR)** register (see page 403) and the **UART Receive Status (UARTRSR)** register. Hardware monitors empty, full and overrun conditions. The **UARTFR** register contains empty and full flags (TXFE, TXFF, RXFE, and RXFF bits) and the **UARTRSR** register shows overrun status via the OE bit.

The trigger points at which the FIFOs generate interrupts is controlled via the **UART Interrupt FIFO Level Select (UARTIFLS)** register (see page 412). Both FIFOs can be individually configured to trigger interrupts at different levels. Available configurations include 1/8, ¼, ½, ¾, and 7/8. For example, if the ¼ option is selected for the receive FIFO, the UART generates a receive interrupt after 4 data bytes are received. Out of reset, both FIFOs are configured to trigger an interrupt at the ½ mark.

### 11.3.6 Interrupts

The UART can generate interrupts when the following conditions are observed:

- Overrun Error
- Break Error
- Parity Error
- Framing Error
- Receive Timeout
- Transmit (when condition defined in the TXIFLSEL bit in the **UARTIFLS** register is met)
- Receive (when condition defined in the RXIFLSEL bit in the **UARTIFLS** register is met)

All of the interrupt events are ORed together before being sent to the interrupt controller, so the UART can only generate a single interrupt request to the controller at any given time. Software can service multiple interrupt events in a single interrupt service routine by reading the **UART Masked Interrupt Status (UARTMIS)** register (see page 417).

The interrupt events that can trigger a controller-level interrupt are defined in the **UART Interrupt Mask (UARTIM** ) register (see page 414) by setting the corresponding IM bit to 1. If interrupts are not used, the raw interrupt status is always visible via the **UART Raw Interrupt Status (UARTRIS)** register (see page 416).

Interrupts are always cleared (for both the **UARTMIS** and **UARTRIS** registers) by setting the corresponding bit in the **UART Interrupt Clear (UARTICR)** register (see page 418).

The receive interrupt changes state when one of the following events occurs:

- If the FIFOs are enabled and the receive FIFO reaches the programmed trigger level, the RXRIS bit is set. The receive interrupt is cleared by reading data from the receive FIFO until it becomes less than the trigger level, or by clearing the interrupt by writing a 1 to the RXIC bit.
- If the FIFOs are disabled (have a depth of one location) and data is received thereby filling the location, the RXRIS bit is set. The receive interrupt is cleared by performing a single read of the receive FIFO, or by clearing the interrupt by writing a 1 to the RXIC bit.

The transmit interrupt changes state when one of the following events occurs:

- If the FIFOs are enabled and the transmit FIFO reaches the programmed trigger level, the TXRIS bit is set. The transmit interrupt is cleared by writing data to the transmit FIFO until it becomes greater than the trigger level, or by clearing the interrupt by writing a 1 to the TXIC bit.
- If the FIFOs are disabled (have a depth of one location) and there is no data present in the transmitters single location, the TXRIS bit is set. It is cleared by performing a single write to the transmit FIFO, or by clearing the interrupt by writing a 1 to the TXIC bit.

### 11.3.7 Loopback Operation

The UART can be placed into an internal loopback mode for diagnostic or debug work. This is accomplished by setting the LBE bit in the **UARTCTL** register (see page 410). In loopback mode, data transmitted on UnTx is received on the UnRx input.

### 11.3.8 IrDA SIR block

The IrDA SIR block contains an IrDA serial IR (SIR) protocol encoder/decoder. When enabled, the SIR block uses the UnTx and UnRx pins for the SIR protocol, which should be connected to an IR transceiver.

The SIR block can receive and transmit, but it is only half-duplex so it cannot do both at the same time. Transmission must be stopped before data can be received. The IrDA SIR physical layer specifies a minimum 10-ms delay between transmission and reception.

## 11.4 Initialization and Configuration

To use the UARTs, the peripheral clock must be enabled by setting the UART0, UART1, or UART2 bits in the **RCGC1** register.

This section discusses the steps that are required to use a UART module. For this example, the UART clock is assumed to be 20 MHz and the desired UART configuration is:

- 115200 baud rate
- Data length of 8 bits
- One stop bit
- No parity
- FIFOs disabled
- No interrupts

The first thing to consider when programming the UART is the baud-rate divisor (BRD), since the **UARTIBRD** and **UARTFBRD** registers must be written before the **UARTLCRH** register. Using the equation described in “Baud-Rate Generation” on page 392, the BRD can be calculated:

```
BRD = 20,000,000 / (16 * 115,200) = 10.8507
```

which means that the DIVINT field of the **UARTIBRD** register (see page 406) should be set to 10. The value to be loaded into the **UARTFBRD** register (see page 407) is calculated by the equation:

```
UARTFBRD[DIVFRAC] = integer(0.8507 * 64 + 0.5) = 54
```

With the BRD values in hand, the UART configuration is written to the module in the following order:

1. Disable the UART by clearing the UARTEN bit in the **UARTCTL** register.
2. Write the integer portion of the BRD to the **UARTIBRD** register.
3. Write the fractional portion of the BRD to the **UARTFBRD** register.
4. Write the desired serial parameters to the **UARTLCRH** register (in this case, a value of 0x0000.0060).
5. Enable the UART by setting the UARTEN bit in the **UARTCTL** register.

## 11.5 Register Map

Table 11-3 on page 397 lists the UART registers. The offset listed is a hexadecimal increment to the register's address, relative to that UART's base address:

- UART0: 0x4000.C000
- UART1: 0x4000.D000
- UART2: 0x4000.E000

Note that the UART module clock must be enabled before the registers can be programmed (see page 214). There must be a delay of 3 system clocks after the UART module clock is enabled before any UART module registers are accessed.

**Note:** The UART must be disabled (see the UARTEN bit in the **UARTCTL** register on page 410) before any of the control registers are reprogrammed. When the UART is disabled during a TX or RX operation, the current transaction is completed prior to the UART stopping.

**Table 11-3. UART Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | UARTDR | R/W | 0x0000.0000 | UART Data | 399 |
| 0x004 | UARTRSR/UARTECR | R/W | 0x0000.0000 | UART Receive Status/Error Clear | 401 |
| 0x018 | UARTFR | RO | 0x0000.0090 | UART Flag | 403 |
| 0x020 | UARTILPR | R/W | 0x0000.0000 | UART IrDA Low-Power Register | 405 |
| 0x024 | UARTIBRD | R/W | 0x0000.0000 | UART Integer Baud-Rate Divisor | 406 |
| 0x028 | UARTFBRD | R/W | 0x0000.0000 | UART Fractional Baud-Rate Divisor | 407 |
| 0x02C | UARTLCRH | R/W | 0x0000.0000 | UART Line Control | 408 |
| 0x030 | UARTCTL | R/W | 0x0000.0300 | UART Control | 410 |
| 0x034 | UARTIFLS | R/W | 0x0000.0012 | UART Interrupt FIFO Level Select | 412 |
| 0x038 | UARTIM | R/W | 0x0000.0000 | UART Interrupt Mask | 414 |
| 0x03C | UARTRIS | RO | 0x0000.000F | UART Raw Interrupt Status | 416 |
| 0x040 | UARTMIS | RO | 0x0000.0000 | UART Masked Interrupt Status | 417 |
| 0x044 | UARTICR | W1C | 0x0000.0000 | UART Interrupt Clear | 418 |
| 0xFD0 | UARTPeriphID4 | RO | 0x0000.0000 | UART Peripheral Identification 4 | 420 |
| 0xFD4 | UARTPeriphID5 | RO | 0x0000.0000 | UART Peripheral Identification 5 | 421 |
| 0xFD8 | UARTPeriphID6 | RO | 0x0000.0000 | UART Peripheral Identification 6 | 422 |
| 0xFDC | UARTPeriphID7 | RO | 0x0000.0000 | UART Peripheral Identification 7 | 423 |
| 0xFE0 | UARTPeriphID0 | RO | 0x0000.0011 | UART Peripheral Identification 0 | 424 |
| 0xFE4 | UARTPeriphID1 | RO | 0x0000.0000 | UART Peripheral Identification 1 | 425 |
| 0xFE8 | UARTPeriphID2 | RO | 0x0000.0018 | UART Peripheral Identification 2 | 426 |
| 0xFEC | UARTPeriphID3 | RO | 0x0000.0001 | UART Peripheral Identification 3 | 427 |

**Table 11-3. UART Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0xFF0 | UARTPCellID0 | RO | 0x0000.000D | UART PrimeCell Identification 0 | 428 |
| 0xFF4 | UARTPCellID1 | RO | 0x0000.00F0 | UART PrimeCell Identification 1 | 429 |
| 0xFF8 | UARTPCellID2 | RO | 0x0000.0005 | UART PrimeCell Identification 2 | 430 |
| 0xFFC | UARTPCellID3 | RO | 0x0000.00B1 | UART PrimeCell Identification 3 | 431 |

## 11.6 Register Descriptions

The remainder of this section lists and describes the UART registers, in numerical order by address offset.

## Register 1: UART Data (UARTDR), offset 0x000

**Important:** This register is read-sensitive. See the register description for details.

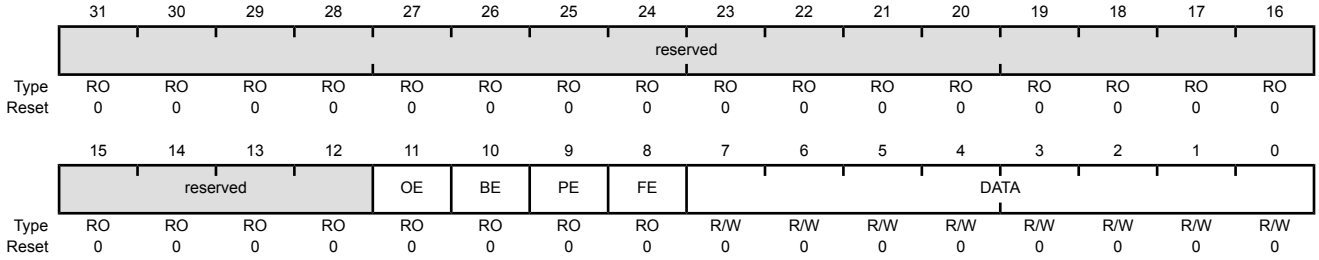
This register is the data register (the interface to the FIFOs).

When FIFOs are enabled, data written to this location is pushed onto the transmit FIFO. If FIFOs are disabled, data is stored in the transmitter holding register (the bottom word of the transmit FIFO). A write to this register initiates a transmission from the UART.

For received data, if the FIFO is enabled, the data byte and the 4-bit status (break, frame, parity, and overrun) is pushed onto the 12-bit wide receive FIFO. If FIFOs are disabled, the data byte and status are stored in the receiving holding register (the bottom word of the receive FIFO). The received data can be retrieved by reading this register.

UART Data (UARTDR)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x000
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11 | OE | RO | 0 | UART Overrun Error<br>The OE values are defined as follows:<br><br>Value Description<br>0 There has been no data loss due to a FIFO overrun.<br>1 New data was received when the FIFO was full, resulting in data loss. |
| 10 | BE | RO | 0 | UART Break Error<br>This bit is set to 1 when a break condition is detected, indicating that the receive data input was held Low for longer than a full-word transmission time (defined as start, data, parity, and stop bits).<br>In FIFO mode, this error is associated with the character at the top of the FIFO. When a break occurs, only one 0 character is loaded into the FIFO. The next character is only enabled after the received data input goes to a 1 (marking state) and the next valid start bit is received. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 9 | PE | RO | 0 | UART Parity Error<br>This bit is set to 1 when the parity of the received data character does not match the parity defined by bits 2 and 7 of the **UARTLCRH** register.<br>In FIFO mode, this error is associated with the character at the top of the FIFO. |
| 8 | FE | RO | 0 | UART Framing Error<br>This bit is set to 1 when the received character does not have a valid stop bit (a valid stop bit is 1). |
| 7:0 | DATA | R/W | 0 | Data Transmitted or Received<br>When written, the data that is to be transmitted via the UART. When read, the data that was received by the UART. |

## Register 2: UART Receive Status/Error Clear (UARTRSR/UARTECR), offset 0x004

The **UARTRSR/UARTECR** register is the receive status register/error clear register.

In addition to the **UARTDR** register, receive status can also be read from the **UARTRSR** register. If the status is read from this register, then the status information corresponds to the entry read from **UARTDR** prior to reading **UARTRSR**. The status information for overrun is set immediately when an overrun condition occurs.

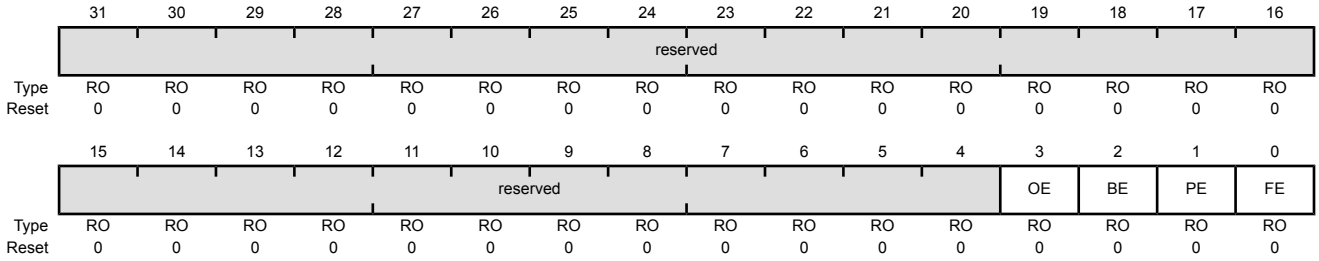
The **UARTRSR** register cannot be written.

A write of any value to the **UARTECR** register clears the framing, parity, break, and overrun errors. All the bits are cleared to 0 on reset.

### Reads

UART Receive Status/Error Clear (UARTRSR/UARTECR)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x004
Type RO, reset 0x0000.0000



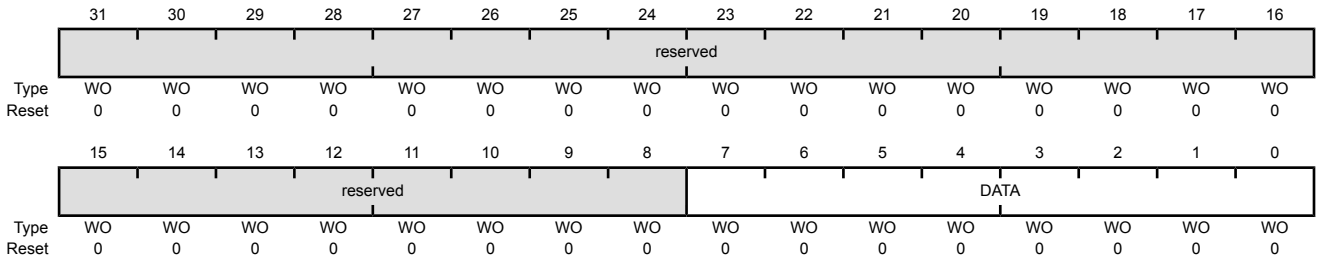

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | OE | RO | 0 | UART Overrun Error<br>When this bit is set to 1, data is received and the FIFO is already full. This bit is cleared to 0 by a write to **UARTECR**.<br>The FIFO contents remain valid since no further data is written when the FIFO is full, only the contents of the shift register are overwritten. The CPU must now read the data in order to empty the FIFO. |
| 2 | BE | RO | 0 | UART Break Error<br>This bit is set to 1 when a break condition is detected, indicating that the received data input was held Low for longer than a full-word transmission time (defined as start, data, parity, and stop bits).<br>This bit is cleared to 0 by a write to **UARTECR**.<br>In FIFO mode, this error is associated with the character at the top of the FIFO. When a break occurs, only one 0 character is loaded into the FIFO. The next character is only enabled after the receive data input goes to a 1 (marking state) and the next valid start bit is received. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | PE | RO | 0 | UART Parity Error<br>This bit is set to 1 when the parity of the received data character does not match the parity defined by bits 2 and 7 of the **UARTLCRH** register.<br>This bit is cleared to 0 by a write to **UARTECR**. |
| 0 | FE | RO | 0 | UART Framing Error<br>This bit is set to 1 when the received character does not have a valid stop bit (a valid stop bit is 1).<br>This bit is cleared to 0 by a write to **UARTECR**.<br>In FIFO mode, this error is associated with the character at the top of the FIFO. |

## Writes

UART Receive Status/Error Clear (UARTRSR/UARTECR)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x004
Type WO, reset 0x0000.0000

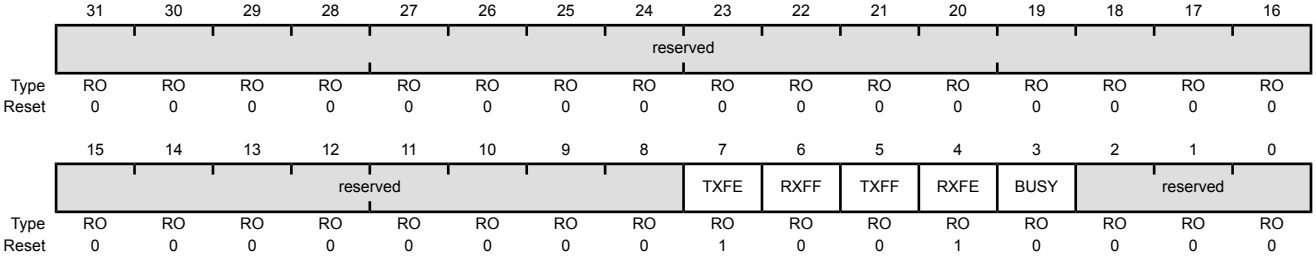



| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | WO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DATA | WO | 0 | Error Clear<br>A write to this register of any data clears the framing, parity, break, and overrun flags. |

## Register 3: UART Flag (UARTFR), offset 0x018

The **UARTFR** register is the flag register. After reset, the TXFF, RXFF, and BUSY bits are 0, and TXFE and RXFE bits are 1.

UART Flag (UARTFR)
UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x018
Type RO, reset 0x0000.0090




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | TXFE | RO | 1 | UART Transmit FIFO Empty<br>The meaning of this bit depends on the state of the FEN bit in the **UARTLCRH** register.<br>If the FIFO is disabled (FEN is 0), this bit is set when the transmit holding register is empty.<br>If the FIFO is enabled (FEN is 1), this bit is set when the transmit FIFO is empty. |
| 6 | RXFF | RO | 0 | UART Receive FIFO Full<br>The meaning of this bit depends on the state of the FEN bit in the **UARTLCRH** register.<br>If the FIFO is disabled, this bit is set when the receive holding register is full.<br>If the FIFO is enabled, this bit is set when the receive FIFO is full. |
| 5 | TXFF | RO | 0 | UART Transmit FIFO Full<br>The meaning of this bit depends on the state of the FEN bit in the **UARTLCRH** register.<br>If the FIFO is disabled, this bit is set when the transmit holding register is full.<br>If the FIFO is enabled, this bit is set when the transmit FIFO is full. |
| 4 | RXFE | RO | 1 | UART Receive FIFO Empty<br>The meaning of this bit depends on the state of the FEN bit in the **UARTLCRH** register.<br>If the FIFO is disabled, this bit is set when the receive holding register is empty.<br>If the FIFO is enabled, this bit is set when the receive FIFO is empty. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | BUSY | RO | 0 | UART Busy<br>When this bit is 1, the UART is busy transmitting data. This bit remains set until the complete byte, including all stop bits, has been sent from the shift register.<br>This bit is set as soon as the transmit FIFO becomes non-empty (regardless of whether UART is enabled). |
| 2:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 4: UART IrDA Low-Power Register (UARTILPR), offset 0x020

The **UARTILPR** register is an 8-bit read/write register that stores the low-power counter divisor value used to derive the low-power SIR pulse width clock by dividing down the system clock (SysClk). All the bits are cleared to 0 when reset.

The internal `IrLPBaud16` clock is generated by dividing down SysClk according to the low-power divisor value written to **UARTILPR**. The duration of SIR pulses generated when low-power mode is enabled is three times the period of the `IrLPBaud16` clock. The low-power divisor value is calculated as follows:

$$ILPDVSR = SysClk / F_{IrLPBaud16}$$

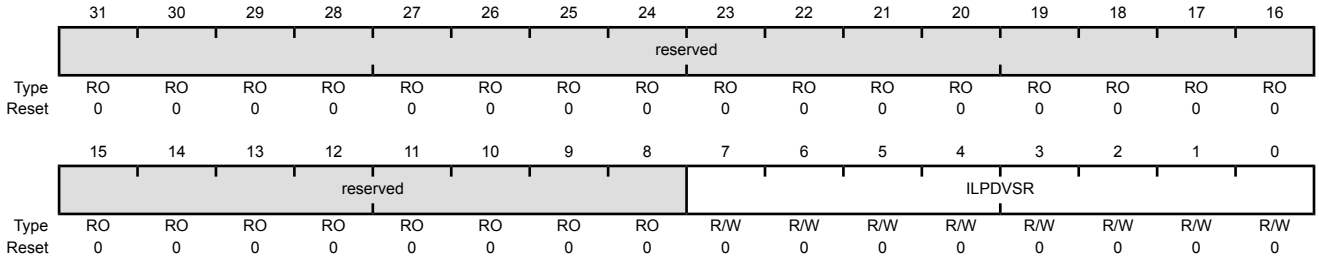
where $F_{IrLPBaud16}$ is nominally 1.8432 MHz.

You must choose the divisor so that 1.42 MHz < $F_{IrLPBaud16}$ < 2.12 MHz, which results in a low-power pulse duration of 1.41–2.11 µs (three times the period of `IrLPBaud16`). The minimum frequency of `IrLPBaud16` ensures that pulses less than one period of `IrLPBaud16` are rejected, but that pulses greater than 1.4 µs are accepted as valid pulses.

**Note:** Zero is an illegal value. Programming a zero value results in no `IrLPBaud16` pulses being generated.

UART IrDA Low-Power Register (UARTILPR)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x020
Type R/W, reset 0x0000.0000



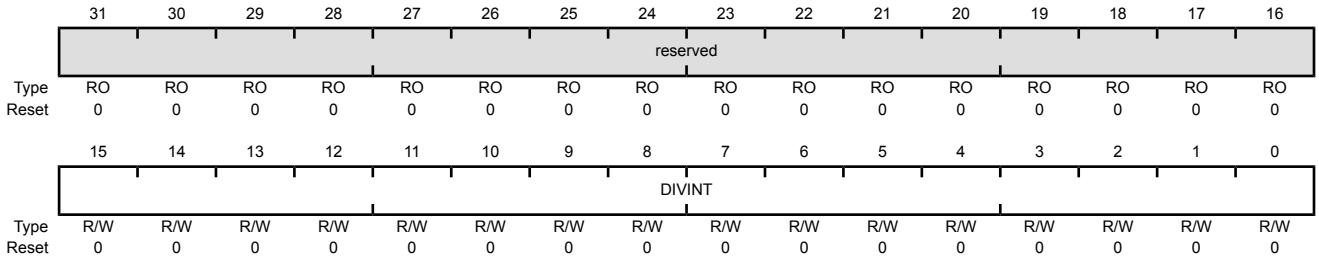

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | ILPDVSR | R/W | 0x00 | IrDA Low-Power Divisor<br>This is an 8-bit low-power divisor value. |

## Register 5: UART Integer Baud-Rate Divisor (UARTIBRD), offset 0x024

The **UARTIBRD** register is the integer part of the baud-rate divisor value. All the bits are cleared on reset. The minimum possible divide ratio is 1 (when **UARTIBRD**=0), in which case the **UARTFBRD** register is ignored. When changing the **UARTIBRD** register, the new value does not take effect until transmission/reception of the current character is complete. Any changes to the baud-rate divisor must be followed by a write to the **UARTLCRH** register. See “Baud-Rate Generation” on page 392 for configuration details.

UART Integer Baud-Rate Divisor (UARTIBRD)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x024
Type R/W, reset 0x0000.0000



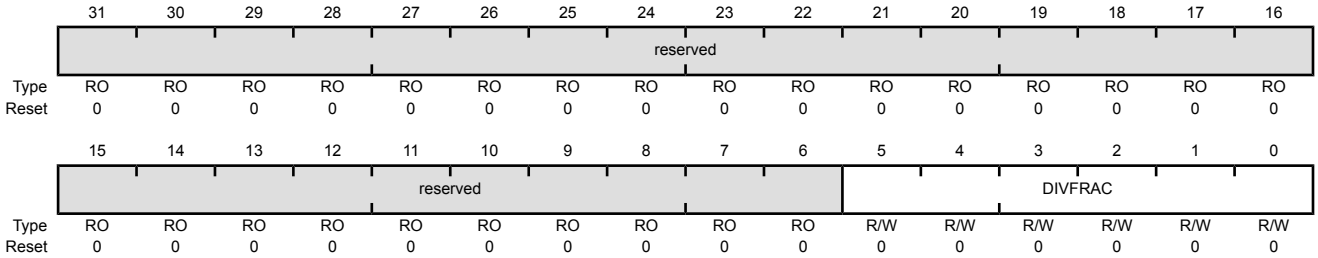

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | DIVINT | R/W | 0x0000 | Integer Baud-Rate Divisor |

## Register 6: UART Fractional Baud-Rate Divisor (UARTFBRD), offset 0x028

The **UARTFBRD** register is the fractional part of the baud-rate divisor value. All the bits are cleared on reset. When changing the **UARTFBRD** register, the new value does not take effect until transmission/reception of the current character is complete. Any changes to the baud-rate divisor must be followed by a write to the **UARTLCRH** register. See “Baud-Rate Generation” on page 392 for configuration details.

UART Fractional Baud-Rate Divisor (UARTFBRD)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x028
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5:0 | DIVFRAC | R/W | 0x000 | Fractional Baud-Rate Divisor |

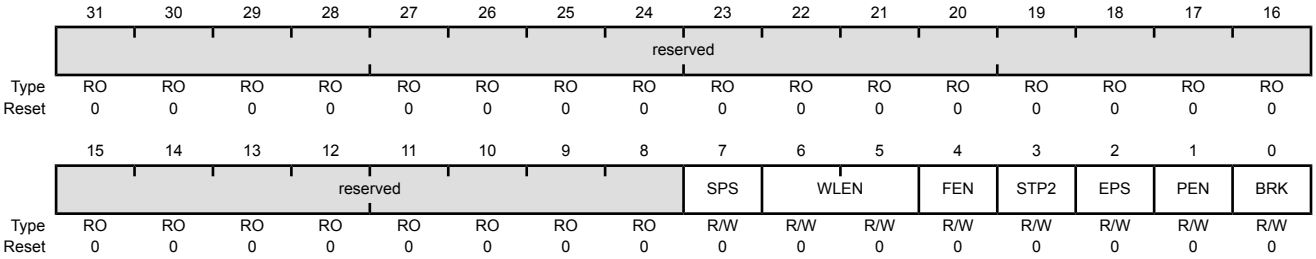
## Register 7: UART Line Control (UARTLCRH), offset 0x02C

The **UARTLCRH** register is the line control register. Serial parameters such as data length, parity, and stop bit selection are implemented in this register.

When updating the baud-rate divisor (**UARTIBRD** and/or **UARTIFRD**), the **UARTLCRH** register must also be written. The write strobe for the baud-rate divisor registers is tied to the **UARTLCRH** register.

UART Line Control (UARTLCRH)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x02C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7 | SPS | R/W | 0 | UART Stick Parity Select<br>When bits 1, 2, and 7 of **UARTLCRH** are set, the parity bit is transmitted and checked as a 0. When bits 1 and 7 are set and 2 is cleared, the parity bit is transmitted and checked as a 1.<br>When this bit is cleared, stick parity is disabled. |
| 6:5 | WLEN | R/W | 0 | UART Word Length<br>The bits indicate the number of data bits transmitted or received in a frame as follows:<br>Value Description<br>0x3 8 bits<br>0x2 7 bits<br>0x1 6 bits<br>0x0 5 bits (default) |
| 4 | FEN | R/W | 0 | UART Enable FIFOs<br>If this bit is set to 1, transmit and receive FIFO buffers are enabled (FIFO mode).<br>When cleared to 0, FIFOs are disabled (Character mode). The FIFOs become 1-byte-deep holding registers. |
| 3 | STP2 | R/W | 0 | UART Two Stop Bits Select<br>If this bit is set to 1, two stop bits are transmitted at the end of a frame. The receive logic does not check for two stop bits being received. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2 | EPS | R/W | 0 | UART Even Parity Select<br>If this bit is set to 1, even parity generation and checking is performed during transmission and reception, which checks for an even number of 1s in data and parity bits.<br>When cleared to 0, then odd parity is performed, which checks for an odd number of 1s.<br>This bit has no effect when parity is disabled by the PEN bit. |
| 1 | PEN | R/W | 0 | UART Parity Enable<br>If this bit is set to 1, parity checking and generation is enabled; otherwise, parity is disabled and no parity bit is added to the data frame. |
| 0 | BRK | R/W | 0 | UART Send Break<br>If this bit is set to 1, a Low level is continually output on the UnTX output, after completing transmission of the current character. For the proper execution of the break command, the software must set this bit for at least two frames (character periods). For normal use, this bit must be cleared to 0. |

## Register 8: UART Control (UARTCTL), offset 0x030

The **UARTCTL** register is the control register. All the bits are cleared on reset except for the Transmit Enable (TXE) and Receive Enable (RXE) bits, which are set to 1.

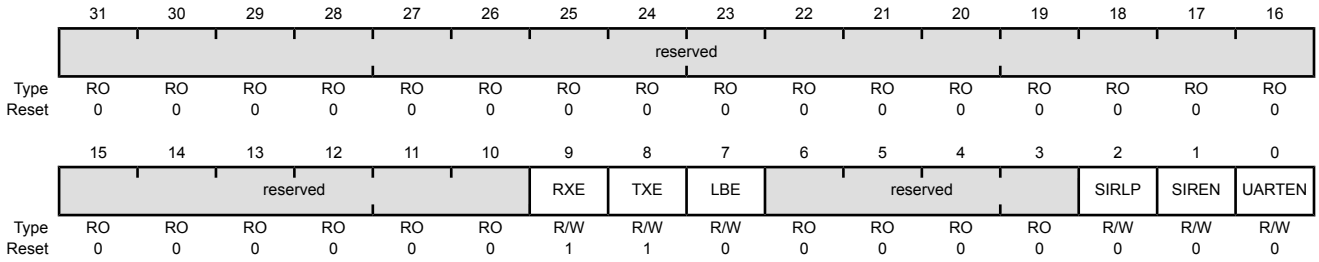
To enable the UART module, the UARTEN bit must be set to 1. If software requires a configuration change in the module, the UARTEN bit must be cleared before the configuration changes are written. If the UART is disabled during a transmit or receive operation, the current transaction is completed prior to the UART stopping.

**Note:** The **UARTCTL** register should not be changed while the UART is enabled or else the results are unpredictable. The following sequence is recommended for making changes to the **UARTCTL** register.

1. Disable the UART.
2. Wait for the end of transmission or reception of the current character.
3. Flush the transmit FIFO by disabling bit 4 (FEN) in the line control register (**UARTLCRH**).
4. Reprogram the control register.
5. Enable the UART.

UART Control (UARTCTL)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x030
Type R/W, reset 0x0000.0300




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:10 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | RXE | R/W | 1 | UART Receive Enable<br>If this bit is set to 1, the receive section of the UART is enabled. When the UART is disabled in the middle of a receive, it completes the current character before stopping.<br>**Note:** To enable reception, the UARTEN bit must also be set. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 8 | TXE | R/W | 1 | UART Transmit Enable<br>If this bit is set to 1, the transmit section of the UART is enabled. When the UART is disabled in the middle of a transmission, it completes the current character before stopping.<br>**Note:** To enable transmission, the UARTEN bit must also be set. |
| 7 | LBE | R/W | 0 | UART Loop Back Enable<br>If this bit is set to 1, the UnTX path is fed through the UnRX path. |
| 6:3 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | SIRLP | R/W | 0 | UART SIR Low Power Mode<br>This bit selects the IrDA encoding mode. If this bit is cleared to 0, low-level bits are transmitted as an active High pulse with a width of 3/16th of the bit period. If this bit is set to 1, low-level bits are transmitted with a pulse width which is 3 times the period of the IrLPBaud16 input signal, regardless of the selected bit rate. Setting this bit uses less power, but might reduce transmission distances. See page 405 for more information. |
| 1 | SIREN | R/W | 0 | UART SIR Enable<br>If this bit is set to 1, the IrDA SIR block is enabled, and the UART will transmit and receive data using SIR protocol. |
| 0 | UARTEN | R/W | 0 | UART Enable<br>If this bit is set to 1, the UART is enabled. When the UART is disabled in the middle of transmission or reception, it completes the current character before stopping. |

## Register 9: UART Interrupt FIFO Level Select (UARTIFLS), offset 0x034

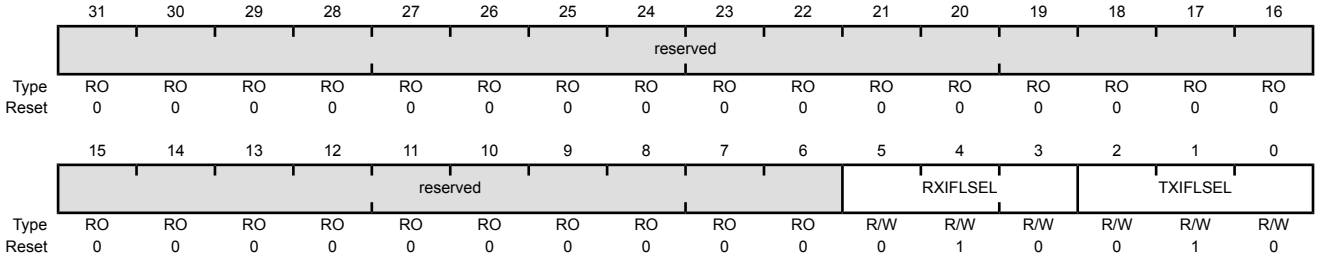
The **UARTIFLS** register is the interrupt FIFO level select register. You can use this register to define the FIFO level at which the TXRIS and RXRIS bits in the **UARTRIS** register are triggered.

The interrupts are generated based on a transition through a level rather than being based on the level. That is, the interrupts are generated when the fill level progresses through the trigger level. For example, if the receive trigger level is set to the half-way mark, the interrupt is triggered as the module is receiving the 9th character.

Out of reset, the TXIFLSEL and RXIFLSEL bits are configured so that the FIFOs trigger an interrupt at the half-way mark.

UART Interrupt FIFO Level Select (UARTIFLS)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x034
Type R/W, reset 0x0000.0012




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5:3 | RXIFLSEL | R/W | 0x2 | UART Receive Interrupt FIFO Level Select<br>The trigger points for the receive interrupt are as follows:<br>Value Description<br>0x0 RX FIFO ≥ ⅛ full<br>0x1 RX FIFO ≥ ¼ full<br>0x2 RX FIFO ≥ ½ full (default)<br>0x3 RX FIFO ≥ ¾ full<br>0x4 RX FIFO ≥ ⅞ full<br>0x5-0x7 Reserved |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 2:0 | TXIFLSEL | R/W | 0x2 | UART Transmit Interrupt FIFO Level Select<br>The trigger points for the transmit interrupt are as follows: |

| Value | Description |
|---|---|
| 0x0 | TX FIFO ≤ ⅞ empty |
| 0x1 | TX FIFO ≤ ¾ empty |
| 0x2 | TX FIFO ≤ ½ empty (default) |
| 0x3 | TX FIFO ≤ ¼ empty |
| 0x4 | TX FIFO ≤ ⅛ empty |
| 0x5-0x7 | Reserved |

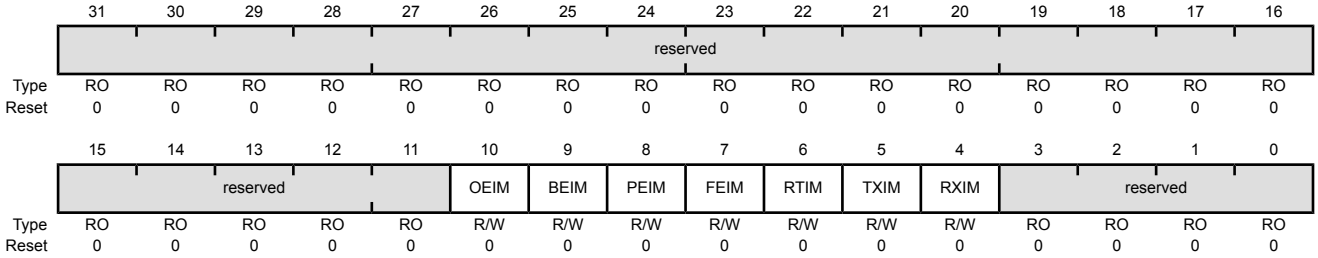
## Register 10: UART Interrupt Mask (UARTIM), offset 0x038

The **UARTIM** register is the interrupt mask set/clear register.

On a read, this register gives the current value of the mask on the relevant interrupt. Writing a 1 to a bit allows the corresponding raw interrupt signal to be routed to the interrupt controller. Writing a 0 prevents the raw interrupt signal from being sent to the interrupt controller.

UART Interrupt Mask (UARTIM)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x038
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | OEIM | R/W | 0 | UART Overrun Error Interrupt Mask<br>On a read, the current mask for the `OEIM` interrupt is returned.<br>Setting this bit to 1 promotes the `OEIM` interrupt to the interrupt controller. |
| 9 | BEIM | R/W | 0 | UART Break Error Interrupt Mask<br>On a read, the current mask for the `BEIM` interrupt is returned.<br>Setting this bit to 1 promotes the `BEIM` interrupt to the interrupt controller. |
| 8 | PEIM | R/W | 0 | UART Parity Error Interrupt Mask<br>On a read, the current mask for the `PEIM` interrupt is returned.<br>Setting this bit to 1 promotes the `PEIM` interrupt to the interrupt controller. |
| 7 | FEIM | R/W | 0 | UART Framing Error Interrupt Mask<br>On a read, the current mask for the `FEIM` interrupt is returned.<br>Setting this bit to 1 promotes the `FEIM` interrupt to the interrupt controller. |
| 6 | RTIM | R/W | 0 | UART Receive Time-Out Interrupt Mask<br>On a read, the current mask for the `RTIM` interrupt is returned.<br>Setting this bit to 1 promotes the `RTIM` interrupt to the interrupt controller. |
| 5 | TXIM | R/W | 0 | UART Transmit Interrupt Mask<br>On a read, the current mask for the `TXIM` interrupt is returned.<br>Setting this bit to 1 promotes the `TXIM` interrupt to the interrupt controller. |

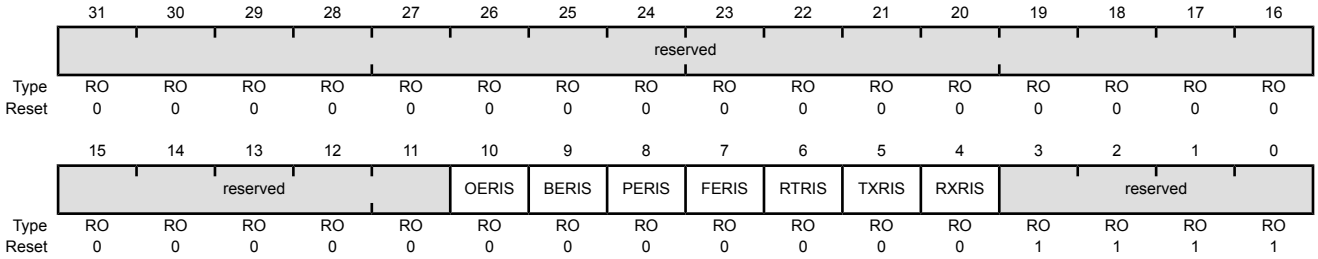
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 4 | RXIM | R/W | 0 | UART Receive Interrupt Mask<br>On a read, the current mask for the RXIM interrupt is returned.<br>Setting this bit to 1 promotes the RXIM interrupt to the interrupt controller. |
| 3:0 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 11: UART Raw Interrupt Status (UARTRIS), offset 0x03C

The **UARTRIS** register is the raw interrupt status register. On a read, this register gives the current raw status value of the corresponding interrupt. A write has no effect.

UART Raw Interrupt Status (UARTRIS)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x03C
Type RO, reset 0x0000.000F



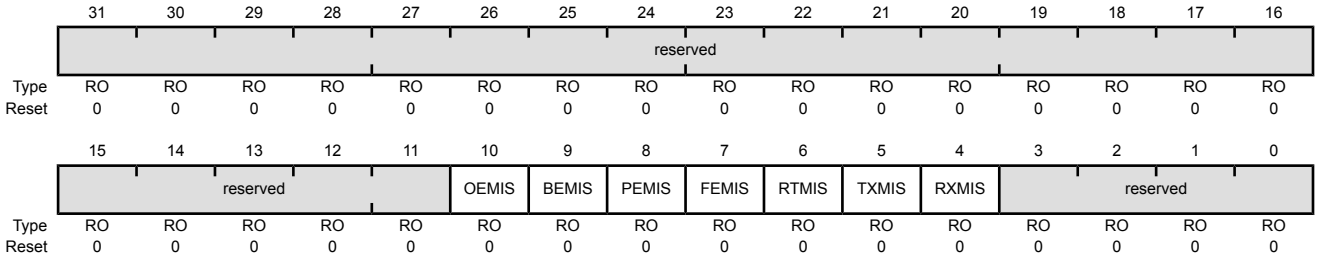

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | OERIS | RO | 0 | UART Overrun Error Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 9 | BERIS | RO | 0 | UART Break Error Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 8 | PERIS | RO | 0 | UART Parity Error Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 7 | FERIS | RO | 0 | UART Framing Error Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 6 | RTRIS | RO | 0 | UART Receive Time-Out Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 5 | TXRIS | RO | 0 | UART Transmit Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 4 | RXRIS | RO | 0 | UART Receive Raw Interrupt Status<br>Gives the raw interrupt state (prior to masking) of this interrupt. |
| 3:0 | reserved | RO | 0xF | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 12: UART Masked Interrupt Status (UARTMIS), offset 0x040

The **UARTMIS** register is the masked interrupt status register. On a read, this register gives the current masked status value of the corresponding interrupt. A write has no effect.

UART Masked Interrupt Status (UARTMIS)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x040
Type RO, reset 0x0000.0000



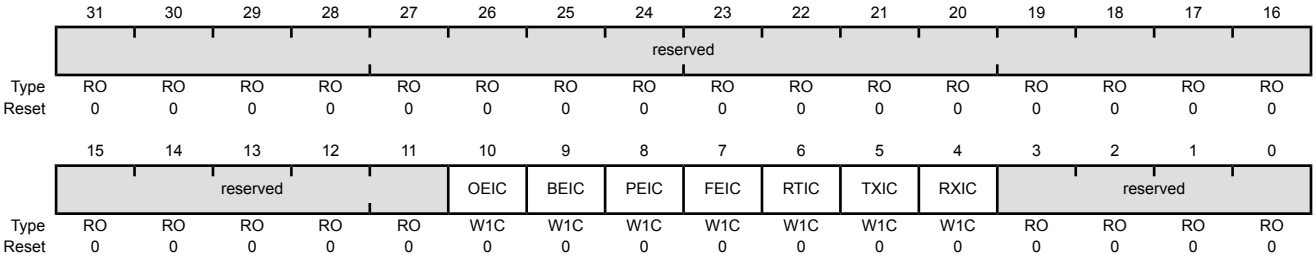

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | OEMIS | RO | 0 | UART Overrun Error Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 9 | BEMIS | RO | 0 | UART Break Error Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 8 | PEMIS | RO | 0 | UART Parity Error Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 7 | FEMIS | RO | 0 | UART Framing Error Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 6 | RTMIS | RO | 0 | UART Receive Time-Out Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 5 | TXMIS | RO | 0 | UART Transmit Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 4 | RXMIS | RO | 0 | UART Receive Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. |
| 3:0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 13: UART Interrupt Clear (UARTICR), offset 0x044

The **UARTICR** register is the interrupt clear register. On a write of 1, the corresponding interrupt (both raw interrupt and masked interrupt, if enabled) is cleared. A write of 0 has no effect.

UART Interrupt Clear (UARTICR)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0x044
Type W1C, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10 | OEIC | W1C | 0 | Overrun Error Interrupt Clear<br>The `OEIC` values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |
| 9 | BEIC | W1C | 0 | Break Error Interrupt Clear<br>The `BEIC` values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |
| 8 | PEIC | W1C | 0 | Parity Error Interrupt Clear<br>The `PEIC` values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |

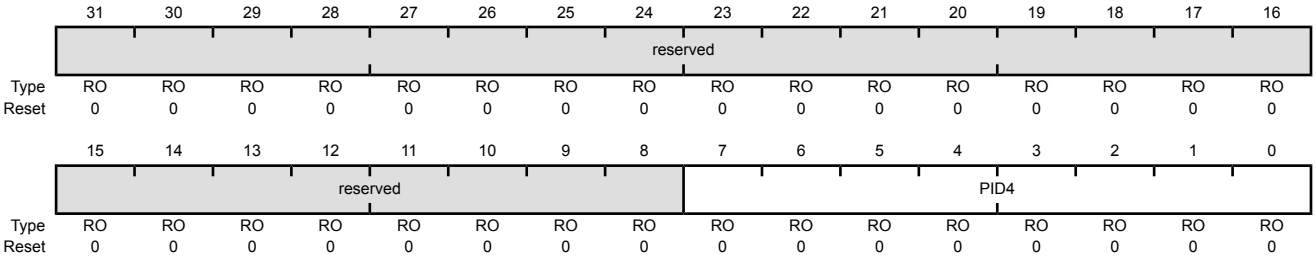
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 7 | FEIC | W1C | 0 | Framing Error Interrupt Clear<br>The FEIC values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |
| 6 | RTIC | W1C | 0 | Receive Time-Out Interrupt Clear<br>The RTIC values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |
| 5 | TXIC | W1C | 0 | Transmit Interrupt Clear<br>The TXIC values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |
| 4 | RXIC | W1C | 0 | Receive Interrupt Clear<br>The RXIC values are defined as follows:<br><br>Value Description<br>0 No effect on the interrupt.<br>1 Clears interrupt. |
| 3:0 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 14: UART Peripheral Identification 4 (UARTPeriphID4), offset 0xFD0

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 4 (UARTPeriphID4)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFD0
Type RO, reset 0x0000.0000



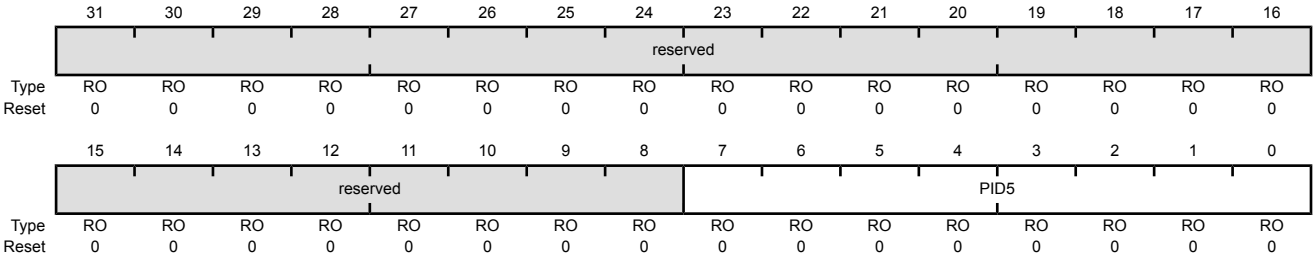

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID4 | RO | 0x0000 | UART Peripheral ID Register[7:0]<br>Can be used by software to identify the presence of this peripheral. |

## Register 15: UART Peripheral Identification 5 (UARTPeriphID5), offset 0xFD4

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 5 (UARTPeriphID5)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFD4
Type RO, reset 0x0000.0000



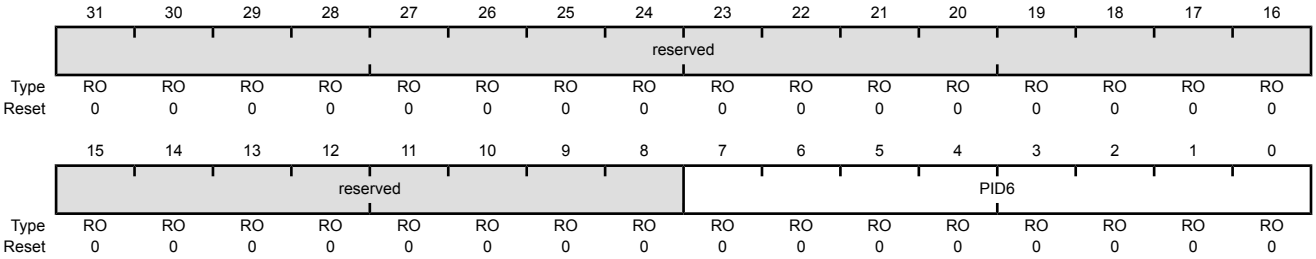

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID5 | RO | 0x0000 | UART Peripheral ID Register[15:8]<br>Can be used by software to identify the presence of this peripheral. |

## Register 16: UART Peripheral Identification 6 (UARTPeriphID6), offset 0xFD8

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 6 (UARTPeriphID6)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFD8
Type RO, reset 0x0000.0000



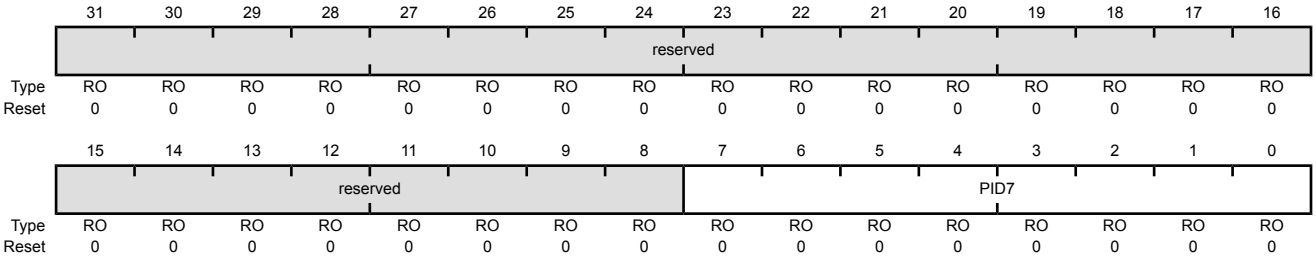

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID6 | RO | 0x0000 | UART Peripheral ID Register[23:16]<br>Can be used by software to identify the presence of this peripheral. |

## Register 17: UART Peripheral Identification 7 (UARTPeriphID7), offset 0xFDC

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 7 (UARTPeriphID7)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFDC
Type RO, reset 0x0000.0000



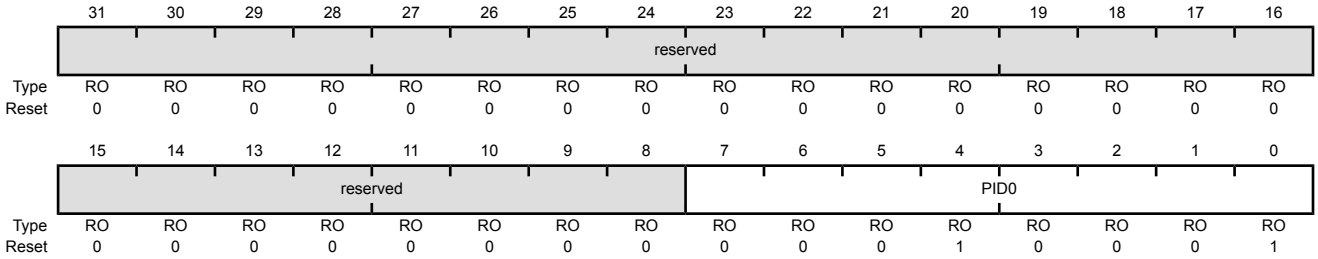

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID7 | RO | 0x0000 | UART Peripheral ID Register[31:24]<br>Can be used by software to identify the presence of this peripheral. |

## Register 18: UART Peripheral Identification 0 (UARTPeriphID0), offset 0xFE0

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 0 (UARTPeriphID0)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFE0
Type RO, reset 0x0000.0011



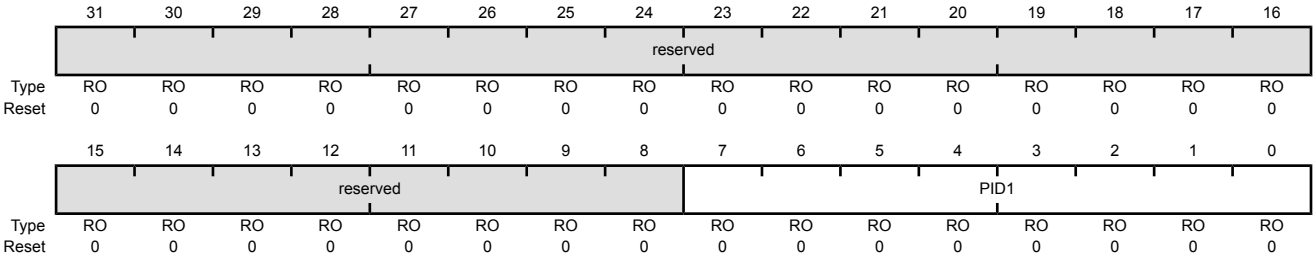

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID0 | RO | 0x11 | UART Peripheral ID Register[7:0]<br>Can be used by software to identify the presence of this peripheral. |

## Register 19: UART Peripheral Identification 1 (UARTPeriphID1), offset 0xFE4

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 1 (UARTPeriphID1)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFE4
Type RO, reset 0x0000.0000



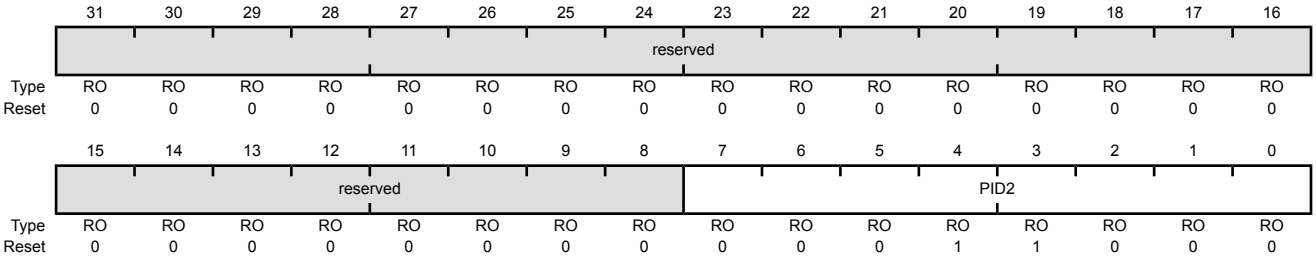

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID1 | RO | 0x00 | UART Peripheral ID Register[15:8]<br>Can be used by software to identify the presence of this peripheral. |

## Register 20: UART Peripheral Identification 2 (UARTPeriphID2), offset 0xFE8

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 2 (UARTPeriphID2)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFE8
Type RO, reset 0x0000.0018



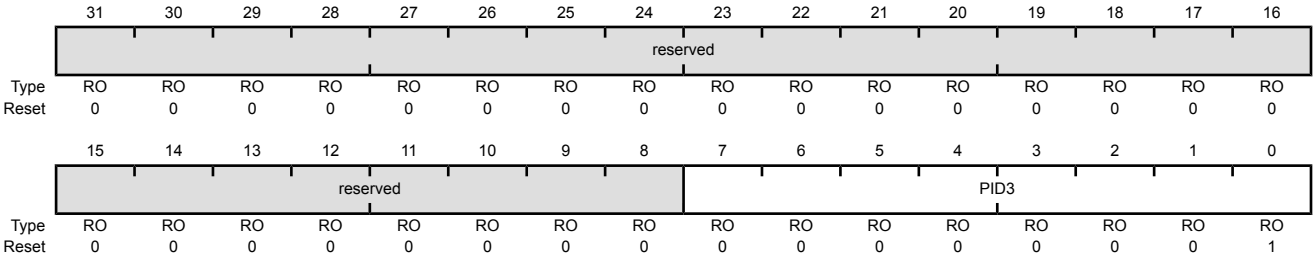

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID2 | RO | 0x18 | UART Peripheral ID Register[23:16]<br>Can be used by software to identify the presence of this peripheral. |

## Register 21: UART Peripheral Identification 3 (UARTPeriphID3), offset 0xFEC

The **UARTPeriphIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART Peripheral Identification 3 (UARTPeriphID3)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFEC
Type RO, reset 0x0000.0001



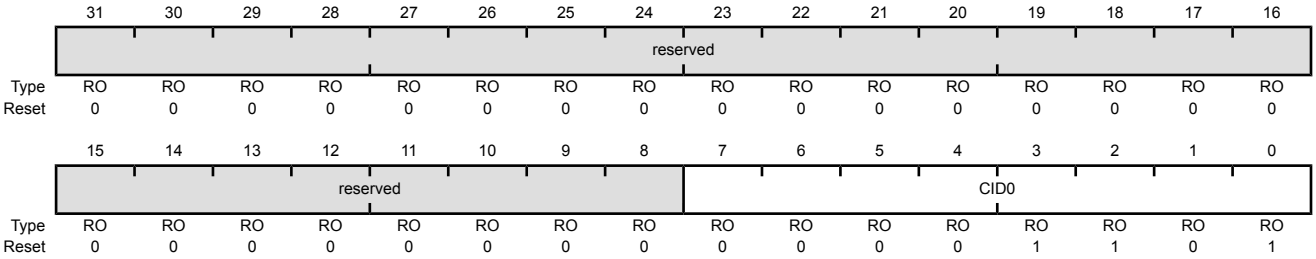

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID3 | RO | 0x01 | UART Peripheral ID Register[31:24]<br>Can be used by software to identify the presence of this peripheral. |

## Register 22: UART PrimeCell Identification 0 (UARTPCellID0), offset 0xFF0

The **UARTPCellIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART PrimeCell Identification 0 (UARTPCellID0)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFF0
Type RO, reset 0x0000.000D



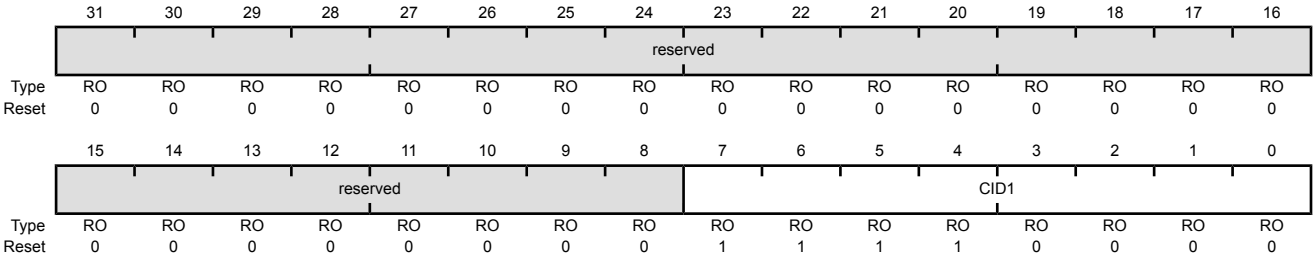

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID0 | RO | 0x0D | UART PrimeCell ID Register[7:0]<br>Provides software a standard cross-peripheral identification system. |

## Register 23: UART PrimeCell Identification 1 (UARTPCellID1), offset 0xFF4

The **UARTPCellIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART PrimeCell Identification 1 (UARTPCellID1)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFF4
Type RO, reset 0x0000.00F0



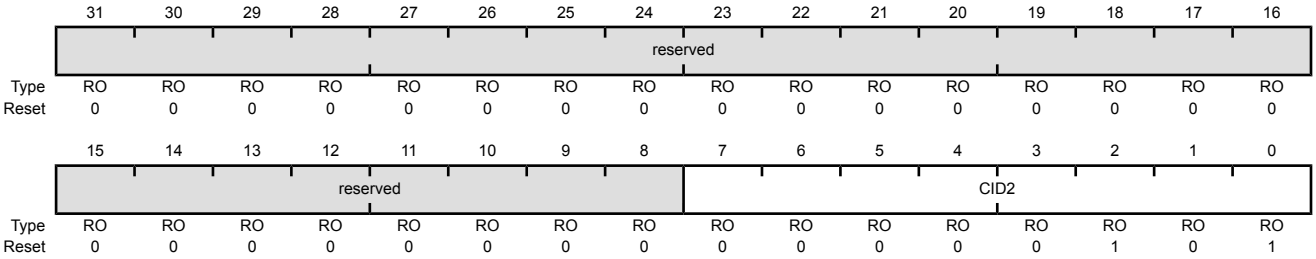

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID1 | RO | 0xF0 | UART PrimeCell ID Register[15:8]<br>Provides software a standard cross-peripheral identification system. |

## Register 24: UART PrimeCell Identification 2 (UARTPCellID2), offset 0xFF8

The **UARTPCellIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART PrimeCell Identification 2 (UARTPCellID2)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFF8
Type RO, reset 0x0000.0005



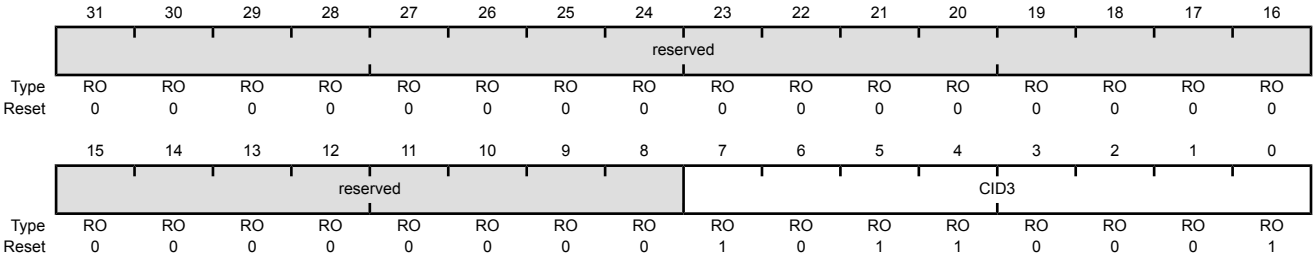

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID2 | RO | 0x05 | UART PrimeCell ID Register[23:16]<br>Provides software a standard cross-peripheral identification system. |

## Register 25: UART PrimeCell Identification 3 (UARTPCellID3), offset 0xFFC

The **UARTPCellIDn** registers are hard-coded and the fields within the registers determine the reset values.

UART PrimeCell Identification 3 (UARTPCellID3)

UART0 base: 0x4000.C000
UART1 base: 0x4000.D000
UART2 base: 0x4000.E000
Offset 0xFFC
Type RO, reset 0x0000.00B1




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID3 | RO | 0xB1 | UART PrimeCell ID Register[31:24]<br>Provides software a standard cross-peripheral identification system. |

# 12 Synchronous Serial Interface (SSI)

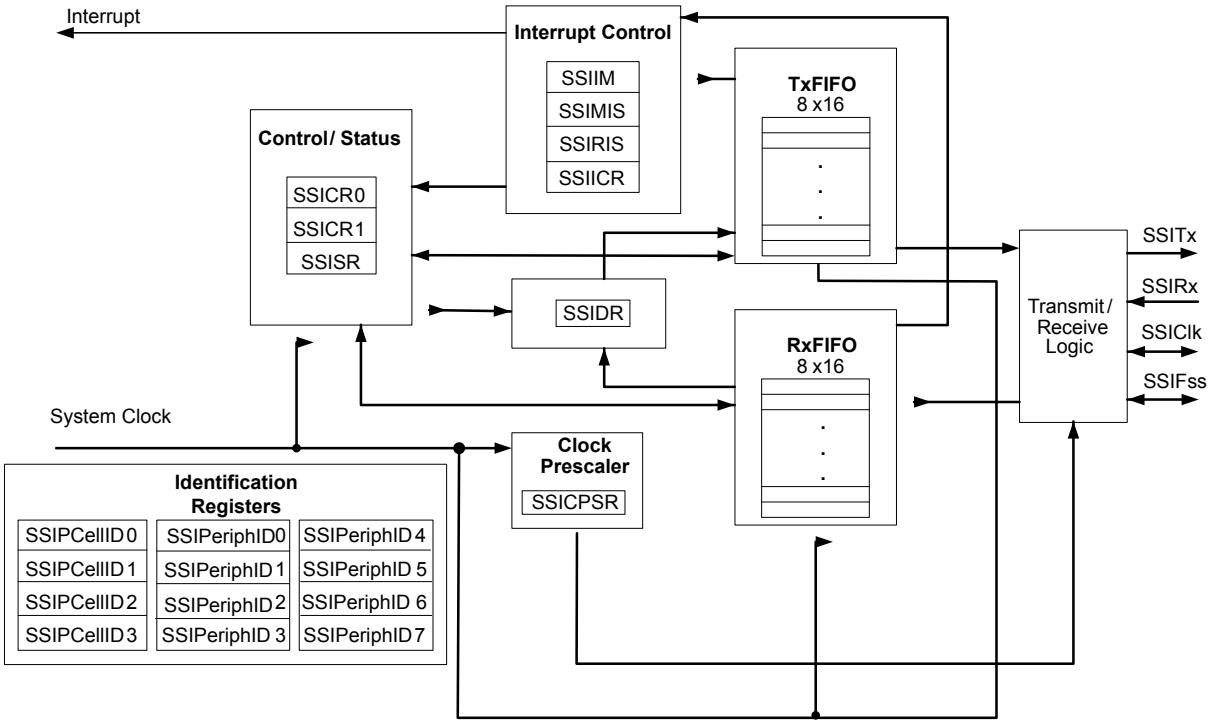
The Stellaris® microcontroller includes two Synchronous Serial Interface (SSI) modules. Each SSI is a master or slave interface for synchronous serial communication with peripheral devices that have either Freescale SPI, MICROWIRE, or Texas Instruments synchronous serial interfaces.

Each Stellaris SSI module has the following features:

- Two SSI modules, each with the following features:
- Master or slave operation
- Programmable clock bit rate and prescale
- Separate transmit and receive FIFOs, 16 bits wide, 8 locations deep
- Programmable interface operation for Freescale SPI, MICROWIRE, or Texas Instruments synchronous serial interfaces
- Programmable data frame size from 4 to 16 bits
- Internal loopback test mode for diagnostic/debug testing

## 12.1 Block Diagram

**Figure 12-1. SSI Module Block Diagram**



## 12.2 Signal Description

Table 12-1 on page 433 and Table 12-2 on page 433 list the external signals of the SSI module and describe the function of each. The SSI signals are alternate functions for some GPIO signals and default to be GPIO signals at reset., with the exception of the SSI0Clk, SSI0Fss, SSI0Rx, and SSI0Tx pins which default to the SSI function. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for the SSI signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the SSI function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 12-1. SSI Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| SSI0Clk | 28 | I/O | TTL | SSI module 0 clock. |
| SSI0Fss | 29 | I/O | TTL | SSI module 0 frame. |
| SSI0Rx | 30 | I | TTL | SSI module 0 receive. |
| SSI0Tx | 31 | O | TTL | SSI module 0 transmit. |
| SSI1Clk | 72 | I/O | TTL | SSI module 1 clock. |
| SSI1Fss | 73 | I/O | TTL | SSI module 1 frame. |
| SSI1Rx | 74 | I | TTL | SSI module 1 receive. |
| SSI1Tx | 75 | O | TTL | SSI module 1 transmit. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 12-2. SSI Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| SSI0Clk | M4 | I/O | TTL | SSI module 0 clock. |
| SSI0Fss | L4 | I/O | TTL | SSI module 0 frame. |
| SSI0Rx | L5 | I | TTL | SSI module 0 receive. |
| SSI0Tx | M5 | O | TTL | SSI module 0 transmit. |
| SSI1Clk | A11 | I/O | TTL | SSI module 1 clock. |
| SSI1Fss | B12 | I/O | TTL | SSI module 1 frame. |
| SSI1Rx | B11 | I | TTL | SSI module 1 receive. |
| SSI1Tx | A12 | O | TTL | SSI module 1 transmit. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 12.3 Functional Description

The SSI performs serial-to-parallel conversion on data received from a peripheral device. The CPU accesses data, control, and status information. The transmit and receive paths are buffered with internal FIFO memories allowing up to eight 16-bit values to be stored independently in both transmit and receive modes.

### 12.3.1 Bit Rate Generation

The SSI includes a programmable bit rate clock divider and prescaler to generate the serial output clock. Bit rates are supported to 2 MHz and higher, although maximum bit rate is determined by peripheral devices.

The serial bit rate is derived by dividing down the input clock (FSysClk). The clock is first divided by an even prescale value CPSDVSR from 2 to 254, which is programmed in the **SSI Clock Prescale**

**(SSICPSR)** register (see page 452). The clock is further divided by a value from 1 to 256, which is 1 + *SCR*, where *SCR* is the value programmed in the **SSI Control0 (SSICR0)** register (see page 445).

The frequency of the output clock SSIClk is defined by:

```
SSIClk = FSysClk / (CPSDVSR * (1 + SCR))
```

**Note:** For master mode, the system clock must be at least two times faster than the SSIClk. For slave mode, the system clock must be at least 12 times faster than the SSIClk.

