



Holtek 32-Bit Microcontroller with ARM® Cortex™-M0+ Core

# **HT32F52342/HT32F52352 Series User Manual**

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# 1 Introduction

## Overview

This user manual provides detailed information including how to use the devices, system and bus architecture, memory organization and peripheral instructions. The target audiences for this document are software developers, application developers and hardware developers. For more information regarding pin assignment, package and electrical characteristics, please refer to the datasheet.

The devices are high performance and low power consumption 32-bit microcontrollers based around an ARM® Cortex™-M0+ processor core. The Cortex™-M0+ is a next-generation processor core which is tightly coupled with Nested Vectored Interrupt Controller (NVIC), SysTick timer, and including advanced debug support.

The devices operate at a frequency of up to 48 MHz with a Flash accelerator to obtain maximum efficiency. It provides up to 128 KB of embedded Flash memory for code/data storage and 16 KB of embedded SRAM memory for system operation and application program usage. A variety of peripherals, such as ADC, I<sup>2</sup>C, USART, UART, SPI, I<sup>2</sup>S, GPTM, MCTM, SCI, CRC-16/32, RTC, WDT, PDMA, EBI, USB2.0 FS, SW-DP (Serial Wire Debug Port), etc., are also implemented in the device series. Several power saving modes provide the flexibility for maximum optimization between wakeup latency and power consumption, an especially important consideration in low power applications.

The above features ensure that the devices are suitable for use in a wide range of applications, especially in areas such as white goods application control, power monitors, alarm systems, consumer products, handheld equipment, data logging applications, motor control and so on.

## Features

- Core
  - 32-bit ARM® Cortex™-M0+ processor core
  - Up to 48 MHz operating frequency
  - 0.93 DMIPS/MHz (Dhrystone v2.1)
  - Single-cycle multiplication
  - Integrated Nested Vectored Interrupt Controller (NVIC)
  - 24-bit SysTick timer
- On-chip Memory
  - Up to 128 KB on-chip Flash memory for instruction/data and options storage
  - 16 KB on-chip SRAM
  - Supports multiple boot modes
- Flash Memory Controller – FMC
  - Flash accelerator for maximum efficiency
  - 32-bit word programming with In System Programming Interface (ISP) and In Application Programming (IAP)
  - Flash protection capability to prevent illegal access
- Reset Control Unit – RSTCU
  - Supply supervisor: Power On Reset / Power Down Reset (POR/PDR) and Programmable Low Voltage Detector (LVD)
- Clock Control Unit – CKCU
  - External 4 to 16 MHz crystal oscillator
  - External 32,768 Hz crystal oscillator
  - Internal 8MHz RC oscillator trimmed to  $\pm 2$  % accuracy at 3.3 V operating voltage and 25 °C operating temperature
  - Internal 32 kHz RC oscillator
  - Integrated system clock PLL
  - Independent clock divider and gating bits for peripheral clock sources
- Power management – PWRCU
  - Single  $V_{DD}$  power supply: 2.0 V to 3.6 V
  - Integrated 1.5 V LDO regulator for CPU core, peripherals and memories power supply
  - $V_{BAT}$  battery power supply for RTC and backup registers
  - Three power domains:  $V_{DD}$ , 1.5 V and Backup
  - Four power saving modes: Sleep, Deep-Sleep1, Deep-Sleep2, Power-Down
- External Interrupt/Event Controller – EXTI
  - Up to 16 EXTI lines with configurable trigger source and type
  - All GPIO pins can be selected as EXTI trigger source
  - Source trigger type includes high level, low level, negative edge, positive edge, or both edge
  - Individual interrupt enable, wakeup enable and status bits for each EXTI line
  - Software interrupt trigger mode for each EXTI line
  - Integrated deglitch filter for short pulse blocking

- Analog to Digital Converter – ADC
  - 12-bit SAR ADC engine
  - Up to 1 MSPS conversion rate
  - Up to 12 external analog input channels
- Analog Comparator – CMP
  - Two rail-to-rail comparator
  - Each comparator has configurable negative inputs used for flexible voltage selection
  - Dedicated I/O pin or internal voltage reference provided by 6-bit scaler.
  - Programmable hysteresis
  - Programming speed and consumption
  - Comparator output can be output to I/O or to timers or ADC trigger inputs
  - 6-bit scaler can be configurable to dedicated I/O for voltage reference.
  - Comparator has interrupt generation capability with wakeup from Sleep or Deep Sleep modes through the EXTI controller.
- IO ports – GPIO
  - Up to 51 GPIOs
  - Port A, B, C, D are mapped as 16 external interrupts – EXTI
  - Almost I/O pins are configurable output driving current.
- Motor Control Timer – MCTM
  - One 16-bit up, down, up/down auto-reload counter
  - Up to 4 independent channels
  - 16-bit programmable prescaler allowing dividing the counter clock frequency by any factor between 1 and 65536
  - Input Capture function
  - Compare Match Output
  - PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
  - Single Pulse Mode Output
  - Complementary Outputs with programmable dead-time insertion
  - Supports 3-phase motor control and hall sensor interface
  - Break input to force the timer's output signals into a reset or fixed condition
- PWM Generation and Capture Timer – GPTM
  - One 16-bit up, down, up/down auto-reload counter
  - Up to 4 independent channels for each timer
  - 16-bit programmable prescaler allowing dividing the counter clock frequency by any factor between 1 and 65536
  - Input Capture function
  - Compare Match Output
  - PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
  - Single Pulse Mode Output
  - Encoder interface controller with two inputs using quadrature decoder

- Single Channel Generation and Capture Timers – SCTM
  - One 16-bit up and auto-reload counter
  - One channel for each timer
  - 16-bit programmable prescaler allowing dividing the counter clock frequency by any factor between 1 and 65536
  - Input Capture function
  - Compare Match Output
  - PWM waveform generation with Edge-aligned
  - Single Pulse Mode Output
- Basic Function Timer – BFTM
  - One 32-bit compare/match count-up counter – no I/O control features
  - One shot mode – counting stops after a match condition
  - Repetitive mode – restart counter after a match condition
- Watchdog Timer
  - 12-bit down counter with 3-bit prescaler
  - Reset event for the system
  - Programmable watchdog timer window function
  - Registers write protection function
- Real Time Clock – RTC
  - 32-bit up-counter with a programmable prescaler
  - Alarm function
  - Interrupt and Wake-up event
- Inter-integrated Circuit – I<sup>2</sup>C
  - Supports both master and slave modes with a frequency of up to 1 MHz
  - Provide an arbitration function and clock synchronization
  - Supports 7-bit and 10-bit addressing modes and general call addressing
  - Supports slave multi-addressing mode with maskable address
- Serial Peripheral Interface – SPI
  - Supports both master and slave mode
  - Frequency of up to ( $f_{\text{PCLK}}/2$ ) MHz for master mode and ( $f_{\text{PCLK}}/3$ ) MHz for slave mode
  - FIFO Depth: 8 levels
  - Multi-master and multi-slave operation
- Universal Synchronous Asynchronous Receiver Transmitter – USART
  - Supports both asynchronous and clocked synchronous serial communication modes
  - Asynchronous operating baud rate up to ( $f_{\text{PCLK}}/16$ ) MHz and synchronous operating rate up to ( $f_{\text{PCLK}}/8$ ) MHz
  - Capability of full duplex communication
  - Fully programmable characteristics of serial communication including: word length, parity bit, stop bit and bit order
  - Error detection: Parity, overrun, and frame error
  - Support Auto hardware flow control mode – RTS, CTS
  - IrDA SIR encoder and decoder
  - RS485 mode with output enable control
  - FIFO Depth:  $8 \times 9$  bits for both receiver and transmitter

- Universal Asynchronous Receiver Transmitter – UART
  - Asynchronous serial communication operating baud-rate up to ( $f_{CLK}/16$ ) MHz
  - Capability of full duplex communication
  - Fully programmable characteristics of serial communication including: word length, parity bit, stop bit and bit order
  - Error detection: Parity, overrun, and frame error
- Smart Card Interface – SCI
  - Supports ISO 7816-3 Standard
  - Character mode
  - Single transmit buffer and single receive buffer
  - 11-bit ETU (elementary time unit) counter
  - 9-bit guard time counter
  - 24-bit general purpose waiting time counter
  - Parity generation and checking
  - Automatic character retry on parity error detection in transmission and reception modes
- Inter-IC Sound – I<sup>2</sup>S
  - Master or slave mode
  - Mono and stereo
  - I<sup>2</sup>S-justified, Left-justified, and Right-justified mode
  - 8/16/24/32-bit sample size with 32-bit channel extended
  - 8 × 32-bit Tx & Rx FIFO with PDMA supported
  - 8-bit Fractional Clock Divider with rate control
- Cyclic Redundancy Check – CRC
  - Support CRC16 polynomial: 0x8005,  $X^{16}+X^{15}+X^2+1$
  - Support CCITT CRC16 polynomial: 0x1021,  $X^{16}+X^{12}+X^5+1$
  - Support IEEE-802.3 CRC32 polynomial: 0x04C11DB7,  $X^{32}+X^{26}+X^{23}+X^{22}+X^{16}+X^{12}+X^{11}+X^{10}+X^8+X^7+X^5+X^4+X^2+X+1$
  - Support 1's complement, byte reverse & bit reverse operation on data and checksum
  - Support byte, half-word & word data size
  - Programmable CRC initial seed value
  - CRC computation done in 1 AHB clock cycle for 8-bit data and 4 AHB clock cycles for 32-bit data
  - Support PDMA to complete a CRC computation of a block of memory
- Peripheral Direct Memory Access – PDMA
  - 6 channels with trigger source grouping
  - 8/16/32-bit width data transfer
  - Supports Address increment, decrement or fixed mode
  - 4-level programmable channel priority
  - Auto reload mode
  - Supports trigger sources:  
ADC, SPI, USART, UART, I<sup>2</sup>C, I<sup>2</sup>S, EBI, GPTM, MCTM, SCI and software request

- External Bus Interface – EBI
  - Programmable interface for various memory types
  - Translate the AHB transactions into the appropriate external device protocol
  - Individual chip select signal for per memory bank
  - Programmable timing to support a wide range of devices
  - Automatic translation when AHB transaction width and external memory interface width is different
  - Write buffer to decrease the stalling of the AHB write burst transaction
  - Support multiplexed and non-multiplexed address and data line configurations
  - Multiplexed address and data line configurations
  - Up to 21 address lines
  - Up to 16-bit data bus width
- Universal Serial Bus Device Controller – USB
  - Complies with USB 2.0 full-speed (12Mbps) specification
  - On-chip USB full-speed transceiver
  - 1 control endpoint (EP0) for control transfer
  - 3 single-buffered endpoints for bulk and interrupt transfer
  - 4 double-buffered endpoints for bulk, interrupt and isochronous transfer
  - 1KB EP-SRAM used as the endpoint data buffers
- Debug Support
  - Serial Wire Debug Port – SW-DP
  - 4 comparators for hardware breakpoint or code / literal patch
  - 2 comparators for hardware watchpoints
- Package and Operation Temperature
  - 48/64-pin LQFP package
  - Operation temperature range: -40 °C to +85 °C

## Device Information

**Table 1. Series Features and Peripheral List**

| Peripherals             |                  | HT32F52342      | HT32F52352 |
|-------------------------|------------------|-----------------|------------|
| Main Flash (KB)         |                  | 64              | 127.5      |
| Option Bytes Flash (KB) |                  | 0.5             | 0.5        |
| SRAM (KB)               |                  | 8               | 16         |
| Timers                  | MCTM             | 1               |            |
|                         | GPTM             | 2               |            |
|                         | SCTM             | 2               |            |
|                         | BFTM             | 2               |            |
|                         | RTC              | 1               |            |
|                         | WDT              | 1               |            |
| Communication           | USB              | 1               |            |
|                         | SPI              | 2               |            |
|                         | USART            | 2               |            |
|                         | UART             | 2               |            |
|                         | I <sup>2</sup> C | 2               |            |
|                         | I <sup>2</sup> S | 1               |            |
|                         | SCI (ISO7816-3)  | 2               |            |
| PDMA                    |                  | 6 channels      |            |
| EBI                     |                  | 1               |            |
| CRC-16/32               |                  | 1               |            |
| EXTI                    |                  | 16              |            |
| 12-bit ADC              |                  | 1               |            |
| Number of channels      |                  | 12 Channels     |            |
| Comparator              |                  | 2               |            |
| GPIO                    |                  | Up to 51        |            |
| CPU frequency           |                  | Up to 48 MHz    |            |
| Operating voltage       |                  | 2.0 V ~ 3.6 V   |            |
| Operating temperature   |                  | -40 °C ~ +85 °C |            |
| Package                 |                  | 48/64-pin LQFP  |            |

## Introduction



## 2 Document Conventions

The conventions used in this document are shown in the following table.

**Table 2. Document Conventions**

| Notation    | Example                                                                                                                                                                                                                                                                                                                                                                                                      | Description                                                                                                                                                                                                                      |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x          | 0x5a05                                                                                                                                                                                                                                                                                                                                                                                                       | The number string with a 0x prefix indicates a hexadecimal number.                                                                                                                                                               |
| 0xnnnn_nnnn | 0x2000_0100                                                                                                                                                                                                                                                                                                                                                                                                  | 32-bit Hexadecimal address or data.                                                                                                                                                                                              |
| b           | b0101                                                                                                                                                                                                                                                                                                                                                                                                        | The number string with a lowercase b prefix indicates a binary number.                                                                                                                                                           |
| NAME [n]    | ADDR [5]                                                                                                                                                                                                                                                                                                                                                                                                     | Specific bit of NAME. NAME can be a register or field of register. For example, ADDR [5] means bit 5 of ADDR register (field).                                                                                                   |
| NAME [m:n]  | ADDR [11:5]                                                                                                                                                                                                                                                                                                                                                                                                  | Specific bits of NAME. NAME can be a register or field of register. For example, ADDR [11:5] means bit 11 to 5 of ADDR register (field).                                                                                         |
| X           | b10X1                                                                                                                                                                                                                                                                                                                                                                                                        | Don't care notation which means any value is allowed.                                                                                                                                                                            |
| RW          | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">             19<br/> <div style="border: 1px solid black; padding: 2px;">SERDYIE</div>             RW 0           </div> <div style="text-align: center;">             18<br/> <div style="border: 1px solid black; padding: 2px;">PLLRDYIE</div>             RW 0           </div> </div> | Software can read and write to this bit.                                                                                                                                                                                         |
| RO          | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">             3<br/> <div style="border: 1px solid black; padding: 2px;">HSIRDY</div>             RO 1           </div> <div style="text-align: center;">             2<br/> <div style="border: 1px solid black; padding: 2px;">HSERDY</div>             RO 0           </div> </div>      | Software can only read this bit. A write operation will have no effect.                                                                                                                                                          |
| RC          | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">             1<br/> <div style="border: 1px solid black; padding: 2px;">PDF</div>             RC 0           </div> <div style="text-align: center;">             0<br/> <div style="border: 1px solid black; padding: 2px;">BAK_PORF</div>             RC 1           </div> </div>       | Software can only read this bit. Read operation will clear it to 0 automatically.                                                                                                                                                |
| WC          | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">             3<br/> <div style="border: 1px solid black; padding: 2px;">SERDYF</div>             WC 0           </div> <div style="text-align: center;">             2<br/> <div style="border: 1px solid black; padding: 2px;">PLLRDYF</div>             WC 0           </div> </div>     | Software can read this bit or clear it by writing 1. Writing a 0 will have no effect.                                                                                                                                            |
| WO          | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">             31<br/> <div style="border: 1px solid black; padding: 2px;"></div>             WO 0           </div> <div style="text-align: center;">             30<br/> <div style="border: 1px solid black; padding: 2px;">DB_CKSRC</div>             WO 0           </div> </div>        | Software can only write to this bit. A read operation always returns 0.                                                                                                                                                          |
| Reserved    | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">             1<br/> <div style="border: 1px solid black; padding: 2px;">LLRDY</div>             RO 0           </div> <div style="text-align: center;">             0<br/> <div style="border: 1px solid black; padding: 2px;">Reserved</div> </div> </div>                                | Reserved bit(s) for future use. Data read from these bits is not well defined and should be treated as random data. Normally these reserved bits should be set to a 0 value. Note that reserved bit must be kept at reset value. |
| Word        |                                                                                                                                                                                                                                                                                                                                                                                                              | Data length of a word is 32-bit.                                                                                                                                                                                                 |
| Half-word   |                                                                                                                                                                                                                                                                                                                                                                                                              | Data length of a half-word is 16-bit.                                                                                                                                                                                            |
| Byte        |                                                                                                                                                                                                                                                                                                                                                                                                              | Data length of a byte is 8-bit.                                                                                                                                                                                                  |

## 3 System Architecture

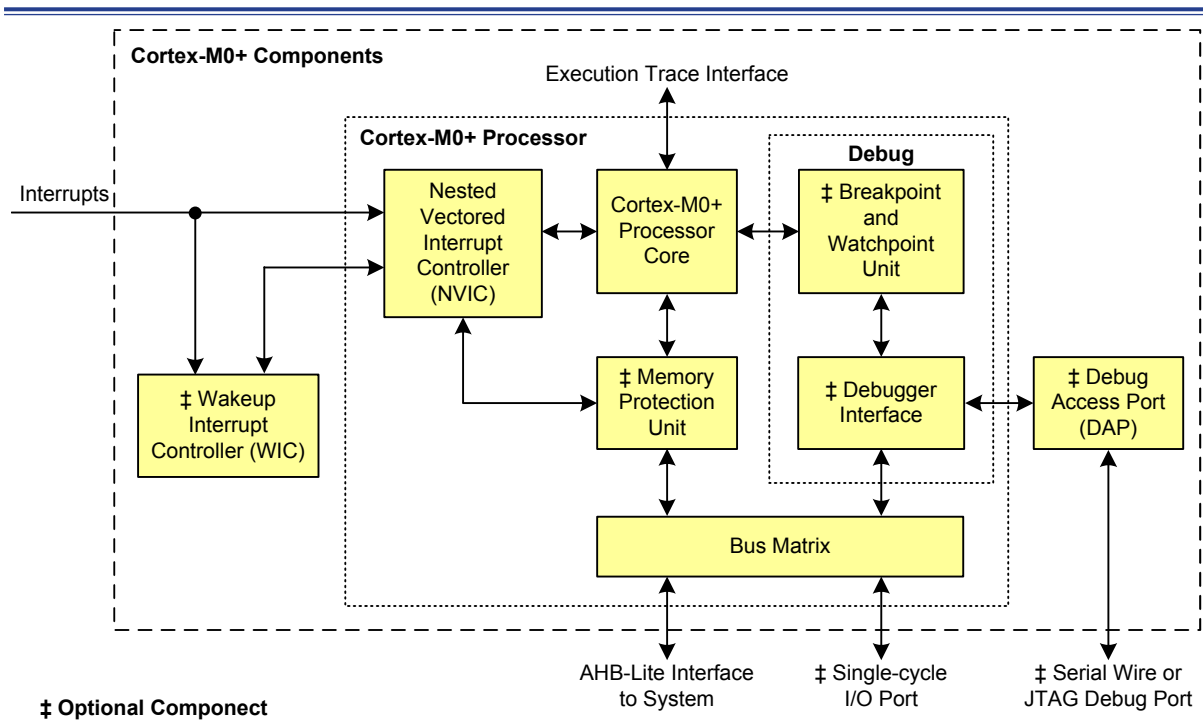
The system architecture of devices that includes the ARM® Cortex™-M0+ processor, bus architecture and memory organization will be described in the following sections. The Cortex™-M0+ is a next generation processor core which offers many new features. Integrated and advanced features make the Cortex™-M0+ processor suitable for market products that require microcontrollers with high performance and low power consumption. In brief, The Cortex™-M0+ processor includes AHB-Lite bus interface. All memory accesses of the Cortex™-M0+ processor are executed on the AHB-Lite bus according to the different purposes and the target memory spaces. The memory organization uses a Harvard architecture, pre-defined memory map and up to 4 GB of memory space, making the system flexible and extendable.

### ARM® Cortex™-M0+ Processor

The Cortex™-M0+ processor is a very low gate count, highly energy efficient processor that is intended for microcontroller and deeply embedded applications that require an area optimized, low-power processor. The processor is based on the ARMv6-M architecture and supports Thumb® instruction sets; single-cycle I/O port; hardware multiplier and low latency interrupt respond time. Some system peripherals listed below are also provided by Cortex™-M0+:

- Internal Bus Matrix connected with AHB-Lite Interface, Single-cycle I/O port and Debug Accesses Port (DAP)
- Nested Vectored Interrupt Controller (NVIC)
- Optional Wakeup Interrupt Controller (WIC)
- Breakpoint and Watchpoint Unit
- Optional Memory Protection Unit (MPU)
- Serial Wire debug Port (SW-DP)
- Optional Micro Trace Buffer Interface (MTB)

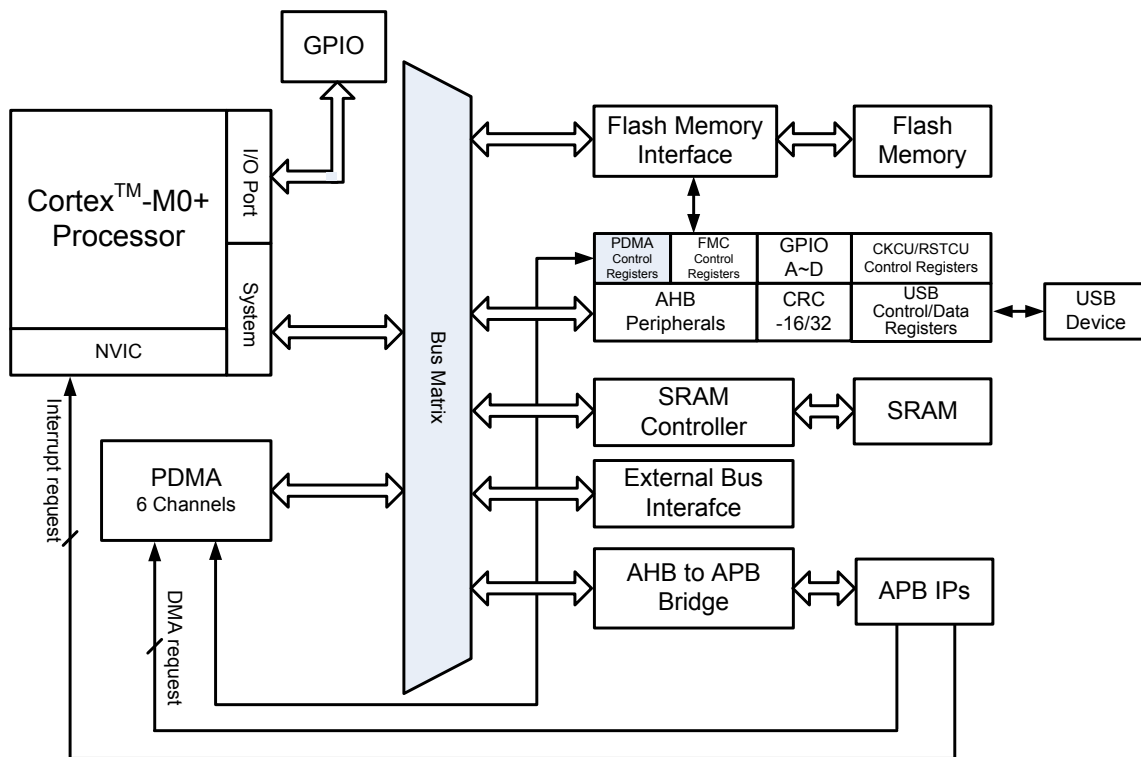
The following figure shows the Cortex™-M0+ processor block diagram. For more information, refer to the ARM® Cortex™-M0+ Technical Reference Manual.



**Figure 2. Cortex™-M0+ Block Diagram**

## Bus Architecture

The HT32F52342/52352 series consist of two masters and five slaves in the bus architecture. The Cortex™-M0+ AHB-Lite bus and Peripheral Direct Memory Access (PDMA) are the masters while the internal SRAM access bus, the internal Flash memory access bus, the AHB peripherals access bus, External Bus Interface (EBI) and the AHB to APB bridges are the slaves. The single 32-bit AHB-Lite system interface provides simple integration to all system regions include the internal SRAM region and the peripheral region. All of the master buses are based on 32-bit Advanced High-performance Bus-Lite (AHB-Lite) protocol. The following figure shows the bus architecture of the HT32F52342/52352 series.



**Figure 3. Bus Architecture**

## Memory Organization

The ARM® Cortex™-M0+ processor accesses and debug accesses share the single external interface to external AHB peripheral. The processor accesses take priority over debug accesses. The maximum address range of the Cortex™-M0+ is 4 GB since it has 32-bit bus address width. Additionally, a pre-defined memory map is provided by the Cortex™-M0+ processor to reduce the software complexity of repeated implementation of different device vendors. However, some regions are used by the ARM® Cortex™-M0+ system peripherals. Refer to the ARM® Cortex™-M0+ Technical Reference Manual for more information. The following figure shows the memory map of HT32F52342/52352 series of devices, including Code, SRAM, peripheral, and other pre-defined regions.

## Memory Map

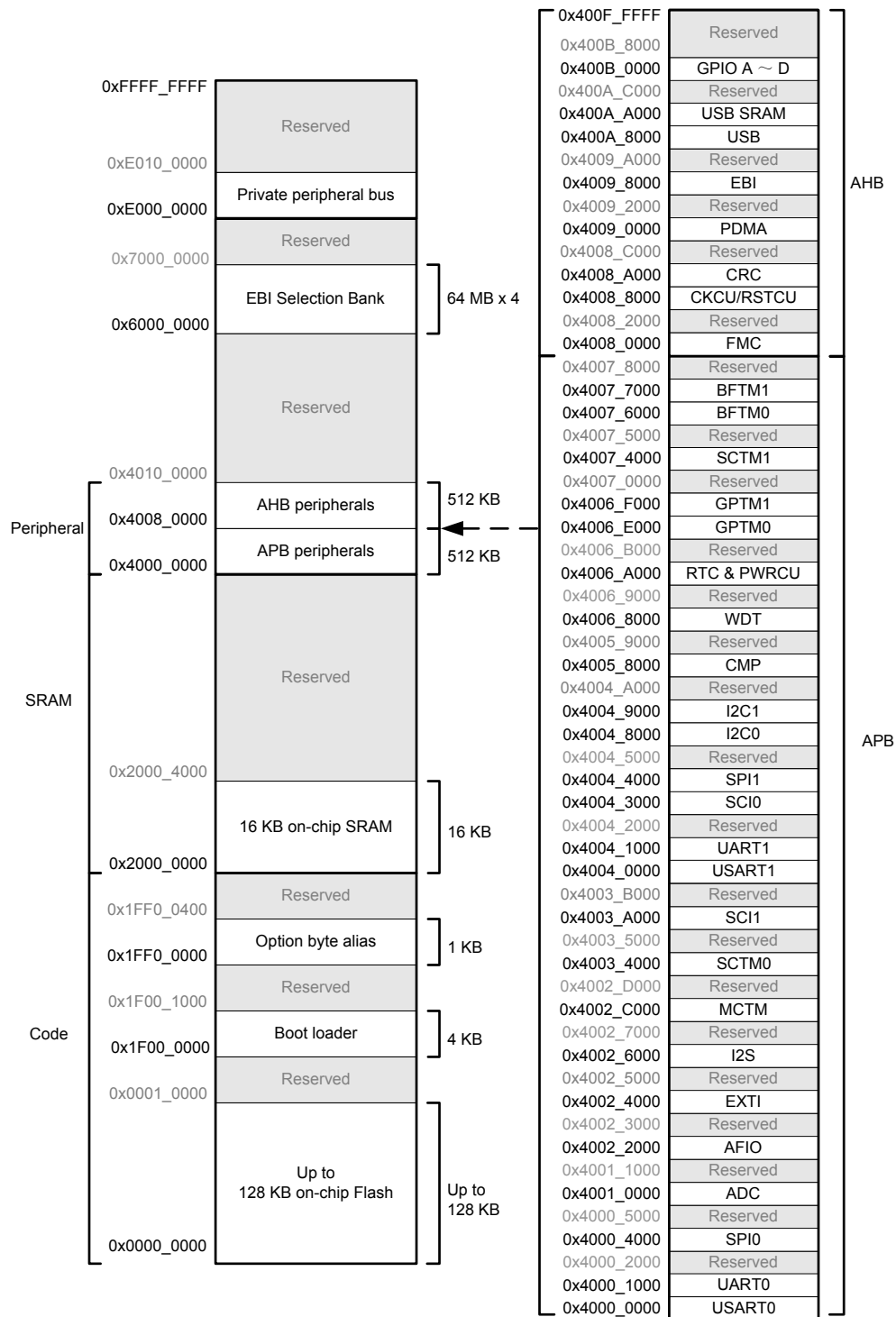


Figure 4. Memory Map

**Table 3. Register Map**

| Start Address | End Address | Peripheral       | Bus |
|---------------|-------------|------------------|-----|
| 0x4000_0000   | 0x4000_0FFF | USART0           | APB |
| 0x4000_1000   | 0x4000_1FFF | UART0            |     |
| 0x4000_2000   | 0x4000_3FFF | Reserved         |     |
| 0x4000_4000   | 0x4000_4FFF | SPI0             |     |
| 0x4000_5000   | 0x4001_9FFF | Reserved         |     |
| 0x4001_0000   | 0x4001_0FFF | ADC              |     |
| 0x4001_1000   | 0x4002_1FFF | Reserved         |     |
| 0x4002_2000   | 0x4002_2FFF | AFIO             |     |
| 0x4002_3000   | 0x4002_3FFF | Reserved         |     |
| 0x4002_4000   | 0x4002_4FFF | EXTI             |     |
| 0x4002_5000   | 0x4002_BFFF | Reserved         |     |
| 0x4002_6000   | 0x4002_6FFF | I <sup>2</sup> S |     |
| 0x4002_7000   | 0x4002_BFFF | Reserved         |     |
| 0x4002_C000   | 0x4002_CFFF | MCTM             |     |
| 0x4002_D000   | 0x4003_3FFF | Reserved         |     |
| 0x4003_4000   | 0x4003_4FFF | SCTM0            |     |
| 0x4003_5000   | 0x4003_9FFF | Reserved         |     |
| 0x4003_A000   | 0x4003_AFFF | SCI1             |     |
| 0x4003_C000   | 0x4004_0FFF | Reserved         |     |
| 0x4004_0000   | 0x4004_0FFF | USART1           |     |
| 0x4004_1000   | 0x4004_1FFF | UART1            |     |
| 0x4004_2000   | 0x4004_2FFF | Reserved         |     |
| 0x4004_3000   | 0x4004_3FFF | SCI0             |     |
| 0x4004_4000   | 0x4004_4FFF | SPI1             |     |
| 0x4004_5000   | 0x4004_7FFF | Reserved         |     |
| 0x4004_8000   | 0x4004_8FFF | I2C0             |     |
| 0x4004_9000   | 0x4004_9FFF | I2C1             |     |
| 0x4004_A000   | 0x4005_7FFF | Reserved         |     |
| 0x4005_8000   | 0x4005_8FFF | Comparator       |     |
| 0x4005_9000   | 0x4006_7FFF | Reserved         |     |
| 0x4006_8000   | 0x4006_8FFF | WDT              |     |
| 0x4006_9000   | 0x4006_9FFF | Reserved         |     |
| 0x4006_A000   | 0x4006_AFFF | RTC/PWRCU        |     |
| 0x4006_B000   | 0x4006_DFFF | Reserved         |     |
| 0x4006_E000   | 0x4006_EFFF | GPTM0            |     |
| 0x4006_F000   | 0x4006_FFFF | GPTM1            |     |
| 0x4007_0000   | 0x4007_3FFF | Reserved         |     |
| 0x4007_4000   | 0x4007_4FFF | SCTM1            |     |
| 0x4007_5000   | 0x4007_5FFF | Reserved         |     |
| 0x4007_6000   | 0x4007_6FFF | BFTM0            |     |
| 0x4007_7000   | 0x4007_7FFF | BFTM1            |     |
| 0x4007_8000   | 0x4007_FFFF | Reserved         |     |

| Start Address | End Address | Peripheral             | Bus |
|---------------|-------------|------------------------|-----|
| 0x4008_0000   | 0x4008_1FFF | FMC                    | AHB |
| 0x4008_2000   | 0x4008_7FFF | Reserved               |     |
| 0x4008_8000   | 0x4008_9FFF | CKCU/RSTCU             |     |
| 0x4008_A000   | 0x4008_BFFF | CRC                    |     |
| 0x4008_C000   | 0x4008_FFFF | Reserved               |     |
| 0x4009_0000   | 0x4009_1FFF | PDMA Control Registers |     |
| 0x4009_2000   | 0x400C_BFFF | Reserved               |     |
| 0x4009_8000   | 0x4009_9FFF | EBI Control Registers  |     |
| 0x4009_A000   | 0x400A_7FFF | Reserved               |     |
| 0x400A_8000   | 0x400A_BFFF | USB                    |     |
| 0x400A_C000   | 0x400A_FFFF | Reserved               |     |
| 0x400B_0000   | 0x400B_1FFF | GPIOA                  |     |
| 0x400B_2000   | 0x400B_3FFF | GPIOB                  |     |
| 0x400B_4000   | 0x400B_5FFF | GPIOC                  |     |
| 0x400B_6000   | 0x400B_7FFF | GPIOD                  |     |
| 0x400B_8000   | 0x400F_FFFF | Reserved               |     |

## Embedded Flash Memory

The HT32F52342/52352 series provide up to 128 KB on-chip Flash memory which is located at address 0x0000\_0000. It supports byte, half-word, and word access operations. Note that the Flash memory only supports read operations for the bus access. Any write operations to the Flash memory will cause a bus fault exception. The Flash memory has up to capacity of 128 pages. Each page has a memory capacity of 1 KB and can be erased independently. A 32-bit programming interface provides the capability of changing bits from 1 to 0. A data storage or firmware upgrade can be implemented using several methods such as In System Programming (ISP), In Application Programming (IAP) or In Circuit Programming (ICP). For more information, refer to the Flash Memory Controller section.

## Embedded SRAM Memory

The HT32F52342/52352 series contain up to 16 KB on-chip SRAM which is located at address 0x2000\_0000. It support byte, half-word and word access operations.

## AHB Peripherals

The address of the AHB peripherals ranges from 0x4008\_0000 to 0x400F\_FFFF. Some peripherals such as Clock Control Unit, Reset Control Unit and Flash Memory Controller are connected to the AHB bus directly. The AHB peripherals clocks are always enabled after a system reset. Access to registers for these peripherals can be achieved directly via the AHB bus. Note that all peripheral registers in the AHB bus support only word access.

## APB Peripherals

The address of APB peripherals ranges from 0x4000\_0000 to 0x4007\_FFFF. An APB to AHB Bridge provides access capability between the CPU and the APB peripherals. Additionally, the APB peripheral clocks are disabled after a system reset. Software must enable the peripheral clock by setting up the APBCCRN register in the Clock Control Unit before accessing the corresponding peripheral register. Note that the APB to AHB Bridge will duplicate the half-word or byte data to word width when a half-word or byte access is performed on the APB peripheral registers. In other words, the access result of a half-word or byte access on the APB peripheral register will vary depending on the data bit width of the access operation on the peripheral registers.

## 4 Flash Memory Controller (FMC)

### Introduction

The Flash Memory Controller (FMC) provides functions of flash operation and pre-fetch buffer for the embedded on-chip Flash memory. Figure below shows the block diagram of FMC which includes programming interface, control register, pre-fetch buffer, and access interface. Since the access speed of Flash memory is slower than the CPU, a wide access interface with pre-fetch buffer is provided to the Flash memory in order to reduce the wait state (which will cause instruction gaps) of the CPU. The functions of word program/page erase are also provided for instruction/data storage of Flash memory.

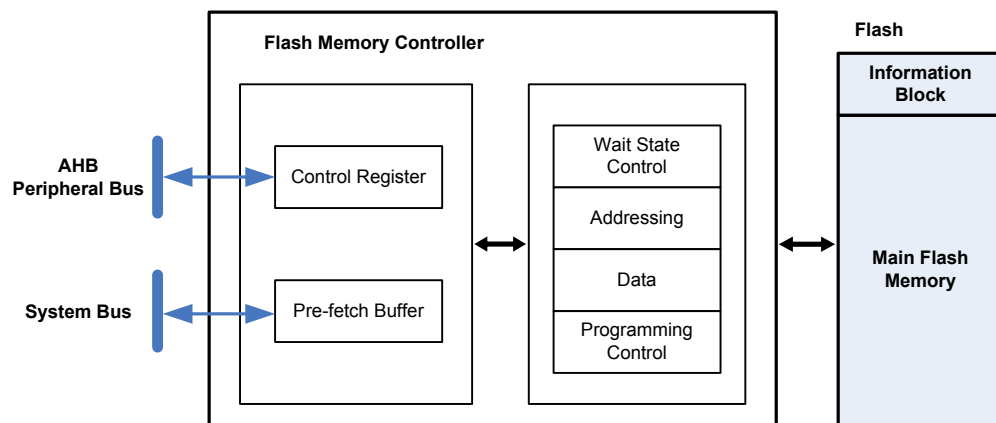


Figure 5. Flash Memory Controller Block Diagram

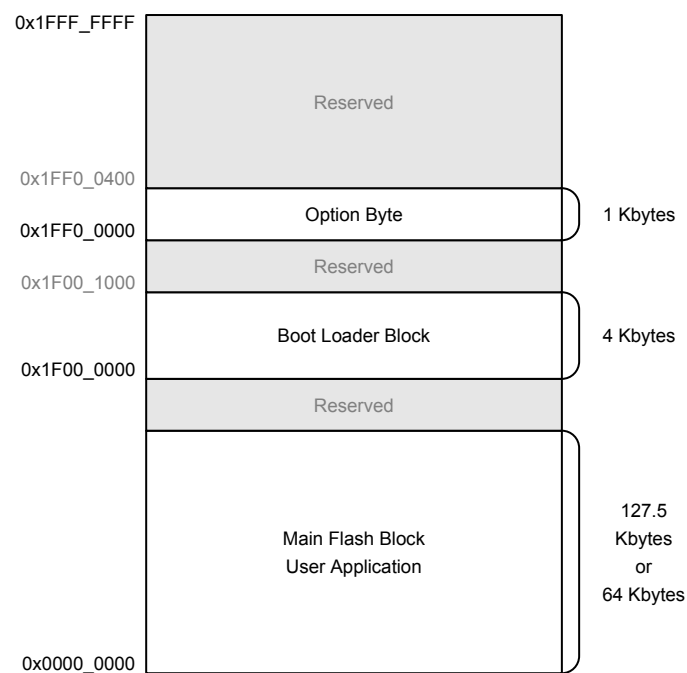
### Features

- Up to 128 KB of on-chip Flash memory for storing instruction/data and options
  - 128 KB (instruction/data + Option Byte)
  - 64 KB (instruction/data + Option Byte)
- Page size of 512 Bytes, totally up to 256 pages depending on the main Flash size
- Wide access interface with pre-fetch buffer to reduce instruction gaps
- Page erase and mass erase capability
- 32-bit word programming
- Interrupt capability when ready or error occurs
- Flash read protection to prevent illegal code/data access
- Page erase/program protection to prevent unexpected operation

## Functional Descriptions

### Flash Memory Map

The following figure is the Flash memory map of the system. The address ranges from 0x0000\_0000 to 0x1FFF\_FFFF (0.5 GB). The address from 0x1F00\_0000 to 0x1F00\_0FFF is mapped to Boot Loader Block (4 KB). Besides, address 0x1FF0\_0000 to 0x1FF0\_03FF is the alias of Option Byte block (1 KB) which locates at the last page of main Flash physically. The memory mapping on system view is shown as below.



**Figure 6. Flash Memory Map**

## Flash Memory Architecture

The Flash memory consists of up to 128 KB main Flash with 512 Bytes per page and 4 KB Information Block for Boot Loader. The main Flash memory contains totally 256 pages (or 128 pages for 64 KB device) which can be erased individually. The following table shows the base address, size, and protection setting bit of each page.

**Table 4. Flash Memory and Option Byte**

| Block             | Name                   | Address                                                                 | Page Protection Bit | Size      |
|-------------------|------------------------|-------------------------------------------------------------------------|---------------------|-----------|
| Main Flash Block  | Page 0                 | 0x0000_0000 ~ 0x0000_01FF                                               | OB_PP [0]           | 512 Bytes |
|                   | Page 1                 | 0x0000_0200 ~ 0x0000_03FF                                               |                     | 512 Bytes |
|                   | Page 2                 | 0x0000_0400 ~ 0x0000_05FF                                               | OB_PP [1]           | 512 Bytes |
|                   | Page 3                 | 0x0000_0600 ~ 0x0000_07FF                                               |                     | 512 Bytes |
|                   | ⋮                      | ⋮                                                                       | ⋮                   | ⋮         |
|                   | Page 252               | 0x0001_F800 ~ 0x0001_F9FF                                               | OB_PP [126]         | 512 Bytes |
|                   | Page 253               | 0x0001_FA00 ~ 0x0001_FBFF                                               |                     | 512 Bytes |
|                   | Page 254               | 0x0001_FC00 ~ 0x0001_FDFF                                               | OB_PP [127]         | 512 Bytes |
|                   | Page 255 (Option Byte) | Physical: 0x0001_FE00 ~ 0x0001_FFFF<br>Alias: 0x1FF0_0000 ~ 0x1FF0_01FF | OB_CP [1]           | 512 Bytes |
| Information Block | Boot Loader            | 0x1F00_0000 ~ 0x1F00_0FFF                                               | NA                  | 4 KB      |

**Notes:** 1. Information Block stores boot loader, this block can not be programmed or erased by user.  
2. Option Byte is always located at last page of main Flash block.

## Wait State Setting

When the HCLK clock is greater than access speed of Flash memory, the wait state cycles must be inserted during the CPU fetch instructions or load data from Flash memory. The wait state can be changed by setting WAIT [2:0] of Flash Cache and Pre-fetch Control Register (CFPR). In order to fit the requirement of wait state, the following two rules shall be considered.

- HCLK clock is changed from lower to higher: Change the wait state setting first and then change the HCLK clock.
- HCLK clock is changed from higher to lower: Change the HCLK clock first and then change the wait state setting.

The following table shows the relationship between the wait state cycle and HCLK. The default wait state is 0 since the HSI (8 MHz) is selected as HCLK clock source after system reset.

**Table 5. Relationship Between Wait State Cycle and HCLK**

| Wait State Cycle | HCLK                   |
|------------------|------------------------|
| 0                | 0 MHz < HCLK ≤ 24 MHz  |
| 1                | 24 MHz < HCLK ≤ 48 MHz |

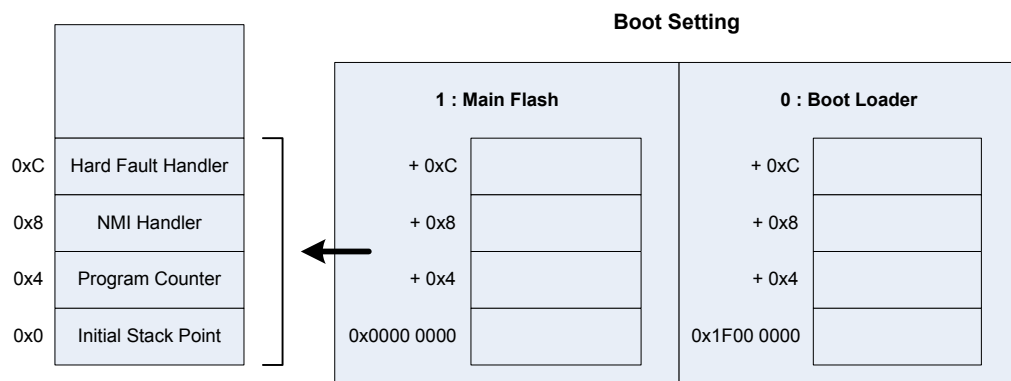
## Booting Configuration

The system provides two kinds of booting mode which can be selected through BOOT pin. The value of BOOT pin is sampled during the power-on reset or system reset. Once the value is decided, the first 4 words of vector will be remapped to the corresponding source according to the booting mode. The booting mode is shown in the following table.

**Table 6. Booting Modes**

| Booting mode selection pin<br>BOOT | Mode        | Descriptions                        |
|------------------------------------|-------------|-------------------------------------|
| 0                                  | Boot Loader | The source of Vector is Boot Loader |
| 1                                  | Main Flash  | The source of Vector is main Flash  |

The Vector Mapping Control Register (VMCR) is provided to change the setting of the vector remapping temporarily after the chip reset. The reset value of VMCR is determined by the value of BOOT pin which will be sampled during the reset.



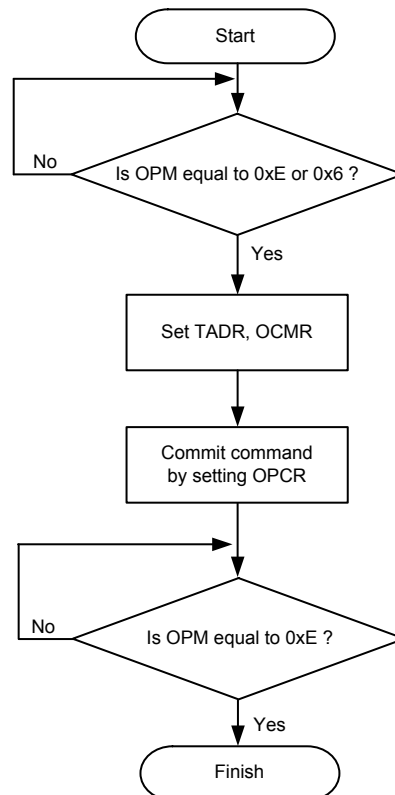
**Figure 7. Vector Remapping**

## Page Erase

The FMC provides a page erase function which is used to reset partial content of Flash memory. Any page can be erased independently without affecting others. The following steps show the access sequence of the register for page erase.

- Check OPCR register to confirm that no Flash memory operation is ongoing (OPM [3:0] equal to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write the page address to TADR register
- Write page erase command to OCMR register (CMD [3:0] = 0x8).
- Commit page erase command to FMC by setting OPCR register (set OPM [3:0] = 0xA).
- Wait until all the operations have been completed by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the page if required.

Note that a correct address of the target page must be confirmed. Software may run away if the target erase page is being used for fetching code or accessing data and FMC will not notify when this happens. Besides, the page erase will be ignored on the protected pages. A Flash Operation Error interrupt will be triggered by FMC if the OREIEN bit in the OIER register is set. Software can check the PPEF bit in the OISR register to detect this condition in the interrupt handler. The following figure displays the flow of page erase operation.



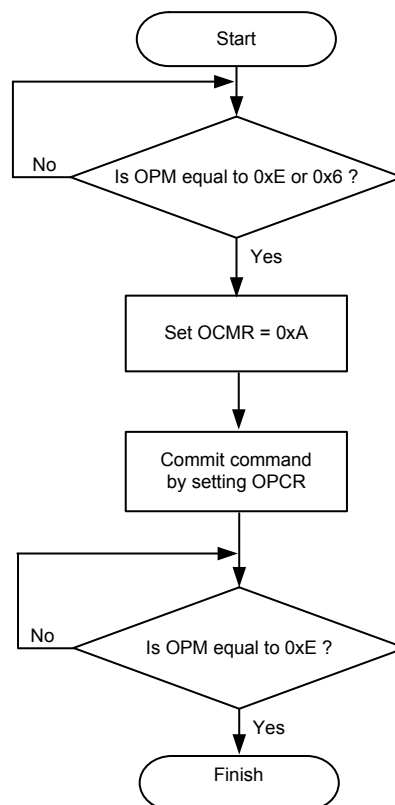
**Figure 8. Page Erase Operation Flowchart**

## Mass Erase

The FMC provides a complete erase function which is used for resetting all the main Flash memory content. The following steps show the sequence of the register access for mass erase.

- Check OPCR register to confirm that no Flash memory operation is ongoing (OPM [3:0] equal to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write mass erase command to OCMR register (CMD [3:0] = 0xA).
- Commit mass erase command to FMC by setting OPCR register (set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Flash memory if required.

Since all Flash data will be reset as 0xFFFF\_FFFF, the mass erase operation can be done by the program that runs in the SRAM or by the debugging tool that access FMC register directly. The software function that is executed on the Flash memory shall not trigger a mass erase operation. The following figure displays the flow of mass erase operation.



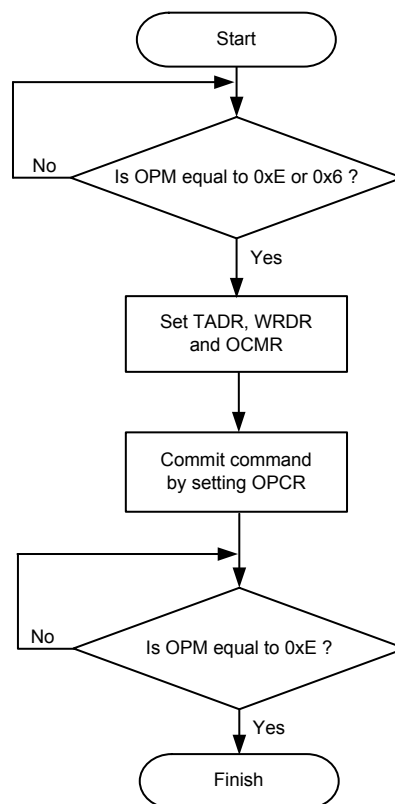
**Figure 9. Mass Erase Operation Flowchart**

## Word Programming

The FMC provides a 32 bits word programming function which is used for modifying the Flash memory content. The following steps show the sequence of register access for word programming.

- Check OPCR register to confirm that no Flash memory operation is ongoing (OPM [3:0] equal to 0xE, or 0x6). Otherwise, wait until the previous operation has been finished.
- Write word address to TADR register. Write data to WRDR register.
- Write word program command to OCMR register (CMD [3:0] = 0x4).
- Commit word program command to FMC by setting OPCR register (set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Flash memory if required.

Note that the word programming operation can not be applied to the same address twice. Successive word programming operation to the same address must be separated by a page erase operation. Besides, the word program will be ignored on protected pages. A Flash operation error interrupt will be triggered by FMC if the OREIEN bit in the OIER register is set. Software can check the PPEF bit in the OISR register to detect this condition in the interrupt handler. The following figure displays the flow of word programming operation.



**Figure 10. Word Programming Operation Flowchart**

## Option Byte Description

The Option Byte can be treated as an independent Flash memory which base address is 0x1FF0\_0000. The following table shows the function description and memory map of Option Byte.

**Table 7. Option Byte Memory Map**

| Option Byte                                                                                                                                                                                                                                                                                                                   | Offset | Description                                                    | Reset Value |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------|-------------|
| Option Byte Base Address = 0x1FF0_0000                                                                                                                                                                                                                                                                                        |        |                                                                |             |
| OB_PP                                                                                                                                                                                                                                                                                                                         | 0x000  | Flash Page Erase/Program Protection (page 254 ~ page 0)        | 0xFFFF_FFFF |
|                                                                                                                                                                                                                                                                                                                               | 0x004  | OB_PP [n] (n = 0 ~ 127)                                        | 0xFFFF_FFFF |
|                                                                                                                                                                                                                                                                                                                               | 0x008  | 0: Flash Page 2n and 2n+1 Erase/Program Protection is enabled  | 0xFFFF_FFFF |
|                                                                                                                                                                                                                                                                                                                               | 0x00C  | 1: Flash Page 2n and 2n+1 Erase/Program Protection is disabled | 0xFFFF_FFFF |
| OB_CP                                                                                                                                                                                                                                                                                                                         | 0x010  | Flash Security Protection                                      | 0xFFFF_FFFF |
|                                                                                                                                                                                                                                                                                                                               |        | OB_CP [0]                                                      |             |
|                                                                                                                                                                                                                                                                                                                               |        | 0: Flash Security protection is enabled                        |             |
|                                                                                                                                                                                                                                                                                                                               |        | 1: Flash Security protection is disabled                       |             |
|                                                                                                                                                                                                                                                                                                                               |        | Option Byte Protection                                         |             |
| OB_CK                                                                                                                                                                                                                                                                                                                         | 0x020  | OB_CP [1]                                                      | 0xFFFF_FFFF |
|                                                                                                                                                                                                                                                                                                                               |        | 0: Option Byte protection is enabled                           |             |
|                                                                                                                                                                                                                                                                                                                               |        | 1: Option Byte protection is disabled                          |             |
|                                                                                                                                                                                                                                                                                                                               |        | OB_CP [31:2]                                                   |             |
|                                                                                                                                                                                                                                                                                                                               |        | Reserved                                                       |             |
| OB_CK                                                                                                                                                                                                                                                                                                                         | 0x020  | Flash Option Byte Checksum                                     | 0xFFFF_FFFF |
|                                                                                                                                                                                                                                                                                                                               |        | OB_CK [31:0]                                                   |             |
| OB_CK should be set as the content value sum of 5 registers which offset address is form 0x000 to 0x010 in Option Byte (0x000 + 0x004 + 0x008 + 0x00C + 0x010) when the OB_PP or OB_CP register's content is not equal to 0xFFFF_FFFF. Otherwise, both page erase/program protection and security protection will be enabled. |        |                                                                |             |

## Page Erase/Program Protection

FMC provides functions of page erase/program protection to prevent unexpected operation of Flash memory. The page erase (CMD [3:0] = 0x8 in the OCMR register) or word program (CMD [3:0] = 0x4) command will not be accepted by FMC on the protected pages, the PPEF bit in the OISR register will then be set by FMC and the Flash operation error interrupt will be triggered to CPU by FMC if the OREIEN bit in the OIER register is set. The page protection function can be enabled for each page independently by setting the OB\_PP registers of the Option Byte. The following table shows the access permission of the main Flash page when the page protection is enabled.

**Table 8. Access Permission of Protected Main Flash Page**

| Mode<br>Operation | ISP/IAP | ICP/Debug Mode |
|-------------------|---------|----------------|
| Read              | O       | O              |
| Program           | X       | X              |
| Page Erase        | X       | X              |
| Mass Erase        | O       | O              |

- Notes:**
1. Note that the setting of write protection is based on page. The above access permission only affects the pages that enable protection function. Other pages are not affected.
  2. Main Flash page protection is configured by OB\_PP [126:0]. Option Byte is physically located at the last page of main Flash. Option Byte page protection is configured by the OB\_CP [1] bit.
  3. The page erase on Option Byte area can disable the page protection of main Flash.
  4. The page protection of Option Byte can only be disabled by a mass erase operation.

The following steps show the register access sequence for page erase/program protection procedure.

- Check OPCR register to confirm that no Flash memory operation is ongoing (OPM [3:0] equal to 0xE or 0x6). Otherwise, wait until the previous operation has been finished.
- Write OB\_PP address to TADR register (TADR = 0x1FF0\_0000).
- Write WRDR register which indicates the protection function of corresponding page is enabled or disabled (0: Enabled, 1: Disabled).
- Write word program command to OCMR register (CMD [3:0] = 0x4).
- Commit word program command to FMC by setting OPCR register (set OPM [3:0] = 0xA).
- Wait until all operations have been finished by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Option Byte if required.
- Program the OB\_CK Option Byte as sum of 5 words 0x000 ~ 0x010 according to the checksum rule of Option Byte.
- Apply a system reset to active the new OB\_PP setting.

## Security Protection

FMC provides function of Security protection to prevent illegal code/data access of Flash memory. This function is useful for protecting the software / firmware from the illegal users. The function is activated by setting the Option Byte OB\_CP [0]. Once the function has been enabled, all the main Flash data access through ICP/Debug mode, programming, and page erase will not be allowed except the user's application. But the mass erase operation will still be accepted by FMC in order to disable this function. The following table shows the access permission of Flash memory when the security protection is enabled.

**Table 9. Access Permission When Security Protection is Enabled**

| Operation \ Mode | User Application <sup>(Note 1)</sup> | ICP/Debug Mode |
|------------------|--------------------------------------|----------------|
| Read             | O                                    | X (read as 0)  |
| Program          | O <sup>(Note 1)</sup>                | X              |
| Page Erase       | O <sup>(Note 1)</sup>                | X              |
| Mass Erase       | O                                    | O              |

**Notes:** 1. User application means the software that is executed or booted from main Flash memory with the JTAG/SW debugger being disconnected. But Option Byte block and page 0 are still in protection and can not Program/Page Erase.

2. Mass erase operation can erase Option Byte block and disable security protection.

The following steps show the register access sequence for Security protection procedure.

- Check OPCR register to confirm that no Flash memory operation is ongoing (OPM [3:0] equal to 0xE or 0x6). Otherwise, wait until the pervious operation has been finished.
- Write OB\_CP address to TADR register (TADR = 0x1FF0\_0010).
- Write WRDR register, set OB\_CP [0] as 0.
- Write word program command to OCMR register (CMD [3:0] = 0x4).
- Commit word program command to FMC by setting OPCR register (set OPM = 0xA).
- Wait until all operations have been finished by checking the value of OPCR register (OPM [3:0] equals to 0xE).
- Read and verify the Option Byte if required.
- Program the OB\_CK Option Byte as sum of 5 words 0x000 ~ 0x010 according to the checksum rule of Option Byte.
- Apply a system reset to active the new OB\_CP setting.

## Register Map

The following table shows the FMC registers and reset values.

**Table 10. FMC Register Map**

| Register                              | Offset                           | Description                                         | Reset Value                                              |
|---------------------------------------|----------------------------------|-----------------------------------------------------|----------------------------------------------------------|
| <b>FMC Base Address = 0x4008_0000</b> |                                  |                                                     |                                                          |
| TADR                                  | 0x000                            | Flash Target Address Register                       | 0x0000_0000                                              |
| WRDR                                  | 0x004                            | Flash Write Data Register                           | 0x0000_0000                                              |
| OCMR                                  | 0x00C                            | Flash Operation Command Register                    | 0x0000_0000                                              |
| OPCR                                  | 0x010                            | Flash Operation Control Register                    | 0x0000_000C                                              |
| OIER                                  | 0x014                            | Flash Operation Interrupt Enable Register           | 0x0000_0000                                              |
| OISR                                  | 0x018                            | Flash Operation Interrupt and Status Register       | 0x0001_0000                                              |
| PPSR                                  | 0x020<br>0x024<br>0x028<br>0x02C | Flash Page Erase/Program Protection Status Register | 0xFFFF_XXXX<br>0xFFFF_XXXX<br>0xFFFF_XXXX<br>0xFFFF_XXXX |
| CPSR                                  | 0x030                            | Flash Security Protection Status Register           | 0xFFFF_XXXX                                              |
| VMCR                                  | 0x100                            | Flash Vector Mapping Control Register               | 0x0000_000X                                              |
| MDID                                  | 0x180                            | Flash Manufacturer and Device ID Register           | 0x0376_XXXX                                              |
| PNSR                                  | 0x184                            | Flash Page Number Status Register                   | 0x0000_00X0                                              |
| PSSR                                  | 0x188                            | Flash Page Size Status Register                     | 0x0000_0400                                              |
| CFCR                                  | 0x200                            | Flash Cache & Pre-fetch Control Register            | 0x0000_0051                                              |
| CIDR0                                 | 0x310                            | Custom ID Register 0                                | 0xFFFF_XXXX                                              |
| CIDR1                                 | 0x314                            | Custom ID Register 1                                | 0xFFFF_XXXX                                              |
| CIDR2                                 | 0x318                            | Custom ID Register 2                                | 0xFFFF_XXXX                                              |
| CIDR3                                 | 0x31C                            | Custom ID Register 3                                | 0xFFFF_XXXX                                              |

**Note:** “X” means various reset values which depend on the Device, Flash value, option byte value, or power on reset setting.

## Register Descriptions

### Flash Target Address Register – TADR

This register specifies the target address of page erase and word programming operation.

offset: 0x000

Reset value: 0x0000\_0000

|            |      |    |    |    |    |    |    |    |    |
|------------|------|----|----|----|----|----|----|----|----|
|            | 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | TADB |    |    |    |    |    |    |    |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23   | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | TADB |    |    |    |    |    |    |    |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | TADB |    |    |    |    |    |    |    |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7    | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | TADB |    |    |    |    |    |    |    |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | TADB  | <p>Flash Target Address Bits</p> <p>For programming operations, the TADR register specifies the address where the data is written. Since the programming length is 32 bits, the TADR shall be set as word-aligned (4 bytes). The TADB [1:0] will be ignored during programming operations. For page erase operations, the TADR register contains the page address which is going to be erased. Since the page size is 512 Byte, the TADB [8:0] will be ignored in order to limit the target address as 512 Byte-aligned. For 128 KB main Flash addressing, TADB [31:17] should be zero and TADB [31:16] should be zero for 64 KB. Address from 0x1FF0_0000 to 0x1FF0_03FF is the 1KB Option Byte. This field for available Flash address, it must be under 0x1FFF_FFFF. Otherwise, the Invalid Target Address interrupt will be occurred if the corresponding interrupt enable bit is set.</p> |

## Flash Write Data Register – WRDR

This register specifies the data to be written for programming operation.

offset: 0x004

Reset value: 0x0000\_0000

|            |      |    |    |    |    |    |    |     |    |
|------------|------|----|----|----|----|----|----|-----|----|
|            | 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24  |    |
|            | WRDB |    |    |    |    |    |    |     |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0   | RW |
|            | 23   | 22 | 21 | 20 | 19 | 18 | 17 | 16  |    |
|            | WRDB |    |    |    |    |    |    |     |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0   | RW |
|            | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8   |    |
|            | WRDB |    |    |    |    |    |    | TA3 |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0   | RW |
|            | 7    | 6  | 5  | 4  | 3  | 2  | 1  | 0   |    |
|            | WRDB |    |    |    |    |    |    |     |    |
| Type/Reset | RW   | 0  | RW | 0  | RW | 0  | RW | 0   | RW |

| Bits   | Field | Descriptions                                                       |
|--------|-------|--------------------------------------------------------------------|
| [31:0] | WRDB  | Flash Write Data Bits<br>The data value for programming operation. |

## Flash Operation Command Register – OCMR

This register is used to specify the Flash operation commands that include read, read ID, word program, page erase and mass erase.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |     |    |    |    |
|------------|----------|----|----|----|-----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27  | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |     |    |    |    |
|            | 23       | 22 | 21 | 20 | 19  | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |     |    |    |    |
|            | 15       | 14 | 13 | 12 | 11  | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |     |    |    |    |
|            | 7        | 6  | 5  | 4  | 3   | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | CMD |    |    |    |
|            |          |    |    |    | RW  | 0  | RW | 0  |
|            |          |    |    |    |     | RW | 0  | RW |
|            |          |    |    |    |     |    | RW | 0  |
|            |          |    |    |    |     |    |    | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                             |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | CMD   | Flash Operation Command<br>The following table shows definitions of CMD [3:0] which specify the Flash operation. If an invalid command is set and IOCMIEN = 1, the Invalid Operation Command interrupt will be occurred. |

| CMD [3:0] | Description    |
|-----------|----------------|
| 0x0       | Idle (default) |
| 0x4       | Word program   |
| 0x8       | Page erase     |
| 0xA       | Mass erase     |
| Others    | Reserved       |

## Flash Operation Control Register – OPCR

This register is used for controlling the command commitment and checking the status of the FMC operations.

Offset: 0x010

Reset value: 0x0000\_000C

|            |          |    |    |     |    |    |    |          |
|------------|----------|----|----|-----|----|----|----|----------|
|            | 31       | 30 | 29 | 28  | 27 | 26 | 25 | 24       |
| Type/Reset | Reserved |    |    |     |    |    |    |          |
|            | 23       | 22 | 21 | 20  | 19 | 18 | 17 | 16       |
| Type/Reset | Reserved |    |    |     |    |    |    |          |
|            | 15       | 14 | 13 | 12  | 11 | 10 | 9  | 8        |
| Type/Reset | Reserved |    |    |     |    |    |    |          |
|            | 7        | 6  | 5  | 4   | 3  | 2  | 1  | 0        |
| Type/Reset | Reserved |    |    | OPM |    |    |    | Reserved |
|            | RW       |    |    | 0   | RW | 0  | RW | 0        |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4:1] | OPM   | <p>Operation Mode</p> <p>The following table shows the operation mode of FMC. User can commit command which is set by the OCMR register to main flash according to the address alias setting in TADR. The content of TADR, WRDR, and OCMR registers shall be prepared before setting this register. After all the operation has been finished, the OPM field will be set as 0xE or 0xF by the FMC hardware. The Idle mode can be set when all the operations have been finished for power saving. Note that the operation status should be checked before the next action is applied to the FMC. The content of TADR, WRDR, OCMR, and OPCR registers should not be changed until the previous operation has been finished.</p> |

| OPM [3:0] | Description                          |
|-----------|--------------------------------------|
| 0x6       | Idle (default)                       |
| 0xA       | Commit command to main Flash         |
| 0xE       | All operation finished on main Flash |
| Others    | Reserved                             |

## Flash Operation Interrupt Enable Register – OIER

This register is used to enable or disable interrupt function of FMC. The FMC generates interrupt to the controller when corresponding interrupt enable bits are set.

Offset: 0x014

Reset value: 0x0000\_0000

|            |          |    |    |        |         |        |         |        |
|------------|----------|----|----|--------|---------|--------|---------|--------|
|            | 31       | 30 | 29 | 28     | 27      | 26     | 25      | 24     |
| Type/Reset | Reserved |    |    |        |         |        |         |        |
|            | 23       | 22 | 21 | 20     | 19      | 18     | 17      | 16     |
| Type/Reset | Reserved |    |    |        |         |        |         |        |
|            | 15       | 14 | 13 | 12     | 11      | 10     | 9       | 8      |
| Type/Reset | Reserved |    |    |        |         |        |         |        |
|            | 7        | 6  | 5  | 4      | 3       | 2      | 1       | 0      |
| Type/Reset | Reserved |    |    | OREIEN | IOCMIEN | OBEIEN | ITADIEN | ORFIEN |
|            |          |    |    | RW     | 0       | RW     | 0       | RW     |
|            |          |    |    |        |         | RW     | 0       | RW     |
|            |          |    |    |        |         |        |         | 0      |

| Bits | Field   | Descriptions                                                                                                                                                           |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4]  | OREIEN  | Operation Error Interrupt Enable<br>0: Operation error does not generate an interrupt<br>1: Operation error generates an interrupt                                     |
| [3]  | IOCMIEN | Invalid Operation Command Interrupt Enable<br>0: Invalid Operation Command does not generate an interrupt<br>1: Invalid Operation Command generates an interrupt       |
| [2]  | OBEIEN  | Option Byte Check Sum Error Interrupt Enable<br>0: Option Byte Check Sum Error does not generate an interrupt<br>1: Option Byte Check Sum Error generates an interrupt |
| [1]  | ITADIEN | Invalid Target Address Interrupt Enable<br>0: Invalid Target Address does not generate an interrupt<br>1: Invalid Target Address generates an interrupt                |
| [0]  | ORFIEN  | Operation Finished Interrupt Enable<br>0: Operation Finish does not generate an interrupt<br>1: Operation Finish generates an interrupt                                |

This register indicates the status of the FMC interrupt to check if an operation has been finished or an error occurs. The status bits (bit [4:0]) are available when the corresponding bits in the OIER register are set.

Reset value: 0x0001\_0000

|            |          |    |    |      |       |      |       |       |    |
|------------|----------|----|----|------|-------|------|-------|-------|----|
|            | 31       | 30 | 29 | 28   | 27    | 26   | 25    | 24    |    |
| Type/Reset | Reserved |    |    |      |       |      |       |       |    |
|            | 23       | 22 | 21 | 20   | 19    | 18   | 17    | 16    |    |
| Type/Reset | Reserved |    |    |      |       |      | PPEF  | RORFF |    |
|            |          |    |    |      |       |      | RO    | 0     | RO |
|            | 15       | 14 | 13 | 12   | 11    | 10   | 9     | 8     | 1  |
| Type/Reset | Reserved |    |    |      |       |      |       |       |    |
|            | 7        | 6  | 5  | 4    | 3     | 2    | 1     | 0     |    |
| Type/Reset | Reserved |    |    | OREF | IOCMF | OBEF | ITADF | ORFF  |    |
|            |          |    |    | WC   | 0     | WC   | 0     | WC    | 0  |

## Flash Memory Controller (FMC)

| Bits | Field | Descriptions                                                                                                                                                                                                                                                     |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | ITADF | Invalid Target Address Flag<br>0: The target address is valid<br>1: The target address TADR is invalid<br>TADR field must be below 0x1FFF_FFFF. The ITAD interrupt will be occurred if the ITADIEN bit in the OIER register is set. Reset this bit by writing 1. |
| [0]  | ORFF  | Operation Finished Flag<br>0: No operation finished interrupt occurred<br>1: Last flash operation command is finished<br>The ORF interrupt will be occurred if the ORFIEN bit in the OIER register is set. Reset this bit by writing 1.                          |

## Flash Page Erase/Program Protection Status Register – PPSR

This register indicates the status of Flash page erase/program protection.

Offset: 0x020 (0) ~ 0x02C (3)

Reset value: 0xFFFF\_FFFF

|            |       |      |      |      |      |      |      |      |   |
|------------|-------|------|------|------|------|------|------|------|---|
|            | 31    | 30   | 29   | 28   | 27   | 26   | 25   | 24   |   |
|            | PPSBn |      |      |      |      |      |      |      |   |
| Type/Reset | RO    | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |
|            | 23    | 22   | 21   | 20   | 19   | 18   | 17   | 16   |   |
|            | PPSBn |      |      |      |      |      |      |      |   |
| Type/Reset | RO    | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |
|            | 15    | 14   | 13   | 12   | 11   | 10   | 9    | 8    |   |
|            | PPSBn |      |      |      |      |      |      |      |   |
| Type/Reset | RO    | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |
|            | 7     | 6    | 5    | 4    | 3    | 2    | 1    | 0    |   |
|            | PPSBn |      |      |      |      |      |      |      |   |
| Type/Reset | RO    | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [127:0] | PPSBn | <p>Page Erase/Program Protection Status Bits (n = 0 ~ 127)</p> <p>PPSB[n] = OB_PP[n]</p> <p>0: The corresponding pages are protected</p> <p>1: The corresponding pages are not protected</p> <p>The content of this register is not dynamically updated and will only be reloaded from the Option Byte when any kind of reset occurs. The erase or program function of specific pages is not allowed when the corresponding bits of the PPSR registers are reset. The reset value of PPSR [127:0] is determined by the Option Byte OB_PP [127:0]. Since the maximum page number of the main flash is various and dependent on the chip specification. Therefore, the every page erase/program protection status bit may protect one or two pages and dependent on the chip specification. The other remained bits of OB_PP and PPSR registers are reserved.</p> |

## Flash Security Protection Status Register – CPSR

This register indicates the status of the Flash Security protection. The content of this register is not dynamically updated and will only be reloaded by the Option Byte loader (which is active when any kind of reset occurs).

Offset: 0x030

Reset value: 0xFFFF\_FFFF

|            |          |    |    |    |    |    |       |        |
|------------|----------|----|----|----|----|----|-------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25    | 24     |
| Type/Reset | Reserved |    |    |    |    |    |       |        |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17    | 16     |
| Type/Reset | Reserved |    |    |    |    |    |       |        |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9     | 8      |
| Type/Reset | Reserved |    |    |    |    |    |       |        |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1     | 0      |
| Type/Reset | Reserved |    |    |    |    |    | OBPSB | CPSB   |
|            |          |    |    |    |    |    | RO    | X RO X |

| Bits | Field | Descriptions                                                                                                                                                                                                        |
|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | OBPSB | Option Byte Page Erase/Program Protection Status Bit<br>0: The Option Byte page is protected.<br>1: The Option Byte page is not protected.<br>The reset value of OBPSB is determined by the Option Byte, OB_CP [1]. |
| [0]  | CPSB  | Flash Security Protection Status Bit<br>0: Flash Security protection is enabled<br>1: Flash Security protection is not enabled<br>The reset value of CPSB is determined by the Option Byte, OB_CP [0].              |

## Flash Vector Mapping Control Register – VMCR

This register is used to control the mapping of vector. The reset vale of VMCR is determined by booting power on the reset setting BOOT pin.

Offset: 0x100

Reset value: 0x0000\_000X

|            |          |    |    |    |    |    |      |          |
|------------|----------|----|----|----|----|----|------|----------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25   | 24       |
| Type/Reset | Reserved |    |    |    |    |    |      |          |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17   | 16       |
| Type/Reset | Reserved |    |    |    |    |    |      |          |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9    | 8        |
| Type/Reset | Reserved |    |    |    |    |    |      |          |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1    | 0        |
| Type/Reset | Reserved |    |    |    |    |    | VMCB | Reserved |
|            |          |    |    |    |    |    | RW   | X 1      |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |      |          |              |     |   |                                                                                          |      |   |                                                                                        |
|------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------|--------------|-----|---|------------------------------------------------------------------------------------------|------|---|----------------------------------------------------------------------------------------|
| [1]  | VMCB     | <p>Vector Mapping Control Bit</p> <p>The VMCB bits is used to control the mapping source of first 4-word vector (address 0x0 ~ 0xC). The following table shows the vector mapping setting.</p> <table> <tr> <th>BOOT</th><th>VMCB [1]</th><th>Descriptions</th></tr> <tr> <td>Low</td><td>0</td><td> <p>Boot Loader mode</p> <p>The source of the vector mapping is the boot loader area.</p> </td></tr> <tr> <td>High</td><td>1</td><td> <p>Main Flash mode</p> <p>The source of the vector mapping is the main Flash area.</p> </td></tr> </table> <p>The reset value of VMCB is determined by the pins status of BOOT during power on reset and system reset. The setting of the vector mapping can be changed temporarily by setting the VMCB bit when the application is running.</p> | BOOT | VMCB [1] | Descriptions | Low | 0 | <p>Boot Loader mode</p> <p>The source of the vector mapping is the boot loader area.</p> | High | 1 | <p>Main Flash mode</p> <p>The source of the vector mapping is the main Flash area.</p> |
| BOOT | VMCB [1] | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |      |          |              |     |   |                                                                                          |      |   |                                                                                        |
| Low  | 0        | <p>Boot Loader mode</p> <p>The source of the vector mapping is the boot loader area.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |          |              |     |   |                                                                                          |      |   |                                                                                        |
| High | 1        | <p>Main Flash mode</p> <p>The source of the vector mapping is the main Flash area.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |      |          |              |     |   |                                                                                          |      |   |                                                                                        |

## Flash Manufacturer and Device ID Register – MDID

This register specifies the manufacture ID and device part number information which can be used as the product identity.

Offset: 0x180

Reset value: 0x0376\_xxxx

|            |        |    |    |    |    |    |    |    |    |   |    |   |
|------------|--------|----|----|----|----|----|----|----|----|---|----|---|
|            | 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |   |    |   |
|            | MFID   |    |    |    |    |    |    |    |    |   |    |   |
| Type/Reset | RO     | 0  | RO | 0  | RO | 0  | RO | 0  | RO | 1 | RO | 1 |
|            | 23     | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |   |    |   |
|            | MFID   |    |    |    |    |    |    |    |    |   |    |   |
| Type/Reset | RO     | 0  | RO | 1  | RO | 1  | RO | 1  | RO | 1 | RO | 0 |
|            | 15     | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |   |    |   |
|            | ChipID |    |    |    |    |    |    |    |    |   |    |   |
| Type/Reset | RO     | X  | RO | X  | RO | X  | RO | X  | RO | X | RO | X |
|            | 7      | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |   |    |   |
|            | ChipID |    |    |    |    |    |    |    |    |   |    |   |
| Type/Reset | RO     | X  | RO | X  | RO | X  | RO | X  | RO | X | RO | X |

| Bits    | Field  | Descriptions                                |
|---------|--------|---------------------------------------------|
| [31:16] | MFID   | Manufacturer ID<br>Read as 0x0376           |
| [15:0]  | ChipID | Chip ID<br>Read the MCU device part number. |

## Flash Page Number Status Register – PNSR

This register specifies the page number of Flash memory.

Offset: 0x184

Reset value: 0x0000\_00XX

|            |      |    |    |    |    |    |    |    |    |
|------------|------|----|----|----|----|----|----|----|----|
|            | 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | PNSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 23   | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | PNSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | PNSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 7    | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | PNSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | X  | RO | X  | RO | X  | RO | X  | RO |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                  |
|--------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | PNSB  | Flash Page Number Status Bits<br>0x0000_0010: Totally 16 pages for the on-chip Flash memory device.<br>0x0000_0020: Totally 32 pages for the on-chip Flash memory device.<br>0x0000_0040: Totally 64 pages for the on-chip Flash memory device.<br>0x0000_0080: Totally 128 pages for the on-chip Flash memory device.<br>0x0000_00FF: Totally 255 pages for the on-chip Flash memory device. |

## Flash Page Size Status Register – PSSR

This register specifies the page size in bytes.

Offset: 0x188

Reset value: 0x0000\_0400

|            |      |    |    |    |    |    |    |    |    |
|------------|------|----|----|----|----|----|----|----|----|
|            | 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | PSSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 23   | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | PSSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | PSSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 1  | RO |
|            | 7    | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | PSSB |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |

| Bits   | Field | Descriptions                                                                                                                                                                                      |
|--------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | PSSB  | Status Bits of Flash Page Size<br>0x200: That means the page size is 512 Byte per page.<br>0x400: That means the page size is 1 KB per page.<br>0x800: That means the page size is 2 KB per page. |

## Flash Cache & Pre-fetch Control Register – CFCR

This register is used for controlling the pre-fetch module of FMC.

Offset: 0x200

Reset value: 0x0000\_13D1

|            |          |    |    |      |          |      |    |    |
|------------|----------|----|----|------|----------|------|----|----|
|            | 31       | 30 | 29 | 28   | 27       | 26   | 25 | 24 |
| Type/Reset | Reserved |    |    |      |          |      |    |    |
|            | 23       | 22 | 21 | 20   | 19       | 18   | 17 | 16 |
| Type/Reset | Reserved |    |    |      |          |      |    |    |
|            | 15       | 14 | 13 | 12   | 11       | 10   | 9  | 8  |
| Type/Reset | Reserved |    |    | CE   | Reserved |      |    |    |
|            | 7        | 6  | 5  | 4    | 3        | 2    | 1  | 0  |
| Type/Reset | Reserved |    |    | PFBE | Reserved | WAIT |    |    |
|            | 1        | 1  | 0  | RW   | 1        | RW   | 0  | RW |
|            |          |    |    |      |          |      | 0  | RW |
|            |          |    |    |      |          |      |    | 1  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                          |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [12]  | CE    | Branch Cache Enable Bit<br>0 = Cache is disabled.<br>1 = Cache is enabled (default).                                                                                                                                                                                                                                  |
| [4]   | PFBE  | Pre-fetch Buffer Enable Bit<br>0: Pre-fetch buffer is disabled. The Instruction/Data is provided by Flash memory directly.<br>1: Pre-fetch buffer is enabled (default).                                                                                                                                               |
| [2:0] | WAIT  | Flash Wait State Setting<br>The WAIT [2:0] is used to set the count of the HCLK wait clock during non-sequential address Flash access. The actual wait clock is (WAIT [2:0] - 1). Since the wide access interface with pre-fetch buffer is provided, the wait state of sequential Flash access is very close to zero. |

| WAIT [2:0] | Wait Status | Allowed HCLK Range     |
|------------|-------------|------------------------|
| 001        | 0           | 0 MHz < HCLK ≤ 24 MHz  |
| 010        | 1           | 24 MHz < HCLK ≤ 48 MHz |
| Others     | Reserved    | Reserved               |

### Custom ID Register n – CIDRn, n = 0 ~ 3

This register specifies the custom ID information which can be used as the custom identity.

Offset: 0x310 (0) ~ 0x31C (3)

Reset value: Various depending on Flash Manufacture Privilege Information Block.

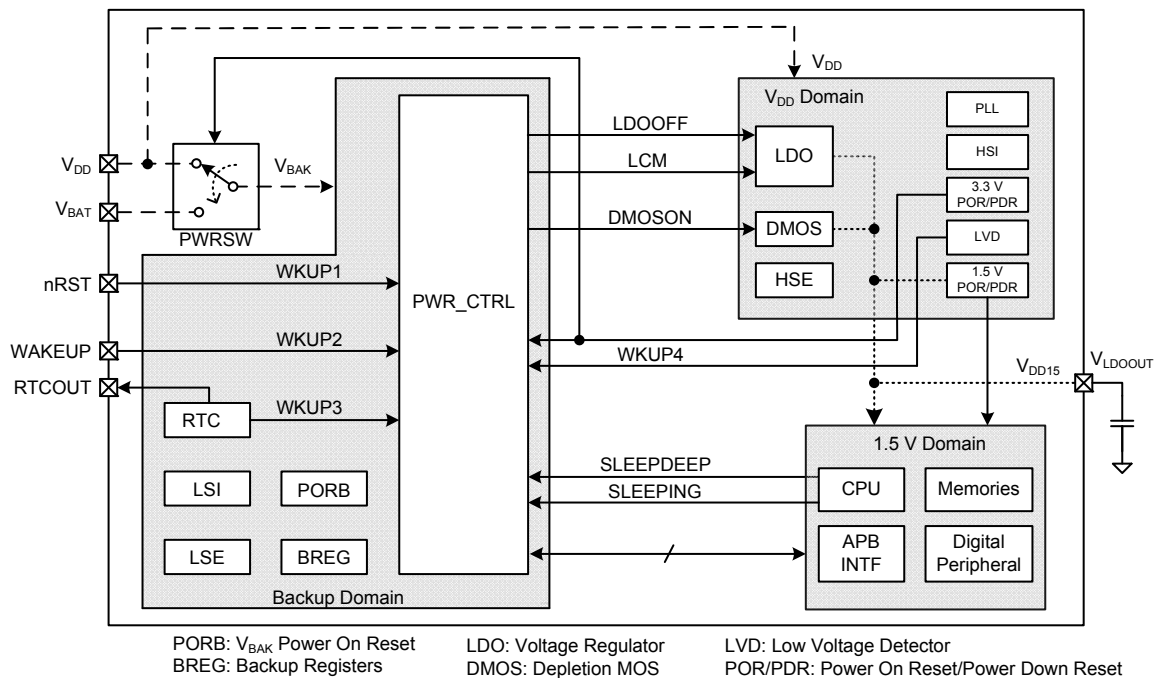
|            |     |      |      |      |      |      |      |      |   |
|------------|-----|------|------|------|------|------|------|------|---|
|            | 31  | 30   | 29   | 28   | 27   | 26   | 25   | 24   |   |
|            | CID |      |      |      |      |      |      |      |   |
| Type/Reset | RO  | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |
|            | 23  | 22   | 21   | 20   | 19   | 18   | 17   | 16   |   |
|            | CID |      |      |      |      |      |      |      |   |
| Type/Reset | RO  | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |
|            | 15  | 14   | 13   | 12   | 11   | 10   | 9    | 8    |   |
|            | CID |      |      |      |      |      |      |      |   |
| Type/Reset | RO  | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |
|            | 7   | 6    | 5    | 4    | 3    | 2    | 1    | 0    |   |
|            | CID |      |      |      |      |      |      |      |   |
| Type/Reset | RO  | X RO | X RO | X RO | X RO | X RO | X RO | X RO | X |

| Bits   | Field | Descriptions                                                                                                         |
|--------|-------|----------------------------------------------------------------------------------------------------------------------|
| [31:0] | CIDn  | Custom ID<br>Read as the CIDn[31:0] (n=0 ~ 3) field in the Custom ID registers in Flash Manufacture Privilege Block. |

## 5 Power Control Unit (PWRCU)

### Introduction

The power consumption can be regarded as one of the most important issues for many embedded system applications. Accordingly the Power Control Unit, PWRCU, provides many types of power saving modes such as Sleep, Deep-Sleep1, Deep-Sleep2, and Power-Down modes. These modes reduce the power consumption and allow the application to achieve the best trade-off between the conflicting demands of CPU operating time, speed and power consumption. The dash line in the Figure 11 indicates the power supply source of three digital power domains.



**Figure 11. PWRCU Block Diagram**

## Features

- Three power domains: Backup,  $V_{DD}$  and 1.5 V power domains.
- Four power saving modes: Sleep, Deep-Sleep1, Deep-Sleep2 and Power-Down modes.
- Internal Voltage regulator supplies 1.5 V voltage source.
- Additional Depletion MOS supplies 1.5 V voltage source with low leakage and low operating current.
- A power reset is generated when one of the following events occurs:  
Power-on / Power-down reset (POR / PDR reset).  
When exiting Power-Down mode.  
The control bits  $BODEN = 1$ ,  $BODRIS=0$  and the supply power  $V_{DD} \leq V_{BOD}$ .
- BOD Brown Out Detector can issue a system reset or an interrupt when  $V_{DD}$  power source is lower than the Brown Out Detector voltage  $V_{BOD}$ .
- LVD Low Voltage Detector can issue an interrupt or wakeup event when  $V_{DD}$  is lower than a programmable threshold voltage  $V_{LVD}$ .
- Switch Battery power ( $V_{BAT}$ ) for backup domain when  $V_{DD}$  is lower than  $V_{PDR}$  voltage.
- 40 bytes of backup registers powered by  $V_{BAK}$  for data storage of user application data when in the Power-Down mode.

## Functional Descriptions

### Backup Domain

#### Power Switch

The Backup Domain is powered by the  $V_{DD}$  power source or the battery power source,  $V_{BAT}$ , which is selected by the power switch  $PWRSW$ . The operating voltage range of the Back Domain is from 2.0 V to 3.6 V. If  $V_{DD}$  is lower than  $V_{PDR}$ , then the power source of the Back Domain will be automatically switched from  $V_{DD}$  to  $V_{BAT}$ . Therefore, even if  $V_{DD}$  is powered down, all the circuitry in the backup domain can operate normally. This means that the backup register contents will be retained, the RTC circuitry will operate normally and the low speed oscillators can keep running.

#### Backup Domain Reset

The Backup Domain reset sources include the Backup Domain Power-On-Reset (PORB) and the Backup Domain software reset which is activated by setting the  $BAKRST$  bit in the  $BAKCR$  register. The PORB signal forces the device to stay in the reset mode until the  $V_{BAK}$  is greater than  $V_{PORB}$ . The application software can set the  $PORBDN$  bit in the  $BAKCR$  register to disable PORB circuit to save the current consumption in the Backup Domain. Also the application software can trigger Backup Domain software reset by setting the  $BAKRST$  bit in the  $BAKCR$  register. All registers of PWRCU and RTC will be reset only by the Backup Domain reset.

### LSE, LSI and RTC

The Real Time Clock circuitry clock source can be derived from either the Low Speed Internal RC oscillator, LSI, or the Low Speed External Crystal oscillator, LSE. Before entering the power saving mode by executing WFI/WFE instruction, the MCU needs to setup the compare register with an expected wakeup time and enable the wakeup function to achieve the RTC timer wakeup event. After entering the power saving mode for a certain amount of time, the Compare Match flag, CMFLAG, will be asserted to wakeup the device when the compare match event occurs. The details of the RTC configuration for wakeup timer will be described in the RTC chapter.

### Backup Registers and Isolation Cells

Ten 32-bit registers, up to 40 bytes, are located in the Backup Domain for user application data storage. These registers are powered by  $V_{BAK}$  which constantly supplies power when the 1.5 V core power is switched off. The Backup Registers are only reset by the Backup Domain power-on-reset, PORB, or the Backup Domain software reset, BAKRST. When the device resumes operation from the 1.5 V power, either by Hardware or Software, access to the Backup registers and the RTC registers are disabled by the isolation cells which protect these registers against possible parasitic write accesses. To resume access operations, users must disable these isolation cells by setting the BKISO bit to 1 in the LPCR register of the Clock Control Unit.

### LDO Power Control

The LDO will be automatically switched off when one of the following conditions occurs:

- The Power-Down or Deep-Sleep 2 mode is entered.
- The control bits  $BODEN = 1$ ,  $BODRIS=0$  and the supply power  $V_{DD} \leq V_{BOD}$ .
- The supply power  $V_{DD33} \leq V_{PDR}$

The LDO will be automatically switched on by hardware when the supply power  $V_{DD} > V_{POR}$  if any of the following conditions occurs:

- Resume operation from the power saving mode - RTC wakeup, LVD wakeup and WAKEUP pin rising edge.
- Detect a falling edge on the external reset pin (nRST).
- The control bit  $BODEN = 1$  and the supply power  $V_{DD} > V_{BOD}$ .

To enter the Deep-Sleep1 mode, the PWRCU will request the LDO to operate in a low current mode, LCM. To enter the Deep-Sleep 2 mode, the PWRCU will turn off the LDO and turn on the DMOS to supply an alternative 1.5 V power.

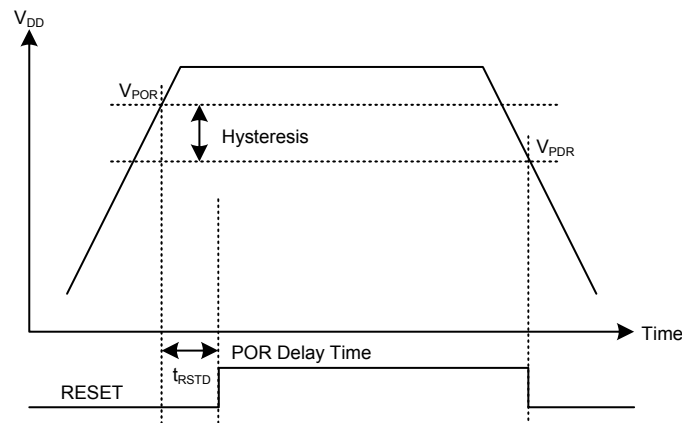
## V<sub>DD</sub> Power Domain

### Voltage Regulator

The voltage regulator, LDO, Depletion MOS, DMOS, Low voltage Detector, LVD and High Speed Internal oscillator, HSI are operated under the  $V_{DD}$  power domain. The LDO can be configured to operate in either normal mode ( $LDOOFF = 0$ ,  $SLEEPDEEP = 0$ ,  $I_{OUT}$  = High current mode) or low current mode ( $LDOOFF = 0$ ,  $SLEEPDEEP=1$ ,  $I_{OUT}$  = Low current mode) to supply the 1.5 V power. An alternative 1.5 V power source is the output of the DMOS which has low static and driving current characteristics. It is controlled using the DMOSON bit in the BAKCR register. The DMOS output has weak output current and regulation capability and only operate in the Deep-Sleep 2 mode for data retention purposes in the  $V_{DD15}$  power domain.

### Power On Reset (POR) / Power Down Reset (PDR)

The device has an integrated POR/PDR circuitry that allows proper operation starting from/down to 2.0 V. The device remains in Power-Down mode when  $V_{DD}$  is below a specified threshold  $V_{PDR}$ , without the need for an external reset circuit. For more details the power on / power down reset threshold voltage, refer to the electrical characteristics of the corresponding datasheet.



**Figure 12. Power On Reset / Power Down Reset Waveform**

### Low Voltage Detector / Brown Out Detector

The Low Voltage Detector, LVD, can detect whether the supply voltage  $V_{DD}$  is lower than a programmable threshold voltage  $V_{LVD}$ . It is selected by the LVDS bits in the LVDCSR register. When a low voltage on the  $V_{DD}$  power pin is detected, the LVDF flag will be active and an interrupt will be generated and sent to the MCU core if the LVDEN and LVDIWEN bits in the LVDCSR register are set. For more details concerning the LVD programmable threshold voltage  $V_{LVD}$ , refer to the electrical characteristics of the corresponding datasheet.

The Brown Out Detector, BOD, is used to detect if the  $V_{DD}$  supply voltage is equal to or lower than  $V_{BOD}$ . When the BODEN bit in the LVDCSR register is set to 1 and the  $V_{DD}$  supply voltage is lower than  $V_{BOD}$  then the BODF flag is active. The PWRCU will regard this as a power down reset situation and then immediately disable the internal LDO regulator when the BODRIS bit is cleared to 0 or issue an interrupt to notify the CPU to execute a power down procedure when the BODRIS bit is set to 1. For more details concerning the Brown Out Detector voltage  $V_{BOD}$ , refer to the electrical characteristics of the corresponding datasheet.

### High Speed Internal Oscillator

The High Speed Internal Oscillator, HSI, is located in the  $V_{DD}$  power domain. When exiting from the Deep-Sleep mode, the HSI clock will be configured as the system clock for a certain period by setting the PSRCEN bit to 1. This bit is located in the Global Clock Control Register, GCCR, in the Clock Control Unit, CKCU. The system clock will not be switched back to the original clock source used before entering the Deep-Sleep mode until the original clock source, which may be either sourced from the PLL or HSE stabilizes. Also the system will force the HSI oscillator to be the system clock after a wake up from Power-Down mode since a 1.5 V power on reset will occur.

### High Speed External Oscillator

The High Speed External Oscillator, HSE, is located in the  $V_{DD}$  power domain. The HSE crystal oscillator can be switched on or off using the HSEEN bit in the Global Clock Control Register (GCCR). The HSE clock can then be used directly as the system clock source or be used as the PLL input clock.

## 1.5 V Power Domain

The main functions that include the APB interface for the backup domain, CPU core logic, AHB/APB peripherals and memories and so on are located in this power domain. Once the 1.5 V is powered up, the POR will generate a reset sequence (Refer to PORB) on 1.5 V power domain. Subsequently, to enter the expected power saving mode, the associated control bits including the LDOOFF, DMOSON, and SLEEPDEEP bits must be configured. Then, once a WFI or WFE instruction is executed, the device will enter an expected power saving mode which will be discussed in the following section.

## Operation Modes

### Run Mode

In the Run mode, the system operates with full functions and all power domains are active. There are two ways to reduce the power consumption in this mode. The first is to slow down the system clock by setting the AHBPRE field in the CKCU AHBCFGR register, and the second is to turn off the unused peripherals clock by setting the APBCCR0 and APBCCR1 registers or slow down peripherals clock by setting the APBPCSR0 and APBPCSR1 registers to meet the application requirement. Reducing the system clock speed before entering the sleep mode will also help to minimize power consumption.

Additionally, there are several power saving modes to provide maximum optimization between device performance and power consumption.

**Table 11. Operation Mode Definitions**

| Mode name       | Hardware Action                                                                                                                                                            |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Run             | After system reset, CPU fetches instructions to execute.                                                                                                                   |
| Sleep           | 1. CPU clock will be stopped.<br>2. Peripherals, Flash and SRAM clocks can be stopped by setting.                                                                          |
| Deep-Sleep1 ~ 2 | 1. Stop all clocks in the 1.5 V power domain.<br>2. Disable HSI, HSE, and PLL.<br>3. Turning on the LDO low current mode or DMOS to reduce the 1.5 V power domain current. |
| Power-Down      | Shut down the 1.5 V power domain                                                                                                                                           |

## Sleep Mode

By default, only the CPU clock will be stopped in the Sleep mode. Clearing the FMCEN or SRAMEN bit in the CKCU AHBCCR register to 0 will have the effect of stopping the Flash clock or SRAM clock after the system enters the Sleep mode. If it is not necessary for the CPU to access the Flash memory and SRAM in the Sleep mode, it is recommended to clear the FMCEN and SRAMEN bits in the AHBCCR register to minimize power consumption. To enter the Sleep mode, it is only necessary to clear the SLEEPDEEP bit to 0 and execute a WFI or WFE instruction. The system will exit from the Sleep mode via any interrupt or event trigger. The accompanying table provides more information about the power saving modes.

**Table 12. Enter/Exit Power Saving Modes**

| Mode        | Mode Entry                   |               |        |        | Mode Exit                                                                                                                                     |
|-------------|------------------------------|---------------|--------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------|
|             | CPU Instruction              | CPU SLEEPDEEP | LDOOFF | DMOSON |                                                                                                                                               |
| Sleep       | WFI or WFE<br>(Takes effect) | 0             | X      | X      | WFI: Any interrupt<br>WFE:<br>Any wakeup event <sup>(1)</sup> or<br>Any interrupt (NVIC on) or<br>Any interrupt with SEVONPEND = 1 (NVIC off) |
| Deep-Sleep1 |                              | 1             | 0      | 0      | Any EXTI in event mode or<br>RTC wakeup or<br>CMP Wakeup or<br>LVD wakeup <sup>(2)</sup> or<br>WAKEUP pin rising edge or<br>USB resume        |
| Deep-Sleep2 |                              | 1             | X      | 1      | RTC wakeup or<br>LVD wakeup <sup>(2)</sup> or<br>WAKEUP pin rising edge                                                                       |
| Power-Down  |                              | 1             | 1      | 0      | RTC wakeup or<br>LVD wakeup <sup>(2)</sup> or<br>WAKEUP pin rising edge or<br>External reset (nRST)                                           |

**Notes:** 1. Wakeup event means EXTI line in event mode, RTC, LVD, and WAKEUP pin rising edge

2. If the system allows the LVD activity to wake it up after the system has entered the power saving mode, the LVDEWEN and LVDEN bits in the LVDCSR register must be set to 1 to make sure that the system can be waked up by a LVD event and then the LDO regulator can be turned on when system is woken up from the Deep-Sleep2 and Power-Down modes.

## Deep-Sleep Mode

To enter Deep-Sleep mode, configure the registers as shown in the preceding table and execute the WFI or WFE instruction. In the Deep-Sleep mode, all clocks including PLL and high speed oscillator, known as HSI and HSE, will be stopped. In addition, Deep-Sleep1 turns the LDO into low current mode while Deep-Sleep2 turns off the LDO and uses a DMOS to keep 1.5 V power. Once the PWRCU receives a wakeup event or an interrupt as shown in the preceding Mode-Exiting table, the LDO will then operate in normal mode and the high speed oscillator will be enabled. Finally, the CPU will return to Run mode to handle the wakeup interrupt if required. A Low Voltage Detection also can be regarded as a wakeup event if the corresponding wakeup control bit LVDEWEN in the LVDCSR register is enabled. The last wakeup event is a transition from low to high on the external WAKEUP pin sent to the PWRCU to resume from Deep-Sleep mode. During the Deep-Sleep mode, retaining the register and memory contents will shorten the wakeup latency.

### Power-Down Mode

The Power-Down mode is derived from the Deep-Sleep mode of the CPU together with the additional control bits LDOOFF and DMOSON. To enter the Power-Down mode, users can configure the registers shown in the preceding Mode-Entering table and execute the WFI or WFE instruction. A RTC wakeup trigger event, a LVD wakeup, a low to high transition on the external WAKEUP pin or an external reset (nRST) signal will force the MCU out of the Power-Down mode. In the Power-Down mode, the 1.5 V power supply will be turned off. The remaining active power supplies are the 3.3 V power ( $V_{DD}/V_{DDA}$ ) and the Backup Domain power ( $V_{BAK}$ ).

After a system reset, the PORSTF bit in the RSTCU GRSR register, the PDF and BAKPORF bits in the BAKSR register should be checked by software to confirm if the device is being resumed from the Power-Down mode by a backup domain power on reset, an unexpected loss of the 1.5 V power or other reset events (nRST, WDT,...). If the device has entered the Power-Down mode under the correct firmware procedure, then the PDF bit will be set. The System information could be saved in the Backup Registers and be retrieved when the 1.5 V power domain is powered on again. More information about the PDF and BAKPORF bits in the BAKSR register and PORSTF bit in the RSTCU GRSR register is shown in the following table.

**Table 13. Power Status After System Reset**

| BAKPORF | PDF | PORSTF | Description                                                                                                                                                                         |
|---------|-----|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | 0   | 1      | Power-up for the first time after the backup domain is reset: Power on reset when $V_{BAK}$ is applied for the first time or executing software reset command on the backup domain. |
| 0       | 0   | 1      | Restart from unexpected loss of the 1.5 V power or other reset (nRST, WDT,...)                                                                                                      |
| 0       | 1   | 1      | Restart from the Power-Down mode.                                                                                                                                                   |
| 1       | 1   | x      | Reserved                                                                                                                                                                            |

## Register Map

The following table shows the PWRCU registers and reset values. Note all the registers in this unit are located in the  $V_{BAK}$  backup power domain.

**Table 14. PWRCU Register Map**

| Register | Offset | Description                                              | Reset Value |
|----------|--------|----------------------------------------------------------|-------------|
| BAKSR    | 0x100  | Backup Domain Status Register                            | 0x0000_0001 |
| BAKCR    | 0x104  | Backup Domain Control Register                           | 0x0000_0000 |
| BAKTEST  | 0x108  | Backup Domain Test Register                              | 0x0000_0027 |
| LVDCSR   | 0x110  | Low Voltage/Brown Out Detect Control and Status Register | 0x0000_0000 |
| BAKREG0  | 0x200  | Backup Register 0                                        | 0x0000_0000 |
| BAKREG1  | 0x204  | Backup Register 1                                        | 0x0000_0000 |
| BAKREG2  | 0x208  | Backup Register 2                                        | 0x0000_0000 |
| BAKREG3  | 0x20C  | Backup Register 3                                        | 0x0000_0000 |
| BAKREG4  | 0x210  | Backup Register 4                                        | 0x0000_0000 |
| BAKREG5  | 0x214  | Backup Register 5                                        | 0x0000_0000 |
| BAKREG6  | 0x218  | Backup Register 6                                        | 0x0000_0000 |
| BAKREG7  | 0x21C  | Backup Register 7                                        | 0x0000_0000 |
| BAKREG8  | 0x220  | Backup Register 8                                        | 0x0000_0000 |
| BAKREG9  | 0x224  | Backup Register 9                                        | 0x0000_0000 |

## Register Descriptions

### Backup Domain Status Register – BAKSR

This register indicates backup domain status.

Offset: 0x100

Reset value: 0x0000\_0001 (Reset only by Backup Domain reset)

|            |          |    |    |    |    |    |     |         |
|------------|----------|----|----|----|----|----|-----|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25  | 24      |
| Type/Reset | Reserved |    |    |    |    |    |     |         |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17  | 16      |
| Type/Reset | Reserved |    |    |    |    |    |     |         |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9   | 8       |
| Type/Reset | Reserved |    |    |    |    |    |     | WUPF    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1   | 0       |
| Type/Reset | Reserved |    |    |    |    |    | PDF | BAKPORF |
|            |          |    |    |    |    |    | RC  | 0       |
|            |          |    |    |    |    |    | RC  | 1       |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | WUPF    | External WAKEUP Pin Flag<br>0: The Wakeup pin is not asserted<br>1: The Wakeup pin is asserted<br>This bit is set by hardware when the WAKEUP pin asserts and is cleared by software read. Software should read this bit to clear it after a system wake up from the power saving mode.                                                                                                                                                                                                                                                                                                                                                                                                               |
| [1]  | PDF     | Power Down Flag<br>0: Wakeup from abnormal $V_{DD15}$ shutdown (Loss of $V_{DD15}$ is unexpected)<br>1: Wakeup from Power-Down mode. The loss of $V_{DD15}$ is under expectation.<br>This bit is set by hardware when the system has successfully entered the Power-Down mode. This bit is cleared by software read.                                                                                                                                                                                                                                                                                                                                                                                  |
| [0]  | BAKPORF | Backup Domain Reset Flag<br>0: Backup Domain reset does not occur<br>1: Backup Domain reset occurs<br>This bit is set by hardware when Backup Domain reset occurs, either a Backup Domain power on reset or Backup Domain software reset. The bit is cleared by software read. This bit must be cleared after the system is first powered, otherwise it will be impossible to detect when a Backup Domain reset has been triggered. When this bit is read as 1, a read software loop must be implemented until the bit returns again to 0. This software loop is necessary to confirm that the Backup Domain is ready for access. It must be implemented after the Backup Domain is first powered up. |

## Backup Domain Control Register – BAKCR

This register provides power control bits for the Deep-Sleep and Power-Down modes.

Offset: 0x104

Reset value: 0x0000\_0000 (Reset only by Backup Domain reset)

|            |          |          |    |          |          |        |          |        |
|------------|----------|----------|----|----------|----------|--------|----------|--------|
|            | 31       | 30       | 29 | 28       | 27       | 26     | 25       | 24     |
| Type/Reset | Reserved |          |    |          |          |        |          |        |
|            | 23       | 22       | 21 | 20       | 19       | 18     | 17       | 16     |
| Type/Reset | Reserved |          |    |          |          |        |          |        |
|            | 15       | 14       | 13 | 12       | 11       | 10     | 9        | 8      |
| Type/Reset | D MOSSTS | Reserved |    | V15RDYSC | Reserved |        | WUPIEN   | WUPEN  |
|            | RO 0     |          |    | RW 0     |          |        | RW 0     | RW 0   |
|            | 7        | 6        | 5  | 4        | 3        | 2      | 1        | 0      |
| Type/Reset | DMOSON   | Reserved |    |          | LDOOFF   | LDOLCM | Reserved | BAKRST |
|            | RW 0     |          |    |          | RW 0     | RW 0   |          | WO 0   |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                                                 |
|------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15] | D MOSSTS | Depletion MOS Status<br>This bit is set to 1 if the DMOSON bit in this register has been set to 1.<br>This bit is cleared to 0 if the DMOSON bit has been set to 0 or if a POR/PDR reset occurred.                                                                                           |
| [12] | V15RDYSC | $V_{DD15}$ Ready Source Selection.<br>0: BKISO bit in the LPCR register located in the CKCU<br>1: $V_{DD15}$ POR<br>Setting this bit to determine what control signal of isolation cells is used to disable the isolation function of the $V_{DD15}$ to $V_{DD}$ power domain level shifter. |
| [9]  | WUPIEN   | External WAKEUP Pin Interrupt Enable<br>0: Disable WAKEUP pin interrupt function<br>1: Enable WAKEUP pin interrupt function<br>The software can set the WUPIEN bit to 1 to assert the LPWUP interrupt in the NVIC unit when both the WUPEN and WUPF bits are set to 1.                       |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | WUPEN  | <p>External WAKEUP Pin Enable</p> <p>0: Disable WAKEUP pin function.<br/>1: Enable WAKEUP pin function.</p> <p>The Software can set the WUPEN bit as 1 to enable the WAKEUP pin function before entering the power saving mode. When WUPEN = 1, a rising edge on the WAKEUP pin wakes up the system from the power saving mode. As the WAKEUP pin is active high, this bit will set an input pull down mode when the bit is high. The corresponding register bits which should be properly setup are the PBPDP[12] to 1 in the PBPDR register, the PBPU [12] to 0 in the PBPUR register and the PBCFG12 [3:0] field to 0x0F in the GPBCFGHR register.</p> <p>Note: This bit is reset by a system reset or a Backup Domain reset. Because this bit is located in the Backup Domain, after reset activity there will be a delay until the bit is active. The bit will not be active until the system reset finished and the Backup Domain ISO signal has been disabled. This means that the bit can not be immediately set by software after a system reset finished and the Backup domain ISO signal disabled. The delay time needed is a minimum of three 32KHz clock periods until the bit reset activity has finished.</p> |
| [7]  | DMOSON | <p>DMOS Control</p> <p>0: DMOS is OFF<br/>1: DMOS is ON</p> <p>A DMOS is implemented to provide an alternative voltage source for the 1.5 V power domain when the CPU enters the Deep-Sleep mode (SLEEPDEEP = 1). The control bit DMOSON is set by software and cleared by software or PORB. If the DMOSON bit is set to 1, the LDO will automatically be turned off when the CPU enters the Deep-Sleep mode.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| [3]  | LDOOFF | <p>LDO Operating Mode Control</p> <p>0: The LDO operates in a low current mode when CPU enters the Deep-Sleep mode (SLEEPDEEP = 1). The V<sub>DD15</sub> power is available.<br/>1: The LDO is turned off when the CPU enters the Deep-Sleep mode (SLEEPDEEP=1). The V<sub>DD15</sub> power is not available.</p> <p>Note: This bit is only available when the DMOSON bit is cleared to 0.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| [2]  | LDOLCM | <p>LDO Low Current Mode</p> <p>0: The LDO is operated in normal current mode.<br/>1: The LDO is operated in low current mode.</p> <p>Note: This bit is only available when CPU is in the run mode. The LDO output current capability will be limited at 10mA below and lower static current when the LDOLCM bit is set. It is suitable for CPU is operated at lower speed system clock to get a lower current consumption. This bit will be clear to 0 when the LDO is power down or V<sub>DD</sub> power domain reset.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [0]  | BAKRST | <p>Backup Domain Software Reset</p> <p>0: No action<br/>1: Backup Domain Software Reset is activated - includes all the related RTC and PWRCU registers.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## Backup Domain Test Register – BAKTEST

This register specifies a read-only value for the software to recognize whether backup domain is ready for access.

Offset: 0x108

Reset value: 0x0000\_0027

|            |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|------------|----------|----|----|----|----|----|----|----|----|---|----|---|----|---|----|---|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |   |    |   |    |   |    |   |
| Type/Reset | BAKTEST  |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|            | RO       | 0  | RO | 0  | RO | 1  | RO | 0  | RO | 0 | RO | 1 | RO | 1 | RO | 1 |

| Bits  | Field   | Descriptions                                                                                            |
|-------|---------|---------------------------------------------------------------------------------------------------------|
| [7:0] | BAKTEST | Backup Domain Test Bits<br>A constant 0x27 will be read when the Backup Domain is ready for CPU access. |

## Low Voltage / Brown Out Detect Control and Status Register – LVDCSR

This register specifies flags, enable bits and option bits for low voltage detector.

Offset: 0x110

Reset value: 0x0000\_0000 (Reset only by Backup Domain reset)

|            |          |          |         |         |      |            |        |        |
|------------|----------|----------|---------|---------|------|------------|--------|--------|
|            | 31       | 30       | 29      | 28      | 27   | 26         | 25     | 24     |
| Type/Reset | Reserved |          |         |         |      |            |        |        |
|            | 23       | 22       | 21      | 20      | 19   | 18         | 17     | 16     |
| Type/Reset | Reserved | LVDS [2] | LVDEWEN | LVDIWEN | LVDF | LVDS [1:0] |        | LV DEN |
|            |          |          | RW 0    | RW 0    | RO 0 | RW 0       | RW 0   | RW 0   |
|            | 15       | 14       | 13      | 12      | 11   | 10         | 9      | 8      |
| Type/Reset | Reserved |          |         |         |      |            |        |        |
|            | 7        | 6        | 5       | 4       | 3    | 2          | 1      | 0      |
| Type/Reset | Reserved |          |         |         | BODF | Reserved   | BODRIS | BODEN  |
|            |          |          |         |         | RO 0 |            | RW 0   | RW 0   |

| Bits          | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [21]          | LVDEWEN    | LVD Event Wakeup Enable<br>0: LVD event wakeup is disabled<br>1: LVD event wakeup is enabled<br>Setting this bit to 1 will enable the LVD event wakeup function to wake up the system when a LVD condition occurs which result in the LVDF bit being asserted. If the system requires to be waked up from the Deep-Sleep or Power-Down mode by a LVD condition, this bit must be set to 1.                                                                                                                                          |
| [20]          | LVDIWEN    | LVD Interrupt Wakeup Enable<br>0: LVD interrupt wakeup is disabled<br>1: LVD interrupt wakeup is enabled<br>Setting this bit to 1 will enable the LVD interrupt function. When a LVD condition occurs and the LVDIWEN bit is set to 1, a LVD interrupt will be generated and sent to the CPU NVIC unit.                                                                                                                                                                                                                             |
| [19]          | LVDF       | Low Voltage Detect Status Flag<br>0: V <sub>DDA</sub> is higher than the specific voltage level<br>1: V <sub>DDA</sub> is equal to or lower than the specific voltage level<br>When the LVD condition occurs, the LVDF flag will be asserted. When the LVDF flag is asserted, a LVD interrupt will be generated for CPU if the LVDIWEN bit is set to 1. However, if the LVDEWEN bit is set to 1 and the LVDIWEN bit is cleared to 0, only a LVD event will be generated rather than a LVD interrupt when the LVDF flag is asserted. |
| [22], [18:17] | LVDS [2:0] | Low Voltage Detect Level Selection<br>For more details concerning the LVD programmable threshold voltage, refer to the electrical characteristics of the corresponding datasheet.                                                                                                                                                                                                                                                                                                                                                   |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [16] | LV DEN | Low Voltage Detect Enable<br>0: Disable Low Voltage Detect<br>1: Enable Low Voltage Detect<br>Setting this bit to 1 will generate a LVD event when the $V_{DDA}$ power is lower than the voltage set by LVDS bits. Therefore when the LVD function is enabled before the system is into the Deep-Sleep2 (DMOS is turn on and LDO is power down) or Power-Down mode (DMOS and LDO is power down), the LVDEWEN bit has to be enabled to avoid the LDO does not activate in the meantime when the CPU is woken up by the low voltage detection activity. |
| [3]  | BODF   | Brown Out Detect Flag<br>0: $V_{DD} > V_{BOD}$<br>1: $V_{DD} \leq V_{BOD}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| [1]  | BODRIS | BOD Reset or Interrupt Selection<br>0: Reset the whole chip<br>1: Generate Interrupt                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [0]  | BODEN  | Brown Out Detector Enable<br>0: Disable Brown Out Detector<br>1: Enable Brown Out Detector                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

## Backup Register n – BAKREGn, n = 0 ~ 9

This register specifies backup register n for storing data during the VDD15 power-off period.

Offset: 0x200 ~ 0x224

Reset value: 0x0000\_0000 (Reset only by Backup Domain reset)

|            |         |    |    |    |    |    |    |    |    |
|------------|---------|----|----|----|----|----|----|----|----|
|            | 31      | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | BAKREGn |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23      | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | BAKREGn |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15      | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | BAKREGn |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7       | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | BAKREGn |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field   | Descriptions                                                                                                                                                                              |
|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | BAKREGn | Backup Register n (n = 0 ~ 9)<br>These registers are used for data storage in general purpose. The contents of BAKREGn registers will remain even if the V <sub>DD15</sub> power is lost. |

## 6 Clock Control Unit (CKCU)

### Introduction

The Clock Control unit (CKCU) provides functions of high speed internal RC oscillator (HSI), High speed external crystal oscillator (HSE), Low speed internal RC oscillator (LSI), Low speed external crystal oscillator (LSE), Phase Lock Loop (PLL), HSE clock monitor, clock prescaler, clock multiplexer and clock gating. The clock of AHB, APB, and CPU are derived from system clock (CK\_SYS) which can come from HSI, HSE or PLL. Watchdog Timer and Real Time Clock (RTC) use either LSI or LSE as their clock source.

A variety of internal clocks can also be wired out through CKOUT for debugging purpose. The clock monitor can be used to get clock failure detection of HSE. Once the clock of HSE does not function (could be broken down or removed or etc), CKCU will force to switch the system clock source to HSI clock to prevent system halt.

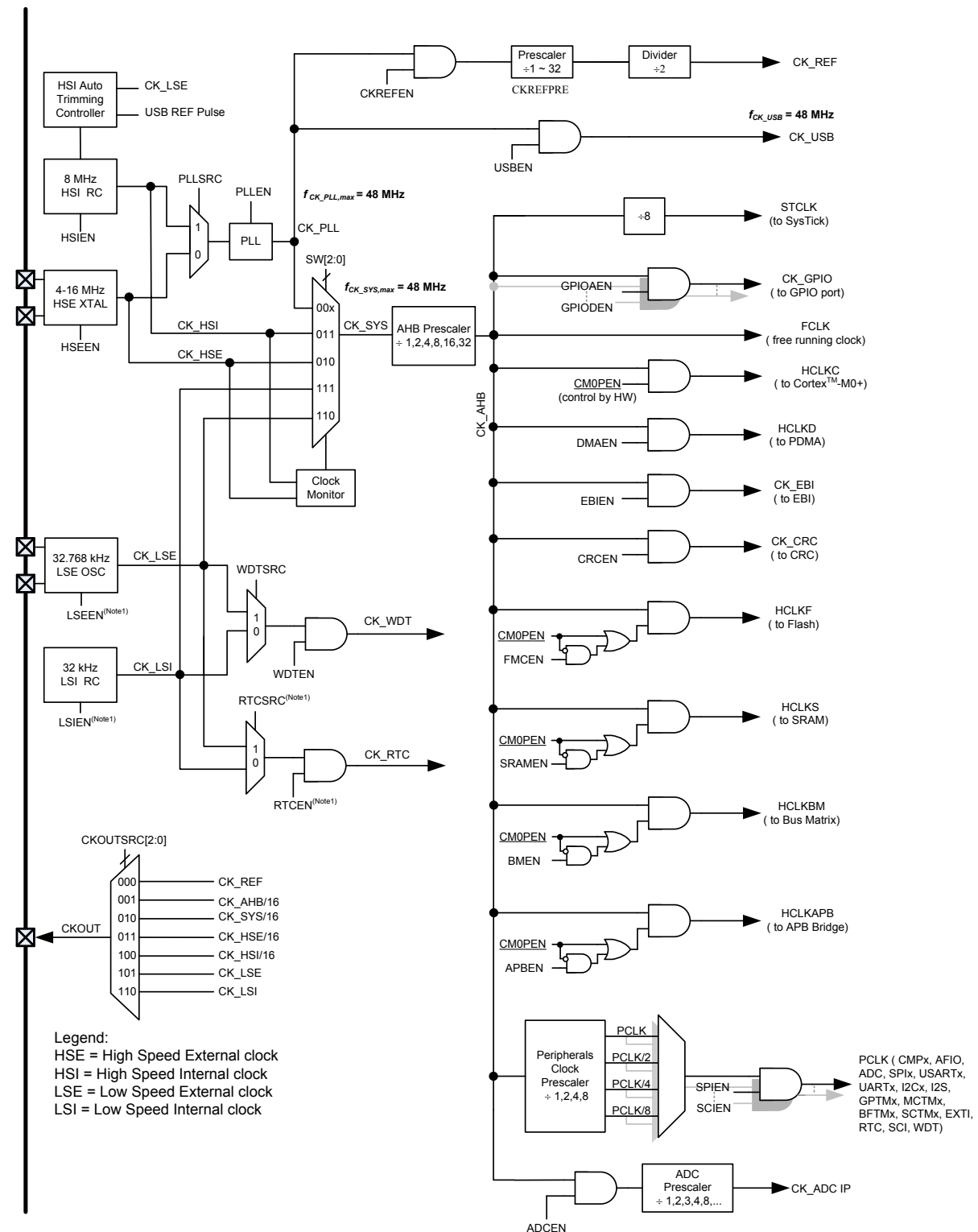


Figure 13. CKCU Block Diagram

## Features

- 4 ~ 16 MHz external crystal oscillator (HSE)
- Internal 8 MHz RC oscillator (HSI) with configuration option calibration and custom trimming capability.
- PLL with selectable clock source (from HSE or HSI) for system clock.
- 32,768 Hz external crystal oscillator (LSE) for Watchdog Timer, RTC or system clock.
- Internal 32 kHz RC oscillator (LSI) for Watchdog Timer, RTC or system clock.
- HSE clock monitor

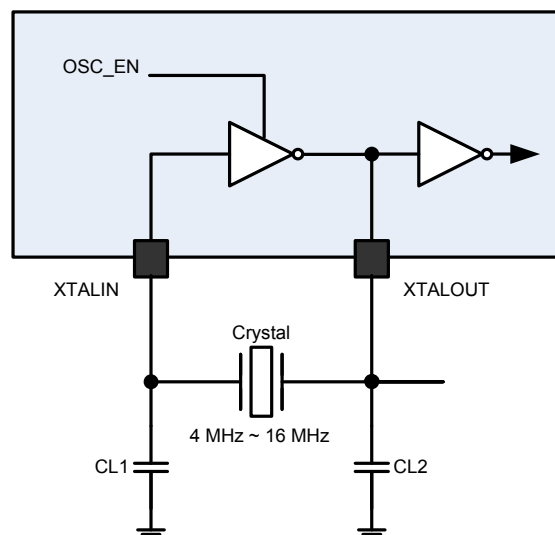
## Function Descriptions

### High Speed External Crystal Oscillator – HSE

The high speed external 4 to 16 MHz crystal oscillator (HSE) produces a highly accurate clock source to the system clock. The related hardware configuration is shown in the following figure. The crystal with specific frequency must be placed across the two HSE pins (XTALIN / XTALOUT) and the external components such as resistors and capacitors are necessary to make it oscillate properly.

The following guidelines are provided to improve the stability of the crystal circuit PCB layout.

- The crystal oscillator should be located as close as possible to the MCU so that the trace lengths are kept as short as possible to reduce any parasitic capacitances.
- Shield any lines in the vicinity of the crystal by using a ground plane to isolate signals and reduce noise.
- Keep frequently switching signal lines away from the crystal area to prevent crosstalk.



**Figure 14. External Crystal, Ceramic, and Resonators for HSE**

The HSE crystal oscillator can be switched on or off using the HSEEN bit in the Global Clock Control Register (GCCR). The HSERDY flag in the Global Clock Status Register (GCSR) will indicate if the high-speed external crystal oscillator is stable. When switching on the HSE oscillator the HSE clock will still not be released until this HSERDY bit is set by the hardware. The specific delay period is well-known as “Start-up time”. As the HSE becomes stable, an interrupt will be generated if the related interrupt enable bit HSIRDYIE in the Global Clock Interrupt Register (GCIR) is set. The HSE clock can then be used directly as the system clock source or be used as the PLL input clock.

## High Speed Internal RC Oscillator – HSI

The high speed internal 8 MHz RC oscillator (HSI) is the default selection of clock source for the CPU when the device is powered up. The HSI RC oscillator provides a clock source in a lower cost because no external components are required. The HSI RC oscillator can be switched on or off using the HSIEN bit in the Global Clock Control Register (GCCR). The HSIRDY flag in the Global Clock Status Register (GCSR) will indicate if the internal RC oscillator is stable. The start-up time of HSI is shorter than the HSE crystal oscillator. An interrupt can be generated if the related interrupt enable bit HSIRDYIE in the Global Clock Interrupt Register (GCIR) is set as the HSI becomes stable. The HSI clock can also be used as the PLL input clock.

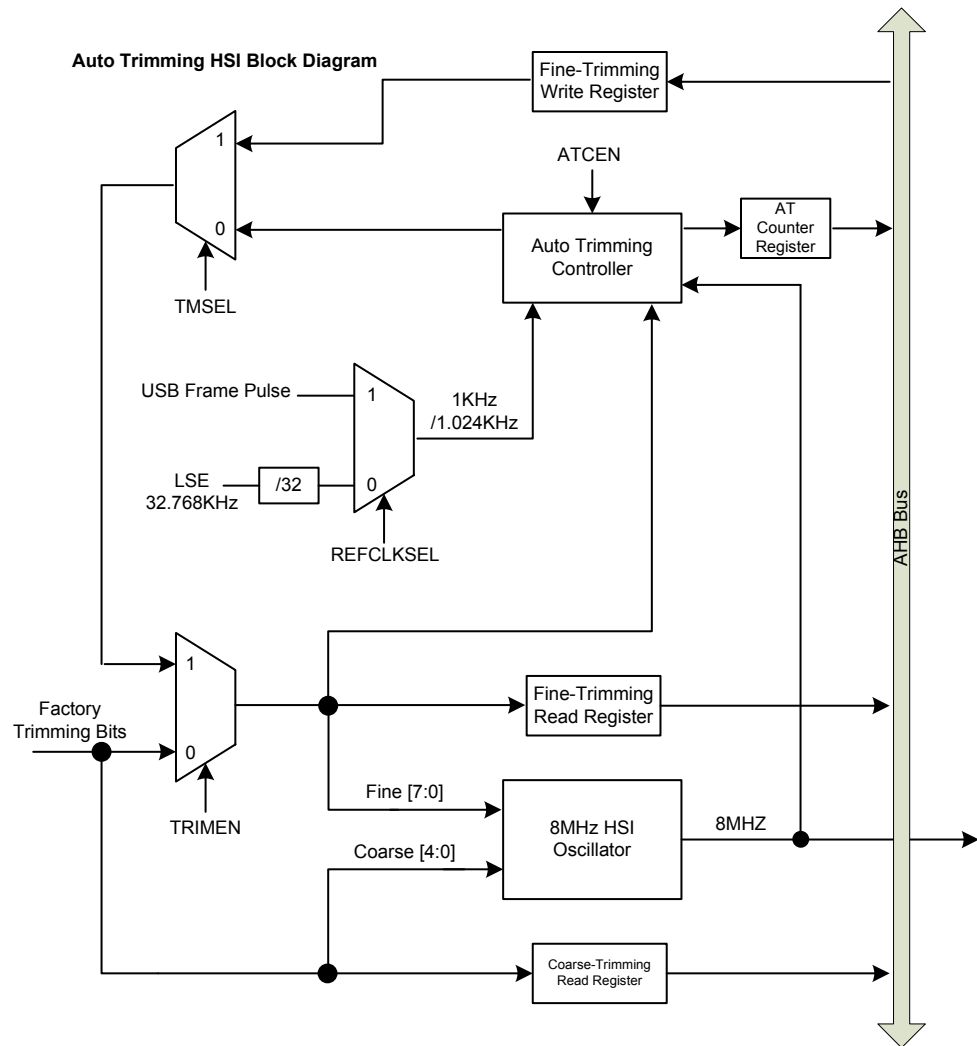
The accuracy of the frequency of the high speed internal RC oscillator HSI can be calibrated via the configuration options, but it is still less accurate than the HSE crystal oscillator. The applications, the environments and the cost will determine the use of the oscillators.

Software could configure PSRCEN bit (Power Saving Wakeup RC Clock Enable) to 1 to force HSI clock to be system clock when wake-up from Deep-Sleep or Power-Down mode. Subsequently, the system clock will be switched back to the original clock source (HSE or PLL) if the original clock source ready flag is asserted. This function can reduce the wakeup time when using the HSE or PLL clock as the system clock.

## Auto Trimming of High Speed Internal RC Oscillator – HSI

The frequency accuracy of the high speed internal RC oscillator HSI can vary from one chip to another due to manufacturing process variations, this is why each device is factory calibrated by HOLTEK for  $\pm 2\%$  accuracy at  $V_{DD} = 3.3\text{ V}$  and  $T_A = 25^\circ\text{C}$ . But the accuracy is not enough for some applications and environments requirement. Therefore, this device provides the trimming mechanism for HSI frequency calibration using more accurate external reference clock. The detail block diagram is shown as Figure 15.

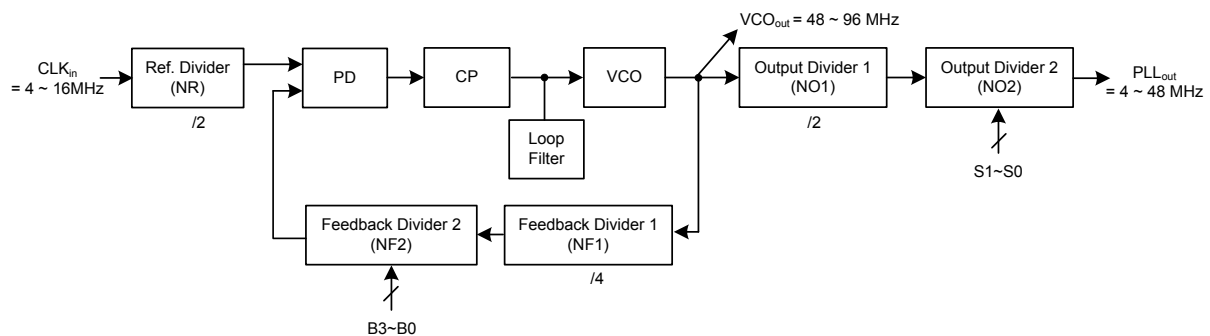
After reset, the factory trimming value is loaded in the HSICOARSE[4:0] and HSIFINE[7:0] bits in the HSI Control Register (HSICR). The HSI frequency accuracy may be affected by the voltage or temperature variation. If the application has to be driven by more accurate HSI frequency, the HSI frequency can be manually trimmed using the HSIFINE[7:0] bits in the HSI Control Register (HSICR) or automatically adjusted via the Auto Trimming Controller together with an external reference clock in the application. The reference clock can be provided from the low speed external crystal or ceramic resonator oscillator LSE with a 32,768 Hz frequency or a 1ms USB frame synchronous signal.



**Figure 15. HSI Auto Trimming Block Diagram**

## Phase Locked Loop – PLL

This PLL can provide 4 ~ 48 MHz clock output which is 1 ~ 12 multiples of a fundamental reference frequency of 4 ~ 16 MHz. The rationale of the clock synthesizer relies on the digital Phase Locked Loop (PLL) which includes a reference divider, a feedback divider, a digital phase frequency detector (PFD), a current-controlled charge pump, a built-in loop filter and a voltage-controlled oscillator (VCO) to achieve a stable phase-locked state.



**Figure 16. PLL Block Diagram**

Frequency of the PLL output clock can be determined by the following formula:

$$PLL_{OUT} = CK_{IN} * \frac{NF1 * NF2}{NR * NO1 * NO2} = CK_{IN} * \frac{4 * NF2}{2 * 2 * NO2} = CK_{IN} * \frac{NF2}{NO2}$$

where NR = Ref divider = 2, NF1 = Feedback Divider 1 = 4, NF2 = Feedback Divider 2 = 1 ~ 16,  
NO1 = Output Divider 1 = 2, NO2 = Output Divider 2 = 1, 2, 4, or 8

Considering the duty cycle of 50%, both input and output frequencies are divided by 2. If a given CLK<sub>in</sub> frequency as the PLL input generates a specific PLL output frequency, it is recommended to load a larger value into the NF2 field to increase the PLL stability and reduce the jitter with but the expense of settling time. The output and feedback divider 2 setup values are described in Table 1 and Table 2. All the configuration bits (S1 ~ S0, B3 ~ B0) in Table 1 and Table 2 are defined in the PLL Configuration Register (PLLCFGR) and PLL Control Register (PLLCR) in the section of Register Definition. Note that the VCO<sub>OUT</sub> frequency should be in the range from 48 MHz to 96 MHz. If the selected configuration exceeds this range, the PLL output frequency will not be guaranteed to match the above PLL<sub>OUT</sub> formula.

The PLL can be switched on or off by using the PLEN bit in the Global Clock Control Register (GCCR). The PLLRDY flag in the Global Clock Status Register (GCSR) will indicate if the PLL clock is stable. An interrupt can be generated if the related interrupt enable bit PLLRDYIE in the Global Clock Interrupt Register (GCIR) is set as the PLL becomes stable.

**Table 15. Output Divider2 Value Mapping**

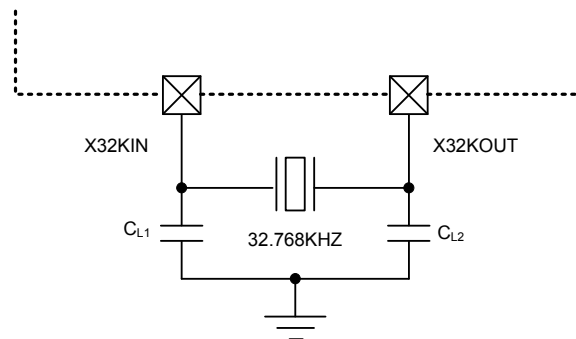
| Output divider 2 setup bits S[1:0]<br>(POTD bits in the PLLCFGR register) | NO2 (Output divider 2 value) |
|---------------------------------------------------------------------------|------------------------------|
| 00                                                                        | 1                            |
| 01                                                                        | 2                            |
| 10                                                                        | 4                            |
| 11                                                                        | 8                            |

**Table 16. Feedback Divider2 Value Mapping**

| Feedback divider2 setup bits B[3:0]<br>(PFBD bits in the PLLCFGR register) | NF2 (Feedback divider 2 value) |
|----------------------------------------------------------------------------|--------------------------------|
| 0000                                                                       | 16                             |
| 0001                                                                       | 1                              |
| 0010                                                                       | 2                              |
| 0011                                                                       | 3                              |
| 0100                                                                       | 4                              |
| 0101                                                                       | 5                              |
| 0110                                                                       | 6                              |
| 0111                                                                       | 7                              |
| 1000                                                                       | 8                              |
| 1001                                                                       | 9                              |
| 1010                                                                       | 10                             |
| 1011                                                                       | 11                             |
| 1100                                                                       | 12                             |
| :                                                                          | :                              |
| :                                                                          | :                              |
| 1111                                                                       | 15                             |

## Low Speed External Crystal Oscillator – LSE

The low speed external crystal or ceramic resonator oscillator with 32,768 Hz frequency produces a low power but highly accurate clock source for the Real-Time-Clock peripheral, Watchdog Timer or system clock. The associated hardware configuration is shown in the following figure. The crystal or ceramic resonator must be placed across the two LSE pins (X32KIN / X32KOUT) and the external components such as resistors and capacitors are necessary to make it oscillate properly. The LSE oscillator can be switched on or off by using the LSEEN bit in the RTC Control Register (RTCCR). The LSERDY flag in the Global Clock Status Register (GCSR) will indicate if the LSE clock is stable. An interrupt can be generated if the related interrupt enable bit LSERDYIE in the Global Clock Interrupt Register (GCIR) is set as the LSE becomes stable.



**Figure 17. External Crystal, Ceramic, and Resonators for LSE**

## Low Speed Internal RC Oscillator – LSI

The low speed internal RC oscillator with a frequency of about 32 kHz produces a low power clock source for the Real-Time-Clock peripheral, Watchdog Timer or system clock. The LSI offers a low cost clock source because no external component is required to make it oscillates. The LSI RC oscillator can be switched on or off by using the LSIEN bit in the RTC Control Register (RTCCR). The LSI frequency accuracy is shown in the datasheet. The LSIRDY flag in the Global Clock Status Register (GCSR) will indicate if the LSI clock is stable. An interrupt can be generated if the related interrupt enable bit LSIRDYIE in the Global Clock Interrupt Register (GCIR) is set as the LSI becomes stable.

## Clock Ready Flag

The CKCU provides the corresponding clock ready flags for the HSI, HSE, PLL, LSI, and LSE to indicate whether these clocks are stable. Before using them as the system clock source or other purpose, it is necessary to confirm the specific clock ready flag is set. Software can check the specific clock is ready or not by polling the individual clock ready status bits in GCSR register. Additionally, the CKCU can trigger an interrupt to notify specific clock is ready if the corresponding interrupt enable bit in the GCIR register is set. Software should clear the interrupt status bit in the GCIR register by interrupt service routine.

## System Clock (CK\_SYS) Selection

After the system reset occurs, the default system clock source CK\_SYS will be the high speed internal RC oscillator HSI. The CK\_SYS may come from the HSI, HSE, LSE, LSI or PLL output clock and it can be switched from one clock source to another by changing the System Clock Switch bits, SW, in the Global Clock Control Register GCCR. The system will still run under the original clock until the destination clock gets ready when the SW value is changed. The corresponding clock ready status bit in the Global Clock Status Register (GCSR) will indicate whether the selected clock is ready to use or not. The CKCU also contains the clock source status bits in the Clock Source Status Register (CKST) to indicate which clock is currently used as the system clock. If a clock source or the PLL output clock is used as the system clock source, it is not possible to stop it. More details about the clock enable function is described in the following.

If any event in the following occurs, the HSI will be enabled.

- Enable PLL and configure its source clock to HSI. (PLEN, PLLSRC)
- Enable Clock monitor. (CKMEN)
- Configure clock switch register to HSI. (SW)
- Configure HSI enable register to 1. (HSIEN)

If any event in the following occurs, the HSE will be enabled.

- Enable PLL and configure its source clock to HSE. (PLEN, PLLSRC)
- Configure clock switch register to HSE. (SW)
- Configure HSE enable register to 1. (HSEEN)

If any event in the following occurs, the PLL will be enabled.

- Enable USB Enable register. (USBEN)
- Configure clock switch register to PLL (SW)
- Configure PLL enable register to 1. (PLEN)

The system clock selection programming guide is listed in the following.

1. Enable any clock source which will become the system clock or PLL input clock.
2. Configuring the PLLSRC register after the ready flags of both HSI and HSE are asserted,
3. Configuring the SW register to change the system clock source will occur after the corresponding ready flag of the clock source is asserted. Note that the system clock will be forced to HSI if the clock monitor is enabled and the PLL output or HSE clock configured as the system clock is stuck at 0 or 1.

## HSE Clock Monitor

The HSE clock monitor function is enabled by the HSE Clock Monitor Enable bit CKMEN in the Global Clock Control Register, GCCR. The HSE clock monitor function should be enabled after the HSE oscillator start-up delay and disabled when the HSE oscillator is stopped. Once the HSE oscillator failure is detected, the HSE oscillator will automatically be disabled. The HSE clock stuck flag CKSF in the Global Clock Interrupt Register GCIR will be set and the HSE oscillator failure event will be generated if the corresponding interrupt enable bit CKSIE in the GCIR is set. This failure interrupt is connected to the CPU Non-Maskable Interrupt, NMI. When the HSE oscillator failure occurs, the HSE will be turned off and the system clock will be switched to the HSI automatically by the hardware. If the HSE is used as the clock input of the PLL circuit whose output is used as the system clock, the PLL circuit will also be turned off as well as the HSE when the failure happens.

## Clock Output Capability

The device has the clock output capability to allow the clocks to be output on the specific external output pin CKOUT. The configuration registers of the corresponding GPIO port must be well configured in the Alternate Function I/O, AFIO, section to output the selected clock signal. There are seven output clock signals to be selected via the device clock output source selection bits CKOUTSRC in the Global Clock Configuration Register, GCFGR.

**Table 17. CKOUT Clock Source**

| CKOUTSRC[2:0] | Clock Source                         |
|---------------|--------------------------------------|
| 000           | CK_REF = CK_PLL / (CKREFPRE + 1) / 2 |
| 001           | HCLKC / 16                           |
| 010           | CK_SYS / 16                          |
| 011           | CK_HSE / 16                          |
| 100           | CK_HSI / 16                          |
| 101           | CK_LSE                               |
| 110           | CK_LSI                               |

## Register Map

The following table shows the CKCU register and reset value.

**Table 18. CKCU Register Map**

| Register | Offset | Description                               | Reset Value                         |
|----------|--------|-------------------------------------------|-------------------------------------|
| GCFGR    | 0x000  | Global Clock Configuration Register       | 0x0000_0102                         |
| GCCR     | 0x004  | Global Clock Control Register             | 0x0000_0803                         |
| GCSR     | 0x008  | Global Clock Status Register              | 0x0000_0028                         |
| GCIR     | 0x00C  | Global Clock Interrupt Register           | 0x0000_0000                         |
| PLLCFGR  | 0x018  | PLL Configuration Register                | 0x0000_0000                         |
| PLLCR    | 0x01C  | PLL Control Register                      | 0x0000_0000                         |
| AHBCFGR  | 0x020  | AHB Configuration Register                | 0x0000_0000                         |
| AHBCCR   | 0x024  | AHB Clock Control Register                | 0x0000_0005                         |
| APBCFGR  | 0x028  | APB Configuration Register                | 0x0000_0000                         |
| APBCCR0  | 0x02C  | APB Clock Control Register 0              | 0x0000_0000                         |
| APBCCR1  | 0x030  | APB Clock Control Register 1              | 0x0000_0000                         |
| CKST     | 0x034  | Clock Source Status Register              | 0x0100_0003                         |
| APBPCR0  | 0x038  | APB Peripheral Clock Selection Register 0 | 0x0000_0000                         |
| APBPCR1  | 0x03C  | APB Peripheral Clock Selection Register 1 | 0x0000_0000                         |
| HSICR    | 0x040  | HSI Control Register                      | 0xFFFF_0000<br>where X is undefined |
| HSIATCR  | 0x044  | HSI Auto Trimming Counter Register        | 0x0000_0000                         |
| LPCR     | 0x300  | Low Power Control Register                | 0x0000_0000                         |
| MCUDBGCR | 0x304  | MCU Debug Control Register                | 0x0000_0000                         |

## Register Descriptions

### Global Clock Configuration Register – GCFGR

This register specifies the clock source for PLL/USART/Watchdog Timer/CKOUT.