See “Synchronous Serial Interface (SSI)” on page 618 to view SSI timing parameters.

## 12.3.2 FIFO Operation

### 12.3.2.1 Transmit FIFO

The common transmit FIFO is a 16-bit wide, 8-locations deep, first-in, first-out memory buffer. The CPU writes data to the FIFO by writing the **SSI Data (SSIDR)** register (see page 449), and data is stored in the FIFO until it is read out by the transmission logic.

When configured as a master or a slave, parallel data is written into the transmit FIFO prior to serial conversion and transmission to the attached slave or master, respectively, through the SSITx pin.

In slave mode, the SSI transmits data each time the master initiates a transaction. If the transmit FIFO is empty and the master initiates, the slave transmits the 8th most recent value in the transmit FIFO. If less than 8 values have been written to the transmit FIFO since the SSI module clock was enabled using the SSI bit in the **RGCG1** register, then 0 is transmitted. Care should be taken to ensure that valid data is in the FIFO as needed. The SSI can be configured to generate an interrupt or a µDMA request when the FIFO is empty.

### 12.3.2.2 Receive FIFO

The common receive FIFO is a 16-bit wide, 8-locations deep, first-in, first-out memory buffer. Received data from the serial interface is stored in the buffer until read out by the CPU, which accesses the read FIFO by reading the **SSIDR** register.

When configured as a master or slave, serial data received through the SSIRx pin is registered prior to parallel loading into the attached slave or master receive FIFO, respectively.

## 12.3.3 Interrupts

The SSI can generate interrupts when the following conditions are observed:

- Transmit FIFO service
- Receive FIFO service
- Receive FIFO time-out
- Receive FIFO overrun

All of the interrupt events are ORed together before being sent to the interrupt controller, so the SSI can only generate a single interrupt request to the controller at any given time. You can mask each of the four individual maskable interrupts by setting the appropriate bits in the **SSI Interrupt Mask (SSIIM)** register (see page 453). Setting the appropriate mask bit to 1 enables the interrupt.

Provision of the individual outputs, as well as a combined interrupt output, allows use of either a global interrupt service routine, or modular device drivers to handle interrupts. The transmit and

receive dynamic dataflow interrupts have been separated from the status interrupts so that data can be read or written in response to the FIFO trigger levels. The status of the individual interrupt sources can be read from the **SSI Raw Interrupt Status (SSIRIS)** and **SSI Masked Interrupt Status (SSIMIS)** registers (see page 455 and page 456, respectively).

### 12.3.4 Frame Formats

Each data frame is between 4 and 16 bits long, depending on the size of data programmed, and is transmitted starting with the MSB. There are three basic frame types that can be selected:

- Texas Instruments synchronous serial
- Freescale SPI
- MICROWIRE

For all three formats, the serial clock (SSIClk) is held inactive while the SSI is idle, and SSIClk transitions at the programmed frequency only during active transmission or reception of data. The idle state of SSIClk is utilized to provide a receive timeout indication that occurs when the receive FIFO still contains data after a timeout period.

For Freescale SPI and MICROWIRE frame formats, the serial frame (SSIFss ) pin is active Low, and is asserted (pulled down) during the entire transmission of the frame.

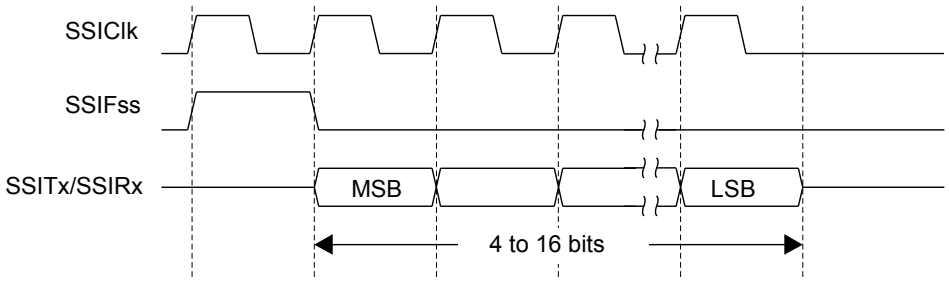
For Texas Instruments synchronous serial frame format, the SSIFss pin is pulsed for one serial clock period starting at its rising edge, prior to the transmission of each frame. For this frame format, both the SSI and the off-chip slave device drive their output data on the rising edge of SSIClk, and latch data from the other device on the falling edge.

Unlike the full-duplex transmission of the other two frame formats, the MICROWIRE format uses a special master-slave messaging technique, which operates at half-duplex. In this mode, when a frame begins, an 8-bit control message is transmitted to the off-chip slave. During this transmit, no incoming data is received by the SSI. After the message has been sent, the off-chip slave decodes it and, after waiting one serial clock after the last bit of the 8-bit control message has been sent, responds with the requested data. The returned data can be 4 to 16 bits in length, making the total frame length anywhere from 13 to 25 bits.

#### 12.3.4.1 Texas Instruments Synchronous Serial Frame Format

Figure 12-2 on page 435 shows the Texas Instruments synchronous serial frame format for a single transmitted frame.

**Figure 12-2. TI Synchronous Serial Frame Format (Single Transfer)**



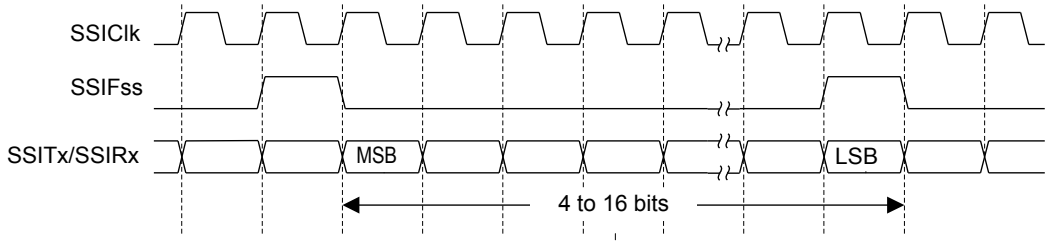

In this mode, SSIClk and SSIFss are forced Low, and the transmit data line SSITx is tristated whenever the SSI is idle. Once the bottom entry of the transmit FIFO contains data, SSIFss is

pulsed High for one SSIClk period. The value to be transmitted is also transferred from the transmit FIFO to the serial shift register of the transmit logic. On the next rising edge of SSIClk, the MSB of the 4 to 16-bit data frame is shifted out on the SSITx pin. Likewise, the MSB of the received data is shifted onto the SSIRx pin by the off-chip serial slave device.

Both the SSI and the off-chip serial slave device then clock each data bit into their serial shifter on the falling edge of each SSIClk. The received data is transferred from the serial shifter to the receive FIFO on the first rising edge of SSIClk after the LSB has been latched.

Figure 12-3 on page 436 shows the Texas Instruments synchronous serial frame format when back-to-back frames are transmitted.

**Figure 12-3. TI Synchronous Serial Frame Format (Continuous Transfer)**




### 12.3.4.2 Freescale SPI Frame Format

The Freescale SPI interface is a four-wire interface where the SSIFss signal behaves as a slave select. The main feature of the Freescale SPI format is that the inactive state and phase of the SSIClk signal are programmable through the SPO and SPH bits within the **SSISCR0** control register.

#### *SPO Clock Polarity Bit*

When the SPO clock polarity control bit is Low, it produces a steady state Low value on the SSIClk pin. If the SPO bit is High, a steady state High value is placed on the SSIClk pin when data is not being transferred.

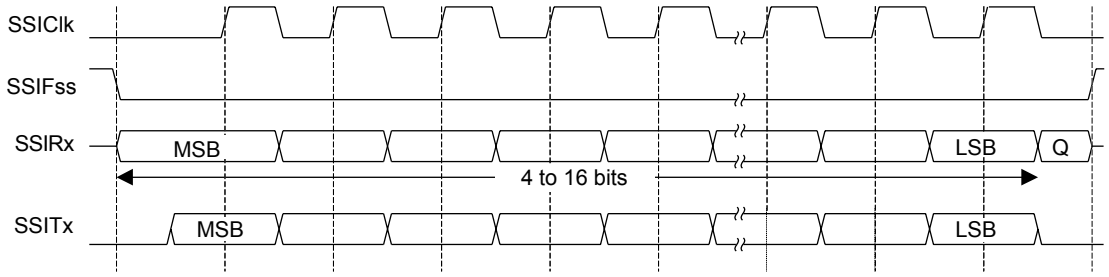
#### *SPH Phase Control Bit*

The SPH phase control bit selects the clock edge that captures data and allows it to change state. It has the most impact on the first bit transmitted by either allowing or not allowing a clock transition before the first data capture edge. When the SPH phase control bit is Low, data is captured on the first clock edge transition. If the SPH bit is High, data is captured on the second clock edge transition.

### 12.3.4.3 Freescale SPI Frame Format with SPO=0 and SPH=0

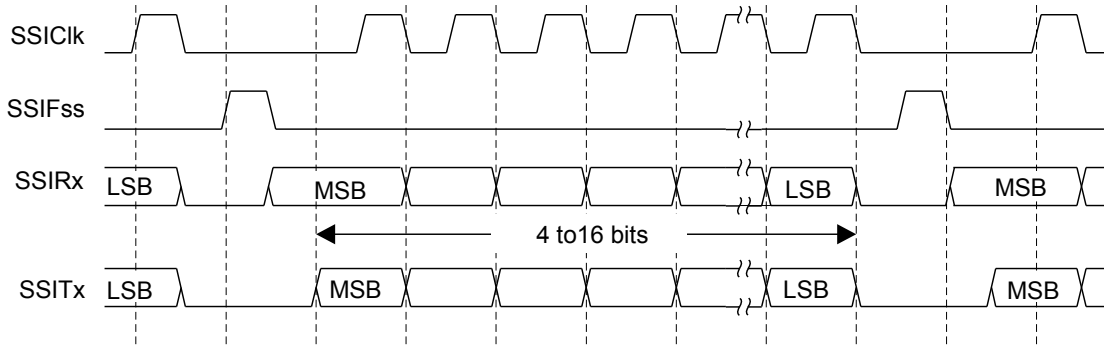
Single and continuous transmission signal sequences for Freescale SPI format with SPO=0 and SPH=0 are shown in Figure 12-4 on page 437 and Figure 12-5 on page 437.

**Figure 12-4. Freescale SPI Format (Single Transfer) with SPO=0 and SPH=0**




**Note:** Q is undefined.

**Figure 12-5. Freescale SPI Format (Continuous Transfer) with SPO=0 and SPH=0**




In this configuration, during idle periods:

- SSIClk is forced Low
- SSIFss is forced High
- The transmit data line SSITx is arbitrarily forced Low
- When the SSI is configured as a master, it enables the SSIClk pad
- When the SSI is configured as a slave, it disables the SSIClk pad

If the SSI is enabled and there is valid data within the transmit FIFO, the start of transmission is signified by the SSIFss master signal being driven Low. This causes slave data to be enabled onto the SSIRx input line of the master. The master SSITx output pad is enabled.

One half SSIClk period later, valid master data is transferred to the SSITx pin. Now that both the master and slave data have been set, the SSIClk master clock pin goes High after one further half SSIClk period.

The data is now captured on the rising and propagated on the falling edges of the SSIClk signal.

In the case of a single word transmission, after all bits of the data word have been transferred, the SSIFss line is returned to its idle High state one SSIClk period after the last bit has been captured.

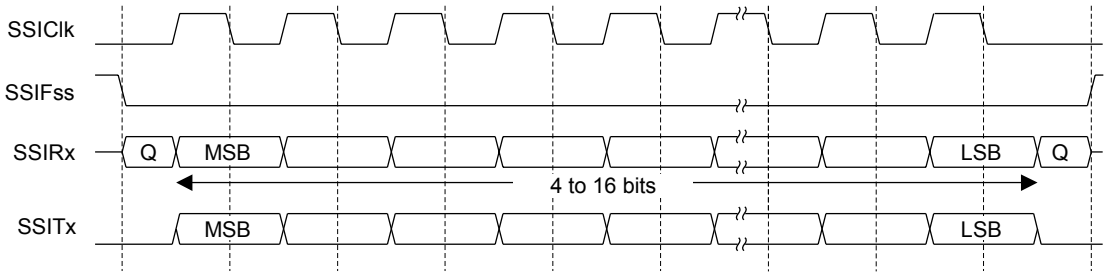
However, in the case of continuous back-to-back transmissions, the SSIFss signal must be pulsed High between each data word transfer. This is because the slave select pin freezes the data in its serial peripheral register and does not allow it to be altered if the SPH bit is logic zero. Therefore, the master device must raise the SSIFss pin of the slave device between each data transfer to

enable the serial peripheral data write. On completion of the continuous transfer, the SSIFss pin is returned to its idle state one SSIClk period after the last bit has been captured.

### 12.3.4.4 Freescale SPI Frame Format with SPO=0 and SPH=1

The transfer signal sequence for Freescale SPI format with SPO=0 and SPH=1 is shown in Figure 12-6 on page 438, which covers both single and continuous transfers.

**Figure 12-6. Freescale SPI Frame Format with SPO=0 and SPH=1**




**Note:** Q is undefined.

In this configuration, during idle periods:

- SSIClk is forced Low
- SSIFss is forced High
- The transmit data line SSITx is arbitrarily forced Low
- When the SSI is configured as a master, it enables the SSIClk pad
- When the SSI is configured as a slave, it disables the SSIClk pad

If the SSI is enabled and there is valid data within the transmit FIFO, the start of transmission is signified by the SSIFss master signal being driven Low. The master SSITx output is enabled. After a further one half SSIClk period, both master and slave valid data is enabled onto their respective transmission lines. At the same time, the SSIClk is enabled with a rising edge transition.

Data is then captured on the falling edges and propagated on the rising edges of the SSIClk signal.

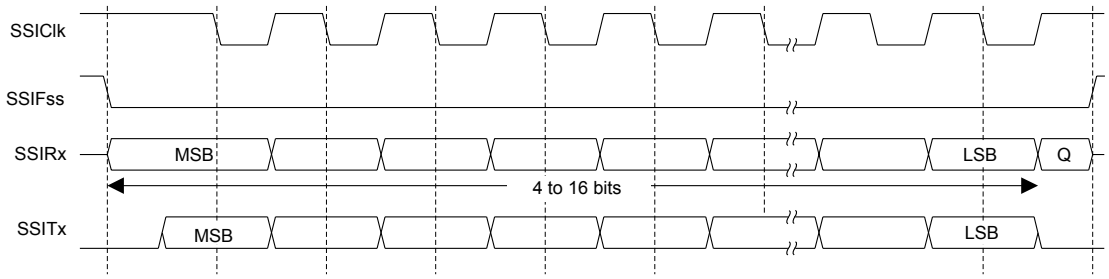
In the case of a single word transfer, after all bits have been transferred, the SSIFss line is returned to its idle High state one SSIClk period after the last bit has been captured.

For continuous back-to-back transfers, the SSIFss pin is held Low between successive data words and termination is the same as that of the single word transfer.

### 12.3.4.5 Freescale SPI Frame Format with SPO=1 and SPH=0

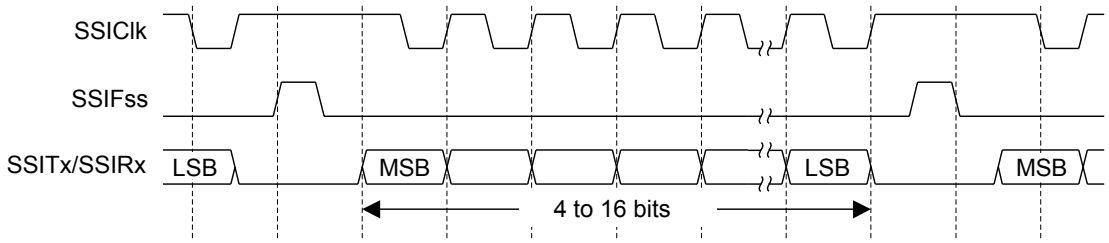
Single and continuous transmission signal sequences for Freescale SPI format with SPO=1 and SPH=0 are shown in Figure 12-7 on page 439 and Figure 12-8 on page 439.

**Figure 12-7. Freescale SPI Frame Format (Single Transfer) with SPO=1 and SPH=0**




**Note:** Q is undefined.

**Figure 12-8. Freescale SPI Frame Format (Continuous Transfer) with SPO=1 and SPH=0**




In this configuration, during idle periods:

- SSIClk is forced High
- SSIFss is forced High
- The transmit data line SSITx is arbitrarily forced Low
- When the SSI is configured as a master, it enables the SSIClk pad
- When the SSI is configured as a slave, it disables the SSIClk pad

If the SSI is enabled and there is valid data within the transmit FIFO, the start of transmission is signified by the SSIFss master signal being driven Low, which causes slave data to be immediately transferred onto the SSIRx line of the master. The master SSITx output pad is enabled.

One half period later, valid master data is transferred to the SSITx line. Now that both the master and slave data have been set, the SSIClk master clock pin becomes Low after one further half SSIClk period. This means that data is captured on the falling edges and propagated on the rising edges of the SSIClk signal.

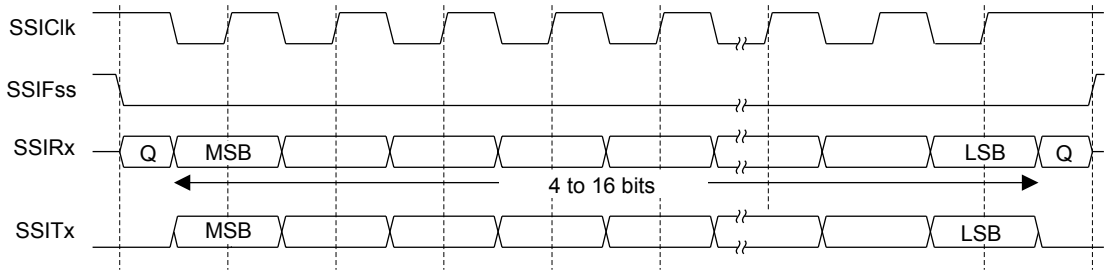
In the case of a single word transmission, after all bits of the data word are transferred, the SSIFss line is returned to its idle High state one SSIClk period after the last bit has been captured.

However, in the case of continuous back-to-back transmissions, the SSIFss signal must be pulsed High between each data word transfer. This is because the slave select pin freezes the data in its serial peripheral register and does not allow it to be altered if the SPH bit is logic zero. Therefore, the master device must raise the SSIFss pin of the slave device between each data transfer to enable the serial peripheral data write. On completion of the continuous transfer, the SSIFss pin is returned to its idle state one SSIClk period after the last bit has been captured.

### 12.3.4.6 Freescale SPI Frame Format with SPO=1 and SPH=1

The transfer signal sequence for Freescale SPI format with SPO=1 and SPH=1 is shown in Figure 12-9 on page 440, which covers both single and continuous transfers.

**Figure 12-9. Freescale SPI Frame Format with SPO=1 and SPH=1**




**Note:** Q is undefined.

In this configuration, during idle periods:

- SSIClk is forced High
- SSIFss is forced High
- The transmit data line SSITx is arbitrarily forced Low
- When the SSI is configured as a master, it enables the SSIClk pad
- When the SSI is configured as a slave, it disables the SSIClk pad

If the SSI is enabled and there is valid data within the transmit FIFO, the start of transmission is signified by the SSIFss master signal being driven Low. The master SSITx output pad is enabled. After a further one-half SSIClk period, both master and slave data are enabled onto their respective transmission lines. At the same time, SSIClk is enabled with a falling edge transition. Data is then captured on the rising edges and propagated on the falling edges of the SSIClk signal.

After all bits have been transferred, in the case of a single word transmission, the SSIFss line is returned to its idle high state one SSIClk period after the last bit has been captured.

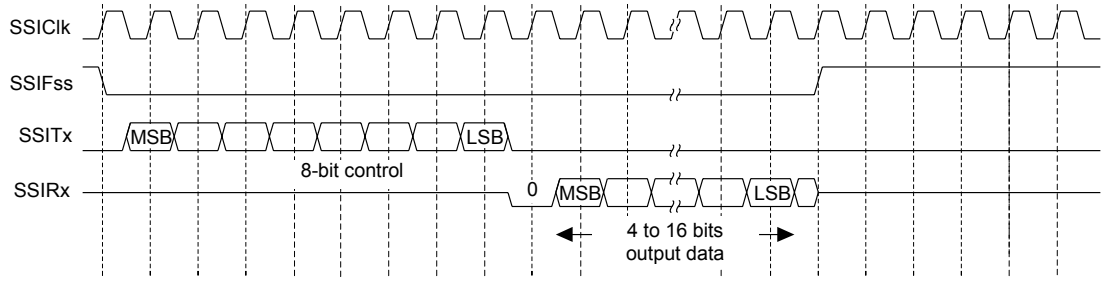
For continuous back-to-back transmissions, the SSIFss pin remains in its active Low state, until the final bit of the last word has been captured, and then returns to its idle state as described above.

For continuous back-to-back transfers, the SSIFss pin is held Low between successive data words and termination is the same as that of the single word transfer.

### 12.3.4.7 MICROWIRE Frame Format

Figure 12-10 on page 441 shows the MICROWIRE frame format, again for a single frame. Figure 12-11 on page 442 shows the same format when back-to-back frames are transmitted.

**Figure 12-10. MICROWIRE Frame Format (Single Frame)**




MICROWIRE format is very similar to SPI format, except that transmission is half-duplex instead of full-duplex, using a master-slave message passing technique. Each serial transmission begins with an 8-bit control word that is transmitted from the SSI to the off-chip slave device. During this transmission, no incoming data is received by the SSI. After the message has been sent, the off-chip slave decodes it and, after waiting one serial clock after the last bit of the 8-bit control message has been sent, responds with the required data. The returned data is 4 to 16 bits in length, making the total frame length anywhere from 13 to 25 bits.

In this configuration, during idle periods:

- SSIClk is forced Low
- SSIFss is forced High
- The transmit data line SSITx is arbitrarily forced Low

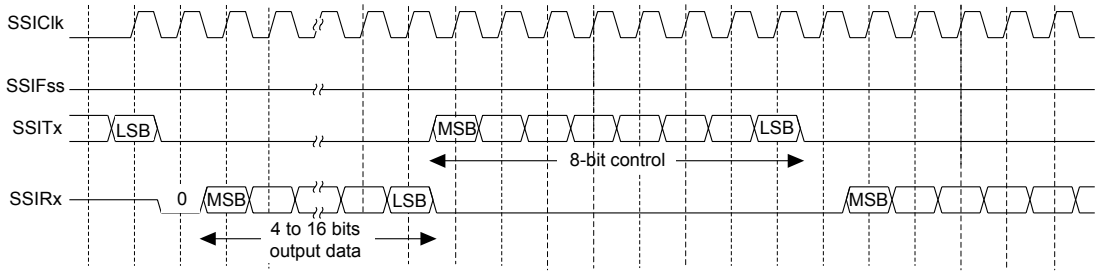
A transmission is triggered by writing a control byte to the transmit FIFO. The falling edge of SSIFss causes the value contained in the bottom entry of the transmit FIFO to be transferred to the serial shift register of the transmit logic, and the MSB of the 8-bit control frame to be shifted out onto the SSITx pin. SSIFss remains Low for the duration of the frame transmission. The SSIRx pin remains tristated during this transmission.

The off-chip serial slave device latches each control bit into its serial shifter on the rising edge of each SSIClk. After the last bit is latched by the slave device, the control byte is decoded during a one clock wait-state, and the slave responds by transmitting data back to the SSI. Each bit is driven onto the SSIRx line on the falling edge of SSIClk. The SSI in turn latches each bit on the rising edge of SSIClk. At the end of the frame, for single transfers, the SSIFss signal is pulled High one clock period after the last bit has been latched in the receive serial shifter, which causes the data to be transferred to the receive FIFO.

**Note:** The off-chip slave device can tristate the receive line either on the falling edge of SSIClk after the LSB has been latched by the receive shifter, or when the SSIFss pin goes High.

For continuous transfers, data transmission begins and ends in the same manner as a single transfer. However, the SSIFss line is continuously asserted (held Low) and transmission of data occurs back-to-back. The control byte of the next frame follows directly after the LSB of the received data from the current frame. Each of the received values is transferred from the receive shifter on the falling edge of SSIClk, after the LSB of the frame has been latched into the SSI.

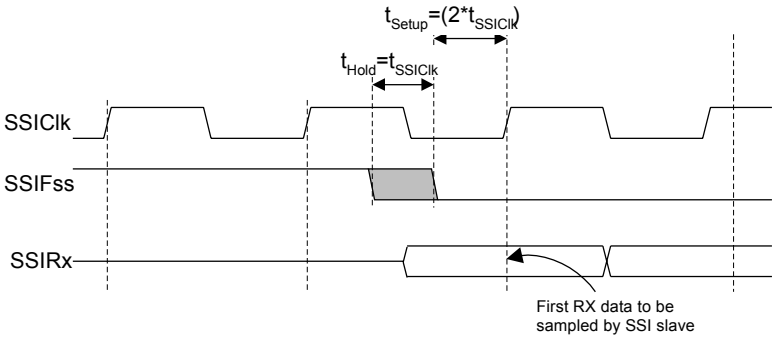
**Figure 12-11. MICROWIRE Frame Format (Continuous Transfer)**




In the MICROWIRE mode, the SSI slave samples the first bit of receive data on the rising edge of SSIClk after SSIFss has gone Low. Masters that drive a free-running SSIClk must ensure that the SSIFss signal has sufficient setup and hold margins with respect to the rising edge of SSIClk.

Figure 12-12 on page 442 illustrates these setup and hold time requirements. With respect to the SSIClk rising edge on which the first bit of receive data is to be sampled by the SSI slave, SSIFss must have a setup of at least two times the period of SSIClk on which the SSI operates. With respect to the SSIClk rising edge previous to this edge, SSIFss must have a hold of at least one SSIClk period.

**Figure 12-12. MICROWIRE Frame Format, SSIFss Input Setup and Hold Requirements**




## 12.4 Initialization and Configuration

To use the SSI, its peripheral clock must be enabled by setting the SSI bit in the **RCGC1** register.

For each of the frame formats, the SSI is configured using the following steps:

1. Ensure that the SSE bit in the **SSICR1** register is disabled before making any configuration changes.
2. Select whether the SSI is a master or slave:
   a. For master operations, set the **SSICR1** register to 0x0000.0000.
   b. For slave mode (output enabled), set the **SSICR1** register to 0x0000.0004.
   c. For slave mode (output disabled), set the **SSICR1** register to 0x0000.000C.
3. Configure the clock prescale divisor by writing the **SSICPSR** register.
4. Write the **SSICR0** register with the following configuration:

- Serial clock rate (SCR)
- Desired clock phase/polarity, if using Freescale SPI mode (SPH and SPO)
- The protocol mode: Freescale SPI, TI SSF, MICROWIRE (FRF)
- The data size (DSS)

5. Enable the SSI by setting the SSE bit in the **SSICR1** register.

As an example, assume the SSI must be configured to operate with the following parameters:

- Master operation
- Freescale SPI mode (SPO=1, SPH=1)
- 1 Mbps bit rate
- 8 data bits

Assuming the system clock is 20 MHz, the bit rate calculation would be:

```
FSSIClk = FSysClk / (CPSDVSR * (1 + SCR))
1x106 = 20x106 / (CPSDVSR * (1 + SCR))
```

In this case, if CPSDVSR=2, SCR must be 9.

The configuration sequence would be as follows:

1. Ensure that the SSE bit in the **SSICR1** register is disabled.
2. Write the **SSICR1** register with a value of 0x0000.0000.
3. Write the **SSICPSR** register with a value of 0x0000.0002.
4. Write the **SSICR0** register with a value of 0x0000.09C7.
5. The SSI is then enabled by setting the SSE bit in the **SSICR1** register to 1.

## 12.5 Register Map

Table 12-3 on page 444 lists the SSI registers. The offset listed is a hexadecimal increment to the register's address, relative to that SSI module's base address:

- SSI0: 0x4000.8000
- SSI1: 0x4000.9000

Note that the SSI module clock must be enabled before the registers can be programmed (see page 214). There must be a delay of 3 system clocks after the SSI module clock is enabled before any SSI module registers are accessed.

**Note:** The SSI must be disabled (see the SSE bit in the **SSICR1** register) before any of the control registers are reprogrammed.

**Table 12-3. SSI Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | SSICR0 | R/W | 0x0000.0000 | SSI Control 0 | 445 |
| 0x004 | SSICR1 | R/W | 0x0000.0000 | SSI Control 1 | 447 |
| 0x008 | SSIDR | R/W | 0x0000.0000 | SSI Data | 449 |
| 0x00C | SSISR | RO | 0x0000.0003 | SSI Status | 450 |
| 0x010 | SSICPSR | R/W | 0x0000.0000 | SSI Clock Prescale | 452 |
| 0x014 | SSIIM | R/W | 0x0000.0000 | SSI Interrupt Mask | 453 |
| 0x018 | SSIRIS | RO | 0x0000.0008 | SSI Raw Interrupt Status | 455 |
| 0x01C | SSIMIS | RO | 0x0000.0000 | SSI Masked Interrupt Status | 456 |
| 0x020 | SSIICR | W1C | 0x0000.0000 | SSI Interrupt Clear | 457 |
| 0xFD0 | SSIPeriphID4 | RO | 0x0000.0000 | SSI Peripheral Identification 4 | 458 |
| 0xFD4 | SSIPeriphID5 | RO | 0x0000.0000 | SSI Peripheral Identification 5 | 459 |
| 0xFD8 | SSIPeriphID6 | RO | 0x0000.0000 | SSI Peripheral Identification 6 | 460 |
| 0xFDC | SSIPeriphID7 | RO | 0x0000.0000 | SSI Peripheral Identification 7 | 461 |
| 0xFE0 | SSIPeriphID0 | RO | 0x0000.0022 | SSI Peripheral Identification 0 | 462 |
| 0xFE4 | SSIPeriphID1 | RO | 0x0000.0000 | SSI Peripheral Identification 1 | 463 |
| 0xFE8 | SSIPeriphID2 | RO | 0x0000.0018 | SSI Peripheral Identification 2 | 464 |
| 0xFEC | SSIPeriphID3 | RO | 0x0000.0001 | SSI Peripheral Identification 3 | 465 |
| 0xFF0 | SSIPCellID0 | RO | 0x0000.000D | SSI PrimeCell Identification 0 | 466 |
| 0xFF4 | SSIPCellID1 | RO | 0x0000.00F0 | SSI PrimeCell Identification 1 | 467 |
| 0xFF8 | SSIPCellID2 | RO | 0x0000.0005 | SSI PrimeCell Identification 2 | 468 |
| 0xFFC | SSIPCellID3 | RO | 0x0000.00B1 | SSI PrimeCell Identification 3 | 469 |

## 12.6 Register Descriptions

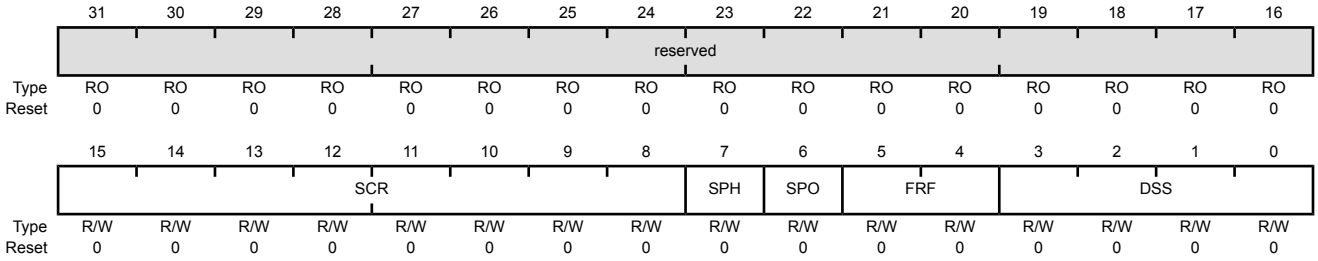
The remainder of this section lists and describes the SSI registers, in numerical order by address offset.

## Register 1: SSI Control 0 (SSICR0), offset 0x000

**SSICR0** is control register 0 and contains bit fields that control various functions within the SSI module. Functionality such as protocol mode, clock rate, and data size are configured in this register.

SSI Control 0 (SSICR0)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x000
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:8 | SCR | R/W | 0x0000 | SSI Serial Clock Rate<br>The value SCR is used to generate the transmit and receive bit rate of the SSI. The bit rate is:<br>`BR=FSSIClk/(CPSDVSR * (1 + SCR))`<br>where CPSDVSR is an even value from 2-254 programmed in the **SSICPSR** register, and SCR is a value from 0-255. |
| 7 | SPH | R/W | 0 | SSI Serial Clock Phase<br>This bit is only applicable to the Freescale SPI Format.<br>The SPH control bit selects the clock edge that captures data and allows it to change state. It has the most impact on the first bit transmitted by either allowing or not allowing a clock transition before the first data capture edge.<br>When the SPH bit is 0, data is captured on the first clock edge transition. If SPH is 1, data is captured on the second clock edge transition. |
| 6 | SPO | R/W | 0 | SSI Serial Clock Polarity<br>This bit is only applicable to the Freescale SPI Format.<br>When the SPO bit is 0, it produces a steady state Low value on the SSIClk pin. If SPO is 1, a steady state High value is placed on the SSIClk pin when data is not being transferred. |

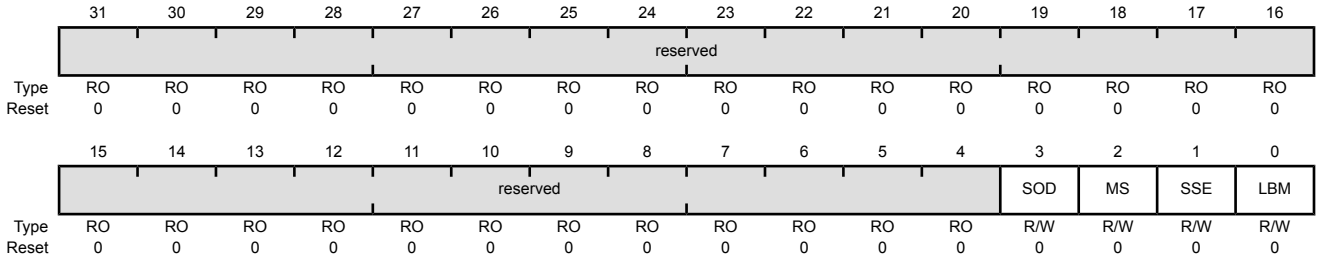
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 5:4 | FRF | R/W | 0x0 | SSI Frame Format Select<br>The FRF values are defined as follows:<br><br>Value Frame Format<br>0x0 Freescale SPI Frame Format<br>0x1 Texas Instruments Synchronous Serial Frame Format<br>0x2 MICROWIRE Frame Format<br>0x3 Reserved |
| 3:0 | DSS | R/W | 0x00 | SSI Data Size Select<br>The DSS values are defined as follows:<br><br>Value Data Size<br>0x0-0x2 Reserved<br>0x3 4-bit data<br>0x4 5-bit data<br>0x5 6-bit data<br>0x6 7-bit data<br>0x7 8-bit data<br>0x8 9-bit data<br>0x9 10-bit data<br>0xA 11-bit data<br>0xB 12-bit data<br>0xC 13-bit data<br>0xD 14-bit data<br>0xE 15-bit data<br>0xF 16-bit data |

## Register 2: SSI Control 1 (SSICR1), offset 0x004

**SSICR1** is control register 1 and contains bit fields that control various functions within the SSI module. Master and slave mode functionality is controlled by this register.

SSI Control 1 (SSICR1)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x004
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | SOD | R/W | 0 | SSI Slave Mode Output Disable<br>This bit is relevant only in the Slave mode (MS=1). In multiple-slave systems, it is possible for the SSI master to broadcast a message to all slaves in the system while ensuring that only one slave drives data onto the serial output line. In such systems, the TXD lines from multiple slaves could be tied together. To operate in such a system, the SOD bit can be configured so that the SSI slave does not drive the SSITx pin.<br>The SOD values are defined as follows:<br>Value Description<br>0 SSI can drive SSITx output in Slave Output mode.<br>1 SSI must not drive the SSITx output in Slave mode. |
| 2 | MS | R/W | 0 | SSI Master/Slave Select<br>This bit selects Master or Slave mode and can be modified only when SSI is disabled (SSE=0).<br>The MS values are defined as follows:<br>Value Description<br>0 Device configured as a master.<br>1 Device configured as a slave. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | SSE | R/W | 0 | SSI Synchronous Serial Port Enable<br>Setting this bit enables SSI operation.<br>The SSE values are defined as follows:<br><br>Value Description<br>0 SSI operation disabled.<br>1 SSI operation enabled.<br><br>**Note:** This bit must be set to 0 before any control registers are reprogrammed. |
| 0 | LBM | R/W | 0 | SSI Loopback Mode<br>Setting this bit enables Loopback Test mode.<br>The LBM values are defined as follows:<br><br>Value Description<br>0 Normal serial port operation enabled.<br>1 Output of the transmit serial shift register is connected internally to the input of the receive serial shift register. |

## Register 3: SSI Data (SSIDR), offset 0x008

**Important:** This register is read-sensitive. See the register description for details.

**SSIDR** is the data register and is 16-bits wide. When **SSIDR** is read, the entry in the receive FIFO (pointed to by the current FIFO read pointer) is accessed. As data values are removed by the SSI receive logic from the incoming data frame, they are placed into the entry in the receive FIFO (pointed to by the current FIFO write pointer).

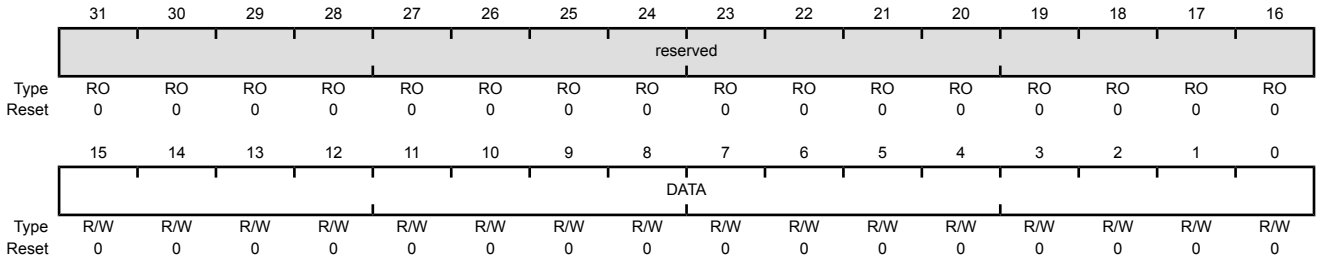
When **SSIDR** is written to, the entry in the transmit FIFO (pointed to by the write pointer) is written to. Data values are removed from the transmit FIFO one value at a time by the transmit logic. It is loaded into the transmit serial shifter, then serially shifted out onto the SSITx pin at the programmed bit rate.

When a data size of less than 16 bits is selected, the user must right-justify data written to the transmit FIFO. The transmit logic ignores the unused bits. Received data less than 16 bits is automatically right-justified in the receive buffer.

When the SSI is programmed for MICROWIRE frame format, the default size for transmit data is eight bits (the most significant byte is ignored). The receive data size is controlled by the programmer. The transmit FIFO and the receive FIFO are not cleared even when the SSE bit in the **SSICR1** register is set to zero. This allows the software to fill the transmit FIFO before enabling the SSI.

SSI Data (SSIDR)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x008
Type R/W, reset 0x0000.0000



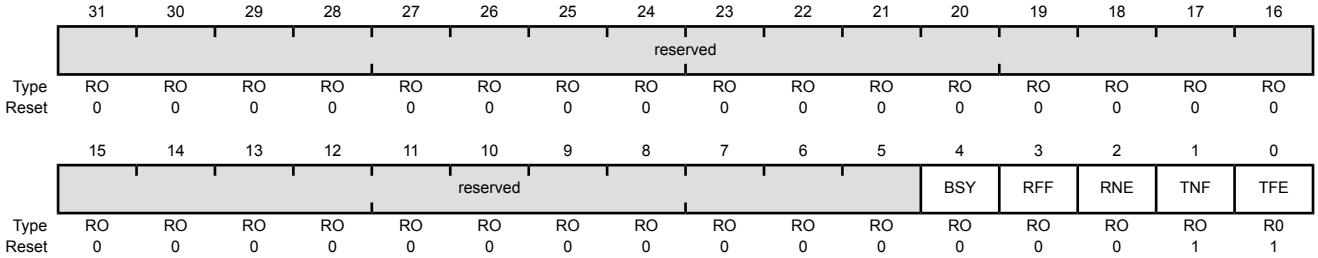

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x0000 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | DATA | R/W | 0x0000 | SSI Receive/Transmit Data<br>A read operation reads the receive FIFO. A write operation writes the transmit FIFO.<br>Software must right-justify data when the SSI is programmed for a data size that is less than 16 bits. Unused bits at the top are ignored by the transmit logic. The receive logic automatically right-justifies the data. |

## Register 4: SSI Status (SSISR), offset 0x00C

**SSISR** is a status register that contains bits that indicate the FIFO fill status and the SSI busy status.

SSI Status (SSISR)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x00C
Type RO, reset 0x0000.0003




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:5 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | BSY | RO | 0 | SSI Busy Bit<br>The BSY values are defined as follows:<br><br>Value Description<br>0 SSI is idle.<br>1 SSI is currently transmitting and/or receiving a frame, or the transmit FIFO is not empty. |
| 3 | RFF | RO | 0 | SSI Receive FIFO Full<br>The RFF values are defined as follows:<br><br>Value Description<br>0 Receive FIFO is not full.<br>1 Receive FIFO is full. |
| 2 | RNE | RO | 0 | SSI Receive FIFO Not Empty<br>The RNE values are defined as follows:<br><br>Value Description<br>0 Receive FIFO is empty.<br>1 Receive FIFO is not empty. |
| 1 | TNF | RO | 1 | SSI Transmit FIFO Not Full<br>The TNF values are defined as follows:<br><br>Value Description<br>0 Transmit FIFO is full.<br>1 Transmit FIFO is not full. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | TFE | R0 | 1 | SSI Transmit FIFO Empty<br>The TFE values are defined as follows:<br><br>Value Description<br>0 Transmit FIFO is not empty.<br>1 Transmit FIFO is empty. |

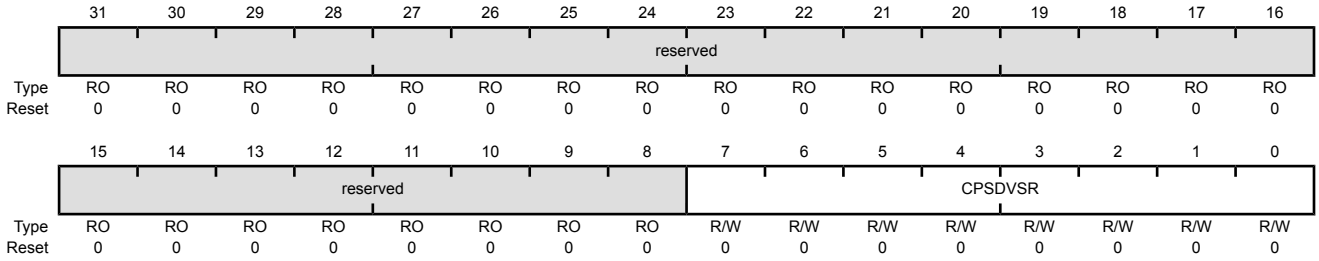
## Register 5: SSI Clock Prescale (SSICPSR), offset 0x010

**SSICPSR** is the clock prescale register and specifies the division factor by which the system clock must be internally divided before further use.

The value programmed into this register must be an even number between 2 and 254. The least-significant bit of the programmed number is hard-coded to zero. If an odd number is written to this register, data read back from this register has the least-significant bit as zero.

SSI Clock Prescale (SSICPSR)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x010
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CPSDVSR | R/W | 0x00 | SSI Clock Prescale Divisor<br>This value must be an even number from 2 to 254, depending on the frequency of SSIClk. The LSB always returns 0 on reads. |

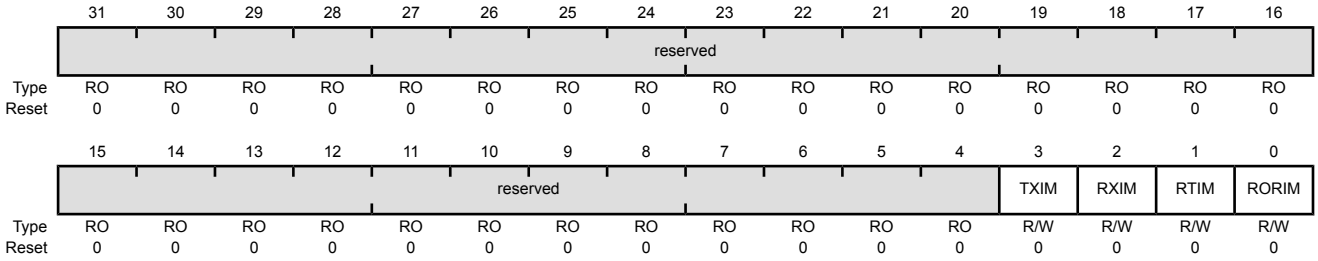
## Register 6: SSI Interrupt Mask (SSIIM), offset 0x014

The **SSIIM** register is the interrupt mask set or clear register. It is a read/write register and all bits are cleared to 0 on reset.

On a read, this register gives the current value of the mask on the relevant interrupt. A write of 1 to the particular bit sets the mask, enabling the interrupt to be read. A write of 0 clears the corresponding mask.

SSI Interrupt Mask (SSIIM)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x014
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | TXIM | R/W | 0 | SSI Transmit FIFO Interrupt Mask<br>The `TXIM` values are defined as follows:<br><br>Value Description<br>0 TX FIFO half-empty or less condition interrupt is masked.<br>1 TX FIFO half-empty or less condition interrupt is not masked. |
| 2 | RXIM | R/W | 0 | SSI Receive FIFO Interrupt Mask<br>The `RXIM` values are defined as follows:<br><br>Value Description<br>0 RX FIFO half-full or more condition interrupt is masked.<br>1 RX FIFO half-full or more condition interrupt is not masked. |
| 1 | RTIM | R/W | 0 | SSI Receive Time-Out Interrupt Mask<br>The `RTIM` values are defined as follows:<br><br>Value Description<br>0 RX FIFO time-out interrupt is masked.<br>1 RX FIFO time-out interrupt is not masked. |

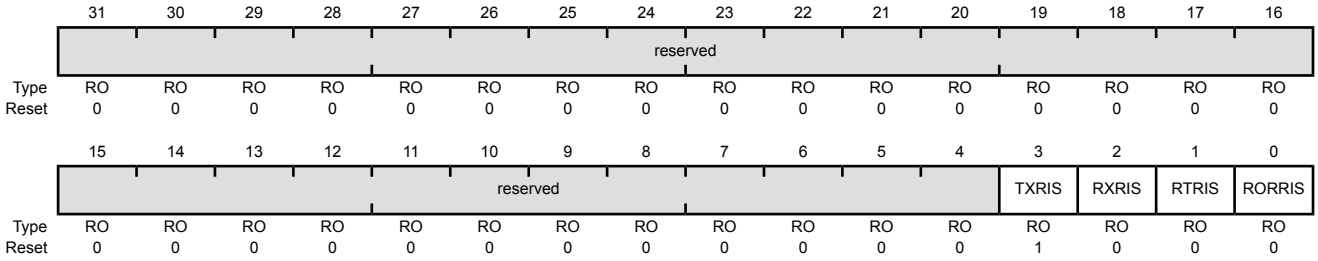
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | RORIM | R/W | 0 | SSI Receive Overrun Interrupt Mask<br>The RORIM values are defined as follows:<br><br>Value Description<br>0 RX FIFO overrun interrupt is masked.<br>1 RX FIFO overrun interrupt is not masked. |

## Register 7: SSI Raw Interrupt Status (SSIRIS), offset 0x018

The **SSIRIS** register is the raw interrupt status register. On a read, this register gives the current raw status value of the corresponding interrupt prior to masking. A write has no effect.

SSI Raw Interrupt Status (SSIRIS)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x018
Type RO, reset 0x0000.0008



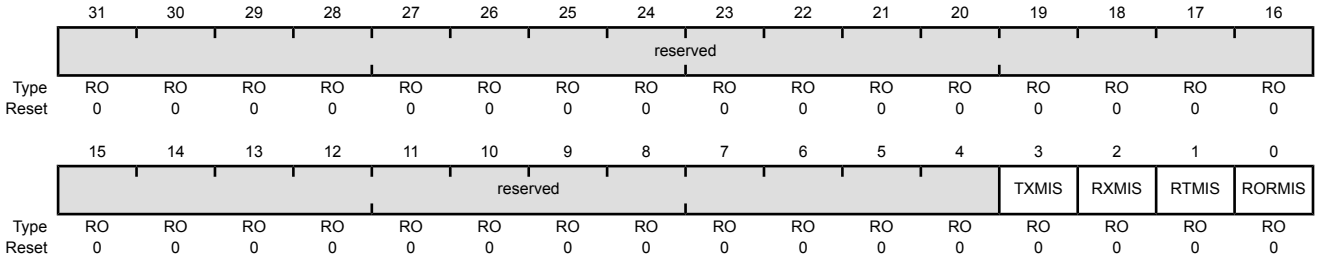

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | TXRIS | RO | 1 | SSI Transmit FIFO Raw Interrupt Status<br>Indicates that the transmit FIFO is half empty or less, when set. |
| 2 | RXRIS | RO | 0 | SSI Receive FIFO Raw Interrupt Status<br>Indicates that the receive FIFO is half full or more, when set. |
| 1 | RTRIS | RO | 0 | SSI Receive Time-Out Raw Interrupt Status<br>Indicates that the receive time-out has occurred, when set. |
| 0 | RORRIS | RO | 0 | SSI Receive Overrun Raw Interrupt Status<br>Indicates that the receive FIFO has overflowed, when set. |

## Register 8: SSI Masked Interrupt Status (SSIMIS), offset 0x01C

The **SSIMIS** register is the masked interrupt status register. On a read, this register gives the current masked status value of the corresponding interrupt. A write has no effect.

SSI Masked Interrupt Status (SSIMIS)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x01C
Type RO, reset 0x0000.0000



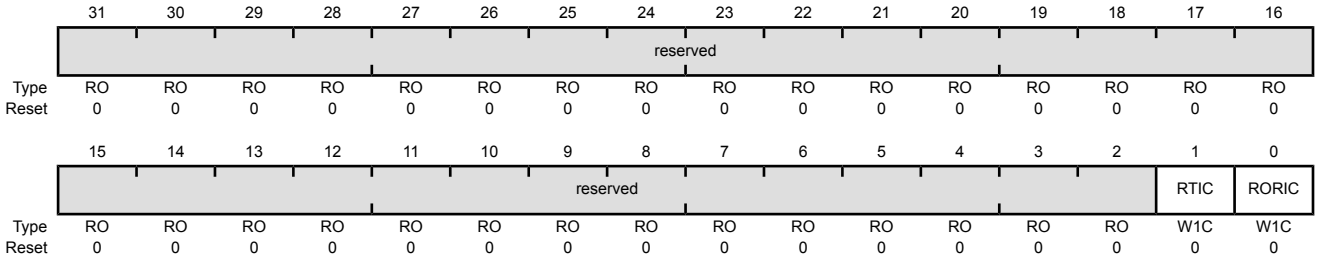

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | TXMIS | RO | 0 | SSI Transmit FIFO Masked Interrupt Status<br>Indicates that the transmit FIFO is half empty or less, when set. |
| 2 | RXMIS | RO | 0 | SSI Receive FIFO Masked Interrupt Status<br>Indicates that the receive FIFO is half full or more, when set. |
| 1 | RTMIS | RO | 0 | SSI Receive Time-Out Masked Interrupt Status<br>Indicates that the receive time-out has occurred, when set. |
| 0 | RORMIS | RO | 0 | SSI Receive Overrun Masked Interrupt Status<br>Indicates that the receive FIFO has overflowed, when set. |

## Register 9: SSI Interrupt Clear (SSIICR), offset 0x020

The **SSIICR** register is the interrupt clear register. On a write of 1, the corresponding interrupt is cleared. A write of 0 has no effect.

SSI Interrupt Clear (SSIICR)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0x020
Type W1C, reset 0x0000.0000



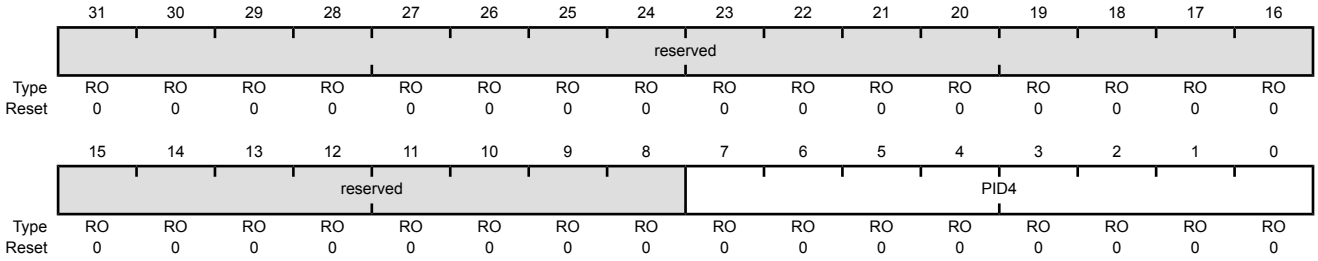

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | RTIC | W1C | 0 | SSI Receive Time-Out Interrupt Clear<br>The `RTIC` values are defined as follows:<br><br>Value Description<br>0 No effect on interrupt.<br>1 Clears interrupt. |
| 0 | RORIC | W1C | 0 | SSI Receive Overrun Interrupt Clear<br>The `RORIC` values are defined as follows:<br><br>Value Description<br>0 No effect on interrupt.<br>1 Clears interrupt. |

## Register 10: SSI Peripheral Identification 4 (SSIPeriphID4), offset 0xFD0

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 4 (SSIPeriphID4)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFD0
Type RO, reset 0x0000.0000



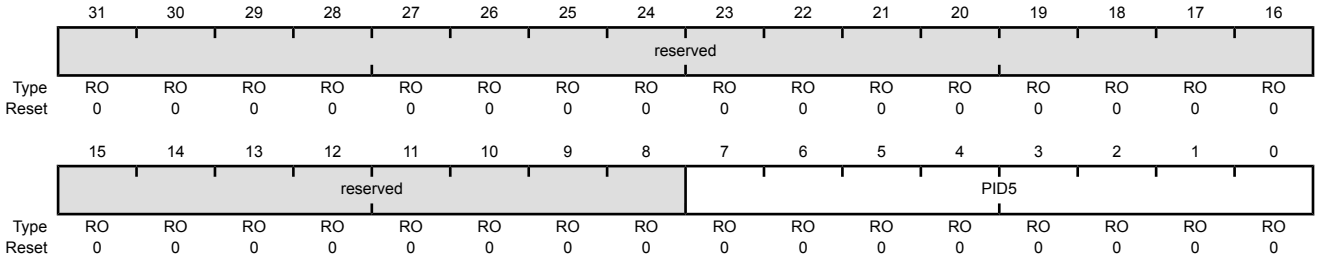

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID4 | RO | 0x00 | SSI Peripheral ID Register[7:0]<br>Can be used by software to identify the presence of this peripheral. |

## Register 11: SSI Peripheral Identification 5 (SSIPeriphID5), offset 0xFD4

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 5 (SSIPeriphID5)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFD4
Type RO, reset 0x0000.0000



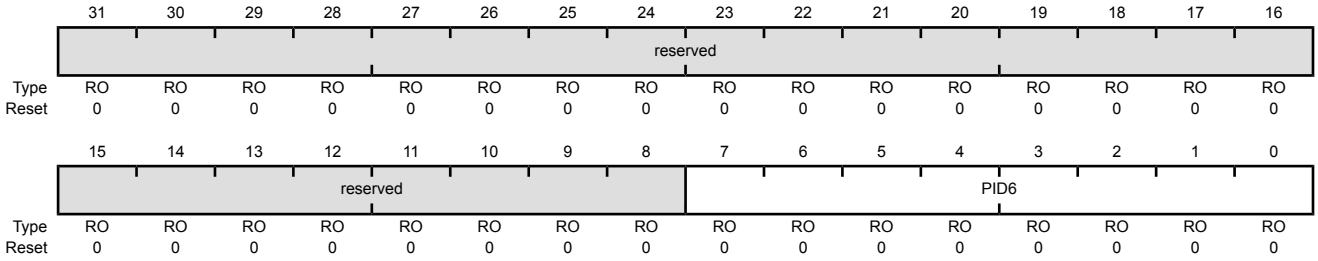

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID5 | RO | 0x00 | SSI Peripheral ID Register[15:8]<br>Can be used by software to identify the presence of this peripheral. |

## Register 12: SSI Peripheral Identification 6 (SSIPeriphID6), offset 0xFD8

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 6 (SSIPeriphID6)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFD8
Type RO, reset 0x0000.0000



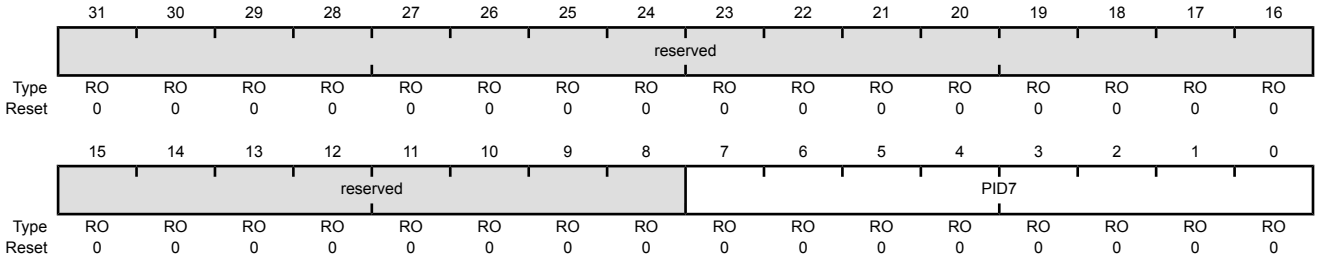

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID6 | RO | 0x00 | SSI Peripheral ID Register[23:16]<br>Can be used by software to identify the presence of this peripheral. |

## Register 13: SSI Peripheral Identification 7 (SSIPeriphID7), offset 0xFDC

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 7 (SSIPeriphID7)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFDC
Type RO, reset 0x0000.0000



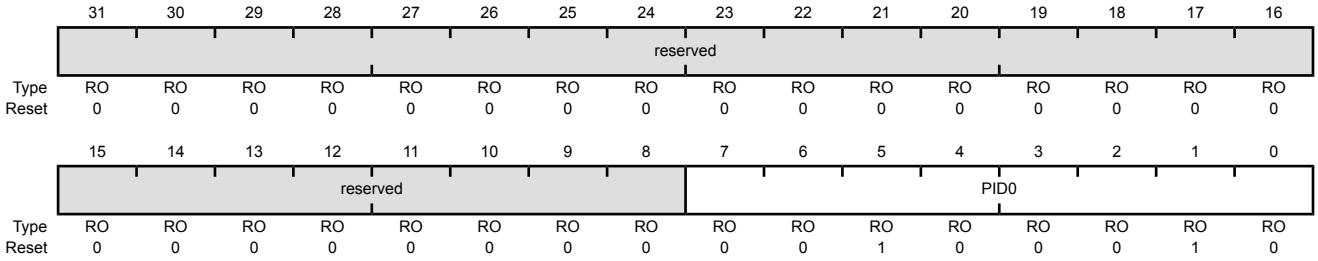

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID7 | RO | 0x00 | SSI Peripheral ID Register[31:24]<br>Can be used by software to identify the presence of this peripheral. |

## Register 14: SSI Peripheral Identification 0 (SSIPeriphID0), offset 0xFE0

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 0 (SSIPeriphID0)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFE0
Type RO, reset 0x0000.0022



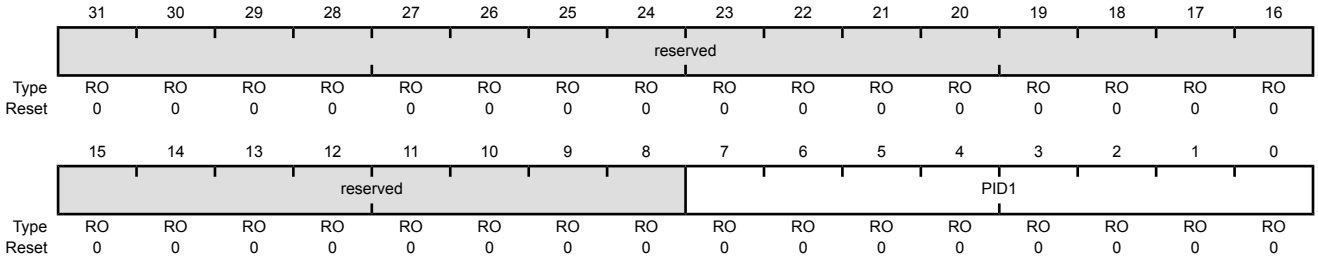

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID0 | RO | 0x22 | SSI Peripheral ID Register[7:0]<br>Can be used by software to identify the presence of this peripheral. |

## Register 15: SSI Peripheral Identification 1 (SSIPeriphID1), offset 0xFE4

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 1 (SSIPeriphID1)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFE4
Type RO, reset 0x0000.0000



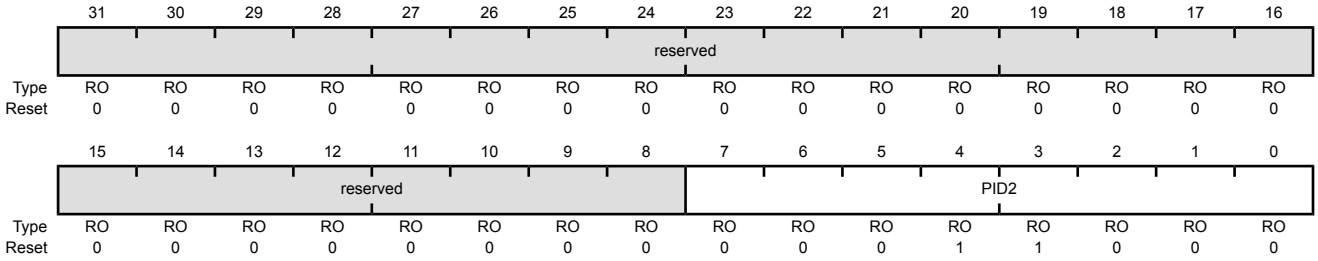

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID1 | RO | 0x00 | SSI Peripheral ID Register [15:8]<br>Can be used by software to identify the presence of this peripheral. |

## Register 16: SSI Peripheral Identification 2 (SSIPeriphID2), offset 0xFE8

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 2 (SSIPeriphID2)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFE8
Type RO, reset 0x0000.0018



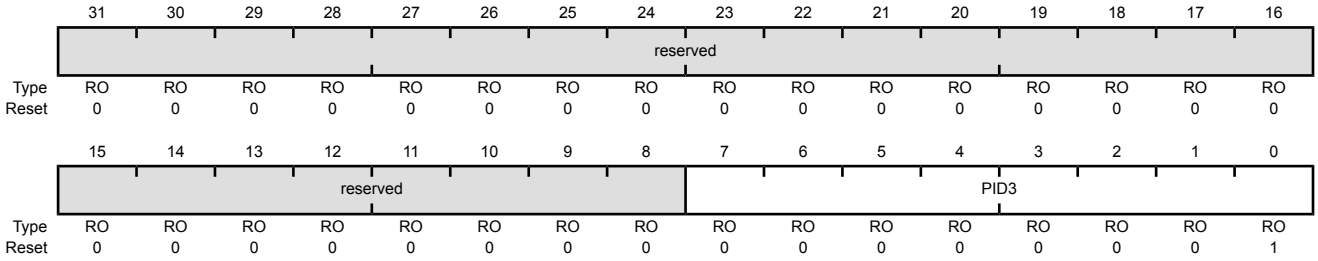

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID2 | RO | 0x18 | SSI Peripheral ID Register [23:16]<br>Can be used by software to identify the presence of this peripheral. |

## Register 17: SSI Peripheral Identification 3 (SSIPeriphID3), offset 0xFEC

The **SSIPeriphIDn** registers are hard-coded and the fields within the register determine the reset value.

SSI Peripheral Identification 3 (SSIPeriphID3)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFEC
Type RO, reset 0x0000.0001



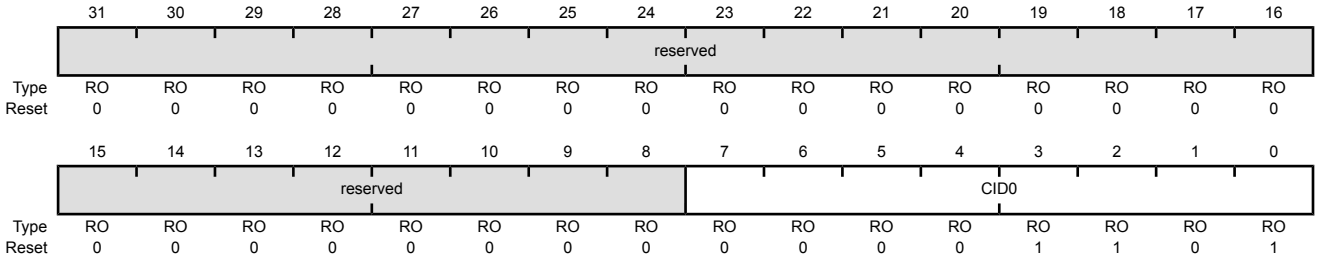

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | PID3 | RO | 0x01 | SSI Peripheral ID Register [31:24]<br>Can be used by software to identify the presence of this peripheral. |

## Register 18: SSI PrimeCell Identification 0 (SSIPCellID0), offset 0xFF0

The **SSIPCellIDn** registers are hard-coded, and the fields within the register determine the reset value.

SSI PrimeCell Identification 0 (SSIPCellID0)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFF0
Type RO, reset 0x0000.000D



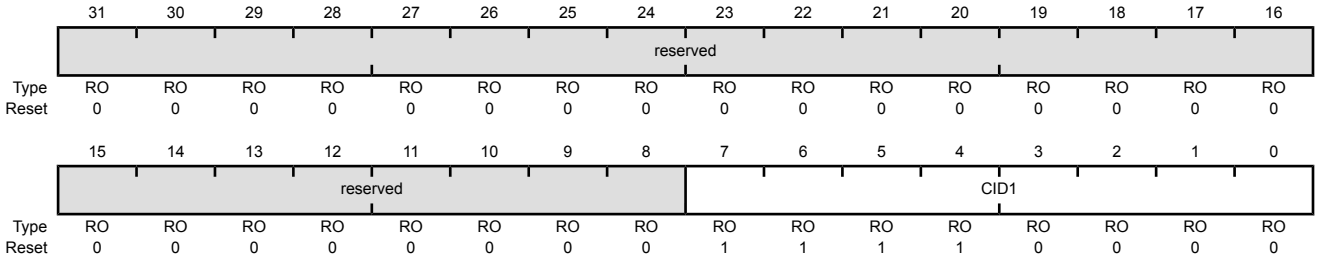

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID0 | RO | 0x0D | SSI PrimeCell ID Register [7:0]<br>Provides software a standard cross-peripheral identification system. |

## Register 19: SSI PrimeCell Identification 1 (SSIPCellID1), offset 0xFF4

The **SSIPCellIDn** registers are hard-coded, and the fields within the register determine the reset value.

SSI PrimeCell Identification 1 (SSIPCellID1)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFF4
Type RO, reset 0x0000.00F0



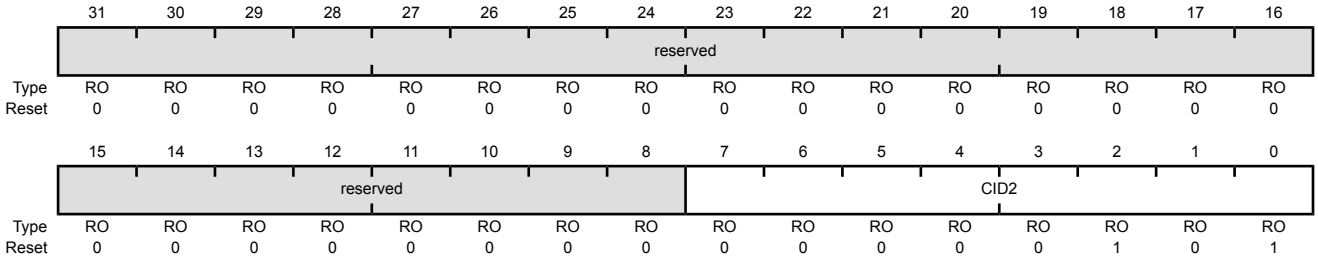

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID1 | RO | 0xF0 | SSI PrimeCell ID Register [15:8]<br>Provides software a standard cross-peripheral identification system. |

## Register 20: SSI PrimeCell Identification 2 (SSIPCellID2), offset 0xFF8

The **SSIPCellIDn** registers are hard-coded, and the fields within the register determine the reset value.