Offset: 0x000

Reset value: 0x0000\_0102

|            |          |    |          |    |          |          |    |        |
|------------|----------|----|----------|----|----------|----------|----|--------|
|            | 31       | 30 | 29       | 28 | 27       | 26       | 25 | 24     |
|            | LPMOD    |    |          |    | Reserved |          |    |        |
| Type/Reset | RO       | 0  | RO       | 0  | RO       | 0        |    |        |
|            | 23       | 22 | 21       | 20 | 19       | 18       | 17 | 16     |
|            | USBPRE   |    | Reserved |    |          |          |    |        |
| Type/Reset | RW       | 0  | RW       | 0  |          |          |    |        |
|            | 15       | 14 | 13       | 12 | 11       | 10       | 9  | 8      |
|            | CKREFPRE |    |          |    |          | Reserved |    | PLLSRC |
| Type/Reset | RW       | 0  | RW       | 0  | RW       | 0        | RW | 0      |
|            | 7        | 6  | 5        | 4  | 3        | 2        | 1  | 0      |
|            | Reserved |    |          |    |          | CKOUTSRC |    |        |
| Type/Reset |          |    |          |    |          | RW       | 0  | RW 1   |

| Bits    | Field    | Descriptions                                                                                                                                                                                                                                                                                                    |
|---------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:29] | LPMOD    | Lower Power Mode Status<br>000: When Chip is in running mode<br>001: When Chip wants to enter Sleep mode<br>010: When Chip wants to enter Deep Sleep mode1<br>011: When Chip wants to enter Deep Sleep mode2<br>100: When Chip wants to enter Power Down mode<br>Others: Reserved<br>Set and reset by hardware. |
| [23:22] | USBPRE   | USB Clock Prescaler Selection<br>00: CK_USB = CK_PLL<br>01: CK_USB = CK_PLL / 2<br>Others: Reserved<br>Set and reset by software to control the USB clock prescaler setting.                                                                                                                                    |
| [15:11] | CKREFPRE | CK_REF Clock Prescaler Selection<br>$CK\_REF = CK\_PLL / (CKREFPRE + 1) / 2$<br>00000: CK_REF = CK_PLL / 2<br>00001: CK_REF = CK_PLL / 4<br>...<br>11111: CK_REF = CK_PLL / 64<br>Set and reset by software to the control CK_REF clock prescaler setting.                                                      |
| [8]     | PLLSRC   | PLL Clock Source Selection<br>0: External 4 ~ 16 MHz crystal oscillator clock is selected (HSE)<br>1: Internal 8 MHz RC oscillator clock is selected (HSI)<br>Set and reset by software to control the PLL clock source.                                                                                        |

| Bits  | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                          |
|-------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2:0] | CKOUTSRC | CKOUT Clock Source Selection<br>000: (CK_REF) is selected where $CK\_REF = CK\_PLL / (CKREFPRE + 1) / 2$<br>001: (CK_AHB / 16) is selected<br>010: (CK_SYS / 16) is selected<br>011: (CK_HSE / 16) is selected<br>100: (CK_HSI / 16) is selected<br>101: CK_LSE is selected<br>110: CK_LSI is selected<br>111: Reserved<br>Set and reset by software. |

## Global Clock Control Register – GCCR

This register specifies the clock enable bits.

Offset: 0x004

Reset value: 0x0000\_0803

|            |          |    |    |    |       |       |        |         |    |
|------------|----------|----|----|----|-------|-------|--------|---------|----|
|            | 31       | 30 | 29 | 28 | 27    | 26    | 25     | 24      |    |
| Type/Reset | Reserved |    |    |    |       |       |        |         |    |
|            | 23       | 22 | 21 | 20 | 19    | 18    | 17     | 16      |    |
| Type/Reset | Reserved |    |    |    |       |       | PSRCEN | CKMEN   |    |
|            |          |    |    |    |       |       | RW     | 0       | RW |
|            | 15       | 14 | 13 | 12 | 11    | 10    | 9      | 8       |    |
| Type/Reset | Reserved |    |    |    | HSIEN | HSEEN | PLLEN  | HSEGAIN |    |
|            |          |    |    |    | RW    | 1     | RW     | 0       | RW |
|            |          |    |    |    |       |       | 0      | RW      | 0  |
|            | 7        | 6  | 5  | 4  | 3     | 2     | 1      | 0       |    |
| Type/Reset | Reserved |    |    |    |       | SW    |        |         |    |
|            |          |    |    |    |       | RW    | 0      | RW      | 1  |
|            |          |    |    |    |       |       |        | 1       | RW |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [17] | PSRCEN | Power Saving Wakeup RC Clock Enable<br>0: No action<br>1: Use Internal 8 MHz RC clock (HSI) as system clock after power down wakeup.<br>The software can set the PSRCEN bit high before entering the power saving mode in order to reduce the waiting time after a wakeup. When the PSRCEN bit is set to 1, the HSI will be used as the CK_SYS clock source after waking up from the power saving mode. This means that the instruction can be executed early before the original CK_SYS source is stable since the HSI clock is provided to CPU. After the original CK_SYS clock source is ready, the CK_SYS clock will automatically be switched back to the originally selected clock source from the HSI clock. |
| [16] | CKMEN  | HSE Clock Monitor Enable<br>0: Disable External 4 ~ 16 MHz crystal oscillator clock monitor<br>1: Enable External 4 ~ 16 MHz crystal oscillator clock monitor<br>When the hardware detects that the HSE clock is stuck at low or high state, the internal hardware will switch the system clock to internal high speed HSI RC clock. The way to recover the original system clock is by an external reset, a power on reset or clearing the CKSF by software.                                                                                                                                                                                                                                                       |
| [11] | HSIEN  | Internal High Speed Oscillator Enable<br>0: Internal 8 MHz RC oscillator is disabled<br>1: Internal 8 MHz RC oscillator is enabled<br>Set and reset by software. This bit can not be reset if the HSI clock is used as the system clock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| [10] | HSEEN  | External High Speed Oscillator Enable<br>0: External 4 ~ 16 MHz crystal oscillator is disabled<br>1: External 4 ~ 16 MHz crystal oscillator is enabled<br>Set and reset by software. This bit can not be reset if the HSE clock is used as the system clock or the PLL input clock.                                                                                                                                                                                                                                                                                                                                                                                                                                 |

| Bits  | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9]   | PLLEN   | <p>PLL Enable</p> <p>0: PLL disabled<br/>1: PLL enabled</p> <p>Set and reset by software. This bit cannot be reset if the PLL clock is used as the system clock.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| [8]   | HSEGAIN | <p>External High Speed Oscillator Gain Selection</p> <p>0: HSE in low gain mode<br/>1: HSE in high gain mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| [2:0] | SW      | <p>System Clock Switch</p> <p>00x: CK_PLL clock out as system clock<br/>010: CK_HSE as system clock<br/>011: CK_HSI as system clock<br/>110: CK_LSE as system clock<br/>111: CK_LSI as system clock<br/>Other: CK_HSI as system clock</p> <p>These bits are used to select the CK_SYS source. When switch the system clock using the SW bit, the system clock will be not immediately switched and a certain delay is necessary. The system clock source selected by the SW bits can be indicated in the CKSWST bits in the clock source status register CKST to make sure which clock is currently used as the system clock. Note that the HSI oscillator will be forced as the system clock when the HSE clock failure is detected as the HSE clock monitor function is enabled.</p> |

## Global Clock Status Register – GCSR

This register indicates the clock ready status.

Offset: 0x008

Reset value: 0x0000\_0028

|            |          |          |        |        |        |        |        |          |
|------------|----------|----------|--------|--------|--------|--------|--------|----------|
|            | 31       | 30       | 29     | 28     | 27     | 26     | 25     | 24       |
| Type/Reset | Reserved |          |        |        |        |        |        |          |
|            | 23       | 22       | 21     | 20     | 19     | 18     | 17     | 16       |
| Type/Reset | Reserved |          |        |        |        |        |        |          |
|            | 15       | 14       | 13     | 12     | 11     | 10     | 9      | 8        |
| Type/Reset | Reserved |          |        |        |        |        |        |          |
|            | 7        | 6        | 5      | 4      | 3      | 2      | 1      | 0        |
| Type/Reset |          | Reserved | LSIRDY | LSERDY | HSIRDY | HSERDY | PLLRDY | Reserved |
|            |          |          | RO     | 1 RO   | 0 RO   | 1 RO   | 0 RO   | 0        |

| Bits | Field  | Descriptions                                                                                                                                                                                                                   |
|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | LSIRDY | Internal Low Speed Oscillator Ready Flag<br>0: Internal 32 kHz RC oscillator is not ready<br>1: Internal 32 kHz RC oscillator is ready<br>Set by hardware to indicate whether the LSI is stable to be used.                    |
| [4]  | LSERDY | External Low Speed Oscillator Ready Flag<br>0: External 32,768 Hz crystal oscillator is not ready<br>1: External 32,768 Hz crystal oscillator is ready<br>Set by hardware to indicate whether the LSE is stable to be used.    |
| [3]  | HSIRDY | Internal High Speed Oscillator Ready Flag<br>0: Internal 8 MHz RC oscillator is not ready<br>1: Internal 8 MHz RC oscillator is ready<br>Set by hardware to indicate whether the HSI is stable to be used.                     |
| [2]  | HSERDY | External High Speed Oscillator Ready Flag<br>0: External 4 ~ 16 MHz crystal oscillator is not ready<br>1: External 4 ~ 16 MHz crystal oscillator is ready<br>Set by hardware to indicate whether the HSE is stable to be used. |
| [1]  | PLLRDY | PLL Clock Ready Flag<br>0: PLL is not ready<br>1: PLL is ready<br>Set by hardware to indicate whether the PLL output is stable to be used.                                                                                     |

## Global Clock Interrupt Register – GCIR

This register specifies the interrupt enable and flag bits.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |          |          |          |          |          |          |       |   |
|------------|----------|----------|----------|----------|----------|----------|----------|-------|---|
|            | 31       | 30       | 29       | 28       | 27       | 26       | 25       | 24    |   |
| Type/Reset | Reserved |          |          |          |          |          |          |       |   |
|            | 23       | 22       | 21       | 20       | 19       | 18       | 17       | 16    |   |
| Type/Reset | Reserved | LSIRDYIE | LSERDYIE | HSIRDYIE | HSERDYIE | PLLRDYIE | Reserved | CKSIE |   |
|            |          | RW       | 0        | RW       | 0        | RW       | 0        | RW    | 0 |
|            | 15       | 14       | 13       | 12       | 11       | 10       | 9        | 8     |   |
| Type/Reset | Reserved |          |          |          |          |          |          |       |   |
|            | 7        | 6        | 5        | 4        | 3        | 2        | 1        | 0     |   |
| Type/Reset | Reserved | LSIRDYF  | LSERDYF  | HSIRDYF  | HSERDYF  | PLLRDYF  | Reserved | CKSF  |   |
|            |          | WC       | 0        | WC       | 0        | WC       | 0        | WC    | 0 |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                                          |
|------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [22] | LSIRDYIE | LSI Ready Interrupt Enable<br>0: Disable LSI stabilization interrupt<br>1: Enable LSI stabilization interrupt<br>Set and reset by software to enable or disable the LSI stabilization interrupt.                                                                                      |
| [21] | LSERDYIE | LSE Ready Interrupt Enable<br>0: Disable LSE stabilization interrupt<br>1: Enable LSE stabilization interrupt<br>Set and reset by software to enable or disable the LSE stabilization interrupt.                                                                                      |
| [20] | HSIRDYIE | HSI Ready Interrupt Enable<br>0: Disable HSI stabilization interrupt<br>1: Enable HSI stabilization interrupt<br>Set and reset by software to enable or disable the HSI stabilization interrupt.                                                                                      |
| [19] | HSERDYIE | HSE Ready Interrupt Enable<br>0: Disable HSE stabilization interrupt<br>1: Enable HSE stabilization interrupt<br>Set and reset by software to enable or disable the HSE stabilization interrupt.                                                                                      |
| [18] | PLLRDYIE | PLL Ready Interrupt Enable<br>0: Disable PLL stabilization interrupt<br>1: Enable PLL stabilization interrupt<br>Set and reset by software to enable or disable the PLL stabilization interrupt.                                                                                      |
| [16] | CKSIE    | Clock Stuck Interrupt Enable<br>0: Disable clock failure interrupt<br>1: Enable clock failure interrupt<br>Set and reset by software to enable or disable the clock failure interrupt caused by clock monitor.                                                                        |
| [6]  | LSIRDYF  | LSI Ready Interrupt Flag<br>0: No LSI stabilization clock ready interrupt event occurs<br>1: LSI stabilization clock ready interrupt occurs<br>Reset by software (Write 1 clear). Set by hardware when the Internal 32 kHz RC oscillator clock is stable and the LSIRDYIE bit is set. |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                          |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | LSERDYF | LSE Ready Interrupt Flag<br>0: No LSE stabilization clock ready interrupt event occurs<br>1: LSE stabilization clock ready interrupt event occurs<br>Reset by software (Write 1 clear). Set by hardware when the External 32,768 Hz crystal oscillator clock is stable and the LSERDYDIE bit is set.  |
| [4]  | HSIRDYF | HSI Ready Interrupt Flag<br>0: No HSI stabilization clock ready interrupt event occurs<br>1: HSI stabilization clock ready interrupt event occurs<br>Reset by software (Write 1 clear). Set by hardware when the Internal 8 MHz RC oscillator clock is stable and the HSIRDYDIE bit is set.           |
| [3]  | HSERDYF | HSE Ready Interrupt Flag<br>0: No HSE stabilization clock ready interrupt event occurs<br>1: HSE stabilization clock ready interrupt event occurs<br>Reset by software (Write 1 clear). Set by hardware when the External 4 ~ 16 MHz crystal oscillator clock is stable and the HSERDYDIE bit is set. |
| [2]  | PLLRDYF | PLL Ready Interrupt Flag<br>0: No PLL stabilization clock ready interrupt event occurs<br>1: PLL stabilization clock ready interrupt event occurs<br>Reset by software (Write 1 clear). Set by hardware when the PLL output clock is stable and the PLLRDYDIE bit is set.                             |
| [0]  | CKSF    | Clock Stuck Interrupt Flag<br>0: Clock works normally<br>1: HSE clock is stuck<br>Reset by software (Write 1 clear). Set by hardware when the HSE clock is stuck and the CKSIE bit is set.                                                                                                            |

## PLL Configuration Register – PLLCFGR

This register specifies the PLL configurations.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |      |    |    |          |      |    |    |
|------------|----------|------|----|----|----------|------|----|----|
|            | 31       | 30   | 29 | 28 | 27       | 26   | 25 | 24 |
|            | Reserved |      |    |    |          | PFBD |    |    |
| Type/Reset |          |      |    |    |          | RW   | 0  | RW |
|            | 23       | 22   | 21 | 20 | 19       | 18   | 17 | 16 |
|            | PFBD     | POTD |    |    | Reserved |      |    |    |
| Type/Reset | RW       | 0    | RW | 0  | RW       | 0    |    |    |
|            | 15       | 14   | 13 | 12 | 11       | 10   | 9  | 8  |
|            | Reserved |      |    |    |          |      |    |    |
| Type/Reset |          |      |    |    |          |      |    |    |
|            | 7        | 6    | 5  | 4  | 3        | 2    | 1  | 0  |
|            | Reserved |      |    |    |          |      |    |    |
| Type/Reset |          |      |    |    |          |      |    |    |

| Bits    | Field | Descriptions                                                                                                                    |
|---------|-------|---------------------------------------------------------------------------------------------------------------------------------|
| [26:23] | PFBD  | PLL VCO Output Clock Feedback Divider (B3 ~ B0 in Figure 16)<br>The feedback Divider divides the output clock from the PLL VCO. |
| [22:21] | POTD  | PLL Output Clock Divider (S1 ~ S0 in Figure 16)                                                                                 |

## PLL Control Register – PLLCR

This register specifies the PLL Bypass mode.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |          |    |    |    |    |    |    |
|------------|----------|----------|----|----|----|----|----|----|
|            | 31       | 30       | 29 | 28 | 27 | 26 | 25 | 24 |
|            | PLLBPS   | Reserved |    |    |    |    |    |    |
| Type/Reset | RW       | 0        |    |    |    |    |    |    |
|            | 23       | 22       | 21 | 20 | 19 | 18 | 17 | 16 |
|            | Reserved |          |    |    |    |    |    |    |
| Type/Reset |          |          |    |    |    |    |    |    |
|            | 15       | 14       | 13 | 12 | 11 | 10 | 9  | 8  |
|            | Reserved |          |    |    |    |    |    |    |
| Type/Reset |          |          |    |    |    |    |    |    |
|            | 7        | 6        | 5  | 4  | 3  | 2  | 1  | 0  |
|            | Reserved |          |    |    |    |    |    |    |
| Type/Reset |          |          |    |    |    |    |    |    |

| Bits | Field  | Descriptions                                                                                               |
|------|--------|------------------------------------------------------------------------------------------------------------|
| [31] | PLLBPS | PLL Bypass Mode Enable<br>0: Disable PLL Bypass mode<br>1: Enable PLL Bypass mode which acts as FOUT = FIN |

## AHB Configuration Register – AHBCFGR

This register specifies the system clock frequency.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |        |    |    |
|------------|----------|----|----|----|----|--------|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26     | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |        |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18     | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |        |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10     | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |        |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2      | 1  | 0  |
| Type/Reset | Reserved |    |    |    |    | AHBPRE |    |    |
|            |          |    |    |    |    | RW     | 0  | RW |
|            |          |    |    |    |    |        | 0  | RW |
|            |          |    |    |    |    |        |    | 0  |

| Bits  | Field  | Descriptions                                                                                                                                                                                                                                                                                                                 |
|-------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2:0] | AHBPRE | AHB Pre-scaler<br>000: CK_AHB = CK_SYS<br>001: CK_AHB = CK_SYS / 2<br>010: CK_AHB = CK_SYS / 4<br>011: CK_AHB = CK_SYS / 8<br>100: CK_AHB = CK_SYS / 16<br>101: CK_AHB = CK_SYS / 32<br>110: CK_AHB = CK_SYS / 32<br>111: CK_AHB = CK_SYS / 32<br>Set and reset by software to control the division factor of the AHB clock. |

## AHB Clock Control Register – AHBCCR

This register specifies the AHB clock enable control bits.

Offset: 0x024

Reset value: 0x0000\_0005

|            |          |       |       |        |          |        |          |       |
|------------|----------|-------|-------|--------|----------|--------|----------|-------|
|            | 31       | 30    | 29    | 28     | 27       | 26     | 25       | 24    |
| Type/Reset | Reserved |       |       |        |          |        |          |       |
|            | 23       | 22    | 21    | 20     | 19       | 18     | 17       | 16    |
| Type/Reset | Reserved |       |       |        | PDEN     | PCEN   | PBEN     | PAEN  |
|            |          |       |       |        | RW       | 0      | RW       | 0     |
|            | 15       | 14    | 13    | 12     | 11       | 10     | 9        | 8     |
| Type/Reset | Reserved |       | CRCEN | EBIEN  | CKREFEN  | USBEN  | Reserved |       |
|            |          |       | RW    | 0      | RW       | 0      | RW       | 0     |
|            | 7        | 6     | 5     | 4      | 3        | 2      | 1        | 0     |
| Type/Reset | Reserved | APBEN | BMEN  | PDMAEN | Reserved | SRAMEN | Reserved | FMCEN |
|            |          | RW    | 1     | RW     | 1        | RW     | 1        |       |
|            |          |       |       | RW     | 0        |        |          | RW    |
|            |          |       |       |        |          |        |          | 1     |

| Bits | Field   | Descriptions                                                                                                       |
|------|---------|--------------------------------------------------------------------------------------------------------------------|
| [19] | PDEN    | GPIO Port D Clock Enable<br>0: Port D clock is disabled<br>1: Port D clock is enabled<br>Set and reset by software |
| [18] | PCEN    | GPIO Port C Clock Enable<br>0: Port C clock is disabled<br>1: Port C clock is enabled<br>Set and reset by software |
| [17] | PBEN    | GPIO Port B Clock Enable<br>0: Port B clock is disabled<br>1: Port B clock is enabled<br>Set and reset by software |
| [16] | PAEN    | GPIO Port A Clock Enable<br>0: Port A clock is disabled<br>1: Port A clock is enabled<br>Set and reset by software |
| [13] | CRCEN   | CRC Module Clock Enable<br>0: CRC clock is disabled<br>1: CRC clock is enabled<br>Set and reset by software.       |
| [12] | EBIEN   | EBI Module Clock Enable<br>0: EBI clock is disabled<br>1: EBI clock is enabled<br>Set and reset by software.       |
| [11] | CKREFEN | CK_REF Clock Enable<br>0: CK_REF clock is disabled<br>1: CK_REF clock is enabled<br>Set and reset by software      |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                    |
|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | USBEN  | USB Clock Enable<br>0: USB clock is disabled<br>1: USB clock is enabled<br>Set and reset by software                                                                                                                                                                                                            |
| [6]  | APBEN  | APB bridge Clock Enable<br>0: APB bridge clock is automatically disabled by hardware during Sleep mode<br>1: APB bridge clock is always enabled during Sleep mode<br>Set and reset by software. User can set the APBEN bit to 0 to reduce the power consumption if the APB bridge is unused during Sleep mode.  |
| [5]  | BMEN   | Bus Matrix Clock Enable<br>0: Bus Matrix clock is automatically disabled by hardware during Sleep mode<br>1: Bus Matrix clock is always enabled during Sleep mode<br>Set and reset by software. User can set the BMEN bit to 0 to reduce the power consumption if the bus matrix is unused during Sleep mode.   |
| [4]  | PDMAEN | Peripheral DMA Clock Enable<br>0: PDMA clock is disabled<br>1: PDMA clock is enabled<br>Set and reset by software.<br>Note: The PDMA can independently operate when the processor enters the sleep mode. But the relative AHB bus slave or peripherals clock has to be enabled.                                 |
| [2]  | SRAMEN | SRAM Clock Enable<br>0: SRAM clock is automatically disabled by hardware during Sleep mode<br>1: SRAM clock is always enabled during Sleep mode<br>Set and reset by software. User can set the SRAMEN bit to 0 to reduce the power consumption if the SRAM is unused during Sleep mode.                         |
| [0]  | FMCEN  | Flash Memory Controller Clock Enable<br>0: FMC clock is automatically disabled by hardware during Sleep mode<br>1: FMC clock is always enabled during Sleep mode<br>Set and reset by software. User can set the FMCEN bit to 0 to reduce the power consumption if the Flash Memory is unused during Sleep mode. |

## APB Configuration Register – APBCFGR

This register specifies the frequency of ADC conversion clock.

Offset: 0x028

Reset value: 0x0001\_0000

|            |          |    |    |    |    |        |    |    |
|------------|----------|----|----|----|----|--------|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26     | 25 | 24 |
|            | Reserved |    |    |    |    |        |    |    |
| Type/Reset |          |    |    |    |    |        |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18     | 17 | 16 |
|            | Reserved |    |    |    |    | ADCDIV |    |    |
| Type/Reset |          |    |    |    |    | RW     | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11 | 10     | 9  | 8  |
|            | Reserved |    |    |    |    |        |    |    |
| Type/Reset |          |    |    |    |    |        |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2      | 1  | 0  |
|            | Reserved |    |    |    |    |        |    |    |
| Type/Reset |          |    |    |    |    |        |    |    |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18:16] | ADCDIV | <p>ADC Clock Frequency Division Selection</p> <p>000: CK_ADC = (CK_AHB / 1)</p> <p>001: CK_ADC = (CK_AHB / 2)</p> <p>010: CK_ADC = (CK_AHB / 4)</p> <p>011: CK_ADC = (CK_AHB / 8)</p> <p>100: CK_ADC = (CK_AHB / 16)</p> <p>101: CK_ADC = (CK_AHB / 32)</p> <p>110: CK_ADC = (CK_AHB / 64)</p> <p>111: CK_ADC = (CK_AHB / 3)</p> <p>Set and reset by software to control the ADC conversion clock division factor.</p> |

## APB Clock Control Register 0 – APBCCR0

This register specifies the APB peripherals clock enable bits.

Offset: 0x02C

Reset value: 0x0000\_0000

|            |          |        |          |        |          |          |        |        |
|------------|----------|--------|----------|--------|----------|----------|--------|--------|
|            | 31       | 30     | 29       | 28     | 27       | 26       | 25     | 24     |
|            | Reserved |        |          |        | SCI1EN   | Reserved | I2SEN  | SCI0EN |
| Type/Reset |          |        |          |        | RW 0     |          | RW 0   | RW 0   |
|            | 23       | 22     | 21       | 20     | 19       | 18       | 17     | 16     |
|            | Reserved |        |          |        |          |          |        |        |
| Type/Reset |          |        |          |        |          |          |        |        |
|            | 15       | 14     | 13       | 12     | 11       | 10       | 9      | 8      |
|            | EXTIEN   | AFIOEN | Reserved |        | UR1EN    | UR0EN    | USR1EN | USR0EN |
| Type/Reset | RW 0     | RW 0   |          |        | RW 0     | RW 0     | RW 0   | RW 0   |
|            | 7        | 6      | 5        | 4      | 3        | 2        | 1      | 0      |
|            | Reserved |        | SPI1EN   | SPI0EN | Reserved |          | I2C1EN | I2C0EN |
| Type/Reset |          |        | RW 0     | RW 0   |          |          | RW 0   | RW 0   |

| Bits | Field  | Descriptions                                                                                                                                          |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| [27] | SCI1EN | Smart Card Interface 1 Clock Enable<br>0: SCI1 clock is disabled<br>1: SCI1 clock is enabled<br>Set and reset by software                             |
| [25] | I2SEN  | I <sup>2</sup> S Interface Clock Enable<br>0: I <sup>2</sup> S clock is disabled<br>1: I <sup>2</sup> S clock is enabled<br>Set and reset by software |
| [24] | SCI0EN | Smart Card Interface 0 Clock Enable<br>0: SCI0 clock is disabled<br>1: SCI0 clock is enabled<br>Set and reset by software                             |
| [15] | EXTIEN | External Interrupt Clock Enable<br>0: EXTI clock is disabled<br>1: EXTI clock is enabled<br>Set and reset by software.                                |
| [14] | AFIOEN | Alternate Function I/O Clock Enable<br>0: AFIO clock is disabled<br>1: AFIO clock is enabled<br>Set and reset by software.                            |
| [11] | UR1EN  | UART1 Clock Enable<br>0: UART1 clock is disabled<br>1: UART1 clock is enabled<br>Set and reset by software.                                           |
| [10] | UR0EN  | UART0 Clock Enable<br>0: UART0 clock is disabled<br>1: UART0 clock is enabled<br>Set and reset by software.                                           |

| Bits | Field  | Descriptions                                                                                                   |
|------|--------|----------------------------------------------------------------------------------------------------------------|
| [9]  | USR1EN | USART1 Clock Enable<br>0: USART1 clock is disabled<br>1: USART1 clock is enabled<br>Set and reset by software. |
| [8]  | USR0EN | USART0 Clock Enable<br>0: USART0 clock is disabled<br>1: USART0 clock is enabled<br>Set and reset by software. |
| [5]  | SPI1EN | SPI1 Clock Enable<br>0: SPI1 clock is disabled<br>1: SPI1 clock is enabled<br>Set and reset by software.       |
| [4]  | SPI0EN | SPI0 Clock Enable<br>0: SPI0 clock is disabled<br>1: SPI0 clock is enabled<br>Set and reset by software.       |
| [1]  | I2C1EN | I2C1 Clock Enable<br>0: I2C1 clock is disabled<br>1: I2C1 clock is enabled<br>Set and reset by software.       |
| [0]  | I2C0EN | I2C0 Clock Enable<br>0: I2C0 clock is disabled<br>1: I2C0 clock is enabled<br>Set and reset by software.       |

## APB Clock Control Register 1 – APBCCR1

This register specifies the APB peripherals clock enable bits.

Offset: 0x030

Reset value: 0x0000\_0000

|            |          |        |          |         |          |    |         |         |
|------------|----------|--------|----------|---------|----------|----|---------|---------|
|            | 31       | 30     | 29       | 28      | 27       | 26 | 25      | 24      |
|            | Reserved |        | SCTM1EN  | SCTM0EN | Reserved |    |         | ADCCEN  |
| Type/Reset |          |        | RW 0     | RW 0    |          |    |         | RW 0    |
|            | 23       | 22     | 21       | 20      | 19       | 18 | 17      | 16      |
|            | Reserved | CMPEN  | Reserved |         |          |    | BFTM1EN | BFTM0EN |
| Type/Reset |          | RW 0   |          |         |          |    | RW 0    | RW 0    |
|            | 15       | 14     | 13       | 12      | 11       | 10 | 9       | 8       |
|            | Reserved |        |          |         |          |    | GPTM1EN | GPTM0EN |
| Type/Reset |          |        |          |         |          |    | RW 0    | RW 0    |
|            | 7        | 6      | 5        | 4       | 3        | 2  | 1       | 0       |
|            | Reserved | BKPREN | Reserved | WDTREN  | Reserved |    | MCTM0EN |         |
| Type/Reset |          | RW 0   |          | RW 0    |          |    | RW 0    |         |

| Bits | Field   | Descriptions                                                                                                     |
|------|---------|------------------------------------------------------------------------------------------------------------------|
| [29] | SCTM1EN | SCTM1 Clock Enable<br>0: SCTM1 clock is disabled<br>1: SCTM1 clock is enabled<br>Set and reset by software.      |
| [28] | SCTM0EN | SCTM0 Clock Enable<br>0: SCTM0 clock is disabled<br>1: SCTM0 clock is enabled<br>Set and reset by software.      |
| [24] | ADCCEN  | ADC Controller Clock Enable<br>0: ADC clock is disabled<br>1: ADC clock is enabled<br>Set and reset by software. |
| [22] | CMPEN   | CMP Clock Enable<br>0: CMP clock is disabled<br>1: CMP clock is enabled<br>Set and reset by software.            |
| [17] | BFTM1EN | BFTM1 Clock Enable<br>0: BFTM1 clock is disabled<br>1: BFTM1 clock is enabled<br>Set and reset by software.      |
| [16] | BFTM0EN | BFTM0 Clock Enable<br>0: BFTM0 clock is disabled<br>1: BFTM0 clock is enabled<br>Set and reset by software.      |
| [9]  | GPTM1EN | GPTM1 Clock Enable<br>0: GPTM1 clock is disabled<br>1: GPTM1 clock is enabled<br>Set and reset by software.      |

| Bits | Field   | Descriptions                                                                                                                                                |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | GPTM0EN | GPTM0 Clock Enable<br>0: GPTM0 clock is disabled<br>1: GPTM0 clock is enabled<br>Set and reset by software.                                                 |
| [6]  | BKPREN  | Backup Domain Clock Enable for Registers Access<br>0: RTC clock is disabled<br>1: RTC clock is enabled<br>Set and reset by software.                        |
| [4]  | WDTREN  | Watchdog Timer Clock Enable for Registers Access<br>0: Watchdog Timer clock is disabled<br>1: Watchdog Timer clock is enabled<br>Set and reset by software. |
| [0]  | MCTM0EN | MCTM0 Clock Enable<br>0: MCTM0 clock is disabled<br>1: MCTM0 clock is enabled<br>Set and reset by software.                                                 |

## Clock Source Status Register – CKST

This register specifies the clock source status.

Offset: 0x034

Reset value: 0x0100\_0003

|            |          |    |    |    |    |        |      |        |
|------------|----------|----|----|----|----|--------|------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26     | 25   | 24     |
|            | Reserved |    |    |    |    | HSIST  |      |        |
| Type/Reset |          |    |    |    |    | RO     | 0 RO | 0 RO 1 |
|            | 23       | 22 | 21 | 20 | 19 | 18     | 17   | 16     |
|            | Reserved |    |    |    |    | HSEST  |      |        |
| Type/Reset |          |    |    |    |    | RO     | 0 RO | 0      |
|            | 15       | 14 | 13 | 12 | 11 | 10     | 9    | 8      |
|            | Reserved |    |    |    |    | PLLST  |      |        |
| Type/Reset |          |    |    |    |    | RO     | 0 RO | 0 RO 0 |
|            | 7        | 6  | 5  | 4  | 3  | 2      | 1    | 0      |
|            | Reserved |    |    |    |    | CKSWST |      |        |
| Type/Reset |          |    |    |    |    | RO     | 0 RO | 1 RO 1 |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                         |
|---------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [26:24] | HSIST  | Internal High Speed Clock Occupation Status (CK_HSI)<br>xx1: HSI is used by System Clock (CK_SYS) (SW = 0x03)<br>x1x: HSI is used by PLL<br>1xx: HSI is used by Clock Monitor                                                                                                        |
| [17:16] | HSEST  | External High Speed Clock Occupation Status (CK_HSE)<br>x1: HSE is used by System Clock (CK_SYS) (SW = 0x02)<br>1x: HSE is used by PLL                                                                                                                                               |
| [11:8]  | PLLST  | PLL Clock Occupation Status<br>xxx1: PLL is used by System Clock (CK_SYS)<br>xx1x: PLL is used by USART<br>x1xx: PLL is used by USB<br>1xxx: PLL is used by CK_REF                                                                                                                   |
| [2:0]   | CKSWST | Clock Switch Status<br>00x: CK_PLL clock out as system clock<br>010: CK_HSE as system clock<br>011: CK_HSI as system clock<br>110: CK_LSE as system clock<br>111: CK_LSI as system clock<br>The fields are status to indicate which clock source is using as system clock currently. |

## APB Peripheral Clock Selection Register 0 – APBPCSR0

This register specifies the APB peripheral clock prescaler selection.

Offset: 0x038

Reset value: 0x0000\_0000

|            |           |    |           |    |          |    |           |    |
|------------|-----------|----|-----------|----|----------|----|-----------|----|
|            | 31        | 30 | 29        | 28 | 27       | 26 | 25        | 24 |
|            | UR1PCLK   |    | UR0PCLK   |    | USR1PCLK |    | USR0PCLK  |    |
| Type/Reset | RW        | 0  | RW        | 0  | RW       | 0  | RW        | 0  |
|            | 23        | 22 | 21        | 20 | 19       | 18 | 17        | 16 |
|            | GPTM1PCLK |    | GPTM0PCLK |    | Reserved |    | MCTM0PCLK |    |
| Type/Reset | RW        | 0  | RW        | 0  | RW       | 0  | RW        | 0  |
|            | 15        | 14 | 13        | 12 | 11       | 10 | 9         | 8  |
|            | BFTM1PCLK |    | BFTM0PCLK |    | Reserved |    |           |    |
| Type/Reset | RW        | 0  | RW        | 0  | RW       | 0  |           |    |
|            | 7         | 6  | 5         | 4  | 3        | 2  | 1         | 0  |
|            | SPI1PCLK  |    | SPI0PCLK  |    | I2C1PCLK |    | I2C0PCLK  |    |
| Type/Reset | RW        | 0  | RW        | 0  | RW       | 0  | RW        | 0  |

| Bits    | Field     | Descriptions                                                                                                                                                                             |
|---------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:30] | UR1PCLK   | UART1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |
| [29:28] | UR0PCLK   | UART0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |
| [27:26] | USR1PCLK  | USART1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [25:24] | USR0PCLK  | USART0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [23:22] | GPTM1PCLK | GPTM1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |

| Bits    | Field     | Descriptions                                                                                                                                                                            |
|---------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [21:20] | GPTM0PCLK | GPTM0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [17:16] | MCTM0PCLK | MCTM0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [15:14] | BFTM1PCLK | BFTM1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB/2<br>10: PCLK = CK_AHB/4<br>11: PCLK = CK_AHB/8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock       |
| [13:12] | BFTM0PCLK | BFTM0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [7:6]   | SPI1PCLK  | SPI1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |
| [5:4]   | SPI0PCLK  | SPI0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |
| [3:2]   | I2C1PCLK  | I2C1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |
| [1:0]   | I2C0PCLK  | I2C0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock  |

## APB Peripheral Clock Selection Register 1 – APBPCSR1

This register specifies the APB peripheral clock prescaler selection.

Offset: 0x03C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    | RW | 0  | RW | 0  |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    | RW | 0  | RW | 0  | RW | 0  |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits    | Field     | Descriptions                                                                                                                                                                                       |
|---------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [27:26] | SCTM1PCLK | SCTM1 Peripheral Clock Selection<br>00: PCLK = CK_AHB / 4<br>01: PCLK = CK_AHB / 8<br>10: PCLK = CK_AHB / 16<br>11: PCLK = CK_AHB / 32<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock      |
| [25:24] | SCTM0PCLK | SCTM0 Peripheral Clock Selection<br>00: PCLK = CK_AHB / 4<br>01: PCLK = CK_AHB / 8<br>10: PCLK = CK_AHB / 16<br>11: PCLK = CK_AHB / 32<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock      |
| [21:20] | I2SPCLK   | I <sup>2</sup> S Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [19:18] | SCI1PCLK  | SCI1 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock             |
| [17:16] | SCI0PCLK  | SCI0 Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock             |

| Bits    | Field    | Descriptions                                                                                                                                                                                               |
|---------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:14] | BKPRCLK  | Backup Domain Register Access Clock Selection<br>00: PCLK = CK_AHB / 4<br>01: PCLK = CK_AHB / 8<br>10: PCLK = CK_AHB / 16<br>11: PCLK = CK_AHB / 32<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock |
| [13:12] | WDTRPCLK | WDT Register Access Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock                 |
| [9:8]   | CMPPCLK  | CMP Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock                      |
| [5:4]   | ADCCPCLK | ADC Controller Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock           |
| [3:2]   | EXTIPCLK | EXTI Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock                     |
| [1:0]   | AFIOPCLK | AFIO Peripheral Clock Selection<br>00: PCLK = CK_AHB<br>01: PCLK = CK_AHB / 2<br>10: PCLK = CK_AHB / 4<br>11: PCLK = CK_AHB / 8<br>PCLK = Peripheral Clock; CK_AHB = AHB and CPU clock                     |

## HSI Control Register – HSICR

This register is used to control the frequency trimming of the HSI RC oscillation.

Offset: 0x040

Reset value: 0xFFFF\_0000 where X is undefined

|            |          |          |           |           |          |          |       |        |   |
|------------|----------|----------|-----------|-----------|----------|----------|-------|--------|---|
|            | 31       | 30       | 29        | 28        | 27       | 26       | 25    | 24     |   |
|            | Reserved |          |           | HSICOARSE |          |          |       |        |   |
| Type/Reset |          |          |           | RO        | X RO     | X RO     | X RO  | X RO   | X |
|            | 23       | 22       | 21        | 20        | 19       | 18       | 17    | 16     |   |
|            | HSIFINE  |          |           |           |          |          |       |        |   |
| Type/Reset | RW       | X RW     | X RW      | X RW      | X RW     | X RW     | X RW  | X RW   | X |
|            | 15       | 14       | 13        | 12        | 11       | 10       | 9     | 8      |   |
|            | Reserved |          |           |           |          |          |       |        |   |
| Type/Reset |          |          |           |           |          |          |       |        |   |
|            | 7        | 6        | 5         | 4         | 3        | 2        | 1     | 0      |   |
|            | FLOCK    | Reserved | REFCLKSEL | TMSEL     | Reserved | Reserved | ATCEN | TRIMEN |   |
| Type/Reset | RO       | 0        | RW        | 0 RW      | 0        |          | RW    | 0 RW   | 0 |

| Bits    | Field     | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [28:24] | HSICOARSE | HSI Clock Coarse Trimming Value<br>These bits are initialized automatically at startup. They are adjusted by factory trimming and can not be trimmed by program.                                                                                                                                                                                                                                                                                                       |
| [23:16] | HSIFINE   | HSI Clock Fine Trimming Value<br>These bits are initialized automatically at startup. They are also adjusted by factory trimming. But these bits provide an additional user-programmable trimming value that is added to the HSICOARSE[4:0] bits to get higher accuracy or compensate the variations in voltage and temperature that influence the HSI frequency. It can be programmed by software or Auto-Trimming Controller (ATC) with an external reference clock. |
| [7]     | FLOCK     | Frequency Lock<br>0: HSI frequency is not trimmed into target range<br>1: HSI frequency is trimmed into target range                                                                                                                                                                                                                                                                                                                                                   |
| [5]     | REFCLKSEL | Reference Clock Selection<br>0: Select 32.768KHz external low speed clock source (LSE)<br>1: Select 1KHz USB frame pulse<br>This bit is used to select the reference clock for the HSI Auto Trimming Controller.                                                                                                                                                                                                                                                       |
| [4]     | TMSEL     | Trimming Mode Selection<br>0: Automatic by Auto Trimming Controller<br>1: Manual by user program<br>This bit is used to select the HSI RC oscillator trimming function by the ATC hardware or user program via the HSIFINE[7:0] bits in the HSI Control Register.                                                                                                                                                                                                      |
| [1]     | ATCEN     | ATC Enable<br>0: Disable Auto Trimming Controller<br>1: Enable Auto Trimming Controller                                                                                                                                                                                                                                                                                                                                                                                |
| [0]     | TRIMEN    | Trimming Enable<br>0: HSI Trimming is disabled<br>1: HSI Trimming is enabled<br>The bit enables the HSI RC oscillator trimming function by the ATC hardware or user programming.                                                                                                                                                                                                                                                                                       |

## HSI Auto Trimming Counter Register – HSIATCR

This register contains the counter value of the HSI auto trimming controller.

Offset: 0x044

Reset value: 0x0000\_0000

|            |          |    |       |    |    |    |    |    |
|------------|----------|----|-------|----|----|----|----|----|
|            | 31       | 30 | 29    | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |       |    |    |    |    |    |
|            | 23       | 22 | 21    | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |       |    |    |    |    |    |
|            | 15       | 14 | 13    | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    | ATCNT |    |    |    |    |    |
|            | 7        | 6  | 5     | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | ATCNT    |    |       |    |    |    |    |    |
|            | RO       | 0  | RO    | 0  | RO | 0  | RO | 0  |
|            | RO       | 0  | RO    | 0  | RO | 0  | RO | 0  |

| Bits   | Field | Descriptions                                                                                   |
|--------|-------|------------------------------------------------------------------------------------------------|
| [13:0] | ATCNT | Auto Trimming Counter<br>These bits are the counter value of the HSI auto trimming controller. |

## Low Power Control Register – LPCR

This register specifies the low power control.

Offset: 0x300

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |     |          |
|------------|----------|----|----|----|----|----|-----|----------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25  | 24       |
| Type/Reset | Reserved |    |    |    |    |    |     |          |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17  | 16       |
| Type/Reset | Reserved |    |    |    |    |    |     |          |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9   | 8        |
| Type/Reset | Reserved |    |    |    |    |    |     | USBSLEEP |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1   | 0        |
| Type/Reset | Reserved |    |    |    |    |    |     | BKISO    |
|            |          |    |    |    |    |    | R/W | 0        |
|            |          |    |    |    |    |    |     | 0        |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                       |
|------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | USBSLEEP | USB Sleep Software Control Enable<br>0: Disable<br>1: Enable USB Software Sleeping<br>Set and reset by software. Please refer to the Power Control Unit chapter for more information.                                                              |
| [0]  | BKISO    | Backup Domain Isolation Control<br>0: Backup domain is isolated from other power domain<br>1: Backup domain is accessible by other power domain<br>Set and reset by software. Please refer to the Power Control Unit chapter for more information. |

## MCU Debug Control Register – MCUDBGCR

This register specifies the MCU debug control.

Offset: 0x304

Reset value: 0x0000\_0000

|            |          |         |          |         |        |        |         |         |     |   |
|------------|----------|---------|----------|---------|--------|--------|---------|---------|-----|---|
|            | 31       | 30      | 29       | 28      | 27     | 26     | 25      | 24      |     |   |
|            | Reserved |         |          |         |        |        |         |         |     |   |
| Type/Reset |          |         |          |         |        |        |         |         |     |   |
|            | 23       | 22      | 21       | 20      | 19     | 18     | 17      | 16      |     |   |
|            | DBSCTM1  | DBSCTM0 | DBSCI1   | DBTRACE | DBUR1  | DBUR0  | DBBFTM1 | DBBFTM0 |     |   |
| Type/Reset | R/W      | 0       | R/W      | 0       | R/W    | 0      | R/W     | 0       | R/W | 0 |
|            | 15       | 14      | 13       | 12      | 11     | 10     | 9       | 8       |     |   |
|            | DBSCI0   | DBDSLP2 | DBI2C1   | DBI2C0  | DBSPI1 | DBSPI0 | DBUSR1  | DBUSR0  |     |   |
| Type/Reset | R/W      | 0       | R/W      | 0       | R/W    | 0      | R/W     | 0       | R/W | 0 |
|            | 7        | 6       | 5        | 4       | 3      | 2      | 1       | 0       |     |   |
|            | DBGPTM1  | DBGPTM0 | Reserved | DBMCTM  | DBWDT  | DBPD   | DBDSLP1 | DBSLP   |     |   |
| Type/Reset | R/W      | 0       | R/W      | 0       | R/W    | 0      | R/W     | 0       | R/W | 0 |

| Bits | Field   | Descriptions                                                                                                                                                                       |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [23] | DBSCTM1 | SCTM1 Debug Mode Enable<br>0: SCTM1 counter continues to count even if the core is halted<br>1: SCTM1 counter stops counting when the core is halted<br>Set and reset by software. |
| [22] | DBSCTM0 | SCTM0 Debug Mode Enable<br>0: SCTM0 counter continues to count even if the core is halted<br>1: SCTM0 counter stops counting when the core is halted<br>Set and reset by software. |
| [21] | DBSCI1  | SCI1 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: SCI1 timeout is frozen when the core is halted<br>Set and reset by software.                                    |
| [20] | DBTRACE | TRACESWO Debug Mode Enable<br>0: Disable TRACESWO output<br>1: Enable TRACESWO output<br>Set and reset by software.                                                                |
| [19] | DBUR1   | UART1 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: UART1 FIFO timeout is frozen when the core is halted<br>Set and reset by software.                             |
| [18] | DBUR0   | UART0 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: UART0 FIFO timeout is frozen when the core is halted<br>Set and reset by software.                             |
| [17] | DBBFTM1 | BFTM1 Debug Mode Enable<br>0: BFTM1 counter continues to count even if the core is halted<br>1: BFTM1 counter stops counting when the core is halted<br>Set and reset by software. |

| Bits | Field   | Descriptions                                                                                                                                                                                                  |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [16] | DBBFTM0 | BFTM0 Debug Mode Enable<br>0: BFTM0 counter continues to count even if the core is halted<br>1: BFTM0 counter stops counting when the core is halted<br>Set and reset by software.                            |
| [15] | DBSCI0  | SCI0 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: SCI0 timeout is frozen when the core is halted<br>Set and reset by software.                                                               |
| [14] | DBDSLP2 | Debug Deep-Sleep2<br>0: LDO = Off (but turn on DMOS), FCLK = Off, and HCLK = Off in Deep-Sleep2<br>1: LDO = On, FCLK = On, and HCLK = On in Deep-Sleep2<br>Set and reset by software.                         |
| [13] | DBI2C1  | I2C1 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: I2C1 timeout is frozen when the core is halted<br>Set and reset by software.                                                               |
| [12] | DB_I2C0 | I2C0 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: I2C0 timeout is frozen when the core is halted<br>Set and reset by software.                                                               |
| [11] | DBSPI1  | SPI1 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: SPI1 FIFO timeout is frozen when the core is halted<br>Set and reset by software.                                                          |
| [10] | DBSPI0  | SPI0 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: SPI0 FIFO timeout is frozen when the core is halted<br>Set and reset by software.                                                          |
| [9]  | DBUSR1  | USART1 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: USART1 FIFO timeout is frozen when the core is halted<br>Set and reset by software.                                                      |
| [8]  | DBUSR0  | USART0 Debug Mode Enable<br>0: Same behavior as in normal mode<br>1: USART0 FIFO timeout is frozen when the core is halted<br>Set and reset by software.                                                      |
| [7]  | DBGPTM1 | GPTM1 Debug Mode Enable<br>0: GPTM1 counter continues to count even if the core is halted<br>1: GPTM1 counter stops counting when the core is halted<br>Set and reset by software.                            |
| [6]  | DBGPTM0 | GPTM0 Debug Mode Enable<br>0: GPTM0 counter continues to count even if the core is halted<br>1: GPTM0 counter stops counting when the core is halted<br>Set and reset by software.                            |
| [4]  | DBMCTM  | MCTM Debug Mode Enable<br>0: MCTM counter continues to count even if the core is halted<br>1: MCTM counter stops counting when the core is halted<br>Set and reset by software.                               |
| [3]  | DBWDT   | Watchdog Timer Debug Mode Enable<br>0: Watchdog Timer counter continues to count even if the core is halted<br>1: Watchdog Timer counter stops counting when the core is halted<br>Set and reset by software. |

| Bits | Field   | Descriptions                                                                                                                                                                   |
|------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | DBPD    | Debug Power-Down Mode<br>0: LDO = Off, FCLK = Off, and HCLK = Off in Power-Down mode<br>1: LDO = On, FCLK = On, and HCLK = On in Power-Down mode<br>Set and reset by software. |
| [1]  | DBDSLP1 | Debug Deep-Sleep1<br>0: LDO = Low power mode, FCLK = Off, and HCLK = Off in Deep-Sleep1<br>1: LDO = On, FCLK = On, and HCLK = On in Deep-Sleep1<br>Set and reset by software.  |
| [0]  | DBSLP   | Debug Sleep Mode<br>0: LDO = On, FCLK = On, and HCLK = Off in Sleep mode<br>1: LDO = On, FCLK = On, and HCLK = On in Sleep mode<br>Set and reset by software.                  |

# 7 Reset Control Unit (RSTCU)

## Introduction

The Reset Control Unit, RSTCU, has three kinds of reset, the power on reset, system reset and APB unit reset. The power on reset, known as a cold reset, resets the full system during a power up. A system reset resets the processor core and peripheral IP components with the exception of the debug port controller. The resets can be triggered by an external signal, internal events and the reset generators. More information about these resets will be described in the following section.

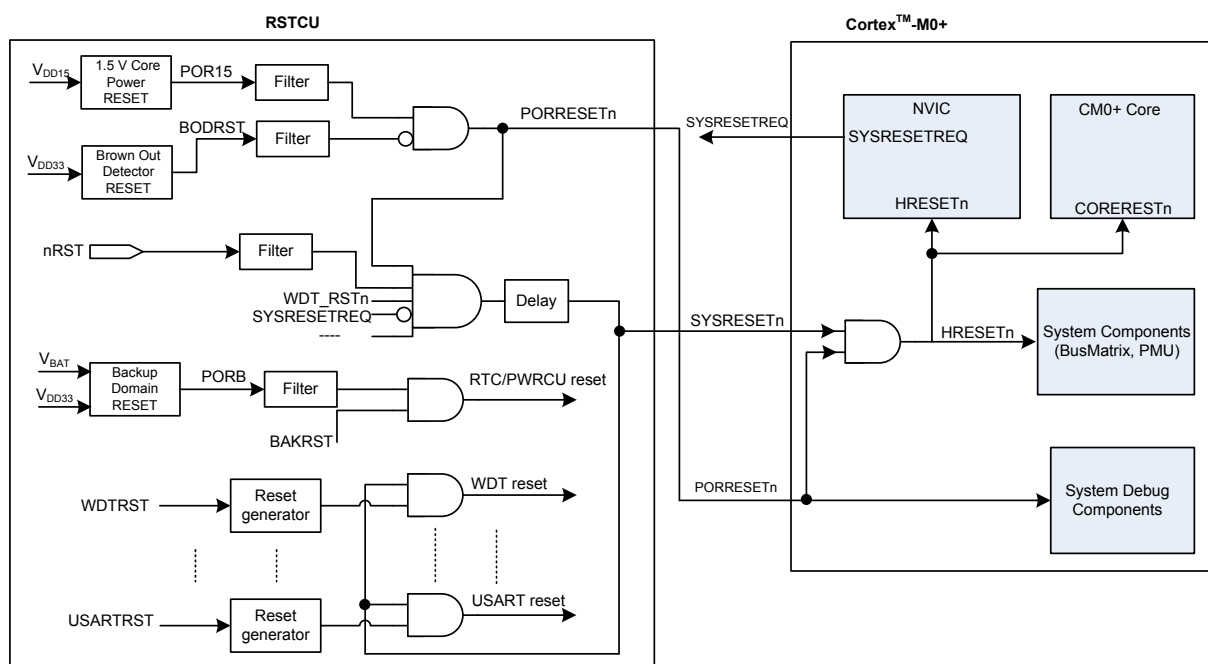
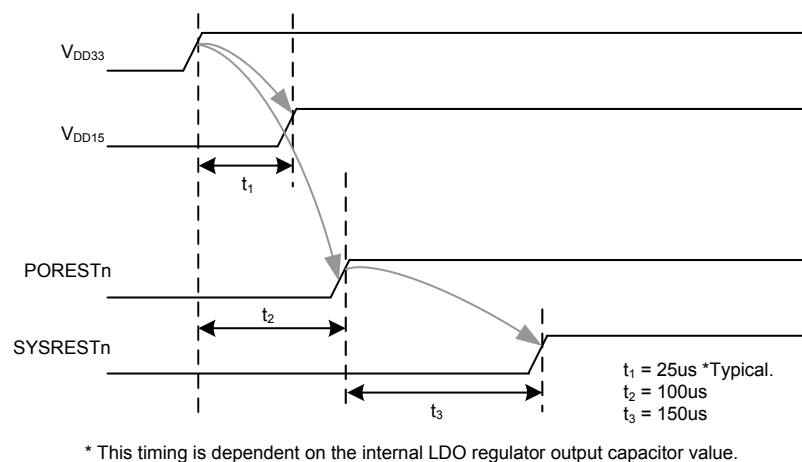


Figure 18. RSTCU Block Diagram

## Functional Descriptions

### Power On Reset

The Power on reset, POR, is generated by either an external reset or the internal reset generator. Both types have an internal filter to prevent glitches from causing erroneous reset operations. By referring to Figure 19, the POR15 active low signal will be de-asserted when the internal LDO voltage regulator is ready to provide 1.5 V power. In addition to the POR15 signal, the Power Control Unit, PWRCU, will assert the BODF signal as a Power Down Reset, PDR, when the BODEN bit in the LVDCSR register is set and the brown-out event occurs. For more details about the PWRCU function, refer to the PWRCU chapter.



**Figure 19. Power On Reset Sequence**

### System Reset

A system reset is generated by a power on reset (PORRESETn), a Watchdog Timer reset (WDT\_RSTn), nRST pin or a software reset (SYSRESETREQ) event. For more information about SYSRESETREQ event, refer to the related chapter in the Cortex™-M0+ reference manual.

### AHB and APB Unit Reset

The AHB and APB unit reset can be divided into hardware and software resets. A hardware reset can be generated by either power on reset or system reset for all AHB and APB units. Each functional IP connected to the AHB and APB buses can be reset individually through the associated software reset bits in the RSTCU. For example, the application software can generate a USART0 reset via the USR0RST bit in the APBPRSTR0 register.

## Register Map

The following table shows the RSTCU registers and reset values.

**Table 19. RSTCU Register Map**

| Register                                | Offset | Description                     | Reset Value |
|-----------------------------------------|--------|---------------------------------|-------------|
| <b>RSTCU Base Address = 0x4008_8000</b> |        |                                 |             |
| GRSR                                    | 0x100  | Global Reset Status Register    | 0x0000_0008 |
| AHBPRSTR                                | 0x104  | AHB Peripheral Reset Register   | 0x0000_0000 |
| APBPRSTR0                               | 0x108  | APB Peripheral Reset Register 0 | 0x0000_0000 |
| APBPRSTR1                               | 0x10C  | APB Peripheral Reset Register 1 | 0x0000_0000 |

## Register Descriptions

### Global Reset Status Register – GRSR

This register specifies a variety of reset status conditions.

Offset: 0x100

Reset value: 0x0000\_0008

|            |          |    |    |    |        |         |         |          |
|------------|----------|----|----|----|--------|---------|---------|----------|
|            | 31       | 30 | 29 | 28 | 27     | 26      | 25      | 24       |
| Type/Reset | Reserved |    |    |    |        |         |         |          |
|            | 23       | 22 | 21 | 20 | 19     | 18      | 17      | 16       |
| Type/Reset | Reserved |    |    |    |        |         |         |          |
|            | 15       | 14 | 13 | 12 | 11     | 10      | 9       | 8        |
| Type/Reset | Reserved |    |    |    |        |         |         |          |
|            | 7        | 6  | 5  | 4  | 3      | 2       | 1       | 0        |
| Type/Reset | Reserved |    |    |    | PORSTF | WDTRSTF | EXTRSTF | NVICRSTF |
|            |          |    |    |    | WC     | 1 WC    | 0 WC    | 0 WC     |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                 |
|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | PORSTF  | Core 1.5 V Power On Reset Flag<br>0: No POR occurred<br>1: POR occurred<br>This bit is set by hardware when a power on reset occurs and reset by writing 1 into it.                                                                          |
| [2]  | WDTRSTF | Watchdog Timer Reset Flag<br>0: No Watchdog Timer reset occurred<br>1: Watchdog Timer occurred<br>This bit is set by hardware when a watchdog timer reset occurs and reset by writing 1 into it or by hardware when a power on reset occurs. |
| [1]  | EXTRSTF | External Pin Reset Flag<br>0: No pin reset occurred<br>1: Pin reset occurred<br>This bit is set by hardware when an external pin reset occurs and reset by writing 1 into it or by hardware when a power on reset occurs.                    |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                   |
|------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | NVICRSTF | NVIC Reset Flag<br>0: No NVIC asserting system reset occurred<br>1: NVIC asserting system reset occurred<br>This bit is set by hardware when a system reset occurs and reset by writing 1 into it or by hardware when a power on reset occurs. |

## AHB Peripheral Reset Register – AHBPRSTR

This register specifies several AHB peripherals software reset control bits.

Offset: 0x104

Reset value: 0x0000\_0000

|            |          |        |        |          |       |       |       |        |    |    |   |    |   |
|------------|----------|--------|--------|----------|-------|-------|-------|--------|----|----|---|----|---|
|            | 31       | 30     | 29     | 28       | 27    | 26    | 25    | 24     |    |    |   |    |   |
| Type/Reset | Reserved |        |        |          |       |       |       |        |    |    |   |    |   |
|            | 23       | 22     | 21     | 20       | 19    | 18    | 17    | 16     |    |    |   |    |   |
| Type/Reset | Reserved |        |        |          |       |       |       |        |    |    |   |    |   |
|            | 15       | 14     | 13     | 12       | 11    | 10    | 9     | 8      |    |    |   |    |   |
| Type/Reset | Reserved |        |        | PERST    | PDRST | PCRST | PBRST | PARST  |    |    |   |    |   |
|            |          |        |        | RW       | 0     | RW    | 0     | RW     | 0  | RW | 0 | RW | 0 |
|            | 7        | 6      | 5      | 4        | 3     | 2     | 1     | 0      |    |    |   |    |   |
| Type/Reset | CRCRST   | EBIRST | USBRST | Reserved |       |       |       | DMARST |    |    |   |    |   |
|            | RW       | 0      | RW     | 0        | RW    | 0     | RW    | 0      | RW | 0  |   |    |   |

| Bits | Field | Descriptions                                                                                                                           |
|------|-------|----------------------------------------------------------------------------------------------------------------------------------------|
| [12] | PERST | GPIO Port E Reset Control<br>0: No reset<br>1: Reset Port E<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [11] | PDRST | GPIO Port D Reset Control<br>0: No reset<br>1: Reset Port D<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [10] | PCRST | GPIO Port C Reset Control<br>0: No reset<br>1: Reset Port C<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [9]  | PBRST | GPIO Port B Reset Control<br>0: No reset<br>1: Reset Port B<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [8]  | PARST | GPIO Port A Reset Control<br>0: No reset<br>1: Reset Port A<br>This bit is set by software and cleared to 0 by hardware automatically. |

| Bits | Field  | Descriptions                                                                                                                                                    |
|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | CRCRST | CRC Reset Control<br>0: No reset<br>1: Reset CRC<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |
| [6]  | EBIRST | EBI Reset Control<br>0: No reset<br>1: Reset USB<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |
| [5]  | USBRST | USB Reset Control<br>0: No reset<br>1: Reset USB<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |
| [0]  | DMARST | Peripheral DMA (PDMA) Reset Control<br>0: No reset<br>1: Reset Peripheral DMA (PDMA)<br>This bit is set by software and cleared to 0 by hardware automatically. |

### APB Peripheral Reset Register 0 – APBPRSTR0

This register specifies several APB peripherals software reset control bits.

Offset: 0x108

Reset value: 0x0000\_0000

|            |          |         |          |         |          |          |         |         |
|------------|----------|---------|----------|---------|----------|----------|---------|---------|
|            | 31       | 30      | 29       | 28      | 27       | 26       | 25      | 24      |
|            | Reserved |         |          |         | SCI1RST  | Reserved | I2SRST  | SCI0RST |
| Type/Reset |          |         |          |         | RW 0     |          | RW 0    | RW 0    |
|            | 23       | 22      | 21       | 20      | 19       | 18       | 17      | 16      |
|            | Reserved |         |          |         |          |          |         |         |
| Type/Reset |          |         |          |         |          |          |         |         |
|            | 15       | 14      | 13       | 12      | 11       | 10       | 9       | 8       |
|            | EXTIRST  | AFIORST | Reserved |         | UR1RST   | UR0RST   | USR1RST | USR0RST |
| Type/Reset | RW 0     | RW 0    |          |         | RW 0     | RW 0     | RW 0    | RW 0    |
|            | 7        | 6       | 5        | 4       | 3        | 2        | 1       | 0       |
|            | Reserved |         | SPI1RST  | SPI0RST | Reserved |          | I2C1RST | I2C0RST |
| Type/Reset |          |         | RW 0     | RW 0    |          |          | RW 0    | RW 0    |

| Bits | Field   | Descriptions                                                                                                                                                    |
|------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [27] | SCI1RST | Smart Card Interface 1 Reset Control<br>0: No reset<br>1: Reset Smart Card Interface<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [25] | I2SRST  | I2S Reset Control<br>0: No reset<br>1: Reset I2S<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |

| Bits | Field   | Descriptions                                                                                                                                                      |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24] | SCI0RST | Smart Card Interface 0 Reset Control<br>0: No reset<br>1: Reset Smart Card Interface<br>This bit is set by software and cleared to 0 by hardware automatically.   |
| [15] | EXTIRST | External Interrupt Controller Reset Control<br>0: No reset<br>1: Reset EXTI<br>This bit is set by software and cleared to 0 by hardware automatically.            |
| [14] | AFIORST | Alternate Function I/O Reset Control<br>0: No reset<br>1: Reset Alternate Function I/O<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [11] | UR1RST  | UART1 Reset Control<br>0: No reset<br>1: Reset UART1<br>This bit is set by software and cleared to 0 by hardware automatically.                                   |
| [10] | UR0RST  | UART0 Reset Control<br>0: No reset<br>1: Reset UART0<br>This bit is set by software and cleared to 0 by hardware automatically.                                   |
| [9]  | USR1RST | USART1 Reset Control<br>0: No reset<br>1: Reset USART1<br>This bit is set by software and cleared to 0 by hardware automatically.                                 |
| [8]  | USR0RST | USART0 Reset Control<br>0: No reset<br>1: Reset USART0<br>This bit is set by software and cleared to 0 by hardware automatically.                                 |
| [5]  | SPI1RST | SPI1 Reset Control<br>0: No reset<br>1: Reset SPI1<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |
| [4]  | SPI0RST | SPI0 Reset Control<br>0: No reset<br>1: Reset SPI0<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |
| [1]  | I2C1RST | I2C1 Reset Control<br>0: No reset<br>1: Reset I2C1<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |
| [0]  | I2C0RST | I2C0 Reset Control<br>0: No reset<br>1: Reset I2C0<br>This bit is set by software and cleared to 0 by hardware automatically.                                     |

## APB Peripheral Reset Register 1 – APBPRSTR1

This register specifies several APB peripherals software reset control bits.

Offset: 0x10C

Reset value: 0x0000\_0000

|            |          |        |          |          |          |    |          |          |    |   |
|------------|----------|--------|----------|----------|----------|----|----------|----------|----|---|
|            | 31       | 30     | 29       | 28       | 27       | 26 | 25       | 24       |    |   |
| Type/Reset | Reserved |        | SCTM1RST | SCTM0RST | Reserved |    |          | ADCRST   |    |   |
|            | RW       |        | 0        | RW       | 0        | RW |          |          | 0  |   |
|            | 23       | 22     | 21       | 20       | 19       | 18 | 17       | 16       |    |   |
| Type/Reset | Reserved | CMPRST | Reserved |          |          |    | BFTM1RST | BFTM0RST |    |   |
|            | RW       |        | 0        | RW       |          |    |          | 0        | RW | 0 |
|            | 15       | 14     | 13       | 12       | 11       | 10 | 9        | 8        |    |   |
| Type/Reset | Reserved |        |          |          |          |    | GPTM1RST | GPTM0RST |    |   |
|            | RW       |        |          |          |          |    | 0        | RW       | 0  |   |
|            | 7        | 6      | 5        | 4        | 3        | 2  | 1        | 0        |    |   |
| Type/Reset | Reserved |        |          | WDTRST   | Reserved |    | MCTM1RST | MCTM0RST |    |   |
|            | RW       |        |          | 0        | RW       |    | 0        | RW       | 0  |   |

| Bits | Field    | Descriptions                                                                                                                                    |
|------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| [29] | SCTM1RST | SCTM1 Reset Control<br>0: No reset<br>1: Reset SCTM1<br>This bit is set by software and cleared to 0 by hardware automatically.                 |
| [28] | SCTM0RST | SCTM0 Reset Control<br>0: No reset<br>1: Reset SCTM0<br>This bit is set by software and cleared to 0 by hardware automatically.                 |
| [24] | ADCRST   | A/D Converter Reset Control<br>0: No reset<br>1: Reset A/D Converter<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [22] | CMPRST   | Comparator Controller Reset Control<br>0: No reset<br>1: Reset CMP<br>This bit is set by software and cleared to 0 by hardware automatically.   |
| [17] | BFTM1RST | BFTM1 Reset Control<br>0: No reset<br>1: Reset BFTM1<br>This bit is set by software and cleared to 0 by hardware automatically.                 |
| [16] | BFTM0RST | BFTM0 Reset Control<br>0: No reset<br>1: Reset BFTM0<br>This bit is set by software and cleared to 0 by hardware automatically.                 |
| [9]  | GPTM1RST | GPTM1 Reset Control<br>0: No reset<br>1: Reset GPTM1<br>This bit is set by software and cleared to 0 by hardware automatically.                 |

| Bits | Field    | Descriptions                                                                                                                                      |
|------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | GPTM0RST | GPTM0 Reset Control<br>0: No reset<br>1: Reset GPTM0<br>This bit is set by software and cleared to 0 by hardware automatically.                   |
| [4]  | WDTRST   | Watchdog Timer Reset Control<br>0: No reset<br>1: Reset Watchdog Timer<br>This bit is set by software and cleared to 0 by hardware automatically. |
| [1]  | MCTM1RST | MCTM1 Reset Control<br>0: No reset<br>1: Reset MCTM1<br>This bit is set by software and cleared to 0 by hardware automatically.                   |
| [0]  | MCTM0RST | MCTM0 Reset Control<br>0: No reset<br>1: Reset MCTM0<br>This bit is set by software and cleared to 0 by hardware automatically.                   |

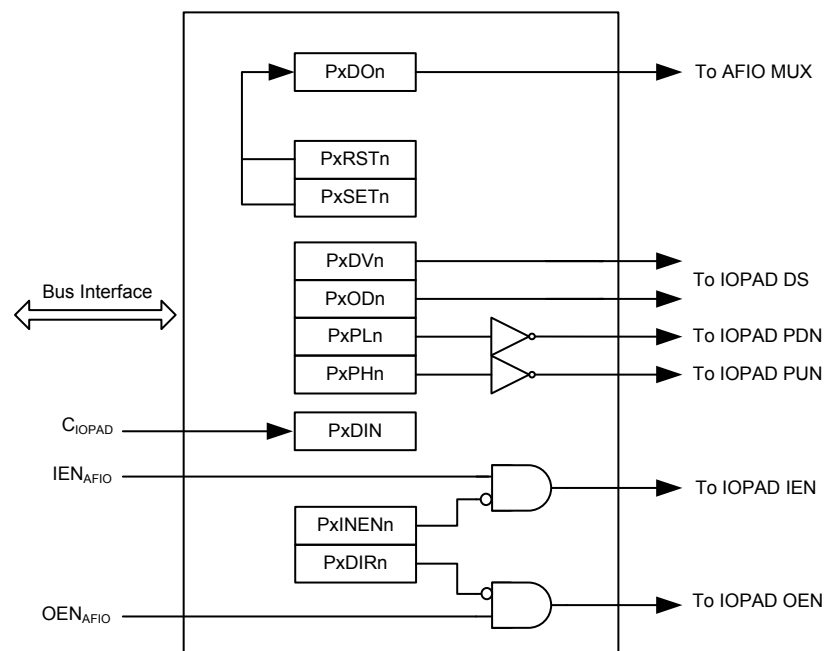
## 8 General Purpose I/O (GPIO)

### Introduction

There are up to 51 General Purpose I/O port, GPIO, named PA0 ~ PA15, PB0 ~ PB15, PC0 ~ PC15 and PD0 ~ PD3 for the device to implement the logic input/output functions. Each of the GPIO ports has related control and configuration registers to satisfy the requirement of specific applications. The really available General Purpose I/O port numbers are dependent on the device specification and package type. Please refer the device data sheet for detail information.

The GPIO ports are pin-shared with other alternative functions (AFs) to obtain maximum flexibility on the package pins. The GPIO pins can be used as alternative functional pins by configuring the corresponding registers regardless of the AF input or output pins.

The external interrupts on the GPIO pins of the device have related control and configuration registers in the External Interrupt Control Unit (EXTI).



**Figure 20. GPIO Block Diagram**

## Features

- Input/output direction control
- Schmitt Trigger Input function enable control
- Input weak pull-up/pull-down control
- Output push-pull/open drain enable control
- Output set/reset control
- Output drive current selection
- External interrupt with programmable trigger edge - using EXTI configuration registers
- Analog input/output configurations – using AFIO configuration registers
- Alternate function input/output configurations - using AFIO configuration registers
- Port configuration lock

## Functional Descriptions

### Default GPIO Pin Configuration

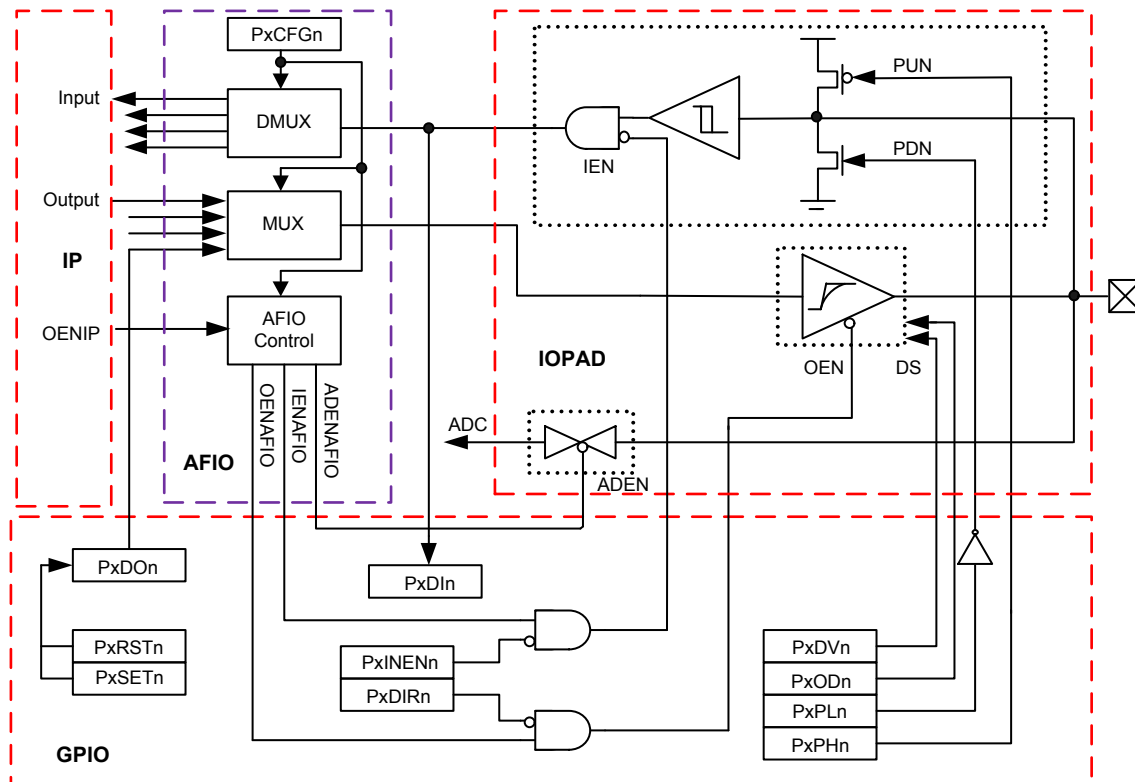
During or just after the reset period, the alternative functions are all inactive and the GPIO ports are configured into the input disable floating mode, i.e. input disabled without pull-up/pull-down resistors. Only the boot and Serial-Wired Debug pins which are pin-shared with the I/O pins are active after a device reset.

- PA8: Input enable with internal pull-up
- PA9\_BOOT: Input enable with internal pull-up
- SWCLK: Input enable with internal pull-up
- SWDIO: Input enable with internal pull-up

### General Purpose I/O – GPIO

The GPIO pins can be configured as inputs or outputs via the data direction control registers PxDIRCR (where x = A ~ D). When the GPIO pins are configured as input pins, the data on the external pads can be read if the enable bits in the input enable function register PxINER are set. The GPIO pull-up/pull-down registers PxPUR/PxPDR can be configured to fit specific applications. When the pull-up and pull-down functions are both enabled, the pull-up function has the higher priority while the pull-down function will be blocked until the pull-up function is released.

The GPIO pins can be configured as output pins where the output data is latched into the data register PxDOCTR. The output type can be setup to be either push-pull or open-drain by the open drain selection register PxODR. Only one or several specific bits of the output data will be set or reset by configuring the port output set and reset control register PxSRR or the port output reset control register PxRR without affecting the unselected bits. As the port output set and reset functions are both enabled, the port output set function has the higher priority and the port output reset function will be blocked. The output driving current of the GPIO pins can be selected by configuring the drive current selection register PxDRVR.



**Figure 21. AFIO/GPIO Control Signal**

PxDIn/PxDOx (x=A ~ D): Data Input/Data Output

PxDIRn (x=A ~ D): Direction

PxDVn (x=A ~ D): Output Drive

PxPLn/PxPHn (x=A ~ D): Pull Low/High

PxRSTn/PxSETn (x=A ~ D): Reset/Set

PxINENn (x=A ~ D): Input Enable

PxODn (x=A ~ D): Open Drain

PxCFGn (x=A ~ D): AFIO Configuration

**Table 20. AFIO, GPIO and IO Pad Control Signal True Table**

| Type                          | AFIO                 |                     |                     | GPIO   |               | PAD  |     |       |
|-------------------------------|----------------------|---------------------|---------------------|--------|---------------|------|-----|-------|
|                               | ADEN <sub>AFIO</sub> | OEN <sub>AFIO</sub> | IEN <sub>AFIO</sub> | PxDIRn | PxINENn       | ADEN | OEN | IEN   |
| GPIO Input <sup>(Note)</sup>  | 1                    | 1                   | 1                   | 0      | 1             | 1    | 1   | 0     |
| GPIO Output <sup>(Note)</sup> | 1                    | 1                   | 1                   | 1      | 0 (1 if need) | 1    | 0   | 1 (0) |
| AFIO Input                    | 1                    | 1                   | 0                   | 0      | X             | 1    | 1   | 0     |
| AFIO Output                   | 1                    | 0                   | 1                   | X      | 0 (1 if need) | 1    | 0   | 1 (0) |
| ADC Input                     | 0                    | 1                   | 1                   | 0      | 0 (1 if need) | 0    | 1   | 1 (0) |
| OSC Output                    | 0                    | 1                   | 1                   | 0      | 0 (1 if need) | 0    | 1   | 1 (0) |

**Note:** The signals, IEN and OEN, for I/O pads are derived from the GPIO register bits PxINENn and PxDIRn respectively when the associated pin is configured in the GPIO input/output mode.

## GPIO Locking Mechanism

The GPIO also offers a lock function to lock the port until a reset event occurs. The PxLOCKR (x = A ~ D) registers are used to lock the port x and lock control options. The value 0x5FA0 is written into the PxLKEY field in the PxLOCKR registers to freeze the PxDIRCR, PxINER, PxPUR, PxPDR, PxODR, PxDRVR control and AFIO mode configuration (GPxCFGHR or GPxCFGRLR, where x = A ~ D). If the value in the PxLOCKR is 0x5FA0\_0001, it means that the Port x Lock function is enabled and the Port x pin 0 is frozen.

## Register Map

The following table shows the GPIO registers and reset values of the Port A ~ D.

**Table 21. GPIO Register Map**

| Register                                 | Offset | Description                                   | Reset Value |
|------------------------------------------|--------|-----------------------------------------------|-------------|
| <b>GPIO A Base Address = 0x400B_0000</b> |        |                                               |             |
| PADIRCR                                  | 0x000  | Port A Data Direction Control Register        | 0x0000_0000 |
| PAINER                                   | 0x004  | Port A Input Function Enable Control Register | 0x0000_3300 |
| PAPUR                                    | 0x008  | Port A Pull-Up Selection Register             | 0x0000_3300 |
| PAPDR                                    | 0x00C  | Port A Pull-Down Selection Register           | 0x0000_0000 |
| PAODR                                    | 0x010  | Port A Open Drain Selection Register          | 0x0000_0000 |
| PADRVR                                   | 0x014  | Port A Drive Current Selection Register       | 0x0000_0000 |
| PALOCKR                                  | 0x018  | Port A Lock Register                          | 0x0000_0000 |
| PADINR                                   | 0x01C  | Port A Data Input Register                    | 0x0000_3300 |
| PADOUTR                                  | 0x020  | Port A Data Output Register                   | 0x0000_0000 |
| PASRR                                    | 0x024  | Port A Output Set and Reset Control Register  | 0x0000_0000 |
| PARR                                     | 0x028  | Port A Output Reset Control Register          | 0x0000_0000 |
| <b>GPIO B Base Address = 0x400B_2000</b> |        |                                               |             |
| PBDIRCR                                  | 0x000  | Port B Data Direction Control Register        | 0x0000_0000 |
| PBINER                                   | 0x004  | Port B Input Function Enable Control Register | 0x0000_0000 |
| PBPUR                                    | 0x008  | Port B Pull-Up Selection Register             | 0x0000_0000 |
| PBPDR                                    | 0x00C  | Port B Pull-Down Selection Register           | 0x0000_0000 |
| PBODR                                    | 0x010  | Port B Open Drain Selection Register          | 0x0000_0000 |
| PBDRVR                                   | 0x014  | Port B Drive Current Selection Register       | 0x0000_0000 |
| PBLOCKR                                  | 0x018  | Port B Lock Register                          | 0x0000_0000 |
| PBDINR                                   | 0x01C  | Port B Data Input Register                    | 0x0000_0000 |
| PBDOUTR                                  | 0x020  | Port B Data Output Register                   | 0x0000_0000 |
| PBSRR                                    | 0x024  | Port B Output Set and Reset Control Register  | 0x0000_0000 |
| PBRR                                     | 0x028  | Port B Output Reset Control Register          | 0x0000_0000 |
| <b>GPIO C Base Address = 0x400B_4000</b> |        |                                               |             |
| PCDIRCR                                  | 0x000  | Port C Data Direction Control Register        | 0x0000_0000 |
| PCINER                                   | 0x004  | Port C Input Function Enable Control Register | 0x0000_0000 |
| PCPUR                                    | 0x008  | Port C Pull-Up Selection Register             | 0x0000_0000 |
| PCPDR                                    | 0x00C  | Port C Pull-Down Selection Register           | 0x0000_0000 |
| PCODR                                    | 0x010  | Port C Open Drain Selection Register          | 0x0000_0000 |
| PCDRVR                                   | 0x014  | Port C Drive Current Selection Register       | 0x0000_0000 |
| PCLOCKR                                  | 0x018  | Port C Lock Register                          | 0x0000_0000 |
| PCDINR                                   | 0x01C  | Port C Data Input Register                    | 0x0000_0000 |

| Register                                 | Offset | Description                                   | Reset Value |
|------------------------------------------|--------|-----------------------------------------------|-------------|
| PCDOUTR                                  | 0x020  | Port C Data Output Register                   | 0x0000_0000 |
| PCSRR                                    | 0x024  | Port C Output Set and Reset Control Register  | 0x0000_0000 |
| PCRR                                     | 0x028  | Port C Output Reset Control Register          | 0x0000_0000 |
| <b>GPIO D Base Address = 0x400B_6000</b> |        |                                               |             |
| PDDIRCR                                  | 0x000  | Port D Data Direction Control Register        | 0x0000_0000 |
| PDINER                                   | 0x004  | Port D Input Function Enable Control Register | 0x0000_0000 |
| PDPUR                                    | 0x008  | Port D Pull-Up Selection Register             | 0x0000_0000 |
| PDPDR                                    | 0x00C  | Port D Pull-Down Selection Register           | 0x0000_0000 |
| PDODR                                    | 0x010  | Port D Open Drain Selection Register          | 0x0000_0000 |
| PDDVR                                    | 0x014  | Port D Drive Current Selection Register       | 0x0000_0000 |
| PDLOCKR                                  | 0x018  | Port D Lock Register                          | 0x0000_0000 |
| PDDINR                                   | 0x01C  | Port D Data Input Register                    | 0x0000_0000 |
| PDDOUTR                                  | 0x020  | Port D Data Output Register                   | 0x0000_0000 |
| PDSRR                                    | 0x024  | Port D Output Set and Reset Control Register  | 0x0000_0000 |
| PDRR                                     | 0x028  | Port D Output Reset Control Register          | 0x0000_0000 |

## Register Descriptions

### Port A Data Direction Control Register – PADIRCR

This register is used to control the direction of the GPIO Port A pin as input or output.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | PADIR    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | PADIR    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field  | Descriptions                                                                                               |
|--------|--------|------------------------------------------------------------------------------------------------------------|
| [15:0] | PADIRn | GPIO Port A pin n Direction Control Bits (n = 0 ~ 15)<br>0: Pin n is input mode<br>1: Pin n is output mode |

## Port A Input Function Enable Control Register – PAINER

This register is used to enable or disable the GPIO Port A input function.

Offset: 0x004

Reset value: 0x0000\_3300

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | PAINEN   |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 1  | RW | 1  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | PAINEN   |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                      |
|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PAINENn | <p>GPIO Port A pin n Input Enable Control Bits (n = 0 ~ 15)</p> <p>0: Pin n input function is disabled.</p> <p>1: Pin n input function is enabled.</p> <p>When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state.</p> |

## Port A Pull-Up Selection Register – PAPUR

This register is used to enable or disable the GPIO Port A pull-up function.

Offset: 0x008

Reset value: 0x0000\_3300

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | PAPU     |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 1  | RW | 1  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | PAPU     |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PAPUn | <p>GPIO Port A pin n Pull-Up Selection Control Bits (n = 0 ~ 15)</p> <p>0: Pin n pull-up function is disabled</p> <p>1: Pin n pull-up function is enabled</p> <p>Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.</p> |

## Port A Pull-Down Selection Register – PAPDR

This register is used to enable or disable the GPIO Port A pull-down function.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PAPD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PAPD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                      |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PAPDn | <p>GPIO Port A pin n Pull-Down Selection Control Bits (n = 0 ~ 15)</p> <p>0: Pin n pull-down function is disabled</p> <p>1: Pin n pull-down function is enabled</p> <p>Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.</p> |

## Port A Open Drain Selection Register – PAODR

This register is used to enable or disable the GPIO Port A open drain function.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PAOD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PAOD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                  |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PAODn | GPIO Port A pin n Open Drain Selection Control Bits (n = 0 ~ 15)<br>0: Pin n Open Drain output is disabled. (The output type is CMOS output)<br>1: Pin n Open Drain output is enabled. (The output type is open-drain output) |

## Port A Output Current Drive Selection Register – PADRVR

This register specifies the GPIO Port A output driving current.

Offset: 0x014

Reset value: 0x0000\_0000

|            |        |   |    |   |        |   |    |   |        |   |    |   |        |   |    |   |
|------------|--------|---|----|---|--------|---|----|---|--------|---|----|---|--------|---|----|---|
|            | 31     |   | 30 |   | 29     |   | 28 |   | 27     |   | 26 |   | 25     |   | 24 |   |
|            | PADV15 |   |    |   | PADV14 |   |    |   | PADV13 |   |    |   | PADV12 |   |    |   |
| Type/Reset | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 |
|            | 23     |   | 22 |   | 21     |   | 20 |   | 19     |   | 18 |   | 17     |   | 16 |   |
|            | PADV11 |   |    |   | PADV10 |   |    |   | PADV9  |   |    |   | PADV8  |   |    |   |
| Type/Reset | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 |
|            | 15     |   | 14 |   | 13     |   | 12 |   | 11     |   | 10 |   | 9      |   | 8  |   |
|            | PADV7  |   |    |   | PADV6  |   |    |   | PADV5  |   |    |   | PADV4  |   |    |   |
| Type/Reset | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 |
|            | 7      |   | 6  |   | 5      |   | 4  |   | 3      |   | 2  |   | 1      |   | 0  |   |
|            | PADV3  |   |    |   | PADV2  |   |    |   | PADV1  |   |    |   | PADV0  |   |    |   |
| Type/Reset | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 | RW     | 0 | RW | 0 |

| Bits   | Field      | Descriptions                                                                                                                                                                                                 |
|--------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | PADVn[1:0] | GPIO Port A pin n Output Current Drive Selection Control Bits (n = 0 ~ 15)<br>00: 4 mA source/sink current<br>01: 8 mA source/sink current<br>10: 12 mA source/sink current<br>11: 16 mA source/sink current |

## Port A Lock Register – PALOCKR

This register specifies the GPIO Port A lock configuration.

Offset: 0x018

Reset value: 0x0000\_0000

|            |        |    |    |    |    |    |    |    |    |
|------------|--------|----|----|----|----|----|----|----|----|
|            | 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | PALKEY |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23     | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | PALKEY |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15     | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | PALOCK |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7      | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | PALOCK |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | PALKEY  | <p>GPIO Port A Lock Key</p> <p>0x5FA0: Port A Lock function is enable<br/>Others: Port A Lock function is disable</p> <p>To lock the Port A function, a value 0x5FA0 should be written into the PALKEY field in this register. To execute a successful write operation on this lock register, the value written into the PALKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PALOCKR register will be aborted. The result of a read operation on the PALKEY field returns the GPIO Port A Lock Status which indicates whether the GPIO Port A is locked or not. If the read value of the PALKEY field is 0, this indicates that the GPIO Port A Lock function is disabled. Otherwise, it indicates that the GPIO Port A Lock function is enabled as the read value is equal to 1.</p> |
| [15:0]  | PALOCKn | <p>GPIO Port A Pin n Lock Control Bits (n = 0 ~ 15)</p> <p>0: Port A Pin n is not locked<br/>1: Port A Pin n is locked</p> <p>The PALOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PALKEY field. The locked configurations including PADIRn, PAINENn, PAPUn, PAPDn, PAODn and PADVn setting in the related GPIO registers. Additionally, the GPACFGHR or GPACFGLR field which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PALOCKR can only be written once which means that PALKEY and PALOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port A reset occurs.</p>                                                                                        |

## Port A Data Input Register – PADINR

This register specifies the GPIO Port A input data.

Offset: 0x01C

Reset value: 0x0000\_3300

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | PADIN    |    |    |    |    |    |    |    |
|            | RO       | 0  | RO | 0  | RO | 1  | RO | 1  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | PADIN    |    |    |    |    |    |    |    |
|            | RO       | 0  | RO | 0  | RO | 0  | RO | 0  |

| Bits   | Field  | Descriptions                                                                                                     |
|--------|--------|------------------------------------------------------------------------------------------------------------------|
| [15:0] | PADINn | GPIO Port A pin n Data Input Bits (n = 0 ~ 15)<br>0: The input data of pin is 0<br>1: The input data of pin is 1 |

## Port A Output Data Register – PADOUTR

This register specifies the GPIO Port A output data.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PADOUT   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PADOUT   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field   | Descriptions                                                                                                                |
|--------|---------|-----------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PADOUTn | GPIO Port A pin n Data Output Bits (n = 0 ~ 15)<br>0: Data to be output on pin n is 0<br>1: Data to be output on pin n is 1 |

## Port A Output Set/Reset Control Register – PASRR

This register is used to set or reset the corresponding bit of the GPIO Port A output data.

Offset: 0x024

Reset value: 0x0000\_0000

|            |       |    |    |    |    |    |    |    |    |
|------------|-------|----|----|----|----|----|----|----|----|
|            | 31    | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | PARST |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | PARST |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 15    | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | PASET |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 7     | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | PASET |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                 |
|---------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | PARSTn | GPIO Port A pin n Output Reset Control Bits (n = 0 ~ 15)<br>0: No effect on the PADOUTn bit<br>1: Reset the PADOUTn bit                                                                                                                                      |
| [15:0]  | PASETn | GPIO Port A pin n Output Set Control Bits (n = 0 ~ 15)<br>0: No effect on the PADOUTn bit<br>1: Set the PADOUTn bit<br>Note that the function enabled by the PASETn bit has the higher priority if both the PASETn and PARSTn bits are set at the same time. |

## Port A Output Reset Register – PARR

This register is used to reset the corresponding bit of the GPIO Port A output data.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | PARST    |    |    |    |    |    |    |    |
|            | WO       | 0  | WO | 0  | WO | 0  | WO | 0  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | PARST    |    |    |    |    |    |    |    |
|            | WO       | 0  | WO | 0  | WO | 0  | WO | 0  |
|            | WO       | 0  | WO | 0  | WO | 0  | WO | 0  |

| Bits   | Field  | Descriptions                                                                                                    |
|--------|--------|-----------------------------------------------------------------------------------------------------------------|
| [15:0] | PARSTn | GPIO Port A pin n Output Reset Bits (n = 0 ~ 15)<br>0: No effect on the PADOUTn bit<br>1: Reset the PADOUTn bit |

## Port B Data Direction Control Register – PBDIRCR

This register is used to control the direction of GPIO Port B pin as input or output.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |       |    |
|------------|----------|----|----|----|----|----|----------|-------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24    |    |
| Type/Reset | Reserved |    |    |    |    |    |          |       |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16    |    |
| Type/Reset | Reserved |    |    |    |    |    |          |       |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8     |    |
| Type/Reset | PBDIR    |    |    |    |    |    | Reserved | PBDIR |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0     | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0     |    |
| Type/Reset | PBDIR    |    |    |    |    |    |          |       |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0     | RW |

| Bits    | Field  | Descriptions                                                  |
|---------|--------|---------------------------------------------------------------|
| [15:10] | PBDIRn | GPIO Port B pin n Direction Control Bits (n = 0 ~ 8, 10 ~ 15) |
| [8:0]   |        | 0: Pin n is input mode<br>1: Pin n is output mode             |

## Port B Input Function Enable Control Register – PBINER

This register is used to enable or disable the GPIO Port B input function.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |        |    |
|------------|----------|----|----|----|----|----|----------|--------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24     |    |
| Type/Reset | Reserved |    |    |    |    |    |          |        |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16     |    |
| Type/Reset | Reserved |    |    |    |    |    |          |        |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8      |    |
| Type/Reset | PBINEN   |    |    |    |    |    | Reserved | PBINEN |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0      |    |
| Type/Reset | PBINEN   |    |    |    |    |    |          |        |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                       |
|---------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:10] | PBINENn | GPIO Port B pin n Input Enable Control Bits (n = 0 ~ 8, 10 ~ 15)                                                                                                                                                                   |
| [8:0]   |         | 0: Pin n input function is disabled.<br>1: Pin n input function is enabled.<br>When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state. |

## Port B Pull-Up Selection Register – PBPUR

This register is used to enable or disable the GPIO Port B pull-up function.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |      |    |
|------------|----------|----|----|----|----|----|----------|------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24   |    |
| Type/Reset | Reserved |    |    |    |    |    |          |      |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16   |    |
| Type/Reset | Reserved |    |    |    |    |    |          |      |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8    |    |
| Type/Reset | PBPU     |    |    |    |    |    | Reserved | PBPU |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0    | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0    |    |
| Type/Reset | PBPU     |    |    |    |    |    |          |      |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0    | RW |

| Bits    | Field | Descriptions                                                                                                                                                                           |
|---------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:10] | PBPUn | GPIO Port B pin n Pull-Up Selection Control Bits (n = 0 ~ 8, 10 ~ 15)                                                                                                                  |
| [8:0]   |       | 0: Pin n pull-up function is disabled<br>1: Pin n pull-up function is enabled                                                                                                          |
|         |       | Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled. |

## Port B Pull-Down Selection Register – PBPDR

This register is used to enable or disable the GPIO Port B pull-down function.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |      |    |
|------------|----------|----|----|----|----|----|----------|------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24   |    |
| Type/Reset | Reserved |    |    |    |    |    |          |      |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16   |    |
| Type/Reset | Reserved |    |    |    |    |    |          |      |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8    |    |
| Type/Reset | PBPD     |    |    |    |    |    | Reserved | PBPD |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0    | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0    |    |
| Type/Reset | PBPD     |    |    |    |    |    |          |      |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0    | RW |

| Bits    | Field | Descriptions                                                                                                                                                                           |
|---------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:10] | PBPDn | GPIO Port B pin n Pull-Down Selection Control Bits (n = 0 ~ 8, 10 ~ 15)                                                                                                                |
| [8:0]   |       | 0: Pin n pull-down function is disabled<br>1: Pin n pull-down function is enabled                                                                                                      |
|         |       | Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled. |

## Port B Open Drain Selection Register – PBODR

This register is used to enable or disable the GPIO Port B open drain function.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |      |    |
|------------|----------|----|----|----|----|----|----------|------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24   |    |
| Type/Reset | Reserved |    |    |    |    |    |          |      |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16   |    |
| Type/Reset | Reserved |    |    |    |    |    |          |      |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8    |    |
| Type/Reset | PBOD     |    |    |    |    |    | Reserved | PBOD |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0    | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0    |    |
| Type/Reset | PBOD     |    |    |    |    |    |          |      |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0    | RW |

| Bits    | Field | Descriptions                                                                                                                                              |
|---------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:10] | PBODn | GPIO Port B pin n Open Drain Selection Control Bits (n = 0 ~ 8, 10 ~ 15)                                                                                  |
| [8:0]   |       | 0: Pin n Open Drain output is disabled. (The output type is CMOS output)<br>1: Pin n Open Drain output is enabled. (The output type is open-drain output) |

## Port B Output Current Drive Selection Register – PBDRVR

This register specifies the GPIO Port B output driving current.

Offset: 0x014

Reset value: 0x0000\_0000

|            |        |    |        |    |          |    |        |    |    |
|------------|--------|----|--------|----|----------|----|--------|----|----|
|            | 31     | 30 | 29     | 28 | 27       | 26 | 25     | 24 |    |
|            | PBDV15 |    | PBDV14 |    | PBDV13   |    | PBDV12 |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW       | 0  | RW     | 0  | RW |
|            | 23     | 22 | 21     | 20 | 19       | 18 | 17     | 16 |    |
|            | PBDV11 |    | PBDV10 |    | Reserved |    | PBDV8  |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW       | 0  | RW     | 0  | RW |
|            | 15     | 14 | 13     | 12 | 11       | 10 | 9      | 8  |    |
|            | PBDV7  |    | PBDV6  |    | PBDV5    |    | PBDV4  |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW       | 0  | RW     | 0  | RW |
|            | 7      | 6  | 5      | 4  | 3        | 2  | 1      | 0  |    |
|            | PBDV3  |    | PBDV2  |    | PBDV1    |    | PBDV0  |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW       | 0  | RW     | 0  | RW |

| Bits               | Field      | Descriptions                                                                                                                                                                                                         |
|--------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:20],<br>[17:0] | PBDVn[1:0] | GPIO Port B pin n Output Current Drive Selection Control Bits (n = 0 ~ 8, 10 ~ 15)<br>00: 4 mA source/sink current<br>01: 8 mA source/sink current<br>10: 12 mA source/sink current<br>11: 16 mA source/sink current |

## Port B Lock Register – PBLOCKR

This register specifies the GPIO Port B lock configuration.

Offset: 0x018

Reset value: 0x0000\_0000

|            |        |    |    |    |    |    |          |        |    |
|------------|--------|----|----|----|----|----|----------|--------|----|
|            | 31     | 30 | 29 | 28 | 27 | 26 | 25       | 24     |    |
|            | PBLKEY |    |    |    |    |    |          |        |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |
|            | 23     | 22 | 21 | 20 | 19 | 18 | 17       | 16     |    |
|            | PBLKEY |    |    |    |    |    |          |        |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |
|            | 15     | 14 | 13 | 12 | 11 | 10 | 9        | 8      |    |
|            | PBLOCK |    |    |    |    |    | Reserved | PBLOCK |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |
|            | 7      | 6  | 5  | 4  | 3  | 2  | 1        | 0      |    |
|            | PBLOCK |    |    |    |    |    |          |        |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |

| Bits             | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16]          | PBLKEY  | GPIO Port Block Key<br>0x5FA0: Port Block function is enable<br>Others: Port B Lock function is disable<br>To lock the Port B function, a value 0x5FA0 should be written into the PBLKEY field in this register. To execute a successful write operation on this lock register, the value written into the PBLKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PBLOCKR register will be aborted. The result of a read operation on the PBLKEY field returns the GPIO Port B Lock Status which indicates whether the GPIO Port B is locked or not. If the read value of the PBLKEY field is 0, this indicates that the GPIO Port B Lock function is disabled. Otherwise, it indicates that the GPIO Port B Lock function is enabled as the read value is equal to 1. |
| [15:10]<br>[8:0] | PBLOCKn | GPIO Port B pin n Lock Control Bits (n = 0 ~ 8, 10 ~ 15)<br>0: Port B pin n is not locked<br>1: Port B pin n is locked<br>The PBLOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PBLKEY field. The locked configurations including PBDIRn, PBINENn, PBPUn, PBDn and PBODn setting in the related GPIO registers. Additionally, the GPBCFGHR or GPBCFGLR field which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PBLOCKR can only be written once which means that PBLKEY and PBLOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port B reset occurs.                                                                                      |

## Port B Data Input Register – PBDINR

This register specifies the GPIO Port B input data.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |       |    |
|------------|----------|----|----|----|----|----|----------|-------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24    |    |
| Type/Reset | Reserved |    |    |    |    |    |          |       |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16    |    |
| Type/Reset | Reserved |    |    |    |    |    |          |       |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8     |    |
| Type/Reset | PBDIN    |    |    |    |    |    | Reserved | PBDIN |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0     |    |
| Type/Reset | PBDIN    |    |    |    |    |    |          |       |    |
|            | RO       | 0  | RO | 0  | RO | 0  | RO       | 0     | RO |
|            | 0        | 0  | 0  | 0  | 0  | 0  | 0        | 0     | 0  |

| Bits    | Field  | Descriptions                                                                               |
|---------|--------|--------------------------------------------------------------------------------------------|
| [15:10] | PBDINn | GPIO Port B pin n Data Input Bits (n = 0 ~ 8, 10 ~ 15)                                     |
| [8:0]   |        | 0: The input data of corresponding pin is 0<br>1: The input data of corresponding pin is 1 |

## Port B Output Data Register – PBDOUTR

This register specifies the GPIO Port B output data.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |        |    |
|------------|----------|----|----|----|----|----|----------|--------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24     |    |
| Type/Reset | Reserved |    |    |    |    |    |          |        |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16     |    |
| Type/Reset | Reserved |    |    |    |    |    |          |        |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8      |    |
| Type/Reset | PBDOUT   |    |    |    |    |    | Reserved | PBDOUT |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0      |    |
| Type/Reset | PBDOUT   |    |    |    |    |    |          |        |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW       | 0      | RW |

| Bits    | Field   | Descriptions                                                             |
|---------|---------|--------------------------------------------------------------------------|
| [15:10] | PBDOUTn | GPIO Port B pin n Data Output Bits (n = 0 ~ 8, 10 ~ 15)                  |
| [8:0]   |         | 0: Data to be output on pin n is 0<br>1: Data to be output on pin n is 1 |

## Port B Output Set/Reset Control Register – PBSRR

This register is used to set or reset the corresponding bit of the GPIO Port B output data.

Offset: 0x024

Reset value: 0x0000\_0000

|            |  | 31    |   | 30 |   | 29 |   | 28 |   | 27 |   | 26 |   | 25 |   | 24       |   |       |  |
|------------|--|-------|---|----|---|----|---|----|---|----|---|----|---|----|---|----------|---|-------|--|
|            |  | PBRST |   |    |   |    |   |    |   |    |   |    |   |    |   | Reserved |   |       |  |
| Type/Reset |  | WO    | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO       |   | 0     |  |
|            |  | 23    |   | 22 |   | 21 |   | 20 |   | 19 |   | 18 |   | 17 |   | 16       |   |       |  |
|            |  | PBRST |   |    |   |    |   |    |   |    |   |    |   |    |   |          |   |       |  |
| Type/Reset |  | WO    | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO       | 0 |       |  |
|            |  | 15    |   | 14 |   | 13 |   | 12 |   | 11 |   | 10 |   | 9  |   | 8        |   |       |  |
|            |  | PBSET |   |    |   |    |   |    |   |    |   |    |   |    |   | Reserved |   | PBSET |  |
| Type/Reset |  | WO    | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO       |   | 0     |  |
|            |  | 7     |   | 6  |   | 5  |   | 4  |   | 3  |   | 2  |   | 1  |   | 0        |   |       |  |
|            |  | PBSET |   |    |   |    |   |    |   |    |   |    |   |    |   |          |   |       |  |
| Type/Reset |  | WO    | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO       | 0 |       |  |

| Bits                                                                                                                                  | Field  | Descriptions                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------|
| [31:26]                                                                                                                               | PBRSTn | GPIO Port B pin n Output Reset Control Bits (n = 0 ~ 8, 10 ~ 15)<br>0: No effect on the PBDOUTn bit<br>1: Reset the PBDOUTn bit |
| [23:16]                                                                                                                               |        |                                                                                                                                 |
| [15:10]                                                                                                                               | PBSETn | GPIO Port B pin n Output Set Control Bits (n = 0 ~ 8, 10 ~ 15)<br>0: No effect on the PBDOUTn bit<br>1: Set the PBDOUTn bit     |
| [8:0]                                                                                                                                 |        |                                                                                                                                 |
| Note that the function enabled by the PBSETn bit has the higher priority if both the PBSETn and PBRSTn bits are set at the same time. |        |                                                                                                                                 |

## Port B Output Reset Register – PBRR

This register is used to reset the corresponding bit of the GPIO Port B output data.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |          |       |    |
|------------|----------|----|----|----|----|----|----------|-------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25       | 24    |    |
| Type/Reset | Reserved |    |    |    |    |    |          |       |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17       | 16    |    |
| Type/Reset | Reserved |    |    |    |    |    |          |       |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9        | 8     |    |
| Type/Reset | PBRST    |    |    |    |    |    | Reserved | PBRST |    |
|            | WO       | 0  | WO | 0  | WO | 0  | WO       | 0     | WO |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1        | 0     |    |
| Type/Reset | PBRST    |    |    |    |    |    |          |       |    |
|            | WO       | 0  | WO | 0  | WO | 0  | WO       | 0     | WO |

| Bits    | Field  | Descriptions                                                |
|---------|--------|-------------------------------------------------------------|
| [15:10] | PBRSTn | GPIO Port B pin n Output Reset Bits (n = 0 ~ 8, 10 ~ 15)    |
| [8:0]   |        | 0: No effect on the PBDOUTn bit<br>1: Reset the PBDOUTn bit |

## Port C Data Direction Control Register – PCDIRCR

This register is used to control the direction of GPIO Port C pin as input or output.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PCDIR    |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PCDIR    |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                               |
|--------|--------|------------------------------------------------------------------------------------------------------------|
| [15:0] | PCDIRn | GPIO Port C pin n Direction Control Bits (n = 0 ~ 15)<br>0: Pin n is input mode<br>1: Pin n is output mode |

## Port C Input Function Enable Control Register – PCINER

This register is used to enable or disable the GPIO Port C input function.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PCINEN   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PCINEN   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                   |
|--------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PCINENn | GPIO Port C pin n Input Enable Control Bits (n = 0 ~ 15)<br>0: Pin n input function is disabled.<br>1: Pin n input function is enabled.<br>When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state. |

## Port C Pull-Up Selection Register – PCPUR

This register is used to enable or disable the GPIO Port C pull-up function.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PCPU     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PCPU     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PCPUn | <p>GPIO Port C pin n Pull-Up Selection Control Bits (n = 0 ~ 15)</p> <p>0: Pin n pull-up function is disabled</p> <p>1: Pin n pull-up function is enabled</p> <p>Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.</p> |

## Port C Pull-Down Selection Register – PCPDR

This register is used to enable or disable the GPIO Port C pull-down function.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PCPD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PCPD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                      |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PCPDn | <p>GPIO Port C pin n Pull-Down Selection Control Bits (n = 0 ~ 15)</p> <p>0: Pin n pull-down function is disabled</p> <p>1: Pin n pull-down function is enabled</p> <p>Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled.</p> |

## Port C Open Drain Selection Register – PCODR

This register is used to enable or disable the GPIO Port C open drain function.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PCOD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PCOD     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                  |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PCODn | GPIO Port C pin n Open Drain Selection Control Bits (n = 0 ~ 15)<br>0: Pin n Open Drain output is disabled. (The output type is CMOS output)<br>1: Pin n Open Drain output is enabled. (The output type is open-drain output) |

## Port C Output Current Drive Selection Register – PCDVR

This register specifies the GPIO Port C output driving current.

Offset: 0x014

Reset value: 0x0000\_0000

|            |        |    |        |    |        |    |        |    |    |
|------------|--------|----|--------|----|--------|----|--------|----|----|
|            | 31     | 30 | 29     | 28 | 27     | 26 | 25     | 24 |    |
|            | PCDV15 |    | PCDV14 |    | PCDV13 |    | PCDV12 |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW     | 0  | RW     | 0  | RW |
|            | 23     | 22 | 21     | 20 | 19     | 18 | 17     | 16 |    |
|            | PCDV11 |    | PCDV10 |    | PCDV9  |    | PCDV8  |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW     | 0  | RW     | 0  | RW |
|            | 15     | 14 | 13     | 12 | 11     | 10 | 9      | 8  |    |
|            | PCDV7  |    | PCDV6  |    | PCDV5  |    | PCDV4  |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW     | 0  | RW     | 0  | RW |
|            | 7      | 6  | 5      | 4  | 3      | 2  | 1      | 0  |    |
|            | PCDV3  |    | PCDV2  |    | PCDV1  |    | PCDV0  |    |    |
| Type/Reset | RW     | 0  | RW     | 0  | RW     | 0  | RW     | 0  | RW |

| Bits   | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | PCDVn[1:0] | <p>GPIO Port C pin n Output Current Drive Selection Control Bits (n = 0 ~ 15)</p> <p>00: 4 mA source/sink current<br/>01: 8 mA source/sink current<br/>10: 12 mA source/sink current<br/>11: 16 mA source/sink current</p> <p>Because the PC13 ~ 15 are located at the Backup Domain. Therefore only the sink current capability can be set with PCDV[0] bit and don't care the PCDV[1] bit.</p> <p>x0: 4 mA sink current<br/>x1: 8 mA sink current</p> <p>For the source current of this pins are always limited at 2mA.</p> |

## Port C Lock Register – PCLOCKR

This register specifies the GPIO Port C lock configuration.

Offset: 0x018

Reset value: 0x0000\_0000

|            |        |    |    |    |    |    |    |    |    |
|------------|--------|----|----|----|----|----|----|----|----|
|            | 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | PCLKEY |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23     | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | PCLKEY |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15     | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | PCLOCK |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7      | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | PCLOCK |    |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | PCLKEY  | <p>GPIO Port C lock Key</p> <p>0x5FA0: Port C Lock function is enable<br/>Others: Port C Lock function is disable</p> <p>To lock the Port C function, a value 0x5FA0 should be written into the PCLKEY field in this register. To execute a successful write operation on this lock register, the value written into the PCLKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PCLOCKR register will be aborted. The result of a read operation on the PCLKEY field returns the GPIO Port C Lock Status which indicates whether the GPIO Port C is locked or not. If the read value of the PCLKEY field is 0, this indicates that the GPIO Port C Lock function is disabled. Otherwise, it indicates that the GPIO Port C Lock function is enabled as the read value is equal to 1.</p> |
| [15:0]  | PCLOCKn | <p>GPIO Port C pin n Lock Control Bits (n = 0 ~ 15)</p> <p>0: Port C pin n is not locked<br/>1: Port C pin n is locked</p> <p>The PCLOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PCLKEY field. The locked configurations including PCDIRn, PCINENn, PCPUn, PCPDn and PCODn setting in the related GPIO registers. Additionally, the GPCCFGHR or GPCCFGLR field which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PCLOCKR can only be written once which means that PCLKEY and PCLOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port C reset occurs.</p>                                                                                               |

## Port C Data Input Register – PCDINR

This register specifies the GPIO Port C input data.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |  |
|------------|----------|----|----|----|----|----|----|----|--|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |  |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |  |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |  |
| Type/Reset | PCDIN    |    |    |    |    |    |    |    |  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |  |
| Type/Reset | PCDIN    |    |    |    |    |    |    |    |  |

| Bits   | Field  | Descriptions                                                                                                                                 |
|--------|--------|----------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PCDINn | GPIO Port C pin n Data Input Bits (n = 0 ~ 15)<br>0: The input data of corresponding pin is 0<br>1: The input data of corresponding pin is 1 |

## Port C Output Data Register – PCDOUTR

This register specifies the GPIO Port C output data.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PCDOUT   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PCDOUT   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field   | Descriptions                                                                                                                |
|--------|---------|-----------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PCDOUTn | GPIO Port C pin n Data Output Bits (n = 0 ~ 15)<br>0: Data to be output on pin n is 0<br>1: Data to be output on pin n is 1 |

## Port C Output Set/Reset Control Register – PCSRR

This register is used to set or reset the corresponding bit of the GPIO Port C output data.

Offset: 0x024

Reset value: 0x0000\_0000

|            |       |    |    |    |    |    |    |    |    |
|------------|-------|----|----|----|----|----|----|----|----|
|            | 31    | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | PCRST |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | PCRST |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 15    | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | PCSET |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 7     | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | PCSET |    |    |    |    |    |    |    |    |
| Type/Reset | WO    | 0  | WO | 0  | WO | 0  | WO | 0  | WO |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                               |
|---------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | PCRSTn | GPIO Port C pin n Output Reset Control Bits (n = 0 ~ 15)<br>0: No effect on the PCDOUn bit<br>1: Reset the PCDOUn bit                                                                                                                                      |
| [15:0]  | PCSETn | GPIO Port C pin n Output Set Control Bits (n = 0 ~ 15)<br>0: No effect on the PCDOUn bit<br>1: Set the PCDOUn bit<br>Note that the function enabled by the PCSETn bit has the higher priority if both the PCSETn and PCRSTn bits are set at the same time. |

## Port C Output Reset Register – PCRR

This register is used to reset the corresponding bit of the GPIO Port C output data.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |  |
|------------|----------|----|----|----|----|----|----|----|--|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |  |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |  |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |  |
| Type/Reset | PCRST    |    |    |    |    |    |    |    |  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |  |
| Type/Reset | PCRST    |    |    |    |    |    |    |    |  |

| Bits   | Field  | Descriptions                                                                                                  |
|--------|--------|---------------------------------------------------------------------------------------------------------------|
| [15:0] | PCRSTn | GPIO Port C pin n Output Reset Bits (n = 0 ~ 15)<br>0: No effect on the PCDOUn bit<br>1: Reset the PCDOUn bit |

## Port D Data Direction Control Register – PDDIRCR

This register is used to control the direction of GPIO Port D pin as input or output.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |
|            | Reserved |    |    |    | PDDIR |    |    |    |
| Type/Reset |          |    |    |    | RW    | 0  | RW | 0  |
|            |          |    |    |    |       |    | RW | 0  |
|            |          |    |    |    |       |    |    |    |
|            |          |    |    |    |       |    |    |    |

| Bits  | Field  | Descriptions                                                                                              |
|-------|--------|-----------------------------------------------------------------------------------------------------------|
| [3:0] | PDDIRn | GPIO Port D pin n Direction Control Bits (n = 0 ~ 3)<br>0: Pin n is input mode<br>1: Pin n is output mode |

## Port D Input Function Enable Control Register – PDINER

This register is used to enable or disable the GPIO Port D input function.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |    |    |
|------------|----------|----|----|----|--------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |        |    |    |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |        |    |    |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |        |    |    |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1  | 0  |
| Type/Reset |          |    |    |    | RW     | 0  | RW | 0  |
|            |          |    |    |    | PDINEN |    |    |    |
|            |          |    |    |    |        | 0  | RW | 0  |
|            |          |    |    |    |        |    | 0  | RW |
|            |          |    |    |    |        |    |    | 0  |

| Bits  | Field   | Descriptions                                                                                                                                                                                                                                                                                  |
|-------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | PDINENn | GPIO Port D pin n Input Enable Control Bits (n = 0 ~ 3)<br>0: Pin n input function is disabled.<br>1: Pin n input function is enabled.<br>When the pin n input function is disabled, the input Schmitt trigger will be turned off and the Schmitt trigger output will remain at a zero state. |

## Port D Pull-Up Selection Register – PDPUR

This register is used to enable or disable the GPIO Port D pull-up function.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | RW | 0  | RW | 0  |
|            |          |    |    |    |    | 0  | RW | 0  |
|            |          |    |    |    |    |    | 0  | RW |
|            |          |    |    |    |    |    |    | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                            |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | PDPUn | GPIO Port D pin n Pull-Up Selection Control Bits (n = 0 ~ 3)<br>0: Pin n pull-up function is disabled<br>1: Pin n pull-up function is enabled<br>Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled. |

## Port D Pull-Down Selection Register – PDPDR

This register is used to enable or disable the GPIO Port D pull-down function.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |      |    |    |    |
|------------|----------|----|----|----|------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27   | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |      |    |    |    |
|            | 23       | 22 | 21 | 20 | 19   | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |      |    |    |    |
|            | 15       | 14 | 13 | 12 | 11   | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |      |    |    |    |
|            | 7        | 6  | 5  | 4  | 3    | 2  | 1  | 0  |
| Type/Reset | RW       |    |    |    | 0    | RW | 0  | RW |
|            |          |    |    |    | PDPD |    |    |    |
|            |          |    |    |    | 0    |    |    |    |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                  |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | PDPDn | GPIO Port D pin n Pull-Down Selection Control Bits (n = 0 ~ 3)<br>0: Pin n pull-down function is disabled<br>1: Pin n pull-down function is enabled<br>Note: When the pull-up and pull-down functions are both enabled, the pull-up function will have the higher priority and therefore the pull-down function will be blocked and disabled. |

## Port D Open Drain Selection Register – PDODR

This register is used to enable or disable the GPIO Port D open drain function.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | RW | 0  | RW | 0  |
|            |          |    |    |    |    | 0  | RW | 0  |
|            |          |    |    |    |    |    | 0  | RW |
|            |          |    |    |    |    |    |    | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                 |
|-------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | PDODn | GPIO Port D pin n Open Drain Selection Control Bits (n = 0 ~ 3)<br>0: Pin n Open Drain output is disabled. (The output type is CMOS output)<br>1: Pin n Open Drain output is enabled. (The output type is open-drain output) |

## Port D Output Current Drive Selection Register – PDDVR

This register specifies the GPIO Port D output driving current.

Offset: 0x014

Reset value: 0x0000\_0000

|            |          |    |       |    |       |    |       |    |
|------------|----------|----|-------|----|-------|----|-------|----|
|            | 31       | 30 | 29    | 28 | 27    | 26 | 25    | 24 |
| Type/Reset | Reserved |    |       |    |       |    |       |    |
|            | 23       | 22 | 21    | 20 | 19    | 18 | 17    | 16 |
| Type/Reset | Reserved |    |       |    |       |    |       |    |
|            | 15       | 14 | 13    | 12 | 11    | 10 | 9     | 8  |
| Type/Reset | Reserved |    |       |    |       |    |       |    |
|            | 7        | 6  | 5     | 4  | 3     | 2  | 1     | 0  |
| Type/Reset | RW       | 0  | RW    | 0  | RW    | 0  | RW    | 0  |
|            | PDDV3    |    | PDDV2 |    | PDDV1 |    | PDDV0 |    |

| Bits  | Field      | Descriptions                                                                                                                                                                                                |
|-------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7:0] | PDDVn[1:0] | GPIO Port D pin n Output Current Drive Selection Control Bits (n = 0 ~ 3)<br>00: 4 mA source/sink current<br>01: 8 mA source/sink current<br>10: 12 mA source/sink current<br>11: 16 mA source/sink current |

## Port D Lock Register – PDLOCKR

This register specifies the GPIO Port D lock configuration.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |    |    |    |
|------------|----------|----|----|----|--------|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25 | 24 |    |
|            | PDLKEY   |    |    |    |        |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW     | 0  | RW | 0  | RW |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17 | 16 |    |
|            | PDLKEY   |    |    |    |        |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW     | 0  | RW | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9  | 8  |    |
|            | Reserved |    |    |    |        |    |    |    |    |
| Type/Reset |          |    |    |    |        |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1  | 0  |    |
|            | Reserved |    |    |    | PDLOCK |    |    |    |    |
| Type/Reset |          |    |    |    | RW     | 0  | RW | 0  | RW |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | PDLKEY  | <p>GPIO Port D Lock Key</p> <p>0x5FA0: Port D Lock function is enable<br/>Others: Port D Lock function is disable</p> <p>To lock the Port D function, a value 0x5FA0 should be written into the PDLKEY field in this register. To execute a successful write operation on this lock register, the value written into the PDLKEY field must be 0x5FA0. If the value written into this field is not equal to 0x5FA0, any write operations on the PDLOCKR register will be aborted. The result of a read operation on the PDLKEY field returns the GPIO Port D Lock Status which indicates whether the GPIO Port D is locked or not. If the read value of the PDLKEY field is 0, this indicates that the GPIO Port D Lock function is disabled. Otherwise, it indicates that the GPIO Port D Lock function is enabled as the read value is equal to 1.</p> |
| [3:0]   | PDLOCKn | <p>GPIO Port D pin n Lock Control Bits (n = 0 ~ 3)</p> <p>0: Port D pin n is not locked<br/>1: Port D pin n is locked</p> <p>The PDLOCKn bits are used to lock the configurations of corresponding GPIO Pins when the correct Lock Key is applied to the PDLKEY field. The locked configurations including PDDIRn, PDINENn, PDPUn, PDPDn and PDODn setting in the related GPIO registers. Additionally, the GPDCFGHR or GPDCFGLR field which is used to configure the alternative function of the associated GPIO pin will also be locked. Note that the PDLOCKR can only be written once which means that PDLKEY and PDLOCKn (lock control bit) should be written together and can not be changed until a system reset or GPIO Port D reset occurs.</p>                                                                                                |

## Port D Data Input Register – PDDINR

This register specifies the GPIO Port D input data.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |
|            | Reserved |    |    |    | PDDIN |    |    |    |
| Type/Reset |          |    |    |    | RO    | 0  | RO | 0  |
|            |          |    |    |    |       | RO | 0  | RO |
|            |          |    |    |    |       |    | RO | 0  |
|            |          |    |    |    |       |    |    | RO |
|            |          |    |    |    |       |    |    | 0  |

| Bits  | Field  | Descriptions                                                                                                                                |
|-------|--------|---------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | PDDINn | GPIO Port D pin n Data Input Bits (n = 0 ~ 3)<br>0: The input data of corresponding pin is 0<br>1: The input data of corresponding pin is 1 |

## Port D Output Data Register – PDDOUTR

This register specifies the GPIO Port D output data.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |    |    |
|------------|----------|----|----|----|--------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25 | 24 |
|            | Reserved |    |    |    |        |    |    |    |
| Type/Reset |          |    |    |    |        |    |    |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17 | 16 |
|            | Reserved |    |    |    |        |    |    |    |
| Type/Reset |          |    |    |    |        |    |    |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9  | 8  |
|            | Reserved |    |    |    |        |    |    |    |
| Type/Reset |          |    |    |    |        |    |    |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1  | 0  |
|            | Reserved |    |    |    | PDDOUT |    |    |    |
| Type/Reset |          |    |    |    | RW     | 0  | RW | 0  |
|            |          |    |    |    |        | 0  | RW | 0  |
|            |          |    |    |    |        |    | 0  | RW |
|            |          |    |    |    |        |    |    | 0  |

| Bits  | Field   | Descriptions                                                                                                               |
|-------|---------|----------------------------------------------------------------------------------------------------------------------------|
| [3:0] | PDDOUTn | GPIO Port D pin n Data Output Bits (n = 0 ~ 3)<br>0: Data to be output on pin n is 0<br>1: Data to be output on pin n is 1 |

## Port D Output Set/Reset Control Register – PDSRR

This register is used to set or reset the corresponding bit of the GPIO Port D output data.

Offset: 0x024

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |
|            | Reserved |    |    |    | PDRST |    |    |    |
| Type/Reset |          |    |    |    | WO    | 0  | WO | 0  |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |
|            | Reserved |    |    |    |       |    |    |    |
| Type/Reset |          |    |    |    |       |    |    |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |
|            | Reserved |    |    |    | PDSET |    |    |    |
| Type/Reset |          |    |    |    | WO    | 0  | WO | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                |
|---------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:16] | PDRSTn | GPIO Port D pin n Output Reset Control Bits (n = 0 ~ 3)<br>0: No effect on the PDDOUTn bit<br>1: Reset the PDDOUTn bit                                                                                                                                      |
| [3:0]   | PDSETn | GPIO Port D pin n Output Set Control Bits (n = 0 ~ 3)<br>0: No effect on the PDDOUTn bit<br>1: Set the PDDOUTn bit<br>Note that the function enabled by the PDSETn bit has the higher priority if both the PDSETn and PDRSTn bits are set at the same time. |

## Port D Output Reset Register – PDRR

This register is used to reset the corresponding bit of the GPIO Port D output data.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | WO | 0  | WO | 0  |
|            |          |    |    |    |    | 0  | WO | 0  |
|            |          |    |    |    |    |    | 0  | WO |
|            |          |    |    |    |    |    |    | 0  |
|            |          |    |    |    |    |    |    |    |

| Bits  | Field  | Descriptions                                                                                                   |
|-------|--------|----------------------------------------------------------------------------------------------------------------|
| [3:0] | PDRSTn | GPIO Port D pin n Output Reset Bits (n = 0 ~ 3)<br>0: No effect on the PDDOUTn bit<br>1: Reset the PDDOUTn bit |

## 9 Alternate Function Input/Output Control Unit (AFIO)

### Introduction

In order to expand the flexibility of the GPIO or the usage of peripheral functions, each IO pin can be configured to have up to sixteen different functions such as GPIO or IP functions by setting the GPxCFGLR or GPxCFGHR register where x is the different port name. According to the usage of the IP resource and application requirements, suitable pin-out locations can be selected by using the peripheral IO remapping mechanism. Additionally, various GPIO pins can be selected to be the EXTI interrupt line by setting the EXTInPIN [3:0] field in the ESSRn register to trigger an interrupt or event. Please refer to the EXTI section for more details.

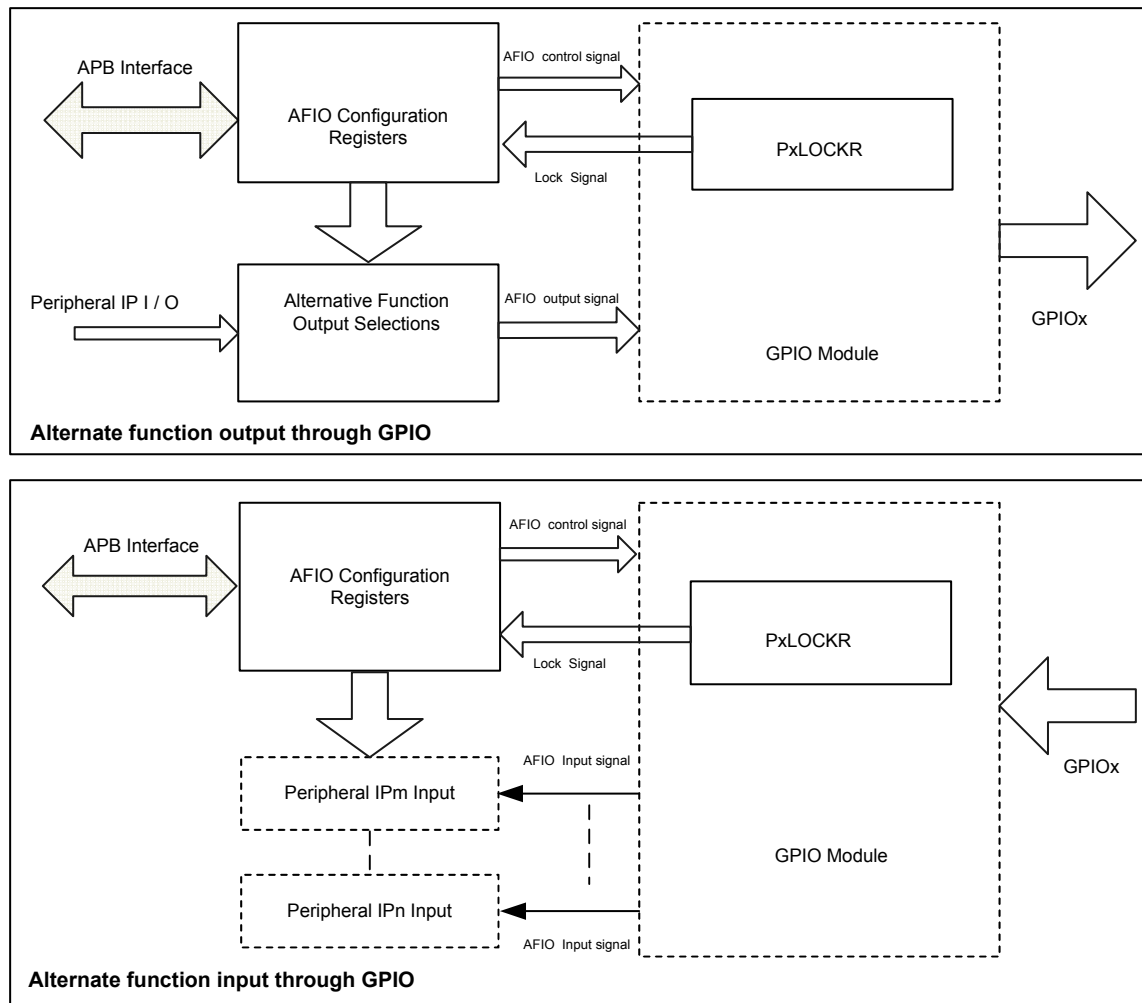


Figure 22. AFIO Block Diagram

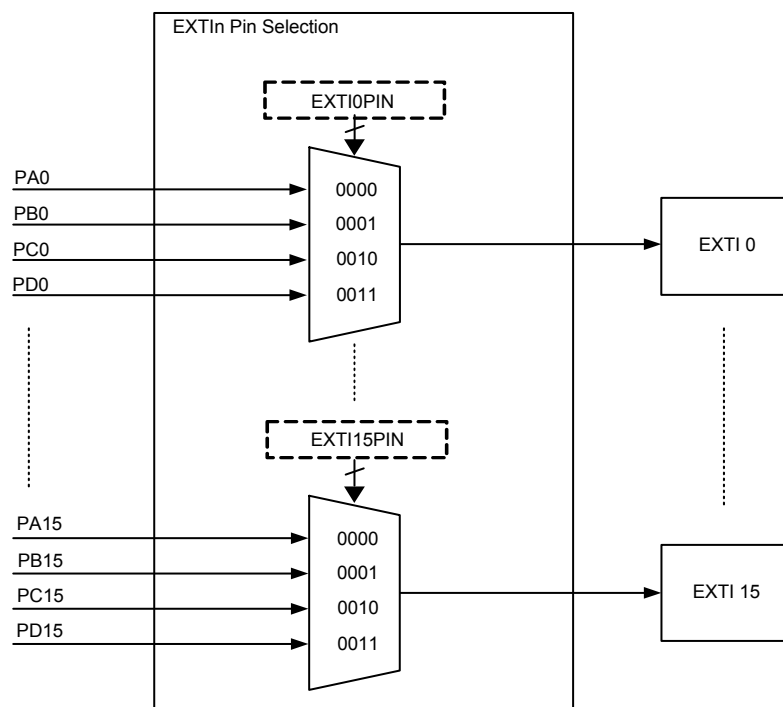
## Features

- APB slave interface for register access
- EXTI source selection
- Configurable pin function for each GPIO, up to sixteen alternative functions on each pin
- AFIO lock mechanism

## Functional Descriptions

### External Interrupt Pin Selection

The GPIO pins are connected to the 16 EXTI lines as shown in the accompanying figure. For example, the user can set the EXTI0PIN [3:0] field in the ESSR0 register to b0000 to select the GPIO PA0 pin as EXTI line 0 input. Since not all the pins of the Port A ~ D pins are available in all package types, please refer to the pin assignment section for detailed pin information. The setting of the EXTIInPIN [3:0] field is invalid when the corresponding pin is not available.



**Figure 23. EXTI Channel Input Selection**

## Alternate Function

Up to sixteen alternative functions can be chosen for each I/O pad by setting the PxCFGn [3:0] field in the GPxCFGLR or GPxCFGHR (n = 0~15, x = A~D) registers. If the pin is selected as an unavailable item which is noted as a “N/A” item in the “Alternate Function Mapping” table in the device datasheet, this pin will be defined as the default alternate function. Please refer to the “Alternate Function Mapping” table in the device datasheet for the detailed mapping of the alternate function I/O pins. In addition to this flexible I/O multiplexing architecture, each peripheral has alternate functions mapped onto different I/O pins to optimize the number of peripherals available in smaller packages. The following description shows the setting of the PxCFGn [3:0] field.

- PxCFGn [3:0] = 0000: The default alternated function (after reset, AF0)
- PxCFGn [3:0] = 0001: Alternate Function 1 (AF1)
- PxCFGn [3:0] = 0010: Alternate Function 2 (AF2)
- .....
- PxCFGn [3:0] = 1110: Alternate Function 14 (AF14)
- PxCFGn [3:0] = 1111: Alternate Function 15 (AF15)

**Table 22. AFIO Selection for Peripheral Map Example**

| AF0            | AF1  | AF2 | AF3 | AF4        | AF5 | AF6         | AF7              | AF8 | AF9 | AF10             | AF11 | AF12 | AF13 | AF14 | AF15         |
|----------------|------|-----|-----|------------|-----|-------------|------------------|-----|-----|------------------|------|------|------|------|--------------|
| System Default | GPIO | ADC | CMP | MCTM /GPTM | SPI | USART /UART | I <sup>2</sup> C | SCI | EBI | I <sup>2</sup> S | N/A  | N/A  | SCTM | N/A  | System Other |

## Lock Mechanism

The device also offers a lock function to lock the AFIO configuration using the GPIO lock register, PxLOCKR, until a reset event occurs. Refer to the GPIO Locking Mechanism section in the GPIO chapter for more details.

## Register Map

The following table shows the AFIO registers and reset value.

**Table 23. AFIO Register Map**

| Register | Offset | Description                               | Reset Value |
|----------|--------|-------------------------------------------|-------------|
| ESSR0    | 0x000  | EXTI Source Selection Register 0          | 0x0000_0000 |
| ESSR1    | 0x004  | EXTI Source Selection Register 1          | 0x0000_0000 |
| GPACFGLR | 0x020  | GPIO Port A AFIO Configuration Register 0 | 0x0000_0000 |
| GPACFGHR | 0x024  | GPIO Port A AFIO Configuration Register 1 | 0x0000_0000 |
| GPBCFGLR | 0x028  | GPIO Port B AFIO Configuration Register 0 | 0x0000_0000 |
| GPBCFGHR | 0x02C  | GPIO Port B AFIO Configuration Register 1 | 0x0000_0000 |
| GPCCFGLR | 0x030  | GPIO Port C AFIO Configuration Register 0 | 0x0000_0000 |
| GPCCFGHR | 0x034  | GPIO Port C AFIO Configuration Register 1 | 0x0000_0000 |
| GPDCFGLR | 0x038  | GPIO Port D AFIO Configuration Register 0 | 0x0000_0000 |
| GPDCFGHR | 0x03C  | GPIO Port D AFIO Configuration Register 1 | 0x0000_0000 |

## Register Descriptions

### EXTI Source Selection Register 0 – ESSR0

This register specifies the IO selection of EXTI0 ~ EXTI7.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | EXTI7PIN |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | EXTI5PIN |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | EXTI3PIN |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | EXTI1PIN |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field         | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | EXTInPIN[3:0] | EXTIn Pin Selection (n = 0 ~ 7)<br>0000: PA Bit n is selected as EXTIn source signal<br>0001: PB Bit n is selected as EXTIn source signal<br>0010: PC Bit n is selected as EXTIn source signal<br>0011: PD Bit n is selected as EXTIn source signal<br>Others: Reserved<br>Note: Since not all GPIO pins are available in all products and package types, refer to the pin assignment section for detailed pin information. The EXTInPIN [3:0] field setting is invalid when the corresponding pin is not available. |

## EXTI Source Selection Register 1 – ESSR1

This register specifies the IO selection of EXTI8~EXTI15.

Offset: 0x004

Reset value: 0x0000\_0000

|            |           |    |    |    |    |    |    |    |   |
|------------|-----------|----|----|----|----|----|----|----|---|
|            | 31        | 30 | 29 | 28 | 27 | 26 | 25 | 24 |   |
|            | EXTI15PIN |    |    |    |    |    |    |    |   |
| Type/Reset | RW        | 0  | RW | 0  | RW | 0  | RW | 0  | 0 |
|            | 23        | 22 | 21 | 20 | 19 | 18 | 17 | 16 |   |
|            | EXTI13PIN |    |    |    |    |    |    |    |   |
| Type/Reset | RW        | 0  | RW | 0  | RW | 0  | RW | 0  | 0 |
|            | 15        | 14 | 13 | 12 | 11 | 10 | 9  | 8  |   |
|            | EXTI11PIN |    |    |    |    |    |    |    |   |
| Type/Reset | RW        | 0  | RW | 0  | RW | 0  | RW | 0  | 0 |
|            | 7         | 6  | 5  | 4  | 3  | 2  | 1  | 0  |   |
|            | EXTI9PIN  |    |    |    |    |    |    |    |   |
| Type/Reset | RW        | 0  | RW | 0  | RW | 0  | RW | 0  | 0 |

| Bits   | Field         | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | EXTInPIN[3:0] | <p>EXTIn Pin Selection (n = 8 ~ 15)</p> <p>0000: PA Bit n is selected as EXTIn source signal</p> <p>0001: PB Bit n is selected as EXTIn source signal</p> <p>0010: PC Bit n is selected as EXTIn source signal</p> <p>0011: PD Bit n is selected as EXTIn source signal</p> <p>Others: Reserved</p> <p>Note: Since not all GPIO pins are available in all products and package types, refer to the pin assignment section for detailed pin information. The EXTInPIN [3:0] field setting is invalid when the corresponding pin is not available.</p> |

## GPIO x Configuration Low Register – GPxCFGLR, x = A, B, C, D

This low register specifies the alternate function of GPIO Port x. x = A, B, C, D

Offset: 0x020, 0x028, 0x030, 0x038

Reset value: 0x0000\_0000

|            |        |    |    |    |    |    |    |    |
|------------|--------|----|----|----|----|----|----|----|
|            | 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|            | PxCFG7 |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 23     | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|            | PxCFG5 |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 15     | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
|            | PxCFG3 |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7      | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|            | PxCFG1 |    |    |    |    |    |    |    |
| Type/Reset | RW     | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field       | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | PxCFGn[3:0] | Port x Pin n Alternate function selection (n = 0~7)<br>0000: Port x pin n is selected as AF0.<br>0001: Port x pin n is selected as AF1.<br>.<br>1110: Port x pin n is selected as AF14<br>1111: Port x pin n is selected as AF15<br>If the pin is selected as an unavailable item which is noted as a "N/A" item in the "Alternate Function Mapping" table in the device datasheet, this pin will be defined as the default alternate function. Please refer to the "Alternate Function Mapping" table in the device datasheet for the detailed mapping of the alternate function I/O pins. |

## GPIO x Configuration High Register – GPxCFGHR, x = A, B, C, D

This high register specifies the alternate function of GPIO Port x. x = A, B, C, D

Offset: 0x024, 0x02C, 0x034, 0x03C

Reset value: 0x0000\_0000

|            |         |    |    |    |    |    |    |    |
|------------|---------|----|----|----|----|----|----|----|
|            | 31      | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|            | PxCFG15 |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 23      | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|            | PxCFG13 |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 15      | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
|            | PxCFG11 |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7       | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|            | PxCFG9  |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field       | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | PxCFGn[3:0] | Port x Pin n Alternate function selection (n = 8~15)<br>0000: Port x pin n is selected as AF0.<br>0001: Port x pin n is selected as AF1.<br>.<br>1110: Port x pin n is selected as AF14<br>1111: Port x pin n is selected as AF15<br>If the pin is selected as an unavailable item which is noted as a "N/A" item in the "Alternate Function Mapping" table in the device datasheet, this pin will be defined as the default alternate function. Please refer to the "Alternate Function Mapping" table in the device datasheet for the detailed mapping of the alternate function I/O pins. |

# 10 Nested Vectored Interrupt Controller (NVIC)

## Introduction

In order to reduce the latency and increase the interrupt processing efficiency, a tightly coupled integrated section, which is named as Nested Vectored Interrupt Controller (NVIC) is provided by the Cortex™-M0+. The NVIC controls the system exceptions and the peripheral interrupt which include functions such as the enable/disable control, priority, clear-pending, active status report, software trigger and vector table remapping. Refer to the Technical Reference Manual of Cortex-M0+ for more details.

Additionally, an integrated simple, 24-bit down count timer (SysTick) is provided by the Cortex™-M0+ to be used as a tick timer for the Real Time Operation System (RTOS) or as a simple counter. The SysTick counts down from the reloaded value and generates a system interrupt when it reached zero. The accompanying table lists the 16 system exceptions types and a variety of peripheral interrupts.

**Table 24. Exception Types**

| Interrupt Number | Exception Number | Exception type | Priority                    | Vector Address | Description                                                                                                                                    |
|------------------|------------------|----------------|-----------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| —                | 0                | —              | —                           | 0x000          | Initial Stack Point value                                                                                                                      |
| —                | 1                | Reset          | -3 (Highest)                | 0x004          | Reset                                                                                                                                          |
| -14              | 2                | NMI            | -2                          | 0x008          | Non-Maskable Interrupt. The clock stuck interrupt signal (clock monitor function provided by Clock Control Unit) is connected to the NMI input |
| -13              | 3                | Hard Fault     | -1                          | 0x00C          | All fault classes                                                                                                                              |
| -                | 4-10             | Reserved       | —                           | —              | —                                                                                                                                              |
| -5               | 11               | SVCall         | Configurable <sup>(1)</sup> | 0x02C          | SVC instruction System service call                                                                                                            |
| -                | 12-13            | Reserved       | —                           | —              | —                                                                                                                                              |
| -2               | 14               | PendSV         | Configurable <sup>(1)</sup> | 0x038          | System Service Pendable request                                                                                                                |
| -1               | 15               | SysTick        | Configurable <sup>(1)</sup> | 0x03C          | SysTick timer decremented to zero                                                                                                              |
| 0                | 16               | LVD            | Configurable <sup>(2)</sup> | 0x040          | Low voltage detection interrupt                                                                                                                |
| 1                | 17               | RTC            | Configurable <sup>(2)</sup> | 0x044          | RTC global interrupt                                                                                                                           |
| 2                | 18               | FMC            | Configurable <sup>(2)</sup> | 0x048          | FMC global interrupt                                                                                                                           |
| 3                | 19               | WKUP           | Configurable <sup>(2)</sup> | 0x04C          | EXTI event wakeup or external WAKEUP pin interrupt                                                                                             |
| 4                | 20               | EXTI0 ~ 1      | Configurable <sup>(2)</sup> | 0x050          | EXTI Line 0 & 1 interrupt                                                                                                                      |
| 5                | 21               | EXTI2 ~ 3      | Configurable <sup>(2)</sup> | 0x054          | EXTI Line 2 & 3 interrupt                                                                                                                      |
| 6                | 22               | EXTI4 ~ 15     | Configurable <sup>(2)</sup> | 0x058          | EXTI Line 4 ~ 15 interrupt                                                                                                                     |
| 7                | 23               | CMP            | Configurable <sup>(2)</sup> | 0x05C          | Comparator global interrupt                                                                                                                    |
| 8                | 24               | ADC            | Configurable <sup>(2)</sup> | 0x060          | ADC global interrupt                                                                                                                           |
| 9                | 25               | Reserved       | —                           | 0x064          | —                                                                                                                                              |
| 10               | 26               | MCTM           | Configurable <sup>(2)</sup> | 0x068          | MCTM global interrupt                                                                                                                          |
| 11               | 27               | GPTM1          | Configurable <sup>(2)</sup> | 0x06C          | GPTM1 global interrupt                                                                                                                         |
| 12               | 28               | GPTM0          | Configurable <sup>(2)</sup> | 0x070          | GPTM0 global interrupt                                                                                                                         |
| 13               | 29               | SCTM0          | Configurable <sup>(2)</sup> | 0x074          | SCTM0 global interrupt                                                                                                                         |
| 14               | 30               | SCTM1          | Configurable <sup>(2)</sup> | 0x078          | SCTM1 global interrupt                                                                                                                         |

| Interrupt Number | Exception Number | Exception type   | Priority                    | Vector Address | Description                         |
|------------------|------------------|------------------|-----------------------------|----------------|-------------------------------------|
| 15               | 31               | Reserved         | —                           | 0x07C          | —                                   |
| 16               | 32               | Reserved         | —                           | 0x080          | —                                   |
| 17               | 33               | BFTM0            | Configurable <sup>(2)</sup> | 0x084          | BFTM0 global interrupt              |
| 18               | 34               | BFTM1            | Configurable <sup>(2)</sup> | 0x088          | BFTM1 global interrupt              |
| 19               | 35               | I2C0             | Configurable <sup>(2)</sup> | 0x08C          | I2C0 global interrupt               |
| 20               | 36               | I2C1             | Configurable <sup>(2)</sup> | 0x090          | I2C1 global interrupt               |
| 21               | 37               | SPI0             | Configurable <sup>(2)</sup> | 0x094          | SPI0 global interrupt               |
| 22               | 38               | SPI1             | Configurable <sup>(2)</sup> | 0x098          | SPI1 global interrupt               |
| 23               | 39               | USART0           | Configurable <sup>(2)</sup> | 0x09C          | USART0 global interrupt             |
| 24               | 40               | USART1           | Configurable <sup>(2)</sup> | 0x0A0          | USART1 global interrupt             |
| 25               | 41               | UART0            | Configurable <sup>(2)</sup> | 0x0A4          | UART0 global interrupt              |
| 26               | 42               | UART1            | Configurable <sup>(2)</sup> | 0x0A8          | UART1 global interrupt              |
| 27               | 43               | SCI0 ~ 1         | Configurable <sup>(2)</sup> | 0x0AC          | SCI0 & SCI1 global interrupt        |
| 28               | 44               | I <sup>2</sup> S | Configurable <sup>(2)</sup> | 0x0B0          | I <sup>2</sup> S global interrupt   |
| 29               | 45               | USB              | Configurable <sup>(2)</sup> | 0x0B4          | USB global interrupt                |
| 30               | 46               | PDMA_CH0~1       | Configurable <sup>(2)</sup> | 0x0B8          | PDMA channel 0 & 1 global interrupt |
| 31               | 47               | PDMA_CH2~5       | Configurable <sup>(2)</sup> | 0x0BC          | PDMA channel 2 ~ 5 global interrupt |

**Notes:** 1. The exception priority can be changed using the NVIC System Handler Priority Registers. For more information, refer to the ARM “Cortex™-M0+ Devices Generic User Guide” document.  
2. The interrupt priority can be changed using the NVIC Interrupt Priority Registers. For more information, refer to the ARM “Cortex™-M0+ Devices Generic User Guide” document.

## Features

- 7 system Cortex™-M0+ exceptions
- Up to 32 Maskable peripheral interrupts
- 16 programmable priority levels (4 bits for interrupt priority setting)
- Non-Maskable interrupt
- Low-latency exception and interrupt handling
- Vector table remapping capability
  - Integrated simple, 24-bit system timer, SYSTICK
  - 24-bit down counter
  - Auto-reloading capability
  - Maskable system interrupt generation when counter decrements to 0
  - SysTick clock source derived from the HCLK clock divided by 8

## Function Descriptions

### SysTick Calibration

The SysTick Calibration Value Register (SCALIB) is provided by the NVIC to give a reference time base of 1ms for the RTOS tick timer or other purpose. The TENMS field in the SCALIB register has a fixed value of 6000 which is the counter reload value to indicate 1 ms when the clock source comes from the SysTick reference input clock STCLK with a frequency of 6 MHz (48 MHz divide by 8).

## Register Map

The following table shows the NVIC registers and reset values.

**Table 25. NVIC Register Map**

| Register                               | Offset | Description                                      | Reset Value   |
|----------------------------------------|--------|--------------------------------------------------|---------------|
| <b>NVIC Base Address = 0xE000_E000</b> |        |                                                  |               |
| SYST_CSR                               | 0x010  | SysTick Control and Status Register              | 0x0000_0000   |
| SYST_RVR                               | 0x014  | SysTick Reload Value Register                    | Unpredictable |
| SYST_CVR                               | 0x018  | SysTick Current Value Register                   | Unpredictable |
| SYST_CALIB                             | 0x01C  | SysTick Calibration Value Register               | 0x4000_2328   |
| NVIC_ISER                              | 0x100  | Interrupt Set Enable Register                    | 0x0000_0000   |
| NVIC_ICER                              | 0x180  | Interrupt Clear Enable Register                  | 0x0000_0000   |
| NVIC_ISPR                              | 0x200  | Interrupt Set Pending Register                   | 0x0000_0000   |
| NVIC_ICPR                              | 0x280  | Interrupt Clear Pending Register                 | 0x0000_0000   |
| NVIC_IPR0                              | 0x400  | Interrupt 0 ~ 3 Priority Register                | 0x0000_0000   |
| NVIC_IPR1                              | 0x404  | Interrupt 4 ~ 7 Priority Register                | 0x0000_0000   |
| NVIC_IPR2                              | 0x408  | Interrupt 8 ~ 11 Priority Register               | 0x0000_0000   |
| NVIC_IPR3                              | 0x40C  | Interrupt 12 ~ 15 Priority Register              | 0x0000_0000   |
| NVIC_IPR4                              | 0x410  | Interrupt 16 ~ 19 Priority Register              | 0x0000_0000   |
| NVIC_IPR5                              | 0x414  | Interrupt 20 ~ 23 Priority Register              | 0x0000_0000   |
| NVIC_IPR6                              | 0x418  | Interrupt 24 ~ 27 Priority Register              | 0x0000_0000   |
| NVIC_IPR7                              | 0x41C  | Interrupt 28 ~ 31 Priority Register              | 0x0000_0000   |
| CPUID                                  | 0xD00  | CPUID register                                   | 0x410CC601    |
| ICSR                                   | 0xD04  | Interrupt Control and State Register             | 0x0000_0000   |
| VTOR                                   | 0xD08  | Vector Table Offset Register                     | 0x0000_0000   |
| AIRCR                                  | 0xD0C  | Application Interrupt and Reset Control Register | 0xFA05_0000   |
| SCR                                    | 0xD10  | System Control Register                          | 0x0000_0000   |
| CCR                                    | 0xD14  | Configuration and Control Register               | 0x0000_0204   |
| SHPR2                                  | 0xD1C  | System Handlers Priority Register 2              | 0x0000_0000   |
| SHPR3                                  | 0xD20  | System Handlers Priority Register 3              | 0x0000_0000   |

**Note:** For more information of the above detail register descriptions, please refer to the “Cortex™-M0+ Devices Generic User Guide” document from ARM.

# 11 External Interrupt/Event Controller (EXTI)

## Introduction

The External Interrupt/Event Controller, EXTI, comprises 16 edge detectors which can generate a wake-up event or interrupt requests independently. In interrupt mode there are five trigger types which can be selected as the external interrupt trigger type, low level, high level, negative edge, positive edge and both edges, selectable using the SRCnTYPE field in the EXTICFGRn (n = 0 ~ 15) register. In the wake-up event mode, the wake-up event polarity can be configured by setting the EXTInWPOL (n = 0 ~ 15) field in the EXTIWAKUPPOLR register. If the EVWUPIEN bit in the EXTIWAKUPCR Register is set, the EVWUP interrupt can be generated when the associated wake-up event occurs and the corresponding EXTI wake-up enable bit is set. Each EXTI line can also be masked independently.

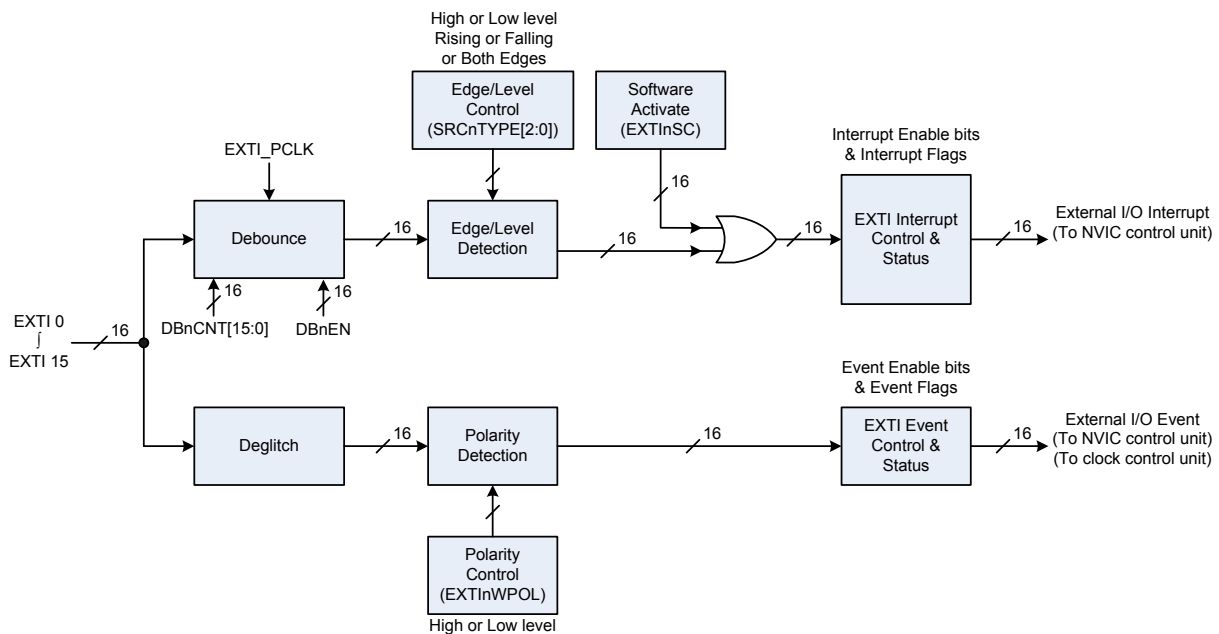


Figure 24. EXTI Block Diagram

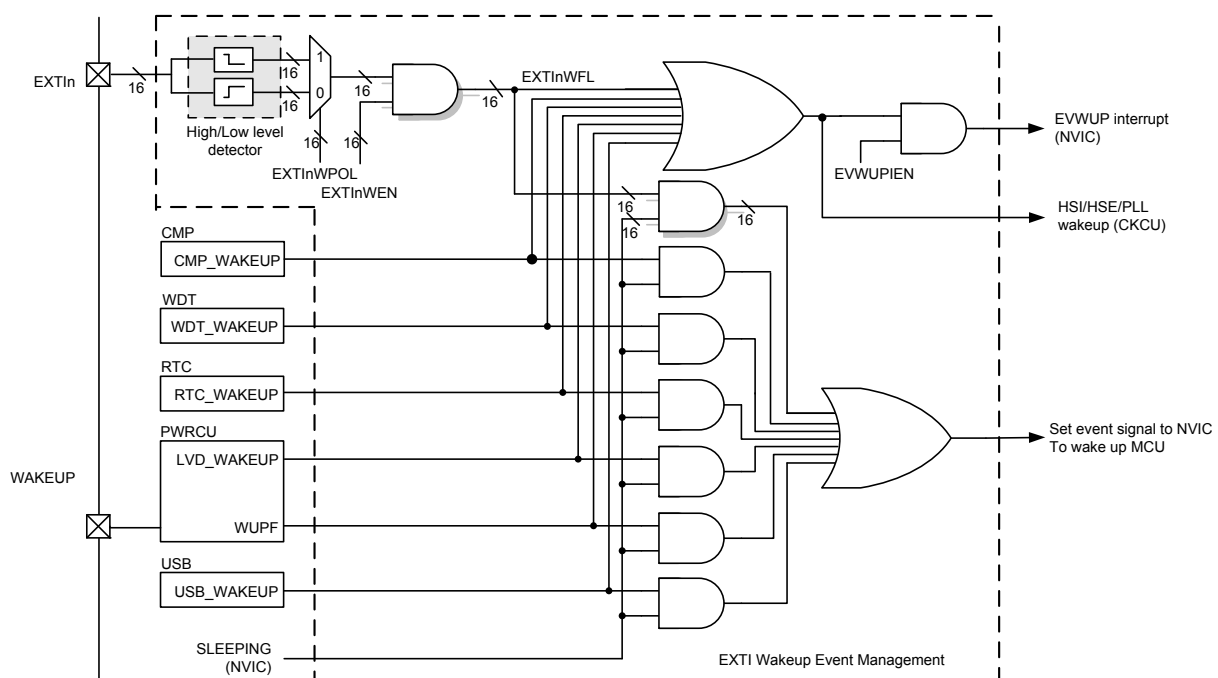
## Features

- Up to 16 EXTI lines with configurable trigger source and type  
All GPIO pins can be selected as EXTI trigger source  
Source trigger type includes high level, low level, negative edge, positive edge, or both edge
- Individual interrupt enable, wakeup enable and status bits for each EXTI line
- Software interrupt trigger mode for each EXTI line
- Integrated deglitch filter for short pulse blocking

## Function Descriptions

### Wakeup Event Management

In order to wakeup the system from the power saving mode, the EXTI controller provides a function which can monitor external events and send them to the CPU core and the Clock Control Unit, CKCU. These external events include EXTI events, Low Voltage Detection, WAKEUP input pin, Comparator, USB and RTC wakeup functions. By configuring the wakeup event enable bit in the corresponding peripheral, the wakeup signal will be sent to the CPU and the CKCU via the EXTI controller when the corresponding wakeup event occurs. Additionally, the software can enable the event wakeup interrupt function by setting the EVWUPIEN bit in the EXTIWAKUPCR register and the EXTI controller will then assert an interrupt when the wakeup event occurs



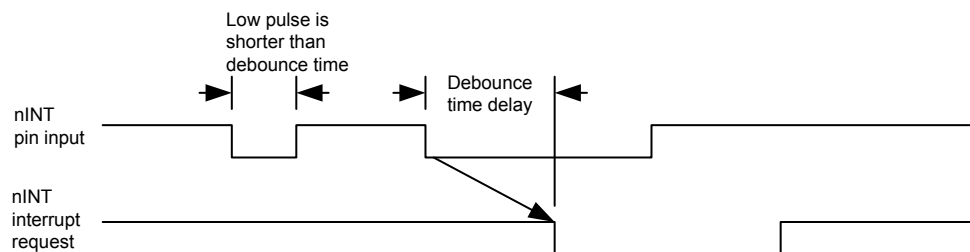
**Figure 25. EXTI Wake-up Event Management**

## External Interrupt/Event Line Mapping

All GPIO pins can be selected as EXTI trigger sources by configuring the EXTI<sub>n</sub>PIN [3:0] field in the AFIO\_ESSR<sub>n</sub> (n= 0 ~ 1) register to trigger an interrupt or event. Refer to the AFIO section for more details.

## Interrupt and Debounce

The application software can set the DBnEN bit in the EXTI<sub>n</sub> Interrupt Configuration Register EXTICFGR<sub>n</sub> (n= 0 ~ 15) to enable the corresponding pin de-bounce function and configure the DBnCNT field in the EXTICFGR<sub>n</sub> so as to select an appropriate de-bounce time for specific applications. The interrupt signal will however be delayed due to the de-bounce function. When the device is woken up from the power saving mode by an external interrupt, an interrupt request will be generated by the EXTI wakeup flag. After the device has been woken up and the clock has recovered, the EXTI wake-up flag that was triggered by the EXTI line must be read and then cleared by application software. The accompanying diagram shows the relationship between the EXTI input signal and the EXTI interrupt/event request signal



**Figure 26. EXTI Interrupt Debounce Function**

## Register Map

The following table shows the EXTI registers and reset values.

**Table 26. EXTI Register Map**

| Register      | Offset | Description                                  | Reset Value |
|---------------|--------|----------------------------------------------|-------------|
| EXTICFGR0     | 0x000  | EXTI Interrupt 0 Configuration Register      | 0x0000_0000 |
| EXTICFGR1     | 0x004  | EXTI Interrupt 1 Configuration Register      | 0x0000_0000 |
| EXTICFGR2     | 0x008  | EXTI Interrupt 2 Configuration Register      | 0x0000_0000 |
| EXTICFGR3     | 0x00C  | EXTI Interrupt 3 Configuration Register      | 0x0000_0000 |
| EXTICFGR4     | 0x010  | EXTI Interrupt 4 Configuration Register      | 0x0000_0000 |
| EXTICFGR5     | 0x014  | EXTI Interrupt 5 Configuration Register      | 0x0000_0000 |
| EXTICFGR6     | 0x018  | EXTI Interrupt 6 Configuration Register      | 0x0000_0000 |
| EXTICFGR7     | 0x01C  | EXTI Interrupt 7 Configuration Register      | 0x0000_0000 |
| EXTICFGR8     | 0x020  | EXTI Interrupt 8 Configuration Register      | 0x0000_0000 |
| EXTICFGR9     | 0x024  | EXTI Interrupt 9 Configuration Register      | 0x0000_0000 |
| EXTICFGR10    | 0x028  | EXTI Interrupt 10 Configuration Register     | 0x0000_0000 |
| EXTICFGR11    | 0x02C  | EXTI Interrupt 11 Configuration Register     | 0x0000_0000 |
| EXTICFGR12    | 0x030  | EXTI Interrupt 12 Configuration Register     | 0x0000_0000 |
| EXTICFGR13    | 0x034  | EXTI Interrupt 13 Configuration Register     | 0x0000_0000 |
| EXTICFGR14    | 0x038  | EXTI Interrupt 14 Configuration Register     | 0x0000_0000 |
| EXTICFGR15    | 0x03C  | EXTI Interrupt 15 Configuration Register     | 0x0000_0000 |
| EXTICR        | 0x040  | EXTI Interrupt Control Register              | 0x0000_0000 |
| EXTIEDGEFLGR  | 0x044  | EXTI Interrupt Edge Flag Register            | 0x0000_0000 |
| EXTIEDGESR    | 0x048  | EXTI Interrupt Edge Status Register          | 0x0000_0000 |
| EXTISCR       | 0x04C  | EXTI Interrupt Software Set Command Register | 0x0000_0000 |
| EXTIWAKUPCR   | 0x050  | EXTI Interrupt Wakeup Control Register       | 0x0000_0000 |
| EXTIWAKUPPOLR | 0x054  | EXTI Interrupt Wakeup Polarity Register      | 0x0000_0000 |
| EXTIWAKUPFLG  | 0x058  | EXTI Interrupt Wakeup Flag Register          | 0x0000_0000 |

## Register Descriptions

### EXTI Interrupt Configuration Register n – EXTICFGRn, n = 0 ~ 15

This register is used to specify the debounce function and select the trigger type.

Offset: 0x000 (0) ~ 0x03C (15)

Reset value: 0x0000\_0000

|            |          |    |          |    |    |    |          |    |
|------------|----------|----|----------|----|----|----|----------|----|
|            | 31       | 30 | 29       | 28 | 27 | 26 | 25       | 24 |
|            | DBnEN    |    | SRCnTYPE |    |    |    | Reserved |    |
| Type/Reset | RW       | 0  | RW       | 0  | RW | 0  | RW       | 0  |
|            | 23       | 22 | 21       | 20 | 19 | 18 | 17       | 16 |
| Type/Reset | Reserved |    |          |    |    |    |          |    |
|            | 15       | 14 | 13       | 12 | 11 | 10 | 9        | 8  |
| Type/Reset | DBnCNT   |    |          |    |    |    |          |    |
|            | 7        | 6  | 5        | 4  | 3  | 2  | 1        | 0  |
| Type/Reset | DBnCNT   |    |          |    |    |    |          |    |
|            | RW       | 0  | RW       | 0  | RW | 0  | RW       | 0  |
|            | RW       | 0  | RW       | 0  | RW | 0  | RW       | 0  |

| Bits           | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                         |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
|----------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--|--|-----------------------|---|---|---|---------------------|---|---|---|----------------------|---|---|---|-------------------------|---|---|---|-------------------------|---|---|---|---------------------|
| [31]           | DBnEN    | EXTIn De-bounce Circuit Enable Bit (n = 0 ~ 15)<br>0: De-bounce circuit is disabled<br>1: De-bounce circuit is enabled                                                                                                                                                                                                                                                                                                                                                                             |                         |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| [30:28]        | SRCnTYPE | EXTIn Interrupt Source Trigger Type (n = 0 ~ 15) <table><tr><th colspan="3">SRCnTYPE [2:0]</th><th>Interrupt Source Type</th></tr><tr><td>0</td><td>0</td><td>0</td><td>Low-level Sensitive</td></tr><tr><td>0</td><td>0</td><td>1</td><td>High-level Sensitive</td></tr><tr><td>0</td><td>1</td><td>0</td><td>Negative-edge Triggered</td></tr><tr><td>0</td><td>1</td><td>1</td><td>Positive-edge Triggered</td></tr><tr><td>1</td><td>X</td><td>X</td><td>Both-edge Triggered</td></tr></table> | SRCnTYPE [2:0]          |  |  | Interrupt Source Type | 0 | 0 | 0 | Low-level Sensitive | 0 | 0 | 1 | High-level Sensitive | 0 | 1 | 0 | Negative-edge Triggered | 0 | 1 | 1 | Positive-edge Triggered | 1 | X | X | Both-edge Triggered |
| SRCnTYPE [2:0] |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Interrupt Source Type   |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| 0              | 0        | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Low-level Sensitive     |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| 0              | 0        | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | High-level Sensitive    |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| 0              | 1        | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Negative-edge Triggered |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| 0              | 1        | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Positive-edge Triggered |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| 1              | X        | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Both-edge Triggered     |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |
| [15:0]         | DBnCNT   | EXTIn De-bounce Counter (n = 0 ~ 15)<br>The de-bounce time is calculated with DBnCNT x APB clock (EXTI_PCLK) period and should be long enough to take effect on the input signal.                                                                                                                                                                                                                                                                                                                  |                         |  |  |                       |   |   |   |                     |   |   |   |                      |   |   |   |                         |   |   |   |                         |   |   |   |                     |

## EXTI Interrupt Control Register – EXTICR

This register is used to control the EXTI interrupt.

Offset: 0x040

Reset value: 0x0000\_0000

|            |          |          |          |          |          |          |         |         |
|------------|----------|----------|----------|----------|----------|----------|---------|---------|
|            | 31       | 30       | 29       | 28       | 27       | 26       | 25      | 24      |
| Type/Reset | Reserved |          |          |          |          |          |         |         |
|            | 23       | 22       | 21       | 20       | 19       | 18       | 17      | 16      |
| Type/Reset | Reserved |          |          |          |          |          |         |         |
|            | 15       | 14       | 13       | 12       | 11       | 10       | 9       | 8       |
| Type/Reset | EXTI15EN | EXTI14EN | EXTI13EN | EXTI12EN | EXTI11EN | EXTI10EN | EXTI9EN | EXTI8EN |
|            | RW       | 0        | RW       | 0        | RW       | 0        | RW      | 0       |
|            | 7        | 6        | 5        | 4        | 3        | 2        | 1       | 0       |
| Type/Reset | EXTI7EN  | EXTI6EN  | EXTI5EN  | EXTI4EN  | EXTI3EN  | EXTI2EN  | EXTI1EN | EXTI0EN |
|            | RW       | 0        | RW       | 0        | RW       | 0        | RW      | 0       |

| Bits   | Field   | Descriptions                                                                                                           |
|--------|---------|------------------------------------------------------------------------------------------------------------------------|
| [15:0] | EXTInEN | EXTIn Interrupt Enable Bit (n = 0 ~ 15)<br>0: EXTI line n interrupt is disabled<br>1: EXTI line n interrupt is enabled |

## EXTI Interrupt Edge Flag Register – EXTIEDGEFLGR

This register is used to indicate if an EXTI edge has been detected.

Offset: 0x044

Reset value: 0x0000\_0000

|            |           |           |           |           |           |           |          |          |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
|            | 31        | 30        | 29        | 28        | 27        | 26        | 25       | 24       |
| Type/Reset | Reserved  |           |           |           |           |           |          |          |
|            | 23        | 22        | 21        | 20        | 19        | 18        | 17       | 16       |
| Type/Reset | Reserved  |           |           |           |           |           |          |          |
|            | 15        | 14        | 13        | 12        | 11        | 10        | 9        | 8        |
| Type/Reset | EXTI15EDF | EXTI14EDF | EXTI13EDF | EXTI12EDF | EXTI11EDF | EXTI10EDF | EXTI9EDF | EXTI8EDF |
|            | WC        | 0         | WC        | 0         | WC        | 0         | WC       | 0        |
|            | 7         | 6         | 5         | 4         | 3         | 2         | 1        | 0        |
| Type/Reset | EXTI7EDF  | EXTI6EDF  | EXTI5EDF  | EXTI4EDF  | EXTI3EDF  | EXTI2EDF  | EXTI1EDF | EXTI0EDF |
|            | WC        | 0         | WC        | 0         | WC        | 0         | WC       | 0        |

| Bits   | Field    | Descriptions                                                                                                                                                                                                                                                                                        |
|--------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | EXTInEDF | <p>EXTIn Both Edge Detection Flag (n = 0 ~ 15)</p> <p>0: No edge is detected</p> <p>1: Positive or negative edge is detected</p> <p>This bit is set by the hardware circuitry when a positive or negative edge is detected on the corresponding EXTI line. Software should write 1 to clear it.</p> |

## EXTI Interrupt Edge Status Register – EXTIEDGESR

This register indicates the polarity of a detected EXTI edge.

Offset: 0x048

Reset value: 0x0000\_0000

|            |           |           |           |           |           |           |          |          |    |   |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|----|---|
|            | 31        | 30        | 29        | 28        | 27        | 26        | 25       | 24       |    |   |
|            | Reserved  |           |           |           |           |           |          |          |    |   |
| Type/Reset |           |           |           |           |           |           |          |          |    |   |
|            | 23        | 22        | 21        | 20        | 19        | 18        | 17       | 16       |    |   |
|            | Reserved  |           |           |           |           |           |          |          |    |   |
| Type/Reset |           |           |           |           |           |           |          |          |    |   |
|            | 15        | 14        | 13        | 12        | 11        | 10        | 9        | 8        |    |   |
|            | EXTI15EDS | EXTI14EDS | EXTI13EDS | EXTI12EDS | EXTI11EDS | EXTI10EDS | EXTI9EDS | EXTI8EDS |    |   |
| Type/Reset | WC        | 0         | WC        | 0         | WC        | 0         | WC       | 0        | WC | 0 |
|            | 7         | 6         | 5         | 4         | 3         | 2         | 1        | 0        |    |   |
|            | EXTI7EDS  | EXTI6EDS  | EXTI5EDS  | EXTI4EDS  | EXTI3EDS  | EXTI2EDS  | EXTI1EDS | EXTI0EDS |    |   |
| Type/Reset | WC        | 0         | WC        | 0         | WC        | 0         | WC       | 0        | WC | 0 |

| Bits   | Field    | Descriptions                                                                                                                                          |
|--------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | EXTInEDS | EXTIn Both Edge Detection Status (n = 0 ~ 15)<br>0: Negative edge is detected<br>1: Positive edge is detected<br>Software should write 1 to clear it. |

## EXTI Interrupt Software Set Command Register – EXTISSCR

This register is used to activate the EXTI interrupt.

Offset: 0x04C

Reset value: 0x0000\_0000

|            |          |          |          |          |          |          |         |         |    |   |
|------------|----------|----------|----------|----------|----------|----------|---------|---------|----|---|
|            | 31       | 30       | 29       | 28       | 27       | 26       | 25      | 24      |    |   |
|            | Reserved |          |          |          |          |          |         |         |    |   |
| Type/Reset |          |          |          |          |          |          |         |         |    |   |
|            | 23       | 22       | 21       | 20       | 19       | 18       | 17      | 16      |    |   |
|            | Reserved |          |          |          |          |          |         |         |    |   |
| Type/Reset |          |          |          |          |          |          |         |         |    |   |
|            | 15       | 14       | 13       | 12       | 11       | 10       | 9       | 8       |    |   |
|            | EXTI15SC | EXTI14SC | EXTI13SC | EXTI12SC | EXTI11SC | EXTI10SC | EXTI9SC | EXTI8SC |    |   |
| Type/Reset | RW       | 0        | RW       | 0        | RW       | 0        | RW      | 0       | RW | 0 |
|            | 7        | 6        | 5        | 4        | 3        | 2        | 1       | 0       |    |   |
|            | EXTI7SC  | EXTI6SC  | EXTI5SC  | EXTI4SC  | EXTI3SC  | EXTI2SC  | EXTI1SC | EXTI0SC |    |   |
| Type/Reset | RW       | 0        | RW       | 0        | RW       | 0        | RW      | 0       | RW | 0 |

| Bits   | Field   | Descriptions                                                                                                                                |
|--------|---------|---------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | EXTInSC | EXTIn Software Set Command (n = 0 ~ 15)<br>0: Deactivates the corresponding EXTI interrupt<br>1: Activates the corresponding EXTI interrupt |

## EXTI Interrupt Wakeup Control Register – EXTIWAKUPCR

This register is used to control the EXTI interrupt and wakeup function.

Offset: 0x050

Reset value: 0x0000\_0000

|            |           |           |           |           |           |           |          |          |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|
|            | 31        | 30        | 29        | 28        | 27        | 26        | 25       | 24       |
|            | EVWUPIEN  | Reserved  |           |           |           |           |          |          |
| Type/Reset | RW        | 0         |           |           |           |           |          |          |
|            | 23        | 22        | 21        | 20        | 19        | 18        | 17       | 16       |
|            | Reserved  |           |           |           |           |           |          |          |
| Type/Reset |           |           |           |           |           |           |          |          |
|            | 15        | 14        | 13        | 12        | 11        | 10        | 9        | 8        |
|            | EXTI15WEN | EXTI14WEN | EXTI13WEN | EXTI12WEN | EXTI11WEN | EXTI10WEN | EXTI9WEN | EXTI8WEN |
| Type/Reset | RW        | 0         | RW        | 0         | RW        | 0         | RW       | 0        |
|            | 7         | 6         | 5         | 4         | 3         | 2         | 1        | 0        |
|            | EXTI7WEN  | EXTI6WEN  | EXTI5WEN  | EXTI4WEN  | EXTI3WEN  | EXTI2WEN  | EXTI1WEN | EXTI0WEN |
| Type/Reset | RW        | 0         | RW        | 0         | RW        | 0         | RW       | 0        |

| Bits   | Field    | Descriptions                                                                                                              |
|--------|----------|---------------------------------------------------------------------------------------------------------------------------|
| [31]   | EVWUPIEN | EXTI Event Wakeup Interrupt Enable Bit<br>0: Disable EVWUP interrupt<br>1: Enable EVWUP interrupt                         |
| [15:0] | EXTInWEN | EXTIn Wakeup Enable Bit (n = 0 ~ 15)<br>0: Power saving mode wakeup is disabled<br>1: Power saving mode wakeup is enabled |

## EXTI Interrupt Wakeup Polarity Register – EXTIWAKUPPOLR

This register is used to select the EXTI line interrupt wakeup polarity.

Offset: 0x054

Reset value: 0x0000\_0000

|            |            |            |            |            |            |            |           |           |    |   |
|------------|------------|------------|------------|------------|------------|------------|-----------|-----------|----|---|
|            | 31         | 30         | 29         | 28         | 27         | 26         | 25        | 24        |    |   |
|            | Reserved   |            |            |            |            |            |           |           |    |   |
| Type/Reset |            |            |            |            |            |            |           |           |    |   |
|            | 23         | 22         | 21         | 20         | 19         | 18         | 17        | 16        |    |   |
|            | Reserved   |            |            |            |            |            |           |           |    |   |
| Type/Reset |            |            |            |            |            |            |           |           |    |   |
|            | 15         | 14         | 13         | 12         | 11         | 10         | 9         | 8         |    |   |
|            | EXTI15WPOL | EXTI14WPOL | EXTI13WPOL | EXTI12WPOL | EXTI11WPOL | EXTI10WPOL | EXTI9WPOL | EXTI8WPOL |    |   |
| Type/Reset | RW         | 0          | RW         | 0          | RW         | 0          | RW        | 0         | RW | 0 |
|            | 7          | 6          | 5          | 4          | 3          | 2          | 1         | 0         |    |   |
|            | EXTI7WPOL  | EXTI6WPOL  | EXTI5WPOL  | EXTI4WPOL  | EXTI3WPOL  | EXTI2WPOL  | EXTI1WPOL | EXTI0WPOL |    |   |
| Type/Reset | RW         | 0          | RW         | 0          | RW         | 0          | RW        | 0         | RW | 0 |

| Bits   | Field     | Descriptions                                                                                                      |
|--------|-----------|-------------------------------------------------------------------------------------------------------------------|
| [15:0] | EXTInWPOL | EXTIn Wakeup Polarity (n = 0 ~ 15)<br>0: EXTIn wakeup is high level active<br>1: EXTIn wakeup is low level active |

## EXTI Interrupt Wakeup Flag Register – EXTIWAKUPFLG

This register is the EXTI interrupt wake flag register.

Offset: 0x058

Reset value: 0x0000\_0000

|            |           |           |           |           |           |           |          |          |    |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|----|
|            | 31        | 30        | 29        | 28        | 27        | 26        | 25       | 24       |    |
| Type/Reset | Reserved  |           |           |           |           |           |          |          |    |
|            | 23        | 22        | 21        | 20        | 19        | 18        | 17       | 16       |    |
| Type/Reset | Reserved  |           |           |           |           |           |          |          |    |
|            | 15        | 14        | 13        | 12        | 11        | 10        | 9        | 8        |    |
| Type/Reset | EXTI15WFL | EXTI14WFL | EXTI13WFL | EXTI12WFL | EXTI11WFL | EXTI10WFL | EXTI9WFL | EXTI8WFL |    |
|            | WC        | 0         | WC        | 0         | WC        | 0         | WC       | 0        | WC |
|            | 7         | 6         | 5         | 4         | 3         | 2         | 1        | 0        |    |
| Type/Reset | EXTI7WFL  | EXTI6WFL  | EXTI5WFL  | EXTI4WFL  | EXTI3WFL  | EXTI2WFL  | EXTI1WFL | EXTI0WFL |    |
|            | WC        | 0         | WC        | 0         | WC        | 0         | WC       | 0        | WC |

| Bits   | Field    | Descriptions                                                                                                                    |
|--------|----------|---------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | EXTInWFL | EXTIn Wakeup Flag (n = 0 ~ 15)<br>0: No wakeup occurs<br>1: System is waken up by EXTIn<br>Software should write 1 to clear it. |

# 12 Analog to Digital Converter (ADC)

## Introduction

A 12-bit multi-channel Analog to Digital Converter is integrated in the device. There are a total of 14 multiplexed channels including 12 external channels on which the external analog signal can be supplied and 2 internal channels. If the input voltage is required to remain within a specific threshold window, the Analog Watchdog function will monitor and detect the signal. An interrupt will then be generated to inform that the input voltage is higher or lower than the set thresholds. There are three conversion modes to convert an analog signal to digital data. The A/D conversion can be operated in one shot, continuous and discontinuous conversion mode. A 16-bit data register is provided to store the data after conversion.

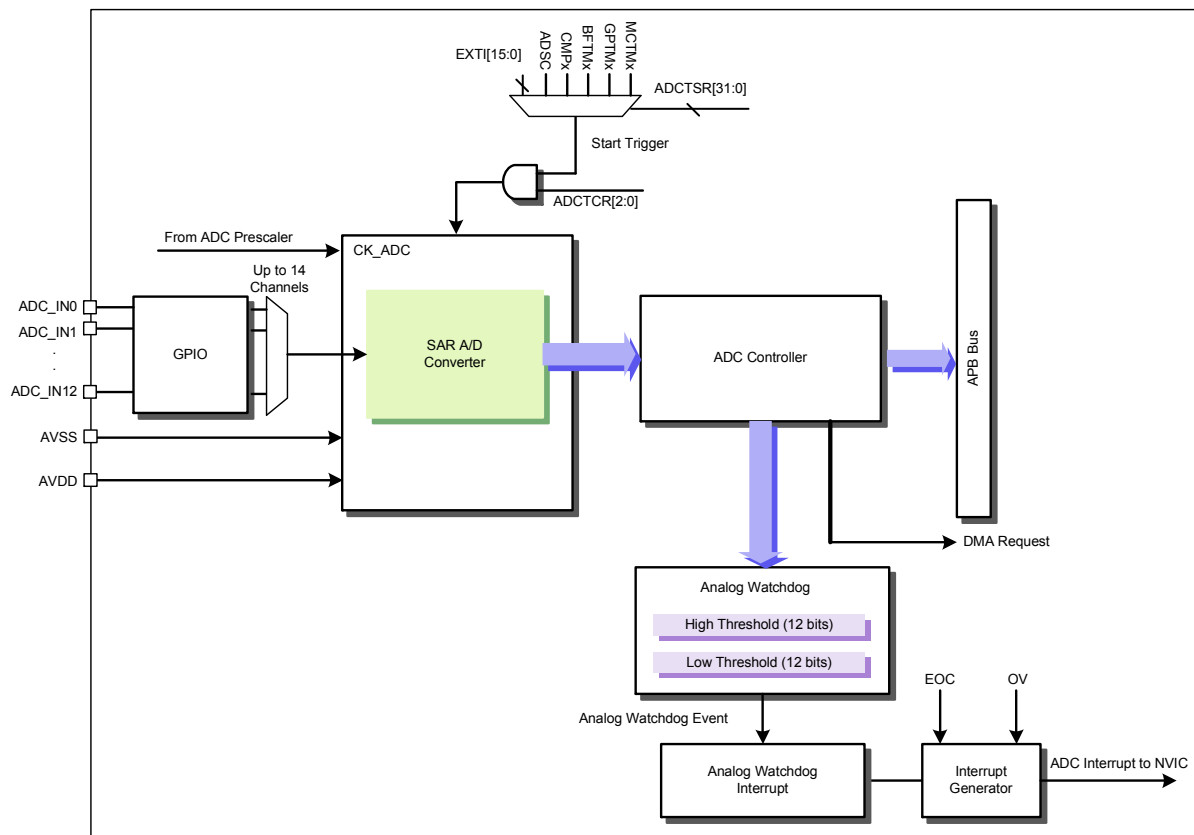


Figure 27. ADC Block Diagram

## Features

- 12-bit SAR ADC engine
- Up to 1 MSPS conversion rate
- 12 external analog input channels
- 2 internal analog input channels for reference voltage detection
- Programmable sampling time for conversion channel
- Up to 8 programmable conversion channel sequence and dedicated data registers for conversion result
- Three conversion mode
  - One shot conversion mode
  - Continuous conversion mode
  - Discontinuous conversion mode.
- Analog watchdog for predefined voltage range monitor
  - Lower/upper threshold register
  - Interrupt generation
- Various trigger start source for conversion modes
  - Software trigger
  - EXTI - external interrupt input pin
  - GPTM0 / GPTM1 trigger
  - MCTM0 / MCTM1 trigger
  - BFTM0 / BFTM1 trigger
  - CMP0 / CMP1 trigger
- Multiple generated interrupts
  - End of single conversion
  - End of subgroup conversion
  - End of cycle conversion
  - Analog Watchdog
  - Data register overwriting
- PDMA request on end of conversion occurred

## Function Descriptions

### ADC Clock Setup

The ADC clock, CK\_ADC is provided by the Clock Controller which is synchronous and divided by with the AHB clock known as HCLK. Refer to the Clock Control Unit chapter for more details. Notes that the ADC requires at least two ADC clock cycles to switch between power-on and power-off conditions (ADEN bit = '0').

### Channel Selection

The A/D converter supports 12 multiplexed channels and organizes the conversion results into a specific group. A conversion group can organize a sequence which can be implemented on the channels arranged in a specific conversion sequence length from 1 to 8. For example, conversion can be carried out with the following channel sequence: CH2, CH4, CH7, CH5, CH6, CH3, CH1 and CH0 one after another.

A group is composed of up to 8 conversions. The selected channels of the group conversion can be specified in the ADCLST0~ADCLST1 registers. The total conversion sequence length is setup using the ADSEQL[2:0] bits in the ADCCONV register.

Modifying the ADCCONV or ADCHCONV register during a conversion process will reset the current conversion, after which a new start pulse is required to restart a new conversion.

### Conversion Mode

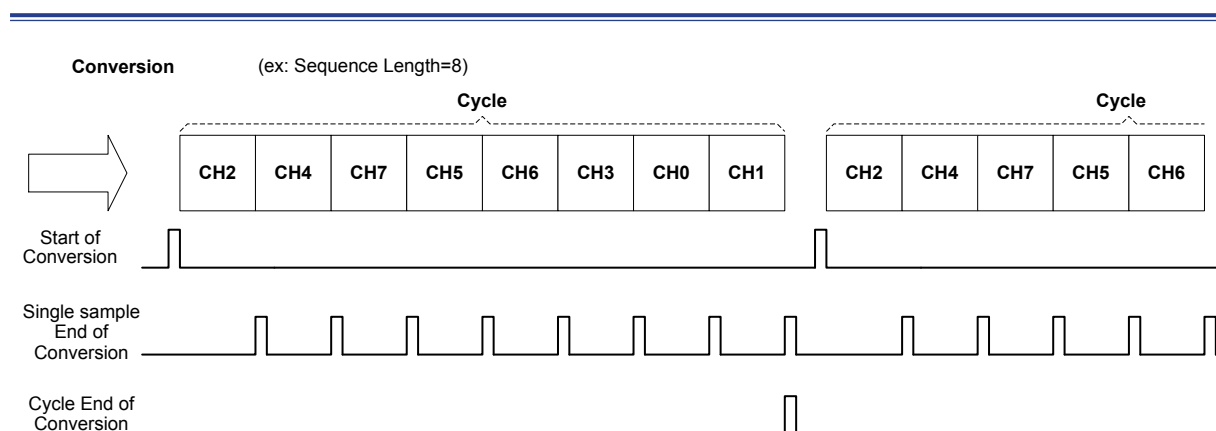
The A/D has three operating conversion modes. The conversion modes are One Shot Conversion Mode, Continuous Conversion Mode, and Discontinuous Conversion mode. Details are provided later.

#### One Shot Conversion Mode

In the One Shot Conversion mode, the ADC will perform conversion cycles on the channels specified in the A/D conversion list registers ADCLSTn with a specific sequence when an A/D converter trigger event occurs. When the A/D conversion mode field ADMODE [1:0] in the ADCCONV register is set to 0x0, the A/D converter will operate in the One Shot Conversion Mode. This mode can be started by a software trigger, a comparator output transition event, an external EXTI event or a TM event determined by the Trigger Control Register ADCTCR and the Trigger Source Register ADCTSR.

#### After Conversion:

- The converted data will be stored in the 16-bit ADCDRy (y = 0~7) registers.
- The ADC single sample end of conversion event raw status flag, ADIRAWS, in the ADCIRAW register will be set when the single sample conversion is finished.
- An interrupt will be generated after a single sample end of conversion if the ADIES bit in the ADCIER register is enabled.
- An interrupt will be generated after a group cycle end of conversion if the ADIEC bit in the ADCIER register is enabled.



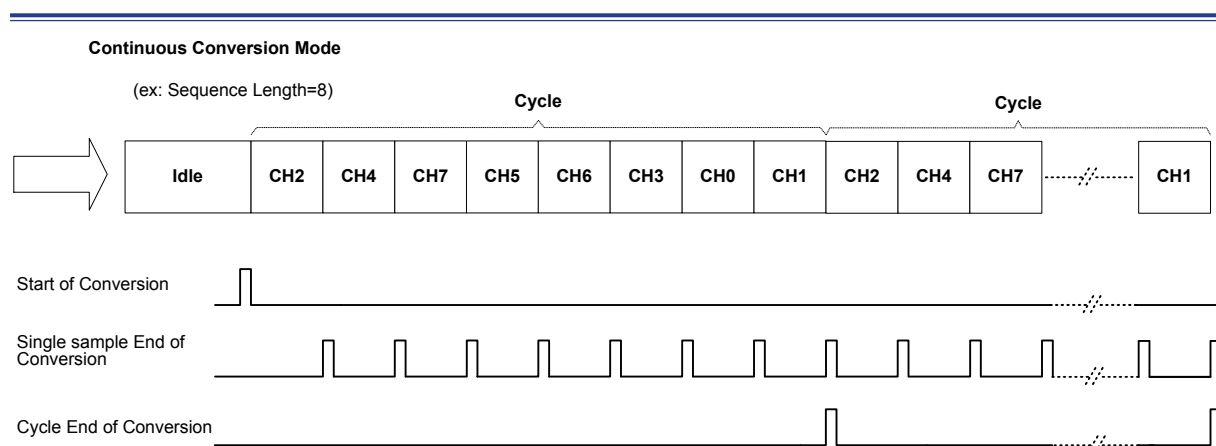
**Figure 28. One Shot Conversion Mode**

### Continuous Conversion Mode

In the Continuous Conversion Mode, repeated conversion cycle will restart automatically without requiring additional A/D start trigger signals after a channel group conversion has completed. When the A/D conversion mode field `ADMODE[1:0]` is set to `0x2`, the A/D converter will operate in the Continuous Conversion Mode which can be started by a software trigger, a comparator output transition event, an external EXTI event or a TM event determined by the Trigger Control Register `ADCTCR` and the Trigger Source Register `ADCTSR`.

#### After conversion:

- The converted data will be stored in the 16-bit `ADCDRy` ( $y = 0 \sim 7$ ) registers.
- The ADC group cycle end of conversion event raw status flag, `ADIRAWC`, in the `ADCIRAW` register will be set when the conversion cycle is finished.
- An interrupt will be generated after a group cycle end of conversion if the `ADIEC` bit in the `ADCIER` register is enabled.



**Figure 29. Continuous Conversion Mode**

### Discontinuous Conversion Mode

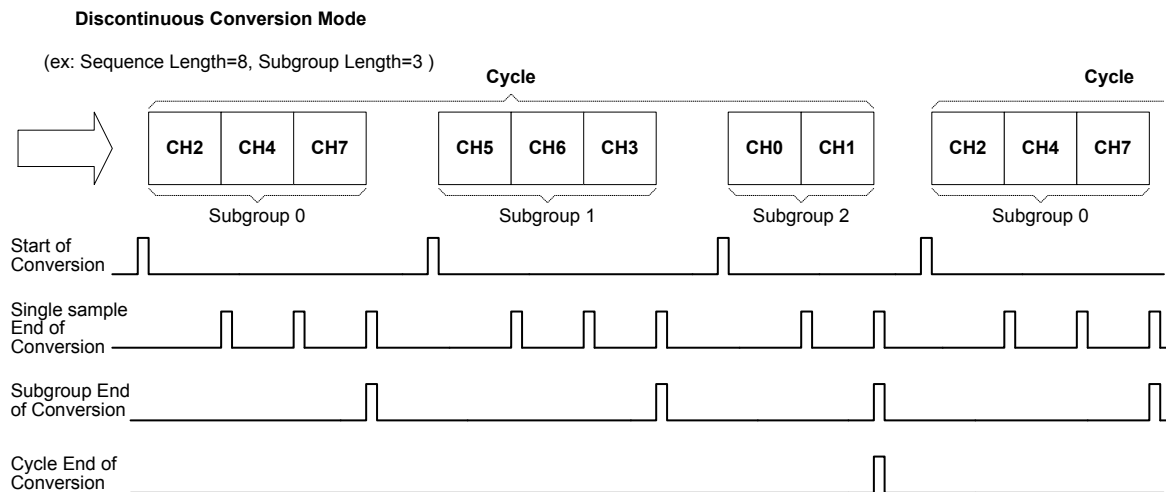
The A/D converter will operate in the Discontinuous Conversion Mode for channels group when the A/D conversion mode bit field ADMODE [1:0] in the ADCCONV register is set to 0x3. The group to be converted can have up to 8 channels and can be arranged in a specific sequence by configuring the ADCLSTn registers where n ranges from 0 to 1. This mode is provided to convert data for the group with a short sequence, named as the A/D conversion subgroup, each time a trigger event occurs. The subgroup length is defined by the ADSUBL [2:0] field in the ADCCONV register to specify the subgroup length. In the Discontinuous Conversion Mode the A/D converter can be started by a software trigger, a comparator output transition event, an external EXTI event or a TM event for the groups determined by the Trigger Control Register ADCTCR and the Trigger Source Register ADCTSR.

In the Discontinuous Conversion Mode, the A/D Converter will start to convert the next n conversions where the number n is the subgroup length defined by the ADSUBL field. When a trigger event occurs, the channels to be converted with a specific sequence are specified in the ADCLSTn registers. After n conversions have completed, the subgroup EOC interrupt raw flag ADIRAWG in the ADCIRAW register will be asserted. The A/D converter will now not continue to perform the next n conversions until the next trigger event occurs. The conversion cycle will end after all the group channels, of which the total number is defined by the ADSEQL[2:0] bits in the ADCCONV register, have finished their conversion, at which point the cycle EOC interrupt raw flag ADIRAWC in the ADCIRAW register will be asserted. If a new trigger event occurs after all the subgroup channels have all been converted, i.e., a complete conversion cycle has been finished, the conversion will restart from the first subgroup.

Example:

A/D subgroup length = 3 (ADSUBL=2) and sequence length = 8 (ADSEQL=7), channels to be converted = 2, 4, 7, 5, 6, 3, 0 and 1 - specific converting sequence as defined in the ADCLSTn registers,

- Trigger 1: subgroup channels to be converted are CH2, CH4 and CH7 with the ADIRAWG flag being asserted after subgroup EOC.
- Trigger 2: subgroup channels to be converted are CH5, CH6 and CH3 with the ADIRAWG flag being asserted after subgroup EOC.
- Trigger 3: subgroup channels to be converted are CH0 and CH1 with the ADIRAWG flag being asserted after subgroup EOC. Also a Cycle end of conversion (EOC) interrupt raw flag ADIRAWC will be asserted.
- Trigger 4: subgroup channels to be converted are CH2, CH4 and CH7 with the ADIRAWG flag being asserted - conversion sequence restarts from the beginning.



**Figure 30. Discontinuous Conversion Mode**

## Start Conversion on External Event

An A/D conversion can be initiated by a software trigger, a comparator output transition event, a General-Purpose Timer Module (GPTM) event, a Motor Control Timer Module (MCTM) event, a Basic Function Timer Module (BFTM) event or an external trigger. Each trigger source can be enabled by setting the corresponding enable control bit in the ADCTCR register and then selected by configuring the associated selection bits in the ADCTSR register to start a group channel conversion.

An A/D converter conversion can be started by setting the software trigger bit, ADSC, in the ADCTSR register for the group channel when the software trigger enable bit, ADSW, in the ADCTCR register is set to 1. After the A/D converter starts converting the analog data, the corresponding enable bit ADSC will be cleared to 0 automatically.

The A/D converter can also be triggered to start a group conversion by a TM event. The TM events include a GPTM or MCTM master trigger output MTO, four GPTM or MCTM channel outputs CH0~CH3 and a BFTM trigger output. If the corresponding Timer trigger enable bit is set to 1 and the trigger output or the TM channel event is selected via the relevant TM event selection bits, the A/D converter will start a conversion when a rising edge of the selected trigger event occurs.

In addition to the internal trigger sources, the A/D converter can be triggered to start a conversion by an external trigger event. The external trigger event is derived from the external lines, EXTI<sub>n</sub>. If the external trigger enable bit ADEXTI is set to 1 and the corresponding EXTI line is selected by configuring the ADEXTIS field in the ADCTSR register, the A/D converter will start a conversion when an EXTI line active edge determined in the EXTI Unit occurs.

## Sampling Time Setting

The conversion channel sampling time can be programmed according to the input resistance of the input voltage source. This sampling time must be enough for the input voltage source to charge the internal sample and hold capacitor in A/D the converter to the input voltage level. Each conversion channel is sampled with the same sampling time. By modifying the ADST[7:0] bits in the ADCSTR register, the sampling time of the analog input signal can be determined.

The total conversion time ( $T_{\text{conv}}$ ) is calculated using the following formula:

$$T_{\text{conv}} = T_{\text{Sampling}} + T_{\text{Latency}}$$

Where the minimum sampling time  $T_{\text{Sampling}} = 1.5$  cycles (when ADST[7:0] = 0) and the minimum channel conversion latency  $T_{\text{Latency}} = 12.5$  cycles.

Example:

With the A/D Converter clock  $CK_{\text{ADC}} = 14$  MHz and a sampling time = 1.5 cycles:

$$T_{\text{conv}} = 1.5 + 12.5 = 14 \text{ cycles} = 1 \mu\text{s}$$

## Data Format

The ADC conversion result can be read in the ADCDRy register and the data format is shown in the following Table 1.

**Table 27. Data format in ADCDR [15:0]**

| Description   | ADCDR register Data Format                      |
|---------------|-------------------------------------------------|
| Right aligned | "0_0_0_0_d11_d10_d9_d8_d7_d6_d5_d4_d3_d2_d1_d0" |

## Analog Watchdog

The A/D converter includes a watchdog function to monitor the converted data. There are two kinds of thresholds for the watchdog monitor function, known as the watchdog upper threshold and watchdog lower threshold, which are specified in the Watchdog Upper and Lower Threshold Registers respectively. The watchdog monitor function is enabled by setting the watchdog upper and lower threshold monitor function enable bits, ADWUE and ADWLE, in the watchdog control register ADCWCR. The channel to be monitored can be specified by configuring the ADWCH and ADWALL bits. When the converted data is less or higher than the lower or upper threshold, as defined in the ADCLTR or ADCUTR registers respectively, the watchdog lower or upper threshold interrupt raw flags, ADIRAWL or ADIRAWU in the ADCIRAW register, will be asserted if the watchdog lower or upper threshold monitor function is enabled. If the lower or upper threshold interrupt raw flag is asserted and the corresponding interrupt is enabled by setting the ADIML or ADIMU bit in the ADCIME register, the A/D watchdog lower or upper threshold interrupt will be generated.

## Interrupts

When an A/D conversion is completed, an End of Conversion EOC event will occur. There are three kinds of EOC events which are known as single sample EOC, subgroup EOC and cycle EOC for A/D conversion. A single sample EOC event will occur and the single sample EOC interrupt raw flag, ADIRAWS bits in the ADCIRAW register, will be asserted when a single channel conversion has completed. A subgroup EOC event will occur and the subgroup EOC interrupt raw flag, ADIRAWG in the ADCIRAW register, will be asserted when a subgroup conversion has completed. A cycle EOC event will occur and the cycle EOC interrupt raw flag, ADIRAWC bits in the ADCIRAW register, will be asserted when a cycle conversion is finished. When a single sample EOC, a subgroup EOC or a cycle EOC raw flag is asserted and the corresponding interrupt enable bit, ADIMC, ADIEG or ADIES bit in the ADCIER register, is set to 1, the associated interrupt will be generated.

After a conversion has completed, the 12-bit digital data will be stored in the associated ADCDRy registers and the value of the data valid flag named as ADVLDy will be changed from low to high. The converted data should be read by the application program, after which the data valid flag ADVLDy will be automatically changed from high to low. Otherwise, a data overwrite event will occur and the data overwrite interrupt raw flag ADIRAWO bit in the ADCIRAW register will be asserted. When the related data overwrite raw flag is asserted, the data overwrite interrupt will be generated if the interrupt enable bit ADIEO in the ADCIER register is set to 1.

If the A/D watchdog monitor function is enabled and the data after a channel conversion is less than the lower threshold or higher than the upper threshold, the watchdog lower or upper threshold interrupt raw flag ADIRAWL or ADIRAWU in the ADCIRAW register will be asserted. When the ADIRAWL or ADIRAWU flag is asserted and the corresponding interrupt enable bit, ADIEL or ADIEU in the ADCIER register, is set a watchdog lower or upper threshold interrupt will be generated.

The A/D Converter interrupt clear bits are used to clear the associated A/D converter interrupt raw and interrupt status bits. Writing a 1 into the specific A/D converter interrupt clear bit in the A/D converter interrupt clear register ADCICLR will clear the corresponding A/D converter interrupt raw and interrupt status bits. These bits are automatically cleared to 0 by hardware after being set to 1.

## PDMA Request

The converted channel value will be stored in the corresponding data register. The A/D Converter can inform the MCU using the A/D Converter EOC interrupt if a new conversion data is already stored in the ADCDRn register. Users also can determine the PDMA request is asserted by setting the ADDMAC, ADDMAG or ADDMAS bits in the ADCDMAR register. A PDMA request will be automatically generated at the relevant end of A/D conversion. The detail description will be introduced in the ADCDMAR register description.

## Register Map

The following table shows the A/D Converter registers and reset values.

**Table 28. A/D Converter Register Map**

| Register | Offset | Description                        | Reset Value |
|----------|--------|------------------------------------|-------------|
| ADCCR    | 0x000  | ADC Conversion Control Register    | 0x0000_0000 |
| ADCLST0  | 0x004  | ADC Conversion List Register 0     | 0x0000_0000 |
| ADCLST1  | 0x008  | ADC Conversion List Register 1     | 0x0000_0000 |
| ADCSTR0  | 0x020  | ADC Input 0 Sampling Time Register | 0x0000_0000 |
| ADCDR0   | 0x030  | ADC Conversion Data Register 0     | 0x0000_0000 |
| ADCDR1   | 0x034  | ADC Conversion Data Register 1     | 0x0000_0000 |
| ADCDR2   | 0x038  | ADC Conversion Data Register 2     | 0x0000_0000 |
| ADCDR3   | 0x03C  | ADC Conversion Data Register 3     | 0x0000_0000 |
| ADCDR4   | 0x040  | ADC Conversion Data Register 4     | 0x0000_0000 |
| ADCDR5   | 0x044  | ADC Conversion Data Register 5     | 0x0000_0000 |
| ADCDR6   | 0x048  | ADC Conversion Data Register 6     | 0x0000_0000 |
| ADCDR7   | 0x04C  | ADC Conversion Data Register 7     | 0x0000_0000 |
| ADCTCR   | 0x070  | ADC Trigger Control Register       | 0x0000_0000 |
| ADCTSR   | 0x074  | ADC Trigger Source Register        | 0x0000_0000 |
| ADCWCR   | 0x078  | ADC Watchdog Control Register      | 0x0000_0000 |
| ADCTR    | 0x07C  | ADC Watchdog Threshold Register    | 0x0000_0000 |
| ADCIER   | 0x080  | ADC Interrupt Enable register      | 0x0000_0000 |
| ADCIRAW  | 0x084  | ADC Interrupt Raw Status Register  | 0x0000_0000 |
| ADCISR   | 0x088  | ADC Interrupt Status Register      | 0x0000_0000 |
| ADCICLR  | 0x08C  | ADC Interrupt Clear Register       | 0x0000_0000 |
| ADCDMAR  | 0x090  | ADC DMA Request Register           | 0x0000_0000 |

## Register Descriptions

### ADC Conversion Control Register – ADCCR

This register specifies the mode setting, sequence length, and subgroup length of the ADC conversion mode. Note that once the content of ADCCR is changed, the conversion in progress will be aborted and the A/D converter will return to an idle state. The application program has to wait for at least one CK\_ADC clock before issuing the next command.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |        |          |    |    |        |        |    |
|------------|----------|--------|----------|----|----|--------|--------|----|
|            | 31       | 30     | 29       | 28 | 27 | 26     | 25     | 24 |
| Type/Reset | Reserved |        |          |    |    |        |        |    |
|            | 23       | 22     | 21       | 20 | 19 | 18     | 17     | 16 |
| Type/Reset | Reserved |        |          |    |    | ADSUBL |        |    |
|            | 15       | 14     | 13       | 12 | 11 | 10     | 9      | 8  |
| Type/Reset | Reserved |        |          |    |    | RW     | 0      | RW |
|            | 7        | 6      | 5        | 4  | 3  | 2      | 1      | 0  |
| Type/Reset | ADCEN    | ADCRST | Reserved |    |    |        | ADMODE |    |
|            | RW       | 0      | RW       | 0  |    |        | RW     | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                        |
|---------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18:16] | ADSUBL | ADC Conversion Subgroup Length<br>The ADSUBL field specifies the conversion channel length of each subgroup in the Discontinuous Conversion Mode. Subgroup length = ADSUBL [2:0] + 1. If the sequence length (ADSEQL [2:0] + 1) is not a multiple of the subgroup length (ADSUBL [2:0] + 1), the last subgroup will be the rest of the group channels that have not been converted. |
| [10:8]  | ADSEQL | ADC Conversion Length<br>0x00: The channel specified by the ADSEQ0 field in the ADCLST0 register will be converted.<br>Others: Sequence length = ADSEQL [2:0] + 1.<br>The ADSEQL field specifies the whole conversion sequence length for the conversion group.                                                                                                                     |
| [7]     | ADCEN  | ADC Enable<br>0: ADC disable<br>1: ADC enable<br>When this bit is cleared to 0, the A/D converter will be disabled and the CK_ADC clock will also be switched off.                                                                                                                                                                                                                  |
| [6]     | ADCRST | ADC Reset<br>0: No effect<br>1: Reset A/D converter except for the A/D Converter controller.                                                                                                                                                                                                                                                                                        |

| Bits  | Field  | Descriptions        |                    |                                                                                                                                                                                                          |
|-------|--------|---------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1:0] | ADMODE | ADC Conversion Mode |                    |                                                                                                                                                                                                          |
|       |        | ADMODE [1:0]        | Mode               | Descriptions                                                                                                                                                                                             |
|       |        | 00                  | One shot mode      | After a start trigger, the conversion will be executed on the specific channels for the whole conversion sequence once.                                                                                  |
|       |        | 01                  | Reserved           |                                                                                                                                                                                                          |
|       |        | 10                  | Continuous mode    | After a start trigger, the conversion will be executed on the specific channels for the whole sequence continuously until conversion mode is changed.                                                    |
|       |        | 11                  | Discontinuous mode | After a start trigger, the conversion will be executed on the current subgroup. When the last subgroup is finished, the conversion will restart from the first subgroup if another start trigger occurs. |

## ADC Conversion List Register 0 – ADCLST0

This register specifies the conversion sequence order No.0 ~ No.3 of the ADC.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |        |    |    |    |    |   |    |   |    |   |
|------------|----------|----|----|--------|----|----|----|----|---|----|---|----|---|
|            | 31       | 30 | 29 | 28     | 27 | 26 | 25 | 24 |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ3 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |
|            | 23       | 22 | 21 | 20     | 19 | 18 | 17 | 16 |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ2 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |
|            | 15       | 14 | 13 | 12     | 11 | 10 | 9  | 8  |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ1 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |
|            | 7        | 6  | 5  | 4      | 3  | 2  | 1  | 0  |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ0 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [28:24] | ADSEQ3 | ADC Conversion Sequence Select 3<br>Select the ADC input channel for the 3 <sup>rd</sup> ADC conversion sequence.<br>0x0: ADC_IN0<br>0x1: ADC_IN1<br>0x2: ADC_IN2<br>0x3: ADC_IN3<br>0x4: ADC_IN4<br>0x5: ADC_IN5<br>0x6: ADC_IN6<br>0x7: ADC_IN7<br>0x8: ADC_IN8<br>0x9: ADC_IN9<br>0xA: ADC_IN10<br>0xB: ADC_IN11<br>0xC ~ 0xF: Reserved<br>0x10: Analog ground, AVSS ( $V_{REF-}$ )<br>0x11: Analog power, AVDD ( $V_{REF+}$ )<br>0x12 ~ 0x1F: Invalid setting. These values must not be selected as it may cause the ADC abnormal operations. |
| [20:16] | ADSEQ2 | ADC Conversion Sequence Select 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [12:8]  | ADSEQ1 | ADC Conversion Sequence Select 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [4:0]   | ADSEQ0 | ADC Conversion Sequence Select 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

## ADC Conversion List Register 1 – ADCLST1

This register specifies the conversion sequence order No.4 ~ No.7 of the ADC.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |        |    |    |    |    |   |    |   |    |   |
|------------|----------|----|----|--------|----|----|----|----|---|----|---|----|---|
|            | 31       | 30 | 29 | 28     | 27 | 26 | 25 | 24 |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ7 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |
|            | 23       | 22 | 21 | 20     | 19 | 18 | 17 | 16 |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ6 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |
|            | 15       | 14 | 13 | 12     | 11 | 10 | 9  | 8  |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ5 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |
|            | 7        | 6  | 5  | 4      | 3  | 2  | 1  | 0  |   |    |   |    |   |
|            | Reserved |    |    | ADSEQ4 |    |    |    |    |   |    |   |    |   |
| Type/Reset |          |    |    | RW     | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [28:24] | ADSEQ7 | ADC Conversion Sequence Select 7<br>Select the ADC input channel for the 7 <sup>th</sup> ADC conversion sequence.<br>0x0: ADC_IN0<br>0x1: ADC_IN1<br>0x2: ADC_IN2<br>0x3: ADC_IN3<br>0x4: ADC_IN4<br>0x5: ADC_IN5<br>0x6: ADC_IN6<br>0x7: ADC_IN7<br>0x8: ADC_IN8<br>0x9: ADC_IN9<br>0xA: ADC_IN10<br>0xB: ADC_IN11<br>0xC ~ 0xF: Reserved<br>0x10: Analog ground, AVSS ( $V_{REF-}$ )<br>0x11: Analog power, AVDD ( $V_{REF+}$ )<br>0x12 ~ 0x1F: Invalid setting. These values must not be selected as it may cause the ADC abnormal operations. |
| [20:16] | ADSEQ6 | ADC Conversion Sequence Select 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [12:8]  | ADSEQ5 | ADC Conversion Sequence Select 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [4:0]   | ADSEQ4 | ADC Conversion Sequence Select 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

This register specifies the A/D converter input channel sampling time.

Reset value: 0x0000\_0000

## Analog to Digital Converter (ADC)

January 27, 2016

## ADC Conversion Data Register y – ADCDRy, y = 0 ~ 7

This register is used to store the conversion data of the conversion sequence order No.y which is specified by the ADSEQy field in the ADCLSTn (n= 0 ~ 1) registers.

Offset: 0x030 ~ 0x04C

Reset value: 0x0000\_0000

|            |          |    |          |    |    |    |    |    |
|------------|----------|----|----------|----|----|----|----|----|
|            | 31       | 30 | 29       | 28 | 27 | 26 | 25 | 24 |
|            | ADVLDy   |    | Reserved |    |    |    |    |    |
| Type/Reset | RC       | 0  |          |    |    |    |    |    |
|            | 23       | 22 | 21       | 20 | 19 | 18 | 17 | 16 |
|            | Reserved |    |          |    |    |    |    |    |
| Type/Reset |          |    |          |    |    |    |    |    |
|            | 15       | 14 | 13       | 12 | 11 | 10 | 9  | 8  |
|            | ADDy     |    |          |    |    |    |    |    |
| Type/Reset | RO       | 0  | RO       | 0  | RO | 0  | RO | 0  |
|            | 7        | 6  | 5        | 4  | 3  | 2  | 1  | 0  |
|            | ADDy     |    |          |    |    |    |    |    |
| Type/Reset | RO       | 0  | RO       | 0  | RO | 0  | RO | 0  |

| Bits   | Field  | Descriptions                                                                                                                               |
|--------|--------|--------------------------------------------------------------------------------------------------------------------------------------------|
| [31]   | ADVLDy | ADC Conversion Data of Sequence Order No.y Valid Bit (y = 0 ~ 7)<br>0: Data are invalid or have been read<br>1: New data is valid          |
| [15:0] | ADDy   | ADC Conversion Data of Sequence Order No.y (y = 0 ~ 7)<br>The conversion result of Sequence Order ADSEQy in the ADCLSTn (n=0 ~1) registers |

## ADC Trigger Control Register – ADCTCR

This register contains the ADC start conversion trigger enable bits.

Offset: 0x070

Reset value: 0x0000\_0000

|            |          |    |    |     |      |      |        |      |
|------------|----------|----|----|-----|------|------|--------|------|
|            | 31       | 30 | 29 | 28  | 27   | 26   | 25     | 24   |
| Type/Reset | Reserved |    |    |     |      |      |        |      |
|            | 23       | 22 | 21 | 20  | 19   | 18   | 17     | 16   |
| Type/Reset | Reserved |    |    |     |      |      |        |      |
|            | 15       | 14 | 13 | 12  | 11   | 10   | 9      | 8    |
| Type/Reset | Reserved |    |    |     |      |      |        |      |
|            | 7        | 6  | 5  | 4   | 3    | 2    | 1      | 0    |
| Type/Reset | Reserved |    |    | CMP | BFTM | GPTM | ADEXTI | ADSW |
|            |          |    |    | RW  | 0    | RW   | 0      | RW   |
|            |          |    |    |     |      | RW   | 0      | RW   |
|            |          |    |    |     |      |      |        | 0    |

| Bits | Field  | Descriptions                                                                                                                                                            |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4]  | CMP    | ADC Conversion CMP Event Trigger enable control<br>0: Disable conversion trigger by CMP output transition<br>1: Enable conversion trigger by CMP output transition      |
| [3]  | BFTM   | ADC Conversion BFTM Event Trigger enable control<br>0: Disable conversion trigger by BFTM events<br>1: Enable conversion trigger by BFTM events                         |
| [2]  | TM     | ADC Conversion GPTM or MCTM Event Trigger enable control<br>0: Disable conversion trigger by GPTM or MCTM events<br>1: Enable conversion trigger by GPTM or MCTM events |
| [1]  | ADEXTI | ADC Conversion EXTI Event Trigger enable control<br>0: Disable conversion trigger by EXTI lines<br>1: Enable conversion trigger by EXTI lines                           |
| [0]  | ADSW   | ADC Conversion Software Trigger enable control<br>0: Disable conversion trigger by software trigger bit<br>1: Enable conversion trigger by software trigger bit         |

## ADC Trigger Source Register – ADCTSR

This register contains the trigger source selection and the software trigger bit of the conversion.

Offset: 0x074

Reset value: 0x0000\_0000

|            |          |    |    |      |       |         |    |      |
|------------|----------|----|----|------|-------|---------|----|------|
|            | 31       | 30 | 29 | 28   | 27    | 26      | 25 | 24   |
|            | Reserved |    |    |      |       | TME     |    |      |
| Type/Reset |          |    |    |      |       | RW      | 0  | RW   |
|            | 23       | 22 | 21 | 20   | 19    | 18      | 17 | 16   |
|            | Reserved |    |    | CMPS | BFTMS | TMS     |    |      |
| Type/Reset |          |    |    | RW   | 0     | RW      | 0  | RW   |
|            | 15       | 14 | 13 | 12   | 11    | 10      | 9  | 8    |
|            | Reserved |    |    |      |       | ADEXTIS |    |      |
| Type/Reset |          |    |    |      |       | RW      | 0  | RW   |
|            | 7        | 6  | 5  | 4    | 3     | 2       | 1  | 0    |
|            | Reserved |    |    |      |       |         |    | ADSC |
| Type/Reset |          |    |    |      |       |         |    | RW   |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                                  |
|---------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [26:24] | TME     | GPTM or MCTM Trigger Event Selection of ADC Conversion<br>000: GPTM or MCTM MTO event<br>001: GPTM or MCTM CH00 event<br>010: GPTM or MCTM CH10 event<br>011: GPTM or MCTM CH20 event<br>100: GPTM or MCTM CH30 event<br>Others: Reserved - Should not be used to avoid unpredictable results |
| [20]    | CMPS    | CMP Trigger Selection of ADC Conversion<br>0: CMP0<br>1: CMP1                                                                                                                                                                                                                                 |
| [19]    | BFTMS   | BFTM Trigger Timer Selection of ADC Conversion<br>0: BFTM0<br>1: BFTM1                                                                                                                                                                                                                        |
| [18:16] | TMS     | GPTM or MCTM Trigger Timer Selection of ADC Conversion<br>000: MCTM<br>001: Reserved<br>010: GPTM0<br>011: GPTM1<br>Others: Reserved - Should not be used to avoid unpredictable results                                                                                                      |
| [11:8]  | ADEXTIS | EXTI Trigger Source Selection of ADC Conversion<br>0x00: EXTI line 0<br>0x01: EXTI line 1<br>...<br>0x0F: EXTI line 15<br>Note that the EXTI line active edge to start an A/D conversion is determined in the External Interrupt/Event Control Unit, EXTI.                                    |
| [0]     | ADSC    | ADC Conversion Software Trigger Bit<br>0: No operation<br>1: Start conversion immediately<br>This bit is set by software to start a conversion manually and then cleared by hardware automatically after conversion started.                                                                  |

## ADC Watchdog Control Register – ADCWCR

This register provides the control bits and status of the ADC watchdog function.

Offset: 0x078

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |       |       |
|------------|----------|----|----|----|--------|----|-------|-------|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25    | 24    |
|            | Reserved |    |    |    | ADUCH  |    |       |       |
| Type/Reset |          |    |    |    | RO     | 0  | RO    | 0     |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17    | 16    |
|            | Reserved |    |    |    | ADLCH  |    |       |       |
| Type/Reset |          |    |    |    | RO     | 0  | RO    | 0     |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9     | 8     |
|            | Reserved |    |    |    | ADWCH  |    |       |       |
| Type/Reset |          |    |    |    | RW     | 0  | RW    | 0     |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1     | 0     |
|            | Reserved |    |    |    | ADWALL |    | ADWUE | ADWLE |
| Type/Reset |          |    |    |    | RW     | 0  | RW    | 0     |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [27:24] | ADUCH  | Upper Threshold Channel Status<br>0000: ADC_IN0 converted data is higher then the upper threshold<br>0001: ADC_IN1 converted data is higher then the upper threshold<br>...<br>1011: ADC_IN11 converted data is higher then the upper threshold<br>Others: Reserved<br>If one of these status bits is set to 1 by the watchdog monitor function, the status field value should first be stored in the user-defined memory location in the corresponding ISR. Otherwise, the ADUCH field will be changed if another input channel converted data is higher than the upper threshold. |
| [19:16] | ADLCH  | Lower Threshold Channel Status<br>0000: ADC_IN0 converted data is lower then the lower threshold<br>0001: ADC_IN1 converted data is lower then the lower threshold<br>...<br>1111: ADC_IN11 converted data is lower then the lower threshold<br>Others: Reserved<br>If one of these status bits is set to 1 by the watchdog monitor function, the status field value should first be stored in the user-defined memory location in the corresponding ISR. Otherwise, the ADLCH field will be changed if another input channel converted data is lower than the lower threshold.     |
| [11:8]  | ADWCH  | ADC Watchdog Specific Channel Selection<br>0000: ADC_IN0 is monitored<br>0001: ADC_IN1 is monitored<br>...<br>1011: ADC_IN11 is monitored<br>Others: Reserved                                                                                                                                                                                                                                                                                                                                                                                                                       |
| [2]     | ADWALL | ADC Watchdog Specific or All Channel Setting<br>0: Only the channel which specified by the ASWCH field is monitored<br>1: All channels are monitored                                                                                                                                                                                                                                                                                                                                                                                                                                |

| Bits | Field | Descriptions                                                                                                                         |
|------|-------|--------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | ADWUE | ADC Watchdog Upper Threshold Enable Bit<br>0: Disable upper threshold monitor function<br>1: Enable upper threshold monitor function |
| [0]  | ADWLE | ADC Watchdog Lower Threshold Enable Bit<br>0: Disable lower threshold monitor function<br>1: Enable lower threshold monitor function |

### ADC Watchdog Threshold Register – ADCTR

This register specifies the upper and lower threshold of the ADC watchdog function.

Offset: 0x07C

Reset value: 0x0000\_0000

|            |          |    |    |    |      |    |    |    |
|------------|----------|----|----|----|------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27   | 26 | 25 | 24 |
|            | Reserved |    |    |    | ADUT |    |    |    |
| Type/Reset |          |    |    |    | RW   | 0  | RW | 0  |
|            | 23       | 22 | 21 | 20 | 19   | 18 | 17 | 16 |
|            | ADUT     |    |    |    |      |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW   | 0  | RW | 0  |
|            | 15       | 14 | 13 | 12 | 11   | 10 | 9  | 8  |
|            | Reserved |    |    |    | ADLT |    |    |    |
| Type/Reset |          |    |    |    | RW   | 0  | RW | 0  |
|            | 7        | 6  | 5  | 4  | 3    | 2  | 1  | 0  |
|            | ADLT     |    |    |    |      |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW   | 0  | RW | 0  |

| Bits    | Field | Descriptions                                                                                             |
|---------|-------|----------------------------------------------------------------------------------------------------------|
| [27:16] | ADUT  | ADC Watchdog Upper Threshold Value<br>Specify the upper threshold for the ADC watchdog monitor function. |
| [11:0]  | ADLT  | ADC Watchdog Lower Threshold Value<br>Specify the lower threshold for the ADC watchdog monitor function. |

## ADC Interrupt Enable Register – ADCIER

This register contains the ADC interrupt enable bits.

Offset: 0x080

Reset value: 0x0000\_0000

|            |          |    |    |    |    |       |       |       |      |
|------------|----------|----|----|----|----|-------|-------|-------|------|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25    | 24    |      |
|            | Reserved |    |    |    |    |       |       | ADIEO |      |
| Type/Reset |          |    |    |    |    |       |       | RW    | 0    |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17    | 16    |      |
|            | Reserved |    |    |    |    |       | ADIEU | ADIEL |      |
| Type/Reset |          |    |    |    |    |       | RW    | 0     | RW 0 |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9     | 8     |      |
|            | Reserved |    |    |    |    |       |       |       |      |
| Type/Reset |          |    |    |    |    |       |       |       |      |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1     | 0     |      |
|            | Reserved |    |    |    |    | ADIEC | ADIEG | ADIES |      |
| Type/Reset |          |    |    |    |    | RW    | 0     | RW 0  | RW 0 |

| Bits | Field | Descriptions                                                                                                                                                   |
|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24] | ADIEO | ADC Data Register Overwrite Interrupt enable<br>0: ADC data register overwrite interrupt is disabled<br>1: ADC data register overwrite interrupt is enabled    |
| [17] | ADIEU | ADC Watchdog Upper Threshold Interrupt enable<br>0: ADC watchdog upper threshold interrupt is disabled<br>1: ADC watchdog upper threshold interrupt is enabled |
| [16] | ADIEL | ADC Watchdog Lower Threshold Interrupt enable<br>0: ADC watchdog lower threshold interrupt is disabled<br>1: ADC watchdog lower threshold interrupt is enabled |
| [2]  | ADIEC | ADC Cycle EOC Interrupt enable<br>0: ADC cycle end of conversion interrupt is disabled<br>1: ADC cycle end of conversion interrupt is enabled                  |
| [1]  | ADIEG | ADC Subgroup EOC Interrupt enable<br>0: ADC subgroup end of conversion interrupt is disabled<br>1: ADC subgroup end of conversion interrupt is enabled         |
| [0]  | ADIES | ADC Single EOC Interrupt enable<br>0: ADC single end of conversion interrupt is disabled<br>1: ADC single end of conversion interrupt is enabled               |

## ADC Interrupt Raw Status Register – ADCIRAW

This register contains the ADC interrupt raw status bits.

Offset: 0x084

Reset value: 0x0000\_0000

|            |          |    |    |    |    |         |         |         |
|------------|----------|----|----|----|----|---------|---------|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26      | 25      | 24      |
|            | Reserved |    |    |    |    |         |         | ADIRAWO |
| Type/Reset |          |    |    |    |    |         |         | RO 0    |
|            | 23       | 22 | 21 | 20 | 19 | 18      | 17      | 16      |
|            | Reserved |    |    |    |    |         | ADIRAWU | ADIRAWL |
| Type/Reset |          |    |    |    |    |         | RO 0    | RO 0    |
|            | 15       | 14 | 13 | 12 | 11 | 10      | 9       | 8       |
|            | Reserved |    |    |    |    |         |         |         |
| Type/Reset |          |    |    |    |    |         |         |         |
|            | 7        | 6  | 5  | 4  | 3  | 2       | 1       | 0       |
|            | Reserved |    |    |    |    | ADIRAWC | ADIRAWG | ADIRAWS |
| Type/Reset |          |    |    |    |    | RO 0    | RO 0    | RO 0    |

| Bits | Field   | Descriptions                                                                                                                                               |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24] | ADIRAWO | ADC Data Register Overwrite Interrupt Raw Status<br>0: ADC data register overwrite event does not occur<br>1: ADC data register overwrite event occurs     |
| [17] | ADIRAWU | ADC Watchdog Upper Threshold Interrupt Raw Status<br>0: ADC watchdog upper threshold event does not occur<br>1: ADC watchdog upper threshold event occurs  |
| [16] | ADIRAWL | ADC Watchdog Lower Threshold Interrupt Raw Status<br>0: ADC watchdog lower threshold event does not occurs<br>1: ADC watchdog lower threshold event occurs |
| [2]  | ADIRAWC | ADC Cycle EOC Interrupt Raw Status<br>0: ADC cycle end of conversion event does not occur<br>1: ADC cycle end of conversion event occurs                   |
| [1]  | ADIRAWG | ADC Subgroup EOC Interrupt Raw Status<br>0: ADC subgroup end of conversion event does not occur<br>1: ADC subgroup end of conversion event occurs          |
| [0]  | ADIRAWS | ADC Single EOC Interrupt Raw Status<br>0: ADC single end of conversion event does not occur<br>1: ADC single end of conversion event occurs                |

## ADC Interrupt Status Register – ADCISR

This register contains the ADC interrupt masked status bits. The corresponding interrupt status will be set to 1 if the associated interrupt event occurs and the related enable bit is set to 1.

Offset: 0x088

Reset value: 0x0000\_0000

|            |          |    |    |    |    |        |        |        |
|------------|----------|----|----|----|----|--------|--------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26     | 25     | 24     |
|            | Reserved |    |    |    |    |        |        | ADISRO |
| Type/Reset |          |    |    |    |    |        |        | RO 0   |
|            | 23       | 22 | 21 | 20 | 19 | 18     | 17     | 16     |
|            | Reserved |    |    |    |    |        | ADISRU | ADISRL |
| Type/Reset |          |    |    |    |    |        | RO 0   | RO 0   |
|            | 15       | 14 | 13 | 12 | 11 | 10     | 9      | 8      |
|            | Reserved |    |    |    |    |        |        |        |
| Type/Reset |          |    |    |    |    |        |        |        |
|            | 7        | 6  | 5  | 4  | 3  | 2      | 1      | 0      |
|            | Reserved |    |    |    |    | ADISRC | ADISRG | ADISRS |
| Type/Reset |          |    |    |    |    | RO 0   | RO 0   | RO 0   |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                               |
|------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24] | ADISRO | ADC Data Register Overwrite Interrupt Status<br>0: ADC data register overwrite interrupt does not occur or the data register overwrite interrupt is disabled.<br>1: ADC data register overwrite interrupt occurs as the data register overwrite interrupt is enabled.      |
| [17] | ADISRU | ADC Watchdog Upper Threshold Interrupt Status<br>0: ADC watchdog upper threshold interrupt does not occur or the watchdog upper threshold interrupt is disabled.<br>1: ADC watchdog upper threshold interrupt occurs as the watchdog upper threshold interrupt is enabled. |
| [16] | ADISRL | ADC Watchdog Lower Threshold Interrupt Status<br>0: ADC watchdog lower threshold interrupt does not occur or the watchdog lower threshold interrupt is disabled.<br>1: ADC watchdog lower threshold interrupt occurs as the watchdog lower threshold interrupt is enabled. |
| [2]  | ADISRC | ADC Cycle EOC Interrupt Status<br>0: ADC cycle end of conversion interrupt does not occur or the cycle end of conversion interrupt is disabled.<br>1: ADC cycle end of conversion interrupt occurs as the cycle end of conversion interrupt is enabled.                    |
| [1]  | ADISRG | ADC Subgroup EOC Interrupt Status<br>0: ADC subgroup end of conversion interrupt does not occur or the subgroup end of conversion interrupt is disabled.<br>1: ADC subgroup end of conversion interrupt occurs as the subgroup end of conversion interrupt is enabled.     |
| [0]  | ADISRS | ADC Single EOC Interrupt Status<br>0: ADC single end of conversion interrupt does not occur or the single end of conversion interrupt is disabled.<br>1: ADC single end of conversion interrupt occurs as the single end of conversion interrupt is enabled.               |

## ADC Interrupt Clear Register – ADCICLR

This register provides the clear bits used to clear the interrupt raw and masked status of the ADC. These bits are set to 1 by software to clear the interrupt status and automatically cleared to 0 by hardware after being set to 1.

Offset: 0x08C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |         |         |         |
|------------|----------|----|----|----|----|---------|---------|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26      | 25      | 24      |
|            | Reserved |    |    |    |    |         |         | ADICLRO |
| Type/Reset |          |    |    |    |    |         |         | WO 0    |
|            | 23       | 22 | 21 | 20 | 19 | 18      | 17      | 16      |
|            | Reserved |    |    |    |    |         | ADICLRU | ADICLRL |
| Type/Reset |          |    |    |    |    |         | WO 0    | WO 0    |
|            | 15       | 14 | 13 | 12 | 11 | 10      | 9       | 8       |
|            | Reserved |    |    |    |    |         |         |         |
| Type/Reset |          |    |    |    |    |         |         |         |
|            | 7        | 6  | 5  | 4  | 3  | 2       | 1       | 0       |
|            | Reserved |    |    |    |    | ADICLRC | ADICLRG | ADICLRS |
| Type/Reset |          |    |    |    |    | WO 0    | WO 0    | WO 0    |

| Bits | Field   | Descriptions                                                                                                |
|------|---------|-------------------------------------------------------------------------------------------------------------|
| [24] | ADICLRO | ADC Data Register Overwrite Interrupt Status Clear Bit<br>0: No effect<br>1: Clear ADISRO and ADIRAWO bits  |
| [17] | ADICLRU | ADC Watchdog Upper Threshold Interrupt Status Clear Bit<br>0: No effect<br>1: Clear ADISRU and ADIRAWU bits |
| [16] | ADICLRL | ADC Watchdog Lower Threshold Interrupt Status Clear Bit<br>0: No effect<br>1: Clear ADISRL and ADIRAWL bits |
| [2]  | ADICLRC | ADC Cycle EOC Interrupt Status Clear Bit<br>0: No effect<br>1: Clear ADISRC and ADIRAWC bits                |
| [1]  | ADICLRG | ADC Subgroup EOC Interrupt Status Clear Bit<br>0: No effect<br>1: Clear ADISRG and ADIRAWG bits             |
| [0]  | ADICLRS | ADC Single EOC Interrupt Status Clear Bit<br>0: No effect<br>1: Clear ADISRS and ADIRAWS bits               |

## ADC DMA Request Register – ADCDMAR

This register contains the ADC DMA request enable bits.

Offset: 0x090

Reset value: 0x0000\_0000

|            |          |    |    |    |    |        |        |        |
|------------|----------|----|----|----|----|--------|--------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26     | 25     | 24     |
| Type/Reset | Reserved |    |    |    |    |        |        |        |
|            | 23       | 22 | 21 | 20 | 19 | 18     | 17     | 16     |
| Type/Reset | Reserved |    |    |    |    |        |        |        |
|            | 15       | 14 | 13 | 12 | 11 | 10     | 9      | 8      |
| Type/Reset | Reserved |    |    |    |    |        |        |        |
|            | 7        | 6  | 5  | 4  | 3  | 2      | 1      | 0      |
| Type/Reset | Reserved |    |    |    |    | ADDMAC | ADDMAG | ADDMAS |
|            |          |    |    |    |    | RW     | 0      | RW     |
|            |          |    |    |    |    |        | 0      | RW     |
|            |          |    |    |    |    |        |        | 0      |

| Bits | Field  | Descriptions                                                                                                                                                     |
|------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | ADDMAC | ADC Cycle EOC DMA Request Enable Bit<br>0: ADC cycle end of conversion DMA request is disabled<br>1: ADC cycle end of conversion DMA request is enabled          |
| [1]  | ADDMAG | ADC Subgroup EOC DMA Request Enable Bit<br>0: ADC subgroup end of conversion DMA request is disabled<br>1: ADC subgroup end of conversion DMA request is enabled |
| [0]  | ADDMAS | ADC Single EOC DMA Request Enable Bit<br>0: ADC single end of conversion DMA request is disabled<br>1: ADC single end of conversion DMA request is enabled       |

# 13 Comparator (CMP)

## Introduction

The two general purpose comparators (CMP) are implemented within the device. They can be configured either as standalone comparators or combined with the different kinds of peripheral IP. Each comparator is capable of asserting interrupts to the NVIC or wakeup the CPU Deep Sleep mode through EXTI wakeup event management unit.

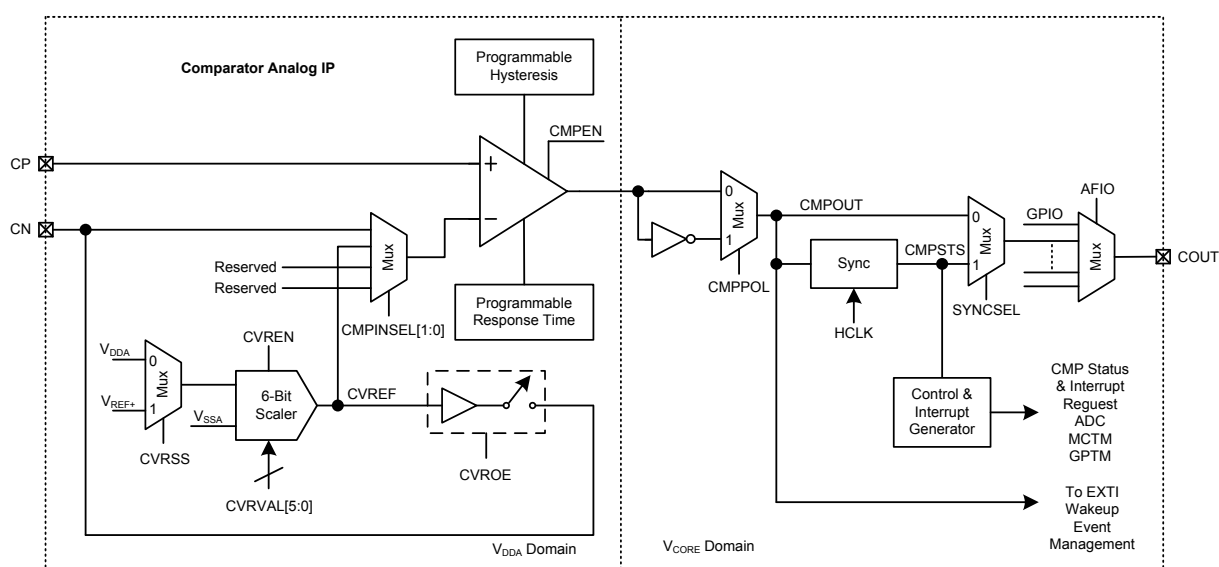


Figure 31. Comparator Block Diagram

## Features

- Rail-to-rail comparator
- Configurable negative inputs used for flexible voltage selection
  - Dedicated I/O pin
  - Internal voltage reference provided by 6-bit scaler
- Programmable hysteresis
- Programming response speed and consumption
- Comparator output used as multiple timers or ADC trigger inputs
- Programmable internal voltage reference provided by 6-bit scaler.
- Comparator output transition with interrupt generation and wake-up functions from Sleep or Deep Sleep modes through the EXTI controller.

## Function Descriptions

### Comparator Inputs and Output

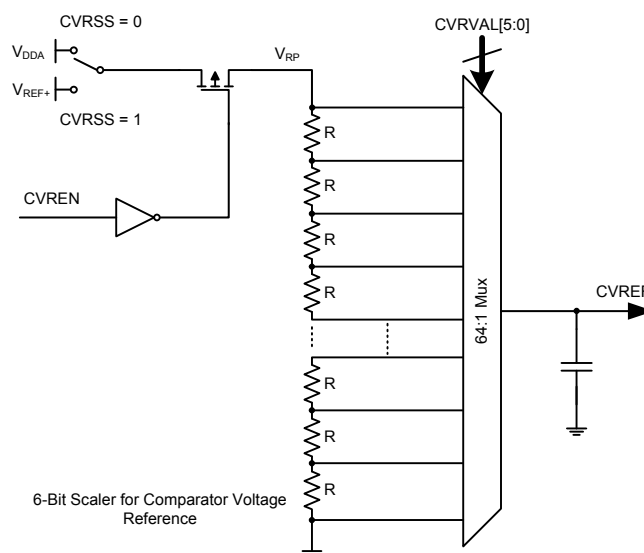
The I/O pins used as comparator inputs or output must be configured in the AFIO controller registers. The detail comparator I/Os information will be referred in the pin assignment table in the datasheet. The output can also be internally connected to a variety of timer or ADC for trigger purpose. The comparator output can be used for both internal and external functions simultaneously.

### Comparator Voltage Reference

The comparator voltage reference is a 64-tap resistor ladder network that provides a selectable reference voltage. It also has a power-down function to conserve the power when the reference is not used. The comparator voltage reference provides 64 distinct levels. The equation used to calculate the comparator voltage reference is as follows:

$$CVREF = CVRVAL \times (V_{RP} - V_{SSA}) / 63,$$

The comparator voltage reference power source,  $V_{RP}$ , can come from either the  $V_{DDA}$  or external  $V_{REF+}$  pin. The voltage source is selected by the CVRSS bit in the Comparator Control Register CMPCR. The primary purpose of the CVREF output is to provide a reference voltage for the analog comparator. It may also be used independently of them and configured output to CN pin by setting the CVROE bit in the Comparator Control Register CVRCR. The settling time of the comparator voltage reference must be considered when changing the CVREF output.

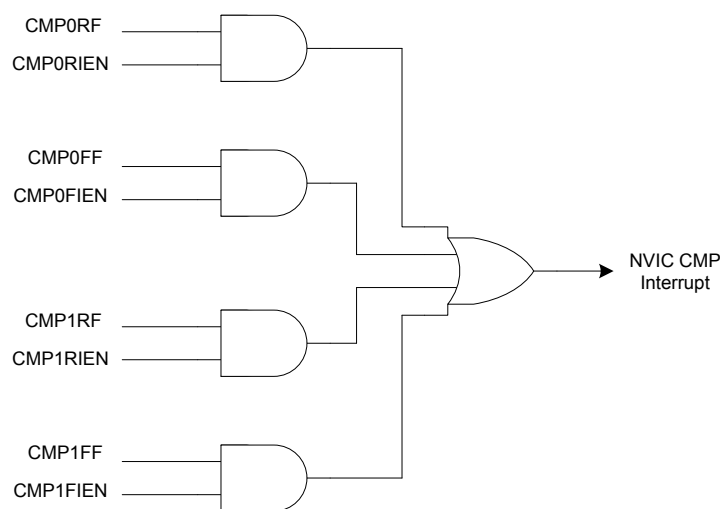


**Figure 32. 6-Bit Scaler for Comparator Voltage Reference Block Diagram**

## Interrupts and Wakeup

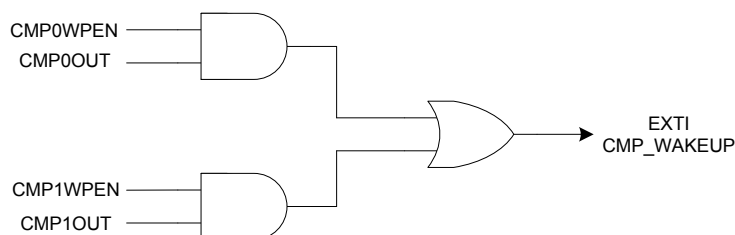
The comparator can generate an interrupt when its output waveform generates a rising or falling edge and its corresponding interrupt enables control bit is also set.

For example, when a comparator output rising edge occurs, the comparator rising edge flag bit CMPRF in the Comparator Transition Flag Register CMPTFR will be set. If the comparator output rising edge interrupt enable control bit CMPRIEN in the Comparator Interrupt Enable Register CMPIER is enabled, an interrupt will then be generated and sent to the NVIC unit. Writing “1” into the comparator rising edge flag bit CMPRF in the Comparator Transition Flag Register CMPTFR will clear the CMPRF bit. The comparator output falling edge interrupt also has the same corresponding interrupt setting. A block diagram of interrupt signal for comparators is shown in Figure 33.



**Figure 33. Interrupt Signals of Comparators**

The comparator outputs are also internally connected to the EXTI Wake-up Event Management unit. The comparator output rising transition is used to wake up the MCU from the Deep Sleep 1 or 2 modes when the comparator wake-up enable bit CMPWPEN is set in the Comparator Control Register CMPPCR. A block diagram of wakeup signal for comparators is shown in Figure 34.



**Figure 34. Wakeup Signals of Comparators**

## Power Mode and Hysteresis

The comparator response time can be programmed to meet the trade-off between the power consumption and application requirement. The bit CMPSM in CMPCR register can be programmed as “1” to get the comparator in the low speed mode with low power consumption.

The comparator also has four hysteresis levels to avoid spurious output transitions in case of noisy signals. The bit CMPHM[1:0] in CMPCR register can be programmed to get the different hysteresis level for the comparator.

## Comparator Write-Protected mechanism

As the comparator can be used for safety purposes, it is necessary to insure that the comparator configurations cannot be altered in case of spurious register access or program counter corruption. For this purpose, the write protection is provided by writing a specific value into the PROTECT filed in the Comparator Control Register CMPCR. The write protection function is enabled in default. Before configuring the bits [15:0] in the Comparator Control Register CMPCR, the register protection bits [31:16] of the CMPCR register has to be written into with the 0x9C3A pattern first. Then the write protection mode is disabled and the CMPCR register becomes programmable. As the same reason, the comparator input and output also can be locked with the corresponding configuration lock bit in the Port n Lock Register PnLOCKR (n = A ~ E) in the GPIO unit.

## Register Map

The following table shows the CMP registers and reset values.

**Table 29. CMP Register Map**

| Register | Offset | Description                                   | Reset Value |
|----------|--------|-----------------------------------------------|-------------|
| CMPCR0   | 0x000  | Comparator Control Register 0                 | 0x0001_0000 |
| CVRVALR0 | 0x004  | Comparator Voltage Reference Value Register 0 | 0x0000_0000 |
| CMPIER0  | 0x008  | Comparator Interrupt Enable Register 0        | 0x0000_0000 |
| CMPTFR0  | 0x00C  | Comparator Transition Flag Register 0         | 0x0000_0000 |
| CMPCR1   | 0x100  | Comparator Control Register 1                 | 0x0001_0000 |
| CVRVALR1 | 0x104  | Comparator Voltage Reference Value Register 1 | 0x0000_0000 |
| CMPIER1  | 0x108  | Comparator Interrupt Enable Register 1        | 0x0000_0000 |
| CMPTFR1  | 0x10C  | Comparator Transition Flag Register 1         | 0x0000_0000 |

## Register Descriptions

### Comparator Control Register n – CMPCRn, n = 0 or 1

This register contains the comparator function and comparator voltage reference control bits.

Offset: 0x000 (n = 0), 0x100 (n = 1)

Reset value: 0x0001\_0000

|            |         |         |          |    |       |       |       |       |      |
|------------|---------|---------|----------|----|-------|-------|-------|-------|------|
|            | 31      | 30      | 29       | 28 | 27    | 26    | 25    | 24    |      |
|            | PROTECT |         |          |    |       |       |       |       |      |
| Type/Reset | RW      | 0       | RW       | 0  | RW    | 0     | RW    | 0     | RW   |
|            | 23      | 22      | 21       | 20 | 19    | 18    | 17    | 16    |      |
|            | PROTECT |         |          |    |       |       |       |       |      |
| Type/Reset | RW      | 0       | RW       | 0  | RW    | 0     | RW    | 0     | RW   |
|            | 15      | 14      | 13       | 12 | 11    | 10    | 9     | 8     |      |
|            | CMPSTS  | CMPWPEN | CMPOSEL  |    |       | CVRSS | CVROE | CVREN |      |
| Type/Reset | R       | 0       | RW/R     | 0  | RW/R  | 0     | RW/R  | 0     | RW/R |
|            | 7       | 6       | 5        | 4  | 3     | 2     | 1     | 0     |      |
|            | SYNCSEL | CMPPOL  | CMPINSEL |    | CMPHM |       | CMPSM | CMPEN |      |
| Type/Reset | RW/R    | 0       | RW/R     | 0  | RW/R  | 0     | RW/R  | 0     | RW/R |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | PROTECT | Register Protection<br>For write operation:<br>0x9C3A: Disable the CMPCR register write protection<br>Others values: Enable the CMPCR register write protection<br>For read operation:<br>0x0000: CMPCR register write protection is disabled<br>0x0001: CMPCR register write protection is enabled<br>These bits are used to enable or disable the write protection of the filed [14:0] of the CMPCR register. Enabling the write protection will make the filed [14:0] of the CMPCR register become read-only to prevent any unexpected write operation. The value read from this field will indicate if the write protection is enabled or not. |
| [15]    | CMPSTS  | Comparator Output Status<br>0: Output is low<br>1: Output is high<br>This read-only bit is a copy of the comparator output status after the polarity selection.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| [14]    | CMPWPEN | Comparator Wake-up Enable<br>0: Disable comparator wake-up function.<br>1: Enable comparator wake-up function.<br>This bit is enabled to wake up the MCU from the Deep-Sleep when the comparator output after the polarity selection changes state from low to high.                                                                                                                                                                                                                                                                                                                                                                               |

| Bits    | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [13:11] | CMPOSEL  | <p>Comparator 0 Output Selection</p> <p>000: No selection<br/>001: GPTM0 capture channel 3<br/>010: MCTM0 capture channel 3<br/>011: MCTM0 break input 1<br/>100: ADC trigger input<br/>Other: Reserved</p> <p>Comparator 1 Output Selection</p> <p>000: No selection<br/>001: GPTM1 capture channel 3<br/>010: MCTM1 capture channel 3<br/>011: MCTM1 break input 1<br/>100: ADC trigger input<br/>Other: Reserved</p> <p>These bits are used to select the destination for the comparator output after the polarity selection.</p> |
| [10]    | CVRSS    | <p>Comparator Voltage Reference Source Selection</p> <p>0: 6-bit scaler reference voltage source comes from <math>V_{DDA}</math><br/>1: 6-bit scaler reference voltage source comes from <math>V_{REF+}</math></p>                                                                                                                                                                                                                                                                                                                   |
| [9]     | CVROE    | <p>Comparator Voltage Reference Output Enable</p> <p>0: Disable 6-bit scaler output to CN pin<br/>1: Enable 6-bit scaler output to CN pin</p>                                                                                                                                                                                                                                                                                                                                                                                        |
| [8]     | CVREN    | <p>Comparator Voltage Reference Enable</p> <p>0: Disable 6-bit scaler for comparator voltage reference<br/>1: Enable 6-bit scaler for comparator voltage reference</p>                                                                                                                                                                                                                                                                                                                                                               |
| [7]     | SYNSEL   | <p>Synchronization Selection</p> <p>0: Asynchronous signal of Comparator output is selected<br/>1: Synchronous signal of comparator output is selected</p> <p>The synchronous comparator output should be selected before being passed to the AFIO unit.</p>                                                                                                                                                                                                                                                                         |
| [6]     | CMPPOL   | <p>Comparator Output Polarity Selection</p> <p>0: Comparator output is not inverted<br/>1: Comparator output is inverted</p>                                                                                                                                                                                                                                                                                                                                                                                                         |
| [5:4]   | CMPINSEL | <p>Comparator Inverted Input Selection</p> <p>00: Comparator external CN pin is selected<br/>01: Comparator internal 6-bit reference voltage scaler output is selected<br/>1x: Reserved</p> <p>These bits are used to select the comparator inverted input source.</p>                                                                                                                                                                                                                                                               |
| [3:2]   | CMPHM    | <p>Comparator Hysteresis Mode Selection</p> <p>00: No hysteresis<br/>01: Low hysteresis mode<br/>10: Middle hysteresis mode<br/>11: High hysteresis mode</p>                                                                                                                                                                                                                                                                                                                                                                         |
| [1]     | CMPSPM   | <p>Comparator Speed Mode Selection</p> <p>0: High speed mode<br/>1: Low speed mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| [0]     | CMPEN    | <p>Comparator Enable</p> <p>0: Disable Comparator (entering the power down mode)<br/>1: Enable Comparator</p>                                                                                                                                                                                                                                                                                                                                                                                                                        |

## Comparator Voltage Reference Value Register n – CVRVALRn, n = 0 or 1

The register is used to set the comparator voltage reference level.

Offset: 0x004 (n = 0), 0x104 (n = 1)

Reset value: 0x0000\_0000

|            |          |    |        |    |    |    |    |    |
|------------|----------|----|--------|----|----|----|----|----|
|            | 31       | 30 | 29     | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |        |    |    |    |    |    |
|            | 23       | 22 | 21     | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |        |    |    |    |    |    |
|            | 15       | 14 | 13     | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |        |    |    |    |    |    |
|            | 7        | 6  | 5      | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved |    | CVRVAL |    |    |    |    |    |
|            |          |    | RW     | 0  | RW | 0  | RW | 0  |
|            |          |    |        |    | RW | 0  | RW | 0  |
|            |          |    |        |    |    | RW | 0  | RW |
|            |          |    |        |    |    |    | RW | 0  |

| Bits  | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5:0] | CVRVAL | <p>Comparator Voltage Reference Value</p> <p>There are 64 levels of the comparator voltage reference which is set using the CVRVAL bits. The relationship between the CVRVAL register value and the comparator voltage reference CVREF is given by the following equation:</p> $CVREF = CVRVAL \times (V_{RP} - V_{SSA}) / 63$ <p>where the <math>V_{RP}</math> can come from the <math>V_{DDA}</math> or <math>V_{REF+}</math>.</p> |

## Comparator Interrupt Enable Register n – CMPIERn, n = 0 or 1

The register is used to enable the comparator n interrupt when the comparator output transition event occurs.

Offset: 0x008 (n = 0), 0x108 (n = 1)

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |         |         |
|------------|----------|----|----|----|----|----|---------|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25      | 24      |
| Type/Reset | Reserved |    |    |    |    |    |         |         |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17      | 16      |
| Type/Reset | Reserved |    |    |    |    |    |         |         |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9       | 8       |
| Type/Reset | Reserved |    |    |    |    |    |         |         |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1       | 0       |
| Type/Reset | Reserved |    |    |    |    |    | CMPRIEN | CMPFIEN |
|            |          |    |    |    |    |    | RW      | 0 RW 0  |

| Bits | Field   | Descriptions                                                                                                                                                           |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | CMPRIEN | Comparator Output Rising Edge Interrupt Enable<br>0: Comparator output rising edge interrupt is disabled.<br>1: Comparator output rising edge interrupt is enabled.    |
| [0]  | CMPFIEN | Comparator Output Falling Edge Interrupt Enable<br>0: Comparator output falling edge interrupt is disabled.<br>1: Comparator output falling edge interrupt is enabled. |

## Comparator Transition Flag Register n – CMPTFRn, n = 0 or 1

This register contains the comparator n transition detection enable bits and flags.

Offset: 0x00C (n = 0), 0x10C (n = 1)

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |         |         |
|------------|----------|----|----|----|----|----|---------|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25      | 24      |
| Type/Reset | Reserved |    |    |    |    |    |         |         |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17      | 16      |
| Type/Reset | Reserved |    |    |    |    |    |         |         |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9       | 8       |
| Type/Reset | Reserved |    |    |    |    |    | CMPRDEN | CMPFDEN |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1       | 0       |
| Type/Reset | Reserved |    |    |    |    |    | CMPRF   | CMPFF   |
|            |          |    |    |    |    |    | R/W     | 0       |
|            |          |    |    |    |    |    | 0       | R/W     |
|            |          |    |    |    |    |    | 0       | 0       |
|            |          |    |    |    |    |    | WC      | 0       |
|            |          |    |    |    |    |    | 0       | WC      |
|            |          |    |    |    |    |    | 0       | 0       |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                              |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9]  | CMPRDEN | Comparator Output Rising Edge Detection Enable<br>0: Disable comparator output rising edge detection<br>1: Enable comparator output rising edge detection<br>Note: The detected comparator transition signal is a copy of the comparator output state after the polarity selection and synchronized by the HCLK clock.    |
| [8]  | CMPFDEN | Comparator Output Falling Edge Detection Enable<br>0: Disable comparator output falling edge detection<br>1: Enable comparator output falling edge detection<br>Note: The detected comparator transition signal is a copy of the comparator output state after the polarity selection and synchronized by the HCLK clock. |
| [1]  | CMPRF   | Comparator Output Rising Edge Flag<br>0: No comparator output rising edge occurs<br>1: Comparator output rising edge occurs<br>This flag is available when the comparator output rising edge detection is enabled.<br>This bit is set to 1 by hardware and cleared by software written a “1” into it.                     |
| [0]  | CMPFF   | Comparator Output Falling Edge Flag<br>0: No Comparator output falling edge occurs<br>1: Comparator output falling edge occurs<br>This flag is available when the comparator output falling edge detection is enabled.<br>This bit is set to 1 by hardware and cleared by software written a “1” into it.                 |

# 14 General-Purpose Timer (GPTM)

## Introduction

The General-Purpose Timer consists of one 16-bit up/down-counter, four 16-bit Capture/Compare Registers (CCRs), one 16-bit Counter-Reload Register (CRR) and several control/status registers. It can be used for a variety of purposes including general timer, input signal pulse width measurement or output waveform generation such as single pulse generation or PWM output. The GPTM supports an encoder interface using a quadrature decoder with two inputs.

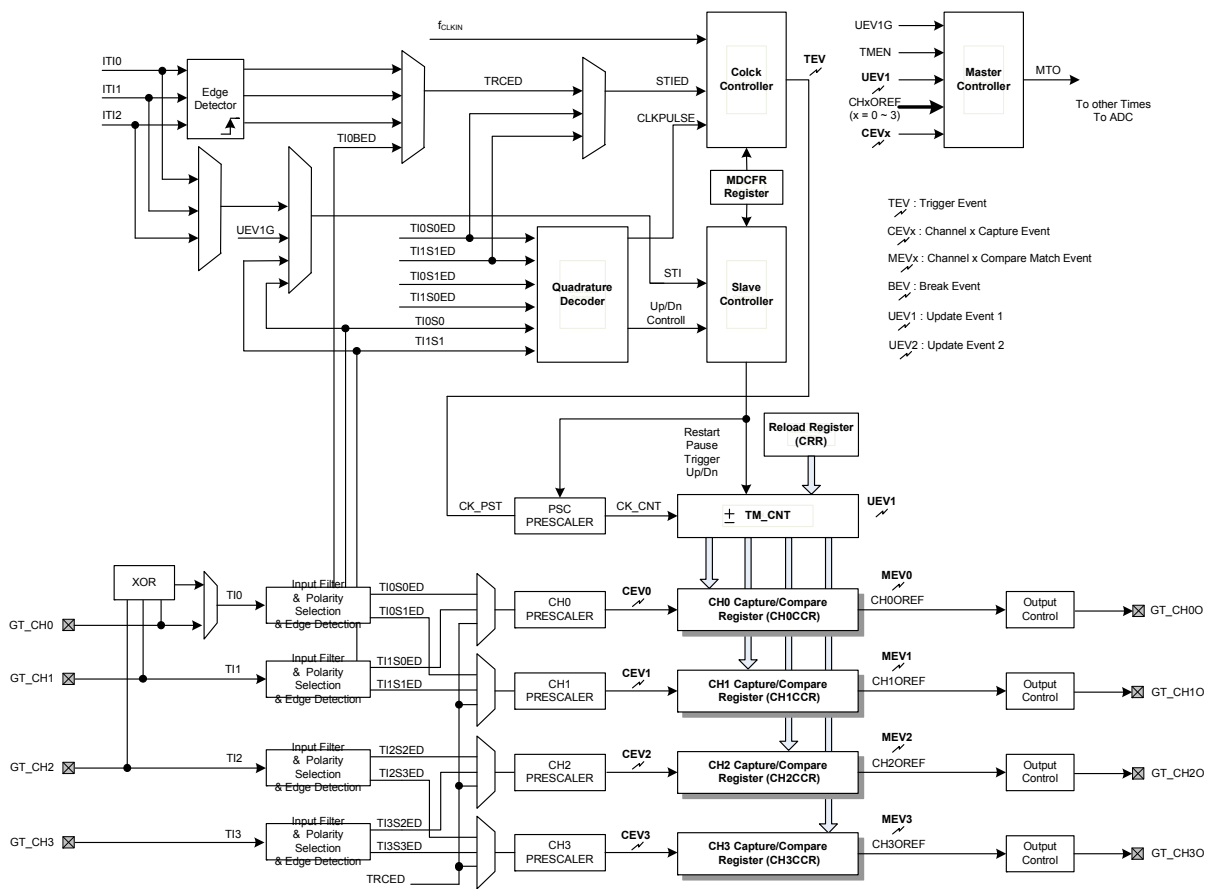


Figure 35. GPTM Block Diagram

## Features

- 16-bit up/down auto-reload counter
- 16-bit programmable prescaler that allows division of the counter clock frequency by any factor between 1 and 65536
- Up to 4 independent channels for:
  - Input Capture function
  - Compare Match Output
  - Generation of PWM waveform – Edge and Center-aligned Mode
  - Single Pulse Mode Output
- Encoder interface controller with two inputs using quadrature decoder
- Synchronization circuit to control the timer with external signals and to interconnect several timers together
- Interrupt/PDMA generation with the following events:
  - Update event
  - Trigger event
  - Input capture event
  - Output compare match event
- GPTM Master/Slave mode controller

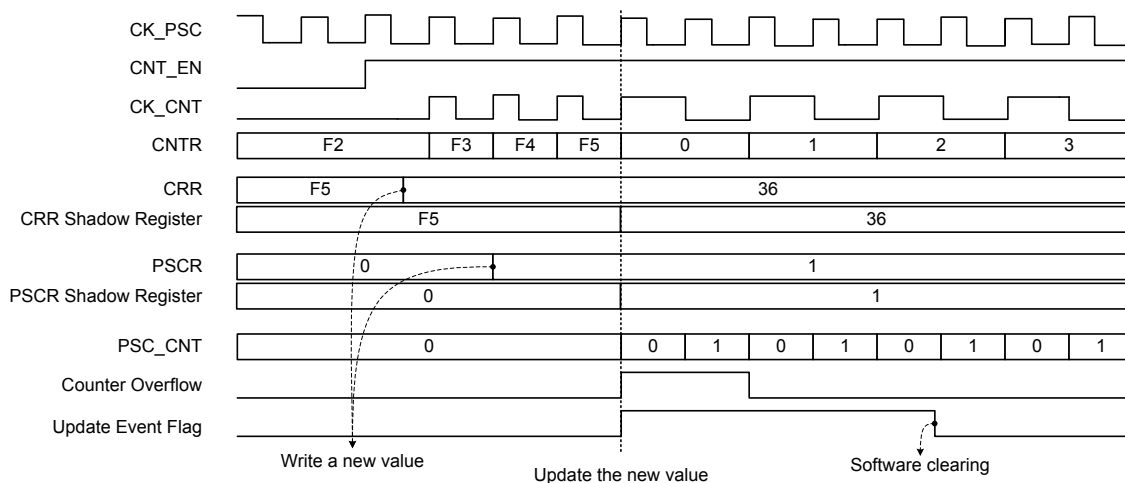
## Functional Descriptions

### Counter Mode

#### Up-Counting

In this mode the counter counts continuously from 0 to the counter-reload value, which is defined in the CRR register, in a count-up direction. Once the counter reaches the counter-reload value, the Timer Module generates an overflow event and the counter restarts to count once again from 0. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 0 for the up-counting mode.

When the update event is generated by setting the UEVG bit in the EVGR register to 1, the counter value will also be initialized to 0.

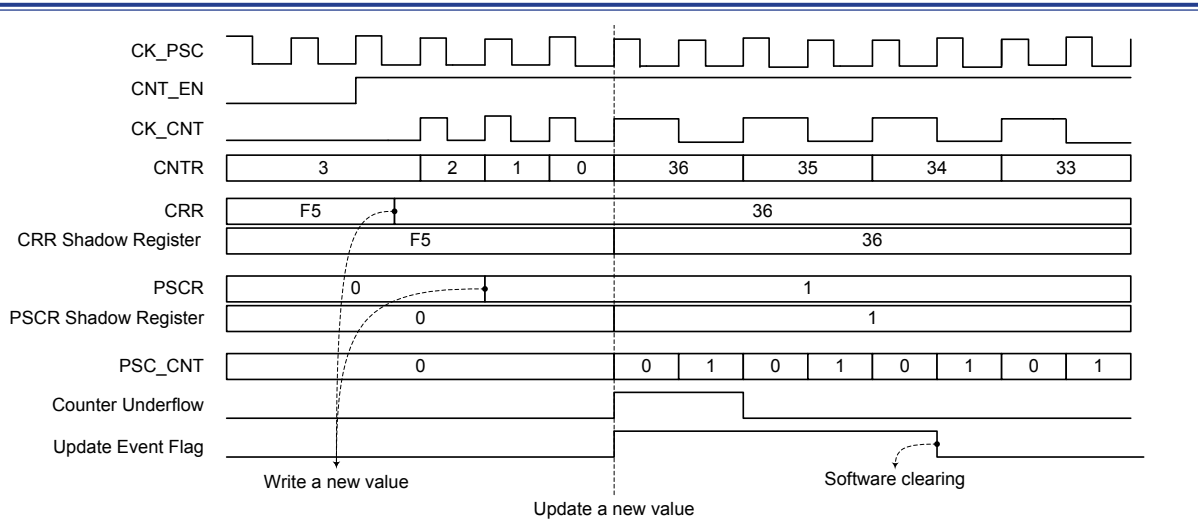


**Figure 36. Up-counting Example**

### Down-Counting

In this mode the counter counts continuously from the counter-reload value, which is defined in the CRR register, to 0 in a count-down direction. Once the counter reaches 0, the Timer module generates an underflow event and the counter restarts to count once again from the counter-reload value. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 1 for the down-counting mode.

When the update event is set by the UEVG bit in the EVGR register, the counter value will also be initialized to the counter-reload value.



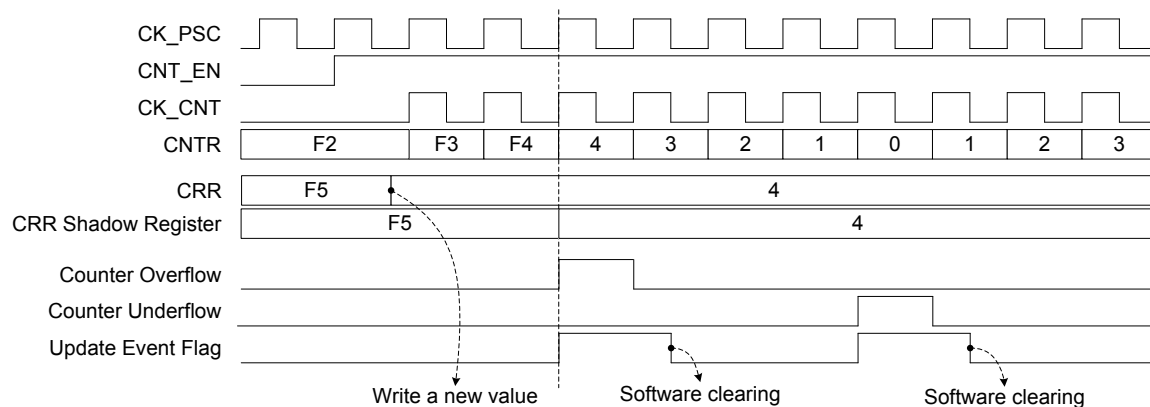
**Figure 37. Down-counting Example**

### Center-Align Counting

In the center-aligned counting mode, the counter counts up from 0 to the counter-reload value and then counts down to 0 alternatively. The Timer module generates an overflow event when the counter counts to the counter-reload value in the up-counting mode and generates an underflow event when the counter counts to 0 in the down-counting mode. The counting direction bit DIR in the CNTCFR register is read-only and indicates the counting direction when in the center-align mode. The counting direction is updated by hardware automatically.

Setting the UEVG bit in the EVGR register will initialize the counter value to 0 irrespective of whether the counter is counting up or down in the center-align counting mode.

The UEVIF bit in the INTSR register can be set to 1 when an overflow or underflow event or both of them occur according to the CMSEL field setting in the CNTCFR register.



**Figure 38. Center-aligned Counting Example**

## Clock Controller

The following describes the Timer Module clock controller which determines the clock source of the internal prescaler counter.

### ■ Internal APB clock $f_{CLKIN}$ :

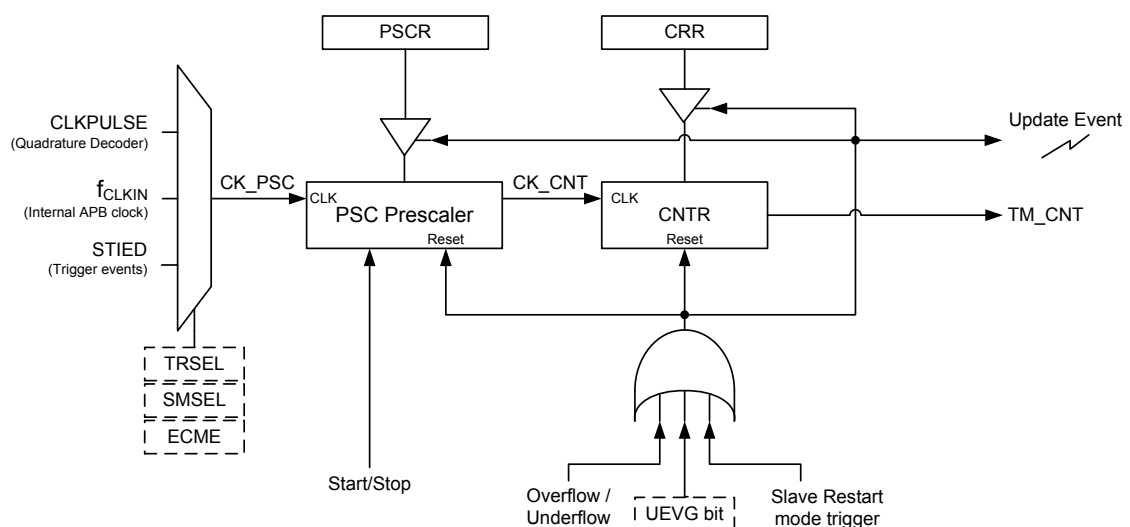
The default internal clock source is the APB clock  $f_{CLKIN}$  used to drive the counter prescaler when the slave mode is disabled. If the slave mode controller is enabled by setting SMSEL field in the MDCFR register to an available value including 0x1, 0x2, 0x3 and 0x7, the prescaler is clocked by other clock sources selected by the TRSEL field in the TRCFR register and described as follows. When the slave mode selection bits SMSEL are set to 0x4, 0x5 or 0x6, the internal APB clock  $f_{CLKIN}$  is the counter prescaler driving clock source.

### ■ Quadrature Decoder:

To select Quadrature Decoder mode the SMSEL field should be set to 0x1, 0x2 or 0x3 in the MDCFR register. The Quadrature Decoder function uses two input states of the GTn\_CH0 and GTn\_CH1 pins to generate the clock pulse to drive the counter prescaler. The counting direction bit DIR is modified by hardware automatically at each transition on the input source signal. The input source signal can be derived from the GTn\_CH0 pin only, the GTn\_CH1 pin only or both GTn\_CH0 and GTn\_CH1 pins.

### ■ STIED:

The counter prescaler can count during each rising edge of the STI signal. This mode can be selected by setting the SMSEL field to 0x7 in the MDCFR register. Here the counter will act as an event counter. The input event, known as STI here, can be selected by setting the TRSEL field to an available value except the value of 0x0. When the STI signal is selected as the clock source, the internal edge detection circuitry will generate a clock pulse during each STI signal rising edge to drive the counter prescaler. It is important to note that if the TRSEL field is set to 0x0 to select the software UEVG bit as the trigger source, then when the SMSEL field is set to 0x7, the counter will be updated instead of counting.



**Figure 39. GPTM Clock Selection Source**

## Trigger Controller

The trigger controller is used to select the trigger source and setup the trigger level or edge trigger condition. For the internal trigger input, it can be selected by the Trigger Selection bits TRSEL in the TRCFR register. For all the trigger sources except the UEVG bit software trigger, the internal edge detection circuitry will generate a clock pulse at each trigger signal rising edge to stimulate some GPTM functions which are triggered by a trigger signal rising edge.

Trigger Controller Block = Edge Trigger Mux + Level Trigger Mux

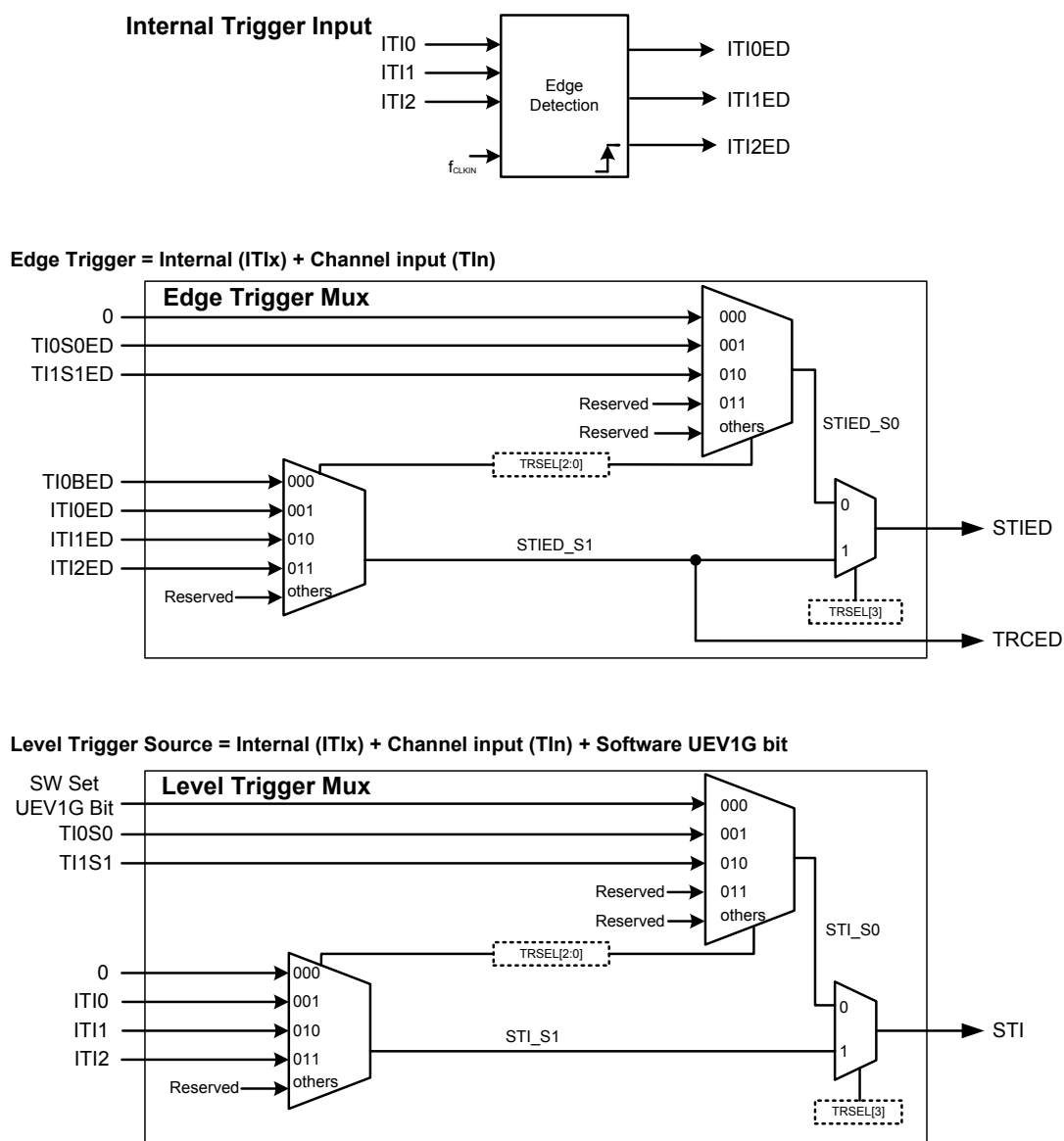


Figure 40. Trigger Control Block

## Slave Controller

The GPTM can be synchronized with an external trigger in several modes including the Restart mode, the Pause mode and the Trigger mode which is selected by the SMSEL field in the MDCFR register. The trigger input of these modes comes from the STI signal which is selected by the TRSEL field in the TRCFR register. The operation modes in the Slave Controller are described in the accompanying sections.

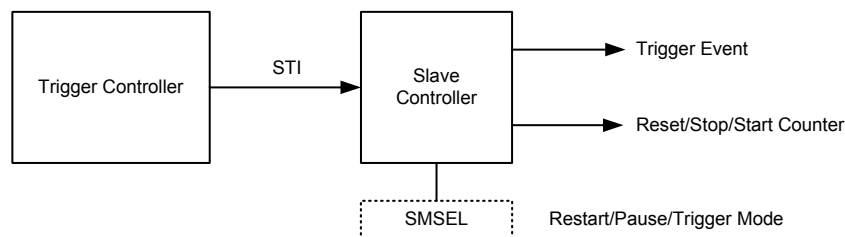


Figure 41. Slave Controller Diagram

## Restart Mode

The counter and its prescaler can be reinitialized in response to a rising edge of the STI signal. When a STI rising edge occurs, the update event software generation bit named UEVG will automatically be asserted by hardware and the trigger event flag will also be set. Then the counter and prescaler will be reinitialized. Although the UEVG bit is set to 1 by hardware, the update event does not really occur. It depends upon whether the update event disable control bit UEVDIS is set to 1 or not. If the UEVDIS is set to 1 to disable the update event to occur, there will no update event be generated, however the counter and prescaler are still reinitialized when the STI rising edge occurs. If the UEVDIS bit in the CNTCFR register is cleared to enable the update event to occur, an update event will be generated together with the STI rising edge, then all the preloaded registers will be updated.

### Timer Counter Reload Register CRR = 32

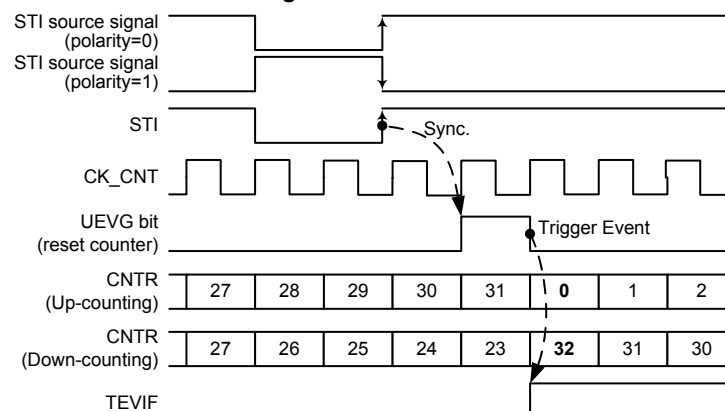
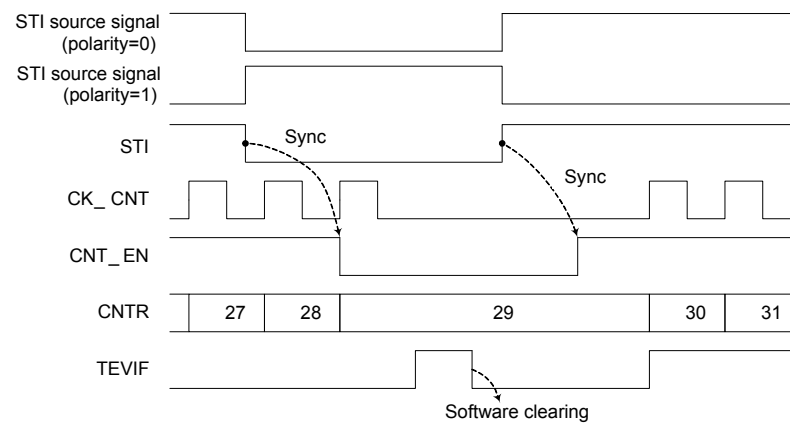


Figure 42. GPTM in Restart Mode

### Pause Mode

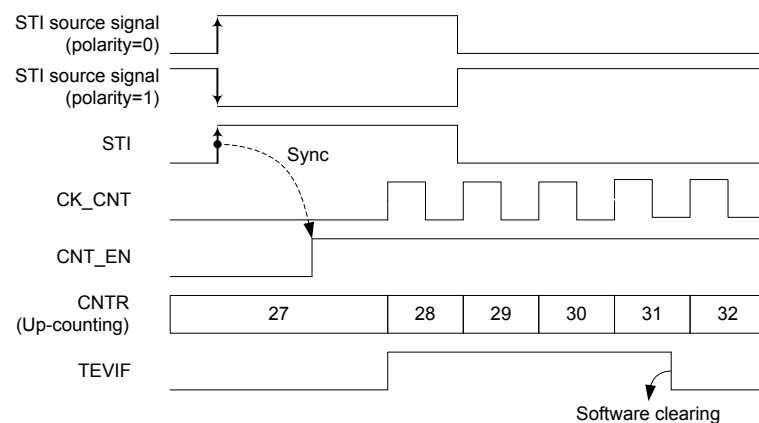
In the Pause Mode, the selected STI input signal level is used to control the counter start/stop operation. The counter starts to count when the selected STI signal is at a high level and stops counting when the STI signal is changed to a low level, here the counter will maintain its present value and will not be reset. Since the Pause function depends upon the STI level to control the counter stop/start operation, the selected STI trigger signal can not be derived from the TI0BED signal.



**Figure 43. GPTM in Pause Mode**

### Trigger Mode

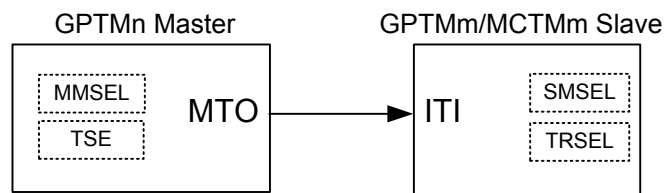
After the counter is disabled to count, the counter can resume counting when a STI rising edge signal occurs. When an STI rising edge occurs, the counter will start to count from the current value in the counter. Note that if the STI signal is selected to be derived from the UEVG bit software trigger, the counter will not resume counting. When software triggering using the UEVG bit is selected as the STI source signal, there will be no clock pulse generated which can be used to make the counter resume counting. Note that the STI signal is only used to enable the counter to resume counting and has no effect on controlling the counter to stop counting.



**Figure 44. GPTM in Trigger Mode**

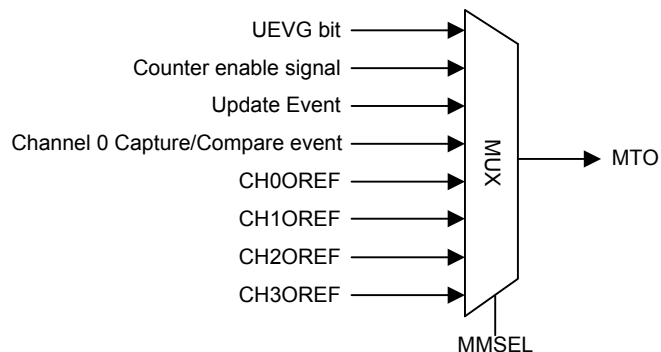
## Master Controller

The GPTMs and MCTMs can be linked together internally for timer synchronization or chaining. When one GPTM is configured to be in the Master Mode, the GPTM Master Controller will generate a Master Trigger Output (MTO) signal which includes a reset, a start, a stop signal or a clock source which is selected by the MMSEL field in the MDCFR register to trigger or drive another GPTM or MCTM, if exists, which is configured in the Slave Mode.



**Figure 45. Master GPTMn and Slave GPTMm/MCTMm Connection**

The Master Mode Selection bits, MMSEL, in the MDCFR register are used to select the MTO source for synchronizing another slave GPTM or MCTM if exists.



**Figure 46. MTO Selection**

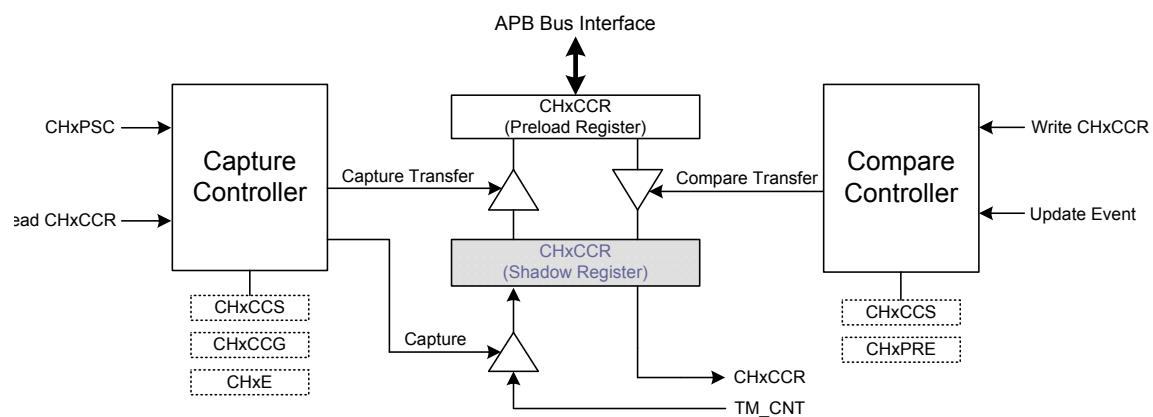
For example, setting the MMSEL field to 0x5 is to select the CH1OREF signal as the MTO signal to synchronize another slave GPTM or MCTM. For a more detailed description, refer to the related MMSEL field definitions in the MDCFR register.

## Channel Controller

The GPTM has four independent channels which can be used as capture inputs or compare match outputs. Each capture input or compare match output channel is composed of a preload register and a shadow register. Data access of the APB bus is always through the read/write preload register.

When used in the input capture mode, the counter value is captured into the CHxCCR shadow register first and then transferred into the CHxCCR preload register when the capture event occurs.

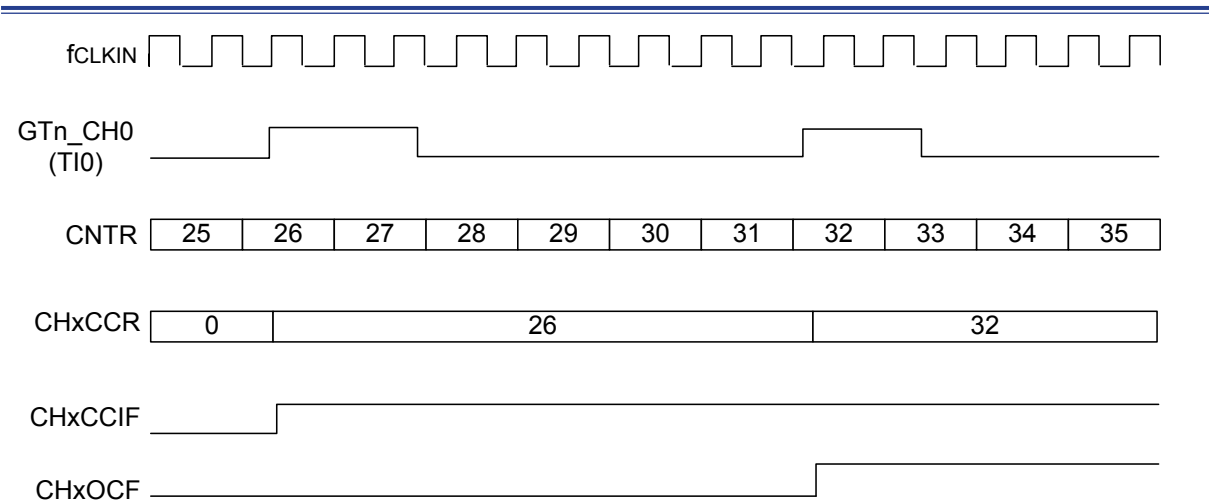
When used in the compare match output mode, the contents of the CHxCCR preload register is copied into the associated shadow register; the counter value is then compared with the register value.



**Figure 47. Capture/Compare Block Diagram**

**Capture Counter Value Transferred to CHxCCR**

When the channel is used as a capture input, the counter value is captured into the Channel Capture/Compare Register (CHxCCR) when an effective input signal transition occurs. Once the capture event occurs, the CHxCCIF flag in the INTSR register is set accordingly. If the CHxCCIF bit is already set, i.e., the flag has not yet been cleared by software, and another capture event on this channel occurs, the corresponding channel Over-Capture flag, named CHxOCF, will be set.



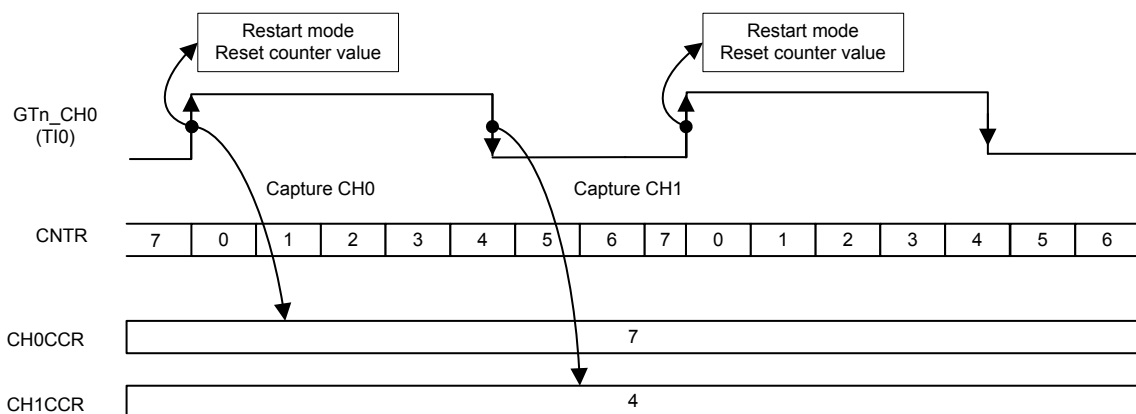
**Figure 48. Input Capture Mode**

### Pulse Width Measurement

The input capture mode can be also used for pulse width measurement from signals on the GT\_CHx pins, TIx. The following example shows how to configure the GPTM operated in the input capture mode to measure the high pulse width and the input period on the GT\_CH0 pin using channel 0 and channel 1. The basic steps are shown as follows.