SSI PrimeCell Identification 2 (SSIPCellID2)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFF8
Type RO, reset 0x0000.0005



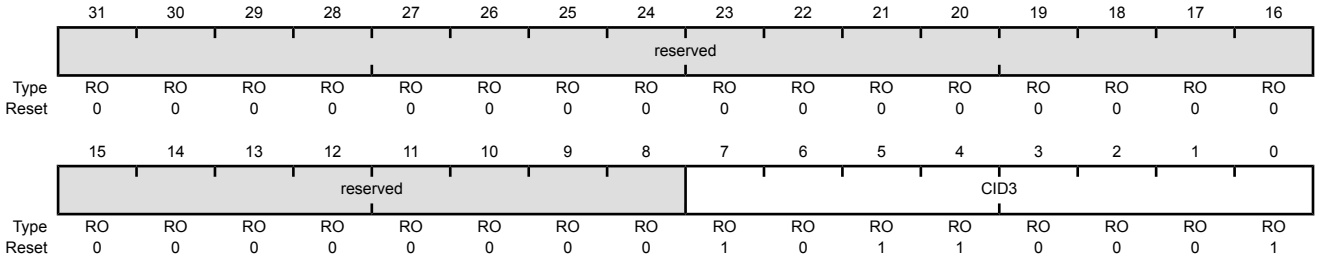

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID2 | RO | 0x05 | SSI PrimeCell ID Register [23:16]<br>Provides software a standard cross-peripheral identification system. |

## Register 21: SSI PrimeCell Identification 3 (SSIPCellID3), offset 0xFFC

The **SSIPCellIDn** registers are hard-coded, and the fields within the register determine the reset value.

SSI PrimeCell Identification 3 (SSIPCellID3)

SSI0 base: 0x4000.8000
SSI1 base: 0x4000.9000
Offset 0xFFC
Type RO, reset 0x0000.00B1




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | CID3 | RO | 0xB1 | SSI PrimeCell ID Register [31:24]<br>Provides software a standard cross-peripheral identification system. |

# 13 Inter-Integrated Circuit ($I^2C$) Interface

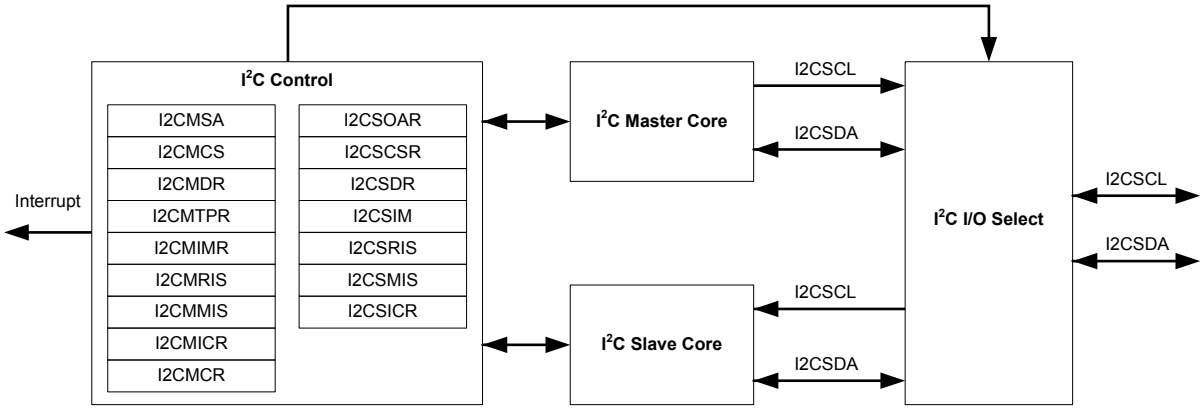
The Inter-Integrated Circuit ($I^2C$) bus provides bi-directional data transfer through a two-wire design (a serial data line SDA and a serial clock line SCL), and interfaces to external $I^2C$ devices such as serial memory (RAMs and ROMs), networking devices, LCDs, tone generators, and so on. The $I^2C$ bus may also be used for system testing and diagnostic purposes in product development and manufacture. The LM3S1960 microcontroller includes two $I^2C$ modules, providing the ability to interact (both send and receive) with other $I^2C$ devices on the bus.

The Stellaris® $I^2C$ interface has the following features:

- Two $I^2C$ modules, each with the following features:
- Devices on the $I^2C$ bus can be designated as either a master or a slave
  - Supports both sending and receiving data as either a master or a slave
  - Supports simultaneous master and slave operation
- Four $I^2C$ modes
  - Master transmit
  - Master receive
  - Slave transmit
  - Slave receive
- Two transmission speeds: Standard (100 Kbps) and Fast (400 Kbps)
- Master and slave interrupt generation
  - Master generates interrupts when a transmit or receive operation completes (or aborts due to an error)
  - Slave generates interrupts when data has been sent or requested by a master
- Master with arbitration and clock synchronization, multimaster support, and 7-bit addressing mode

## 13.1 Block Diagram

**Figure 13-1. I²C Block Diagram**




## 13.2 Signal Description

Table 13-1 on page 471 and Table 13-2 on page 471 list the external signals of the I²C interface and describe the function of each. The I²C interface signals are alternate functions for some GPIO signals and default to be GPIO signals at reset., with the exception of the I2C0SCL and I2CSDA pins which default to the I²C function. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for the I²C signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the I²C function. Note that the I²C pins should be set to open drain using the **GPIO Open Drain Select (GPIOODR)** register. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 13-1. I2C Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| I2C0SCL | 70 | I/O | OD | I²C module 0 clock. |
| I2C0SDA | 71 | I/O | OD | I²C module 0 data. |
| I2C1SCL | 34 | I/O | OD | I²C module 1 clock. |
| I2C1SDA | 35 | I/O | OD | I²C module 1 data. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 13-2. I2C Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| I2C0SCL | C11 | I/O | OD | I²C module 0 clock. |
| I2C0SDA | C12 | I/O | OD | I²C module 0 data. |
| I2C1SCL | L6 | I/O | OD | I²C module 1 clock. |
| I2C1SDA | M6 | I/O | OD | I²C module 1 data. |

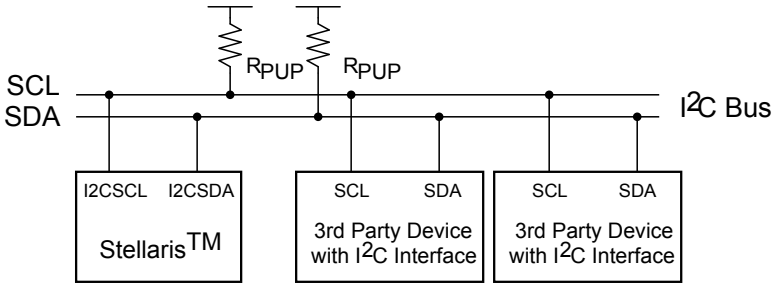
a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 13.3 Functional Description

Each I2C module is comprised of both master and slave functions which are implemented as separate peripherals. For proper operation, the SDA and SCL pins must be connected to bi-directional open-drain pads. A typical I2C bus configuration is shown in Figure 13-2 on page 472.

See "Inter-Integrated Circuit (I2C) Interface" on page 620 for I2C timing diagrams.

**Figure 13-2. I2C Bus Configuration**




### 13.3.1 I2C Bus Functional Overview

The I2C bus uses only two signals: SDA and SCL, named `I2CSDA` and `I2CSCL` on Stellaris microcontrollers. SDA is the bi-directional serial data line and SCL is the bi-directional serial clock line. The bus is considered idle when both lines are High.

Every transaction on the I2C bus is nine bits long, consisting of eight data bits and a single acknowledge bit. The number of bytes per transfer (defined as the time between a valid START and STOP condition, described in "START and STOP Conditions" on page 472) is unrestricted, but each byte has to be followed by an acknowledge bit, and data must be transferred MSB first. When a receiver cannot receive another complete byte, it can hold the clock line SCL Low and force the transmitter into a wait state. The data transfer continues when the receiver releases the clock SCL.

#### 13.3.1.1 START and STOP Conditions

The protocol of the I2C bus defines two states to begin and end a transaction: START and STOP. A High-to-Low transition on the SDA line while the SCL is High is defined as a START condition, and a Low-to-High transition on the SDA line while SCL is High is defined as a STOP condition. The bus is considered busy after a START condition and free after a STOP condition. See Figure 13-3 on page 472.

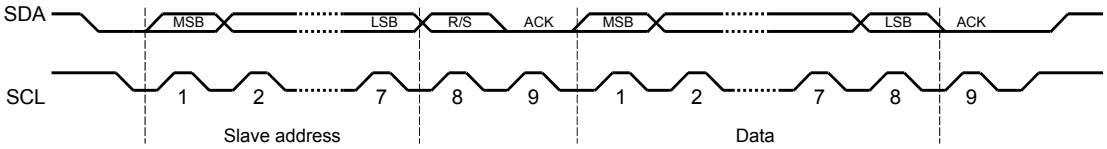
**Figure 13-3. START and STOP Conditions**

#### 13.3.1.2 Data Format with 7-Bit Address

Data transfers follow the format shown in Figure 13-4 on page 473. After the START condition, a slave address is sent. This address is 7-bits long followed by an eighth bit, which is a data direction bit (`R/S` bit in the **I2CMSA** register). A zero indicates a transmit operation (send), and a one indicates

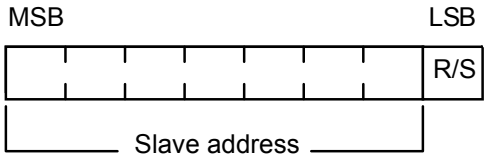
a request for data (receive). A data transfer is always terminated by a STOP condition generated by the master, however, a master can initiate communications with another device on the bus by generating a repeated START condition and addressing another slave without first generating a STOP condition. Various combinations of receive/send formats are then possible within a single transfer.

**Figure 13-4. Complete Data Transfer with a 7-Bit Address**




The first seven bits of the first byte make up the slave address (see Figure 13-5 on page 473). The eighth bit determines the direction of the message. A zero in the R/S position of the first byte means that the master will write (send) data to the selected slave, and a one in this position means that the master will receive data from the slave.

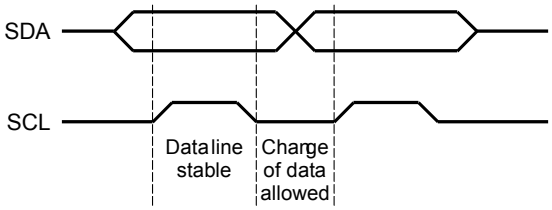
**Figure 13-5. R/S Bit in First Byte**




### 13.3.1.3 Data Validity

The data on the SDA line must be stable during the high period of the clock, and the data line can only change when SCL is Low (see Figure 13-6 on page 473).

**Figure 13-6. Data Validity During Bit Transfer on the I$^2$C Bus**




### 13.3.1.4 Acknowledge

All bus transactions have a required acknowledge clock cycle that is generated by the master. During the acknowledge cycle, the transmitter (which can be the master or slave) releases the SDA line. To acknowledge the transaction, the receiver must pull down SDA during the acknowledge clock cycle. The data sent out by the receiver during the acknowledge cycle must comply with the data validity requirements described in “Data Validity” on page 473.

When a slave receiver does not acknowledge the slave address, SDA must be left High by the slave so that the master can generate a STOP condition and abort the current transfer. If the master device is acting as a receiver during a transfer, it is responsible for acknowledging each transfer made by the slave. Since the master controls the number of bytes in the transfer, it signals the end of data to the slave transmitter by not generating an acknowledge on the last data byte. The slave

transmitter must then release SDA to allow the master to generate the STOP or a repeated START condition.

#### 13.3.1.5 Arbitration

A master may start a transfer only if the bus is idle. It's possible for two or more masters to generate a START condition within minimum hold time of the START condition. In these situations, an arbitration scheme takes place on the SDA line, while SCL is High. During arbitration, the first of the competing master devices to place a '1' (High) on SDA while another master transmits a '0' (Low) will switch off its data output stage and retire until the bus is idle again.

Arbitration can take place over several bits. Its first stage is a comparison of address bits, and if both masters are trying to address the same device, arbitration continues on to the comparison of data bits.

### 13.3.2 Available Speed Modes

The I2C clock rate is determined by the parameters: CLK_PRD, TIMER_PRD, SCL_LP, and SCL_HP.

where:

CLK_PRD is the system clock period

SCL_LP is the low phase of SCL (fixed at 6)

SCL_HP is the high phase of SCL (fixed at 4)

TIMER_PRD is the programmed value in the **I2C Master Timer Period (I2CMTPR)** register (see page 492).

The I2C clock period is calculated as follows:

```
SCL_PERIOD = 2*(1 + TIMER_PRD)*(SCL_LP + SCL_HP)*CLK_PRD
```

For example:

```
CLK_PRD = 50 ns
TIMER_PRD = 2
SCL_LP=6
SCL_HP=4
```

yields a SCL frequency of:

```
1/T = 333 Khz
```

Table 13-3 on page 474 gives examples of timer period, system clock, and speed mode (Standard or Fast).

**Table 13-3. Examples of I2C Master Timer Period versus Speed Mode**

| System Clock | Timer Period | Standard Mode | Timer Period | Fast Mode |
|---|---|---|---|---|
| 4 MHz | 0x01 | 100 Kbps | - | - |
| 6 MHz | 0x02 | 100 Kbps | - | - |
| 12.5 MHz | 0x06 | 89 Kbps | 0x01 | 312 Kbps |
| 16.7 MHz | 0x08 | 93 Kbps | 0x02 | 278 Kbps |
| 20 MHz | 0x09 | 100 Kbps | 0x02 | 333 Kbps |
| 25 MHz | 0x0C | 96.2 Kbps | 0x03 | 312 Kbps |

**Table 13-3. Examples of I²C Master Timer Period versus Speed Mode *(continued)***

| System Clock | Timer Period | Standard Mode | Timer Period | Fast Mode |
|---|---|---|---|---|
| 33 MHz | 0x10 | 97.1 Kbps | 0x04 | 330 Kbps |
| 40 MHz | 0x13 | 100 Kbps | 0x04 | 400 Kbps |
| 50 MHz | 0x18 | 100 Kbps | 0x06 | 357 Kbps |

### 13.3.3 Interrupts

The I²C can generate interrupts when the following conditions are observed:

- Master transaction completed
- Master arbitration lost
- Master transaction error
- Slave transaction received
- Slave transaction requested

There is a separate interrupt signal for the I²C master and I²C slave modules. While both modules can generate interrupts for multiple conditions, only a single interrupt signal is sent to the interrupt controller.

#### 13.3.3.1 I²C Master Interrupts

The I²C master module generates an interrupt when a transaction completes (either transmit or receive), when arbitration is lost, or when an error occurs during a transaction. To enable the I²C master interrupt, software must set the IM bit in the **I²C Master Interrupt Mask (I2CMIMR)** register. When an interrupt condition is met, software must check the ERROR and ARBLST bits in the **I²C Master Control/Status (I2CMCS)** register to verify that an error didn't occur during the last transaction and to ensure that arbitration has not been lost. An error condition is asserted if the last transaction wasn't acknowledged by the slave. If an error is not detected and the master has not lost arbitration, the application can proceed with the transfer. The interrupt is cleared by writing a 1 to the IC bit in the **I²C Master Interrupt Clear (I2CMICR)** register.

If the application doesn't require the use of interrupts, the raw interrupt status is always visible via the **I²C Master Raw Interrupt Status (I2CMRIS)** register.

#### 13.3.3.2 I²C Slave Interrupts

The slave module can generate an interrupt when data has been received or requested. This interrupt is enabled by writing a 1 to the DATAIM bit in the **I²C Slave Interrupt Mask (I2CSIMR)** register. Software determines whether the module should write (transmit) or read (receive) data from the **I²C Slave Data (I2CSDR)** register, by checking the RREQ and TREQ bits of the **I²C Slave Control/Status (I2CSCSR)** register. If the slave module is in receive mode and the first byte of a transfer is received, the FBR bit is set along with the RREQ bit. The interrupt is cleared by writing a 1 to the DATAIC bit in the **I²C Slave Interrupt Clear (I2CSICR)** register.

If the application doesn't require the use of interrupts, the raw interrupt status is always visible via the **I²C Slave Raw Interrupt Status (I2CSRIS)** register.

### 13.3.4 Loopback Operation

The I2C modules can be placed into an internal loopback mode for diagnostic or debug work. This is accomplished by setting the LPBK bit in the **I2C Master Configuration (I2CMCR)** register. In loopback mode, the SDA and SCL signals from the master and slave modules are tied together.

### 13.3.5 Command Sequence Flow Charts

This section details the steps required to perform the various I2C transfer types in both master and slave mode.

#### 13.3.5.1 I2C Master Command Sequences

The figures that follow show the command sequences available for the I2C master.

**Figure 13-7. Master Single SEND**

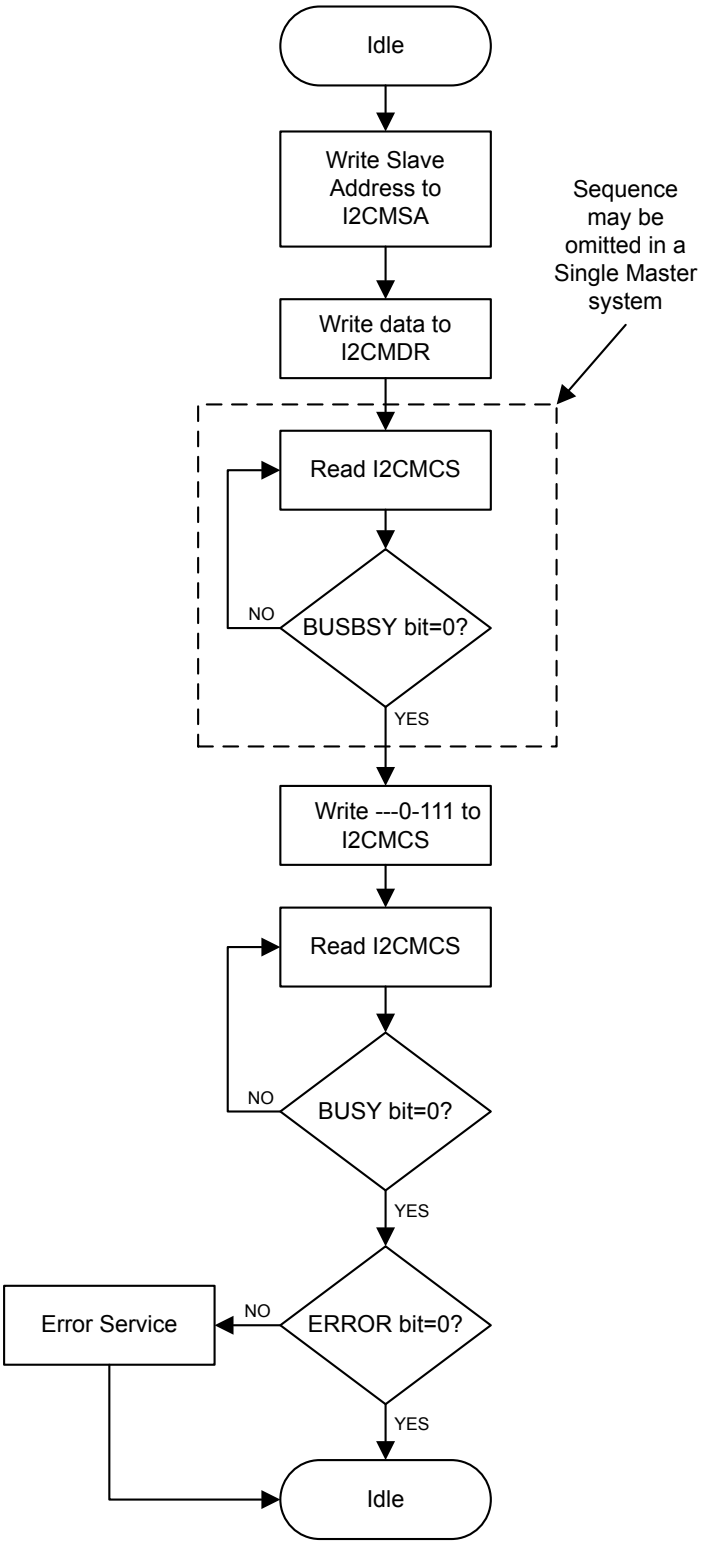


**Figure 13-8. Master Single RECEIVE**

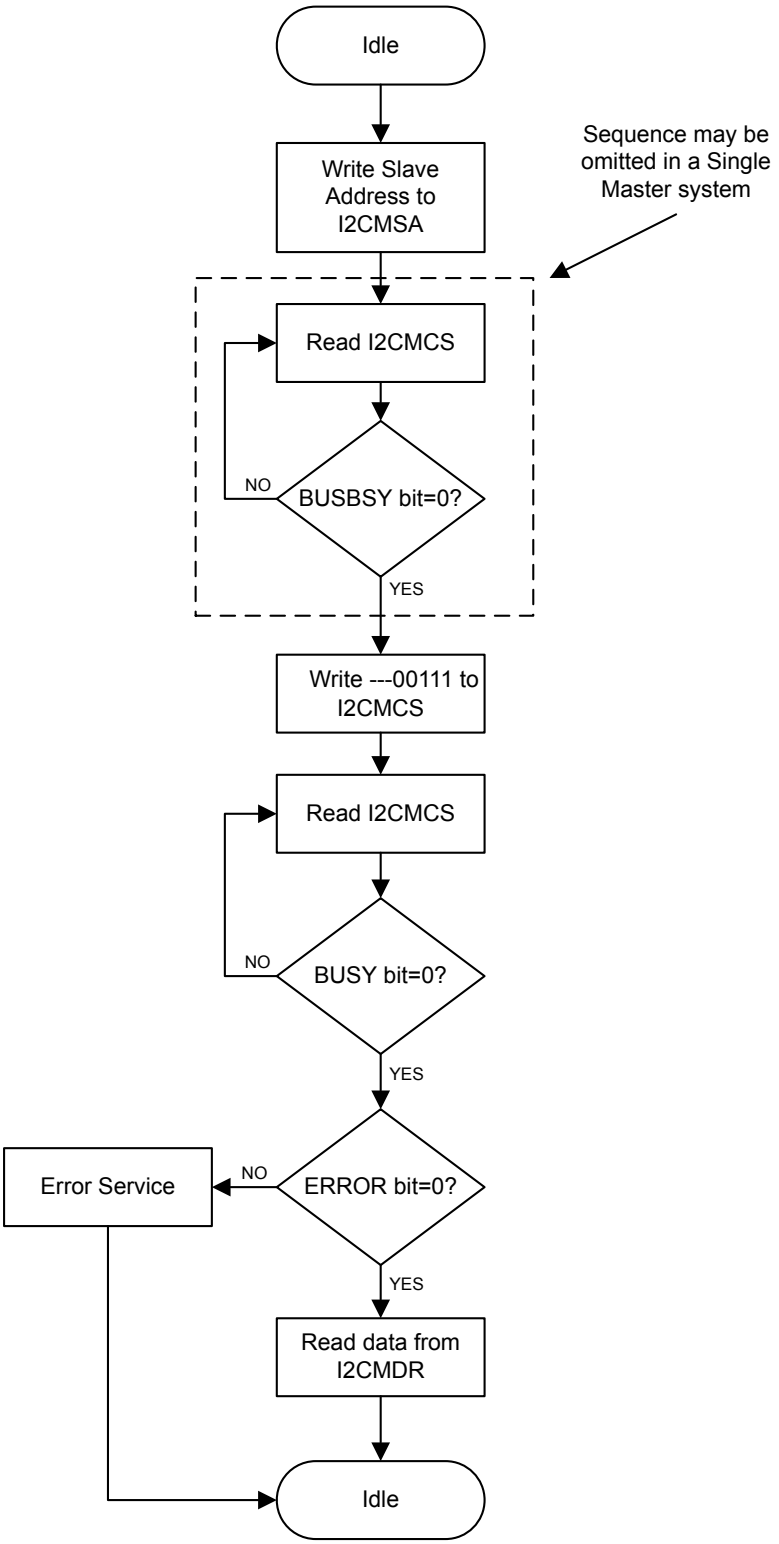


**Figure 13-9. Master Burst SEND**

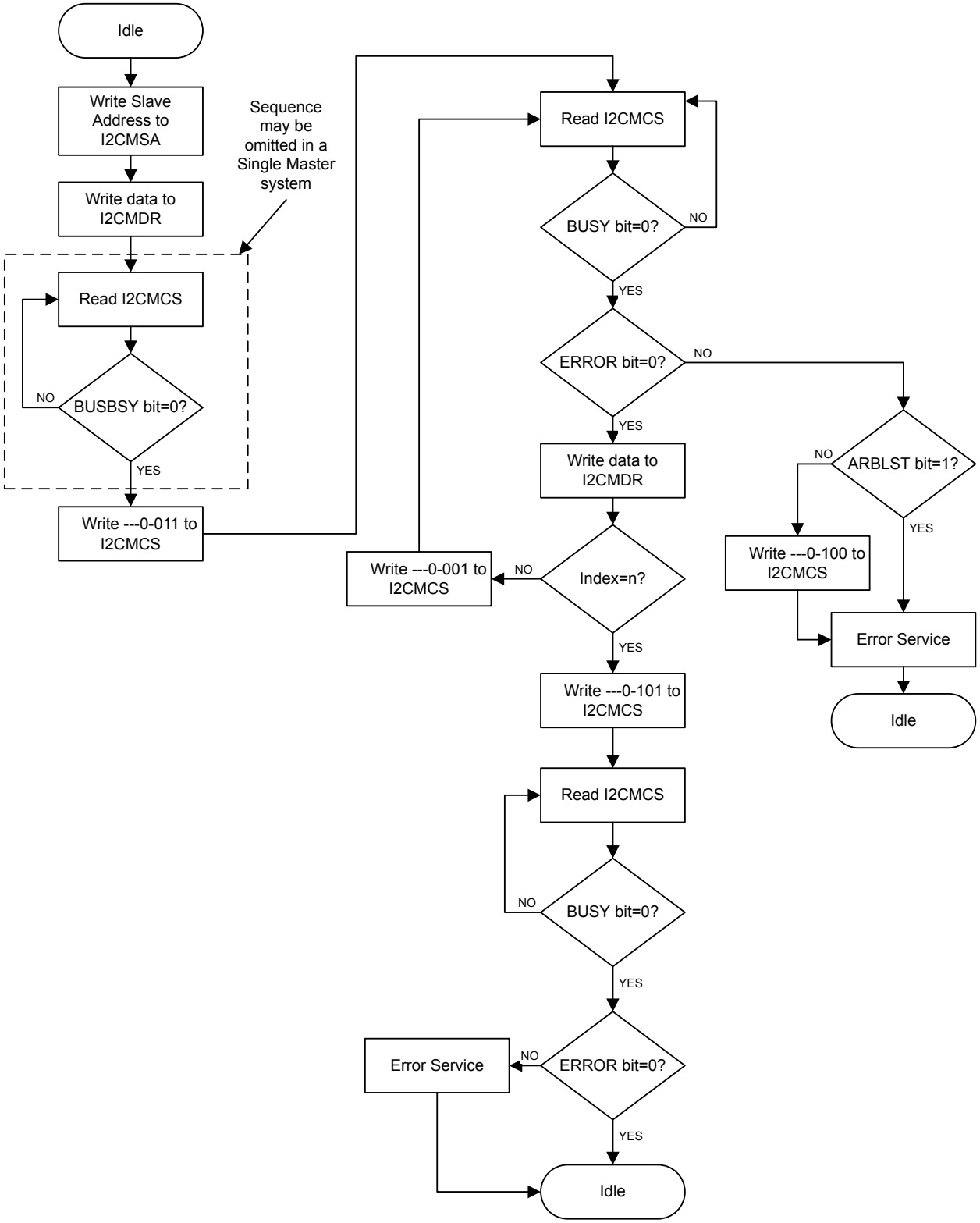


**Figure 13-10. Master Burst RECEIVE**

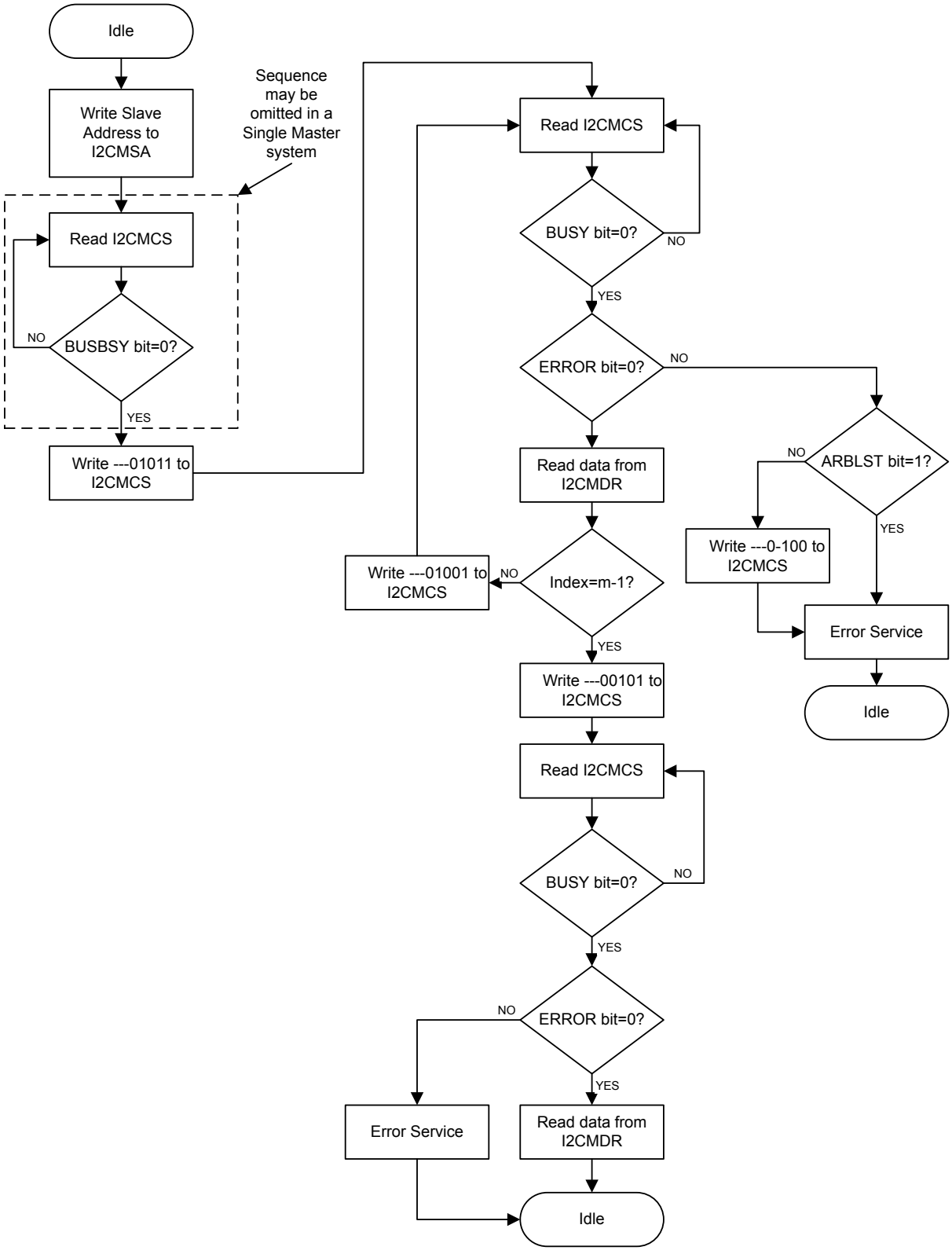


**Figure 13-11. Master Burst RECEIVE after Burst SEND**

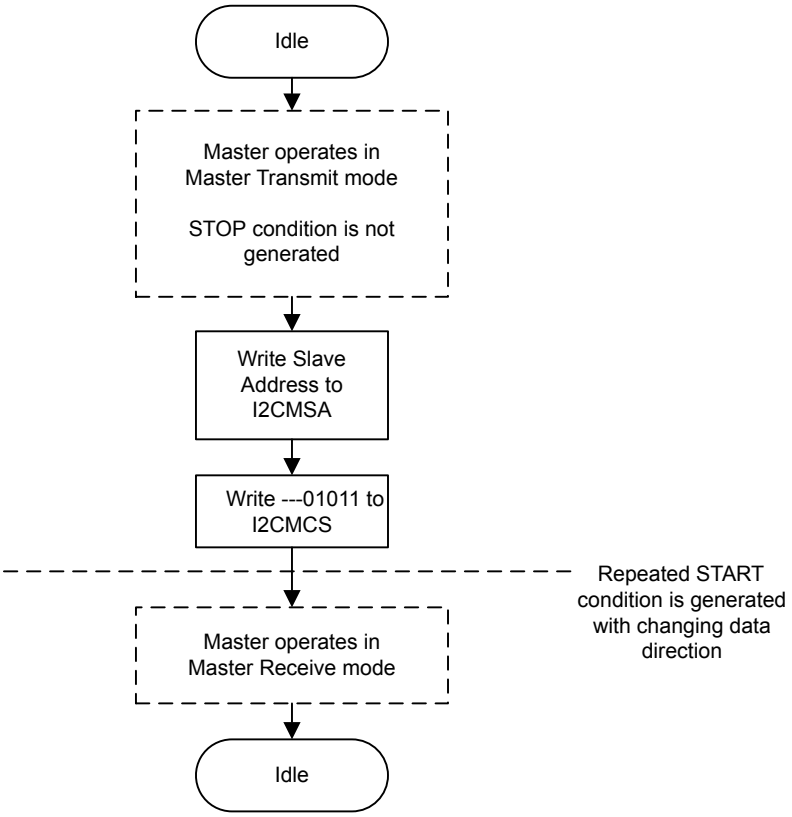
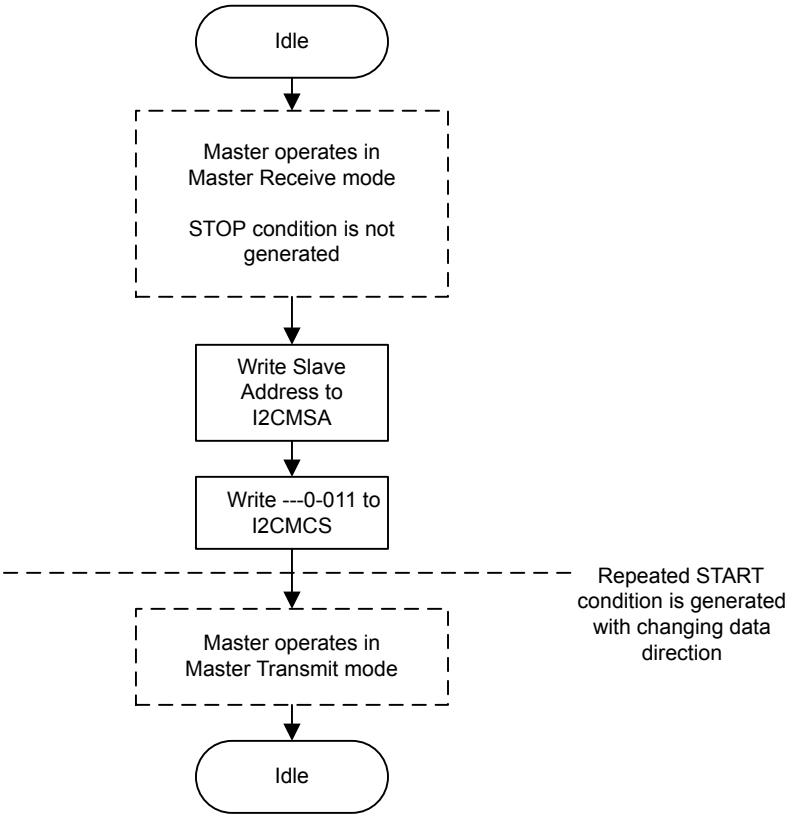


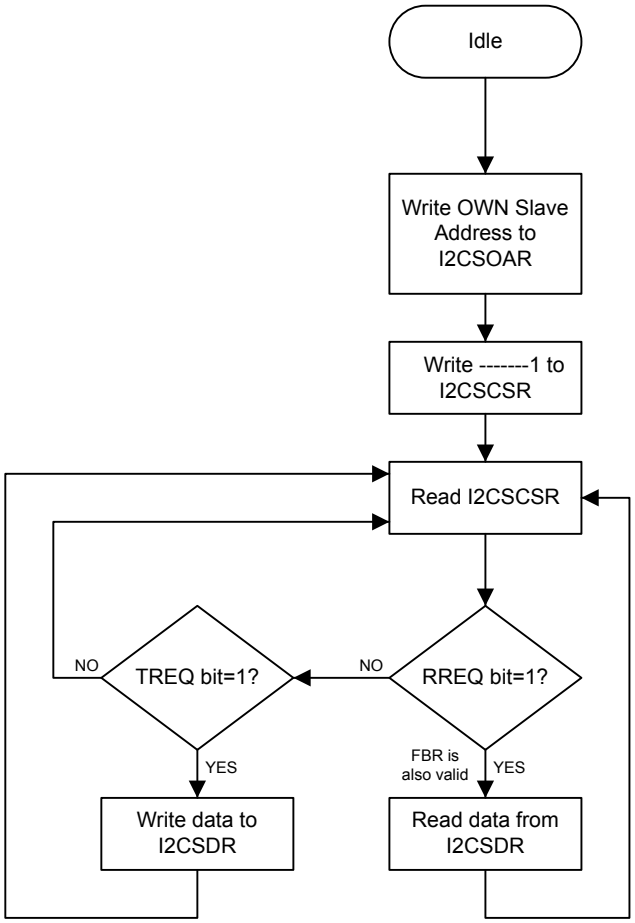
**Figure 13-12. Master Burst SEND after Burst RECEIVE**




### 13.3.5.2 I2C Slave Command Sequences

Figure 13-13 on page 483 presents the command sequence available for the I2C slave.

**Figure 13-13. Slave Command Sequence**




## 13.4 Initialization and Configuration

The following example shows how to configure the $I^2C$ module to send a single byte as a master. This assumes the system clock is 20 MHz.

1. Enable the $I^2C$ clock by writing a value of 0x0000.1000 to the **RCGC1** register in the System Control module.
2. Enable the clock to the appropriate GPIO module via the **RCGC2** register in the System Control module.
3. In the GPIO module, enable the appropriate pins for their alternate function using the **GPIOAFSEL** register. Also, be sure to enable the same pins for Open Drain operation.
4. Initialize the $I^2C$ Master by writing the **I2CMCR** register with a value of 0x0000.0020.
5. Set the desired SCL clock speed of 100 Kbps by writing the **I2CMTPR** register with the correct value. The value written to the **I2CMTPR** register represents the number of system clock periods in one SCL clock period. The TPR value is determined by the following equation:

```
TPR = (System Clock / (2 * (SCL_LP + SCL_HP) * SCL_CLK)) - 1;
TPR = (20MHz / (2 * (6 + 4) * 100000)) - 1;
TPR = 9
```

Write the **I2CMTPR** register with the value of 0x0000.0009.

6. Specify the slave address of the master and that the next operation will be a Send by writing the **I2CMSA** register with a value of 0x0000.0076. This sets the slave address to 0x3B.
7. Place data (byte) to be sent in the data register by writing the **I2CMDR** register with the desired data.
8. Initiate a single byte send of the data from Master to Slave by writing the **I2CMCS** register with a value of 0x0000.0007 (STOP, START, RUN).
9. Wait until the transmission completes by polling the **I2CMCS** register's BUSBSY bit until it has been cleared.

## 13.5 Register Map

Table 13-4 on page 484 lists the I2C registers. All addresses given are relative to the I2C base addresses for the master and slave:

- I2C 0: 0x4002.0000
- I2C 1: 0x4002.1000

Note that the I2C module clock must be enabled before the registers can be programmed (see page 214). There must be a delay of 3 system clocks after the I2C module clock is enabled before any I2C module registers are accessed.

The hw_i2c.h file in the StellarisWare® Driver Library uses a base address of 0x800 for the I2C slave registers. Be aware when using registers with offsets between 0x800 and 0x818 that StellarisWare uses an offset between 0x000 and 0x018 with the slave base address.

**Table 13-4. Inter-Integrated Circuit (I2C) Interface Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| **I2C Master** | | | | | |
| 0x000 | I2CMSA | R/W | 0x0000.0000 | I2C Master Slave Address | 486 |
| 0x004 | I2CMCS | R/W | 0x0000.0000 | I2C Master Control/Status | 487 |
| 0x008 | I2CMDR | R/W | 0x0000.0000 | I2C Master Data | 491 |
| 0x00C | I2CMTPR | R/W | 0x0000.0001 | I2C Master Timer Period | 492 |
| 0x010 | I2CMIMR | R/W | 0x0000.0000 | I2C Master Interrupt Mask | 493 |
| 0x014 | I2CMRIS | RO | 0x0000.0000 | I2C Master Raw Interrupt Status | 494 |
| 0x018 | I2CMMIS | RO | 0x0000.0000 | I2C Master Masked Interrupt Status | 495 |
| 0x01C | I2CMICR | WO | 0x0000.0000 | I2C Master Interrupt Clear | 496 |
| 0x020 | I2CMCR | R/W | 0x0000.0000 | I2C Master Configuration | 497 |

**Table 13-4. Inter-Integrated Circuit ($I^2C$) Interface Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| **$I^2C$ Slave** | | | | | |
| 0x800 | I2CSOAR | R/W | 0x0000.0000 | I2C Slave Own Address | 499 |
| 0x804 | I2CSCSR | RO | 0x0000.0000 | I2C Slave Control/Status | 500 |
| 0x808 | I2CSDR | R/W | 0x0000.0000 | I2C Slave Data | 502 |
| 0x80C | I2CSIMR | R/W | 0x0000.0000 | I2C Slave Interrupt Mask | 503 |
| 0x810 | I2CSRIS | RO | 0x0000.0000 | I2C Slave Raw Interrupt Status | 504 |
| 0x814 | I2CSMIS | RO | 0x0000.0000 | I2C Slave Masked Interrupt Status | 505 |
| 0x818 | I2CSICR | WO | 0x0000.0000 | I2C Slave Interrupt Clear | 506 |

## 13.6 Register Descriptions ($I^2C$ Master)

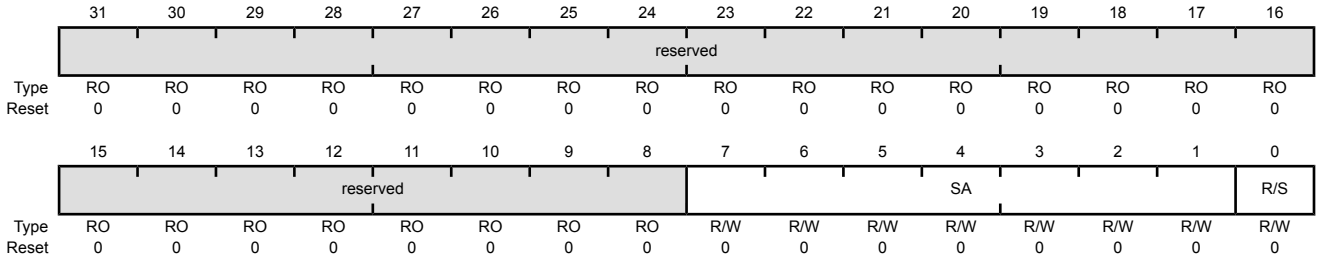
The remainder of this section lists and describes the $I^2C$ master registers, in numerical order by address offset. See also “Register Descriptions ($I^2C$ Slave)” on page 498.

## Register 1: I2C Master Slave Address (I2CMSA), offset 0x000

This register consists of eight bits: seven address bits (A6-A0), and a Receive/Send bit, which determines if the next operation is a Receive (High), or Send (Low).

I2C Master Slave Address (I2CMSA)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x000
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:1 | SA | R/W | 0 | I2C Slave Address<br>This field specifies bits A6 through A0 of the slave address. |
| 0 | R/S | R/W | 0 | Receive/Send<br>The R/S bit specifies if the next operation is a Receive (High) or Send (Low).<br><br>Value Description<br>0 Send.<br>1 Receive. |

## Register 2: I²C Master Control/Status (I2CMCS), offset 0x004

This register accesses four control bits when written, and accesses seven status bits when read.

The status register consists of seven bits, which when read determine the state of the I²C bus controller.

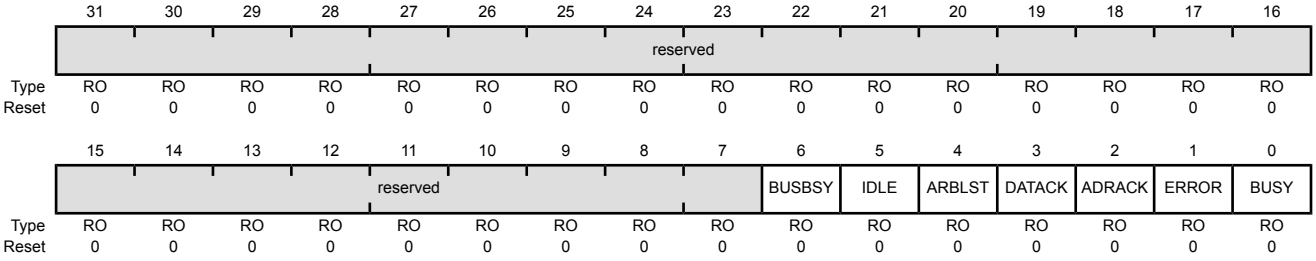
The control register consists of four bits: the RUN, START, STOP, and ACK bits. The START bit causes the generation of the START, or REPEATED START condition.

The STOP bit determines if the cycle stops at the end of the data cycle, or continues on to a burst. To generate a single send cycle, the **I²C Master Slave Address (I2CMSA)** register is written with the desired address, the R/S bit is set to 0, and the Control register is written with ACK=X (0 or 1), STOP=1, START=1, and RUN=1 to perform the operation and stop. When the operation is completed (or aborted due an error), the interrupt pin becomes active and the data may be read from the **I2CMDR** register. When the I²C module operates in Master receiver mode, the ACK bit must be set normally to logic 1. This causes the I²C bus controller to send an acknowledge automatically after each byte. This bit must be reset when the I²C bus controller requires no further data to be sent from the slave transmitter.

### Reads

I2C Master Control/Status (I2CMCS)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x004
Type RO, reset 0x0000.0000



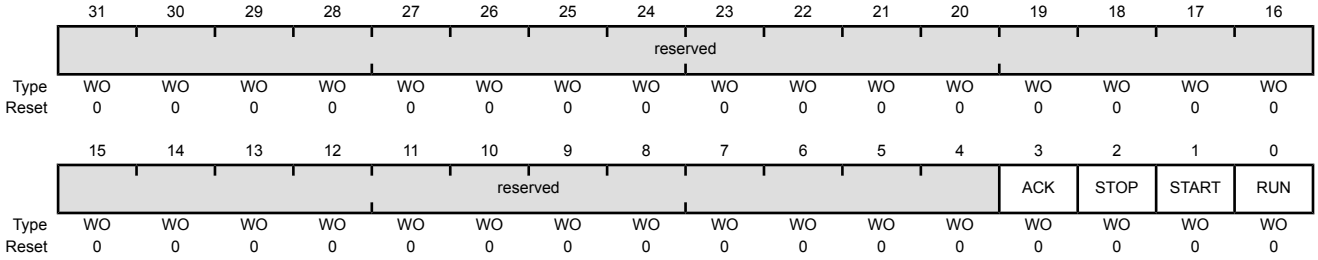

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:7 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6 | BUSBSY | RO | 0 | Bus Busy<br>This bit specifies the state of the I²C bus. If set, the bus is busy; otherwise, the bus is idle. The bit changes based on the START and STOP conditions. |
| 5 | IDLE | RO | 0 | I²C Idle<br>This bit specifies the I²C controller state. If set, the controller is idle; otherwise the controller is not idle. |
| 4 | ARBLST | RO | 0 | Arbitration Lost<br>This bit specifies the result of bus arbitration. If set, the controller lost arbitration; otherwise, the controller won arbitration. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | DATACK | RO | 0 | Acknowledge Data<br>This bit specifies the result of the last data operation. If set, the transmitted data was not acknowledged; otherwise, the data was acknowledged. |
| 2 | ADRACK | RO | 0 | Acknowledge Address<br>This bit specifies the result of the last address operation. If set, the transmitted address was not acknowledged; otherwise, the address was acknowledged. |
| 1 | ERROR | RO | 0 | Error<br>This bit specifies the result of the last bus operation. If set, an error occurred on the last operation; otherwise, no error was detected. The error can be from the slave address not being acknowledged or the transmit data not being acknowledged. |
| 0 | BUSY | RO | 0 | I2C Busy<br>This bit specifies the state of the controller. If set, the controller is busy; otherwise, the controller is idle. When the BUSY bit is set, the other status bits are not valid. |

## Writes

I2C Master Control/Status (I2CMCS)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x004
Type WO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | WO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | ACK | WO | 0 | Data Acknowledge Enable<br>When set, causes received data byte to be acknowledged automatically by the master. See field decoding in Table 13-5 on page 489. |
| 2 | STOP | WO | 0 | Generate STOP<br>When set, causes the generation of the STOP condition. See field decoding in Table 13-5 on page 489. |
| 1 | START | WO | 0 | Generate START<br>When set, causes the generation of a START or repeated START condition. See field decoding in Table 13-5 on page 489. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 0 | RUN | WO | 0 | I²C Master Enable<br>When set, allows the master to send or receive data. See field decoding in Table 13-5 on page 489. |

**Table 13-5. Write Field Decoding for I2CMCS[3:0] Field (Sheet 1 of 3)**

| Current State | I2CMSA[0] | I2CMCS[3:0] | | | | Description |
|---|---|---|---|---|---|---|
| | R/S | ACK | STOP | START | RUN | |
| Idle | 0 | X[a] | 0 | 1 | 1 | START condition followed by SEND (master goes to the Master Transmit state). |
| | 0 | X | 1 | 1 | 1 | START condition followed by a SEND and STOP condition (master remains in Idle state). |
| | 1 | 0 | 0 | 1 | 1 | START condition followed by RECEIVE operation with negative ACK (master goes to the Master Receive state). |
| | 1 | 0 | 1 | 1 | 1 | START condition followed by RECEIVE and STOP condition (master remains in Idle state). |
| | 1 | 1 | 0 | 1 | 1 | START condition followed by RECEIVE (master goes to the Master Receive state). |
| | 1 | 1 | 1 | 1 | 1 | Illegal. |
| | All other combinations not listed are non-operations. | | | | | NOP. |
| Master Transmit | X | X | 0 | 0 | 1 | SEND operation (master remains in Master Transmit state). |
| | X | X | 1 | 0 | 0 | STOP condition (master goes to Idle state). |
| | X | X | 1 | 0 | 1 | SEND followed by STOP condition (master goes to Idle state). |
| | 0 | X | 0 | 1 | 1 | Repeated START condition followed by a SEND (master remains in Master Transmit state). |
| | 0 | X | 1 | 1 | 1 | Repeated START condition followed by SEND and STOP condition (master goes to Idle state). |
| | 1 | 0 | 0 | 1 | 1 | Repeated START condition followed by a RECEIVE operation with a negative ACK (master goes to Master Receive state). |
| | 1 | 0 | 1 | 1 | 1 | Repeated START condition followed by a SEND and STOP condition (master goes to Idle state). |
| | 1 | 1 | 0 | 1 | 1 | Repeated START condition followed by RECEIVE (master goes to Master Receive state). |
| | 1 | 1 | 1 | 1 | 1 | Illegal. |
| | All other combinations not listed are non-operations. | | | | | NOP. |

**Table 13-5. Write Field Decoding for I2CMCS[3:0] Field (Sheet 1 of 3) *(continued)***

| Current State | I2CMSA[0] | I2CMCS[3:0] | | | | Description |
|---|---|---|---|---|---|---|
| | R/S | ACK | STOP | START | RUN | |
| Master Receive | X | 0 | 0 | 0 | 1 | RECEIVE operation with negative ACK (master remains in Master Receive state). |
| | X | X | 1 | 0 | 0 | STOP condition (master goes to Idle state).[b] |
| | X | 0 | 1 | 0 | 1 | RECEIVE followed by STOP condition (master goes to Idle state). |
| | X | 1 | 0 | 0 | 1 | RECEIVE operation (master remains in Master Receive state). |
| | X | 1 | 1 | 0 | 1 | Illegal. |
| | 1 | 0 | 0 | 1 | 1 | Repeated START condition followed by RECEIVE operation with a negative ACK (master remains in Master Receive state). |
| | 1 | 0 | 1 | 1 | 1 | Repeated START condition followed by RECEIVE and STOP condition (master goes to Idle state). |
| | 1 | 1 | 0 | 1 | 1 | Repeated START condition followed by RECEIVE (master remains in Master Receive state). |
| | 0 | X | 0 | 1 | 1 | Repeated START condition followed by SEND (master goes to Master Transmit state). |
| | 0 | X | 1 | 1 | 1 | Repeated START condition followed by SEND and STOP condition (master goes to Idle state). |
| | All other combinations not listed are non-operations. | | | | | NOP. |

a. An X in a table cell indicates the bit can be 0 or 1.

b. In Master Receive mode, a STOP condition should be generated only after a Data Negative Acknowledge executed by the master or an Address Negative Acknowledge executed by the slave.

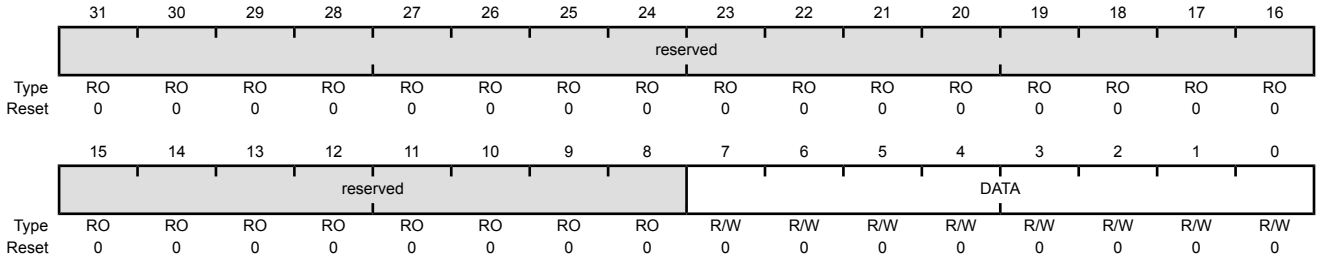
## Register 3: I²C Master Data (I2CMDR), offset 0x008

**Important:** This register is read-sensitive. See the register description for details.

This register contains the data to be transmitted when in the Master Transmit state, and the data received when in the Master Receive state.

I2C Master Data (I2CMDR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x008
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DATA | R/W | 0x00 | Data Transferred<br>Data transferred during transaction. |

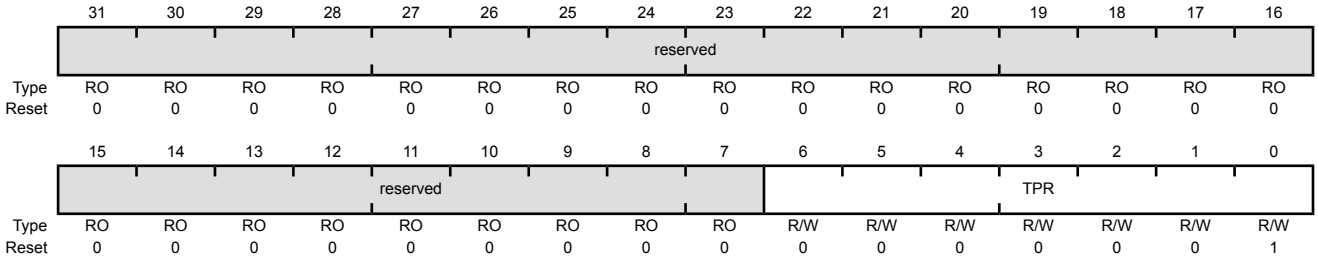
## Register 4: I2C Master Timer Period (I2CMTPR), offset 0x00C

This register specifies the period of the SCL clock.

**Caution – Take care not to set bit 7 when accessing this register as unpredictable behavior can occur.**

I2C Master Timer Period (I2CMTPR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x00C
Type R/W, reset 0x0000.0001



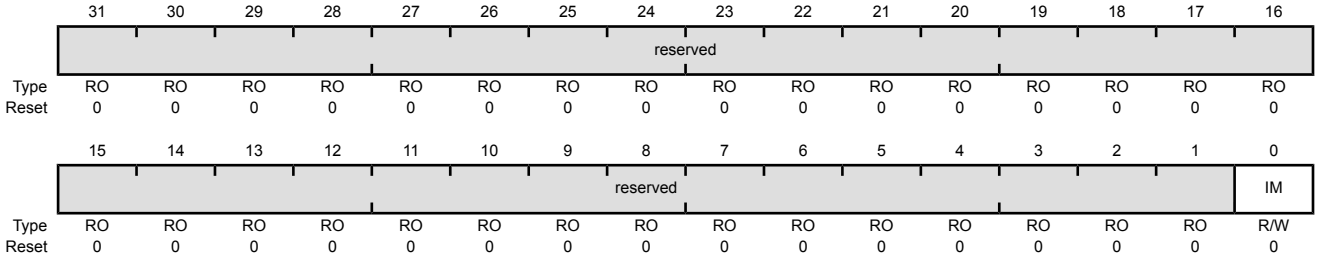

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:7 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6:0 | TPR | R/W | 0x1 | SCL Clock Period<br>This field specifies the period of the SCL clock.<br>`SCL_PRD = 2*(1 + TPR)*(SCL_LP + SCL_HP)*CLK_PRD`<br>where:<br>SCL_PRD is the SCL line period (I2C clock).<br>TPR is the Timer Period register value (range of 1 to 127).<br>SCL_LP is the SCL Low period (fixed at 6).<br>SCL_HP is the SCL High period (fixed at 4). |

## Register 5: I²C Master Interrupt Mask (I2CMIMR), offset 0x010

This register controls whether a raw interrupt is promoted to a controller interrupt.

I2C Master Interrupt Mask (I2CMIMR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x010
Type R/W, reset 0x0000.0000



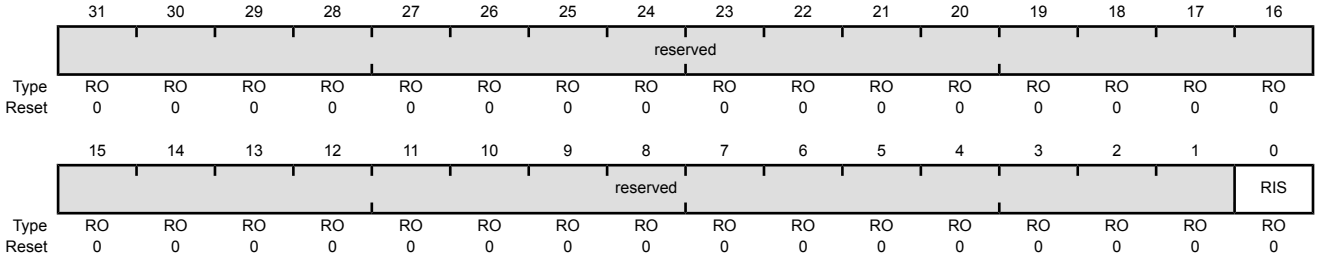

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | IM | R/W | 0 | Interrupt Mask<br>This bit controls whether a raw interrupt is promoted to a controller interrupt. If set, the interrupt is not masked and the interrupt is promoted; otherwise, the interrupt is masked. |

## Register 6: I2C Master Raw Interrupt Status (I2CMRIS), offset 0x014

This register specifies whether an interrupt is pending.

I2C Master Raw Interrupt Status (I2CMRIS)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x014
Type RO, reset 0x0000.0000



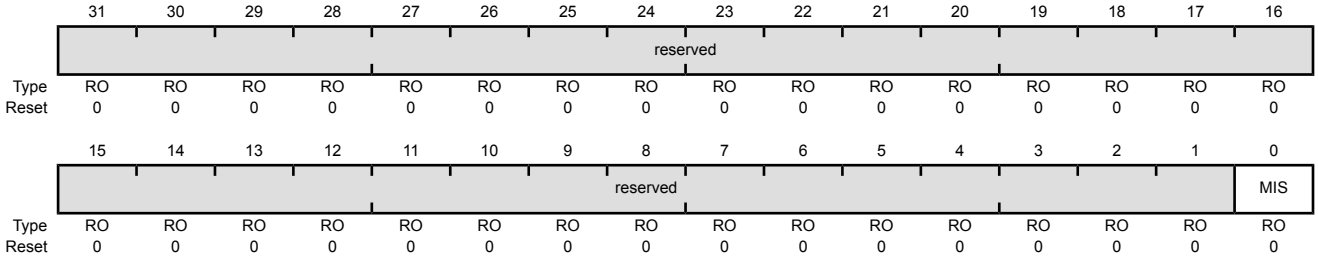

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | RIS | RO | 0 | Raw Interrupt Status<br>This bit specifies the raw interrupt state (prior to masking) of the I2C master block. If set, an interrupt is pending; otherwise, an interrupt is not pending. |

## Register 7: I²C Master Masked Interrupt Status (I2CMMIS), offset 0x018

This register specifies whether an interrupt was signaled.

I2C Master Masked Interrupt Status (I2CMMIS)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x018
Type RO, reset 0x0000.0000



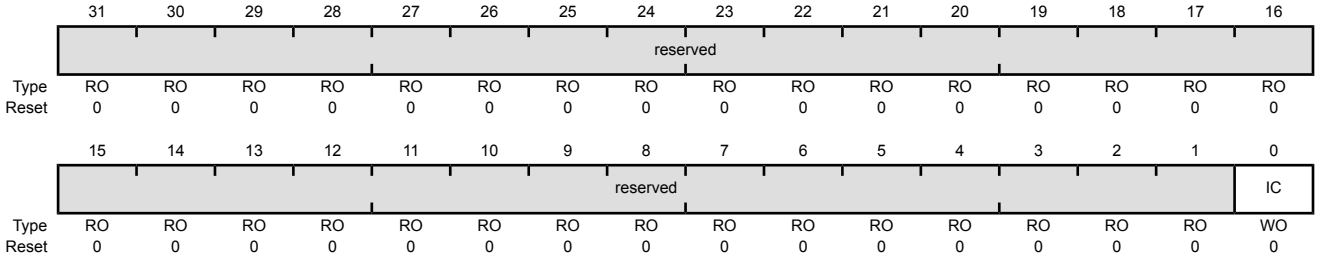

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | MIS | RO | 0 | Masked Interrupt Status<br>This bit specifies the raw interrupt state (after masking) of the I²C master block. If set, an interrupt was signaled; otherwise, an interrupt has not been generated since the bit was last cleared. |

## Register 8: I2C Master Interrupt Clear (I2CMICR), offset 0x01C

This register clears the raw interrupt.

I2C Master Interrupt Clear (I2CMICR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x01C
Type WO, reset 0x0000.0000



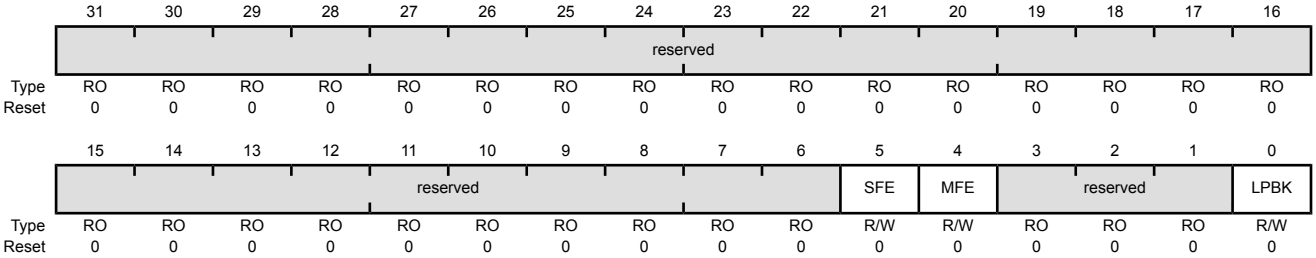

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | IC | WO | 0 | Interrupt Clear<br>This bit controls the clearing of the raw interrupt. A write of 1 clears the interrupt; otherwise, a write of 0 has no affect on the interrupt state. A read of this register returns no meaningful data. |

## Register 9: I²C Master Configuration (I2CMCR), offset 0x020

This register configures the mode (Master or Slave) and sets the interface for test mode loopback.

I2C Master Configuration (I2CMCR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x020
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | SFE | R/W | 0 | I²C Slave Function Enable<br>This bit specifies whether the interface may operate in Slave mode. If set, Slave mode is enabled; otherwise, Slave mode is disabled. |
| 4 | MFE | R/W | 0 | I²C Master Function Enable<br>This bit specifies whether the interface may operate in Master mode. If set, Master mode is enabled; otherwise, Master mode is disabled and the interface clock is disabled. |
| 3:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | LPBK | R/W | 0 | I²C Loopback<br>This bit specifies whether the interface is operating normally or in Loopback mode. If set, the device is put in a test mode loopback configuration; otherwise, the device operates normally. |

## 13.7 Register Descriptions ($I^2C$ Slave)

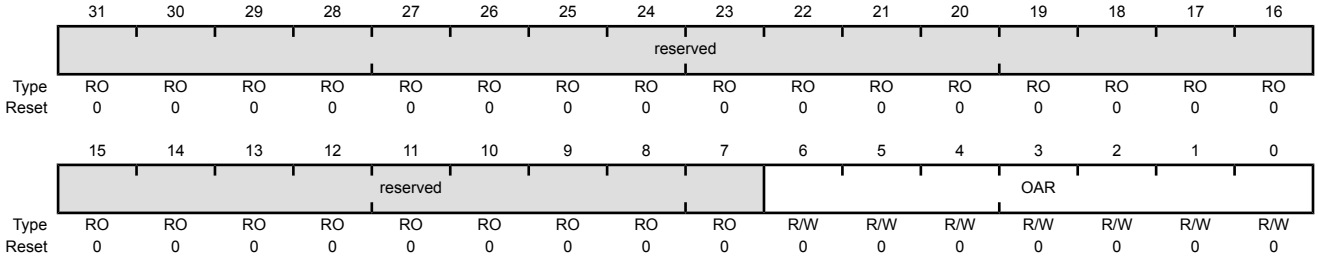
The remainder of this section lists and describes the $I^2C$ slave registers, in numerical order by address offset. See also “Register Descriptions ($I^2C$ Master)” on page 485.

## Register 10: I²C Slave Own Address (I2CSOAR), offset 0x800

This register consists of seven address bits that identify the Stellaris I²C device on the I²C bus.

I2C Slave Own Address (I2CSOAR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x800
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:7 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 6:0 | OAR | R/W | 0x00 | I²C Slave Own Address<br>This field specifies bits A6 through A0 of the slave address. |

## Register 11: I2C Slave Control/Status (I2CSCSR), offset 0x804

This register accesses one control bit when written, and three status bits when read.

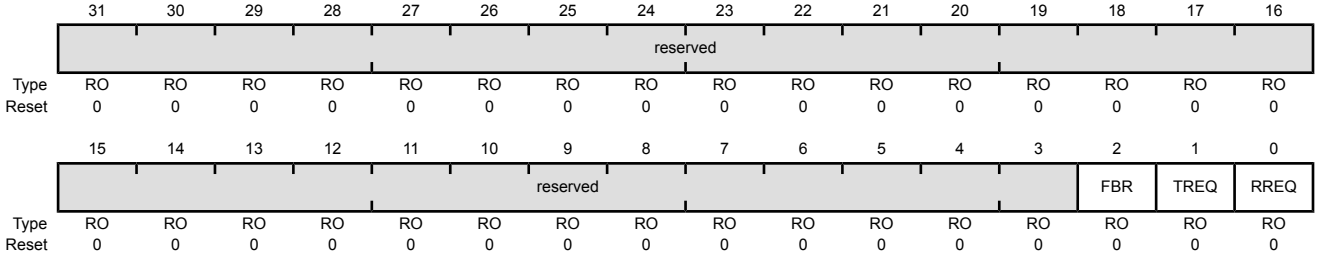
The read-only Status register consists of three bits: the FBR, RREQ, and TREQ bits. The First Byte Received (FBR) bit is set only after the Stellaris device detects its own slave address and receives the first data byte from the I2C master. The Receive Request (RREQ) bit indicates that the Stellaris I2C device has received a data byte from an I2C master. Read one data byte from the **I2C Slave Data (I2CSDR)** register to clear the RREQ bit. The Transmit Request (TREQ) bit indicates that the Stellaris I2C device is addressed as a Slave Transmitter. Write one data byte into the **I2C Slave Data (I2CSDR)** register to clear the TREQ bit.

The write-only Control register consists of one bit: the DA bit. The DA bit enables and disables the Stellaris I2C slave operation.