- Configure the capture channel 0 (CH0CCS = 0x1) to select the TI0 signal as the capture input.
- Configure the CH0P bit to 0 to choose the rising edge of the TI0 input as the active polarity.
- Configure the capture channel 1 (CH1CCS = 0x2) to select the TI0 signal as the capture input.
- Configure the CH1P bit to 1 to choose the falling edge of the TI0 input as the active polarity.
- Configure the TRSEL bits to 0x0001 to select TI0S0 as the trigger input.
- Configure the Slave controller to operate in the Restart mode by setting the SMSEL field in the MDCFR register to 0x4
- Enable the input capture mode by setting the CH0E and CH1E bits in the CHCTR register to 1.

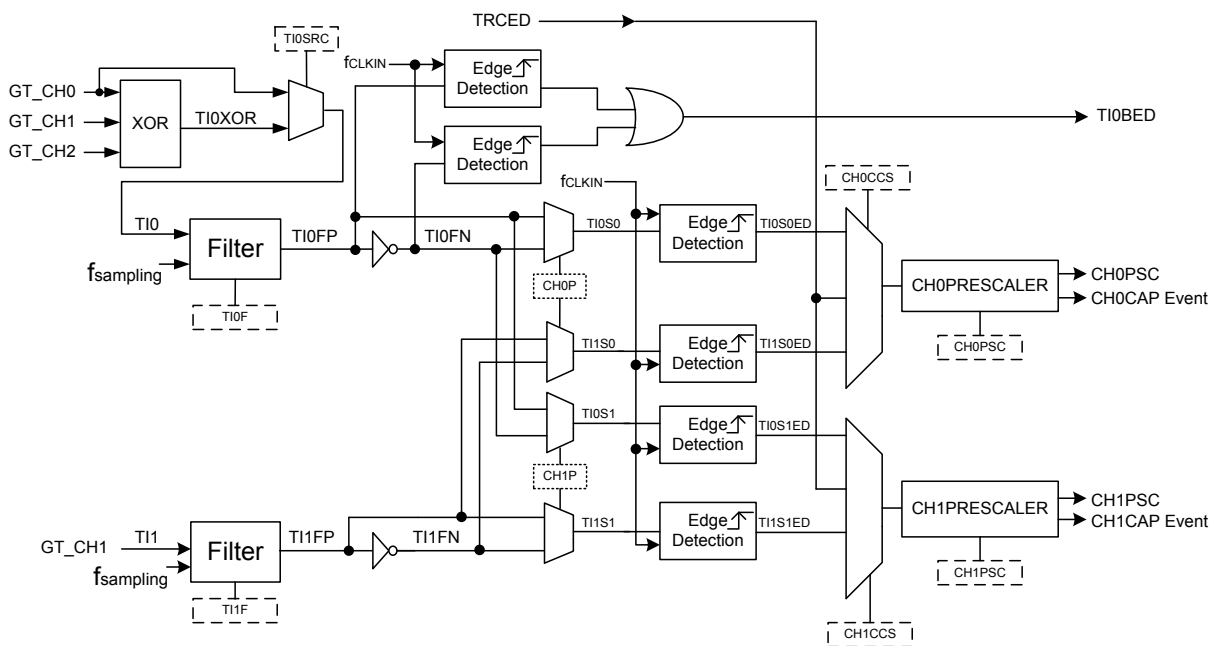
As the following diagram shows, the high pulse width on the GT\_CH0 pin will be captured into the CH1CCR register while the input period will be captured into the CH0CCR register after input capture operation.



**Figure 49. PWM Pulse Width Measurement Example**

## Input Stage

The input stage consists of a digital filter, a channel polarity selection, edge detection and a channel prescaler. The channel 0 input signal (TI0) can be chosen to come from the GT\_CH0 signal or the Exclusive-OR function of the GT\_CH0, GT\_CH1 and GT\_CH2 signals. The channel input signal (Tix) is sampled by a digital filter to generate a filtered input signal TixFP. Then the channel polarity and the edge detection block can generate a TixS0ED or TixS1ED signal for the input capture function. The effective input event number can be set by the channel input prescaler register (CHxPSC).



**Figure 50. Channel 0 and Channel 1 Input Stages**



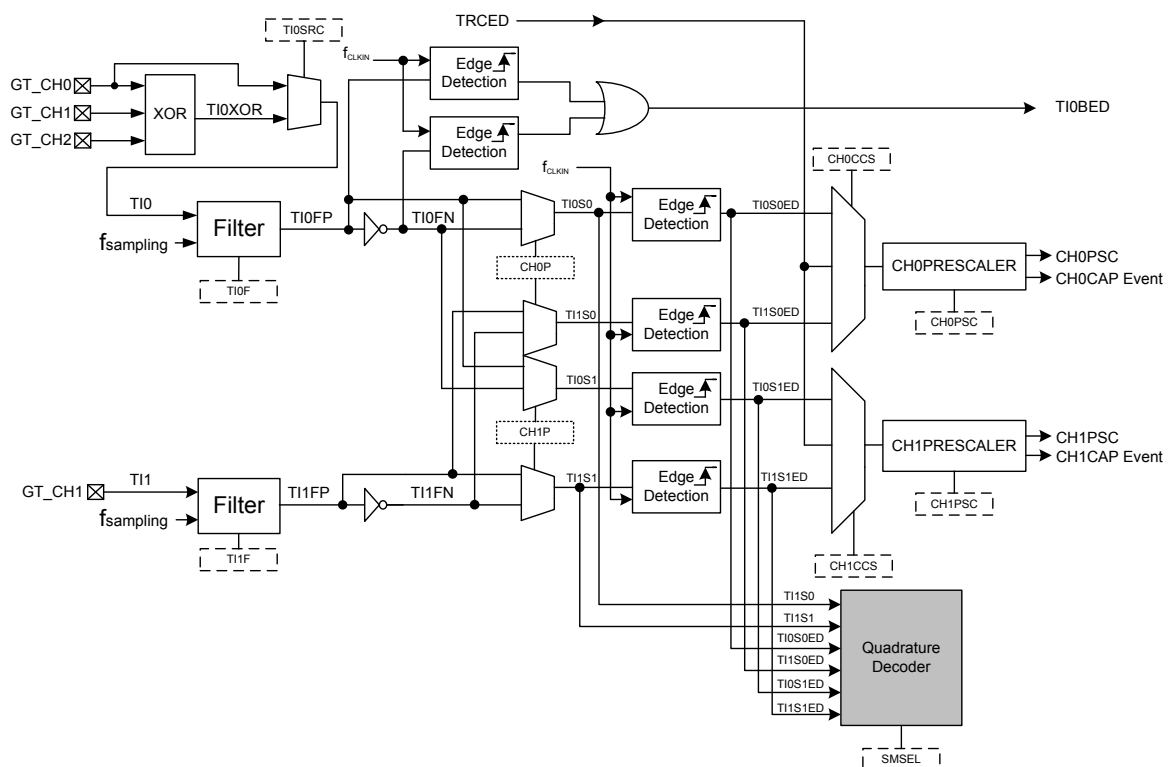
### Digital Filter

The digital filters are embedded in the input stage for the GT\_CH0 ~ GT\_CH3 pins respectively. The digital filter in the GPTM is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal. The N value can be 0, 2, 4, 5, 6 or 8 according to the user selection for each filter.



## Quadrature Decoder

The Quadrature Decoder function uses two quadrantal inputs TI0 and TI1 derived from the GT\_CH0 and GT\_CH1 pins respectively to interact to generate the counter value. The DIR bit is modified by hardware automatically during each input source transition. The input source can be either TI0 only, TI1 only or both TI0 and TI1, the selection made by setting the SMSEL field to 0x01, 0x02 or 0x03. The mechanism for changing the counter direction is shown in the following table. The Quadrature decoder can be regarded as an external clock with a directional selection. This means that the counter counts continuously in the interval between 0 and the counter-reload value. Therefore, users must configure the CRR register before the counter starts to count.

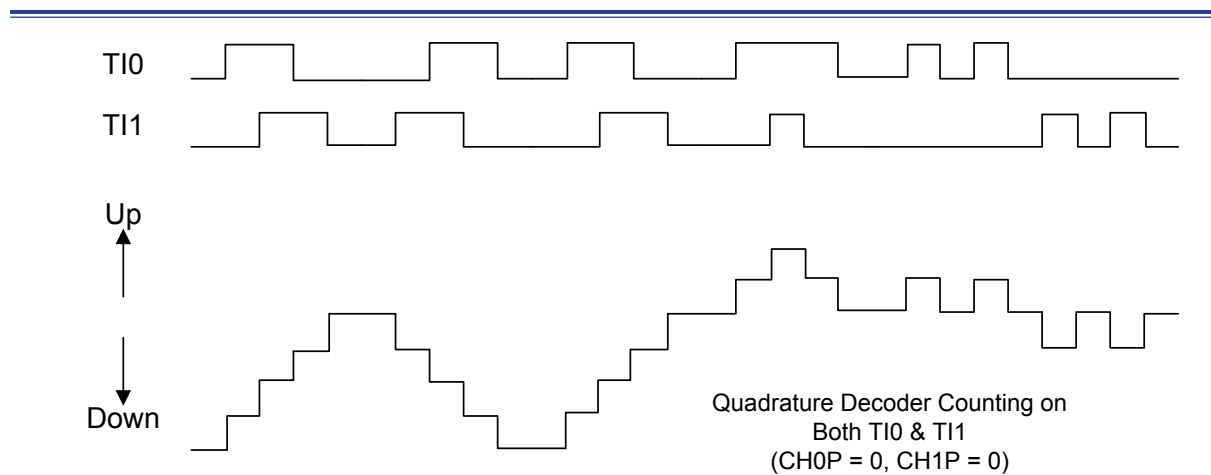


**Figure 53. Input Stage and Quadrature Decoder Block Diagram**

**Table 30. Counting Direction and Encoding Signals**

| Counting mode                             | Level        | TI0S0  |         | TI1S1  |         |
|-------------------------------------------|--------------|--------|---------|--------|---------|
|                                           |              | Rising | Falling | Rising | Falling |
| Counting on TI0 only<br>(SMSEL = 0x01)    | TI1S1 = High | Down   | Up      | —      | —       |
|                                           | TI1S1 = Low  | Up     | Down    | —      | —       |
| Counting on TI1 only<br>(SMSEL = 0x02)    | TI0S0 = High | —      | —       | Up     | Down    |
|                                           | TI0S0 = Low  | —      | —       | Down   | Up      |
| Counting on TI0 and TI1<br>(SMSEL = 0x03) | TI1S1 = High | Down   | Up      | X      | X       |
|                                           | TI1S1 = Low  | Up     | Down    | X      | X       |
|                                           | TI0S0 = High | X      | X       | Up     | Down    |
|                                           | TI0S0 = Low  | X      | X       | Down   | Up      |

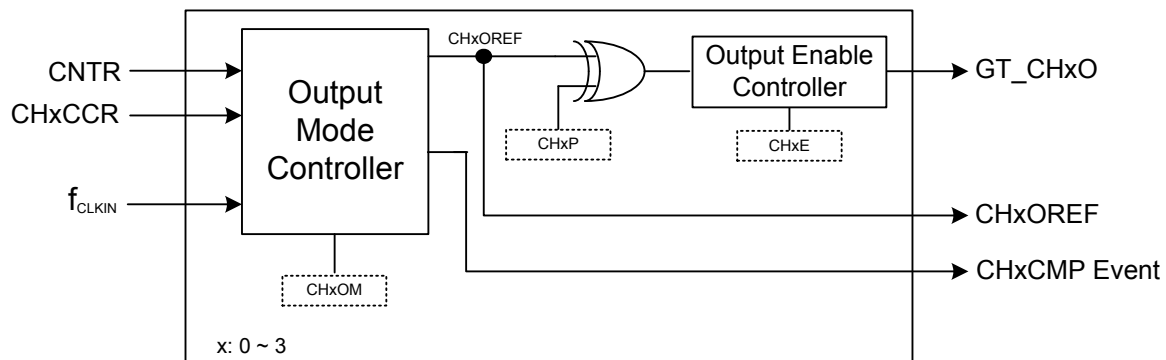
Note: “—” → means “no counting”, “X” → impossible



**Figure 54. Both TI0 and TI1 Quadrature Decoder Counting**

## Output Stage

The GPTM has four channels for compare match, single pulse or PWM output function. The channel output GT\_CHxO is controlled by the CHxOM, CHxP and CHxE bits in the corresponding CHxOCFR, CHPOLR and CHCTR registers.



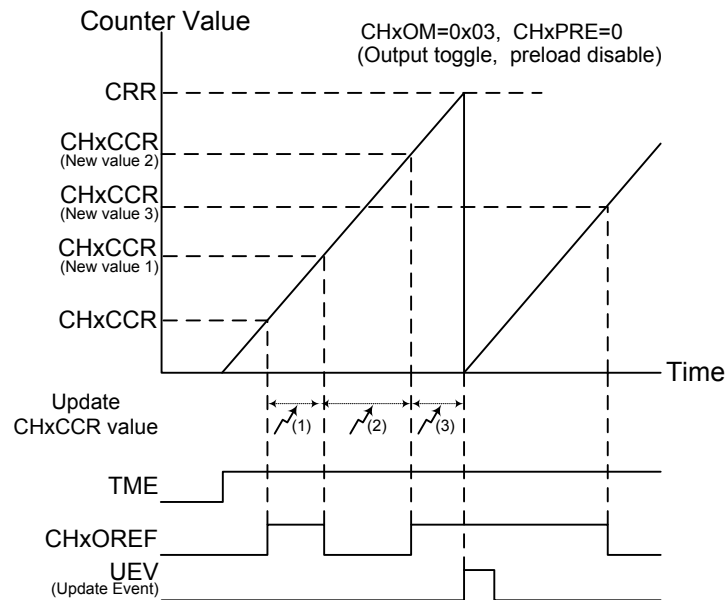
**Figure 55. Output Stage Block Diagram**

## Channel Output Reference Signal

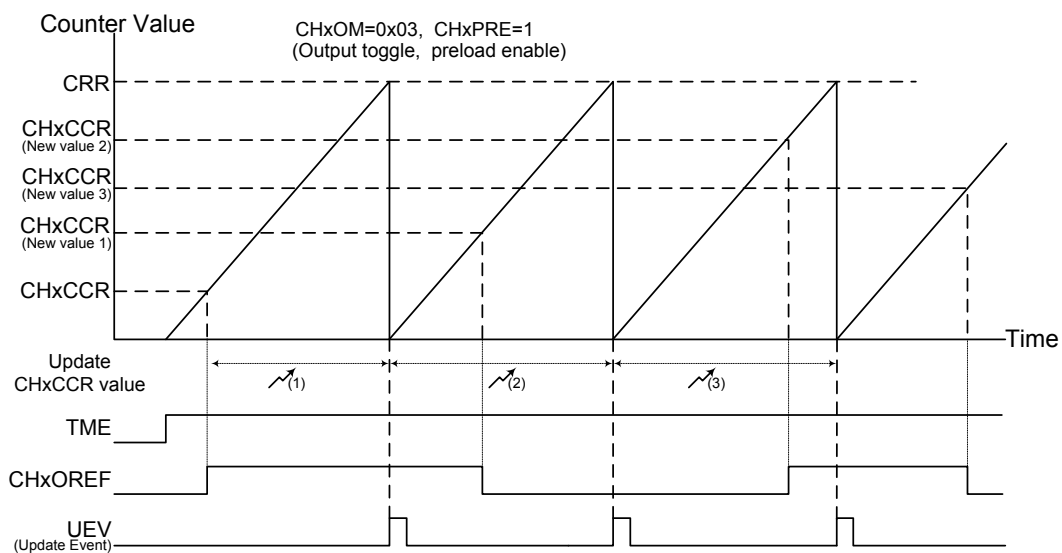
When the GPTM is used in the compare match output mode, the CHxOREF signal (Channel x Output Reference signal) is defined by the CHxOM bit setup. The CHxOREF signal has several types of output function which defines what happens to the output when the counter value matches the contents of the CHxCCR register. In addition to the low, high and toggle CHxOREF output types; there are also PWM mode 1 and PWM mode 2 outputs. In these modes, the CHxOREF signal level is changed according to the count direction and the relationship between the counter value and the CHxCCR content. There are also two modes which will force the output into an inactive or active state irrespective of the CHxCCR content or counter values. With regard to a more detailed description refer to the relative bit definition. The accompanying Table 2 shows a summary of the output type setup.

**Table 31. Compare Match Output Setup**

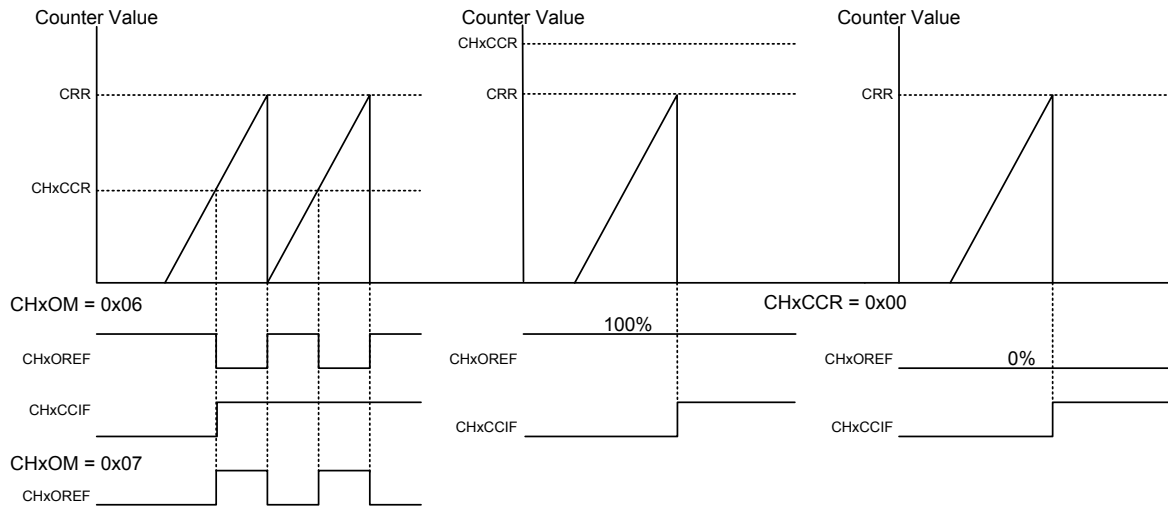
| CHxOM value | Compare Match Level  |
|-------------|----------------------|
| 0x00        | No change            |
| 0x01        | Clear Output to 0    |
| 0x02        | Set Output to 1      |
| 0x03        | Toggle Output        |
| 0x04        | Force Inactive Level |
| 0x05        | Force Active Level   |
| 0x06        | PWM Mode 1           |
| 0x07        | PWM Mode 2           |



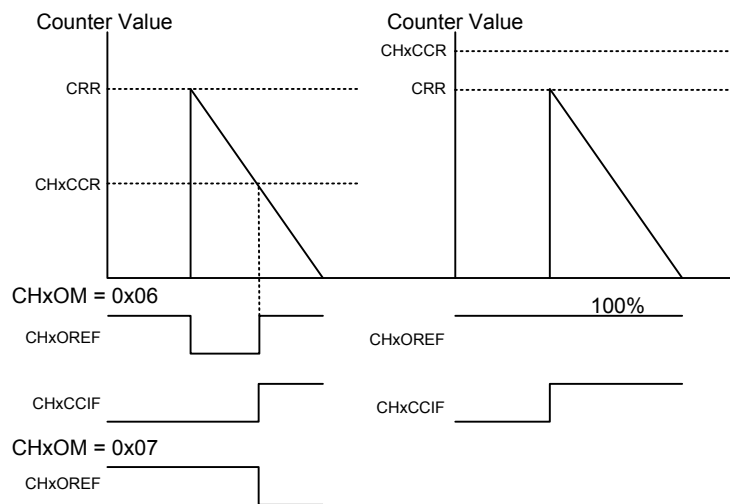
**Figure 56. Toggle Mode Channel Output Reference Signal (CHxPRE = 0)**



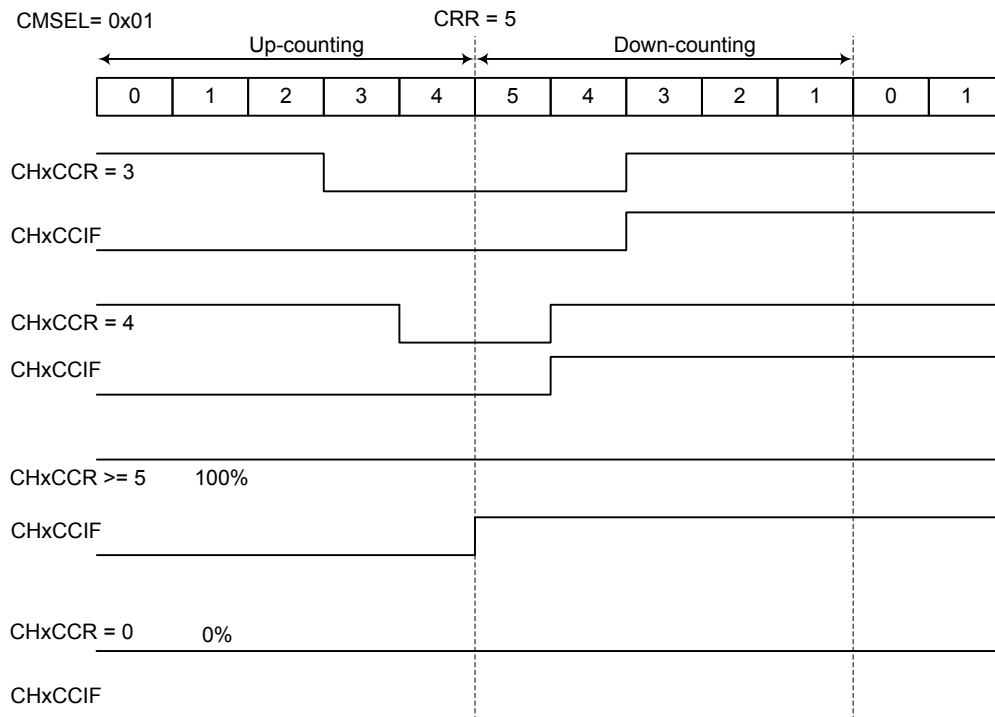
**Figure 57. Toggle Mode Channel Output Reference Signal (CHxPRE = 1)**



**Figure 58. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode**



**Figure 59. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode**



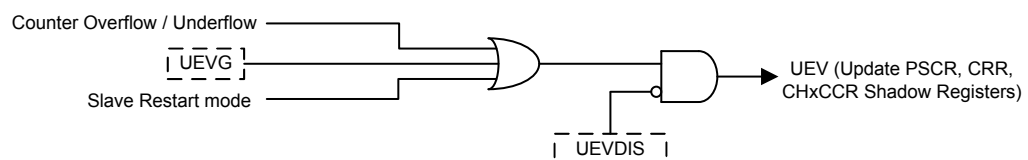
**Figure 60. PWM Mode Channel Output Reference Signal and Counter in Centre-align Mode**

## Update Management

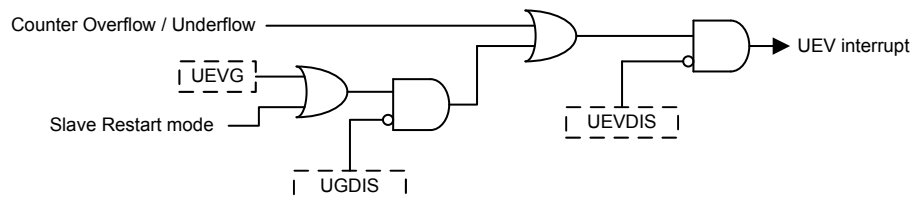
The Update event is used to update the CRR, the PSCR and the CHxCCR values from the actual registers to the corresponding shadow registers. An update event occurs when the counter overflows or underflows, the software update control bit is triggered or an update event from the slave controller is generated.

The UEVDIS bit in the CNTCFR register can determine whether the update event occurs or not. When the update event occurs, the corresponding update event interrupt will be generated depending upon whether the update event interrupt generation function is enabled or not by configuring the UGDIS bit in the CNTCFR register. For more detail description, refer to the UEVDIS and UGDIS bit definition in the CNTCFR register.

### Update Event Management



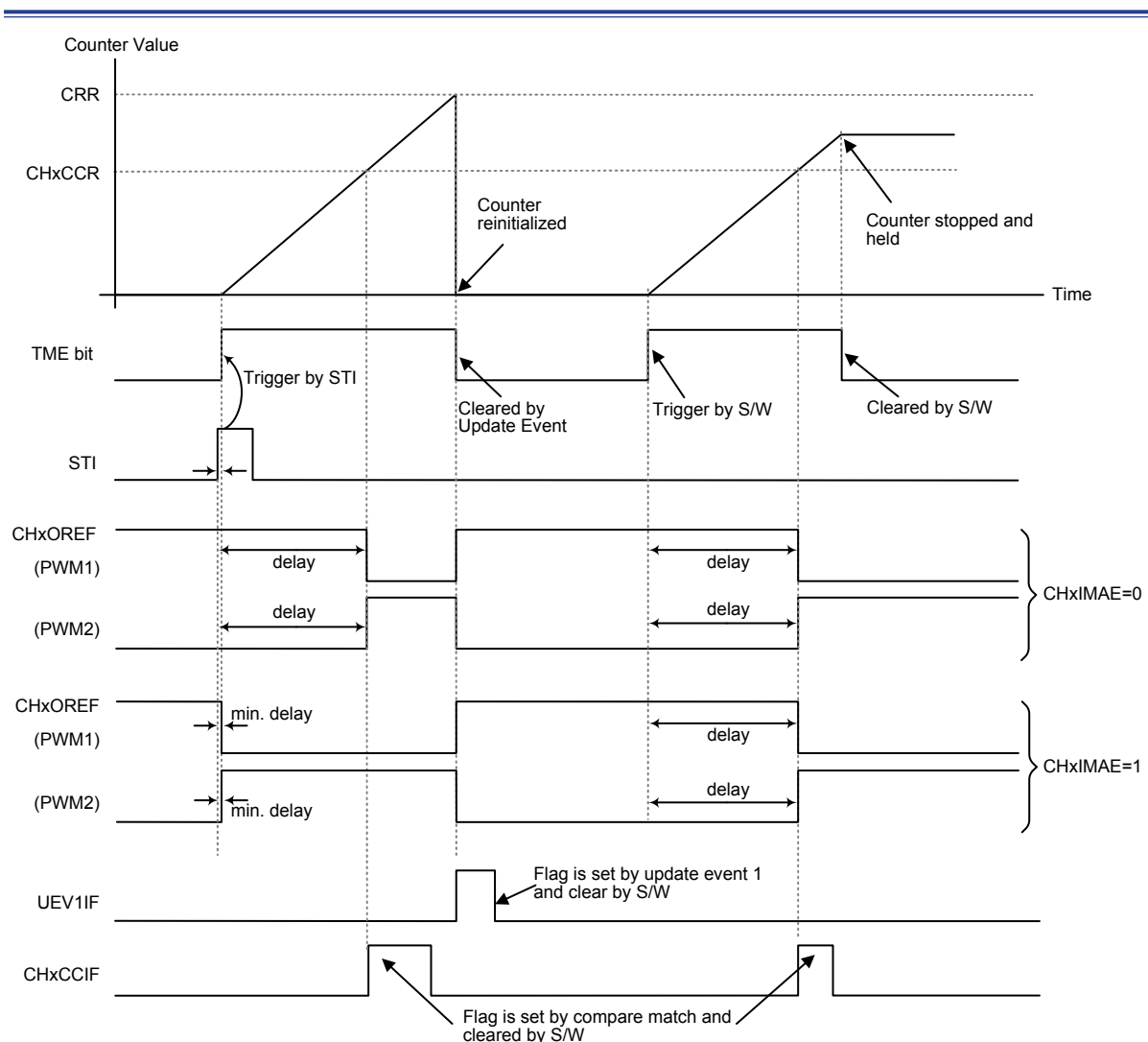
### Update Event Interrupt Management



**Figure 61. Update Event Setting Diagram**

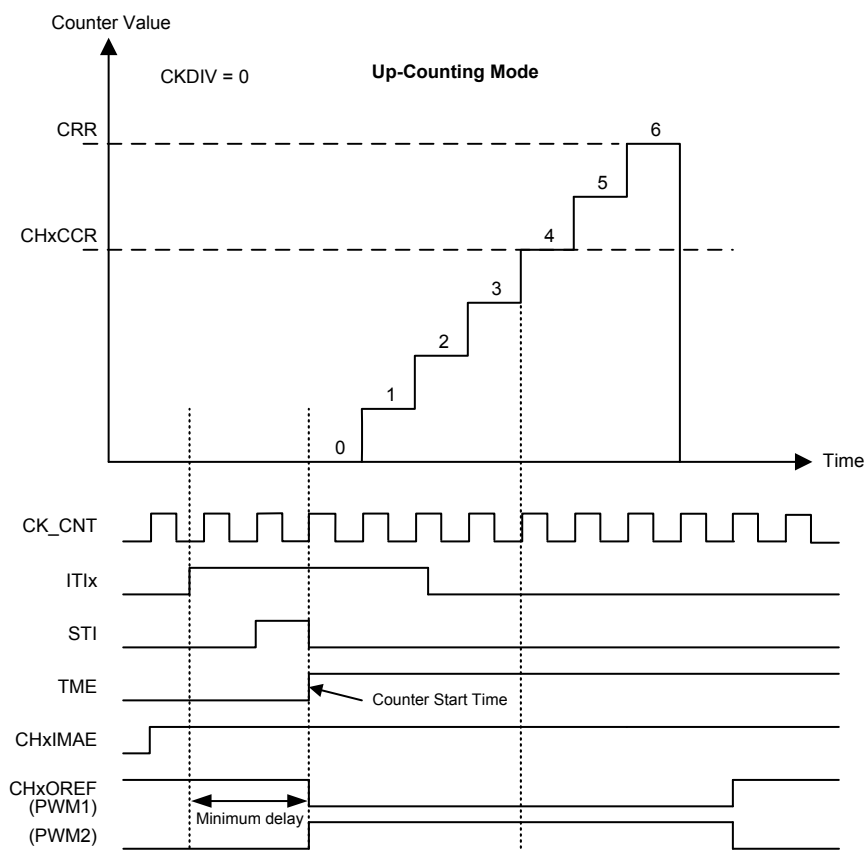
## Single Pulse Mode

Once the timer is set to operate in the single pulse mode, it is not necessary to set the timer enable bit TME in the CTR register to 1 to enable the counter. The trigger to generate a pulse can be sourced from the STI signal rising edge or by setting the TME bit to 1 using software. Setting the TME bit to 1 or a trigger from the STI signal rising edge can generate a pulse and then keep the TME bit at a high state until the update event occurs or the TME bit is written to 0 by software. If the TME bit is cleared to 0 using software, the counter will be stopped and its value held. If the TME bit is automatically cleared to 0 by a hardware update event, the counter will be reinitialized.



**Figure 62. Single Pulse Mode**

In the Single Pulse mode, the STI active edge which sets the TME bit to 1 will enable the counter. However, there exist several clock delays to perform the comparison result between the counter value and the CHxCCR value. In order to reduce the delay to a minimum value, the user can set the CHxIMAE bit in each CHxOCCR register. After a STI rising edge trigger occurs in the single pulse mode, the CHxOREF signal will immediately be forced to the state which the CHxOREF signal will change to as the compare match event occurs without taking the comparison result into account. The CHxIMAE bit is available only when the output channel is configured to operate in the PWM1 or PWM2 output mode and the trigger source is derived from the STI signal.

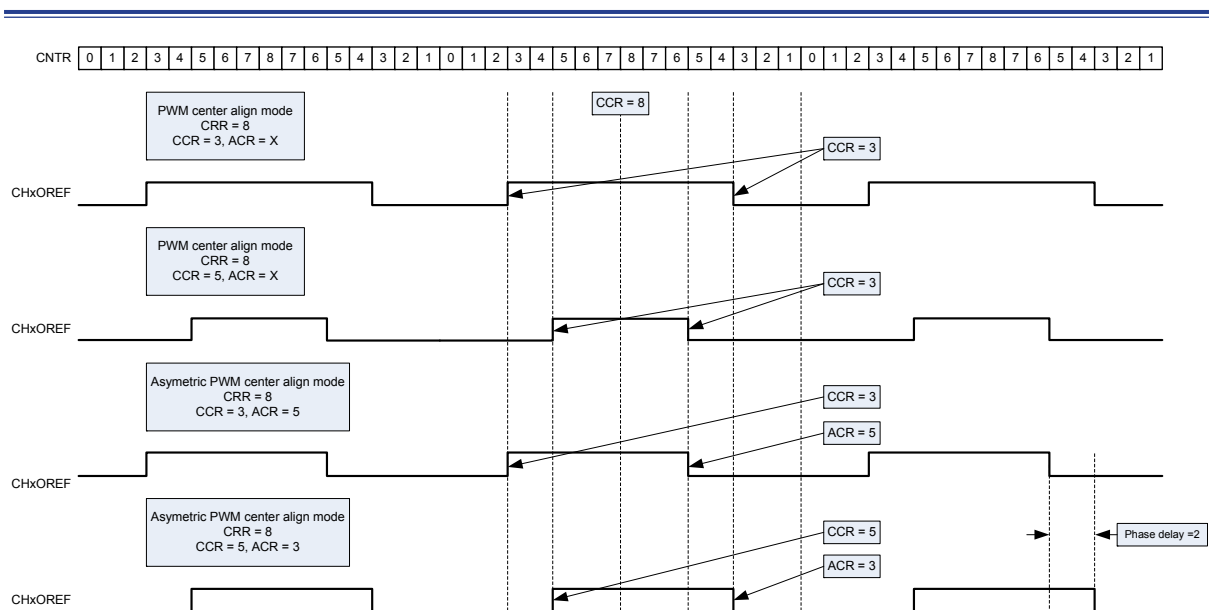


**Figure 63. Immediate Active Mode Minimum Delay**

## Asymmetric PWM Mode

Asymmetric PWM mode allows two center-aligned PWM signals to be generated with a programmable phase shift. While the PWM frequency is determined by the value of the CRR register, the duty cycle and the phase-shift are determined by the CHxCCR and CHxACR register. When the counter is counting up, the PWM using the value in CHxCCR as up-count compare value. When the counter is into counting down stage, the PWM using the value in CHxACR as down-count compare value. The Figure 64 is shown an example for asymmetric PWM mode in center-aligned counting mode.

Note: Asymmetric PWM mode can only be operated in center-aligned counting mode.



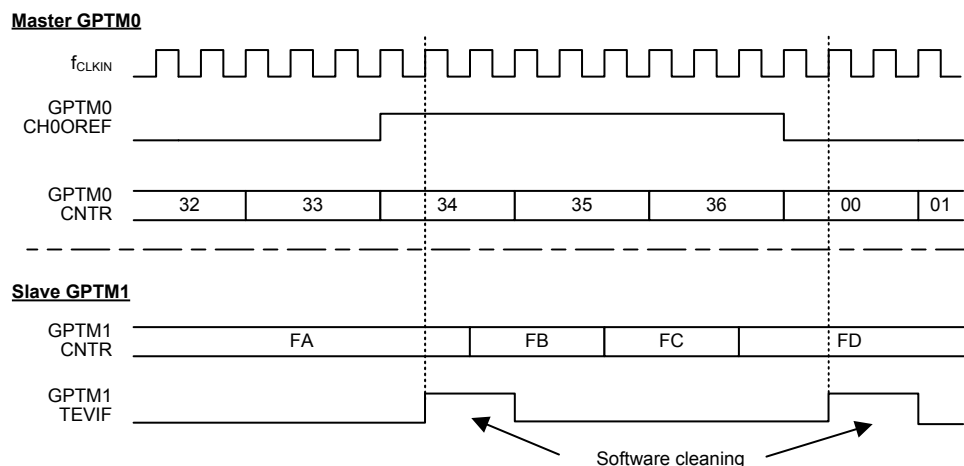
**Figure 64. Asymmetric PWM mode versus center align counting mode**

## Timer Interconnection

The timers can be internally connected together for timer chaining or synchronization. This can be implemented by configuring one timer to operate in the Master mode while configuring another timer to be in the Slave mode. The following figures present several examples of trigger selection for the master and slave modes.

### Using one timer to enable/disable another timer start or stop counting

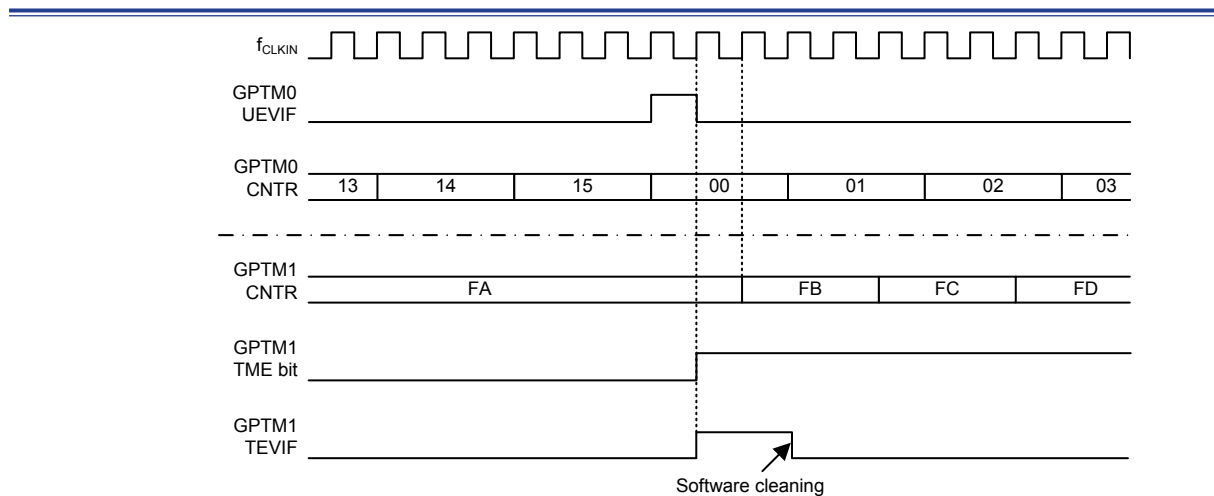
- Configure GPTM0 as the master mode to send its channel 0 Output Reference signal CH0OREF as a trigger output (MMSEL = 0x04).
- Configure GPTM0 CH0OREF waveform.
- Configure GPTM1 to receive its input trigger source from the GPTM0 trigger output (TRSEL=0x09)
- Configure GPTM1 to operate in the pause mode (SMSEL = 0x05).
- Enable GPTM1 by writing "1" to the TME bit.
- Enable GPTM0 by writing "1" to the TME bit.



**Figure 65. Pausing GPTM1 using the GPTM0 CH0OREF Signal**

### Using one timer to trigger another timer start counting

- Configure GPTM0 to operate in the master mode to send its Update Event UEV as the trigger output (MMSEL = 0x02).
- Configure the GPTM0 period by setting the CRR register.
- Configure GPTM1 to get the input trigger source from the GPTM0 trigger output (TRSEL=0x09)
- Configure GPTM1 to be in the slave trigger mode (SMSEL = 0x06).
- Start GPTM0 by writing "1" to the TME bit.

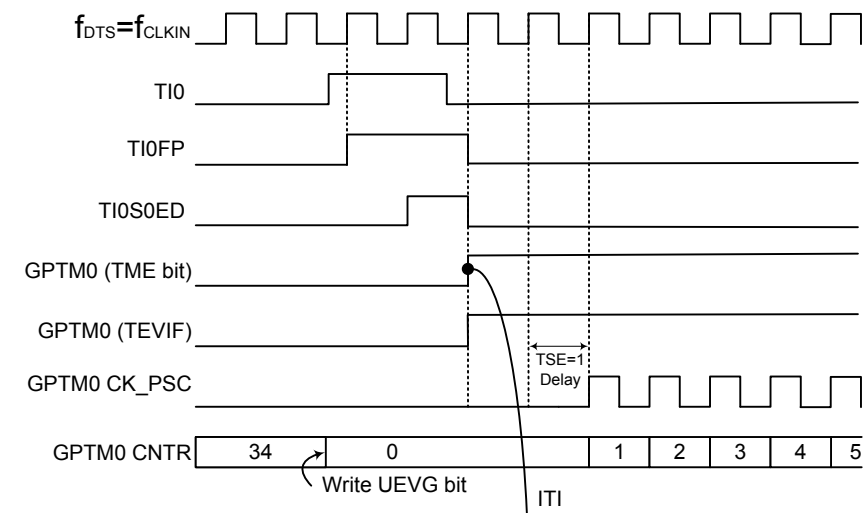


**Figure 66. Triggering GPTM1 with GPTM0 Update Event**

### Starting two timers synchronously in response to an external trigger

- Configure GPTM0 to operate in the master mode to send its enable signal as a trigger output (MMSEL = 0x01).
- Configure GPTM0 slave mode to receive its input trigger source from GTn\_CH0 pin (TRSEL = 0x01).
- Configure GPTM0 to be in the slave trigger mode (SMSEL = 0x06).
- Enable the GPTM0 master timer synchronization function by setting the TSE bit in the MDCFR register to 1 to synchronize the slave timer.
- Configure GPTM1 to receive its input trigger source from the GPTM0 trigger output (TRSEL = 0x09).
- Configure GPTM1 to be in the slave trigger mode (SMSEL = 0x06).

#### Master GPTM0



#### Slave GPTM1

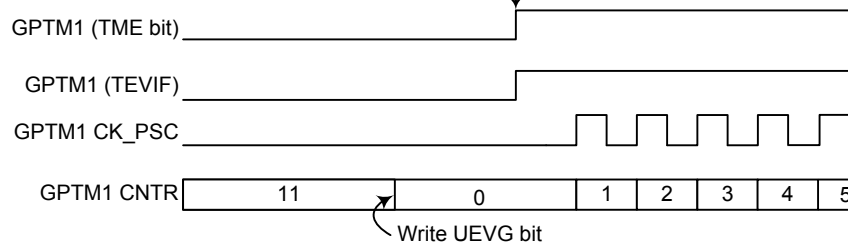


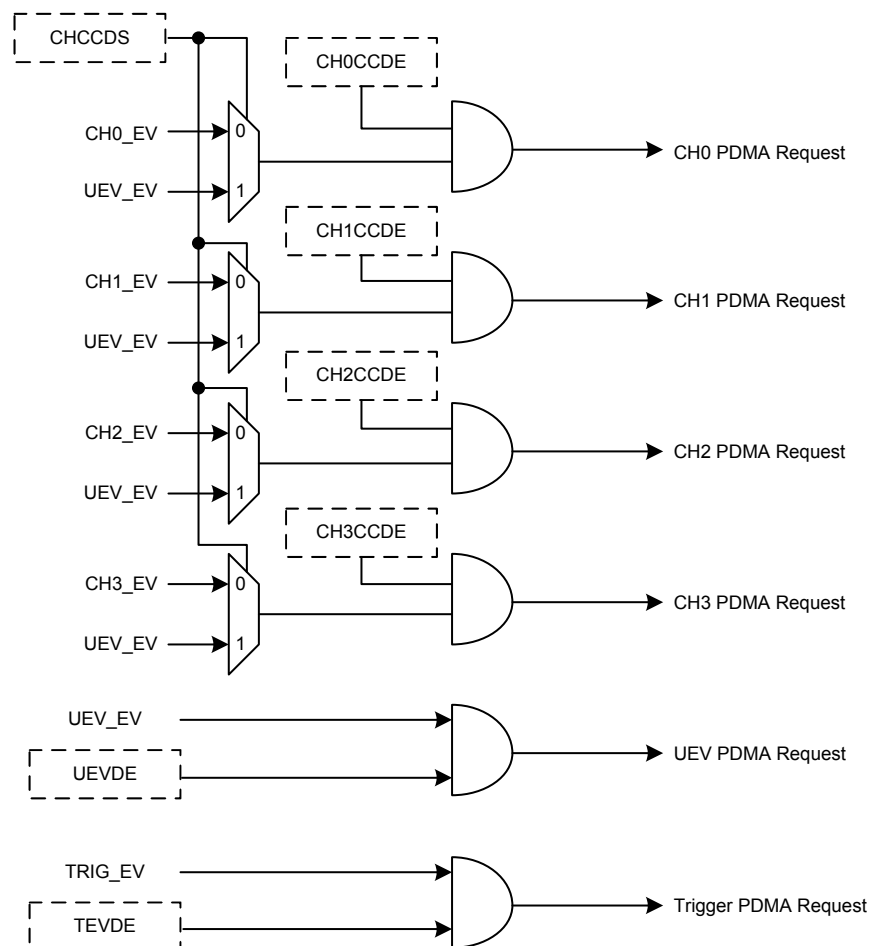
Figure 67. Trigger GPTM0 and GPTM1 with the GPTM0 CH0 Input

## Trigger ADC Start

To interconnect to the Analog-to-Digital Converter, the GPTM can output the MTO signal or the channel compare match output signal CHxOREF (x = 0 ~ 3) to be used as an Analog-to-Digital Converter input trigger signal.

## PDMA Request

The GPTM supports the interface for PDMA data transfer. There are certain events which can generate the PDMA requests if the corresponding enable control bits are set to 1 to enable the PDMA access. These events are the GPTM update events, trigger events and channel capture/compare events. When the PDMA request is generated from the GPTM channel, it can be derived from the channel capture/compare event or the GPTM update event selected by the channel PDMA selection bit, CHCCDS, for all channels. For more detailed PDMA configuring information, refer to the corresponding section in the PDMA chapter.



**Figure 68. GPTM PDMA Mapping Diagram**

## Register Map

The following table shows the GPTM registers and reset values.

**Table 32. GPTM Register Map**

| Register | Offset | Description                             | Reset Value |
|----------|--------|-----------------------------------------|-------------|
| CNTCFR   | 0x000  | Timer Counter Configuration Register    | 0x0000_0000 |
| MDCFR    | 0x004  | Timer Mode Configuration Register       | 0x0000_0000 |
| TRCFR    | 0x008  | Timer Trigger Configuration Register    | 0x0000_0000 |
| CTR      | 0x010  | Timer Control Register                  | 0x0000_0000 |
| CH0ICFR  | 0x020  | Channel 0 Input Configuration Register  | 0x0000_0000 |
| CH1ICFR  | 0x024  | Channel 1 Input Configuration Register  | 0x0000_0000 |
| CH2ICFR  | 0x028  | Channel 2 Input Configuration Register  | 0x0000_0000 |
| CH3ICFR  | 0x02C  | Channel 3 Input Configuration Register  | 0x0000_0000 |
| CH0OCFR  | 0x040  | Channel 0 Output Configuration Register | 0x0000_0000 |
| CH1OCFR  | 0x044  | Channel 1 Output Configuration Register | 0x0000_0000 |
| CH2OCFR  | 0x048  | Channel 2 Output Configuration Register | 0x0000_0000 |
| CH3OCFR  | 0x04C  | Channel 3 Output Configuration Register | 0x0000_0000 |
| CHCTR    | 0x050  | Channel Control Register                | 0x0000_0000 |
| CHPOLR   | 0x054  | Channel Polarity Configuration Register | 0x0000_0000 |
| DICTR    | 0x074  | Timer PDMA / Interrupt Control Register | 0x0000_0000 |
| EVGR     | 0x078  | Timer Event Generator Register          | 0x0000_0000 |
| INTSR    | 0x07C  | Timer Interrupt Status Register         | 0x0000_0000 |
| CNTR     | 0x080  | Timer Counter Register                  | 0x0000_0000 |
| PSCR     | 0x084  | Timer Prescaler Register                | 0x0000_0000 |
| CRR      | 0x088  | Timer Counter Reload Register           | 0x0000_FFFF |
| CH0CCR   | 0x090  | Channel 0 Capture/Compare Register      | 0x0000_0000 |
| CH1CCR   | 0x094  | Channel 1 Capture/Compare Register      | 0x0000_0000 |
| CH2CCR   | 0x098  | Channel 2 Capture/Compare Register      | 0x0000_0000 |
| CH3CCR   | 0x09C  | Channel 3 Capture/Compare Register      | 0x0000_0000 |
| CH0ACR   | 0x0A0  | Channel 0 Asymmetric Compare Register   | 0x0000_0000 |
| CH1ACR   | 0x0A4  | Channel 1 Asymmetric Compare Register   | 0x0000_0000 |
| CH2ACR   | 0x0A8  | Channel 2 Asymmetric Compare Register   | 0x0000_0000 |
| CH3ACR   | 0x0AC  | Channel 3 Asymmetric Compare Register   | 0x0000_0000 |

## Register Descriptions

### Timer Counter Configuration Register – CNTCFR

This register specifies the GPTM counter configuration.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |       |        |
|------------|----------|----|----|----|----|----|-------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25    | 24     |
| Type/Reset | Reserved |    |    |    |    |    |       | DIR    |
|            |          |    |    |    |    |    |       | RW 0   |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17    | 16     |
| Type/Reset | Reserved |    |    |    |    |    | CMSEL |        |
|            |          |    |    |    |    |    | RW 0  | RW 0   |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9     | 8      |
| Type/Reset | Reserved |    |    |    |    |    | CKDIV |        |
|            |          |    |    |    |    |    | RW 0  | RW 0   |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1     | 0      |
| Type/Reset | Reserved |    |    |    |    |    | UGDIS | UEVDIS |
|            |          |    |    |    |    |    | RW 0  | RW 0   |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24]    | DIR   | Counting Direction<br>0: Count-up<br>1: Count-down<br>Note: This bit is read only when the Timer is configured to be in the Center-aligned mode or when used as a Quadrature decoder.                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| [17:16] | CMSEL | Counter Mode Selection<br>00: Edge aligned mode. Normal up-counting and down-counting available for this mode. Counting direction is defined by the DIR bit.<br>01: Center aligned mode 1. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-down period.<br>10: Center aligned mode 2. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up period.<br>11: Center aligned mode 3. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up and count-down period. |
| [9:8]   | CKDIV | Clock Division<br>These two bits define the frequency ratio between the timer clock ( $f_{CLKIN}$ ) and the dead-time clock ( $f_{DTS}$ ). The dead-time clock is also used for digital filter sampling clock.<br>00: $f_{DTS} = f_{CLKIN}$<br>01: $f_{DTS} = f_{CLKIN} / 2$<br>10: $f_{DTS} = f_{CLKIN} / 4$<br>11: Reserved                                                                                                                                                                                                                                                                                                 |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                    |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | UGDIS  | Update event interrupt generation disable control<br>0: Any of the following events will generate an update PDMA request or interrupt<br>- Counter overflow/underflow<br>- Setting the UEVG bit<br>- Update generation through the slave mode<br>1: Only counter overflow/underflow generates an update PDMA request or interrupt                                               |
| [0]  | UEVDIS | Update event Disable control<br>0: Enable the update event request by one of following events:<br>- Counter overflow/underflow<br>- Setting the UEVG bit<br>- Update generation through the slave mode<br>1: Disable the update event (However the counter and the prescaler are reinitialized if the UEVG bit is set or if a hardware restart is received from the slave mode) |

## Timer Mode Configuration Register – MDCFR

This register specifies the GPTM master and slave mode selection and single pulse mode.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |    |       |    |        |   |
|------------|----------|----|----|----|----|-------|----|--------|---|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25 | 24     |   |
|            | Reserved |    |    |    |    |       |    | SPMSET |   |
| Type/Reset |          |    |    |    |    |       |    | RW     | 0 |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17 | 16     |   |
|            | Reserved |    |    |    |    | MMSEL |    |        |   |
| Type/Reset |          |    |    |    |    | RW    | 0  | RW     | 0 |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9  | 8      |   |
|            | Reserved |    |    |    |    | SMSEL |    |        |   |
| Type/Reset |          |    |    |    |    | RW    | 0  | RW     | 0 |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1  | 0      |   |
|            | Reserved |    |    |    |    |       |    | TSE    |   |
| Type/Reset |          |    |    |    |    |       |    | RW     | 0 |

| Bits | Field  | Descriptions                                                                                                                                                                                                         |
|------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24] | SPMSET | Single Pulse Mode Setting<br>0: Counter counts normally irrespective of whether the update event occurred or not.<br>1: Counter stops counting at the next update event and then the TME bit is cleared by hardware. |

| Bits        | Field                | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
|-------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------------|-----|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------|----------------------------------------------------------|-----|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----------------------|------------------------------------------------------------------------------------------------------------------------------|-----|----------------|------------------------------------------------------------------------------------|-----|----------------|------------------------------------------------------------------------------------|-----|----------------|------------------------------------------------------------------------------------|-----|----------------|------------------------------------------------------------------------------------|
| [18:16]     | MMSEL                | <p>Master Mode Selection</p> <p>Master mode selection is used to select the MTO signal source which is used to synchronize the other slave timer.</p> <table> <tr> <th>MMSEL [2:0]</th><th>Mode</th><th>Descriptions</th></tr> <tr> <td>000</td><td>Reset Mode</td><td>The MTO in the Reset mode is an output derived from one of the following cases:<br/>Software setting UEVG bit<br/>The STI trigger input signal which will be output on the MTO signal line when the Timer is used in the slave Restart mode</td></tr> <tr> <td>001</td><td>Enable Mode</td><td>The Counter Enable signal is used as the trigger output.</td></tr> <tr> <td>010</td><td>Update Mode</td><td>The update event is used as the trigger output according to one of the following cases when the UEVDIS bit is cleared to 0:<br/>Counter overflow / underflow<br/>Software setting UEVG<br/>Slave trigger input when used in slave restart mode</td></tr> <tr> <td>011</td><td>Capture/Compare Mode</td><td>When a Channel 0 capture or compare match event occurs, it will generate a positive pulse used as the master trigger output.</td></tr> <tr> <td>100</td><td>Compare Mode 0</td><td>The Channel 0 Output reference signal named CH0OREF is used as the trigger output.</td></tr> <tr> <td>101</td><td>Compare Mode 1</td><td>The Channel 1 Output reference signal named CH1OREF is used as the trigger output.</td></tr> <tr> <td>110</td><td>Compare Mode 2</td><td>The Channel 2 Output reference signal named CH2OREF is used as the trigger output.</td></tr> <tr> <td>111</td><td>Compare Mode 3</td><td>The Channel 3 Output reference signal named CH3OREF is used as the trigger output.</td></tr> </table> | MMSEL [2:0] | Mode | Descriptions | 000 | Reset Mode | The MTO in the Reset mode is an output derived from one of the following cases:<br>Software setting UEVG bit<br>The STI trigger input signal which will be output on the MTO signal line when the Timer is used in the slave Restart mode | 001 | Enable Mode | The Counter Enable signal is used as the trigger output. | 010 | Update Mode | The update event is used as the trigger output according to one of the following cases when the UEVDIS bit is cleared to 0:<br>Counter overflow / underflow<br>Software setting UEVG<br>Slave trigger input when used in slave restart mode | 011 | Capture/Compare Mode | When a Channel 0 capture or compare match event occurs, it will generate a positive pulse used as the master trigger output. | 100 | Compare Mode 0 | The Channel 0 Output reference signal named CH0OREF is used as the trigger output. | 101 | Compare Mode 1 | The Channel 1 Output reference signal named CH1OREF is used as the trigger output. | 110 | Compare Mode 2 | The Channel 2 Output reference signal named CH2OREF is used as the trigger output. | 111 | Compare Mode 3 | The Channel 3 Output reference signal named CH3OREF is used as the trigger output. |
| MMSEL [2:0] | Mode                 | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 000         | Reset Mode           | The MTO in the Reset mode is an output derived from one of the following cases:<br>Software setting UEVG bit<br>The STI trigger input signal which will be output on the MTO signal line when the Timer is used in the slave Restart mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 001         | Enable Mode          | The Counter Enable signal is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 010         | Update Mode          | The update event is used as the trigger output according to one of the following cases when the UEVDIS bit is cleared to 0:<br>Counter overflow / underflow<br>Software setting UEVG<br>Slave trigger input when used in slave restart mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 011         | Capture/Compare Mode | When a Channel 0 capture or compare match event occurs, it will generate a positive pulse used as the master trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 100         | Compare Mode 0       | The Channel 0 Output reference signal named CH0OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 101         | Compare Mode 1       | The Channel 1 Output reference signal named CH1OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 110         | Compare Mode 2       | The Channel 2 Output reference signal named CH2OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |
| 111         | Compare Mode 3       | The Channel 3 Output reference signal named CH3OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |      |              |     |            |                                                                                                                                                                                                                                           |     |             |                                                          |     |             |                                                                                                                                                                                                                                             |     |                      |                                                                                                                              |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |     |                |                                                                                    |

| Bits   | Field | Descriptions                                                                                                                                                 |                           |                                                                                                                                                                                                                                                                      |
|--------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10:8] | SMSEL | Slave Mode Selection                                                                                                                                         |                           |                                                                                                                                                                                                                                                                      |
|        |       | SMSEL [2:0]                                                                                                                                                  | Mode                      | Descriptions                                                                                                                                                                                                                                                         |
|        |       | 000                                                                                                                                                          | Disable mode              | The prescaler is clocked directly by the internal clock.                                                                                                                                                                                                             |
|        |       | 001                                                                                                                                                          | Quadrature Decoder mode 1 | The counter uses the clock pulse generated from the interaction between the TI0 and TI1 signals to drive the counter prescaler. A transition of the TI0 edge is used in this mode depending upon the TI1 level.                                                      |
|        |       | 010                                                                                                                                                          | Quadrature Decoder mode 2 | The counter uses the clock pulse generated from the interaction between the TI0 and TI1 signals to drive the counter prescaler. A transition of the TI1 edge is used in this mode depending upon the TI0 level.                                                      |
|        |       | 011                                                                                                                                                          | Quadrature Decoder mode 3 | The counter uses the clock pulse generated from the interaction between the TI0 and TI1 signals to drive the counter prescaler. A transition of one channel edge is used in the quadrature decoder mode 3 depending upon the other channel level.                    |
|        |       | 100                                                                                                                                                          | Restart Mode              | The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.                                                                                         |
|        |       | 101                                                                                                                                                          | Pause Mode                | The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal. |
|        |       | 110                                                                                                                                                          | Trigger Mode              | The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the counter start control is determined by the STI signal.                                                                             |
| 111    | STIED | The rising edge of the selected trigger signal STI will clock the counter.                                                                                   |                           |                                                                                                                                                                                                                                                                      |
| [0]    | TSE   | Timer Synchronization Enable<br>0: No action<br>1: Master timer (current timer) will generate a delay to synchronize its slave timer through the MTO signal. |                           |                                                                                                                                                                                                                                                                      |

## Timer Trigger Configuration Register – TRCFR

This register specifies the trigger source selection of GPTM.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | TRSEL |    |    |    |
|            |          |    |    |    | RW    | 0  | RW | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TRSEL | <p>Trigger Source Selection</p> <p>These bits are used to select the trigger input (STI) for counter synchronizing.</p> <p>0000: Software Trigger by setting the UEVG bit</p> <p>0001: Filtered input of channel 0 (TI0S0)</p> <p>0010: Filtered input of channel 1 (TI1S1)</p> <p>0011: Reserved</p> <p>1000: Channel 0 Edge Detector (TI0BED)</p> <p>1001: Internal Timing Module Trigger 0 (ITI0)</p> <p>1010: Internal Timing Module Trigger 1 (ITI1)</p> <p>1011: Internal Timing Module Trigger 2 (ITI2)</p> <p>Others: Default 0</p> <p>Note: These bits must be updated only when they are not in use, i.e. the slave mode is disabled by setting the SMSEL field to 0x00.</p> |

**Table 33. GPTM Internal Trigger Connection**

| Slave Timing Module | ITI0  | ITI1  | ITI2  |
|---------------------|-------|-------|-------|
| GPTM0               | GPTM1 | MCTM0 | MCTM1 |
| GPTM1               | GPTM0 | MCTM0 | MCTM1 |

## Timer Counter Register – CTR

This register specifies the timer enable bit (TME), CRR buffer enable bit (CRBE) and Channel PDMA selection bit (CHCCDS).

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |      |        |
|------------|----------|----|----|----|----|----|------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25   | 24     |
| Type/Reset | Reserved |    |    |    |    |    |      |        |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17   | 16     |
| Type/Reset | Reserved |    |    |    |    |    |      | CHCCDS |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9    | 8      |
| Type/Reset | Reserved |    |    |    |    |    |      |        |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1    | 0      |
| Type/Reset | Reserved |    |    |    |    |    | CRBE | TME    |
|            |          |    |    |    |    |    | RW   | 0      |
|            |          |    |    |    |    |    | RW   | 0      |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                              |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [16] | CHCCDS | Channel PDMA event selection<br>0: Channel PDMA request derived from the channel capture/compare event.<br>1: Channel PDMA request derived from the Update event.                                                                                                                                                                                                                         |
| [1]  | CRBE   | Counter-Reload register Buffer Enable<br>0: Counter reload register can be updated immediately<br>1: Counter reload register can not be updated until the update event occurs                                                                                                                                                                                                             |
| [0]  | TME    | Timer Enable bit<br>0: GPTM off<br>1: GPTM on - GPTM functions normally<br>When the TME bit is cleared to 0, the counter is stopped and the GPTM consumes no power in any operation mode except for the single pulse mode and the slave trigger mode. In these two modes the TME bit can automatically be set to 1 by hardware which permits all the GPTM registers to function normally. |

## Channel 0 Input Configuration Register – CH0ICFR

This register specifies the channel 0 input mode configuration.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |          |    |    |        |    |        |    |
|------------|----------|----------|----|----|--------|----|--------|----|
|            | 31       | 30       | 29 | 28 | 27     | 26 | 25     | 24 |
|            | TI0SRC   | Reserved |    |    |        |    |        |    |
| Type/Reset | RW       | 0        |    |    |        |    |        |    |
|            | 23       | 22       | 21 | 20 | 19     | 18 | 17     | 16 |
|            | Reserved |          |    |    | CH0PSC |    | CH0CCS |    |
| Type/Reset |          |          |    |    | RW     | 0  | RW     | 0  |
|            | 15       | 14       | 13 | 12 | 11     | 10 | 9      | 8  |
|            | Reserved |          |    |    |        |    |        |    |
| Type/Reset |          |          |    |    |        |    |        |    |
|            | 7        | 6        | 5  | 4  | 3      | 2  | 1      | 0  |
|            | Reserved |          |    |    | TI0F   |    |        |    |
| Type/Reset |          |          |    |    | RW     | 0  | RW     | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31]    | TI0SRC | Channel 0 Input Source TI0 Selection<br>0: The GT_CH0 pin is connected to channel 0 input TI0<br>1: The XOR operation output of the GT_CH0, GT_CH1, and GT_CH2 pins are connected to the channel 0 input TI0                                                                                                                                                                                                                                                                                                                                                               |
| [19:18] | CH0PSC | Channel 0 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 0 capture input. Note that the prescaler is reset once the Channel 0 Capture/Compare Enable bit, CH0E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 0 capture input signal is chosen for each active event<br>01: Channel 0 Capture input signal is chosen for every 2 events<br>10: Channel 0 Capture input signal is chosen for every 4 events<br>11: Channel 0 Capture input signal is chosen for every 8 events |
| [17:16] | CH0CCS | Channel 0 Capture/Compare Selection<br>00: Channel 0 is configured as an output<br>01: Channel 0 is configured as an input derived from the TI0 signal<br>10: Channel 0 is configured as an input derived from the TI1 signal<br>11: Channel 0 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH0CCS field can be accessed only when the CH0E bit is cleared to 0.                                                                                                                                           |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TIOF  | <p>Channel 0 Input Source TIO Filter Setting</p> <p>These bits define the frequency divided ratio used to sample the TIO signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 8</math></p> |

## Channel 1 Input Configuration Register – CH1ICFR

This register specifies the channel 1 input mode configuration.

Offset: 0x024

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |        |    |
|------------|----------|----|----|----|--------|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    | CH1PSC |    | CH1CCS |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1      | 0  |
| Type/Reset | Reserved |    |    |    | TI1F   |    |        |    |
|            |          |    |    |    | RW     | 0  | RW     | 0  |
|            |          |    |    |    |        |    | RW     | 0  |
|            |          |    |    |    |        |    |        | RW |
|            |          |    |    |    |        |    |        | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CH1PSC | Channel 1 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 1 capture input. Note that the prescaler is reset once the Channel 1 Capture/Compare Enable bit, CH1E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 1 capture input signal is chosen for each active event<br>01: Channel 1 Capture input signal is chosen for every 2 events<br>10: Channel 1 Capture input signal is chosen for every 4 events<br>11: Channel 1 Capture input signal is chosen for every 8 events |
| [17:16] | CH1CCS | Channel 1 Capture/Compare Selection<br>00: Channel 1 is configured as an output<br>01: Channel 1 is configured as an input derived from the TI1 signal<br>10: Channel 1 is configured as an input derived from the TI0 signal<br>11: Channel 1 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH1CCS field can be accessed only when the CH1E bit is cleared to 0.                                                                                                                                           |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | T11F  | <p>Channel 1 Input Source T11 Filter Setting</p> <p>These bits define the frequency divided ratio used to sample the T11 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 8</math></p> |

## Channel 2 Input Configuration Register – CH2ICFR

This register specifies the channel 2 input mode configuration.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |        |    |
|------------|----------|----|----|----|--------|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    | CH2PSC |    | CH2CCS |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1      | 0  |
| Type/Reset | Reserved |    |    |    | TI2F   |    |        |    |
|            |          |    |    |    | RW     | 0  | RW     | 0  |
|            |          |    |    |    |        |    | RW     | 0  |
|            |          |    |    |    |        |    |        | RW |
|            |          |    |    |    |        |    |        | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CH2PSC | Channel 2 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 2 capture input. Note that the prescaler is reset once the Channel 2 Capture/Compare Enable bit, CH2E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 2 capture input signal is chosen for each active event<br>01: Channel 2 Capture input signal is chosen for every 2 events<br>10: Channel 2 Capture input signal is chosen for every 4 events<br>11: Channel 2 Capture input signal is chosen for every 8 events |
| [17:16] | CH2CCS | Channel 2 Capture/Compare Selection<br>00: Channel 2 is configured as an output<br>01: Channel 2 is configured as an input derived from the TI2 signal<br>10: Channel 2 is configured as an input derived from the TI3 signal<br>11: Channel 2 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH2CCS field can be accessed only when the CH2E bit is cleared to 0                                                                                                                                            |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TI2F  | <p>Channel 2 Input Source TI2 Filter Setting</p> <p>These bits define the frequency divided ratio used to sample the TI2 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 8</math></p> |

## Channel 3 Input Configuration Register – CH3ICFR

This register specifies the channel 3 input mode configuration.

Offset: 0x02C

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |        |    |
|------------|----------|----|----|----|--------|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    | CH3PSC |    | CH3CCS |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1      | 0  |
| Type/Reset | Reserved |    |    |    | TI3F   |    |        |    |
|            |          |    |    |    | RW     | 0  | RW     | 0  |
|            |          |    |    |    |        |    | RW     | 0  |
|            |          |    |    |    |        |    |        | RW |
|            |          |    |    |    |        |    |        | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CH3PSC | Channel 3 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 3 capture input. Note that the prescaler is reset once the Channel 3 Capture/Compare Enable bit, CH3E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 3 capture input signal is chosen for each active event<br>01: Channel 3 Capture input signal is chosen for every 2 events<br>10: Channel 3 Capture input signal is chosen for every 4 events<br>11: Channel 3 Capture input signal is chosen for every 8 events |
| [17:16] | CH3CCS | Channel 3 Capture/Compare Selection<br>00: Channel 3 is configured as an output<br>01: Channel 3 is configured as an input derived from the TI3 signal<br>10: Channel 3 is configured as an input derived from the TI2 signal<br>11: Channel 3 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH3CCS field can be accessed only when the CH3E bit is cleared to 0                                                                                                                                            |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TI3F  | <p>Channel 3 Input Source TI3 Filter Setting</p> <p>These bits define the frequency divided ratio used to sample the TI3 signal. The Digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 8</math></p> |

## Channel 0 Output Configuration Register – CH0OCFR

This register specifies the channel 0 output mode configuration.

Offset: 0x040

Reset value: 0x0000\_0000

|            |          |    |         |        |          |    |            |          |      |
|------------|----------|----|---------|--------|----------|----|------------|----------|------|
|            | 31       | 30 | 29      | 28     | 27       | 26 | 25         | 24       |      |
| Type/Reset | Reserved |    |         |        |          |    |            |          |      |
|            | 23       | 22 | 21      | 20     | 19       | 18 | 17         | 16       |      |
| Type/Reset | Reserved |    |         |        |          |    |            |          |      |
|            | 15       | 14 | 13      | 12     | 11       | 10 | 9          | 8        |      |
| Type/Reset | Reserved |    |         |        |          |    |            | CH0OM[3] |      |
|            |          |    |         |        |          |    |            |          | RW 0 |
|            | 7        | 6  | 5       | 4      | 3        | 2  | 1          | 0        |      |
| Type/Reset | Reserved |    | CH0IMAE | CH0PRE | Reserved |    | CH0OM[2:0] |          |      |
|            |          |    | RW 0    | RW 0   |          |    | RW 0       | RW 0     | RW 0 |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH0IMAE | Channel 0 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode is enabled<br>The CH0OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH0CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH0IMAE bit is available only if the channel 0 is configured to be operated in the PWM mode 1 or the PWM mode 2. |
| [4]  | CH0PRE  | Channel 0 Capture/Compare Register (CH0CCR) Preload Enable<br>0: CH0CCR preload function is disabled.<br>The CH0CCR register can be immediately assigned a new value when the CH0PRE bit is cleared to 0 and the updated CH0CCR value is used immediately.<br>1: CH0CCR preload function is enabled.<br>The new CH0CCR value will not be transferred to its shadow register until the update event occurs.                                                                                                                    |

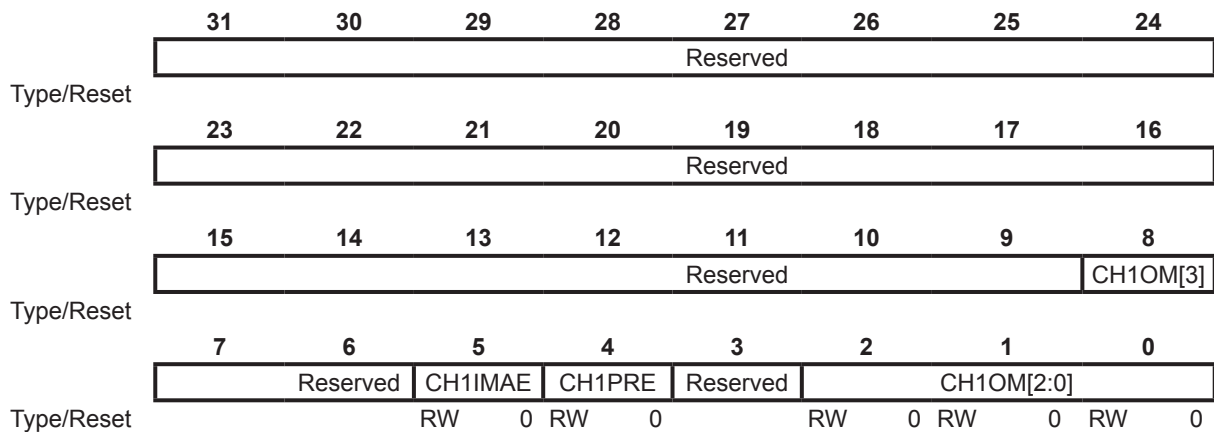
| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH0OM[3:0] | <p>Channel 0 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH0OREF.</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH0OREF is forced to 0</p> <p>0101: Force active – CH0OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 has an active level when CNTR &lt; CH0CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 0 has an inactive level when CNTR &gt; CH0CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 is has an inactive level when CNTR &lt; CH0CCR or otherwise has an active level.</li> <li>- During down-counting, channel 0 has an active level when CNTR &gt; CH0CCR or otherwise has an inactive level.</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 has an active level when CNTR &lt; CH0CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 0 has an inactive level when CNTR &gt; CH0CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 has an inactive level when CNTR &lt; CH0CCR or otherwise has an active level.</li> <li>- During down-counting, channel 0 has an active level when CNTR &gt; CH0CCR or otherwise has an inactive level</li> </ul> <p>Note: When channel 0 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel 1 Output Configuration Register – CH1OCFR

This register specifies the channel 1 output mode configuration.

Offset: 0x044

Reset value: 0x0000\_0000



| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH1IMAE | <p>Channel 1 Immediate Active Enable</p> <p>0: No action</p> <p>1: Single pulse Immediate Active Mode is enabled</p> <p>The CH1OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH1CCR values.</p> <p>The effective duration ends automatically at the next overflow or underflow event.</p> <p>Note: The CH1IMAE bit is available only if the channel 1 is configured to be operated in the PWM mode 1 or the PWM mode 2.</p> |
| [4]  | CH1PRE  | <p>Channel 1 Capture/Compare Register (CH1CCR) Preload Enable</p> <p>0: CH1CCR preload function is disabled.</p> <p>The CH1CCR register can be immediately assigned a new value when the CH1PRE bit is cleared to 0 and the updated CH1CCR value is used immediately.</p> <p>1: CH1CCR preload function is enabled</p> <p>The new CH1CCR value will not be transferred to its shadow register until the update event occurs.</p>                                                                                                                         |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH1OM[3:0] | <p>Channel 1 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH1OREF.</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH1OREF is forced to 0</p> <p>0101: Force active – CH1OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an active level when CNTR &lt; CH1CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 1 has an inactive level when CNTR &gt; CH1CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an inactive level when CNTR &lt; CH1CCR or otherwise has an active level.</li> <li>- During down-counting, channel 1 has an active level when CNTR &gt; CH1CCR or otherwise has an inactive level.</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an active level when CNTR &lt; CH1CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 1 has an inactive level when CNTR &gt; CH1CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an inactive level when CNTR &lt; CH1CCR or otherwise has an active level.</li> <li>- During down-counting, channel 1 has an active level when CNTR &gt; CH1CCR or otherwise has an inactive level.</li> </ul> <p>Note: When channel 1 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel 2 Output Configuration Register – CH2OCFR

This register specifies the channel 2 output mode configuration.

Offset: 0x048

Reset value: 0x0000\_0000

|            |          |    |         |        |          |            |    |          |
|------------|----------|----|---------|--------|----------|------------|----|----------|
|            | 31       | 30 | 29      | 28     | 27       | 26         | 25 | 24       |
| Type/Reset | Reserved |    |         |        |          |            |    |          |
|            | 23       | 22 | 21      | 20     | 19       | 18         | 17 | 16       |
| Type/Reset | Reserved |    |         |        |          |            |    |          |
|            | 15       | 14 | 13      | 12     | 11       | 10         | 9  | 8        |
| Type/Reset | Reserved |    |         |        |          |            |    | CH2OM[3] |
|            | 7        | 6  | 5       | 4      | 3        | 2          | 1  | 0        |
| Type/Reset | Reserved |    | CH2IMAE | CH2PRE | Reserved | CH2OM[2:0] |    |          |
|            | RW       |    | 0       | RW     | 0        | RW         | 0  | RW       |
|            |          |    |         |        |          |            |    | 0        |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH2IMAE | Channel 2 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode is enabled<br>The CH2OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH2CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH2IMAE bit is available only if the channel 2 is configured to be operated in the PWM mode 1 or the PWM mode 2. |
| [4]  | CH2PRE  | Channel 2 Capture/Compare Register (CH2CCR) Preload Enable<br>0: CH2CCR preload function is disabled.<br>The CH2CCR register can be immediately assigned a new value when the CH2PRE bit is cleared to 0 and the updated CH2CCR value is used immediately.<br>1: CH2CCR preload function is enabled<br>The new CH2CCR value will not be transferred to its shadow register until the update event occurs.                                                                                                                     |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH2OM[3:0] | <p>Channel 2 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH2OREF.</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH2OREF is forced to 0</p> <p>0101: Force active – CH2OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an active level when CNTR &lt; CH2CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 2 has an inactive level when CNTR &gt; CH2CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an inactive level when CNTR &lt; CH2CCR or otherwise has an active level.</li> <li>- During down-counting, channel 2 has an active level when CNTR &gt; CH2CCR or otherwise has an inactive level.</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an active level when CNTR &lt; CH2CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 2 has an inactive level when CNTR &gt; CH2CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an inactive level when CNTR &lt; CH2CCR or otherwise has an active level.</li> <li>- During down-counting, channel 2 has an active level when CNTR &gt; CH2CCR or otherwise has an inactive level.</li> </ul> <p>Note: When channel 2 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel 3 Output Configuration Register – CH3OCFR

This register specifies the channel 3 output mode configuration.

Offset: 0x04C

Reset value: 0x0000\_0000

|            |          |    |         |        |          |            |    |          |
|------------|----------|----|---------|--------|----------|------------|----|----------|
|            | 31       | 30 | 29      | 28     | 27       | 26         | 25 | 24       |
| Type/Reset | Reserved |    |         |        |          |            |    |          |
|            | 23       | 22 | 21      | 20     | 19       | 18         | 17 | 16       |
| Type/Reset | Reserved |    |         |        |          |            |    |          |
|            | 15       | 14 | 13      | 12     | 11       | 10         | 9  | 8        |
| Type/Reset | Reserved |    |         |        |          |            |    | CH3OM[3] |
|            | 7        | 6  | 5       | 4      | 3        | 2          | 1  | 0        |
| Type/Reset | Reserved |    | CH3IMAE | CH3PRE | Reserved | CH3OM[2:0] |    |          |
|            | RW       |    | 0       | RW     | 0        | RW         | 0  | RW       |
|            | 0        |    |         | 0      |          | 0          |    |          |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH3IMAE | Channel 3 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode is enabled<br>The CH3OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH3CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH3IMAE bit is available only if the channel 3 is configured to be operated in the PWM mode 1 or the PWM mode 2. |
| [4]  | CH3PRE  | Channel 3 Capture/Compare Register (CH3CCR) Preload Enable<br>0: CH3CCR preload function is disabled.<br>The CH3CCR register can be immediately assigned a new value when the CH3PRE bit is cleared to 0 and the updated CH3CCR value is used immediately.<br>1: CH3CCR preload function is enabled<br>The new CH3CCR value will not be transferred to its shadow register until the update event occurs.                                                                                                                     |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH3OM[3:0] | <p>Channel 3 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH3OREF</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH3OREF is forced to 0</p> <p>0101: Force active – CH3OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an active level when CNTR &lt; CH3CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 3 has an inactive level when CNTR &gt; CH3CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an inactive level when CNTR &lt; CH3CCR or otherwise has an active level.</li> <li>- During down-counting, channel 3 has an active level when CNTR &gt; CH3CCR or otherwise has an inactive level</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an active level when CNTR &lt; CH3CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 3 has an inactive level when CNTR &gt; CH3CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an inactive level when CNTR &lt; CH3CCR or otherwise has an active level.</li> <li>- During down-counting, channel 3 has an active level when CNTR &gt; CH3CCR or otherwise has an inactive level</li> </ul> <p>Note: When channel 3 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel Control Register – CHCTR

This register contains the channel capture input or compare output function enable control bits.

Offset: 0x050

Reset value: 0x0000\_0000

|            |          |      |          |      |          |      |          |      |
|------------|----------|------|----------|------|----------|------|----------|------|
|            | 31       | 30   | 29       | 28   | 27       | 26   | 25       | 24   |
| Type/Reset | Reserved |      |          |      |          |      |          |      |
|            | 23       | 22   | 21       | 20   | 19       | 18   | 17       | 16   |
| Type/Reset | Reserved |      |          |      |          |      |          |      |
|            | 15       | 14   | 13       | 12   | 11       | 10   | 9        | 8    |
| Type/Reset | Reserved |      |          |      |          |      |          |      |
|            | 7        | 6    | 5        | 4    | 3        | 2    | 1        | 0    |
| Type/Reset | Reserved | CH3E | Reserved | CH2E | Reserved | CH1E | Reserved | CH0E |
|            |          | RW   | 0        |      | RW       | 0    |          | RW   |
|            |          |      |          |      |          |      |          | 0    |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                            |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | CH3E  | Channel 3 Capture/Compare Enable<br>- Channel 3 is configured as an input (CH3CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 3 is configured as an output (CH3CCS = 0x00)<br>0: Off –Channel 3 output signal CH3O is not active<br>1: On –Channel 3 output signal CH3O generated on the corresponding output pin |
| [4]  | CH2E  | Channel 2 Capture/Compare Enable<br>- Channel 2 is configured as an input (CH2CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 2 is configured as an output (CH2CCS = 0x00)<br>0: Off –Channel 2 output signal CH2O is not active<br>1: On –Channel 2 output signal CH2O generated on the corresponding output pin |
| [2]  | CH1E  | Channel 1 Capture/Compare Enable<br>- Channel 1 is configured as an input (CH1CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 1 is configured as an output (CH1CCS = 0x00)<br>0: Off –Channel 1 output signal CH1O is not active<br>1: On –Channel 1 output signal CH1O generated on the corresponding output pin |
| [0]  | CH0E  | Channel 0 Capture/Compare Enable<br>- Channel 0 is configured as an input (CH0CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 0 is configured as an output (CH0CCS = 0x00)<br>0: Off –Channel 0 output signal CH0O is not active<br>1: On –Channel 0 output signal CH0O generated on the corresponding output pin |

## Channel Polarity Configuration Register – CHPOLR

This register contains the channel capture input or compare output polarity control.

Offset: 0x054

Reset value: 0x0000\_0000

|            |          |      |          |      |          |      |          |      |
|------------|----------|------|----------|------|----------|------|----------|------|
|            | 31       | 30   | 29       | 28   | 27       | 26   | 25       | 24   |
| Type/Reset | Reserved |      |          |      |          |      |          |      |
|            | 23       | 22   | 21       | 20   | 19       | 18   | 17       | 16   |
| Type/Reset | Reserved |      |          |      |          |      |          |      |
|            | 15       | 14   | 13       | 12   | 11       | 10   | 9        | 8    |
| Type/Reset | Reserved |      |          |      |          |      |          |      |
|            | 7        | 6    | 5        | 4    | 3        | 2    | 1        | 0    |
| Type/Reset | Reserved | CH3P | Reserved | CH2P | Reserved | CH1P | Reserved | CH0P |
|            | RW       | 0    | RW       | 0    | RW       | 0    | RW       | 0    |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                      |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | CH3P  | Channel 3 Capture/Compare Polarity<br>- When Channel 3 is configured as an input<br>0: capture event occurs on a Channel 3 rising edge<br>1: capture event occurs on a Channel 3 falling edge<br>- When Channel 3 is configured as an output (CH3CCS = 0x00)<br>0: Channel 3 Output active high<br>1: Channel 3 Output active low |
| [4]  | CH2P  | Channel 2 Capture/Compare Polarity<br>- When Channel 2 is configured as an input<br>0: capture event occurs on a Channel 2 rising edge<br>1: capture event occurs on a Channel 2 falling edge<br>- When Channel 2 is configured as an output (CH2CCS = 0x00)<br>0: Channel 2 Output active high<br>1: Channel 2 Output active low |
| [2]  | CH1P  | Channel 1 Capture/Compare Polarity<br>- When Channel 1 is configured as an input<br>0: capture event occurs on a Channel 1 rising edge<br>1: capture event occurs on a Channel 1 falling edge<br>- Channel 1 is configured as an output (CH1CCS = 0x00)<br>0: Channel 1 Output active high<br>1: Channel 1 Output active low      |
| [0]  | CH0P  | Channel 0 Capture/Compare Polarity<br>- When Channel 0 is configured as an input<br>0: capture event occurs on a Channel 0 rising edge<br>1: capture event occurs on a Channel 0 falling edge<br>- When Channel 0 is configured as an output (CH0CCS = 0x00)<br>0: Channel 0 Output active high<br>1: Channel 0 Output active low |

## Timer PDMA/Interrupt Control Register – DICTR

This register contains the timer PDMA and interrupt enable control bits.

Offset: 0x074

Reset value: 0x0000\_0000

|            |          |    |    |    |         |         |          |         |
|------------|----------|----|----|----|---------|---------|----------|---------|
|            | 31       | 30 | 29 | 28 | 27      | 26      | 25       | 24      |
|            | Reserved |    |    |    |         | TEVDE   | Reserved | UEVDE   |
| Type/Reset |          |    |    |    |         | RW 0    |          | RW 0    |
|            | 23       | 22 | 21 | 20 | 19      | 18      | 17       | 16      |
|            | Reserved |    |    |    | CH3CCDE | CH2CCDE | CH1CCDE  | CH0CCDE |
| Type/Reset |          |    |    |    | RW 0    | RW 0    | RW 0     | RW 0    |
|            | 15       | 14 | 13 | 12 | 11      | 10      | 9        | 8       |
|            | Reserved |    |    |    |         | TEVIE   | Reserved | UEVIE   |
| Type/Reset |          |    |    |    |         | RW 0    |          | RW 0    |
|            | 7        | 6  | 5  | 4  | 3       | 2       | 1        | 0       |
|            | Reserved |    |    |    | CH3CCIE | CH2CCIE | CH1CCIE  | CH0CCIE |
| Type/Reset |          |    |    |    | RW 0    | RW 0    | RW 0     | RW 0    |

| Bits | Field   | Descriptions                                                                                                             |
|------|---------|--------------------------------------------------------------------------------------------------------------------------|
| [26] | TEVDE   | Trigger event PDMA Request Enable<br>0: Trigger PDMA request disabled<br>1: Trigger PDMA request enabled                 |
| [24] | UEVDE   | Update event PDMA Request Enable<br>0: Update event PDMA request disabled<br>1: Update event PDMA request enabled        |
| [19] | CH3CCDE | Channel 3 Capture/Compare PDMA Request Enable<br>0: Channel 3 PDMA request disabled<br>1: Channel 3 PDMA request enabled |
| [18] | CH2CCDE | Channel 2 Capture/Compare PDMA Request Enable<br>0: Channel 2 PDMA request disabled<br>1: Channel 2 PDMA request enabled |
| [17] | CH1CCDE | Channel 1 Capture/Compare PDMA Request Enable<br>0: Channel 1 PDMA request disabled<br>1: Channel 1 PDMA request enabled |
| [16] | CH0CCDE | Channel 0 Capture/Compare PDMA Request Enable<br>0: Channel 0 PDMA request disabled<br>1: Channel 0 PDMA request enabled |
| [10] | TEVIE   | Trigger event Interrupt Enable<br>0: Trigger event interrupt disabled<br>1: Trigger event interrupt enabled              |
| [8]  | UEVIE   | Update event Interrupt Enable<br>0: Update event interrupt disabled<br>1: Update event interrupt enabled                 |
| [3]  | CH3CCIE | Channel 3 Capture/Compare Interrupt Enable<br>0: Channel 3 interrupt disabled<br>1: Channel 3 interrupt enabled          |
| [2]  | CH2CCIE | Channel 2 Capture/Compare Interrupt Enable<br>0: Channel 2 interrupt disabled<br>1: Channel 2 interrupt enabled          |

| Bits | Field   | Descriptions                                                                                                    |
|------|---------|-----------------------------------------------------------------------------------------------------------------|
| [1]  | CH1CCIE | Channel 1 Capture/Compare Interrupt Enable<br>0: Channel 1 interrupt disabled<br>1: Channel 1 interrupt enabled |
| [0]  | CH0CCIE | Channel 0 Capture/Compare Interrupt Enable<br>0: Channel 0 interrupt disabled<br>1: Channel 0 interrupt enabled |

## Timer Event Generator Register – EVGR

This register contains the software event generation bits.

Offset: 0x078

Reset value: 0x0000\_0000

|            |          |    |    |    |        |        |          |        |
|------------|----------|----|----|----|--------|--------|----------|--------|
|            | 31       | 30 | 29 | 28 | 27     | 26     | 25       | 24     |
| Type/Reset | Reserved |    |    |    |        |        |          |        |
|            | 23       | 22 | 21 | 20 | 19     | 18     | 17       | 16     |
| Type/Reset | Reserved |    |    |    |        |        |          |        |
|            | 15       | 14 | 13 | 12 | 11     | 10     | 9        | 8      |
| Type/Reset | Reserved |    |    |    |        | TEVG   | Reserved | UEVG   |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1        | 0      |
| Type/Reset | Reserved |    |    |    | CH3CCG | CH2CCG | CH1CCG   | CH0CCG |
|            |          |    |    |    | WO     | 0      | WO       | 0      |
|            |          |    |    |    |        | WO     | 0        | WO     |
|            |          |    |    |    |        |        | WO       | 0      |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | TEVG   | <p>Trigger Event Generation</p> <p>The trigger event TEV can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: TEVIF flag is set</p>                                                                                                                                                                                                                                                                                     |
| [8]  | UEVG   | <p>Update Event Generation</p> <p>The update event UEV can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Reinitialize the counter</p> <p>The counter value returns to 0 or the CRR preload value, depending on the counter mode in which the current timer is being used. An update operation of any related registers will also be performed. For more detail descriptions, refer to the corresponding section.</p> |
| [3]  | CH3CCG | <p>Channel 3 Capture/Compare Generation</p> <p>A Channel 3 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel 3</p> <p>If Channel 3 is configured as an input, the counter value is captured into the CH3CCR register and then the CH3CCIF bit is set. If Channel 3 is configured as an output, the CH3CCIF bit is set.</p>                       |
| [2]  | CH2CCG | <p>Channel 2 Capture/Compare Generation</p> <p>A Channel 2 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel 2</p> <p>If Channel 2 is configured as an input, the counter value is captured into the CH2CCR register and then the CH2CCIF bit is set. If Channel 2 is configured as an output, the CH2CCIF bit is set.</p>                       |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | CH1CCG | <p>Channel 1 Capture/Compare Generation</p> <p>A Channel 1 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action</p> <p>1: Capture/compare event is generated on channel 1</p> <p>If Channel 1 is configured as an input, the counter value is captured into the CH1CCR register and then the CH1CCIF bit is set. If Channel 1 is configured as an output, the CH1CCIF bit is set.</p> |
| [0]  | CH0CCG | <p>Channel 0 Capture/Compare Generation</p> <p>A Channel 0 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action</p> <p>1: Capture/compare event is generated on channel 0</p> <p>If Channel 0 is configured as an input, the counter value is captured into the CH0CCR register and then the CH0CCIF bit is set. If Channel 0 is configured as an output, the CH0CCIF bit is set.</p> |

## Timer Interrupt Status Register – INTSR

This register stores the timer interrupt status.

Offset: 0x07C

Reset value: 0x0000\_0000

|            |          |        |        |        |         |         |          |         |
|------------|----------|--------|--------|--------|---------|---------|----------|---------|
|            | 31       | 30     | 29     | 28     | 27      | 26      | 25       | 24      |
| Type/Reset | Reserved |        |        |        |         |         |          |         |
|            | 23       | 22     | 21     | 20     | 19      | 18      | 17       | 16      |
| Type/Reset | Reserved |        |        |        |         |         |          |         |
|            | 15       | 14     | 13     | 12     | 11      | 10      | 9        | 8       |
| Type/Reset | Reserved |        |        |        |         | TEVIF   | Reserved | UEVIF   |
|            | 7        | 6      | 5      | 4      | 3       | 2       | 1        | 0       |
| Type/Reset | CH3OCF   | CH2OCF | CH1OCF | CH0OCF | CH3CCIF | CH2CCIF | CH1CCIF  | CH0CCIF |
|            | RW       | 0      | RW     | 0      | RW      | 0       | RW       | 0       |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                  |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | TEVIF  | Trigger Event Interrupt Flag<br>This flag is set by hardware on a trigger event and is cleared by software.<br>0: No trigger event occurs<br>1: Trigger event occurs                                                                                                                                                                                                          |
| [8]  | UEVIF  | Update Event Interrupt Flag.<br>This bit is set by hardware on an update event and is cleared by software.<br>0: No update event occurs<br>1: Update event occurs<br>Note: The update event is derived from the following conditions:<br>- The counter overflows or underflows<br>- The UEVG bit is asserted<br>- A restart trigger event occurs from the slave trigger input |
| [7]  | CH3OCF | Channel 3 Over-Capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH3CCIF bit is already set and it is not yet cleared by software                                                                                                                                       |
| [6]  | CH2OCF | Channel 2 Over-Capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH2CCIF bit is already set and it is not cleared yet by software                                                                                                                                       |
| [5]  | CH1OCF | Channel 1 Over-Capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH1CCIF bit is already set and it is not cleared yet by software.                                                                                                                                      |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4]  | CH0OCF  | Channel 0 Over-Capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH0CCIFbit is already set and it is not yet cleared by software.                                                                                                                                                                                                                                                                                                                                   |
| [3]  | CH3CCIF | Channel 3 Capture/Compare Interrupt Flag<br>- Channel 3 is configured as an output:<br>0: No match event occurs<br>1: The contents of the counter CNTR have matched the contents of the CH3CCR register.<br>This flag is set by hardware when the counter value matches the CH3CCR value except in the center-aligned mode. It is cleared by software.<br>- Channel 3 is configured as an input:<br>0: No input capture occurs<br>1: Input capture occurs<br>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH3CCR register. |
| [2]  | CH2CCIF | Channel 2 Capture/Compare Interrupt Flag<br>- Channel 2 is configured as an output:<br>0: No match event occurs<br>1: The contents of the counter CNTR have matched the contents of the CH2CCR register<br>This flag is set by hardware when the counter value matches the CH2CCR value except in the center-aligned mode. It is cleared by software.<br>- Channel 2 is configured as an input:<br>0: No input capture occurs<br>1: Input capture occurs.<br>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH2CCR register. |
| [1]  | CH1CCIF | Channel 1 Capture/Compare Interrupt Flag<br>- Channel 1 is configured as an output:<br>0: No match event occurs<br>1: The contents of the counter CNTR have matched the contents of the CH1CCR register<br>This flag is set by hardware when the counter value matches the CH1CCR value except in the center-aligned mode. It is cleared by software.<br>- Channel 1 is configured as an input:<br>0: No input capture occurs<br>1: Input capture occurs<br>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH1CCR register.  |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | CH0CCIF | <p>Channel 0 Capture/Compare Interrupt Flag</p> <ul style="list-style-type: none"><li>- Channel 0 is configured as an output:<ul style="list-style-type: none"><li>0: No match event occurs</li><li>1: The contents of the counter CNTR have matched the content of the CH0CCR register</li></ul>This flag is set by hardware when the counter value matches the CH0CCR value except in the center-aligned mode. It is cleared by software.</li><li>- Channel 0 is configured as an input:<ul style="list-style-type: none"><li>0: No input capture occurs</li><li>1: Input capture occurs</li></ul>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH0CCR register.</li></ul> |

## Timer Counter Register – CNTR

This register stores the timer counter value.

Offset: 0x080

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset |          |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset |          |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
|            | CNTV     |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|            | CNTV     |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field | Descriptions   |
|--------|-------|----------------|
| [15:0] | CNTV  | Counter Value. |

## Timer Prescaler Register – PSCR

This register specifies the timer prescaler value to generate the counter clock.

Offset: 0x084

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PSCV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PSCV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                 |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PSCV  | <p>Prescaler Value</p> <p>These bits are used to specify the prescaler value to generate the counter clock frequency <math>f_{CK\_CNT}</math>.</p> $f_{CK\_CNT} = \frac{f_{CK\_PSC}}{PSCV[15:0] + 1}, \text{ where the } f_{CK\_PSC} \text{ is the prescaler clock source.}$ |

## Timer Counter Reload Register – CRR

This register specifies the timer counter reload value.

Offset: 0x088

Reset value: 0x0000\_FFFF

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CRV      |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 1  | RW | 1  | RW | 1  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CRV      |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 1  | RW | 1  | RW | 1  | RW |

| Bits   | Field | Descriptions                                                                                          |
|--------|-------|-------------------------------------------------------------------------------------------------------|
| [15:0] | CRV   | Counter Reload Value<br>The CRV is the reload value which is loaded into the actual counter register. |

## Channel 0 Capture/Compare Register – CH0CCR

This register specifies the timer channel 0 capture/compare value.

Offset: 0x090

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH0CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH0CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH0CCV | <p>Channel 0 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 0 is configured as an output<br/>The CH0CCR value is compared with the counter value and the comparison result is used to trigger the CH0OREF output signal.</li> <li>- When Channel 0 is configured as an input<br/>The CH0CCR register stores the counter value captured by the last channel 0 capture event.</li> </ul> |

## Channel 1 Capture/Compare Register – CH1CCR

This register specifies the timer channel 1 capture/compare value.

Offset: 0x094

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH1CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH1CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH1CCV | <p>Channel 1 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 1 is configured as an output<br/>The CH1CCR value is compared with the counter value and the comparison result is used to trigger the CH1OREF output signal.</li> <li>- When Channel 1 is configured as an input<br/>The CH1CCR register stores the counter value captured by the last channel 1 capture event.</li> </ul> |

## Channel 2 Capture/Compare Register – CH2CCR

This register specifies the timer channel 2 capture/compare value.

Offset: 0x098

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH2CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH2CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH2CCV | <p>Channel 2 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 2 is configured as an output<br/>The CH2CCR value is compared with the counter value and the comparison result is used to trigger the CH2OREF output signal.</li> <li>- When Channel 2 is configured as an input<br/>The CH2CCR register stores the counter value captured by the last channel 2 capture event.</li> </ul> |

## Channel 3 Capture/Compare Register – CH3CCR

This register specifies the timer channel 3 capture/compare value.

Offset: 0x09C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH3CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH3CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH3CCV | <p>Channel 3 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 3 is configured as an output<br/>The CH3CCR value is compared with the counter value and the comparison result is used to trigger the CH3OREF output signal.</li> <li>- When Channel 3 is configured as an input<br/>The CH3CCR register stores the counter value captured by the last channel 3 capture event.</li> </ul> |

## Channel 0 Asymmetric Compare Register – CH0ACR

This register specifies the timer channel 0 asymmetric compare value.

Offset: 0x0A0

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH0ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH0ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                    |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH0ACV | Channel 0 Asymmetric Compare Value<br>When channel 0 is configured as asymmetric PWM mode and the counter is counting down, the value written in this register will be compared to the counter. |

## Channel 1 Asymmetric Compare Register – CH1ACR

This register specifies the timer channel 1 asymmetric compare value.

Offset: 0x0A4

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH1ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH1ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                    |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH1ACV | Channel 1 Asymmetric Compare Value<br>When channel 1 is configured as asymmetric PWM mode and the counter is counting down, the value written in this register will be compared to the counter. |

## Channel 2 Asymmetric Compare Register – CH2ACR

This register specifies the timer channel 2 asymmetric compare value.

Offset: 0x0A8

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH2ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH2ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                    |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH2ACV | Channel 2 Asymmetric Compare Value<br>When channel 2 is configured as asymmetric PWM mode and the counter is counting down, the value written in this register will be compared to the counter. |

## Channel 3 Asymmetric Compare Register – CH3ACR

This register specifies the timer channel 3 asymmetric compare value.

Offset: 0x0AC

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH3ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH3ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                    |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH3ACV | Channel 3 Asymmetric Compare Value<br>When channel 3 is configured as asymmetric PWM mode and the counter is counting down, the value written in this register will be compared to the counter. |

# 15 Basic Function Timer (BFTM)

## Introduction

The Basic Function Timer Module, BFTM, is a 32-bit up-counting counter designed to measure time intervals, generate one shot pulses or generate repetitive interrupts. The BFTM can operate in two modes which are repetitive and one shot modes. The repetitive mode restarts the counter at each compare match event which is generated by the internal comparator. The BFTM also supports a one shot mode which will force the counter to stop counting when a compare match event occurs.

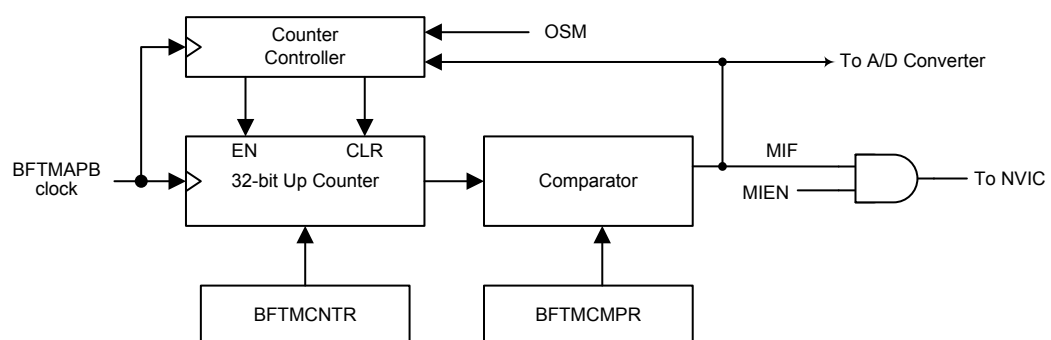


Figure 69. BFTM Block Diagram

## Features

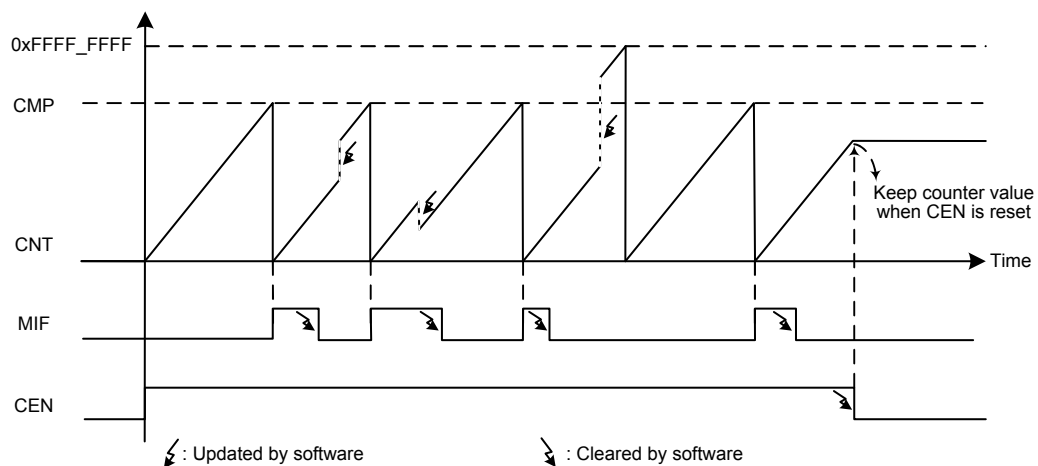
- 32-bit up-counting counter
- Compare Match function
- Includes debug mode
- Clock source: BFTM APB clock
- Counter value can be R/W on the fly
- One shot mode: counter stops counting when compare match occurs
- Repetitive mode: counter restarts when compare match occurs
- Compare Match interrupt enable/disable control

## Functional Description

The BFTM is a 32-bit up-counting counter which is driven by the BFTM APB clock, PCLK. The counter value can be changed or read at any time even when the timer is counting. The BFTM supports two operating modes known as the repetitive mode and one shot mode allowing the measurement of time intervals or the generation of periodic time durations.

### Repetitive Mode

The BFTM counts up from zero to a specific compare value which is pre-defined by the BFTMCMPR register. When the BFTM operates in the repetitive mode and the counter reaches a value equal to the specific compare value in the BFTMCMPR register, the timer will generate a compare match event signal, MIF. When this occurs, the counter will be reset to 0 and resume its counting operation. When the MIF signal is generated, a BFTM compare match interrupt will also be generated periodically if the compare match interrupt is enabled by setting the corresponding interrupt control bit, MIEN, to 1. The counter value will remain unchanged and the counter will stop counting if it is disabled by clearing the CEN bit to 0.



**Figure 70. BFTM – Repetitive Mode**

## One Shot Mode

By setting the OSM bit in BFTMCR register to 1, the BFTM will operate in the one shot mode. The BFTM starts to count when the CEN bit is set to 1 by the application program. The counter value will remain unchanged if the CEN bit is cleared to 0 by the application program. However, the counter value will be reset to 0 and stop counting when the CEN bit is cleared automatically to 0 by the internal hardware when a counter compare match event occurs.

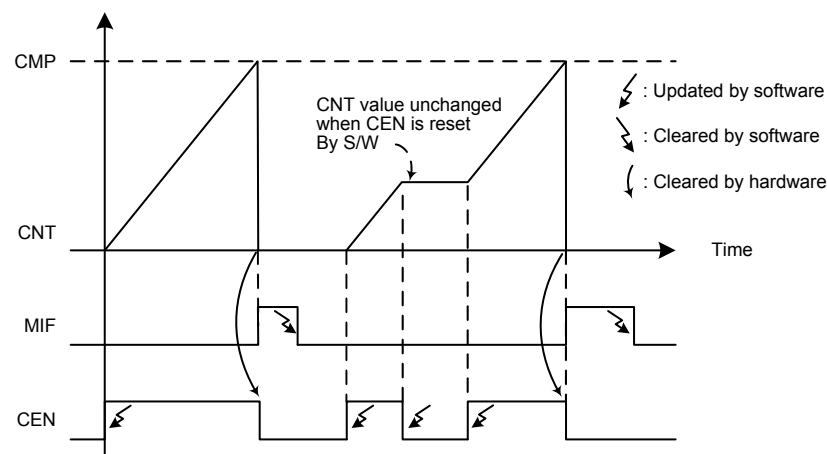


Figure 71. BFTM – One Shot Mode

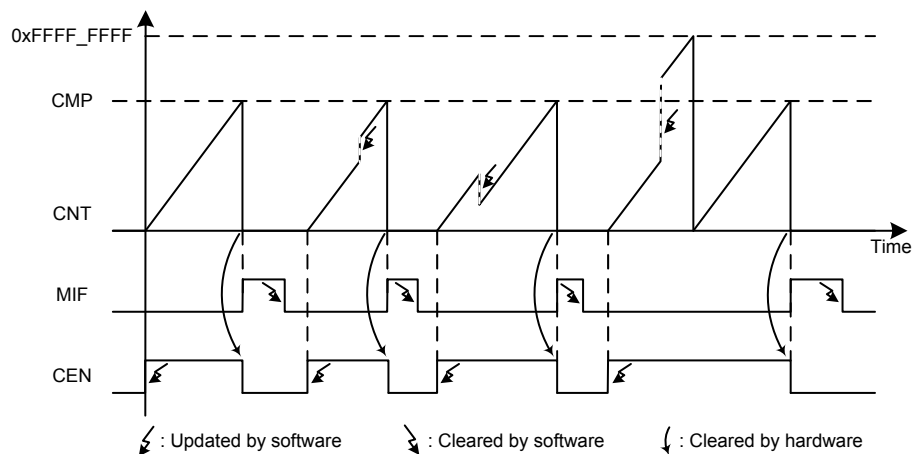


Figure 72. BFTM – One Shot Mode Counter Updating

## Trigger ADC Start

When a BFTM compare match event occurs, a compare match interrupt flag, MIF, will be generated which can be used as an A/D Converter input trigger source.

## Register Map

The following table shows the BFTM registers and their reset values.

**Table 34. BFTM Register Map**

| Register | Offset | Description                 | Reset Value |
|----------|--------|-----------------------------|-------------|
| BFTMCR   | 0x000  | BFTM Control Register       | 0x0000_0000 |
| BFTMSR   | 0x004  | BFTM Status Register        | 0x0000_0000 |
| BFTMCNTR | 0x008  | BFTM Counter Value Register | 0x0000_0000 |
| BFTMCMR  | 0x00C  | BFTM Compare Value Register | 0xFFFF_FFFF |

## Register Descriptions

### BFTM Control Register – BFTMCR

This register specifies the overall BFTM control bits.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |     |     |      |
|------------|----------|----|----|----|----|-----|-----|------|
|            | 31       | 30 | 29 | 28 | 27 | 26  | 25  | 24   |
| Type/Reset | Reserved |    |    |    |    |     |     |      |
|            | 23       | 22 | 21 | 20 | 19 | 18  | 17  | 16   |
| Type/Reset | Reserved |    |    |    |    |     |     |      |
|            | 15       | 14 | 13 | 12 | 11 | 10  | 9   | 8    |
| Type/Reset | Reserved |    |    |    |    |     |     |      |
|            | 7        | 6  | 5  | 4  | 3  | 2   | 1   | 0    |
| Type/Reset | Reserved |    |    |    |    | CEN | OSM | MIEN |
|            |          |    |    |    |    | RW  | 0   | RW   |
|            |          |    |    |    |    |     | 0   | RW   |
|            |          |    |    |    |    |     |     | 0    |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | CEN   | BFTM Counter Enable Control<br>0: BFTM is disabled<br>1: BFTM is enabled<br>When this bit is set to 1, the BFTM counter will start to count. The counter will stop counting and the counter value will remain unchanged when the CEN bit is cleared to 0 by the application program regardless of whether it is in the repetitive or one shot mode. However, in the one shot mode, the counter will stop counting and be reset to 0 when the CEN bit is cleared to 0 by the timer hardware circuitry which results from a compare match event. |
| [1]  | OSM   | BFTM One Shot Mode Selection<br>0: Counter operates in repetitive mode<br>1: Counter operates in one shot mode                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| [0]  | MIEN  | BFTM Compare Match Interrupt Enable Control<br>0: Compare Match Interrupt is disabled<br>1: Compare Match Interrupt is enabled                                                                                                                                                                                                                                                                                                                                                                                                                 |

## BFTM Status Register – BFTMSR

This register specifies the BFTM status.

Offset: 0x004

Reset value: 0x0000\_0004

|            |          |    |    |    |    |    |    |       |
|------------|----------|----|----|----|----|----|----|-------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24    |
| Type/Reset | Reserved |    |    |    |    |    |    |       |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16    |
| Type/Reset | Reserved |    |    |    |    |    |    |       |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8     |
| Type/Reset | Reserved |    |    |    |    |    |    |       |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0     |
| Type/Reset | Reserved |    |    |    |    |    |    | MIF   |
|            |          |    |    |    |    |    |    | W0C 0 |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                      |
|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | MIF   | <p>BFTM Compare Match Interrupt Flag</p> <p>0: No compare match event occurs</p> <p>1: Compare match event occurs</p> <p>When the counter value, CNT, is equal to the compare register value, CMP, a compare match event will occur and the corresponding interrupt flag, MIF will be set. The MIF bit is cleared to 0 by writing a data "0".</p> |

## BFTM Counter Register – BFTMCNTR

This register specifies the BFTMn counter value.

Offset: 0x008

Reset value: 0x0000\_0000

|            |     |    |    |    |    |    |    |    |    |
|------------|-----|----|----|----|----|----|----|----|----|
|            | 31  | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | CNT |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23  | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | CNT |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15  | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | CNT |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7   | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | CNT |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                          |
|--------|-------|-----------------------------------------------------------------------------------------------------------------------|
| [31:0] | CNT   | BFTM Counter Register<br>A 32-bit BFTM counter value is stored in this field which can be read or written on-the-fly. |

## BFTM Compare Value Register – BFTMCMPR

The register specifies the BFTM compare value.

Offset: 0x00C

Reset value: 0xFFFF\_FFFF

|            |     |    |    |    |    |    |    |    |    |
|------------|-----|----|----|----|----|----|----|----|----|
|            | 31  | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | CMP |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 1  | RW | 1  | RW | 1  | RW | 1  | RW |
|            | 23  | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | CMP |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 1  | RW | 1  | RW | 1  | RW | 1  | RW |
|            | 15  | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | CMP |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 1  | RW | 1  | RW | 1  | RW | 1  | RW |
|            | 7   | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | CMP |    |    |    |    |    |    |    |    |
| Type/Reset | RW  | 1  | RW | 1  | RW | 1  | RW | 1  | RW |

| Bits   | Field | Descriptions                                                                                                                                 |
|--------|-------|----------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | CMP   | BFTM Compare Value Register<br>This register specifies a 32-bit BFTM compare value which is used for comparison with the BFTM counter value. |

## Motor Control Timer (MCTM)

The Motor Control Timer consists of one 16-bit up/down-counter, four 16-bit Capture/Compare Registers (CCRs), one 16-bit Counter-Reload Register (CRR), one 8-bit Repetition Counter (REPR) and several control/status registers. It can be used for a variety of purposes which include general time measurement, input signal pulse width measurement, output waveform generation for signals such as single pulse generation or PWM generation, including dead time insertion.



## Features

- 16-bit up/down auto-reload counter.
- 16-bit programmable prescaler that allows division the counter clock frequency by any factor between 1 and 65536.
- Up to 4 independent channels for:
  - Input Capture function
  - Compare Match Output
  - PWM waveform Generation – Edge and Center-aligned Counting Mode
  - Single Pulse Mode Output
- Complementary Outputs with programmable dead-time insertion
- Repetition counter updates timer registers only after a given number of counter cycles.
- Synchronization circuit controls the timer with external signals and can interconnect several timers together.
- Interrupt/PDMA generation on the following events:
  - Update event 1
  - Update event 2
  - Trigger event
  - Input capture event
  - Output compare match
  - Break event – only interrupt
- MCTM Master/Slave mode controller
- Supports 3-phase motor control and hall sensor interface
- Break input signals to assert the timer output signals in reset state or in a known state

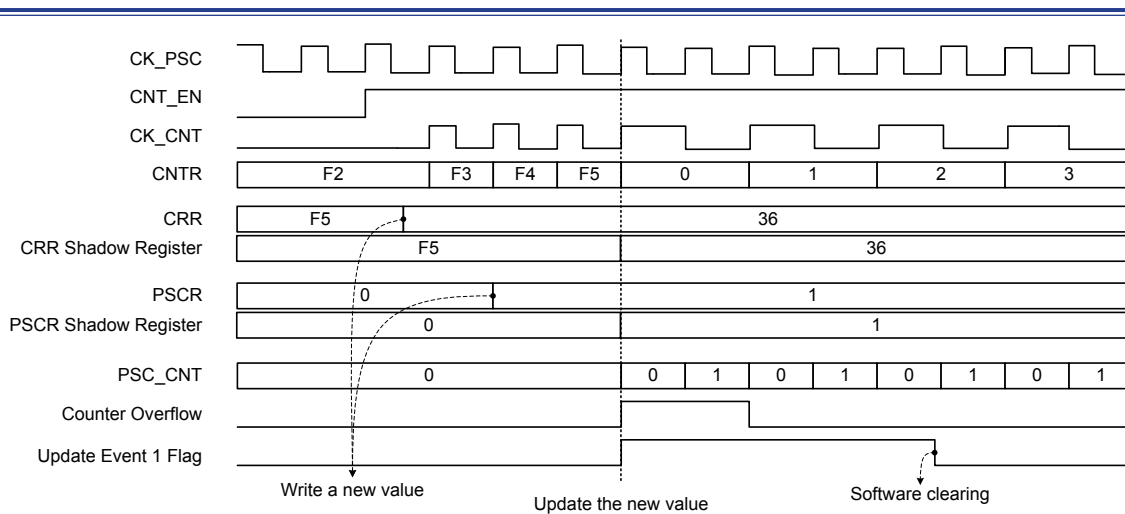
## Functional Descriptions

### Counter Mode

#### Up-Counting

In this mode the counter counts continuously from 0 to the counter-reload value, which is defined in the CRR register, in a count-up direction. Once the counter reaches the counter-reload value, the Timer Module generates an overflow event and the counter restarts to count once again from 0. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 0 for the up-counting mode.

When an update event 1 is generated by setting the UEV1G bit in the EVGR register to 1, the counter value will also be initialised to 0.

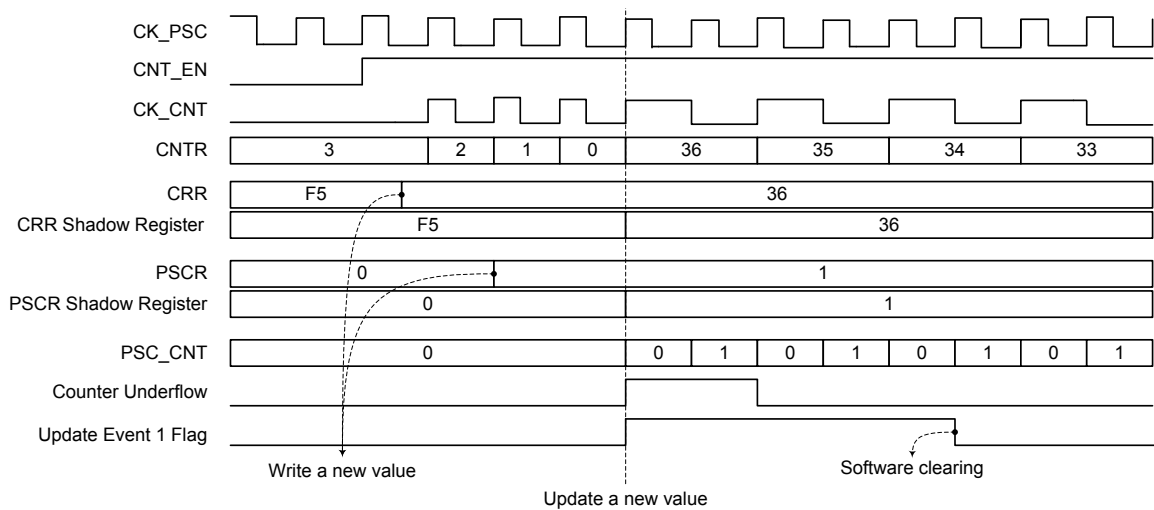


**Figure 74. Up-counting Example**

### Down-Counting

In this mode the counter counts continuously from the counter-reload value, which is defined in the CRR register, to 0 in a count-down direction. Once the counter reaches 0, the Timer module generates an underflow event and the counter restarts to count once again from the counter-reload value. This action will continue repeatedly. The counting direction bit DIR in the CNTCFR register should be set to 1 for the down-counting mode.

When an update event 1 is generated by setting the UEV1G bit in the EVGR register to 1, the counter value will also be initialised to the counter-reload value.



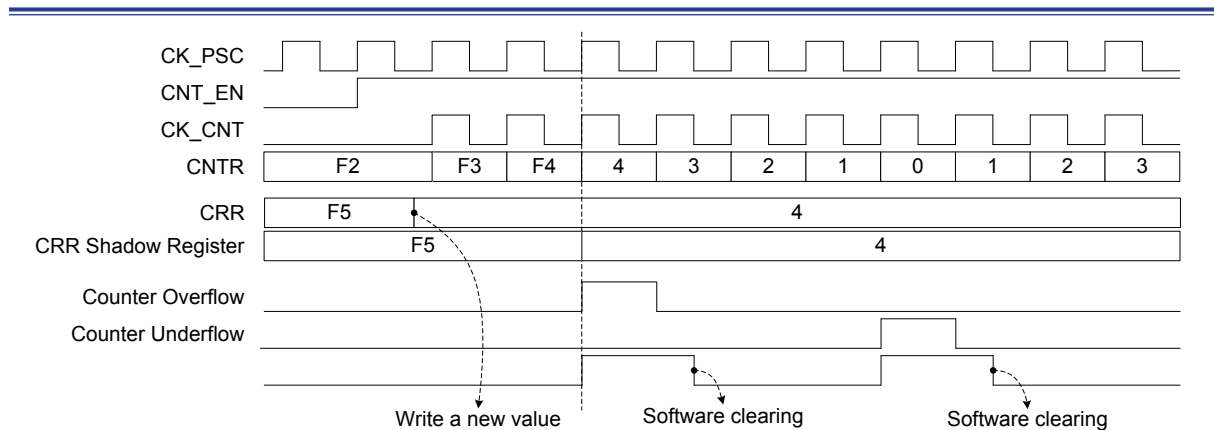
**Figure 75. Down-counting Example**

### Center-aligned Counting

In the center-aligned counting mode, the counter counts up from 0 to the counter-reload value and then counts down to 0 alternatively. The Timer Module generates an overflow event when the counter counts to the counter-reload value in the up-counting mode and generates an underflow event when the counter counts to 0 in the down-counting mode. The counting direction bit DIR in the CNTCFR register is read-only and indicates the count direction when in the center-aligned counting mode. The count direction is updated by hardware automatically.

Setting the UEVIG bit in the EVGR register will initialise the counter value to 0 irrespective of whether the counter is counting up or down in the center-aligned counting mode.

The UEV1IF bit in the INTSR register can be set to 1 according to the CMSEL field setting in the CNTCFR register. When CMSEL=0x01, an underflow event will set the UEV1IF bit to 1. When CMSEL=0x10, an overflow event will set the UEV1IF bit to 1. When CMSEL=0x11, either underflow or overflow event will set the UEV1IF bit to 1.

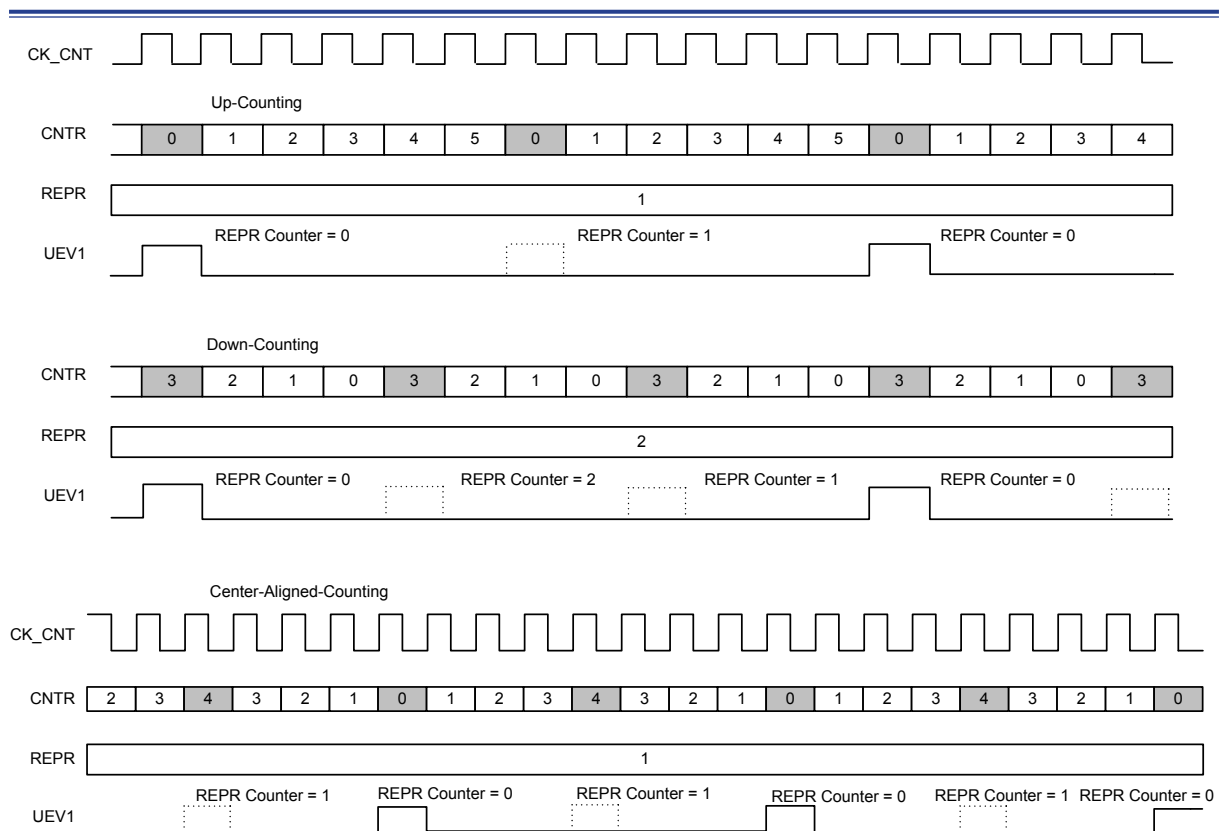


**Figure 76. Center-aligned Counting Example**

### Repetition Down-counter Operation

The update event 1 is usually generated at each overflow or underflow event occurrence. However, when the repetition operation is active by assigning a non-zero value into the REPR register, the update event is only generated if the REPR counter has reached zero. The REPR value is decreased when the following conditions occur:

- At each counter overflow in the up-counting mode
- At each counter underflow in the down-counting mode
- At each counter overflow and underflow in the center-aligned counting mode



**Figure 77. Update Event 1 Dependent Repetition Mechanism Example**

## Clock Controller

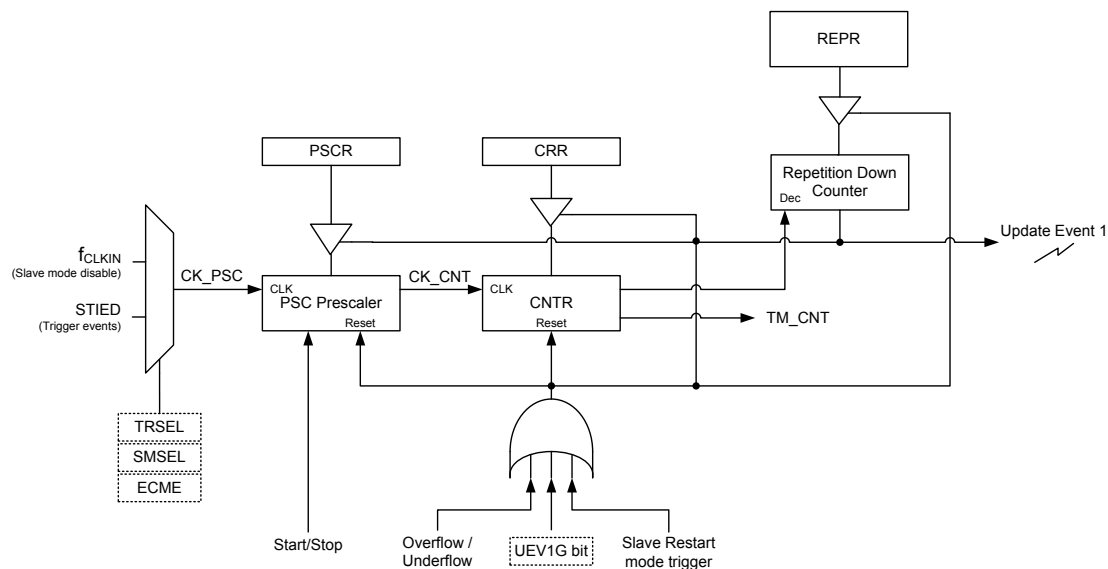
The following describes the Timer Module clock controller which determines the internal prescaler counter clock source.

### ■ Internal APB clock $f_{CLKIN}$

The default internal clock source is the APB clock  $f_{CLKIN}$  which is used to drive the counter prescaler when the slave mode is disabled. When the slave mode selection bits SMSEL are set to 0x4, 0x5 or 0x6, the internal APB clock  $f_{CLKIN}$  is the counter prescaler driving clock source.

### ■ STIED

The counter prescaler can count during each rising edge of the STI signal. This mode can be selected by setting the SMSEL field to 0x7 in the MDCFR register. Here the counter will act as an event counter. The input event, known as STI here, can be selected by setting the TRSEL field to an available value except the value of 0x0. When the STI signal is selected as the clock source, the internal edge detection circuitry will generate a clock pulse during each STI signal rising edge to drive the counter prescaler. It is important to note that if the TRSEL field is set to 0x0 to select the software UEV1G bit as the trigger source, then when the SMSEL field is set to 0x7, the counter will be updated instead of counting.



**Figure 78. MCTM Clock Selection Source**

The trigger controller is used to select the trigger source and setup the trigger level and edge trigger conditions. For the internal trigger input (ITIx), it can be selected by the Trigger Selection bits, TRSEL, in the TRCFR register. For all the trigger sources except the UEVI<sub>G</sub> bit software trigger, the internal edge detection circuitry will generate a clock pulse at each trigger signal rising edge to activate some MCTM functions which are triggered by a trigger signal rising edge.

## Motor Control Timer (MCTM)



## Slave Controller

The MCTM can be synchronised with an internal/external trigger in several modes including the Restart mode, the Pause mode and the Trigger mode which are selected by the SMSEL field in the MDCFR register. The trigger input of these modes comes from the STI signal which is selected by the TRSEL field in the TRCFR register. The operation modes in the Slave Controller are described in the accompanying sections.

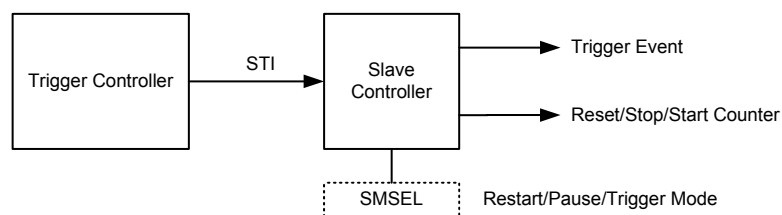


Figure 80. Slave Controller Diagram

## Restart Mode

The counter and its prescaler can be reinitialised in response to an STI signal rising edge. If the UEV1DIS bit is set to 1 to disable the update event, then no update event will be generated, however the counter and prescaler are still reinitialized when an STI rising edge occurs. If the UEV1DIS bit in the CNTCFR register is cleared to enable the update event, then an update event will be generated together with the STI rising edge and all the preloaded registers will be updated.

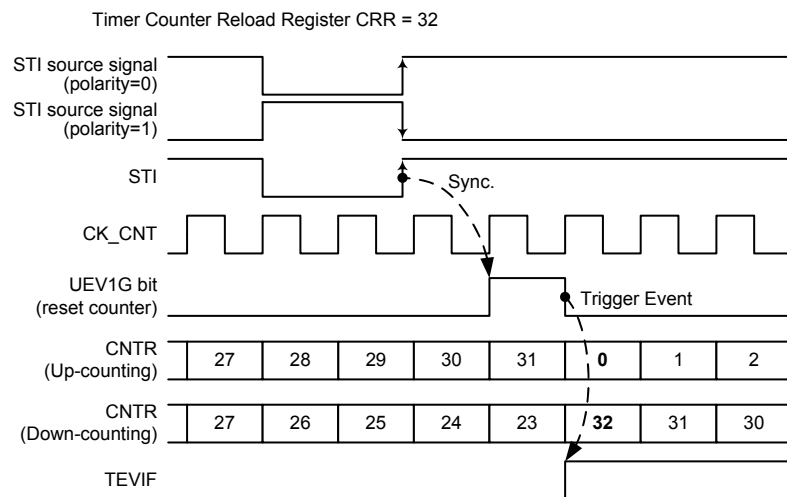
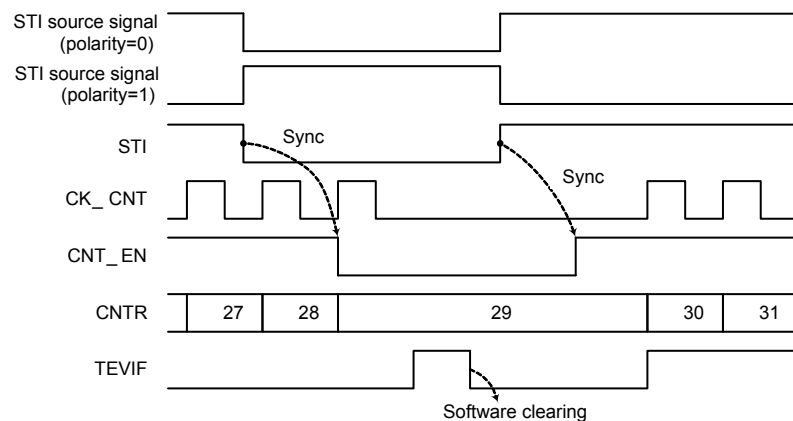


Figure 81. MCTM in Restart Mode

### Pause Mode

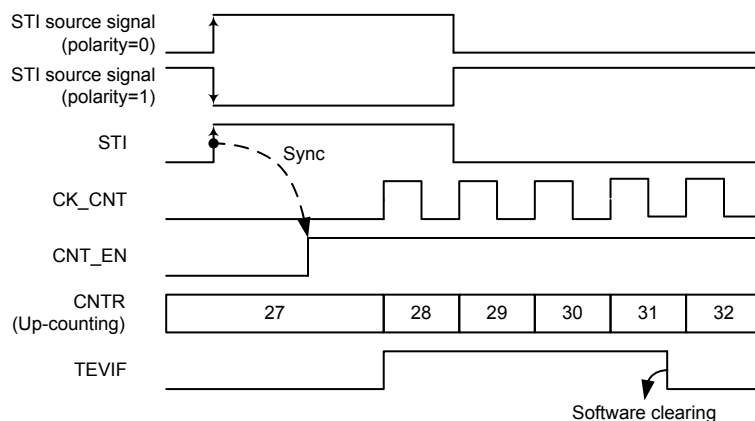
In the Pause Mode, the selected STI input signal level is used to control the counter start/stop operation. The counter starts to count when the selected STI signal is at a high level and stops counting when the STI signal is changed to a low level. When the counter stops, it will maintain its present value and not be reset. Since the Pause function depends upon the STI level to control the counter stop/start operation, the selected STI trigger signal can not be derived from the TI0BED signal.



**Figure 82. MCTM in Pause Mode**

### Trigger Mode

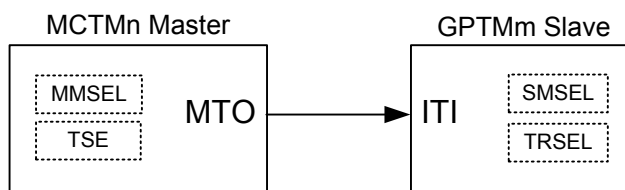
After the counter is disabled to count, the counter can resume counting when an STI rising edge signal occurs. When an STI rising edge occurs, the counter will start to count from the current value in the counter. Note that if the STI signal is selected to be sourced from the UEV1G bit software trigger, the counter will not resume counting. When software triggering using the UEV1G bit is selected as the STI source signal, there will be no clock pulse generated which can be used to make the counter resume counting. Note that the STI signal is only used to enable the counter to resume counting and has no effect to stop counting.



**Figure 83. MCTM in Trigger Mode**

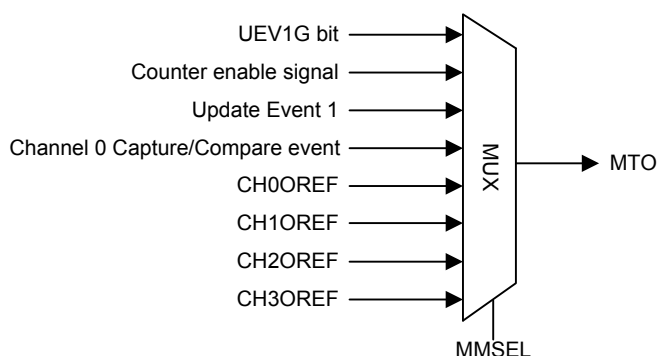
## Master Controller

The MCTMs and GPTMs can be linked together internally for timer synchronisation or chaining. When one MCTM is configured to be in the Master Mode, the MCTM Master Controller will generate a Master Trigger Output (MTO) signal which can reset, restart, stop the Slave counter or be a clock source of the Slave Counter. This can be selected by the MMSEL field in the MDCFR register to trigger or drive another MCTM or GPTM which should be configured in the Slave Mode.



**Figure 84. Master MCTMn and Slave GPTM Connection**

The Master Mode Selection bits, MMSEL, in the MDCFR register are used to select the MTO source for synchronising another slave MCTM or GPTM.



**Figure 85. MTO Selection**

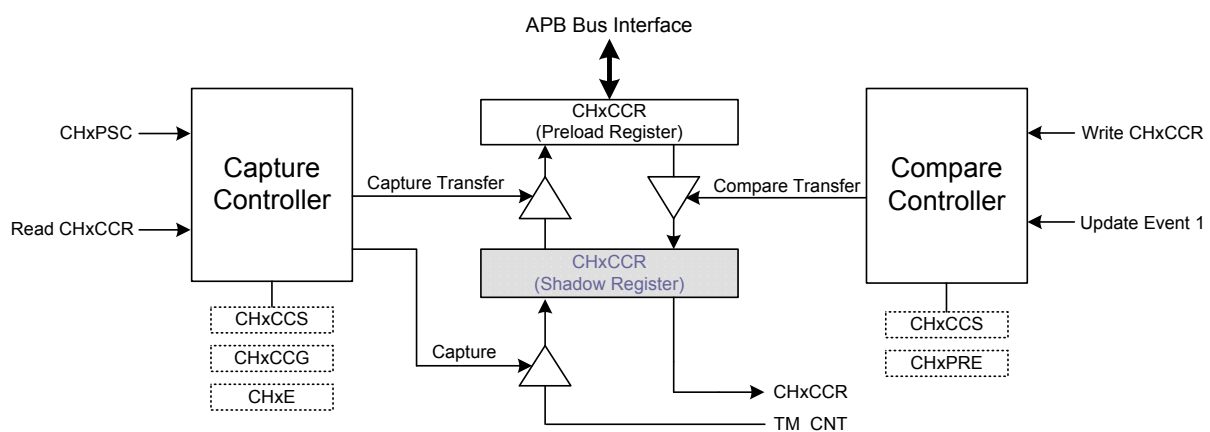
For example, setting the MMSEL field to 0x5 is to select the CH1OREF signal as the MTO signal to synchronise another slave MCTM or GPTM. For a more detailed description, refer to the related MMSEL field definitions in the MDCFR register.

## Channel Controller

The MCTM has four independent channels which can be used as capture inputs or compare match outputs. Each capture input or compare match output channel is composed of a preload register and a shadow register. Data access of the APB bus is always implemented through the read/write preload register.

When used in the input capture mode, the counter value is captured into the CHxCCR shadow register first and then transferred into the CHxCCR preload register when the capture event occurs.

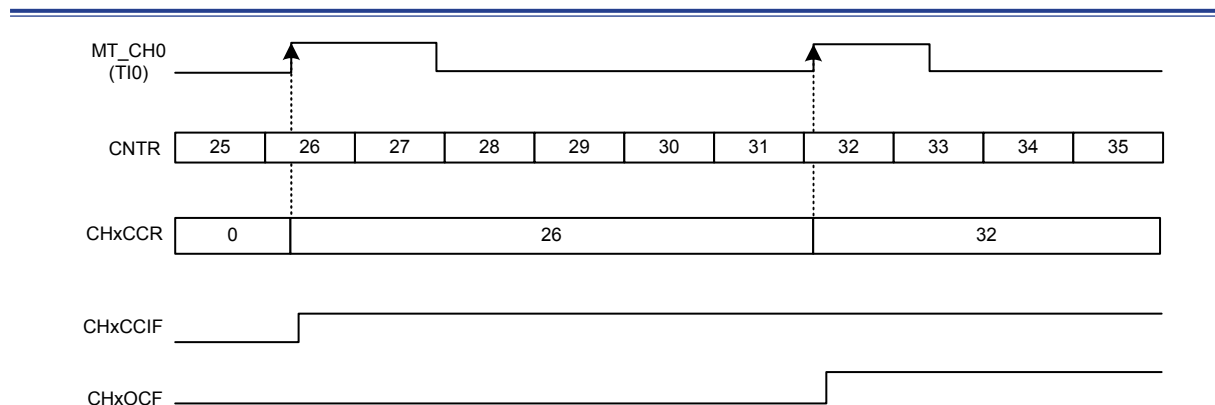
When used in the compare match output mode, the contents of the CHxCCR preload register is copied into the associated shadow register, the counter value is then compared with the register value.



**Figure 86. Capture/Compare Block Diagram**

### Capture Counter Value Transferred to CHxCCR

When the channel is used as a capture input, the counter value is captured into the Channel Capture/Compare Register (CHxCCR) when an effective input signal transition occurs. Once the capture event occurs, the CHxCCIF flag in the INTSR register is set accordingly. If the CHxCCIF bit is already set, i.e., the flag has not yet been cleared by software, and another capture event on this channel occurs, the corresponding channel Over-Capture flag, named CHxOCF, will be set.



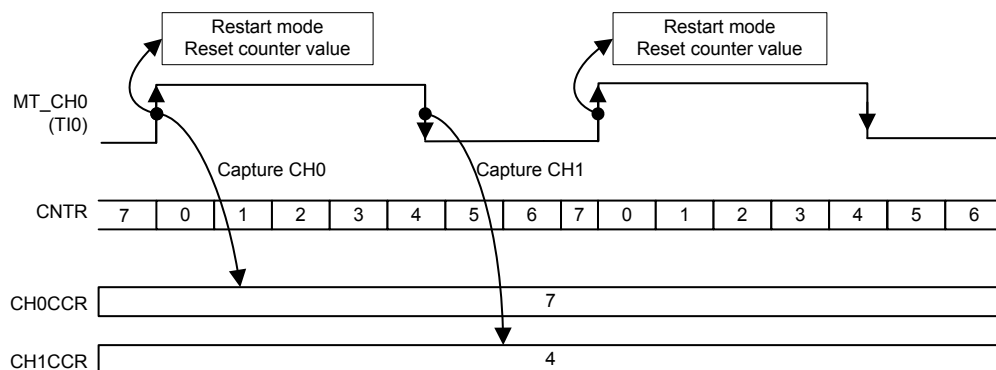
**Figure 87. Input Capture Mode**

### Pulse Width Measurement

The input capture mode can be also used for pulse width measurement from signals on the MT\_CHx pins, TIX. The following example shows how to configure the MCTM when operated in the input capture mode to measure the high pulse width and the input period on the MT\_CH0 pin using channel 0 and channel 1. The basic steps are shown as follows.