### Reads

I2C Slave Control/Status (I2CSCSR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x804
Type RO, reset 0x0000.0000

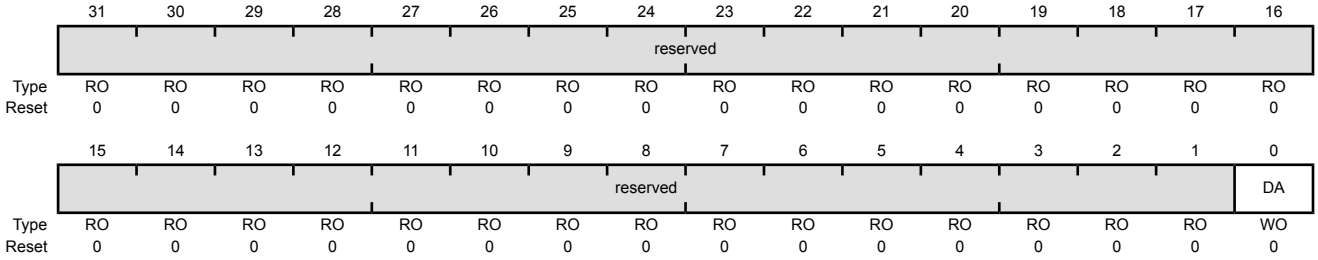



| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | FBR | RO | 0 | First Byte Received<br>Indicates that the first byte following the slave's own address is received. This bit is only valid when the RREQ bit is set, and is automatically cleared when data has been read from the **I2CSDR** register.<br>**Note:** This bit is not used for slave transmit operations. |
| 1 | TREQ | RO | 0 | Transmit Request<br>This bit specifies the state of the I2C slave with regards to outstanding transmit requests. If set, the I2C unit has been addressed as a slave transmitter and uses clock stretching to delay the master until data has been written to the **I2CSDR** register. Otherwise, there is no outstanding transmit request. |
| 0 | RREQ | RO | 0 | Receive Request<br>This bit specifies the status of the I2C slave with regards to outstanding receive requests. If set, the I2C unit has outstanding receive data from the I2C master and uses clock stretching to delay the master until the data has been read from the **I2CSDR** register. Otherwise, no receive data is outstanding. |

### Writes

I2C Slave Control/Status (I2CSCSR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x804
Type WO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | DA | WO | 0 | Device Active<br><br>Value Description<br>0 Disables the $I^2C$ slave operation.<br>1 Enables the $I^2C$ slave operation.<br><br>Once this bit has been set, it should not be set again unless it has been cleared by writing a 0 or by a reset, otherwise transfer failures may occur. |

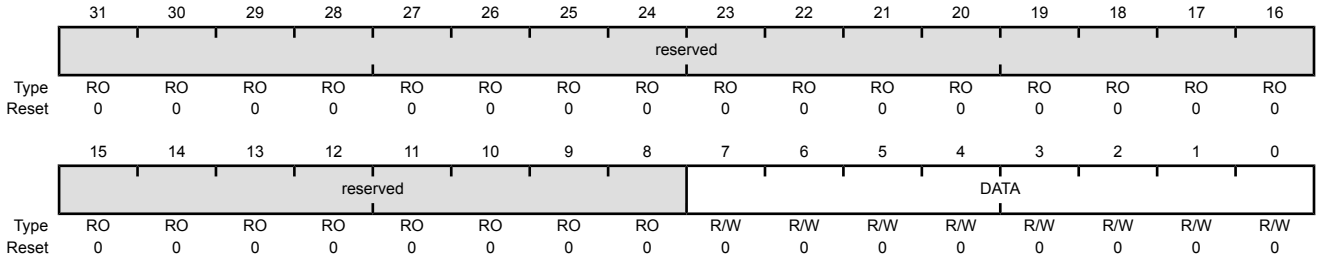
## Register 12: I2C Slave Data (I2CSDR), offset 0x808

**Important:** This register is read-sensitive. See the register description for details.

This register contains the data to be transmitted when in the Slave Transmit state, and the data received when in the Slave Receive state.

I2C Slave Data (I2CSDR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x808
Type R/W, reset 0x0000.0000



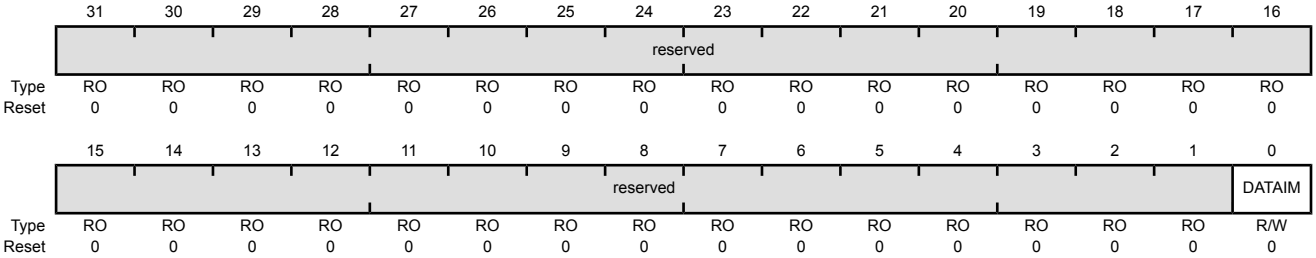

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:8 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 7:0 | DATA | R/W | 0x0 | Data for Transfer<br>This field contains the data for transfer during a slave receive or transmit operation. |

## Register 13: I²C Slave Interrupt Mask (I2CSIMR), offset 0x80C

This register controls whether a raw interrupt is promoted to a controller interrupt.

I2C Slave Interrupt Mask (I2CSIMR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x80C
Type R/W, reset 0x0000.0000



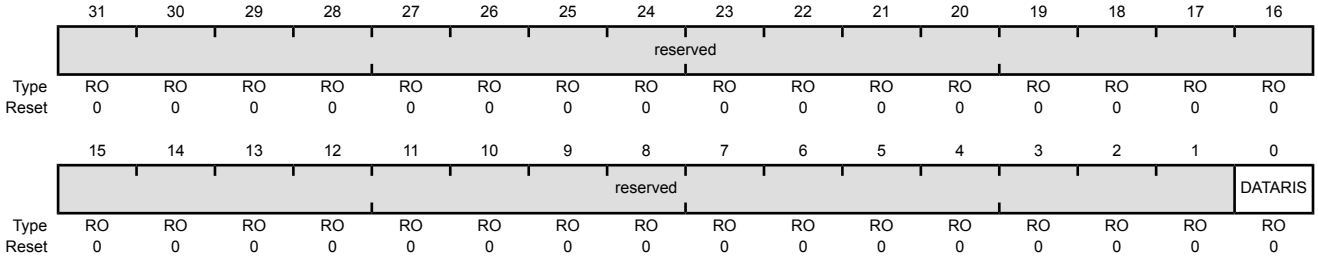

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | DATAIM | R/W | 0 | Data Interrupt Mask<br>This bit controls whether the raw interrupt for data received and data requested is promoted to a controller interrupt. If set, the interrupt is not masked and the interrupt is promoted; otherwise, the interrupt is masked. |

## Register 14: I2C Slave Raw Interrupt Status (I2CSRIS), offset 0x810

This register specifies whether an interrupt is pending.

I2C Slave Raw Interrupt Status (I2CSRIS)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x810
Type RO, reset 0x0000.0000



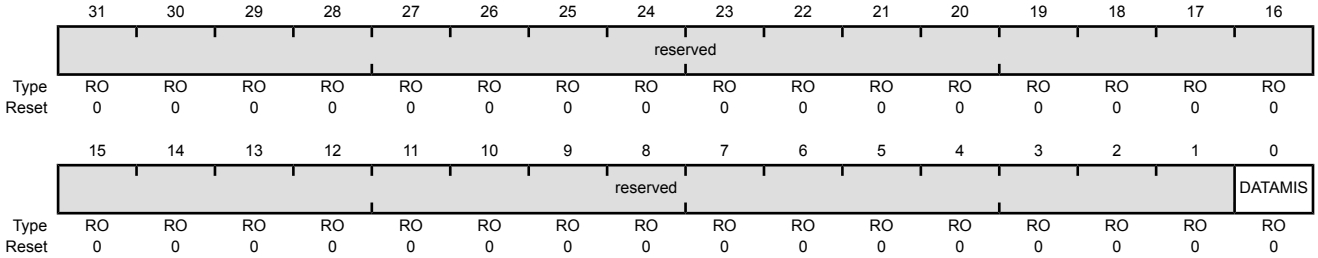

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | DATARIS | RO | 0 | Data Raw Interrupt Status<br>This bit specifies the raw interrupt state for data received and data requested (prior to masking) of the I2C slave block. If set, an interrupt is pending; otherwise, an interrupt is not pending. |

## Register 15: I²C Slave Masked Interrupt Status (I2CSMIS), offset 0x814

This register specifies whether an interrupt was signaled.

I2C Slave Masked Interrupt Status (I2CSMIS)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x814
Type RO, reset 0x0000.0000



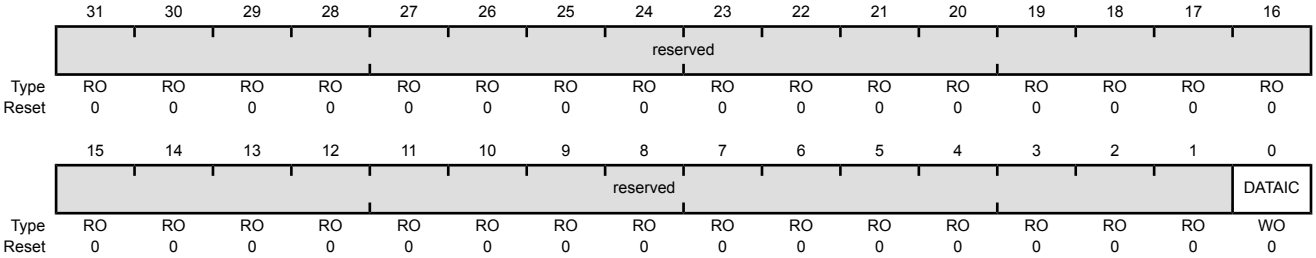

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | DATAMIS | RO | 0 | Data Masked Interrupt Status<br>This bit specifies the interrupt state for data received and data requested (after masking) of the I²C slave block. If set, an interrupt was signaled; otherwise, an interrupt has not been generated since the bit was last cleared. |

## Register 16: I2C Slave Interrupt Clear (I2CSICR), offset 0x818

This register clears the raw interrupt. A read of this register returns no meaningful data.

I2C Slave Interrupt Clear (I2CSICR)

I2C 0 base: 0x4002.0000
I2C 1 base: 0x4002.1000
Offset 0x818
Type WO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | DATAIC | WO | 0 | Data Interrupt Clear<br>This bit controls the clearing of the raw interrupt for data received and data requested. When set, it clears the DATARIS interrupt bit; otherwise, it has no effect on the DATARIS bit value. |

# 14 Analog Comparators

An analog comparator is a peripheral that compares two analog voltages, and provides a logical output that signals the comparison result.

**Note:** Not all comparators have the option to drive an output pin.

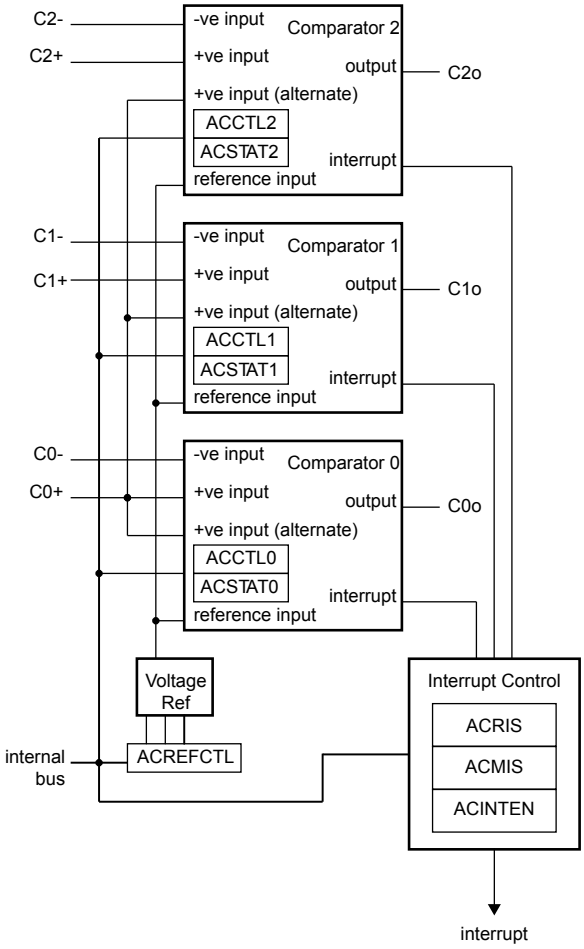
The comparator can provide its output to a device pin, acting as a replacement for an analog comparator on the board, or it can be used to signal the application via interrupts to cause it to start capturing a sample sequence.

The Stellaris® Analog Comparators module has the following features:

- Three independent integrated analog comparators
- Configurable for output to drive an output pin or generate an interrupt
- Compare external pin input to external pin input or to internal programmable voltage reference
- Compare a test voltage against any one of these voltages
  - An individual external reference voltage
  - A shared single external reference voltage
  - A shared internal reference voltage

## 14.1 Block Diagram

**Figure 14-1. Analog Comparator Module Block Diagram**




## 14.2 Signal Description

Table 14-1 on page 508 and Table 14-2 on page 509 list the external signals of the Analog Comparators and describe the function of each. The Analog Comparator output signals are alternate functions for some GPIO signals and default to be GPIO signals at reset. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for the Analog Comparator signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the Analog Comparator function. The positive and negative input signals are configured by clearing the DEN bit in the **GPIO Digital Enable (GPIODEN)** register. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 14-1. Analog Comparators Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| C0+ | 90 | I | Analog | Analog comparator 0 positive input. |
| C0- | 92 | I | Analog | Analog comparator 0 negative input. |
| C0o | 58 | O | TTL | Analog comparator 0 output. |

**Table 14-1. Analog Comparators Signals (100LQFP) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| C1+ | 24 | I | Analog | Analog comparator 1 positive input. |
| C1- | 91 | I | Analog | Analog comparator 1 negative input. |
| C1o | 46 | O | TTL | Analog comparator 1 output. |
| C2+ | 23 | I | Analog | Analog comparator 2 positive input. |
| C2- | 22 | I | Analog | Analog comparator 2 negative input. |
| C2o | 43 | O | TTL | Analog comparator 2 output. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 14-2. Analog Comparators Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| C0+ | A7 | I | Analog | Analog comparator 0 positive input. |
| C0- | A6 | I | Analog | Analog comparator 0 negative input. |
| C0o | L9 | O | TTL | Analog comparator 0 output. |
| C1+ | M1 | I | Analog | Analog comparator 1 positive input. |
| C1- | B7 | I | Analog | Analog comparator 1 negative input. |
| C1o | L8 | O | TTL | Analog comparator 1 output. |
| C2+ | M2 | I | Analog | Analog comparator 2 positive input. |
| C2- | L2 | I | Analog | Analog comparator 2 negative input. |
| C2o | M8 | O | TTL | Analog comparator 2 output. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 14.3 Functional Description

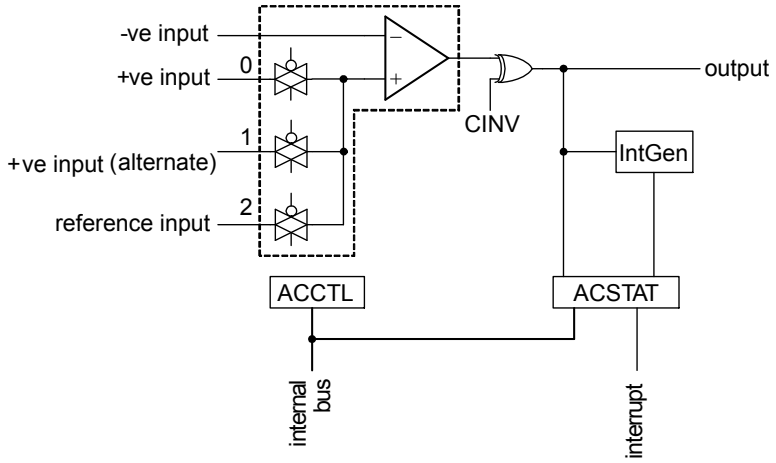
**Important:** It is recommended that the Digital-Input enable (the GPIODEN bit in the GPIO module) for the analog input pin be disabled to prevent excessive current draw from the I/O pads.

The comparator compares the VIN- and VIN+ inputs to produce an output, VOUT.

```
VIN- < VIN+, VOUT = 1
VIN- > VIN+, VOUT = 0
```

As shown in Figure 14-2 on page 510, the input source for VIN- is an external input. In addition to an external input, input sources for VIN+ can be the +ve input of comparator 0 or an internal reference.

**Figure 14-2. Structure of Comparator Unit**




A comparator is configured through two status/control registers (**ACCTL** and **ACSTAT** ). The internal reference is configured through one control register (**ACREFCTL**). Interrupt status and control is configured through three registers (**ACMIS**, **ACRIS**, and **ACINTEN**).

Typically, the comparator output is used internally to generate controller interrupts. It may also be used to drive an external pin.

**Important:** The ASRCP bits in the **ACCTLn** register must be set before using the analog comparators.

## 14.3.1 Internal Reference Programming

The structure of the internal reference is shown in Figure 14-3 on page 510. This is controlled by a single configuration register (**ACREFCTL**). Table 14-3 on page 510 shows the programming options to develop specific internal reference values, to compare an external voltage against a particular voltage generated internally.

**Figure 14-3. Comparator Internal Reference Structure**

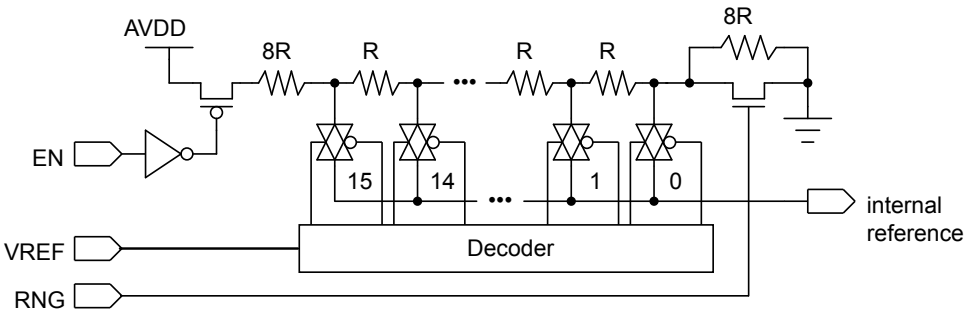



**Table 14-3. Internal Reference Voltage and ACREFCTL Field Values**

| ACREFCTL Register | | Output Reference Voltage Based on VREF Field Value |
|---|---|---|
| EN Bit Value | RNG Bit Value | |
| EN=0 | RNG=X | 0 V (GND) for any value of VREF; however, it is recommended that RNG=1 and VREF=0 for the least noisy ground reference. |

**Table 14-3. Internal Reference Voltage and ACREFCTL Field Values *(continued)***

| ACREFCTL Register | | Output Reference Voltage Based on VREF Field Value |
|---|---|---|
| **EN Bit Value** | **RNG Bit Value** | |
| EN=1 | RNG=0 | Total resistance in ladder is 31 R.<br>$V_{REF} = AV_{DD} \times \frac{R_{VREF}}{R_T}$<br>$V_{REF} = AV_{DD} \times \frac{(VREF + 8)}{31}$<br>$V_{REF} = 0.85 + 0.106 \times VREF$<br>The range of internal reference in this mode is 0.85-2.448 V. |
| | RNG=1 | Total resistance in ladder is 23 R.<br>$V_{REF} = AV_{DD} \times \frac{R_{VREF}}{R_T}$<br>$V_{REF} = AV_{DD} \times \frac{VREF}{23}$<br>$V_{REF} = 0.143 \times VREF$<br>The range of internal reference for this mode is 0-2.152 V. |

## 14.4 Initialization and Configuration

The following example shows how to configure an analog comparator to read back its output value from an internal register.

1. Enable the analog comparator 0 clock by writing a value of 0x0010.0000 to the **RCGC1** register in the System Control module.
2. In the GPIO module, enable the GPIO port/pin associated with C0- as a GPIO input.
3. Configure the internal voltage reference to 1.65 V by writing the **ACREFCTL** register with the value 0x0000.030C.
4. Configure comparator 0 to use the internal voltage reference and to *not* invert the output by writing the **ACCTL0** register with the value of 0x0000.040C.
5. Delay for some time.
6. Read the comparator output value by reading the **ACSTAT0** register's OVAL value.

Change the level of the signal input on C0- to see the OVAL value change.

## 14.5 Register Map

Table 14-4 on page 512 lists the comparator registers. The offset listed is a hexadecimal increment to the register's address, relative to the Analog Comparator base address of 0x4003.C000.

Note that the analog comparator module clock must be enabled before the registers can be programmed (see page 214). There must be a delay of 3 system clocks after the ADC module clock is enabled before any ADC module registers are accessed.

**Table 14-4. Analog Comparators Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | ACMIS | R/W1C | 0x0000.0000 | Analog Comparator Masked Interrupt Status | 513 |
| 0x004 | ACRIS | RO | 0x0000.0000 | Analog Comparator Raw Interrupt Status | 514 |
| 0x008 | ACINTEN | R/W | 0x0000.0000 | Analog Comparator Interrupt Enable | 515 |
| 0x010 | ACREFCTL | R/W | 0x0000.0000 | Analog Comparator Reference Voltage Control | 516 |
| 0x020 | ACSTAT0 | RO | 0x0000.0000 | Analog Comparator Status 0 | 517 |
| 0x024 | ACCTL0 | R/W | 0x0000.0000 | Analog Comparator Control 0 | 518 |
| 0x040 | ACSTAT1 | RO | 0x0000.0000 | Analog Comparator Status 1 | 517 |
| 0x044 | ACCTL1 | R/W | 0x0000.0000 | Analog Comparator Control 1 | 518 |
| 0x060 | ACSTAT2 | RO | 0x0000.0000 | Analog Comparator Status 2 | 517 |
| 0x064 | ACCTL2 | R/W | 0x0000.0000 | Analog Comparator Control 2 | 518 |

## 14.6 Register Descriptions

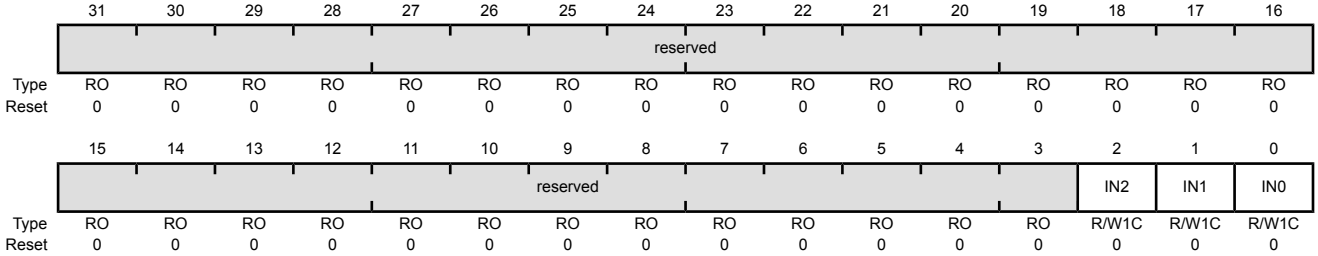
The remainder of this section lists and describes the Analog Comparator registers, in numerical order by address offset.

## Register 1: Analog Comparator Masked Interrupt Status (ACMIS), offset 0x000

This register provides a summary of the interrupt status (masked) of the comparator.

Analog Comparator Masked Interrupt Status (ACMIS)

Base 0x4003.C000
Offset 0x000
Type R/W1C, reset 0x0000.0000



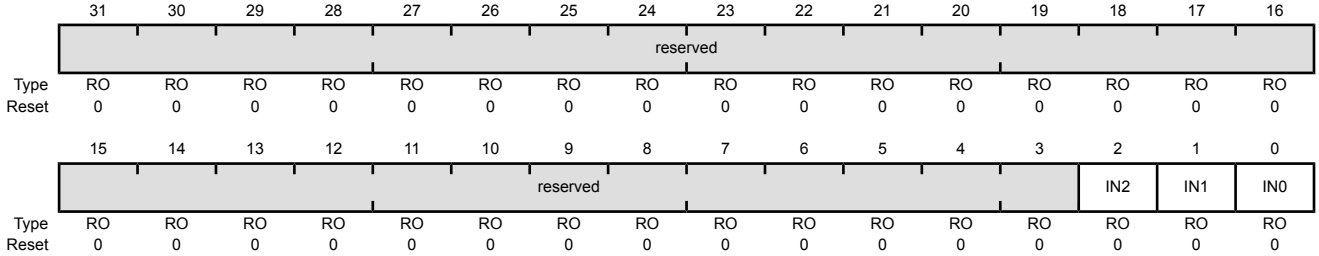

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | IN2 | R/W1C | 0 | Comparator 2 Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. Write 1 to this bit to clear the pending interrupt. |
| 1 | IN1 | R/W1C | 0 | Comparator 1 Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. Write 1 to this bit to clear the pending interrupt. |
| 0 | IN0 | R/W1C | 0 | Comparator 0 Masked Interrupt Status<br>Gives the masked interrupt state of this interrupt. Write 1 to this bit to clear the pending interrupt. |

## Register 2: Analog Comparator Raw Interrupt Status (ACRIS), offset 0x004

This register provides a summary of the interrupt status (raw) of the comparator.

Analog Comparator Raw Interrupt Status (ACRIS)

Base 0x4003.C000
Offset 0x004
Type RO, reset 0x0000.0000



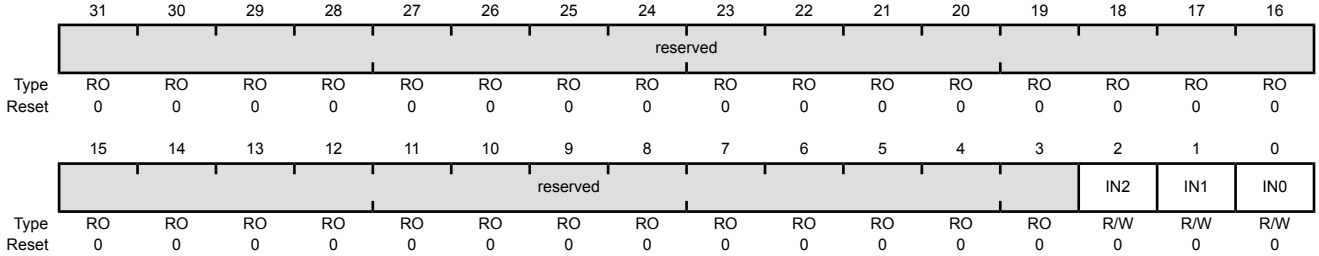

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | IN2 | RO | 0 | Comparator 2 Interrupt Status<br>When set, indicates that an interrupt has been generated by comparator 2. |
| 1 | IN1 | RO | 0 | Comparator 1 Interrupt Status<br>When set, indicates that an interrupt has been generated by comparator 1. |
| 0 | IN0 | RO | 0 | Comparator 0 Interrupt Status<br>When set, indicates that an interrupt has been generated by comparator 0. |

## Register 3: Analog Comparator Interrupt Enable (ACINTEN), offset 0x008

This register provides the interrupt enable for the comparator.

Analog Comparator Interrupt Enable (ACINTEN)

Base 0x4003.C000
Offset 0x008
Type R/W, reset 0x0000.0000



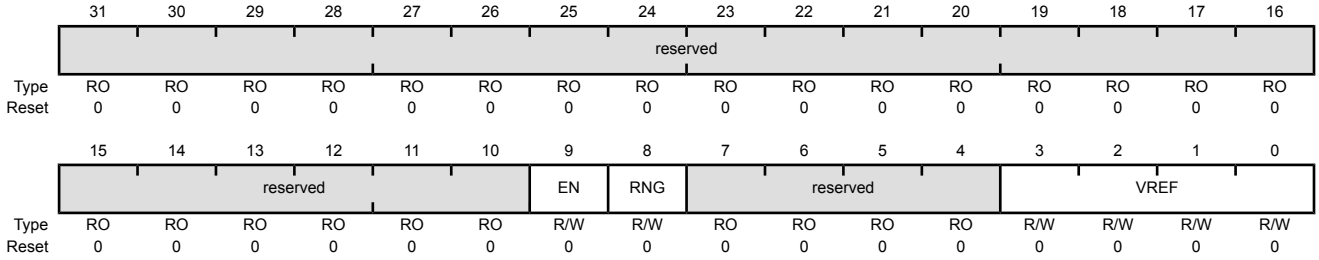

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | IN2 | R/W | 0 | Comparator 2 Interrupt Enable<br>When set, enables the controller interrupt from the comparator 2 output |
| 1 | IN1 | R/W | 0 | Comparator 1 Interrupt Enable<br>When set, enables the controller interrupt from the comparator 1 output. |
| 0 | IN0 | R/W | 0 | Comparator 0 Interrupt Enable<br>When set, enables the controller interrupt from the comparator 0 output. |

## Register 4: Analog Comparator Reference Voltage Control (ACREFCTL), offset 0x010

This register specifies whether the resistor ladder is powered on as well as the range and tap.

Analog Comparator Reference Voltage Control (ACREFCTL)

Base 0x4003.C000
Offset 0x010
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:10 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 9 | EN | R/W | 0 | Resistor Ladder Enable<br>The EN bit specifies whether the resistor ladder is powered on. If 0, the resistor ladder is unpowered. If 1, the resistor ladder is connected to the analog $V_{DD}$.<br>This bit is reset to 0 so that the internal reference consumes the least amount of power if not used and programmed. |
| 8 | RNG | R/W | 0 | Resistor Ladder Range<br>The RNG bit specifies the range of the resistor ladder. If 0, the resistor ladder has a total resistance of 31 R. If 1, the resistor ladder has a total resistance of 23 R. |
| 7:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3:0 | VREF | R/W | 0x00 | Resistor Ladder Voltage Ref<br>The VREF bit field specifies the resistor ladder tap that is passed through an analog multiplexer. The voltage corresponding to the tap position is the internal reference voltage available for comparison. See Table 14-3 on page 510 for some output reference voltage examples. |

## Register 5: Analog Comparator Status 0 (ACSTAT0), offset 0x020

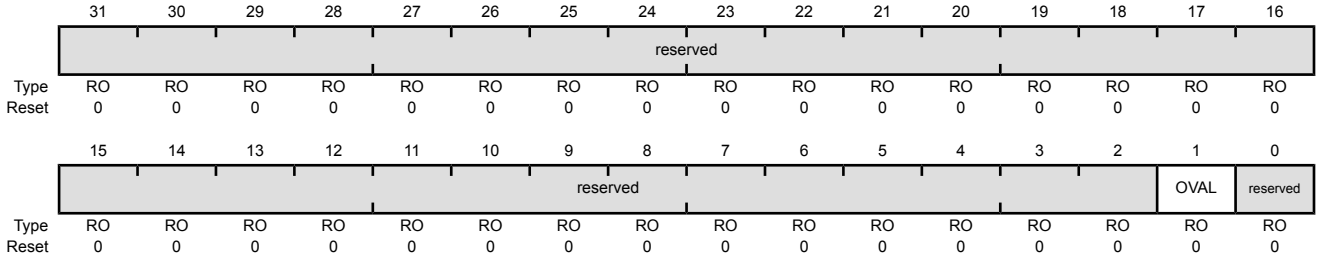
## Register 6: Analog Comparator Status 1 (ACSTAT1), offset 0x040

## Register 7: Analog Comparator Status 2 (ACSTAT2), offset 0x060

These registers specify the current output value of the comparator.

Analog Comparator Status 0 (ACSTAT0)

Base 0x4003.C000
Offset 0x020
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | OVAL | RO | 0 | Comparator Output Value<br>The 0VAL bit specifies the current output value of the comparator. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

## Register 8: Analog Comparator Control 0 (ACCTL0), offset 0x024

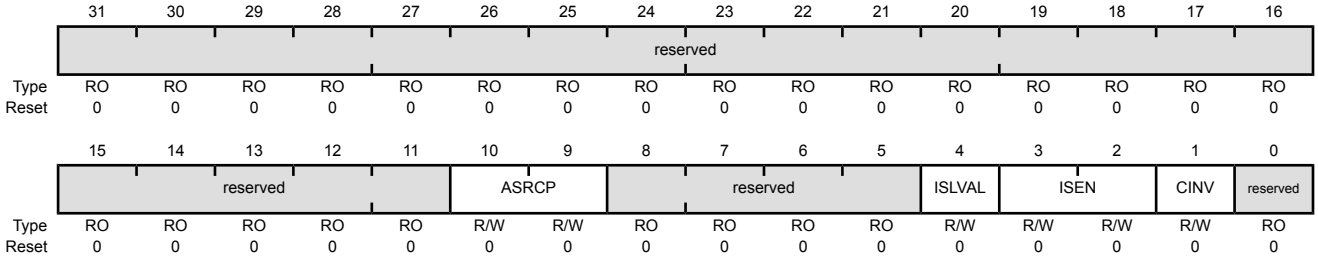
## Register 9: Analog Comparator Control 1 (ACCTL1), offset 0x044

## Register 10: Analog Comparator Control 2 (ACCTL2), offset 0x064

These registers configure the comparator's input and output.

Analog Comparator Control 0 (ACCTL0)

Base 0x4003.C000
Offset 0x024
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:11 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 10:9 | ASRCP | R/W | 0x00 | Analog Source Positive<br>The ASRCP field specifies the source of input voltage to the VIN+ terminal of the comparator. The encodings for this field are as follows:<br>Value Function<br>0x0 Pin value<br>0x1 Pin value of C0+<br>0x2 Internal voltage reference<br>0x3 Reserved |
| 8:5 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 4 | ISLVAL | R/W | 0 | Interrupt Sense Level Value<br>The ISLVAL bit specifies the sense value of the input that generates an interrupt if in Level Sense mode. If 0, an interrupt is generated if the comparator output is Low. Otherwise, an interrupt is generated if the comparator output is High. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3:2 | ISEN | R/W | 0x0 | Interrupt Sense<br>The ISEN field specifies the sense of the comparator output that generates an interrupt. The sense conditioning is as follows:<br><br>Value Function<br>0x0 Level sense, see ISLVAL<br>0x1 Falling edge<br>0x2 Rising edge<br>0x3 Either edge |
| 1 | CINV | R/W | 0 | Comparator Output Invert<br>The CINV bit conditionally inverts the output of the comparator. If 0, the output of the comparator is unchanged. If 1, the output of the comparator is inverted prior to being processed by hardware. |
| 0 | reserved | RO | 0 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |

# 15 Pulse Width Modulator (PWM)

Pulse width modulation (PWM) is a powerful technique for digitally encoding analog signal levels. High-resolution counters are used to generate a square wave, and the duty cycle of the square wave is modulated to encode an analog signal. Typical applications include switching power supplies and motor control.

The Stellaris® PWM module consists of three PWM generator blocks and a control block. The control block determines the polarity of the PWM signals, and which signals are passed through to the pins.

Each PWM generator block produces two PWM signals that can either be independent signals (other than being based on the same timer and therefore having the same frequency) or a single pair of complementary signals with dead-band delays inserted. The output of the PWM generation blocks are managed by the output control block before being passed to the device pins.

The Stellaris PWM module provides a great deal of flexibility. It can generate simple PWM signals, such as those required by a simple charge pump. It can also generate paired PWM signals with dead-band delays, such as those required by a half-H bridge driver. Three generator blocks can also generate the full six channels of gate controls required by a 3-phase inverter bridge.

Each Stellaris PWM module has the following features:

- Three PWM generator blocks, each with one 16-bit counter, two PWM comparators, a PWM signal generator, a dead-band generator, and an interrupt selector
- One fault input in hardware to promote low-latency shutdown
- One 16-bit counter
  - Runs in Down or Up/Down mode
  - Output frequency controlled by a 16-bit load value
  - Load value updates can be synchronized
  - Produces output signals at zero and load value
- Two PWM comparators
  - Comparator value updates can be synchronized
  - Produces output signals on match
- PWM generator
  - Output PWM signal is constructed based on actions taken as a result of the counter and PWM comparator output signals
  - Produces two independent PWM signals
- Dead-band generator
  - Produces two PWM signals with programmable dead-band delays suitable for driving a half-H bridge
  - Can be bypassed, leaving input PWM signals unmodified

- Flexible output control block with PWM output enable of each PWM signal
  - PWM output enable of each PWM signal
  - Optional output inversion of each PWM signal (polarity control)
  - Optional fault handling for each PWM signal
  - Synchronization of timers in the PWM generator blocks
  - Interrupt status summary of the PWM generator blocks

## 15.1 Block Diagram

Figure 15-1 on page 521 provides the Stellaris PWM module unit diagram and Figure 15-2 on page 522 provides a more detailed diagram of a Stellaris PWM generator. The LM3S1960 controller contains three generator blocks (PWM0, PWM1, and PWM2) and generates six independent PWM signals or three paired PWM signals with dead-band delays inserted.

**Figure 15-1. PWM Unit Diagram**

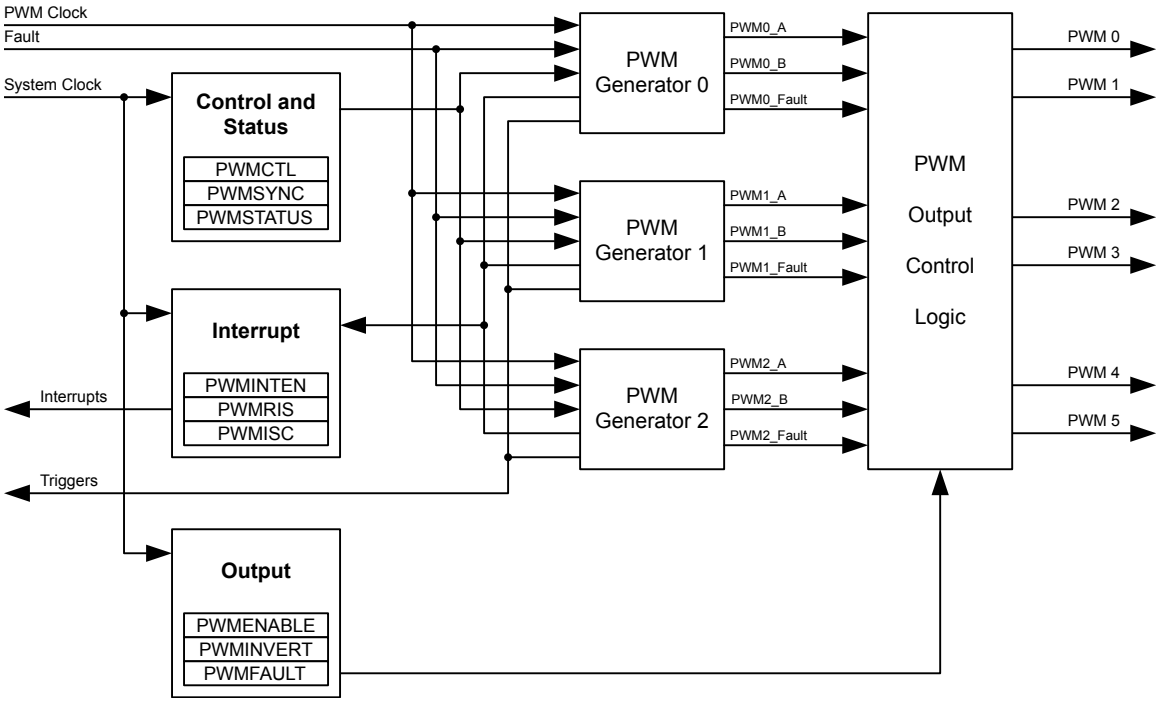
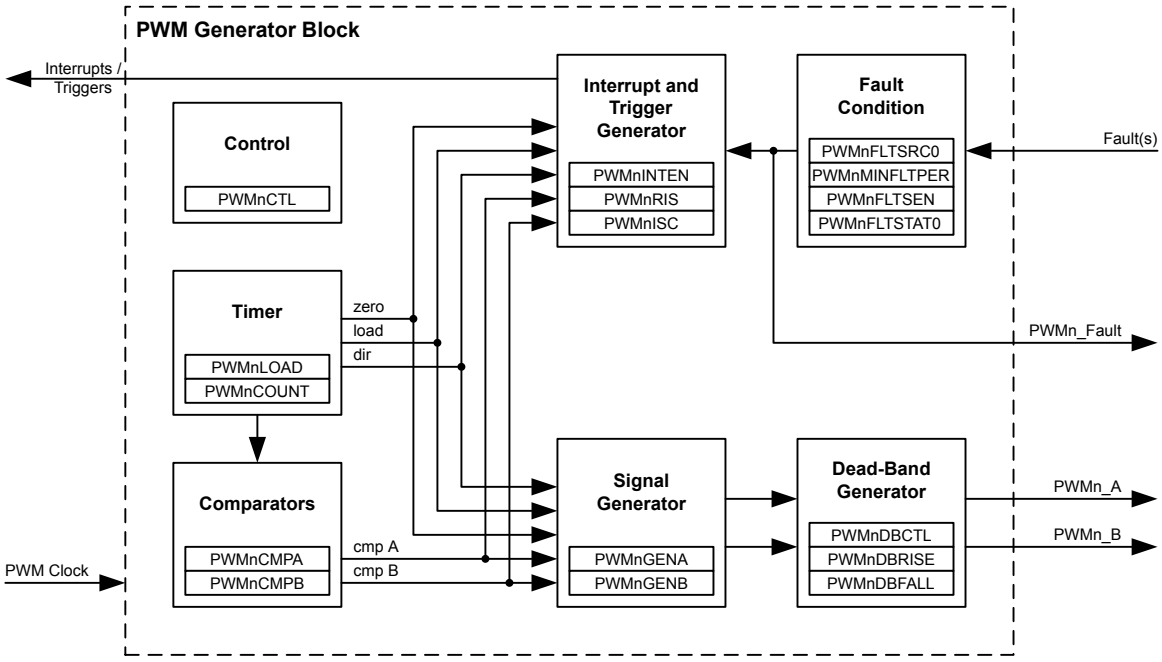


**Figure 15-2. PWM Module Block Diagram**




## 15.2 Signal Description

Table 15-1 on page 522 and Table 15-2 on page 522 list the external signals of the PWM module and describe the function of each. The PWM controller signals are alternate functions for some GPIO signals and default to be GPIO signals at reset. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for these PWM signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the PWM function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 15-1. PWM Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| Fault | 99 | I | TTL | PWM Fault. |
| PWM0 | 47 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| PWM1 | 61 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| PWM2 | 66 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| PWM3 | 67 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| PWM4 | 2 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| PWM5 | 1 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 15-2. PWM Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| Fault | F2 | I | TTL | PWM Fault. |
| PWM0 | M9 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| PWM1 | H12 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| PWM2 | E12 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |

**Table 15-2. PWM Signals (108BGA) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PWM3 | D12 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| PWM4 | C2 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| PWM5 | C1 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

# 15.3 Functional Description

## 15.3.1 PWM Timer

The timer in each PWM generator runs in one of two modes: Count-Down mode or Count-Up/Down mode. In Count-Down mode, the timer counts from the load value to zero, goes back to the load value, and continues counting down. In Count-Up/Down mode, the timer counts from zero up to the load value, back down to zero, back up to the load value, and so on. Generally, Count-Down mode is used for generating left- or right-aligned PWM signals, while the Count-Up/Down mode is used for generating center-aligned PWM signals.

The timers output three signals that are used in the PWM generation process: the direction signal (this is always Low in Count-Down mode, but alternates between Low and High in Count-Up/Down mode), a single-clock-cycle-width High pulse when the counter is zero, and a single-clock-cycle-width High pulse when the counter is equal to the load value. Note that in Count-Down mode, the zero pulse is immediately followed by the load pulse.

## 15.3.2 PWM Comparators

There are two comparators in each PWM generator that monitor the value of the counter; when either match the counter, they output a single-clock-cycle-width High pulse. When in Count-Up/Down mode, these comparators match both when counting up and when counting down; they are therefore qualified by the counter direction signal. These qualified pulses are used in the PWM generation process. If either comparator match value is greater than the counter load value, then that comparator never outputs a High pulse.

Figure 15-3 on page 524 shows the behavior of the counter and the relationship of these pulses when the counter is in Count-Down mode. Figure 15-4 on page 524 shows the behavior of the counter and the relationship of these pulses when the counter is in Count-Up/Down mode.

**Figure 15-3. PWM Count-Down Mode**

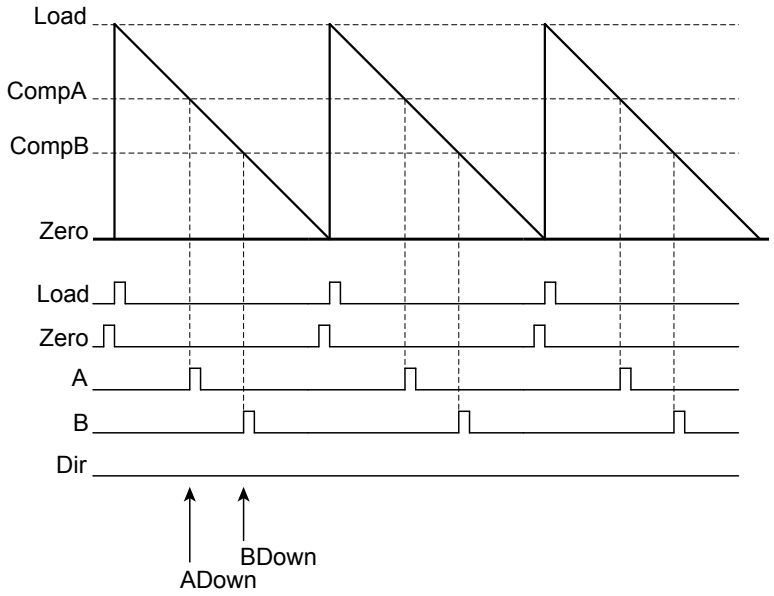
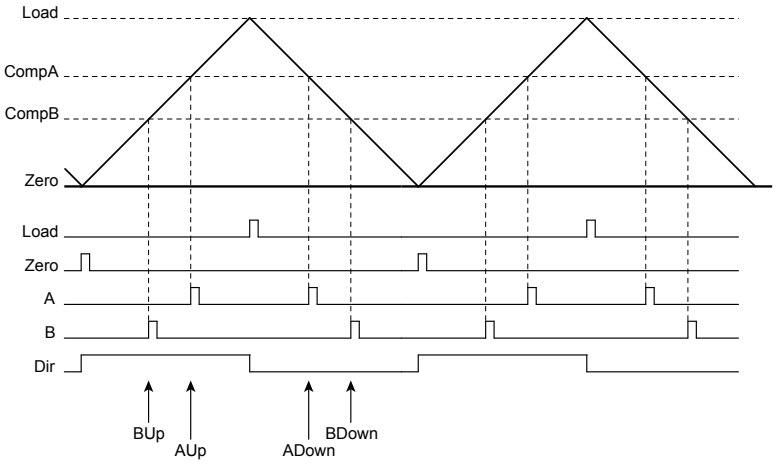



**Figure 15-4. PWM Count-Up/Down Mode**

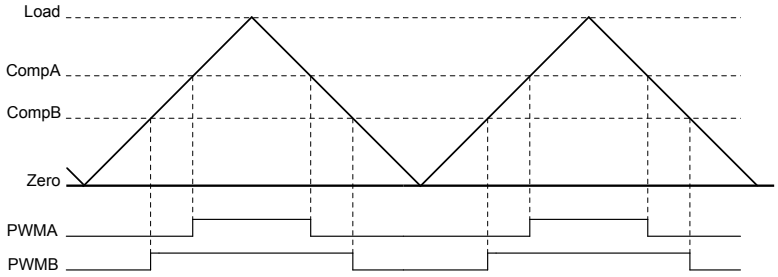



### 15.3.3 PWM Signal Generator

The PWM generator takes these pulses (qualified by the direction signal), and generates two PWM signals. In Count-Down mode, there are four events that can affect the PWM signal: zero, load, match A down, and match B down. In Count-Up/Down mode, there are six events that can affect the PWM signal: zero, load, match A down, match A up, match B down, and match B up. The match A or match B events are ignored when they coincide with the zero or load events. If the match A and match B events coincide, the first signal, PWMA, is generated based only on the match A event, and the second signal, PWMB, is generated based only on the match B event.

For each event, the effect on each output PWM signal is programmable: it can be left alone (ignoring the event), it can be toggled, it can be driven Low, or it can be driven High. These actions can be used to generate a pair of PWM signals of various positions and duty cycles, which do or do not overlap. Figure 15-5 on page 525 shows the use of Count-Up/Down mode to generate a pair of center-aligned, overlapped PWM signals that have different duty cycles.

**Figure 15-5. PWM Generation Example In Count-Up/Down Mode**



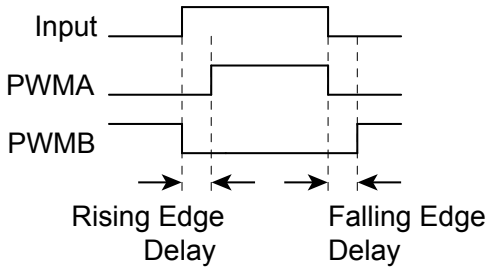

In this example, the first generator is set to drive High on match A up, drive Low on match A down, and ignore the other four events. The second generator is set to drive High on match B up, drive Low on match B down, and ignore the other four events. Changing the value of comparator A changes the duty cycle of the PWMA signal, and changing the value of comparator B changes the duty cycle of the PWMB signal.

### 15.3.4 Dead-Band Generator

The two PWM signals produced by the PWM generator are passed to the dead-band generator. If disabled, the PWM signals simply pass through unmodified. If enabled, the second PWM signal is lost and two PWM signals are generated based on the first PWM signal. The first output PWM signal is the input signal with the rising edge delayed by a programmable amount. The second output PWM signal is the inversion of the input signal with a programmable delay added between the falling edge of the input signal and the rising edge of this new signal.

This is therefore a pair of active High signals where one is always High, except for a programmable amount of time at transitions where both are Low. These signals are therefore suitable for driving a half-H bridge, with the dead-band delays preventing shoot-through current from damaging the power electronics. Figure 15-6 on page 525 shows the effect of the dead-band generator on an input PWM signal.

**Figure 15-6. PWM Dead-Band Generator**




### 15.3.5 Interrupt Selector

The PWM generator also takes the same four (or six) counter events and uses them to generate an interrupt. Any of these events or a set of these events can be selected as a source for an interrupt; when any of the selected events occur, an interrupt is generated. The selection of events allows the interrupt to occur at a specific position within the PWM signal. Note that interrupts are based on the raw events; delays in the PWM signal edges caused by the dead-band generator are not taken into account.

### 15.3.6 Synchronization Methods

There is a global reset capability that can synchronously reset any or all of the counters in the PWM generators. If multiple PWM generators are configured with the same counter load value, this can be used to guarantee that they also have the same count value (this does imply that the PWM generators must be configured before they are synchronized). With this, more than two PWM signals can be produced with a known relationship between the edges of those signals since the counters always have the same values.

The counter load values and comparator match values of the PWM generator can be updated in two ways. The first is immediate update mode, where a new value is used as soon as the counter reaches zero. By waiting for the counter to reach zero, a guaranteed behavior is defined, and overly short or overly long output PWM pulses are prevented.

The other update method is synchronous, where the new value is not used until a global synchronized update signal is asserted, at which point the new value is used as soon as the counter reaches zero. This second mode allows multiple items in multiple PWM generators to be updated simultaneously without odd effects during the update; everything runs from the old values until a point at which they all run from the new values. The Update mode of the load and comparator match values can be individually configured in each PWM generator block. It typically makes sense to use the synchronous update mechanism across PWM generator blocks when the timers in those blocks are synchronized, though this is not required in order for this mechanism to function properly.

### 15.3.7 Fault Conditions

There are two external conditions that affect the PWM block; the signal input on the Fault pin and the stalling of the controller by a debugger. There are two mechanisms available to handle such conditions: the output signals can be forced into an inactive state and/or the PWM timers can be stopped.

Each output signal has a fault bit. If set, a fault input signal causes the corresponding output signal to go into the inactive state. If the inactive state is a safe condition for the signal to be in for an extended period of time, this keeps the output signal from driving the outside world in a dangerous manner during the fault condition. A fault condition can also generate a controller interrupt.

Each PWM generator can also be configured to stop counting during a stall condition. The user can select for the counters to run until they reach zero then stop, or to continue counting and reloading. A stall condition does not generate a controller interrupt.

### 15.3.8 Output Control Block

With each PWM generator block producing two raw PWM signals, the output control block takes care of the final conditioning of the PWM signals before they go to the pins. Via a single register, the set of PWM signals that are actually enabled to the pins can be modified; this can be used, for example, to perform commutation of a brushless DC motor with a single register write (and without modifying the individual PWM generators, which are modified by the feedback control loop). Similarly, fault control can disable any of the PWM signals as well. A final inversion can be applied to any of the PWM signals, making them active Low instead of the default active High.

## 15.4 Initialization and Configuration

The following example shows how to initialize the PWM Generator 0 with a 25-KHz frequency, and with a 25% duty cycle on the `PWM0` pin and a 75% duty cycle on the `PWM1` pin. This example assumes the system clock is 20 MHz.

1. Enable the PWM clock by writing a value of 0x0010.0000 to the **RCGC0** register in the System Control module.
2. Enable the clock to the appropriate GPIO module via the **RCGC2** register in the System Control module.
3. In the GPIO module, enable the appropriate pins for their alternate function using the **GPIOAFSEL** register.
4. Configure the **Run-Mode Clock Configuration (RCC)** register in the System Control module to use the PWM divide (USEPWMDIV) and set the divider (PWMDIV) to divide by 2 (000).
5. Configure the PWM generator for countdown mode with immediate updates to the parameters.
   - Write the **PWM0CTL** register with a value of 0x0000.0000.
   - Write the **PWM0GENA** register with a value of 0x0000.008C.
   - Write the **PWM0GENB** register with a value of 0x0000.080C.
6. Set the period. For a 25-KHz frequency, the period = 1/25,000, or 40 microseconds. The PWM clock source is 10 MHz; the system clock divided by 2. This translates to 400 clock ticks per period. Use this value to set the **PWM0LOAD** register. In Count-Down mode, set the Load field in the **PWM0LOAD** register to the requested period minus one.
   - Write the **PWM0LOAD** register with a value of 0x0000.018F.
7. Set the pulse width of the PWM0 pin for a 25% duty cycle.
   - Write the **PWM0CMPA** register with a value of 0x0000.012B.
8. Set the pulse width of the PWM1 pin for a 75% duty cycle.
   - Write the **PWM0CMPB** register with a value of 0x0000.0063.
9. Start the timers in PWM generator 0.
   - Write the **PWM0CTL** register with a value of 0x0000.0001.
10. Enable PWM outputs.
    - Write the **PWMENABLE** register with a value of 0x0000.0003.

## 15.5 Register Map

Table 15-3 on page 528 lists the PWM registers. The offset listed is a hexadecimal increment to the register's address, relative to the PWM base address of 0x4002.8000. Note that the PWM module clock must be enabled before the registers can be programmed (see page 208). There must be a delay of 3 system clocks after the PWM module clock is enabled before any PWM module registers are accessed.

### Table 15-3. PWM Register Map

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | PWMCTL | R/W | 0x0000.0000 | PWM Master Control | 530 |
| 0x004 | PWMSYNC | R/W | 0x0000.0000 | PWM Time Base Sync | 531 |
| 0x008 | PWMENABLE | R/W | 0x0000.0000 | PWM Output Enable | 532 |
| 0x00C | PWMINVERT | R/W | 0x0000.0000 | PWM Output Inversion | 533 |
| 0x010 | PWMFAULT | R/W | 0x0000.0000 | PWM Output Fault | 534 |
| 0x014 | PWMINTEN | R/W | 0x0000.0000 | PWM Interrupt Enable | 535 |
| 0x018 | PWMRIS | RO | 0x0000.0000 | PWM Raw Interrupt Status | 536 |
| 0x01C | PWMISC | R/W1C | 0x0000.0000 | PWM Interrupt Status and Clear | 537 |
| 0x020 | PWMSTATUS | RO | 0x0000.0000 | PWM Status | 538 |
| 0x040 | PWM0CTL | R/W | 0x0000.0000 | PWM0 Control | 539 |
| 0x044 | PWM0INTEN | R/W | 0x0000.0000 | PWM0 Interrupt Enable | 541 |
| 0x048 | PWM0RIS | RO | 0x0000.0000 | PWM0 Raw Interrupt Status | 543 |
| 0x04C | PWM0ISC | R/W1C | 0x0000.0000 | PWM0 Interrupt Status and Clear | 544 |
| 0x050 | PWM0LOAD | R/W | 0x0000.0000 | PWM0 Load | 545 |
| 0x054 | PWM0COUNT | RO | 0x0000.0000 | PWM0 Counter | 546 |
| 0x058 | PWM0CMPA | R/W | 0x0000.0000 | PWM0 Compare A | 547 |
| 0x05C | PWM0CMPB | R/W | 0x0000.0000 | PWM0 Compare B | 548 |
| 0x060 | PWM0GENA | R/W | 0x0000.0000 | PWM0 Generator A Control | 549 |
| 0x064 | PWM0GENB | R/W | 0x0000.0000 | PWM0 Generator B Control | 552 |
| 0x068 | PWM0DBCTL | R/W | 0x0000.0000 | PWM0 Dead-Band Control | 555 |
| 0x06C | PWM0DBRISE | R/W | 0x0000.0000 | PWM0 Dead-Band Rising-Edge Delay | 556 |
| 0x070 | PWM0DBFALL | R/W | 0x0000.0000 | PWM0 Dead-Band Falling-Edge-Delay | 557 |
| 0x080 | PWM1CTL | R/W | 0x0000.0000 | PWM1 Control | 539 |
| 0x084 | PWM1INTEN | R/W | 0x0000.0000 | PWM1 Interrupt Enable | 541 |
| 0x088 | PWM1RIS | RO | 0x0000.0000 | PWM1 Raw Interrupt Status | 543 |
| 0x08C | PWM1ISC | R/W1C | 0x0000.0000 | PWM1 Interrupt Status and Clear | 544 |
| 0x090 | PWM1LOAD | R/W | 0x0000.0000 | PWM1 Load | 545 |
| 0x094 | PWM1COUNT | RO | 0x0000.0000 | PWM1 Counter | 546 |
| 0x098 | PWM1CMPA | R/W | 0x0000.0000 | PWM1 Compare A | 547 |
| 0x09C | PWM1CMPB | R/W | 0x0000.0000 | PWM1 Compare B | 548 |
| 0x0A0 | PWM1GENA | R/W | 0x0000.0000 | PWM1 Generator A Control | 549 |
| 0x0A4 | PWM1GENB | R/W | 0x0000.0000 | PWM1 Generator B Control | 552 |

**Table 15-3. PWM Register Map *(continued)***

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x0A8 | PWM1DBCTL | R/W | 0x0000.0000 | PWM1 Dead-Band Control | 555 |
| 0x0AC | PWM1DBRISE | R/W | 0x0000.0000 | PWM1 Dead-Band Rising-Edge Delay | 556 |
| 0x0B0 | PWM1DBFALL | R/W | 0x0000.0000 | PWM1 Dead-Band Falling-Edge-Delay | 557 |
| 0x0C0 | PWM2CTL | R/W | 0x0000.0000 | PWM2 Control | 539 |
| 0x0C4 | PWM2INTEN | R/W | 0x0000.0000 | PWM2 InterruptEnable | 541 |
| 0x0C8 | PWM2RIS | RO | 0x0000.0000 | PWM2 Raw Interrupt Status | 543 |
| 0x0CC | PWM2ISC | R/W1C | 0x0000.0000 | PWM2 Interrupt Status and Clear | 544 |
| 0x0D0 | PWM2LOAD | R/W | 0x0000.0000 | PWM2 Load | 545 |
| 0x0D4 | PWM2COUNT | RO | 0x0000.0000 | PWM2 Counter | 546 |
| 0x0D8 | PWM2CMPA | R/W | 0x0000.0000 | PWM2 Compare A | 547 |
| 0x0DC | PWM2CMPB | R/W | 0x0000.0000 | PWM2 Compare B | 548 |
| 0x0E0 | PWM2GENA | R/W | 0x0000.0000 | PWM2 Generator A Control | 549 |
| 0x0E4 | PWM2GENB | R/W | 0x0000.0000 | PWM2 Generator B Control | 552 |
| 0x0E8 | PWM2DBCTL | R/W | 0x0000.0000 | PWM2 Dead-Band Control | 555 |
| 0x0EC | PWM2DBRISE | R/W | 0x0000.0000 | PWM2 Dead-Band Rising-Edge Delay | 556 |
| 0x0F0 | PWM2DBFALL | R/W | 0x0000.0000 | PWM2 Dead-Band Falling-Edge-Delay | 557 |

## 15.6 Register Descriptions

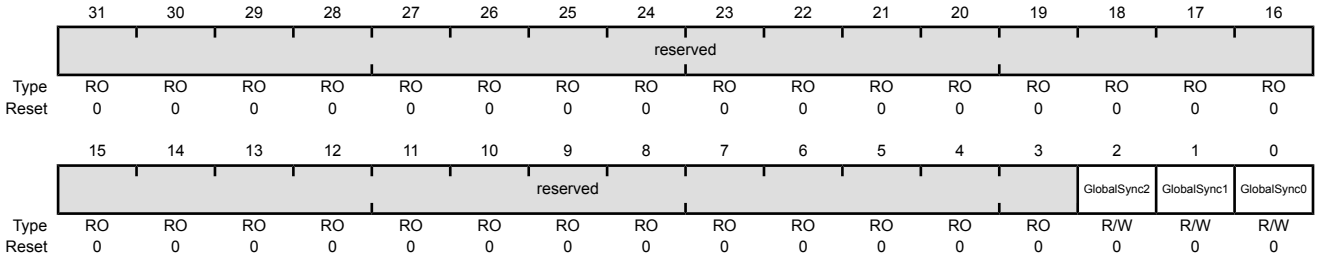
The remainder of this section lists and describes the PWM registers, in numerical order by address offset.

## Register 1: PWM Master Control (PWMCTL), offset 0x000

This register provides master control over the PWM generation blocks.

PWM Master Control (PWMCTL)

Base 0x4002.8000
Offset 0x000
Type R/W, reset 0x0000.0000



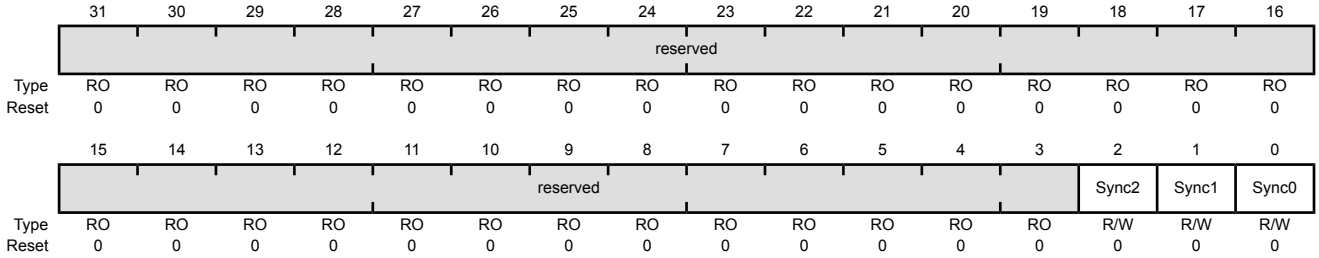

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | GlobalSync2 | R/W | 0 | Update PWM Generator 2<br>Same as `GlobalSync0` but for PWM generator 2. |
| 1 | GlobalSync1 | R/W | 0 | Update PWM Generator 1<br>Same as `GlobalSync0` but for PWM generator 1. |
| 0 | GlobalSync0 | R/W | 0 | Update PWM Generator 0<br>Setting this bit causes any queued update to a load or comparator register in PWM generator 0 to be applied the next time the corresponding counter becomes zero. This bit automatically clears when the updates have completed; it cannot be cleared by software. |

## Register 2: PWM Time Base Sync (PWMSYNC), offset 0x004

This register provides a method to perform synchronization of the counters in the PWM generation blocks. Writing a bit in this register to 1 causes the specified counter to reset back to 0; writing multiple bits resets multiple counters simultaneously. The bits auto-clear after the reset has occurred; reading them back as zero indicates that the synchronization has completed.

PWM Time Base Sync (PWMSYNC)

Base 0x4002.8000
Offset 0x004
Type R/W, reset 0x0000.0000



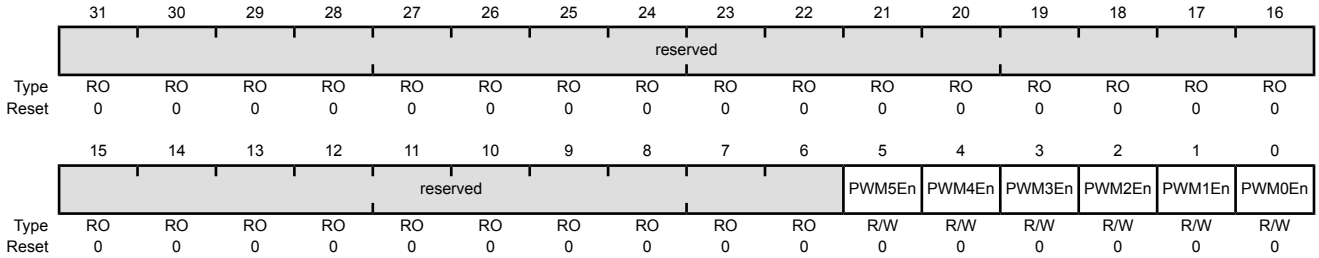

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | Sync2 | R/W | 0 | Reset Generator 2 Counter<br>Performs a reset of the PWM generator 2 counter. |
| 1 | Sync1 | R/W | 0 | Reset Generator 1 Counter<br>Performs a reset of the PWM generator 1 counter. |
| 0 | Sync0 | R/W | 0 | Reset Generator 0 Counter<br>Performs a reset of the PWM generator 0 counter. |

## Register 3: PWM Output Enable (PWMENABLE), offset 0x008

This register provides a master control of which generated PWM signals are output to device pins. By disabling a PWM output, the generation process can continue (for example, when the time bases are synchronized) without driving PWM signals to the pins. When bits in this register are set, the corresponding PWM signal is passed through to the output stage, which is controlled by the **PWMINVERT** register. When bits are not set, the PWM signal is replaced by a zero value which is also passed to the output stage.

PWM Output Enable (PWMENABLE)

Base 0x4002.8000
Offset 0x008
Type R/W, reset 0x0000.0000



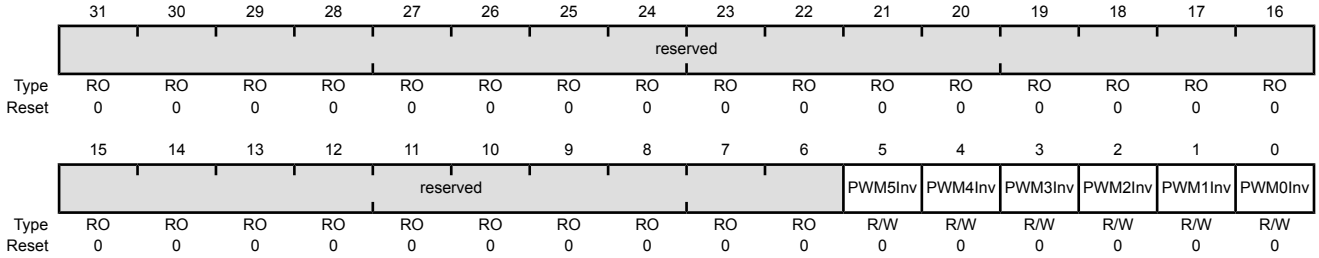

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | PWM5En | R/W | 0 | PWM5 Output Enable<br>When set, allows the generated PWM5 signal to be passed to the device pin. |
| 4 | PWM4En | R/W | 0 | PWM4 Output Enable<br>When set, allows the generated PWM4 signal to be passed to the device pin. |
| 3 | PWM3En | R/W | 0 | PWM3 Output Enable<br>When set, allows the generated PWM3 signal to be passed to the device pin. |
| 2 | PWM2En | R/W | 0 | PWM2 Output Enable<br>When set, allows the generated PWM2 signal to be passed to the device pin. |
| 1 | PWM1En | R/W | 0 | PWM1 Output Enable<br>When set, allows the generated PWM1 signal to be passed to the device pin. |
| 0 | PWM0En | R/W | 0 | PWM0 Output Enable<br>When set, allows the generated PWM0 signal to be passed to the device pin. |

## Register 4: PWM Output Inversion (PWMINVERT), offset 0x00C

This register provides a master control of the polarity of the PWM signals on the device pins. The PWM signals generated by the PWM generator are active High; they can optionally be made active Low via this register. Disabled PWM channels are also passed through the output inverter (if so configured) so that inactive channels maintain the correct polarity.