- Configure the capture channel 0 (CH0CCS = 0x1) to select the TI0 signal as the capture input.
- Configure the CH0P bit to 0 to choose the rising edge of the TI0 input as the active polarity.
- Configure the capture channel 1 (CH1CCS = 0x2) to select the TI0 signal as the capture input.
- Set the CH1P bit to 1 to choose the falling edge of the TI0 input as the active polarity.
- Setup the TRSEL bits to 0x0001 to select TI0S0 as the trigger input.
- Configure the Slave controller to operate in the Restart mode by setting the SMSEL field in the MDCFR register to 0x4
- Enable the input capture mode by setting the CH0E and CH1E bits in the CHCTR register to 1.

As the following diagram shows, the high pulse width on the MT\_CH0 pin will be captured into the CH1CCR register while the input period will be captured into the CH0CCR register after an input capture operation.

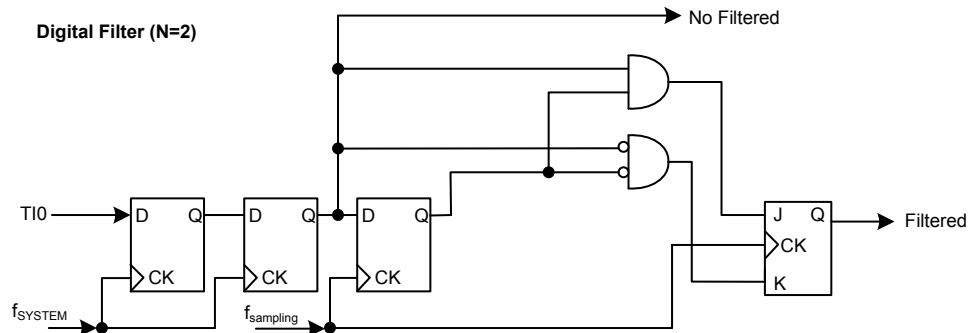


**Figure 88. PWM Pulse Width Measurement Example**

## Motor Control Timer (MCTM)

### Digital Filter

The digital filters are embedded in the input stage and clock controller block for the MT\_CH0 ~ MT\_CH3 pins. The digital filter in the MCTM is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal. The N value can be 0, 2, 4, 5, 6 or 8 according to the selection for each filter.

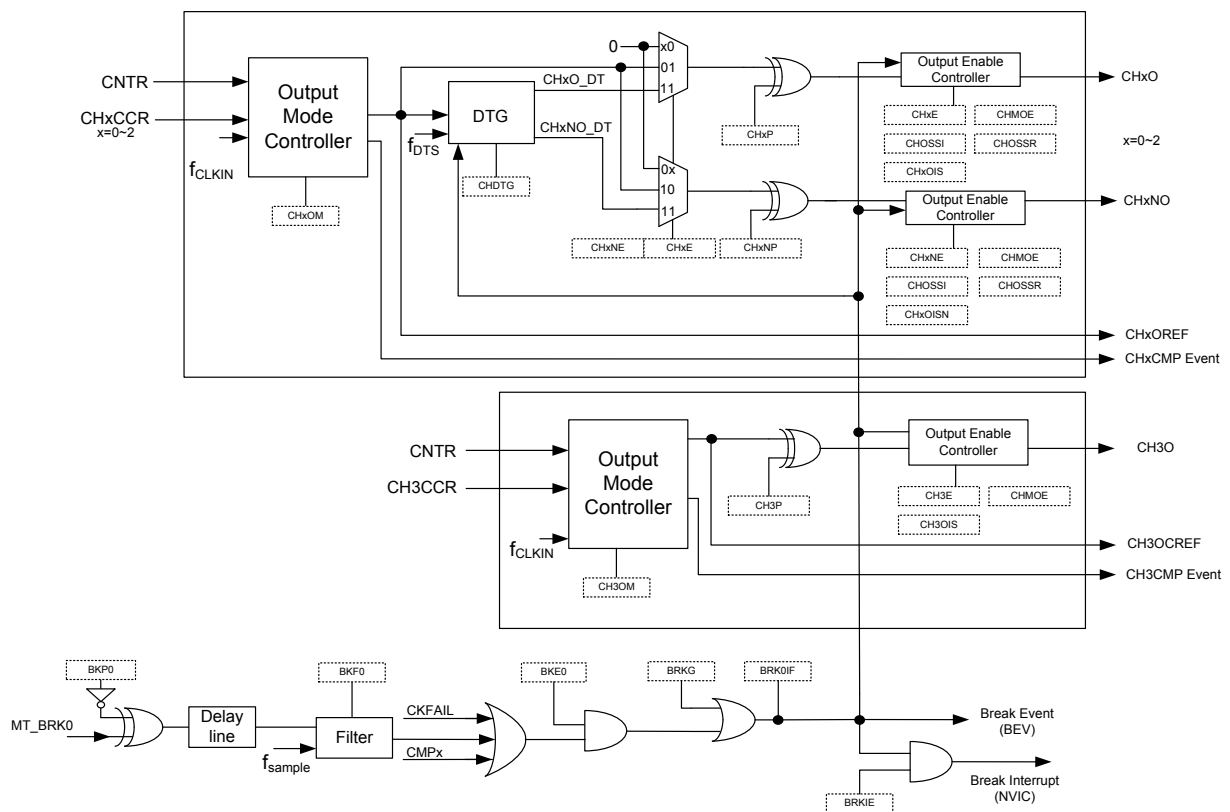


**Figure 91. TI0 Digital Filter Diagram with N = 2**

## Output Stage

The MCTM supports complementary outputs for channels 0, 1 and 2 with dead time insertion. The MCTM channel 3 output function is almost the same as that of GPTM channel 3 except for the break function.

The channel outputs, CHxO and CHxNO, are referenced to the CHxOREF signal. These channel outputs generate a wide variety of wide waveforms according to the configuration values of corresponding control bits, as shown by the dashed box in the diagram.



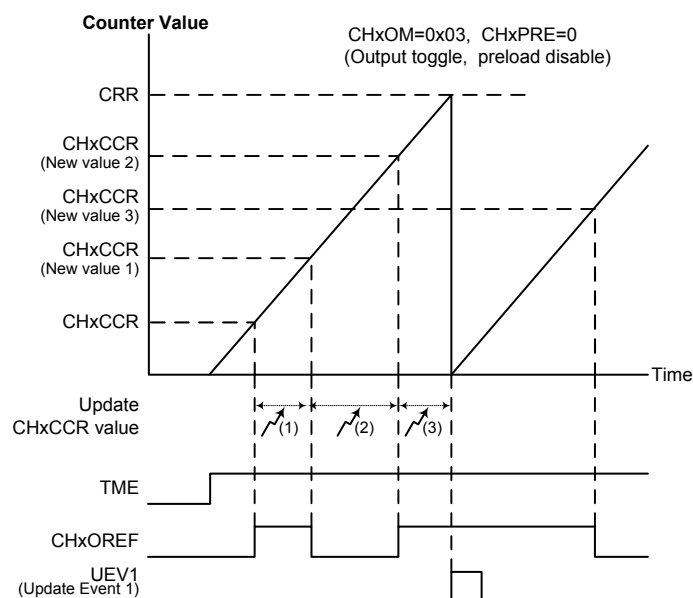
**Figure 92. Output Stage Block Diagram**

### Channel Output Reference Signal

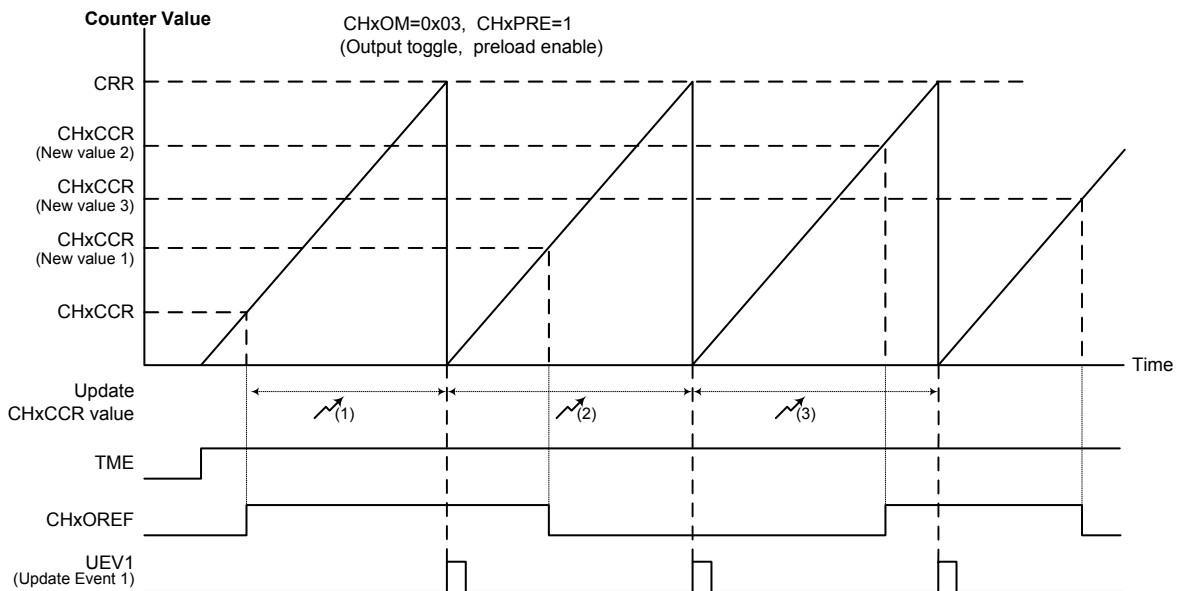
When the MCTM is used in the compare match output mode, the CHxOREF signal (Channel x Output Reference signal) is defined by the CHxOM bit setup. The CHxOREF signal has several types of output function which defines what happens to the output when the counter value matches the contents of the CHxCCR register. In addition to the low, high and toggle CHxOREF output types; there are also PWM mode 1 and PWM mode 2 outputs. In these modes, the CHxOREF signal level is changed according to the count direction and the relationship between the counter value and the CHxCCR content. There are also two modes which will force the output into an inactive or active state irrespective of the CHxCCR content or counter values. With regard to a more detailed description refer to the relative bit definition. The accompanying Table 1 shows a summary of the output type setup.

**Table 35. Compare Match Output Setup**

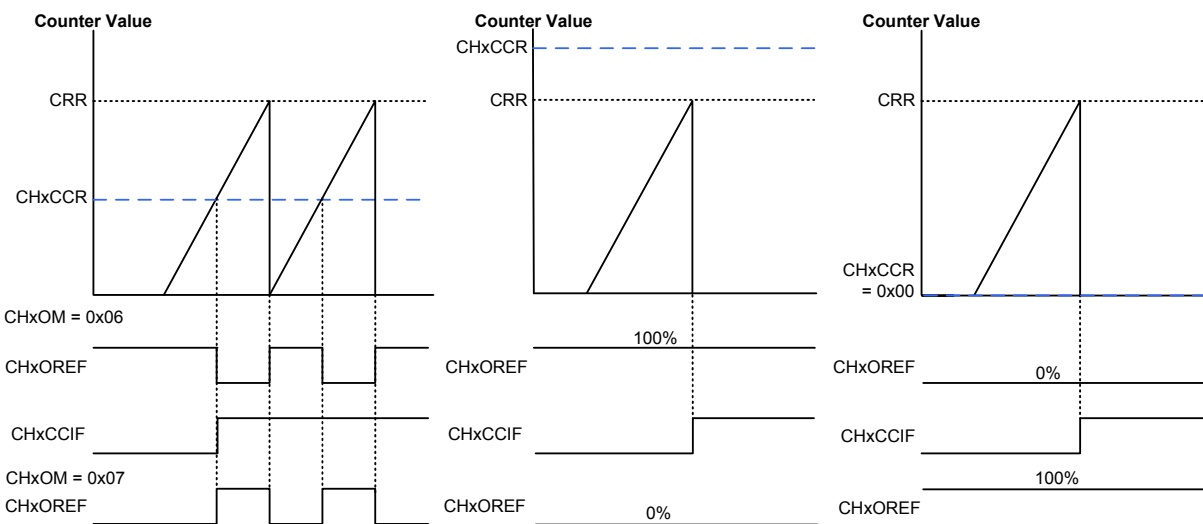
| CHxOM value | Compare Match Level  |
|-------------|----------------------|
| 0x00        | No change            |
| 0x01        | Clear Output to 0    |
| 0x02        | Set Output to 1      |
| 0x03        | Toggle Output        |
| 0x04        | Force Inactive Level |
| 0x05        | Force Active Level   |
| 0x06        | PWM Mode 1           |
| 0x07        | PWM Mode 2           |



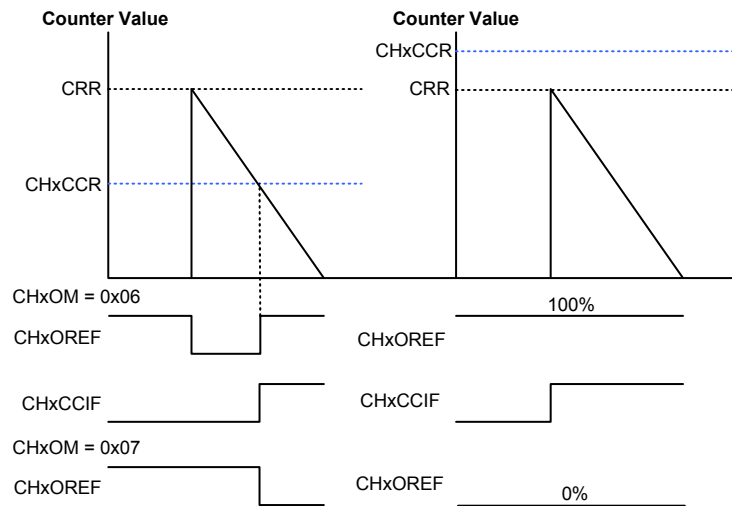
**Figure 93. Toggle Mode Channel Output Reference Signal – CHxPRE = 0**



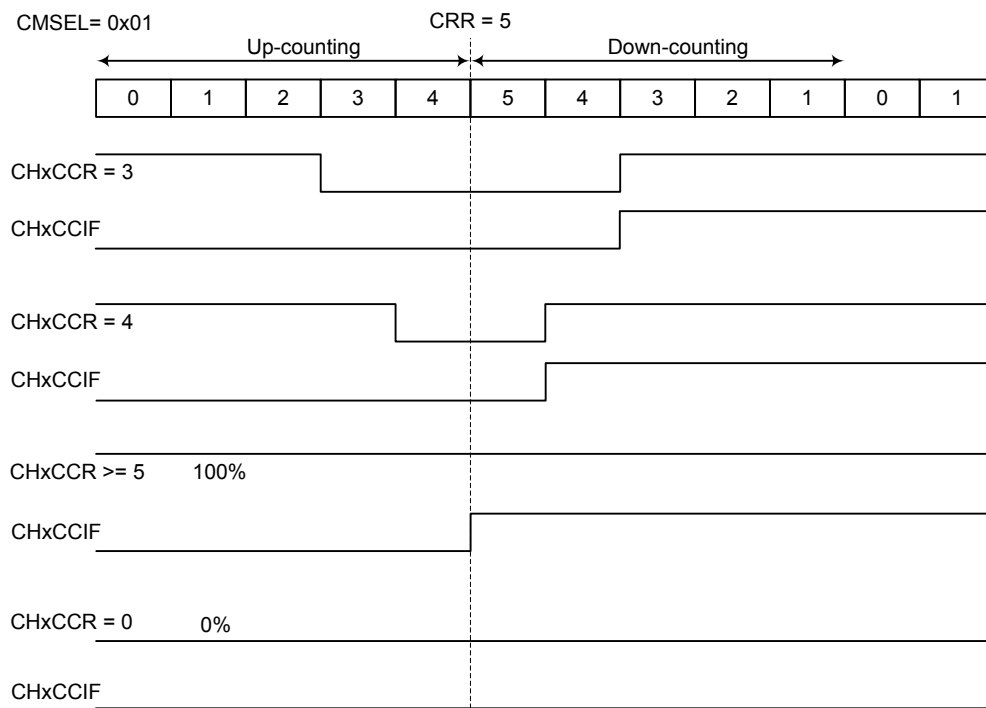
**Figure 94. Toggle Mode Channel Output Reference Signal – CHxPRE = 1**



**Figure 95. PWM Mode Channel Output Reference Signal and Counter in Up-counting Mode**



**Figure 96. PWM Mode Channel Output Reference Signal and Counter in Down-counting Mode**

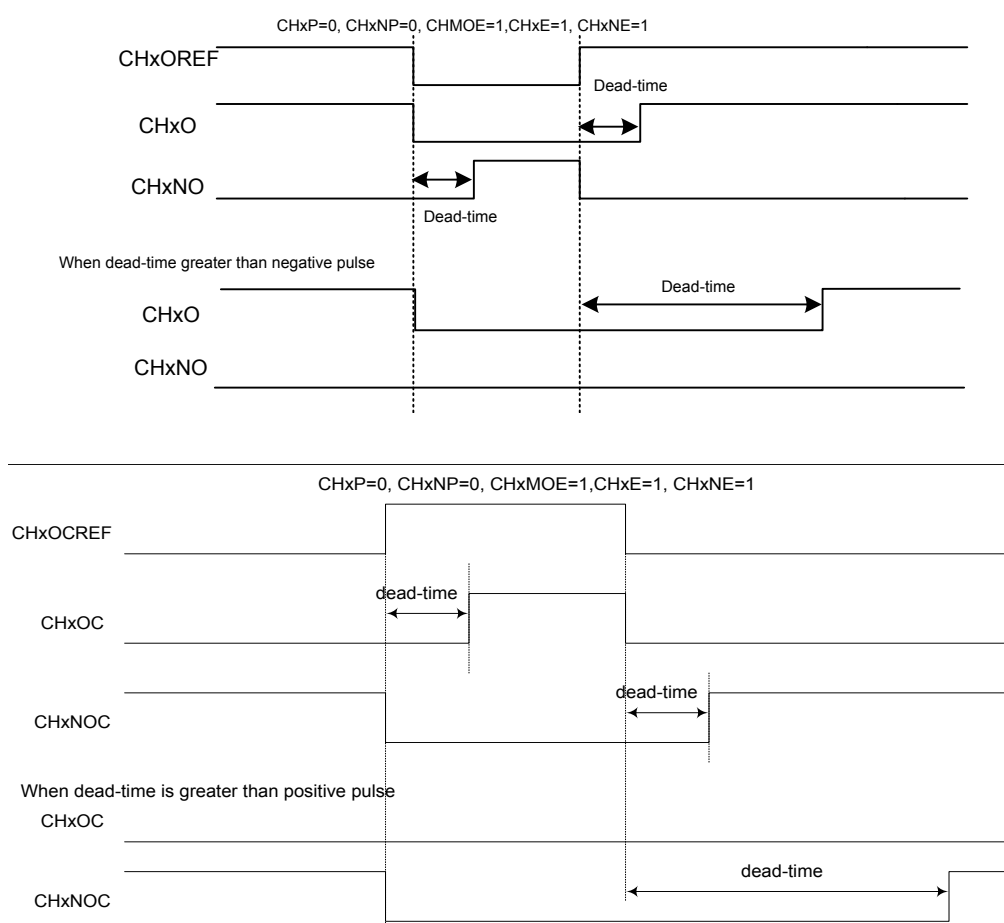


**Figure 97. PWM Mode 1 Channel Output Reference Signal and Counter in Centre-aligned Counting Mode**

### Dead Time Generator

An 8-bit dead time generator function is included for channels 0~2. The dead time insertion is enabled by setting both the CHxE and CHxNE bits. The relationship between the CHxO and CHxNO signals with respect to the CHxOREF signal is as follows:

- The CHxO signal is the same as the CHxOREF signal except for the rising edge which is delayed with a dead time relative to the reference signal rising edge.
- The CHxNO is the opposite of the CHxOREF signal except for the rising edge which is delayed with a dead time relative to the reference signal falling edge.

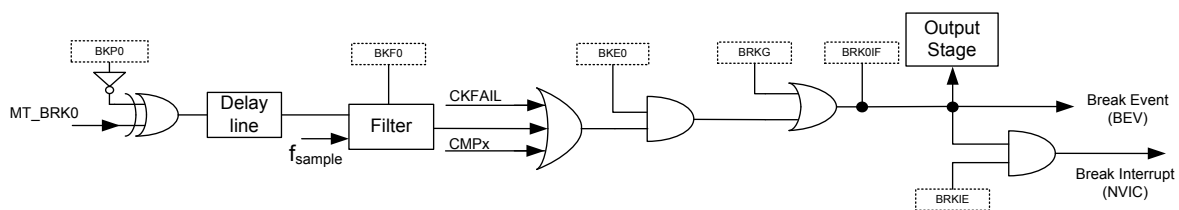


**Figure 98. Dead-time Insertion Performed for Complementary Outputs**

If the delay is greater than the width of the active output of CHxO or CHxNO, then the corresponding PWM pulses will not be generated.

### Break Function

The MCTM includes break function and one input signals for MCTM break. The MT\_BRK is default function and from external MT\_BRK pin. The detail block diagram is shown as below figure.



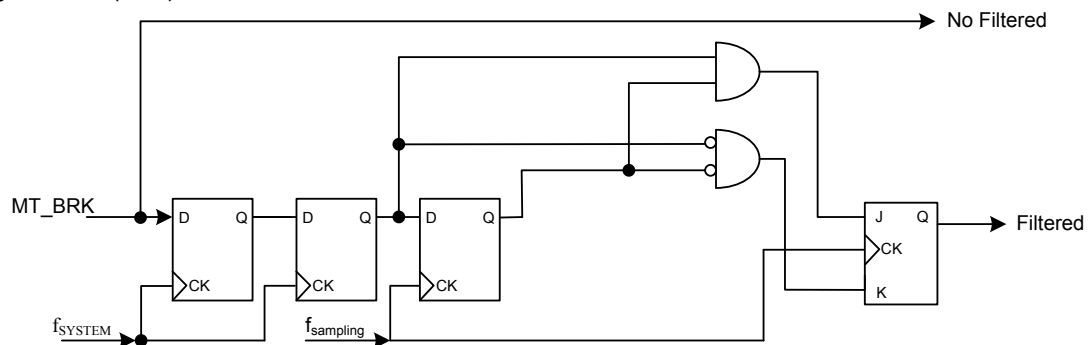
**Figure 99. MCTM Break Signal Block Diagram**

When the MT\_BRK input has an active level or the Clock Monitor Circuitry detects a clock failure event or comparator transition, a break event will be generated if the break function is enabled. Meanwhile, each channel output will be forced to a reset state, an inactive or idle state. Moreover, a break event can also be generated by the software asserting the BRKG bit in the EVGR register even if the break function is disabled.

The MT\_BRK input signal can be enabled by setting the BKE bit in the CHBRKCTR register. The internal polarity of break activity function is logic high. So the break input polarity can be selected by setting the BKP bit in CHBRKCTR register. The BKE and BKP bits can be modified at the same time.

The digital filters are embedded in the input stage and clock controller block for the break signal. The input filter of the MT\_BRK signal can be enabled by by setting the BKF bits in the CHBRKCTR register. The digital filter is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal.

**Digital Filter (N=2)**



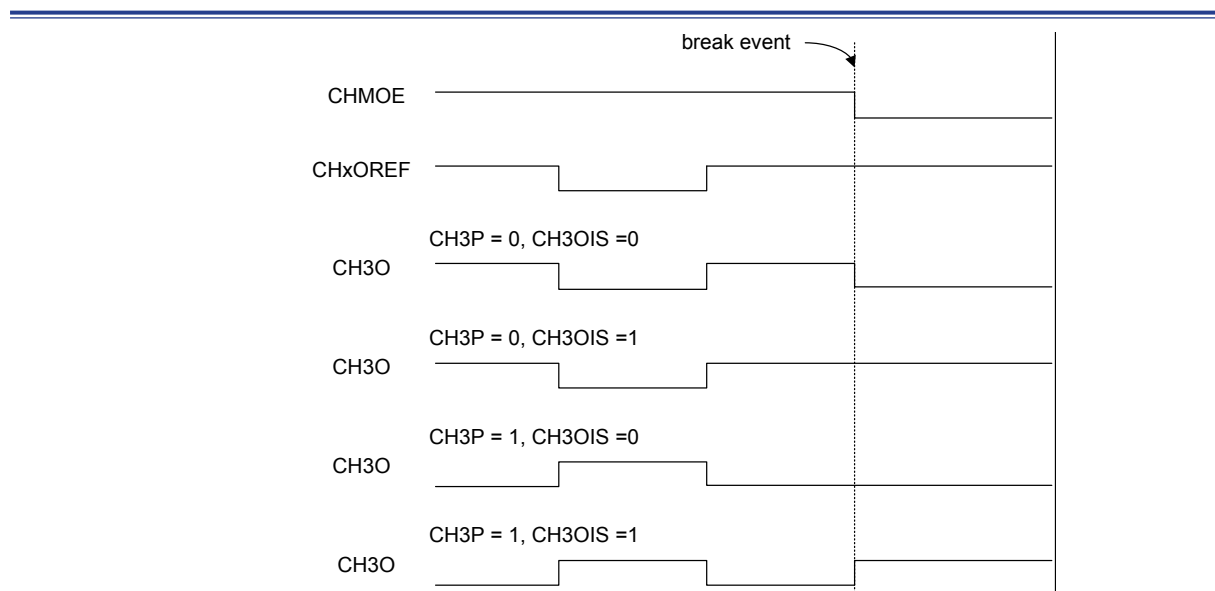
**Figure 100. MT\_BRK Pin Digital Filter Diagram with N = 2**

When using the break function, the channel output enable signals and output levels are changed depending on several control bits which include the CHMOE, CHOSSI, CHOSSR, CHxOIS and CHxOISN bits. Once a break event occurs, the output enable bit CHMOE will be cleared asynchronously. The break interrupt flag, BRKIF, will be set and then an interrupt will be generated if the break function interrupt is enabled by setting the BRKIE bit to 1. The channel output behavior is as described below:

- If complementary outputs are used, the channel outputs a level signal first which can be selected to be either a disable or inactive level, selected by configuring the CHOSSI bit in the CHBRKCTR register. After the dead-time duration, the outputs will be changed to the idle state. The idle state is determined by the CHxOIS/CHxOISN bits in the CHBRKCFR register.

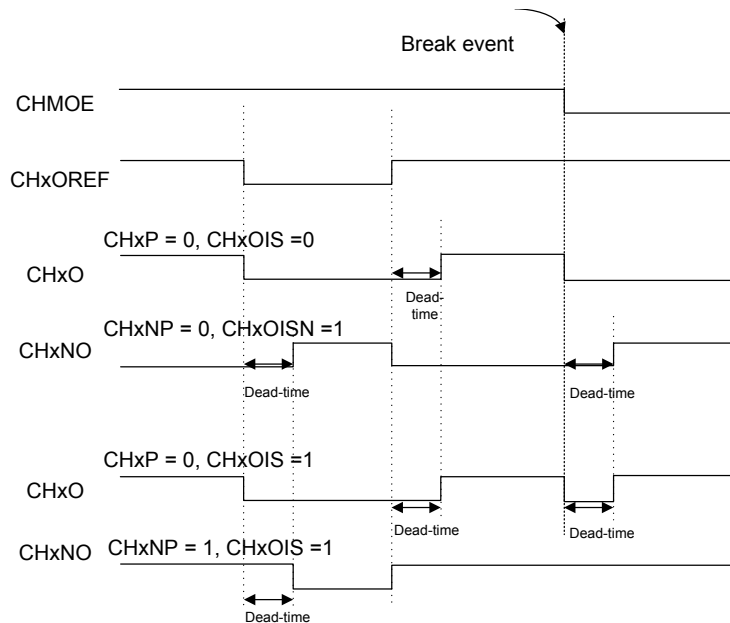
- If complementary outputs are not used (Channel 3), the channel will output an idle state.

The main output enable control bit, CHMOE can not be set until the break event is cleared.



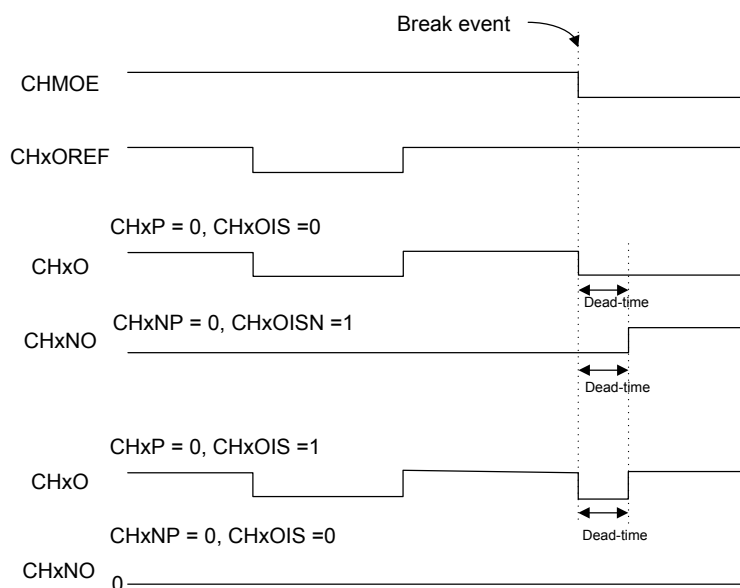
**Figure 101. Channel 3 Output with a Break Event Occurrence**

The accompanying diagram shows that the complementary output states when a break event occurs where the complementary outputs are enabled by setting both the CHxE and CHxNE bits to 1.



**Figure 102. Channel 0 ~ 2 Complementary Outputs with a Break Event Occurrence**

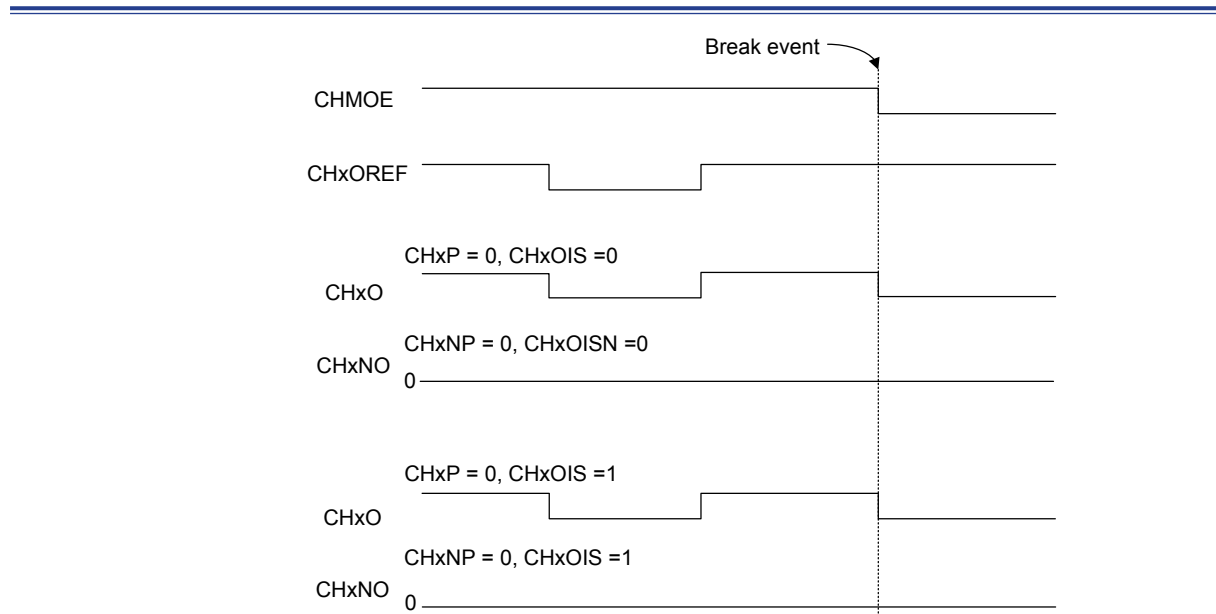
The accompanying diagram shows the output states in the case of the output being enabled by setting the CHxE bit to 1 and the complementary output being disabled by clearing the CHxNE to 0 when a break event occurs.



**Figure 103. Channel 0 ~ 2 Only One Output Enabled when Fault Event Occurs**

The CHxO and CHxNO complementary outputs should not be set to an active level at the same time. The hardware will protect the MCTM circuitry to force only one channel output to be in the active state.

Example: Both CHxOIS and CHxOISN are set to active levels after a break event; only the CHxO waveform is generated.



**Figure 104. Hardware Protection When Both CHxO and CHxNO Are in Active Condition**

CHMOE can be set automatically by update event 1 if the automatic output enable function is enabled by setting the CHAOE bit in the CHBRKCTR register to 1.

#### Channel Complementary Output with Break Function

The Channel complementary outputs, CHxO and CHxNO, are enabled by a combination of the CHxE, CHxNE, CHMOE, CHOSSR, CHOSSI control bits.

**Table 36. Output Control Bits for Complementary Output with a Break Event Occurrence**

| Control bit |       |        |      |       | Output status                                                                                                                                                                                                |                                                                                                  |
|-------------|-------|--------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| CHMOE       | CHOSI | CHOSSR | CHxE | CHxNE | MT_CHx Pin output state                                                                                                                                                                                      | MT_CHxN Pin output state                                                                         |
| 1<br>(Run)  | x     | 0      | 0    | 0     | Output disabled - floating<br>- not driven by the timer<br>MT_CHx <sup>(Note 1)</sup> = floating<br>MT_CHx_OEN <sup>(Note 2)</sup> = 1                                                                       | Output disabled - floating<br>- not driven by the timer<br>MT_CHxN = floating<br>MT_CHxN_OEN = 1 |
|             |       | 0      | 0    | 1     | Output disabled - floating<br>- not driven by the timer<br>MT_CHx_OEN = 1                                                                                                                                    | Output enabled<br>MT_CHxN = CHx_OREF<br>xor CHxNP<br>MT_CHxN_OEN = 0                             |
|             |       | 0      | 1    | 0     | Output enabled<br>MT_CHx = CHx_OREF xor<br>CHxP<br>MT_CHx_OEN = 0                                                                                                                                            | Output disabled - floating<br>- not driven by the timer<br>MT_CHxN = floating<br>MT_CHxN_OEN = 1 |
|             |       | 0      | 1    | 1     | Output enabled<br>MT_CHx = CHx_OREF xor<br>CHxP + dead-time<br>MT_CHx_OEN = 0                                                                                                                                | Output enabled<br>MT_CHxN = not CHx_<br>OREF xor CHxNP + dead-<br>time<br>MT_CHxN_OEN = 0        |
|             |       | 1      | 0    | 0     | Output disabled - floating<br>- not driven by the timer<br>MT_CHx = floating<br>MT_CHx_OEN = 1                                                                                                               | Output disabled floating<br>- not driven by the timer<br>MT_CHxN = floating<br>MT_CHxN_OEN = 1   |
|             |       | 1      | 0    | 1     | Off-State<br>MT_CHx = CHxP<br>MT_CHx_OEN = 0                                                                                                                                                                 | Output enabled<br>MT_CHxN = CHx_OREF<br>xor CHxNP<br>MT_CHxN_OEN = 0                             |
|             |       | 1      | 1    | 0     | Output enabled<br>MT_CHx = CHx_OCREF<br>xor CHxP<br>MT_CHx_OEN = 0                                                                                                                                           | Off-State<br>MT_CHxN = CHxNP<br>MT_CHxN_OEN = 0                                                  |
|             |       | 1      | 1    | 1     | Output enabled<br>MT_CHx = CHx_OREF xor<br>CHxP + dead-time<br>MT_CHx_OEN = 0                                                                                                                                | Output enabled<br>MT_CHxN = not CHx_<br>OREF xor CHxNP + dead-<br>time<br>MT_CHxN_OEN = 0        |
| 0<br>(Idle) | 0     | x      | 0    | 0     | Before dead-time: Output disabled - floating<br>MT_CHx = floating, MT_CHxN = floating<br>MT_CHx_OEN = 1, MT_CHxN_OEN = 1                                                                                     |                                                                                                  |
|             | 0     |        | 0    | 1     |                                                                                                                                                                                                              |                                                                                                  |
|             | 0     |        | 1    | 0     |                                                                                                                                                                                                              |                                                                                                  |
|             | 0     |        | 1    | 1     |                                                                                                                                                                                                              |                                                                                                  |
|             | 1     |        | 0    | 0     | Before dead-time: Off state<br>MT_CHx = CHxP, MT_CHxN = CHxNP<br>MT_CHx_OEN = 0, MT_CHxN_OEN = 0<br>After dead-time: Output enabled<br>MT_CHx = CHxOIS, MT_CHxN = CHxOISN<br>MT_CHx_OEN = 0, MT_CHxN_OEN = 0 |                                                                                                  |
|             | 1     |        | 0    | 1     |                                                                                                                                                                                                              |                                                                                                  |
|             | 1     |        | 1    | 0     |                                                                                                                                                                                                              |                                                                                                  |
|             | 1     |        | 1    | 1     |                                                                                                                                                                                                              |                                                                                                  |

**Note:** 1. The MT\_CHx pin is the MCTM I/O Pin.

2. The MT\_CHx\_OEN and MT\_CHxN\_OEN signals are the MCTM I/O pin output enable combinational logic control signals which are active low.

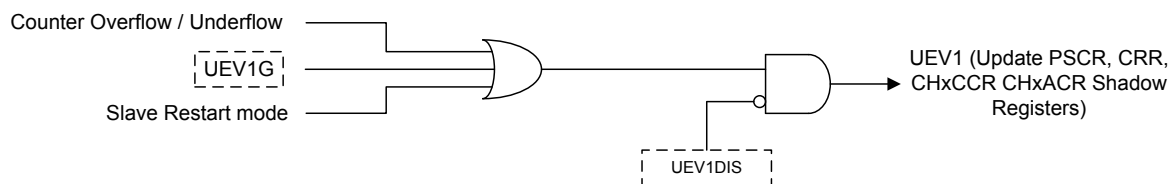
## Update Management

The update events are categorised into two different types which are the update event 1, UEV1, and update event 2, UEV2. The update event 1 is used to update the CRR, the PSCR and the CHxCCR values from the actual registers to the corresponding shadow registers. An update event 1 occurs when the counter overflows or underflows, the UEV1G bit is set or the slave restart mode is triggered. The update event 2 is used to update the CHxE, CHxNE and CHxOM control bits. An update event 2 is generated when a rising edge on the STI occurs or the corresponding software update control bit is set.

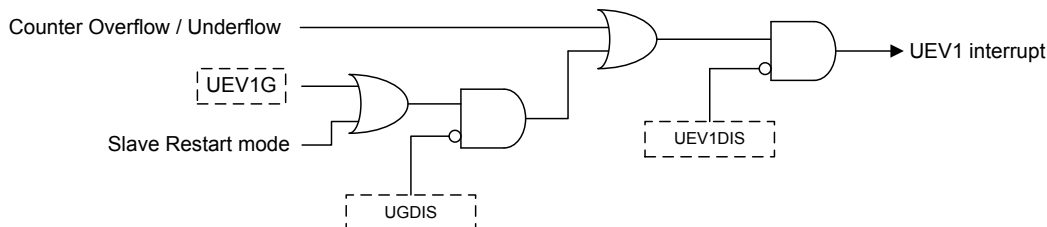
### Update Event 1

The UEV1DIS bit in the CNTCFR register can determine whether an update event 1 occurs or not. When the update event 1 occurs, the corresponding update event interrupt will be generated depending upon whether the update event 1 interrupt generation function is enabled or not by configuring the UGDIS bit in the CNTCFR register. For a more detailed description, refer to the UEV1DIS and UGDIS bit definition in the CNTCFR register.

#### Update Event 1 Management



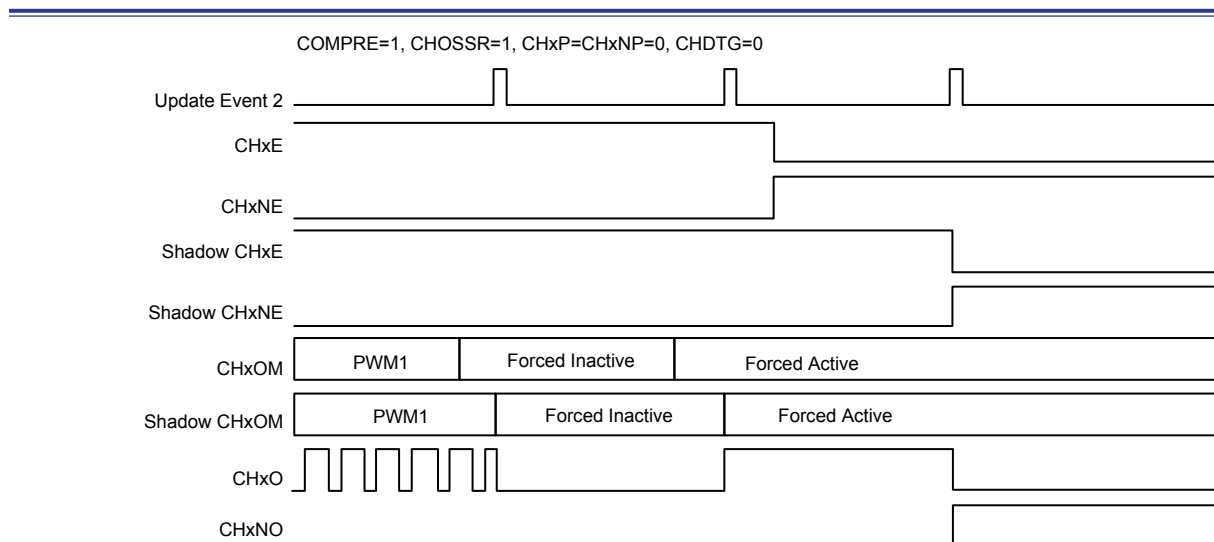
#### Update Event 1 Interrupt Management



**Figure 105. Update Event 1 Setup Diagram**

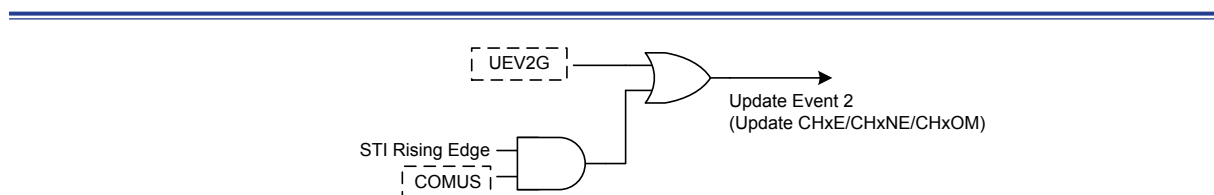
## Update Event 2

The CHxE, CHxNE, CHxOM control bits for the complementary outputs can be preloaded by setting the COMPRE bit in the CTR register. Here the shadow bits of the CHxE, CHxNE, and CHxOM bits will be updated when an update event 2 occurs.



**Figure 106. CHxE, CHxNE and CHxOM Updated by Update Event 2**

An update event 2 can be generated by setting the software update bit, UEV2G, in the EVGR register or by the rising edge of the STI signal if the COMUS bit is set in the CTR register.



**Figure 107. Update Event 2 Setup Diagram**

## Single Pulse Mode

Once the timer is set to operate in the single pulse mode, it is not necessary to set the timer enable bit TME in the CTR register to 1 to enable the counter. The trigger to generate a pulse can be sourced from the STI signal rising edge or by setting the TME bit to 1 using software. Setting the TME bit to 1 or a trigger from the STI signal rising edge can generate a pulse and then keep the TME bit at a high state until the update event 1 occurs or the TME bit is cleared to 0 by software. If the TME bit is cleared to 0 using software, the counter will be stopped and its value held. If the TME bit is automatically cleared to 0 by a hardware update event 1, the counter will be reinitialised.

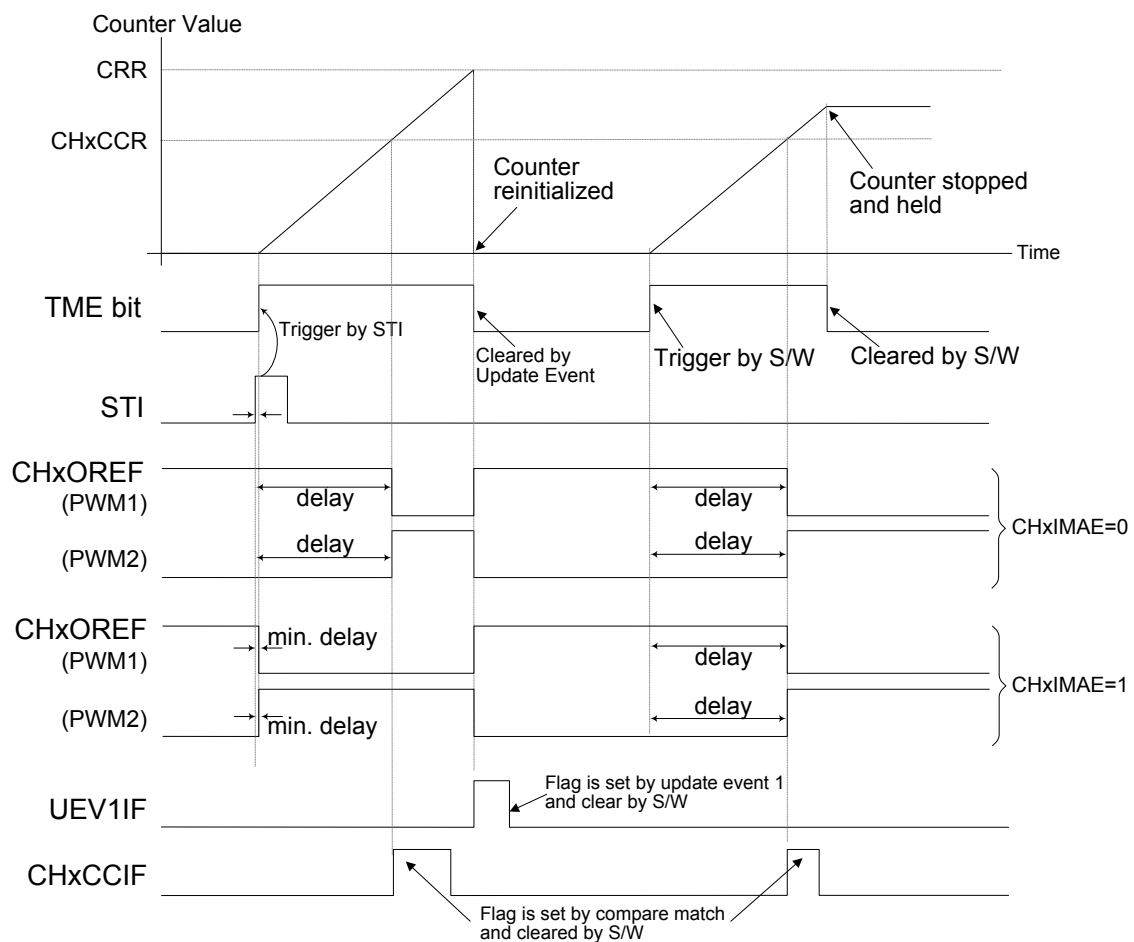
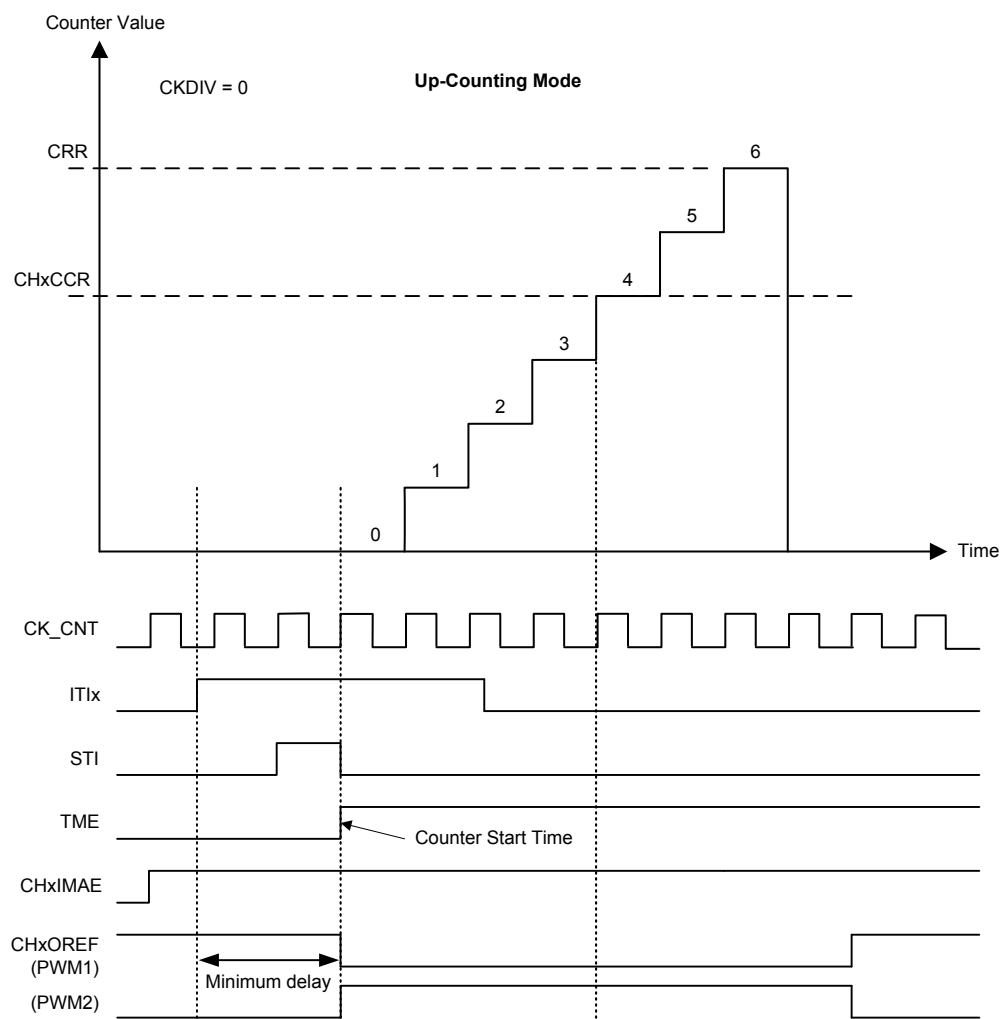


Figure 108. Single Pulse Mode

In the Single Pulse mode, the STI active edge which sets the TME bit to 1 will enable the counter. However, there exist several clock delays to perform the comparison result between the counter value and the CHxCCR value. In order to reduce the delay to a minimum value, users can set the CHxIMAE bit in each CHxOCFR register. After a STI rising edge trigger occurs in the single pulse mode, the CHxOREF signal will immediately be forced to the state to which the CHxOREF signal will change to as the compare match event occurs without taking the comparison result into account. The CHxIMAE bit is available only when the output channel is configured to operate in the PWM1 or PWM2 output mode and the trigger source is derived from the STI signal.

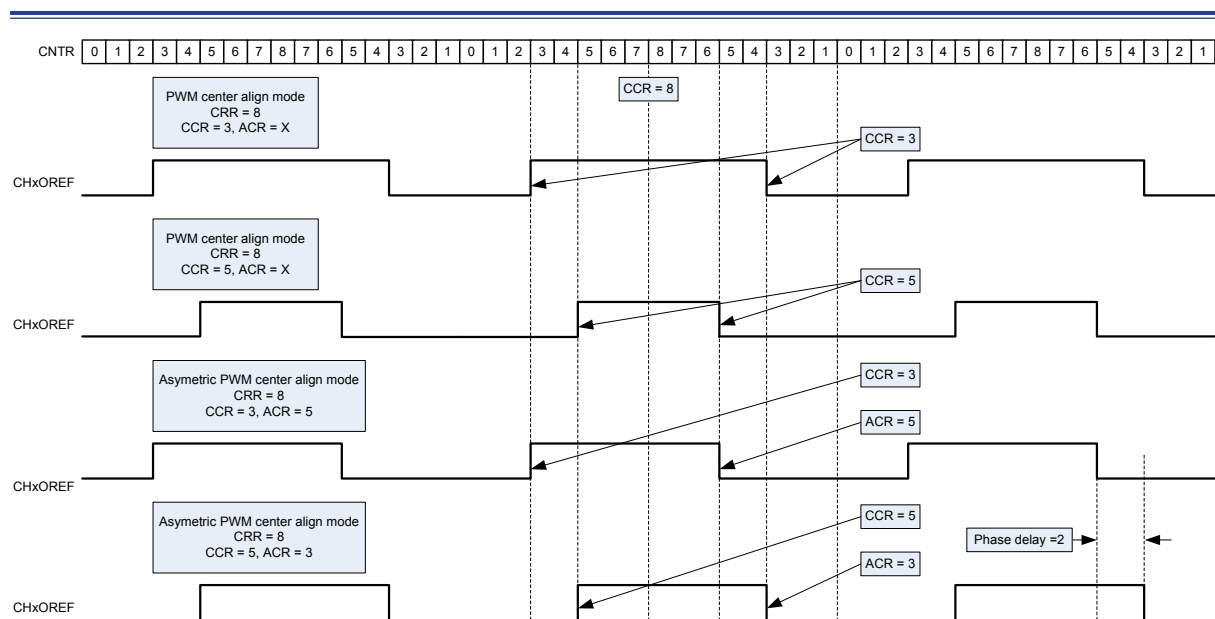


**Figure 109. Immediate Active Mode Minimum Delay**

## Asymmetric PWM Mode

Asymmetric PWM mode allows two center-aligned PWM signals to be generated with a programmable phase shift. While the PWM frequency is determined by the value of the MCTMx\_CRR register, the duty cycle and the phase-shift are determined by the CHxCCR and CHxACR register. When the counter is counting up, the PWM using the value in CHxCCR as up-count compare value. When the counter is in counting down stage, then the value in the CHxACR register is used as the down-count compare value. The Figure 110 is shown an example for asymmetric PWM mode in Center-aligned Counting mode.

Note: Asymmetric PWM mode can only be operated in Center-aligned Counting mode.



**Figure 110. Asymmetric PWM Mode versus Center-aligned Counting Mode**

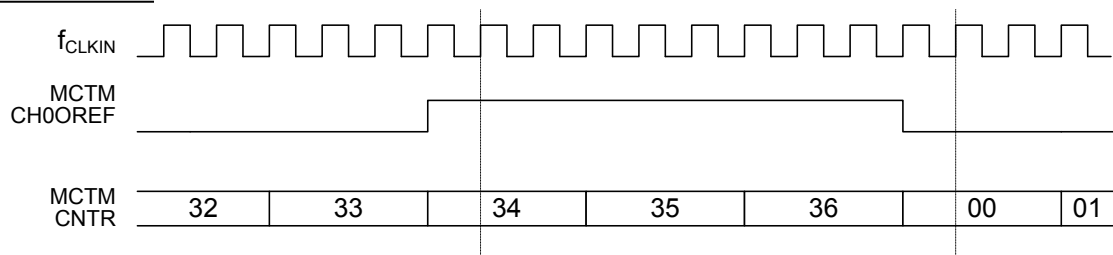
## Timer Interconnection

The timers can be internally connected together for timer chaining or synchronization. This can be implemented by configuring one timer to operate in the master mode while configuring another timer to be in the slave mode. The following figures present several examples of trigger selection for the master and slave modes.

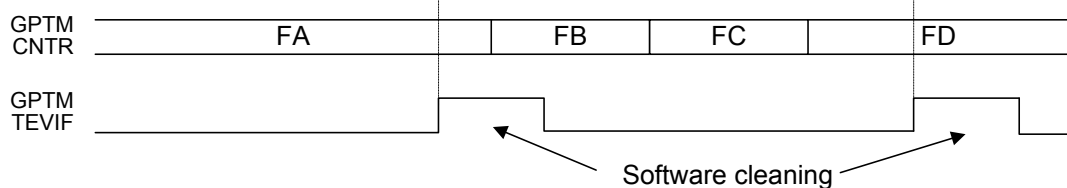
### Using one timer to trigger another timer to start or stop counting

- Configure MCTM to be in the master mode and to send its channel 0 Output Reference signal CH0OREF as a trigger output (MMSEL = 0x04).
- Configure the MCTM CH0OREF waveform.
- Configure the GPTM to receive its input trigger source from the MCTM trigger output (TRSEL = 0x0A).
- Configure GPTM to operate in the pause mode (SMSEL = 0x05).
- Enable GPTM by writing '1' to the TME bit.
- Enable MCTM by writing '1' to the TME bit.

#### Master MCTM



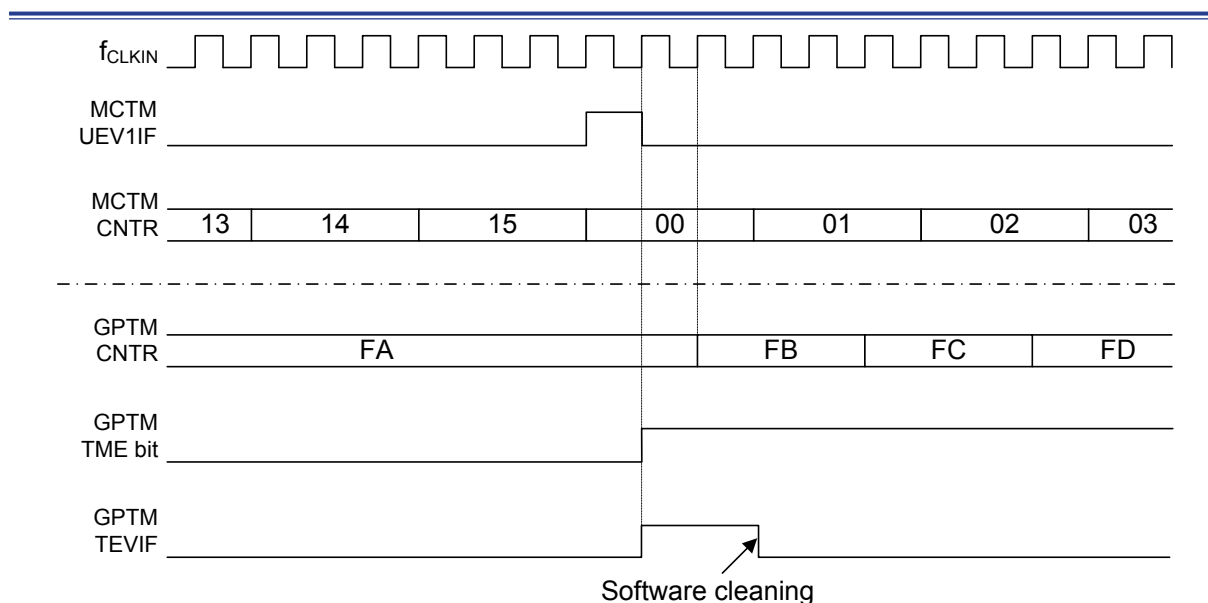
#### Slave GPTM



**Figure 111. Pausing GPTM using the MCTM CH0OREF Signal**

### Using one timer to trigger another timer to start counting

- Configure MCTM to operate in the master mode and to send its Update Event UEV as the trigger output (MMSEL = 0x02).
- Configure the MCTM period by setting the CHxCRR register.
- Configure GPTM to get the input trigger source from the MCTM trigger output (TRSEL = 0x0A).
- Configure GPTM to be in the slave trigger mode (SMSEL = 0x06).
- Start MCTM by writing '1' to the TME bit.

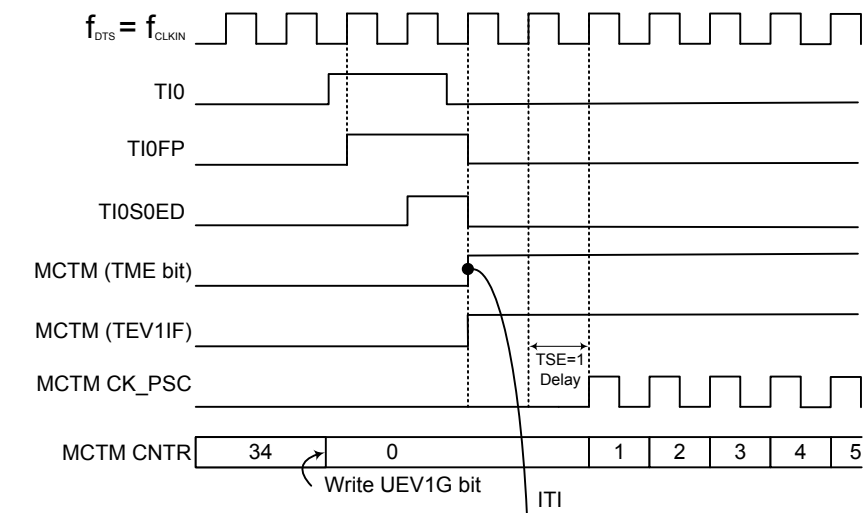


**Figure 112. Triggering GPTM with MCTM Update Event 1**

### Starting two timers synchronously in response to an external trigger

- Configure MCTM to operate in the master mode to send its enable signal as a trigger output (MMSEL = 0x01).
- Configure MCTM slave mode to receive its input trigger source from MT\_CH0 pin (TRSEL = 0x01).
- Configure MCTM to be in the slave trigger mode (SMSEL = 0x06).
- Enable the MCTM master timer synchronisation function by setting the TSE bit in the MDCFR register to 1 to synchronise the slave timer.
- Configure GPTM to receive its input trigger source from the MCTM trigger output (TRSEL = 0x0A).
- Configure GPTM to be in the slave trigger mode (SMSEL = 0x06).

#### Master MCTM



#### Slave GPTM

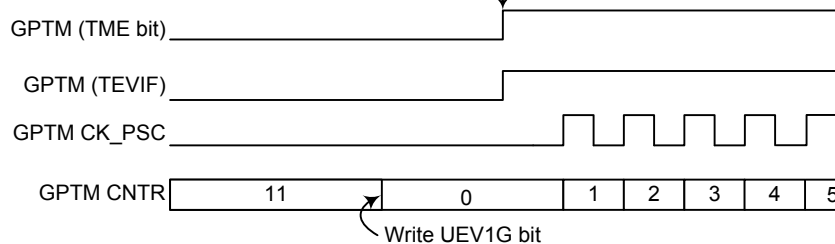


Figure 113. Trigger MCTM and GPTM with the MCTM CH0 Input

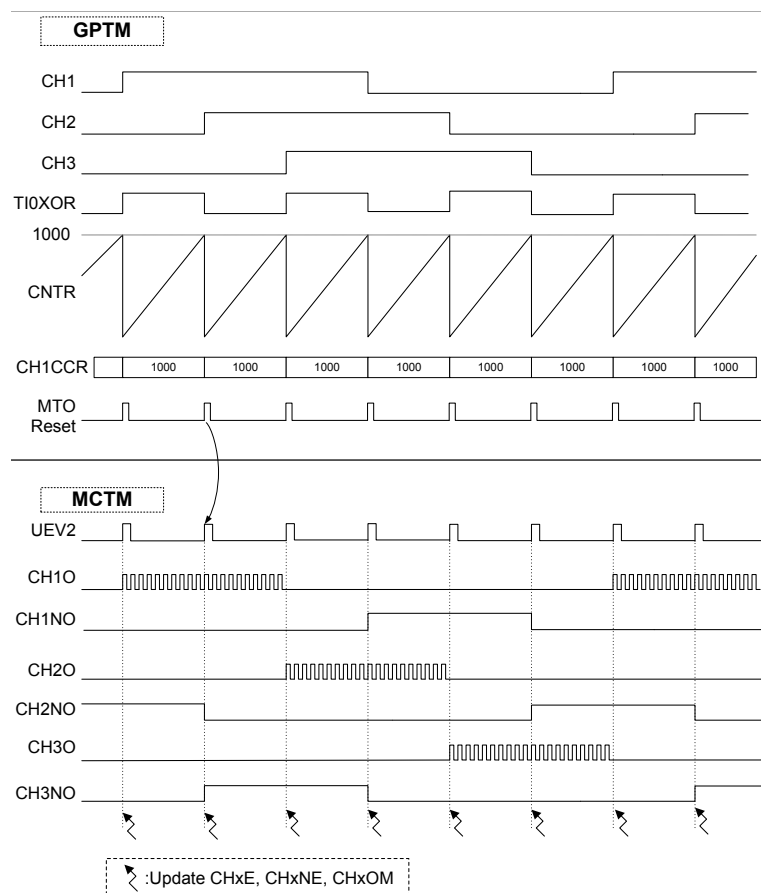
## Using one timer as a hall sensor interface to trigger another timer with update event 2

### GPTM:

- Configure channel 0 to choose an input XOR function (TI0SRC = 1)
- Configure channel 0 to be in the input capture mode and TRCED as capture source (CH0CCS= 0x03) and Enable channel 0 (CH0E=1)
- Configure the UEVG bit as the source of MTO (MMSEL= 0x00)
- Configure TI0BED to be connected to STI (TRSEL = 0x08)
- Configure the counter to be in the slave restart mode (SMSEL = 0x04)
- Enable GPTM (TME=1)

### MCTM:

- Select GPTM MTO to be the STI source of MCTM (TRSEL = 0x0A)
- Enable the CHxE, CHxNE and CHxOM preload function (COMPRES = 1)
- Select the rising edge on STI to generate an update event 2 (COMUS = 1)
- Enable the update event 2 interrupt (UEV2IE = 1)
- In the update event 2 ISR: write CHxE, CHxNE and CHxOM register for the next step



**Figure 114. CH1XOR Input as Hall Sensor Interface**

## Trigger ADC Start

To interconnect to the Analog-to-Digital Converter, the MCTM can output the MTO signal or the channel compare match output signal CHxOREF (x = 0 ~ 3) to be used as an Analog-to-Digital Converter input trigger signal.

## Lock Level Table

In addition to the break input and output management, a write protection has been internally implemented in the break circuitry to safeguard the application. Users can choose one protection level selected by the LOCKLV bits to protect the relative control bits of the registers. The LOCKLV bits can only be written once after an MCTM or system reset. Then the protected bits will be locked and can not be changed anymore except by the MCTM reset or when the system is reset.

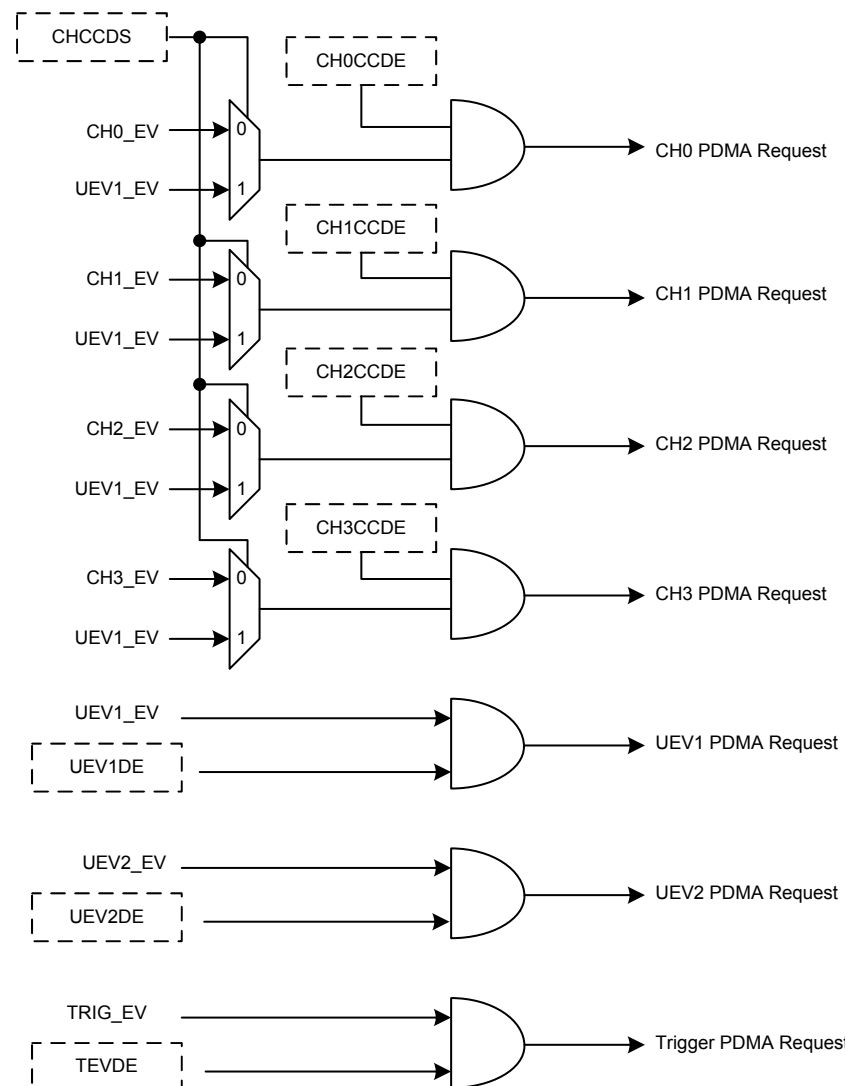
**Table 37. Lock Level Table**

| Lock Configuration           | Protected Bits |        |         |        |                       |                      |
|------------------------------|----------------|--------|---------|--------|-----------------------|----------------------|
| Lock Level 1 (LOCKLV = "01") | CHDTG          | CHxOIS | CHxOISN | BKE    | BKP                   | CHAOE                |
| Lock Level 2 (LOCKLV = "10") | CHDTG          | CHxOIS | CHxOISN | BKE    | BKP                   | CHAOE                |
|                              | CHxP           | CHxNP  | CHOSSI  | CHOSSR | MCTMEN <sup>(1)</sup> | CKMEN <sup>(2)</sup> |
| Lock Level 3 (LOCKLV = "11") | CHDTG          | CHxOIS | CHxOISN | BKE    | BKP                   | CHAOE                |
|                              | CHxP           | CHxNP  | CHOSSI  | CHOSSR | MCTMEN <sup>(1)</sup> | CKMEN <sup>(2)</sup> |
|                              | CHxPRE         | CHxOM  |         |        |                       |                      |

1. The MCTMEN bit of the APBCCR1 register is located in the CKCU unit and use to control the clock source of the MCTM unit.
2. The CKMEN bit of the GCCR register is located in the CKCU unit and use to monitor the high speed external clock (HSE) source. If the CKMEN bit is enabled and when hardware detects HSE clock stuck at low/high state, internal hardware will automatically switch the system clock to internal high speed RC clock (HSI) to protect the system safety.
3. When the MCTMEN and CKMEN control bits of the CKCU lock protection mode is enabled in the MCTM unit, the bits will be allowed to enable only and inhibited to disable again.

## PDMA Request

The MCTM has a PDMA data transfer interface. There are certain events which can generate PDMA requests if the corresponding enable control bits are set to 1 to enable the PDMA access. These events are the MCTM update events, trigger event and channel capture/compare events. When the PDMA request is generated from the MCTM channel, it can be derived from the channel capture/compare event or the MCTM update event 1 selected by the channel PDMA selection bit, CHCCDS, for all channels. For more detailed PDMA configuring information, refer to the corresponding section in the PDMA chapter.



**Figure 115. MCTM PDMA Mapping Diagram**

## Register Map

The following table shows the MCTM registers and reset values.

**Table 38. MCTM Register Map**

| Register | Offset | Description                             | Reset Value |
|----------|--------|-----------------------------------------|-------------|
| CNTCFR   | 0x000  | Timer Counter Configuration Register    | 0x0000_0000 |
| MDCFR    | 0x004  | Timer Mode Configuration Register       | 0x0000_0000 |
| TRCFR    | 0x008  | Timer Trigger Configuration Register    | 0x0000_0000 |
| CTR      | 0x010  | Timer Control Register                  | 0x0000_0000 |
| CH0ICFR  | 0x020  | Channel 0 Input Configuration Register  | 0x0000_0000 |
| CH1ICFR  | 0x024  | Channel 1 Input Configuration Register  | 0x0000_0000 |
| CH2ICFR  | 0x028  | Channel 2 Input Configuration Register  | 0x0000_0000 |
| CH3ICFR  | 0x02C  | Channel 3 Input Configuration Register  | 0x0000_0000 |
| CH0OCFR  | 0x040  | Channel 0 Output Configuration Register | 0x0000_0000 |
| CH1OCFR  | 0x044  | Channel 1 Output Configuration Register | 0x0000_0000 |
| CH2OCFR  | 0x048  | Channel 2 Output Configuration Register | 0x0000_0000 |
| CH3OCFR  | 0x04C  | Channel 3 Output Configuration Register | 0x0000_0000 |
| CHCTR    | 0x050  | Channel Control Register                | 0x0000_0000 |
| CHPOLR   | 0x054  | Channel Polarity Configuration Register | 0x0000_0000 |
| CHBRKCFR | 0x06C  | Channel Break Configuration Register    | 0x0000_0000 |
| CHBRKCTR | 0x070  | Channel Break Control Register          | 0x0000_0000 |
| DICTR    | 0x074  | Timer PDMA/Interrupt Control Register   | 0x0000_0000 |
| EVGR     | 0x078  | Timer Event Generator Register          | 0x0000_0000 |
| INTSR    | 0x07C  | Timer Interrupt Status Register         | 0x0000_0000 |
| CNTR     | 0x080  | Timer Counter Register                  | 0x0000_0000 |
| PSCR     | 0x084  | Timer Prescaler Register                | 0x0000_0000 |
| CRR      | 0x088  | Timer Counter Reload Register           | 0x0000_FFFF |
| REPR     | 0x08C  | Timer Repetition Register               | 0x0000_0000 |
| CH0CCR   | 0x090  | Channel 0 Capture/Compare Register      | 0x0000_0000 |
| CH1CCR   | 0x094  | Channel 1 Capture/Compare Register      | 0x0000_0000 |
| CH2CCR   | 0x098  | Channel 2 Capture/Compare Register      | 0x0000_0000 |
| CH3CCR   | 0x09C  | Channel 3 Capture/Compare Register      | 0x0000_0000 |
| CH0ACR   | 0x0A0  | Channel 0 Asymmetric Compare Register   | 0x0000_0000 |
| CH1ACR   | 0x0A4  | Channel 1 Asymmetric Compare Register   | 0x0000_0000 |
| CH2ACR   | 0x0A8  | Channel 2 Asymmetric Compare Register   | 0x0000_0000 |
| CH3ACR   | 0x0AC  | Channel 3 Asymmetric Compare Register   | 0x0000_0000 |

## Register Descriptions

### Timer Counter Configuration Register – CNTCFR

This register specifies the MCTM counter configuration.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |       |         |
|------------|----------|----|----|----|----|----|-------|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25    | 24      |
| Type/Reset | Reserved |    |    |    |    |    |       | DIR     |
|            |          |    |    |    |    |    |       | RW 0    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17    | 16      |
| Type/Reset | Reserved |    |    |    |    |    | CMSEL |         |
|            |          |    |    |    |    |    | RW 0  | RW 0    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9     | 8       |
| Type/Reset | Reserved |    |    |    |    |    | CKDIV |         |
|            |          |    |    |    |    |    | RW 0  | RW 0    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1     | 0       |
| Type/Reset | Reserved |    |    |    |    |    | UGDIS | UEV1DIS |
|            |          |    |    |    |    |    | RW 0  | RW 0    |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24]    | DIR   | Counting Direction<br>0: Count-up<br>1: Count-down<br>Note: This bit is read only when the Timer is configured to be in the Center-aligned counting mode or when used as a Quadrature decoder.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| [17:16] | CMSEL | Counter Mode Selection<br>00: Edge-aligned counting mode. Normal up-counting and down-counting available for this mode. Counting direction is defined by the DIR bit.<br>01: Center-aligned counting mode 1. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-down period.<br>10: Center-aligned counting mode 2. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up period.<br>11: Center-aligned counting mode 3. The counter counts up and down alternatively. The compare match interrupt flag is set during the count-up and count-down period. |
| [9:8]   | CKDIV | Clock Division<br>These two bits define the frequency ratio between the timer clock ( $f_{CLKIN}$ ) and the dead-time clock ( $f_{DTS}$ ). The dead-time clock is also used as the digital filter sampling clock.<br>00: $f_{DTS} = f_{CLKIN}$<br>01: $f_{DTS} = f_{CLKIN}/2$<br>10: $f_{DTS} = f_{CLKIN}/4$<br>11: Reserved                                                                                                                                                                                                                                                                                                                                      |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                             |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | UGDIS   | Update event 1 interrupt generation disable control<br>0: Any of the following events will generate an update PDMA request or interrupt<br>- Counter overflow / underflow<br>- Setting the UEV1G bit<br>- Update generation through the slave mode<br>1: Only counter overflow/underflow generates an update PDMA request or interrupt                                                   |
| [0]  | UEV1DIS | Update event 1 Disable control<br>0: Enable the update event 1 request by one of following events<br>- Counter overflow / underflow<br>- Setting the UEV1G bit<br>- Update generation through the slave mode<br>1: Disable the update event 1 – however the counter and the prescaler are reinitialised if the UEV1G bit is set or if a hardware restart is received from the slave mode |

## Timer Mode Configuration Register – MDCFR

This register specifies the MCTM master and slave mode selection and single pulse mode.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |    |       |    |        |   |
|------------|----------|----|----|----|----|-------|----|--------|---|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25 | 24     |   |
|            | Reserved |    |    |    |    |       |    | SPMSET |   |
| Type/Reset |          |    |    |    |    |       |    | RW     | 0 |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17 | 16     |   |
|            | Reserved |    |    |    |    | MMSEL |    |        |   |
| Type/Reset |          |    |    |    |    | RW    | 0  | RW     | 0 |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9  | 8      |   |
|            | Reserved |    |    |    |    | SMSEL |    |        |   |
| Type/Reset |          |    |    |    |    | RW    | 0  | RW     | 0 |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1  | 0      |   |
|            | Reserved |    |    |    |    |       |    | TSE    |   |
| Type/Reset |          |    |    |    |    |       |    | RW     | 0 |

| Bits | Field  | Descriptions                                                                                                                                                                                                     |
|------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [24] | SPMSET | Single Pulse Mode Setting<br>0: Counter counts normally irrespective of whether a update event occurred or not<br>1: Counter stops counting at the next update event and then the TME bit is cleared by hardware |

| Bits        | Field                | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
|-------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------------|-----|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------|----------------------------------------------------------|-----|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----|------------------|------------------------------------------------------------------------------------|-----|------------------|------------------------------------------------------------------------------------|-----|------------------|------------------------------------------------------------------------------------|-----|------------------|------------------------------------------------------------------------------------|
| [18:16]     | MMSEL                | <p>Master Mode Selection</p> <p>Master mode selection is used to select the MTO signal source which is used to synchronise the other slave timer.</p> <table> <tr> <th>MMSEL [2:0]</th><th>Mode</th><th>Descriptions</th></tr> <tr> <td>000</td><td>Reset Mode</td><td>The MTO in the Reset mode is an output derived from one of the following cases:<br/>1. Software setting UEV1G bit<br/>2. Slave has trigger input when used in slave restart mode</td></tr> <tr> <td>001</td><td>Enable Mode</td><td>The Counter Enable signal is used as the trigger output.</td></tr> <tr> <td>010</td><td>Update Mode</td><td>The update event 1 is used as the trigger output according to one of the following cases when the UEV1DIS bit is cleared to 0:<br/>1. Counter overflow/underflow<br/>2. Software setting UEV1G<br/>3. Slave has trigger input when used in slave restart mode</td></tr> <tr> <td>011</td><td>Capture/Compare Mode</td><td>When a Channel 0 capture or compare match event occurs, it will generate a positive pulse which is used as the master trigger output.</td></tr> <tr> <td>100</td><td>Compare output 0</td><td>The Channel 0 Output reference signal named CH0OREF is used as the trigger output.</td></tr> <tr> <td>101</td><td>Compare output 1</td><td>The Channel 1 Output reference signal named CH1OREF is used as the trigger output.</td></tr> <tr> <td>110</td><td>Compare output 2</td><td>The Channel 2 Output reference signal named CH2OREF is used as the trigger output.</td></tr> <tr> <td>111</td><td>Compare output 3</td><td>The Channel 3 Output reference signal named CH3OREF is used as the trigger output.</td></tr> </table> | MMSEL [2:0] | Mode | Descriptions | 000 | Reset Mode | The MTO in the Reset mode is an output derived from one of the following cases:<br>1. Software setting UEV1G bit<br>2. Slave has trigger input when used in slave restart mode | 001 | Enable Mode | The Counter Enable signal is used as the trigger output. | 010 | Update Mode | The update event 1 is used as the trigger output according to one of the following cases when the UEV1DIS bit is cleared to 0:<br>1. Counter overflow/underflow<br>2. Software setting UEV1G<br>3. Slave has trigger input when used in slave restart mode | 011 | Capture/Compare Mode | When a Channel 0 capture or compare match event occurs, it will generate a positive pulse which is used as the master trigger output. | 100 | Compare output 0 | The Channel 0 Output reference signal named CH0OREF is used as the trigger output. | 101 | Compare output 1 | The Channel 1 Output reference signal named CH1OREF is used as the trigger output. | 110 | Compare output 2 | The Channel 2 Output reference signal named CH2OREF is used as the trigger output. | 111 | Compare output 3 | The Channel 3 Output reference signal named CH3OREF is used as the trigger output. |
| MMSEL [2:0] | Mode                 | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 000         | Reset Mode           | The MTO in the Reset mode is an output derived from one of the following cases:<br>1. Software setting UEV1G bit<br>2. Slave has trigger input when used in slave restart mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 001         | Enable Mode          | The Counter Enable signal is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 010         | Update Mode          | The update event 1 is used as the trigger output according to one of the following cases when the UEV1DIS bit is cleared to 0:<br>1. Counter overflow/underflow<br>2. Software setting UEV1G<br>3. Slave has trigger input when used in slave restart mode                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 011         | Capture/Compare Mode | When a Channel 0 capture or compare match event occurs, it will generate a positive pulse which is used as the master trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 100         | Compare output 0     | The Channel 0 Output reference signal named CH0OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 101         | Compare output 1     | The Channel 1 Output reference signal named CH1OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 110         | Compare output 2     | The Channel 2 Output reference signal named CH2OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |
| 111         | Compare output 3     | The Channel 3 Output reference signal named CH3OREF is used as the trigger output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |            |                                                                                                                                                                                |     |             |                                                          |     |             |                                                                                                                                                                                                                                                            |     |                      |                                                                                                                                       |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |     |                  |                                                                                    |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|--------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----|--------------|----------------------------------------------------------|-----|----------|--|-----|----------|--|-----|----------|--|-----|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------|-------------------------------------------------------------------------------|
| [10:8] | SMSEL | Slave Mode Selection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |              |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | <table><tr><th>SMSEL [2:0]</th><th>Mode</th><th>Descriptions</th></tr><tr><td>000</td><td>Disable mode</td><td>The prescaler is clocked directly by the internal clock.</td></tr><tr><td>001</td><td>Reserved</td><td></td></tr><tr><td>010</td><td>Reserved</td><td></td></tr><tr><td>011</td><td>Reserved</td><td></td></tr><tr><td>100</td><td>Restart Mode</td><td>The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.</td></tr><tr><td>101</td><td>Pause Mode</td><td>The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal.</td></tr><tr><td>110</td><td>Trigger Mode</td><td>The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the star of counter is controlled.</td></tr><tr><td>111</td><td>STIED</td><td>The rising edge of the selected trigger signal STI will be the counter clock.</td></tr></table> | SMSEL [2:0]  | Mode                                                                                                                                                                                                                                                                 | Descriptions | 000 | Disable mode | The prescaler is clocked directly by the internal clock. | 001 | Reserved |  | 010 | Reserved |  | 011 | Reserved |  | 100 | Restart Mode | The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated. | 101 | Pause Mode | The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal. | 110 | Trigger Mode | The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the star of counter is controlled. | 111 | STIED | The rising edge of the selected trigger signal STI will be the counter clock. |
|        |       | SMSEL [2:0]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Mode         | Descriptions                                                                                                                                                                                                                                                         |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Disable mode | The prescaler is clocked directly by the internal clock.                                                                                                                                                                                                             |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reserved     |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 010                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reserved     |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 011                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reserved     |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Restart Mode | The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.                                                                                         |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Pause Mode   | The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal. |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
|        |       | 110                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Trigger Mode | The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the star of counter is controlled.                                                                                                     |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
| 111    | STIED | The rising edge of the selected trigger signal STI will be the counter clock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |              |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |
| [0]    | TSE   | Timer Synchronisation Enable<br>0: No action<br>1: Master timer (current timer) will generate a delay to synchronise its slave timer through the MTO signal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |                                                                                                                                                                                                                                                                      |              |     |              |                                                          |     |          |  |     |          |  |     |          |  |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                  |     |       |                                                                               |

## Timer Trigger Configuration Register – TRCFR

This register specifies the trigger source selection of MCTM.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | TRSEL |    |    |    |
|            |          |    |    |    | RW    | 0  | RW | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TRSEL | <p>Trigger Source Selection</p> <p>These bits are used to select the trigger input (STI) for counter synchronising.</p> <p>0000: Software Trigger by setting the UEV1G bit</p> <p>0001: Channel 0 filtered input – TI0S0</p> <p>0010: Channel 1 filtered input – TI1S1</p> <p>0011: Reserved</p> <p>1000: Channel 0 Edge Detector – TI0BED</p> <p>1001: Internal Timer Trigger 0 – ITI0</p> <p>1010: Internal Timer Trigger 1 – ITI1</p> <p>1011: Internal Timer Trigger 2 – ITI2</p> <p>Others: Default 0</p> |

Note: These bits must be updated only when they are not in use, i.e. the slave mode is disabled by setting the SMSEL field to 0x00.

**Table 39. MCTM Internal Trigger Connection**

| Slave Timing Module | ITI0  | ITI1  | ITI2  |
|---------------------|-------|-------|-------|
| MCTM0               | MCTM1 | GPTM0 | GPTM1 |
| MCTM1               | MCTM0 | GPTM0 | GPTM1 |

## Timer Counter Register – CTR

This register specifies the timer enable bit (TME), CRR buffer enable bit (CRBE), Capture/compare control bit and Channel PDMA selection bit (CHCCDS).

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |       |         |      |
|------------|----------|----|----|----|----|----|-------|---------|------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25    | 24      |      |
| Type/Reset | Reserved |    |    |    |    |    |       |         |      |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17    | 16      |      |
| Type/Reset | Reserved |    |    |    |    |    |       | CHCCDS  |      |
|            |          |    |    |    |    |    |       |         | RW 0 |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9     | 8       |      |
| Type/Reset | Reserved |    |    |    |    |    | COMUS | COMPARE |      |
|            |          |    |    |    |    |    | RW 0  | RW 0    |      |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1     | 0       |      |
| Type/Reset | Reserved |    |    |    |    |    | CRBE  | TME     |      |
|            |          |    |    |    |    |    | RW 0  | RW 0    |      |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [16] | CHCCDS  | Channel Capture/Compare PDMA Selection<br>0: Channel PDMA request derived from the channel capture/compare event.<br>1: Channel PDMA request derived from the update event 1.                                                                                                                                                                                                               |
| [9]  | COMUS   | Capture/Compare Control Update Selection<br>0: Updated by setting the UEV2G bit only<br>1: Updated by setting the UEV2G bit or when a STI signal rising edge occurs<br>This bit is only available when the capture/compare preload function is enabled by setting the COMPARE bit to 1.                                                                                                     |
| [8]  | COMPARE | Capture/Compare Preloaded Enable Control<br>0: CHxE, CHxNE and CHxOM bits are not preloaded<br>1: CHxE, CHxNE and CHxOM bits are preloaded<br>If this bit is set to 1, the corresponding capture/compare control bits including the CHxE, CHxNE and CHxOM bits will be updated when the update event 2 occurs.                                                                              |
| [1]  | CRBE    | Counter-Reload register Buffer Enable<br>0: Counter reload register can be updated immediately<br>1: Counter reload register can not be updated until the update event occurs                                                                                                                                                                                                               |
| [0]  | TME     | Timer Enable bit<br>0: MCTM off<br>1: MCTM on – MCTM functions normally<br>When the TME bit is cleared to 0, the counter is stopped and the MCTM consumes no power in any operational mode except for the single pulse mode and the slave trigger mode. In these two modes the TME bit can automatically be set to 1 by hardware which permits all the MCTM registers to function normally. |

## Channel 0 Input Configuration Register – CH0ICFR

This register specifies the channel 0 input mode configuration.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |          |    |    |        |    |        |    |
|------------|----------|----------|----|----|--------|----|--------|----|
|            | 31       | 30       | 29 | 28 | 27     | 26 | 25     | 24 |
|            | TI0SRC   | Reserved |    |    |        |    |        |    |
| Type/Reset | RW       | 0        |    |    |        |    |        |    |
|            | 23       | 22       | 21 | 20 | 19     | 18 | 17     | 16 |
|            | Reserved |          |    |    | CH0PSC |    | CH0CCS |    |
| Type/Reset |          |          |    |    | RW     | 0  | RW     | 0  |
|            | 15       | 14       | 13 | 12 | 11     | 10 | 9      | 8  |
|            | Reserved |          |    |    |        |    |        |    |
| Type/Reset |          |          |    |    |        |    |        |    |
|            | 7        | 6        | 5  | 4  | 3      | 2  | 1      | 0  |
|            | Reserved |          |    |    | TI0F   |    |        |    |
| Type/Reset |          |          |    |    | RW     | 0  | RW     | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31]    | TI0SRC | Channel 0 Input Source TI0 Selection<br>0: The MT_CH0 pin is connected to the channel 0 input TI0<br>1: The XOR operation output of the MT_CH0, MT_CH1, and MT_CH2 pins are connected to the channel 0 input TI0                                                                                                                                                                                                                                                                                                                                                           |
| [19:18] | CH0PSC | Channel 0 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 0 capture input. Note that the prescaler is reset once the Channel 0 Capture/Compare Enable bit, CH0E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 0 capture input signal is chosen for each active event<br>01: Channel 0 Capture input signal is chosen for every 2 events<br>10: Channel 0 Capture input signal is chosen for every 4 events<br>11: Channel 0 Capture input signal is chosen for every 8 events |
| [17:16] | CH0CCS | Channel 0 Capture/Compare Selection<br>00: Channel 0 is configured as an output<br>01: Channel 0 is configured as an input derived from the TI0 signal<br>10: Channel 0 is configured as an input derived from the TI1 signal<br>11: Channel 0 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH0CCS field can be accessed only when the CH0E bit is cleared to 0.                                                                                                                                           |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TIOF  | <p>Channel 0 Input Source TIO Filter Setting</p> <p>These bits define the frequency divided ratio used to sample the TIO signal. The Digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{SYSTEM}</math>.</p> <p>0001: <math>f_{SAMPLING} = f_{CLKIN}</math>, <math>N = 2</math></p> <p>0010: <math>f_{SAMPLING} = f_{CLKIN}</math>, <math>N = 4</math></p> <p>0011: <math>f_{SAMPLING} = f_{CLKIN}</math>, <math>N = 8</math></p> <p>0100: <math>f_{SAMPLING} = f_{DTS}/2</math>, <math>N = 6</math></p> <p>0101: <math>f_{SAMPLING} = f_{DTS}/2</math>, <math>N = 8</math></p> <p>0110: <math>f_{SAMPLING} = f_{DTS}/4</math>, <math>N = 6</math></p> <p>0111: <math>f_{SAMPLING} = f_{DTS}/4</math>, <math>N = 8</math></p> <p>1000: <math>f_{SAMPLING} = f_{DTS}/8</math>, <math>N = 6</math></p> <p>1001: <math>f_{SAMPLING} = f_{DTS}/8</math>, <math>N = 8</math></p> <p>1010: <math>f_{SAMPLING} = f_{DTS}/16</math>, <math>N = 5</math></p> <p>1011: <math>f_{SAMPLING} = f_{DTS}/16</math>, <math>N = 6</math></p> <p>1100: <math>f_{SAMPLING} = f_{DTS}/16</math>, <math>N = 8</math></p> <p>1101: <math>f_{SAMPLING} = f_{DTS}/32</math>, <math>N = 5</math></p> <p>1110: <math>f_{SAMPLING} = f_{DTS}/32</math>, <math>N = 6</math></p> <p>1111: <math>f_{SAMPLING} = f_{DTS}/32</math>, <math>N = 8</math></p> |

## Channel 1 Input Configuration Register – CH1ICFR

This register specifies the channel 1 input mode configuration.

Offset: 0x024

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |        |    |
|------------|----------|----|----|----|--------|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    | CH1PSC |    | CH1CCS |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1      | 0  |
| Type/Reset | Reserved |    |    |    | TI1F   |    |        |    |
|            |          |    |    |    | RW     | 0  | RW     | 0  |
|            |          |    |    |    |        |    | RW     | 0  |
|            |          |    |    |    |        |    |        | RW |
|            |          |    |    |    |        |    |        | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CH1PSC | Channel 1 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 1 capture input. Note that the prescaler is reset once the Channel 1 Capture/Compare Enable bit, CH1E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 1 capture input signal is chosen for each active event<br>01: Channel 1 Capture input signal is chosen for every 2 events<br>10: Channel 1 Capture input signal is chosen for every 4 events<br>11: Channel 1 Capture input signal is chosen for every 8 events |
| [17:16] | CH1CCS | Channel 1 Capture/Compare Selection<br>00: Channel 1 is configured as an output<br>01: Channel 1 is configured as an input derived from the TI1 signal<br>10: Channel 1 is configured as an input derived from the TI0 signal<br>11: Channel 1 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH1CCS field can be accessed only when the CH1E bit is cleared to 0.                                                                                                                                           |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TI1F  | <p>Channel 1 Input Source TI1 Filter Setting</p> <p>These bits define the frequency divide ratio used to sample the TI1 signal. The Digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/32, N = 8</math></p> |

## Channel 2 Input Configuration Register – CH2ICFR

This register specifies the channel 2 input mode configuration.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |        |    |
|------------|----------|----|----|----|--------|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    | CH2PSC |    | CH2CCS |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1      | 0  |
| Type/Reset | Reserved |    |    |    | TI2F   |    |        |    |
|            |          |    |    |    | RW     | 0  | RW     | 0  |
|            |          |    |    |    |        |    | RW     | 0  |
|            |          |    |    |    |        |    |        | RW |
|            |          |    |    |    |        |    |        | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CH2PSC | Channel 2 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 2 capture input. Note that the prescaler is reset once the Channel 2 Capture/Compare Enable bit, CH2E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 2 capture input signal is chosen for each active event<br>01: Channel 2 Capture input signal is chosen for every 2 events<br>10: Channel 2 Capture input signal is chosen for every 4 events<br>11: Channel 2 Capture input signal is chosen for every 8 events |
| [17:16] | CH2CCS | Channel 2 Capture/Compare Selection<br>00: Channel 2 is configured as an output<br>01: Channel 2 is configured as an input derived from the TI2 signal<br>10: Channel 2 is configured as an input derived from the TI3 signal<br>11: Channel 2 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH2CCS field can be accessed only when the CH2E bit is cleared to 0.                                                                                                                                           |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TI2F  | <p>Channel 2 Input Source TI2 Filter Setting</p> <p>These bits define the frequency divide ratio used to sample the TI2 signal. The Digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 8</math></p> |

## Channel 3 Input Configuration Register – CH3ICFR

This register specifies the channel 3 input mode configuration.

Offset: 0x02C

Reset value: 0x0000\_0000

|            |          |    |    |    |        |    |        |    |
|------------|----------|----|----|----|--------|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    | CH3PSC |    | CH3CCS |    |
|            | 15       | 14 | 13 | 12 | 11     | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |        |    |        |    |
|            | 7        | 6  | 5  | 4  | 3      | 2  | 1      | 0  |
| Type/Reset | Reserved |    |    |    | TI3F   |    |        |    |
|            |          |    |    |    | RW     | 0  | RW     | 0  |
|            |          |    |    |    |        |    | RW     | 0  |
|            |          |    |    |    |        |    |        | RW |
|            |          |    |    |    |        |    |        | 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CH3PSC | Channel 3 Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel 3 capture input. Note that the prescaler is reset once the Channel 3 Capture/Compare Enable bit, CH3E, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel 3 capture input signal is chosen for each active event<br>01: Channel 3 Capture input signal is chosen for every 2 events<br>10: Channel 3 Capture input signal is chosen for every 4 events<br>11: Channel 3 Capture input signal is chosen for every 8 events |
| [17:16] | CH3CCS | Channel 3 Capture/Compare Selection<br>00: Channel 3 is configured as an output<br>01: Channel 3 is configured as an input derived from the TI3 signal<br>10: Channel 3 is configured as an input derived from the TI2 signal<br>11: Channel 3 is configured as an input which comes from the TRCED signal derived from the Trigger Controller<br>Note: The CH3CCS field can be accessed only when the CH3E bit is cleared to 0.                                                                                                                                           |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TI3F  | <p>Channel 3 Input Source TI3 Filter Setting</p> <p>These bits define the frequency divide ratio used to sample the TI3 signal. The digital filter in the GPTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2, N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4, N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8, N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16, N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32, N = 8</math></p> |

## Channel 0 Output Configuration Register – CH0OCFR

This register specifies the channel 0 output mode configuration.

Offset: 0x040

Reset value: 0x0000\_0000

|            |          |    |         |        |          |    |            |          |      |
|------------|----------|----|---------|--------|----------|----|------------|----------|------|
|            | 31       | 30 | 29      | 28     | 27       | 26 | 25         | 24       |      |
| Type/Reset | Reserved |    |         |        |          |    |            |          |      |
|            | 23       | 22 | 21      | 20     | 19       | 18 | 17         | 16       |      |
| Type/Reset | Reserved |    |         |        |          |    |            |          |      |
|            | 15       | 14 | 13      | 12     | 11       | 10 | 9          | 8        |      |
| Type/Reset | Reserved |    |         |        |          |    |            | CH0OM[3] |      |
|            |          |    |         |        |          |    |            |          | RW 0 |
|            | 7        | 6  | 5       | 4      | 3        | 2  | 1          | 0        |      |
| Type/Reset | Reserved |    | CH0IMAE | CH0PRE | Reserved |    | CH0OM[2:0] |          |      |
|            |          |    | RW 0    | RW 0   |          |    | RW 0       | RW 0     | RW 0 |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH0IMAE | Channel 0 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode is enabled<br>CH0OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH0CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH0IMAE bit is available only if channel 0 is configured operate in PWM mode 1 or PWM mode 2. |
| [4]  | CH0PRE  | Channel 0 Capture/Compare Register (CH0CCR) Preload Enable<br>0: CH0CCR preload function is disabled<br>The CH0CCR register can be immediately assigned a new value when the CH0PRE bit is cleared to 0 and the updated CH0CCR value is used immediately.<br>1: CH0CCR preload function is enabled<br>The new CH0CCR value will not be transferred to its shadow register until an update event 1 occurs.                                                                                              |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH0OM[3:0] | <p>Channel 0 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH0OREF.</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH0OREF is forced to 0</p> <p>0101: Force active – CH0OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 has an active level when CNTR &lt; CH0CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 0 has an inactive level when CNTR &gt; CH0CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 is has an inactive level when CNTR &lt; CH0CCR or otherwise has an active level.</li> <li>- During down-counting, channel 0 has an active level when CNTR &gt; CH0CCR or otherwise has an inactive level.</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 has an active level when CNTR &lt; CH0CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 0 has an inactive level when CNTR &gt; CH0CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 0 has an inactive level when CNTR &lt; CH0CCR or otherwise has an active level.</li> <li>- During down-counting, channel 0 has an active level when CNTR &gt; CH0CCR or otherwise has an inactive level</li> </ul> <p>Note: When channel 0 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel 1 Output Configuration Register – CH1OCFR

This register specifies the channel 1 output mode configuration.

Offset: 0x044

Reset value: 0x0000\_0000

|            |          |    |         |        |          |            |    |          |    |
|------------|----------|----|---------|--------|----------|------------|----|----------|----|
|            | 31       | 30 | 29      | 28     | 27       | 26         | 25 | 24       |    |
| Type/Reset | Reserved |    |         |        |          |            |    |          |    |
|            | 23       | 22 | 21      | 20     | 19       | 18         | 17 | 16       |    |
| Type/Reset | Reserved |    |         |        |          |            |    |          |    |
|            | 15       | 14 | 13      | 12     | 11       | 10         | 9  | 8        |    |
| Type/Reset | Reserved |    |         |        |          |            |    | CH1OM[3] |    |
|            |          |    |         |        |          |            |    | RW       | 0  |
|            | 7        | 6  | 5       | 4      | 3        | 2          | 1  | 0        |    |
| Type/Reset | Reserved |    | CH1IMAE | CH1PRE | Reserved | CH1OM[2:0] |    |          |    |
|            |          |    | RW      | 0      | RW       | 0          | RW | 0        | RW |
|            |          |    |         |        |          |            |    |          | 0  |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH1IMAE | Channel 1 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode enabled<br>The CH1OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH1CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH1IMAE bit is available only if channel 1 is configured to be operated in PWM mode 1 or PWM mode 2. |
| [4]  | CH1PRE  | Channel 1 Capture/Compare Register (CH1CCR) Preload Enable<br>0: CH1CCR preload function is disabled.<br>The CH1CCR register can be immediately assigned a new value when the CH1PRE bit is cleared to 0 and the updated CH1CCR value is used immediately.<br>1: CH1CCR preload function is enabled<br>The new CH1CCR value will not be transferred to its shadow register until an update event 1 occurs.                                                                                                     |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH1OM[3:0] | <p>Channel 1 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH1OREF.</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH1OREF is forced to 0</p> <p>0101: Force active – CH1OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an active level when CNTR &lt; CH1CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 1 has an inactive level when CNTR &gt; CH1CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an inactive level when CNTR &lt; CH1CCR or otherwise has an active level.</li> <li>- During down-counting, channel 1 has an active level when CNTR &gt; CH1CCR or otherwise has an inactive level.</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an active level when CNTR &lt; CH1CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 1 has an inactive level when CNTR &gt; CH1CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 1 has an inactive level when CNTR &lt; CH1CCR or otherwise has an active level.</li> <li>- During down-counting, channel 1 has an active level when CNTR &gt; CH1CCR or otherwise has an inactive level.</li> </ul> <p>Note: When channel 1 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel 2 Output Configuration Register – CH2OCFR

This register specifies the channel 2 output mode configuration.

Offset: 0x048

Reset value: 0x0000\_0000

|            |          |    |         |        |          |    |            |          |
|------------|----------|----|---------|--------|----------|----|------------|----------|
|            | 31       | 30 | 29      | 28     | 27       | 26 | 25         | 24       |
| Type/Reset | Reserved |    |         |        |          |    |            |          |
|            | 23       | 22 | 21      | 20     | 19       | 18 | 17         | 16       |
| Type/Reset | Reserved |    |         |        |          |    |            |          |
|            | 15       | 14 | 13      | 12     | 11       | 10 | 9          | 8        |
| Type/Reset | Reserved |    |         |        |          |    |            | CH2OM[3] |
|            |          |    |         |        |          |    | RW         | 0        |
|            | 7        | 6  | 5       | 4      | 3        | 2  | 1          | 0        |
| Type/Reset | Reserved |    | CH2IMAE | CH2PRE | Reserved |    | CH2OM[2:0] |          |
|            |          |    | RW      | 0      | RW       | 0  | RW         | 0        |
|            |          |    |         |        |          |    |            |          |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH2IMAE | Channel 2 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode enabled<br>The CH2OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH2CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH2IMAE bit is available only if the channel 2 is configured to be operated in PWM mode 1 or PWM mode 2. |
| [4]  | CH2PRE  | Channel 2 Capture/Compare Register (CH2CCR) Preload Enable<br>0: CH2CCR preload function is disabled.<br>The CH2CCR register can be immediately assigned a new value when the CH2PRE bit is cleared to 0 and the updated CH2CCR value is used immediately.<br>1: CH2CCR preload function is enabled<br>The new CH2CCR value will not be transferred to its shadow register until an update event 1 occurs.                                                                                                         |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH2OM[3:0] | <p>Channel 2 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH2OREF.</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH2OREF is forced to 0</p> <p>0101: Force active – CH2OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an active level when CNTR &lt; CH2CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 2 has an inactive level when CNTR &gt; CH2CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an inactive level when CNTR &lt; CH2CCR or otherwise has an active level.</li> <li>- During down-counting, channel 2 has an active level when CNTR &gt; CH2CCR or otherwise has an inactive level.</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an active level when CNTR &lt; CH2CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 2 has an inactive level when CNTR &gt; CH2CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 2 has an inactive level when CNTR &lt; CH2CCR or otherwise has an active level.</li> <li>- During down-counting, channel 2 has an active level when CNTR &gt; CH2CCR or otherwise has an inactive level.</li> </ul> <p>Note: When channel 2 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel 3 Output Configuration Register – CH3OCFR

This register specifies the channel 3 output mode configuration.

Offset: 0x04C

Reset value: 0x0000\_0000

|            |          |    |         |        |          |            |      |          |      |
|------------|----------|----|---------|--------|----------|------------|------|----------|------|
|            | 31       | 30 | 29      | 28     | 27       | 26         | 25   | 24       |      |
| Type/Reset | Reserved |    |         |        |          |            |      |          |      |
|            | 23       | 22 | 21      | 20     | 19       | 18         | 17   | 16       |      |
| Type/Reset | Reserved |    |         |        |          |            |      |          |      |
|            | 15       | 14 | 13      | 12     | 11       | 10         | 9    | 8        |      |
| Type/Reset | Reserved |    |         |        |          |            |      | CH3OM[3] |      |
|            |          |    |         |        |          |            |      |          | RW 0 |
|            | 7        | 6  | 5       | 4      | 3        | 2          | 1    | 0        |      |
| Type/Reset | Reserved |    | CH3IMAE | CH3PRE | Reserved | CH3OM[2:0] |      |          |      |
|            |          |    | RW 0    | RW 0   |          | RW 0       | RW 0 | RW 0     |      |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | CH3IMAE | Channel 3 Immediate Active Enable<br>0: No action<br>1: Single pulse Immediate Active Mode enabled<br>The CH3OREF will be forced to the compare matched level immediately after an available trigger event occurs irrespective of the result of the comparison between the CNTR and the CH3CCR values.<br>The effective duration ends automatically at the next overflow or underflow event.<br>Note: The CH3IMAE bit is available only if channel 3 is configured to be operated in PWM mode 1 or PWM mode 2. |
| [4]  | CH3PRE  | Channel 3 Capture/Compare Register (CH3CCR) Preload Enable<br>0: CH3CCR preload function is disabled.<br>The CH3CCR register can be immediately assigned a new value when the CH3PRE bit is cleared to 0 and the updated CH3CCR value is used immediately.<br>1: CH3CCR preload function is enabled<br>The new CH3CCR value will not be transferred to its shadow register until an update event 1 occurs.                                                                                                     |

| Bits     | Field      | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8][2:0] | CH3OM[3:0] | <p>Channel 3 Output Mode Setting</p> <p>These bits define the functional types of the output reference signal CH3OREF</p> <p>0000: No Change</p> <p>0001: Output 0 on compare match</p> <p>0010: Output 1 on compare match</p> <p>0011: Output toggles on compare match</p> <p>0100: Force inactive – CH3OREF is forced to 0</p> <p>0101: Force active – CH3OREF is forced to 1</p> <p>0110: PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an active level when CNTR &lt; CH3CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 3 has an inactive level when CNTR &gt; CH3CCR or otherwise has an active level.</li> </ul> <p>0111: PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an inactive level when CNTR &lt; CH3CCR or otherwise has an active level.</li> <li>- During down-counting, channel 3 has an active level when CNTR &gt; CH3CCR or otherwise has an inactive level</li> </ul> <p>1110: Asymmetric PWM mode 1</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an active level when CNTR &lt; CH3CCR or otherwise has an inactive level.</li> <li>- During down-counting, channel 3 has an inactive level when CNTR &gt; CH3CCR or otherwise has an active level.</li> </ul> <p>1111: Asymmetric PWM mode 2</p> <ul style="list-style-type: none"> <li>- During up-counting, channel 3 has an inactive level when CNTR &lt; CH3CCR or otherwise has an active level.</li> <li>- During down-counting, channel 3 has an active level when CNTR &gt; CH3CCR or otherwise has an inactive level</li> </ul> <p>Note: When channel 3 is used as asymmetric PWM output mode, the Counter Mode Selection bit in Counter Configuration Register must be configured as Center-aligned Counting mode (CMSEL = 01/02/03)</p> |

## Channel Control Register – CHCTR

This register contains the channel capture input or compare output function enable control bits.

Offset: 0x050

Reset value: 0x0000\_0000

|            |          |      |       |      |       |      |       |      |
|------------|----------|------|-------|------|-------|------|-------|------|
|            | 31       | 30   | 29    | 28   | 27    | 26   | 25    | 24   |
| Type/Reset | Reserved |      |       |      |       |      |       |      |
|            | 23       | 22   | 21    | 20   | 19    | 18   | 17    | 16   |
| Type/Reset | Reserved |      |       |      |       |      |       |      |
|            | 15       | 14   | 13    | 12   | 11    | 10   | 9     | 8    |
| Type/Reset | Reserved |      |       |      |       |      |       |      |
|            | 7        | 6    | 5     | 4    | 3     | 2    | 1     | 0    |
| Type/Reset | Reserved | CH3E | CH2NE | CH2E | CH1NE | CH1E | CH0NE | CH0E |
|            | RW       | 0    | RW    | 0    | RW    | 0    | RW    | 0    |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | CH3E  | Channel 3 Capture/Compare Enable<br>- Channel 3 is configured as an input (CH3CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 3 is configured as an output (CH3CCS = 0x00)<br>0: Off – Channel 3 output signal CH3O is not active<br>1: On – Channel 3 output signal CH3O is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR and CH3OIS bits.                                                                                                                                    |
| [5]  | CH2NE | Channel 2 Capture/Compare Complementary Enable<br>0: Off – Channel 2 complementary output CH2NO is not active. The CH2NO level is then determined by the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2E bits.<br>1: On – Channel 2 complementary output CH2NO is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2E bits.                                                                                                                                                                                      |
| [4]  | CH2E  | Channel 2 Capture/Compare Enable<br>- Channel 2 is configured as an input (CH2CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 2 is configured as an output (CH2CCS = 0x00)<br>0: Off – Channel 2 output signal CH2O is not active. The CH2O level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2NE bits.<br>1: On – Channel 2 output signal CH2O is generated on the corresponding output pin determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH2OIS, CH2OISN and CH2NE bits. |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | CH1NE | Channel 1 Capture/Compare Complementary Enable<br>0: Off – Channel 1 complementary output CH1NO is not active. The CH1NO level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1E bits.<br>1: On – Channel 1 complementary output CH1NO is generated on the corresponding output pin determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1E bits.                                                                                                                                                                    |
| [2]  | CH1E  | Channel 1 Capture/Compare Enable<br>- Channel 1 is configured as an input (CH1CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 1 is configured as an output (CH1CCS = 0x00)<br>0: Off – Channel 1 output signal CH1O is not active. The CH1O level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1NE bits.<br>1: On – Channel 1 output signal CH1O is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR, CH1OIS, CH1OISN and CH1NE bits.  |
| [1]  | CH0NE | Channel 0 Capture/Compare Complementary Enable<br>0: Off – Channel 0 complementary output CH0NO is not active. The CH0NO level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0E bits.<br>1: On – Channel 0 complementary output CH0NO is generated on the corresponding output pin depending on the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0E bits.                                                                                                                                                                     |
| [0]  | CH0E  | Channel 0 Capture/Compare Enable<br>- Channel 0 is configured as an input (CH0CCS = 0x01/0x02/0x03)<br>0: Input Capture Mode disabled<br>1: Input Capture Mode enabled<br>- Channel 0 is configured as an output (CH0CCS = 0x00)<br>0: Off – Channel 0 output signal CH0O is not active. The CH0O level is then determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0NE bits.<br>1: On – Channel 0 output signal CH0O is generated on the corresponding output pin determined by the condition of the CHMOE, CHOSSI, CHOSSR, CH0OIS, CH0OISN and CH0NE bits. |

## Channel Polarity Configuration Register – CHPOLR

This register contains the channel capture input or compare output polarity control.

Offset: 0x054

Reset value: 0x0000\_0000

|            |          |      |       |      |       |      |       |      |
|------------|----------|------|-------|------|-------|------|-------|------|
|            | 31       | 30   | 29    | 28   | 27    | 26   | 25    | 24   |
| Type/Reset | Reserved |      |       |      |       |      |       |      |
|            | 23       | 22   | 21    | 20   | 19    | 18   | 17    | 16   |
| Type/Reset | Reserved |      |       |      |       |      |       |      |
|            | 15       | 14   | 13    | 12   | 11    | 10   | 9     | 8    |
| Type/Reset | Reserved |      |       |      |       |      |       |      |
|            | 7        | 6    | 5     | 4    | 3     | 2    | 1     | 0    |
| Type/Reset | Reserved | CH3P | CH2NP | CH2P | CH1NP | CH1P | CH0NP | CH0P |
|            | RW       | 0    | RW    | 0    | RW    | 0    | RW    | 0    |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                      |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | CH3P  | Channel 3 Capture/Compare Polarity<br>- When Channel 3 is configured as an input<br>0: capture event occurs on a Channel 3 rising edge<br>1: capture event occurs on a Channel 3 falling edge<br>- When Channel 3 is configured as an output (CH3CCS = 0x00)<br>0: Channel 3 Output active high<br>1: Channel 3 Output active low |
| [5]  | CH2NP | Channel 2 Capture/Compare Complementary Polarity<br>0: Channel 2 Output active high.<br>1: Channel 2 Output active low                                                                                                                                                                                                            |
| [4]  | CH2P  | Channel 2 Capture/Compare Polarity<br>- When Channel 2 is configured as an input<br>0: capture event occurs on a Channel 2 rising edge<br>1: capture event occurs on a Channel 2 falling edge<br>- When Channel 2 is configured as an output (CH2CCS = 0x00)<br>0: Channel 2 Output active high<br>1: Channel 2 Output active low |
| [3]  | CH1NP | Channel 1 Capture/Compare Complementary Polarity<br>0: Channel 1 Output active high.<br>1: Channel 1 Output active low.                                                                                                                                                                                                           |
| [2]  | CH1P  | Channel 1 Capture/Compare Polarity<br>- When Channel 1 is configured as an input<br>0: capture event occurs on a Channel 1 rising edge<br>1: capture event occurs on a Channel 1 falling edge<br>- Channel 1 is configured as an output (CH1CCS = 0x00)<br>0: Channel 1 Output active high<br>1: Channel 1 Output active low      |
| [1]  | CH0NP | Channel 0 Capture/Compare Complementary Polarity<br>0: Channel 0 Output active high.<br>1: Channel 0 Output active low.                                                                                                                                                                                                           |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                      |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | CH0P  | Channel 0 Capture/Compare Polarity<br>- When Channel 0 is configured as an input<br>0: capture event occurs on a Channel 0 rising edge<br>1: capture event occurs on a Channel 0 falling edge<br>- When Channel 0 is configured as an output (CH0CCS = 0x00)<br>0: Channel 0 Output active high<br>1: Channel 0 Output active low |

## Channel Break Configuration Register – CHBRKCFR

This register specifies the channel output idle state when using the break function.

Offset: 0x06C

Reset value: 0x0000\_0000

|            |          |        |         |        |         |        |         |        |
|------------|----------|--------|---------|--------|---------|--------|---------|--------|
|            | 31       | 30     | 29      | 28     | 27      | 26     | 25      | 24     |
| Type/Reset | Reserved |        |         |        |         |        |         |        |
|            | 23       | 22     | 21      | 20     | 19      | 18     | 17      | 16     |
| Type/Reset | Reserved |        |         |        |         |        |         |        |
|            | 15       | 14     | 13      | 12     | 11      | 10     | 9       | 8      |
| Type/Reset | Reserved |        |         |        |         |        |         |        |
|            | 7        | 6      | 5       | 4      | 3       | 2      | 1       | 0      |
| Type/Reset | Reserved | CH3OIS | CH2OISN | CH2OIS | CH1OISN | CH1OIS | CH0OISN | CH0OIS |
|            |          | RW     | 0       | RW     | 0       | RW     | 0       | RW     |
|            |          |        |         |        |         |        |         | 0      |

| Bits | Field   | Descriptions                                                                                                                                                                        |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | CH3OIS  | MTx_CH3O Output Idle State<br>0: Channel 3 output CH3O = 0 when CHMOE = 0.<br>1: Channel 3 output CH3O = 1 when CHMOE = 0.                                                          |
| [5]  | CH2OISN | MTx_CH2NO Output Idle State<br>0: Channel 2 complementary output CH2NO=0 after a dead time when CHMOE=0<br>1: Channel 2 complementary output CH2NO=1 after a dead time when CHMOE=0 |
| [4]  | CH2OIS  | MTx_CH2O Output Idle State<br>0: Channel 2 output CH2O = 0 after a dead time when CHMOE = 0<br>1: Channel 2 output CH2O = 1 after a dead time when CHMOE = 0                        |
| [3]  | CH1OISN | MTx_CH1NO Output Idle State<br>0: Channel 1 complementary output CH1NO=0 after a dead time when CHMOE=0<br>1: Channel 1 complementary output CH1NO=1 after a dead time when CHMOE=0 |
| [2]  | CH1OIS  | MTx_CH1O Output Idle State<br>0: Channel 1 output CH1O = 0 after a dead time when CHMOE = 0<br>1: Channel 1 output CH1O = 1 after a dead time when CHMOE = 0                        |
| [1]  | CH0OISN | MTx_CH0NO Output Idle State<br>0: Channel 0 complementary output CH1NO=0 after a dead time when CHMOE=0<br>1: Channel 0 complementary output CH1NO=1 after a dead time when CHMOE=0 |
| [0]  | CH0OIS  | MTx_CH0O Output Idle State<br>0: Channel 0 output CH0O = 0 after a dead time when CHMOE = 0<br>1: Channel 0 output CH0O = 1 after a dead time when CHMOE = 0                        |

## Channel Break Control Register – CHBRKCTR

This register specifies the channel break control bits.

Offset: 0x070

Reset value: 0x0000\_0000

|            |          |    |        |        |          |       |        |     |
|------------|----------|----|--------|--------|----------|-------|--------|-----|
|            | 31       | 30 | 29     | 28     | 27       | 26    | 25     | 24  |
|            | CHDTG    |    |        |        |          |       |        |     |
| Type/Reset | RW       | 0  | RW     | 0      | RW       | 0     | RW     | 0   |
|            | 23       | 22 | 21     | 20     | 19       | 18    | 17     | 16  |
|            | Reserved |    | CHOSSR | CHOSSI | Reserved | GFSEL | LOCKLV |     |
| Type/Reset | Reserved |    | RW     | 0      | RW       | 0     | RW     | 0   |
|            | 15       | 14 | 13     | 12     | 11       | 10    | 9      | 8   |
|            | Reserved |    |        |        | BKF      |       |        |     |
| Type/Reset | Reserved |    |        |        | RW       | 0     | RW     | 0   |
|            | 7        | 6  | 5      | 4      | 3        | 2     | 1      | 0   |
|            | Reserved |    | CHAOE  | CHMOE  | Reserved |       | BKP    | BKE |
| Type/Reset | Reserved |    | RW     | 0      | RW       | 0     | RW     | 0   |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:24] | CHDTG  | Channel Dead Time Duration Definition<br>CHDTG[7:5]=0xx: Channel Dead Time=CHDTG [7:0]× $t_{dtg}$ , with $t_{dtg}=t_{DTS}$<br>CHDTG[7:5]=10x: Channel Dead Time=(64 + CHDTG [5:0])× $t_{dtg}$ , with $t_{dtg}=2\times t_{DTS}$<br>CHDTG[7:5]=110: Channel Dead Time=(32 + CHDTG [4:0])× $t_{dtg}$ , with $t_{dtg}=8\times t_{DTS}$<br>CHDTG[7:5]=111: Channel Dead Time=(32 + CHDTG [4:0])× $t_{dtg}$ , with $t_{dtg}=16\times t_{DTS}$ |
| [21]    | CHOSSR | Channel Off State (CHxO, CHxNE=0) Selection for Normal Run State (CHMOE = 1)<br>0: When inactive, MTn_CHxO/MTn_CHxNO output disable - not driven by timer<br>1: When inactive, MTn_CHxO/MTn_CHxNO output enabled with their inactive level                                                                                                                                                                                              |
| [20]    | CHOSSI | Channel Off State Selection for Idle Mode (CHMOE = 0)<br>0: When inactive, MTn_CHxO/MTn_CHxNO output disable - not driven by timer<br>1: When inactive, MTn_CHxO/MTn_CHxNO output enabled with their idle level depending upon the condition of the the CHxOIS and CHxOISN bits.                                                                                                                                                        |
| [18]    | GFSEL  | Deglitch Filter Selction for Break<br>0: no input deglitch filter<br>1: 50ns deglitch filter                                                                                                                                                                                                                                                                                                                                            |
| [17:16] | LOCKLV | Lock Level Setting<br>These bits offer write protection against software errors. The bits can be written only once after a reset.<br>00: LOCK OFF. Register write protected function disabled.<br>01: LOCK Level 1<br>10: LOCK Level 2<br>11: LOCK Level 3                                                                                                                                                                              |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11:8] | BKF   | <p>Break Input Filter Setting</p> <p>These bits define the frequency ratio used to sample the MT_BRK signal. The digital filter in the MCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter – don't need sample clock.<br/>           0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 2</math>.<br/>           0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 4</math>.<br/>           0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}, N = 8</math>.<br/>           0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/2, N = 6</math>.<br/>           0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/2, N = 8</math>.<br/>           0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/4, N = 6</math>.<br/>           0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/4, N = 8</math>.<br/>           1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/8, N = 6</math>.<br/>           1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/8, N = 8</math>.<br/>           1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/16, N = 5</math>.<br/>           1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/16, N = 6</math>.<br/>           1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/16, N = 8</math>.<br/>           1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/32, N = 5</math>.<br/>           1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/32, N = 6</math>.<br/>           1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}}/32, N = 8</math>.</p> |
| [5]    | CHAOE | <p>Channel Automatic Output Enable</p> <p>0: CHMOE can be set only by software.<br/>           1: CHMOE can be set by software or automatically by an update event</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| [4]    | CHMOE | <p>Channel Main Output Enable</p> <p>Cleared asynchronously by hardware on a break event occurrence.</p> <p>0: MTn_CHxO and MTn_CHxNO are disabled or forced to idle states.<br/>           1: MTn_CHxO and MTn_CHxNO are enabled if the enable bits (CHxE, CHxNE) are set.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| [1]    | BKP   | <p>Break Input Polarity.</p> <p>0: Break input active low<br/>           1: Break input active high</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [0]    | BKE   | <p>Break Enable</p> <p>0: Break inputs disabled<br/>           1: Break inputs enabled</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

## Timer PDMA/Interrupt Control Register – DICTR

This register contains the timer PDMA and interrupt enable control bits.

Offset: 0x074

Reset value: 0x0000\_0000

|            |          |    |    |    |         |         |         |         |
|------------|----------|----|----|----|---------|---------|---------|---------|
|            | 31       | 30 | 29 | 28 | 27      | 26      | 25      | 24      |
|            | Reserved |    |    |    |         | TEVDE   | UEV2DE  | UEV1DE  |
| Type/Reset |          |    |    |    |         | RW 0    | RW 0    | RW 0    |
|            | 23       | 22 | 21 | 20 | 19      | 18      | 17      | 16      |
|            | Reserved |    |    |    | CH3CCDE | CH2CCDE | CH1CCDE | CH0CCDE |
| Type/Reset |          |    |    |    | RW 0    | RW 0    | RW 0    | RW 0    |
|            | 15       | 14 | 13 | 12 | 11      | 10      | 9       | 8       |
|            | Reserved |    |    |    | BRKIE   | TEVIE   | UEV2IE  | UEV1IE  |
| Type/Reset |          |    |    |    | RW 0    | RW 0    | RW 0    | RW 0    |
|            | 7        | 6  | 5  | 4  | 3       | 2       | 1       | 0       |
|            | Reserved |    |    |    | CH3CCIE | CH2CCIE | CH1CCIE | CH0CCIE |
| Type/Reset |          |    |    |    | RW 0    | RW 0    | RW 0    | RW 0    |

| Bits | Field   | Descriptions                                                                                                             |
|------|---------|--------------------------------------------------------------------------------------------------------------------------|
| [26] | TEVDE   | Trigger event PDMA Request Enable<br>0: Trigger PDMA request disabled<br>1: Trigger PDMA request enabled                 |
| [25] | UEV2DE  | Update event 2 PDMA Request Enable<br>0: Update event 2 PDMA request disabled<br>1: Update event 2 PDMA request enabled  |
| [24] | UEV1DE  | Update event 1 DMA Request Enable<br>0: Update event 1 PDMA request disabled<br>1: Update event 1 PDMA request enabled   |
| [19] | CH3CCDE | Channel 3 Capture/Compare PDMA Request Enable<br>0: Channel 3 PDMA request disabled<br>1: Channel 3 PDMA request enabled |
| [18] | CH2CCDE | Channel 2 Capture/Compare PDMA Request Enable<br>0: Channel 2 PDMA request disabled<br>1: Channel 2 PDMA request enabled |
| [17] | CH1CCDE | Channel 1 Capture/Compare PDMA Request Enable<br>0: Channel 1 PDMA request disabled<br>1: Channel 1 PDMA request enabled |
| [16] | CH0CCDE | Channel 0 Capture/Compare PDMA Request Enable<br>0: Channel 0 PDMA request disabled<br>1: Channel 0 PDMA request enabled |
| [11] | BRKIE   | Break event Interrupt Enable<br>0: Break event interrupt disabled<br>1: Break event interrupt enabled                    |
| [10] | TEVIE   | Trigger event Interrupt Enable<br>0: Trigger event interrupt disabled<br>1: Trigger event interrupt enabled              |
| [9]  | UEV2IE  | Update event 2 Interrupt Enable<br>0: Update event 2 interrupt disabled<br>1: Update event 2 interrupt enabled           |

| Bits | Field   | Descriptions                                                                                                    |
|------|---------|-----------------------------------------------------------------------------------------------------------------|
| [8]  | UEV1IE  | Update event 1 Interrupt Enable<br>0: Update event 1 interrupt disabled<br>1: Update event 1 interrupt enabled  |
| [3]  | CH3CCIE | Channel 3 Capture/Compare Interrupt Enable<br>0: Channel 3 interrupt disabled<br>1: Channel 3 interrupt enabled |
| [2]  | CH2CCIE | Channel 2 Capture/Compare Interrupt Enable<br>0: Channel 2 interrupt disabled<br>1: Channel 2 interrupt enabled |
| [1]  | CH1CCIE | Channel 1 Capture/Compare Interrupt Enable<br>0: Channel 1 interrupt disabled<br>1: Channel 1 interrupt enabled |
| [0]  | CH0CCIE | Channel 0 Capture/Compare Interrupt Enable<br>0: Channel 0 interrupt disabled<br>1: Channel 0 interrupt enabled |

## Timer Event Generator Register – EVGR

This register contains the software event generation bits.

Offset: 0x078

Reset value: 0x0000\_0000

|            |          |    |    |    |        |        |        |        |
|------------|----------|----|----|----|--------|--------|--------|--------|
|            | 31       | 30 | 29 | 28 | 27     | 26     | 25     | 24     |
| Type/Reset | Reserved |    |    |    |        |        |        |        |
|            | 23       | 22 | 21 | 20 | 19     | 18     | 17     | 16     |
| Type/Reset | Reserved |    |    |    |        |        |        |        |
|            | 15       | 14 | 13 | 12 | 11     | 10     | 9      | 8      |
| Type/Reset | Reserved |    |    |    | BRKG   | TEVG   | UEV2G  | UEV1G  |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1      | 0      |
| Type/Reset | Reserved |    |    |    | CH3CCG | CH2CCG | CH1CCG | CH0CCG |
|            |          |    |    |    | WO     | 0      | WO     | 0      |
|            |          |    |    |    | WO     | 0      | WO     | 0      |
|            |          |    |    |    | WO     | 0      | WO     | 0      |
|            |          |    |    |    | WO     | 0      | WO     | 0      |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11] | BRKG  | Software Break Event Generation<br>The break event BEV can be generated by setting this bit. It is automatically cleared by hardware.<br>0: No action.<br>1: The BRKIF flag is set and then the CHMOE bit will be cleared.                                                                                                                                                                                                                                      |
| [10] | TEVG  | Trigger Event Generation<br>The trigger event TEV can be generated by setting this bit. It is cleared by hardware automatically.<br>0: No action<br>1: The TEVIF flag is set                                                                                                                                                                                                                                                                                    |
| [9]  | UEV2G | Update Event 2 Generation<br>The update event 2 UEV2 can be generated by setting this bit. It is cleared by hardware automatically.<br>0: No action<br>1: Update the CHxE, CHxNE, and CHxOM bits when COMPARE bit in CTR Register is set to 1.                                                                                                                                                                                                                  |
| [8]  | UEV1G | Update Event 1 Generation<br>The update event 1 UEV1 can be generated by setting this bit. It is cleared by hardware automatically.<br>0: No action<br>1: Reinitialise the counter<br>The counter value returns to 0 or the CRR preload value, depending on the counter mode in which the current timer is being used. An update operation on any related registers will also be executed. For a more detailed description, refer to the corresponding section. |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | CH3CCG | <p>Channel 3 Capture/Compare Generation</p> <p>A Channel 3 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel 3</p> <p>If Channel 3 is configured as an input, the counter value is captured into the CH3CCR register and then the CH3CCIF bit is set. If Channel 3 is configured as an output, the CH3CCIF bit is set.</p> |
| [2]  | CH2CCG | <p>Channel 2 Capture/Compare Generation</p> <p>A Channel 2 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel 2</p> <p>If Channel 2 is configured as an input, the counter value is captured into the CH2CCR register and then the CH2CCIF bit is set. If Channel 2 is configured as an output, the CH2CCIF bit is set.</p> |
| [1]  | CH1CCG | <p>Channel 1 Capture/Compare Generation</p> <p>A Channel 1 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel 1</p> <p>If Channel 1 is configured as an input, the counter value is captured into the CH1CCR register and then the CH1CCIF bit is set. If Channel 1 is configured as an output, the CH1CCIF bit is set.</p> |
| [0]  | CH0CCG | <p>Channel 0 Capture/Compare Generation</p> <p>A Channel 0 capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel 0</p> <p>If Channel 0 is configured as an input, the counter value is captured into the CH0CCR register and then the CH0CCIF bit is set. If Channel 0 is configured as an output, the CH0CCIF bit is set.</p> |

## Timer Interrupt Status Register – INTSR

This register stores the timer interrupt status.

Offset: 0x07C

Reset value: 0x0000\_0000

|            |          |        |        |        |         |         |         |         |
|------------|----------|--------|--------|--------|---------|---------|---------|---------|
|            | 31       | 30     | 29     | 28     | 27      | 26      | 25      | 24      |
| Type/Reset | Reserved |        |        |        |         |         |         |         |
|            | 23       | 22     | 21     | 20     | 19      | 18      | 17      | 16      |
| Type/Reset | Reserved |        |        |        |         |         |         |         |
|            | 15       | 14     | 13     | 12     | 11      | 10      | 9       | 8       |
| Type/Reset | Reserved |        |        |        | BRKIF   | TEVIF   | UEV2IF  | UEV1IF  |
|            | 7        | 6      | 5      | 4      | 3       | 2       | 1       | 0       |
| Type/Reset | CH3OCF   | CH2OCF | CH1OCF | CH0OCF | CH3CCIF | CH2CCIF | CH1CCIF | CH0CCIF |
|            | RW       | 0      | RW     | 0      | RW      | 0       | RW      | 0       |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                   |
|------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11] | BRKIF  | Break Event Interrupt Flag<br>This flag is set by hardware when a break event occurs and is cleared by software.<br>0: No break event occurred<br>1: Break event occurred                                                                                                                                                                                                                                      |
| [10] | TEVIF  | Trigger Event Interrupt Flag<br>This flag is set by hardware when a trigger event occurs and is cleared by software.<br>0: No trigger event occurred<br>1: Trigger event occurred                                                                                                                                                                                                                              |
| [9]  | UEV2IF | Update Event 2 Interrupt Flag<br>This bit is set by hardware when an update event 2 occurs and is cleared by software.<br>0: No update event 2 occurred<br>1: Update event 2 occurred                                                                                                                                                                                                                          |
| [8]  | UEV1IF | Update Event 1 Interrupt Flag<br>This bit is set by hardware when a update event 1 occurs and is cleared by software.<br>0: No update event 1 occurred<br>1: Update event 1 occurred<br>Note: The update event 1 is sourced from the following conditions:<br>- A counter overflow or underflow<br>- The UEV1G bit is set with UEVDIS=0<br>- A STI rising edge is received in slave restart mode with UEVDIS=0 |
| [7]  | CH3OCF | Channel 3 Over-capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH3CCIF bit is already set and it is not yet cleared by software.                                                                                                                                                                       |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | CH2OCF  | Channel 2 Over-capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH2CCIF bit is already set and it is not cleared yet by software.                                                                                                                                                                                                                                                                                                                                                                |
| [5]  | CH1OCF  | Channel 1 Over-capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH1CCIF bit is already set and it is not cleared yet by software.                                                                                                                                                                                                                                                                                                                                                                |
| [4]  | CH0OCF  | Channel 0 Over-capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CH0CCIFbit is already set and it is not yet cleared by software                                                                                                                                                                                                                                                                                                                                                                  |
| [3]  | CH3CCIF | Channel 3 Capture/Compare Interrupt Flag<br>- Channel 3 is configured as an output<br>0: No match event occurred<br>1: The contents of the counter CNTR have matched the contents of the CH3CCR register.<br>This flag is set by hardware when the counter value matches the CH3CCR value with exception in the center-aligned counting mode. It is cleared by software.<br>- Channel 3 is configured as an input<br>0: No input capture occurred<br>1: Input capture occurred<br>This bit is set by hardware when a capture event occurs. It is cleared by software or by reading the CH3CCR register. |
| [2]  | CH2CCIF | Channel 2 Capture/Compare Interrupt Flag<br>- Channel 2 is configured as an output<br>0: No match event occurred<br>1: The contents of the counter CNTR have matched the contents of the CH2CCR register<br>This flag is set by hardware when the counter value matches the CH2CCR value with exception in the center-aligned counting mode. It is cleared by software.<br>- Channel 2 is configured as an input<br>0: No input capture occurred<br>1: Input capture occurred.<br>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH2CCR register.          |
| [1]  | CH1CCIF | Channel 1 Capture/Compare Interrupt Flag<br>- Channel 1 is configured as an output<br>0: No match event occurred<br>1: The contents of the counter CNTR have matched the contents of the CH1CCR register<br>This flag is set by hardware when the counter value matches the CH1CCR value with exception in the center-aligned counting mode. It is cleared by software.<br>- Channel 1 is configured as an input<br>0: No input capture occurred<br>1: Input capture occurred<br>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH1CCR register.           |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | CH0CCIF | <p>Channel 0 Capture/Compare Interrupt Flag</p> <ul style="list-style-type: none"><li>- Channel 0 is configured as an output<ul style="list-style-type: none"><li>0: No match event occurs</li><li>1: The contents of the counter CNTR have matched the content of the CH0CCR register</li></ul></li><li>- Channel 0 is configured as an input<ul style="list-style-type: none"><li>0: No input capture occurred</li><li>1: Input capture occurred</li></ul></li></ul> <p>This flag is set by hardware when the counter value matches the CH0CCR value with exception in the center-aligned counting mode. It is cleared by software.</p> <p>This bit is set by hardware on a capture event. It is cleared by software or by reading the CH0CCR register.</p> |

## Timer Counter Register – CNTR

This register stores the timer counter value.

Offset: 0x080

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CNTV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CNTV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions   |
|--------|-------|----------------|
| [15:0] | CNTV  | Counter Value. |

## Timer Prescaler Register – PSCR

This register specifies the timer prescaler value to generate the counter clock.

Offset: 0x084

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PSCV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PSCV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                       |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PSCV  | <p>Prescaler Value</p> <p>These bits are used to specify the prescaler value to generate the counter clock frequency <math>f_{CK\_CNT}</math>.</p> $f_{CK\_CNT} = \frac{f_{CK\_PSC}}{PSCV[15:0] + 1}, \text{ where the } f_{CK\_PSC} \text{ is the prescaler input clock source.}$ |

## Timer Counter Reload Register – CRR

This register specifies the timer counter reload value.

Offset: 0x088

Reset value: 0x0000\_FFFF

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CRV      |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 1  | RW | 1  | RW | 1  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CRV      |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 1  | RW | 1  | RW | 1  | RW |

| Bits   | Field | Descriptions                                                                                          |
|--------|-------|-------------------------------------------------------------------------------------------------------|
| [15:0] | CRV   | Counter Reload Value<br>The CRV is the reload value which is loaded into the actual counter register. |

## Timer Repetition Register – REPR

This register specifies the timer repetition counter value.

Offset: 0x08C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | REPV     |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits  | Field | Descriptions                                                                                                |
|-------|-------|-------------------------------------------------------------------------------------------------------------|
| [7:0] | REPV  | Repetition Counter Value.<br>These bits allow the user to specify the update rate of the compare registers. |

## Channel 0 Capture/Compare Register – CH0CCR

This register specifies the timer channel 0 capture/compare value.

Offset: 0x090

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH0CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH0CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH0CCV | <p>Channel 0 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 0 is configured as an output<br/>The CH0CCR value is compared with the counter value and the comparison result is used to trigger the CH0OREF output signal.</li> <li>- When Channel 0 is configured as an input<br/>The CH0CCR register stores the counter value captured by the last channel 0 capture event.</li> </ul> |

## Channel 1 Capture/Compare Register – CH1CCR

This register specifies the timer channel 1 capture/compare value.

Offset: 0x094

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH1CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH1CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH1CCV | <p>Channel 1 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 1 is configured as an output<br/>The CH1CCR value is compared with the counter value and the comparison result is used to trigger the CH1OREF output signal.</li> <li>- When Channel 1 is configured as an input<br/>The CH1CCR register stores the counter value captured by the last channel 1 capture event.</li> </ul> |

## Channel 2 Capture/Compare Register – CH2CCR

This register specifies the timer channel 2 capture/compare value.

Offset: 0x098

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH2CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH2CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH2CCV | <p>Channel 2 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 2 is configured as an output<br/>The CH2CCR value is compared with the counter value and the comparison result is used to trigger the CH2OREF output signal.</li> <li>- When Channel 2 is configured as an input<br/>The CH2CCR register stores the counter value captured by the last channel 2 capture event.</li> </ul> |

## Channel 3 Capture/Compare Register – CH3CCR

This register specifies the timer channel 3 capture/compare value.

Offset: 0x09C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH3CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH3CCV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH3CCV | <p>Channel 3 Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel 3 is configured as an output<br/>The CH3CCR value is compared with the counter value and the comparison result is used to trigger the CH3OREF output signal.</li> <li>- When Channel 3 is configured as an input<br/>The CH3CCR register stores the counter value captured by the last channel 3 capture event.</li> </ul> |

## Channel 0 Asymmetric Compare Register – CH0ACR

This register specifies the timer channel 0 asymmetric compare value.

Offset: 0x0A0

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH0ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH0ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                      |
|--------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH0ACV | Channel 0 Asymmetric Compare Value<br>When channel 0 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter. |

## Channel 1 Asymmetric Compare Register – CH1ACR

This register specifies the timer channel 1 asymmetric compare value.

Offset: 0x0A4

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH1ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH1ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                      |
|--------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH1ACV | Channel 1 Asymmetric Compare Value<br>When channel 1 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter. |

## Channel 2 Asymmetric Compare Register – CH2ACR

This register specifies the timer channel 2 asymmetric compare value.

Offset: 0x0A8

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH2ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH2ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                      |
|--------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH2ACV | Channel 2 Asymmetric Compare Value<br>When channel 2 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter. |

## Channel 3 Asymmetric Compare Register – CH3ACR

This register specifies the timer channel 3 asymmetric compare value.

Offset: 0x0AC

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CH3ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CH3ACV   |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                      |
|--------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CH3ACV | Channel 3 Asymmetric Compare Value<br>When channel 3 is configured as asymmetric PWM mode and the counter is counting down, the value written into this register will be compared to the counter. |

# 17 Single-Channel Timer (SCTM)

## Introduction

The Single-Channel Timer consists of one 16-bit up-counter, one 16-bit Capture/Compare Registers (CCRs), one 16-bit Counter-Reload Register (CRR) and several control/status registers. It can be used for a variety of purposes including general timer, input signal pulse width measurement or output waveform generation such as single pulse generation or PWM output.