PWM Output Inversion (PWMINVERT)

Base 0x4002.8000
Offset 0x00C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | PWM5Inv | R/W | 0 | Invert PWM5 Signal<br>When set, the generated PWM5 signal is inverted. |
| 4 | PWM4Inv | R/W | 0 | Invert PWM4 Signal<br>When set, the generated PWM4 signal is inverted. |
| 3 | PWM3Inv | R/W | 0 | Invert PWM3 Signal<br>When set, the generated PWM3 signal is inverted. |
| 2 | PWM2Inv | R/W | 0 | Invert PWM2 Signal<br>When set, the generated PWM2 signal is inverted. |
| 1 | PWM1Inv | R/W | 0 | Invert PWM1 Signal<br>When set, the generated PWM1 signal is inverted. |
| 0 | PWM0Inv | R/W | 0 | Invert PWM0 Signal<br>When set, the generated PWM0 signal is inverted. |

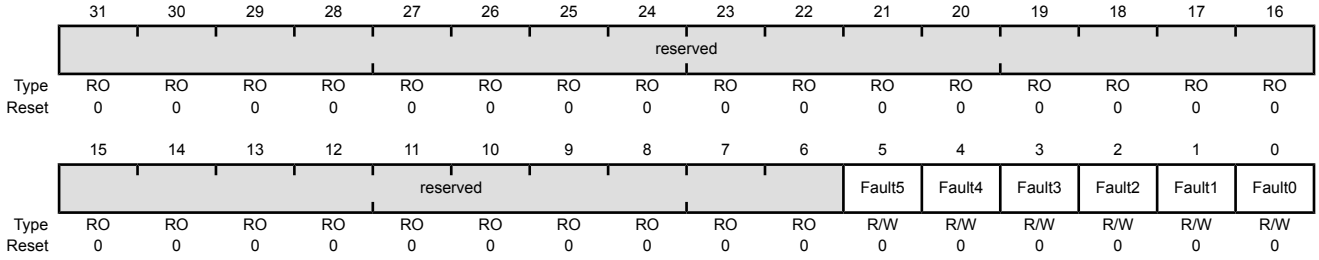
## Register 5: PWM Output Fault (PWMFAULT), offset 0x010

This register controls the behavior of the PWM outputs in the presence of fault conditions. Both the fault inputs and debug events are considered fault conditions. On a fault condition, each PWM signal can be passed through unmodified or driven Low. For outputs that are configured for pass-through, the debug event handling on the corresponding PWM generator also determines if the PWM signal continues to be generated.

Fault condition control occurs before the output inverter, so PWM signals driven Low on fault are inverted if the channel is configured for inversion (therefore, the pin is driven High on a fault condition).

PWM Output Fault (PWMFAULT)

Base 0x4002.8000
Offset 0x010
Type R/W, reset 0x0000.0000



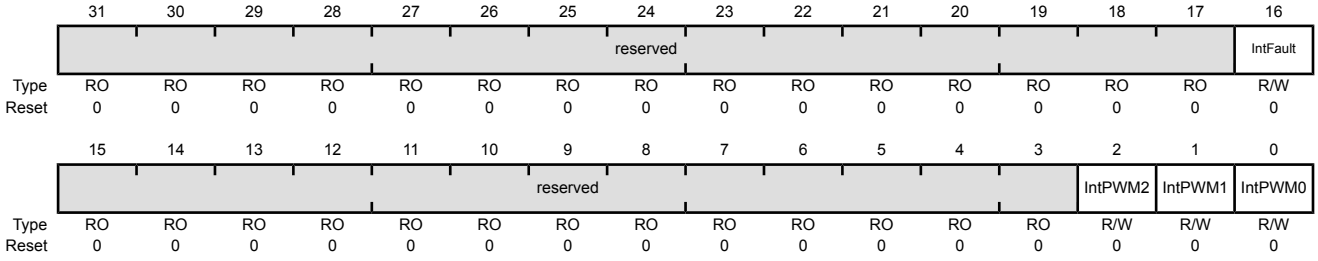

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | Fault5 | R/W | 0 | PWM5 Fault<br>When set, the PWM5 output signal is driven Low on a fault condition. |
| 4 | Fault4 | R/W | 0 | PWM4 Fault<br>When set, the PWM4 output signal is driven Low on a fault condition. |
| 3 | Fault3 | R/W | 0 | PWM3 Fault<br>When set, the PWM3 output signal is driven Low on a fault condition. |
| 2 | Fault2 | R/W | 0 | PWM2 Fault<br>When set, the PWM2 output signal is driven Low on a fault condition. |
| 1 | Fault1 | R/W | 0 | PWM1 Fault<br>When set, the PWM1 output signal is driven Low on a fault condition. |
| 0 | Fault0 | R/W | 0 | PWM0 Fault<br>When set, the PWM0 output signal is driven Low on a fault condition. |

## Register 6: PWM Interrupt Enable (PWMINTEN), offset 0x014

This register controls the global interrupt generation capabilities of the PWM module. The events that can cause an interrupt are the fault input and the individual interrupts from the PWM generators.

PWM Interrupt Enable (PWMINTEN)

Base 0x4002.8000
Offset 0x014
Type R/W, reset 0x0000.0000



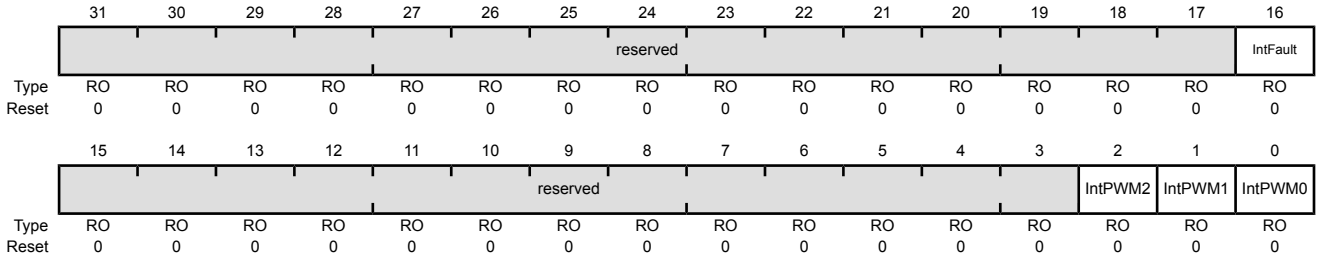

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:17 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 16 | IntFault | R/W | 0 | Fault Interrupt Enable<br>When set, an interrupt occurs when the fault input is asserted. |
| 15:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | IntPWM2 | R/W | 0 | PWM2 Interrupt Enable<br>When set, an interrupt occurs when the PWM generator 2 block asserts an interrupt. |
| 1 | IntPWM1 | R/W | 0 | PWM1 Interrupt Enable<br>When set, an interrupt occurs when the PWM generator 1 block asserts an interrupt. |
| 0 | IntPWM0 | R/W | 0 | PWM0 Interrupt Enable<br>When set, an interrupt occurs when the PWM generator 0 block asserts an interrupt. |

## Register 7: PWM Raw Interrupt Status (PWMRIS), offset 0x018

This register provides the current set of interrupt sources that are asserted, regardless of whether they cause an interrupt to be asserted to the controller. The fault interrupt is latched on detection; it must be cleared through the **PWM Interrupt Status and Clear (PWMISC)** register (see page 537). The PWM generator interrupts simply reflect the status of the PWM generators; they are cleared via the interrupt status register in the PWM generator blocks. Bits set to 1 indicate the events that are active; zero bits indicate that the event in question is not active.

PWM Raw Interrupt Status (PWMRIS)

Base 0x4002.8000
Offset 0x018
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:17 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 16 | IntFault | RO | 0 | Fault Interrupt Asserted<br>Indicates that the fault input is asserting. |
| 15:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | IntPWM2 | RO | 0 | PWM2 Interrupt Asserted<br>Indicates that the PWM generator 2 block is asserting its interrupt. |
| 1 | IntPWM1 | RO | 0 | PWM1 Interrupt Asserted<br>Indicates that the PWM generator 1 block is asserting its interrupt. |
| 0 | IntPWM0 | RO | 0 | PWM0 Interrupt Asserted<br>Indicates that the PWM generator 0 block is asserting its interrupt. |

## Register 8: PWM Interrupt Status and Clear (PWMISC), offset 0x01C

This register provides a summary of the interrupt status of the individual PWM generator blocks. A bit set to 1 indicates that the corresponding generator block is asserting an interrupt. The individual interrupt status registers in each block must be consulted to determine the reason for the interrupt, and used to clear the interrupt. For the fault interrupt, a write of 1 to that bit position clears the latched interrupt status.

PWM Interrupt Status and Clear (PWMISC)

Base 0x4002.8000
Offset 0x01C
Type R/W1C, reset 0x0000.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | | | | | | | | IntFault |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | R/W1C |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | | | | | | IntPWM2 | IntPWM1 | IntPWM0 |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

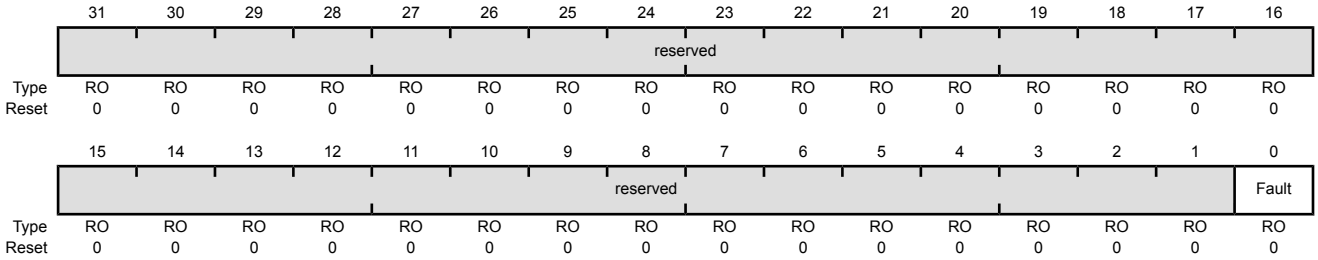
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:17 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 16 | IntFault | R/W1C | 0 | Fault Interrupt Asserted<br>Indicates that the fault input is asserting an interrupt. |
| 15:3 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 2 | IntPWM2 | RO | 0 | PWM2 Interrupt Status<br>Indicates if the PWM generator 2 block is asserting an interrupt. |
| 1 | IntPWM1 | RO | 0 | PWM1 Interrupt Status<br>Indicates if the PWM generator 1 block is asserting an interrupt. |
| 0 | IntPWM0 | RO | 0 | PWM0 Interrupt Status<br>Indicates if the PWM generator 0 block is asserting an interrupt. |

## Register 9: PWM Status (PWMSTATUS), offset 0x020

This register provides the status of the FAULT input signal.

PWM Status (PWMSTATUS)

Base 0x4002.8000
Offset 0x020
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | Fault | RO | 0 | Fault Interrupt Status<br>When set, indicates the fault input is asserted. |

## Register 10: PWM0 Control (PWM0CTL), offset 0x040

## Register 11: PWM1 Control (PWM1CTL), offset 0x080

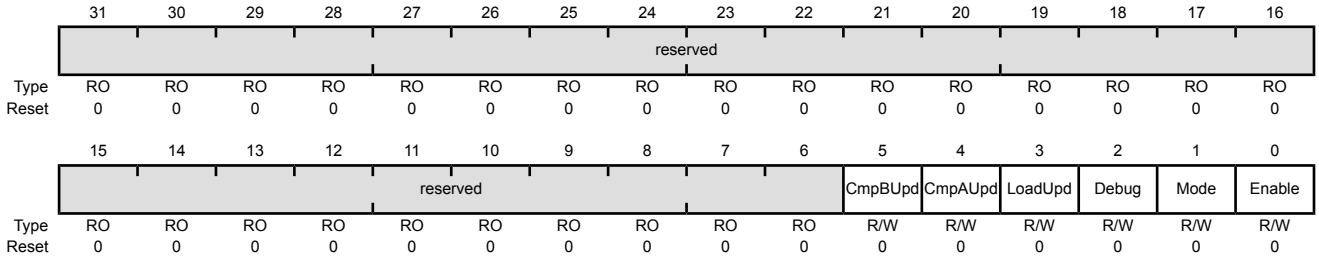
## Register 12: PWM2 Control (PWM2CTL), offset 0x0C0

These registers configure the PWM signal generation blocks (PWM0CTL controls the PWM generator 0 block, and so on). The Register Update mode, Debug mode, Counting mode, and Block Enable mode are all controlled via these registers. The blocks produce the PWM signals, which can be either two independent PWM signals (from the same counter), or a paired set of PWM signals with dead-band delays added.

The PWM0 block produces the PWM0 and PWM1 outputs, the PWM1 block produces the PWM2 and PWM3 outputs, and the PWM2 block produces the PWM4 and PWM5 outputs.

PWM0 Control (PWM0CTL)

Base 0x4002.8000
Offset 0x040
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | CmpBUpd | R/W | 0 | Comparator B Update Mode<br>Same as CmpAUpd but for the comparator B register. |
| 4 | CmpAUpd | R/W | 0 | Comparator A Update Mode<br>The Update mode for the comparator A register. When not set, updates to the register are reflected to the comparator the next time the counter is 0. When set, updates to the register are delayed until the next time the counter is 0 after a synchronous update has been requested through the **PWM Master Control (PWMCTL)** register (see page 530). |
| 3 | LoadUpd | R/W | 0 | Load Register Update Mode<br>The Update mode for the load register. When not set, updates to the register are reflected to the counter the next time the counter is 0. When set, updates to the register are delayed until the next time the counter is 0 after a synchronous update has been requested through the **PWM Master Control (PWMCTL)** register. |
| 2 | Debug | R/W | 0 | Debug Mode<br>The behavior of the counter in Debug mode. When not set, the counter stops running when it next reaches 0, and continues running again when no longer in Debug mode. When set, the counter always runs. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1 | Mode | R/W | 0 | Counter Mode<br>The mode for the counter. When not set, the counter counts down from the load value to 0 and then wraps back to the load value (Count-Down mode). When set, the counter counts up from 0 to the load value, back down to 0, and then repeats (Count-Up/Down mode). |
| 0 | Enable | R/W | 0 | PWM Block Enable<br>Master enable for the PWM generation block. When not set, the entire block is disabled and not clocked. When set, the block is enabled and produces PWM signals. |

### Register 13: PWM0 Interrupt Enable (PWM0INTEN), offset 0x044

### Register 14: PWM1 Interrupt Enable (PWM1INTEN), offset 0x084

### Register 15: PWM2 InterruptEnable (PWM2INTEN), offset 0x0C4

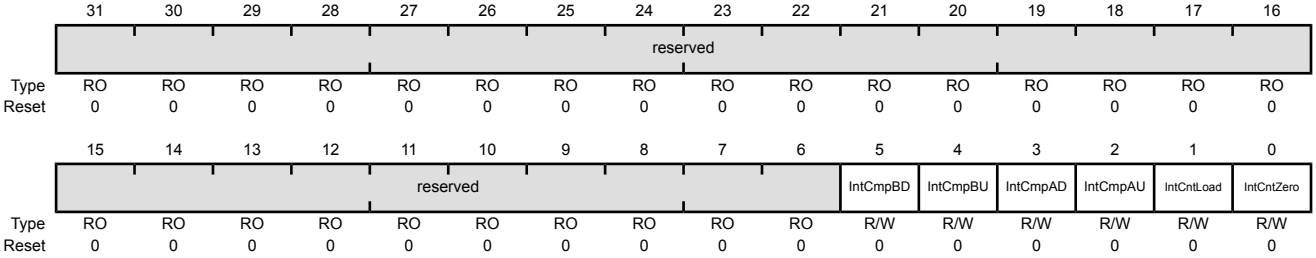
These registers control the interrupt generation capabilities of the PWM generators (**PWM0INTEN** controls the PWM generator 0 block, and so on). The events that can cause an interrupt are:

- The counter being equal to the load register
- The counter being equal to zero
- The counter being equal to the comparator A register while counting up
- The counter being equal to the comparator A register while counting down
- The counter being equal to the comparator B register while counting up
- The counter being equal to the comparator B register while counting down

Any combination of these events can generate either an interrupt.

PWM0 Interrupt Enable (PWM0INTEN)

Base 0x4002.8000
Offset 0x044
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | IntCmpBD | R/W | 0 | Interrupt for Counter=Comparator B Down<br>Value Description<br>1 A raw interrupt occurs when the counter matches the value in the **PWMnCMPB** register value while counting down.<br>0 No interrupt. |
| 4 | IntCmpBU | R/W | 0 | Interrupt for Counter=Comparator B Up<br>Value Description<br>1 A raw interrupt occurs when the counter matches the value in the **PWMnCMPB** register value while counting up.<br>0 No interrupt. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 3 | IntCmpAD | R/W | 0 | Interrupt for Counter=Comparator A Down<br><br>Value Description<br>1 A raw interrupt occurs when the counter matches the value in the **PWMnCMPA** register value while counting down.<br>0 No interrupt. |
| 2 | IntCmpAU | R/W | 0 | Interrupt for Counter=Comparator A Up<br><br>Value Description<br>1 A raw interrupt occurs when the counter matches the value in the **PWMnCMPA** register value while counting up.<br>0 No interrupt. |
| 1 | IntCntLoad | R/W | 0 | Interrupt for Counter=Load<br><br>Value Description<br>1 A raw interrupt occurs when the counter matches the value in the **PWMnLOAD** register value.<br>0 No interrupt. |
| 0 | IntCntZero | R/W | 0 | Interrupt for Counter=0<br><br>Value Description<br>1 A raw interrupt occurs when the counter is zero.<br>0 No interrupt. |

## Register 16: PWM0 Raw Interrupt Status (PWM0RIS), offset 0x048

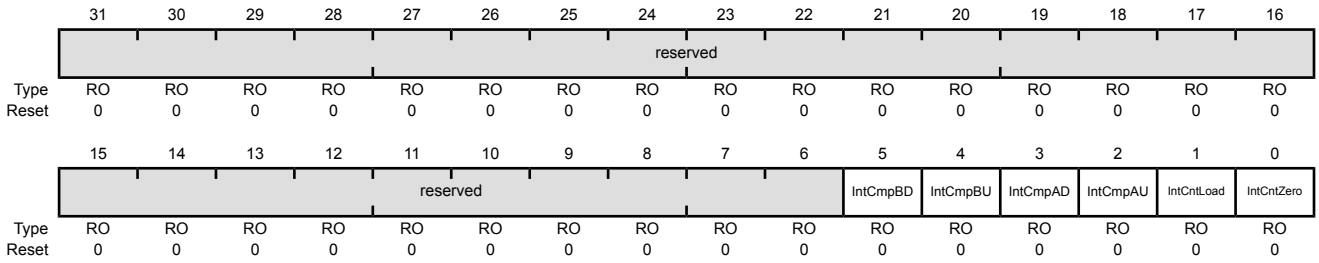
## Register 17: PWM1 Raw Interrupt Status (PWM1RIS), offset 0x088

## Register 18: PWM2 Raw Interrupt Status (PWM2RIS), offset 0x0C8

These registers provide the current set of interrupt sources that are asserted, regardless of whether they cause an interrupt to be asserted to the controller (**PWM0RIS** controls the PWM generator 0 block, and so on). Bits set to 1 indicate the latched events that have occurred; bits set to 0 indicate that the event in question has not occurred.

PWM0 Raw Interrupt Status (PWM0RIS)

Base 0x4002.8000
Offset 0x048
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | IntCmpBD | RO | 0 | Comparator B Down Interrupt Status<br>Indicates that the counter has matched the comparator B value while counting down. |
| 4 | IntCmpBU | RO | 0 | Comparator B Up Interrupt Status<br>Indicates that the counter has matched the comparator B value while counting up. |
| 3 | IntCmpAD | RO | 0 | Comparator A Down Interrupt Status<br>Indicates that the counter has matched the comparator A value while counting down. |
| 2 | IntCmpAU | RO | 0 | Comparator A Up Interrupt Status<br>Indicates that the counter has matched the comparator A value while counting up. |
| 1 | IntCntLoad | RO | 0 | Counter=Load Interrupt Status<br>Indicates that the counter has matched the **PWMnLOAD** register. |
| 0 | IntCntZero | RO | 0 | Counter=0 Interrupt Status<br>Indicates that the counter has matched 0. |

## Register 19: PWM0 Interrupt Status and Clear (PWM0ISC), offset 0x04C

## Register 20: PWM1 Interrupt Status and Clear (PWM1ISC), offset 0x08C

## Register 21: PWM2 Interrupt Status and Clear (PWM2ISC), offset 0x0CC

These registers provide the current set of interrupt sources that are asserted to the controller (**PWM0ISC** controls the PWM generator 0 block, and so on). Bits set to 1 indicate the latched events that have occurred; bits set to 0 indicate that the event in question has not occurred. These are R/W1C registers; writing a 1 to a bit position clears the corresponding interrupt reason.

PWM0 Interrupt Status and Clear (PWM0ISC)

Base 0x4002.8000
Offset 0x04C
Type R/W1C, reset 0x0000.0000

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| reserved | | | | | | | | | | | | | | | |
| RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| reserved | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | R/W1C | R/W1C | R/W1C | R/W1C | R/W1C | R/W1C |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:6 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 5 | IntCmpBD | R/W1C | 0 | Comparator B Down Interrupt<br>Indicates that the counter has matched the comparator B value while counting down. |
| 4 | IntCmpBU | R/W1C | 0 | Comparator B Up Interrupt<br>Indicates that the counter has matched the comparator B value while counting up. |
| 3 | IntCmpAD | R/W1C | 0 | Comparator A Down Interrupt<br>Indicates that the counter has matched the comparator A value while counting down. |
| 2 | IntCmpAU | R/W1C | 0 | Comparator A Up Interrupt<br>Indicates that the counter has matched the comparator A value while counting up. |
| 1 | IntCntLoad | R/W1C | 0 | Counter=Load Interrupt<br>Indicates that the counter has matched the **PWMnLOAD** register. |
| 0 | IntCntZero | R/W1C | 0 | Counter=0 Interrupt<br>Indicates that the counter has matched 0. |

### Register 22: PWM0 Load (PWM0LOAD), offset 0x050

### Register 23: PWM1 Load (PWM1LOAD), offset 0x090

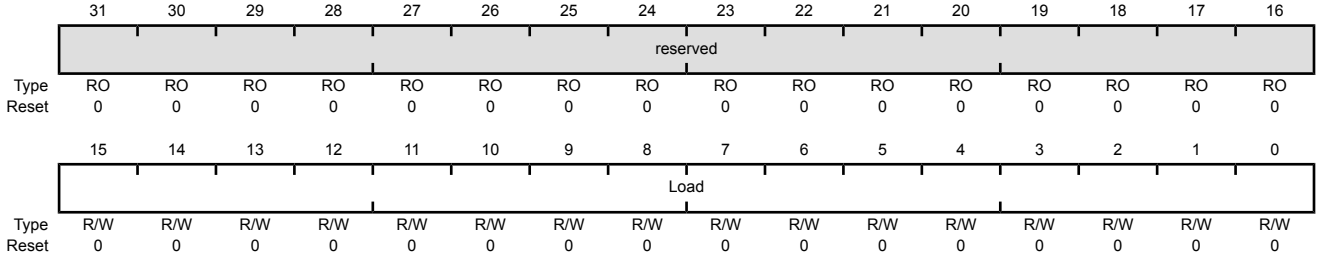
### Register 24: PWM2 Load (PWM2LOAD), offset 0x0D0

These registers contain the load value for the PWM counter (**PWM0LOAD** controls the PWM generator 0 block, and so on). Based on the counter mode, either this value is loaded into the counter after it reaches zero, or it is the limit of up-counting after which the counter decrements back to zero.

If the Load Value Update mode is immediate, this value is used the next time the counter reaches zero; if the mode is synchronous, it is used the next time the counter reaches zero after a synchronous update has been requested through the **PWM Master Control (PWMCTL)** register (see page 530). If this register is re-written before the actual update occurs, the previous value is never used and is lost.

PWM0 Load (PWM0LOAD)

Base 0x4002.8000
Offset 0x050
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | Load | R/W | 0 | Counter Load Value<br>The counter load value. |

## Register 25: PWM0 Counter (PWM0COUNT), offset 0x054

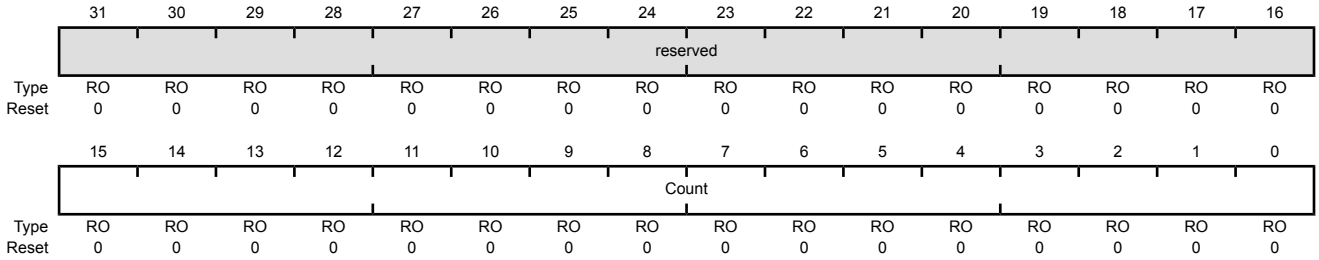
## Register 26: PWM1 Counter (PWM1COUNT), offset 0x094

## Register 27: PWM2 Counter (PWM2COUNT), offset 0x0D4

These registers contain the current value of the PWM counter (**PWM0COUNT** is the value of the PWM generator 0 block, and so on). When this value matches the load register, a pulse is output; this can drive the generation of a PWM signal (via the **PWMnGENA/PWMnGENB** registers, see page 549 and page 552) or drive an interrupt (via the **PWMnINTEN** register, see page 541). A pulse with the same capabilities is generated when this value is zero.

PWM0 Counter (PWM0COUNT)

Base 0x4002.8000
Offset 0x054
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | Count | RO | 0x00 | Counter Value<br>The current value of the counter. |

### Register 28: PWM0 Compare A (PWM0CMPA), offset 0x058

### Register 29: PWM1 Compare A (PWM1CMPA), offset 0x098

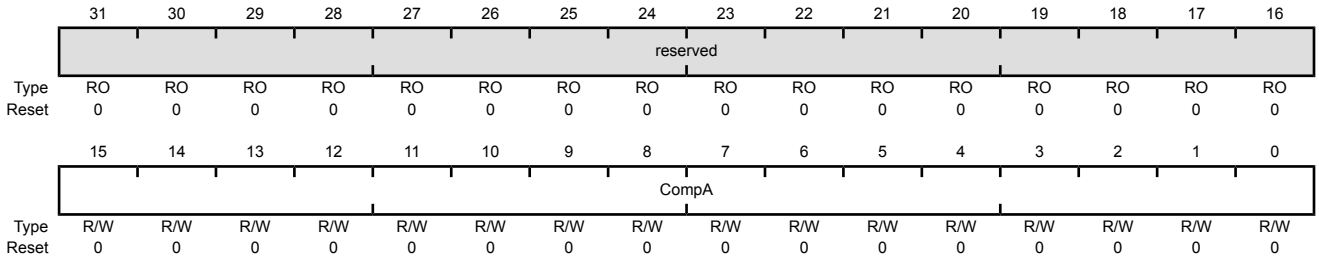
### Register 30: PWM2 Compare A (PWM2CMPA), offset 0x0D8

These registers contain a value to be compared against the counter (**PWM0CMPA** controls the PWM generator 0 block, and so on). When this value matches the counter, a pulse is output; this can drive the generation of a PWM signal (via the **PWMnGENA/PWMnGENB** registers) or drive an interrupt (via the **PWMnINTEN** register). If the value of this register is greater than the **PWMnLOAD** register (see page 545), then no pulse is ever output.

If the comparator A update mode is immediate (based on the CmpAUpd bit in the **PWMnCTL** register), this 16-bit CompA value is used the next time the counter reaches zero. If the update mode is synchronous, it is used the next time the counter reaches zero after a synchronous update has been requested through the **PWM Master Control (PWMCTL)** register (see page 530). If this register is rewritten before the actual update occurs, the previous value is never used and is lost.

PWM0 Compare A (PWM0CMPA)

Base 0x4002.8000
Offset 0x058
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | CompA | R/W | 0x00 | Comparator A Value<br>The value to be compared against the counter. |

### Register 31: PWM0 Compare B (PWM0CMPB), offset 0x05C

### Register 32: PWM1 Compare B (PWM1CMPB), offset 0x09C

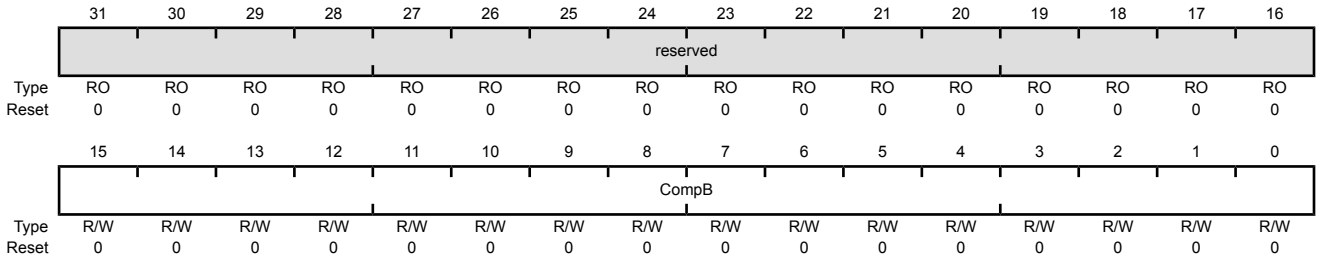
### Register 33: PWM2 Compare B (PWM2CMPB), offset 0x0DC

These registers contain a value to be compared against the counter (**PWM0CMPB** controls the PWM generator 0 block, and so on). When this value matches the counter, a pulse is output; this can drive the generation of a PWM signal (via the **PWMnGENA/PWMnGENB** registers) or drive an interrupt (via the **PWMnINTEN** register). If the value of this register is greater than the **PWMnLOAD** register, no pulse is ever output.

If the comparator B update mode is immediate (based on the CmpBUpd bit in the **PWMnCTL** register), this 16-bit CompB value is used the next time the counter reaches zero. If the update mode is synchronous, it is used the next time the counter reaches zero after a synchronous update has been requested through the **PWM Master Control (PWMCTL)** register (see page 530). If this register is rewritten before the actual update occurs, the previous value is never used and is lost.

PWM0 Compare B (PWM0CMPB)

Base 0x4002.8000
Offset 0x05C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:16 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 15:0 | CompB | R/W | 0x00 | Comparator B Value<br>The value to be compared against the counter. |

## Register 34: PWM0 Generator A Control (PWM0GENA), offset 0x060

## Register 35: PWM1 Generator A Control (PWM1GENA), offset 0x0A0

## Register 36: PWM2 Generator A Control (PWM2GENA), offset 0x0E0

These registers control the generation of the PWMnA signal based on the load and zero output pulses from the counter, as well as the compare A and compare B pulses from the comparators (**PWM0GENA** controls the PWM generator 0 block, and so on). When the counter is running in Count-Down mode, only four of these events occur; when running in Count-Up/Down mode, all six occur. These events provide great flexibility in the positioning and duty cycle of the PWM signal that is produced.

The **PWM0GENA** register controls generation of the PWM0A signal; **PWM1GENA**, the PWM1A signal; and **PWM2GENA**, the PWM2A signal.

If a zero or load event coincides with a compare A or compare B event, the zero or load action is taken and the compare A or compare B action is ignored. If a compare A event coincides with a compare B event, the compare A action is taken and the compare B action is ignored.

PWM0 Generator A Control (PWM0GENA)

Base 0x4002.8000
Offset 0x060
Type R/W, reset 0x0000.0000

| Bit | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| Type | RO | RO | RO | RO | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:10 | ActCmpBD | R/W | 0x0 | Action for Comparator B Down<br>The action to be taken when the counter matches comparator B while counting down.<br>The table below defines the effect of the event on the output signal. |

| Value | Description |
|---|---|
| 0x0 | Do nothing. |
| 0x1 | Invert the output signal. |
| 0x2 | Set the output signal to 0. |
| 0x3 | Set the output signal to 1. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 9:8 | ActCmpBU | R/W | 0x0 | Action for Comparator B Up<br>The action to be taken when the counter matches comparator B while counting up. Occurs only when the Mode bit in the **PWMnCTL** register (see page 539) is set to 1.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |
| 7:6 | ActCmpAD | R/W | 0x0 | Action for Comparator A Down<br>The action to be taken when the counter matches comparator A while counting down.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |
| 5:4 | ActCmpAU | R/W | 0x0 | Action for Comparator A Up<br>The action to be taken when the counter matches comparator A while counting up. Occurs only when the Mode bit in the **PWMnCTL** register is set to 1.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |
| 3:2 | ActLoad | R/W | 0x0 | Action for Counter=Load<br>The action to be taken when the counter matches the load value.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1:0 | ActZero | R/W | 0x0 | Action for Counter=0<br>The action to be taken when the counter is zero.<br>The table below defines the effect of the event on the output signal. |

| Value | Description |
|---|---|
| 0x0 | Do nothing. |
| 0x1 | Invert the output signal. |
| 0x2 | Set the output signal to 0. |
| 0x3 | Set the output signal to 1. |

## Register 37: PWM0 Generator B Control (PWM0GENB), offset 0x064

## Register 38: PWM1 Generator B Control (PWM1GENB), offset 0x0A4

## Register 39: PWM2 Generator B Control (PWM2GENB), offset 0x0E4

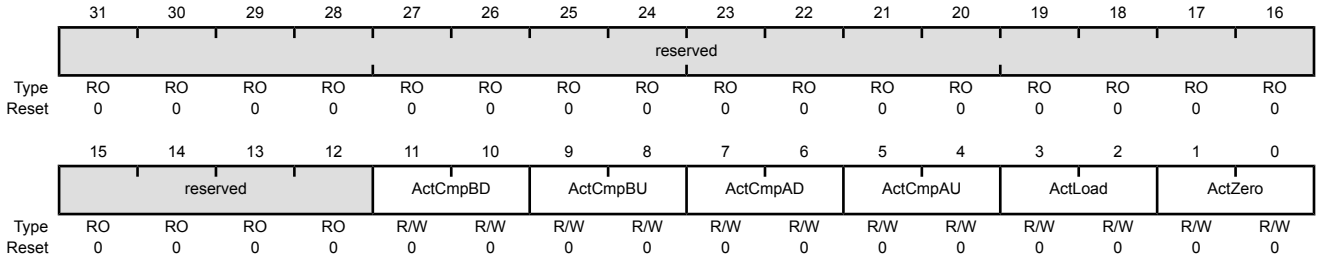
These registers control the generation of the PWMnB signal based on the load and zero output pulses from the counter, as well as the compare A and compare B pulses from the comparators (**PWM0GENB** controls the PWM generator 0 block, and so on). When the counter is running in Down mode, only four of these events occur; when running in Up/Down mode, all six occur. These events provide great flexibility in the positioning and duty cycle of the PWM signal that is produced.

The **PWM0GENB** register controls generation of the PWM0B signal; **PWM1GENB**, the PWM1B signal; and **PWM2GENB**, the PWM2B signal.

If a zero or load event coincides with a compare A or compare B event, the zero or load action is taken and the compare A or compare B action is ignored. If a compare A event coincides with a compare B event, the compare B action is taken and the compare A action is ignored.

PWM0 Generator B Control (PWM0GENB)

Base 0x4002.8000
Offset 0x064
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:10 | ActCmpBD | R/W | 0x0 | Action for Comparator B Down<br>The action to be taken when the counter matches comparator B while counting down.<br>The table below defines the effect of the event on the output signal. |

| Value | Description |
|---|---|
| 0x0 | Do nothing. |
| 0x1 | Invert the output signal. |
| 0x2 | Set the output signal to 0. |
| 0x3 | Set the output signal to 1. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 9:8 | ActCmpBU | R/W | 0x0 | Action for Comparator B Up<br>The action to be taken when the counter matches comparator B while counting up. Occurs only when the Mode bit in the **PWMnCTL** register is set to 1.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |
| 7:6 | ActCmpAD | R/W | 0x0 | Action for Comparator A Down<br>The action to be taken when the counter matches comparator A while counting down.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |
| 5:4 | ActCmpAU | R/W | 0x0 | Action for Comparator A Up<br>The action to be taken when the counter matches comparator A while counting up. Occurs only when the Mode bit in the **PWMnCTL** register is set to 1.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |
| 3:2 | ActLoad | R/W | 0x0 | Action for Counter=Load<br>The action to be taken when the counter matches the load value.<br>The table below defines the effect of the event on the output signal.<br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 1:0 | ActZero | R/W | 0x0 | Action for Counter=0<br>The action to be taken when the counter is 0.<br>The table below defines the effect of the event on the output signal.<br><br>Value Description<br>0x0 Do nothing.<br>0x1 Invert the output signal.<br>0x2 Set the output signal to 0.<br>0x3 Set the output signal to 1. |

## Register 40: PWM0 Dead-Band Control (PWM0DBCTL), offset 0x068

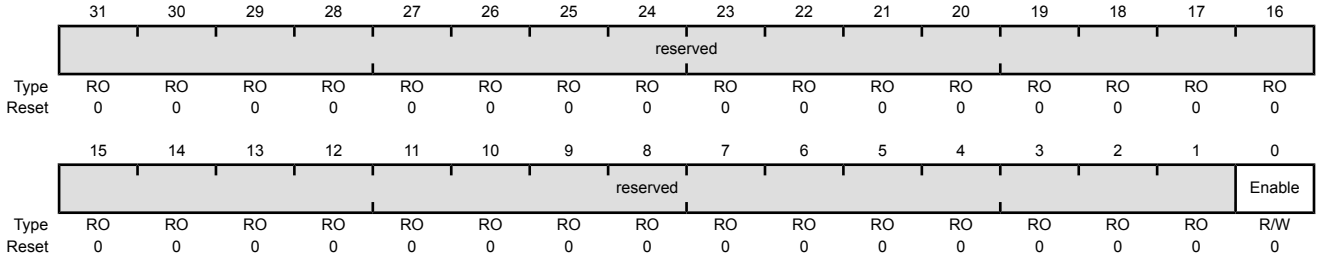
## Register 41: PWM1 Dead-Band Control (PWM1DBCTL), offset 0x0A8

## Register 42: PWM2 Dead-Band Control (PWM2DBCTL), offset 0x0E8

The **PWM0DBCTL** register controls the dead-band generator, which produces the PWM0 and PWM1 signals based on the PWM0A and PWM0B signals. When disabled, the PWM0A signal passes through to the PWM0 signal and the PWM0B signal passes through to the PWM1 signal. When enabled and inverting the resulting waveform, the PWM0B signal is ignored; the PWM0 signal is generated by delaying the rising edge(s) of the PWM0A signal by the value in the **PWM0DBRISE** register (see page 556), and the PWM1 signal is generated by delaying the falling edge(s) of the PWM0A signal by the value in the **PWM0DBFALL** register (see page 557). In a similar manner, PWM2 and PWM3 are produced from the PWM1A and PWM1B signals, and PWM4 and PWM5 are produced from the PWM2A and PWM2B signals.

PWM0 Dead-Band Control (PWM0DBCTL)

Base 0x4002.8000
Offset 0x068
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:1 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 0 | Enable | R/W | 0 | Dead-Band Generator Enable<br>When set, the dead-band generator inserts dead bands into the output signals; when clear, it simply passes the PWM signals through. |

## Register 43: PWM0 Dead-Band Rising-Edge Delay (PWM0DBRISE), offset 0x06C

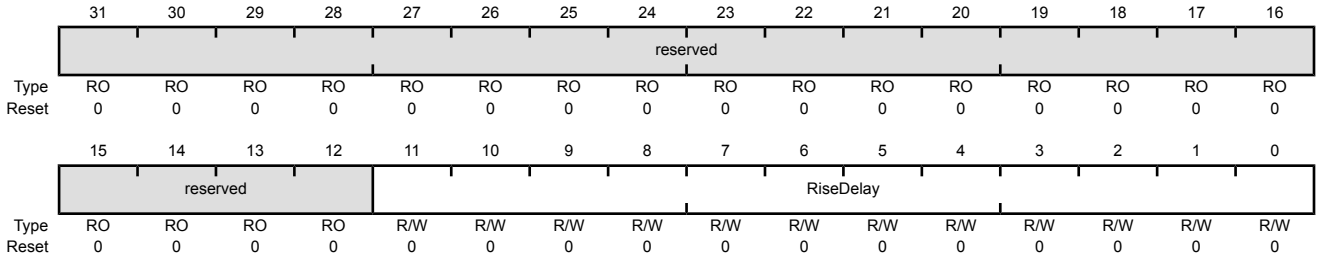
## Register 44: PWM1 Dead-Band Rising-Edge Delay (PWM1DBRISE), offset 0x0AC

## Register 45: PWM2 Dead-Band Rising-Edge Delay (PWM2DBRISE), offset 0x0EC

The **PWM0DBRISE** register contains the number of clock ticks to delay the rising edge of the PWM0A signal when generating the PWM0 signal. If the dead-band generator is disabled through the **PWMnDBCTL** register, the **PWM0DBRISE** register is ignored. If the value of this register is larger than the width of a High pulse on the input PWM signal, the rising-edge delay consumes the entire High time of the signal, resulting in no High time on the output. Care must be taken to ensure that the input High time always exceeds the rising-edge delay. In a similar manner, PWM2 is generated from PWM1A with its rising edge delayed and PWM4 is produced from PWM2A with its rising edge delayed.

PWM0 Dead-Band Rising-Edge Delay (PWM0DBRISE)

Base 0x4002.8000
Offset 0x06C
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | RiseDelay | R/W | 0 | Dead-Band Rise Delay<br>The number of clock ticks to delay the rising edge. |

## Register 46: PWM0 Dead-Band Falling-Edge-Delay (PWM0DBFALL), offset 0x070

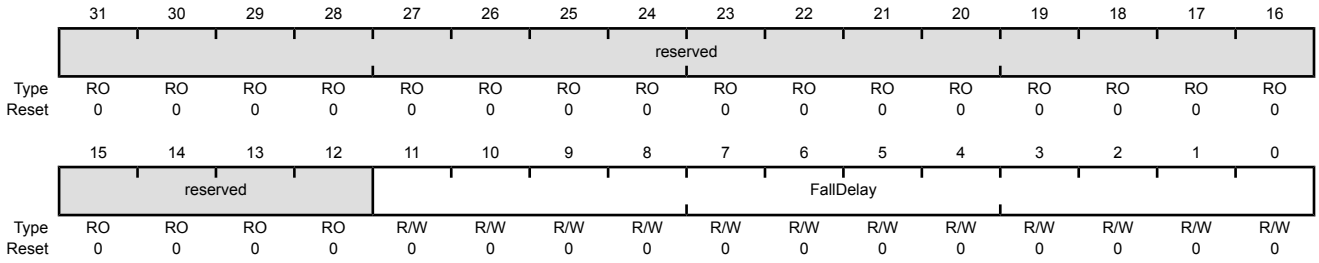
## Register 47: PWM1 Dead-Band Falling-Edge-Delay (PWM1DBFALL), offset 0x0B0

## Register 48: PWM2 Dead-Band Falling-Edge-Delay (PWM2DBFALL), offset 0x0F0

The **PWM0DBFALL** register contains the number of clock ticks to delay the falling edge of the PWM0A signal when generating the PWM1 signal. If the dead-band generator is disabled, this register is ignored. If the value of this register is larger than the width of a Low pulse on the input PWM signal, the falling-edge delay consumes the entire Low time of the signal, resulting in no Low time on the output. Care must be taken to ensure that the input Low time always exceeds the falling-edge delay. In a similar manner, PWM3 is generated from PWM1A with its falling edge delayed and PWM5 is produced from PWM2A with its falling edge delayed.

PWM0 Dead-Band Falling-Edge-Delay (PWM0DBFALL)

Base 0x4002.8000
Offset 0x070
Type R/W, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:12 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 11:0 | FallDelay | R/W | 0x00 | Dead-Band Fall Delay<br>The number of clock ticks to delay the falling edge. |

# 16 Quadrature Encoder Interface (QEI)

A quadrature encoder, also known as a 2-channel incremental encoder, converts linear displacement into a pulse signal. By monitoring both the number of pulses and the relative phase of the two signals, you can track the position, direction of rotation, and speed. In addition, a third channel, or index signal, can be used to reset the position counter.

The LM3S1960 microcontroller includes two quadrature encoder interface (QEI) modules. Each QEI module interprets the code produced by a quadrature encoder wheel to integrate position over time and determine direction of rotation. In addition, it can capture a running estimate of the velocity of the encoder wheel.

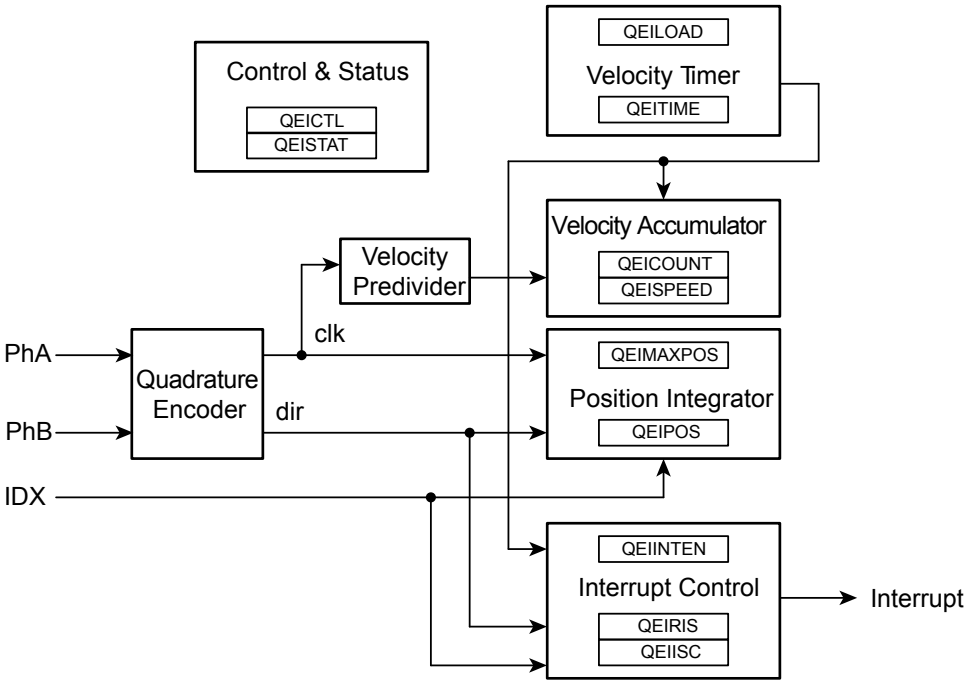
Each Stellaris® quadrature encoder has the following features:

- Two QEI modules, each with the following features:
- Position integrator that tracks the encoder position
- Velocity capture using built-in timer
- The input frequency of the QEI inputs may be as high as 1/4 of the processor frequency (for example, 12.5 MHz for a 50-MHz system)
- Interrupt generation on:
  - Index pulse
  - Velocity-timer expiration
  - Direction change
  - Quadrature error detection

## 16.1 Block Diagram

Figure 16-1 on page 559 provides a block diagram of a Stellaris QEI module.

**Figure 16-1. QEI Block Diagram**




## 16.2 Signal Description

Table 16-1 on page 559 and Table 16-2 on page 559 list the external signals of the QEI module and describe the function of each. The QEI signals are alternate functions for some GPIO signals and default to be GPIO signals at reset. The column in the table below titled "Pin Assignment" lists the possible GPIO pin placements for these QEI signals. The AFSEL bit in the **GPIO Alternate Function Select (GPIOAFSEL)** register (page 303) should be set to choose the QEI function. For more information on configuring GPIOs, see “General-Purpose Input/Outputs (GPIOs)” on page 280.

**Table 16-1. QEI Signals (100LQFP)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| IDX0 | 10 | I | TTL | QEI module 0 index. |
| IDX1 | 84 | I | TTL | QEI module 1 index. |
| PhA0 | 11 | I | TTL | QEI module 0 phase A. |
| PhA1 | 37 | I | TTL | QEI module 1 phase A. |
| PhB0 | 83 | I | TTL | QEI module 0 phase B. |
| PhB1 | 36 | I | TTL | QEI module 1 phase B. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 16-2. QEI Signals (108BGA)**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| IDX0 | G1 | I | TTL | QEI module 0 index. |
| IDX1 | D11 | I | TTL | QEI module 1 index. |
| PhA0 | G2 | I | TTL | QEI module 0 phase A. |
| PhA1 | L7 | I | TTL | QEI module 1 phase A. |

**Table 16-2. QEI Signals (108BGA) *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PhB0 | D10 | I | TTL | QEI module 0 phase B. |
| PhB1 | C10 | I | TTL | QEI module 1 phase B. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

## 16.3 Functional Description

The QEI module interprets the two-bit gray code produced by a quadrature encoder wheel to integrate position over time and determine direction of rotation. In addition, it can capture a running estimate of the velocity of the encoder wheel.

The position integrator and velocity capture can be independently enabled, though the position integrator must be enabled before the velocity capture can be enabled. The two phase signals, PhA and PhB, can be swapped before being interpreted by the QEI module to change the meaning of forward and backward, and to correct for miswiring of the system. Alternatively, the phase signals can be interpreted as a clock and direction signal as output by some encoders.

The QEI module supports two modes of signal operation: quadrature phase mode and clock/direction mode. In quadrature phase mode, the encoder produces two clocks that are 90 degrees out of phase; the edge relationship is used to determine the direction of rotation. In clock/direction mode, the encoder produces a clock signal to indicate steps and a direction signal to indicate the direction of rotation. This mode is determined by the SigMode bit of the **QEI Control (QEICTL)** register (see page 564).

When the QEI module is set to use the quadrature phase mode (SigMode bit equals zero), the capture mode for the position integrator can be set to update the position counter on every edge of the PhA signal or to update on every edge of both PhA and PhB. Updating the position counter on every PhA and PhB provides more positional resolution at the cost of less range in the positional counter.

When edges on PhA lead edges on PhB , the position counter is incremented. When edges on PhB lead edges on PhA , the position counter is decremented. When a rising and falling edge pair is seen on one of the phases without any edges on the other, the direction of rotation has changed.

The positional counter is automatically reset on one of two conditions: sensing the index pulse or reaching the maximum position value. Which mode is determined by the ResMode bit of the **QEI Control (QEICTL)** register.

When ResMode is 1, the positional counter is reset when the index pulse is sensed. This limits the positional counter to the values [0:N-1], where N is the number of phase edges in a full revolution of the encoder wheel. The **QEIMAXPOS** register must be programmed with N-1 so that the reverse direction from position 0 can move the position counter to N-1. In this mode, the position register contains the absolute position of the encoder relative to the index (or home) position once an index pulse has been seen.

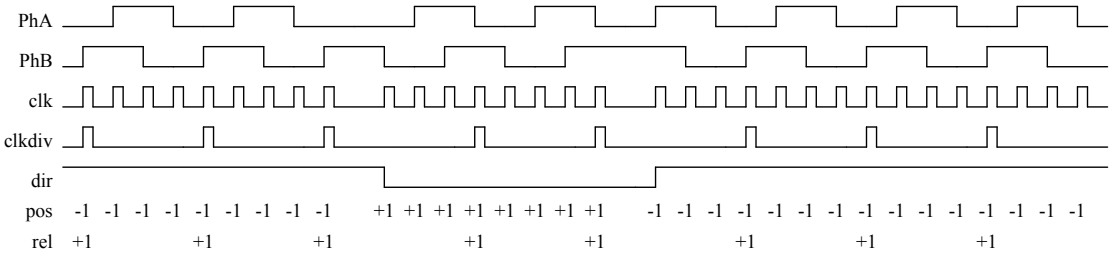
When ResMode is 0, the positional counter is constrained to the range [0:M], where M is the programmable maximum value. The index pulse is ignored by the positional counter in this mode.

The velocity capture has a configurable timer and a count register. It counts the number of phase edges (using the same configuration as for the position integrator) in a given time period. The edge count from the previous time period is available to the controller via the **QEISPEED** register, while the edge count for the current time period is being accumulated in the **QEICOUNT** register. As soon as the current time period is complete, the total number of edges counted in that time period is made available in the **QEISPEED** register (losing the previous value), the **QEICOUNT** is reset to 0, and

counting commences on a new time period. The number of edges counted in a given time period is directly proportional to the velocity of the encoder.

Figure 16-2 on page 561 shows how the Stellaris quadrature encoder converts the phase input signals into clock pulses, the direction signal, and how the velocity predivider operates (in Divide by 4 mode).

**Figure 16-2. Quadrature Encoder and Velocity Predivider Operation**




The period of the timer is configurable by specifying the load value for the timer in the **QEILOAD** register. When the timer reaches zero, an interrupt can be triggered, and the hardware reloads the timer with the **QEILOAD** value and continues to count down. At lower encoder speeds, a longer timer period is needed to be able to capture enough edges to have a meaningful result. At higher encoder speeds, both a shorter timer period and/or the velocity predivider can be used.

The following equation converts the velocity counter value into an rpm value:

```
rpm = (clock * (2 ^ VelDiv) * Speed * 60) ÷ (Load * ppr * edges)
```

where:

`clock` is the controller clock rate

`ppr` is the number of pulses per revolution of the physical encoder

`edges` is 2 or 4, based on the capture mode set in the **QEICTL** register (2 for `CapMode` set to 0 and 4 for `CapMode` set to 1)

For example, consider a motor running at 600 rpm. A 2048 pulse per revolution quadrature encoder is attached to the motor, producing 8192 phase edges per revolution. With a velocity predivider of ÷1 (`VelDiv` set to 0) and clocking on both `PhA` and `PhB` edges, this results in 81,920 pulses per second (the motor turns 10 times per second). If the timer were clocked at 10,000 Hz, and the load value was 2,500 (¼ of a second), it would count 20,480 pulses per update. Using the above equation:

```
rpm = (10000 * 1 * 20480 * 60) ÷ (2500 * 2048 * 4) = 600 rpm
```

Now, consider that the motor is sped up to 3000 rpm. This results in 409,600 pulses per second, or 102,400 every ¼ of a second. Again, the above equation gives:

```
rpm = (10000 * 1 * 102400 * 60) ÷ (2500 * 2048 * 4) = 3000 rpm
```

Care must be taken when evaluating this equation since intermediate values may exceed the capacity of a 32-bit integer. In the above examples, the clock is 10,000 and the divider is 2,500; both could be predivided by 100 (at compile time if they are constants) and therefore be 100 and 25. In fact, if they were compile-time constants, they could also be reduced to a simple multiply by 4, cancelled by the ÷4 for the edge-count factor.

**Important:** Reducing constant factors at compile time is the best way to control the intermediate values of this equation, as well as reducing the processing requirement of computing this equation.

The division can be avoided by selecting a timer load value such that the divisor is a power of 2; a simple shift can therefore be done in place of the division. For encoders with a power of 2 pulses per revolution, this is a simple matter of selecting a power of 2 load value. For other encoders, a load value must be selected such that the product is very close to a power of two. For example, a 100 pulse per revolution encoder could use a load value of 82, resulting in 32,800 as the divisor, which is 0.09% above $2^{14}$; in this case a shift by 15 would be an adequate approximation of the divide in most cases. If absolute accuracy were required, the controller's divide instruction could be used.

The QEI module can produce a controller interrupt on several events: phase error, direction change, reception of the index pulse, and expiration of the velocity timer. Standard masking, raw interrupt status, interrupt status, and interrupt clear capabilities are provided.

## 16.4 Initialization and Configuration

The following example shows how to configure the Quadrature Encoder module to read back an absolute position:

1. Enable the QEI clock by writing a value of 0x0000.0100 to the **RCGC1** register in the System Control module.
2. Enable the clock to the appropriate GPIO module via the **RCGC2** register in the System Control module.
3. In the GPIO module, enable the appropriate pins for their alternate function using the **GPIOAFSEL** register.
4. Configure the quadrature encoder to capture edges on both signals and maintain an absolute position by resetting on index pulses. Using a 1000-line encoder at four edges per line, there are 4000 pulses per revolution; therefore, set the maximum position to 3999 (0xF9F) since the count is zero-based.
   - Write the **QEICTL** register with the value of 0x0000.0018.
   - Write the **QEIMAXPOS** register with the value of 0x0000.0F9F.
5. Enable the quadrature encoder by setting bit 0 of the **QEICTL** register.
6. Delay for some time.
7. Read the encoder position by reading the **QEIPOS** register value.

## 16.5 Register Map

Table 16-3 on page 563 lists the QEI registers. The offset listed is a hexadecimal increment to the register's address, relative to the module's base address:

- QEI0: 0x4002.C000
- QEI1: 0x4002.D000

Note that the QEI module clock must be enabled before the registers can be programmed (see page 214). There must be a delay of 3 system clocks after the QEI module clock is enabled before any QEI module registers are accessed.

**Table 16-3. QEI Register Map**

| Offset | Name | Type | Reset | Description | See page |
|---|---|---|---|---|---|
| 0x000 | QEICTL | R/W | 0x0000.0000 | QEI Control | 564 |
| 0x004 | QEISTAT | RO | 0x0000.0000 | QEI Status | 566 |
| 0x008 | QEIPOS | R/W | 0x0000.0000 | QEI Position | 567 |
| 0x00C | QEIMAXPOS | R/W | 0x0000.0000 | QEI Maximum Position | 568 |
| 0x010 | QEILOAD | R/W | 0x0000.0000 | QEI Timer Load | 569 |
| 0x014 | QEITIME | RO | 0x0000.0000 | QEI Timer | 570 |
| 0x018 | QEICOUNT | RO | 0x0000.0000 | QEI Velocity Counter | 571 |
| 0x01C | QEISPEED | RO | 0x0000.0000 | QEI Velocity | 572 |
| 0x020 | QEIINTEN | R/W | 0x0000.0000 | QEI Interrupt Enable | 573 |
| 0x024 | QEIRIS | RO | 0x0000.0000 | QEI Raw Interrupt Status | 574 |
| 0x028 | QEIISC | R/W1C | 0x0000.0000 | QEI Interrupt Status and Clear | 575 |

## 16.6 Register Descriptions

The remainder of this section lists and describes the QEI registers, in numerical order by address offset.

## Register 1: QEI Control (QEICTL), offset 0x000

This register contains the configuration of the QEI module. Separate enables are provided for the quadrature encoder and the velocity capture blocks; the quadrature encoder must be enabled in order to capture the velocity, but the velocity does not need to be captured in applications that do not need it. The phase signal interpretation, phase swap, Position Update mode, Position Reset mode, and velocity predivider are all set via this register.

QEI Control (QEICTL)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x000
Type R/W, reset 0x0000.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | | | | | | | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | reserved | | | STALLEN | INVI | INVB | INVA | VelDiv | | | VelEn | ResMode | CapMode | SigMode | Swap | Enable |
| Type | RO | RO | RO | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:13 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 12 | STALLEN | R/W | 0 | Stall QEI<br>When set, the QEI stalls when the microcontroller asserts Halt. |
| 11 | INVI | R/W | 0 | Invert Index Pulse<br>When set , the input Index Pulse is inverted. |
| 10 | INVB | R/W | 0 | Invert PhB<br>When set, the PhB input is inverted. |
| 9 | INVA | R/W | 0 | Invert PhA<br>When set, the PhA input is inverted. |
| 8:6 | VelDiv | R/W | 0x0 | Predivide Velocity<br>A predivider of the input quadrature pulses before being applied to the QEICOUNT accumulator. This field can be set to the following values:<br><br>Value Predivider<br>0x0 ÷1<br>0x1 ÷2<br>0x2 ÷4<br>0x3 ÷8<br>0x4 ÷16<br>0x5 ÷32<br>0x6 ÷64<br>0x7 ÷128 |

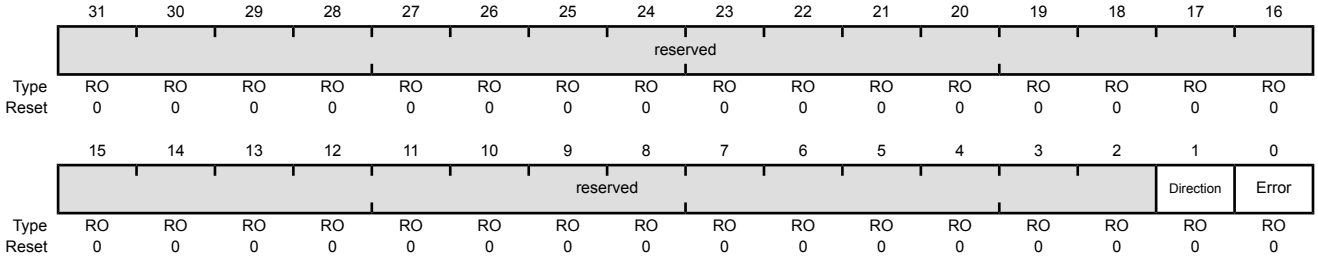
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 5 | VelEn | R/W | 0 | Capture Velocity<br>When set, enables capture of the velocity of the quadrature encoder. |
| 4 | ResMode | R/W | 0 | Reset Mode<br>The Reset mode for the position counter. When 0, the position counter is reset when it reaches the maximum; when 1, the position counter is reset when the index pulse is captured. |
| 3 | CapMode | R/W | 0 | Capture Mode<br>The Capture mode defines the phase edges that are counted in the position. When 0, only the PhA edges are counted; when 1, the PhA and PhB edges are counted, providing twice the positional resolution but half the range. |
| 2 | SigMode | R/W | 0 | Signal Mode<br>When 1, the PhA and PhB signals are clock and direction; when 0, they are quadrature phase signals. |
| 1 | Swap | R/W | 0 | Swap Signals<br>Swaps the PhA and PhB signals. |
| 0 | Enable | R/W | 0 | Enable QEI<br>Enables the quadrature encoder module. |

## Register 2: QEI Status (QEISTAT), offset 0x004

This register provides status about the operation of the QEI module.

QEI Status (QEISTAT)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x004
Type RO, reset 0x0000.0000



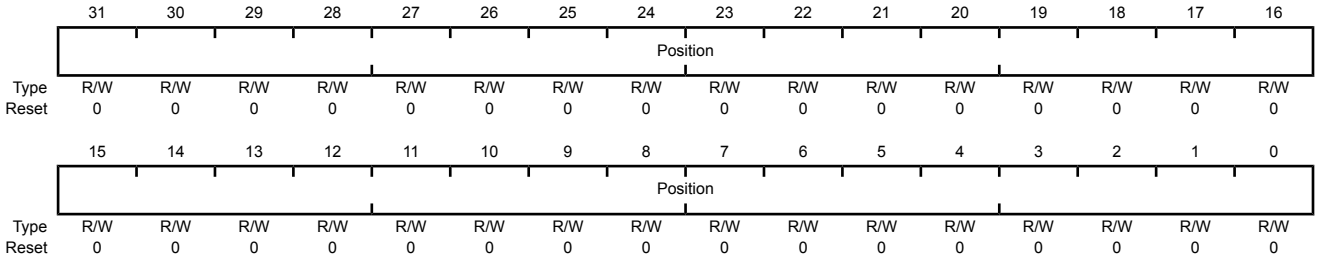

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:2 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 1 | Direction | RO | 0 | Direction of Rotation<br>Indicates the direction the encoder is rotating.<br>The `Direction` values are defined as follows:<br><br>Value Description<br>0 Forward rotation<br>1 Reverse rotation |
| 0 | Error | RO | 0 | Error Detected<br>Indicates that an error was detected in the gray code sequence (that is, both signals changing at the same time). |

## Register 3: QEI Position (QEIPOS), offset 0x008

This register contains the current value of the position integrator. Its value is updated by inputs on the QEI phase inputs, and can be set to a specific value by writing to it.

QEI Position (QEIPOS)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x008
Type R/W, reset 0x0000.0000



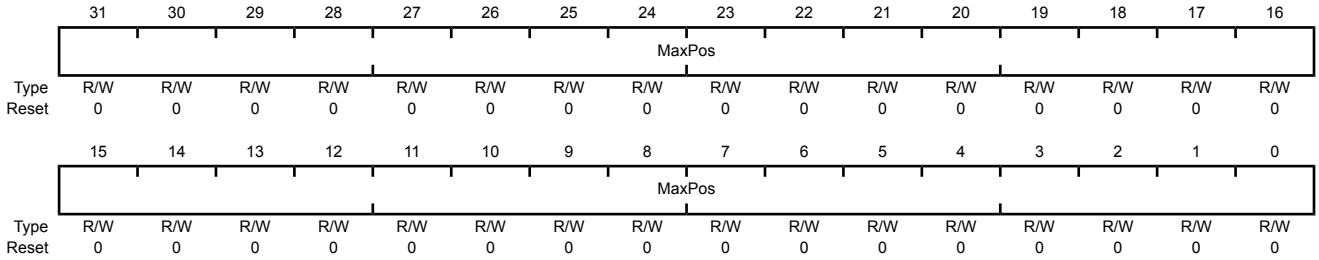

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | Position | R/W | 0x00 | Current Position Integrator Value<br>The current value of the position integrator. |

## Register 4: QEI Maximum Position (QEIMAXPOS), offset 0x00C

This register contains the maximum value of the position integrator. When moving forward, the position register resets to zero when it increments past this value. When moving backward, the position register resets to this value when it decrements from zero.

QEI Maximum Position (QEIMAXPOS)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x00C
Type R/W, reset 0x0000.0000



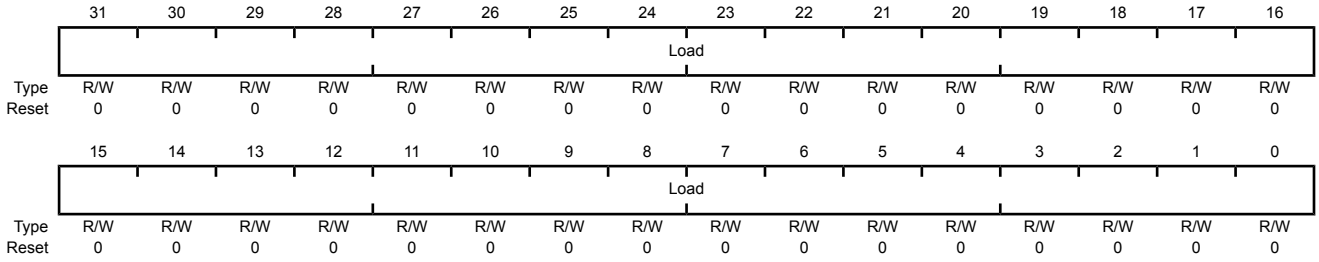

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | MaxPos | R/W | 0x00 | Maximum Position Integrator Value<br>The maximum value of the position integrator. |

## Register 5: QEI Timer Load (QEILOAD), offset 0x010

This register contains the load value for the velocity timer. Since this value is loaded into the timer the clock cycle after the timer is zero, this value should be one less than the number of clocks in the desired period. So, for example, to have 2000 clocks per timer period, this register should contain 1999.

QEI Timer Load (QEILOAD)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x010
Type R/W, reset 0x0000.0000



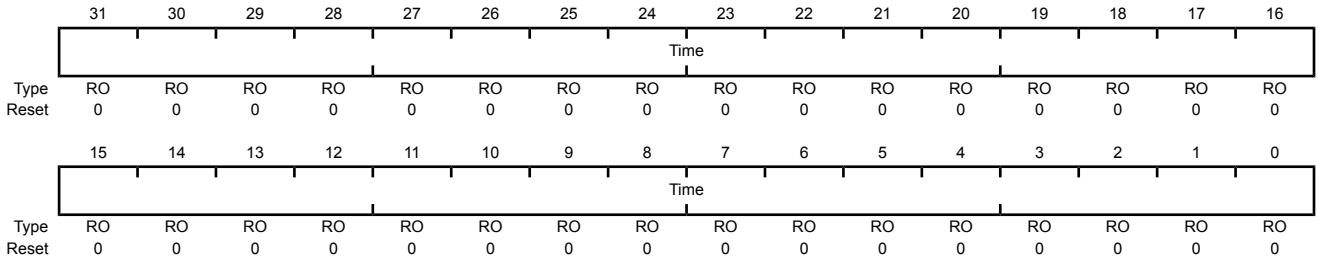

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | Load | R/W | 0x00 | Velocity Timer Load Value<br>The load value for the velocity timer. |

## Register 6: QEI Timer (QEITIME), offset 0x014

This register contains the current value of the velocity timer. This counter does not increment when VelEn in **QEICTL** is 0.

QEI Timer (QEITIME)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x014
Type RO, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | Time | RO | 0x00 | Velocity Timer Current Value<br>The current value of the velocity timer. |

## Register 7: QEI Velocity Counter (QEICOUNT), offset 0x018

This register contains the running count of velocity pulses for the current time period. Since this is a running total, the time period to which it applies cannot be known with precision (that is, a read of this register does not necessarily correspond to the time returned by the **QEITIME** register since there is a small window of time between the two reads, during which time either value may have changed). The **QEISPEED** register should be used to determine the actual encoder velocity; this register is provided for information purposes only. This counter does not increment when VelEn in **QEICTL** is 0.

QEI Velocity Counter (QEICOUNT)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x018
Type RO, reset 0x0000.0000

| | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Count | | | | | | | | | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Count | | | | | | | | | | | | | | | |
| Type | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO | RO |
| Reset | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

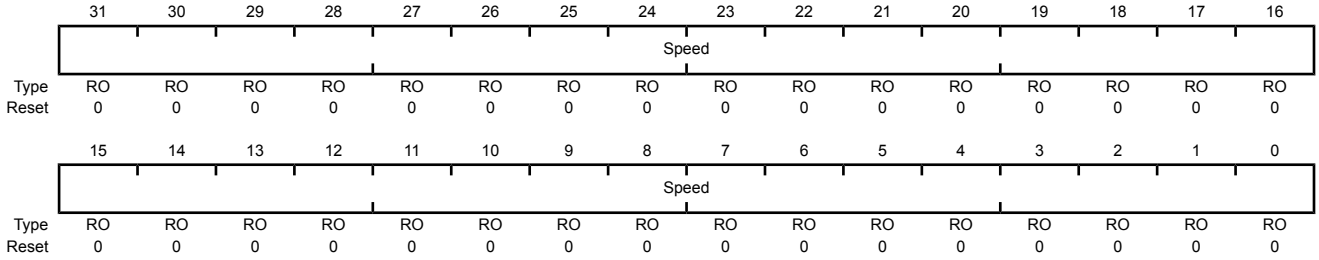
| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | Count | RO | 0x00 | Velocity Pulse Count<br>The running total of encoder pulses during this velocity timer period. |

## Register 8: QEI Velocity (QEISPEED), offset 0x01C

This register contains the most recently measured velocity of the quadrature encoder. This corresponds to the number of velocity pulses counted in the previous velocity timer period. This register does not update when VelEn in **QEICTL** is 0.

QEI Velocity (QEISPEED)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x01C
Type RO, reset 0x0000.0000



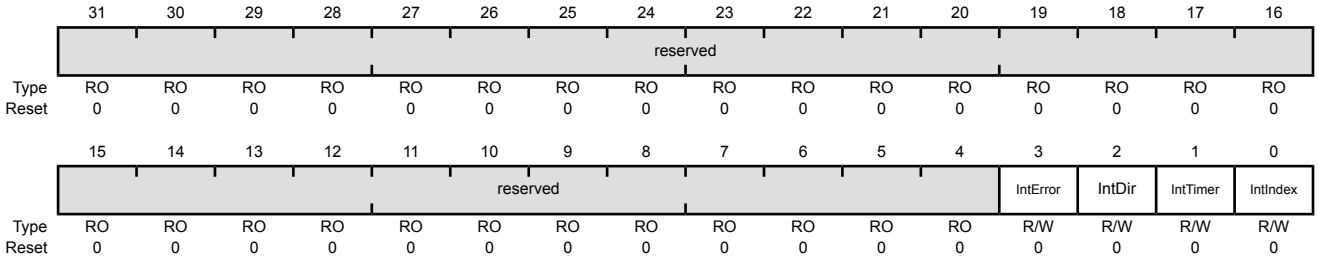

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:0 | Speed | RO | 0x00 | Velocity<br>The measured speed of the quadrature encoder in pulses per period. |

## Register 9: QEI Interrupt Enable (QEIINTEN), offset 0x020

This register contains enables for each of the QEI module's interrupts. An interrupt is asserted to the controller if its corresponding bit in this register is set to 1.

QEI Interrupt Enable (QEIINTEN)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x020
Type R/W, reset 0x0000.0000



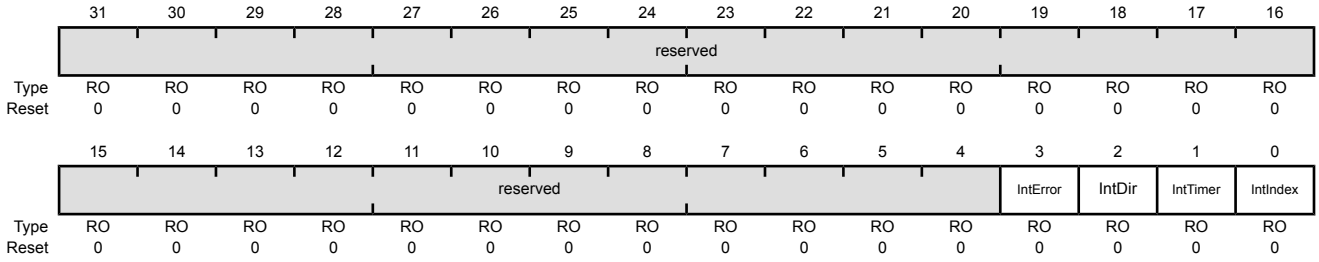

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | IntError | R/W | 0 | Phase Error Interrupt Enable<br>When 1, an interrupt occurs when a phase error is detected. |
| 2 | IntDir | R/W | 0 | Direction Change Interrupt Enable<br>When 1, an interrupt occurs when the direction changes. |
| 1 | IntTimer | R/W | 0 | Timer Expires Interrupt Enable<br>When 1, an interrupt occurs when the velocity timer expires. |
| 0 | IntIndex | R/W | 0 | Index Pulse Detected Interrupt Enable<br>When 1, an interrupt occurs when the index pulse is detected. |

## Register 10: QEI Raw Interrupt Status (QEIRIS), offset 0x024

This register provides the current set of interrupt sources that are asserted, regardless of whether they cause an interrupt to be asserted to the controller (this is set through the **QEIINTEN** register). Bits set to 1 indicate the latched events that have occurred; a zero bit indicates that the event in question has not occurred.

QEI Raw Interrupt Status (QEIRIS)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x024
Type RO, reset 0x0000.0000



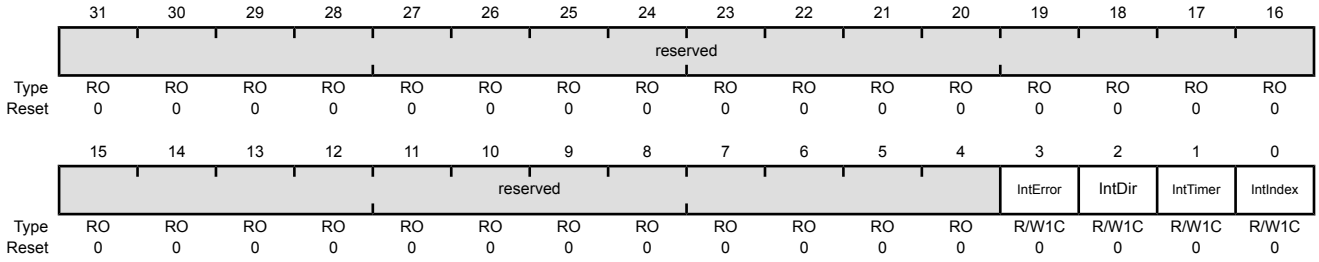

| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | IntError | RO | 0 | Phase Error Detected<br>Indicates that a phase error was detected. |
| 2 | IntDir | RO | 0 | Direction Change Detected<br>Indicates that the direction has changed. |
| 1 | IntTimer | RO | 0 | Velocity Timer Expired<br>Indicates that the velocity timer has expired. |
| 0 | IntIndex | RO | 0 | Index Pulse Asserted<br>Indicates that the index pulse has occurred. |

## Register 11: QEI Interrupt Status and Clear (QEIISC), offset 0x028

This register provides the current set of interrupt sources that are asserted to the controller. Bits set to 1 indicate the latched events that have occurred; a zero bit indicates that the event in question has not occurred. This is a R/W1C register; writing a 1 to a bit position clears the corresponding interrupt reason.

QEI Interrupt Status and Clear (QEIISC)

QEI0 base: 0x4002.C000
QEI1 base: 0x4002.D000
Offset 0x028
Type R/W1C, reset 0x0000.0000




| Bit/Field | Name | Type | Reset | Description |
|---|---|---|---|---|
| 31:4 | reserved | RO | 0x00 | Software should not rely on the value of a reserved bit. To provide compatibility with future products, the value of a reserved bit should be preserved across a read-modify-write operation. |
| 3 | IntError | R/W1C | 0 | Phase Error Interrupt<br>Indicates that a phase error was detected. |
| 2 | IntDir | R/W1C | 0 | Direction Change Interrupt<br>Indicates that the direction has changed. |
| 1 | IntTimer | R/W1C | 0 | Velocity Timer Expired Interrupt<br>Indicates that the velocity timer has expired. |
| 0 | IntIndex | R/W1C | 0 | Index Pulse Interrupt<br>Indicates that the index pulse has occurred. |

# 17 Pin Diagram

The LM3S1960 microcontroller pin diagrams are shown below.

**Figure 17-1. 100-Pin LQFP Package Pin Diagram**

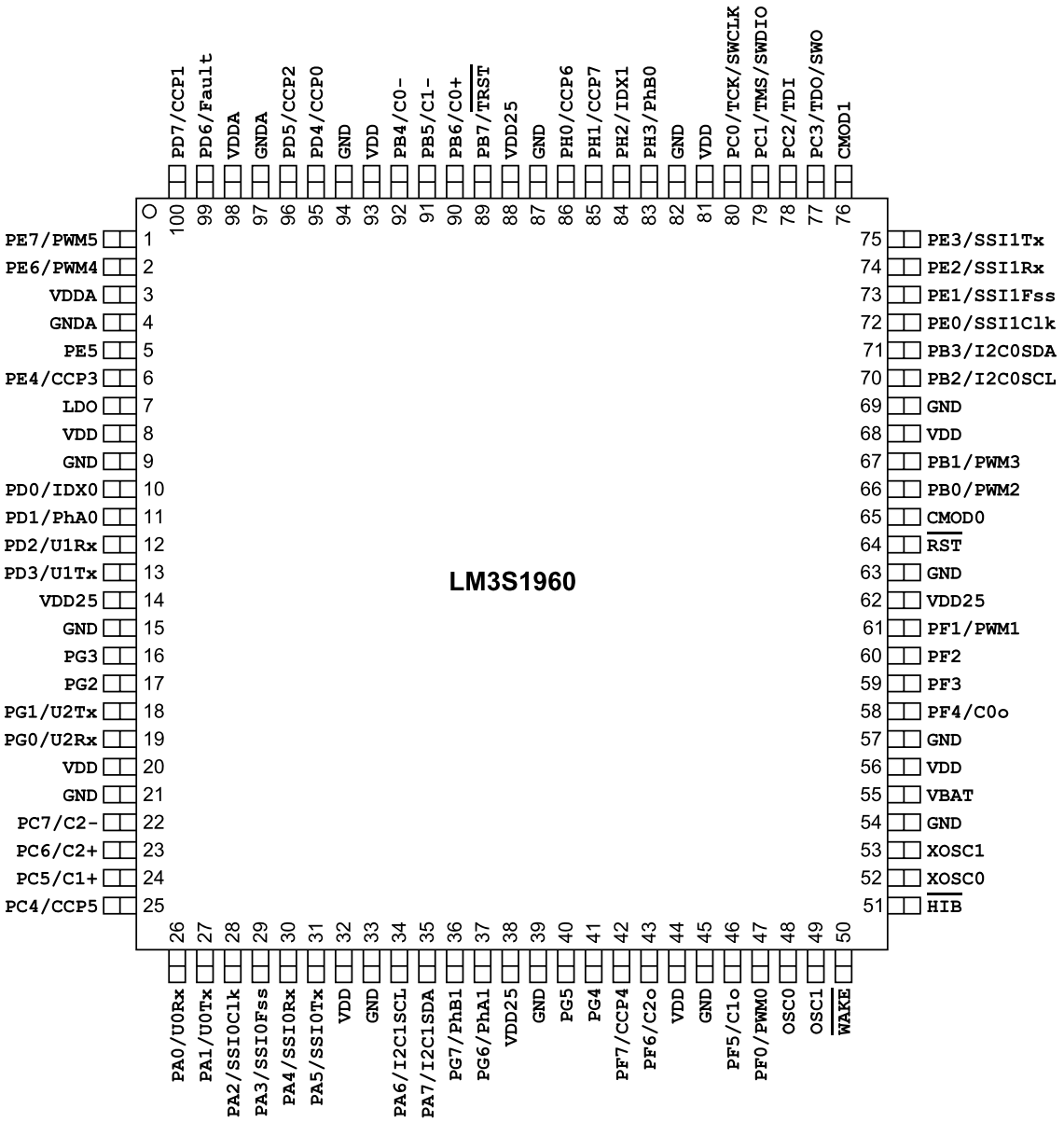
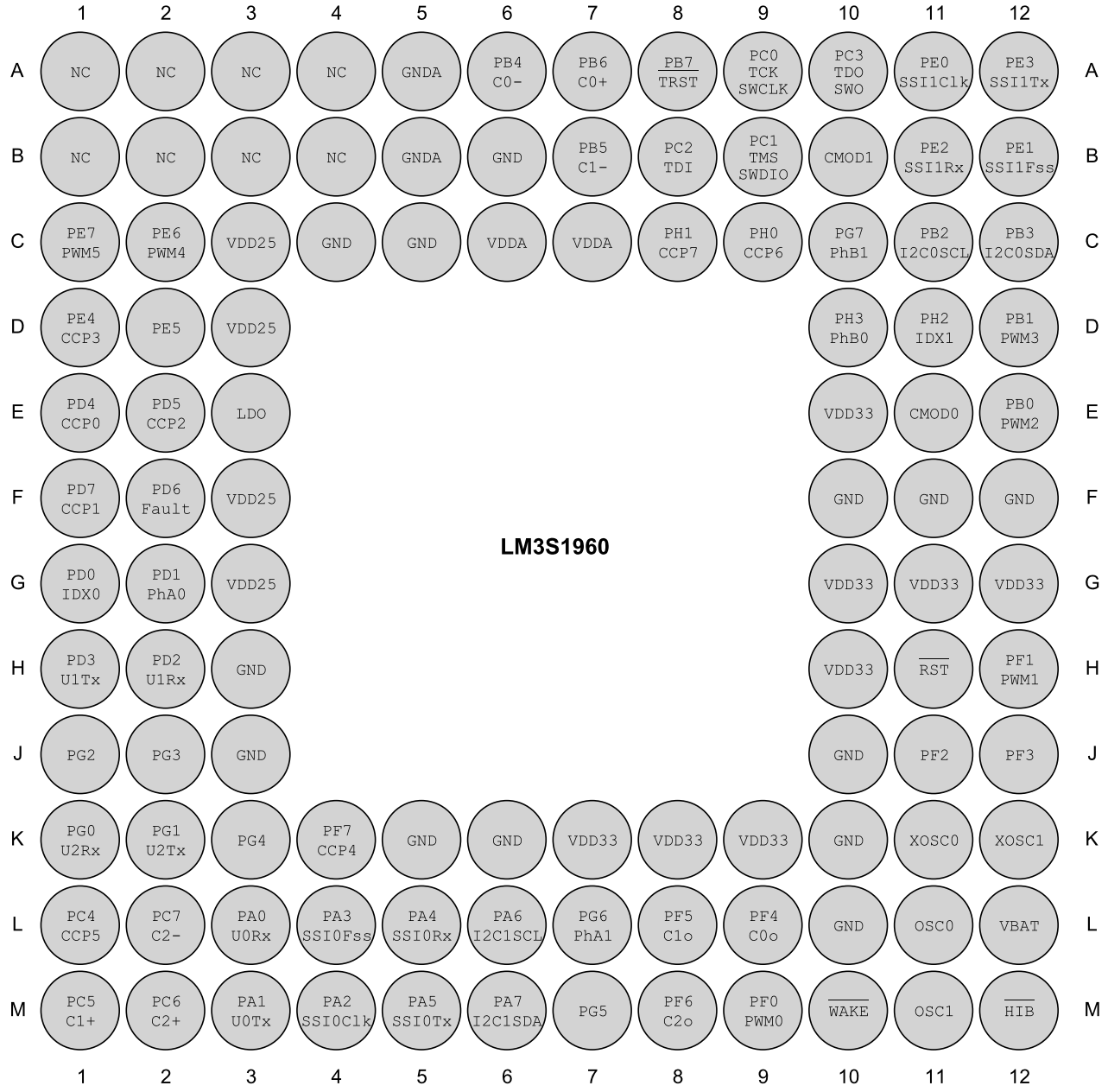


**Figure 17-2. 108-Ball BGA Package Pin Diagram (Top View)**



# 18 Signal Tables

The following tables list the signals available for each pin. Functionality is enabled by software with the **GPIOAFSEL** register.

**Important:** All multiplexed pins are GPIOs by default, with the exception of the five JTAG pins (PB7 and PC[3:0]) which default to the JTAG functionality.

Table 18-1 on page 578 shows the pin-to-signal-name mapping, including functional characteristics of the signals. Table 18-2 on page 582 lists the signals in alphabetical order by signal name.

Table 18-3 on page 587 groups the signals by functionality, except for GPIOs. Table 18-4 on page 590 lists the GPIO pins and their alternate functionality.

**Note:** All digital inputs are Schmitt triggered.

## 18.1 100-Pin LQFP Package Pin Tables

**Table 18-1. Signals by Pin Number**

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| 1 | PE7 | I/O | TTL | GPIO port E bit 7. |
| | PWM5 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |
| 2 | PE6 | I/O | TTL | GPIO port E bit 6. |
| | PWM4 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| 3 | VDDA | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| 4 | GNDA | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| 5 | PE5 | I/O | TTL | GPIO port E bit 5. |
| 6 | PE4 | I/O | TTL | GPIO port E bit 4. |
| | CCP3 | I/O | TTL | Capture/Compare/PWM 3. |
| 7 | LDO | - | Power | Low drop-out regulator output voltage. This pin requires an external capacitor between the pin and GND of 1 µF or greater. When the on-chip LDO is used to provide power to the logic, the LDO pin must also be connected to the VDD25 pins at the board level in addition to the decoupling capacitor(s). |
| 8 | VDD | - | Power | Positive supply for I/O and some logic. |
| 9 | GND | - | Power | Ground reference for logic and I/O pins. |
| 10 | PD0 | I/O | TTL | GPIO port D bit 0. |
| | IDX0 | I | TTL | QEI module 0 index. |
| 11 | PD1 | I/O | TTL | GPIO port D bit 1. |
| | PhA0 | I | TTL | QEI module 0 phase A. |
| 12 | PD2 | I/O | TTL | GPIO port D bit 2. |
| | U1Rx | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |

**Table 18-1. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| 13 | PD3 | I/O | TTL | GPIO port D bit 3. |
| | U1Tx | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| 14 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| 15 | GND | - | Power | Ground reference for logic and I/O pins. |
| 16 | PG3 | I/O | TTL | GPIO port G bit 3. |
| 17 | PG2 | I/O | TTL | GPIO port G bit 2. |
| 18 | PG1 | I/O | TTL | GPIO port G bit 1. |
| | U2Tx | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |
| 19 | PG0 | I/O | TTL | GPIO port G bit 0. |
| | U2Rx | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| 20 | VDD | - | Power | Positive supply for I/O and some logic. |
| 21 | GND | - | Power | Ground reference for logic and I/O pins. |
| 22 | PC7 | I/O | TTL | GPIO port C bit 7. |
| | C2- | I | Analog | Analog comparator 2 negative input. |
| 23 | PC6 | I/O | TTL | GPIO port C bit 6. |
| | C2+ | I | Analog | Analog comparator 2 positive input. |
| 24 | PC5 | I/O | TTL | GPIO port C bit 5. |
| | C1+ | I | Analog | Analog comparator 1 positive input. |
| 25 | PC4 | I/O | TTL | GPIO port C bit 4. |
| | CCP5 | I/O | TTL | Capture/Compare/PWM 5. |
| 26 | PA0 | I/O | TTL | GPIO port A bit 0. |
| | U0Rx | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| 27 | PA1 | I/O | TTL | GPIO port A bit 1. |
| | U0Tx | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| 28 | PA2 | I/O | TTL | GPIO port A bit 2. |
| | SSI0Clk | I/O | TTL | SSI module 0 clock. |
| 29 | PA3 | I/O | TTL | GPIO port A bit 3. |
| | SSI0Fss | I/O | TTL | SSI module 0 frame. |
| 30 | PA4 | I/O | TTL | GPIO port A bit 4. |
| | SSI0Rx | I | TTL | SSI module 0 receive. |
| 31 | PA5 | I/O | TTL | GPIO port A bit 5. |
| | SSI0Tx | O | TTL | SSI module 0 transmit. |
| 32 | VDD | - | Power | Positive supply for I/O and some logic. |
| 33 | GND | - | Power | Ground reference for logic and I/O pins. |
| 34 | PA6 | I/O | TTL | GPIO port A bit 6. |
| | I2C1SCL | I/O | OD | $I^2C$ module 1 clock. |

**Table 18-1. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| 35 | PA7 | I/O | TTL | GPIO port A bit 7. |
| | I2C1SDA | I/O | OD | $I^2C$ module 1 data. |
| 36 | PG7 | I/O | TTL | GPIO port G bit 7. |
| | PhB1 | I | TTL | QEI module 1 phase B. |
| 37 | PG6 | I/O | TTL | GPIO port G bit 6. |
| | PhA1 | I | TTL | QEI module 1 phase A. |
| 38 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| 39 | GND | - | Power | Ground reference for logic and I/O pins. |
| 40 | PG5 | I/O | TTL | GPIO port G bit 5. |
| 41 | PG4 | I/O | TTL | GPIO port G bit 4. |
| 42 | PF7 | I/O | TTL | GPIO port F bit 7. |
| | CCP4 | I/O | TTL | Capture/Compare/PWM 4. |
| 43 | PF6 | I/O | TTL | GPIO port F bit 6. |
| | C2o | O | TTL | Analog comparator 2 output. |
| 44 | VDD | - | Power | Positive supply for I/O and some logic. |
| 45 | GND | - | Power | Ground reference for logic and I/O pins. |
| 46 | PF5 | I/O | TTL | GPIO port F bit 5. |
| | C1o | O | TTL | Analog comparator 1 output. |
| 47 | PF0 | I/O | TTL | GPIO port F bit 0. |
| | PWM0 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| 48 | OSC0 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| 49 | OSC1 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| 50 | $\overline{\text{WAKE}}$ | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| 51 | $\overline{\text{HIB}}$ | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| 52 | XOSC0 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| 53 | XOSC1 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| 54 | GND | - | Power | Ground reference for logic and I/O pins. |
| 55 | VBAT | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| 56 | VDD | - | Power | Positive supply for I/O and some logic. |
| 57 | GND | - | Power | Ground reference for logic and I/O pins. |
| 58 | PF4 | I/O | TTL | GPIO port F bit 4. |
| | C0o | O | TTL | Analog comparator 0 output. |
| 59 | PF3 | I/O | TTL | GPIO port F bit 3. |
| 60 | PF2 | I/O | TTL | GPIO port F bit 2. |

**Table 18-1. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| 61 | PF1 | I/O | TTL | GPIO port F bit 1. |
| | PWM1 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| 62 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| 63 | GND | - | Power | Ground reference for logic and I/O pins. |
| 64 | $\overline{\text{RST}}$ | I | TTL | System reset input. |
| 65 | CMOD0 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| 66 | PB0 | I/O | TTL | GPIO port B bit 0. |
| | PWM2 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| 67 | PB1 | I/O | TTL | GPIO port B bit 1. |
| | PWM3 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| 68 | VDD | - | Power | Positive supply for I/O and some logic. |
| 69 | GND | - | Power | Ground reference for logic and I/O pins. |
| 70 | PB2 | I/O | TTL | GPIO port B bit 2. |
| | I2C0SCL | I/O | OD | $I^2C$ module 0 clock. |
| 71 | PB3 | I/O | TTL | GPIO port B bit 3. |
| | I2C0SDA | I/O | OD | $I^2C$ module 0 data. |
| 72 | PE0 | I/O | TTL | GPIO port E bit 0. |
| | SSI1Clk | I/O | TTL | SSI module 1 clock. |
| 73 | PE1 | I/O | TTL | GPIO port E bit 1. |
| | SSI1Fss | I/O | TTL | SSI module 1 frame. |
| 74 | PE2 | I/O | TTL | GPIO port E bit 2. |
| | SSI1Rx | I | TTL | SSI module 1 receive. |
| 75 | PE3 | I/O | TTL | GPIO port E bit 3. |
| | SSI1Tx | O | TTL | SSI module 1 transmit. |
| 76 | CMOD1 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| 77 | PC3 | I/O | TTL | GPIO port C bit 3. |
| | SWO | O | TTL | JTAG TDO and SWO. |
| | TDO | O | TTL | JTAG TDO and SWO. |
| 78 | PC2 | I/O | TTL | GPIO port C bit 2. |
| | TDI | I | TTL | JTAG TDI. |
| 79 | PC1 | I/O | TTL | GPIO port C bit 1. |
| | SWDIO | I/O | TTL | JTAG TMS and SWDIO. |
| | TMS | I/O | TTL | JTAG TMS and SWDIO. |
| 80 | PC0 | I/O | TTL | GPIO port C bit 0. |
| | SWCLK | I | TTL | JTAG/SWD CLK. |
| | TCK | I | TTL | JTAG/SWD CLK. |
| 81 | VDD | - | Power | Positive supply for I/O and some logic. |
| 82 | GND | - | Power | Ground reference for logic and I/O pins. |

### Table 18-1. Signals by Pin Number *(continued)*

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| 83 | PH3 | I/O | TTL | GPIO port H bit 3. |
| | PhB0 | I | TTL | QEI module 0 phase B. |
| 84 | PH2 | I/O | TTL | GPIO port H bit 2. |
| | IDX1 | I | TTL | QEI module 1 index. |
| 85 | PH1 | I/O | TTL | GPIO port H bit 1. |
| | CCP7 | I/O | TTL | Capture/Compare/PWM 7. |
| 86 | PH0 | I/O | TTL | GPIO port H bit 0. |
| | CCP6 | I/O | TTL | Capture/Compare/PWM 6. |
| 87 | GND | - | Power | Ground reference for logic and I/O pins. |
| 88 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| 89 | PB7 | I/O | TTL | GPIO port B bit 7. |
| | TRST | I | TTL | JTAG TRST. |
| 90 | PB6 | I/O | TTL | GPIO port B bit 6. |
| | C0+ | I | Analog | Analog comparator 0 positive input. |
| 91 | PB5 | I/O | TTL | GPIO port B bit 5. |
| | C1- | I | Analog | Analog comparator 1 negative input. |
| 92 | PB4 | I/O | TTL | GPIO port B bit 4. |
| | C0- | I | Analog | Analog comparator 0 negative input. |
| 93 | VDD | - | Power | Positive supply for I/O and some logic. |
| 94 | GND | - | Power | Ground reference for logic and I/O pins. |
| 95 | PD4 | I/O | TTL | GPIO port D bit 4. |
| | CCP0 | I/O | TTL | Capture/Compare/PWM 0. |
| 96 | PD5 | I/O | TTL | GPIO port D bit 5. |
| | CCP2 | I/O | TTL | Capture/Compare/PWM 2. |
| 97 | GNDA | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| 98 | VDDA | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| 99 | PD6 | I/O | TTL | GPIO port D bit 6. |
| | Fault | I | TTL | PWM Fault. |
| 100 | PD7 | I/O | TTL | GPIO port D bit 7. |
| | CCP1 | I/O | TTL | Capture/Compare/PWM 1. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

### Table 18-2. Signals by Signal Name

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| C0+ | 90 | I | Analog | Analog comparator 0 positive input. |
| C0- | 92 | I | Analog | Analog comparator 0 negative input. |

**Table 18-2. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| C0o | 58 | O | TTL | Analog comparator 0 output. |
| C1+ | 24 | I | Analog | Analog comparator 1 positive input. |
| C1- | 91 | I | Analog | Analog comparator 1 negative input. |
| C1o | 46 | O | TTL | Analog comparator 1 output. |
| C2+ | 23 | I | Analog | Analog comparator 2 positive input. |
| C2- | 22 | I | Analog | Analog comparator 2 negative input. |
| C2o | 43 | O | TTL | Analog comparator 2 output. |
| CCP0 | 95 | I/O | TTL | Capture/Compare/PWM 0. |
| CCP1 | 100 | I/O | TTL | Capture/Compare/PWM 1. |
| CCP2 | 96 | I/O | TTL | Capture/Compare/PWM 2. |
| CCP3 | 6 | I/O | TTL | Capture/Compare/PWM 3. |
| CCP4 | 42 | I/O | TTL | Capture/Compare/PWM 4. |
| CCP5 | 25 | I/O | TTL | Capture/Compare/PWM 5. |
| CCP6 | 86 | I/O | TTL | Capture/Compare/PWM 6. |
| CCP7 | 85 | I/O | TTL | Capture/Compare/PWM 7. |
| CMOD0 | 65 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| CMOD1 | 76 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| Fault | 99 | I | TTL | PWM Fault. |
| GND | 9<br>15<br>21<br>33<br>39<br>45<br>54<br>57<br>63<br>69<br>82<br>87<br>94 | - | Power | Ground reference for logic and I/O pins. |
| GNDA | 4<br>97 | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| $\overline{\text{HIB}}$ | 51 | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| I2C0SCL | 70 | I/O | OD | $I^2C$ module 0 clock. |
| I2C0SDA | 71 | I/O | OD | $I^2C$ module 0 data. |
| I2C1SCL | 34 | I/O | OD | $I^2C$ module 1 clock. |
| I2C1SDA | 35 | I/O | OD | $I^2C$ module 1 data. |
| IDX0 | 10 | I | TTL | QEI module 0 index. |
| IDX1 | 84 | I | TTL | QEI module 1 index. |

**Table 18-2. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| LDO | 7 | - | Power | Low drop-out regulator output voltage. This pin requires an external capacitor between the pin and GND of 1 µF or greater. When the on-chip LDO is used to provide power to the logic, the LDO pin must also be connected to the VDD25 pins at the board level in addition to the decoupling capacitor(s). |
| OSC0 | 48 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| OSC1 | 49 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| PA0 | 26 | I/O | TTL | GPIO port A bit 0. |
| PA1 | 27 | I/O | TTL | GPIO port A bit 1. |
| PA2 | 28 | I/O | TTL | GPIO port A bit 2. |
| PA3 | 29 | I/O | TTL | GPIO port A bit 3. |
| PA4 | 30 | I/O | TTL | GPIO port A bit 4. |
| PA5 | 31 | I/O | TTL | GPIO port A bit 5. |
| PA6 | 34 | I/O | TTL | GPIO port A bit 6. |
| PA7 | 35 | I/O | TTL | GPIO port A bit 7. |
| PB0 | 66 | I/O | TTL | GPIO port B bit 0. |
| PB1 | 67 | I/O | TTL | GPIO port B bit 1. |
| PB2 | 70 | I/O | TTL | GPIO port B bit 2. |
| PB3 | 71 | I/O | TTL | GPIO port B bit 3. |
| PB4 | 92 | I/O | TTL | GPIO port B bit 4. |
| PB5 | 91 | I/O | TTL | GPIO port B bit 5. |
| PB6 | 90 | I/O | TTL | GPIO port B bit 6. |
| PB7 | 89 | I/O | TTL | GPIO port B bit 7. |
| PC0 | 80 | I/O | TTL | GPIO port C bit 0. |
| PC1 | 79 | I/O | TTL | GPIO port C bit 1. |
| PC2 | 78 | I/O | TTL | GPIO port C bit 2. |
| PC3 | 77 | I/O | TTL | GPIO port C bit 3. |
| PC4 | 25 | I/O | TTL | GPIO port C bit 4. |
| PC5 | 24 | I/O | TTL | GPIO port C bit 5. |
| PC6 | 23 | I/O | TTL | GPIO port C bit 6. |
| PC7 | 22 | I/O | TTL | GPIO port C bit 7. |
| PD0 | 10 | I/O | TTL | GPIO port D bit 0. |
| PD1 | 11 | I/O | TTL | GPIO port D bit 1. |
| PD2 | 12 | I/O | TTL | GPIO port D bit 2. |
| PD3 | 13 | I/O | TTL | GPIO port D bit 3. |
| PD4 | 95 | I/O | TTL | GPIO port D bit 4. |
| PD5 | 96 | I/O | TTL | GPIO port D bit 5. |
| PD6 | 99 | I/O | TTL | GPIO port D bit 6. |
| PD7 | 100 | I/O | TTL | GPIO port D bit 7. |
| PE0 | 72 | I/O | TTL | GPIO port E bit 0. |

**Table 18-2. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PE1 | 73 | I/O | TTL | GPIO port E bit 1. |
| PE2 | 74 | I/O | TTL | GPIO port E bit 2. |
| PE3 | 75 | I/O | TTL | GPIO port E bit 3. |
| PE4 | 6 | I/O | TTL | GPIO port E bit 4. |
| PE5 | 5 | I/O | TTL | GPIO port E bit 5. |
| PE6 | 2 | I/O | TTL | GPIO port E bit 6. |
| PE7 | 1 | I/O | TTL | GPIO port E bit 7. |
| PF0 | 47 | I/O | TTL | GPIO port F bit 0. |
| PF1 | 61 | I/O | TTL | GPIO port F bit 1. |
| PF2 | 60 | I/O | TTL | GPIO port F bit 2. |
| PF3 | 59 | I/O | TTL | GPIO port F bit 3. |
| PF4 | 58 | I/O | TTL | GPIO port F bit 4. |
| PF5 | 46 | I/O | TTL | GPIO port F bit 5. |
| PF6 | 43 | I/O | TTL | GPIO port F bit 6. |
| PF7 | 42 | I/O | TTL | GPIO port F bit 7. |
| PG0 | 19 | I/O | TTL | GPIO port G bit 0. |
| PG1 | 18 | I/O | TTL | GPIO port G bit 1. |
| PG2 | 17 | I/O | TTL | GPIO port G bit 2. |
| PG3 | 16 | I/O | TTL | GPIO port G bit 3. |
| PG4 | 41 | I/O | TTL | GPIO port G bit 4. |
| PG5 | 40 | I/O | TTL | GPIO port G bit 5. |
| PG6 | 37 | I/O | TTL | GPIO port G bit 6. |
| PG7 | 36 | I/O | TTL | GPIO port G bit 7. |
| PH0 | 86 | I/O | TTL | GPIO port H bit 0. |
| PH1 | 85 | I/O | TTL | GPIO port H bit 1. |
| PH2 | 84 | I/O | TTL | GPIO port H bit 2. |
| PH3 | 83 | I/O | TTL | GPIO port H bit 3. |
| PhA0 | 11 | I | TTL | QEI module 0 phase A. |
| PhA1 | 37 | I | TTL | QEI module 1 phase A. |
| PhB0 | 83 | I | TTL | QEI module 0 phase B. |
| PhB1 | 36 | I | TTL | QEI module 1 phase B. |
| PWM0 | 47 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| PWM1 | 61 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| PWM2 | 66 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| PWM3 | 67 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| PWM4 | 2 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| PWM5 | 1 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |
| $\overline{\text{RST}}$ | 64 | I | TTL | System reset input. |
| SSI0Clk | 28 | I/O | TTL | SSI module 0 clock. |
| SSI0Fss | 29 | I/O | TTL | SSI module 0 frame. |
| SSI0Rx | 30 | I | TTL | SSI module 0 receive. |

**Table 18-2. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| SSI0Tx | 31 | O | TTL | SSI module 0 transmit. |
| SSI1Clk | 72 | I/O | TTL | SSI module 1 clock. |
| SSI1Fss | 73 | I/O | TTL | SSI module 1 frame. |
| SSI1Rx | 74 | I | TTL | SSI module 1 receive. |
| SSI1Tx | 75 | O | TTL | SSI module 1 transmit. |
| SWCLK | 80 | I | TTL | JTAG/SWD CLK. |
| SWDIO | 79 | I/O | TTL | JTAG TMS and SWDIO. |
| SWO | 77 | O | TTL | JTAG TDO and SWO. |
| TCK | 80 | I | TTL | JTAG/SWD CLK. |
| TDI | 78 | I | TTL | JTAG TDI. |
| TDO | 77 | O | TTL | JTAG TDO and SWO. |
| TMS | 79 | I/O | TTL | JTAG TMS and SWDIO. |
| TRST | 89 | I | TTL | JTAG TRST. |
| U0Rx | 26 | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| U0Tx | 27 | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U1Rx | 12 | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |
| U1Tx | 13 | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U2Rx | 19 | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| U2Tx | 18 | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |
| VBAT | 55 | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| VDD | 8<br>20<br>32<br>44<br>56<br>68<br>81<br>93 | - | Power | Positive supply for I/O and some logic. |
| VDD25 | 14<br>38<br>62<br>88 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| VDDA | 3<br>98 | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| WAKE | 50 | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |

**Table 18-2. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| XOSC0 | 52 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| XOSC1 | 53 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 18-3. Signals by Function, Except for GPIO**

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| Analog Comparators | C0+ | 90 | I | Analog | Analog comparator 0 positive input. |
| | C0- | 92 | I | Analog | Analog comparator 0 negative input. |
| | C0o | 58 | O | TTL | Analog comparator 0 output. |
| | C1+ | 24 | I | Analog | Analog comparator 1 positive input. |
| | C1- | 91 | I | Analog | Analog comparator 1 negative input. |
| | C1o | 46 | O | TTL | Analog comparator 1 output. |
| | C2+ | 23 | I | Analog | Analog comparator 2 positive input. |
| | C2- | 22 | I | Analog | Analog comparator 2 negative input. |
| | C2o | 43 | O | TTL | Analog comparator 2 output. |
| General-Purpose Timers | CCP0 | 95 | I/O | TTL | Capture/Compare/PWM 0. |
| | CCP1 | 100 | I/O | TTL | Capture/Compare/PWM 1. |
| | CCP2 | 96 | I/O | TTL | Capture/Compare/PWM 2. |
| | CCP3 | 6 | I/O | TTL | Capture/Compare/PWM 3. |
| | CCP4 | 42 | I/O | TTL | Capture/Compare/PWM 4. |
| | CCP5 | 25 | I/O | TTL | Capture/Compare/PWM 5. |
| | CCP6 | 86 | I/O | TTL | Capture/Compare/PWM 6. |
| | CCP7 | 85 | I/O | TTL | Capture/Compare/PWM 7. |
| Hibernate | HIB | 51 | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| | VBAT | 55 | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| | WAKE | 50 | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| | XOSC0 | 52 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| | XOSC1 | 53 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| I2C | I2C0SCL | 70 | I/O | OD | $I^2C$ module 0 clock. |
| | I2C0SDA | 71 | I/O | OD | $I^2C$ module 0 data. |
| | I2C1SCL | 34 | I/O | OD | $I^2C$ module 1 clock. |
| | I2C1SDA | 35 | I/O | OD | $I^2C$ module 1 data. |

**Table 18-3. Signals by Function, Except for GPIO *(continued)***

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| JTAG/SWD/SWO | SWCLK | 80 | I | TTL | JTAG/SWD CLK. |
| | SWDIO | 79 | I/O | TTL | JTAG TMS and SWDIO. |
| | SWO | 77 | O | TTL | JTAG TDO and SWO. |
| | TCK | 80 | I | TTL | JTAG/SWD CLK. |
| | TDI | 78 | I | TTL | JTAG TDI. |
| | TDO | 77 | O | TTL | JTAG TDO and SWO. |
| | TMS | 79 | I/O | TTL | JTAG TMS and SWDIO. |
| | TRST | 89 | I | TTL | JTAG TRST. |
| PWM | Fault | 99 | I | TTL | PWM Fault. |
| | PWM0 | 47 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| | PWM1 | 61 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| | PWM2 | 66 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| | PWM3 | 67 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| | PWM4 | 2 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| | PWM5 | 1 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |

**Table 18-3. Signals by Function, Except for GPIO *(continued)***

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| Power | GND | 9<br>15<br>21<br>33<br>39<br>45<br>54<br>57<br>63<br>69<br>82<br>87<br>94 | - | Power | Ground reference for logic and I/O pins. |
| | GNDA | 4<br>97 | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| | LDO | 7 | - | Power | Low drop-out regulator output voltage. This pin requires an external capacitor between the pin and GND of 1 µF or greater. When the on-chip LDO is used to provide power to the logic, the LDO pin must also be connected to the VDD25 pins at the board level in addition to the decoupling capacitor(s). |
| | VDD | 8<br>20<br>32<br>44<br>56<br>68<br>81<br>93 | - | Power | Positive supply for I/O and some logic. |
| | VDD25 | 14<br>38<br>62<br>88 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| | VDDA | 3<br>98 | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| QEI | IDX0 | 10 | I | TTL | QEI module 0 index. |
| | IDX1 | 84 | I | TTL | QEI module 1 index. |
| | PhA0 | 11 | I | TTL | QEI module 0 phase A. |
| | PhA1 | 37 | I | TTL | QEI module 1 phase A. |
| | PhB0 | 83 | I | TTL | QEI module 0 phase B. |
| | PhB1 | 36 | I | TTL | QEI module 1 phase B. |

**Table 18-3. Signals by Function, Except for GPIO *(continued)***

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| SSI | SSI0Clk | 28 | I/O | TTL | SSI module 0 clock. |
| | SSI0Fss | 29 | I/O | TTL | SSI module 0 frame. |
| | SSI0Rx | 30 | I | TTL | SSI module 0 receive. |
| | SSI0Tx | 31 | O | TTL | SSI module 0 transmit. |
| | SSI1Clk | 72 | I/O | TTL | SSI module 1 clock. |
| | SSI1Fss | 73 | I/O | TTL | SSI module 1 frame. |
| | SSI1Rx | 74 | I | TTL | SSI module 1 receive. |
| | SSI1Tx | 75 | O | TTL | SSI module 1 transmit. |
| System Control & Clocks | CMOD0 | 65 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| | CMOD1 | 76 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| | OSC0 | 48 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| | OSC1 | 49 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| | RST | 64 | I | TTL | System reset input. |
| UART | U0Rx | 26 | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| | U0Tx | 27 | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| | U1Rx | 12 | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |
| | U1Tx | 13 | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| | U2Rx | 19 | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| | U2Tx | 18 | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 18-4. GPIO Pins and Alternate Functions**

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PA0 | 26 | U0Rx | |
| PA1 | 27 | U0Tx | |
| PA2 | 28 | SSI0Clk | |
| PA3 | 29 | SSI0Fss | |
| PA4 | 30 | SSI0Rx | |
| PA5 | 31 | SSI0Tx | |
| PA6 | 34 | I2C1SCL | |
| PA7 | 35 | I2C1SDA | |
| PB0 | 66 | PWM2 | |
| PB1 | 67 | PWM3 | |
| PB2 | 70 | I2C0SCL | |
| PB3 | 71 | I2C0SDA | |

**Table 18-4. GPIO Pins and Alternate Functions *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PB4 | 92 | C0- | |
| PB5 | 91 | C1- | |
| PB6 | 90 | C0+ | |
| PB7 | 89 | $\overline{\text{TRST}}$ | |
| PC0 | 80 | TCK | SWCLK |
| PC1 | 79 | TMS | SWDIO |
| PC2 | 78 | TDI | |
| PC3 | 77 | TDO | SWO |
| PC4 | 25 | CCP5 | |
| PC5 | 24 | C1+ | |
| PC6 | 23 | C2+ | |
| PC7 | 22 | C2- | |
| PD0 | 10 | IDX0 | |
| PD1 | 11 | PhA0 | |
| PD2 | 12 | U1Rx | |
| PD3 | 13 | U1Tx | |
| PD4 | 95 | CCP0 | |
| PD5 | 96 | CCP2 | |
| PD6 | 99 | Fault | |
| PD7 | 100 | CCP1 | |
| PE0 | 72 | SSI1Clk | |
| PE1 | 73 | SSI1Fss | |
| PE2 | 74 | SSI1Rx | |
| PE3 | 75 | SSI1Tx | |
| PE4 | 6 | CCP3 | |
| PE5 | 5 | | |
| PE6 | 2 | PWM4 | |
| PE7 | 1 | PWM5 | |
| PF0 | 47 | PWM0 | |
| PF1 | 61 | PWM1 | |
| PF2 | 60 | | |
| PF3 | 59 | | |
| PF4 | 58 | C0o | |
| PF5 | 46 | C1o | |
| PF6 | 43 | C2o | |
| PF7 | 42 | CCP4 | |
| PG0 | 19 | U2Rx | |
| PG1 | 18 | U2Tx | |
| PG2 | 17 | | |
| PG3 | 16 | | |
| PG4 | 41 | | |

**Table 18-4. GPIO Pins and Alternate Functions *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PG5 | 40 | | |
| PG6 | 37 | PhA1 | |
| PG7 | 36 | PhB1 | |
| PH0 | 86 | CCP6 | |
| PH1 | 85 | CCP7 | |
| PH2 | 84 | IDX1 | |
| PH3 | 83 | PhB0 | |

## 18.2 108-Ball BGA Package Pin Tables

**Table 18-5. Signals by Pin Number**

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| A1 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| A2 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| A3 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| A4 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| A5 | GNDA | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| A6 | PB4 | I/O | TTL | GPIO port B bit 4. |
| | C0- | I | Analog | Analog comparator 0 negative input. |
| A7 | PB6 | I/O | TTL | GPIO port B bit 6. |
| | C0+ | I | Analog | Analog comparator 0 positive input. |
| A8 | PB7 | I/O | TTL | GPIO port B bit 7. |
| | TRST | I | TTL | JTAG TRST. |
| A9 | PC0 | I/O | TTL | GPIO port C bit 0. |
| | SWCLK | I | TTL | JTAG/SWD CLK. |
| | TCK | I | TTL | JTAG/SWD CLK. |
| A10 | PC3 | I/O | TTL | GPIO port C bit 3. |
| | SWO | O | TTL | JTAG TDO and SWO. |
| | TDO | O | TTL | JTAG TDO and SWO. |
| A11 | PE0 | I/O | TTL | GPIO port E bit 0. |
| | SSI1Clk | I/O | TTL | SSI module 1 clock. |
| A12 | PE3 | I/O | TTL | GPIO port E bit 3. |
| | SSI1Tx | O | TTL | SSI module 1 transmit. |
| B1 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| B2 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| B3 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| B4 | NC | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| B5 | GNDA | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| B6 | GND | - | Power | Ground reference for logic and I/O pins. |

**Table 18-5. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| B7 | PB5 | I/O | TTL | GPIO port B bit 5. |
| | C1- | I | Analog | Analog comparator 1 negative input. |
| B8 | PC2 | I/O | TTL | GPIO port C bit 2. |
| | TDI | I | TTL | JTAG TDI. |
| B9 | PC1 | I/O | TTL | GPIO port C bit 1. |
| | SWDIO | I/O | TTL | JTAG TMS and SWDIO. |
| | TMS | I/O | TTL | JTAG TMS and SWDIO. |
| B10 | CMOD1 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| B11 | PE2 | I/O | TTL | GPIO port E bit 2. |
| | SSI1Rx | I | TTL | SSI module 1 receive. |
| B12 | PE1 | I/O | TTL | GPIO port E bit 1. |
| | SSI1Fss | I/O | TTL | SSI module 1 frame. |
| C1 | PE7 | I/O | TTL | GPIO port E bit 7. |
| | PWM5 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |
| C2 | PE6 | I/O | TTL | GPIO port E bit 6. |
| | PWM4 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| C3 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| C4 | GND | - | Power | Ground reference for logic and I/O pins. |
| C5 | GND | - | Power | Ground reference for logic and I/O pins. |
| C6 | VDDA | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| C7 | VDDA | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| C8 | PH1 | I/O | TTL | GPIO port H bit 1. |
| | CCP7 | I/O | TTL | Capture/Compare/PWM 7. |
| C9 | PH0 | I/O | TTL | GPIO port H bit 0. |
| | CCP6 | I/O | TTL | Capture/Compare/PWM 6. |
| C10 | PG7 | I/O | TTL | GPIO port G bit 7. |
| | PhB1 | I | TTL | QEI module 1 phase B. |
| C11 | PB2 | I/O | TTL | GPIO port B bit 2. |
| | I2C0SCL | I/O | OD | $I^2C$ module 0 clock. |
| C12 | PB3 | I/O | TTL | GPIO port B bit 3. |
| | I2C0SDA | I/O | OD | $I^2C$ module 0 data. |
| D1 | PE4 | I/O | TTL | GPIO port E bit 4. |
| | CCP3 | I/O | TTL | Capture/Compare/PWM 3. |
| D2 | PE5 | I/O | TTL | GPIO port E bit 5. |

**Table 18-5. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| D3 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| D10 | PH3 | I/O | TTL | GPIO port H bit 3. |
| | PhB0 | I | TTL | QEI module 0 phase B. |
| D11 | PH2 | I/O | TTL | GPIO port H bit 2. |
| | IDX1 | I | TTL | QEI module 1 index. |
| D12 | PB1 | I/O | TTL | GPIO port B bit 1. |
| | PWM3 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| E1 | PD4 | I/O | TTL | GPIO port D bit 4. |
| | CCP0 | I/O | TTL | Capture/Compare/PWM 0. |
| E2 | PD5 | I/O | TTL | GPIO port D bit 5. |
| | CCP2 | I/O | TTL | Capture/Compare/PWM 2. |
| E3 | LDO | - | Power | Low drop-out regulator output voltage. This pin requires an external capacitor between the pin and GND of 1 µF or greater. When the on-chip LDO is used to provide power to the logic, the LDO pin must also be connected to the VDD25 pins at the board level in addition to the decoupling capacitor(s). |
| E10 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| E11 | CMOD0 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| E12 | PB0 | I/O | TTL | GPIO port B bit 0. |
| | PWM2 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| F1 | PD7 | I/O | TTL | GPIO port D bit 7. |
| | CCP1 | I/O | TTL | Capture/Compare/PWM 1. |
| F2 | PD6 | I/O | TTL | GPIO port D bit 6. |
| | Fault | I | TTL | PWM Fault. |
| F3 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| F10 | GND | - | Power | Ground reference for logic and I/O pins. |
| F11 | GND | - | Power | Ground reference for logic and I/O pins. |
| F12 | GND | - | Power | Ground reference for logic and I/O pins. |
| G1 | PD0 | I/O | TTL | GPIO port D bit 0. |
| | IDX0 | I | TTL | QEI module 0 index. |
| G2 | PD1 | I/O | TTL | GPIO port D bit 1. |
| | PhA0 | I | TTL | QEI module 0 phase A. |
| G3 | VDD25 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| G10 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| G11 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| G12 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| H1 | PD3 | I/O | TTL | GPIO port D bit 3. |
| | U1Tx | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |

**Table 18-5. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| H2 | PD2 | I/O | TTL | GPIO port D bit 2. |
| | U1Rx | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |
| H3 | GND | - | Power | Ground reference for logic and I/O pins. |
| H10 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| H11 | $\overline{\text{RST}}$ | I | TTL | System reset input. |
| H12 | PF1 | I/O | TTL | GPIO port F bit 1. |
| | PWM1 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| J1 | PG2 | I/O | TTL | GPIO port G bit 2. |
| J2 | PG3 | I/O | TTL | GPIO port G bit 3. |
| J3 | GND | - | Power | Ground reference for logic and I/O pins. |
| J10 | GND | - | Power | Ground reference for logic and I/O pins. |
| J11 | PF2 | I/O | TTL | GPIO port F bit 2. |
| J12 | PF3 | I/O | TTL | GPIO port F bit 3. |
| K1 | PG0 | I/O | TTL | GPIO port G bit 0. |
| | U2Rx | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| K2 | PG1 | I/O | TTL | GPIO port G bit 1. |
| | U2Tx | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |
| K3 | PG4 | I/O | TTL | GPIO port G bit 4. |
| K4 | PF7 | I/O | TTL | GPIO port F bit 7. |
| | CCP4 | I/O | TTL | Capture/Compare/PWM 4. |
| K5 | GND | - | Power | Ground reference for logic and I/O pins. |
| K6 | GND | - | Power | Ground reference for logic and I/O pins. |
| K7 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| K8 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| K9 | VDD33 | - | Power | Positive supply for I/O and some logic. |
| K10 | GND | - | Power | Ground reference for logic and I/O pins. |
| K11 | XOSC0 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| K12 | XOSC1 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| L1 | PC4 | I/O | TTL | GPIO port C bit 4. |
| | CCP5 | I/O | TTL | Capture/Compare/PWM 5. |
| L2 | PC7 | I/O | TTL | GPIO port C bit 7. |
| | C2- | I | Analog | Analog comparator 2 negative input. |
| L3 | PA0 | I/O | TTL | GPIO port A bit 0. |
| | U0Rx | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| L4 | PA3 | I/O | TTL | GPIO port A bit 3. |
| | SSI0Fss | I/O | TTL | SSI module 0 frame. |

**Table 18-5. Signals by Pin Number *(continued)***

| Pin Number | Pin Name | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| L5 | PA4 | I/O | TTL | GPIO port A bit 4. |
| | SSI0Rx | I | TTL | SSI module 0 receive. |
| L6 | PA6 | I/O | TTL | GPIO port A bit 6. |
| | I2C1SCL | I/O | OD | $I^2C$ module 1 clock. |
| L7 | PG6 | I/O | TTL | GPIO port G bit 6. |
| | PhA1 | I | TTL | QEI module 1 phase A. |
| L8 | PF5 | I/O | TTL | GPIO port F bit 5. |
| | C1o | O | TTL | Analog comparator 1 output. |
| L9 | PF4 | I/O | TTL | GPIO port F bit 4. |
| | C0o | O | TTL | Analog comparator 0 output. |
| L10 | GND | - | Power | Ground reference for logic and I/O pins. |
| L11 | OSC0 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| L12 | VBAT | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| M1 | PC5 | I/O | TTL | GPIO port C bit 5. |
| | C1+ | I | Analog | Analog comparator 1 positive input. |
| M2 | PC6 | I/O | TTL | GPIO port C bit 6. |
| | C2+ | I | Analog | Analog comparator 2 positive input. |
| M3 | PA1 | I/O | TTL | GPIO port A bit 1. |
| | U0Tx | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| M4 | PA2 | I/O | TTL | GPIO port A bit 2. |
| | SSI0Clk | I/O | TTL | SSI module 0 clock. |
| M5 | PA5 | I/O | TTL | GPIO port A bit 5. |
| | SSI0Tx | O | TTL | SSI module 0 transmit. |
| M6 | PA7 | I/O | TTL | GPIO port A bit 7. |
| | I2C1SDA | I/O | OD | $I^2C$ module 1 data. |
| M7 | PG5 | I/O | TTL | GPIO port G bit 5. |
| M8 | PF6 | I/O | TTL | GPIO port F bit 6. |
| | C2o | O | TTL | Analog comparator 2 output. |
| M9 | PF0 | I/O | TTL | GPIO port F bit 0. |
| | PWM0 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| M10 | $\overline{\text{WAKE}}$ | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| M11 | OSC1 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| M12 | $\overline{\text{HIB}}$ | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 18-6. Signals by Signal Name**

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| C0+ | A7 | I | Analog | Analog comparator 0 positive input. |
| C0- | A6 | I | Analog | Analog comparator 0 negative input. |
| C0o | L9 | O | TTL | Analog comparator 0 output. |
| C1+ | M1 | I | Analog | Analog comparator 1 positive input. |
| C1- | B7 | I | Analog | Analog comparator 1 negative input. |
| C1o | L8 | O | TTL | Analog comparator 1 output. |
| C2+ | M2 | I | Analog | Analog comparator 2 positive input. |
| C2- | L2 | I | Analog | Analog comparator 2 negative input. |
| C2o | M8 | O | TTL | Analog comparator 2 output. |
| CCP0 | E1 | I/O | TTL | Capture/Compare/PWM 0. |
| CCP1 | F1 | I/O | TTL | Capture/Compare/PWM 1. |
| CCP2 | E2 | I/O | TTL | Capture/Compare/PWM 2. |
| CCP3 | D1 | I/O | TTL | Capture/Compare/PWM 3. |
| CCP4 | K4 | I/O | TTL | Capture/Compare/PWM 4. |
| CCP5 | L1 | I/O | TTL | Capture/Compare/PWM 5. |
| CCP6 | C9 | I/O | TTL | Capture/Compare/PWM 6. |
| CCP7 | C8 | I/O | TTL | Capture/Compare/PWM 7. |
| CMOD0 | E11 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| CMOD1 | B10 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| Fault | F2 | I | TTL | PWM Fault. |
| GND | B6<br>C4<br>C5<br>F10<br>F11<br>F12<br>H3<br>J3<br>J10<br>K5<br>K6<br>K10<br>L10 | - | Power | Ground reference for logic and I/O pins. |
| GNDA | A5<br>B5 | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| HIB | M12 | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| I2C0SCL | C11 | I/O | OD | $I^2C$ module 0 clock. |
| I2C0SDA | C12 | I/O | OD | $I^2C$ module 0 data. |
| I2C1SCL | L6 | I/O | OD | $I^2C$ module 1 clock. |
| I2C1SDA | M6 | I/O | OD | $I^2C$ module 1 data. |
| IDX0 | G1 | I | TTL | QEI module 0 index. |
| IDX1 | D11 | I | TTL | QEI module 1 index. |

**Table 18-6. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| LDO | E3 | - | Power | Low drop-out regulator output voltage. This pin requires an external capacitor between the pin and GND of 1 µF or greater. When the on-chip LDO is used to provide power to the logic, the LDO pin must also be connected to the VDD25 pins at the board level in addition to the decoupling capacitor(s). |
| NC | A1<br>A2<br>A3<br>A4<br>B1<br>B2<br>B3<br>B4 | - | - | No connect. Leave the pin electrically unconnected/isolated. |
| OSC0 | L11 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| OSC1 | M11 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| PA0 | L3 | I/O | TTL | GPIO port A bit 0. |
| PA1 | M3 | I/O | TTL | GPIO port A bit 1. |
| PA2 | M4 | I/O | TTL | GPIO port A bit 2. |
| PA3 | L4 | I/O | TTL | GPIO port A bit 3. |
| PA4 | L5 | I/O | TTL | GPIO port A bit 4. |
| PA5 | M5 | I/O | TTL | GPIO port A bit 5. |
| PA6 | L6 | I/O | TTL | GPIO port A bit 6. |
| PA7 | M6 | I/O | TTL | GPIO port A bit 7. |
| PB0 | E12 | I/O | TTL | GPIO port B bit 0. |
| PB1 | D12 | I/O | TTL | GPIO port B bit 1. |
| PB2 | C11 | I/O | TTL | GPIO port B bit 2. |
| PB3 | C12 | I/O | TTL | GPIO port B bit 3. |
| PB4 | A6 | I/O | TTL | GPIO port B bit 4. |
| PB5 | B7 | I/O | TTL | GPIO port B bit 5. |
| PB6 | A7 | I/O | TTL | GPIO port B bit 6. |
| PB7 | A8 | I/O | TTL | GPIO port B bit 7. |
| PC0 | A9 | I/O | TTL | GPIO port C bit 0. |
| PC1 | B9 | I/O | TTL | GPIO port C bit 1. |
| PC2 | B8 | I/O | TTL | GPIO port C bit 2. |
| PC3 | A10 | I/O | TTL | GPIO port C bit 3. |
| PC4 | L1 | I/O | TTL | GPIO port C bit 4. |
| PC5 | M1 | I/O | TTL | GPIO port C bit 5. |
| PC6 | M2 | I/O | TTL | GPIO port C bit 6. |
| PC7 | L2 | I/O | TTL | GPIO port C bit 7. |
| PD0 | G1 | I/O | TTL | GPIO port D bit 0. |
| PD1 | G2 | I/O | TTL | GPIO port D bit 1. |
| PD2 | H2 | I/O | TTL | GPIO port D bit 2. |
| PD3 | H1 | I/O | TTL | GPIO port D bit 3. |

**Table 18-6. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PD4 | E1 | I/O | TTL | GPIO port D bit 4. |
| PD5 | E2 | I/O | TTL | GPIO port D bit 5. |
| PD6 | F2 | I/O | TTL | GPIO port D bit 6. |
| PD7 | F1 | I/O | TTL | GPIO port D bit 7. |
| PE0 | A11 | I/O | TTL | GPIO port E bit 0. |
| PE1 | B12 | I/O | TTL | GPIO port E bit 1. |
| PE2 | B11 | I/O | TTL | GPIO port E bit 2. |
| PE3 | A12 | I/O | TTL | GPIO port E bit 3. |
| PE4 | D1 | I/O | TTL | GPIO port E bit 4. |
| PE5 | D2 | I/O | TTL | GPIO port E bit 5. |
| PE6 | C2 | I/O | TTL | GPIO port E bit 6. |
| PE7 | C1 | I/O | TTL | GPIO port E bit 7. |
| PF0 | M9 | I/O | TTL | GPIO port F bit 0. |
| PF1 | H12 | I/O | TTL | GPIO port F bit 1. |
| PF2 | J11 | I/O | TTL | GPIO port F bit 2. |
| PF3 | J12 | I/O | TTL | GPIO port F bit 3. |
| PF4 | L9 | I/O | TTL | GPIO port F bit 4. |
| PF5 | L8 | I/O | TTL | GPIO port F bit 5. |
| PF6 | M8 | I/O | TTL | GPIO port F bit 6. |
| PF7 | K4 | I/O | TTL | GPIO port F bit 7. |
| PG0 | K1 | I/O | TTL | GPIO port G bit 0. |
| PG1 | K2 | I/O | TTL | GPIO port G bit 1. |
| PG2 | J1 | I/O | TTL | GPIO port G bit 2. |
| PG3 | J2 | I/O | TTL | GPIO port G bit 3. |
| PG4 | K3 | I/O | TTL | GPIO port G bit 4. |
| PG5 | M7 | I/O | TTL | GPIO port G bit 5. |
| PG6 | L7 | I/O | TTL | GPIO port G bit 6. |
| PG7 | C10 | I/O | TTL | GPIO port G bit 7. |
| PH0 | C9 | I/O | TTL | GPIO port H bit 0. |
| PH1 | C8 | I/O | TTL | GPIO port H bit 1. |
| PH2 | D11 | I/O | TTL | GPIO port H bit 2. |
| PH3 | D10 | I/O | TTL | GPIO port H bit 3. |
| PhA0 | G2 | I | TTL | QEI module 0 phase A. |
| PhA1 | L7 | I | TTL | QEI module 1 phase A. |
| PhB0 | D10 | I | TTL | QEI module 0 phase B. |
| PhB1 | C10 | I | TTL | QEI module 1 phase B. |
| PWM0 | M9 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| PWM1 | H12 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| PWM2 | E12 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| PWM3 | D12 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| PWM4 | C2 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |

**Table 18-6. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| PWM5 | C1 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |
| RST | H11 | I | TTL | System reset input. |
| SSI0Clk | M4 | I/O | TTL | SSI module 0 clock. |
| SSI0Fss | L4 | I/O | TTL | SSI module 0 frame. |
| SSI0Rx | L5 | I | TTL | SSI module 0 receive. |
| SSI0Tx | M5 | O | TTL | SSI module 0 transmit. |
| SSI1Clk | A11 | I/O | TTL | SSI module 1 clock. |
| SSI1Fss | B12 | I/O | TTL | SSI module 1 frame. |
| SSI1Rx | B11 | I | TTL | SSI module 1 receive. |
| SSI1Tx | A12 | O | TTL | SSI module 1 transmit. |
| SWCLK | A9 | I | TTL | JTAG/SWD CLK. |
| SWDIO | B9 | I/O | TTL | JTAG TMS and SWDIO. |
| SWO | A10 | O | TTL | JTAG TDO and SWO. |
| TCK | A9 | I | TTL | JTAG/SWD CLK. |
| TDI | B8 | I | TTL | JTAG TDI. |
| TDO | A10 | O | TTL | JTAG TDO and SWO. |
| TMS | B9 | I/O | TTL | JTAG TMS and SWDIO. |
| TRST | A8 | I | TTL | JTAG TRST. |
| U0Rx | L3 | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| U0Tx | M3 | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U1Rx | H2 | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |
| U1Tx | H1 | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| U2Rx | K1 | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| U2Tx | K2 | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |
| VBAT | L12 | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| VDD25 | C3<br>D3<br>F3<br>G3 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| VDD33 | E10<br>G10<br>G11<br>G12<br>H10<br>K7<br>K8<br>K9 | - | Power | Positive supply for I/O and some logic. |

**Table 18-6. Signals by Signal Name *(continued)***

| Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|
| VDDA | C6<br>C7 | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| WAKE | M10 | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| XOSC0 | K11 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| XOSC1 | K12 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 18-7. Signals by Function, Except for GPIO**

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| Analog Comparators | C0+ | A7 | I | Analog | Analog comparator 0 positive input. |
| | C0- | A6 | I | Analog | Analog comparator 0 negative input. |
| | C0o | L9 | O | TTL | Analog comparator 0 output. |
| | C1+ | M1 | I | Analog | Analog comparator 1 positive input. |
| | C1- | B7 | I | Analog | Analog comparator 1 negative input. |
| | C1o | L8 | O | TTL | Analog comparator 1 output. |
| | C2+ | M2 | I | Analog | Analog comparator 2 positive input. |
| | C2- | L2 | I | Analog | Analog comparator 2 negative input. |
| | C2o | M8 | O | TTL | Analog comparator 2 output. |
| General-Purpose Timers | CCP0 | E1 | I/O | TTL | Capture/Compare/PWM 0. |
| | CCP1 | F1 | I/O | TTL | Capture/Compare/PWM 1. |
| | CCP2 | E2 | I/O | TTL | Capture/Compare/PWM 2. |
| | CCP3 | D1 | I/O | TTL | Capture/Compare/PWM 3. |
| | CCP4 | K4 | I/O | TTL | Capture/Compare/PWM 4. |
| | CCP5 | L1 | I/O | TTL | Capture/Compare/PWM 5. |
| | CCP6 | C9 | I/O | TTL | Capture/Compare/PWM 6. |
| | CCP7 | C8 | I/O | TTL | Capture/Compare/PWM 7. |

**Table 18-7. Signals by Function, Except for GPIO *(continued)***

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| Hibernate | HIB | M12 | O | OD | An open-drain output with internal pull-up that indicates the processor is in Hibernate mode. |
| | VBAT | L12 | - | Power | Power source for the Hibernation module. It is normally connected to the positive terminal of a battery and serves as the battery backup/Hibernation module power-source supply. |
| | WAKE | M10 | I | TTL | An external input that brings the processor out of Hibernate mode when asserted. |
| | XOSC0 | K11 | I | Analog | Hibernation module oscillator crystal input or an external clock reference input. Note that this is either a crystal or a 32.768-kHz oscillator for the Hibernation module RTC. |
| | XOSC1 | K12 | O | Analog | Hibernation module oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| I2C | I2C0SCL | C11 | I/O | OD | $I^2C$ module 0 clock. |
| | I2C0SDA | C12 | I/O | OD | $I^2C$ module 0 data. |
| | I2C1SCL | L6 | I/O | OD | $I^2C$ module 1 clock. |
| | I2C1SDA | M6 | I/O | OD | $I^2C$ module 1 data. |
| JTAG/SWD/SWO | SWCLK | A9 | I | TTL | JTAG/SWD CLK. |
| | SWDIO | B9 | I/O | TTL | JTAG TMS and SWDIO. |
| | SWO | A10 | O | TTL | JTAG TDO and SWO. |
| | TCK | A9 | I | TTL | JTAG/SWD CLK. |
| | TDI | B8 | I | TTL | JTAG TDI. |
| | TDO | A10 | O | TTL | JTAG TDO and SWO. |
| | TMS | B9 | I/O | TTL | JTAG TMS and SWDIO. |
| | TRST | A8 | I | TTL | JTAG TRST. |
| PWM | Fault | F2 | I | TTL | PWM Fault. |
| | PWM0 | M9 | O | TTL | PWM 0. This signal is controlled by PWM Generator 0. |
| | PWM1 | H12 | O | TTL | PWM 1. This signal is controlled by PWM Generator 0. |
| | PWM2 | E12 | O | TTL | PWM 2. This signal is controlled by PWM Generator 1. |
| | PWM3 | D12 | O | TTL | PWM 3. This signal is controlled by PWM Generator 1. |
| | PWM4 | C2 | O | TTL | PWM 4. This signal is controlled by PWM Generator 2. |
| | PWM5 | C1 | O | TTL | PWM 5. This signal is controlled by PWM Generator 2. |

**Table 18-7. Signals by Function, Except for GPIO *(continued)***

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| Power | GND | B6<br>C4<br>C5<br>F10<br>F11<br>F12<br>H3<br>J3<br>J10<br>K5<br>K6<br>K10<br>L10 | - | Power | Ground reference for logic and I/O pins. |
| | GNDA | A5<br>B5 | - | Power | The ground reference for the analog circuits ( Analog Comparators, etc.). These are separated from GND to minimize the electrical noise contained on VDD from affecting the analog functions. |
| | LDO | E3 | - | Power | Low drop-out regulator output voltage. This pin requires an external capacitor between the pin and GND of 1 µF or greater. When the on-chip LDO is used to provide power to the logic, the LDO pin must also be connected to the VDD25 pins at the board level in addition to the decoupling capacitor(s). |
| | VDD25 | C3<br>D3<br>F3<br>G3 | - | Power | Positive supply for most of the logic function, including the processor core and most peripherals. |
| | VDD33 | E10<br>G10<br>G11<br>G12<br>H10<br>K7<br>K8<br>K9 | - | Power | Positive supply for I/O and some logic. |
| | VDDA | C6<br>C7 | - | Power | The positive supply (3.3 V) for the analog circuits (ADC, Analog Comparators, etc.). These are separated from VDD to minimize the electrical noise contained on VDD from affecting the analog functions. VDDA pins must be connected to 3.3 V, regardless of system implementation. |
| QEI | IDX0 | G1 | I | TTL | QEI module 0 index. |
| | IDX1 | D11 | I | TTL | QEI module 1 index. |
| | PhA0 | G2 | I | TTL | QEI module 0 phase A. |
| | PhA1 | L7 | I | TTL | QEI module 1 phase A. |
| | PhB0 | D10 | I | TTL | QEI module 0 phase B. |
| | PhB1 | C10 | I | TTL | QEI module 1 phase B. |

**Table 18-7. Signals by Function, Except for GPIO *(continued)***

| Function | Pin Name | Pin Number | Pin Type | Buffer Type[a] | Description |
|---|---|---|---|---|---|
| SSI | SSI0Clk | M4 | I/O | TTL | SSI module 0 clock. |
| | SSI0Fss | L4 | I/O | TTL | SSI module 0 frame. |
| | SSI0Rx | L5 | I | TTL | SSI module 0 receive. |
| | SSI0Tx | M5 | O | TTL | SSI module 0 transmit. |
| | SSI1Clk | A11 | I/O | TTL | SSI module 1 clock. |
| | SSI1Fss | B12 | I/O | TTL | SSI module 1 frame. |
| | SSI1Rx | B11 | I | TTL | SSI module 1 receive. |
| | SSI1Tx | A12 | O | TTL | SSI module 1 transmit. |
| System Control & Clocks | CMOD0 | E11 | I | TTL | CPU Mode bit 0. Input must be set to logic 0 (grounded); other encodings reserved. |
| | CMOD1 | B10 | I | TTL | CPU Mode bit 1. Input must be set to logic 0 (grounded); other encodings reserved. |
| | OSC0 | L11 | I | Analog | Main oscillator crystal input or an external clock reference input. |
| | OSC1 | M11 | O | Analog | Main oscillator crystal output. Leave unconnected when using a single-ended clock source. |
| | RST | H11 | I | TTL | System reset input. |
| UART | U0Rx | L3 | I | TTL | UART module 0 receive. When in IrDA mode, this signal has IrDA modulation. |
| | U0Tx | M3 | O | TTL | UART module 0 transmit. When in IrDA mode, this signal has IrDA modulation. |
| | U1Rx | H2 | I | TTL | UART module 1 receive. When in IrDA mode, this signal has IrDA modulation. |
| | U1Tx | H1 | O | TTL | UART module 1 transmit. When in IrDA mode, this signal has IrDA modulation. |
| | U2Rx | K1 | I | TTL | UART module 2 receive. When in IrDA mode, this signal has IrDA modulation. |
| | U2Tx | K2 | O | TTL | UART module 2 transmit. When in IrDA mode, this signal has IrDA modulation. |

a. The TTL designation indicates the pin has TTL-compatible voltage levels.