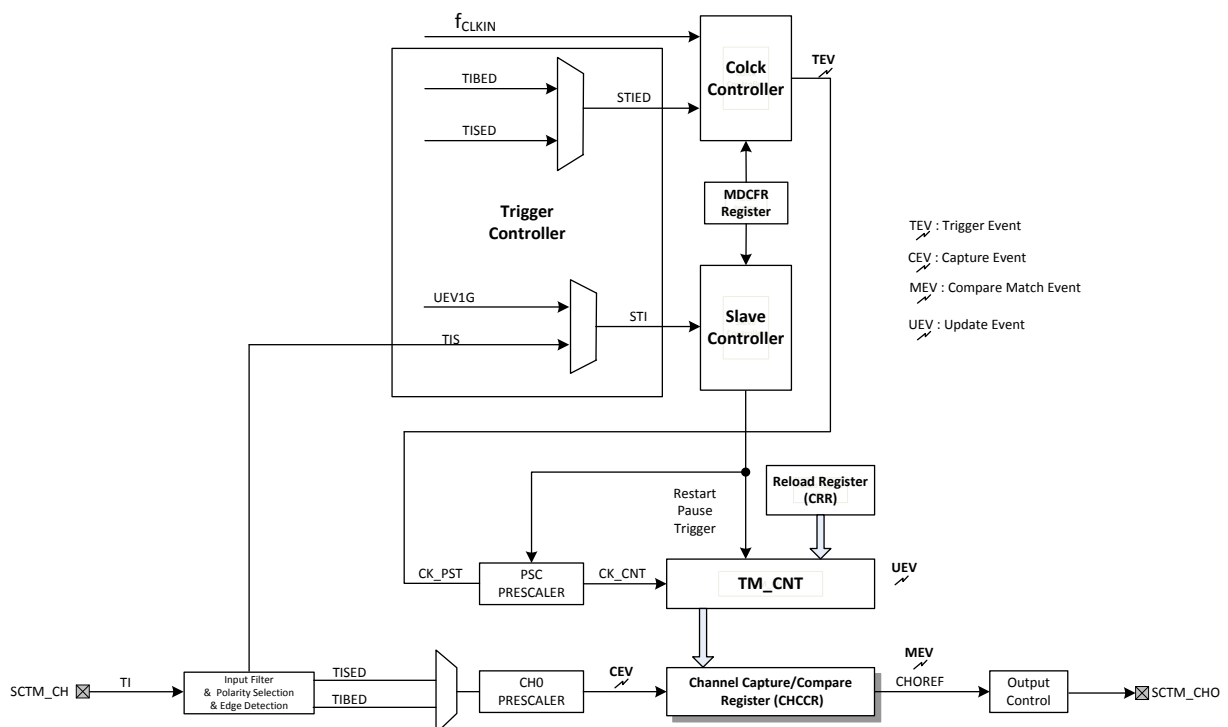


Figure 116. SCTM Block Diagram

## Features

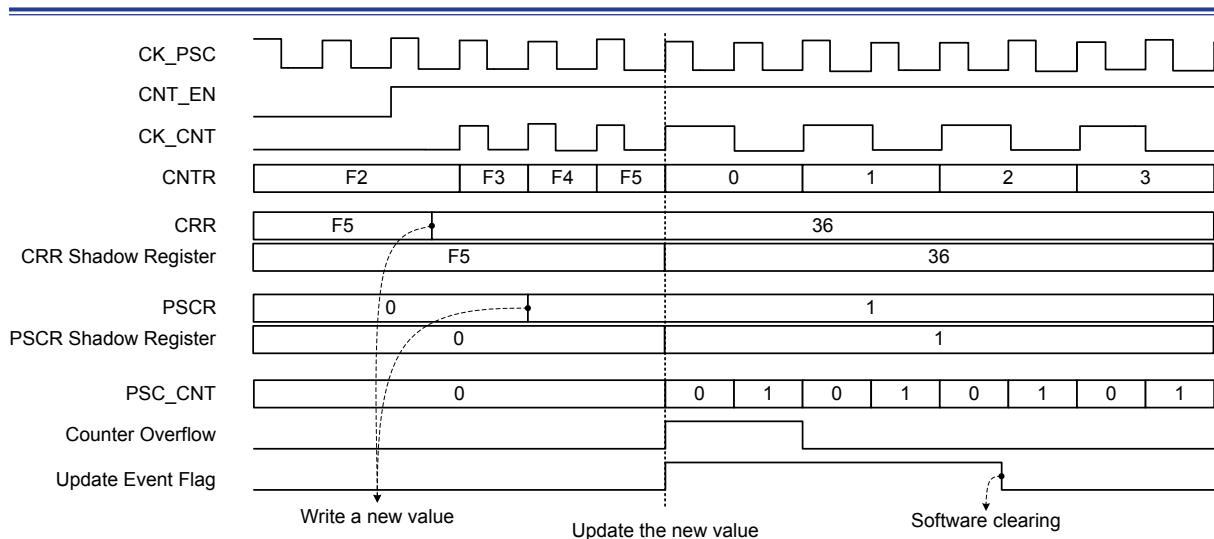
- 16-bit auto-reload up counter
- 16-bit programmable prescaler that allows division of the counter clock frequency by any factor between 1 and 65536
- Single channel for:
  - Input Capture function
  - Compare Match Output
  - PWM waveform output
- Interrupt generation with the following events:
  - Update event
  - Trigger event
  - Input capture event
  - Output compare match event

## Functional Descriptions

### Counter Mode

#### Up-Counting

The counter counts continuously from 0 to the counter-reload value, which is defined in the CRR register. Once the counter reaches the counter-reload value, the Timer Module generates an overflow event and the counter restarts to count once again from 0. This action will continue repeatedly. When the update event is generated by setting the UEVG bit in the EVGR register to 1, the counter value will also be initialized to 0.



**Figure 117. Up-counting Example**

## Clock Controller

The following describes the Timer Module clock controller which determines the clock source of the internal prescaler counter.

### ■ Internal APB clock $f_{CLKIN}$

The default internal clock source is the APB clock  $f_{CLKIN}$  used to drive the counter prescaler when the slave mode is disabled. If the slave mode controller is enabled by setting SMSEL field in the MDCFR register to 0x7, the prescaler is clocked by other clock sources selected by the TRSEL field in the TRCFR register and described as follows. When the slave mode selection bits SMSEL are set to 0x4, 0x5 or 0x6, the internal APB clock  $f_{CLKIN}$  is the counter prescaler driving clock source.

### ■ STIED

The counter prescaler can count during each rising edge of the STI signal. This mode can be selected by setting the SMSEL field to 0x7 in the MDCFR register. Here the counter will act as an event counter. The input event, known as STI here, can be selected by setting the TRSEL field to an available value except the value of 0x0. When the STI signal is selected as the clock source, the internal edge detection circuitry will generate a clock pulse during each STI signal rising edge to drive the counter prescaler. It is important to note that if the TRSEL field is set to 0x0 to select the software UEVG bit as the trigger source, then when the SMSEL field is set to 0x7, the counter will be updated instead of counting.

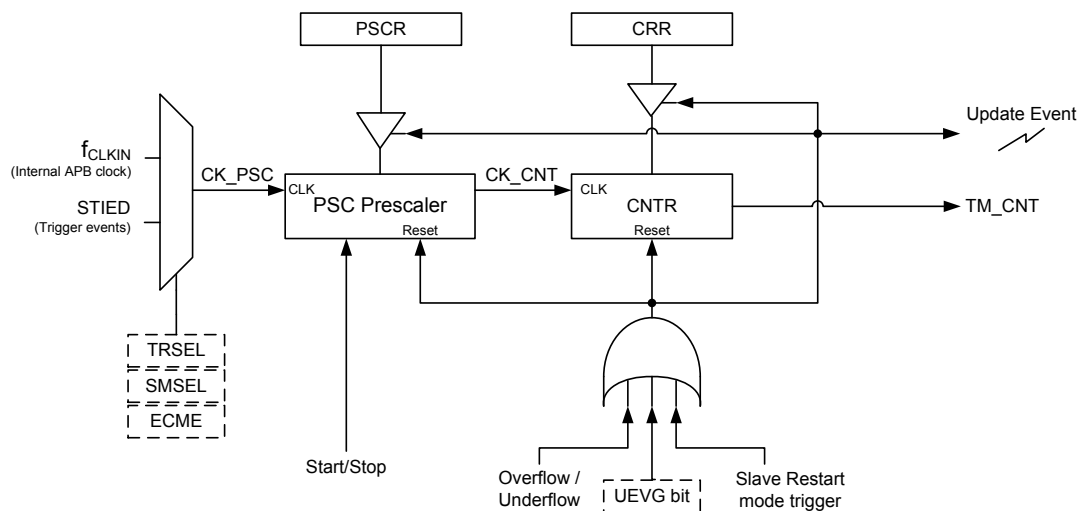


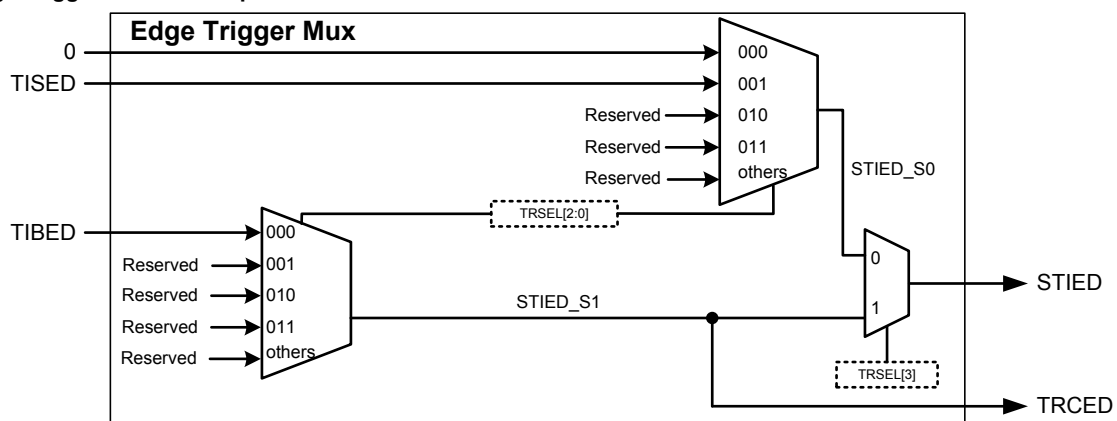
Figure 118. SCTM Clock Selection Source

## Trigger Controller

The trigger controller is used to select the trigger source and setup the trigger level or edge trigger condition. For the internal trigger input, it can be selected by the Trigger Selection bits TRSEL in the TRCFR register. For all the trigger sources except the UEVG bit software trigger, the internal edge detection circuitry will generate a clock pulse at each trigger signal rising edge to stimulate some SCTM functions which are triggered by a trigger signal rising edge.

Trigger Controller Block = Edge Trigger Mux + Level Trigger Mux

Edge Trigger = Channel input



Level Trigger Source = Channel input + Software UEV1G bit

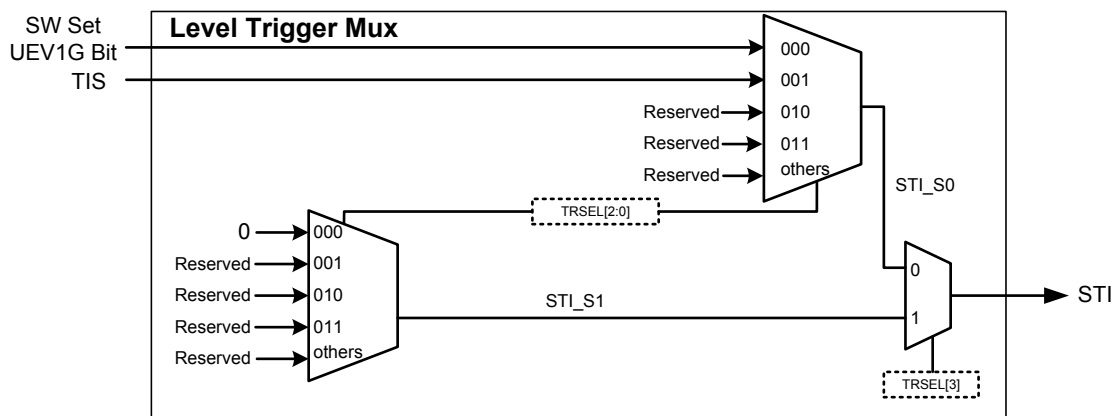


Figure 119. Trigger Control Block

## Slave Controller

The SCTM can be synchronized with an external trigger in several modes including the Restart mode, the Pause mode and the Trigger mode which is selected by the SMSEL field in the MDCFR register. The trigger input of these modes comes from the STI signal which is selected by the TRSEL field in the TRCFR register. The operation modes in the Slave Controller are described in the accompanying sections.

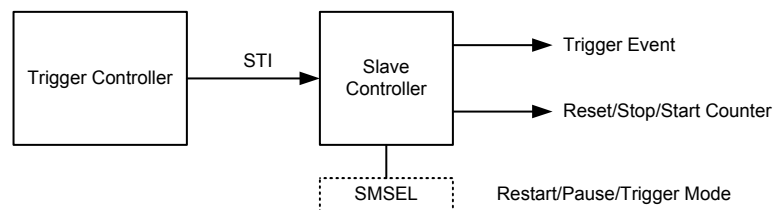


Figure 120. Slave Controller Diagram

## Restart Mode

The counter and its prescaler can be reinitialized in response to a rising edge of the STI signal. When a STI rising edge occurs, the update event software generation bit named UEVG will automatically be asserted by hardware and the trigger event flag will also be set. Then the counter and prescaler will be reinitialized. Although the UEVG bit is set to 1 by hardware, the update event does not really occur. It depends upon whether the update event disable control bit UEVDIS is set to 1 or not. If the UEVDIS is set to 1 to disable the update event to occur, there will no update event be generated, however the counter and prescaler are still reinitialized when the STI rising edge occurs. If the UEVDIS bit in the CNTCFR register is cleared to enable the update event to occur, an update event will be generated together with the STI rising edge, then all the preloaded registers will be updated.

### Timer Counter Reload Register CRR = 32

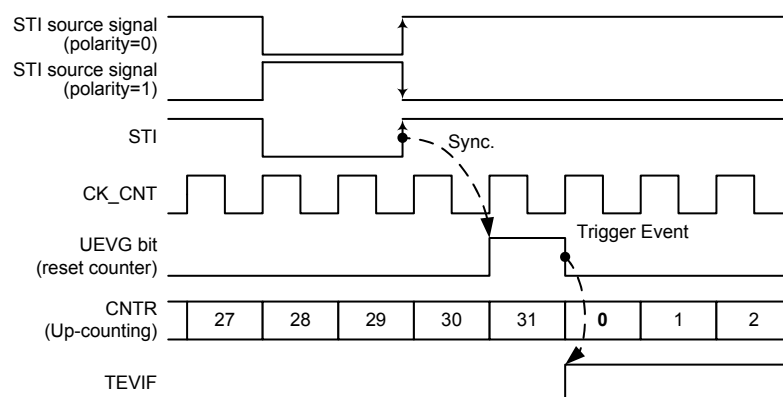


Figure 121. SCTM in Restart Mode

### Pause Mode

In the Pause Mode, the selected STI input signal level is used to control the counter start/stop operation. The counter starts to count when the selected STI signal is at a high level and stops counting when the STI signal is changed to a low level, here the counter will maintain its present value and will not be reset. Since the Pause function depends upon the STI level to control the counter stop/start operation, the selected STI trigger signal can not be derived from the TIBED signal.

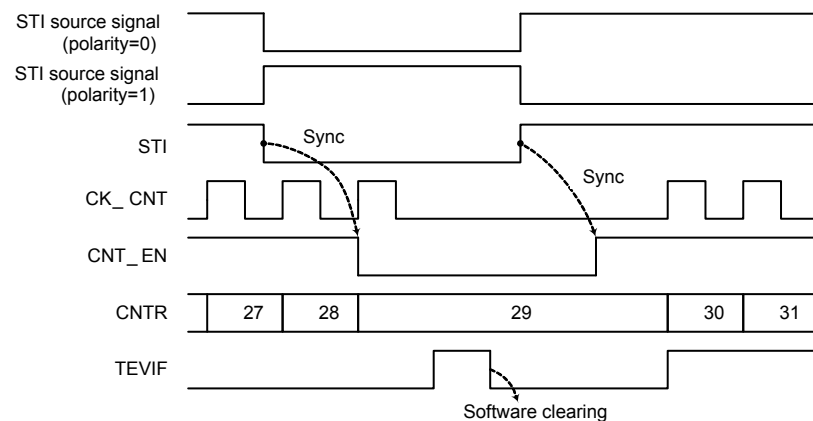


Figure 122. SCTM in Pause Mode

### Trigger Mode

After the counter is disabled to count, the counter can resume counting when a STI rising edge signal occurs. When an STI rising edge occurs, the counter will start to count from the current value in the counter. Note that if the STI signal is selected to be derived from the UEVG bit software trigger, the counter will not resume counting. When software triggering using the UEVG bit is selected as the STI source signal, there will be no clock pulse generated which can be used to make the counter resume counting. Note that the STI signal is only used to enable the counter to resume counting and has no effect on controlling the counter to stop counting.

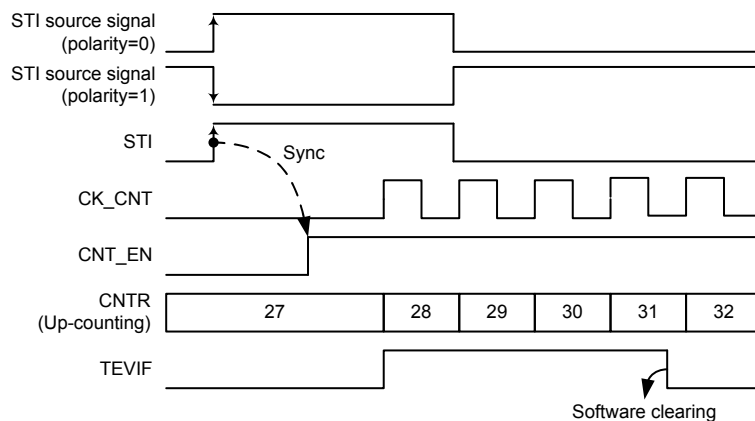


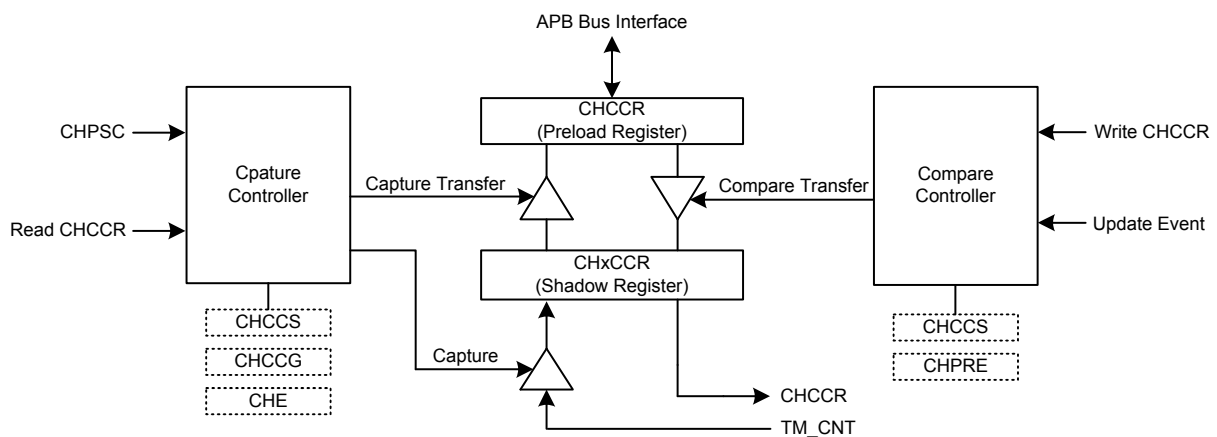
Figure 123. SCTM in Trigger Mode

## Channel Controller

The SCTM channel can be used as the capture input or compare match output. The capture input or compare match output channel is composed of a preload register and a shadow register. Data access of the APB bus is always through the read/write preload register.

When used in the input capture mode, the counter value is captured into the CHCCR shadow register first and then transferred into the CHCCR preload register when the capture event occurs.

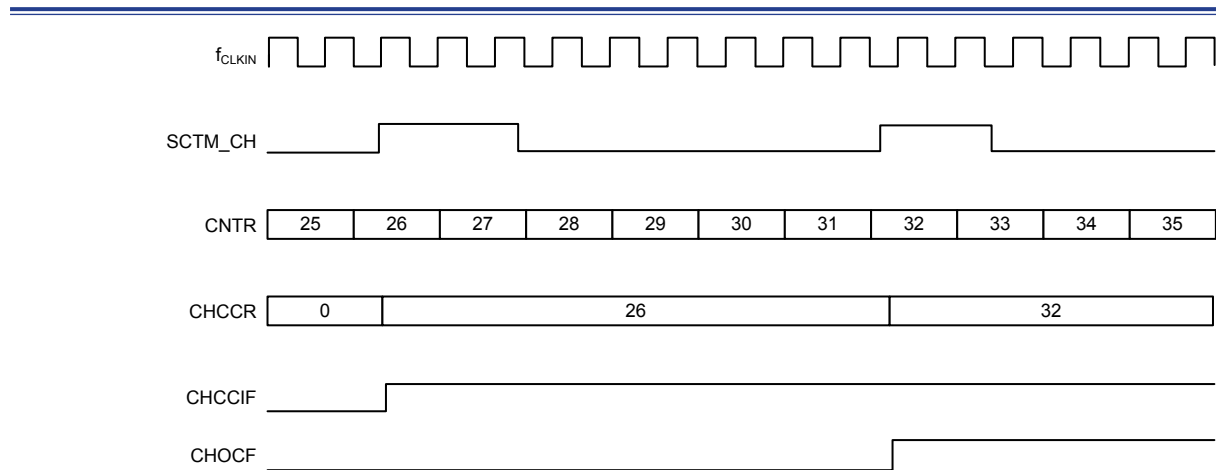
When used in the compare match output mode, the contents of the CHCCR preload register is copied into the associated shadow register; the counter value is then compared with the register value.



**Figure 124. Capture/Compare Block Diagram**

### Capture Counter Value Transferred to CHCCR

When the channel is used as a capture input, the counter value is captured into the Channel Capture/Compare Register (CHCCR) when an effective input signal transition occurs. Once the capture event occurs, the CHCCIF flag in the INTSR register is set accordingly. If the CHCCIF bit is already set, i.e., the flag has not yet been cleared by software, and another capture event on this channel occurs, the corresponding channel Over-Capture flag, named CHOCF, will be set.



**Figure 125. Input Capture Mode**

## Input Stage

The input stage consists of a digital filter, a channel polarity selection, edge detection and a channel prescaler. The channel input signal (TI) is sampled by a digital filter to generate a filtered input signal TIFP. Then the channel polarity and the edge detection block can generate a TISED signal for the input capture function. The effective input event number can be set by the channel input prescaler register (CHPSC).

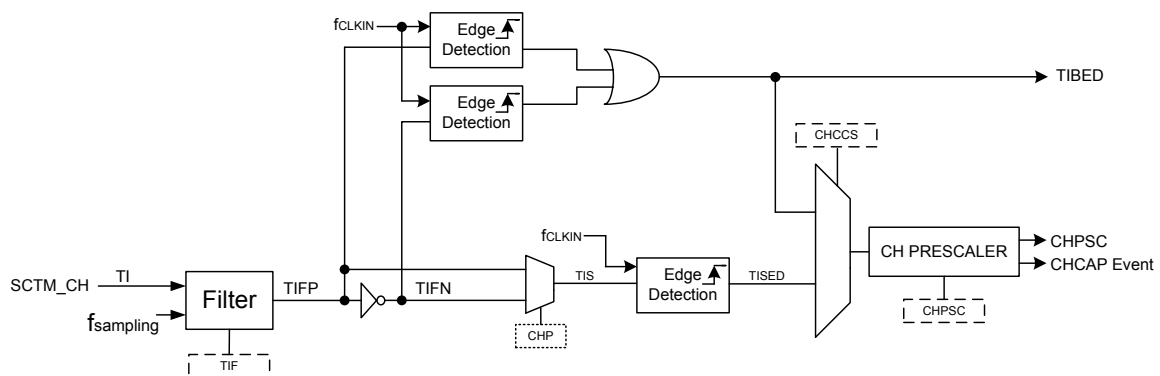


Figure 126. Channel Input Stages

## Digital Filter

The digital filters are embedded in the channel input stage. The digital filter in the SCTM is an N-event counter where N refers to how many valid transitions are necessary to output a filtered signal. The N value can be 0, 2, 4, 5, 6 or 8 according to the user selection for this digital filter.

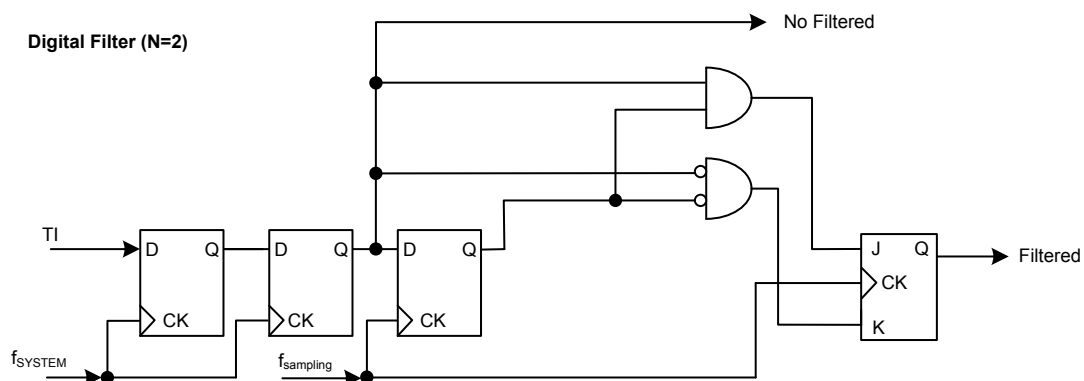


Figure 127. TI Digital Filter Diagram with N = 2

## Output Stage

The SCTM output has function for compare match, single pulse or PWM output. The channel output SCTM\_CHO is controlled by the CHOM, CHP and CHE bits in the corresponding CHOCFR, CHPOLR and CHCTR registers.

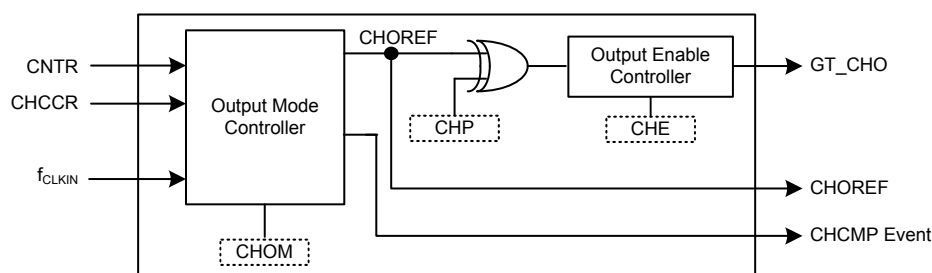


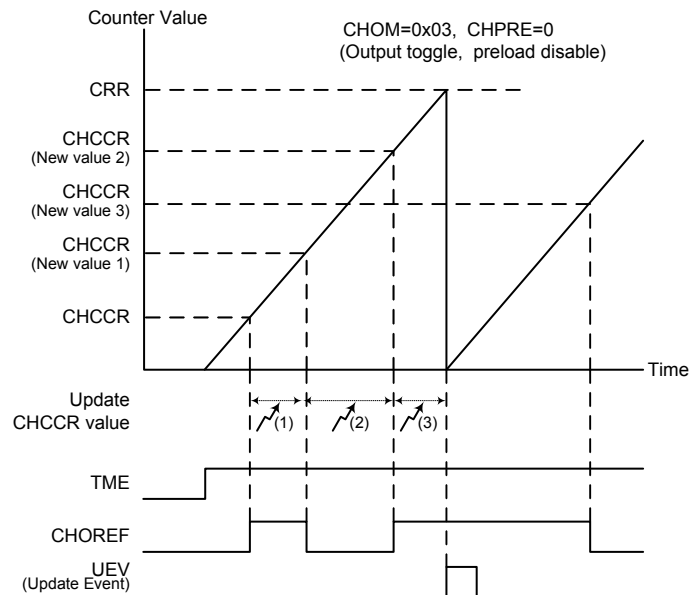
Figure 128. Output Stage Block Diagram

### Channel Output Reference Signal

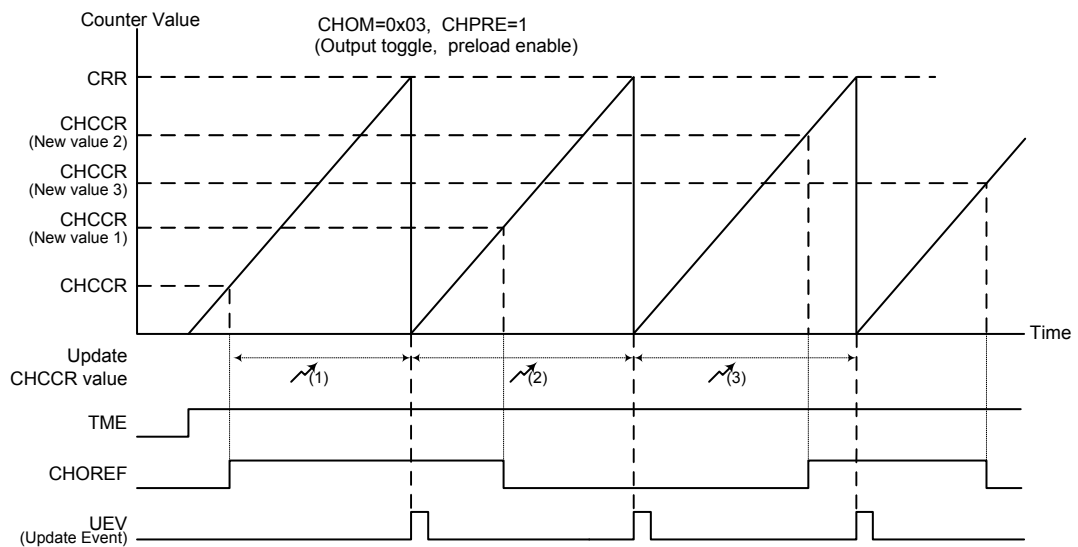
When the SCTM is used in the compare match output mode, the CHOREF signal (Channel Output Reference signal) is defined by the CHOM bit setup. The CHOREF signal has several types of output function which defines what happens to the output when the counter value matches the contents of the CHCCR register. In addition to the low, high and toggle CHOREF output types; there are also PWM mode 1 and PWM mode 2 outputs. In these modes, the CHOREF signal level is changed according to the relationship between the counter value and the CHCCR content. There are also two modes which will force the output into an inactive or active state irrespective of the CHCCR content or counter values. With regard to a more detailed description refer to the relative bit definition. The accompanying Table 1 shows a summary of the output type setup.

Table 40. Compare Match Output Setup

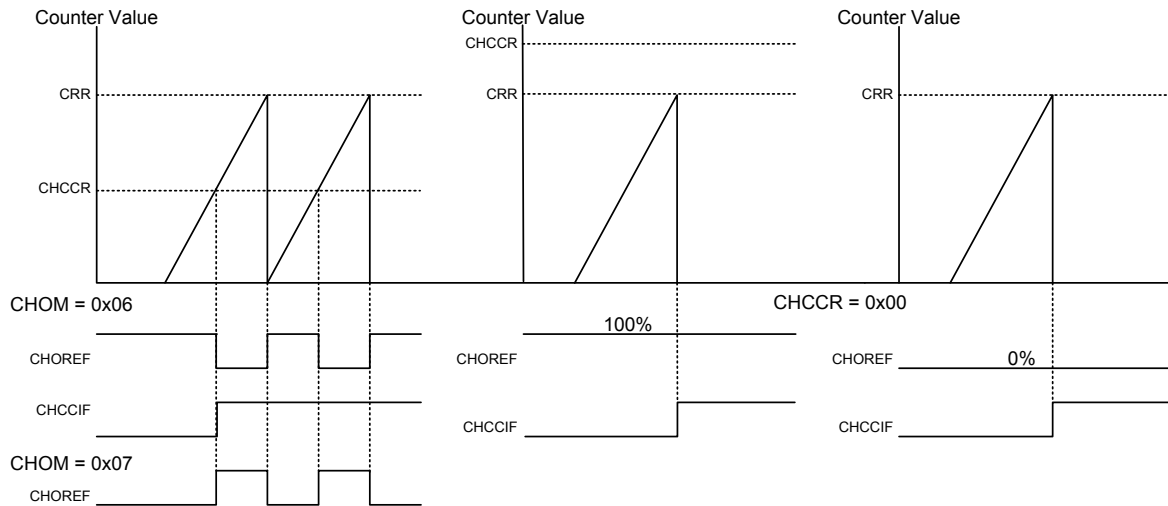
| CHOM value | Compare Match Level  |
|------------|----------------------|
| 0x00       | No change            |
| 0x01       | Clear Output to 0    |
| 0x02       | Set Output to 1      |
| 0x03       | Toggle Output        |
| 0x04       | Force Inactive Level |
| 0x05       | Force Active Level   |
| 0x06       | PWM Mode 1           |
| 0x07       | PWM Mode 2           |



**Figure 129. Toggle Mode Channel Output Reference Signal (CHPRE = 0)**



**Figure 130. Toggle Mode Channel Output Reference Signal (CHPRE = 1)**



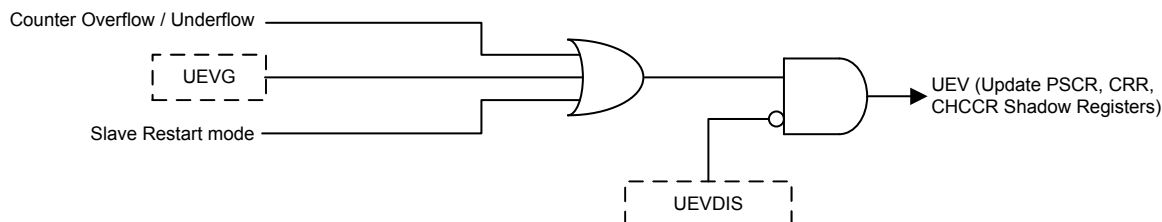
**Figure 131. PWM Mode Channel Output Reference Signal**

## Update Management

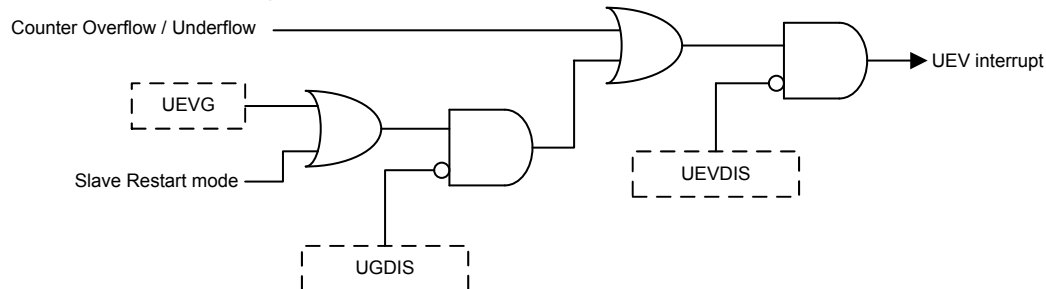
The Update event is used to update the CRR, the PSCR and the CHCCR values from the actual registers to the corresponding shadow registers. An update event will occur when the counter overflows, the software update control bit is triggered or an update event from the slave controller is generated.

The UEVDIS bit in the CNTCFR register can determine whether the update event occurs or not. When the update event occurs, the corresponding update event interrupt will be generated depending upon whether the update event interrupt generation function is enabled or not by configuring the UGDIS bit in the CNTCFR register. For more detailed description, refer to the UEVDIS and UGDIS bit definition in the CNTCFR register.

#### Update Event Management



#### Update Event Interrupt Management



**Figure 132. Update Event Setting Diagram**

## Register Map

The following table shows the SCTM registers and reset values.

**Table 41. SCTM Register Map**

| Register | Offset | Description                             | Reset Value |
|----------|--------|-----------------------------------------|-------------|
| CNTCFR   | 0x000  | Timer Counter Configuration Register    | 0x0000_0000 |
| MDCFR    | 0x004  | Timer Mode Configuration Register       | 0x0000_0000 |
| TRCFR    | 0x008  | Timer Trigger Configuration Register    | 0x0000_0000 |
| CTR      | 0x010  | Timer Control Register                  | 0x0000_0000 |
| CHICFR   | 0x020  | Channel Input Configuration Register    | 0x0000_0000 |
| CHOCFR   | 0x040  | Channel Output Configuration Register   | 0x0000_0000 |
| CHCTR    | 0x050  | Channel Control Register                | 0x0000_0000 |
| CHPOLR   | 0x054  | Channel Polarity Configuration Register | 0x0000_0000 |
| DICTR    | 0x074  | Timer Interrupt Control Register        | 0x0000_0000 |
| EVGR     | 0x078  | Timer Event Generator Register          | 0x0000_0000 |
| INTSR    | 0x07C  | Timer Interrupt Status Register         | 0x0000_0000 |
| CNTR     | 0x080  | Timer Counter Register                  | 0x0000_0000 |
| PSCR     | 0x084  | Timer Prescaler Register                | 0x0000_0000 |
| CRR      | 0x088  | Timer Counter Reload Register           | 0x0000_FFFF |
| CHCCR    | 0x090  | Channel Capture/Compare Register        | 0x0000_0000 |

## Timer Counter Configuration Register – CNTCFR

|         |       |
|---------|-------|
| Offset: | 0x000 |
|---------|-------|

Reset value: 0x0000 0000

|            |          |    |    |    |    |    |       |    |        |
|------------|----------|----|----|----|----|----|-------|----|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25    | 24 |        |
| Type/Reset | Reserved |    |    |    |    |    |       |    |        |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17    | 16 |        |
| Type/Reset | Reserved |    |    |    |    |    |       |    |        |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9     | 8  |        |
| Type/Reset | Reserved |    |    |    |    |    | CKDIV |    |        |
|            |          |    |    |    |    |    | RW    | 0  |        |
|            |          |    |    |    |    |    | 0     | RW |        |
|            |          |    |    |    |    |    |       | 0  |        |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1     | 0  |        |
| Type/Reset | Reserved |    |    |    |    |    | UGDIS |    | UEVDIS |
|            |          |    |    |    |    |    | RW    | 0  |        |
|            |          |    |    |    |    |    | 0     | RW |        |
|            |          |    |    |    |    |    |       | 0  |        |

| Bits  | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9:8] | CKDIV  | <p>Clock Division</p> <p>These two bits define the frequency ratio between the timer clock (<math>f_{CLKIN}</math>) and the dead-time clock (<math>f_{DTS}</math>). The dead-time clock is also used for digital filter sampling clock.</p> <p>00: <math>f_{DTS} = f_{CLKIN}</math><br/>           01: <math>f_{DTS} = f_{CLKIN} / 2</math><br/>           10: <math>f_{DTS} = f_{CLKIN} / 4</math><br/>           11: Reserved</p>             |
| [1]   | UGDIS  | <p>Update event interrupt generation disable control</p> <p>0: Any of the following events will generate an update interrupt</p> <ul style="list-style-type: none"> <li>- Counter overflow</li> <li>- Setting the UEVG bit</li> <li>- Update generation through the slave mode</li> </ul> <p>1: Only counter overflow generates an update interrupt</p>                                                                                         |
| [0]   | UEVDIS | <p>Update event Disable control</p> <p>0: Enable the update event request by one of following events:</p> <ul style="list-style-type: none"> <li>- Counter overflow</li> <li>- Setting the UEVG bit</li> <li>- Update generation through the slave mode</li> </ul> <p>1: Disable the update event (However the counter and the prescaler are reinitialized if the UEVG bit is set or if a hardware restart is received from the slave mode)</p> |

## Timer Mode Configuration Register – MDCFR

This register specifies the SCTM master and slave mode selection and single pulse mode.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |    |       |    |    |
|------------|----------|----|----|----|----|-------|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |       |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |       |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    | SMSEL |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1  | 0  |
| Type/Reset | Reserved |    |    |    |    |       |    |    |

| Bits        | Field        | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
|-------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------------|-----|--------------|----------------------------------------------------------|-----|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------|----------------------------------------------------------------------------|--------|----------|--|
| [10:8]      | SMSEL        | Slave Mode Selection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
|             |              | <table> <tr> <th>SMSEL [2:0]</th><th>Mode</th><th>Descriptions</th></tr> <tr> <td>000</td><td>Disable mode</td><td>The prescaler is clocked directly by the internal clock.</td></tr> <tr> <td>100</td><td>Restart Mode</td><td>The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.</td></tr> <tr> <td>101</td><td>Pause Mode</td><td>The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal.</td></tr> <tr> <td>110</td><td>Trigger Mode</td><td>The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the counter start control is determined by the STI signal.</td></tr> <tr> <td>111</td><td>STIED</td><td>The rising edge of the selected trigger signal STI will clock the counter.</td></tr> <tr> <td>Others</td><td>Reserved</td><td></td></tr> </table> | SMSEL [2:0] | Mode | Descriptions | 000 | Disable mode | The prescaler is clocked directly by the internal clock. | 100 | Restart Mode | The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated. | 101 | Pause Mode | The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal. | 110 | Trigger Mode | The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the counter start control is determined by the STI signal. | 111 | STIED | The rising edge of the selected trigger signal STI will clock the counter. | Others | Reserved |  |
| SMSEL [2:0] | Mode         | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
| 000         | Disable mode | The prescaler is clocked directly by the internal clock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
| 100         | Restart Mode | The counter value restarts from 0 or the CRR shadow register value depending upon the counter mode on the rising edge of the STI signal. The registers will also be updated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
| 101         | Pause Mode   | The counter starts to count when the selected trigger input STI is high. The counter stops counting on the instant, not being reset, when the STI signal changes its state to a low level. Both the counter start and stop control are determined by the STI signal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
| 110         | Trigger Mode | The counter starts to count from the original value in the counter on the rising edge of the selected trigger input STI. Only the counter start control is determined by the STI signal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
| 111         | STIED        | The rising edge of the selected trigger signal STI will clock the counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |
| Others      | Reserved     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |      |              |     |              |                                                          |     |              |                                                                                                                                                                              |     |            |                                                                                                                                                                                                                                                                      |     |              |                                                                                                                                                                                          |     |       |                                                                            |        |          |  |

## Timer Trigger Configuration Register – TRCFR

This register specifies the trigger source selection of SCTM.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |       |    |    |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    | TRSEL |    |    |    |
|            |          |    |    |    | RW    | 0  | RW | 0  |
|            |          |    |    |    |       | RW | 0  | RW |
|            |          |    |    |    |       |    | RW | 0  |
|            |          |    |    |    |       |    |    | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TRSEL | <p>Trigger Source Selection</p> <p>These bits are used to select the trigger input (STI) for counter synchronizing.</p> <p>0000: Software Trigger by setting the UEVG bit</p> <p>0001: Filtered input of channel 0 (TIS)</p> <p>0011: Reserved</p> <p>1000: Channel both edge detector (TIBED)</p> <p>Others: Default 0</p> <p>Note: These bits must be updated only when they are not in use, i.e. the slave mode is disabled by setting the SMSEL field to 0x00.</p> |

## Timer Counter Register – CTR

This register specifies the timer enable bit (TME), CRR buffer enable bit (CRBE).

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |      |        |
|------------|----------|----|----|----|----|----|------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25   | 24     |
| Type/Reset | Reserved |    |    |    |    |    |      |        |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17   | 16     |
| Type/Reset | Reserved |    |    |    |    |    |      |        |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9    | 8      |
| Type/Reset | Reserved |    |    |    |    |    |      |        |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1    | 0      |
| Type/Reset | Reserved |    |    |    |    |    | CRBE | TME    |
|            |          |    |    |    |    |    | RW   | 0 RW 0 |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                              |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | CRBE  | Counter-Reload register Buffer Enable<br>0: Counter reload register can be updated immediately<br>1: Counter reload register cannot be updated until the update event occurs                                                                                                                                                                                                              |
| [0]  | TME   | Timer Enable bit<br>0: SCTM off<br>1: SCTM on - SCTM functions normally<br>When the TME bit is cleared to 0, the counter is stopped and the SCTM consumes no power in any operation mode except for the single pulse mode and the slave trigger mode. In these two modes the TME bit can automatically be set to 1 by hardware which permits all the SCTM registers to function normally. |

## Channel Input Configuration Register – CHICFR

This register specifies the channel input mode configuration.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |       |    |       |    |
|------------|----------|----|----|----|-------|----|-------|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25    | 24 |
| Type/Reset | Reserved |    |    |    |       |    |       |    |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17    | 16 |
| Type/Reset | Reserved |    |    |    | CHPSC |    | CHCCS |    |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9     | 8  |
| Type/Reset | Reserved |    |    |    |       |    |       |    |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1     | 0  |
| Type/Reset | Reserved |    |    |    | TIF   |    |       |    |
|            |          |    |    |    | RW    | 0  | RW    | 0  |
|            |          |    |    |    |       |    | RW    | 0  |
|            |          |    |    |    |       |    |       | RW |
|            |          |    |    |    |       |    |       | 0  |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19:18] | CHPSC | Channel Capture Input Source Prescaler Setting<br>These bits define the effective events of the channel capture input. Note that the prescaler is reset once the Channel Capture/Compare Enable bit, CHE, in the Channel Control register named CHCTR is cleared to 0.<br>00: No prescaler, channel capture input signal is chosen for each active event.<br>01: Channel Capture input signal is chosen for every 2 events.<br>10: Channel Capture input signal is chosen for every 4 events.<br>11: Channel Capture input signal is chosen for every 8 events. |
| [17:16] | CHCCS | Channel Capture/Compare Selection.<br>00: Channel is configured as an output.<br>01: Channel is configured as an input derived from the TI signal.<br>10: Reserved.<br>11: Channel is configured as an input which comes from the TIBED signal.<br>Note: The CHCCS field can be accessed only when the CHE bit is cleared to 0.                                                                                                                                                                                                                                 |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3:0] | TIF   | <p>Channel Input Source TI Filter Setting</p> <p>These bits define the frequency divided ratio used to sample the TI signal. The Digital filter in the SCTM is an N-event counter where N is defined as how many valid transitions are necessary to output a filtered signal.</p> <p>0000: No filter, the sampling clock is <math>f_{\text{SYSTEM}}</math>.</p> <p>0001: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}</math>, <math>N = 2</math></p> <p>0010: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}</math>, <math>N = 4</math></p> <p>0011: <math>f_{\text{SAMPLING}} = f_{\text{CLKIN}}</math>, <math>N = 8</math></p> <p>0100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2</math>, <math>N = 6</math></p> <p>0101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 2</math>, <math>N = 8</math></p> <p>0110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4</math>, <math>N = 6</math></p> <p>0111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 4</math>, <math>N = 8</math></p> <p>1000: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8</math>, <math>N = 6</math></p> <p>1001: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 8</math>, <math>N = 8</math></p> <p>1010: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16</math>, <math>N = 5</math></p> <p>1011: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16</math>, <math>N = 6</math></p> <p>1100: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 16</math>, <math>N = 8</math></p> <p>1101: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32</math>, <math>N = 5</math></p> <p>1110: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32</math>, <math>N = 6</math></p> <p>1111: <math>f_{\text{SAMPLING}} = f_{\text{DTS}} / 32</math>, <math>N = 8</math></p> |

## Channel Output Configuration Register – CHOCFR

This register specifies the channel output mode configuration.

Offset: 0x040

Reset value: 0x0000\_0000

|            |          |    |    |        |          |           |    |    |
|------------|----------|----|----|--------|----------|-----------|----|----|
|            | 31       | 30 | 29 | 28     | 27       | 26        | 25 | 24 |
| Type/Reset | Reserved |    |    |        |          |           |    |    |
|            | 23       | 22 | 21 | 20     | 19       | 18        | 17 | 16 |
| Type/Reset | Reserved |    |    |        |          |           |    |    |
|            | 15       | 14 | 13 | 12     | 11       | 10        | 9  | 8  |
| Type/Reset | Reserved |    |    |        |          |           |    |    |
|            | 7        | 6  | 5  | 4      | 3        | 2         | 1  | 0  |
| Type/Reset | Reserved |    |    | CH0PRE | Reserved | CHOM[2:0] |    |    |
|            |          |    |    | RW     | 0        | RW        | 0  | RW |
|            |          |    |    |        |          | 0         | RW | 0  |

| Bits  | Field     | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4]   | CHPRE     | Channel Capture/Compare Register (CHCCR) Preload Enable<br>0: CHCCR preload function is disabled.<br>The CHCCR register can be immediately assigned a new value when the CHPRE bit is cleared to 0 and the updated CHCCR value is used immediately.<br>1: CHCCR preload function is enabled.<br>The new CHCCR value will not be transferred to its shadow register until the update event occurs.                                                                                                                                                                                                     |
| [2:0] | CHOM[2:0] | Channel Output Mode Setting<br>These bits define the functional types of the output reference signal CHOREF.<br>000: No Change<br>001: Output 0 on compare match<br>010: Output 1 on compare match<br>011: Output toggles on compare match<br>100: Force inactive – CHOREF is forced to 0<br>101: Force active – CHOREF is forced to 1<br>110: PWM mode 1<br>- During up-counting, channel has an active level when CNTR < CHCCR or otherwise has an inactive level.<br>111: PWM mode 2<br>- During up-counting, channel is has an inactive level when CNTR < CHCCR or otherwise has an active level. |

## Channel Control Register – CHCTR

This register contains the channel capture input or compare output function enable control bits.

Offset: 0x050

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |      |
|------------|----------|----|----|----|----|----|----|------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24   |
| Type/Reset | Reserved |    |    |    |    |    |    |      |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16   |
| Type/Reset | Reserved |    |    |    |    |    |    |      |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8    |
| Type/Reset | Reserved |    |    |    |    |    |    |      |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0    |
| Type/Reset | Reserved |    |    |    |    |    |    | CHE  |
|            |          |    |    |    |    |    |    | RW 0 |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | CHE   | <p>Channel Capture/Compare Enable</p> <ul style="list-style-type: none"> <li>- Channel is configured as an input (CHCCS = 0x01/0x03) <ul style="list-style-type: none"> <li>0: Input Capture Mode disabled</li> <li>1: Input Capture Mode enabled</li> </ul> </li> <li>- Channel is configured as an output (CHCCS = 0x00) <ul style="list-style-type: none"> <li>0: Off –Channel output signal CHO is not active</li> <li>1: On –Channel output signal CHO generated on the corresponding output pin</li> </ul> </li> </ul> |

## Channel Polarity Configuration Register – CHPOLR

This register contains the channel capture input or compare output polarity control.

Offset: 0x054

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |      |
|------------|----------|----|----|----|----|----|----|------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24   |
| Type/Reset | Reserved |    |    |    |    |    |    |      |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16   |
| Type/Reset | Reserved |    |    |    |    |    |    |      |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8    |
| Type/Reset | Reserved |    |    |    |    |    |    |      |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0    |
| Type/Reset | Reserved |    |    |    |    |    |    | CH0P |
|            |          |    |    |    |    |    |    | RW 0 |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                       |
|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | CHP   | Channel Capture/Compare Polarity<br>- When Channel is configured as an input<br>0: capture event occurs on a Channel rising edge<br>1: capture event occurs on a Channel falling edge<br>- When Channel is configured as an output (CHCCS = 0x00)<br>0: Channel Output active high<br>1: Channel Output active low |

This register contains the timer interrupt enable control bits.

Reset value: 0x0000 0000

|            |          |    |    |    |    |       |          |        |
|------------|----------|----|----|----|----|-------|----------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25       | 24     |
| Type/Reset | Reserved |    |    |    |    |       |          |        |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17       | 16     |
| Type/Reset | Reserved |    |    |    |    |       |          |        |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9        | 8      |
| Type/Reset | Reserved |    |    |    |    | TEVIE | Reserved | UEVIE  |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1        | 0      |
| Type/Reset | Reserved |    |    |    |    |       |          | CHCCIE |
|            |          |    |    |    |    |       |          |        |

| Bits | Field  | Descriptions                                                                                                |
|------|--------|-------------------------------------------------------------------------------------------------------------|
| [10] | TEVIE  | Trigger event Interrupt Enable<br>0: Trigger event interrupt disabled<br>1: Trigger event interrupt enabled |
| [8]  | UEVIE  | Update event Interrupt Enable<br>0: Update event interrupt disabled<br>1: Update event interrupt enabled    |
| [0]  | CHCCIE | Channel Capture/Compare Interrupt Enable<br>0: Channel interrupt disabled<br>1: Channel interrupt enabled   |

## Timer Event Generator Register – EVGR

This register contains the software event generation bits.

Offset: 0x078

Reset value: 0x0000\_0000

|            |          |    |    |    |    |      |          |       |
|------------|----------|----|----|----|----|------|----------|-------|
|            | 31       | 30 | 29 | 28 | 27 | 26   | 25       | 24    |
| Type/Reset | Reserved |    |    |    |    |      |          |       |
|            | 23       | 22 | 21 | 20 | 19 | 18   | 17       | 16    |
| Type/Reset | Reserved |    |    |    |    |      |          |       |
|            | 15       | 14 | 13 | 12 | 11 | 10   | 9        | 8     |
| Type/Reset | Reserved |    |    |    |    | TEVG | Reserved | UEVG  |
|            | 7        | 6  | 5  | 4  | 3  | 2    | 1        | 0     |
| Type/Reset | Reserved |    |    |    |    |      |          | CHCCG |
|            |          |    |    |    |    |      |          | WO 0  |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | TEVG  | <p>Trigger Event Generation</p> <p>The trigger event TEV can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: TEVIF flag is set</p>                                                                                                                                                                                                                                                                                     |
| [8]  | UEVG  | <p>Update Event Generation</p> <p>The update event UEV can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Reinitialize the counter</p> <p>The counter value returns to 0 or the CRR preload value, depending on the counter mode in which the current timer is being used. An update operation of any related registers will also be performed. For more detail descriptions, refer to the corresponding section.</p> |
| [0]  | CHCCG | <p>Channel Capture/Compare Generation</p> <p>A Channel capture/compare event can be generated by setting this bit. It is cleared by hardware automatically.</p> <p>0: No action<br/>1: Capture/compare event is generated on channel.</p> <p>If Channel is configured as an input, the counter value is captured into the CHCCR register and then the CHCCIF bit is set. If Channel is configured as an output, the CHCCIF bit is set.</p>                                   |

## Timer Interrupt Status Register – INTSR

This register stores the timer interrupt status.

Offset: 0x07C

Reset value: 0x0000\_0000

|            |          |    |    |       |          |       |          |        |
|------------|----------|----|----|-------|----------|-------|----------|--------|
|            | 31       | 30 | 29 | 28    | 27       | 26    | 25       | 24     |
| Type/Reset | Reserved |    |    |       |          |       |          |        |
|            | 23       | 22 | 21 | 20    | 19       | 18    | 17       | 16     |
| Type/Reset | Reserved |    |    |       |          |       |          |        |
|            | 15       | 14 | 13 | 12    | 11       | 10    | 9        | 8      |
| Type/Reset | Reserved |    |    |       |          | TEVIF | Reserved | UEVIF  |
|            | 7        | 6  | 5  | 4     | 3        | 2     | 1        | 0      |
| Type/Reset | Reserved |    |    | CHOCF | Reserved |       |          | CHCCIF |
|            |          |    |    | RW    |          |       |          | RW     |
|            |          |    |    | 0     |          |       |          | 0      |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | TEVIF  | Trigger Event Interrupt Flag<br>This flag is set by hardware on a trigger event and is cleared by software.<br>0: No trigger event occurs<br>1: Trigger event occurs                                                                                                                                                                                                                                                                                                                                                         |
| [8]  | UEVIF  | Update Event Interrupt Flag.<br>This bit is set by hardware on an update event and is cleared by software.<br>0: No update event occurs<br>1: Update event occurs<br>Note: The update event is derived from the following conditions:<br>- The counter overflows or underflows<br>- The UEVG bit is asserted<br>- A restart trigger event occurs from the slave trigger input                                                                                                                                                |
| [4]  | CHOCF  | Channel Over-Capture Flag<br>This flag is set by hardware and cleared by software.<br>0: No over-capture event is detected<br>1: Capture event occurs again when the CHCCIF bit is already set and it is not yet cleared by software.                                                                                                                                                                                                                                                                                        |
| [0]  | CHCCIF | Channel Capture/Compare Interrupt Flag<br>- Channel is configured as an output:<br>0: No match event occurs<br>1: The contents of the counter CNTR have matched the content of the CHCCR register<br>This flag is set by hardware when the counter value matches the CHCCR value. It is cleared by software.<br>- Channel is configured as an input:<br>0: No input capture occurs<br>1: Input capture occurs<br>This bit is set by hardware on a capture event. It is cleared by software or by reading the CHCCR register. |

## Timer Counter Register – CNTR

This register stores the timer counter value.

Offset: 0x080

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset |          |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset |          |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
|            | CNTV     |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|            | CNTV     |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field | Descriptions   |
|--------|-------|----------------|
| [15:0] | CNTV  | Counter Value. |

## Timer Prescaler Register – PSCR

This register specifies the timer prescaler value to generate the counter clock.

Offset: 0x084

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PSCV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PSCV     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                 |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PSCV  | <p>Prescaler Value</p> <p>These bits are used to specify the prescaler value to generate the counter clock frequency <math>f_{CK\_CNT}</math>.</p> $f_{CK\_CNT} = \frac{f_{CK\_PSC}}{PSCV[15:0] + 1}, \text{ where the } f_{CK\_PSC} \text{ is the prescaler clock source.}$ |

## Timer Counter Reload Register – CRR

This register specifies the timer counter reload value.

Offset: 0x088

Reset value: 0x0000\_FFFF

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CRV      |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 1  | RW | 1  | RW | 1  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CRV      |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 1  | RW | 1  | RW | 1  | RW |

| Bits   | Field | Descriptions                                                                                          |
|--------|-------|-------------------------------------------------------------------------------------------------------|
| [15:0] | CRV   | Counter Reload Value<br>The CRV is the reload value which is loaded into the actual counter register. |

## Channel Capture/Compare Register – CHCCR

This register specifies the timer channel capture/compare value.

Offset: 0x090

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CHCCV    |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CHCCV    |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CHCCV | <p>Channel Capture/Compare Value</p> <ul style="list-style-type: none"> <li>- When Channel is configured as an output<br/>The CHCCR value is compared with the counter value and the comparison result is used to trigger the CHOREF output signal.</li> <li>- When Channel is configured as an input<br/>The CHCCR register stores the counter value captured by the last channel capture event.</li> </ul> |

# 18 Real Time Clock (RTC)

## Introduction

The Real Time Clock, RTC, circuitry includes the APB interface, a 32-bit up-counter, a control register, a prescaler, a compare register and a status register. Most of the RTC circuits are located in the Backup Domain, as shown shaded in the accompanying figure, except for the APB interface. The APB interface is located in the  $V_{DD15}$  domain. Therefore, it is necessary to be isolated from the ISO signal that comes from the power control unit when the  $V_{DD15}$  domain is powered off, i.e., when the device enters the Power-Down mode. The RTC counter is used as a wakeup timer to let the system resume from the Power-Down mode. The detailed RTC function will be described in the following sections.

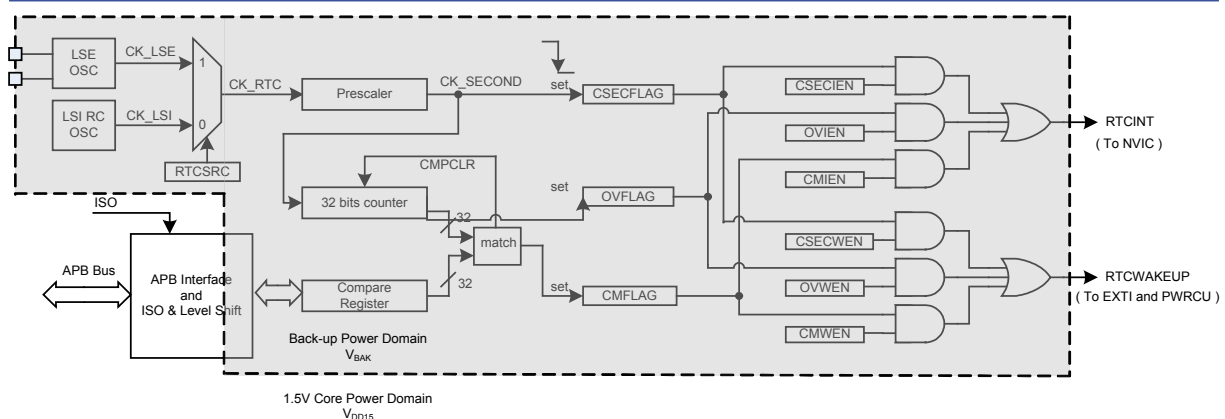


Figure 133. RTC Block Diagram

## Features

- 32-bit up counter for counting elapsed time
- Programmable clock prescaler
  - Division factor: 1, 2, 4, 8, ..., 32768
- 32-bit compare register for alarm usage
- RTC clock source
  - LSE oscillator clock
  - LSI oscillator clock
- Three RTC Interrupt/wakeup settings
  - RTC second clock interrupt/wakeup
  - RTC compare match interrupt/wakeup
  - RTC counter overflow interrupt/wakeup
- The RTC interrupt/wakeup event can work together with power management to wake up the chip from power saving mode

## Functional Descriptions

### RTC Related Register Reset

The RTC registers can only be reset by either a Backup Domain power on reset, PORB, or by a Backup Domain software reset by setting the BAKRST bit in the BAKCR register. Other reset events have no effect to clear the RTC registers.

### Reading RTC Register

The RTC control logic and the related registers are powered by the  $V_{BAK}$  supply voltage. Therefore, the RTC circuitry remains operational in the Power-Down mode where  $V_{DD15}$  is powered off. Only the APB bus, which is located in the  $V_{DD15}$  domain, is interconnected to the circuits located in the VBAK domain using level shift circuitry and isolated by the ISO signals when the  $V_{DD15}$  supply voltage is powered off. The isolation function must be disabled by setting the BAKISO bit to 1 in the LPCR register as described in the Clock Control Unit before accessing the RTC registers using the APB bus.

### Low Speed Clock Configuration

The default RTC clock source, CK\_RTC, is derived from the LSI oscillator. The CK\_RTC clock can be derived from either the external 32768 Hz crystal oscillator, named the LSE oscillator, or the internal 32K RC oscillator named the LSI oscillator, by setting the RTCSRC bit in the RTCCR register. A prescaler is provided to divide the CK\_RTC by a ratio ranged from  $2^0$  to  $2^{15}$  determined by the RPRE [3:0] field. For instance, setting the prescaler value RPRE [3:0] to 0x0F will generate an exact 1 Hz CK\_SECOND clock if the CK\_RTC clock frequency is equal to 32,768 Hz. The LSI and LSE oscillators can be enabled by the LSIEN and LSEEN control bits in the RTCCR register respectively. In addition, the LSE oscillator startup mode can be selected by configuring the LSESM bit in the RTCCR register. This enables the LSE oscillator to have either a shorter startup time or a lower power consumption, both of which are traded off depending upon specific application requirements. An example of the startup time and the power consumption for different startup modes are shown in the accompanying table for reference.

**Table 42. LSE Startup Mode Operating Current and Startup Time**

| Startup mode   | LSECM Setting<br>in the RTCCR register | Operating Current | Startup time |
|----------------|----------------------------------------|-------------------|--------------|
| Normal startup | 0                                      | 2.0 $\mu$ A       | Above 500 ms |
| Fast startup   | 1                                      | 3.5 $\mu$ A       | Below 300 ms |

@  $V_{DD} = 3.3$  V and LSE clock = 32,768 Hz; these values are only for reference, actual values are dependent on the specification of the external 32.768KHz crystal.

## RTC Counter Operation

The RTC provides a 32-bit up-counter which increments at the falling edge of the CK\_SECOND clock and whose value can be read from the RTCCNT register asynchronously via the APB bus. A 32-bit compare register, RTCCMP, is provided to store the specific value to be compared with the RTCCNT content. This is used to define a pre-determined time interval. When the RTCCNT register content is equal to the RTCCMP register value, the match flag CMFLAG in the RTCSR register will be set by hardware and an interrupt or wakeup event can be sent according to the corresponding enable bits in the RTCIWEN register. The RTC counter will be either reset to zero or keep counting when the compare match event occurs, dependent upon the CMPCLR bit in the RTCCR register. For example, if the RPRE [3:0] is set to 0x0F, the RTCCMP register content is set to a decimal value of 60 and the CMPCLR bit is set to 1, then the CMFLAG bit will be set every minute. In addition, the OVFLAG bit in the RTCSR register will be set when the RTC counter overflows. A read operation on the RTCSR register clears the status flags including the CSECFLAG, CMFLAG and OVFLAG bits.

## Interrupt and Wakeup Control

The falling edge of the CK\_SECOND clock causes the CSECFLAG bit in the RTCSR register to be set and generates an interrupt if the corresponding interrupt enable bit, CSECIEN, in the RTCIWEN register is set. The wakeup event can also be generated to wake up the HSI/HSE oscillators, the PLL circuitry, the LDO and the CPU core if the corresponding wakeup enable bit CSECWEN is set. When the RTC counter overflows or a compare match event occurs, it will generate an interrupt or a wake up event determined by the corresponding interrupt or wakeup enable control bits, OVIEN/OVWEN or CMIEN/CMWEN bits, in the RTCIWEN register. Refer to the related register definitions for more details.

## RTCOUT Output Pin Configuration

The following table shows RTCOUT output format according to the mode, polarity, and event selection setting.

**Table 43. RTCOUT Output Mode and Active Level Setting**

| ROWM              | ROES               | RTCOUT Output Waveform |                                                                      |
|-------------------|--------------------|------------------------|----------------------------------------------------------------------|
| 0<br>(Pulse mode) | 0<br>Compare match | RTCCMP                 | ----- 4 -----                                                        |
|                   |                    | RTCCNT                 | ----- 3 ----- 4 ----- 5 -----                                        |
|                   |                    | RTCOUT (ROAP = 0)      | ----- T <sub>R</sub> -----                                           |
|                   |                    | RTCOUT (ROAP = 1)      | ----- T <sub>R</sub> -----                                           |
|                   |                    | ROLF                   | -----                                                                |
|                   | 1<br>Second clock  | RTCCMP                 | ----- X -----                                                        |
|                   |                    | RTCCNT                 | ----- 3 ----- 4 ----- 5 -----                                        |
|                   |                    | RTCOUT (ROAP = 0)      | ----- T <sub>R</sub> ----- T <sub>R</sub> ----- T <sub>R</sub> ----- |
|                   |                    | RTCOUT (ROAP = 1)      | ----- T <sub>R</sub> ----- T <sub>R</sub> ----- T <sub>R</sub> ----- |
|                   |                    | ROLF                   | -----                                                                |
| 1<br>(Level mode) | 0<br>Compare match | RTCCMP                 | ----- 4 -----                                                        |
|                   |                    | RTCCNT                 | ----- 3 ----- 4 ----- 5 -----                                        |
|                   |                    | RTCOUT (ROAP = 0)      | ----- 1 -----                                                        |
|                   |                    | RTCOUT (ROAP = 1)      | ----- 1 -----                                                        |
|                   |                    | ROLF                   | ----- → -----                                                        |
|                   | 1<br>Second clock  | RTCCMP                 | ----- X -----                                                        |
|                   |                    | RTCCNT                 | ----- 3 ----- 4 ----- 5 -----                                        |
|                   |                    | RTCOUT (ROAP = 0)      | ----- 1 -----                                                        |
|                   |                    | RTCOUT (ROAP = 1)      | ----- 1 -----                                                        |
|                   |                    | ROLF                   | ----- → -----                                                        |

T<sub>R</sub>: RTCOUT output pulse time = 1 / f<sub>CK\_RTC</sub>  
→: Clear by software reading ROLF bit

## Register Map

The following table shows the RTC registers and reset values. Note all the registers in this unit are located at the V<sub>BAK</sub> backup power domain.

**Table 44. RTC Register Map**

| Register | Offset | Description                              | Reset Value |
|----------|--------|------------------------------------------|-------------|
| RTCCNT   | 0x000  | RTC Counter Register                     | 0x0000_0000 |
| RTCCMP   | 0x004  | RTC Compare Register                     | 0x0000_0000 |
| RTCCR    | 0x008  | RTC Control Register                     | 0x0000_0F04 |
| RTCSR    | 0x00C  | RTC Status Register                      | 0x0000_0000 |
| RTCIWEN  | 0x010  | RTC Interrupt and Wakeup Enable Register | 0x0000_0000 |

## Register Descriptions

### RTC Counter Register – RTCCNT

This register defines a 32-bit up counter which is incremented by the CK\_SECOND clock.

Offset: 0x000

Reset value: 0x0000\_0000

|            |         |    |    |    |    |    |    |    |    |
|------------|---------|----|----|----|----|----|----|----|----|
|            | 31      | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | RTCCNTV |    |    |    |    |    |    |    |    |
| Type/Reset | RO      | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 23      | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | RTCCNTV |    |    |    |    |    |    |    |    |
| Type/Reset | RO      | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 15      | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | RTCCNTV |    |    |    |    |    |    |    |    |
| Type/Reset | RO      | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 7       | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | RTCCNTV |    |    |    |    |    |    |    |    |
| Type/Reset | RO      | 0  | RO | 0  | RO | 0  | RO | 0  | RO |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | RTCCNTV | <p>RTC Counter</p> <p>The current value of the RTC counter is returned when reading the RTCCNT register. The RTCCNT register is updated during the falling edge of the CK_SECOND. This register is reset by one of the following conditions:</p> <ul style="list-style-type: none"> <li>- Backup Domain software reset - set the BAKRST bit in the BAKCR register</li> <li>- Backup Domain power on reset - PORB</li> <li>- Compare match (RTCCNT=RTCCMP) when CMPCLR=1 (in the RTCCR register)</li> <li>- RTCEN bit changed from 0 to 1</li> </ul> |

## RTC Compare Register – RTCCMP

This register defines a specific value to be compared with the RTC counter value.

Offset: 0x004

Reset value: 0x0000\_0000 (Reset by Backup Domain reset only)

|            |         |    |    |    |    |    |    |    |    |
|------------|---------|----|----|----|----|----|----|----|----|
|            | 31      | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | RTCCMPV |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23      | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | RTCCMPV |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15      | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | RTCCMPV |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7       | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | RTCCMPV |    |    |    |    |    |    |    |    |
| Type/Reset | RW      | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | RTCCMPV | <p>RTC Compare Match Value</p> <p>A match condition happens when the value in the RTCCNT register is equal to RTCCMP value. An interrupt can be generated if the CMIEN bit in the RTCIWEN register is set. When the CMPCLR bit in the RTCCR register is set to 0 and a match condition happens, the CMFLAG bit in the RTCSR register is set while the value in the RTCCNT register is not affected and will continue to count until overflow. When the CMPCLR bit is set to 1 and a match condition happens, the CMFLAG bit in the RTCSR register is set and the RTCCNT register will be reset to zero and then the counter continues to count.</p> |

## RTC Control Register – RTCCR

This register specifies a range of RTC circuitry control bits.

Offset: 0x008

Reset value: 0x0000\_0F04 (Reset by Backup Domain reset only)

|            |          |    |       |        |       |       |        |       |    |
|------------|----------|----|-------|--------|-------|-------|--------|-------|----|
|            | 31       | 30 | 29    | 28     | 27    | 26    | 25     | 24    |    |
| Type/Reset | Reserved |    |       |        |       |       |        |       |    |
|            | 23       | 22 | 21    | 20     | 19    | 18    | 17     | 16    |    |
| Type/Reset | Reserved |    |       | ROLF   | ROAP  | ROWM  | ROES   | ROEN  |    |
|            |          |    |       | RC     | 0     | RW    | 0      | RW    | 0  |
|            | 15       | 14 | 13    | 12     | 11    | 10    | 9      | 8     |    |
| Type/Reset | Reserved |    |       |        | RPRE  |       |        |       |    |
|            |          |    |       |        | RW    | 1     | RW     | 1     | RW |
|            | 7        | 6  | 5     | 4      | 3     | 2     | 1      | 0     |    |
| Type/Reset | Reserved |    | LSESM | CMPCLR | LSEEN | LSIEN | RTCSRC | RTCEN |    |
|            |          |    | RW    | 0      | RW    | 0     | RW     | 1     | RW |
|            |          |    |       |        |       |       |        | 0     | RW |
|            |          |    |       |        |       |       |        |       | 0  |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [20] | ROLF  | <p>RTCOUNT Level Mode Flag</p> <p>0: RTCOUNT Output is inactive</p> <p>1: RTCOUNT Output is holding as active level</p> <p>Set by hardware when level mode (ROWM = 1) and a RTCOUNT output event occurred. Cleared by software reading this flag. The RTCOUNT signal will return to the inactive level after software has read this bit.</p>                                                                                                                    |
| [19] | ROAP  | <p>RTCOUNT Output Active Polarity</p> <p>0: Active level is high</p> <p>1: Active level is low</p>                                                                                                                                                                                                                                                                                                                                                              |
| [18] | ROWM  | <p>RTCOUNT Output Waveform Mode</p> <p>0: Pulse mode</p> <p>The output pulse duration is one RTC clock (CK_RTC) period.</p> <p>1: Level mode</p> <p>The RTCOUNT signal will remain at an active level until the ROLF bit is cleared by software reading the ROLF bit.</p>                                                                                                                                                                                       |
| [17] | ROES  | <p>RTCOUNT Output Event Selection</p> <p>0: RTC compare match is selected</p> <p>1: RTC second clock (CK_SECOND) event is selected</p> <p>The ROES bit can be used to select whether the RTCOUNT signal is output on the RTCOUNT pin when a RTC compare match event or the RTC second clock (CK_SECOND) event occurs.</p>                                                                                                                                       |
| [16] | ROEN  | <p>RTCOUNT Output Pin Enable</p> <p>0: Disable RTCOUNT output pin</p> <p>1: Enable RTCOUNT output pin</p> <p>When the ROEN bit is set to 1, the RTCOUNT signal will be at an active level once a RTC compare match on the RTC second clock (CK_SECOOD) event occurs. The active polarity and output waveform mode can be configured by the ROAP and ROWM bits respectively. When the ROEN bit is cleared to 0, the RTCOUNT pin will be in a floating state.</p> |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11:8] | RPRE    | <p>RTC Clock Prescaler Select</p> $CK\_SECOND = CK\_RTC / 2^{RPRE}$ <p>0000: <math>CK\_SECOND = CK\_RTC / 2^0</math><br/> 0001: <math>CK\_SECOND = CK\_RTC / 2^1</math><br/> 0010: <math>CK\_SECOND = CK\_RTC / 2^2</math><br/> ...<br/> 1111: <math>CK\_SECOND = CK\_RTC / 2^{15}</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| [5]    | LSESM   | <p>LSE oscillator Startup Mode</p> <p>0: Normal startup and requires less operating power<br/> 1: Fast startup but requires higher operating current</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| [4]    | CMPCLR  | <p>Compare Match Counter Clear</p> <p>0: 32-bit RTC counter is not affected when compare match condition occurs<br/> 1: 32-bit RTC counter is cleared when compare match condition occurs</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| [3]    | LSEEN   | <p>LSE oscillator Enable Control</p> <p>0: LSE oscillator disabled<br/> 1: LSE oscillator enabled</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| [2]    | LSIEN   | <p>LSI oscillator Enable Control</p> <p>0: LSI oscillator disabled<br/> 1: LSI oscillator enabled</p> <p>The LSIEN bit default value is 1 which means the LSI oscillator is enabled automatically after the Backup Domain powered up.</p> <p>Note: After the backup domain is powered on, the internal LSI RC oscillator will start to oscillate. The frequency range of the LSI oscillator is shown in the LSI oscillator electrical characteristics in the datasheet. The device also provides a production trim value to obtain a more accurate oscillation frequency. The procedure is to disable the LSI oscillator and then enable it again after the backup domain is powered on. After the trimming procedure has completed, the system will automatically load the production trim value to the frequency trimming circuit of the LSI RC oscillator.</p> |
| [1]    | RTC SRC | <p>RTC Clock Source Selection</p> <p>0: LSI oscillator selected as the RTC clock source<br/> 1: LSE oscillator selected as the RTC clock source</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| [0]    | RTCEN   | <p>RTC Enable Control</p> <p>0: RTC is disabled<br/> 1: RTC is enabled</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## RTC Status Register – RTCSR

This register stores the counter flags.

Offset: 0x00C

Reset value: 0x0000\_0000 (Reset by Backup Domain reset and RTCEN bit change from 1 to 0)

|            |          |    |    |    |    |        |        |          |
|------------|----------|----|----|----|----|--------|--------|----------|
|            | 31       | 30 | 29 | 28 | 27 | 26     | 25     | 24       |
| Type/Reset | Reserved |    |    |    |    |        |        |          |
|            | 23       | 22 | 21 | 20 | 19 | 18     | 17     | 16       |
| Type/Reset | Reserved |    |    |    |    |        |        |          |
|            | 15       | 14 | 13 | 12 | 11 | 10     | 9      | 8        |
| Type/Reset | Reserved |    |    |    |    |        |        |          |
|            | 7        | 6  | 5  | 4  | 3  | 2      | 1      | 0        |
| Type/Reset | Reserved |    |    |    |    | OVFLAG | CMFLAG | CSECFLAG |
|            |          |    |    |    |    | RC     | 0 RC   | 0 RC 0   |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | OVFLAG   | Counter Overflow Flag<br>0: Counter overflow not occurred since the last RTCSR register read operation<br>1: Counter overflow has occurred since the last RTCSR register read operation<br>This bit is set by hardware when the counter value in the RTCCNT register changes from 0xFFFF_FFFF to 0x0000_0000 and cleared by read operation. This bit is suggested to read in the RTC IRQ handler and should be taken care when software polling is used.                                                                                     |
| [1]  | CMFLAG   | Compare Match Condition Flag<br>0: Compare match condition not occurred since the last RTCSR register read operation<br>1: Compare match condition has occurred since the last RTCSR register read operation.<br>This bit is set by hardware on the CK_SECOND clock falling edge when the RTCCNT register value is equal to the RTCCMP register content. It is cleared by software reading this bit. This bit is suggested for access in the corresponding RTC interrupt routine – do not use software polling during software free running. |
| [0]  | CSECFLAG | CK_SECOND Occurrence Flag<br>0: CK_SECOND not occurred since the last RTCSR register read operation<br>1: CK_SECOND has occurred since the last RTCSR register read operation<br>This bit is set by hardware on the CK_SECOND clock falling edge. It is cleared by software reading this bit. This bit is suggested for access in the corresponding RTC interrupt routine – do not use software polling during software free running.                                                                                                        |

## RTC Interrupt and Wakeup Enable Register – RTCIWEN

This register contains the interrupt and wakeup enable bits.

Offset: 0x010

Reset value: 0x0000\_0000 (Reset by Backup Domain reset only)

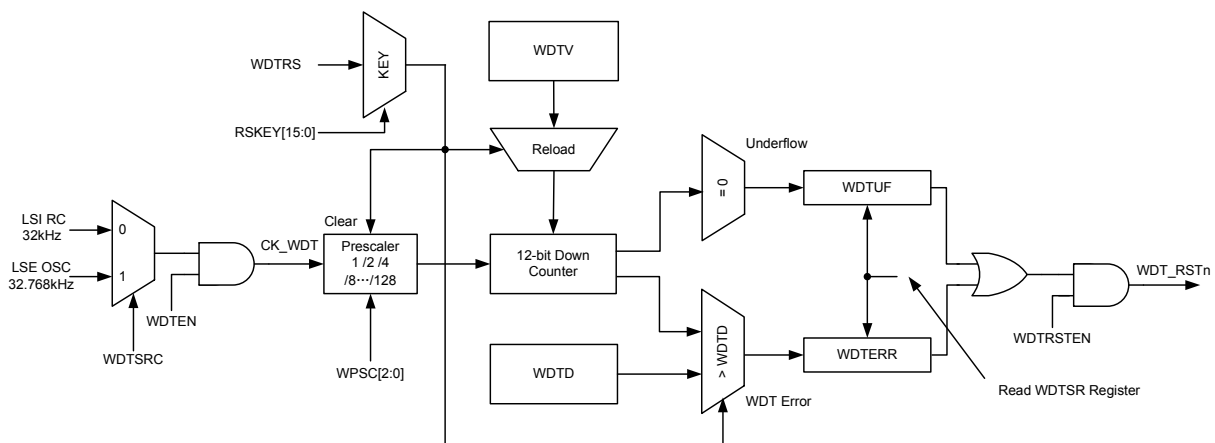
|            |          |    |    |    |    |       |       |         |
|------------|----------|----|----|----|----|-------|-------|---------|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25    | 24      |
| Type/Reset | Reserved |    |    |    |    |       |       |         |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17    | 16      |
| Type/Reset | Reserved |    |    |    |    |       |       |         |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9     | 8       |
| Type/Reset | Reserved |    |    |    |    | OVWEN | CMWEN | CSECWEN |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1     | 0       |
| Type/Reset | Reserved |    |    |    |    | RW 0  | RW 0  | RW 0    |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1     | 0       |
| Type/Reset | Reserved |    |    |    |    | OVWEN | CMWEN | CSECWEN |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1     | 0       |
| Type/Reset | Reserved |    |    |    |    | RW 0  | RW 0  | RW 0    |

| Bits | Field   | Descriptions                                                                                                                              |
|------|---------|-------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | OVWEN   | Counter Overflow Wakeup Enable<br>0: Counter overflow wakeup disabled<br>1: Counter overflow wakeup enabled                               |
| [9]  | CMWEN   | Compare Match Wakeup Enable<br>0: Compare match wakeup disabled<br>1: Compare match wakeup enabled                                        |
| [8]  | CSECWEN | Counter Clock CK_SECOND Wakeup Enable<br>0: Counter Clock CK_SECOND wakeup disabled<br>1: Counter Clock CK_SECOND wakeup enabled          |
| [2]  | OVWEN   | Counter Overflow Interrupt Enable<br>0: Counter Overflow Interrupt disabled<br>1: Counter Overflow Interrupt enabled                      |
| [1]  | CMWEN   | Compare Match Interrupt Enable<br>0: Compare Match Interrupt disabled<br>1: Compare Match Interrupt enabled                               |
| [0]  | CSECWEN | Counter Clock CK_SECOND Interrupt Enable<br>0: Counter Clock CK_SECOND Interrupt disabled<br>1: Counter Clock CK_SECOND Interrupt enabled |

# 19 Watchdog Timer (WDT)

## Introduction

The Watchdog timer is a hardware timing circuitry that can be used to detect a system lock-up due to software trapped in a deadlock. The Watchdog timer can be operated in a reset mode. The Watchdog timer will generate a reset when the counter counts down to a zero value. Therefore, the software should reload the counter value before a Watchdog timer underflow occurs. In addition, a reset is also generated if the software reloads the counter before it reaches a delta value. That means that the Watchdog timer prevents a software deadlock that continuously triggers the Watchdog, the reload must occur when the Watchdog timer value has a value within a limited window of 0 and WDTD. The Watchdog timer counter can be stopped when the processor is in the debug or sleep mode. The register write protection function can be enabled to prevent an unexpected change in the Watchdog timer configuration.



**Figure 134. Watchdog Timer Block Diagram**

## Features

- Clock source from either internal 32 kHz RC oscillator (LSI) or 32,768 Hz oscillator (LSE)
- Can be independently setup to keep running or to stop when entering the sleep or deep sleep mode 1
- 12-bit down counter with 3-bit prescaler structure
- Provides reset to the system
- Limited reload window setup function for custom Watchdog timer reload times
- Watchdog Timer may be stopped when the processor is in the debug
- Reload lock key to prevent unexpected operation
- Configuration register write protection function for counter value, reset enable, delta value, and prescaler

## Functional Description

The Watchdog timer is formed from a 12-bit count-down and a fixed 3-bit prescaler. The largest time-out period is 16 seconds, using the LSE or LSI clock and a 1/128 maximum prescaler value.

The Watchdog timer configuration setup includes a programmable counter reload value, reset enable, window value and prescaler value. These configurations are setup using the WDTMR0 and WDTMR1 registers which must be properly programmed before the Watchdog timer starts counting. In order to prevent unexpected write operations to those configurations, a register write protection function can be enabled by writing any value, other than 0x35CA to PROTECT[15:0], in the WDTPR register. A value of 0x35CA can be written to PROTECT[15:0] to disable the register write protection function before accessing any configuration register. A read operation on PROTECT[0] can obtain the enable/disable status of the register write protection function.

During normal operation, the Watchdog timer counter should be reloaded before it underflows to prevent the generation of a Watchdog reset. The 12-bit count-down counter can be reloaded with the required Watchdog Timer Counter Value (WDTV) by first setting the WDTRS bit to 1 with the correct key, which is 0x5FA0 in the WDTCR register.

If a software deadlock occurs during a Watchdog timer reload routine, the reload operation will still go ahead and therefore the software deadlock cannot be detected. To prevent this situation from occurring, the reload operation must be executed in such a way that the value of the Watchdog timer counter is limited within a delta value (WDTD). If the Watchdog timer counter value is greater than the delta value and a reload operation is executed, a Watchdog Timer error will occur. The Watchdog timer error will generate a Watchdog reset if the related functional control is enabled. Additionally, the above features can be disabled by programming a WDTD value greater than or equal to the WDTV value.

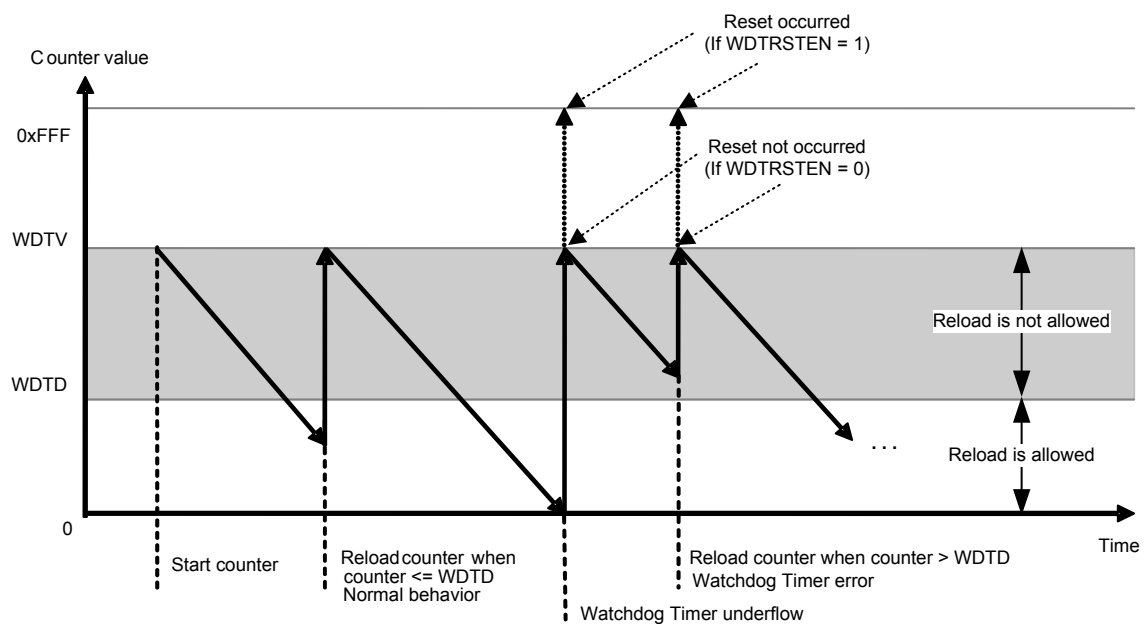
The WDERR and WDTUF flags in the WDTSTS register will be set respectively when the Watchdog timer underflows or when a Watchdog timer error occurs. A system reset or write-one operation on the WDTSTS register clears the WDERR and WDTUF flags.

The watchdog timer uses two clocks: PCLK and CK\_WDT. The PCLK clock is used for APB access to the watchdog registers. The CK\_WDT clock is used for the Watchdog timer functionality and counting. There is some synchronization logic between these two clock domains.

When the system enters the Sleep or Deep sleep mode 1, the Watchdog timer counter will either continue to count or stop depending on the WDTSHLT bits in the WDTMR0 register. The Watchdog stops counting when the WDTSHLT bits are set in the Sleep mode. The count value is retained so that it continues counting after the system is woken up from the Sleep mode. A Watchdog reset will occur any time when the Watchdog timer is running and when it has an operating clock source. When the system enters the debug mode, the Watchdog timer counter will either continue to count or stop depending on the DB\_WDT bit (in the MCUIDBGCR register) in the Clock Control Unit.

The Watchdog timer should be used in the following manners:

- Set the Watchdog timer reload value (WDTV) and reset in the WDTMR0 register.
- Set the Watchdog timer delta value (WDTD) and prescaler in the WDTMR1 register.
- Start the Watchdog timer by writing to the WDTCR register with WDTRS = 1 and RSKEY = 0x5FA0.
- Write to the WDTPR register to lock all the Watchdog timer registers except for WDTCR and WDTPR.
- The Watchdog timer counter should be reloaded again within the delta value (WDTD).



**Figure 135. Watchdog Timer Behavior**

## Register Map

The following table shows the Watchdog Timer registers and reset values.

**Table 45. Watchdog Timer Register Map**

| Register | Offset | Description                             | Reset Value |
|----------|--------|-----------------------------------------|-------------|
| WDTCR    | 0x000  | Watchdog Timer Control Register         | 0x0000_0000 |
| WDTMR0   | 0x004  | Watchdog Timer Mode Register 0          | 0x0000_0FFF |
| WDTMR1   | 0x008  | Watchdog Timer Mode Register 1          | 0x0000_7FFF |
| WDTSR    | 0x00C  | Watchdog Timer Status Register          | 0x0000_0000 |
| WDTPR    | 0x010  | Watchdog Timer Protection Register      | 0x0000_0000 |
| WDTCSR   | 0x018  | Watchdog Timer Clock Selection Register | 0x0000_0000 |

## Register Descriptions

### Watchdog Timer Control Register – WDTCR

This register is used to reload the Watchdog timer.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |       |    |
|------------|----------|----|----|----|----|----|----|-------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24    |    |
|            | RSKEY    |    |    |    |    |    |    |       |    |
| Type/Reset | WO       | 0  | WO | 0  | WO | 0  | WO | 0     | WO |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16    |    |
|            | RSKEY    |    |    |    |    |    |    |       |    |
| Type/Reset | WO       | 0  | WO | 0  | WO | 0  | WO | 0     | WO |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8     |    |
|            | Reserved |    |    |    |    |    |    |       |    |
| Type/Reset |          |    |    |    |    |    |    |       |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0     |    |
|            | Reserved |    |    |    |    |    |    | WDTRS |    |
| Type/Reset |          |    |    |    |    |    |    | WO    | 0  |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                               |
|---------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | RSKEY | Watchdog Timer Reload Lock Key<br>The RSKEY [15:0] bits should be written with a 0x5FA0 value to enable the WDT reload operation function. Writing any other value except 0x5FA0 in this field will abort the write operation.                             |
| [0]     | WDTRS | Watchdog Timer Reload<br>0: No effect<br>1: Reload Watchdog Timer.<br>This bit is used to reload the Watchdog timer counter as a WDTV value which is stored in the WDTMR0 register. It is set to 1 by software and cleared to 0 by hardware automatically. |

## Watchdog Timer Mode Register 0 – WDTMR0

This register specifies the Watchdog timer counter reload value and reset enable control.

Offset: 0x004

Reset value: 0x0000\_0FFF

|            |          |      |         |          |      |      |      |       |      |
|------------|----------|------|---------|----------|------|------|------|-------|------|
|            | 31       | 30   | 29      | 28       | 27   | 26   | 25   | 24    |      |
| Type/Reset | Reserved |      |         |          |      |      |      |       |      |
|            | 23       | 22   | 21      | 20       | 19   | 18   | 17   | 16    |      |
| Type/Reset | Reserved |      |         |          |      |      |      | WDTEN |      |
|            |          |      |         |          |      |      |      |       | RW 0 |
|            | 15       | 14   | 13      | 12       | 11   | 10   | 9    | 8     |      |
| Type/Reset | WDTSHLT  |      | WDRSTEN | Reserved | WDTV |      |      |       |      |
|            | RW 0     | RW 0 | RW 0    |          | RW 1 | RW 1 | RW 1 | RW 1  |      |
|            |          |      |         |          |      |      |      |       |      |
|            | 7        | 6    | 5       | 4        | 3    | 2    | 1    | 0     |      |
| Type/Reset | WDTV     |      |         |          |      |      |      |       |      |
|            | RW 1     | RW 1 | RW 1    | RW 1     | RW 1 | RW 1 | RW 1 | RW 1  |      |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [16]    | WDTEN   | Watchdog Timer Running Enable<br>0: Watchdog timer is disabled<br>1: Watchdog timer is enabled to run.<br>When the Watchdog timer is disabled, the counter will be reset to its hardware default condition. When the WDTEN bit is set, the Watchdog timer will be reloaded with the WDTV value and count down.                                                                                                                                                                                                                                                                                                                                                             |
| [15:14] | WDTSHLT | Watchdog Timer Sleep Halt<br>00: The Watchdog runs when the system is in the Sleep mode or Deep Sleep mode 1<br>01: The Watchdog runs when the system is in the Sleep mode and halts in Deep Sleep mode 1<br>10 or 11: The Watchdog halts when the system is in the Sleep mode and Deep Sleep mode 1<br>Note that the Watchdog timer always halts when the system is in Deep Sleep mode 2. If a Watchdog interrupt occurs in Sleep or Deep Sleep mode 1, it will wake up the device. The Watchdog stops counting when the WDTSHLT bits are set in the Sleep mode. The count value is retained so that it continues counting after the system wakes up from the Sleep mode. |
| [13]    | WDRSTEN | Watchdog Timer Reset Enable<br>0: A Watchdog Timer underflow or error has no effect on the reset of system.<br>1: A Watchdog Timer underflow or error triggers a Watchdog timer system reset.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| [11:0]  | WDTV    | Watchdog Timer Counter Value<br>WDTV defines the value loaded into the 12-bit Watchdog down counter.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

## Watchdog Timer Mode Register 1 – WDTMR1

This register specifies the Watchdog delta value and the prescaler selection.

Offset: 0x008

Reset value: 0x0000\_7FFF

|            |          |      |    |    |    |      |    |    |   |
|------------|----------|------|----|----|----|------|----|----|---|
|            | 31       | 30   | 29 | 28 | 27 | 26   | 25 | 24 |   |
| Type/Reset | Reserved |      |    |    |    |      |    |    |   |
|            | 23       | 22   | 21 | 20 | 19 | 18   | 17 | 16 |   |
| Type/Reset | Reserved |      |    |    |    |      |    |    |   |
|            | 15       | 14   | 13 | 12 | 11 | 10   | 9  | 8  |   |
| Type/Reset | Reserved | WPSC |    |    |    | WDTD |    |    |   |
|            |          | RW   | 1  | RW | 1  | RW   | 1  | RW | 1 |
|            | 7        | 6    | 5  | 4  | 3  | 2    | 1  | 0  |   |
| Type/Reset | WDTD     |      |    |    |    |      |    |    |   |
|            | RW       | 1    | RW | 1  | RW | 1    | RW | 1  |   |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [14:12] | WPSC  | Watchdog Timer Prescaler Selection<br>000: 1/1<br>001: 1/2<br>010: 1/4<br>011: 1/8<br>100: 1/16<br>101: 1/32<br>110: 1/64<br>111: 1/128                                                                                                                                                                                                                                                                                                                                                      |
| [11:0]  | WDTD  | Watchdog Timer Delta Value<br>Define the permitted range to reload the Watchdog timer. If the Watchdog timer counter value is less than or equal to WDTD, writing to the WDTCR register with WDTRS = 1 and RSKEY = 0x5FA0 will reload the timer. If the Watchdog Timer value is greater than WDTD, then writing WDTCR with WDTRS = 1 and RSKEY = 0x5FA0 will cause a Watchdog Timer error. This feature can be disabled by programming a WDTD value greater then or equal to the WDTV value. |

## Watchdog Timer Status Register – WDTSR

This register specifies the Watchdog timer status.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |        |        |
|------------|----------|----|----|----|----|----|--------|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25     | 24     |
| Type/Reset | Reserved |    |    |    |    |    |        |        |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17     | 16     |
| Type/Reset | Reserved |    |    |    |    |    |        |        |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9      | 8      |
| Type/Reset | Reserved |    |    |    |    |    |        |        |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1      | 0      |
| Type/Reset | Reserved |    |    |    |    |    | WDTERR | WDTUF  |
|            |          |    |    |    |    |    | WC     | 0 WC 0 |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                           |
|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | WDTERR | Watchdog Timer Error<br>0: No Watchdog timer error has occurred since the last read of this register<br>1: A Watchdog timer error has occurred since the last read of this register<br>Note: A reload operation when the Watchdog timer counter value is larger than WDTD causes a Watchdog timer error. Note that this bit is a write-one-clear flag. |
| [0]  | WDTUF  | Watchdog timer Underflow<br>0: No Watchdog timer underflow since the last read of this register<br>1: A Watchdog timer underflow has occurred since the last read of this register<br>Note that this bit is a write-one-clear flag.                                                                                                                    |

## Watchdog Timer Protection Register – WDTPR

This register specifies the Watchdog timer protect key configuration.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | PROTECT  |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | PROTECT  |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | PROTECT | <p>Watchdog Timer Register Protection</p> <p>For write operation:</p> <p>0x35CA: Disable the Watchdog timer register write protection</p> <p>Others: Enable the Watchdog timer register write protection</p> <p>For read operation:</p> <p>0x0000: Watchdog timer register write protection is disabled</p> <p>0x0001: Watchdog timer register write protection is enabled</p> <p>This register is used to enable/disable the Watchdog timer configuration register write protection function. All configuration registers become read only except for WDTCR and WDTPR when the register write protection is enabled. Additionally, the read operation of PROTECT[0] can obtain the enable/disable status of the register write protection function.</p> |

## Watchdog Timer Clock Selection Register – WDTCSR

This register specifies the Watchdog timer clock source selection and lock configuration.

Offset: 0x018

Reset value: 0x0000\_0FFF

|            |          |    |    |         |          |    |    |        |
|------------|----------|----|----|---------|----------|----|----|--------|
|            | 31       | 30 | 29 | 28      | 27       | 26 | 25 | 24     |
| Type/Reset | Reserved |    |    |         |          |    |    |        |
|            | 23       | 22 | 21 | 20      | 19       | 18 | 17 | 16     |
| Type/Reset | Reserved |    |    |         |          |    |    |        |
|            | 15       | 14 | 13 | 12      | 11       | 10 | 9  | 8      |
| Type/Reset | Reserved |    |    |         |          |    |    |        |
|            | 7        | 6  | 5  | 4       | 3        | 2  | 1  | 0      |
| Type/Reset | Reserved |    |    | WDTLOCK | Reserved |    |    | WDTSEL |
|            |          |    |    | RW 0    |          |    |    | RW 0   |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4]  | WDTLOCK | Watchdog Timer Lock Mode<br>0: This bit is only set to 0 on any reset. It cannot be cleared by software.<br>1: This bit is set once only by software and locks the Watchdog timer function. Software can set this bit to 1 at any time. Once the WDTLOCK bit is set, the function and registers of the Watchdog timer cannot be modified or disabled, including the Watchdog timer clock source, and only waits for a system reset to disable the lock mode. |
| [0]  | WDTSRC  | Watchdog Timer Clock Source Selection<br>0: Internal 32 kHz RC oscillator clock selected (LSI)<br>1: External 32.768 kHz crystal oscillator clock selected (LSE)<br>Select using software to control the Watchdog timer clock source.                                                                                                                                                                                                                        |

## 20 Inter-Integrated Circuit (I<sup>2</sup>C)

### Introduction

The I<sup>2</sup>C Module is an internal circuit allowing communication with an external I<sup>2</sup>C interface which is an industry standard two line serial interface used for connection to external hardware. These two serial lines are known as a serial data line, SDA, and a serial clock line, SCL. The I<sup>2</sup>C module provides three data transfer rates: (1) 100 kHz in the Standard mode, (2) 400 kHz in the Fast mode and (3) 1MHz in the Fast-mode plus. The SCL period generation register is used to setup different kinds of duty cycle implementation for the SCL pulse.

The SDA line which is connected to the whole I<sup>2</sup>C bus is a bi-directional data line between the master and slave devices used for the transmission and reception of data. The I<sup>2</sup>C module also has an arbitration detection function to prevent the situation where more than one master attempts to transmit data on the I<sup>2</sup>C bus at the same time.

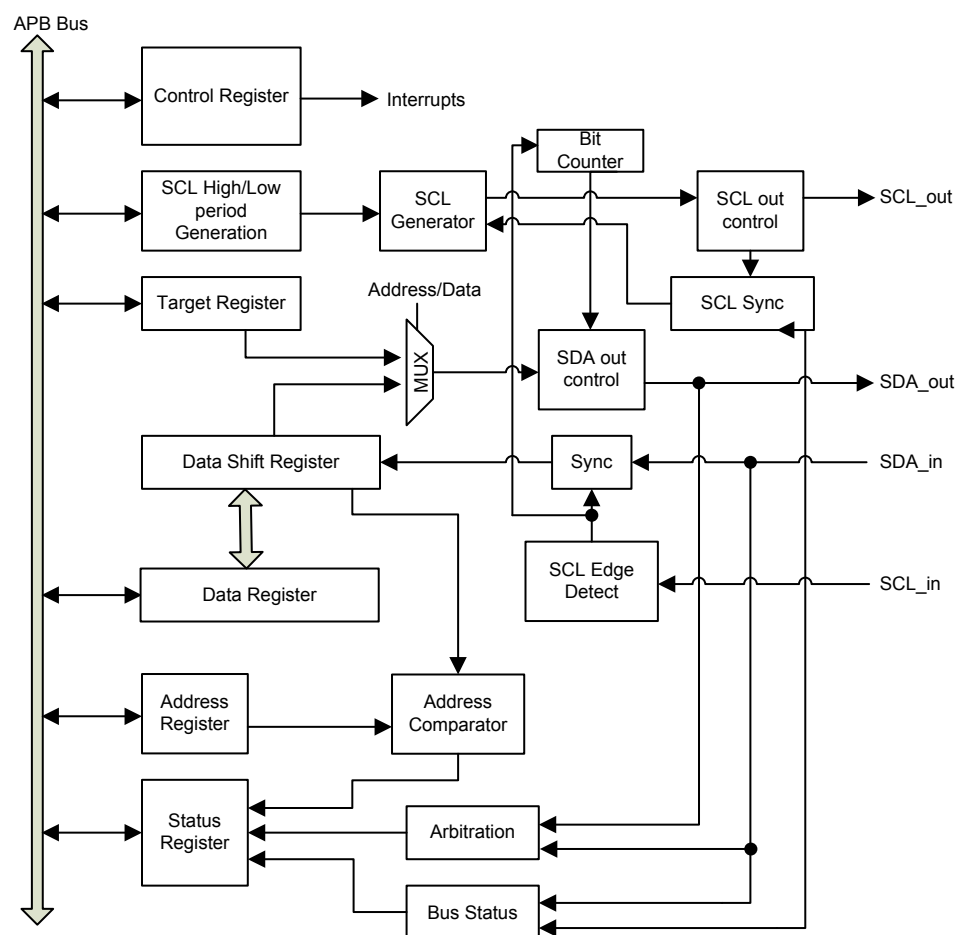


Figure 136. I<sup>2</sup>C Module Block Diagram

## Features

- Two-wire I<sup>2</sup>C serial interface
  - Serial data line (SDA) and serial clock (SCL)
- Multiple speed modes
  - Standard mode – 100 kHz
  - Fast mode – 400 kHz
  - Fast mode plus – 1 MHz
- Bi-directional data transfer between master and slave
- Multi-master bus – no central master
  - The same interface can act as Master or Slave
- Arbitration among simultaneously transmitting masters without corrupting of serial data on the bus
- Clock synchronization
  - Allow devices with different bit rates to communicate via one serial bus
- Supports 7-bit and 10-bit addressing mode and general call addressing.
- Multiple slave addresses using address mask function
- Time-out function
- Supports PDMA Interface

## Functional Descriptions

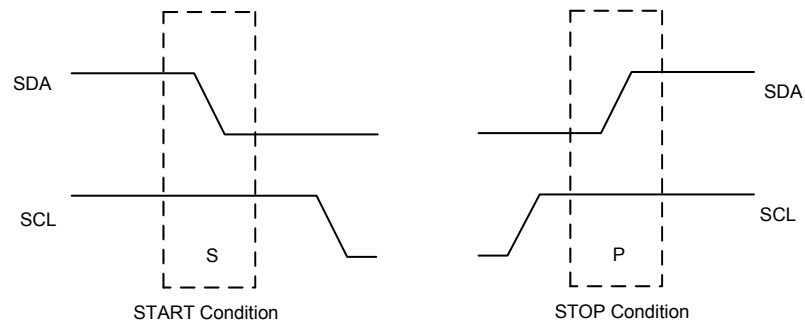
### Two Wire Serial Interface

The I<sup>2</sup>C module has two external lines, the serial data SDA and serial clock SCL lines, to carry information between the interconnected devices connected to the bus. The SCL and SDA lines are both bidirectional and must be connected to a pull-high resistor. When the I<sup>2</sup>C bus is in the free or idle state, both pins are at a high level to perform the required wired-AND function for multiple connected devices.

### START and STOP Conditions

A master device can initialize a transfer by sending a START signal and terminate the transfer with a STOP signal. A START signal is usually referred to as the “S” bit, which is defined as a High to Low transition on the SDA line while the SCL line is high. A STOP signal is usually referred to as the “P” bit, which is defined as a Low to High transition on the SDA line while SCL is high.

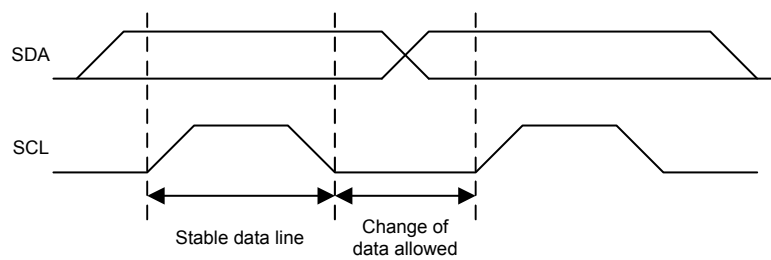
A repeated START, which is denoted as the “Sr” bit, is functionally identical to the normal START condition. A repeated START signal allows the I<sup>2</sup>C interface to communicate with another slave device or with the same device but in a different transfer direction without releasing the I<sup>2</sup>C bus control.



**Figure 137. START and STOP Condition**

### Data Validity

The data on the SDA line must be stable during the high period of the SCL clock. The SDA data state can only be changed when the clock signal on the SCL line is in a low state.



**Figure 138. Data Validity**

## Addressing Format

The I<sup>2</sup>C interface starts to transfer data after the master device has sent the address to confirm the targeted slave device. The address frame is sent just after the START signal by master device. The addressing mode selection bit named ADRM in the I2CCR register should be defined to choose either the 7-bit or 10-bit addressing mode.

## 7-bits Address Format

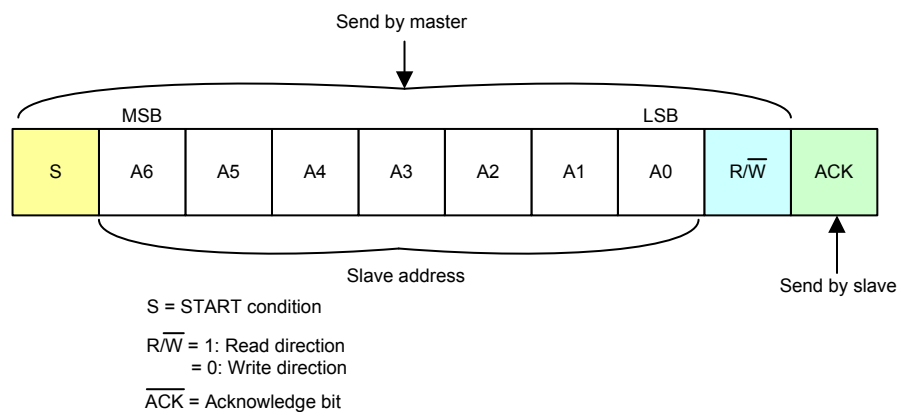
The 7-bit address format is composed of the seven-bit length slave address, which the master device wants to communicate with a  $R/\overline{W}$  bit and an ACK bit. The  $R/\overline{W}$  bit defines the direction of the data transfer.

**R/ $\overline{\text{W}}$ =0 (Write):** The master transmits data to the addressed slave.

**R/ $\overline{\text{W}}$ =1 (Read):** The master receives data from the addressed slave.

The slave address can be assigned through the ADDR field in the I2CADDR register. The slave device sends back the acknowledge bit (ACK) if its slave address matches the transmitted address sent by master.

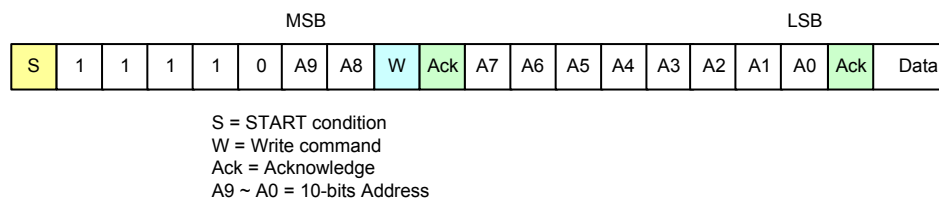
Note that it is forbidden to own the same address for two slave devices.



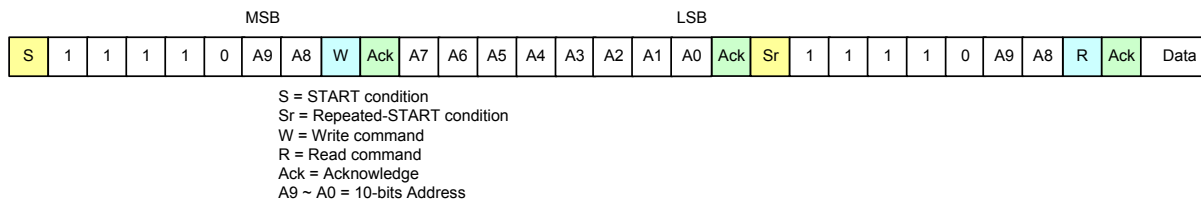
### Figure 139. 7-bit Addressing Mode

### 10-bit Address Format

In order to prevent address clashes, due to the limited range of the 7-bit addresses, a new 10-bit address scheme has been introduced. This enhancement can be mixed with the 7-bit addressing mode which increases the available address range about ten times. For the 10-bit addressing mode, the first two bytes after a START signal include a header byte and an address byte that usually determines which slave will be selected by the master. The header byte is composed of a leading “11110”, 10<sup>th</sup> and 9<sup>th</sup> bits of the slave address. The second byte is the remaining 8 bit address of the slave device.



**Figure 140. 10-bit Addressing Write Transmit Mode**



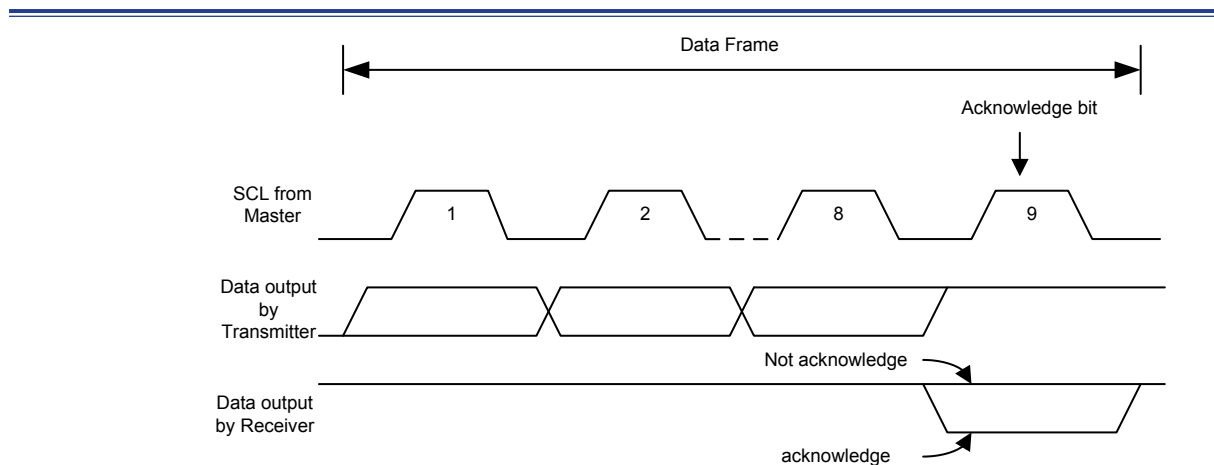
**Figure 141. 10-bit Addressing Read Receive Mode**

## Data Transfer and Acknowledge

Once the slave device address has been matched, the data can be transmitted to or received from the slave device according to the transfer direction specified by the R/ $\overline{W}$  bit. Each byte is followed by an acknowledge bit on the 9<sup>th</sup> SCL clock

If the slave device returns a Not Acknowledge (NACK) signal to the master device, the master device can generate a STOP signal to terminate the data transfer or generate a repeated START signal to restart the transfer.

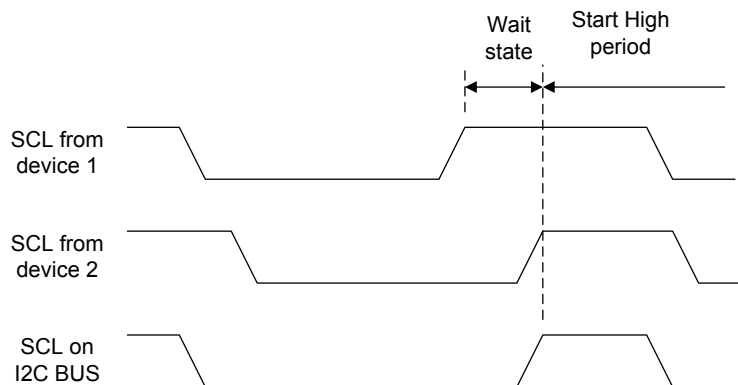
If the master device sends a Not Acknowledge (NACK) signal to the slave device, the slave device should release the SDA line for the master device to generate a STOP signal to terminate the transfer.



**Figure 142. I<sup>2</sup>C Bus Acknowledge**

## Clock Synchronization

Only one master device can generate the SCL clock under normal operation. However when there is more than one master trying to generate the SCL clock, the clock should be synchronized so that the data output can be compared. Clock synchronization is performed using the wired-AND connection of the I<sup>2</sup>C interface to the SCL line.

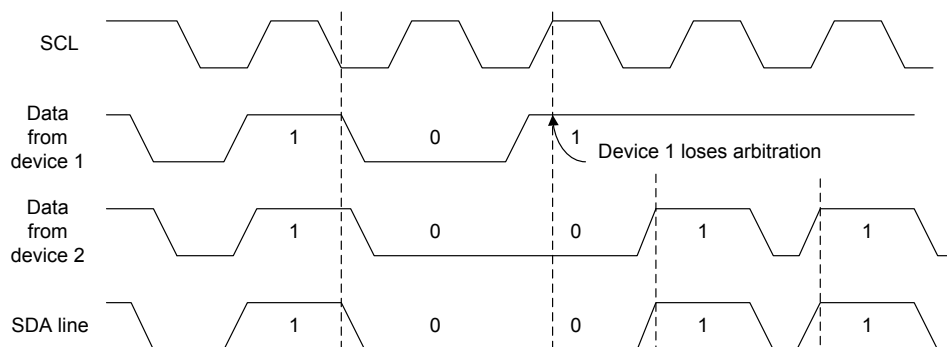


**Figure 143. Clock Synchronization during Arbitration**

## Arbitration

A master may start a transfer only if the I<sup>2</sup>C bus line is in the free or idle mode. If two or more masters generate a START signal at approximately the same time, an arbitration procedure will occur.

Arbitration takes place on the SDA line and can continue for many bits. The arbitration procedure gives a higher priority to the device that transmits serial data with a binary low bit (logic low). Other master devices which want to transmit binary high bits (logic high) will lose the arbitration. As soon as a master loses the arbitration, the I<sup>2</sup>C module will set the ARBLOS bit in the I2CSR register and generate an interrupt if the interrupt enable bit, ARBLSIEN, in the I2CIER register is set to 1. Meanwhile, it stops sending data and listens to the bus in order to detect an I<sup>2</sup>C stop signal. When the stop signal is detected, the master which has lost the arbitration may try to access the bus again.



**Figure 144. Two Master Arbitration Procedure**

## General Call Address

The general call addressing function can be used to address all the devices connected to the I<sup>2</sup>C bus. The master device can activate the general call function by writing a value “00” into the TAR and setting the RWD bit to 0 in the I2CTAR register on the addressing frame.

The device can support the general call addressing function by setting the corresponding enable control bit GCEN to 1. If the GCEN bit is set to 1 to support the general call addressing, the AA bit in the I2CCR register should also be set to 1 to send an acknowledge signal back when the device receives an address frame with a value of 00H. When this condition occurs, the general call flag, GCS, will be set to 1, but the ADRS flag will not be set.

## Bus Error

If an unpredictable START or STOP condition occurs when the data is being transferred on the I<sup>2</sup>C bus, it will be considered as a bus error and the transferring data will be aborted. When a bus error event occurs, the relevant bus error flag BUSERR in the I2CSR register will set to 1 and both the SDA and SCL lines are released. The BUSERR flag should be cleared by writing a 1 to it to initiate the I<sup>2</sup>C module to an idle state.

## Address Mask Enable

The I<sup>2</sup>C module provides address mask function for user to decide which address bit can be ignored during the comparison with the address frame sent from the master. The ADRS flag will be asserted when the unmasked address bits and the address frame sent from the master are matched. Note that this function is only available in the slave mode.

For instance, the user sets a data transfer with 7-bit addressing mode together with the I2CADDMR register value as 0x05h and the I2CADDR register value as 0x55h, this means if an address which is sent by an I<sup>2</sup>C master on the bus is equal to 0x50h, 0x51h, 0x54h or 0x55h, the I<sup>2</sup>C slave address will all be considered to be matched and the ADRS flag in the I2CSR register will be asserted after the address frame.

## Address Snoop

The Address Snoop register, I2CADDSSR, is used to monitor the calling address on the I<sup>2</sup>C bus during the whole data transfer operation no matter if the I<sup>2</sup>C module operates as a master or a slave device. Note that the I2CADDSSR register is a read only register and each calling address on the I<sup>2</sup>C bus will be stored in the I2CADDSSR register automatically even if the I<sup>2</sup>C device is not addressed.

## Operation Mode

The I<sup>2</sup>C module can operate in one of the following modes:

- Master Transmitter
- Master Receiver
- Slave Transmitter
- Slave Receiver

The I<sup>2</sup>C module operates in the slave mode by default. The interface will switch to the master mode automatically after generating a START signal.

## Master Transmitter Mode

### Start condition

Users write the target slave device address and communication direction into the I2CTAR register after setting the I2CEN bit in the I2CCR register. The STA flag in the I2CSR register is set by hardware after a start condition occurs. In order to send the following address frame, the STA flag must be cleared to 0 if it has been set to 1. The STA flag is cleared by reading the I2CSR register.

### Address Frame

The ADRS flag in the I2CSR register will be set after the address frame is sent by the master device and the acknowledge signal from the address matched slave device is received. In order to send the following data frame, the ADRS flag must be cleared to 0 if it has been set to 1. The ADRS bit is cleared by reading the I2CSR register.

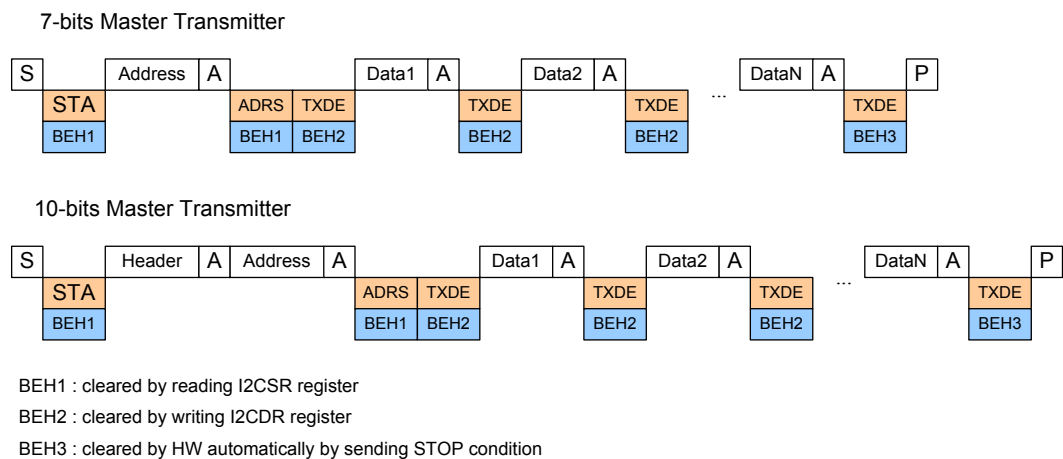
### Data Frame

The data to be transmitted to the slave device must be transferred to the I2CDR register.

The TXDE bit in the I2CSR register is set to indicate that the I2CDR register is empty, which results in the SCL line being held at a logic low state. New data must then be transferred to the I2CDR register to continue the data transfer process. Writing a data into the I2CDR register will clear the TXDE flag.

### Close / Continue Transmission

After transmitting the last data byte, the STOP bit in the I2CCR register can be set to terminate the transmission or re-assign another slave device by configuring the I2CTAR register to restart a new transfer.



**Figure 145. Master Transmitter Timing Diagram**

## Master Receiver Mode

### Start condition

The target slave device address and communication direction must be written into the I2CTAR register. The STA flag in the I2CSR register is set by hardware after a start condition occurs. In order to send the following address frame, the STA flag must be cleared to 0 if it has been set to 1. The STA flag is cleared by reading the I2CSR register.

### Address Frame

In the 7-bit addressing mode: The ADRS flag is set after the address frame is sent by the master device and the acknowledge signal from the address matched slave device is received. In order to receive the following data frame, the ADRS bit must be cleared to 0 if it has been set to 1. The ADRS bit is cleared after reading the I2CSR register.

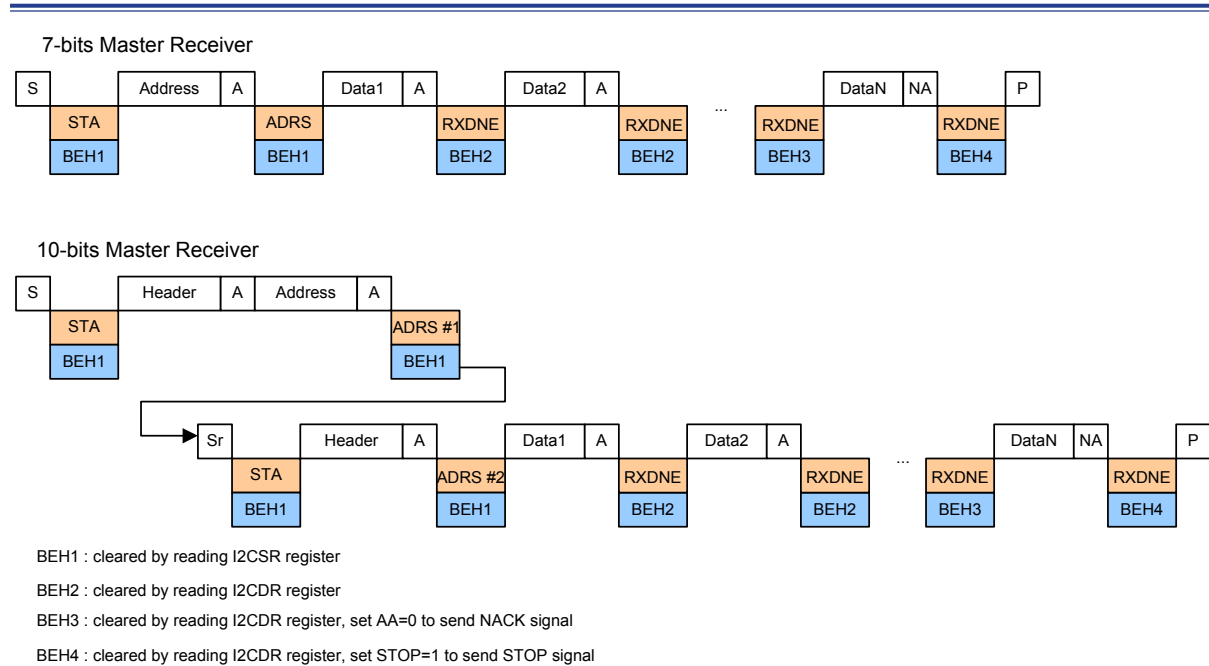
In the 10-bit addressing mode: The ADRS bit in the I2CSR register will be set twice in the 10-bit addressing mode. The first time the ADRS bit is set is when the 10-bit address is sent and the acknowledge signal from the slave device is received. The second time the ADRS bit is set is when the header byte is sent and the slave acknowledge signal is received. In order to receive the following data frame, the ADRS bit must be cleared to 0 if it has been set to 1. The ADRS bit is cleared after reading the I2CSR register. The detailed master receiver mode timing diagram is shown in the following figure.

### Data Frame

In the master receiver mode, data is transmitted from the slave device. Once a data is received by the master device, the RXDNE flag in the I2CSR register is set but it will not hold the SCL line. However, if the device receives a complete new data byte and the RXDNE flag has already been set to 1, the RXBF bit in the I2CSR register will be set to 1 and the SCL line will be held at a logic low state. When this situation occurs, data from the I2CDR register should be read to continue the data transfer process. The RXDNE flag can be cleared after reading the I2CDR register.

### Close / Continue Transmission

The master device needs to reset the AA bit in the I2CCR register to send a NACK signal to the slave device before the last data byte transfer has been completed. After the last data byte has been received from the slave device, the master device will hold the SCL line at a logic low state following after a NACK signal sent by the master device to the slave device. The STOP bit can be set to terminate the data transfer process or re-assign the I2CTAR register to restart a new transfer.



**Figure 146. Master Receiver Timing Diagram**

## Slave Transmitter Mode

### Address Frame

In the 7-bit addressing mode, the ADRS bit in the I2CSR register is set after the slave device receives the calling address which matches with the slave device address. In the 10-bit addressing mode, the ADRS bit is set when the first header byte is matched and the second address byte is matched respectively. After the ADRS bit has been set to 1, it must be cleared to 0 to continue the data transfer process. The ADRS bit is cleared after reading the I2CSR register.

### Data Frame

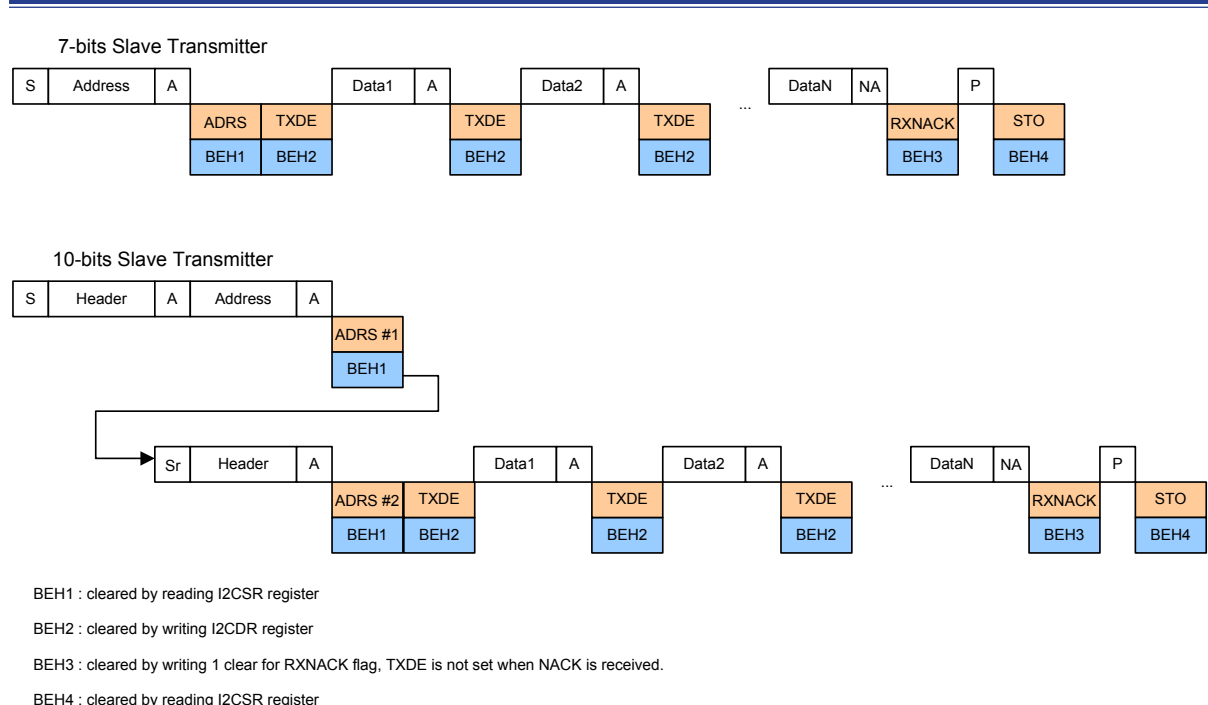
In the Slave transmitter mode, the TXDE bit is set to indicate that the I2CDR is empty, which results in the SCL line being held at a logic low state. New transmission data must then be written into the I2CDR register to continue the data transfer process. Writing a data into the I2CDR register will clear the TXDE bit.

### Receive Not-Acknowledge

When the slave device receives a Not-Acknowledge signal, the RXNACK bit in the I2CSR Register is set but it will not hold the SCL line. Writing “1” to RXNACK will clear the RXNACK flag.

### STOP Condition

When the slave device detects a STOP condition, the STO bit in the I2CSR register is set to indicate that the I<sup>2</sup>C interface transmission is terminated. Reading the I2CSR register can clear the STO flag.



**Figure 147. Slave Transmitter Timing Diagram**

## Slave Receiver Mode

### Address Frame

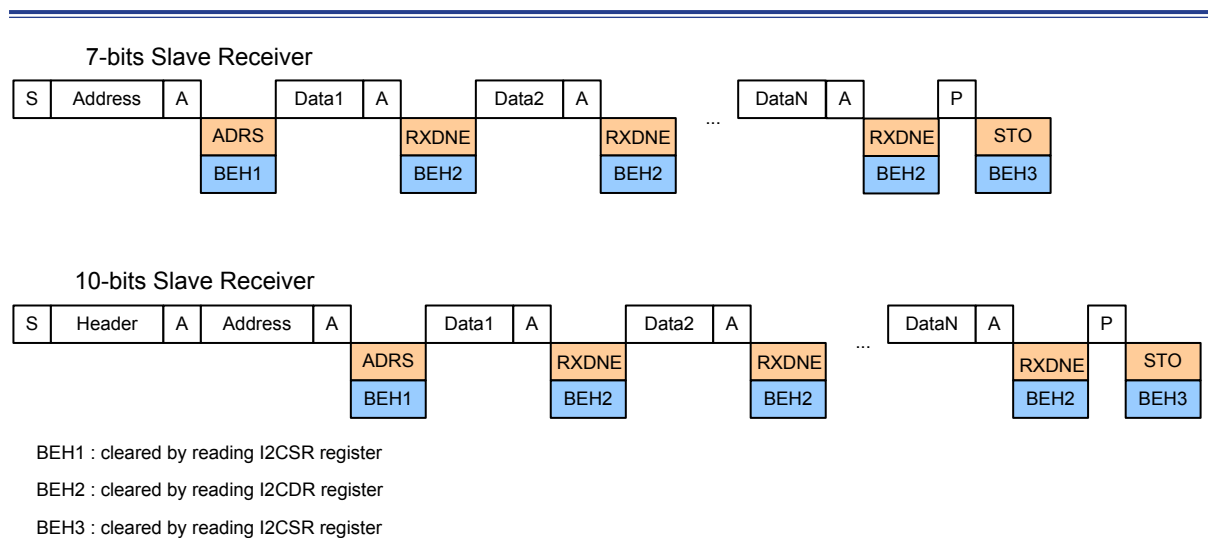
The ADRS bit in the I2CSR register is set after the slave device receives the calling address which matches with the slave device address. After the ADRS bit has been set to 1, it must be cleared to 0 to continue the data transfer process. The ADRS flag is cleared after reading the I2CSR register.

### Data Frame

In the slave receiver mode, the data is transmitted from the master device. Once a data byte is received by the slave device, the RXDNE flag in the I2CSR register is set but it will not hold the SCL line. However, if the device receives a complete new data byte and the RXDNE bit has been set to 1, the RXBF bit in the I2CSR register will be set to 1 and the SCL line will be held at a logic low state. When this situation occurs, data from the I2CDR register should be read to continue the data transfer process. The RXDNE flag bit can be cleared after reading the I2CDR register.

### STOP condition

When the slave device detects a STOP condition, the STO flag bit in the I2CSR register is set to indicate that the I<sup>2</sup>C interface transmission is terminated. Reading the I2CSR register can clear the STO flag bit.



**Figure 148. Slave Receiver Timing Diagram**

## Conditions of Holding SCL Line

The following conditions will cause the SCL line to be held at a logic low state by hardware resulting in all the I<sup>2</sup>C transfers being stopped. Data transfer will be continued after the creating conditions are eliminated.

**Table 46. Conditions of Holding SCL line**

| Type  | Condition                              | Description                                                                                                                                                                                                                       | Eliminated                                                                                                                 |
|-------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Flag  | TXDE                                   | I <sup>2</sup> C is used in transmitted mode and I2CDR register needs to have data to transmit.<br>(Note: TXDE won't be assert after receiving a NACK)                                                                            | Master case:<br>Writing data to I2CDR register<br>Set TAR<br>Set STOP<br><br>Slave case:<br>Writing data to I2CDR register |
|       | GCS                                    | I <sup>2</sup> C is addressed as slave through general call                                                                                                                                                                       | Reading I2CSR register                                                                                                     |
|       | ADRS                                   | Master:<br>I <sup>2</sup> C is sent over address frame and is returned an ACK from slave<br>(Note: Reference Fig.11 and Fig.12)<br>Slave:<br>I <sup>2</sup> C is addressed as slave device<br>(Note: Reference Fig.13 and Fig.14) | Reading I2CSR register                                                                                                     |
|       | STA                                    | Master send START signal                                                                                                                                                                                                          | Reading I2CSR register                                                                                                     |
|       | RXBF                                   | Received a complete new data and meanwhile the RXDNE flag has been set already before.                                                                                                                                            | Reading I2CDR register                                                                                                     |
| Event | Master receives NACK                   | No matter in address or data frame, once received a NACK signal will hold SCL line in master mode.                                                                                                                                | Set TAR<br>Set STOP                                                                                                        |
|       | Master send NACK used in received mode | Occurred when receiving the last data byte in Master received mode.<br>(Note: Reference Fig.11, and RXNACK flag won't be assert at this case)                                                                                     | Set TAR<br>Set STOP                                                                                                        |

## I<sup>2</sup>C Timeout Function

In order to reduce the occurrence of I<sup>2</sup>C lockup problem due to the reception of erroneous clock source, a timeout function is provided. If the I<sup>2</sup>C bus clock source is not received for a certain timeout period, then a corresponding I<sup>2</sup>C timeout flag will be asserted. This timeout period is determined by a 16-bit down-counting counter with a programmable preload value. The timeout counter is driven by the I<sup>2</sup>C timeout clock,  $f_{I2CTO}$ , which is specified by the timeout prescaler field in the I2CTOUT register. The TOUT field in the I2CTOUT register is used to define the timeout counter preload value. The timeout function is enabled by setting the ENTOUT bit in the I2CCR register. The timeout counter will start to count down from the preloaded value if the ENTOUT bit is set to 1 and one of the following conditions occurs:

- The I<sup>2</sup>C master module sends a START signal.
- The I<sup>2</sup>C slave module detects a START signal.
- The RXBF, TXDE, RXDNE, RXNACK, GCS or ADRS flags are asserted.

The timeout counter will stop counting when the ENTOUT bit is cleared. However, the counter will also stop counting when the conditions, listed as follows occur:

- The I<sup>2</sup>C slave module is not addressed.
- The I<sup>2</sup>C slave module detects a STOP signal.
- The I<sup>2</sup>C master module sends a STOP signal.
- The ARBLOS or BUSERR flags in the I2CSR register are asserted.

If the timeout counter underflows, the corresponding timeout flag, TOUTF, in the I2CSR register will be set to 1 and a timeout interrupt will be generated if the relevant interrupt is enabled.

## PDMA Interface

The PDMA interface is integrated in the I<sup>2</sup>C module. The PDMA function can be enabled by setting the TXDMAE or RxDMAE bit to 1 in the transmitter or receiver mode respectively. When the data register is empty in the transmitter mode and the TXDMAE bit is set to 1, the PDMA function will be activated to move data from a certain memory location into the I<sup>2</sup>C data register. Similarly, when the data register is not empty in the receiver mode and the RxDMAE bit is set to 1, the PDMA function will also be activated to move data from the I<sup>2</sup>C data register to a specific memory location.

The DMA NACK control bit, DMANACK, is used to determine whether the NACK signal is sent or not when the I<sup>2</sup>C module operates in the master receiver mode and the PDMA function is enabled. If the DMANACK bit is set to 1 and the data has all been received and moved using the PDMA interface, a NACK signal will automatically be sent out to properly terminate the data transfer.

For a more detailed description on the PDMA configurations, refer to the PDMA chapter.

## Register Map

The following table shows the I<sup>2</sup>C registers and reset values.

**Table 47. I<sup>2</sup>C Register Map**

| Register  | Offset | Description                                          | Reset Value |
|-----------|--------|------------------------------------------------------|-------------|
| I2CCR     | 0x000  | I <sup>2</sup> C Control Register                    | 0x0000_2000 |
| I2CIER    | 0x004  | I <sup>2</sup> C Interrupt Enable Register           | 0x0000_0000 |
| I2CADDR   | 0x008  | I <sup>2</sup> C Address Register                    | 0x0000_0000 |
| I2CSR     | 0x00C  | I <sup>2</sup> C Status Register                     | 0x0000_0000 |
| I2CSHPGR  | 0x010  | I <sup>2</sup> C SCL High Period Generation Register | 0x0000_0000 |
| I2CSLPGR  | 0x014  | I <sup>2</sup> C SCL Low Period Generation Register  | 0x0000_0000 |
| I2CDR     | 0x018  | I <sup>2</sup> C Data Register                       | 0x0000_0000 |
| I2CTAR    | 0x01C  | I <sup>2</sup> C Target Register                     | 0x0000_0000 |
| I2CADDRMR | 0x020  | I <sup>2</sup> C Address Mask Register               | 0x0000_0000 |
| I2CADDRSR | 0x024  | I <sup>2</sup> C Address Snoop Register              | 0x0000_0000 |
| I2CTOUT   | 0x028  | I <sup>2</sup> C Timeout Register                    | 0x0000_0000 |

## Register Descriptions

### I<sup>2</sup>C Control Register – I2CCR

This register specifies the corresponding I<sup>2</sup>C function enable control.