**Table 18-8. GPIO Pins and Alternate Functions**

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PA0 | L3 | U0Rx | |
| PA1 | M3 | U0Tx | |
| PA2 | M4 | SSI0Clk | |
| PA3 | L4 | SSI0Fss | |
| PA4 | L5 | SSI0Rx | |
| PA5 | M5 | SSI0Tx | |
| PA6 | L6 | I2C1SCL | |
| PA7 | M6 | I2C1SDA | |
| PB0 | E12 | PWM2 | |
| PB1 | D12 | PWM3 | |
| PB2 | C11 | I2C0SCL | |
| PB3 | C12 | I2C0SDA | |

**Table 18-8. GPIO Pins and Alternate Functions *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PB4 | A6 | C0- | |
| PB5 | B7 | C1- | |
| PB6 | A7 | C0+ | |
| PB7 | A8 | TRST | |
| PC0 | A9 | TCK | SWCLK |
| PC1 | B9 | TMS | SWDIO |
| PC2 | B8 | TDI | |
| PC3 | A10 | TDO | SWO |
| PC4 | L1 | CCP5 | |
| PC5 | M1 | C1+ | |
| PC6 | M2 | C2+ | |
| PC7 | L2 | C2- | |
| PD0 | G1 | IDX0 | |
| PD1 | G2 | PhA0 | |
| PD2 | H2 | U1Rx | |
| PD3 | H1 | U1Tx | |
| PD4 | E1 | CCP0 | |
| PD5 | E2 | CCP2 | |
| PD6 | F2 | Fault | |
| PD7 | F1 | CCP1 | |
| PE0 | A11 | SSI1Clk | |
| PE1 | B12 | SSI1Fss | |
| PE2 | B11 | SSI1Rx | |
| PE3 | A12 | SSI1Tx | |
| PE4 | D1 | CCP3 | |
| PE5 | D2 | | |
| PE6 | C2 | PWM4 | |
| PE7 | C1 | PWM5 | |
| PF0 | M9 | PWM0 | |
| PF1 | H12 | PWM1 | |
| PF2 | J11 | | |
| PF3 | J12 | | |
| PF4 | L9 | C0o | |
| PF5 | L8 | C1o | |
| PF6 | M8 | C2o | |
| PF7 | K4 | CCP4 | |
| PG0 | K1 | U2Rx | |
| PG1 | K2 | U2Tx | |
| PG2 | J1 | | |
| PG3 | J2 | | |
| PG4 | K3 | | |

**Table 18-8. GPIO Pins and Alternate Functions *(continued)***

| IO | Pin Number | Multiplexed Function | Multiplexed Function |
|---|---|---|---|
| PG5 | M7 | | |
| PG6 | L7 | PhA1 | |
| PG7 | C10 | PhB1 | |
| PH0 | C9 | CCP6 | |
| PH1 | C8 | CCP7 | |
| PH2 | D11 | IDX1 | |
| PH3 | D10 | PhB0 | |

## 18.3 Connections for Unused Signals

Table 18-9 on page 606 show how to handle signals for functions that are not used in a particular system implementation for devices that are in a 100-pin LQFP package. Two options are shown in the table: an acceptable practice and a preferred practice for reduced power consumption and improved EMC characteristics. If a module is not used in a system, and its inputs are grounded, it is important that the clock to the module is never enabled by setting the corresponding bit in the **RCGCx** register.

**Table 18-9. Connections for Unused Signals (100-pin LQFP)**

| Function | Signal Name | Pin Number | Acceptable Practice | Preferred Practice |
|---|---|---|---|---|
| GPIO | All unused GPIOs | - | NC | GND |
| Hibernate | $\overline{\text{HIB}}$ | 51 | NC | NC |
| | VBAT | 55 | NC | GND |
| | $\overline{\text{WAKE}}$ | 50 | NC | GND |
| | XOSC0 | 52 | NC | GND |
| | XOSC1 | 53 | NC | NC |
| No Connects | NC | - | NC | NC |
| System Control | OSC0 | 48 | NC | GND |
| | OSC1 | 49 | NC | NC |
| | $\overline{\text{RST}}$ | 64 | Pull up as shown in Figure 5-1 on page 168 | Connect through a capacitor to GND as close to pin as possible |

Table 18-10 on page 606 show how to handle signals for functions that are not used in a particular system implementation for devices that are in a 108-pin BGA package. Two options are shown in the table: an acceptable practice and a preferred practice for reduced power consumption and improved EMC characteristics. If a module is not used in a system, and its inputs are grounded, it is important that the clock to the module is never enabled by setting the corresponding bit in the **RCGCx** register.

**Table 18-10. Connections for Unused Signals, 108-pin BGA**

| Function | Signal Name | Pin Number | Acceptable Practice | Preferred Practice |
|---|---|---|---|---|
| GPIO | All unused GPIOs | - | NC | GND |

**Table 18-10. Connections for Unused Signals, 108-pin BGA *(continued)***

| Function | Signal Name | Pin Number | Acceptable Practice | Preferred Practice |
|---|---|---|---|---|
| Hibernate | HIB | M12 | NC | NC |
| | VBAT | L12 | NC | GND |
| | WAKE | M10 | NC | GND |
| | XOSC0 | K11 | NC | GND |
| | XOSC1 | K12 | NC | NC |
| No Connects | NC | - | NC | NC |
| System Control | OSC0 | L11 | NC | GND |
| | OSC1 | M11 | NC | NC |
| | RST | H11 | Pull up as shown in Figure 5-1 on page 168 | Connect through a capacitor to GND as close to pin as possible |

# 19 Operating Characteristics

### Table 19-1. Temperature Characteristics

| Characteristic | Symbol | Value | Unit |
|---|---|---|---|
| Industrial operating temperature range | $T_A$ | -40 to +85 | °C |
| Extended operating temperature range | $T_A$ | -40 to +105 | °C |
| Unpowered storage temperature range | $T_S$ | -65 to +150 | °C |

### Table 19-2. Thermal Characteristics

| Characteristic | Symbol | Value | Unit |
|---|---|---|---|
| Thermal resistance (junction to ambient)[a] | $\Theta_{JA}$ | 32 | °C/W |
| Junction temperature[b] | $T_J$ | $T_A + (P \bullet \Theta_{JA})$ | °C |

a. Junction to ambient thermal resistance $\theta_{JA}$ numbers are determined by a package simulator.

b. Power dissipation is a function of temperature.

### Table 19-3. ESD Absolute Maximum Ratings[a]

| Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|
| $V_{ESDHBM}$ | - | - | 2.0 | kV |
| $V_{ESDCDM}$ | - | - | 1.0 | kV |
| $V_{ESDMM}$ | - | - | 100 | V |

a. All Stellaris parts are ESD tested following the JEDEC standard.

# 20 Electrical Characteristics

## 20.1 DC Characteristics

### 20.1.1 Maximum Ratings

The maximum ratings are the limits to which the device can be subjected without permanently damaging the device.

**Note:** The device is not guaranteed to operate properly at the maximum ratings.

**Table 20-1. Maximum Ratings**

| Characteristic[a] | Symbol | Value | | Unit |
|---|---|---|---|---|
| | | Min | Max | |
| I/O supply voltage ($V_{DD}$) | $V_{DD}$ | 0 | 4 | V |
| Core supply voltage ($V_{DD25}$) | $V_{DD25}$ | 0 | 3 | V |
| Analog supply voltage ($V_{DDA}$) | $V_{DDA}$ | 0 | 4 | V |
| Battery supply voltage ($V_{BAT}$) | $V_{BAT}$ | 0 | 4 | V |
| Input voltage | $V_{IN}$ | -0.3 | 5.5 | V |
| Input voltage for a GPIO configured as an analog input | | -0.3 | $V_{DD}$ + 0.3 | V |
| Maximum current per output pins | I | - | 25 | mA |
| Maximum input voltage on a non-power pin when the microcontroller is unpowered | $V_{NON}$ | - | 300 | mV |

a. Voltages are measured with respect to GND.

**Important:** This device contains circuitry to protect the inputs against damage due to high-static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum-rated voltages to this high-impedance circuit. Reliability of operation is enhanced if unused inputs are connected to an appropriate logic voltage level (for example, either GND or $V_{DD}$).

### 20.1.2 Recommended DC Operating Conditions

For special high-current applications, the GPIO output buffers may be used with the following restrictions. With the GPIO pins configured as 8-mA output drivers, a total of four GPIO outputs may be used to sink current loads up to 18 mA each. At 18-mA sink current loading, the $V_{OL}$ value is specified as 1.2 V. The high-current GPIO package pins must be selected such that there are only a maximum of two per side of the physical package or BGA pin group with the total number of high-current GPIO outputs not exceeding four for the entire package.

**Table 20-2. Recommended DC Operating Conditions**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $V_{DD}$ | I/O supply voltage | 3.0 | 3.3 | 3.6 | V |
| $V_{DD25}$ | Core supply voltage | 2.25 | 2.5 | 2.75 | V |
| $V_{DDA}$ | Analog supply voltage | 3.0 | 3.3 | 3.6 | V |
| $V_{BAT}$ | Battery supply voltage | 2.3 | 3.0 | 3.6 | V |
| $V_{IH}$ | High-level input voltage | 2.0 | - | 5.0 | V |
| $V_{IL}$ | Low-level input voltage | -0.3 | - | 1.3 | V |

**Table 20-2. Recommended DC Operating Conditions *(continued)***

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $V_{OH}$[a] | High-level output voltage | 2.4 | - | - | V |
| $V_{OL}$[a] | Low-level output voltage | - | - | 0.4 | V |
| $I_{OH}$ | High-level source current, $V_{OH}$=2.4 V | | | | |
| | 2-mA Drive | 2.0 | - | - | mA |
| | 4-mA Drive | 4.0 | - | - | mA |
| | 8-mA Drive | 8.0 | - | - | mA |
| $I_{OL}$ | Low-level sink current, $V_{OL}$=0.4 V | | | | |
| | 2-mA Drive | 2.0 | - | - | mA |
| | 4-mA Drive | 4.0 | - | - | mA |
| | 8-mA Drive | 8.0 | - | - | mA |

a. $V_{OL}$ and $V_{OH}$ shift to 1.2 V when using high-current GPIOs.

## 20.1.3 On-Chip Low Drop-Out (LDO) Regulator Characteristics

**Table 20-3. LDO Regulator Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $V_{LDOOUT}$ | Programmable internal (logic) power supply output value | 2.25 | 2.5 | 2.75 | V |
| | Output voltage accuracy | - | 2% | - | % |
| $t_{PON}$ | Power-on time | - | - | 100 | µs |
| $t_{ON}$ | Time on | - | - | 200 | µs |
| $t_{OFF}$ | Time off | - | - | 100 | µs |
| $V_{STEP}$ | Step programming incremental voltage | - | 50 | - | mV |
| $C_{LDO}$ | External filter capacitor size for internal power supply | 1.0 | - | 3.0 | µF |

## 20.1.4 GPIO Module Characteristics

**Table 20-4. GPIO Module DC Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $R_{GPIOPU}$ | GPIO internal pull-up resistor | 50 | - | 110 | kΩ |
| $R_{GPIOPD}$ | GPIO internal pull-down resistor | 55 | - | 180 | kΩ |
| $I_{LKG}$ | GPIO input leakage current[a] | - | - | 2 | µA |

a. The leakage current is measured with GND or $V_{DD}$ applied to the corresponding pin(s). The leakage of digital port pins is measured individually. The port pin is configured as an input and the pullup/pulldown resistor is disabled.

## 20.1.5 Power Specifications

The power measurements specified in the tables that follow are run on the core processor using SRAM with the following specifications (except as noted):

- $V_{DD}$ = 3.3 V
- $V_{DD25}$ = 2.50 V

- $V_{BAT}$ = 3.0 V
- $V_{DDA}$ = 3.3 V
- Temperature = 25°C
- Clock Source (MOSC) =3.579545 MHz Crystal Oscillator
- Main oscillator (MOSC) = enabled
- Internal oscillator (IOSC) = disabled

**Table 20-5. Detailed Power Specifications**

| Parameter | Parameter Name | Conditions | 3.3 V $V_{DD}$, $V_{DDA}$ | | 2.5 V $V_{DD25}$ | | 3.0 V $V_{BAT}$ | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Nom | Max | Nom | Max | Nom | Max | |
| $I_{DD_RUN}$ | Run mode 1 (Flash loop) | $V_{DD25}$ = 2.50 V<br>Code= while(1){} executed out of Flash<br>Peripherals = All ON<br>System Clock = 50 MHz (with PLL) | 3 | pending[a] | 108 | pending[a] | 0 | pending[a] | mA |
| | Run mode 2 (Flash loop) | $V_{DD25}$ = 2.50 V<br>Code= while(1){} executed out of Flash<br>Peripherals = All OFF<br>System Clock = 50 MHz (with PLL) | 0 | pending[a] | 53 | pending[a] | 0 | pending[a] | mA |
| | Run mode 1 (SRAM loop) | $V_{DD25}$ = 2.50 V<br>Code= while(1){} executed in SRAM<br>Peripherals = All ON<br>System Clock = 50 MHz (with PLL) | 3 | pending[a] | 102 | pending[a] | 0 | pending[a] | mA |
| | Run mode 2 (SRAM loop) | $V_{DD25}$ = 2.50 V<br>Code= while(1){} executed in SRAM<br>Peripherals = All OFF<br>System Clock = 50 MHz (with PLL) | 0 | pending[a] | 47 | pending[a] | 0 | pending[a] | mA |
| $I_{DD_SLEEP}$ | Sleep mode | $V_{DD25}$ = 2.50 V<br>Peripherals = All OFF<br>System Clock = 50 MHz (with PLL) | 0 | pending[a] | 17 | pending[a] | 0 | pending[a] | mA |
| $I_{DD_DEEPSLEEP}$ | Deep-Sleep mode | LDO = 2.25 V<br>Peripherals = All OFF<br>System Clock = IOSC30KHZ/64 | 0.14 | pending[a] | 0.18 | pending[a] | 0 | pending[a] | mA |

**Table 20-5. Detailed Power Specifications *(continued)***

| Parameter | Parameter Name | Conditions | 3.3 V $V_{DD}$, $V_{DDA}$ | | 2.5 V $V_{DD25}$ | | 3.0 V $V_{BAT}$ | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Nom | Max | Nom | Max | Nom | Max | |
| $I_{DD_HIBERNATE}$ | Hibernate mode | $V_{BAT}$ = 3.0 V<br>$V_{DD}$ = 0 V<br>$V_{DD25}$ = 0 V<br>$V_{DDA}$ = 0 V<br>Peripherals = All OFF<br>System Clock = OFF<br>Hibernate Module = 32 kHz | 0 | 0 | 0 | 0 | 16 | pending[a] | µA |

a. Pending characterization completion.

## 20.1.6 Flash Memory Characteristics

**Table 20-6. Flash Memory Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $PE_{CYC}$ | Number of guaranteed program/erase cycles before failure[a] | 10,000 | 100,000 | - | cycles |
| $T_{RET}$ | Data retention at average operating temperature of 85˚C (industrial) or 105˚C (extended) | 10 | - | - | years |
| $T_{PROG}$ | Word program time | 20 | - | - | µs |
| $T_{ERASE}$ | Page erase time | 20 | - | - | ms |
| $T_{ME}$ | Mass erase time | - | - | 250 | ms |

a. A program/erase cycle is defined as switching the bits from 1-> 0 -> 1.

## 20.1.7 Hibernation

**Table 20-7. Hibernation Module DC Characteristics**

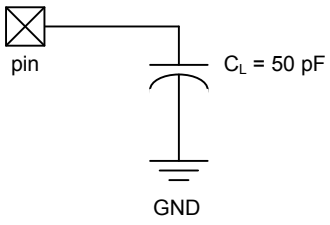
| Parameter | Parameter Name | Value | Unit |
|---|---|---|---|
| $V_{LOWBAT}$ | Low battery detect voltage | 2.35 | V |
| $R_{WAKEPU}$ | $\overline{WAKE}$ internal pull-up resistor | 200 | kΩ |

# 20.2 AC Characteristics

## 20.2.1 Load Conditions

Unless otherwise specified, the following conditions are true for all timing measurements. Timing measurements are for 4-mA drive strength.

**Figure 20-1. Load Conditions**



### 20.2.2 Clocks

**Table 20-8. Phase Locked Loop (PLL) Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $f_{ref_crystal}$ | Crystal reference[a] | 3.579545 | - | 8.192 | MHz |
| $f_{ref_ext}$ | External clock reference[a] | 3.579545 | - | 8.192 | MHz |
| $f_{pll}$ | PLL frequency[b] | - | 400 | - | MHz |
| $T_{READY}$ | PLL lock time | - | - | 0.5 | ms |

a. The exact value is determined by the crystal value programmed into the XTAL field of the **Run-Mode Clock Configuration (RCC)** register.

b. PLL frequency is automatically calculated by the hardware based on the XTAL field of the **RCC** register.

Table 20-9 on page 613 shows the actual frequency of the PLL based on the crystal frequency used (defined by the XTAL field in the **RCC** register).

**Table 20-9. Actual PLL Frequency**

| XTAL | Crystal Frequency (MHz) | PLL Frequency (MHz) | Error |
|---|---|---|---|
| 0x4 | 3.5795 | 400.904 | 0.0023% |
| 0x5 | 3.6864 | 398.1312 | 0.0047% |
| 0x6 | 4.0 | 400 | - |
| 0x7 | 4.096 | 401.408 | 0.0035% |
| 0x8 | 4.9152 | 398.1312 | 0.0047% |
| 0x9 | 5.0 | 400 | - |
| 0xA | 5.12 | 399.36 | 0.0016% |
| 0xB | 6.0 | 400 | - |
| 0xC | 6.144 | 399.36 | 0.0016% |
| 0xD | 7.3728 | 398.1312 | 0.0047% |
| 0xE | 8.0 | 400 | 0.0047% |
| 0xF | 8.192 | 398.6773333 | 0.0033% |

**Table 20-10. Clock Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $f_{IOSC}$ | Internal 12 MHz oscillator frequency | 8.4 | 12 | 15.6 | MHz |
| $f_{IOSC30KHZ}$ | Internal 30 KHz oscillator frequency | 15 | 30 | 45 | KHz |
| $f_{XOSC}$ | Hibernation module oscillator frequency | - | 4.194304 | - | MHz |
| $f_{XOSC_XTAL}$ | Crystal reference for hibernation oscillator | - | 4.194304 | - | MHz |
| $f_{XOSC_EXT}$ | External clock reference for hibernation module | - | 32.768 | - | KHz |
| $f_{MOSC}$ | Main oscillator frequency | 1 | - | 8.192 | MHz |
| $t_{MOSC_per}$ | Main oscillator period | 125 | - | 1000 | ns |
| $f_{ref_crystal_bypass}$ | Crystal reference using the main oscillator (PLL in BYPASS mode) | 1 | - | 8.192 | MHz |
| $f_{ref_ext_bypass}$ | External clock reference (PLL in BYPASS mode) | 0 | - | 50 | MHz |
| $f_{system_clock}$ | System clock | 0 | - | 50 | MHz |

**Table 20-11. Crystal Characteristics**

| Parameter Name | Value | | | | Units |
|---|---|---|---|---|---|
| Frequency | 8 | 6 | 4 | 3.5 | MHz |
| Frequency tolerance | ±50 | ±50 | ±50 | ±50 | ppm |
| Aging | ±5 | ±5 | ±5 | ±5 | ppm/yr |
| Oscillation mode | Parallel | Parallel | Parallel | Parallel | - |
| Temperature stability (-40°C to 85°C) | ±25 | ±25 | ±25 | ±25 | ppm |
| Temperature stability (-40°C to 105°C) | ±25 | ±25 | ±25 | ±25 | ppm |
| Motional capacitance (typ) | 27.8 | 37.0 | 55.6 | 63.5 | pF |
| Motional inductance (typ) | 14.3 | 19.1 | 28.6 | 32.7 | mH |
| Equivalent series resistance (max) | 120 | 160 | 200 | 220 | Ω |
| Shunt capacitance (max) | 10 | 10 | 10 | 10 | pF |
| Load capacitance (typ) | 16 | 16 | 16 | 16 | pF |
| Drive level (typ) | 100 | 100 | 100 | 100 | µW |

## 20.2.3 JTAG and Boundary Scan

**Table 20-12. JTAG Characteristics**

| Parameter No. | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| J1 | $f_{TCK}$ | TCK operational clock frequency | 0 | - | 10 | MHz |
| J2 | $t_{TCK}$ | TCK operational clock period | 100 | - | - | ns |
| J3 | $t_{TCK_LOW}$ | TCK clock Low time | - | $t_{TCK}/2$ | - | ns |
| J4 | $t_{TCK_HIGH}$ | TCK clock High time | - | $t_{TCK}/2$ | - | ns |
| J5 | $t_{TCK_R}$ | TCK rise time | 0 | - | 10 | ns |
| J6 | $t_{TCK_F}$ | TCK fall time | 0 | - | 10 | ns |
| J7 | $t_{TMS_SU}$ | TMS setup time to TCK rise | 20 | - | - | ns |
| J8 | $t_{TMS_HLD}$ | TMS hold time from TCK rise | 20 | - | - | ns |
| J9 | $t_{TDI_SU}$ | TDI setup time to TCK rise | 25 | - | - | ns |
| J10 | $t_{TDI_HLD}$ | TDI hold time from TCK rise | 25 | - | - | ns |
| J11 $t_{TDO_ZDV}$ | TCK fall to Data Valid from High-Z | 2-mA drive | - | 23 | 35 | ns |
| | | 4-mA drive | | 15 | 26 | ns |
| | | 8-mA drive | | 14 | 25 | ns |
| | | 8-mA drive with slew rate control | | 18 | 29 | ns |
| J12 $t_{TDO_DV}$ | TCK fall to Data Valid from Data Valid | 2-mA drive | - | 21 | 35 | ns |
| | | 4-mA drive | | 14 | 25 | ns |
| | | 8-mA drive | | 13 | 24 | ns |
| | | 8-mA drive with slew rate control | | 18 | 28 | ns |
| J13 $t_{TDO_DVZ}$ | TCK fall to High-Z from Data Valid | 2-mA drive | - | 9 | 11 | ns |
| | | 4-mA drive | | 7 | 9 | ns |
| | | 8-mA drive | | 6 | 8 | ns |
| | | 8-mA drive with slew rate control | | 7 | 9 | ns |
| J14 | $t_{TRST}$ | TRST assertion time | 100 | - | - | ns |
| J15 | $t_{TRST_SU}$ | TRST setup time to TCK rise | 10 | - | - | ns |

**Figure 20-2. JTAG Test Clock Input Timing**

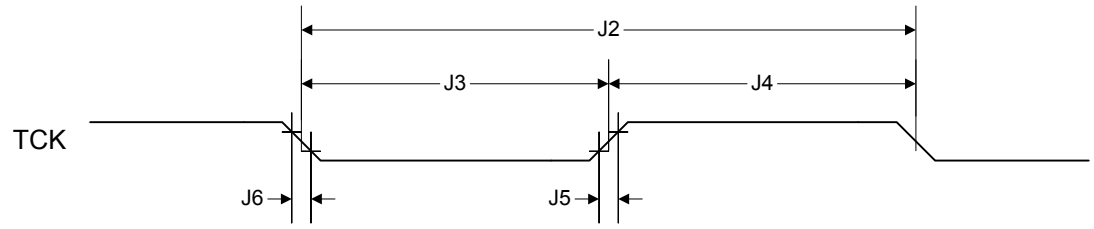



**Figure 20-3. JTAG Test Access Port (TAP) Timing**

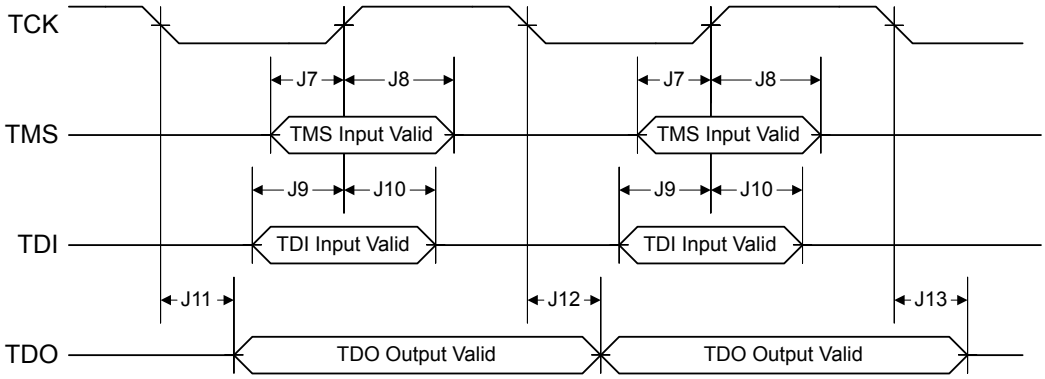
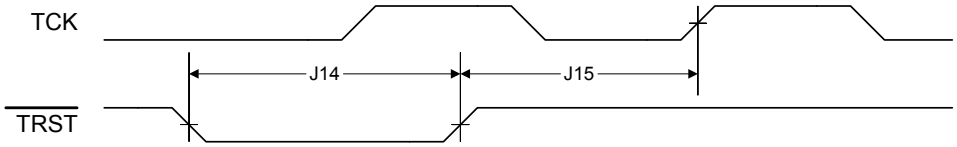



**Figure 20-4. JTAG TRST Timing**




## 20.2.4 Reset

**Table 20-13. Reset Characteristics**

| Parameter No. | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| R1 | $V_{TH}$ | Reset threshold | - | 2.0 | - | V |
| R2 | $V_{BTH}$ | Brown-Out threshold | 2.85 | 2.9 | 2.95 | V |
| R3 | $T_{POR}$ | Power-On Reset timeout | - | 10 | - | ms |
| R4 | $T_{BOR}$ | Brown-Out timeout | - | 500 | - | µs |
| R5 | $T_{IRPOR}$ | Internal reset timeout after POR | 6 | - | 11 | ms |
| R6 | $T_{IRBOR}$ | Internal reset timeout after BOR[a] | 0 | - | 1 | µs |

**Table 20-13. Reset Characteristics *(continued)***

| Parameter No. | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| R7 | $T_{IRHWR}$ | Internal reset timeout after hardware reset ($\overline{RST}$ pin) | 0 | - | 1 | ms |
| R8 | $T_{IRSWR}$ | Internal reset timeout after software-initiated system reset [a] | 2.5 | - | 20 | µs |
| R9 | $T_{IRWDR}$ | Internal reset timeout after watchdog reset[a] | 2.5 | - | 20 | µs |
| R10 | $T_{VDDRISE}$ | Supply voltage ($V_{DD}$) rise time (0V-3.3V), power on reset | - | - | 100 | ms |
| | | Supply voltage ($V_{DD}$) rise time (0V-3.3V), waking from hibernation | - | - | 250 | µs |
| R11 | $T_{MIN}$ | Minimum $\overline{RST}$ pulse width | 2 | - | - | µs |

a. 20 * $t_{MOSC_per}$

**Figure 20-5. External Reset Timing ($\overline{RST}$)**

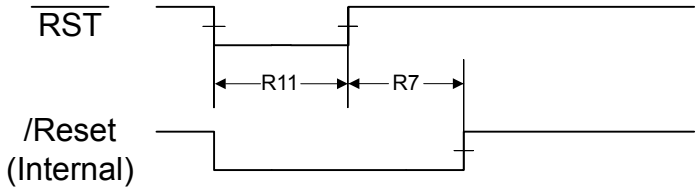



**Figure 20-6. Power-On Reset Timing**

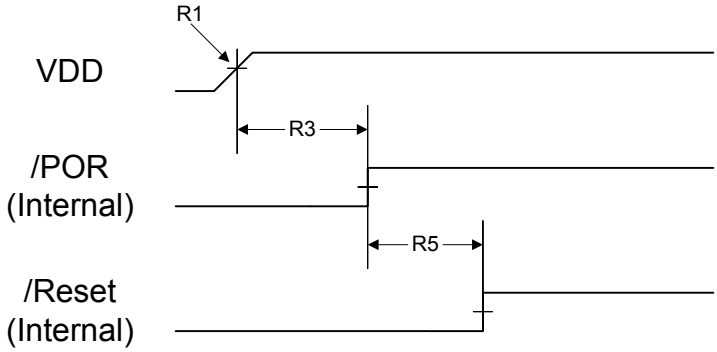



**Figure 20-7. Brown-Out Reset Timing**

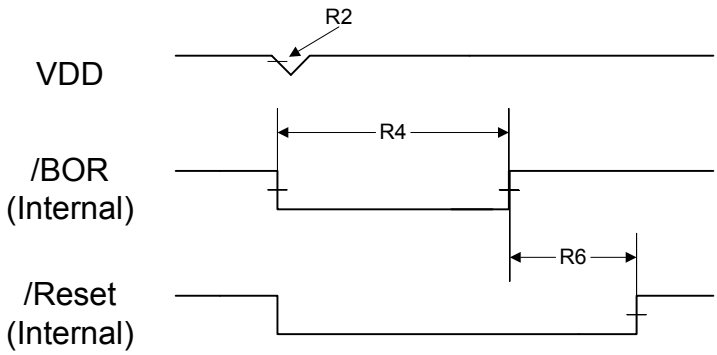


**Figure 20-8. Software Reset Timing**

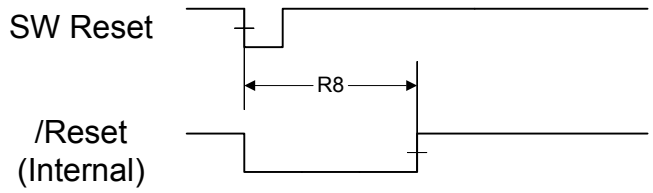
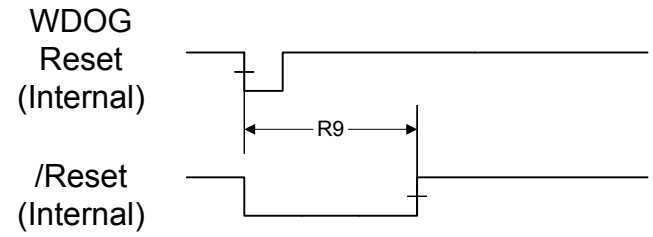



**Figure 20-9. Watchdog Reset Timing**




## 20.2.5 Sleep Modes

**Table 20-14. Sleep Modes AC Characteristics**[a]

| Parameter No | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| D1 | $t_{WAKE_S}$ | Time to wake from interrupt in sleep or deep-sleep mode, not using the PLL | - | - | 7 | system clocks |
| D2 | $t_{WAKE_PLL_S}$ | Time to wake from interrupt in sleep or deep-sleep mode when using the PLL | - | - | $T_{READY}$ | ms |

a. Values in this table assume the IOSC is the clock source during sleep or deep-sleep mode.

## 20.2.6 Hibernation Module

The Hibernation Module requires special system implementation considerations since it is intended to power-down all other sections of its host device. The system power-supply distribution and interfaces to the device must be driven to 0 $V_{DC}$ or powered down with the same external voltage regulator controlled by $\overline{HIB}$.

The external voltage regulators controlled by $\overline{HIB}$ must have a settling time of 250 µs or less.

**Table 20-15. Hibernation Module AC Characteristics**

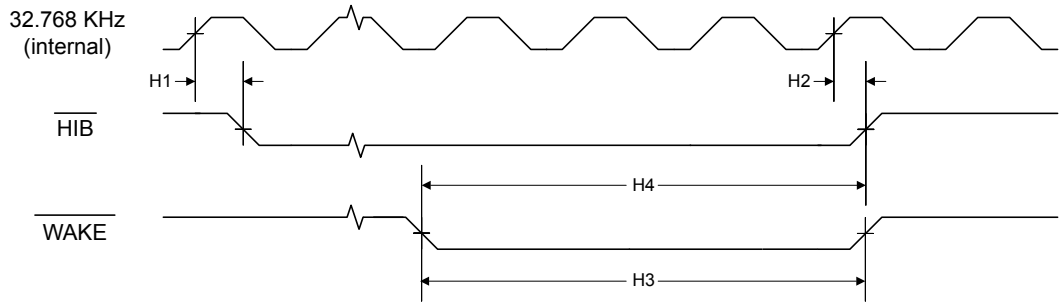
| Parameter No | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| H1 | $t_{HIB_LOW}$ | Internal 32.768 KHz clock reference rising edge to /HIB asserted | - | 200 | - | µs |
| H2 | $t_{HIB_HIGH}$ | Internal 32.768 KHz clock reference rising edge to /HIB deasserted | - | 30 | - | µs |
| H3 | $t_{WAKE_ASSERT}$ | /WAKE assertion time | 62 | - | - | µs |
| H4 | $t_{WAKETOHIB}$ | /WAKE assert to /HIB desassert | 62 | - | 124 | µs |
| H5 | $t_{XOSC_SETTLE}$ | XOSC settling time[a] | 20 | - | - | ms |
| H6 | $t_{HIB_REG_ACCESS}$ | Access time to or from a non-volatile register in HIB module to complete | 92 | - | - | µs |

**Table 20-15. Hibernation Module AC Characteristics *(continued)***

| Parameter No | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| H7 | $t_{HIB_TO_VDD}$ | HIB deassert to VDD and VDD25 at minimum operational level | - | - | 250 | µs |

a. This parameter is highly sensitive to PCB layout and trace lengths, which may make this parameter time longer. Care must be taken in PCB design to minimize trace lengths and RLC (resistance, inductance, capacitance).

**Figure 20-10. Hibernation Module Timing**




## 20.2.7 General-Purpose I/O (GPIO)

**Note:** All GPIOs are 5 V-tolerant.

**Table 20-16. GPIO Characteristics**

| Parameter | Parameter Name | Condition | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| $t_{GPIOR}$ | GPIO Rise Time (from 20% to 80% of $V_{DD}$) | 2-mA drive | - | 17 | 26 | ns |
| | | 4-mA drive | | 9 | 13 | ns |
| | | 8-mA drive | | 6 | 9 | ns |
| | | 8-mA drive with slew rate control | | 10 | 12 | ns |
| $t_{GPIOF}$ | GPIO Fall Time (from 80% to 20% of $V_{DD}$) | 2-mA drive | - | 17 | 25 | ns |
| | | 4-mA drive | | 8 | 12 | ns |
| | | 8-mA drive | | 6 | 10 | ns |
| | | 8-mA drive with slew rate control | | 11 | 13 | ns |

## 20.2.8 Synchronous Serial Interface (SSI)

**Table 20-17. SSI Characteristics**

| Parameter No. | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| S1 | $t_{clk_per}$ | SSIClk cycle time | 2 | - | 65024 | system clocks |
| S2 | $t_{clk_high}$ | SSIClk high time | - | 0.5 | - | t clk_per |
| S3 | $t_{clk_low}$ | SSIClk low time | - | 0.5 | - | t clk_per |
| S4 | $t_{clkrf}$ | SSIClk rise/fall time[a] | - | 6 | 10 | ns |
| S5 | $t_{DMd}$ | Data from master valid delay time | 0 | - | 1 | system clocks |
| S6 | $t_{DMs}$ | Data from master setup time | 1 | - | - | system clocks |
| S7 | $t_{DMh}$ | Data from master hold time | 2 | - | - | system clocks |
| S8 | $t_{DSs}$ | Data from slave setup time | 1 | - | - | system clocks |

**Table 20-17. SSI Characteristics *(continued)***

| Parameter No. | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| S9 | $t_{DSh}$ | Data from slave hold time | 2 | - | - | system clocks |

a. Note that the delays shown are using 8-mA drive strength.

**Figure 20-11. SSI Timing for TI Frame Format (FRF=01), Single Transfer Timing Measurement**

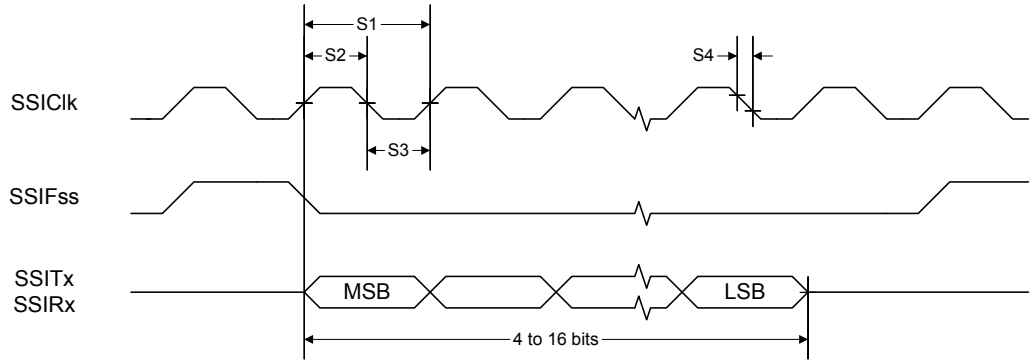



**Figure 20-12. SSI Timing for MICROWIRE Frame Format (FRF=10), Single Transfer**

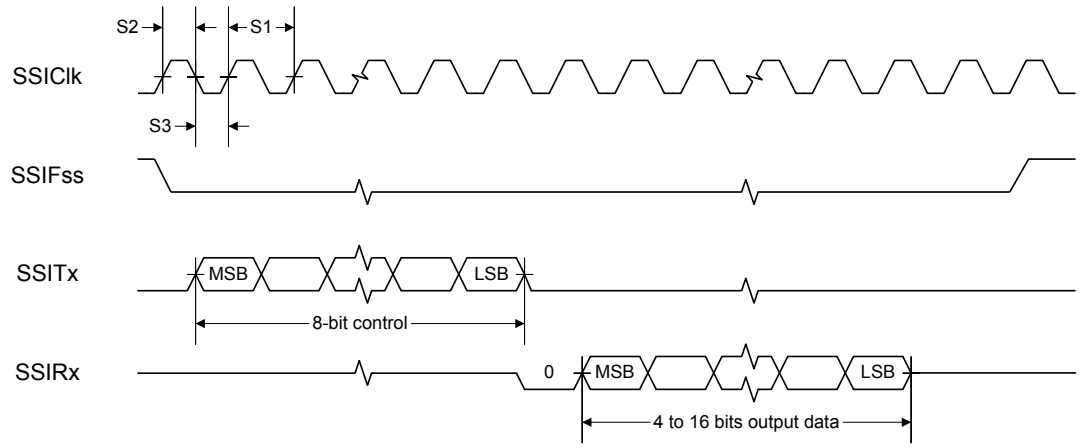
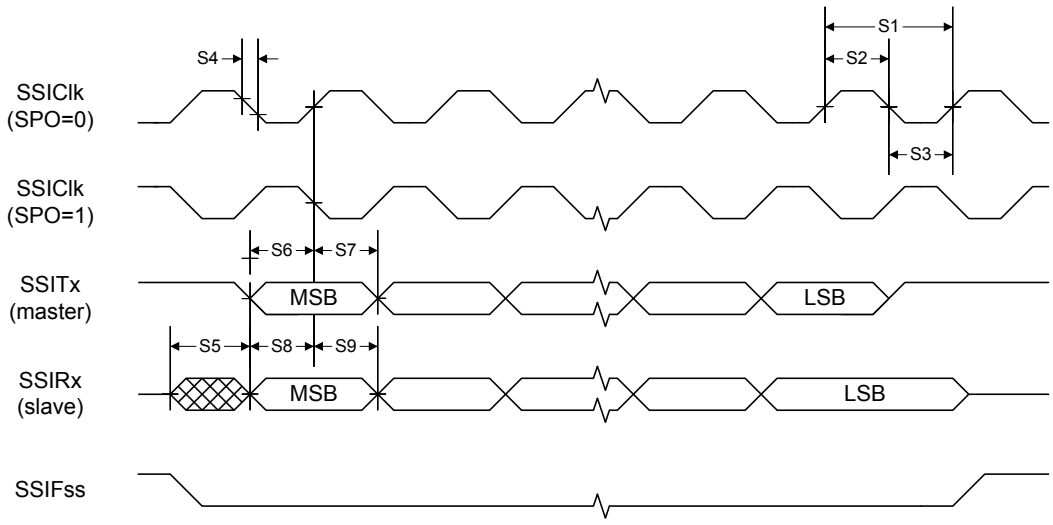


**Figure 20-13. SSI Timing for SPI Frame Format (FRF=00), with SPH=1**




## 20.2.9 Inter-Integrated Circuit ($I^2C$) Interface

**Table 20-18. $I^2C$ Characteristics**

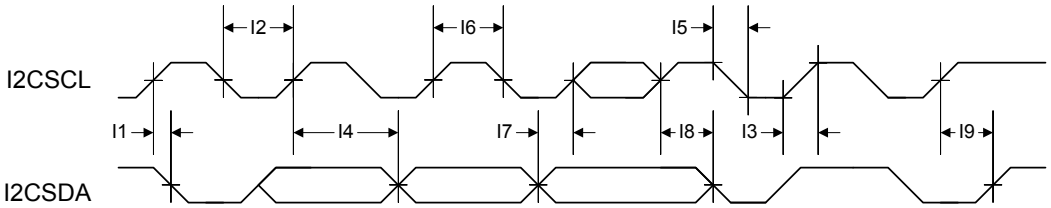
| Parameter No. | Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|---|
| I1[a] | $t_{SCH}$ | Start condition hold time | 36 | - | - | system clocks |
| I2[a] | $t_{LP}$ | Clock Low period | 36 | - | - | system clocks |
| I3[b] | $t_{SRT}$ | I2CSCL/I2CSDA rise time ($V_{IL}$ =0.5 V to $V_{IH}$ =2.4 V) | - | - | (see note b) | ns |
| I4[a] | $t_{DH}$ | Data hold time | 2 | - | - | system clocks |
| I5[c] | $t_{SFT}$ | I2CSCL/I2CSDA fall time ($V_{IH}$ =2.4 V to $V_{IL}$ =0.5 V) | - | 9 | 10 | ns |
| I6[a] | $t_{HT}$ | Clock High time | 24 | - | - | system clocks |
| I7[a] | $t_{DS}$ | Data setup time | 18 | - | - | system clocks |
| I8[a] | $t_{SCSR}$ | Start condition setup time (for repeated start condition only) | 36 | - | - | system clocks |
| I9[a] | $t_{SCS}$ | Stop condition setup time | 24 | - | - | system clocks |

a. Values depend on the value programmed into the TPR bit in the **$I^2C$ Master Timer Period (I2CMTPR)** register; a TPR programmed for the maximum I2CSCL frequency (TPR=0x2) results in a minimum output timing as shown in the table above. The $I^2C$ interface is designed to scale the actual data transition time to move it to the middle of the I2CSCL Low period. The actual position is affected by the value programmed into the TPR; however, the numbers given in the above values are minimum values.

b. Because I2CSCL and I2CSDA are open-drain-type outputs, which the controller can only actively drive Low, the time I2CSCL or I2CSDA takes to reach a high level depends on external signal capacitance and pull-up resistor values.

c. Specified at a nominal 50 pF load.

**Figure 20-14. I²C Timing**




## 20.2.10 Analog Comparator

**Table 20-19. Analog Comparator Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $V_{OS}$ | Input offset voltage | - | ±10 | ±25 | mV |
| $V_{CM}$ | Input common mode voltage range | 0 | - | $V_{DD}$-1.5 | V |
| $C_{MRR}$ | Common mode rejection ratio | 50 | - | - | dB |
| $T_{RT}$ | Response time | - | - | 1 | µs |
| $T_{MC}$ | Comparator mode change to Output Valid | - | - | 10 | µs |

**Table 20-20. Analog Comparator Voltage Reference Characteristics**

| Parameter | Parameter Name | Min | Nom | Max | Unit |
|---|---|---|---|---|---|
| $R_{HR}$ | Resolution high range | - | $V_{DD}$/31 | - | LSB |
| $R_{LR}$ | Resolution low range | - | $V_{DD}$/23 | - | LSB |
| $A_{HR}$ | Absolute accuracy high range | - | - | ±1/2 | LSB |
| $A_{LR}$ | Absolute accuracy low range | - | - | ±1/4 | LSB |

# A Serial Flash Loader

## A.1 Serial Flash Loader

The Stellaris® serial flash loader is a preprogrammed flash-resident utility used to download code to the flash memory of a device without the use of a debug interface. The serial flash loader uses a simple packet interface to provide synchronous communication with the device. The flash loader runs off the crystal and does not enable the PLL, so its speed is determined by the crystal used. The two serial interfaces that can be used are the UART0 and SSI0 interfaces. For simplicity, both the data format and communication protocol are identical for both serial interfaces.

## A.2 Interfaces

Once communication with the flash loader is established via one of the serial interfaces, that interface is used until the flash loader is reset or new code takes over. For example, once you start communicating using the SSI port, communications with the flash loader via the UART are disabled until the device is reset.

### A.2.1 UART

The Universal Asynchronous Receivers/Transmitters (UART) communication uses a fixed serial format of 8 bits of data, no parity, and 1 stop bit. The baud rate used for communication is automatically detected by the flash loader and can be any valid baud rate supported by the host and the device. The auto detection sequence requires that the baud rate should be no more than 1/32 the crystal frequency of the board that is running the serial flash loader. This is actually the same as the hardware limitation for the maximum baud rate for any UART on a Stellaris device which is calculated as follows:

```
Max Baud Rate = System Clock Frequency / 16
```

In order to determine the baud rate, the serial flash loader needs to determine the relationship between its own crystal frequency and the baud rate. This is enough information for the flash loader to configure its UART to the same baud rate as the host. This automatic baud-rate detection allows the host to use any valid baud rate that it wants to communicate with the device.

The method used to perform this automatic synchronization relies on the host sending the flash loader two bytes that are both 0x55. This generates a series of pulses to the flash loader that it can use to calculate the ratios needed to program the UART to match the host's baud rate. After the host sends the pattern, it attempts to read back one byte of data from the UART. The flash loader returns the value of 0xCC to indicate successful detection of the baud rate. If this byte is not received after at least twice the time required to transfer the two bytes, the host can resend another pattern of 0x55, 0x55, and wait for the 0xCC byte again until the flash loader acknowledges that it has received a synchronization pattern correctly. For example, the time to wait for data back from the flash loader should be calculated as at least 2*(20(bits/sync)/baud rate (bits/sec)). For a baud rate of 115200, this time is 2*(20/115200) or 0.35 ms.

### A.2.2 SSI

The Synchronous Serial Interface (SSI) port also uses a fixed serial format for communications, with the framing defined as Motorola format with SPH set to 1 and SPO set to 1. See "Frame Formats" on page 435 in the SSI chapter for more information on formats for this transfer protocol. Like the UART, this interface has hardware requirements that limit the maximum speed that the SSI clock can run. This allows the SSI clock to be at most 1/12 the crystal frequency of the board running

the flash loader. Since the host device is the master, the SSI on the flash loader device does not need to determine the clock as it is provided directly by the host.

## A.3 Packet Handling

All communications, with the exception of the UART auto-baud, are done via defined packets that are acknowledged (ACK) or not acknowledged (NAK) by the devices. The packets use the same format for receiving and sending packets, including the method used to acknowledge successful or unsuccessful reception of a packet.

### A.3.1 Packet Format

All packets sent and received from the device use the following byte-packed format.

```
struct
{
 unsigned char ucSize;
 unsigned char ucCheckSum;
 unsigned char Data[];
};
```

| | |
|---|---|
| ucSize | The first byte received holds the total size of the transfer including the size and checksum bytes. |
| ucChecksum | This holds a simple checksum of the bytes in the data buffer only. The algorithm is Data[0]+Data[1]+…+ Data[`ucSize`-3]. |
| Data | This is the raw data intended for the device, which is formatted in some form of command interface. There should be `ucSize`–2 bytes of data provided in this buffer to or from the device. |

### A.3.2 Sending Packets

The actual bytes of the packet can be sent individually or all at once; the only limitation is that commands that cause flash memory access should limit the download sizes to prevent losing bytes during flash programming. This limitation is discussed further in the section that describes the serial flash loader command, COMMAND_SEND_DATA (see “COMMAND_SEND_DATA (0x24)” on page 625).

Once the packet has been formatted correctly by the host, it should be sent out over the UART or SSI interface. Then the host should poll the UART or SSI interface for the first non-zero data returned from the device. The first non-zero byte will either be an ACK (0xCC) or a NAK (0x33) byte from the device indicating the packet was received successfully (ACK) or unsuccessfully (NAK). This does not indicate that the actual contents of the command issued in the data portion of the packet were valid, just that the packet was received correctly.

### A.3.3 Receiving Packets

The flash loader sends a packet of data in the same format that it receives a packet. The flash loader may transfer leading zero data before the first actual byte of data is sent out. The first non-zero byte is the size of the packet followed by a checksum byte, and finally followed by the data itself. There is no break in the data after the first non-zero byte is sent from the flash loader. Once the device communicating with the flash loader receives all the bytes, it must either ACK or NAK the packet to indicate that the transmission was successful. The appropriate response after sending a NAK to the flash loader is to resend the command that failed and request the data again. If needed, the host may send leading zeros before sending down the ACK/NAK signal to the flash loader, as the

flash loader only accepts the first non-zero data as a valid response. This zero padding is needed by the SSI interface in order to receive data to or from the flash loader.

## A.4 Commands

The next section defines the list of commands that can be sent to the flash loader. The first byte of the data should always be one of the defined commands, followed by data or parameters as determined by the command that is sent.

### A.4.1 COMMAND_PING (0X20)

This command simply accepts the command and sets the global status to success. The format of the packet is as follows:

```
Byte[0] = 0x03;
Byte[1] = checksum(Byte[2]);
Byte[2] = COMMAND_PING;
```

The ping command has 3 bytes and the value for COMMAND_PING is 0x20 and the checksum of one byte is that same byte, making Byte[1] also 0x20. Since the ping command has no real return status, the receipt of an ACK can be interpreted as a successful ping to the flash loader.

### A.4.2 COMMAND_GET_STATUS (0x23)

This command returns the status of the last command that was issued. Typically, this command should be sent after every command to ensure that the previous command was successful or to properly respond to a failure. The command requires one byte in the data of the packet and should be followed by reading a packet with one byte of data that contains a status code. The last step is to ACK or NAK the received data so the flash loader knows that the data has been read.

```
Byte[0] = 0x03
Byte[1] = checksum(Byte[2])
Byte[2] = COMMAND_GET_STATUS
```

### A.4.3 COMMAND_DOWNLOAD (0x21)

This command is sent to the flash loader to indicate where to store data and how many bytes will be sent by the COMMAND_SEND_DATA commands that follow. The command consists of two 32-bit values that are both transferred MSB first. The first 32-bit value is the address to start programming data into, while the second is the 32-bit size of the data that will be sent. This command also triggers an erase of the full area to be programmed so this command takes longer than other commands. This results in a longer time to receive the ACK/NAK back from the board. This command should be followed by a COMMAND_GET_STATUS to ensure that the Program Address and Program size are valid for the device running the flash loader.

The format of the packet to send this command is a follows:

```
Byte[0] = 11
Byte[1] = checksum(Bytes[2:10])
Byte[2] = COMMAND_DOWNLOAD
Byte[3] = Program Address [31:24]
Byte[4] = Program Address [23:16]
Byte[5] = Program Address [15:8]
Byte[6] = Program Address [7:0]
Byte[7] = Program Size [31:24]
```

```
Byte[8] = Program Size [23:16]
Byte[9] = Program Size [15:8]
Byte[10] = Program Size [7:0]
```

### A.4.4 COMMAND_SEND_DATA (0x24)

This command should only follow a COMMAND_DOWNLOAD command or another COMMAND_SEND_DATA command if more data is needed. Consecutive send data commands automatically increment address and continue programming from the previous location. The caller should limit transfers of data to a maximum 8 bytes of packet data to allow the flash to program successfully and not overflow input buffers of the serial interfaces. The command terminates programming once the number of bytes indicated by the COMMAND_DOWNLOAD command has been received. Each time this function is called it should be followed by a COMMAND_GET_STATUS to ensure that the data was successfully programmed into the flash. If the flash loader sends a NAK to this command, the flash loader does not increment the current address to allow retransmission of the previous data.

```
Byte[0] = 11
Byte[1] = checksum(Bytes[2:10])
Byte[2] = COMMAND_SEND_DATA
Byte[3] = Data[0]
Byte[4] = Data[1]
Byte[5] = Data[2]
Byte[6] = Data[3]
Byte[7] = Data[4]
Byte[8] = Data[5]
Byte[9] = Data[6]
Byte[10] = Data[7]
```

### A.4.5 COMMAND_RUN (0x22)

This command is used to tell the flash loader to execute from the address passed as the parameter in this command. This command consists of a single 32-bit value that is interpreted as the address to execute. The 32-bit value is transmitted MSB first and the flash loader responds with an ACK signal back to the host device before actually executing the code at the given address. This allows the host to know that the command was received successfully and the code is now running.

```
Byte[0] = 7
Byte[1] = checksum(Bytes[2:6])
Byte[2] = COMMAND_RUN
Byte[3] = Execute Address[31:24]
Byte[4] = Execute Address[23:16]
Byte[5] = Execute Address[15:8]
Byte[6] = Execute Address[7:0]
```

### A.4.6 COMMAND_RESET (0x25)

This command is used to tell the flash loader device to reset. This is useful when downloading a new image that overwrote the flash loader and wants to start from a full reset. Unlike the COMMAND_RUN command, this allows the initial stack pointer to be read by the hardware and set up for the new code. It can also be used to reset the flash loader if a critical error occurs and the host device wants to restart communication with the flash loader.

```
Byte[0] = 3
Byte[1] = checksum(Byte[2])
Byte[2] = COMMAND_RESET
```

The flash loader responds with an ACK signal back to the host device before actually executing the software reset to the device running the flash loader. This allows the host to know that the command was received successfully and the part will be reset.

# B Register Quick Reference

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **The Cortex-M3 Processor** | | | | | | | | | | | | | | | |
| **R0, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R1, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R2, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R3, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R4, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R5, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R6, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R7, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R8, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R9, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R10, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R11, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **R12, type R/W, , reset -** (see page 54) | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **SP, type R/W, , reset -** (see page 55) | | | | | | | | | | | | | | | |
| SP | | | | | | | | | | | | | | | |
| SP | | | | | | | | | | | | | | | |
| **LR, type R/W, , reset 0xFFFF.FFFF** (see page 56) | | | | | | | | | | | | | | | |
| LINK | | | | | | | | | | | | | | | |
| LINK | | | | | | | | | | | | | | | |
| **PC, type R/W, , reset -** (see page 57) | | | | | | | | | | | | | | | |
| PC | | | | | | | | | | | | | | | |
| PC | | | | | | | | | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **PSR, type R/W, , reset 0x0100.0000** (see page 58) | | | | | | | | | | | | | | | |
| N | Z | C | V | Q | ICI / IT | | THUMB | | | | | | | | |
| ICI / IT | | | | | | | | | | ISRNUM | | | | | |
| **PRIMASK, type R/W, , reset 0x0000.0000** (see page 62) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | PRIMASK |
| **FAULTMASK, type R/W, , reset 0x0000.0000** (see page 63) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | FAULTMASK |
| **BASEPRI, type R/W, , reset 0x0000.0000** (see page 64) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | BASEPRI | | | | | | | |
| **CONTROL, type R/W, , reset 0x0000.0000** (see page 65) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | ASP | TMPL |

**Cortex-M3 Peripherals**

**System Timer (SysTick) Registers**

Base 0xE000.E000

| **STCTRL, type R/W, offset 0x010, reset 0x0000.0000** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | COUNT |
| | | | | | | | | | | | | | CLK_SRC | INTEN | ENABLE |
| **STRELOAD, type R/W, offset 0x014, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | RELOAD | | | | | | | |
| RELOAD | | | | | | | | | | | | | | | |
| **STCURRENT, type R/WC, offset 0x018, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | CURRENT | | | | | | | |
| CURRENT | | | | | | | | | | | | | | | |

**Cortex-M3 Peripherals**

**Nested Vectored Interrupt Controller (NVIC) Registers**

Base 0xE000.E000

| **EN0, type R/W, offset 0x100, reset 0x0000.0000** |
|---|
| INT |
| INT |
| **EN1, type R/W, offset 0x104, reset 0x0000.0000** |
| |
| INT |
| **DIS0, type R/W, offset 0x180, reset 0x0000.0000** |
| INT |
| INT |
| **DIS1, type R/W, offset 0x184, reset 0x0000.0000** |
| |
| INT |
| **PEND0, type R/W, offset 0x200, reset 0x0000.0000** |
| INT |
| INT |
| **PEND1, type R/W, offset 0x204, reset 0x0000.0000** |
| |
| INT |
| **UNPEND0, type R/W, offset 0x280, reset 0x0000.0000** |
| INT |
| INT |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **UNPEND1, type R/W, offset 0x284, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | INT | | | | | | | | | | | |
| **ACTIVE0, type RO, offset 0x300, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INT | | | | | | | | | | | | | | | |
| INT | | | | | | | | | | | | | | | |
| **ACTIVE1, type RO, offset 0x304, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | INT | | | | | | | | | | | |
| **PRI0, type R/W, offset 0x400, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI1, type R/W, offset 0x404, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI2, type R/W, offset 0x408, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI3, type R/W, offset 0x40C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI4, type R/W, offset 0x410, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI5, type R/W, offset 0x414, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI6, type R/W, offset 0x418, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI7, type R/W, offset 0x41C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI8, type R/W, offset 0x420, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI9, type R/W, offset 0x424, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **PRI10, type R/W, offset 0x428, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| INTD | | | | | | | | INTC | | | | | | | |
| INTB | | | | | | | | INTA | | | | | | | |
| **SWTRIG, type WO, offset 0xF00, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | INTID | | | | | |

**Cortex-M3 Peripherals**

**System Control Block (SCB) Registers**

Base 0xE000.E000

| **CPUID, type RO, offset 0xD00, reset 0x411F.C231** | | |
|---|---|---|
| IMP | VAR | CON |
| PARTNO | | REV |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **INTCTRL, type R/W, offset 0xD04, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| NMISET | | | PENDSV | UNPENDSV | PENDSTSET | PENDSTCLR | | ISRPRE | ISRPEND | | | | | VECPEND | |
| VECPEND | | | | RETBASE | | | | | | VECACT | | | | | |
| **VTABLE, type R/W, offset 0xD08, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | BASE | OFFSET | | | | | | | | | | | | |
| OFFSET | | | | | | | | | | | | | | | |
| **APINT, type R/W, offset 0xD0C, reset 0xFA05.0000** | | | | | | | | | | | | | | | |
| VECTKEY | | | | | | | | | | | | | | | |
| ENDIANESS | | | | | PRIGROUP | | | | | | | | SYSRESREQ | VECTCLRACT | VECTRESET |
| **SYSCTRL, type R/W, offset 0xD10, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | SEVONPEND | | SLEEPDEEP | SLEEPEXIT | |
| **CFGCTRL, type R/W, offset 0xD14, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | STKALIGN | BFHFNMIGN | | | | DIV0 | UNALIGNED | | MAINPEND | BASETHR |
| **SYSPRI1, type R/W, offset 0xD18, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | USAGE | | | | | | | |
| BUS | | | | | | | | MEM | | | | | | | |
| **SYSPRI2, type R/W, offset 0xD1C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| SVC | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **SYSPRI3, type R/W, offset 0xD20, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| TICK | | | | | | | | PENDSV | | | | | | | |
| | | | | | | | | DEBUG | | | | | | | |
| **SYSHNDCTRL, type R/W, offset 0xD24, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | USAGE | BUS | MEM |
| SVC | BUSP | MEMP | USAGEP | TICK | PNDSV | | MON | SVCA | | | | USGA | | BUSA | MEMA |
| **FAULTSTAT, type R/W1C, offset 0xD28, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | DIV0 | UNALIGN | | | | | NOCP | INVPC | INVSTAT | UNDEF |
| BFARV | | | BSTKE | BUSTKE | IMPRE | PRECISE | IBUS | MMARV | | | MSTKE | MUSTKE | | DERR | IERR |
| **HFAULTSTAT, type R/W1C, offset 0xD2C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| DBG | FORCED | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | VECT | |
| **MMADDR, type R/W, offset 0xD34, reset -** | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| **FAULTADDR, type R/W, offset 0xD38, reset -** | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |

## Cortex-M3 Peripherals

### Memory Protection Unit (MPU) Registers

Base 0xE000.E000

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MPUTYPE, type RO, offset 0xD90, reset 0x0000.0800** | | | | | | | | | | | | | | | |
| | | | | | | | | IREGION | | | | | | | |
| DREGION | | | | | | | | | | | | | | | SEPARATE |
| **MPUCTRL, type R/W, offset 0xD94, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | PRIVDEFEN | HFNMIENA | ENABLE |
| **MPUNUMBER, type R/W, offset 0xD98, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | NUMBER | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **MPUBASE, type R/W, offset 0xD9C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | VALID | | REGION | | |
| **MPUBASE1, type R/W, offset 0xDA4, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | VALID | | REGION | | |
| **MPUBASE2, type R/W, offset 0xDAC, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | VALID | | REGION | | |
| **MPUBASE3, type R/W, offset 0xDB4, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | | | | | |
| ADDR | | | | | | | | | | | VALID | | REGION | | |
| **MPUATTR, type R/W, offset 0xDA0, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | XN | | AP | | | | | TEX | | | S | C | B |
| SRD | | | | | | | | | | SIZE | | | | | ENABLE |
| **MPUATTR1, type R/W, offset 0xDA8, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | XN | | AP | | | | | TEX | | | S | C | B |
| SRD | | | | | | | | | | SIZE | | | | | ENABLE |
| **MPUATTR2, type R/W, offset 0xDB0, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | XN | | AP | | | | | TEX | | | S | C | B |
| SRD | | | | | | | | | | SIZE | | | | | ENABLE |
| **MPUATTR3, type R/W, offset 0xDB8, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | XN | | AP | | | | | TEX | | | S | C | B |
| SRD | | | | | | | | | | SIZE | | | | | ENABLE |