Offset: 0x000 (0)

Reset value: 0x0000\_2000

|            |           |              |        |          |         |        |        |      |
|------------|-----------|--------------|--------|----------|---------|--------|--------|------|
|            | 31        | 30           | 29     | 28       | 27      | 26     | 25     | 24   |
| Type/Reset | Reserved  |              |        |          |         |        |        |      |
|            | 23        | 22           | 21     | 20       | 19      | 18     | 17     | 16   |
| Type/Reset | Reserved  |              |        |          |         |        |        |      |
|            | 15        | 14           | 13     | 12       | 11      | 10     | 9      | 8    |
| Type/Reset | SEQFILTER | COMBFILTEREn | ENTOUT | Reserved | DMANACK | RXDMAE | TXDMAE |      |
|            | RW 0      | RW 0         | RW 0   | RW 0     | RW 0    | RW 0   | RW 0   | RW 0 |
|            | 7         | 6            | 5      | 4        | 3       | 2      | 1      | 0    |
| Type/Reset | ADRM      | Reserved     |        |          | I2CEN   | GCEN   | STOP   | AA   |
|            | RW 0      |              |        |          | RW 0    | RW 0   | RW 0   | RW 0 |

| Bits    | Field        | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [14:15] | SEQFILTER    | SDA or SCL Input Sequential Filter Configuration Bits<br>00: Sequential filter disable<br>01: 1 PCLK glitch filter<br>1x: 2 PCLK glitch filter<br>Note: This setting would affect the frequency of SCL. Detail is described in I2CSLPGR register.                                                                                                                                                                                                                                    |
| [13]    | COMBFILTEREn | SDA or SCL Input Combinational Filter Enable Bit<br>0: Combinational filter Disable<br>1: Combinational filter Enable                                                                                                                                                                                                                                                                                                                                                                |
| [12]    | ENTOUT       | I <sup>2</sup> C Timeout Function Enable Control<br>0: Timeout Function disabled<br>1: Timeout Function enabled<br>This bit is used to enable or disable the I <sup>2</sup> C timeout function. When the I2CEN bit is cleared to 0, the ENTOUT bit will be automatically cleared to 0 by hardware. It is recommended that users have to properly configure the PSC and TOUT fields in the I2CTOUT register before the timeout counter starts to count by setting the ENOUT bit to 1. |
| [10]    | DMANACK      | DMA Mode NACK Control<br>0: No operation<br>1: The I <sup>2</sup> C master receiver module sends a NACK signal automatically after receiving the last byte from the slave transmitter in the DMA mode<br>When the I2CEN bit is cleared to 0, the DMANACK bit is automatically cleared to 0 by hardware.                                                                                                                                                                              |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9]  | RXDMAE | <p>DMA Mode RX Request Enable Control</p> <p>0: RX DMA request disabled<br/>1: RX DMA request enabled</p> <p>If the data register is not empty in the receiver mode and the RXDMAE bit is set to 1, the relevant PDMA channel will be activated to move the data from the data register to a specific location which is defined in the corresponding PDMA register. When the I2CEN bit is cleared to 0, the RXDMAE bit is automatically cleared to 0 by hardware.</p> |
| [8]  | TXDMAE | <p>DMA Mode TX Request Enable Control</p> <p>0: TX DMA request disabled<br/>1: TX DMA request enabled</p> <p>If the data register is empty in the transmitter mode and the TXDMAE bit is set to 1, the relevant PDMA channel will be activated to move the data from a specific location defined in the related PDMA register to the data register. When the I2CEN bit is cleared to 0, the TXDMAE bit is automatically cleared to 0 by hardware.</p>                 |
| [7]  | ADRM   | <p>Addressing Mode</p> <p>0: 7-bit addressing mode<br/>1: 10-bit addressing mode</p> <p>When the I<sup>2</sup>C master/slave module operates in the 7-bit addressing mode, it can only send out and respond to a 7-bit address and vice versa. When the I2CEN bit is disabled, the ADRM bit is automatically cleared to 0 by hardware.</p>                                                                                                                            |
| [3]  | I2CEN  | <p>I<sup>2</sup>C Interface Enable</p> <p>0: I<sup>2</sup>C interface disabled<br/>1: I<sup>2</sup>C interface enabled</p>                                                                                                                                                                                                                                                                                                                                            |
| [2]  | GCEN   | <p>General Call Enable</p> <p>0: General call disabled<br/>1: General call enabled</p> <p>When the device receives the calling address with a value of 0x00 and if both the GCEN and the AA bits are set to 1, then the I<sup>2</sup>C interface is addressed as a slave and the GCS bit in the I2CSR register is set to 1. When the I2CEN bit is cleared to 0, the GCEN bit is automatically cleared to 0 by hardware.</p>                                           |
| [1]  | STOP   | <p>STOP Condition Control</p> <p>0: No action<br/>1: Send a STOP condition in master mode</p> <p>This bit is set to 1 by software to generate a STOP condition and automatically cleared to 0 by hardware. The STOP bit is only available for the master device.</p>                                                                                                                                                                                                  |
| [0]  | AA     | <p>Acknowledge Bit</p> <p>0: Send a Not Acknowledge (NACK) signal after a byte is received<br/>1: Send an Acknowledge (ACK) signal after a byte is received</p> <p>When the I2CEN bit is cleared to 0, the AA bit is automatically cleared to 0 by hardware.</p>                                                                                                                                                                                                      |

## I<sup>2</sup>C Interrupt Enable Register – I2CIER

This register specifies the corresponding I<sup>2</sup>C interrupt enable bits.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |    |    |    |        |          |          |          |
|------------|----------|----|----|----|--------|----------|----------|----------|
|            | 31       | 30 | 29 | 28 | 27     | 26       | 25       | 24       |
| Type/Reset | Reserved |    |    |    |        |          |          |          |
|            | 23       | 22 | 21 | 20 | 19     | 18       | 17       | 16       |
| Type/Reset | Reserved |    |    |    |        | RXBFIE   | TXDEIE   | RXDNEIE  |
|            |          |    |    |    |        | RW       | 0        | RW       |
|            |          |    |    |    |        | 0        | RW       | 0        |
|            | 15       | 14 | 13 | 12 | 11     | 10       | 9        | 8        |
| Type/Reset | Reserved |    |    |    | TOUTIE | BUSERRIE | RXNACKIE | ARBLOSIE |
|            |          |    |    |    | RW     | 0        | RW       | 0        |
|            |          |    |    |    | 0      | RW       | 0        | RW       |
|            | 7        | 6  | 5  | 4  | 3      | 2        | 1        | 0        |
| Type/Reset | Reserved |    |    |    | GCSIE  | ADRSIE   | STOIE    | STAIE    |
|            |          |    |    |    | RW     | 0        | RW       | 0        |
|            |          |    |    |    | 0      | RW       | 0        | RW       |

| Bits | Field    | Descriptions                                                                                                                                                                                                      |
|------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18] | RXBFIE   | RX Buffer Full Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                           |
| [17] | TXDEIE   | Data Register Empty Interrupt Enable Bit in Transmitter Mode<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.  |
| [16] | RXDNEIE  | Data Register Not Empty Interrupt Enable Bit in Received Mode<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware. |
| [11] | TOUTIE   | Timeout Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                                  |
| [10] | BUSERRIE | Bus Error Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                                |
| [9]  | RXNACKIE | Received Not Acknowledge Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                 |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                 |
|------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | ARBLOSIE | Arbitration Loss Interrupt Enable Bit in the I <sup>2</sup> C multi-master mode<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                          |
| [3]  | GCSIE    | General Call Slave Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                                                                  |
| [2]  | ADRSIE   | Slave Address Match Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware.                                                                 |
| [1]  | STOIE    | STOP Condition Detected Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware. The bit is used for the I <sup>2</sup> C slave mode only.   |
| [0]  | STAIE    | START Condition Transmit Interrupt Enable Bit<br>0: Interrupt disabled<br>1: Interrupt enabled<br>When the I2CEN bit in the I2CCR register is cleared to 0, this bit is cleared to 0 by hardware. The bit is used for the I <sup>2</sup> C master mode only. |

## I<sup>2</sup>C Address Register – I2CADDR

This register specifies the I<sup>2</sup>C device address.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | Reserved |    |    |    |    |    | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | ADDR     |    |    |    |    |    |    |    | 0  |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                               |
|-------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9:0] | ADDR  | <p>Device Address</p> <p>The register indicates the I<sup>2</sup>C device address. When the I<sup>2</sup>C device is used in the 7-bit addressing mode, only the ADDR[6:0] bits will be compared with the received address sent from the I<sup>2</sup>C master device.</p> |

## I<sup>2</sup>C Status Register – I2CSR

This register contains the I<sup>2</sup>C operation status.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |       |        |         |        |        |        |   |
|------------|----------|----|-------|--------|---------|--------|--------|--------|---|
|            | 31       | 30 | 29    | 28     | 27      | 26     | 25     | 24     |   |
| Type/Reset | Reserved |    |       |        |         |        |        |        |   |
|            | 23       | 22 | 21    | 20     | 19      | 18     | 17     | 16     |   |
| Type/Reset | Reserved |    | TXNRX | MASTER | BUSBUSY | RXBF   | TXDE   | RXDNE  |   |
|            |          |    | RO    | 0 RO   | 0 RO    | 0 RO   | 0 RO   | 0 RO   | 0 |
|            | 15       | 14 | 13    | 12     | 11      | 10     | 9      | 8      |   |
| Type/Reset | Reserved |    |       |        | TOUTF   | BUSERR | RXNACK | ARBLOS |   |
|            |          |    |       |        | WC      | 0 WC   | 0 WC   | 0 WC   | 0 |
|            | 7        | 6  | 5     | 4      | 3       | 2      | 1      | 0      |   |
| Type/Reset | Reserved |    |       |        | GCS     | ADRS   | STO    | STA    |   |
|            |          |    |       |        | RC      | 0 RC   | 0 RC   | 0 RC   | 0 |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [21] | TXNRX   | Transmitter / Receiver Mode<br>0: Receiver mode<br>1: Transmitter mode<br>Read only bit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| [20] | MASTER  | Master Mode<br>0: I <sup>2</sup> C is in the slave mode or idle<br>1: I <sup>2</sup> C is in the master mode<br>The I <sup>2</sup> C interface is switched as a master device on the I <sup>2</sup> C bus when the I2CTAR register is assigned and the I <sup>2</sup> C bus is idle. The MASTER bit is cleared by hardware when software disables the I <sup>2</sup> C bus by clearing the I2CEN bit to 0 or sends a STOP condition to the I <sup>2</sup> C bus or the bus error is detected. This bit is set and cleared by hardware and is a read only bit. |
| [19] | BUSBUSY | Bus Busy<br>0: I <sup>2</sup> C bus is idle<br>1: I <sup>2</sup> C bus is busy<br>The I <sup>2</sup> C interface hardware starts to detect the I <sup>2</sup> C bus status if the interface is enabled by setting the I2CEN bit to 1. It is set to 1 when the SDA or SCL signal is detected to have a logic low state and cleared when a STOP condition is detected.                                                                                                                                                                                          |
| [18] | RXBF    | Buffer Full Flag in Receiver Mode<br>0: Data buffer is not full<br>1: Data buffer is full<br>This bit is set when the data register I2CDR has already stored a data byte and meanwhile the data shift register also has been received a complete new data byte. The RXBF bit is cleared by software reading the I2CDR register.                                                                                                                                                                                                                               |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [17] | TXDE   | <p>Data Register Empty Using in Transmitter Mode</p> <p>0: Data register I2CDR not empty<br/>1: Data register I2CDR empty</p> <p>This bit is set when the I2CDR register is empty in the Transmitter mode. Note that the TXDE bit will be set after the address frame is being transmitted to inform that the data to be transmitted should be loaded into the I2CDR register. The TXDE bit is cleared by software writing data to the I2CDR register in both the master and slave mode or cleared automatically by hardware after setting the STOP signal to terminate the data transfer or setting the I2CTAR register to restart a new data transfer in the master mode.</p>                                             |
| [16] | RXDNE  | <p>Data Register Not Empty in Receiver Mode</p> <p>0: Data register I2CDR empty<br/>1: Data register I2CDR not empty</p> <p>This bit is set when the I2CDR register is not empty in the receiver mode. The RXDNE bit is cleared by software reading the data byte from the I2CDR register.</p>                                                                                                                                                                                                                                                                                                                                                                                                                              |
| [11] | TOUTF  | <p>Timeout Counter Underflow Flag</p> <p>0: No timeout counter underflow occurred<br/>1: Timeout counter underflow occurred</p> <p>Writing "1" to this bit will clear the TOUTF flag.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| [10] | BUSERR | <p>Bus Error Flag</p> <p>0: No bus error has occurs<br/>1: Bus error has occurred</p> <p>This bit is set by hardware when the I<sup>2</sup>C interface detects a misplaced START or STOP condition in a transfer process. Writing a "1" to this bit will clear the BUSERR flag.</p> <p>In Master Mode: Once the Bus Error event occurs, both the SDA and SCL lines are released by hardware and the BUSERR flag is asserted. The application software has to clear the BUSERR flag before the next address byte is transmitted.</p> <p>In Slave Mode: Once a misplaced START or STOP condition has been detected by the slave device, the software must clear the BUSERR flag before the next address byte is received.</p> |
| [9]  | RXNACK | <p>Received Not Acknowledge Flag</p> <p>0: Acknowledge is returned from receiver<br/>1: Not Acknowledge is returned from receiver</p> <p>The RXNACK bit indicates that the not Acknowledge signal is received in master or slave transmitter mode. Writing "1" to this bit will clear the RXNACK flag.</p>                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [8]  | ARBLOS | <p>Arbitration Loss Flag</p> <p>0: No arbitration loss is detected<br/>1: Bit arbitration loss is detected</p> <p>This bit is set by hardware on the current clock which the I<sup>2</sup>C interface loses the bus arbitration to another master during the address or data frame transmission. Writing "1" to this bit will clear the ARBLOS flag. Once the ARBLOS flag is asserted by hardware, the ARBLOS flag must be cleared before the next transmission.</p>                                                                                                                                                                                                                                                        |
| [3]  | GCS    | <p>General Call Slave Flag</p> <p>0: No general call slave occurs<br/>1: I<sup>2</sup>C interface is addressed by a general call command</p> <p>When the I<sup>2</sup>C interface receives an address with a value of 0x00 or 0x000 in the 7-bit or 10-bit addressing mode, if both the GCEN and the AA bit are set to 1, then it is switched as a general call slave. This flag is cleared automatically after being read.</p>                                                                                                                                                                                                                                                                                             |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | ADRS  | <p>Address Transmit (master mode) / Address Receive (slave mode) Flag</p> <p>Address Sent in Master Mode</p> <p>0: Address frame has not been transmitted<br/>1: Address frame has been transmitted</p> <p>For the 7-bit addressing mode, this bit is set after the master device receives the address frame acknowledge bit sent from the slave device. For the 10-bit addressing mode, this bit is set after receiving the acknowledge bit of the first header byte and the second address.</p> <p>Address Matched in Slave Mode</p> <p>0: I<sup>2</sup>C interface is not addressed<br/>1: I<sup>2</sup>C interface is addressed as slave</p> <p>When the I<sup>2</sup>C interface has received the calling address that matches the address defined in the I2CADDR register together with the AA bit being set to 1 in the I2CCR register, it will be switched to a slave mode. This flag is cleared automatically after the I2CSR register has been read.</p> |
| [1]  | STO   | <p>STOP Condition Detected Flag</p> <p>0: No STOP condition detected<br/>1: STOP condition detected in slave mode</p> <p>This bit is only available for the slave mode and is cleared automatically after the I2CSR register is read.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| [0]  | STA   | <p>START Condition Transmit</p> <p>0: No START condition detected<br/>1: START condition is transmitted in master mode</p> <p>This bit is only available for the master mode and is cleared automatically after the I2CSR register is read.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

## I<sup>2</sup>C SCL High Period Generation Register – I2CSHPGR

This register specifies the I<sup>2</sup>C SCL clock high period interval.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | SHPG     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | SHPG     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | SHPG  | <p>SCL Clock High Period Generation</p> <p>High period duration setting <math>SCL_{HIGH} = T_{PCLK} \times (SHPG + d)</math></p> <p>where <math>T_{PCLK}</math> is the APB bus peripheral clock (PCLK) period, and d value depends on the setting of the SEQFILTER field in the I<sup>2</sup>C Control Register (I2CCR).</p> <p>If SEQFILTER=00, d=6</p> <p>If SEQFILTER=01, d=8</p> <p>If SEQFILTER=10 or 11, d=9</p> |

## I<sup>2</sup>C SCL Low Period Generation Register – I2CSLPGR

This register specifies the I<sup>2</sup>C SCL clock low period interval.

Offset: 0x014

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | SLPG     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | SLPG     |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | SLPG  | <p>SCL Clock Low Period Generation</p> <p>Low period duration setting <math>SCL_{LOW} = T_{PCLK} \times (SLPG + d)</math></p> <p>where <math>T_{PCLK}</math> is the APB bus peripheral clock (PCLK) period, and d value depends on the setting of the SEQFILTER field in the I<sup>2</sup>C Control Register (I2CCR).</p> <p>If SEQFILTER=00, d=6</p> <p>If SEQFILTER=01, d=8</p> <p>If SEQFILTER=10 or 11, d=9</p> |

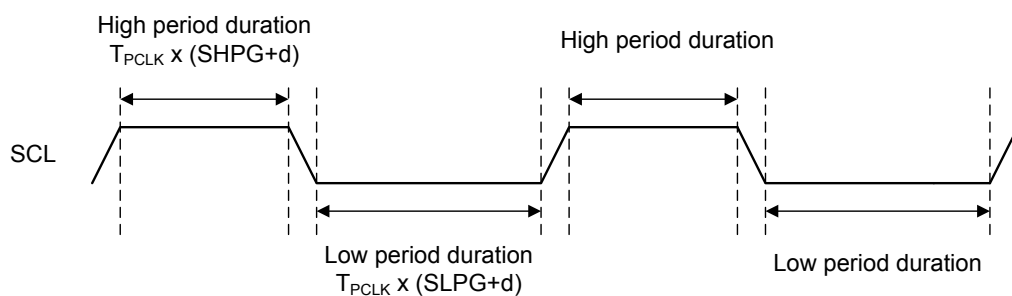


Figure 149. SCL Timing Diagram

Table 48. I<sup>2</sup>C Clock Setting Example

| I <sup>2</sup> C Clock  | $T_{SCL} = T_{PCLK} \times [ (SHPG + d) + (SLPG + d) ]$ (where d = 6)<br>SHPG + SLPG value at PCLK |       |       |       |
|-------------------------|----------------------------------------------------------------------------------------------------|-------|-------|-------|
|                         | 8MHz                                                                                               | 24MHz | 48MHz | 72MHz |
| 100 kHz (Standard Mode) | 68                                                                                                 | 228   | 468   | 708   |
| 400 kHz (Fast Mode)     | 8                                                                                                  | 48    | 108   | 168   |
| 1 MHz (Fast-Mode Plus)  | x                                                                                                  | 12    | 36    | 60    |

## I<sup>2</sup>C Data Register – I2CDR

This register specifies the data to be transmitted or received by the I<sup>2</sup>C module.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | DATA     |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7:0] | DATA  | <p>I<sup>2</sup>C Data Register</p> <p>For the transmitter mode, a data byte which is transmitted to a slave device can be assigned to these bits. The TXDE flag is cleared if the application software assigns new data to the I2CDR register. For the receiver mode, a data byte is received bit by bit from MSB to LSB through the I<sup>2</sup>C interface and stored in the data shift register. Once the acknowledge bit is given, the data shift register value is delivered into the I2CDR register if the RXDNE flag is equal to 0.</p> |

## I<sup>2</sup>C Target Register – I2CTAR

This register specifies the target device address to be communicated.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |     |    |     |    |
|------------|----------|----|----|----|----|-----|----|-----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26  | 25 | 24  |    |
| Type/Reset | Reserved |    |    |    |    |     |    |     |    |
|            | 23       | 22 | 21 | 20 | 19 | 18  | 17 | 16  |    |
| Type/Reset | Reserved |    |    |    |    |     |    |     |    |
|            | 15       | 14 | 13 | 12 | 11 | 10  | 9  | 8   |    |
| Type/Reset | Reserved |    |    |    |    | RWD |    | TAR |    |
|            | 7        | 6  | 5  | 4  | 3  | 2   | 1  | 0   |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0   | RW | 0   | RW |
|            | TAR      |    |    |    |    |     |    |     | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10]  | RWD   | Read or Write Direction<br>0: Write direction to target slave address<br>1: Read direction from target slave address<br>If this bit is set to 1 in the 10-bit master receiver mode, the I <sup>2</sup> C interface will initiate a byte with a value of 11110XX0b in the first header frame and then continue to deliver a byte with a value of 11110XX1b in the second header frame by hardware automatically.                                                       |
| [9:0] | TAR   | Target Slave Address<br>The I <sup>2</sup> C interface will assign a START signal and send a target slave address automatically once the data is written to this register. When the system wants to send a repeated START signal to the I <sup>2</sup> C bus, the timing is suggested to set the I2CTAR register after a byte transfer is completed. It is not allowed to set TAR in the address frame. I2CTAR[9:7] is not available under the 7-bit addressing mode. |

## I<sup>2</sup>C Address Mask Register – I2CADDRMR

This register specifies which bit of the I<sup>2</sup>C address is masked and not compared with corresponding bit of the received address frame.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |        |    |
|------------|----------|----|----|----|----|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |    |    |        |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    |    |    |        |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |    |    | ADDRMR |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1      | 0  |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW     | 0  |

| Bits  | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9:0] | ADDRMR | <p>Address Mask Control Bit</p> <p>The ADDRMR[i] is used to specify whether the i<sup>th</sup> bit of the ADDR in the I2CADDR register is masked and is compared with the received address frame or not on the I<sup>2</sup>C bus. The register is only used for the I<sup>2</sup>C slave mode only.</p> <p>0: i<sup>th</sup> bit of the ADDR is compared with the address frame on the I<sup>2</sup>C bus.</p> <p>1: i<sup>th</sup> bit of the ADDR is masked and not compared with the address frame on the I<sup>2</sup>C bus.</p> |

## I<sup>2</sup>C Address Snoop Register – I2CADDRSR

This register is used to indicate the address frame value appeared on the I<sup>2</sup>C bus.

Offset: 0x024

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |        |    |
|------------|----------|----|----|----|----|----|--------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25     | 24 |
| Type/Reset | Reserved |    |    |    |    |    |        |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17     | 16 |
| Type/Reset | Reserved |    |    |    |    |    |        |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9      | 8  |
| Type/Reset | Reserved |    |    |    |    |    | ADDRSR |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1      | 0  |
| Type/Reset | ADDRSR   |    |    |    |    |    |        |    |
|            | RO       | 0  | RO | 0  | RO | 0  | RO     | 0  |
| Type/Reset | RO       | 0  | RO | 0  | RO | 0  | RO     | 0  |

| Bits  | Field  | Descriptions                                                                                                                                              |
|-------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9:0] | ADDRSR | Address Snoop<br>Once the I2CEN bit is enabled, the calling address value on the I <sup>2</sup> C bus will automatically be loaded into this ADDSR field. |

## I<sup>2</sup>C Timeout Register – I2CTOUT

This register specifies the I<sup>2</sup>C Timeout counter preload value and clock prescaler ratio.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |     |    |    |  |
|------------|----------|----|----|----|----|-----|----|----|--|
|            | 31       | 30 | 29 | 28 | 27 | 26  | 25 | 24 |  |
| Type/Reset | Reserved |    |    |    |    |     |    |    |  |
|            | 23       | 22 | 21 | 20 | 19 | 18  | 17 | 16 |  |
| Type/Reset | Reserved |    |    |    |    | PSC |    |    |  |
|            | 15       | 14 | 13 | 12 | 11 | 10  | 9  | 8  |  |
| Type/Reset | TOUT     |    |    |    |    |     |    |    |  |
|            | 7        | 6  | 5  | 4  | 3  | 2   | 1  | 0  |  |
| Type/Reset | TOUT     |    |    |    |    |     |    |    |  |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18:16] | PSC   | <p>I<sup>2</sup>C Time-out Counter Prescaler Selection</p> <p>This PSC field is used to specify the I<sup>2</sup>C time-out counter clock frequency, <math>f_{I2CTO}</math>. The time-out clock frequency is obtained using the formula.</p> $f_{I2CTO} = \frac{f_{PCLK}}{2^{PSC}}$ <p>PSC=0 → <math>f_{I2CTO} = f_{PCLK} / 2^0 = f_{PCLK}</math><br/> PSC=1 → <math>f_{I2CTO} = f_{PCLK} / 2^1 = f_{PCLK} / 2</math><br/> PSC=2 → <math>f_{I2CTO} = f_{PCLK} / 2^2 = f_{PCLK} / 4</math><br/> ...<br/> PSC=7 → <math>f_{I2CTO} = f_{PCLK} / 2^7 = f_{PCLK} / 128</math></p>                                                                                                                                                                                                                                                                                             |
| [15:0]  | TOUT  | <p>I<sup>2</sup>C Timeout Counter Preload Value</p> <p>The TOUT field is used to define the counter preloaded value</p> <p>The counter value is reloaded as the following conditions occur:</p> <ol style="list-style-type: none"> <li>1. The RXBF, TXDE, RXDNE, RXNACK, GCS or ADRS flag in the I2CSR register is asserted.</li> <li>2. The I<sup>2</sup>C master module sends a START signal.</li> <li>3. The I<sup>2</sup>C slave module detects a START signal.</li> </ol> <p>The counter stops counting as the following conditions occur:</p> <ol style="list-style-type: none"> <li>1. The I<sup>2</sup>C slave device is not addressed.</li> <li>2. The I<sup>2</sup>C master module sends a STOP signal.</li> <li>3. The I<sup>2</sup>C slave module detects a STOP signal.</li> <li>4. The ARBLOS or BUSERR flag in the I2CSR register is asserted.</li> </ol> |

# 21 Serial Peripheral Interface (SPI)

## Introduction

The Serial Peripheral Interface, SPI, provides an SPI protocol data transmit and receive functions in both master or slave mode. The SPI interface uses 4 pins, among which are serial data input and output lines MISO and MOSI, the clock line SCK, and the slave select line SEL. One SPI device acts as a master who controls the data flow using the SEL and SCK signals to indicate the start of the data communication and the data sampling rate. To receive the data bits, the streamlined data bits which range from 1 bit to 16 bits specified by the DFL field in the SPIInCR1 register are latched in a specific clock edge and stored in the data register or in the Rx FIFO. Data transmission is carried in a similar way but with the reverse sequence. The mode fault detection provides a capability for multi-master applications.

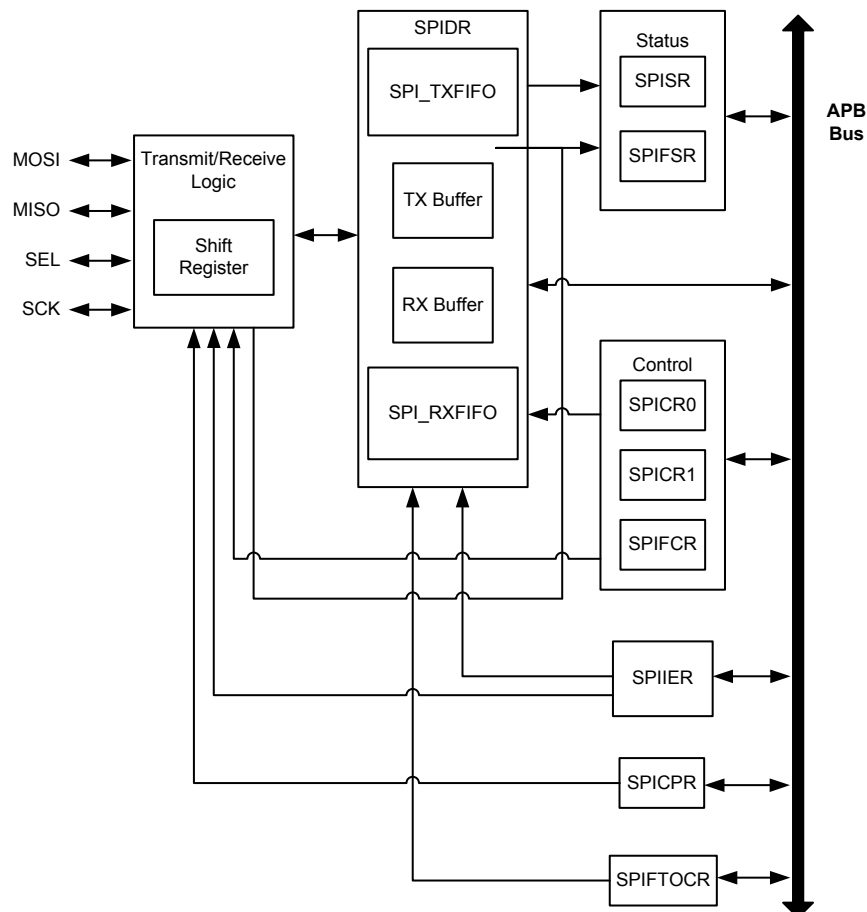


Figure 150. SPI Block Diagram

## Features

- Master or slave mode
- Master mode speed up to  $f_{\text{CLK}}/2$
- Slave mode speed up to  $f_{\text{CLK}}/3$
- Programmable data frame length up to 16 bits
- FIFO Depth: 8 levels
- MSB or LSB first shift selection
- Programmable slave select high or low active polarity
- Multi-master and multi-slave operation
- Master mode supports the dual output read mode of SPI series NOR Flash
- Four error flags with individual interrupt
  - Read overrun
  - Write collision
  - Mode fault
  - Slave abort
- Support PDMA interface

## Function Descriptions

### Master Mode

Each data frame can range from 1 to 16 bits in data length. The first bit of the transmitted data can be either an MSB or LSB determined by the FIRSTBIT bit in the SPICR1 register. The SPI module is configured as a master or a slave by setting the MODE bit in the SPICR1 register. When the MODE bit is set, the SPI module is configured as a master and will generate the serial clock on the SCK pin. The data stream will transmit data in the shift register to the MOSI pin on the serial clock edge. The SEL pin is active during the full data transmission. When the SELAP bit in the SPICR1 register is set, the SEL pin is active high during the complete data transactions. When the SELM bit in the SPICR1 register is set, the SEL pin will be driven by the hardware automatically and the time interval between the active SEL edge and the first edge of SCK is equal to half an SCK period.

### Slave Mode

In the slave mode, the SCK pin acts as an input pin and the serial clock will be derived from the external master device. The SEL pin also acts as an input. When the SELAP bit is cleared to 0, the SEL signal is active low during the full data stream reception. When the SELAP bit is set to 1, the SEL signal will be active high during the full data stream byte reception.

Note: For the slave mode, the APB clock, known as  $f_{\text{CLK}}$ , must be at least 3 times faster than the external SCK clock input frequency.

## SPI Serial Frame Format

The SPI interface format is base on the Clock Polarity, CPOL, and the Clock Phase, CPHA, configurations.

### ■ Clock Polarity Bit – CPOL

When the Clock Polarity bit is cleared to 0, the SCK line idle state is LOW. When the Clock Polarity bit is set to 1, the SCK line idle state is HIGH.

### ■ Clock Phase Bit – CPHA

When the Clock Phase bit is cleared to 0, the data is sampled on the first SCK clock transition. When the Clock Phase bit is set to 1, the data is sampled on the second SCK clock transition.

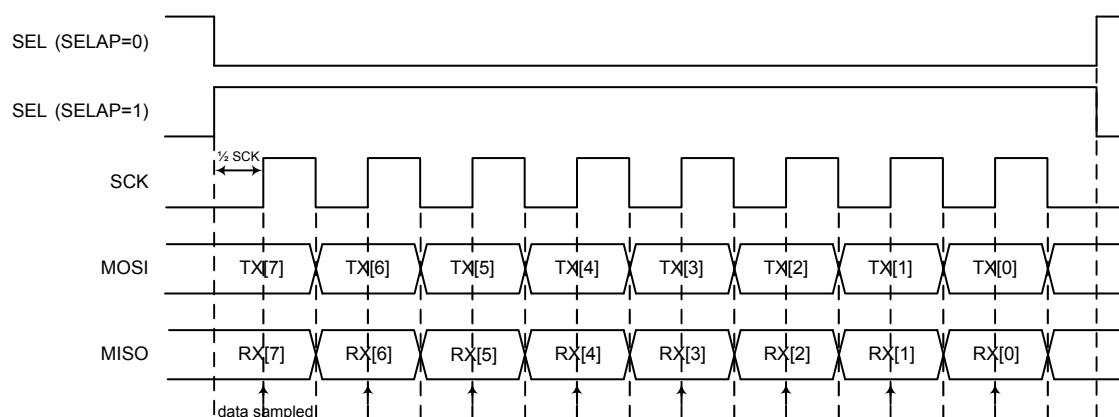
There are four formats contained in the SPI interface. Table 1 shows how to configure these formats by setting the FORMAT field in the SPICR1 register.

**Table 49. SPI Interface Format Setup**

| FORMAT [2:0] | CPOL     | CPHA |
|--------------|----------|------|
| 001          | 0        | 0    |
| 010          | 0        | 1    |
| 110          | 1        | 0    |
| 101          | 1        | 1    |
| Others       | Reserved |      |

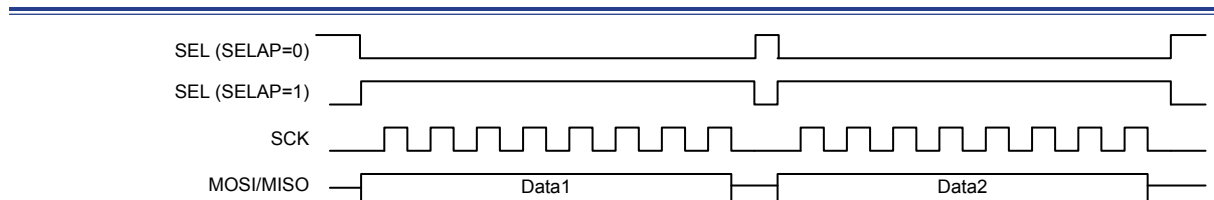
### CPOL = 0, CPHA = 0

In this format, the received data is sampled on the SCK line rising edge while the transmitted data is changed on the SCK line falling edge. In the master mode, the first bit is driven when data is written into the SPIDR Register. In the slave mode, the first bit is driven when the SEL signal goes to an active level. Figure 151 shows the single byte data transfer timing of this format.



**Figure 151. SPI Single Byte Transfer Timing Diagram – CPOL = 0, CPHA = 0**

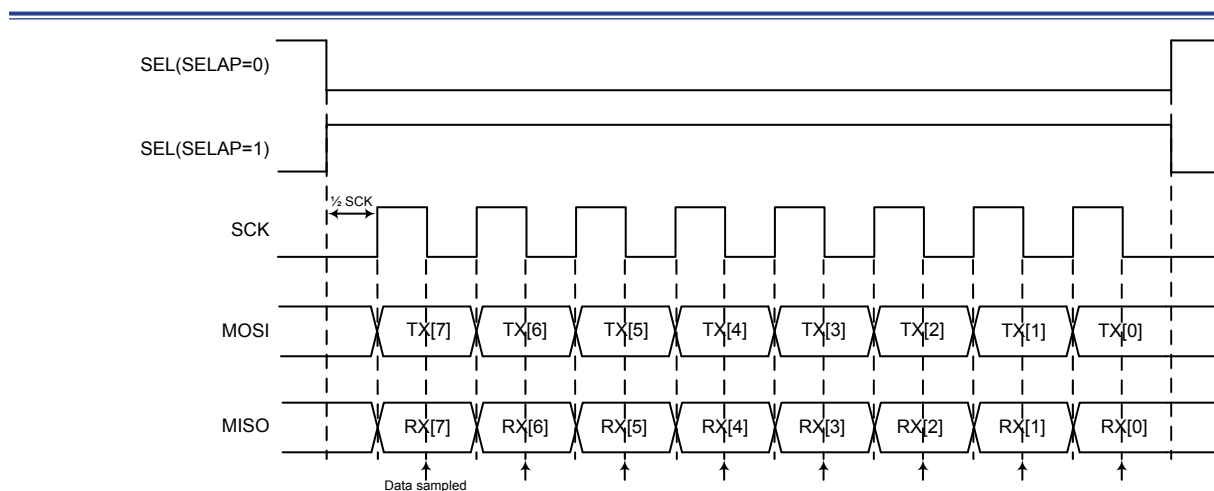
Figure 152 shows the continuous data transfer timing diagram of this format. Note that the SEL signal must change to an inactive level between each data frame.



**Figure 152. SPI Continuous Data Transfer Timing Diagram – CPOL = 0, CPHA = 0**

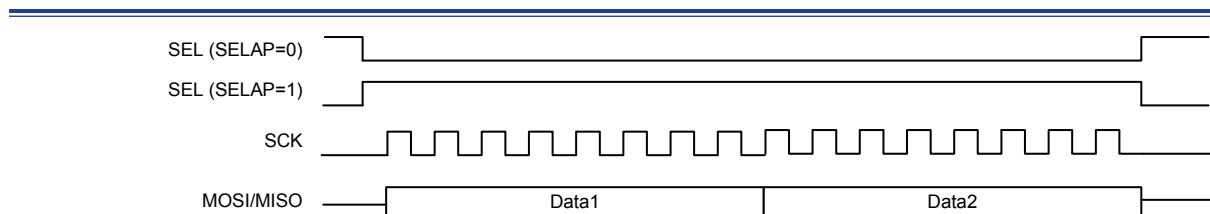
#### CPOL = 0, CPHA = 1

In this format, the received data is sampled on the SCK line falling edge while the transmitted data is changed on the SCK line rising edge. In the master mode, the first bit is driven when data is written into the SPIDR register. In the slave mode, the first bit is driven at the first SCK clock rising edge. Figure 153 shows the single data byte transfer timing.



**Figure 153. SPI Single Byte Transfer Timing Diagram – CPOL = 0, CPHA = 1**

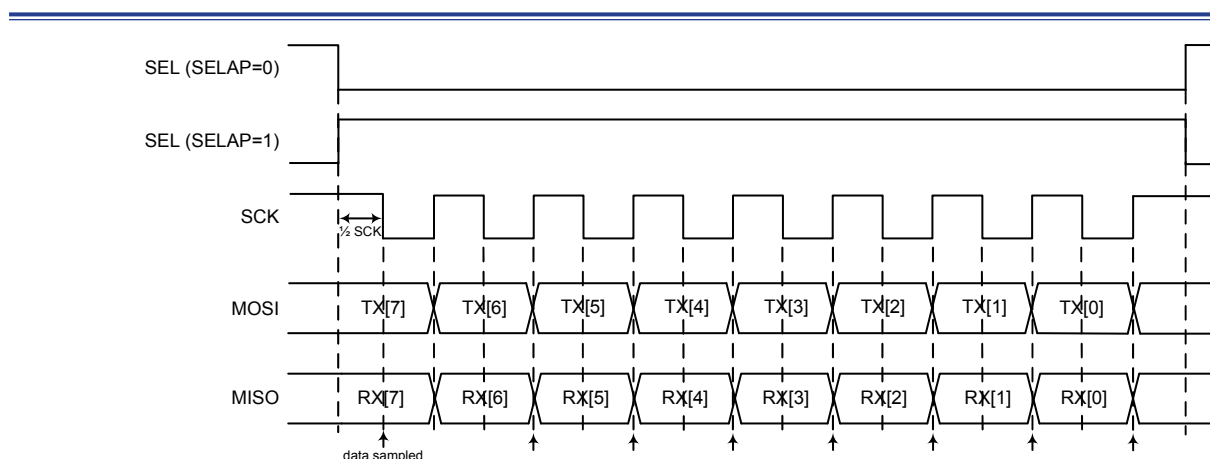
Figure 154 shows the continuous data transfer diagram timing. Note that the SEL signal must remain active until the last data transfer has completed.



**Figure 154. SPI Continuous Transfer Timing Diagram – CPOL = 0, CPHA = 1**

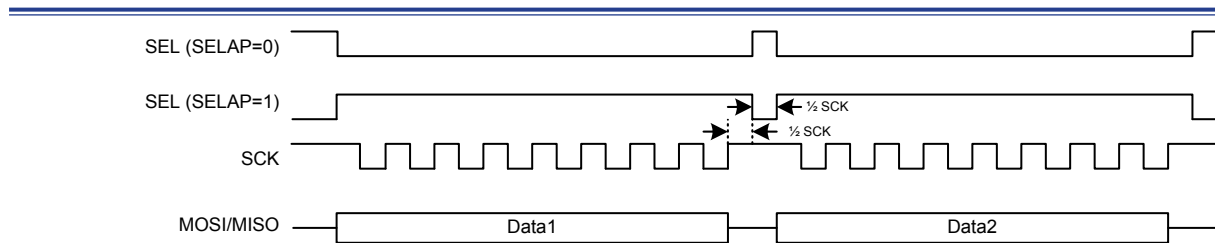
#### CPOL = 1, CPHA = 0

In this format, the received data is sampled on the SCK line falling edge while the transmitted data is changed on the SCK line rising edge. In the master mode, the first bit is driven when data is written into the SPIDR register. In the slave mode, the first bit is driven when the SEL signal changes to an active level. Figure 155 shows the single byte transfer timing of this format.



**Figure 155. SPI Single Byte Transfer Timing Diagram – CPOL = 1, CPHA = 0**

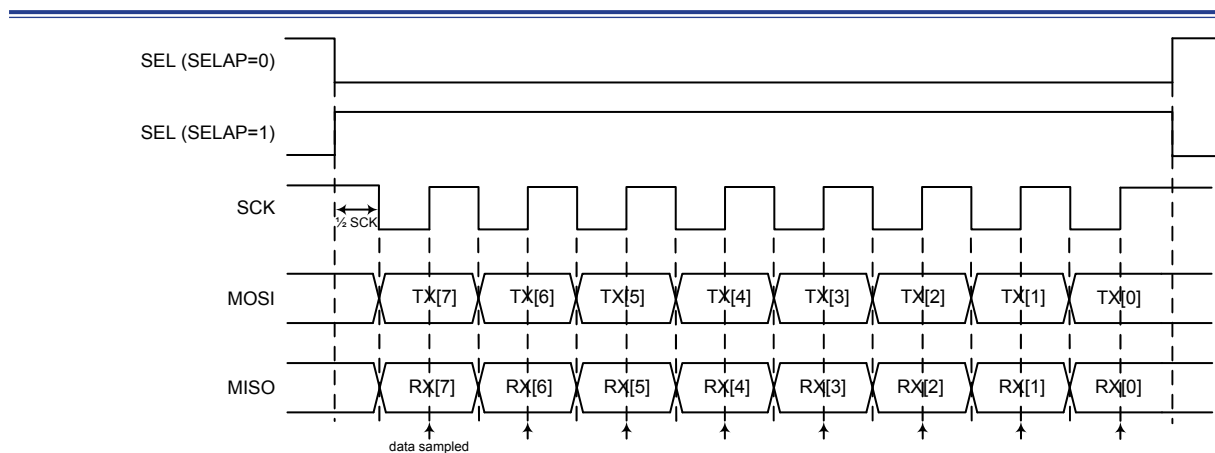
Figure 156 shows the continuous data transfer timing of this format. Note that the SEL signal must change to an inactive level between each data frame.



**Figure 156. SPI Continuous Transfer Timing Diagram – CPOL = 1, CPHA = 0**

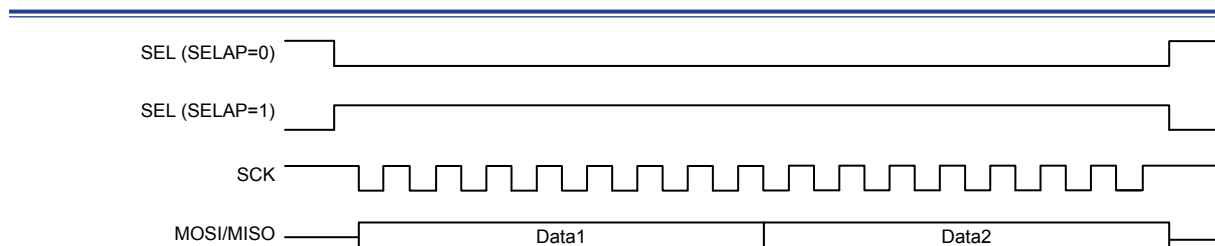
### CPOL = 1, CPHA = 1

In this format, the received data is sampled on the SCK line rising edge while the transmitted data is changed on the SCK line falling edge. In the master mode, the first bit is driven when data is written into the SPIDR register. In the slave mode, the first bit is driven at the first SCK falling edge. Figure 157 shows the single byte transfer timing of this format.



**Figure 157. SPI Single Byte Transfer Timing Diagram – CPOL = 1, CPHA = 1**

Figure 158 shows the continuous data transfer timing of this format. Note that the SEL signal must remain active until the last data transfer has completed.



**Figure 158. SPI Continuous Transfer Timing Diagram – CPOL = 1, CPHA = 1**

## Status Flags

### Tx Buffer Empty – TXBE

This TXBE flag is set when the TX buffer is empty in the non-FIFO mode or when the TX FIFO data length is equal to or less than the TX FIFO threshold level as defined by the TXFTLS field in the SPIFCR register in the FIFO mode. The following data to be transmitted can then be loaded into the buffer again. After this, the TXBE flag will be reset when the TX buffer already contains new data in the non-FIFO mode or the TX FIFO data length is greater than the TX FIFO threshold level determined by the TXFTLS bits in FIFO mode.

### Transmission Register Empty – TXE

This TXE flag is set when both the TX buffer and the TX shift registers are empty. It will be reset when the TX buffer or the TX shift register contains new transmitted data.

### Rx Buffer Not Empty – RXBNE

This RXBNE flag is set when there is valid received data in the RX Buffer in the non-FIFO mode or the RX FIFO data length is equal to or greater than the RX FIFO threshold level as defined by the RXFTLS field in the SPIFCR register in the SPI FIFO mode. This flag will be automatically cleared by hardware when the received data have been read out from the RX buffer totally in the non-FIFO mode or when the RX FIFO data length is less than the RX FIFO threshold level set in the RXFTLS field.

### Time Out Flag – TO

The time out function is only available in the SPI FIFO mode and is disabled by loading a zero value into the TOC field in the Time Out Counter register. The time out counter will start counting if the SPI RX FIFO is not empty, once data is read from the SPIDR register or new data is received, the time out counter will be reset to 0 and count again. When the time out counter value is equal to the value specified by the TOC field in the SPIFTOCR register, the TO flag will be set. The flag is cleared by writing 1 to this bit.

### Mode Fault – MF

The mode fault flag can be used to detect SPI bus usage in the SPI multi-master mode. For the multi-master mode, the SPI module is configured as a master device and the SEL signal is setup as an input signal. The mode fault flag is set when the SPI SEL pin is suddenly changed to an active level by another SPI master. This means that another SPI master is requesting to use the SPI bus. Therefore, when an SPI mode fault occurs, it will force the SPI module to operate in the slave mode and also disable all of the SPI interface signals to avoid SPI bus signal collisions. For the same reason, if the SPI master wants to transfer data, it also needs to inform other SPI masters by driving its SEL signal to an active state. The detailed configuration diagram for the SPI multi-master mode is shown in the following figure.

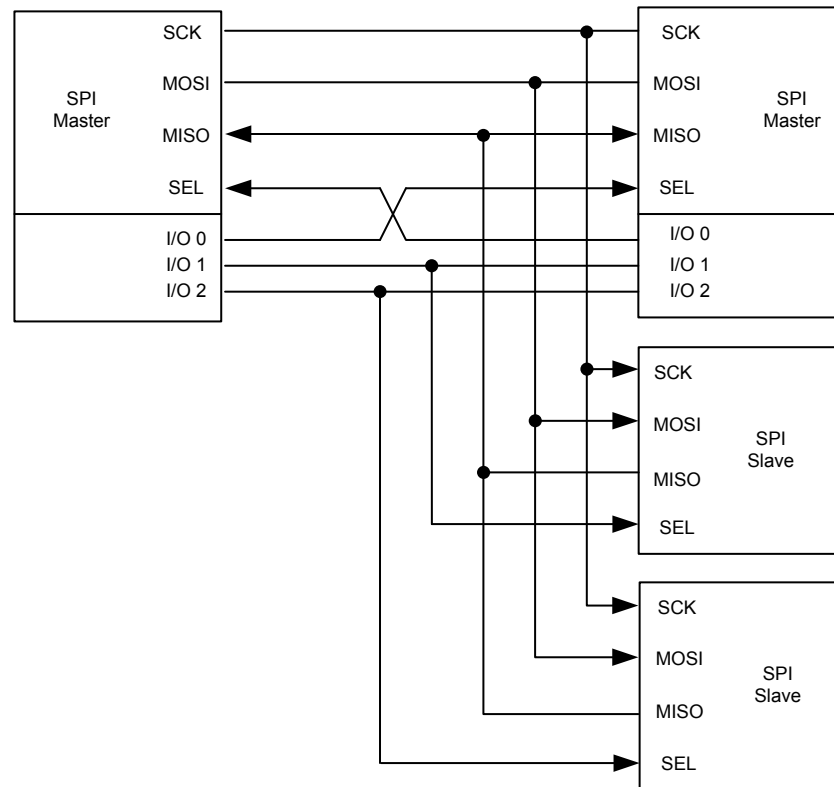


Figure 159. SPI Multi-Master Slave Environment

Table 50. SPI Mode Fault Trigger Conditions

| Mode fault        | Descriptions                                                                                                                                                                                                                                                                                                             |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trigger condition | <ol style="list-style-type: none"> <li>1. SPI Master mode</li> <li>2. SELOEN = 0 in the SPICR0 register – SEL pin is configured to be the input mode</li> <li>3. SEL signal changes to an active level when driven by the external SPI master</li> </ol>                                                                 |
| SPI behavior      | <ol style="list-style-type: none"> <li>1. Mode fault flag is set.</li> <li>2. The SPIEN bit in the SPICR0 register is reset. This disables the SPI interface and blocks all output signals from the device.</li> <li>3. The MODE bit in the SPICR1 register is reset. This forces the device into slave mode.</li> </ol> |

Table 51. SPI Master Mode SEL Pin Status

|                        | SEL as Input - SELOEN = 0                        |           | SEL as Output - SELOEN = 1                                |                              |
|------------------------|--------------------------------------------------|-----------|-----------------------------------------------------------|------------------------------|
| Multi-master           | Support                                          |           | Not support                                               |                              |
| SPI SEL control signal | Use Another GPIO to replace the SEL pin function |           | SEL pin in hardware or software mode - using SELM setting |                              |
| Continuous transfer    | Case 1                                           | Case 2    | Case 1                                                    | Case 2                       |
|                        | Not supported                                    | Supported | Using hardware control                                    | Hardware or software control |

**Case 1:** SEL signal must be inactive between each data transfer.

**Case 2:** SEL signal will not to be active until the last data frame has finished.

**Note:** When the SPI is in the slave mode, the SEL signal is always an input and not affected by the SELOEN bit in the SPICR0 register.

### Write Collision – WC

The following conditions will assert the Write Collision Flag.

- The FIFOEN bit in the SPIFCR register is cleared  
The write collision flag is asserted when new data is written into the SPIDR register while both the TX buffer and the shift register are already full. Any new data written into the TX buffer will be lost.
- The FIFOEN bit in the SPIFCR register is set  
The write collision flag is asserted to indicate that new data is written into the SPIDR register while both the TX FIFO and the TX shift register are already full. Any new data written into the TX FIFO will be lost.

### Read Overrun – RO

- The FIFOEN bit in the SPIFCR register is cleared  
The read overrun flag is asserted to indicate that both the RX shift register and the RX buffer are already full, if one more data is received. This will result in the newly received data not being shifted into the SPI shift register. As a result the latest received data will be lost.
- The FIFOEN bit in the SPIFCR register is set  
The read overrun flag is set to indicate that the RX shift register and the RX FIFO are both full, if one more data is received. This means that the latest received data can not be shifted into the SPI shift register. As a result the latest received data will be lost.

### Slave Abort – SA

In the SPI slave mode, the slave abort flag is set to indicate that the SEL pin suddenly changed to an inactive state during the reception of a data frame transfer. The data frame length is set by the DFL field in the SPICR1 register.

### PDMA Interface

The PDMA interface is integrated in the SPI module. The PDMA function can be enabled by setting the TXDMAE or RXDMAE bit to 1 in the transmitter or receiver mode respectively. When the transmit buffer empty flag, TXBE, is asserted and the TXDMAE bit is set to 1, the PDMA function will be activated to move data from the memory location that users designated into the SPI data register or the TX FIFO until the TXBE flag is cleared to 0. The TXBE flag will be asserted when the transmit buffer is empty in the non-FIFO mode or the data contained in the TX FIFO is equal to or less than the level defined by the TXFTLS field in the FIFO mode.

Similarly, when the receive buffer not empty flag, RXBNE, is asserted and the RXDMAE bit is set to 1, the PDMA function will be activated to move data from the SPI data register or the RX FIFO to the memory location that users designated until the RXBNE flag is cleared to 0. The RXBNE flag will be asserted when the receive buffer is not empty in the non-FIFO mode or the data contained in the RX FIFO is equal to or greater than the level defined by the RXFTLS field in the FIFO mode.

For a more detailed description on the PDMA configurations, refer to the PDMA chapter.

## Register Map

The following table shows the SPI registers and their reset values.

**Table 52. SPI Register Map**

| Register | Offset | Description                        | Reset Value |
|----------|--------|------------------------------------|-------------|
| SPICR0   | 0x000  | SPI Control Register 0             | 0x0000_0000 |
| SPICR1   | 0x004  | SPI Control Register 1             | 0x0000_0000 |
| SPIIER   | 0x008  | SPI Interrupt Enable Register      | 0x0000_0000 |
| SPICPR   | 0x00C  | SPI Clock Prescaler Register       | 0x0000_0000 |
| SPIDR    | 0x010  | SPI Data Register                  | 0x0000_0000 |
| SPISR    | 0x014  | SPI Status Register                | 0x0000_0003 |
| SPIFCR   | 0x018  | SPI FIFO Control Register          | 0x0000_0000 |
| SPIFSR   | 0x01C  | SPI FIFO Status Register           | 0x0000_0000 |
| SPIFTOCR | 0x020  | SPI FIFO Time Out Counter Register | 0x0000_0000 |

## Register Descriptions

### SPI Control Register 0 – SPICR0

This register specifies the SEL control and the SPI enable bits.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |        |          |       |        |        |        |       |    |
|------------|----------|--------|----------|-------|--------|--------|--------|-------|----|
|            | 31       | 30     | 29       | 28    | 27     | 26     | 25     | 24    |    |
| Type/Reset | Reserved |        |          |       |        |        |        |       |    |
|            | 23       | 22     | 21       | 20    | 19     | 18     | 17     | 16    |    |
| Type/Reset | Reserved |        |          |       |        |        |        |       |    |
|            | 15       | 14     | 13       | 12    | 11     | 10     | 9      | 8     |    |
| Type/Reset | SELHT    |        |          |       | GUADT  |        |        |       |    |
|            | RW       | 0      | RW       | 0     | RW     | 0      | RW     | 0     | RW |
|            | 7        | 6      | 5        | 4     | 3      | 2      | 1      | 0     |    |
| Type/Reset | GUADTEN  | DUALEN | Reserved | SSELC | SELOEN | RXDMAE | TXDMAE | SPIEN |    |
|            | RW       | 0      | RW       | 0     | RW     | 0      | RW     | 0     | RW |

| Bits    | Field | Descriptions                                                                                                                                                         |
|---------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:12] | SELHT | <p>Chip Select Hold Time</p> <p>0x0: 1/2 SCK</p> <p>0x1: 1 SCK</p> <p>0x2: 3/2 SCK</p> <p>0x3: 2 SCK</p> <p>....</p> <p>Note that SELHT is for master mode only.</p> |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11:8] | GUADT   | Guard Time<br>GUADTEN=1<br>0x0:1 SCK<br>0x1:2 SCK<br>0x2: 3 SCK<br>...<br>Note that GUADT is for master mode only.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| [7]    | GUADTEN | Guard Time Enable<br>0: Guard Time is 1/2 SCK<br>1: When set this bit, Guard time can be controlled by GUADT<br>Note that GUADTEN is for master mode only.                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [6]    | DUALEN  | Dual Port Enable<br>0: Dual port is disabled<br>1: Dual port is enabled<br>The control bit is used to support the dual output read mode of the series SPI NOR Flash. When this bit is set and the MOSI signal will change the direction from output to input and receive the series data stream. That means the DUALEN control bit is only for master mode.                                                                                                                                                                                                                                                 |
| [4]    | SSELC   | Software Slave Select Control<br>0: Set the SEL output to an inactive state<br>1: Set the SEL output to an active state<br>The application Software can setup the SEL output to an active or inactive state by configuring the SSELC bit. The active level is configured by the SELAP bit in the SPICR1 register. Note that the SSELC bit is only available when the SELOEN bit is set to 1 for enabling the SEL output meanwhile the SELM bit is cleared to 0 for controlling the SEL signal by software. Otherwise, the SSELC bit has no effect.                                                          |
| [3]    | SELOEN  | Slave Select Output Enable<br>0: Set the SEL signal to the input mode for Multi-master mode<br>1: Set the SEL signal to the output mode for slave select<br>The SELOEN is only available in the master mode to setup the SEL signal as an input or output signal. When the SEL signal is configured to operate in the output mode, it is used as a slave select signal in either the hardware or software mode according to the SELM bit setting in the SPICR1 register. The SEL signal is used for mode fault detection in the multi-master environment when it is configured to operate in the input mode |
| [2]    | RXDMAE  | RX PDMA request enable<br>0: SPI RX path PDMA request disabled.<br>1: SPI RX path PDMA request enabled.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| [1]    | TXDMAE  | TX PDMA request enable<br>0: SPI TX path PDMA request disabled.<br>1: SPI TX path PDMA request enabled.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| [0]    | SPIEN   | SPI Enable<br>0: SPI interface is disabled<br>1: SPI interface is enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

## SPI Control Register 1 – SPICR1

This register specifies the SPI parameters including the data length, the transfer format, the SEL active polarity/mode, the LSB/MSB control, and the master/slave mode.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |      |      |          |       |        |    |    |
|------------|----------|------|------|----------|-------|--------|----|----|
|            | 31       | 30   | 29   | 28       | 27    | 26     | 25 | 24 |
| Type/Reset | Reserved |      |      |          |       |        |    |    |
|            | 23       | 22   | 21   | 20       | 19    | 18     | 17 | 16 |
| Type/Reset | Reserved |      |      |          |       |        |    |    |
|            | 15       | 14   | 13   | 12       | 11    | 10     | 9  | 8  |
| Type/Reset | Reserved | MODE | SELM | FIRSTBIT | SELAP | FORMAT |    |    |
|            |          | RW   | 0    | RW       | 0     | RW     | 0  | RW |
|            | 7        | 6    | 5    | 4        | 3     | 2      | 1  | 0  |
| Type/Reset | Reserved |      |      |          | DFL   |        |    |    |
|            |          |      |      |          | RW    | 0      | RW | 0  |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                       |
|------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [14] | MODE     | Master or Slave Mode<br>0: Slave mode<br>1: Master mode                                                                                                                                                                                                            |
| [13] | SELM     | Slave Select Mode<br>0: SEL signal is controlled by software – asserted or de-asserted by the SSEL bit<br>1: SEL signal is controlled by hardware – generated automatically by the SPI hardware<br>Note that SELM bit is available for master mode only - MODE = 1 |
| [12] | FIRSTBIT | LSB or MSB Transmitted First<br>0: MSB transmitted first<br>1: LSB transmitted first                                                                                                                                                                               |
| [11] | SELAP    | Slave Select Active Polarity<br>0: SEL signal is active low<br>1: SEL signal is active high                                                                                                                                                                        |

| Bits         | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
|--------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------|------|-----|---|---|-----|---|---|-----|---|---|-----|---|---|--------|----------|--|
| [10:8]       | FORMAT   | <p>SPI Data Transfer Format</p> <p>These three bits are used to determine the data transfer format of the SPI interface</p> <table border="1"> <thead> <tr> <th>FORMAT [2:0]</th><th>CPOL</th><th>CPHA</th></tr> </thead> <tbody> <tr> <td>001</td><td>0</td><td>0</td></tr> <tr> <td>010</td><td>0</td><td>1</td></tr> <tr> <td>110</td><td>1</td><td>0</td></tr> <tr> <td>101</td><td>1</td><td>1</td></tr> <tr> <td>Others</td><td>Reserved</td><td></td></tr> </tbody> </table> <p>CPOL: Clock Polarity<br/>           0: SCK Idle state is low<br/>           1: SCK Idle state is high</p> <p>CPHA: Clock Phase<br/>           0: Data is captured on the first SCK clock edge<br/>           1: Data is captured on the second SCK clock edge</p> | FORMAT [2:0] | CPOL | CPHA | 001 | 0 | 0 | 010 | 0 | 1 | 110 | 1 | 0 | 101 | 1 | 1 | Others | Reserved |  |
| FORMAT [2:0] | CPOL     | CPHA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
| 001          | 0        | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
| 010          | 0        | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
| 110          | 1        | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
| 101          | 1        | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
| Others       | Reserved |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |
| [3:0]        | DFL      | <p>Data Frame Length</p> <p>Selects the data transfer frame from 1 bit to 16 bits.</p> <p>0x1: 1 bit<br/>           0x2: 2 bits<br/>           ...<br/>           0xF: 15 bits<br/>           0x0: 16 bits</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |              |      |      |     |   |   |     |   |   |     |   |   |     |   |   |        |          |  |

## SPI Interrupt Enable Register – SPInIER

This register contains the corresponding SPI interrupt enable control bit.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |       |       |       |       |          |        |         |
|------------|----------|-------|-------|-------|-------|----------|--------|---------|
|            | 31       | 30    | 29    | 28    | 27    | 26       | 25     | 24      |
| Type/Reset | Reserved |       |       |       |       |          |        |         |
|            | 23       | 22    | 21    | 20    | 19    | 18       | 17     | 16      |
| Type/Reset | Reserved |       |       |       |       |          |        |         |
|            | 15       | 14    | 13    | 12    | 11    | 10       | 9      | 8       |
| Type/Reset | Reserved |       |       |       |       |          |        |         |
|            | 7        | 6     | 5     | 4     | 3     | 2        | 1      | 0       |
| Type/Reset | TOIEN    | SAIEN | MFIEN | ROIEN | WCIEN | RXBNEIEN | TXEIEN | TXBEIEN |
|            | RW       | 0     | RW    | 0     | RW    | 0        | RW     | 0       |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                  |
|------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | TOIEN    | Time Out Interrupt Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                          |
| [6]  | SAIEN    | Slave Abort Interrupt Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                       |
| [5]  | MFIEN    | Mode Fault Interrupt Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                        |
| [4]  | ROIEN    | Read Overrun Interrupt Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                      |
| [3]  | WCIEN    | Write Collision Interrupt Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                   |
| [2]  | RXBNEIEN | RX Buffer Not Empty Interrupt Enable<br>0: Disable<br>1: Enable<br>Generates an interrupt request when the RXBNE flag is set and when RXBNEIEN is set. In the FIFO mode, the interrupt request being generated depends upon the RX FIFO trigger level setting |
| [1]  | TXEIEN   | Tx Empty Interrupt Enable<br>0: Disable<br>1: Enable<br>The TX register empty interrupt request will be generated when the TXE flag and the TXEIEN bit are set                                                                                                |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                   |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | TXBEIEN | <p>Tx Buffer Empty Interrupt Enable</p> <p>0: Disable<br/>1: Enable</p> <p>The TX buffer empty interrupt request will be generated when the TXBE flag and the TXBEIEN bit are set. In the FIFO mode, the interrupt request being generated depends upon the TX FIFO trigger level setting.</p> |

### SPI Clock Prescaler Register – SPICPR

This register specifies the SPI clock prescaler ratio.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | CP       |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | CP       |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                     |
|--------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | CP    | <p>SPI Clock Prescaler</p> <p>The SPI clock (SCK) is determined by the following equation:<br/> <math>f_{SCK} = f_{PCLK} / (2 \times (CP + 1))</math>, where the CP ranges is from 0 to 65535</p> <p>Note: For the SPI slave mode, the system clock (<math>f_{PCLK}</math>) must be at least 3 times faster than the external SPI SCK input.</p> |

## SPI Data Register – SPIDR

This register stores the SPI received or transmitted Data.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|------------|----------|----|----|----|----|----|----|----|----|---|----|---|----|---|----|---|----|---|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |   |    |   |    |   |    |   |    |   |
|            | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
| Type/Reset |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |   |    |   |    |   |    |   |    |   |
|            | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
| Type/Reset |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |   |    |   |    |   |    |   |    |   |
|            | DR       |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 | RW | 0 | RW | 0 |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |   |    |   |    |   |    |   |    |   |
|            | DR       |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 | RW | 0 | RW | 0 |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                     |
|--------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | DR    | <p>Data Register</p> <p>The SPI data register is used to store the serial bus transmitted or received data. In the non-FIFO mode, writing data into the SPI data register will also load the data into the data transmission buffer, known as the TX buffer. Reading data from the SPI data register will return the data held in the data received buffer, named RX buffer.</p> |

## SPI Status Register – SPISR

This register contains the relevant SPI status.

Offset: 0x014

Reset value: 0x0000\_0003

|            |          |    |    |    |    |       |     |      |    |
|------------|----------|----|----|----|----|-------|-----|------|----|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25  | 24   |    |
| Type/Reset | Reserved |    |    |    |    |       |     |      |    |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17  | 16   |    |
| Type/Reset | Reserved |    |    |    |    |       |     |      |    |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9   | 8    |    |
| Type/Reset | Reserved |    |    |    |    |       |     | BUSY |    |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1   | 0    |    |
| Type/Reset | TO       | SA | MF | RO | WC | RXBNE | TXE | TXBE |    |
|            | WC       | 0  | WC | 0  | WC | 0     | WC  | 0    | RO |
|            |          |    |    |    |    |       |     |      | 0  |
|            |          |    |    |    |    |       |     |      | 1  |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | BUSY  | <p>SPI Busy flag</p> <p>0: SPI not busy</p> <p>1: SPI busy</p> <p>In the master mode, this flag is reset when the TX buffer and TX shift register are both empty and is set when the TX buffer or the TX shift register are not empty.</p> <p>In the slave mode, this flag is set when SEL changes to an active level and is reset when SEL changes to an inactive level.</p>                                                                                     |
| [7]  | TO    | <p>Time Out flag</p> <p>0: No Rx FIFO time out</p> <p>1: Rx FIFO time out has occurred.</p> <p>Write 1 to clear it.</p> <p>Once the time out counter value is equal to the TOC field setting in the SPIFTOCR register, the time out flag will be set and an interrupt will be generated if the TOIEN bit in the SPIIER register is enabled. This bit is cleared by writing 1</p> <p>Note: This Time Out flag function is only available in the SPI FIFO mode.</p> |
| [6]  | SA    | <p>Slave Abort flag</p> <p>0: No slave abort</p> <p>1: Slave abort has occurred.</p> <p>This bit is set by hardware and cleared by writing 1.</p>                                                                                                                                                                                                                                                                                                                 |
| [5]  | MF    | <p>Mode Fault flag</p> <p>0: No mode fault</p> <p>1: Mode fault has occurred</p> <p>This bit is set by hardware and cleared by writing 1.</p>                                                                                                                                                                                                                                                                                                                     |
| [4]  | RO    | <p>Read Overrun flag</p> <p>0: No read overrun</p> <p>1: Read overrun has occurred.</p> <p>This bit is set by hardware and cleared by writing 1.</p>                                                                                                                                                                                                                                                                                                              |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | WC    | Write Collision flag<br>0: No write collision<br>1: Write collision has occurred.<br>This bit is set by hardware and cleared by writing 1.                                                                                                                                                                                                                                                                                                                                               |
| [2]  | RXBNE | Receive Buffer Not Empty flag<br>0: Rx buffer empty<br>1: Rx buffer not empty<br>This bit indicates the RX buffer status in the non-FIFO mode. It is also used to indicate if the RX FIFO trigger level has been reached in the FIFO mode. This bit will be cleared when the SPI RX buffer is empty in the non-FIFO mode or if the number of data contained in RX FIFO is less than the trigger level which is specified by the RXFTLS field in the SPIFCR register in the SPI FIFO mode |
| [1]  | TXE   | Transmission Register Empty flag<br>0: Tx buffer or Tx shift register is not empty<br>1: Tx buffer and Tx shift register both are empty                                                                                                                                                                                                                                                                                                                                                  |
| [0]  | TXBE  | Transmit Buffer Empty flag<br>0: Tx buffer not empty<br>1: Tx buffer empty<br>In the FIFO mode, this bit indicates that the number of data contained in TX FIFO is equal to or less than the trigger level specified by the TXFTLS field in the SPIFCR register.                                                                                                                                                                                                                         |

## SPI FIFO Control Register – SPIFCR

This register contains the related SPI FIFO control including the FIFO enable control and the FIFO trigger level selections.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |    |    |    |        |        |          |    |
|------------|----------|----|----|----|--------|--------|----------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26     | 25       | 24 |
| Type/Reset | Reserved |    |    |    |        |        |          |    |
|            | 23       | 22 | 21 | 20 | 19     | 18     | 17       | 16 |
| Type/Reset | Reserved |    |    |    |        |        |          |    |
|            | 15       | 14 | 13 | 12 | 11     | 10     | 9        | 8  |
| Type/Reset | Reserved |    |    |    |        | FIFOEN | Reserved |    |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1        | 0  |
| Type/Reset | RXFTLS   |    |    |    | TXFTLS |        |          |    |
|            | RW       | 0  | RW | 0  | RW     | 0      | RW       | 0  |

| Bits  | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                         |
|-------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10]  | FIFOEN | FIFO Enable<br>0: FIFO disable<br>1: FIFO enable<br>This bit cannot be set or reset when the SPI interface is in transmitting.                                                                                                                                                                                                                                       |
| [7:4] | RXFTLS | Rx FIFO Trigger Level Select<br>0000: Trigger level is 0<br>0001: Trigger level is 1<br>...<br>1000: Trigger level is 8<br>Others: Reserved<br>The RXFTLS field is used to specify the RX FIFO trigger level. When the number of data contained in the RX FIFO is equal to or greater than the trigger level defined by the RXFTLS field, the RXBNE flag will be set |
| [3:0] | TXFTLS | Tx FIFO Trigger Level Select<br>0000: Trigger level is 0<br>0001: Trigger level is 1<br>...<br>1000: Trigger level is 8<br>Others: Reserved<br>The TXFTLS field is used to specify the TX FIFO trigger level. When the number of data contained in the TX FIFO is equal to or less than the trigger level defined by the TXFTLS field, the TXBE flag will be set.    |

## SPI FIFO Status Register – SPIFSR

This register contains the relevant SPI FIFO status.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |      |    |    |    |
|------------|----------|----|----|----|------|----|----|----|
|            | 31       | 30 | 29 | 28 | 27   | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |      |    |    |    |
|            | 23       | 22 | 21 | 20 | 19   | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |      |    |    |    |
|            | 15       | 14 | 13 | 12 | 11   | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |      |    |    |    |
|            | 7        | 6  | 5  | 4  | 3    | 2  | 1  | 0  |
| Type/Reset | RXFS     |    |    |    | TXFS |    |    |    |
|            | RO       | 0  | RO | 0  | RO   | 0  | RO | 0  |

| Bits  | Field | Descriptions                                                                                                                       |
|-------|-------|------------------------------------------------------------------------------------------------------------------------------------|
| [7:4] | RXFS  | Rx FIFO Status<br>0000: Rx FIFO empty<br>0001: Rx FIFO contains 1 data<br>...<br>1000: Rx FIFO contains 8 data<br>Others: Reserved |
| [3:0] | TXFS  | Tx FIFO Status<br>0000: Tx FIFO empty<br>0001: Tx FIFO contains 1 data<br>...<br>1000: Tx FIFO contains 8 data<br>Others: Reserved |

## SPI FIFO Time Out Counter Register – SPIFTOCR

This register stores the SPI Rx FIFO time out counter value.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | Reserved |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | Reserved |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | TOC      |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | TOC      |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | TOC   | <p>Time Out Counter</p> <p>The time out counter starts to count from 0 after the SPI RX FIFO receives a data, and reset the counter value once the data is read from the SPIDR register by software or another new data is received. If the FIFO does not receive new data or the software does not read data from the SPIDR register the time out counter value will continuously increase. When the time out counter value is equal to the TOC setting value, the TO flag in the SPISR register will be set and an interrupt will be generated if the TOIEN bit in the SPIEN register is set. The time out counter will be stopped when the RX FIFO is empty. The SPI FIFO time out function can be disabled by setting the TOC field to zero. The time out counter is driven by the system APB clock, named <math>f_{PCLK}</math>.</p> |

# 22 Universal Synchronous Asynchronous Receiver Transmitter (USART)

## Introduction

The Universal Synchronous Asynchronous Receiver Transceiver, USART, provides a flexible full duplex data exchange using synchronous or asynchronous transfer. The USART is used to translate data between parallel and serial interfaces, and is also commonly used for RS232 standard communication. The USART peripheral function supports a variety of interrupts.

The USART module includes an 8-byte transmit FIFO, TX\_FIFO, and a 8-byte receive FIFO, RX\_FIFO. Software can detect a USART error status by reading USART Status & Interrupt Flag Register, USRSIFR. The status includes the condition of the transfer operations as well as several error conditions resulting from Parity, Overrun, Framing and Break events.

The USART includes a programmable baud rate generator which is capable of dividing the USART clock of the CK\_APB (CK\_USART) to produce a baud rate clock for the USART transmitter and receiver.

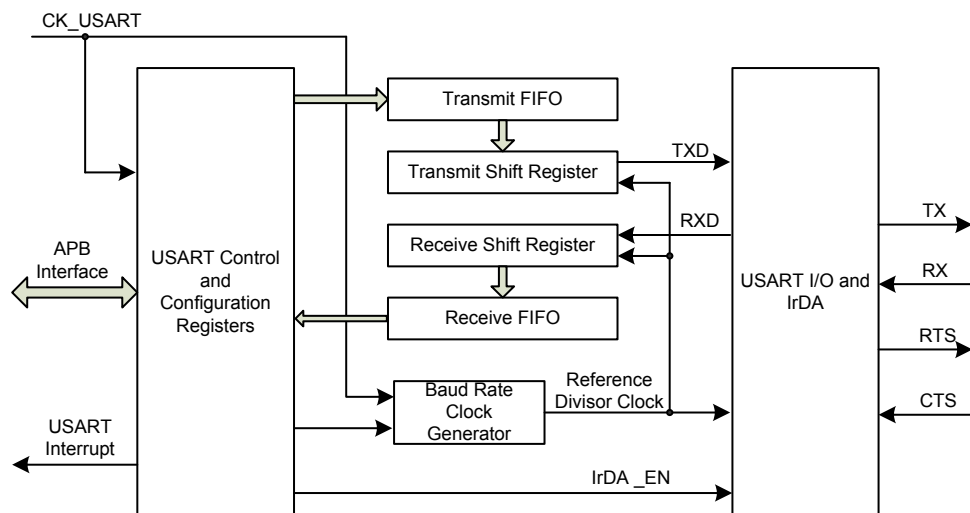


Figure 160. USART Block Diagram

## Features

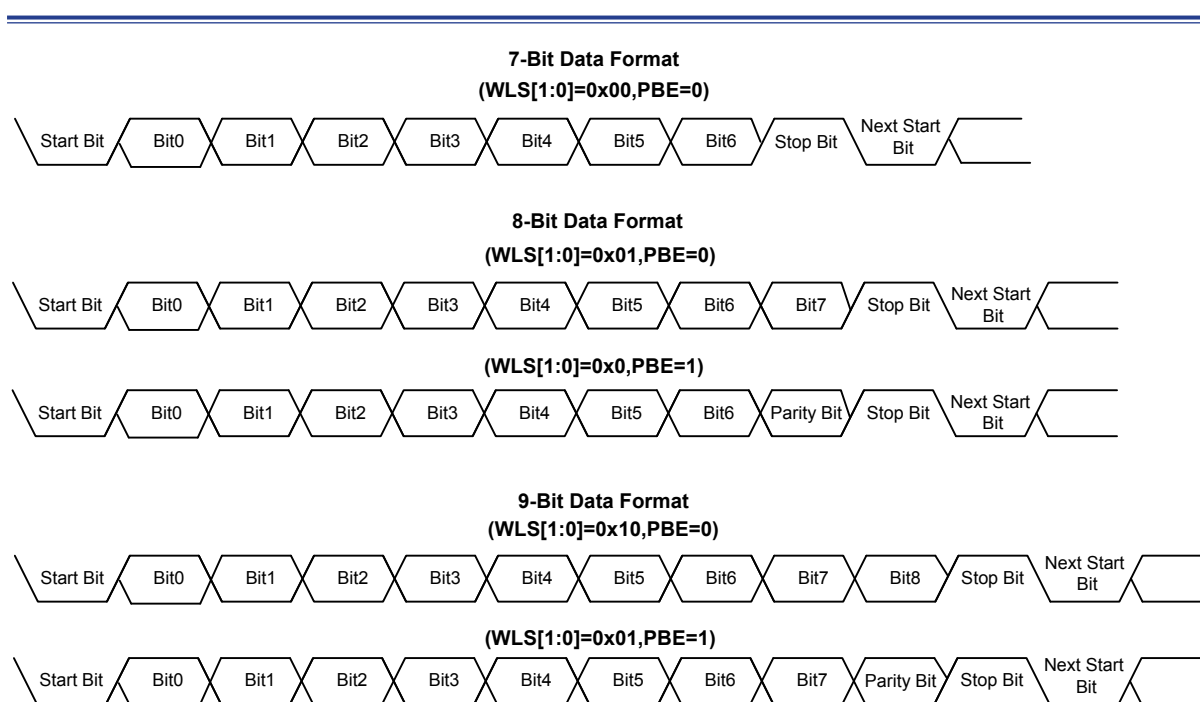
- Supports both asynchronous and clocked synchronous serial communication modes
- Full Duplex Communication Capability
- Programming baud rate up to 3 Mbit/s for asynchronous mode and 6 Mbit/s for synchronous mode
- IrDA SIR encoder and decoder
  - Support of normal 3/16 bit duration and low-power (1.41 ~ 2.23  $\mu$ s) durations
- Supports RS485 mode with output enable
- Auto hardware flow control mode – RTS, CTS
- Fully programmable serial communication functions including:
  - Word length: 7, 8, or 9-bit character
  - Parity: Even, odd, or no-parity bit generation and detection
  - Stop bit: 1 or 2 stop bit generation
  - Bit order: LSB-first or MSB-first transfer
- Error detection: Parity, overrun, and frame error
- FIFO:
  - Receive FIFO: 8  $\times$  9 bits (max 9 data bits)
  - Transmit FIFO: 8  $\times$  9 bits (max 9 data bits)
- Supports PDMA Interface

## Function Descriptions

### Serial Data Format

The USART module performs a parallel-to-serial conversion on data that is written to the transmit FIFO registers and then sends the data with the following format: Start bit, 7 ~ 9 LSB first data bits, optional Parity bit and finally 1 ~ 2 Stop bits. The Start bit has the opposite polarity of the data line idle state. The Stop bit is the same as the data line idle state and provides a delay before the next start situation. The both Start and Stop bits are used for data synchronization during the asynchronous data transmission.

The USART module also performs a serial-to-parallel conversion on the data that is read from the receive FIFO registers. It will first check the Parity bit and will then look for a Stop bit. If the Stop bit is not found, the USART module will consider the entire word transmission to have failed and respond with a Framing Error.



**Figure 161. USART Serial Data Format**

## Baud Rate Generation

The baud rate for the USART receiver and transmitter are both set with the same values. The baud-rate divisor, BRD, has the following relationship with the USART clock which is known as CK\_USART.

$$\text{Baud Rate Clock} = \text{CK\_USART} / \text{BRD}$$

Where CK\_USART clock is the APB clock connected to the USART while the BRD range is from 16 to 65535 for asynchronous mode and 8 to 65535 for synchronous mode.

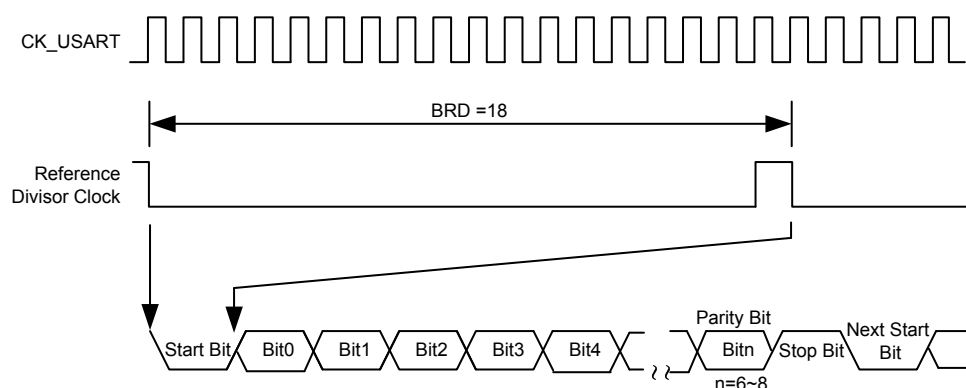


Figure 162. USART Clock CK\_USART and Data Frame Timing

Table 53. Baud Rate Deviation Error Calculation – CK\_USART = 40 MHz

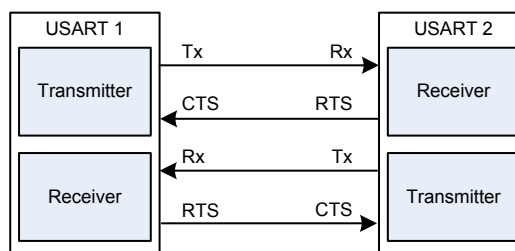
| Baud rate |       | CK_USART = 40 MHz |       |                      |
|-----------|-------|-------------------|-------|----------------------|
| No        | Kbps  | Actual            | BRD   | Deviation Error rate |
| 1         | 2.4   | 2.4               | 16667 | 0.00%                |
| 2         | 9.6   | 9.6               | 4167  | -0.01%               |
| 3         | 19.2  | 19.2              | 2083  | 0.02%                |
| 4         | 57.6  | 57.6              | 694   | 0.06%                |
| 5         | 115.2 | 115.3             | 347   | 0.06%                |
| 6         | 230.4 | 229.9             | 174   | -0.22%               |
| 7         | 460.8 | 459.8             | 87    | -0.22%               |
| 8         | 921.6 | 930.2             | 43    | 0.94%                |
| 9         | 2250  | 2222.2            | 18    | -1.23%               |
| 10        | 3000  | 3076.9            | 13    | 2.56%                |

**Table 54. Baud Rate Deviation Error Calculation – CK\_USART = 48 MHz**

| Baud rate |       | CK_USART = 48 MHz |       |                      |
|-----------|-------|-------------------|-------|----------------------|
| No        | Kbps  | Actual            | BRD   | Deviation Error rate |
| 1         | 2.4   | 2.4               | 20000 | 0.00%                |
| 2         | 9.6   | 9.6               | 5000  | 0.00%                |
| 3         | 19.2  | 19.2              | 2500  | 0.00%                |
| 4         | 57.6  | 57.6              | 833   | 0.04%                |
| 5         | 115.2 | 115.1             | 417   | -0.08%               |
| 6         | 230.4 | 230.8             | 208   | 0.16%                |
| 7         | 460.8 | 461.5             | 104   | 0.16%                |
| 8         | 921.6 | 923.1             | 52    | 0.16%                |
| 9         | 2250  | 2285.7            | 21    | 1.59%                |
| 10        | 3000  | 3000              | 16    | 0.00%                |

## Hardware Flow Control

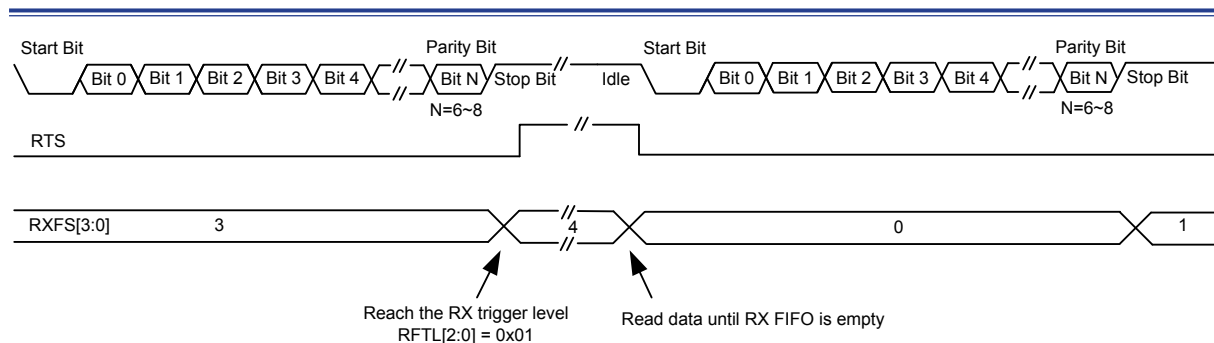
The USART supports the hardware flow control function which is enabled by setting the HFCEN bit in the USRCR register to 1. It is possible to control the serial data flow between 2 USART devices by using the CTS input and the RTS output. The Figure 163 shows the connection diagram in this mode. The hardware flow control function is categorized into two types. One is the RTS flow control function and the other is the CTS flow control function.



**Figure 163. Hardware Flow Control between 2 USARTs**

### RTS Flow Control

In the RTS flow control, the USART RTS pin is active with a logic low state when the receive data register is empty. It means that the receiver is ready to receive a new data. When the RX\_FIFO reaches the trigger level which is specified by configuring the RXTL field in the USRFCR register, the USART RTS pin is inactive with a logic high state. Figure 164 shows the example of RTS flow control.

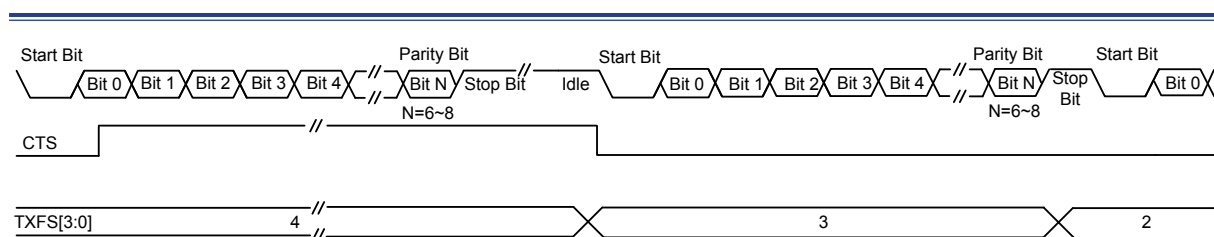


**Figure 164. USART RTS Flow Control**

### CTS Flow Control

If the hard flow control function is enabled, the URTXEN bit in the USRCR register will be controlled by the USART CTS input signal. If the USART CTS pin is forced to a logic low state, the URTXEN bit will automatically be set to 1 to enable the data transmission. However, if the USART CTS pin is forced to a logic high state, the URTXEN bit will be cleared to 0 and then the data transmission will also be disabled.

When the USART CTS pin is forced to a logic high state during a data transmission period, the current data transmission will be continued until the stop bit is completed. The Figure 165 shows an example of communication with CTS flow control.

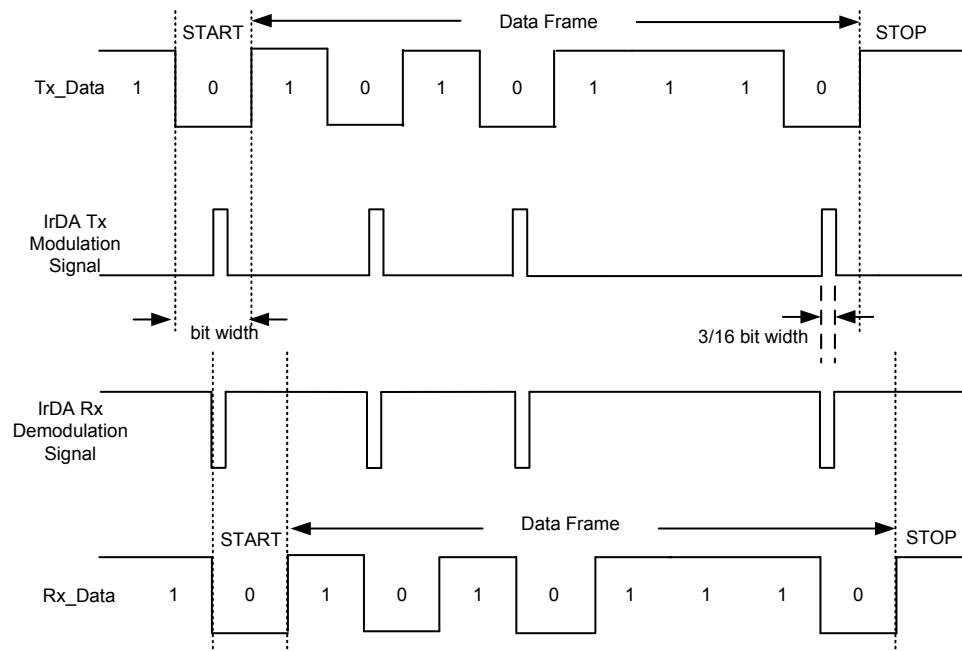


**Figure 165. USART CTS Flow Control**

## IrDA

The USART IrDA mode is provided half-duplex point-to-point wireless communication.

The USART module includes an integrated modulator and demodulator which allow a wireless communication using infrared transceivers. The transmitter specifies a logic data '0' as a 'high' pulse and a logic data '1' as a 'low' level while the Receiver specifies a logic data '0' as a 'low' pulse and a logic data '1' as a 'high' level in the IrDA mode.



**Figure 166. IrDA Modulation and Demodulation**

The IrDA mode provides two operation modes, one is the normal mode, and the other is the low-power mode.

### IrDA Normal Mode

For the IrDA normal mode, the width of each transmitted pulse generated by the transmitter modulator is specified as 3/16th of the baud rate clock period. The receiver pulse width for the IrDA receiver demodulator is based on the IrDA receive debounce filter which is implemented using an 8-bit down-counting counter. The debounce filter counter value is specified by the IrDAPSC field in the IrDACR register. When a falling edge is detected on the receiver pin, the debounce filter counter starts to count down, driven by the CK\_USART clock. If a rising edge is detected on the receiver pin, the counter stops counting and is reloaded with the IrDAPSC value. When a low pulse falling edge on the receiver pin is detected and then before the debounce filter has counted down to zero, a rising edge is also detected, then this low pulse will be considered as glitch noise and will be discarded. If a low pulse falling edge appears on the receiver pin but no rising edge is detected before the debounce counter reaches 0, then the input is regarded as a valid data “0” for this bit duration. The IrDAPSC value must be set to be greater than or equal to 0x01, then the IrDA receiver demodulation operation can function properly. The IrDAPSC value can be adjusted to meet the USART baud rate setting to filter the IrDA received glitch noise of which the width is smaller than the prescaler setting duration.

### IrDA Low-Power Mode

In the IrDA low-power mode, the transmitted IrDA pulse width generated by the transmitter modulator is not kept at 3/16 of the baud rate clock period. Instead, the pulse width is fixed and is calculated by the following formula. The transmitted pulse width can be adjusted by the IrDAPSC field to meet the minimum pulse width specification of the external IrDA Receiver device.

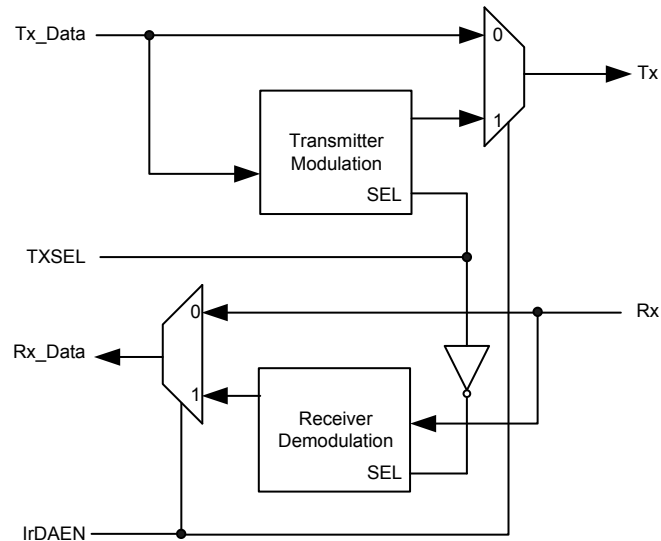
$$T_{\text{IrDA\_L}} = 3 \times \text{IrDAPSC} / \text{CK\_USART}$$

Note:  $T_{\text{IrDA\_L}}$  is transmitted pulse width in the low power mode.

The IrDAPSC field is the IrDA prescaler value in the IrDA Control Register IrDACR.

The debounce behavior in the IrDA low-power receiving mode is similar to the IrDA normal mode. For glitch detection, the low pulse of which the pulse width is shorter than  $1 \times (\text{IrDAPSC} / \text{CK\_USART})$  should be discarded in the IrDA receiver demodulation. A valid low data is accepted if its low pulse width is greater than  $2 \times (\text{IrDAPSC} / \text{CK\_USART})$  duration.

The IrDA physical layer specification specifies a minimum delay with a value of 10 ms between the transmission and reception switch; and this IrDA receiver set-up time also should be managed by the software.



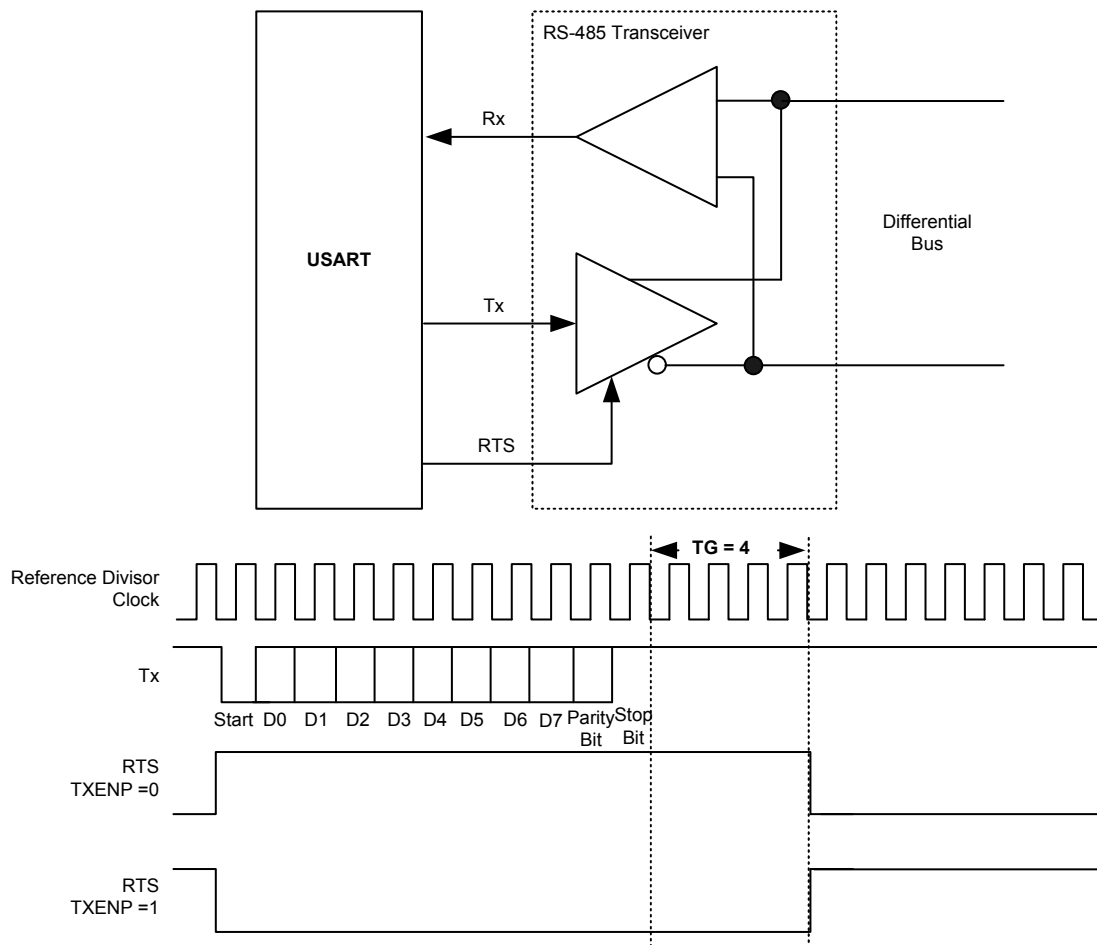
**Figure 167. USART I/O and IrDA Block Diagram**

## RS485 Mode

The RS485 mode of the USART provides the data transmission on the interface transmitted over a 2-wire twisted pair bus. The RS485 transceiver interprets the voltage levels of the differential signals with respect to a third common voltage. Without this common reference, the transceiver may interpret the differential signals incorrectly. This enhances the noise rejection capabilities of the RS485 interface. The USART RTS pin is used to control the external RS485 transceiver whose polarity can be selected by configuring the TXENP bit in the RS485 Control Register, named RS485CR, when the USART operates in the RS485 mode.

### RS485 Auto Direction Mode – AUD

When the RS485 mode is configured as a master transmitter, it will operate in the Auto Direction Mode, AUD. In the AUD mode the polarity of the USART RTS pin is configurable according to the TXENP bit in the RS485 Control Register in the RS485 mode. This pin can be used to control the external RS485 transceiver to enable the transmitter.



**Figure 168. RS485 Interface and Waveform**

### RS485 Normal Multi-drop Operation Mode – NMM

When the RS485 mode is configured as an addressable slave, it will operate in the Normal Multi-drop Operation Mode, NMM. This mode is enabled when the RSNMM field is set in the RS485CR register. Regardless of the URRXEN value in the USRCR register, all the received data with a parity bit “0” will be ignored until the first address byte is detected with a parity bit “1” and then the received address byte will be stored in the RXFIFO. Once the first address data is detected and stored in the RXFIFO, the RSADD flag in the USRSIFR register will be set and generate an interrupt if the RSADDIE bit in the USRIER register is set to 1. Application software can determine whether the receiver is enabled or disabled to accept the following data by configuring the URRXEN bit. When the receiver is enabled by setting the URRXEN bit to 1, all received data will be stored in the RXFIFO. Otherwise, all received data will be ignored if the receiver is disabled by clearing the URRXEN bit to 0.

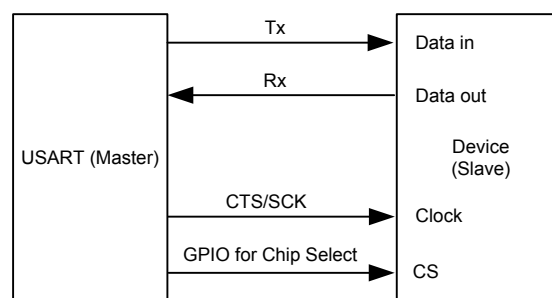
### RS485 Auto Address Detection Operation Mode – AAD

Except in the Normal Multi-drop Operation Mode, the RS485 mode can operate in the Auto Address Detection Operation Mode, AAD, when it is configured as an addressable slave. This mode is enabled by setting the RSAAD field to 1 in the RS485CR register. The receiver will detect the address frame with a parity bit “1” and then compare the received address data with the ADDMATCH field value which is a programmable 8-bit address value specified in the RS485CR register. If the address data matches the ADDMATCH value, it will be stored in the RXFIFO and the URRXEN bit will be automatically set. When the receiver is enabled, all received data will be stored in the RXFIFO until the next address frame does not match the ADDMATCH value and then the receiver will be automatically disabled. After the receiver is enabled, software can disable the receiver by setting the URRXEN bit to ‘0’.

## Synchronous Master Mode

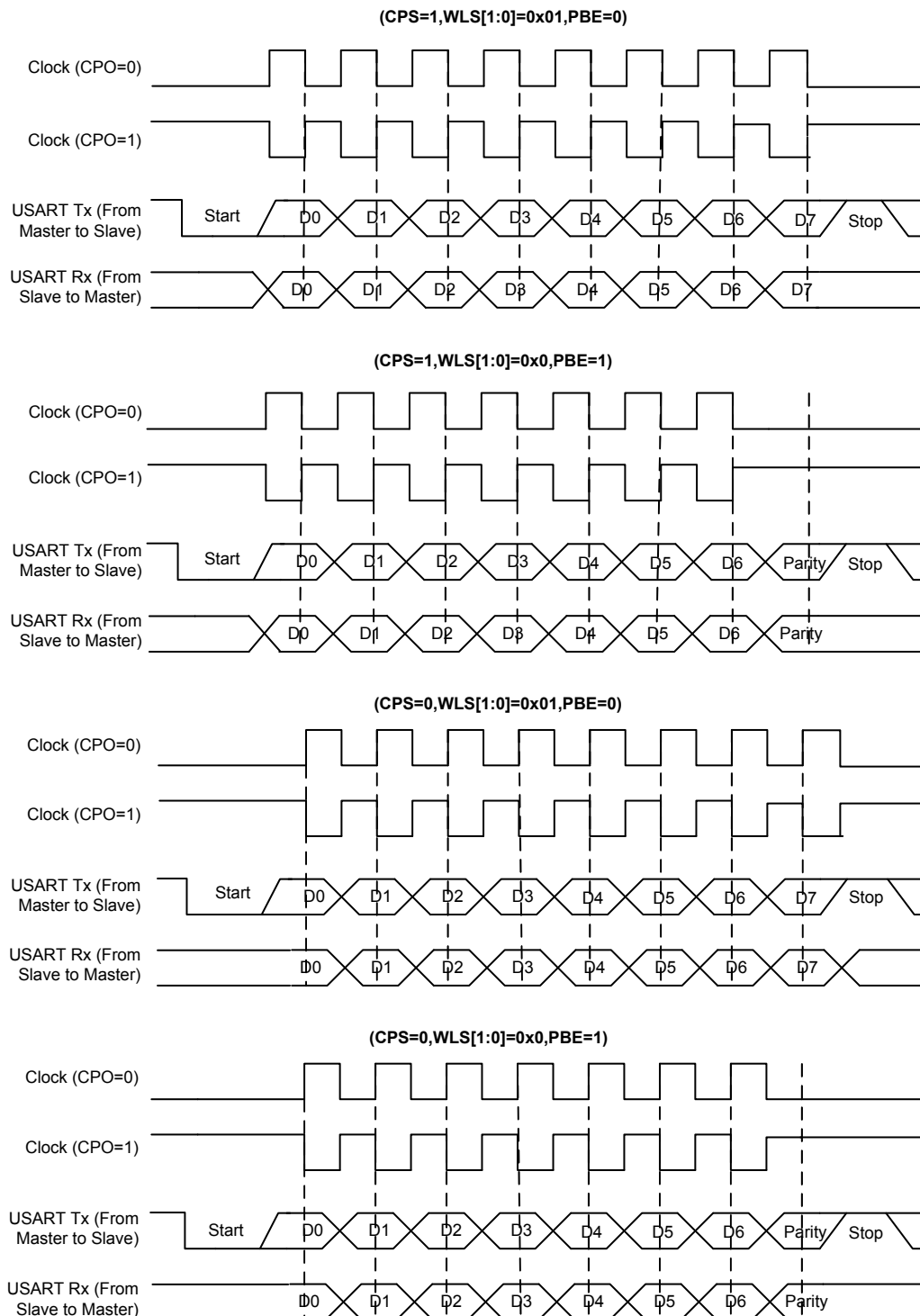
The data is transmitted in a full-duplex style in the USART Synchronous Master Mode, i.e., data transmission and reception both occur at the same time and only support master mode. The USART CTS pin is the synchronous USART transmitter clock output. In this mode, no clock pulses will be sent to the CTS pin during the start bit, parity bit and stop bit duration. The CPS bit in the Synchronous Control Register SYNCR, can be used to determine whether data is captured on the first or the second clock edge. The CPO bit in the SYNCR can be use to configure the clock polarity in the USART Synchronous Mode idle state. Detailed timing information is shown in Figure 169.

In the USART synchronous Mode, the USART CTS/SCK clock output pin is only used to transmit the data to slave device. If the transmission data register USRDR, is written with valid data, the USART synchronous mode will automatically transmit this data with the corresponding clock output and the USART receiver will also receive data on the RX pin. Otherwise the receiver will not obtain synchronous data if no data is transmitted.



**Figure 169. USART Synchronous Transmission Example**

Note: The USART supports the synchronous master mode only: it cannot receive or send data related to an input clock. The USART CTS/SCK clock is always an output.



**Figure 170. 8-bit Format USART Synchronous Waveform**

## Interrupts and Status

The USART can generate interrupts when the following event occurs and corresponding interrupt enable bits are set:

- Receive FIFO time-out interrupt: An interrupt will be generated when the USART receive FIFO does not receive a new data package during the specified time-out interval.
- Receiver line status interrupts: The interrupts will be generated when the USART receiver overrun error, parity error, framing error and break events occur.
- Transmit FIFO threshold level interrupt: An interrupt will be generated when the data to be transmitted in the USART Transmit FIFO is less than the specified threshold level.
- Transmit complete interrupt: An interrupt will be generated when the Transmit FIFO is empty and the content of the transmit shift register (TSR) is also completely shifted.
- Receive FIFO threshold level interrupt: An interrupt will be generated when the FIFO received data amount has reached the specified threshold level.

## PDMA Interface

The PDMA interface is integrated in the USART. The PDMA function can be enabled by setting the TXDMAEN or RXDMAEN bit in the USRCR register to 1 in the transmit or receive mode respectively. When the data to be transmitted in the USART Transmit FIFO is less than the TX\_FIFOTHRESHOLD level specified by the TXFTHL field in the USRFCR register and the TXDMAEN bit is set to 1, the PDMA function will be activated to move data from a source location into the USART TX\_FIFOTHRESHOLD.

Similarly, when the received data amount in the receive FIFO is equal to the RX\_FIFOTHRESHOLD level specified by the RXFTHL field in the USRFCR register and the RXDMAEN bit is set to 1, the PDMA function will be activated to move data from the USART RX\_FIFOTHRESHOLD to a specific destination location. For a more detailed description on the PDMA configurations, refer to the PDMA chapter.

## Register Map

The following table shows the USART registers and reset values.

**Table 55. USART Register Map**

| Register | Offset | Description                            | Reset Value |
|----------|--------|----------------------------------------|-------------|
| USRDR    | 0x000  | USART Data Register                    | 0x0000_0000 |
| USRCR    | 0x004  | USART Control Register                 | 0x0000_0000 |
| USRFCR   | 0x008  | USART FIFO Control Register            | 0x0000_0000 |
| USRIER   | 0x00C  | USART Interrupt Enable Register        | 0x0000_0000 |
| USRSIFR  | 0x010  | USART Status & Interrupt Flag Register | 0x0000_0180 |
| USRTPR   | 0x014  | USART Timing Parameter Register        | 0x0000_0000 |
| IrDACR   | 0x018  | USART IrDA Control Register            | 0x0000_0000 |
| RS485CR  | 0x01C  | USART RS485 Control Register           | 0x0000_0000 |
| SYNCR    | 0x020  | USART Synchronous Control Register     | 0x0000_0000 |
| USRDLR   | 0x024  | USART Divider Latch Register           | 0x0000_0010 |
| USRTSTR  | 0x028  | USART Test Register                    | 0x0000_0000 |

## Register Descriptions

### USART Data Register – USRDR

The register is used to access the USART transmitted and received FIFO data.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | Reserved |    |    |    |    |    |    | DB |    |
|            |          |    |    |    |    |    |    |    | 0  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | DB       |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            |          |    |    |    |    |    |    |    | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8:0] | DB    | <p>Reading data via this receiver buffer register will return the data from the receive FIFO. The receive FIFO has a capacity of up to 8 x 9 bits. By reading this register, the USART will return a 7, 8 and 9-bit received data. The DB field bit 8 is valid for 9-bit mode only and is fixed at 0 for the 8-bit mode. For the 7-bits mode, the DB[6:0] contains the available bits.</p> <p>Writing data to this buffer register will load data into the Transmit FIFO. The Transmit FIFO has a capacity of up to 8 x 9 bits. By writing to this register, the USART will send out 7, 8 or 9-bit transmitted data. The DB field bit 8 is valid for the 9-bit mode only and will be ignored for the 8-bit mode. For the 7-bit mode, the DB[6:0] contains the available bits.</p> |

## USART Control Register – USRCR

The register specifies the serial parameters such as data length, parity, and stop bit for the USART. It also contains the USART enable control bits together with the USART mode and data transfer mode selections.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |         |        |        |       |      |      |    |
|------------|----------|---------|--------|--------|-------|------|------|----|
|            | 31       | 30      | 29     | 28     | 27    | 26   | 25   | 24 |
| Type/Reset | Reserved |         |        |        |       |      |      |    |
|            | 23       | 22      | 21     | 20     | 19    | 18   | 17   | 16 |
| Type/Reset | Reserved |         |        |        |       |      |      |    |
|            | 15       | 14      | 13     | 12     | 11    | 10   | 9    | 8  |
| Type/Reset | RTS      | BCB     | SPE    | EPE    | PBE   | NSB  | WLS  |    |
|            | RW       | 0       | RW     | 0      | RW    | 0    | RW   | 0  |
|            | 7        | 6       | 5      | 4      | 3     | 2    | 1    | 0  |
| Type/Reset | RXDMAEN  | TXDMAEN | URRXEN | URTXEN | HFCEN | TRSM | MODE |    |
|            | RW       | 0       | RW     | 0      | RW    | 0    | RW   | 0  |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15] | RTS   | Request-To-Send Signal<br>0: Drive USART RTS pin to logic 1<br>1: Drive USART RTS pin to logic 0<br>Note that the RTS bit is used to control the USART RTS pin status when the HFCEN bit is reset.<br>When the HFCEN bit is set, this RTS bit indicates the pin status that is controlled by hardware flow control function.                                                                                |
| [14] | BCB   | Break Control Bit<br>When this bit is set 1, the serial data output on the USART TX pin will be forced to the Spacing State (logic 0). This bit acts only on USART TX output pin and has no effect on the transmitter logic.                                                                                                                                                                                |
| [13] | SPE   | Stick Parity Enable<br>0: Disable stick parity<br>1: Stick Parity bit is transmitted<br>This bit is only available when the PBE bit is set to 1. If both the PBE and SPE bits are set to 1 and the EPE bit is cleared to 0, the transmitted parity bit will be stuck to 1. However, when the PBE and SPE bits are set to 1 and also the EPE bit is set to 1, the transmitted parity bit will be stuck to 0. |
| [12] | EPE   | Even Parity Enable<br>0: Odd number of logic 1's are transmitted or checked in the data word and parity bits.<br>1: Even number of logic 1's are transmitted or checked in the data word and parity bits.<br>This bit is only available when PBE is set to 1.                                                                                                                                               |

| Bits  | Field   | Descriptions                                                                                                                                                                                                                                                                                  |
|-------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11]  | PBE     | Parity Bit Enable<br>0: Parity bit is not generated (transmitted data) or checked (receive data) during transfer.<br>1: Parity bit is generated or checked during transfer.<br>Note: When the WLS field is set to "10" to select the 9-bit data format, writing to the PBE bit has no effect. |
| [10]  | NSB     | Number of "STOP bit"<br>0: One "STOP bit" is generated in the transmitted data<br>1: Two "STOP bit" is generated when 8- and 9-bit word length is selected.                                                                                                                                   |
| [9:8] | WLS     | Word Length Select<br>00: 7 bits<br>01: 8 bits<br>10: 9 bits<br>11: Reserved                                                                                                                                                                                                                  |
| [7]   | RXDMAEN | USART RX DMA Enable<br>0: Disabled<br>1: Enabled                                                                                                                                                                                                                                              |
| [6]   | TXDMAEN | USART TX DMA Enable<br>0: Disabled<br>1: Enabled                                                                                                                                                                                                                                              |
| [5]   | URRXEN  | USART RX Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                                                                    |
| [4]   | URTXEN  | USART TX Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                                                                    |
| [3]   | HFCEN   | Hardware Flow Control Function Enable<br>0: Disabled<br>1: Enabled                                                                                                                                                                                                                            |
| [2]   | TRSM    | Transfer Mode Selection<br>This bit is used to select the data transfer protocol.<br>0: LSB first<br>1: MSB first                                                                                                                                                                             |
| [1:0] | MODE    | USART Mode Selection.<br>00: Normal operation<br>01: IrDA<br>10: RS485<br>11: Synchronous                                                                                                                                                                                                     |

## USART FIFO Control Register – USRFCR

This register specifies the USART FIFO control and configurations including threshold level and reset function together with the USART FIFO status.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |      |    |          |    |     |     |
|------------|----------|----|------|----|----------|----|-----|-----|
|            | 31       | 30 | 29   | 28 | 27       | 26 | 25  | 24  |
|            | Reserved |    |      |    | RXFS     |    |     |     |
| Type/Reset |          |    |      |    | RO       | 0  | RO  | 0   |
|            | 23       | 22 | 21   | 20 | 19       | 18 | 17  | 16  |
|            | Reserved |    |      |    | TXFS     |    |     |     |
| Type/Reset |          |    |      |    | RO       | 0  | RO  | 0   |
|            | 15       | 14 | 13   | 12 | 11       | 10 | 9   | 8   |
|            | Reserved |    |      |    |          |    |     |     |
| Type/Reset |          |    |      |    |          |    |     |     |
|            | 7        | 6  | 5    | 4  | 3        | 2  | 1   | 0   |
|            | RXTL     |    | TXTL |    | Reserved |    | RXR | TXR |
| Type/Reset | RW       | 0  | RW   | 0  | RW       | 0  | WO  | 0   |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                  |
|---------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [27:24] | RXFS  | <b>RX_FIFO Status</b><br>The RXFS field shows the current number of data contained in the RX_FIFO.<br>0000: RX_FIFO is empty<br>0001: RX_FIFO contains 1 data<br>...<br>1000: RX_FIFO contains 8 data<br>Others: Reserved                                     |
| [19:16] | TXFS  | <b>TX_FIFO Status</b><br>The TXFS field shows the current number of data contained in the TX_FIFO.<br>0000: TX_FIFO is empty<br>0001: TX_FIFO contains 1 data<br>...<br>1000: TX_FIFO contains 8 data<br>Others: Reserved                                     |
| [7:6]   | RXTL  | <b>RX_FIFO Threshold Level Setting</b><br>00: 1 byte<br>01: 2 bytes<br>10: 4 bytes<br>11: 6 bytes<br>The RXTL field defines the RX_FIFO trigger level.                                                                                                        |
| [5:4]   | TXTL  | <b>TX_FIFO Threshold Level Setting</b><br>00: 0 byte<br>01: 2 bytes<br>10: 4 bytes<br>11: 6 bytes<br>The TXTL field determines the TX_FIFO trigger level.                                                                                                     |
| [1]     | RXR   | <b>RX_FIFO Reset</b><br>Setting this bit will generate a reset pulse to reset the RX_FIFO which will empty the RX_FIFO, i.e., the RX pointer will be reset to 0 after a reset signal. This bit returns to 0 automatically after the reset pulse is generated. |

| Bits | Field | Descriptions                                                                                                                                                                                                                                       |
|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | TXR   | TX_FIFO Reset<br>Setting this bit will generate a reset pulse to reset TX_FIFO which will empty the TX_FIFO, i.e., the TX pointer will be reset to 0 after a reset signal. This bit returns to 0 automatically after the reset pulse is generated. |

## USART Interrupt Enable Register – USRIER

This register is used to enable the related USART interrupt function. The USART module generates interrupts to the controller when the corresponding events occur and the corresponding interrupt enable bits are set.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |     |      |      |      |       |        |        |
|------------|----------|-----|------|------|------|-------|--------|--------|
|            | 31       | 30  | 29   | 28   | 27   | 26    | 25     | 24     |
| Type/Reset | Reserved |     |      |      |      |       |        |        |
|            | 23       | 22  | 21   | 20   | 19   | 18    | 17     | 16     |
| Type/Reset | Reserved |     |      |      |      |       |        |        |
|            | 15       | 14  | 13   | 12   | 11   | 10    | 9      | 8      |
| Type/Reset | Reserved |     |      |      |      |       | CTSIE  | RXTOIE |
|            | 7        | 6   | 5    | 4    | 3    | 2     | 1      | 0      |
| Type/Reset | RSADDIE  | BIE | FEIE | PEIE | OEIE | TXCIE | TXDEIE | RXDRIE |
|            | RW       | 0   | RW   | 0    | RW   | 0     | RW     | 0      |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                 |
|------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9]  | CTSIE   | CTS Clear-To-Send Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the CTSC bit is set in the USRSIFR register.                                                                                                        |
| [8]  | RXTOIE  | Receive FIFO Time-Out Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>Receive FIFO Time-Out Interrupt means that receive FIFO is not empty and no activities have occurred in the receive FIFO during the time-out duration specified by the RXTOC field. |
| [7]  | RSADDIE | RS485 Address Detection Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the RSADD bit is set in the USRSIFR register.                                                                                                 |
| [6]  | BIE     | Break Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the BII bit is set in the USRSIFR register.                                                                                                                     |

| Bits | Field  | Descriptions                                                                                                                                                            |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | FEIE   | Framing Error Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the FEI bit is set in the URSIFR register.         |
| [4]  | PEIE   | Parity Error Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the PEI bit is set in the USRSIFR register.         |
| [3]  | OEIE   | Overrun Error Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the OEI bit is set in the USRSIFR register.        |
| [2]  | TXCIE  | Transmit Complete Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the TXC bit is set in the USRSIFR register.    |
| [1]  | TXDEIE | Transmit Data Empty Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the TXDE bit is set in the USRSIFR register. |
| [0]  | RXDRIE | Receive Data Ready Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt will be generated when the RXDR bit is set in the USRSIFR register.  |

## USART Status & Interrupt Flag Register – USRSIFR

This register contains the corresponding USART status.

Offset: 0x010

Reset value: 0x0000\_0180

|            |          |       |      |     |      |      |        |       |
|------------|----------|-------|------|-----|------|------|--------|-------|
|            | 31       | 30    | 29   | 28  | 27   | 26   | 25     | 24    |
| Type/Reset | Reserved |       |      |     |      |      |        |       |
|            | 23       | 22    | 21   | 20  | 19   | 18   | 17     | 16    |
| Type/Reset | Reserved |       |      |     |      |      |        |       |
|            | 15       | 14    | 13   | 12  | 11   | 10   | 9      | 8     |
| Type/Reset | Reserved |       |      |     | CTSS | CTSC | RSADDE | TXC   |
|            | 7        | 6     | 5    | 4   | 3    | 2    | 1      | 0     |
| Type/Reset | TXDE     | RXTOF | RXDR | BII | FEI  | PEI  | OEI    | RXDNE |
|            | RO       | 1     | W1C  | 0   | RO   | 0    | W1C    | 0     |
|            | RO       | 0     | W1C  | 0   | W1C  | 0    | W1C    | 0     |
|            | RO       | 0     | W1C  | 0   | W1C  | 0    | W1C    | 0     |
|            | RO       | 0     | W1C  | 0   | W1C  | 0    | W1C    | 0     |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                              |
|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11] | CTSS  | CTS Clear-To-Send Status<br>0: CTS pin is inactive<br>1: CTS pin is active and kept at a logic low state                                                                                                                                                                                                                                                                                                                  |
| [10] | CTSC  | CTS Status Change Flag<br>This bit will be set whenever the CTS input pin status is changed and an Interrupt will be generated if the CTSIE = 1 in the USRIER register. Writing 1 to this bit clears the flag.                                                                                                                                                                                                            |
| [9]  | RSADD | RS485 Address Detection<br>0: Address is not detected<br>1: Address is detected<br>This bit will be set to 1 when the receiver detects the address. An interrupt will be generated if RSADDIE = 1 in the USRIER register. Writing 1 to this bit clears the flag.<br>Note: This bit is only used in the RS485 mode by setting the MODE field in the USRCR register.                                                        |
| [8]  | TXC   | Transmit Complete<br>0: Either transmit FIFO (TX_FIFO) or transmit shift register (TSR) is not empty<br>1: Both the TX_FIFO and TSR register are empty<br>An interrupt will be generated if TXCIE=1 in the USRIER register. This bit is cleared by a write to the USRDR register with new data.                                                                                                                           |
| [7]  | TXDE  | Transmit Data FIFO Empty<br>0: TX_FIFO level is higher than threshold<br>1: TX_FIFO level is less than threshold<br>The TXDE bit will be set when transmit FIFO level is less than the transmit FIFO threshold level setting which is set by the TXTL field in the USRFCR register. This bit will be cleared when the new data is written into the USRDR register and the TX_FIFO level is higher than threshold setting. |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | RXTOF | Receive FIFO Time-Out Flag<br>0: RX_FIFO Time-Out does not occur.<br>1: RX_FIFO Time-Out occurs.<br>This bit is clear when RX_FIFO is empty.                                                                                                                                                                                                                                                                                                            |
| [5]  | RXDR  | Receive FIFO Ready Flag<br>0: RX_FIFO level is less than threshold<br>1: RX_FIFO level is higher than threshold<br>The RXDR bit will be set when the FIFO received data amount reaches the specified threshold level which is set by the RXTL field in the USRFCR register. This bit will be cleared when the data is read from the USRDNR register and the RX_FIFO level is less than threshold setting.                                               |
| [4]  | BII   | Break Interrupt Indicator<br>This bit will be set to 1 whenever the received data input is held in the “spacing state” (logic 0) for longer than a full word transmission time, which is the total time of “start bit” + “data bits” + “parity” + “stop bits” duration. Writing 1 to this bit clears the flag.                                                                                                                                          |
| [3]  | FEI   | Framing Error Indicator<br>This bit will be set to 1 whenever the received character does not have a valid “stop bit”, which means the stop bit following the last data bit or parity bit is detected as a logic 0. Writing 1 to this bit clears the flag.                                                                                                                                                                                              |
| [2]  | PEI   | Parity Error Indicator<br>This bit will be set to 1 whenever the received character does not have a valid “parity bit”. Writing 1 to this bit clears the flag.                                                                                                                                                                                                                                                                                          |
| [1]  | OEI   | Overrun Error Indicator<br>An overrun error will occur only after the RX_FIFO is full and when the next character has been completely received in the RX shift register. The character in the shift register is overwritten when an overrun event occurs, but the data in the RX shift register will not be transferred to the RX_FIFO. The OEI bit is used to indicate the overrun event as soon as it happens. Writing 1 to this bit clears the flag. |
| [0]  | RXDNE | RX_FIFO Data Not Empty<br>0: RX_FIFO is empty<br>1: RX_FIFO contains at least 1 received data word                                                                                                                                                                                                                                                                                                                                                      |

## USART Timing Parameter Register – USRTPR

This register contains the USART timing parameters including the transmitter time guard parameters and the receive FIFO time-out value together with the RX\_FIFO time-out function enable control.

Offset: 0x014

Reset value: 0x0000\_0000

|            |              |    |    |    |    |    |    |    |
|------------|--------------|----|----|----|----|----|----|----|
|            | 31           | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved     |    |    |    |    |    |    |    |
|            | 23           | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved     |    |    |    |    |    |    |    |
|            | 15           | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | TG           |    |    |    |    |    |    |    |
|            | RW           | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | 7            | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | RW           | 0  | RW | 0  | RW | 0  | RW | 0  |
|            | RXTOEN RXTOC |    |    |    |    |    |    |    |
|            | RW           | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:8] | TG     | Transmitter Time Guard<br>The transmitter time guard counter is driven by the baud rate clock. When the TX_FIFO transmits data, the counter will be reset and then starts to count. Only when the counter content is equal to the TG value, are further word transmission transactions allowed.                                                                                                                                                                                                                  |
| [7]    | RXTOEN | Receive FIFO Time-Out Counter Enable<br>0: Receive FIFO Time-Out Counter is disabled<br>1: Receive FIFO Time-Out Counter is enabled                                                                                                                                                                                                                                                                                                                                                                              |
| [6:0]  | RXTOC  | Receive FIFO Time-Out Counter Compare Value<br>The RX_FIFO time-out counter is driven by the baud rate clock. When the RX_FIFO receives new data, the counter will be reset and then starts to count. Once the time-out counter content is equal to the time-out counter compare value RXTOC, a receive FIFO time-out interrupt, RXTOI, will be generated if the RXTOIE bit in the USRIER register is set to 1. New received data or the empty RX_FIFO after being read will clear the RX_FIFO time-out counter. |

## USART IrDA Control Register – IrDACR

This register is used to control the IrDA mode of USART.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |    |       |       |    |       |        |        |    |
|------------|----------|----|-------|-------|----|-------|--------|--------|----|
|            | 31       | 30 | 29    | 28    | 27 | 26    | 25     | 24     |    |
| Type/Reset | Reserved |    |       |       |    |       |        |        |    |
|            | 23       | 22 | 21    | 20    | 19 | 18    | 17     | 16     |    |
| Type/Reset | Reserved |    |       |       |    |       |        |        |    |
|            | 15       | 14 | 13    | 12    | 11 | 10    | 9      | 8      |    |
| Type/Reset | IrDAPSC  |    |       |       |    |       |        |        |    |
|            | RW       | 0  | RW    | 0     | RW | 0     | RW     | 0      | RW |
|            | 7        | 6  | 5     | 4     | 3  | 2     | 1      | 0      |    |
| Type/Reset | Reserved |    | RXINV | TXINV | LB | TXSEL | IrDALP | IrDAEN |    |
|            |          |    | RW    | 0     | RW | 0     | RW     | 0      | RW |

| Bits   | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:8] | IrDAPSC | <p>IrDA Prescaler value</p> <p>This field contains the 8-bit debounce prescaler value.</p> <p>The debounce count-down counter is driven by the USART clock, named as CK_USART. The counting period is specified by the IrDAPSC field. The IrDAPSC field must be set to a value equal to or greater than 0x01 for normal debounce counter operation. If the pulse width is less than the duration specified by the IrDAPSC field, the pulse will be considered as glitch noise and discarded.</p> <p>00000000: Reserved – can not be used.<br/> 00000001: CK_USART clock divided by 1<br/> 00000010: CK_USART clock divided by 2<br/> 00000011: CK_USART clock divided by 3<br/> ...</p> |
| [5]    | RXINV   | <p>RX Signal Inverse Control</p> <p>0: No inversion<br/> 1: RX input signal is inverted</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| [4]    | TXINV   | <p>TX Signal Inverse Control</p> <p>0: No inversion<br/> 1: TX output signal is inverted</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| [3]    | LB      | <p>IrDA Loop Back Mode</p> <p>0: Disable IrDA loop back mode<br/> 1: Enable IrDA loop back mode for self testing.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| [2]    | TXSEL   | <p>Transmit Select</p> <p>0: Enable IrDA receiver<br/> 1: Enable IrDA transmitter</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| [1]    | IrDALP  | <p>IrDA Low Power Mode</p> <p>Select the IrDA operation mode.</p> <p>0: Normal mode<br/> 1: IrDA low power mode</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

| Bits | Field  | Descriptions                                                       |
|------|--------|--------------------------------------------------------------------|
| [0]  | IrDAEN | IrDA Enable control<br>0: Disable IrDA mode<br>1: Enable IrDA mode |

## USART RS485 Control Register – RS485CR

This register is used to control the RS485 mode of USART.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |       |       |       |
|------------|----------|----|----|----|----|-------|-------|-------|
|            | 31       | 30 | 29 | 28 | 27 | 26    | 25    | 24    |
|            | Reserved |    |    |    |    |       |       |       |
| Type/Reset |          |    |    |    |    |       |       |       |
|            | 23       | 22 | 21 | 20 | 19 | 18    | 17    | 16    |
|            | Reserved |    |    |    |    |       |       |       |
| Type/Reset |          |    |    |    |    |       |       |       |
|            | 15       | 14 | 13 | 12 | 11 | 10    | 9     | 8     |
|            | ADDMATCH |    |    |    |    |       |       |       |
| Type/Reset | RW 0     |    |    |    |    |       |       |       |
|            | 7        | 6  | 5  | 4  | 3  | 2     | 1     | 0     |
|            | Reserved |    |    |    |    | RSAAD | RSNMM | TXENP |
| Type/Reset |          |    |    |    | RW | 0     | RW    | 0     |

| Bits   | Field    | Descriptions                                                                                                                                      |
|--------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:8] | ADDMATCH | RS485 Auto Address Match value<br>The field contains the address match value for the RS485 auto address detection operation mode.                 |
| [2]    | RSAAD    | RS485 Auto Address Detection Operation Mode Control<br>0: Disable<br>1: Enable                                                                    |
| [1]    | RSNMM    | RS485 Normal Multi-drop Operation Mode Control<br>0: Disable<br>1: Enable                                                                         |
| [0]    | TXENP    | USART RTS/TXE Pin Polarity<br>0: RTS/TXE is active high in the RS485 transmission mode<br>1: RTS/TXE is active low in the RS485 transmission mode |

## USART Synchronous Control Register – SYNCR

This register is used to control the USART synchronous mode.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |     |     |          |       |
|------------|----------|----|----|----|-----|-----|----------|-------|
|            | 31       | 30 | 29 | 28 | 27  | 26  | 25       | 24    |
| Type/Reset | Reserved |    |    |    |     |     |          |       |
|            | 23       | 22 | 21 | 20 | 19  | 18  | 17       | 16    |
| Type/Reset | Reserved |    |    |    |     |     |          |       |
|            | 15       | 14 | 13 | 12 | 11  | 10  | 9        | 8     |
| Type/Reset | Reserved |    |    |    |     |     |          |       |
|            | 7        | 6  | 5  | 4  | 3   | 2   | 1        | 0     |
| Type/Reset | Reserved |    |    |    | CPO | CPS | Reserved | CLKEN |
|            |          |    |    |    | RW  | 0   | RW       | 0     |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                 |
|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | CPO   | <p>Clock Polarity</p> <p>0: CTS/SCK pin idle state is low.<br/>1: CTS/SCK pin idle state is high.</p> <p>Selects the polarity of the clock output on the USART CTS/SCK pin in the synchronous mode. Works in conjunction with the CPS bit to specify the desired clock idle state.</p>                                       |
| [2]  | CPS   | <p>Clock Phase</p> <p>0: Data is captured on the first clock edge.<br/>1: Data is captured on the second clock edge.</p> <p>This bit allows the user to select the phase of the clock output on the USART CTS/SCK pin in the synchronous mode. Works in conjunction with the CPO bit to determine the data capture edge.</p> |
| [0]  | CLKEN | <p>Clock Enable</p> <p>0: CTS/SCK pin disabled<br/>1: CTS/SCK pin enabled</p> <p>Enable/disable the USART CTS/SCK pin.</p>                                                                                                                                                                                                   |

## USART Divider Latch Register – USRDLR

The register is used to determine the USART clock divided ratio to generate the appropriate baud rate.

Offset: 0x024

Reset value: 0x0000\_0010

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | BRD      |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | BRD      |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                               |
|--------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | BRD   | <p>Baud Rate Divider</p> <p>The 16 bits define the USART clock divider ratio.</p> <p>Baud Rate = CK_USART / BRD</p> <p>Where the CK_USART clock is the clock connected to the USART module.</p> <p>BRD = 16 ~ 65536 for asynchronous mode</p> <p>BRD = 8 ~ 65535 for synchronous mode.</p> |

## USART Test Register – USRTSTR

This register controls the USART debug mode.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |    |    |    | RW | 0  |
|            |          |    |    |    |    |    | RW | 0  |

| Bits  | Field | Descriptions                                                                                                      |
|-------|-------|-------------------------------------------------------------------------------------------------------------------|
| [1:0] | LBM   | Loopback Test Mode Select<br>00: Normal Operation<br>01: Reserved<br>10: Automatic Echo Mode<br>11: Loopback Mode |

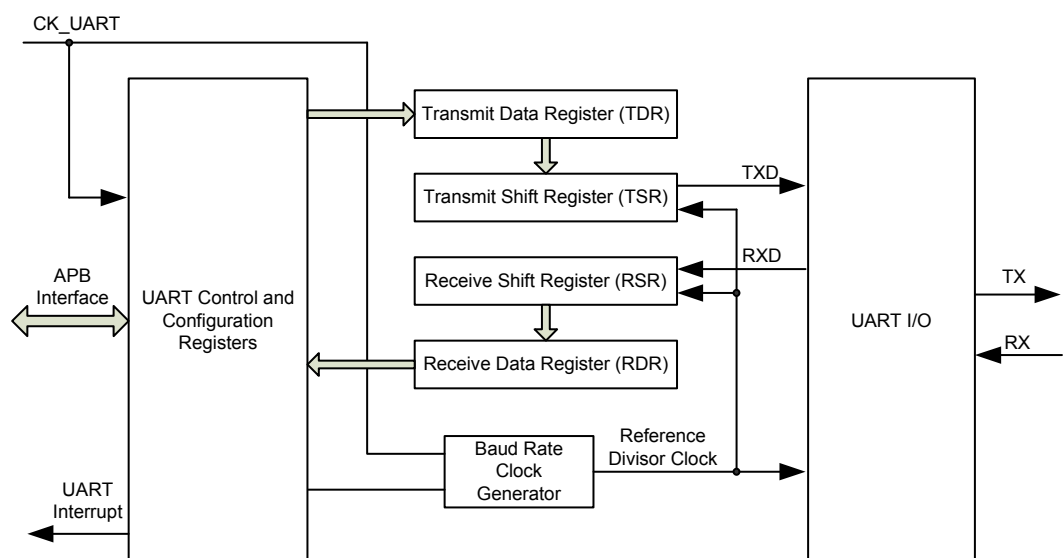
# 23 Universal Asynchronous Receiver Transmitter (UART)

## Introduction

The Universal Asynchronous Receiver Transceiver, UART, provides a flexible full duplex data exchange using asynchronous transfer. The UART is used to translate data between parallel and serial interfaces, and is also commonly used for RS232 standard communication. The UART peripheral function supports a variety of interrupts.

The UART module includes a transmit data register TDR and transmit shift register TSR, and a receive data register RDR and receive shift register RSR. Software can detect a UART error status by reading UART Status & Interrupt Flag Register, URSIFR. The status includes the condition of the transfer operations as well as several error conditions resulting from Parity, Overrun, Framing and Break events.

The UART includes a programmable baud rate generator which is capable of dividing the UART clock of the CK\_APB (CK\_UART) to produce a baud rate clock for the UART transmitter and receiver.



**Figure 171. UART Block Diagram**

## Features

- Supports asynchronous serial communication modes
- Full Duplex Communication Capability
- Programming baud rate up to 3 Mbit/s.
- Fully programmable serial communication functions including:
  - Word length: 7, 8, or 9-bit character
  - Parity: Even, odd, or no-parity bit generation and detection
  - Stop bit: 1 or 2 stop bit generation
  - Bit order: LSB-first or MSB-first transfer
- Error detection: Parity, overrun, and frame error
- Supports PDMA Interface

## Function Descriptions

### Serial Data Format

The UART module performs a parallel-to-serial conversion on data that is written to the transmit data register and then sends the data with the following format: Start bit, 7 ~ 9 LSB first data bits, optional Parity bit and finally 1 ~ 2 Stop bits. The Start bit has the opposite polarity of the data line idle state. The Stop bit is the same as the data line idle state and provides a delay before the next start situation. The both Start and Stop bits are used for data synchronization during the asynchronous data transmission.

The UART module also performs a serial-to-parallel conversion on the data that is read from the receive data register. It will first check the Parity bit and will then look for a Stop bit. If the Stop bit is not found, the UART module will consider the entire word transmission to have failed and respond with a Framing Error.

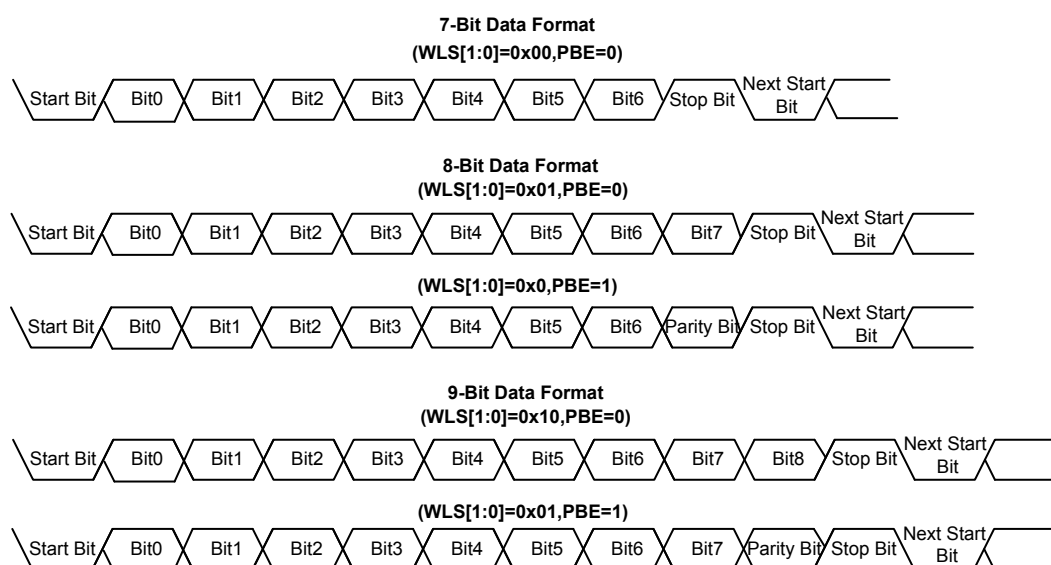


Figure 172. UART Serial Data Format

## Baud Rate Generation

The baud rate for the UART receiver and transmitter are both set with the same values. The baud-rate divisor, BRD, has the following relationship with the UART clock which is known as CK\_UART.

$$\text{Baud Rate Clock} = \text{CK\_UART} / \text{BRD}$$

Where CK\_UART clock is the APB clock connected to the UART while the BRD range is from 16 to 65535.

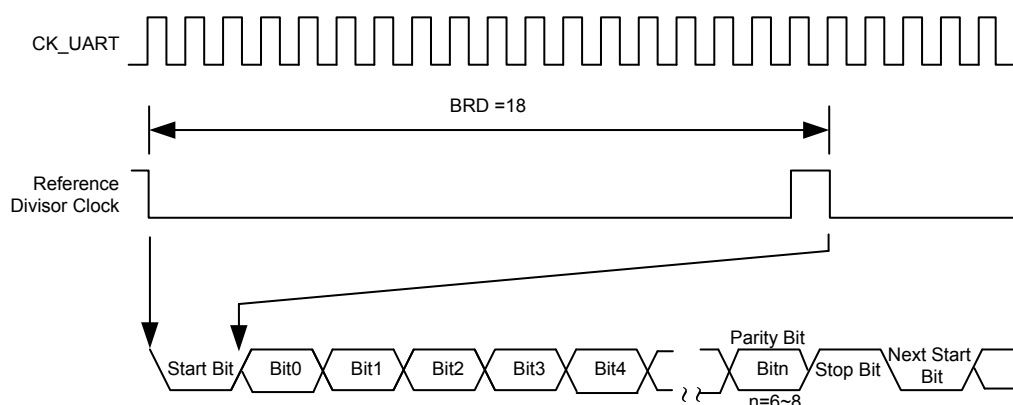


Figure 173. UART Clock CK\_UART and Data Frame Timing

Table 56. Baud Rate Deviation Error Calculation – CK\_USART = 40 MHz

| Baud rate |       | CK_UART = 40 MHz |       |                      |
|-----------|-------|------------------|-------|----------------------|
| No        | Kbps  | Actual           | BRD   | Deviation Error rate |
| 1         | 2.4   | 2.4              | 16667 | 0.00%                |
| 2         | 9.6   | 9.6              | 4167  | -0.01%               |
| 3         | 19.2  | 19.2             | 2083  | 0.02%                |
| 4         | 57.6  | 57.6             | 694   | 0.06%                |
| 5         | 115.2 | 115.3            | 347   | 0.06%                |
| 6         | 230.4 | 229.9            | 174   | -0.22%               |
| 7         | 460.8 | 459.8            | 87    | -0.22%               |
| 8         | 921.6 | 930.2            | 43    | 0.94%                |
| 9         | 2250  | 2222.2           | 18    | -1.23%               |
| 10        | 3000  | 3076.9           | 13    | 2.56%                |

**Table 57. Baud Rate Deviation Error Calculation – CK\_UART = 48 MHz**

| Baud rate |       | CK_UART = 48 MHz |       |                      |
|-----------|-------|------------------|-------|----------------------|
| No        | Kbps  | Actual           | BRD   | Deviation Error rate |
| 1         | 2.4   | 2.4              | 20000 | 0.00%                |
| 2         | 9.6   | 9.6              | 5000  | 0.00%                |
| 3         | 19.2  | 19.2             | 2500  | 0.00%                |
| 4         | 57.6  | 57.6             | 833   | 0.04%                |
| 5         | 115.2 | 115.1            | 417   | -0.08%               |
| 6         | 230.4 | 230.8            | 208   | 0.16%                |
| 7         | 460.8 | 461.5            | 104   | 0.16%                |
| 8         | 921.6 | 923.1            | 52    | 0.16%                |
| 9         | 2250  | 2285.7           | 21    | 1.59%                |
| 10        | 3000  | 3000             | 16    | 0.00%                |

## Interrupts and Status

The UART can generate interrupts when the following event occurs and corresponding interrupt enable bits are set:

- Receiver line status interrupts: The interrupts are generated when the overrun error, parity error, framing error or break event occurs for the UART receiver.
- Transmit data register empty interrupt: An interrupt is generated when the content of the transmit data register is transferred to the transmit shift register (TSR).
- Transmit complete interrupt: An interrupt is generated when the transmit data register (TDR) is empty and the content of the transmit shift register (TSR) is also completely shifted.
- Receive data ready interrupt: An interrupt is generated when the content of the receive shift register RDR has been transferred to the URDR register and is ready to read.

## PDMA Interface

The PDMA interface is integrated in the UART. The PDMA function can be enabled by setting the TXDMAEN or RXDMAEN bit in the URCR register to 1 in the transmit or receive mode respectively. When the UART transmit data register TDR is empty and the TXDMAEN bit is set to 1, the PDMA function will be activated to move data from a source location into the UART transmit data register TDR.

Similarly, when the received data has been in the UART receive data register RDR and the RXDMAEN bit is set to 1, the PDMA function will be activated to move data from the UART receive data register RDR to a specific destination location. For a more detailed description on the PDMA configurations, refer to the PDMA chapter.

## Register Map

The following table shows the UART registers and reset values.