## System Control

Base 0x400F.E000

| **DID0, type RO, offset 0x000, reset -** (see page 181) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | VER | | | | | | | CLASS | | | | | | | |
| MAJOR | | | | | | | | MINOR | | | | | | | |
| **PBORCTL, type R/W, offset 0x030, reset 0x0000.7FFD** (see page 183) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | BORIOR | |
| **LDOPCTL, type R/W, offset 0x034, reset 0x0000.0000** (see page 184) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | VADJ | | | | | |
| **RIS, type RO, offset 0x050, reset 0x0000.0000** (see page 185) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | PLLLRIS | | | | | BORRIS | |
| **IMC, type R/W, offset 0x054, reset 0x0000.0000** (see page 186) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | PLLLIM | | | | | BORIM | |
| **MISC, type R/W1C, offset 0x058, reset 0x0000.0000** (see page 187) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | PLLLMIS | | | | | BORMIS | |
| **RESC, type R/W, offset 0x05C, reset -** (see page 188) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | SW | WDT | BOR | POR | EXT |
| **RCC, type R/W, offset 0x060, reset 0x078E.3AD1** (see page 189) | | | | | | | | | | | | | | | |
| | | | | ACG | | SYSDIV | | | USESYSDIV | | USEPWMDIV | | PWMDIV | | |
| | | PWRDN | | BYPASS | | XTAL | | | | OSCSRC | | | | IOSCDIS | MOSCDIS |
| **PLLCFG, type RO, offset 0x064, reset -** (see page 193) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | F | | | | | | | | | R | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **RCC2, type R/W, offset 0x070, reset 0x0780.2810** (see page 194) | | | | | | | | | | | | | | | |
| USERCC2 | | | SYSDIV2 | | | | | | | | | | | | |
| | | PWRDN2 | | BYPASS2 | | | | | OSCSRC2 | | | | | | |
| **DSLPCLKCFG, type R/W, offset 0x144, reset 0x0780.0000** (see page 196) | | | | | | | | | | | | | | | |
| | | | DSDIVORIDE | | | | | | | | | | | | |
| | | | | | | | | | DSOSCSRC | | | | | | |
| **DID1, type RO, offset 0x004, reset -** (see page 197) | | | | | | | | | | | | | | | |
| VER | | | | FAM | | | | PARTNO | | | | | | | |
| PINCOUNT | | | | | | | | TEMP | | | PKG | | ROHS | QUAL | |
| **DC0, type RO, offset 0x008, reset 0x00FF.007F** (see page 199) | | | | | | | | | | | | | | | |
| SRAMSZ | | | | | | | | | | | | | | | |
| FLASHSZ | | | | | | | | | | | | | | | |
| **DC1, type RO, offset 0x010, reset 0x0010.30DF** (see page 200) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | PWM | | | | |
| MINSYSDIV | | | | | | | | MPU | HIB | | PLL | WDT | SWO | SWD | JTAG |
| **DC2, type RO, offset 0x014, reset 0x070F.5337** (see page 202) | | | | | | | | | | | | | | | |
| | | | | | COMP2 | COMP1 | COMP0 | | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| | I2C1 | | I2C0 | | | QEI1 | QEI0 | | | SSI1 | SSI0 | | UART2 | UART1 | UART0 |
| **DC3, type RO, offset 0x018, reset 0xBF00.FFFF** (see page 204) | | | | | | | | | | | | | | | |
| 32KHZ | | CCP5 | CCP4 | CCP3 | CCP2 | CCP1 | CCP0 | | | | | | | | |
| PWMFAULT | C2O | C2PLUS | C2MINUS | C1O | C1PLUS | C1MINUS | C0O | C0PLUS | C0MINUS | PWM5 | PWM4 | PWM3 | PWM2 | PWM1 | PWM0 |
| **DC4, type RO, offset 0x01C, reset 0x0000.C0FF** (see page 206) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CCP7 | CCP6 | | | | | | | GPIOH | GPIOG | GPIOF | GPIOE | GPIOD | GPIOC | GPIOB | GPIOA |
| **RCGC0, type R/W, offset 0x100, reset 0x00000040** (see page 208) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | PWM | | | | |
| | | | | | | | | | HIB | | | WDT | | | |
| **SCGC0, type R/W, offset 0x110, reset 0x00000040** (see page 210) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | PWM | | | | |
| | | | | | | | | | HIB | | | WDT | | | |
| **DCGC0, type R/W, offset 0x120, reset 0x00000040** (see page 212) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | PWM | | | | |
| | | | | | | | | | HIB | | | WDT | | | |
| **RCGC1, type R/W, offset 0x104, reset 0x00000000** (see page 214) | | | | | | | | | | | | | | | |
| | | | | | COMP2 | COMP1 | COMP0 | | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| | I2C1 | | I2C0 | | | QEI1 | QEI0 | | | SSI1 | SSI0 | | UART2 | UART1 | UART0 |
| **SCGC1, type R/W, offset 0x114, reset 0x00000000** (see page 217) | | | | | | | | | | | | | | | |
| | | | | | COMP2 | COMP1 | COMP0 | | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| | I2C1 | | I2C0 | | | QEI1 | QEI0 | | | SSI1 | SSI0 | | UART2 | UART1 | UART0 |
| **DCGC1, type R/W, offset 0x124, reset 0x00000000** (see page 220) | | | | | | | | | | | | | | | |
| | | | | | COMP2 | COMP1 | COMP0 | | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| | I2C1 | | I2C0 | | | QEI1 | QEI0 | | | SSI1 | SSI0 | | UART2 | UART1 | UART0 |
| **RCGC2, type R/W, offset 0x108, reset 0x00000000** (see page 223) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | GPIOH | GPIOG | GPIOF | GPIOE | GPIOD | GPIOC | GPIOB | GPIOA |
| **SCGC2, type R/W, offset 0x118, reset 0x00000000** (see page 225) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | GPIOH | GPIOG | GPIOF | GPIOE | GPIOD | GPIOC | GPIOB | GPIOA |
| **DCGC2, type R/W, offset 0x128, reset 0x00000000** (see page 227) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | GPIOH | GPIOG | GPIOF | GPIOE | GPIOD | GPIOC | GPIOB | GPIOA |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **SRCR0, type R/W, offset 0x040, reset 0x00000000** (see page 229) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | PWM | | | | |
| | | | | | | | | | HIB | | | WDT | | | |
| **SRCR1, type R/W, offset 0x044, reset 0x00000000** (see page 230) | | | | | | | | | | | | | | | |
| | | | | | COMP2 | COMP1 | COMP0 | | | | | TIMER3 | TIMER2 | TIMER1 | TIMER0 |
| | I2C1 | | I2C0 | | | QEI1 | QEI0 | | | SSI1 | SSI0 | | UART2 | UART1 | UART0 |
| **SRCR2, type R/W, offset 0x048, reset 0x00000000** (see page 232) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | GPIOH | GPIOG | GPIOF | GPIOE | GPIOD | GPIOC | GPIOB | GPIOA |
| **Hibernation Module**<br>Base 0x400F.C000 | | | | | | | | | | | | | | | |
| **HIBRTCC, type RO, offset 0x000, reset 0x0000.0000** (see page 242) | | | | | | | | | | | | | | | |
| RTCC | | | | | | | | | | | | | | | |
| RTCC | | | | | | | | | | | | | | | |
| **HIBRTCM0, type R/W, offset 0x004, reset 0xFFFF.FFFF** (see page 243) | | | | | | | | | | | | | | | |
| RTCM0 | | | | | | | | | | | | | | | |
| RTCM0 | | | | | | | | | | | | | | | |
| **HIBRTCM1, type R/W, offset 0x008, reset 0xFFFF.FFFF** (see page 244) | | | | | | | | | | | | | | | |
| RTCM1 | | | | | | | | | | | | | | | |
| RTCM1 | | | | | | | | | | | | | | | |
| **HIBRTCLD, type R/W, offset 0x00C, reset 0xFFFF.FFFF** (see page 245) | | | | | | | | | | | | | | | |
| RTCLD | | | | | | | | | | | | | | | |
| RTCLD | | | | | | | | | | | | | | | |
| **HIBCTL, type R/W, offset 0x010, reset 0x8000.0000** (see page 246) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | VABORT | CLK32EN | LOWBATEN | PINWEN | RTCWEN | CLKSEL | HIBREQ | RTCEN |
| **HIBIM, type R/W, offset 0x014, reset 0x0000.0000** (see page 248) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | EXTW | LOWBAT | RTCALT1 | RTCALT0 |
| **HIBRIS, type RO, offset 0x018, reset 0x0000.0000** (see page 249) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | EXTW | LOWBAT | RTCALT1 | RTCALT0 |
| **HIBMIS, type RO, offset 0x01C, reset 0x0000.0000** (see page 250) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | EXTW | LOWBAT | RTCALT1 | RTCALT0 |
| **HIBIC, type R/W1C, offset 0x020, reset 0x0000.0000** (see page 251) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | EXTW | LOWBAT | RTCALT1 | RTCALT0 |
| **HIBRTCT, type R/W, offset 0x024, reset 0x0000.7FFF** (see page 252) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| TRIM | | | | | | | | | | | | | | | |
| **HIBDATA, type R/W, offset 0x030-0x12C, reset -** (see page 253) | | | | | | | | | | | | | | | |
| RTD | | | | | | | | | | | | | | | |
| RTD | | | | | | | | | | | | | | | |
| **Internal Memory**<br>**Flash Memory Control Registers (Flash Control Offset)**<br>Base 0x400F.D000 | | | | | | | | | | | | | | | |
| **FMA, type R/W, offset 0x000, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | OFFSET |
| OFFSET | | | | | | | | | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **FMD, type R/W, offset 0x004, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **FMC, type R/W, offset 0x008, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| WRKEY | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | COMT | MERASE | ERASE | WRITE |
| **FCRIS, type RO, offset 0x00C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | PRIS | ARIS |
| **FCIM, type R/W, offset 0x010, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | PMASK | AMASK |
| **FCMISC, type R/W1C, offset 0x014, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | PMISC | AMISC |
| **Internal Memory**<br>**Flash Memory Protection Registers (System Control Offset)**<br>Base 0x400F.E000 | | | | | | | | | | | | | | | |
| **USECRL, type R/W, offset 0x140, reset 0x31** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | USEC | | | | | | | |
| **FMPRE0, type R/W, offset 0x130 and 0x200, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| **FMPPE0, type R/W, offset 0x134 and 0x400, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |
| **USER_DBG, type R/W, offset 0x1D0, reset 0xFFFF.FFFE** | | | | | | | | | | | | | | | |
| NW | DATA | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | DBG1 | DBG0 |
| **USER_REG0, type R/W, offset 0x1E0, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| NW | DATA | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **USER_REG1, type R/W, offset 0x1E4, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| NW | DATA | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **FMPRE1, type R/W, offset 0x204, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| **FMPRE2, type R/W, offset 0x208, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| **FMPRE3, type R/W, offset 0x20C, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| READ_ENABLE | | | | | | | | | | | | | | | |
| **FMPPE1, type R/W, offset 0x404, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |
| **FMPPE2, type R/W, offset 0x408, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **FMPPE3, type R/W, offset 0x40C, reset 0xFFFF.FFFF** | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |
| PROG_ENABLE | | | | | | | | | | | | | | | |

## General-Purpose Input/Outputs (GPIOs)

GPIO Port A base: 0x4000.4000
GPIO Port B base: 0x4000.5000
GPIO Port C base: 0x4000.6000
GPIO Port D base: 0x4000.7000
GPIO Port E base: 0x4002.4000
GPIO Port F base: 0x4002.5000
GPIO Port G base: 0x4002.6000
GPIO Port H base: 0x4002.7000

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GPIODATA, type R/W, offset 0x000, reset 0x0000.0000** (see page 294) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DATA | | | | | | | |
| **GPIODIR, type R/W, offset 0x400, reset 0x0000.0000** (see page 295) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DIR | | | | | | | |
| **GPIOIS, type R/W, offset 0x404, reset 0x0000.0000** (see page 296) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | IS | | | | | | | |
| **GPIOIBE, type R/W, offset 0x408, reset 0x0000.0000** (see page 297) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | IBE | | | | | | | |
| **GPIOIEV, type R/W, offset 0x40C, reset 0x0000.0000** (see page 298) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | IEV | | | | | | | |
| **GPIOIM, type R/W, offset 0x410, reset 0x0000.0000** (see page 299) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | IME | | | | | | | |
| **GPIORIS, type RO, offset 0x414, reset 0x0000.0000** (see page 300) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | RIS | | | | | | | |
| **GPIOMIS, type RO, offset 0x418, reset 0x0000.0000** (see page 301) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | MIS | | | | | | | |
| **GPIOICR, type W1C, offset 0x41C, reset 0x0000.0000** (see page 302) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | IC | | | | | | | |
| **GPIOAFSEL, type R/W, offset 0x420, reset -** (see page 303) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | AFSEL | | | | | | | |
| **GPIODR2R, type R/W, offset 0x500, reset 0x0000.00FF** (see page 305) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DRV2 | | | | | | | |
| **GPIODR4R, type R/W, offset 0x504, reset 0x0000.0000** (see page 306) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DRV4 | | | | | | | |
| **GPIODR8R, type R/W, offset 0x508, reset 0x0000.0000** (see page 307) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DRV8 | | | | | | | |
| **GPIOODR, type R/W, offset 0x50C, reset 0x0000.0000** (see page 308) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | ODE | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **GPIOPUR, type R/W, offset 0x510, reset -** (see page 309) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PUE | | | | | | | |
| **GPIOPDR, type R/W, offset 0x514, reset 0x0000.0000** (see page 310) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PDE | | | | | | | |
| **GPIOSLR, type R/W, offset 0x518, reset 0x0000.0000** (see page 311) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | SRL | | | | | | | |
| **GPIODEN, type R/W, offset 0x51C, reset -** (see page 312) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DEN | | | | | | | |
| **GPIOLOCK, type R/W, offset 0x520, reset 0x0000.0001** (see page 313) | | | | | | | | | | | | | | | |
| LOCK | | | | | | | | | | | | | | | |
| LOCK | | | | | | | | | | | | | | | |
| **GPIOCR, type -, offset 0x524, reset -** (see page 314) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CR | | | | | | | |
| **GPIOPeriphID4, type RO, offset 0xFD0, reset 0x0000.0000** (see page 316) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID4 | | | | | | | |
| **GPIOPeriphID5, type RO, offset 0xFD4, reset 0x0000.0000** (see page 317) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID5 | | | | | | | |
| **GPIOPeriphID6, type RO, offset 0xFD8, reset 0x0000.0000** (see page 318) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID6 | | | | | | | |
| **GPIOPeriphID7, type RO, offset 0xFDC, reset 0x0000.0000** (see page 319) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID7 | | | | | | | |
| **GPIOPeriphID0, type RO, offset 0xFE0, reset 0x0000.0061** (see page 320) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID0 | | | | | | | |
| **GPIOPeriphID1, type RO, offset 0xFE4, reset 0x0000.0000** (see page 321) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID1 | | | | | | | |
| **GPIOPeriphID2, type RO, offset 0xFE8, reset 0x0000.0018** (see page 322) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID2 | | | | | | | |
| **GPIOPeriphID3, type RO, offset 0xFEC, reset 0x0000.0001** (see page 323) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID3 | | | | | | | |
| **GPIOPCellID0, type RO, offset 0xFF0, reset 0x0000.000D** (see page 324) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID0 | | | | | | | |
| **GPIOPCellID1, type RO, offset 0xFF4, reset 0x0000.00F0** (see page 325) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID1 | | | | | | | |
| **GPIOPCellID2, type RO, offset 0xFF8, reset 0x0000.0005** (see page 326) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID2 | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **GPIOPCellID3, type RO, offset 0xFFC, reset 0x0000.00B1** (see page 327) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID3 | | | | | | | |
| **General-Purpose Timers**<br>Timer0 base: 0x4003.0000<br>Timer1 base: 0x4003.1000<br>Timer2 base: 0x4003.2000<br>Timer3 base: 0x4003.3000 | | | | | | | | | | | | | | | |
| **GPTMCFG, type R/W, offset 0x000, reset 0x0000.0000** (see page 341) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | GPTMCFG | | |
| **GPTMTAMR, type R/W, offset 0x004, reset 0x0000.0000** (see page 342) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | TAAMS | TACMR | TAMR | |
| **GPTMTBMR, type R/W, offset 0x008, reset 0x0000.0000** (see page 344) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | TBAMS | TBCMR | TBMR | |
| **GPTMCTL, type R/W, offset 0x00C, reset 0x0000.0000** (see page 346) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | TBPWML | | | TBEVENT | | TBSTALL | TBEN | | TAPWML | | RTCEN | TAEVENT | | TASTALL | TAEN |
| **GPTMIMR, type R/W, offset 0x018, reset 0x0000.0000** (see page 349) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | CBEIM | CBMIM | TBTOIM | | | | | RTCIM | CAEIM | CAMIM | TATOIM |
| **GPTMRIS, type RO, offset 0x01C, reset 0x0000.0000** (see page 351) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | CBERIS | CBMRIS | TBTORIS | | | | | RTCRIS | CAERIS | CAMRIS | TATORIS |
| **GPTMMIS, type RO, offset 0x020, reset 0x0000.0000** (see page 352) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | CBEMIS | CBMMIS | TBTOMIS | | | | | RTCMIS | CAEMIS | CAMMIS | TATOMIS |
| **GPTMICR, type W1C, offset 0x024, reset 0x0000.0000** (see page 353) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | CBECINT | CBMCINT | TBTOCINT | | | | | RTCCINT | CAECINT | CAMCINT | TATOCINT |
| **GPTMTAILR, type R/W, offset 0x028, reset 0xFFFF.FFFF** (see page 355) | | | | | | | | | | | | | | | |
| | | | | | | | | TAILRH | | | | | | | |
| | | | | | | | | TAILRL | | | | | | | |
| **GPTMTBILR, type R/W, offset 0x02C, reset 0x0000.FFFF** (see page 356) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | TBILRL | | | | | | | |
| **GPTMTAMATCHR, type R/W, offset 0x030, reset 0xFFFF.FFFF** (see page 357) | | | | | | | | | | | | | | | |
| | | | | | | | | TAMRH | | | | | | | |
| | | | | | | | | TAMRL | | | | | | | |
| **GPTMTBMATCHR, type R/W, offset 0x034, reset 0x0000.FFFF** (see page 358) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | TBMRL | | | | | | | |
| **GPTMTAPR, type R/W, offset 0x038, reset 0x0000.0000** (see page 359) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | TAPSR | | | | | | | |
| **GPTMTBPR, type R/W, offset 0x03C, reset 0x0000.0000** (see page 360) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | TBPSR | | | | | | | |
| **GPTMTAPMR, type R/W, offset 0x040, reset 0x0000.0000** (see page 361) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | TAPSMR | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **GPTMTBPMR, type R/W, offset 0x044, reset 0x0000.0000** (see page 362) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | TBPSMR | | | | | | | |
| **GPTMTAR, type RO, offset 0x048, reset 0xFFFF.FFFF** (see page 363) | | | | | | | | | | | | | | | |
| TARH | | | | | | | | | | | | | | | |
| TARL | | | | | | | | | | | | | | | |
| **GPTMTBR, type RO, offset 0x04C, reset 0x0000.FFFF** (see page 364) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| TBRL | | | | | | | | | | | | | | | |

## Watchdog Timer
Base 0x4000.0000

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WDTLOAD, type R/W, offset 0x000, reset 0xFFFF.FFFF** (see page 369) | | | | | | | | | | | | | | | |
| WDTLoad | | | | | | | | | | | | | | | |
| WDTLoad | | | | | | | | | | | | | | | |
| **WDTVALUE, type RO, offset 0x004, reset 0xFFFF.FFFF** (see page 370) | | | | | | | | | | | | | | | |
| WDTValue | | | | | | | | | | | | | | | |
| WDTValue | | | | | | | | | | | | | | | |
| **WDTCTL, type R/W, offset 0x008, reset 0x0000.0000** (see page 371) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | RESEN | INTEN |
| **WDTICR, type WO, offset 0x00C, reset -** (see page 372) | | | | | | | | | | | | | | | |
| WDTIntClr | | | | | | | | | | | | | | | |
| WDTIntClr | | | | | | | | | | | | | | | |
| **WDTRIS, type RO, offset 0x010, reset 0x0000.0000** (see page 373) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | WDTRIS |
| **WDTMIS, type RO, offset 0x014, reset 0x0000.0000** (see page 374) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | WDTMIS |
| **WDTTEST, type R/W, offset 0x418, reset 0x0000.0000** (see page 375) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | STALL | | | | | | | | |
| **WDTLOCK, type R/W, offset 0xC00, reset 0x0000.0000** (see page 376) | | | | | | | | | | | | | | | |
| WDTLock | | | | | | | | | | | | | | | |
| WDTLock | | | | | | | | | | | | | | | |
| **WDTPeriphID4, type RO, offset 0xFD0, reset 0x0000.0000** (see page 377) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID4 | | | | | | | |
| **WDTPeriphID5, type RO, offset 0xFD4, reset 0x0000.0000** (see page 378) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID5 | | | | | | | |
| **WDTPeriphID6, type RO, offset 0xFD8, reset 0x0000.0000** (see page 379) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID6 | | | | | | | |
| **WDTPeriphID7, type RO, offset 0xFDC, reset 0x0000.0000** (see page 380) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID7 | | | | | | | |
| **WDTPeriphID0, type RO, offset 0xFE0, reset 0x0000.0005** (see page 381) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID0 | | | | | | | |
| **WDTPeriphID1, type RO, offset 0xFE4, reset 0x0000.0018** (see page 382) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID1 | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **WDTPeriphID2, type RO, offset 0xFE8, reset 0x0000.0018** (see page 383) | | | | | | | | | | | | | | | |
| | | | | | | | | PID2 | | | | | | | |
| **WDTPeriphID3, type RO, offset 0xFEC, reset 0x0000.0001** (see page 384) | | | | | | | | | | | | | | | |
| | | | | | | | | PID3 | | | | | | | |
| **WDTPCellID0, type RO, offset 0xFF0, reset 0x0000.000D** (see page 385) | | | | | | | | | | | | | | | |
| | | | | | | | | CID0 | | | | | | | |
| **WDTPCellID1, type RO, offset 0xFF4, reset 0x0000.00F0** (see page 386) | | | | | | | | | | | | | | | |
| | | | | | | | | CID1 | | | | | | | |
| **WDTPCellID2, type RO, offset 0xFF8, reset 0x0000.0005** (see page 387) | | | | | | | | | | | | | | | |
| | | | | | | | | CID2 | | | | | | | |
| **WDTPCellID3, type RO, offset 0xFFC, reset 0x0000.00B1** (see page 388) | | | | | | | | | | | | | | | |
| | | | | | | | | CID3 | | | | | | | |
| **Universal Asynchronous Receivers/Transmitters (UARTs)**<br>UART0 base: 0x4000.C000<br>UART1 base: 0x4000.D000<br>UART2 base: 0x4000.E000 | | | | | | | | | | | | | | | |
| **UARTDR, type R/W, offset 0x000, reset 0x0000.0000** (see page 399) | | | | | | | | | | | | | | | |
| | | | | OE | BE | PE | FE | DATA | | | | | | | |
| **UARTRSR/UARTECR, type RO, offset 0x004, reset 0x0000.0000 (Reads)** (see page 401) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | OE | BE | PE | FE |
| **UARTRSR/UARTECR, type WO, offset 0x004, reset 0x0000.0000 (Writes)** (see page 401) | | | | | | | | | | | | | | | |
| | | | | | | | | DATA | | | | | | | |
| **UARTFR, type RO, offset 0x018, reset 0x0000.0090** (see page 403) | | | | | | | | | | | | | | | |
| | | | | | | | | TXFE | RXFF | TXFF | RXFE | BUSY | | | |
| **UARTILPR, type R/W, offset 0x020, reset 0x0000.0000** (see page 405) | | | | | | | | | | | | | | | |
| | | | | | | | | ILPDVSR | | | | | | | |
| **UARTIBRD, type R/W, offset 0x024, reset 0x0000.0000** (see page 406) | | | | | | | | | | | | | | | |
| DIVINT | | | | | | | | | | | | | | | |
| **UARTFBRD, type R/W, offset 0x028, reset 0x0000.0000** (see page 407) | | | | | | | | | | | | | | | |
| | | | | | | | | | | DIVFRAC | | | | | |
| **UARTLCRH, type R/W, offset 0x02C, reset 0x0000.0000** (see page 408) | | | | | | | | | | | | | | | |
| | | | | | | | | SPS | WLEN | | FEN | STP2 | EPS | PEN | BRK |
| **UARTCTL, type R/W, offset 0x030, reset 0x0000.0300** (see page 410) | | | | | | | | | | | | | | | |
| | | | | | | RXE | TXE | LBE | | | | | SIRLP | SIREN | UARTEN |
| **UARTIFLS, type R/W, offset 0x034, reset 0x0000.0012** (see page 412) | | | | | | | | | | | | | | | |
| | | | | | | | | | | RXIFLSEL | | | TXIFLSEL | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **UARTIM, type R/W, offset 0x038, reset 0x0000.0000** (see page 414) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | OEIM | BEIM | PEIM | FEIM | RTIM | TXIM | RXIM | | | | |
| **UARTRIS, type RO, offset 0x03C, reset 0x0000.000F** (see page 416) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | OERIS | BERIS | PERIS | FERIS | RTRIS | TXRIS | RXRIS | | | | |
| **UARTMIS, type RO, offset 0x040, reset 0x0000.0000** (see page 417) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | OEMIS | BEMIS | PEMIS | FEMIS | RTMIS | TXMIS | RXMIS | | | | |
| **UARTICR, type W1C, offset 0x044, reset 0x0000.0000** (see page 418) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | OEIC | BEIC | PEIC | FEIC | RTIC | TXIC | RXIC | | | | |
| **UARTPeriphID4, type RO, offset 0xFD0, reset 0x0000.0000** (see page 420) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID4 | | | | | | | |
| **UARTPeriphID5, type RO, offset 0xFD4, reset 0x0000.0000** (see page 421) | | | | | | | | | | | | | | | |
| | | | | | | | | PID5 | | | | | | | |
| **UARTPeriphID6, type RO, offset 0xFD8, reset 0x0000.0000** (see page 422) | | | | | | | | | | | | | | | |
| | | | | | | | | PID6 | | | | | | | |
| **UARTPeriphID7, type RO, offset 0xFDC, reset 0x0000.0000** (see page 423) | | | | | | | | | | | | | | | |
| | | | | | | | | PID7 | | | | | | | |
| **UARTPeriphID0, type RO, offset 0xFE0, reset 0x0000.0011** (see page 424) | | | | | | | | | | | | | | | |
| | | | | | | | | PID0 | | | | | | | |
| **UARTPeriphID1, type RO, offset 0xFE4, reset 0x0000.0000** (see page 425) | | | | | | | | | | | | | | | |
| | | | | | | | | PID1 | | | | | | | |
| **UARTPeriphID2, type RO, offset 0xFE8, reset 0x0000.0018** (see page 426) | | | | | | | | | | | | | | | |
| | | | | | | | | PID2 | | | | | | | |
| **UARTPeriphID3, type RO, offset 0xFEC, reset 0x0000.0001** (see page 427) | | | | | | | | | | | | | | | |
| | | | | | | | | PID3 | | | | | | | |
| **UARTPCellID0, type RO, offset 0xFF0, reset 0x0000.000D** (see page 428) | | | | | | | | | | | | | | | |
| | | | | | | | | CID0 | | | | | | | |
| **UARTPCellID1, type RO, offset 0xFF4, reset 0x0000.00F0** (see page 429) | | | | | | | | | | | | | | | |
| | | | | | | | | CID1 | | | | | | | |
| **UARTPCellID2, type RO, offset 0xFF8, reset 0x0000.0005** (see page 430) | | | | | | | | | | | | | | | |
| | | | | | | | | CID2 | | | | | | | |
| **UARTPCellID3, type RO, offset 0xFFC, reset 0x0000.00B1** (see page 431) | | | | | | | | | | | | | | | |
| | | | | | | | | CID3 | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **Synchronous Serial Interface (SSI)**<br>SSI0 base: 0x4000.8000<br>SSI1 base: 0x4000.9000 | | | | | | | | | | | | | | | |
| **SSICR0, type R/W, offset 0x000, reset 0x0000.0000** (see page 445) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| SCR | | | | | | | | SPH | SPO | FRF | | DSS | | | |
| **SSICR1, type R/W, offset 0x004, reset 0x0000.0000** (see page 447) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | SOD | MS | SSE | LBM |
| **SSIDR, type R/W, offset 0x008, reset 0x0000.0000** (see page 449) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| DATA | | | | | | | | | | | | | | | |
| **SSISR, type RO, offset 0x00C, reset 0x0000.0003** (see page 450) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | BSY | RFF | RNE | TNF | TFE |
| **SSICPSR, type R/W, offset 0x010, reset 0x0000.0000** (see page 452) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CPSDVSR | | | | | | | |
| **SSIIM, type R/W, offset 0x014, reset 0x0000.0000** (see page 453) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | TXIM | RXIM | RTIM | RORIM |
| **SSIRIS, type RO, offset 0x018, reset 0x0000.0008** (see page 455) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | TXRIS | RXRIS | RTRIS | RORRIS |
| **SSIMIS, type RO, offset 0x01C, reset 0x0000.0000** (see page 456) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | TXMIS | RXMIS | RTMIS | RORMIS |
| **SSIICR, type W1C, offset 0x020, reset 0x0000.0000** (see page 457) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | RTIC | RORIC |
| **SSIPeriphID4, type RO, offset 0xFD0, reset 0x0000.0000** (see page 458) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID4 | | | | | | | |
| **SSIPeriphID5, type RO, offset 0xFD4, reset 0x0000.0000** (see page 459) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID5 | | | | | | | |
| **SSIPeriphID6, type RO, offset 0xFD8, reset 0x0000.0000** (see page 460) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID6 | | | | | | | |
| **SSIPeriphID7, type RO, offset 0xFDC, reset 0x0000.0000** (see page 461) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID7 | | | | | | | |
| **SSIPeriphID0, type RO, offset 0xFE0, reset 0x0000.0022** (see page 462) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID0 | | | | | | | |
| **SSIPeriphID1, type RO, offset 0xFE4, reset 0x0000.0000** (see page 463) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID1 | | | | | | | |
| **SSIPeriphID2, type RO, offset 0xFE8, reset 0x0000.0018** (see page 464) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID2 | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **SSIPeriphID3, type RO, offset 0xFEC, reset 0x0000.0001** (see page 465) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | PID3 | | | | | | | |
| **SSIPCellID0, type RO, offset 0xFF0, reset 0x0000.000D** (see page 466) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID0 | | | | | | | |
| **SSIPCellID1, type RO, offset 0xFF4, reset 0x0000.00F0** (see page 467) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID1 | | | | | | | |
| **SSIPCellID2, type RO, offset 0xFF8, reset 0x0000.0005** (see page 468) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID2 | | | | | | | |
| **SSIPCellID3, type RO, offset 0xFFC, reset 0x0000.00B1** (see page 469) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | CID3 | | | | | | | |
| **Inter-Integrated Circuit ($I^2C$) Interface** | | | | | | | | | | | | | | | |
| **$I^2C$ Master** | | | | | | | | | | | | | | | |
| I2C 0 base: 0x4002.0000<br>I2C 1 base: 0x4002.1000 | | | | | | | | | | | | | | | |
| **I2CMSA, type R/W, offset 0x000, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | SA | | | | | | | R/S |
| **I2CMCS, type RO, offset 0x004, reset 0x0000.0000 (Reads)** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | BUSBSY | IDLE | ARBLST | DATACK | ADRACK | ERROR | BUSY |
| **I2CMCS, type WO, offset 0x004, reset 0x0000.0000 (Writes)** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | ACK | STOP | START | RUN |
| **I2CMDR, type R/W, offset 0x008, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DATA | | | | | | | |
| **I2CMTPR, type R/W, offset 0x00C, reset 0x0000.0001** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | TPR | | | | | | |
| **I2CMIMR, type R/W, offset 0x010, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | IM |
| **I2CMRIS, type RO, offset 0x014, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | RIS |
| **I2CMMIS, type RO, offset 0x018, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | MIS |
| **I2CMICR, type WO, offset 0x01C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | IC |
| **I2CMCR, type R/W, offset 0x020, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | SFE | MFE | | | | LPBK |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **Inter-Integrated Circuit (I²C) Interface**<br>**I²C Slave**<br>I2C 0 base: 0x4002.0000<br>I2C 1 base: 0x4002.1000 | | | | | | | | | | | | | | | |
| **I2CSOAR, type R/W, offset 0x800, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | OAR | | | | | | |
| **I2CSCSR, type RO, offset 0x804, reset 0x0000.0000 (Reads)** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | FBR | TREQ | RREQ |
| **I2CSCSR, type WO, offset 0x804, reset 0x0000.0000 (Writes)** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | DA |
| **I2CSDR, type R/W, offset 0x808, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | DATA | | | | | | | |
| **I2CSIMR, type R/W, offset 0x80C, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | DATAIM |
| **I2CSRIS, type RO, offset 0x810, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | DATARIS |
| **I2CSMIS, type RO, offset 0x814, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | DATAMIS |
| **I2CSICR, type WO, offset 0x818, reset 0x0000.0000** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | DATAIC |
| **Analog Comparators**<br>Base 0x4003.C000 | | | | | | | | | | | | | | | |
| **ACMIS, type R/W1C, offset 0x000, reset 0x0000.0000** (see page 513) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | IN2 | IN1 | IN0 |
| **ACRIS, type RO, offset 0x004, reset 0x0000.0000** (see page 514) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | IN2 | IN1 | IN0 |
| **ACINTEN, type R/W, offset 0x008, reset 0x0000.0000** (see page 515) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | IN2 | IN1 | IN0 |
| **ACREFCTL, type R/W, offset 0x010, reset 0x0000.0000** (see page 516) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | EN | RNG | | | | | VREF | | | |
| **ACSTAT0, type RO, offset 0x020, reset 0x0000.0000** (see page 517) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | OVAL | |
| **ACSTAT1, type RO, offset 0x040, reset 0x0000.0000** (see page 517) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | OVAL | |
| **ACSTAT2, type RO, offset 0x060, reset 0x0000.0000** (see page 517) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | OVAL | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **ACCTL0, type R/W, offset 0x024, reset 0x0000.0000** (see page 518) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | ASRCP | | | | | | ISLVAL | ISEN | | CINV | |
| **ACCTL1, type R/W, offset 0x044, reset 0x0000.0000** (see page 518) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | ASRCP | | | | | | ISLVAL | ISEN | | CINV | |
| **ACCTL2, type R/W, offset 0x064, reset 0x0000.0000** (see page 518) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | ASRCP | | | | | | ISLVAL | ISEN | | CINV | |
| **Pulse Width Modulator (PWM)**<br>Base 0x4002.8000 | | | | | | | | | | | | | | | |
| **PWMCTL, type R/W, offset 0x000, reset 0x0000.0000** (see page 530) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | GlobalSync2 | GlobalSync1 | GlobalSync0 |
| **PWMSYNC, type R/W, offset 0x004, reset 0x0000.0000** (see page 531) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | Sync2 | Sync1 | Sync0 |
| **PWMENABLE, type R/W, offset 0x008, reset 0x0000.0000** (see page 532) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | PWM5En | PWM4En | PWM3En | PWM2En | PWM1En | PWM0En |
| **PWMINVERT, type R/W, offset 0x00C, reset 0x0000.0000** (see page 533) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | PWM5Inv | PWM4Inv | PWM3Inv | PWM2Inv | PWM1Inv | PWM0Inv |
| **PWMFAULT, type R/W, offset 0x010, reset 0x0000.0000** (see page 534) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | Fault5 | Fault4 | Fault3 | Fault2 | Fault1 | Fault0 |
| **PWMINTEN, type R/W, offset 0x014, reset 0x0000.0000** (see page 535) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | IntFault |
| | | | | | | | | | | | | | IntPWM2 | IntPWM1 | IntPWM0 |
| **PWMRIS, type RO, offset 0x018, reset 0x0000.0000** (see page 536) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | IntFault |
| | | | | | | | | | | | | | IntPWM2 | IntPWM1 | IntPWM0 |
| **PWMISC, type R/W1C, offset 0x01C, reset 0x0000.0000** (see page 537) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | IntFault |
| | | | | | | | | | | | | | IntPWM2 | IntPWM1 | IntPWM0 |
| **PWMSTATUS, type RO, offset 0x020, reset 0x0000.0000** (see page 538) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | Fault |
| **PWM0CTL, type R/W, offset 0x040, reset 0x0000.0000** (see page 539) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | CmpBUpd | CmpAUpd | LoadUpd | Debug | Mode | Enable |
| **PWM1CTL, type R/W, offset 0x080, reset 0x0000.0000** (see page 539) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | CmpBUpd | CmpAUpd | LoadUpd | Debug | Mode | Enable |
| **PWM2CTL, type R/W, offset 0x0C0, reset 0x0000.0000** (see page 539) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | CmpBUpd | CmpAUpd | LoadUpd | Debug | Mode | Enable |
| **PWM0INTEN, type R/W, offset 0x044, reset 0x0000.0000** (see page 541) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM1INTEN, type R/W, offset 0x084, reset 0x0000.0000** (see page 541) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **PWM2INTEN, type R/W, offset 0x0C4, reset 0x0000.0000** (see page 541) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM0RIS, type RO, offset 0x048, reset 0x0000.0000** (see page 543) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM1RIS, type RO, offset 0x088, reset 0x0000.0000** (see page 543) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM2RIS, type RO, offset 0x0C8, reset 0x0000.0000** (see page 543) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM0ISC, type R/W1C, offset 0x04C, reset 0x0000.0000** (see page 544) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM1ISC, type R/W1C, offset 0x08C, reset 0x0000.0000** (see page 544) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM2ISC, type R/W1C, offset 0x0CC, reset 0x0000.0000** (see page 544) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | IntCmpBD | IntCmpBU | IntCmpAD | IntCmpAU | IntCntLoad | IntCntZero |
| **PWM0LOAD, type R/W, offset 0x050, reset 0x0000.0000** (see page 545) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Load | | | | | | | | | | | | | | | |
| **PWM1LOAD, type R/W, offset 0x090, reset 0x0000.0000** (see page 545) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Load | | | | | | | | | | | | | | | |
| **PWM2LOAD, type R/W, offset 0x0D0, reset 0x0000.0000** (see page 545) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Load | | | | | | | | | | | | | | | |
| **PWM0COUNT, type RO, offset 0x054, reset 0x0000.0000** (see page 546) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Count | | | | | | | | | | | | | | | |
| **PWM1COUNT, type RO, offset 0x094, reset 0x0000.0000** (see page 546) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Count | | | | | | | | | | | | | | | |
| **PWM2COUNT, type RO, offset 0x0D4, reset 0x0000.0000** (see page 546) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Count | | | | | | | | | | | | | | | |
| **PWM0CMPA, type R/W, offset 0x058, reset 0x0000.0000** (see page 547) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CompA | | | | | | | | | | | | | | | |
| **PWM1CMPA, type R/W, offset 0x098, reset 0x0000.0000** (see page 547) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CompA | | | | | | | | | | | | | | | |
| **PWM2CMPA, type R/W, offset 0x0D8, reset 0x0000.0000** (see page 547) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CompA | | | | | | | | | | | | | | | |
| **PWM0CMPB, type R/W, offset 0x05C, reset 0x0000.0000** (see page 548) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CompB | | | | | | | | | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **PWM1CMPB, type R/W, offset 0x09C, reset 0x0000.0000** (see page 548) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CompB | | | | | | | | | | | | | | | |
| **PWM2CMPB, type R/W, offset 0x0DC, reset 0x0000.0000** (see page 548) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| CompB | | | | | | | | | | | | | | | |
| **PWM0GENA, type R/W, offset 0x060, reset 0x0000.0000** (see page 549) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| **PWM1GENA, type R/W, offset 0x0A0, reset 0x0000.0000** (see page 549) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| **PWM2GENA, type R/W, offset 0x0E0, reset 0x0000.0000** (see page 549) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| **PWM0GENB, type R/W, offset 0x064, reset 0x0000.0000** (see page 552) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| **PWM1GENB, type R/W, offset 0x0A4, reset 0x0000.0000** (see page 552) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| **PWM2GENB, type R/W, offset 0x0E4, reset 0x0000.0000** (see page 552) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | ActCmpBD | | ActCmpBU | | ActCmpAD | | ActCmpAU | | ActLoad | | ActZero | |
| **PWM0DBCTL, type R/W, offset 0x068, reset 0x0000.0000** (see page 555) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | Enable |
| **PWM1DBCTL, type R/W, offset 0x0A8, reset 0x0000.0000** (see page 555) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | Enable |
| **PWM2DBCTL, type R/W, offset 0x0E8, reset 0x0000.0000** (see page 555) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | Enable |
| **PWM0DBRISE, type R/W, offset 0x06C, reset 0x0000.0000** (see page 556) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | RiseDelay | | | | | | | | | | | |
| **PWM1DBRISE, type R/W, offset 0x0AC, reset 0x0000.0000** (see page 556) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | RiseDelay | | | | | | | | | | | |
| **PWM2DBRISE, type R/W, offset 0x0EC, reset 0x0000.0000** (see page 556) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | RiseDelay | | | | | | | | | | | |
| **PWM0DBFALL, type R/W, offset 0x070, reset 0x0000.0000** (see page 557) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | FallDelay | | | | | | | | | | | |
| **PWM1DBFALL, type R/W, offset 0x0B0, reset 0x0000.0000** (see page 557) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | FallDelay | | | | | | | | | | | |
| **PWM2DBFALL, type R/W, offset 0x0F0, reset 0x0000.0000** (see page 557) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | FallDelay | | | | | | | | | | | |

| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **Quadrature Encoder Interface (QEI)**<br>QEI0 base: 0x4002.C000<br>QEI1 base: 0x4002.D000 | | | | | | | | | | | | | | | |
| **QEICTL, type R/W, offset 0x000, reset 0x0000.0000** (see page 564) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | STALLEN | INVI | INVB | INVA | VelDiv | | | VelEn | ResMode | CapMode | SigMode | Swap | Enable |
| **QEISTAT, type RO, offset 0x004, reset 0x0000.0000** (see page 566) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | Direction | Error |
| **QEIPOS, type R/W, offset 0x008, reset 0x0000.0000** (see page 567) | | | | | | | | | | | | | | | |
| Position | | | | | | | | | | | | | | | |
| Position | | | | | | | | | | | | | | | |
| **QEIMAXPOS, type R/W, offset 0x00C, reset 0x0000.0000** (see page 568) | | | | | | | | | | | | | | | |
| MaxPos | | | | | | | | | | | | | | | |
| MaxPos | | | | | | | | | | | | | | | |
| **QEILOAD, type R/W, offset 0x010, reset 0x0000.0000** (see page 569) | | | | | | | | | | | | | | | |
| Load | | | | | | | | | | | | | | | |
| Load | | | | | | | | | | | | | | | |
| **QEITIME, type RO, offset 0x014, reset 0x0000.0000** (see page 570) | | | | | | | | | | | | | | | |
| Time | | | | | | | | | | | | | | | |
| Time | | | | | | | | | | | | | | | |
| **QEICOUNT, type RO, offset 0x018, reset 0x0000.0000** (see page 571) | | | | | | | | | | | | | | | |
| Count | | | | | | | | | | | | | | | |
| Count | | | | | | | | | | | | | | | |
| **QEISPEED, type RO, offset 0x01C, reset 0x0000.0000** (see page 572) | | | | | | | | | | | | | | | |
| Speed | | | | | | | | | | | | | | | |
| Speed | | | | | | | | | | | | | | | |
| **QEIINTEN, type R/W, offset 0x020, reset 0x0000.0000** (see page 573) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | IntError | IntDir | IntTimer | IntIndex |
| **QEIRIS, type RO, offset 0x024, reset 0x0000.0000** (see page 574) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | IntError | IntDir | IntTimer | IntIndex |
| **QEIISC, type R/W1C, offset 0x028, reset 0x0000.0000** (see page 575) | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | IntError | IntDir | IntTimer | IntIndex |

# C Ordering and Contact Information

## C.1 Ordering Information

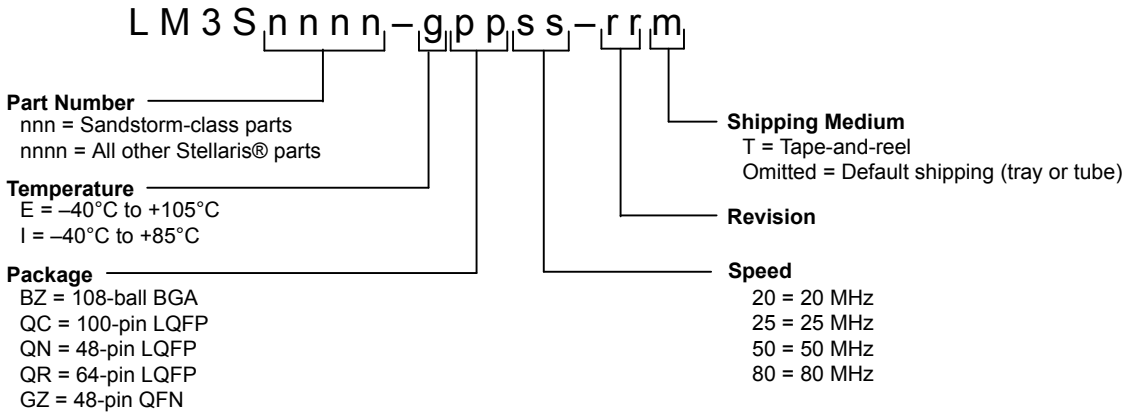


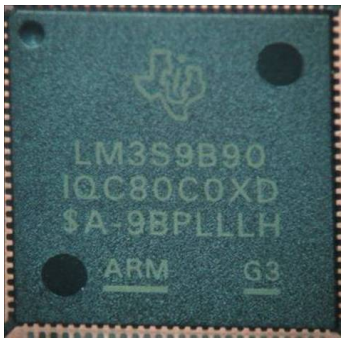

**Table C-1. Part Ordering Information**

| Orderable Part Number | Description |
|---|---|
| LM3S1960-IBZ50-A2 | Stellaris® LM3S1960 Microcontroller Industrial Temperature 108-ball BGA |
| LM3S1960-IBZ50-A2T | Stellaris LM3S1960 Microcontroller Industrial Temperature 108-ball BGA Tape-and-reel |
| LM3S1960-EQC50-A2 | Stellaris LM3S1960 Microcontroller Extended Temperature 100-pin LQFP |
| LM3S1960-EQC50-A2T | Stellaris LM3S1960 Microcontroller Extended Temperature 100-pin LQFP Tape-and-reel |
| LM3S1960-IQC50-A2 | Stellaris LM3S1960 Microcontroller Industrial Temperature 100-pin LQFP |
| LM3S1960-IQC50-A2T | Stellaris LM3S1960 Microcontroller Industrial Temperature 100-pin LQFP Tape-and-reel |

## C.2 Part Markings

The Stellaris microcontrollers are marked with an identifying number. This code contains the following information:

- The first line indicates the part number, for example, LM3S9B90.
- In the second line, the first eight characters indicate the temperature, package, speed, revision, and product status. For example in the figure below, IQC80C0X indicates an Industrial temperature (I), 100-pin LQFP package (QC), 80-MHz (80), revision C0 (C0) device. The letter immediately following the revision indicates product status. An X indicates experimental and requires a waiver; an S indicates the part is fully qualified and released to production.
- The remaining characters contain internal tracking numbers.




## C.3 Kits

The Stellaris Family provides the hardware and software tools that engineers need to begin development quickly.

- Reference Design Kits accelerate product development by providing ready-to-run hardware and comprehensive documentation including hardware design files
- Evaluation Kits provide a low-cost and effective means of evaluating Stellaris microcontrollers before purchase
- Development Kits provide you with all the tools you need to develop and prototype embedded applications right out of the box

See the website at www.ti.com/stellaris for the latest tools available, or ask your distributor.

## C.4 Support Information

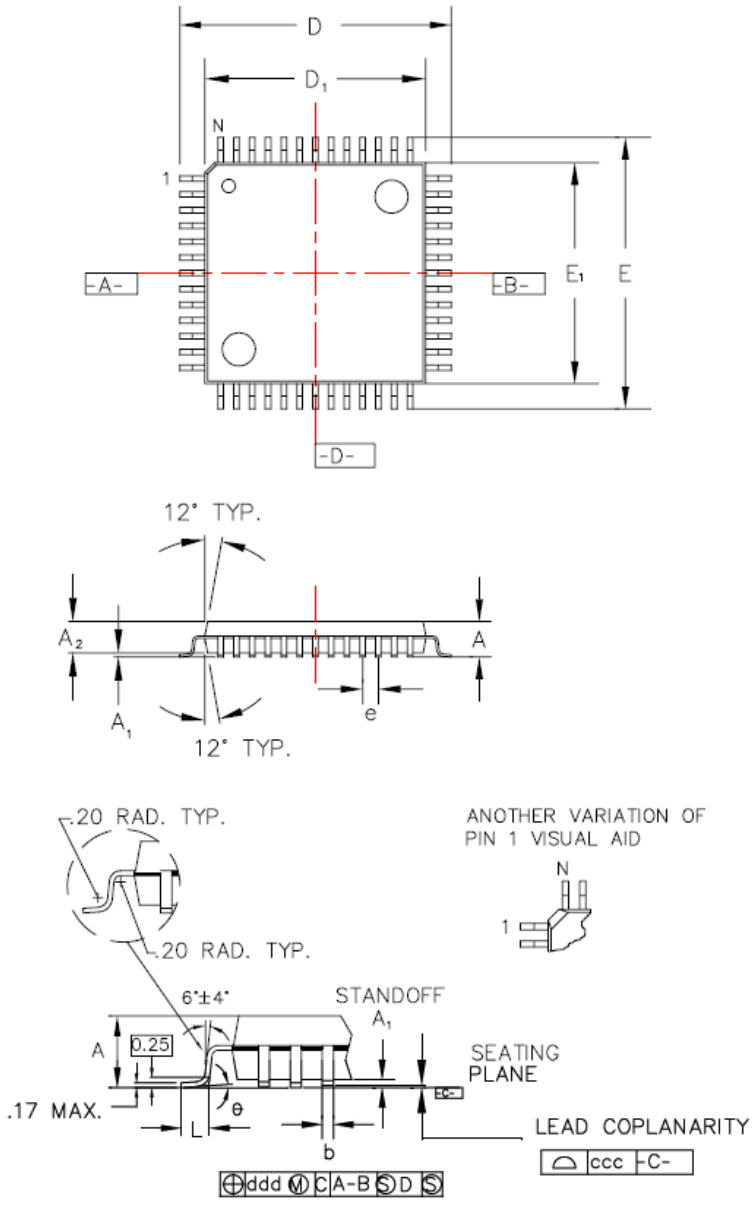
For support on Stellaris products, contact the TI Worldwide Product Information Center nearest you: http://www-k.ext.ti.com/sc/technical-support/product-information-centers.htm.

# D Package Information

## D.1 100-Pin LQFP Package

### D.1.1 Package Dimensions

**Figure D-1. Stellaris LM3S1960 100-Pin LQFP Package Dimensions**




**Note:** The following notes apply to the package drawing.

**1.** All dimensions shown in mm.

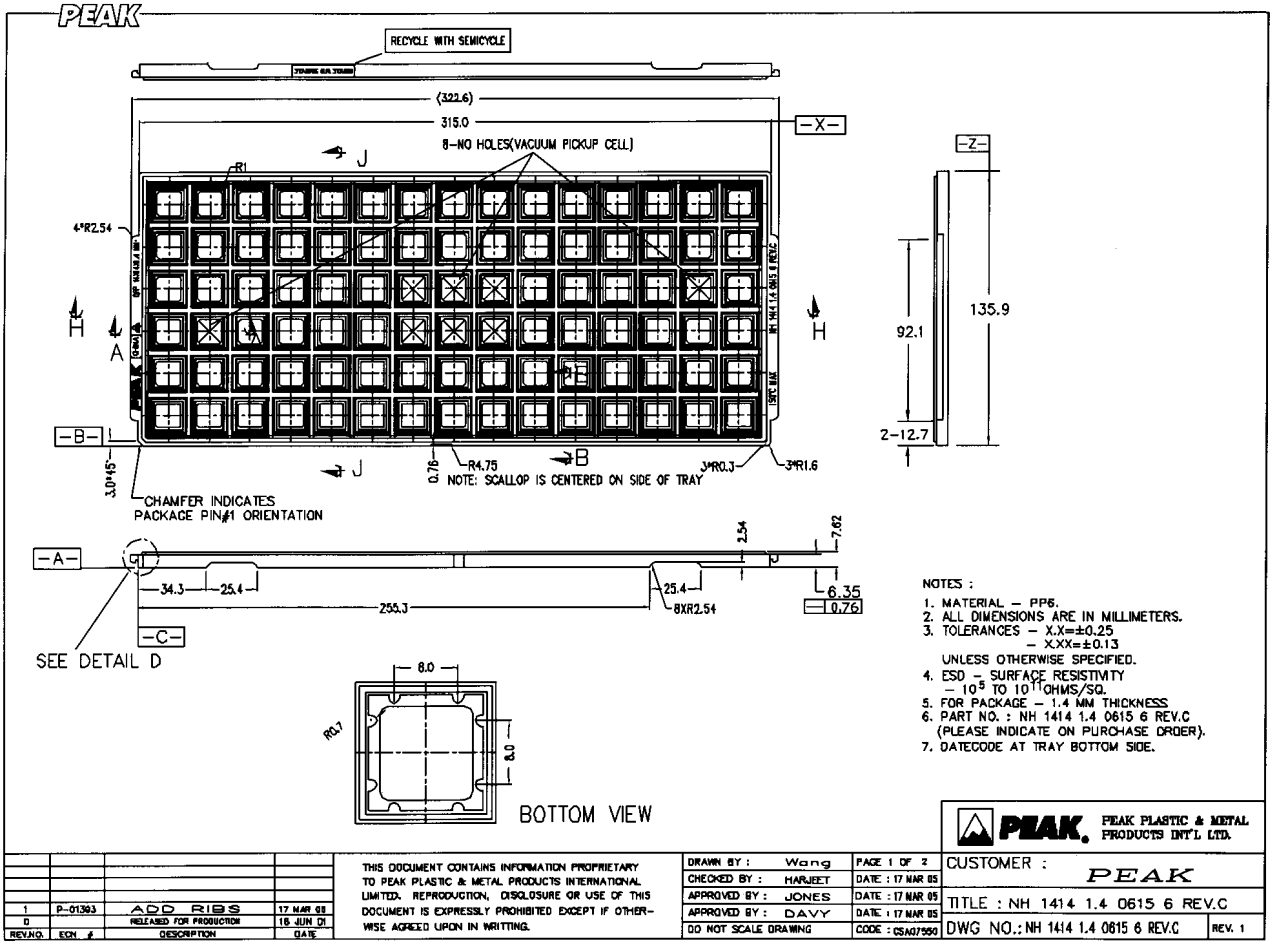
**2.** Dimensions shown are nominal with tolerances indicated.

**3.** Foot length 'L' is measured at gage plane 0.25 mm above seating plane.

| Body +2.00 mm Footprint, 1.4 mm package thickness | | |
|---|---|---|
| Symbols | Leads | 100L |
| A | Max. | 1.60 |
| $A_1$ | - | 0.05 Min./0.15 Max. |
| $A_2$ | ±0.05 | 1.40 |
| D | ±0.20 | 16.00 |
| $D_1$ | ±0.05 | 14.00 |
| E | ±0.20 | 16.00 |
| $E_1$ | ±0.05 | 14.00 |
| L | +0.15/-0.10 | 0.60 |
| e | Basic | 0.50 |
| b | +0.05 | 0.22 |
| θ | - | 0˚-7˚ |
| ddd | Max. | 0.08 |
| ccc | Max. | 0.08 |
| JEDEC Reference Drawing | | MS-026 |
| Variation Designator | | BED |

## D.1.2 Tray Dimensions

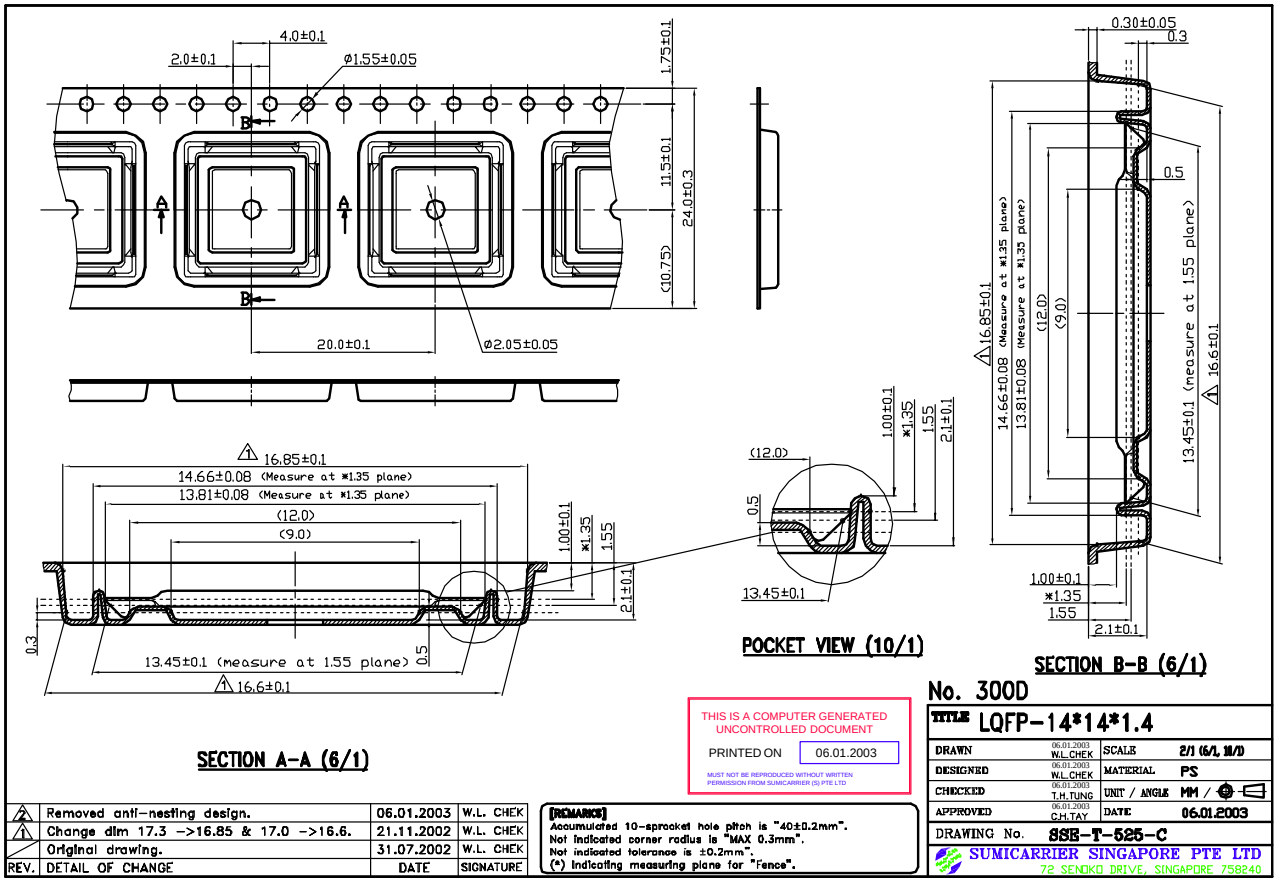
**Figure D-2. 100-Pin LQFP Tray Dimensions**




## D.1.3 Tape and Reel Dimensions

**Note:** In the figure that follows, pin 1 is located in the top right corner of the device.

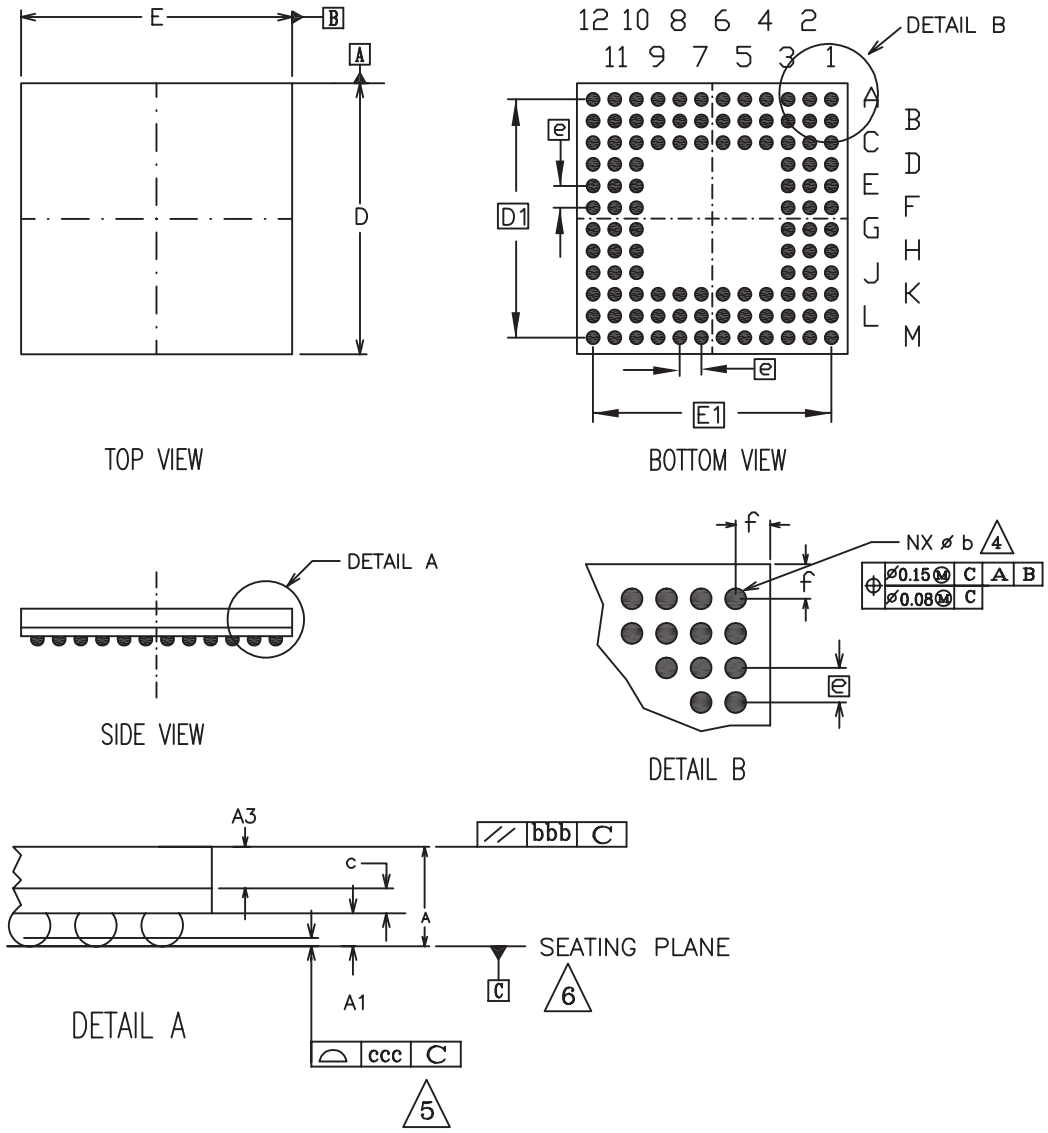
**Figure D-3. 100-Pin LQFP Tape and Reel Dimensions**



## D.2 108-Ball BGA Package

### D.2.1 Package Dimensions

**Figure D-4. Stellaris LM3S1960 108-Ball BGA Package Dimensions**



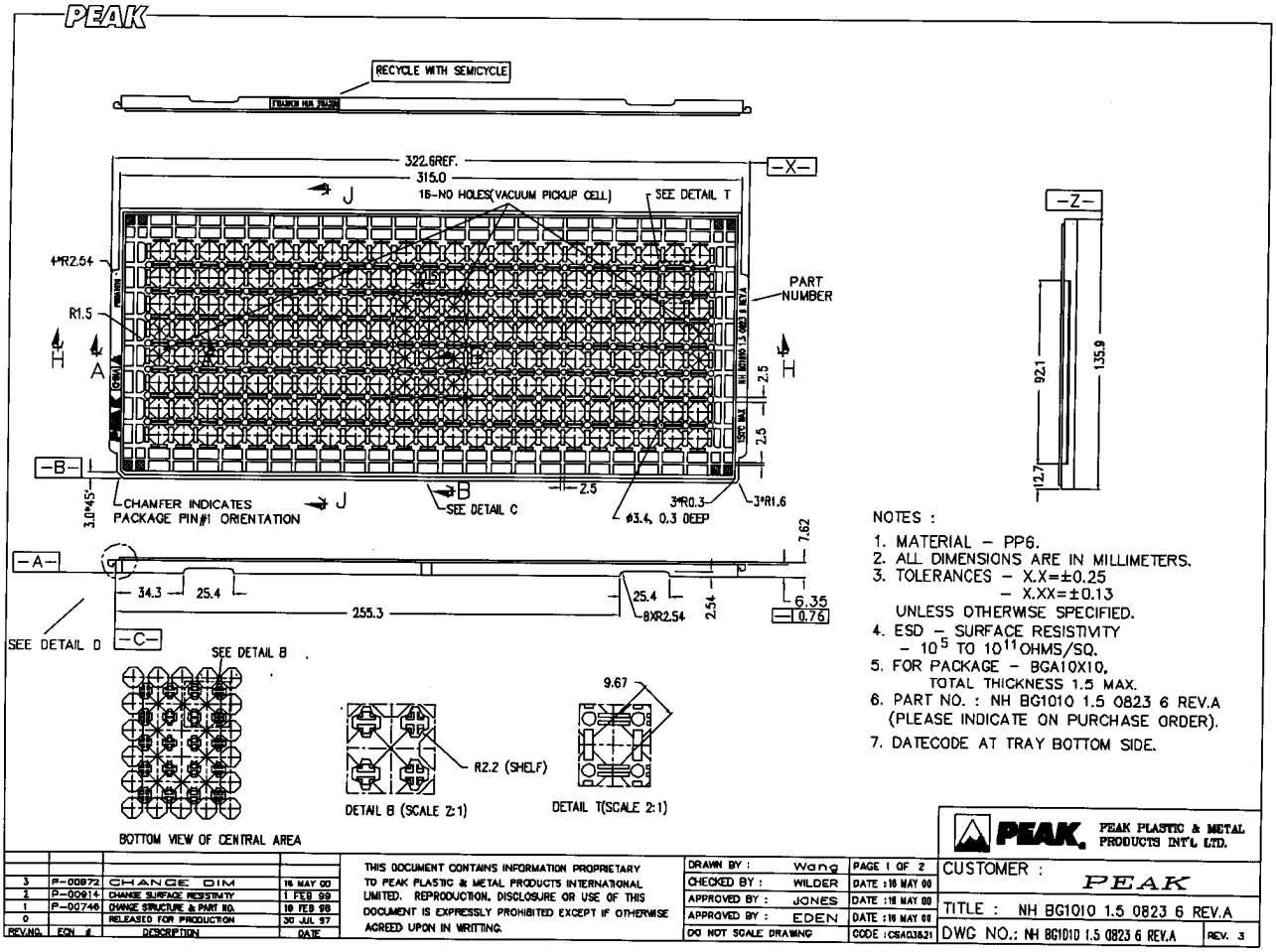
**Note:** The following notes apply to the package drawing.

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. 'e' REPRESENTS THE BASIC SOLDER BALL GRID PITCH.
3. 'M' REPRESENTS THE BASIC SOLDER BALL MATRIX SIZE.
   AND SYMBOL 'N' IS THE NUMBER OF BALLS AFTER DEPOPULATING.
4. 'b' IS MEASURABLE AT THE MAXIMUM SOLDER BALL DIAMETER AFTER REFLOW
   PARALLEL TO PRIMARY DAIUM [C] .
5. DIMENSION 'ccc' IS MEASURED PARALLEL TO PRIMARY DATUM [C] .
6. PRIMARY DATUM [C] AND SEATING PLANE ARE DEFINED BY THE SPHERICAL
   CROWNS OF THE SOLDER BALLS.
7. PACKAGE SURFACE SHALL BE MATTE FINISH CHARMILLES 24 TO 27.
8. SUBSTRATE MATERIAL BASE IS BT RESIN.
9. THE OVERALL PACKAGE THICKNESS "A" ALREADY CONSIDERS COLLAPSE BALLS
10. DIMENSIONING AND TOLERANCING PER ASME Y14.5M 1994.
11. EXCEPT DIMENSION b.

| Symbols | MIN | NOM | MAX |
|---|---|---|---|
| A | 1.22 | 1.36 | 1.50 |
| A1 | 0.29 | 0.34 | 0.39 |
| A3 | 0.65 | 0.70 | 0.75 |
| c | 0.28 | 0.32 | 0.36 |
| D | 9.85 | 10.00 | 10.15 |
| D1 | | 8.80 BSC | |
| E | 9.85 | 10.00 | 10.15 |
| E1 | | 8.80 BSC | |
| b | 0.43 | 0.48 | 0.53 |
| bbb | | .20 | |
| ddd | | .12 | |
| e | | 0.80 BSC | |
| f | - | 0.60 | - |
| M | | 12 | |
| n | | 108 | |
| REF: JEDEC MO-219F | | | |

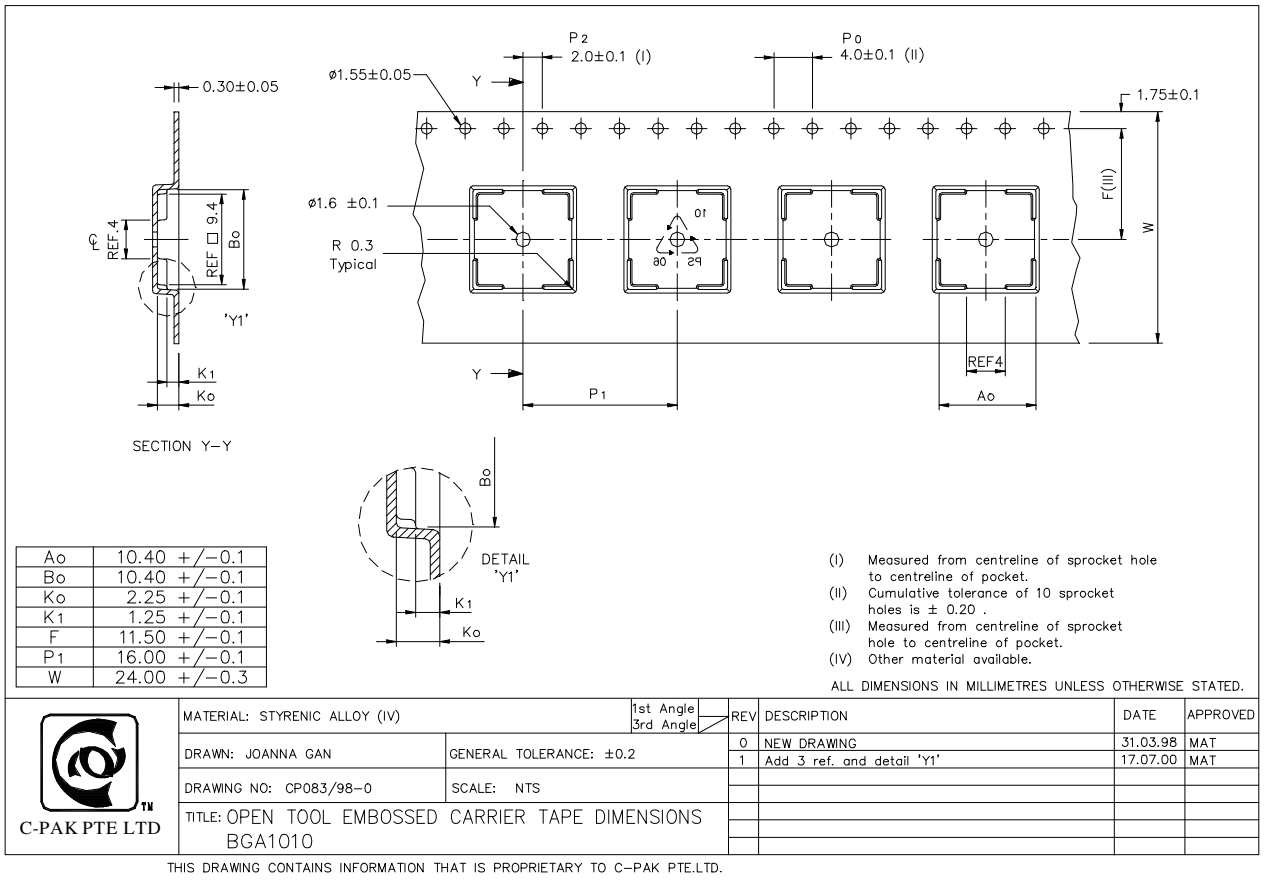
## D.2.2 Tray Dimensions

**Figure D-5. 108-Ball BGA Tray Dimensions**



## D.2.3 Tape and Reel Dimensions

**Figure D-6. 108-Ball BGA Tape and Reel Dimensions**




| | |
|---|---|
| Ao | 10.40 +/–0.1 |
| Bo | 10.40 +/–0.1 |
| Ko | 2.25 +/–0.1 |
| K1 | 1.25 +/–0.1 |
| F | 11.50 +/–0.1 |
| P1 | 16.00 +/–0.1 |
| W | 24.00 +/–0.3 |

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