**Table 58. UART Register Map**

| Register | Offset | Description                           | Reset Value |
|----------|--------|---------------------------------------|-------------|
| URDR     | 0x000  | UART Data Register                    | 0x0000_0000 |
| URCR     | 0x004  | UART Control Register                 | 0x0000_0000 |
| URIER    | 0x00C  | UART Interrupt Enable Register        | 0x0000_0000 |
| URSIFR   | 0x010  | UART Status & Interrupt Flag Register | 0x0000_0180 |
| URDLR    | 0x024  | UART Divider Latch Register           | 0x0000_0010 |
| URTSTR   | 0x028  | UART Test Register                    | 0x0000_0000 |

## Register Descriptions

### UART Data Register – URDR

The register is used to access the UART transmitted and received data.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    | DB |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | DB       |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8:0] | DB    | <p>By reading this register, the UART will return a 7, 8 and 9-bit received data. The DB field bit 8 is valid for 9-bit mode only and is fixed at 0 for the 8-bit mode. For the 7-bits mode, the DB[6:0] contains the available bits.</p> <p>By writing to this register, the UART will send out 7, 8 or 9-bit transmitted data. The DB field bit 8 is valid for the 9-bit mode only and will be ignored for the 8-bit mode. For the 7-bit mode, the DB[6:0] contains the available bits.</p> |

## UART Control Register – URCR

The register specifies the serial parameters such as data length, parity, and stop bit for the UART.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |         |        |        |          |      |          |    |   |    |   |    |   |
|------------|----------|---------|--------|--------|----------|------|----------|----|---|----|---|----|---|
|            | 31       | 30      | 29     | 28     | 27       | 26   | 25       | 24 |   |    |   |    |   |
| Type/Reset | Reserved |         |        |        |          |      |          |    |   |    |   |    |   |
|            | 23       | 22      | 21     | 20     | 19       | 18   | 17       | 16 |   |    |   |    |   |
| Type/Reset | Reserved |         |        |        |          |      |          |    |   |    |   |    |   |
|            | 15       | 14      | 13     | 12     | 11       | 10   | 9        | 8  |   |    |   |    |   |
| Type/Reset | Reserved | BCB     | SPE    | EPE    | PBE      | NSB  | WLS      |    |   |    |   |    |   |
|            |          | RW      | 0      | RW     | 0        | RW   | 0        | RW | 0 | RW | 0 | RW | 0 |
|            | 7        | 6       | 5      | 4      | 3        | 2    | 1        | 0  |   |    |   |    |   |
| Type/Reset | RXDMAEN  | TXDMAEN | URRXEN | URTXEN | Reserved | TRSM | Reserved |    |   |    |   |    |   |
|            | RW       | 0       | RW     | 0      | RW       | 0    | RW       | 0  |   |    |   |    |   |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [14] | BCB   | Break Control Bit<br>When this bit is set 1, the serial data output on the UART TX pin will be forced to the Spacing State (logic 0). This bit acts only on UART TX output pin and has no effect on the transmitter logic.                                                                                                                                                                                  |
| [13] | SPE   | Stick Parity Enable<br>0: Disable stick parity<br>1: Stick Parity bit is transmitted<br>This bit is only available when the PBE bit is set to 1. If both the PBE and SPE bits are set to 1 and the EPE bit is cleared to 0, the transmitted parity bit will be stuck to 1. However, when the PBE and SPE bits are set to 1 and also the EPE bit is set to 1, the transmitted parity bit will be stuck to 0. |
| [12] | EPE   | Even Parity Enable<br>0: Odd number of logic 1's are transmitted or checked in the data word and parity bits.<br>1: Even number of logic 1's are transmitted or checked in the data word and parity bits.<br>This bit is only available when PBE is set to 1.                                                                                                                                               |
| [11] | PBE   | Parity Bit Enable<br>0: Parity bit is not generated (transmitted data) and checked (receive data) during transfer.<br>1: Parity bit is generated and checked during transfer.<br>Note: When the WLS field is set to "10" to select the 9-bit data format, writing to the PBE bit has no effect.                                                                                                             |
| [10] | NSB   | Number of "STOP bit"<br>0: One "STOP bit" is generated in the transmitted data<br>1: Two "STOP bit" is generated when 8- and 9-bit word length is selected.                                                                                                                                                                                                                                                 |

| Bits  | Field   | Descriptions                                                                                                      |
|-------|---------|-------------------------------------------------------------------------------------------------------------------|
| [9:8] | WLS     | Word Length Select<br>00: 7 bits<br>01: 8 bits<br>10: 9 bits<br>11: Reserved                                      |
| [7]   | RXDMAEN | UART RX DMA Enable<br>0: Disabled<br>1: Enabled                                                                   |
| [6]   | TXDMAEN | UART TX DMA Enable<br>0: Disabled<br>1: Enabled                                                                   |
| [5]   | URRXEN  | UART RX Enable<br>0: Disable<br>1: Enable                                                                         |
| [4]   | URTXEN  | UART TX Enable<br>0: Disable<br>1: Enable                                                                         |
| [2]   | TRSM    | Transfer Mode Selection<br>This bit is used to select the data transfer protocol.<br>0: LSB first<br>1: MSB first |

## UART Interrupt Enable Register – URIER

This register is used to enable the related UART interrupt function. The UART module generates interrupts to the controller when the corresponding events occur and the corresponding interrupt enable bits are set.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |     |      |      |      |       |        |        |
|------------|----------|-----|------|------|------|-------|--------|--------|
|            | 31       | 30  | 29   | 28   | 27   | 26    | 25     | 24     |
| Type/Reset | Reserved |     |      |      |      |       |        |        |
|            | 23       | 22  | 21   | 20   | 19   | 18    | 17     | 16     |
| Type/Reset | Reserved |     |      |      |      |       |        |        |
|            | 15       | 14  | 13   | 12   | 11   | 10    | 9      | 8      |
| Type/Reset | Reserved |     |      |      |      |       |        |        |
|            | 7        | 6   | 5    | 4    | 3    | 2     | 1      | 0      |
| Type/Reset | Reserved | BIE | FEIE | PEIE | OEIE | TXCIE | TXDEIE | RXDRIE |
|            |          | RW  | 0    | RW   | 0    | RW    | 0      | RW     |
|            |          |     | 0    |      | 0    |       | 0      |        |
|            |          |     |      | 0    |      | 0     |        | 0      |

| Bits | Field | Descriptions                                                                                                                                                                                                  |
|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | BIE   | Break Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the break interrupt is enabled and the BII bit is set in the URSIFR register.                         |
| [5]  | FEIE  | Framing Error Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the framing error interrupt is enabled and the FEI bit is set in the URSIFR register.         |
| [4]  | PEIE  | Parity Error Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the parity error interrupt is enabled and the PEI bit is set in the URSIFR register.           |
| [3]  | OEIE  | Overrun Error Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the overrun error interrupt is enabled and the OEI bit is set in the URSIFR register.         |
| [2]  | TXCIE | Transmit Complete Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the transmit complete interrupt is enabled and the TXC bit is set in the URSIFR register. |

| Bits | Field  | Descriptions                                                                                                                                                                                                                         |
|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | TXDEIE | Transmit Data Register Empty Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the transmit data register empty interrupt is enabled and the TXDE bit is set in the URSIFR register. |
| [0]  | RXDRIE | Receive Data Ready Interrupt Enable<br>0: Disable interrupt<br>1: Enable interrupt<br>An interrupt is generated when the receive data ready interrupt is enabled and the RXDR bit is set in the URSIFR register.                     |

### UART Status & Interrupt Flag Register – URSIFR

This register contains the corresponding UART status.

Offset: 0x010

Reset value: 0x0000\_0180

|            |          |          |      |     |     |     |     |          |     |
|------------|----------|----------|------|-----|-----|-----|-----|----------|-----|
|            | 31       | 30       | 29   | 28  | 27  | 26  | 25  | 24       |     |
| Type/Reset | Reserved |          |      |     |     |     |     |          |     |
|            | 23       | 22       | 21   | 20  | 19  | 18  | 17  | 16       |     |
| Type/Reset | Reserved |          |      |     |     |     |     |          |     |
|            | 15       | 14       | 13   | 12  | 11  | 10  | 9   | 8        |     |
| Type/Reset | Reserved |          |      |     |     |     |     | TXC      |     |
|            | 7        | 6        | 5    | 4   | 3   | 2   | 1   | 0        |     |
| Type/Reset | TXDE     | Reserved | RXDR | BII | FEI | PEI | OEI | Reserved |     |
|            | RO       | 1        | RO   | 0   | W1C | 0   | W1C | 0        | W1C |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                           |
|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | TXC   | Transmit Complete<br>0: Either the transmit data register (TDR) or transmit shift register (TSR) is not empty.<br>1: Both the transmit data register (TDR) and transmit shift register (TSR) are empty.<br>An interrupt is generated if TXCIE=1 in the URIER register. This bit is cleared by a write to the URDR register with new data.                                              |
| [7]  | TXDE  | Transmit Data Register Empty<br>0: Transmit data register is not empty.<br>1: Transmit data register is empty.<br>The TXDE bit is set by hardware when the content of the transmit data register is transferred to the transmit shift register (TSR). An interrupt is generated if TXEIE=1 in the URIER register. This bit is cleared by a write to the URDR register with a new data. |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | RXDR  | <p>RX Data Ready</p> <p>0: Receive data register is empty<br/>1: Received data in the receive data register is ready to read.</p> <p>This bit is set by hardware when the content of the receive shift register RDR has been transferred to the URDR register. It is cleared by a read to the URDR register. An interrupt is generated if RXDRIE=1 in the URIER register.</p>                                                                                                                                         |
| [4]  | BII   | <p>Break Interrupt Indicator</p> <p>This bit is set to 1 whenever the received data input is held in the "spacing state" (logic 0) for longer than a full character transmission time, which is the total time of "start bit" + "data bits" + "parity" + "stop bits" duration. Writing 1 to this bit clears the flag.</p>                                                                                                                                                                                             |
| [3]  | FEI   | <p>Framing Error Indicator</p> <p>This bit is set 1 whenever the received character does not have a valid "stop bit", which means the stop bit following the last data bit or parity bit is detected as logic 0. Writing 1 to this bit clears the flag.</p>                                                                                                                                                                                                                                                           |
| [2]  | PEI   | <p>Parity Error Indicator</p> <p>This bit is set to 1 whenever the received character does not have a valid "parity bit". Writing 1 to this bit clears the flag.</p>                                                                                                                                                                                                                                                                                                                                                  |
| [1]  | OEI   | <p>Overrun Error Indicator</p> <p>An overrun error will occur only after the receive data register is full and when the next character has been completely received in the receive shift register. The character in the receive shift register will be overwritten when an overrun event occurs. But the data in the receive shift register will not be transferred to the receive data register. The OEI bit is used to indicate the overrun event as soon as it happens. Writing 1 to this bit clears the flag.</p> |

## UART Divider Latch Register – URDLR

The register is used to determine the UART clock divided ratio to generate the appropriate baud rate.

Offset: 0x024

Reset value: 0x0000\_0010

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | BRD      |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | BRD      |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                      |
|--------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:0] | BRD   | <p>Baud Rate Divider</p> <p>The 16 bits define the UART clock divider ratio.</p> <p>Baud Rate = CK_UART / BRD</p> <p>Where the CK_UART clock is the clock connected to the UART module.</p> <p>BRD = 16 ~ 65536 for UART mode</p> |

## UART Test Register – URTSTR

This register controls the UART debug mode.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |     |        |
|------------|----------|----|----|----|----|----|-----|--------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25  | 24     |
| Type/Reset | Reserved |    |    |    |    |    |     |        |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17  | 16     |
| Type/Reset | Reserved |    |    |    |    |    |     |        |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9   | 8      |
| Type/Reset | Reserved |    |    |    |    |    |     |        |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1   | 0      |
| Type/Reset | Reserved |    |    |    |    |    | LBM |        |
|            |          |    |    |    |    |    | RW  | 0 RW 0 |

| Bits  | Field | Descriptions                                                                                                      |
|-------|-------|-------------------------------------------------------------------------------------------------------------------|
| [1:0] | LBM   | Loopback Test Mode Select<br>00: Normal Operation<br>01: Reserved<br>10: Automatic Echo Mode<br>11: Loopback Mode |

## 24 Smart Card Interface (SCI)

### Introduction

The Smart Card Interface, SCI, is compatible with the ISO 7816-3 standard. This interface includes functions for card Insertion/Removal detection, SCI data transfer control logic and data buffers, internal Timer Counters and corresponding control logic circuits to perform the required Smart Card operations. The Smart Card interface acts as a Smart Card Reader to facilitate communication with the external Smart Card. The overall functions of the Smart Card interface are controlled by a series of registers including control and status registers together with several corresponding interrupts which are generated to get the attention of the microcontroller for SCI transfer status.

As the complexity of ISO7816-3 standard data protocol does not permit comprehensive specifications to be provided in this datasheet, the reader should therefore consult other external information for a detailed understanding of this standard.

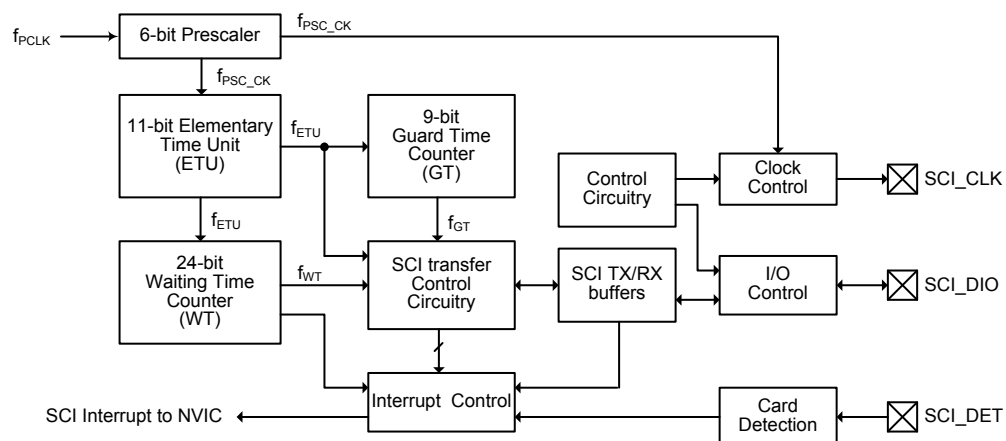


Figure 174. SCI Block Diagram

## Features

- Supports ISO 7816-3 standard
- Character Transfer Mode
- 1 transmit buffer and 1 receive buffer
- 11-bit ETU (elementary time unit) counter
- 9-bit guard time counter
- 24-bit general purpose waiting time counter
- Parity generation and checking
- Automatic character repetition on parity error detection in transmission and reception modes
- Supports PDMA access at a transmission or reception completion

## Functional Descriptions

To communicate with an external Smart Card, the integrated Smart Card Interface has a series of external pins known as SCI\_CLK, SCI\_DIO and SCI\_DET. The SCI\_CLK pin is the clock output signal used to communicate with the external Smart Card together with the serial data pin named SCI\_DIO. The operation of the SCI\_CLK and SCI\_DIO pins can be selected to be the SCI data Transfer Mode which is driven automatically by the SCI control circuits or to be the Manual mode which is controlled by configuring the internal CLK and DIO register bits respectively by the application program. The SCI\_DET pin is the external card detection input pin. Insertion or removal of the external Smart Card can be automatically detected and generate an interrupt signal which is sent to the microcontroller if the corresponding interrupt function is enabled.

For proper data transfer, some timing related procedures must be executed before the Smart Card Interface can begin to communicate with the external card. There are three counters named Elementary Time Unit, ETU, Guard Time Counter, GT, and Waiting Time Counter, WT, which are used for the timing related functions in Smart Card Interface data transfer operations.

### Elementary Time Unit Counter

The Elementary Time Unit, ETU, is an 11-bit up-counting counter which generates a clock denoted as  $f_{ETU}$  to be used as the operating frequency source for the SCI data transmission and reception. The clock source of the ETU comes from the Smart Card clock, named  $f_{PSC\_CK}$ , which is derived from the 6-bit prescaler. The data transfer of the SCI is a character frame based protocol, which basically consists of a Start bit, 8-bits of data and a Parity bit. The time period,  $t_{ETU}$  ( $1/f_{ETU}$ ), generated by the ETU, is the time unit for a character bit. There is a register related to the Elementary Time Unit known as the ETUR register which stores the expected contents of the ETU. Each time the ETUR register is written, the ETU circuitry will reload the new written value and restart counting. The elementary time unit  $t_{ETU}$  is obtained from the following formula which defines the bit rate in the ISO 7816-3 standard specification.

$$1\text{etu} = t_{ETU} = \frac{E_i}{D_i} \times \frac{1}{f}$$

where:

- $t_{\text{etu}}$  is the nominal duration of the data bit on the signal SCI\_DIO provided to the card by the interface
- $D_i$  is the bit-rate adjustment factor
- $F_i$  is the clock rate conversion factor
- $f$  is the frequency value of the clock signal SCI\_CLK provided to the card by the interface

$D_i$  is an encoded decimal value based on a 4-bit field, named DI, as represented in the accompanying table.

**Table 59. DI Field Based  $D_i$  Encoded Decimal Values**

| DI field        | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 1000 | 1001 |
|-----------------|------|------|------|------|------|------|------|------|
| $D_i$ (decimal) | 1    | 2    | 4    | 8    | 16   | 32   | 12   | 20   |

$F_i$  is an encoded decimal value based on a 4-bit field, named FI, as represented in the following table.

**Table 60. FI Field Based  $F_i$  Encoded Decimal Values**

| FI field        | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 1001 | 1010 | 1011 | 1100 | 1101 |
|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|
| $F_i$ (decimal) | 372  | 372  | 558  | 744  | 1116 | 1488 | 1860 | 512  | 768  | 1024 | 1536 | 2048 |

The values of  $F_i$  and  $D_i$ , as they appear in the preceding tables, will be obtained from the Answer-to-Reset packet sent from the external Smart Card to the Smart Card Interface the first time the external Smart Card is inserted. When the SCI receives the  $F_i$  and  $D_i$  information, the  $F_i$  and  $D_i$  values can be obtained by looking up the preceding two tables. After the  $F_i$  and  $D_i$  values are obtained, the value which should be written into the ETUR register can be calculated by  $F_i/D_i$ . The following table shows the possible ETU values obtained by the  $F_i/D_i$  ratio.

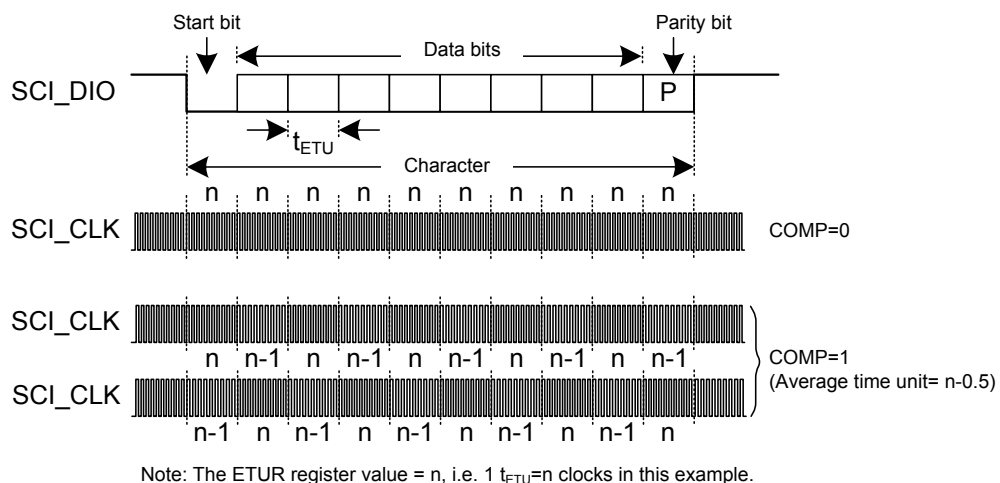
**Table 61. Possible ETU Values Obtained with the  $F_i/D_i$  Ratio**

| $F_i/D_i$ | 372   | 558   | 774   | 1116  | 1488 | 1860  | 512   | 768  | 1024  | 1536 | 2048  |
|-----------|-------|-------|-------|-------|------|-------|-------|------|-------|------|-------|
| 1         | 372   | 558   | 744   | 1116  | 1488 | 1860  | 512   | 768  | 1024  | 1536 | 2048  |
| 2         | 186   | 279   | 372   | 558   | 744  | 930   | 256   | 384  | 512   | 768  | 1024  |
| 4         | 93    | 139.5 | 186   | 279   | 372  | 465   | 128   | 192  | 256   | 384  | 512   |
| 8         | 46.5  | 69.75 | 93    | 139.5 | 186  | 232.5 | 64    | 96   | 128   | 192  | 256   |
| 16        | 23.25 | 34.87 | 46.5  | 69.75 | 93   | 116.2 | 32    | 48   | 64    | 96   | 128   |
| 32        | 22.62 | 17.43 | 23.25 | 34.87 | 46.5 | 58.13 | 16    | 24   | 32    | 48   | 64    |
| 12        | 31    | 46.5  | 62    | 93    | 124  | 155   | 42.66 | 64   | 85.33 | 128  | 170.6 |
| 20        | 18.6  | 27.9  | 37.2  | 55.8  | 74.4 | 93    | 25.6  | 38.4 | 51.2  | 76.8 | 102.4 |

### Compensation mode

As the value of the ETUR register is obtained by the above procedure, the calculation results of the value may not be an integer. If the calculation result is not an integer and is less than the integer  $n$  but greater than the integer  $(n-1)$ , either the integer  $n$  or  $(n-1)$  should be written into the ETUR register depending upon whether the result is closer to integer  $n$  or  $(n-1)$ . The integer  $n$  mentioned here is a decimal.

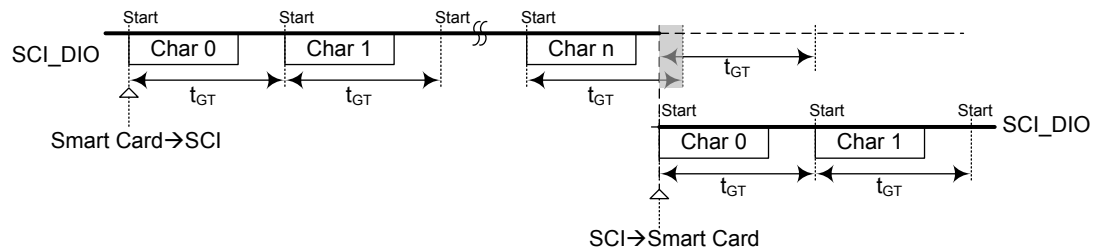
If the calculation result is close to the value of  $(n-0.5)$ , the compensation mode should be enabled by setting the compensation enable control bit, COMP, in the ETUR register to 1 for successful data transfer. When the result is close to the value of  $(n-0.5)$  and the compensation mode is enabled, the value written into the ETUR register should be  $n$ . The ETU circuitry will then generate the time unit sequence with  $n$  clock cycles and next  $(n-1)$  clock cycles alternately and so on. This results in an average time unit of  $(n-0.5)$  clock cycles and allows a time granularity down to a half clock cycle. Note that the ETU will reload the ETUR register value and restart counting at the time when the Start bit appears in the SCI data Transfer Mode.



**Figure 175. Character Frame and Compensation Mode**

### Guard Time Counter

The Guard Time Counter, GT, is a 9-bit up-counting counter which generates a minimum time duration known as a character frame, denoted as  $t_{GT}$ , between the leading edges of two consecutive characters in the SCI data transfer. The clock source of the guard time counter comes from the ETU, named  $f_{ETU}$  in the block diagram. There is a register related to the guard time counter known as the GTR register, which stores the expected value of the guard time counter. The guard time value will be reloaded at the end of the current guard time period. Note that the guard time between the last character received from the Smart Card and the next character transmitted by the SCI circuitry which should be properly managed by the application program. There is no guard time insertion when the first character is transmitted.



**Figure 176. Guard Time Duration**

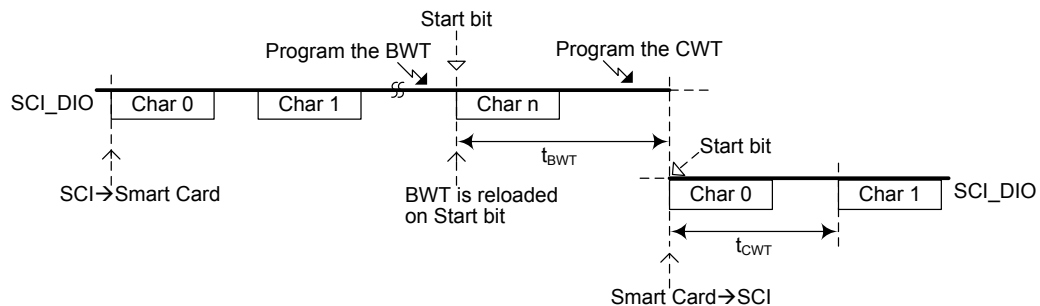
## Waiting Time Counter

The Waiting Time counter, WT, is a 24-bit down counting counter which generates a maximum time duration, denoted as  $t_{WT}$ , for data transfer. The clock source of the waiting time counter comes from the ETU and is named  $f_{ETU}$ .

There is a register for the waiting time counter known as the WTR register which stores the expected waiting time counter value. The waiting time counter can be used in both the SCI data Transfer Mode and manual mode and can reload the value for specific conditions. The function of the waiting time counter is controlled by the WTEN bit in the CR register. When the SCI is configured to be operated in the SCI data Transfer Mode and the waiting time counter is enabled by setting the WTEN bit to 1, the updated WTR register value will be loaded into the waiting time counter when the Start bit is detected. Note that the WTEN bit should not be set to 1 to enable the waiting time counter in the SCI data Transfer Mode until after the external Smart Card is inserted.

If the SCI is configured to operate in the manual mode, the waiting time counter can be used as a general purpose timer and this timer is enabled or disabled by setting or clearing the WTEN bit. The updated WTR register value will not be loaded into the waiting time counter if the waiting time counter is enabled. When the waiting time counter is disabled by setting the WTEN bit to 0 and an updated value is written into the WTR register, the new value will immediately be loaded into the waiting time counter and then the counter will start to count after the WTEN bit is again set to 1.

Software can change the Waiting Time value on-the-fly. For example, in T=1 mode, the value of the Block Waiting Time,  $t_{BWT}$ , should be written into the WTR register before the Start bit of the last transmitted character occurs. After the transmission of the last character is completed, software should write the Character Waiting Time value,  $t_{CWT}$ , into the WTR register.



**Figure 177. Character and Block Waiting Time Duration – CWT and BWT**

## Card Clock and Data Selection

The SCI communicates with an external Smart Card using a series of external pins. These are the serial data pin, SCI\_DIO, output clock pin, SCI\_CLK, and the Card Detection input pin, SCI\_DET.

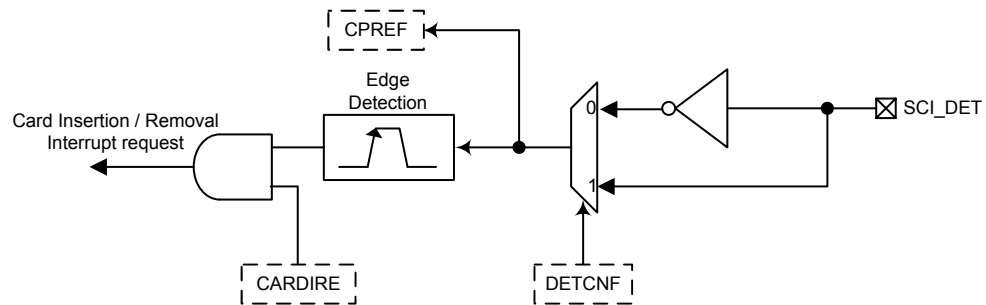
The SCI serial data pin, named SCI\_DIO, can be controlled by the SCI hardware circuitry or the software control bits depending upon whether the SCI is operated in the SCI Transfer Mode or in the Manual Mode. The mode selection is determined by the SCIM bit in the CR register. The SCI\_DIO pin status is controlled by the CDIO bit in the CCR register when the SCI is configured to operate in the Manual mode by clearing the SCIM bit in the CR register. In the Manual Mode the SCI\_DIO pin status is a copy of the CDIO bit. However, when the SCI is configured to operate in the SCI Transfer Mode, the SCI\_DIO pin status is determined by the SCI transfer circuitry.

The SCI clock output pin named SCI\_CLK can be controlled by the 6-bit SCI prescaler or the software control bits depending upon the condition of the CLKSEL bit in the CCR register. The SCI\_CLK pin status is controlled by the CCLK bit in the CCR register when the CLKSEL bit is cleared to 0. The SCI\_CLK pin status is a copy of the CCLK bit. However, when the CLKSEL bit is set to 1, the SCI\_CLK signal is sourced from the 6-bit prescaler output. The prescaler division ratio is determined by the PSC field in the PSCR register.

## Card Detection

When an external Smart Card is inserted, the internal card detector can detect this insertion operation and generate a card insertion interrupt if the corresponding interrupt enable control bit, CARDIRE, in the IER register is set to 1. Similarly, if the card is removed, the internal card detector can also detect the removal and consequently generate a card removal interrupt when the corresponding interrupt function is enabled by setting the control bit, CARDIRE, in the IER register, to 1.

The card detector can support two kinds of card detect switch mechanisms. One is a normally open switch mechanism when the card is not present and the other is a normally closed switch mechanism. After noting which card detect switch mechanism type is used, the card switch selection should be configured by setting the selection bit, DETCNF, in the CR register to correctly detect the card presence. No matter what type of the card switch is selected, by configuring the DETCNF bit, the card Insertion/Removal flag, CPREF, in the SR register will be set to 1 when the card is actually present on the SCI\_DET pin. Note that there are no hardware de-bounce circuits in the card detector. Any change of the SCI\_DET pin level will cause the CPREF bit to change. The required de-bounce time should be handled by the application program.



**Figure 178. SCI Card Detection Diagram**

## SCI Data Transfer Mode

The SCI data transfer with the external Smart Card is implemented with two operating modes. One is the SCI mode while the other is the Manual Mode. The data Transfer Mode is selected by the SCI mode selection bit, SCIM, in the CR register. When the SCIM bit is set to 1, the SCI mode is enabled and data will automatically be transferred by the SCI transfer circuitry. Otherwise, data transfer operates in the Manual Mode if the SCIM bit is cleared to 0. The SCI transfer interface is a half-duplex interface and communicates with the external Smart Card via the SCI\_CLK and SCI\_DIO pins. After a reset condition the SCI transfer interface is in the reception mode but the SCI transfer operation is disabled. When the SCI mode is enabled, data transfer is driven by the SCI transfer circuitry automatically through the SCI\_CLK and SCI\_DIO pins.

There are two data registers related to data transmission and reception, TXB and RXB, which store the data to be transmitted and received respectively. If a character is written into the TXB register in the SCI Transfer Mode, the SCI transfer interface will automatically switch to the Transmission Mode from the reception mode after a reset. When the SCI transmission or reception has finished, the corresponding request flag, named TXCF or RXCF, in the SR register is set to 1. If the transmit buffer is empty, the transmit buffer empty flag, TXBEF, in the SR register will be set to 1.

## Parity Check Function

The SCI transfer interface supports a parity generator and a parity check function. As the parity error occurs during a data transfer, the corresponding request flag, named PARF in the SR register, will be set to 1. Once the PARF bit is set to 1, the parity error pending flag, PARP, in the IPR register will also be set to 1 if the relevant interrupt control bit, PARE, in the IER register is enabled.

If the data transmitted by the SCI is received by the external Smart Card without a parity error, the SCI transmission request flag, TXCF, will be set to 1 and the SCI parity error request flag, PARF, will be cleared to 0. If the data transmitted by the external Smart Card is received by the SCI without a parity error, the SCI reception request flag, RXCF, will be set to 1 and the parity error flag, PARF, will be cleared to 0.

### Repetition Function

There is a Character Repetition function supported by the SCI transfer circuitry when a parity error occurs. The Character Repetition function is enabled by setting the CREP bit in the CR register to 1. A repetition function will then be activated when a parity error occurs during a data transfer. The repetition time number can be selected to be 4 or 5 by configuring the RETRY bit in the CR register.

When the CREP bit is set to 1, the character repetition function will be activated. Taking a 4 time repetition as an example, when the CREP bit is set to 1 and the RETRY bit is set to 1, in the Transmission Mode, the SCI will repeatedly transmit the data a maximum of 4 times when an error signal occurs. However, if the SCI is informed that there is still an error signal during the 4 transmissions, the parity error flag PARF will be set to 1 after the same data has been transmitted 4 times but the TXCF flag will not be set. At this time the data in the transmit buffer will be loaded into the transmit shift register and the transmit buffer will be empty which will result in the TXBEF flag being set to 1.

Similarly, when the SCI operates in the reception mode, it will inform the external Smart Card that there is a parity error for a maximum of 4 times if the character repetition function is enabled. If the SCI informs the external Smart Card that there is still an error signal for the 4 receptions, the parity error flag, PARF, will be set to 1 together with the reception request flag, RXCF.

If the CREP bit is cleared to 0, the character repetition function will be disabled. When the SCI operates in the reception mode, both the PARF and RXCF bits will be set to 1 as data with a parity error has been received. If the SCI is informed that there is a parity error in the Transmission Mode, the PARF bit will be set to 1 but the TXCF bit will not be set.

### Manual Data Transfer Mode

When the SCIM bit is cleared to 0, data will be transferred in the Manual Mode. In the Manual Mode, the data is controlled by the control bit, CDIO, in the CCR register. The CDIO bit value will be reflected immediately on the SCI\_DIO pin in the Manual Mode. Note that in the Manual Mode the character repetition function can not be used as well as the related flags and all the data transfer is handled by the application program. The clock used to drive the external Smart Card that appears on the SCI\_CLK pin can be derived from the internal clock source, which is the 6-bit prescaler output,  $f_{PSC\_CK}$ , or from the control bit, CCLK, in the CCR register. The clock source is selected using the bit, CLKSEL, in the CCR register. When CLKSEL bit is set to 1, the clock used to drive the Smart Card will be sourced from the 6-bit prescaler output,  $f_{PSC\_CK}$ . If the clock is to be managed manually, the CLKSEL bit should first be cleared to 0 and then the value of the CCLK bit will be present in the SCI\_CLK pin.

### Data Transfer Direction Convention

If the direction convention used by the Smart Card is the same as the convention used by the SCI, the SCI will generate a reception interrupt if the reception interrupt is enabled without a parity error flag. Otherwise, the SCI will generate a reception interrupt and the parity error flag will be asserted. By checking the parity error flag, the SCI can know if the data direction convention is correct or not.

## Interrupt Generator

There are several conditions for the SCI to generate an SCI interrupt. When these conditions are met, an interrupt signal will be generated to obtain the attention of the microcontroller. These conditions are a Smart Card Insertion/Removal, a Waiting Time Counter Underflow, a Parity error, an end of a Character Transmission or Reception and an empty Transmit buffer. When a Smart Card interrupt is generated by any of these conditions, then if the SCI global interrupt and the corresponding SCI interrupt are together enabled, the program will jump to the corresponding interrupt vector where it can be serviced before returning to the main program.

For SCI interrupt events, there are corresponding pending flags which can be masked by the relevant interrupt enable control bit. When the related interrupt enable control is disabled, the corresponding interrupt pending flag will not be affected by the request flag and no interrupt will be generated. If the related interrupt enable control is enabled, the relevant interrupt pending flag will be affected by the request flag and then the interrupt will be generated. The pending flag register, named IPR, is read only and once the pending flag is read by the application program, it will be automatically cleared while the related request flag should be cleared by the application program manually.

For an SCI Interrupt to be serviced, in addition to the bits for the corresponding interrupt enable control in the SCI being set, the SCI global interrupt enable control bit in the NVIC must also be set. If this SCI global interrupt control bit is not set, then no SCI interrupt will be serviced.

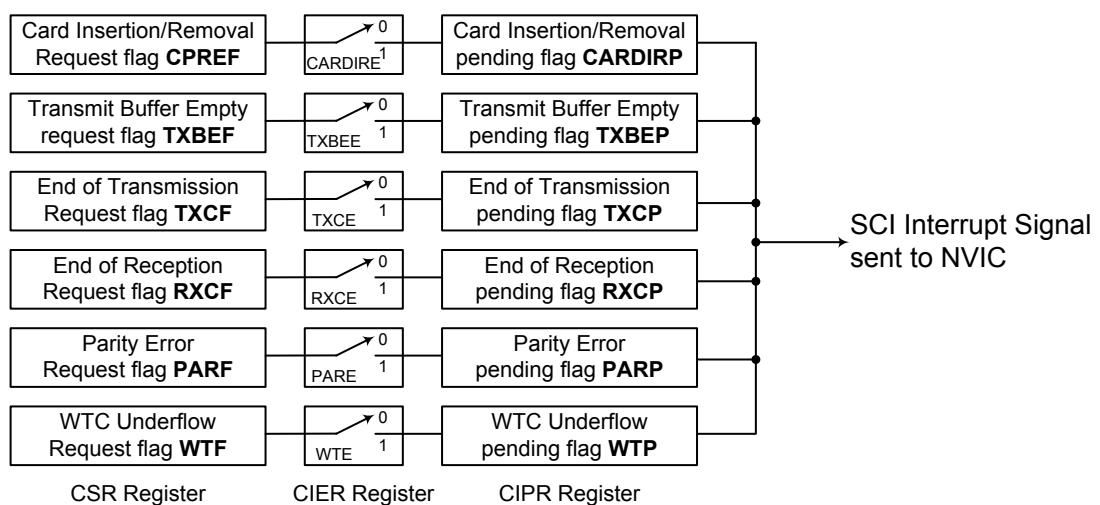


Figure 179. SCI Interrupt Structure

## PDMA Interface

The PDMA interface is integrated in the SCI module. The PDMA function can be enabled by setting the TXDMA or RXDMA bit to 1 in the transmitter or receiver mode respectively. When the transmit buffer is empty which results in the transmit buffer empty flag, TXBEF, being asserted and the TXDMA bit is set to 1, the PDMA function will be activated to move data from a certain memory location into the SCI Transmit buffer. Similarly, when the SCI receives a character which results in the character received flag, RXCF, being asserted and the RXDMA bit is set to 1, the PDMA function will be activated to move data from the SCI Receive buffer to a specific memory location.

For a more detailed descriptions on the PDMA configurations, refer to the PDMA chapter.

## Register Map

There are several registers associated with the Smart Card function. Some of these registers control the SCI overall function as well as the interrupts, while some of the registers contain the status bits which indicate the Smart Card data transfer situation and error conditions. Also there are two registers for the SCI transmission and reception respectively to store the data received from or to be transmitted to the external Smart Card. The following table shows the SCI register list and reset values.

**Table 62. SCI Register Map**

| Register | Offset | Description                       | Reset Value |
|----------|--------|-----------------------------------|-------------|
| CR       | 0x000  | SCI Control Register              | 0x0000_0000 |
| SR       | 0x004  | SCI Status Register               | 0x0000_0080 |
| CCR      | 0x008  | SCI Contact Control Register      | 0x0000_0008 |
| ETUR     | 0x00C  | SCI Elementary Time Unit Register | 0x0000_0174 |
| GTR      | 0x010  | SCI Guard Time Register           | 0x0000_000C |
| WTR      | 0x014  | SCI Waiting Time Register         | 0x0000_2580 |
| IER      | 0x018  | SCI Interrupt Enable Register     | 0x0000_0000 |
| IPR      | 0x01C  | SCI Interrupt Pending Register    | 0x0000_0000 |
| TXB      | 0x020  | SCI Transmit Buffer               | 0x0000_0000 |
| RXB      | 0x024  | SCI Receive Buffer                | 0x0000_0000 |
| PSCR     | 0x028  | SCI Prescaler Register            | 0x0000_0000 |

## Register Descriptions

### SCI Control Register – CR

This register contains the SCI control bits.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |        |       |       |      |      |       |       |    |
|------------|----------|--------|-------|-------|------|------|-------|-------|----|
|            | 31       | 30     | 29    | 28    | 27   | 26   | 25    | 24    |    |
| Type/Reset | Reserved |        |       |       |      |      |       |       |    |
|            | 23       | 22     | 21    | 20    | 19   | 18   | 17    | 16    |    |
| Type/Reset | Reserved |        |       |       |      |      |       |       |    |
|            | 15       | 14     | 13    | 12    | 11   | 10   | 9     | 8     |    |
| Type/Reset | Reserved |        |       |       |      |      | RXDMA | TXDMA |    |
|            |          |        |       |       |      |      | RW    | 0     | RW |
|            | 7        | 6      | 5     | 4     | 3    | 2    | 1     | 0     |    |
| Type/Reset | Reserved | DETCNF | ENSCI | RETRY | SCIM | WTEN | CREP  | CONV  |    |
|            |          | RW     | 0     | RW    | 0    | RW   | 0     | RW    | 0  |

| Bits   | Field       | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
|--------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------|--------|---|---|----------------|---|---|-------------|---|---|-------------|---|---|----------------|
| [9]    | RXDMA       | SCI reception DMA request enable<br>0: SCI reception DMA request is disabled<br>1: SCI reception DMA request is enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| [8]    | TXDMA       | SCI transmission DMA request enable control<br>0: SCI transmission DMA request is disabled<br>1: SCI transmission DMA request is enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| [6]    | DETCNF      | Card switch type selection<br>0: Switch is normally opened if no card is present<br>1: Switch is normally closed if no card is present<br><table border="1"> <thead> <tr> <th>DETCNF</th><th>SCI_DET pin</th><th>STATUS</th></tr> </thead> <tbody> <tr> <td>0</td><td>1</td><td>No card insert</td></tr> <tr> <td>0</td><td>0</td><td>Card insert</td></tr> <tr> <td>1</td><td>1</td><td>Card insert</td></tr> <tr> <td>1</td><td>0</td><td>No card insert</td></tr> </tbody> </table> <p>This bit is set and cleared by the application program to configure the card detector switch type.</p> | DETCNF | SCI_DET pin | STATUS | 0 | 1 | No card insert | 0 | 0 | Card insert | 1 | 1 | Card insert | 1 | 0 | No card insert |
| DETCNF | SCI_DET pin | STATUS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| 0      | 1           | No card insert                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| 0      | 0           | Card insert                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| 1      | 1           | Card insert                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| 1      | 0           | No card insert                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| [5]    | ENSCI       | SCI finite state machine enable bit<br>0: SCI FSM is disabled and forced to its initial state<br>1: SCI FSM is enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |
| [4]    | RETRY       | Character transfer repetition time selection for a parity error condition<br>0: Data transfer 5 times when parity error occurs<br>1: Data transfer 4 times when parity error occurs<br>The bit is available only when the CREP bit is set to 1. When this bit is set to 1, the data will be transmitted or received 4 times once a parity error occurs. If the bit is cleared to 0, the data will be transferred 5 times if a parity error occurs.                                                                                                                                               |        |             |        |   |   |                |   |   |             |   |   |             |   |   |                |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | SCIM  | <p>SCI Mode Selection</p> <p>0: SCI data transfer in manual mode<br/>1: SCI data transfer in SCI mode</p> <p>This bit is set and cleared by the application program to select the SCI data Transfer Mode. If it is cleared to 0, the SCI_DIO pin status is the same as the value of the CDIO bit in the CCR register. If it is set to 1, the SCI_DIO pin is driven by the internal SCI control circuitry. Before the data transfer type is switched from the Manual Mode to the SCI Mode, the CDIO bit must be set to 1 to avoid an SCI malfunction.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| [2]  | WTEN  | <p>Waiting Time Counter enable control</p> <p>0: Waiting Time Counter stops counting<br/>1: Waiting Time Counter starts counting</p> <p>The WTEN bit is set and cleared by the application program. When the WTEN bit is cleared to 0, a write access to the WTR register will load the value into the waiting time counter. If it is set to 1, the waiting time counter is enabled and automatically reloaded with the value at each start bit occurrence.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| [1]  | CREP  | <p>Automatic character repetition enable control for a parity error condition</p> <p>0: No retry on parity error<br/>1: Automatic retry on parity error</p> <p>The CREP bit is set and cleared by the application program. When the CREP bit is cleared to 0, both the RXCF and PARF flags will be set when a parity error occurs in the reception mode after the data is received. However, in the Transmission Mode, the PARF flag will be set but the TXCF flag will not be set when a parity error occurs. If the CREP bit is set to 1, a character transfer will automatically be activated 4 or 5 times depending upon the RETRY bit value. In the Transmission Mode the character will be re-transmitted if the transmitted data has a parity error. Here the parity error flag, PARF, will be set at the end of the 4<sup>th</sup> or 5<sup>th</sup> transmission without the TXCF bit being set. In the reception mode if the received data has a parity error, the SCI will inform the external Smart Card for 4 or 5 times and then the PARF and RXCF flags will both be set at the end of the 4<sup>th</sup> or 5<sup>th</sup> reception.</p> |
| [0]  | CONV  | <p>Data direction convention select</p> <p>0: LSB is transferred first; a data "1" is a logic high level on the SCI_DIO pin and the parity bit is added after the MSB.<br/>1: MSB is transferred first; a data "1" is a logic low level on the SCI_DIO pin and the parity bit is added after the LSB.</p> <p>This bit is set and cleared by the application program to select if the data is transmitted LSB or MSB first. When the data direction convention is the same as the data direction specified by the external Smart Card, only the RXCF flag will be set to 1 without a parity error. Otherwise, both the RXCF and PARF flags will be set to 1 after the data is received.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

## SCI Status Register – SR

This register contains the SCI status bits.

Offset: 0x004

Reset value: 0x0000\_0080

|            |          |       |          |    |     |       |      |       |
|------------|----------|-------|----------|----|-----|-------|------|-------|
|            | 31       | 30    | 29       | 28 | 27  | 26    | 25   | 24    |
| Type/Reset | Reserved |       |          |    |     |       |      |       |
|            | 23       | 22    | 21       | 20 | 19  | 18    | 17   | 16    |
| Type/Reset | Reserved |       |          |    |     |       |      |       |
|            | 15       | 14    | 13       | 12 | 11  | 10    | 9    | 8     |
| Type/Reset | Reserved |       |          |    |     |       |      |       |
|            | 7        | 6     | 5        | 4  | 3   | 2     | 1    | 0     |
| Type/Reset | TXBEF    | CPREF | reserved |    | WTF | TXCF  | RXCF | PARF  |
|            | RO       | 1 RO  | 0        |    | RO  | 0 W0C | 0 RO | 0 W0C |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | TXBEF | Transmit Buffer Empty Request Flag<br>0: Transmit buffer is not empty<br>1: Transmit buffer is empty<br>This bit is used to indicate if the transmit buffer is empty and is set or cleared by hardware automatically.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| [6]  | CPREF | Card Presence Request Flag<br>0: No card is present<br>1: A card is present<br>This bit is used to indicate if a card is present and is set or cleared by hardware automatically. The card presence detection function is enabled after the ENSCI bit is set.                                                                                                                                                                                                                                                                                                                                                                                               |
| [3]  | WTF   | Waiting Time Counter Underflow Request Flag<br>0: No Waiting Time Counter underflow<br>1: The Waiting Time Counter underflows<br>This bit is set and cleared by the application program and indicates if the Waiting Time Counter underflows.                                                                                                                                                                                                                                                                                                                                                                                                               |
| [2]  | TXCF  | Character Transmission Request Flag.<br>0: No character transmitted<br>1: A character has been transmitted<br>This bit is set by hardware and cleared by writing a "0" into it.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| [1]  | RXCF  | Character Received Request Flag.<br>0: No character received<br>1: A character has been received<br>This bit is set by hardware and cleared after a read access to the RXB register by the application program. The RXCF bit will be set to 1 when a character is received regardless of the result of the parity check.<br>When the character has been received, the received data stored in the RXB register should be moved to the data memory as specified by the application program. If the contents of the RXB register are not read before the end of the next character to be shifted in, the data stored in the RXB register will be overwritten. |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | PARF  | <p>Parity Error Request Flag.</p> <p>0: No parity error occurs<br/>1: Parity error has occurred</p> <p>This bit is set by hardware and cleared by writing a “0” into it. When a character is received, the parity check circuitry will check that the parity is correct or not. If the result of the parity check is not correct, the parity error request flag, PARF, will be set to 1. Otherwise, the PARF bit will remain zero. In the Transmission Mode when the SCI is informed that there is a parity error in the transmitted character by the external Smart Card, the PARF bit will also be set to 1.</p> |

## SCI Contact Control Register – CCR

This register specifies the SCI pin setting and clock selection.

Offset: 0x008

Reset value: 0x0000\_0008

|            |          |          |    |    |      |      |          |    |
|------------|----------|----------|----|----|------|------|----------|----|
|            | 31       | 30       | 29 | 28 | 27   | 26   | 25       | 24 |
| Type/Reset | Reserved |          |    |    |      |      |          |    |
|            | 23       | 22       | 21 | 20 | 19   | 18   | 17       | 16 |
| Type/Reset | Reserved |          |    |    |      |      |          |    |
|            | 15       | 14       | 13 | 12 | 11   | 10   | 9        | 8  |
| Type/Reset | Reserved |          |    |    |      |      |          |    |
|            | 7        | 6        | 5  | 4  | 3    | 2    | 1        | 0  |
| Type/Reset | CLKSEL   | Reserved |    |    | CDIO | CCLK | Reserved |    |
|            | RW       | 0        |    |    | RW   | 1    | RW       | 0  |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | CLKSEL | Card Clock Selection<br>0: The CCLK bit content is present on the external SCI_CLK pin<br>1: The clock output on the external SCI_CLK pin is sourced from the $f_{PSC\_CK}$ clock<br>This bit is used to select the external SCI_CLK pin clock source. It is set and cleared by the application program. It is recommended that to activate the clock at a known level a certain value should be first programmed into the CCLK bit before the CLKSEL bit is switched from 1 to 0.                                                                                                                                                          |
| [3]  | CDIO   | SCI_DIO pin control<br>0: SCI_DIO pin is logic level 0<br>1: SCI_DIO pin in open-drain condition<br>This bit is available only when the SCIM bit in the CR register is cleared to 0 to configure the SCI to operate in the Manual Transfer Mode. It is set and cleared by application program to control the external SCI_DIO pin status in the Manual Mode. Reading this bit will return the present status of the SCI_DIO pin.                                                                                                                                                                                                            |
| [2]  | CCLK   | SCI_CLK pin control.<br>0: SCI_CLK pin is logic level 0<br>1: SCI_CLK pin is logic level 1<br>This bit is available only when the SCIM bit in the CR register is cleared to 0 to configure the SCI to operate in the Manual Transfer Mode. It is set and cleared by application program to control the external SCI_CLK pin status in the Manual Mode. Reading this bit will return the current value in the register and not the present status of the external SCI_CLK pin. To ensure that the clock remains at a known level a certain value should be first programmed into the CCLK bit before the CLKSEL bit is switched from 1 to 0. |

## SCI Elementary Time Unit Register – ETUR

The register specifies the value determined by the formula described in the ETU section. It also includes the Compensation function enable control bit for the ETU time granularity.

Offset: 0x00C

Reset value: 0x0000\_0174

|            |          |          |    |    |    |     |    |    |    |    |    |   |
|------------|----------|----------|----|----|----|-----|----|----|----|----|----|---|
|            | 31       | 30       | 29 | 28 | 27 | 26  | 25 | 24 |    |    |    |   |
| Type/Reset | Reserved |          |    |    |    |     |    |    |    |    |    |   |
|            | 23       | 22       | 21 | 20 | 19 | 18  | 17 | 16 |    |    |    |   |
| Type/Reset | Reserved |          |    |    |    |     |    |    |    |    |    |   |
|            | 15       | 14       | 13 | 12 | 11 | 10  | 9  | 8  |    |    |    |   |
| Type/Reset | COMP     | Reserved |    |    |    | ETU |    |    |    |    |    |   |
|            | RW       | 0        |    |    |    | RW  | 0  | RW | 0  | RW | 1  |   |
|            | 7        | 6        | 5  | 4  | 3  | 2   | 1  | 0  |    |    |    |   |
| Type/Reset | ETU      |          |    |    |    |     |    |    |    |    |    |   |
|            | RW       | 0        | RW | 1  | RW | 1   | RW | 1  | RW | 0  | RW | 0 |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                         |
|--------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15]   | COMP  | Elementary Time Unit Compensation mode enable control<br>0: Compensation mode is disabled<br>1: Compensation mode is enabled<br>This bit is set and cleared by application program and used to control the ETU compensation function. For more details regarding the compensation function consult the Elementary Time Unit section. |
| [10:0] | ETU   | ETU value for a character data bit<br>This field is configured by the application program to modify the ETU time duration. Note that the value of ETU must be in the range of 0x00C to 0x7FF. To obtain the maximum ETU decimal value of 2048, a 0x000 value should be written into this bit field.                                  |

## SCI Guard Time Register – GTR

This register specifies the guard time value obtained from the Answer-to-Reset packet described in the Guard Time Counter section.

Offset: 0x010

Reset value: 0x0000\_000C

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | Reserved |    |    |    |    |    |    | GT |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | GT       |    |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits  | Field | Descriptions                                                                                                                                                                                                                                                                               |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8:0] | GT    | Character Guard Time value<br>This field is configured by the application program to modify the guard time duration. The updated GT value will be loaded into the GT counter at the end of the current guard time period. Note that the GT value must be in the range from 0x00C to 0x1FF. |

## SCI Waiting Time Register – WTR

This register specifies the waiting time value obtained from the Answer-to-Reset packet described in the Waiting Time Counter section.

Offset: 0x014

Reset value: 0x0000\_2580

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | WT       |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | WT       |    |    |    |    |    |    |    |    |
|            | RW       | 1  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                         |
|--------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [23:0] | WT    | Character Waiting Time value expressed in ETU (0/16777215).<br>This field is configured by the application program to modify the waiting time duration. The reload conditions of the updated waiting time counter value are described in the waiting time counter section. Refer to the waiting time counter section for more details. Note that the WT value can range from 0x00_0000 to 0xFF_FFFF. |

## SCI Interrupt Enable Register – IER

This register specifies the interrupt enable control bits for all of the interrupt events in the SCI.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |         |          |    |     |      |      |      |
|------------|----------|---------|----------|----|-----|------|------|------|
|            | 31       | 30      | 29       | 28 | 27  | 26   | 25   | 24   |
| Type/Reset | Reserved |         |          |    |     |      |      |      |
|            | 23       | 22      | 21       | 20 | 19  | 18   | 17   | 16   |
| Type/Reset | Reserved |         |          |    |     |      |      |      |
|            | 15       | 14      | 13       | 12 | 11  | 10   | 9    | 8    |
| Type/Reset | Reserved |         |          |    |     |      |      |      |
|            | 7        | 6       | 5        | 4  | 3   | 2    | 1    | 0    |
| Type/Reset | TXBEE    | CARDIRE | Reserved |    | WTE | TXCE | RXCE | PARE |
|            | RW       | 0       | RW       | 0  | RW  | 0    | RW   | 0    |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                   |
|------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | TXBEE   | Transmit buffer empty interrupt enable control<br>0: Disabled<br>1: Enabled<br>This bit is set and cleared by application program and is used to control the Transmit Buffer Empty interrupt. If this bit is set to 1, the transmit buffer empty interrupt will be generated when the transmit buffer is empty.                                                |
| [6]  | CARDIRE | Card Insertion / Removal interrupt enable control<br>0: Disabled<br>1: Enabled<br>This bit is set and cleared by application program and is used to control the card insertion/removal interrupt. If this bit is set to 1, the card insertion/removal interrupt will be generated when the external Smart Card is inserted or removed.                         |
| [3]  | WTE     | Waiting Timer Underflow interrupt enable control<br>0: Disabled<br>1: Enabled<br>This bit is set and cleared by the application program and is used to control the Waiting Timer underflow interrupt. If this bit is set to 1, the waiting time counter underflow interrupt will be generated when the waiting time counter underflows.                        |
| [2]  | TXCE    | Character Transmission Completion interrupt enable control<br>0: Disabled<br>1: Enabled<br>This bit is set and cleared by the application program and is used to control the Character Transmission Completion interrupt. If this bit is set to 1, the Character Transmission Completion interrupt will be generated at the end of the character transmission. |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                       |
|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | RXCE  | Character Reception Completion interrupt enable control<br>0: Disabled<br>1: Enabled<br>This bit is set and cleared by the application program and is used to control the Character Reception Completion interrupt. If this bit is set to 1, the Character Reception Completion interrupt will be generated at the end of the character reception. |
| [0]  | PARE  | Parity Error interrupt enable control<br>0: Disabled<br>1: Enabled<br>This bit is set and cleared by the application program and is used to control the parity error interrupt. if this bit is set to 1, the Parity Error interrupt will be generated when a parity error occurs.                                                                  |

## SCI Interrupt Pending Register – IPR

This register contains the interrupt pending flags for all of the interrupt events in the SCI. These pending flags can be masked by the corresponding interrupt enable control bits.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |         |          |    |     |      |      |      |
|------------|----------|---------|----------|----|-----|------|------|------|
|            | 31       | 30      | 29       | 28 | 27  | 26   | 25   | 24   |
| Type/Reset | Reserved |         |          |    |     |      |      |      |
|            | 23       | 22      | 21       | 20 | 19  | 18   | 17   | 16   |
| Type/Reset | Reserved |         |          |    |     |      |      |      |
|            | 15       | 14      | 13       | 12 | 11  | 10   | 9    | 8    |
| Type/Reset | Reserved |         |          |    |     |      |      |      |
|            | 7        | 6       | 5        | 4  | 3   | 2    | 1    | 0    |
| Type/Reset | TXBEP    | CARDIRP | Reserved |    | WTP | TXCP | RXCP | PARP |
|            | RC       | 0       | RC       | 0  | RC  | 0    | RC   | 0    |

| Bits | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | TXBEP   | Transmit Buffer Empty interrupt pending flag<br>0: No interrupt pending<br>1: Interrupt pending<br>This bit is set by hardware and cleared by a read access to this register using the application program. This bit is used to indicate if there is a Transmit Buffer Empty interrupt pending or not. If the Transmit Buffer is empty and the corresponding interrupt enable control bit is set to 1, this bit will be set to 1 to indicate that the transmit buffer empty interrupt is pending.                               |
| [6]  | CARDIRP | Card Insertion/Removal interrupt pending flag<br>0: No interrupt pending<br>1: Interrupt pending<br>This bit is set by hardware and cleared by a read access to this register using the application program. It is used to indicate if there is an external Smart Card insertion/removal interrupt pending or not. If an external Smart Card is inserted or removed and the corresponding interrupt enable control bit is set to 1, this bit will be set to 1 to indicate that the Card insertion/removal interrupt is pending. |
| [3]  | WTP     | Waiting Timer Underflow interrupt pending flag<br>0: No interrupt pending<br>1: Interrupt pending<br>This bit is set by hardware and cleared by a read access to this register using the application program. It is used to indicate if there is a waiting time counter underflow interrupt pending or not. If the waiting time counter underflows and the corresponding interrupt enable control bit is set to 1, this bit will be set to 1 to indicate that the waiting time counter underflow interrupt is pending.          |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | TXCP  | <p>Character Transmission Completion interrupt pending flag</p> <p>0: No interrupt pending<br/>1: Interrupt pending</p> <p>This bit is set by hardware and cleared by a read access to this register using the application program. It is used to indicate if there is a Character Transmission Completion interrupt pending or not. If a character has been transmitted and the related interrupt enable control bit is set to 1, this bit will be set to 1 to indicate that the character transmission completion interrupt is pending.</p> |
| [1]  | RXCP  | <p>Character Reception Completion interrupt pending flag</p> <p>0: No interrupt pending<br/>1: Interrupt pending</p> <p>This bit is set by hardware and cleared by a read access to this register using the application program. It is used to indicate if there is a Character Reception Completion interrupt pending or not. If a character has been received and the relevant interrupt enable control bit is set to 1, this bit will be set to 1 to indicate that the character reception completion interrupt is pending.</p>            |
| [0]  | PARP  | <p>Parity Error interrupt pending flag</p> <p>0: No interrupt pending<br/>1: Interrupt pending</p> <p>This bit is set by hardware and cleared by a read access to this register using the application program. It is used to indicate if there is a Parity Error interrupt pending or not. If the parity error occurs and its interrupt enable control bit is set to 1, this bit will be set to 1 to indicate that the parity error interrupt is pending.</p>                                                                                 |

## SCI Transmit Buffer – TXB

This register is used to store the SCI data to be transmitted.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | TB       |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits  | Field | Descriptions                    |
|-------|-------|---------------------------------|
| [7:0] | TB    | SCI data byte to be transmitted |

## SCI Receive Buffer – RXB

This register is used to store the SCI received data.

Offset: 0x024

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | RB       |    |    |    |    |    |    |    |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0  |

| Bits  | Field | Descriptions           |
|-------|-------|------------------------|
| [7:0] | RB    | SCI Received data byte |

## SCI Prescaler Register – PSCR

This register specifies the prescaler division ratio which is used the SCI internal clock.

Offset: 0x028

Reset value: 0x0000\_0000

|            |          |    |     |    |    |    |    |    |
|------------|----------|----|-----|----|----|----|----|----|
|            | 31       | 30 | 29  | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |    |     |    |    |    |    |    |
|            | 23       | 22 | 21  | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved |    |     |    |    |    |    |    |
|            | 15       | 14 | 13  | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |    |     |    |    |    |    |    |
|            | 7        | 6  | 5   | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved |    | PSC |    |    |    |    |    |
|            |          |    | RW  | 0  | RW | 0  | RW | 0  |
|            |          |    |     |    | RW | 0  | RW | 0  |
|            |          |    |     |    |    | RW | 0  | RW |
|            |          |    |     |    |    |    | RW | 0  |

| Bits  | Field | Descriptions                                                                                                       |
|-------|-------|--------------------------------------------------------------------------------------------------------------------|
| [5:0] | PSC   | SCI prescaler division ratio<br>0: $f_{PSC\_CK} = f_{PCLK}$<br>1~63: $f_{PSC\_CK} = \frac{f_{PCLK}}{2 \times PSC}$ |

# 25 USB Device Controller (USB)

## Introduction

The USB device controller is compliant with the USB 2.0 full-speed specification. There is one control endpoint known as Endpoint 0 and seven configurable endpoints (EP1~EP7). A 1024-byte EP-SRAM is used for the endpoint buffers. Each endpoint buffer size is programmable by corresponding registers, which provides maximum flexibility for various applications. The integrated USB full-speed transceiver helps to minimize overall system complexity and cost. The USB also contains the suspend and resume features to meet low-power consumption requirement. The accompanying figure shows the USB block diagram.

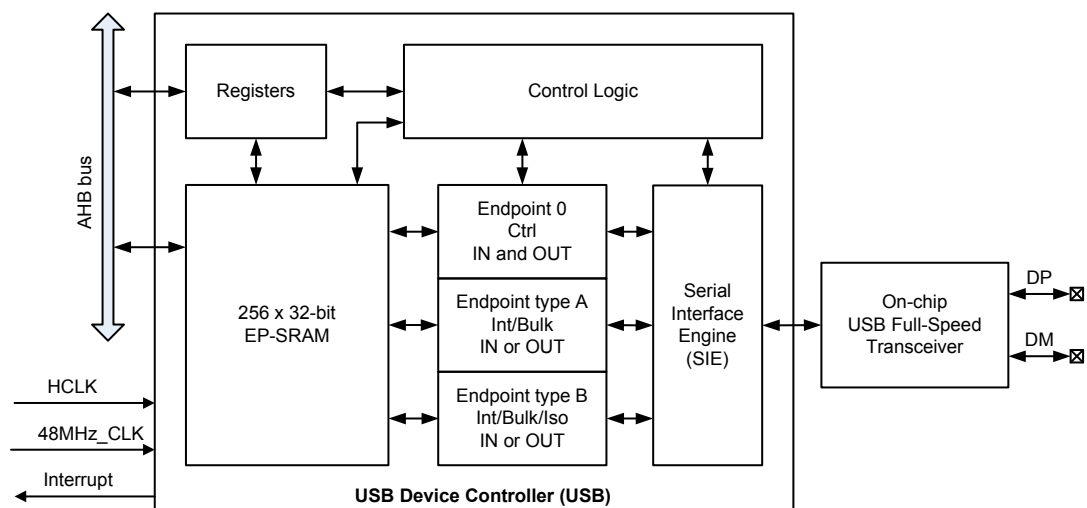


Figure 180. USB Block Diagram

## Features

- Complies with USB 2.0 full-speed (12Mbps) specification
- Fully integrated USB full-speed transceiver
- 1 control endpoint (EP0) for control transfer
- 3 single-buffered endpoint (EP1~EP3) for bulk and interrupt transfer
- 4 double-buffered endpoint (EP4~EP7) for bulk, interrupt and isochronous transfer
- 1,024 bytes EP-SRAM used as endpoint data buffers

## Functional Descriptions

### Endpoints

The USB Endpoint 0 is the only bidirectional endpoint dedicated to USB control transfer. The device also contains seven unidirectional endpoints for other USB transfer types. There are three endpoints (EP1~EP3) which supports a single buffering function which is used for Bulk and Interrupt IN or OUT data transfer. There are four other endpoints (EP4~EP7) which supports single or double buffering functions for Bulk, Interrupt and Isochronous IN or OUT data transfer. The address of the seven unidirectional endpoints (EP1~EP7) can be configured by the application software. The following table lists the endpoint characteristics.

**Table 63. Endpoint Characteristics**

| Endpoint Number | Number Address | Transfer Type              | Direction  | Buffer Type                |
|-----------------|----------------|----------------------------|------------|----------------------------|
| 0               | Fixed          | Control                    | IN and OUT | Single buffering           |
| 1~3             | Configurable   | Interrupt/Bulk             | IN or OUT  | Single buffering           |
| 4~7             | Configurable   | Interrupt/Bulk/Isochronous | IN or OUT  | Single or Double buffering |

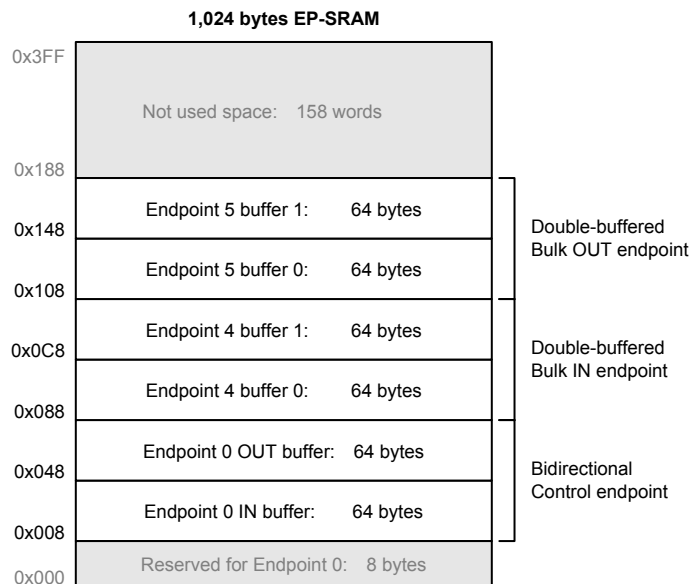
### EP-SRAM

The USB controller contains a dedicated memory space, EP-SRAM, which is used for the USB endpoint buffers. The EP-SRAM, which is connected to the APB bus, can be accessed by the CPU and PDMA. The EP-SRAM base address is 0x400A\_A000 with an offset which ranges from 0x000 to 0x3FF. The EP-SRAM first two words are reserved for Endpoint 0 to temporarily store the 8-byte SETUP data. Therefore the valid start address of the endpoint buffer should start from 0x008 and align to a 4-byte boundary. Each endpoint buffer size is programmable. The following table lists the maximum USB endpoint buffer size which is compliant with USB 2.0 full-speed device specification.

**Table 64. USB Data Types and Buffer Size**

| Transfer Type | Direction      | Supported Buffer Size | Bandwidth      | CRC | Retrying  |
|---------------|----------------|-----------------------|----------------|-----|-----------|
| Control       | Bidirectional  | 8, 16, 32, 64         | Not guaranteed | Yes | Automatic |
| Bulk          | Unidirectional | 8, 16, 32, 64         | Not guaranteed | Yes | Yes       |
| Interrupt     | Unidirectional | ≤ 64                  | Not guaranteed | Yes | Yes       |
| Isochronous   | Unidirectional | < 512                 | Guaranteed     | Yes | No        |

In the following endpoint buffer allocation example, the Endpoint “4” is configured as a double-buffered Bulk IN endpoint while the Endpoint “5” is configured as a double-buffered Bulk OUT endpoint. Each endpoint buffer size is set to 64-bytes.



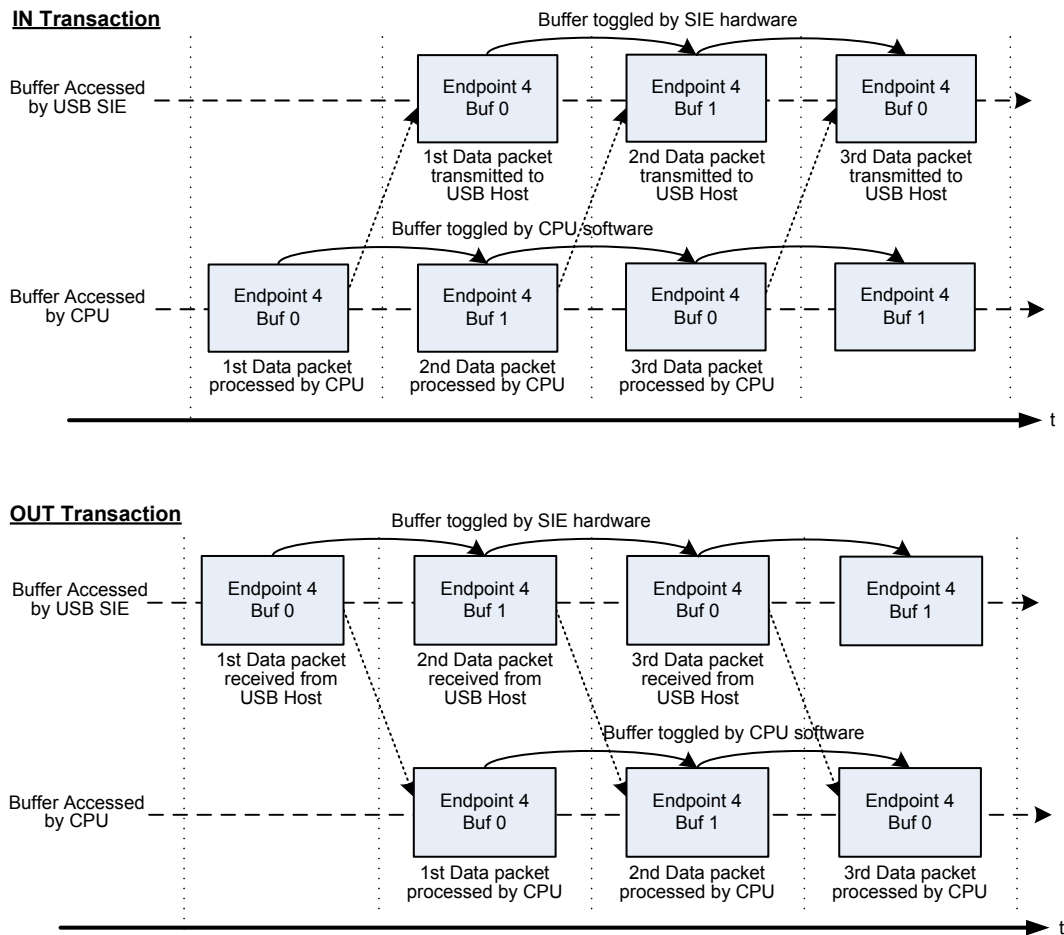
**Figure 181. Endpoint Buffer Allocation Example**

## Serial Interface Engine – SIE

The Serial Interface Engine, SIE, which is connected to the USB full-speed transceiver and internal USB control circuitry provides a temporal buffer for the transmitted and received data. The SIE also decodes the SE0 signal, SE1 signal, J-state, K-state, USB RESET event and End of Packet event signals, EOP, when the USB module receives data, transmits data or transmits the resume signal for remote control. The SIE detects the number of SOF packets and generates the SOF interrupt signal to the USB control circuitry which includes data format conversion from parallel to serial or serial to parallel. It also includes, CRC checking and generation, PID decoder, bit-stuffing and de-bit-stuffing functions.

## Double-Buffering

The double buffering function is recommended to be enabled when the corresponding endpoint is specified to be used for Isochronous transfer or high throughput Bulk transfer. The double buffering function stores the preceding data packet sent by the USB host in a simple buffer for the CPU to process and the hardware will ensure that it continues to receive the current data packet in the other buffer during a OUT transaction, and vice versa. Using a double buffering function can achieve the highest possible data transfer rate. The details regarding double buffering usage is provided in the corresponding UDBTG and MDBTG control bit description in the USBEPnCSR register where the denotation n ranges from 4 to 7.



**Figure 182. Double-buffering Operation Example**

## Suspend Mode and Wake-up

According to USB specifications, the device must enter the suspend mode after a 3 ms bus idle time. When the USB device enters the suspend mode, the current from the USB bus must not be greater than 500  $\mu$ A to meet the specification suspend mode current requirements. The USB control circuitry will generate a suspend interrupt if the bus is in the idle state for 3 ms. Here the software should set the LPMODE and PDWN bits in the USBCSR register to 1. The LPMODE bit is used to determine whether the USB controller enters the low power mode or not by holding the USB bus in a reset condition while the PDWN bit is used to determine if the integrated USB full-speed transceiver is turned off or not.

There are two ways for the USB host to wake up the USB device, one is to send a USB reset signal, SE0, and the other is to send a USB resume signal known as the K-state. After a wake-up signal, regardless of whether a SE0 signal or a K-state is detected, the USB device will be woken up.

## Remote Wake-up

As the USB device has a remote wake-up function, it can wake up the USB host by sending a resume request signal by setting the GENRSM bit in the USBCSR register to 1. Once the USB host receives the remote wake-up signal from the USB device, it will send a resume signal to the USB device.

## Register Map

The following table shows the USB registers and reset values.

**Table 65. USB Register Map**

| Register                              | Offset | Description                                | Reset Value |
|---------------------------------------|--------|--------------------------------------------|-------------|
| <b>USB Base Address = 0x400A_8000</b> |        |                                            |             |
| USBCSR                                | 0x000  | USB Control and Status Register            | 0x0000_00X6 |
| USBIER                                | 0x004  | USB Interrupt Enable Register              | 0x0000_0000 |
| USBISR                                | 0x008  | USB Interrupt Status Register              | 0x0000_0000 |
| USBFCR                                | 0x00C  | USB Frame Count Register                   | 0x0000_0000 |
| USBDEVAR                              | 0x010  | USB Device Address Register                | 0x0000_0000 |
| USBEP0CSR                             | 0x014  | USB Endpoint 0 Control and Status Register | 0x0000_0002 |
| USBEP0IER                             | 0x018  | USB Endpoint 0 Interrupt Enable Register   | 0x0000_0000 |
| USBEP0ISR                             | 0x01C  | USB Endpoint 0 Interrupt Status Register   | 0x0000_0000 |
| USBEP0TCR                             | 0x020  | USB Endpoint 0 Transfer Count Register     | 0x0000_0000 |
| USBEP0CFGR                            | 0x024  | USB Endpoint 0 Configuration Register      | 0x8000_0002 |
| USBEP1CSR                             | 0x028  | USB Endpoint 1 Control and Status Register | 0x0000_0002 |
| USBEP1IER                             | 0x02C  | USB Endpoint 1 Interrupt Enable Register   | 0x0000_0000 |
| USBEP1ISR                             | 0x030  | USB Endpoint 1 Interrupt Status Register   | 0x0000_0000 |
| USBEP1TCR                             | 0x034  | USB Endpoint 1 Transfer Count Register     | 0x0000_0000 |
| USBEP1CFGR                            | 0x038  | USB Endpoint 1 Configuration Register      | 0x1000_03FF |
| USBEP2CSR                             | 0x03C  | USB Endpoint 2 Control and Status Register | 0x0000_0002 |
| USBEP2IER                             | 0x040  | USB Endpoint 2 Interrupt Enable Register   | 0x0000_0000 |
| USBEP2ISR                             | 0x044  | USB Endpoint 2 Interrupt Status Register   | 0x0000_0000 |
| USBEP2TCR                             | 0x048  | USB Endpoint 2 Transfer Count Register     | 0x0000_0000 |
| USBEP2CFGR                            | 0x04C  | USB Endpoint 2 Configuration Register      | 0x1000_03FF |
| USBEP3CSR                             | 0x050  | USB Endpoint 3 Control and Status Register | 0x0000_0002 |

| Register   | Offset | Description                                | Reset Value |
|------------|--------|--------------------------------------------|-------------|
| USBEP3IER  | 0x054  | USB Endpoint 3 Interrupt Enable Register   | 0x0000_0000 |
| USBEP3ISR  | 0x058  | USB Endpoint 3 Interrupt Status Register   | 0x0000_0000 |
| USBEP3TCR  | 0x05C  | USB Endpoint 3 Transfer Count Register     | 0x0000_0000 |
| USBEP3CFGR | 0x060  | USB Endpoint 3 Configuration Register      | 0x1000_03FF |
| USBEP4CSR  | 0x064  | USB Endpoint 4 Control and Status Register | 0x0000_0002 |
| USBEP4IER  | 0x068  | USB Endpoint 4 Interrupt Enable Register   | 0x0000_0000 |
| USBEP4ISR  | 0x06C  | USB Endpoint 4 Interrupt Status Register   | 0x0000_0000 |
| USBEP4TCR  | 0x070  | USB Endpoint 4 Transfer Count Register     | 0x0000_0000 |
| USBEP4CFGR | 0x074  | USB Endpoint 4 Configuration Register      | 0x1000_03FF |
| USBEP5CSR  | 0x078  | USB Endpoint 5 Control and Status Register | 0x0000_0002 |
| USBEP5IER  | 0x07C  | USB Endpoint 5 Interrupt Enable Register   | 0x0000_0000 |
| USBEP5ISR  | 0x080  | USB Endpoint 5 Interrupt Status Register   | 0x0000_0000 |
| USBEP5TCR  | 0x084  | USB Endpoint 5 Transfer Count Register     | 0x0000_0000 |
| USBEP5CFGR | 0x088  | USB Endpoint 5 Configuration Register      | 0x1000_03FF |
| USBEP6CSR  | 0x08C  | USB Endpoint 6 Control and Status Register | 0x0000_0002 |
| USBEP6IER  | 0x090  | USB Endpoint 6 Interrupt Enable Register   | 0x0000_0000 |
| USBEP6ISR  | 0x094  | USB Endpoint 6 Interrupt Status Register   | 0x0000_0000 |
| USBEP6TCR  | 0x098  | USB Endpoint 6 Transfer Count Register     | 0x0000_0000 |
| USBEP6CFGR | 0x09C  | USB Endpoint 6 Configuration Register      | 0x1000_03FF |
| USBEP7CSR  | 0x0A0  | USB Endpoint 7 Control and Status Register | 0x0000_0002 |
| USBEP7IER  | 0x0A4  | USB Endpoint 7 Interrupt Enable Register   | 0x0000_0000 |
| USBEP7ISR  | 0x0A8  | USB Endpoint 7 Interrupt Status Register   | 0x0000_0000 |
| USBEP7TCR  | 0x0AC  | USB Endpoint 7 Transfer Count Register     | 0x0000_0000 |
| USBEP7CFGR | 0x0B0  | USB Endpoint 7 Configuration Register      | 0x1000_03FF |

## Register Descriptions

### USB Control and Status Register – USBCSR

This register specifies the USB control bits and USB data line status.

Offset: 0x000

Reset value: 0x0000\_00X6

|            |          |      |        |          |        |        |          |          |
|------------|----------|------|--------|----------|--------|--------|----------|----------|
|            | 31       | 30   | 29     | 28       | 27     | 26     | 25       | 24       |
| Type/Reset | Reserved |      |        |          |        |        |          |          |
|            | 23       | 22   | 21     | 20       | 19     | 18     | 17       | 16       |
| Type/Reset | Reserved |      |        |          |        |        |          |          |
|            | 15       | 14   | 13     | 12       | 11     | 10     | 9        | 8        |
| Type/Reset | Reserved |      |        |          | DPWKEN | DPPUEN | SRAMRSTC | ADRSET   |
|            | 7        | 6    | 5      | 4        | 3      | 2      | 1        | 0        |
| Type/Reset | RXDM     | RXDP | GENRSM | Reserved | LPMODE | PDWN   | FRES     | Reserved |
|            | RO       | X RO | X RW   | 0        | RW     | 0 RW   | 1 RW     | 1        |

| Bits | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11] | DPWKEN   | DP Wake Up Enable<br>0: Disable DP wake up<br>1: Enable DP wake up                                                                                                                                                                                                                                                                                                                                                                                              |
| [10] | DPPUEN   | DP Pull Up Enable<br>0: Disable DP pull up<br>1: Enable DP pull up                                                                                                                                                                                                                                                                                                                                                                                              |
| [9]  | SRAMRSTC | USB SRAM reset condition<br>0: Reset USB SRAM when (DP, DM) = (0, 0)<br>1: User can access USB SRAM in spite of (DP, DM) state                                                                                                                                                                                                                                                                                                                                  |
| [8]  | ADRSET   | Device Address Setting Control<br>This bit is used to determine when the USB SIE updates the device address with the value of the UDEVA register.<br>0: The SIE updates the device address immediately after an address is written into the UDEVA register.<br>1: The SIE updates the device address after the USB Host has successfully read the data from the device by the IN operation. This bit is cleared by the SIE after the device address is updated. |
| [7]  | RXDM     | Received DM Line Status<br>This bit is used to observe the status of DM data line status at the end of suspend routines to determine whether a wakeup event has occurred.                                                                                                                                                                                                                                                                                       |
| [6]  | RXDP     | Received DP Line Status<br>This bit is used to observe the status of DP data line status at the end of suspend routines to determine whether a wakeup event has occurred.                                                                                                                                                                                                                                                                                       |
| [5]  | GENRSM   | Resume Request Generation Control<br>This bit is used to generate a resume request which is sent to the USB host by writing 1 into this bit location. The USB remote wakeup function is always enabled. This bit will be cleared to 0 after a resume signal, sent by the USB host, has been received.                                                                                                                                                           |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | LPMODE | <p>Low-power Mode Control</p> <p>This bit is used to determine the USB operating mode. Setting this bit will force the USB to enter the low-power mode. When USB bus traffic, known as a wakeup event, is detected by the hardware, this bit should be cleared by software.</p> <p>0: Exit the Low-power mode<br/>1: Enter the Low-power mode</p>                                                             |
| [2]  | PDWN   | <p>Power Down Mode Control</p> <p>Setting this bit will power down the full-speed USB PHY transceiver. This will disconnect the USB PHY transceiver from the USB bus.</p> <p>0: Exit the Power-Down mode<br/>1: Enter the Power-Down mode</p>                                                                                                                                                                 |
| [1]  | FRES   | <p>Force USB Reset Control</p> <p>This bit is used to reset the USB circuitry. Setting this bit will force the USB into a reset state until the software clears it. A USB reset interrupt will be generated if the corresponding interrupt enable bit in the USBIER register is set to 1. All related USB registers are reset to their default values.</p> <p>0: Release USB reset<br/>1: Force USB reset</p> |

**Table 66. Resume Event Detection**

| [RXDP, RXDM] Status | Wakeup event               | Required resume software action |
|---------------------|----------------------------|---------------------------------|
| 00                  | Root reset                 | None                            |
| 10                  | None (noise on bus)        | Go back to suspend mode         |
| 01                  | Root resume                | None                            |
| 11                  | Not allowed (noise on bus) | Go back to suspend mode         |

## USB Interrupt Enable Register – USBIER

This register specifies the USB interrupt enable control.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |       |        |        |       |        |       |       |    |
|------------|----------|-------|--------|--------|-------|--------|-------|-------|----|
|            | 31       | 30    | 29     | 28     | 27    | 26     | 25    | 24    |    |
| Type/Reset | Reserved |       |        |        |       |        |       |       |    |
|            | 23       | 22    | 21     | 20     | 19    | 18     | 17    | 16    |    |
| Type/Reset | Reserved |       |        |        |       |        |       |       |    |
|            | 15       | 14    | 13     | 12     | 11    | 10     | 9     | 8     |    |
| Type/Reset | EP7IE    | EP6IE | EP5IE  | EP4IE  | EP3IE | EP2IE  | EP1IE | EP0IE |    |
|            | RW       | 0     | RW     | 0      | RW    | 0      | RW    | 0     | RW |
|            | 7        | 6     | 5      | 4      | 3     | 2      | 1     | 0     |    |
| Type/Reset | Reserved |       | ESOFIE | SUSPIE | RSMIE | URSTIE | SOFIE | UGIE  |    |
|            |          |       | RW     | 0      | RW    | 0      | RW    | 0     | RW |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                            |
|--------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:8] | EPnIE  | Endpoint n Interrupt Enable Control (n = 0 ~ 7)<br>0: Disable interrupt<br>1: Enable interrupt                                                                                                                                                                                                                                                          |
| [5]    | ESOFIE | Expected Start Of Frame (ESOF) Interrupt Enable Control<br>0: Disable ESOF interrupt<br>1: Enable ESOF interrupt                                                                                                                                                                                                                                        |
| [4]    | SUSPIE | Suspend Interrupt Enable Control<br>0: Disable suspend interrupt<br>1: Enable suspend interrupt                                                                                                                                                                                                                                                         |
| [3]    | RSMIE  | Resume Interrupt Enable Control<br>0: Disable Resume interrupt<br>1: Enable Resume interrupt                                                                                                                                                                                                                                                            |
| [2]    | URSTIE | USB Reset Interrupt Enable Control<br>0: Disable USB Reset interrupt<br>1: Enable USB Reset interrupt                                                                                                                                                                                                                                                   |
| [1]    | SOFIE  | Start Of Frame (SOF) Interrupt Enable Control<br>0: Disable SOF interrupt<br>1: Enable SOF interrupt                                                                                                                                                                                                                                                    |
| [0]    | UGIE   | USB Global Interrupt Enable Control<br>0: USB Global interrupt is disabled<br>1: USB Global interrupt is enabled<br><br>This bit must be set to 1 to enable the corresponding USB interrupt function, If this bit is cleared to 0, the relevant USB interrupt will not be generated. However, the corresponding interrupt flags will still be asserted. |

## USB Interrupt Status Register – USBISR

This register specifies the USB interrupt status.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |        |        |       |        |       |          |          |
|------------|----------|--------|--------|-------|--------|-------|----------|----------|
|            | 31       | 30     | 29     | 28    | 27     | 26    | 25       | 24       |
| Type/Reset | Reserved |        |        |       |        |       |          |          |
|            | 23       | 22     | 21     | 20    | 19     | 18    | 17       | 16       |
| Type/Reset | Reserved |        |        |       |        |       |          |          |
|            | 15       | 14     | 13     | 12    | 11     | 10    | 9        | 8        |
| Type/Reset | EP7IF    | EP6IF  | EP5IF  | EP4IF | EP3IF  | EP2IF | EP1IF    | EP0IF    |
|            | WC       | 0      | WC     | 0     | WC     | 0     | WC       | 0        |
|            | 7        | 6      | 5      | 4     | 3      | 2     | 1        | 0        |
| Type/Reset | Reserved | ESOFIF | SUSPIF | RSMIF | URSTIF | SOFIF | Reserved | Reserved |
|            |          | RW     | 0      | WC    | 0      | WC    | 0        | WC       |

| Bits   | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [15:8] | EPnIF  | Endpoint n Interrupt Flag (n = 0 ~ 7)<br>This bit is set by the hardware to indicate the generation of relevant endpoint interrupt.<br>Writing 1 into this bit to clear it. It is important to note that the interrupt flag can only be cleared when the endpoint interrupt status bit in the USBEPnISR register is equal to 0.                                                                                                                                                                                                                                                                                                                                                                     |
| [5]    | ESOFIF | Expected Start Of Frame Interrupt Flag<br>This bit is set by the hardware when an SOF packet is expected to be received. The USB host sends an SOF (Start Of Frame) packet each millisecond. If the USB device hardware does not receive it properly, an ESOF interrupt will be generated when the ESOFIE bit in the USBIER register is set to 1. If three consecutive ESOF interrupts are generated, which means that the SOF packet has been missed 3 times, the SUSPIF will be set to 1. This bit will be set to 1 when the missing SOF packets occur if the timer is not yet locked.<br>This bit can be read or written. However, only 0 can be written into this bit. Writing 1 has no effect. |
| [4]    | SUSPIF | Suspend Interrupt Flag<br>This bit is set by the hardware when no data transfer has occurred for 3ms, indicating that a suspend request has been sent from the USB host. The suspend condition check is enabled immediately after a USB reset.<br>This bit is cleared to 0 by writing 1.                                                                                                                                                                                                                                                                                                                                                                                                            |
| [3]    | RSMIF  | Resume Interrupt Flag<br>This bit is set by the hardware. When this bit is set to 1, this means that a device resume has occurred.<br>This bit is cleared to 0 by writing 1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | URSTIF | <p>USB Reset Interrupt Flag</p> <p>This bit is set by the hardware when the USB reset has been detected. When a USB reset occurs, the internal protocol state machine will be reset and an USB reset interrupt will be generated if the URSTIE bit in the USBIER register is set to 1. Data reception and transmission are disabled until the URSTIF bit is cleared to 0. The USB configuration related registers ( USBCSR, USBIER, USBISR, USBFCR and USBDEVAR) will not be reset by a USB reset event except for the USB device address (USBDEVAR), this is to ensure that a USB reset interrupt can be safely excited and any data transactions immediately followed by the USB reset can be completely accessed by the software. Therefore the microcontroller must properly reset these registers. The USB endpoint related registers (USBEPnCSR, USBEPnISR and USBEPnTCR) are also reset by a USB reset event, however, the endpoint configuration (USBEPnCFGR) and interrupt enable (USBEPnIER) registers are not affected by the USB reset event and will remain unchanged.</p> <p>This bit is cleared to 0 by writing 1.</p> |
| [1]  | SOFIF  | <p>SOF Interrupt Flag</p> <p>This bit is set by the hardware when a start-of-frame packet has been received.</p> <p>This bit is cleared to 0 by writing 1.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## USB Frame Count Register – USBFCR

This register specifies the lost Start-of-Frame number and the USB frame count.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |   |
|------------|----------|----|----|----|----|----|----|----|---|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |   |
| Type/Reset | Reserved |    |    |    |    |    |    |    |   |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |   |
| Type/Reset | Reserved |    |    |    |    | RO | 0  | RO | 0 |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |   |
| Type/Reset | Reserved |    |    |    |    | RO | 0  | RO | 0 |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |   |
| Type/Reset | FRNUM    |    |    |    |    |    |    |    | 0 |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                                  |
|---------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18:17] | LSOF   | Lost Start-of-Frame number<br>These bits are written and incremented by 1 by the hardware each time the ESOFIF bit is set. It is used to count the number of lost SOF packets. When a SOF packet has been received, these bits are cleared.                                                                                                                                                   |
| [16]    | SOFLCK | Start-of-Frame Lock Flag<br>This bit is set by the hardware when SOF packets have been received before the frame timer times out. Once this flag is set to 1, the frame number which is sent from the USB host will be loaded into the Frame Number field in the USBFCR register. If there no SOF packet has been received during the 1ms frame time duration, this bit will be cleared to 0. |
| [10:0]  | FRNUM  | Frame Number<br>This field stores the frame number received from the USB host.                                                                                                                                                                                                                                                                                                                |

## USB Device Address Register – USBDEVA

This register specifies the USB device address.

Offset: 0x010

Reset value: 0x0000\_0000

|            |          |      |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|------------|----------|------|----|----|----|----|----|----|---|----|---|----|---|----|---|----|---|
|            | 31       | 30   | 29 | 28 | 27 | 26 | 25 | 24 |   |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved |      |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|            | 23       | 22   | 21 | 20 | 19 | 18 | 17 | 16 |   |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved |      |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|            | 15       | 14   | 13 | 12 | 11 | 10 | 9  | 8  |   |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved |      |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|            | 7        | 6    | 5  | 4  | 3  | 2  | 1  | 0  |   |    |   |    |   |    |   |    |   |
| Type/Reset | Reserved | DEVA |    |    |    |    |    |    |   |    |   |    |   |    |   |    |   |
|            |          | RW   | 0  | RW | 0  | RW | 0  | RW | 0 | RW | 0 | RW | 0 | RW | 0 | RW | 0 |

| Bits  | Field | Descriptions                                                                                                                 |
|-------|-------|------------------------------------------------------------------------------------------------------------------------------|
| [6:0] | DEVA  | Device Address<br>This field is used to specify the USB device address. This field is cleared when a USB reset event occurs. |

## USB Endpoint 0 Control and Status Register – USBEP0CSR

This register specifies the Endpoint 0 control and status.

Offset: 0x014

Reset value: 0x0000\_0002

|            |          |    |       |       |       |       |       |       |
|------------|----------|----|-------|-------|-------|-------|-------|-------|
|            | 31       | 30 | 29    | 28    | 27    | 26    | 25    | 24    |
| Type/Reset | Reserved |    |       |       |       |       |       |       |
|            | 23       | 22 | 21    | 20    | 19    | 18    | 17    | 16    |
| Type/Reset | Reserved |    |       |       |       |       |       |       |
|            | 15       | 14 | 13    | 12    | 11    | 10    | 9     | 8     |
| Type/Reset | Reserved |    |       |       |       |       |       |       |
|            | 7        | 6  | 5     | 4     | 3     | 2     | 1     | 0     |
| Type/Reset | Reserved |    | STLRX | NAKRX | DTGRX | STLTX | NAKTX | DTGTX |
|            | RW       |    | 0     | RW    | 0     | RW    | 0     | RW    |
|            |          |    |       |       |       |       | 1     | RW    |
|            |          |    |       |       |       |       |       | 0     |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | STLRX | <p>STALL Status for reception (OUT) transfer</p> <p>This bit is set to 1 by the application software and then returns a STALL signal in the handshake phase of an OUT transaction if a functional error is detected. This means that a control request delivered from the USB host is not supported by the USB device. The STALL status is cleared by the hardware circuitry when a SETUP token is received.</p> <p>This bit can be read and written and can only be toggled by writing 1.</p>                                                                                                                                                                                                                                         |
| [4]  | NAKRX | <p>NAK Status for reception (OUT) transfer</p> <p>This bit is toggled from 0 to 1 by the hardware circuitry, which will result in a NAK signal in the handshake phase of an OUT transaction after an ACK signal has been transmitted. This means that the USB device will be temporarily unable to accept data from the USB host. Therefore, more time will be required for the received data to be properly processed.</p> <p>This bit can be read and written and can only be toggled by writing 1.</p>                                                                                                                                                                                                                              |
| [3]  | DTGRX | <p>Data Toggle Status for reception (OUT) transfer</p> <p>This bit contains the expected value of the data toggle bit (0=DATA0, 1=DTAT1) for the next data packet to be received. When the current valid data packet is received and the corresponding ACK signal is sent to the USB host by the USB device, the hardware circuitry will toggle this bit and the device will be ready to receive the next data packet. For Endpoint 0, the hardware circuitry will toggle this bit to 1 after the SETUP token is received as Endpoint 0 is addressed. This bit can also be toggled by the software to initialize its value for certain applications.</p> <p>This bit can be read and written and can only be toggled by writing 1.</p> |
| [2]  | STLTX | <p>STALL Status for transmission (IN) transfer</p> <p>This bit is set to 1 by the application software and then returns a STALL signal in response to an IN token if a functional error is detected. This means that the USB device is unable to transmit data. The STALL status is cleared by the hardware circuitry when a SETUP token is received.</p> <p>This bit can be read and written and can only be toggled by writing 1.</p>                                                                                                                                                                                                                                                                                                |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1]  | NAKTX | NAK Status for transmission (IN) transfer<br>This bit is toggled from 0 to 1 by the hardware circuitry, which will result in a NAK signal in the handshake phase of an IN transaction after an ACK signal has been received. It indicates that the USB device is temporarily unable to transmit data to the USB host. Therefore, there will be more time for the application software to properly prepare the data to be transmitted.<br>This bit can be read and written and can only be toggled by writing 1.                                                                                                                                                                                                    |
| [0]  | DTGTX | Data Toggle Status for transmission (IN) transfer<br>This bit contains the required value of the data toggle bit (0=DATA0, 1=DATA1) for the next data packet to be transmitted. When the current data packet is transmitted by the USB device and the corresponding ACK signal sent by the USB host is received, the hardware circuitry will toggle this bit and the next data packet will be transmitted. For Endpoint 0, the hardware circuitry will toggle this bit to 1 after the SETUP token is received as Endpoint 0 is addressed. This bit can also be toggled by the software to initialize its value for certain applications.<br>This bit can be read and written and can only be toggled by writing 1. |

### USB Endpoint 0 Interrupt Enable Register – USBEP0IER

This register specifies the Endpoint 0 interrupt control bits.

Offset: 0x018

Reset value: 0x0000\_0000

|            |          |       |       |        |        |        |        |        |
|------------|----------|-------|-------|--------|--------|--------|--------|--------|
|            | 31       | 30    | 29    | 28     | 27     | 26     | 25     | 24     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 23       | 22    | 21    | 20     | 19     | 18     | 17     | 16     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 15       | 14    | 13    | 12     | 11     | 10     | 9      | 8      |
| Type/Reset | Reserved |       |       |        | ZLRXIE | SDERIE | SDRXIE | STRXIE |
|            |          |       |       |        | RW     | 0      | RW     | 0      |
|            | 7        | 6     | 5     | 4      | 3      | 2      | 1      | 0      |
| Type/Reset | UERIE    | STLIE | NAKIE | IDTXIE | ITRXIE | ODOVIE | ODRXIE | OTRXIE |
|            | RW       | 0     | RW    | 0      | RW     | 0      | RW     | 0      |

| Bits | Field  | Descriptions                                                                                      |
|------|--------|---------------------------------------------------------------------------------------------------|
| [11] | ZLRXIE | Zero Length Data Received Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt |
| [10] | SDERIE | SETUP Data Error Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt          |
| [9]  | SDRXIE | SETUP Data Received Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt       |

| Bits | Field  | Descriptions                                                                                    |
|------|--------|-------------------------------------------------------------------------------------------------|
| [8]  | STRXIE | SETUP Token Received Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt    |
| [7]  | UERIE  | USB Error Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt               |
| [6]  | STLIE  | STALL Transmitted Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt       |
| [5]  | NAKIE  | NAK Transmitted Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt         |
| [4]  | IDTXIE | IN Data Transmitted Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt     |
| [3]  | ITRXIE | IN Token Received Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt       |
| [2]  | ODOVIE | OUT Data Buffer Overrun Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt |
| [1]  | ODRXIE | OUT Data Received Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt       |
| [0]  | OTRXIE | OUT Token Received Interrupt Enable Control<br>0: Disable interrupt<br>1: Enable interrupt      |

## USB Endpoint 0 Interrupt Status Register – USBEP0ISR

This register specifies the Endpoint 0 interrupt status.

Offset: 0x01C

Reset value: 0x0000\_0000

|            |          |    |    |    |        |        |        |        |    |
|------------|----------|----|----|----|--------|--------|--------|--------|----|
|            | 31       | 30 | 29 | 28 | 27     | 26     | 25     | 24     |    |
| Type/Reset | Reserved |    |    |    |        |        |        |        |    |
|            | 23       | 22 | 21 | 20 | 19     | 18     | 17     | 16     |    |
| Type/Reset | Reserved |    |    |    |        |        |        |        |    |
|            | 15       | 14 | 13 | 12 | 11     | 10     | 9      | 8      |    |
| Type/Reset | Reserved |    |    |    | ZLRXIF | SDERIF | SDRXIF | STRXIF |    |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1      | 0      |    |
| Type/Reset | WC       | 0  | WC | 0  | WC     | 0      | WC     | 0      | WC |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1      | 0      |    |
| Type/Reset | WC       | 0  | WC | 0  | WC     | 0      | WC     | 0      | WC |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1      | 0      |    |
| Type/Reset | WC       | 0  | WC | 0  | WC     | 0      | WC     | 0      | WC |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1      | 0      |    |
| Type/Reset | WC       | 0  | WC | 0  | WC     | 0      | WC     | 0      | WC |
|            | 7        | 6  | 5  | 4  | 3      | 2      | 1      | 0      |    |
| Type/Reset | WC       | 0  | WC | 0  | WC     | 0      | WC     | 0      | WC |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                        |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11] | ZLRXIF | Zero Length Data Received Interrupt Flag<br>This bit is set by the hardware when a zero length data packet is received.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                                                                                                                                          |
| [10] | SDERIF | SETUP Data Error Interrupt Flag<br>This bit is set by the hardware when the SETUP data packet length is not 8 bytes.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                                                                                                                                             |
| [9]  | SDRXIF | SETUP Data Received Interrupt Flag<br>This bit is set by the hardware when a SETUP data packet from the USB host has been received. This bit is cleared by the hardware when a SETUP Token is received or by writing 1. If the received SETUP data is not accessed by the application software before the next SETUP packet is received, the SETUP data buffer will be overwritten. |
| [8]  | STRXIF | SETUP Token Received Interrupt Flag<br>This bit is set by the hardware when a SETUP token is received and is cleared by writing 1.                                                                                                                                                                                                                                                  |
| [7]  | UERIF  | USB Error Interrupt Flag<br>This bit is set by the hardware when an error occurs during the Endpoint 0 transaction.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                                                                                                                                              |
| [6]  | STLIF  | STALL Transmitted Interrupt Flag<br>This bit is set by the hardware when a STALL signal is sent in response to an IN or OUT transaction.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                                                                                                                         |
| [5]  | NAKIF  | NAK Transmitted Interrupt Flag<br>This bit is set by the hardware when a NAK signal is sent in response to an IN or OUT transaction.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                                                                                                                             |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                         |
|------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4]  | IDTXIF | IN Data Transmitted Interrupt Flag<br>This bit is set by the hardware when a data packet is transmitted to and then an ACK signal is received from the USB host.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                  |
| [3]  | ITRXIF | IN Token Received Interrupt Flag<br>This bit is set by the hardware when the IN token is received from the USB host.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                              |
| [2]  | ODOVIF | OUT Data Buffer Overrun Interrupt Flag<br>This bit is set by the hardware when the number of received data bytes is larger than the endpoint buffer size.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                         |
| [1]  | ODRXIF | OUT Data Received Interrupt Flag<br>This bit is set by the hardware when a data packet is successfully received from the USB host and then an ACK signal is sent to the USB host.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1. |
| [0]  | OTRXIF | OUT Token Received Interrupt Flag<br>This bit is set by the hardware when the OUT token is received from the USB host.<br>This bit is cleared by hardware when a SETUP Token is received or by writing 1.                                                            |

### USB Endpoint 0 Transfer Count Register – USBEP0TCR

This register specifies the Endpoint 0 data transfer byte count.

Offset: 0x020

Reset value: 0x0000\_0000

|            |          |       |    |    |    |    |    |    |
|------------|----------|-------|----|----|----|----|----|----|
|            | 31       | 30    | 29 | 28 | 27 | 26 | 25 | 24 |
| Type/Reset | Reserved |       |    |    |    |    |    |    |
|            | 23       | 22    | 21 | 20 | 19 | 18 | 17 | 16 |
| Type/Reset | Reserved | RXCNT |    |    |    |    |    |    |
|            |          | RO    | 0  | RO | 0  | RO | 0  | RO |
|            | 15       | 14    | 13 | 12 | 11 | 10 | 9  | 8  |
| Type/Reset | Reserved |       |    |    |    |    |    |    |
|            | 7        | 6     | 5  | 4  | 3  | 2  | 1  | 0  |
| Type/Reset | Reserved | TXCNT |    |    |    |    |    |    |
|            |          | RW    | 0  | RW | 0  | RW | 0  | RW |

| Bits    | Field | Descriptions                                                                                                                                                                                                              |
|---------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [22:16] | RXCNT | Reception Byte Count<br>The bit field contains the number of data bytes received by Endpoint 0 in the preceding SETUP transaction.                                                                                        |
| [6:0]   | TXCNT | Transmission Byte Count<br>The bit field contains the number of data bytes to be transmitted by Endpoint 0 in the next IN token. If the value of this field is zero, it indicates that a zero length packet will be sent. |

## USB Endpoint 0 Configuration Register – USBEP0CFGR

This register specifies the Endpoint 0 configurations.

Offset: 0x024

Reset value: 0x8000\_0002

|            |          |                     |      |      |      |      |        |       |
|------------|----------|---------------------|------|------|------|------|--------|-------|
|            | 31       | 30                  | 29   | 28   | 27   | 26   | 25     | 24    |
|            | EPEN     | Reserved            |      |      |      |      |        | EPADR |
| Type/Reset | RO 1     | RO 0 RO 0 RO 0 RO 0 |      |      |      |      |        | 0     |
|            | 23       | 22                  | 21   | 20   | 19   | 18   | 17     | 16    |
|            | Reserved |                     |      |      |      |      |        | EPLEN |
| Type/Reset |          |                     |      |      |      |      |        | RW 0  |
|            | 15       | 14                  | 13   | 12   | 11   | 10   | 9      | 8     |
|            | EPLEN    |                     |      |      |      |      | EPBUFA |       |
| Type/Reset | RW 0     | RW 0                | RW 0 | RW 0 | RW 0 | RW 0 | RW 0   | RW 0  |
|            | 7        | 6                   | 5    | 4    | 3    | 2    | 1      | 0     |
|            | EPBUFA   |                     |      |      |      |      |        |       |
| Type/Reset | RW 0     | RW 0                | RW 0 | RW 0 | RW 0 | RW 0 | RW 1   | RW 0  |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                |
|---------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31]    | EPEN   | Endpoint Enable Control<br>This bit is always set to 1 by the hardware circuitry to always enable Endpoint 0.                                                                                                                                                                               |
| [27:24] | EPADR  | Endpoint Address<br>This field is always set to 0 by the hardware circuitry.                                                                                                                                                                                                                |
| [16:10] | EPLEN  | Endpoint Buffer Length<br>This field is used to specify the control transfer packet size which can be 8, 16, 32 or 64 bytes as defined in the USB full-speed standard specification.                                                                                                        |
| [9:0]   | EPBUFA | Endpoint Buffer Address<br>This field is used to specify the start address of the Endpoint 0 buffer allocated in the EP_SRAM. It starts from 0x008 and should be aligned to 4-byte boundary.<br>Start address of EP0 IN buffer = EPBUFA<br>Start address of EP0 OUT buffer = EPBUFA + EPLEN |

## USB Endpoint 1 ~ 3 Control and Status Register – USBEPnCSR, n = 1 ~ 3

This register specifies the Endpoint 1 ~ 3 control and status bit.

Offset: 0x028 (n = 1), 0x03C (n = 2), 0x050 (n = 3)

Reset value: 0x0000\_0002

|            |          |          |       |       |       |       |       |       |
|------------|----------|----------|-------|-------|-------|-------|-------|-------|
|            | 31       | 30       | 29    | 28    | 27    | 26    | 25    | 24    |
| Type/Reset | Reserved |          |       |       |       |       |       |       |
|            | 23       | 22       | 21    | 20    | 19    | 18    | 17    | 16    |
| Type/Reset | Reserved |          |       |       |       |       |       |       |
|            | 15       | 14       | 13    | 12    | 11    | 10    | 9     | 8     |
| Type/Reset | Reserved |          |       |       |       |       |       |       |
|            | 7        | 6        | 5     | 4     | 3     | 2     | 1     | 0     |
| Type/Reset |          | Reserved | STLRX | NAKRX | DTGRX | STLTX | NAKTX | DTGTX |
|            |          |          | RW    | 0     | RW    | 0     | RW    | 0     |
|            |          |          |       | 0     |       |       | 0     |       |
|            |          |          |       |       |       |       |       | 0     |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [5]  | STLRX | <p>STALL bit for reception transfers</p> <p>This bit is set to 1 by the application software if a functional error has been detected. This bit can be read and written and can only be toggled by writing 1. It can also be toggled by the software to initialize the value under certain conditions.</p>                                                                                                                                                                                                                                                                                       |
| [4]  | NAKRX | <p>NAK bit for reception transfers</p> <p>This bit is toggled from 0 to 1 by the hardware circuitry, which will result in a NAK signal in the handshake phase of an OUT transaction after an ACK signal has been transmitted. It means that the USB device will be temporarily unable to accept data from the USB host until the received data is properly processed.</p> <p>This bit can be read and written and can be only toggled by writing 1.</p>                                                                                                                                         |
| [3]  | DTGRX | <p>Data Toggle bit for reception transfers</p> <p>This bit contains the expected value of the data toggle bit (0=DATA0, 1=DATA1) for the next data packet to be received. When the current valid data packet is received and the corresponding ACK signal is sent to the USB host by the USB device, the hardware circuitry will toggle this bit and the device will be ready to receive the next data packet.</p> <p>This bit can be read and written and can only be toggled by writing 1. This bit can also be toggled by the software to initialize its value under certain conditions.</p> |
| [2]  | STLTX | <p>STALL bit for transmission transfers</p> <p>This bit is set to 1 by the application software if a functional error has been detected. This bit can be read and written and can be only toggled by writing 1. It can also be toggled by the software to initialize its value under certain conditions.</p>                                                                                                                                                                                                                                                                                    |
| [1]  | NAKTX | <p>NAK bit for transmission transfers</p> <p>This bit is toggled from 0 to 1 by the hardware circuitry, which will result in a NAK signal in the handshake phase of an IN transaction after an ACK signal has been received. It means that the USB device will be temporarily unable to transmit data packet until the data to be transmitted is appropriately prepared by the application software.</p> <p>This bit can be read and written and can be only toggled by writing 1.</p>                                                                                                          |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | DTGTX | <p>Data Toggle bit for transmission transfers.</p> <p>This bit contains the required value of the data toggle bit (0=DATA0, 1=DATA1) for the next data packet to be transmitted. When the current data packet is transmitted by the USB device and the corresponding ACK signal sent from the USB host is received, the hardware circuitry will toggle this bit and then the next data packet will be transmitted.</p> <p>This bit can be read and written and can only be toggled by writing 1. It can also be toggled by the software to initialize its value under certain conditions.</p> |

### USB Endpoint 1 ~ 3 Interrupt Enable Register – USBEPnIER, n = 1 ~ 3

This register specifies the Endpoint 1 ~ 3 interrupt enable control bits.

Offset: 0x02C (n = 1), 0x040 (n = 2), 0x054 (n = 3)

Reset value: 0x0000\_0000

|            |          |       |       |        |        |        |        |        |
|------------|----------|-------|-------|--------|--------|--------|--------|--------|
|            | 31       | 30    | 29    | 28     | 27     | 26     | 25     | 24     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 23       | 22    | 21    | 20     | 19     | 18     | 17     | 16     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 15       | 14    | 13    | 12     | 11     | 10     | 9      | 8      |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 7        | 6     | 5     | 4      | 3      | 2      | 1      | 0      |
| Type/Reset | UERIE    | STLIE | NAKIE | IDTXIE | ITRXIE | ODOVIE | ODRXIE | OTRXIE |
|            | RW       | 0     | RW    | 0      | RW     | 0      | RW     | 0      |
|            | 0        |       | 0     |        | 0      |        | 0      |        |
|            |          |       |       |        |        |        |        | 0      |

| Bits | Field  | Descriptions                                                                                                 |
|------|--------|--------------------------------------------------------------------------------------------------------------|
| [7]  | UERIE  | <p>USB Error Interrupt Enable Control.</p> <p>1: Enable interrupt<br/>0: Disable interrupt</p>               |
| [6]  | STLIE  | <p>STALL Transmitted Interrupt Enable Control.</p> <p>1: Enable interrupt<br/>0: Disable interrupt</p>       |
| [5]  | NAKIE  | <p>NAK Transmitted Interrupt Enable Control.</p> <p>1: Enable interrupt<br/>0: Disable interrupt</p>         |
| [4]  | IDTXIE | <p>IN Data Transmitted Interrupt Enable Control.</p> <p>1: Enable interrupt<br/>0: Disable interrupt</p>     |
| [3]  | ITRXIE | <p>IN Token Received Interrupt Enable Control.</p> <p>1: Enable interrupt<br/>0: Disable interrupt</p>       |
| [2]  | ODOVIE | <p>OUT Data Buffer Overrun Interrupt Enable Control.</p> <p>1: Enable interrupt<br/>0: Disable interrupt</p> |

| Bits | Field  | Descriptions                                                                                |
|------|--------|---------------------------------------------------------------------------------------------|
| [1]  | ODRXIE | OUT Data Received Interrupt Enable Control.<br>1: Enable interrupt<br>0: Disable interrupt  |
| [0]  | OTRXIE | OUT Token Received Interrupt Enable Control.<br>1: Enable interrupt<br>0: Disable interrupt |

### USB Endpoint 1 ~ 3 Interrupt Status Register – USBEPnISR, n = 1 ~ 3

This register specifies the Endpoint 1 ~ 3 interrupt status.

Offset: 0x030 (n = 1), 0x044 (n = 2), 0x058 (n = 3)

Reset value: 0x0000\_0000

|            |          |       |       |        |        |        |        |        |
|------------|----------|-------|-------|--------|--------|--------|--------|--------|
|            | 31       | 30    | 29    | 28     | 27     | 26     | 25     | 24     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 23       | 22    | 21    | 20     | 19     | 18     | 17     | 16     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 15       | 14    | 13    | 12     | 11     | 10     | 9      | 8      |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 7        | 6     | 5     | 4      | 3      | 2      | 1      | 0      |
| Type/Reset | UERIF    | STLIF | NAKIF | IDTXIF | ITRXIF | ODOVIF | ODRXIF | OTRXIF |
|            | WC       | 0     | WC    | 0      | WC     | 0      | WC     | 0      |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                           |
|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | UERIF  | USB Error Interrupt Flag.<br>This bit is set by the hardware when an error occurs during the transaction.<br>Writing 1 into this status bit will clear it to 0.                                                                                        |
| [6]  | STLIF  | STALL Transmitted Interrupt Flag.<br>This bit is set by hardware circuitry when a STALL-token is sent in response to an IN or OUT token and is cleared to 0 by writing 1.                                                                              |
| [5]  | NAKIF  | NAK Transmitted Interrupt Flag.<br>This bit is set by hardware circuitry when a NAK-token is sent in response to an IN or OUT token and is cleared to 0 by writing 1.                                                                                  |
| [4]  | IDTXIF | IN Data Transmitted Interrupt Flag.<br>This bit is set by hardware circuitry when a data packet is successfully transmitted to the host in response to an IN-token and an ACK-token is received.<br>Writing 1 into this status bit will clear it to 0. |
| [3]  | ITRXIF | IN Token Received Interrupt Flag.<br>This bit is set by the hardware circuitry when the endpoint receives an IN token from the host and is cleared to 0 by writing 1.                                                                                  |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                                           |
|------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2]  | ODOVIF | OUT Data Buffer Overrun Interrupt Flag.<br>This bit is set by the hardware circuitry when the received data byte count is larger than the corresponding endpoint OUT data buffersize.<br>Writing 1 into this status bit will clear it to 0.                            |
| [1]  | ODRXIF | OUT Data Received Interrupt Flag.<br>This bit is set by the hardware circuitry when a data packet is successfully received from the host for an OUT-token and when an endpoint n ACK signal is sent to the host.<br>Writing 1 into this status bit will clear it to 0. |
| [0]  | OTRXIF | OUT Token Received Interrupt Flag.<br>This bit is set by the hardware circuitry when the endpoint receives an OUT token from the host and is cleared to 0 by writing 1.                                                                                                |

### USB Endpoint 1 ~ 3 Transfer Count Register – USBEPnTCR, n = 1 ~ 3

This register specifies the Endpoint 1 ~ 3 transfer byte count.

Offset: 0x034 (n = 1), 0x048 (n = 2), 0x05C (n = 3)

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |      |   |
|------------|----------|----|----|----|----|----|----|------|---|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24   |   |
| Type/Reset | Reserved |    |    |    |    |    |    |      |   |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16   |   |
| Type/Reset | Reserved |    |    |    |    |    |    |      |   |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8    |   |
| Type/Reset | Reserved |    |    |    |    |    |    | TCNT |   |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0    |   |
| Type/Reset | TCNT     |    |    |    |    |    |    |      |   |
|            | RW       | 0  | RW | 0  | RW | 0  | RW | 0    |   |
|            | 0        | RW | 0  | RW | 0  | RW | 0  | RW   | 0 |

| Bits  | Field | Descriptions                                                                                                                                                                                                      |
|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8:0] | TCNT  | Transfer Byte Count<br>This field contains the number of bytes received by the endpoint n in the preceding OUT transaction or the number of bytes to be transmitted by the endpoint n in the next IN transaction. |

## USB Endpoint 1 ~ 3 Configuration Register – USBEPnCFGR, n = 1 ~ 3

This register specifies the Endpoint 1 ~ 3 configurations.

Offset: 0x038 (n = 1), 0x04C (n = 2), 0x060 (n = 3)

Reset value: 0x1000\_03FF

|            |          |          |        |       |       |      |        |      |
|------------|----------|----------|--------|-------|-------|------|--------|------|
|            | 31       | 30       | 29     | 28    | 27    | 26   | 25     | 24   |
|            | EPEN     | Reserved | EPTYPE | EPDIR | EPADR |      |        |      |
| Type/Reset | RW 0     |          | RW 0   | RW 1  | RW 0  | RW 0 | RW 0   | RW 0 |
|            | 23       | 22       | 21     | 20    | 19    | 18   | 17     | 16   |
|            | Reserved |          |        |       |       |      | EPLEN  |      |
| Type/Reset |          |          |        |       |       |      | RW 0   |      |
|            | 15       | 14       | 13     | 12    | 11    | 10   | 9      | 8    |
|            | EPLEN    |          |        |       |       |      | EPBUFA |      |
| Type/Reset | RW 0     | RW 0     | RW 0   | RW 0  | RW 0  | RW 0 | RW 1   | RW 1 |
|            | 7        | 6        | 5      | 4     | 3     | 2    | 1      | 0    |
|            | EPBUFA   |          |        |       |       |      |        |      |
| Type/Reset | RW 1     | RW 1     | RW 1   | RW 1  | RW 1  | RW 1 | RW 1   | RW 1 |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                                                                                                            |
|---------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31]    | EPEN   | Enable Control<br>0: Disable the endpoint n<br>1: Enable the endpoint n                                                                                                                                                                                                                                                                                                                 |
| [29]    | EPTYPE | Transfer Type<br>This bit is set to 0 by the hardware circuitry to specify that the endpoint n transfer type is an Interrupt or Bulk transfer type.                                                                                                                                                                                                                                     |
| [28]    | EPDIR  | Transfer Direction<br>0: OUT<br>1: IN                                                                                                                                                                                                                                                                                                                                                   |
| [27:24] | EPADR  | Endpoint Address<br>The EPADR field value can be assigned by the application software to specify the address of the endpoint n. It is important to note that this EPADR field should not be set to 0; otherwise, the endpoint will be disabled.                                                                                                                                         |
| [16:10] | EPLEN  | Buffer Length<br>This field is used to specify the endpoint n data packet size. The field value must be word-aligned to a 4-byte boundary. The maximum size in this field can be 64 bytes which is the maximum payload as defined in the USB full-speed standard specification. Note that the EPLEN value should not be assigned to 0 which will result in the endpoint being disabled. |
| [9:0]   | EPBUFA | Endpoint Buffer Address<br>This field is used to specify the endpoint n data buffer start address which ranges from 0x008 to 0x3FC in the EP-SRAM which has a capacity of 1024 bytes and whose field value must be a multiple of 4.                                                                                                                                                     |

## USB Endpoint 4 ~ 7 Control and Status Register – USBEPnCSR, n = 4 ~ 7

This register specifies the Endpoint 4 ~ 7 control and status bits.

Offset: 0x064 (n = 4), 0x078 (n = 5), 0x08C (n = 6), 0x0A0 (n = 7)

Reset value: 0x0000\_0002

|            |          |       |       |       |       |       |       |       |
|------------|----------|-------|-------|-------|-------|-------|-------|-------|
|            | 31       | 30    | 29    | 28    | 27    | 26    | 25    | 24    |
| Type/Reset | Reserved |       |       |       |       |       |       |       |
|            | 23       | 22    | 21    | 20    | 19    | 18    | 17    | 16    |
| Type/Reset | Reserved |       |       |       |       |       |       |       |
|            | 15       | 14    | 13    | 12    | 11    | 10    | 9     | 8     |
| Type/Reset | Reserved |       |       |       |       |       |       |       |
|            | 7        | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
| Type/Reset | UDBTG    | MDBTG | STLRX | NAKRX | DTGRX | STLTX | NAKTX | DTGTX |
|            | RW       | 0     | RW    | 0     | RW    | 0     | RW    | 0     |

| Bits | Field | Descriptions |
|------|-------|--------------|
|------|-------|--------------|

|     |       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7] | UDBTG | <p>USB Double Buffer Toggle bit</p> <p>The UDBTG and MDBTG bits are used to indicate which data buffer is accessed by the USB SIE hardware and which data buffer is accessed by the CPU software if the double buffering function is enabled. The UDBTG bit will be toggled by the SIE hardware circuitry after the current buffer operation is complete. After the UDBTG bit is toggled by the SIE, a NAK signal will be sent automatically to the USB host by the hardware circuitry. Therefore, the data transfer will be stopped temporarily until the data in the other buffer has been properly setup after which the MDBTG bit is toggled by the CPU application software.</p> <p>The following tables show the double buffering operation and the UDBTG and MDBTG bit status for an IN or OUT transaction.</p> |
|-----|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| Transaction Type | UDBTG | MDBTG | Buffer read by SIE | Buffer written by CPU |
|------------------|-------|-------|--------------------|-----------------------|
| IN               | 0     | 0     | None*              | EP_BUF0               |
|                  | 0     | 1     | EP_BUF0            | EP_BUF1               |
|                  | 1     | 0     | EP_BUF1            | EP_BUF0               |
|                  | 1     | 1     | None*              | EP_BUF1               |

| Transaction Type | UDBTG | MDBTG | Buffer written by SIE | Buffer read by CPU |
|------------------|-------|-------|-----------------------|--------------------|
| OUT              | 0     | 0     | None*                 | EP_BUF1            |
|                  | 0     | 1     | EP_BUF0               | EP_BUF1            |
|                  | 1     | 0     | EP_BUF1               | EP_BUF0            |
|                  | 1     | 1     | None*                 | EP_BUF0            |

\* Means the USB device sends a NAK signal to the USB host using the hardware circuitry.

The UDBTG and MDBTG bits setting procedure for the double buffering function is shown in the following example:

[UDBTG, MDBTG]=[0, 0]→[0, 1]→[1, 1]→[1, 0]→[0, 0]→[0, 1]→[1, 1]→[1, 0]→...

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [6]  | MDBTG | <p>CPU Double Buffer Toggle bit</p> <p>The MDBTG bit is used to indicate which data buffer is accessed by the CPU if the double buffering function is enabled. It can be toggled to switch to the other buffer by the CPU application software after the data in the current buffer accessed by the CPU has been properly setup. The double buffering operation together with the UDBTG and MDBTG bits are shown in the preceding two tables for the UDBTG bit definition</p>                                                                                                                                                                                                                                                                                                                                                                                                              |
| [5]  | STLRX | <p>STALL bit for reception transfers</p> <p>This bit is set to 1 by the application software if a functional error has been detected. This bit can be read and written and can only be toggled by writing 1. It can also be toggled by software to initialize its value under certain conditions.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| [4]  | NAKRX | <p>NAK bit for reception transfers</p> <p>This bit is toggled from 0 to 1 by the hardware circuitry, which will result in a NAK signal in the handshake phase of an OUT transaction after an ACK signal has been transmitted. It means that the USB device will be temporarily unable to accept data from the USB host until the received data is properly processed. If the endpoint is defined as an Isochronous transfer type, this bit is not available for usage. The hardware will not change the NAKRX bit status after a complete transaction.</p> <p>This bit can be read and written and can be only toggled by writing 1.</p>                                                                                                                                                                                                                                                   |
| [3]  | DTGRX | <p>Data Toggle bit for reception transfers</p> <p>If the endpoint is not used for Isochronous transfer, this bit is available for usage. This bit contains the expected value of the data toggle bit (0 = DATA0, 1 = DATA1) for the next data packet to be received. When the current valid data packet is received and the corresponding ACK signal is sent to the USB host by the USB device, the hardware circuitry will toggle this bit and the device will be ready to receive the next data packet. If the endpoint is defined as an Isochronous transfer type, this bit is not used since no data toggling is used and only the DATA0 packet will be transferred for normal Isochronous transfers.</p> <p>This bit can be read and written and can only be toggled by writing 1. This bit can also be toggled by the software to initialize its value under certain conditions.</p> |
| [2]  | STLTX | <p>STALL bit for transmission transfers</p> <p>This bit is set to 1 by the application software if there a functional error has been detected.</p> <p>This bit can be read and written and can be only toggled by writing 1. It can be toggled by the software to initialize its value under certain conditions.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| [1]  | NAKTX | <p>NAK bit for transmission transfers</p> <p>This bit is toggled from 0 to 1 by the hardware circuitry, which will result in a NAK signal in the handshake phase of an IN transaction after an ACK signal has been received. It means that the USB device will be temporarily unable to transmit a data packet until the data to be transmitted is properly setup by the application software. If the endpoint is defined as an Isochronous transfer type, then this bit is not available for usage. The hardware will not change the NAKTX bit status after a complete transaction.</p> <p>This bit can be read and written and can be only toggled by writing 1. It can also be toggled by the software to initialize its value under certain conditions.</p>                                                                                                                            |

| Bits | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [0]  | DTGTX | <p>Data Toggle bit for transmission transfers.</p> <p>If the endpoint is not used for Isochronous transfer, this bit is available for usage. This bit contains the required value of the data toggle bit (0 = DATA0, 1 = DATA1) for the next data packet to be transmitted. When the current data packet is transmitted by the USB device and the corresponding ACK signal sent from the USB host is received, the hardware circuitry will toggle this bit and then the next data packet will be transmitted. If the endpoint is used for Isochronous transfer, this bit is not used since no data toggling is used and only the DATA0 packet will be transferred for normal Isochronous transfer.</p> <p>This bit can be read and written and can only be toggled by writing 1. It can also be toggled by the software to initialize its value under certain conditions.</p> |

## USB Endpoint 4 ~ 7 Interrupt Enable Register – USBEPnIER, n = 4 ~ 7

This register specifies the Endpoint 4 ~ 7 interrupt enable control bits.

Offset: 0x068 (n = 4), 0x07C (n = 5), 0x090 (n = 6), 0x0A4 (n = 7)

Reset value: 0x0000\_0000

|            |          |       |       |        |        |        |        |        |
|------------|----------|-------|-------|--------|--------|--------|--------|--------|
|            | 31       | 30    | 29    | 28     | 27     | 26     | 25     | 24     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 23       | 22    | 21    | 20     | 19     | 18     | 17     | 16     |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 15       | 14    | 13    | 12     | 11     | 10     | 9      | 8      |
| Type/Reset | Reserved |       |       |        |        |        |        |        |
|            | 7        | 6     | 5     | 4      | 3      | 2      | 1      | 0      |
| Type/Reset | RW       | 0     | RW    | 0      | RW     | 0      | RW     | 0      |
|            | UERIE    | STLIE | NAKIE | IDTXIE | ITRXIE | ODOVIE | ODRXIE | OTRXIE |

| Bits | Field  | Descriptions                                                                                    |
|------|--------|-------------------------------------------------------------------------------------------------|
| [7]  | UERIE  | USB Error Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt               |
| [6]  | STLIE  | STALL Transmitted Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt       |
| [5]  | NAKIE  | NAK Transmitted Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt         |
| [4]  | IDTXIE | IN Data Transmitted Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt     |
| [3]  | ITRXIE | IN Token Received Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt       |
| [2]  | ODOVIE | OUT Data Buffer Overrun Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt |
| [1]  | ODRXIE | OUT Data Received Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt       |
| [0]  | OTRXIE | OUT Token Received Interrupt Enable Control<br>1: Enable interrupt<br>0: Disable interrupt      |

## USB Endpoint 4 ~ 7 Interrupt Status Register – USBEPnISR, n = 4 ~ 7

This register specifies the Endpoint 4 ~ 7 interrupt status.

Offset: 0x06C (n = 4), 0x080 (n = 5), 0x094 (n = 6), 0x0A8 (n = 7)

Reset value: 0x0000\_0000

|            |          |       |       |        |        |        |        |        |    |
|------------|----------|-------|-------|--------|--------|--------|--------|--------|----|
|            | 31       | 30    | 29    | 28     | 27     | 26     | 25     | 24     |    |
| Type/Reset | Reserved |       |       |        |        |        |        |        |    |
|            | 23       | 22    | 21    | 20     | 19     | 18     | 17     | 16     |    |
| Type/Reset | Reserved |       |       |        |        |        |        |        |    |
|            | 15       | 14    | 13    | 12     | 11     | 10     | 9      | 8      |    |
| Type/Reset | Reserved |       |       |        |        |        |        |        |    |
|            | 7        | 6     | 5     | 4      | 3      | 2      | 1      | 0      |    |
| Type/Reset | WC       | 0     | WC    | 0      | WC     | 0      | WC     | 0      | WC |
|            | UERIF    | STLIF | NAKIF | IDTXIF | ITRXIF | ODOVIF | ODRXIF | OTRXIF | 0  |

| Bits | Field  | Descriptions                                                                                                                                                                                                                                           |
|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]  | UERIF  | USB Error Interrupt flag<br>This bit is set by the hardware circuitry when an error occurs during the transaction. Writing 1 into this status bit will clear it to 0.                                                                                  |
| [6]  | STLIF  | STALL Transmitted Interrupt flag<br>This bit is set by the hardware circuitry when a STALL-token is sent in response to an IN or OUT token and is cleared to 0 by writing 1.                                                                           |
| [5]  | NAKIF  | NAK Transmitted Interrupt flag<br>This bit is set by the hardware circuitry when a NAK-token is sent in response to an IN or OUT token and is cleared to 0 by writing 1.                                                                               |
| [4]  | IDTXIF | IN Data Transmitted Interrupt flag<br>This bit is set by the hardware circuitry when a data packet is successfully transmitted to the host in response to an IN-token and an ACK-token is received. Writing 1 into this status bit will clear it to 0. |
| [3]  | ITRXIF | IN Token Received Interrupt flag<br>This bit is set by the hardware circuitry when the endpoint receives an IN token from the host and is cleared to 0 by writing 1.                                                                                   |
| [2]  | ODOVIF | OUT Data Buffer Overrun Interrupt flag<br>This bit is set by the hardware circuitry when the received data byte count is larger than the endpoint OUT data buffer size. Writing 1 into this status bit will clear it to 0.                             |
| [1]  | ODRXIF | OUT Data Received Interrupt flag<br>This bit is set by the hardware circuitry when a data packet is successfully received from the host for an OUT-token and an ACK signal is sent to the host. Writing 1 into this status bit will clear it to 0.     |
| [0]  | OTRXIF | OUT Token Received Interrupt flag<br>This bit is set by the hardware circuitry when the endpoint receives an OUT token from the host and is cleared to 0 by writing 1.                                                                                 |

## USB Endpoint 4 ~ 7 Transfer Count Register – USBEPnTCR, n = 4 ~ 7

This register specifies the Endpoint 4 ~ 7 transfer byte count.

Offset: 0x070 (n = 4), 0x084 (n = 5), 0x098 (n = 6), 0x0AC (n = 7)

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |       |    |    |
|------------|----------|----|----|----|----|----|-------|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25    | 24 |    |
|            | Reserved |    |    |    |    |    | TCNT1 |    |    |
| Type/Reset |          |    |    |    |    |    | RW    | 0  | RW |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17    | 16 |    |
|            | TCNT1    |    |    |    |    |    |       |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW    | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9     | 8  |    |
|            | Reserved |    |    |    |    |    | TCNT0 |    |    |
| Type/Reset |          |    |    |    |    |    | RW    | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1     | 0  |    |
|            | TCNT0    |    |    |    |    |    |       |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW    | 0  | RW |

| Bits    | Field | Descriptions                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [25:16] | TCNT1 | Buffer 1 Transfer Byte Count<br>This bit field contains the number of data bytes received by the endpoint n buffer 1 in the preceding OUT transaction or the number of data bytes to be transmitted by the endpoint n buffer1 in the next IN transaction.                                                                                                                                         |
| [9:0]   | TCNT0 | Buffer 0 Transfer Byte Count<br>This bit field contains the number of data bytes received by the endpoint n buffer 0 in the preceding OUT transaction or the number of data bytes to be transmitted by the endpoint n buffer 0 in the next IN transaction. Only the TCNT0 field is used for the endpoint data transfer count when the endpoint is configured as a single-buffering transfer type. |

## USB Endpoint 4 ~ 7 Configuration Register – USBEPnCFGR, n = 4 ~ 7

This register specifies the Endpoint 4 ~ 7 configurations.

Offset: 0x074 (n = 4), 0x088 (n = 5), 0x09C (n = 6), 0x0B0 (n = 7)

Reset value: 0x1000\_03FF

|            |        |          |        |       |       |       |        |      |
|------------|--------|----------|--------|-------|-------|-------|--------|------|
|            | 31     | 30       | 29     | 28    | 27    | 26    | 25     | 24   |
|            | EPEN   | Reserved | EPTYPE | EPDIR | EPADR |       |        |      |
| Type/Reset | RW 0   |          | RW 1   | RW 0  | RW 0  | RW 0  | RW 0   |      |
|            | 23     | 22       | 21     | 20    | 19    | 18    | 17     | 16   |
|            | SDBS   | Reserved |        |       |       | EPLEN |        |      |
| Type/Reset | RW 0   | RW 0     | RW 0   | RW 0  | RW 0  |       |        |      |
|            | 15     | 14       | 13     | 12    | 11    | 10    | 9      | 8    |
|            | EPLEN  |          |        |       |       |       | EPBUFA |      |
| Type/Reset | RW 0   | RW 0     | RW 0   | RW 0  | RW 0  | RW 0  | RW 1   | RW 1 |
|            | 7      | 6        | 5      | 4     | 3     | 2     | 1      | 0    |
|            | EPBUFA |          |        |       |       |       |        |      |
| Type/Reset | RW 1   | RW 1     | RW 1   | RW 1  | RW 1  | RW 1  | RW 1   | RW 1 |

| Bits    | Field  | Descriptions                                                                                                                                                                                                                                                                                |
|---------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31]    | EPEN   | Enable Control<br>0: Disable the endpoint n<br>1: Enable the endpoint n                                                                                                                                                                                                                     |
| [29]    | EPTYPE | Transfer Type<br>0: Interrupt or Bulk transfer type<br>1: Isochronous transfer type                                                                                                                                                                                                         |
| [28]    | EPDIR  | Transfer Direction<br>0: OUT<br>1: IN                                                                                                                                                                                                                                                       |
| [27:24] | EPADR  | Endpoint Address<br>The EPADR field can be configured by the application software to specify the address of endpoint n. It is important to note that this EPADR field should not be set to 0; otherwise, the endpoint n will be disabled.                                                   |
| [23]    | SDBS   | Single-Buffering or Double-Buffering Selection<br>0: Single-buffering<br>1: Double-buffering<br>If SDBS bit is set to 1, the endpoint buffer size is twice that of the EPLEN value:<br>- Endpoint Buffer 0 start address is EPBUFA<br>- Endpoint Buffer 1 start address is (EPBUFA + EPLEN) |
| [19:10] | EPLEN  | Buffer Length<br>This field is used to specify the endpoint n data packet size whose field value must be word-aligned to a 4-byte boundary. Note that the endpoint will be disabled if the LEN value is assigned to 0.                                                                      |
| [9:0]   | EPBUFA | Buffer Address<br>This field is used to specify the endpoint n data buffer start address which ranges from 0x008 to 0x3FC in the EP-SRAM which has a capacity of 1024 bytes where the endpoint transfer data is stored. Note that the buffer start address value must be a multiple of 4.   |

## 26 Peripheral Direct Memory Access (PDMA)

### Introduction

The Peripheral Direct Memory Access circuitry, PDMA, provides 6 unidirectional channels for dedicated peripherals to implement the peripheral-to-memory and memory-to-peripheral data transfer. The memory-to-memory data transfer such as the FLASH-to-SRAM or SRAM-to-SRAM type is also supported and requested by the application program. Each PDMA channel configuration is independent. The PDMA channel transfer is split into multiple block transactions and the size of a block is equal to the block length multiplied by the data width.

### Features

- 6 unidirectional PDMA channels
- Memory-to-peripheral, peripheral-to-memory and memory-to-memory data transfer
- 8-bit, 16-bit and 32-bit width data transfer
- Software and hardware requested data transfer with configurable channel priority
- Linear, circular and non-increment address modes
- 4 transfer event flags – Transfer complete, Half Transfer, Block End and Transfer Error
- Auto-Reload function

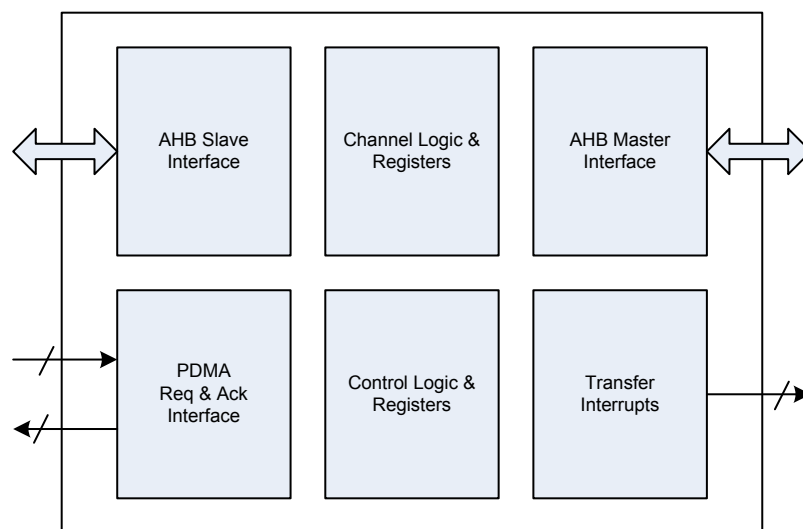


Figure 183. PDMA Block Diagram

## Functional Description

### AHB Master

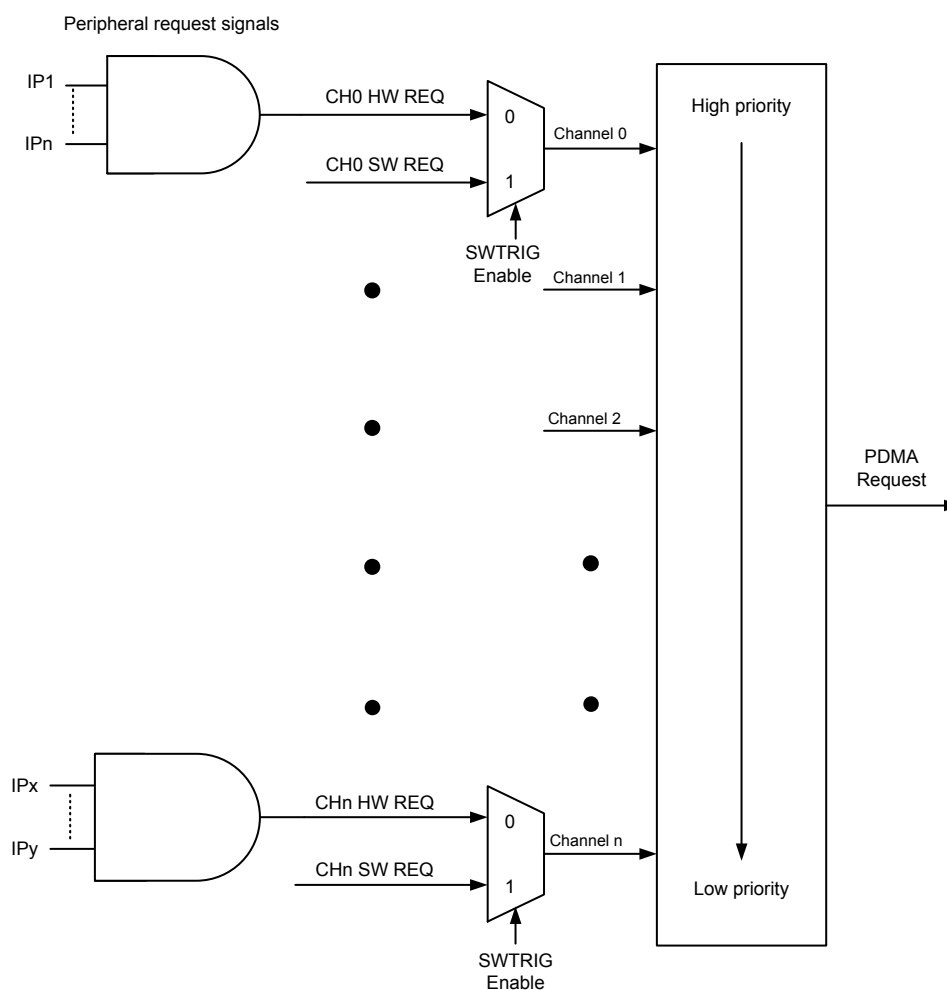
The PDMA is an AHB master connected to other AHB peripherals such as the FLASH memory, the SRAM memory and the AHB-to-APB bridges through the bus-matrix. The CPU and PDMA can access different AHB slaves at the same time via the bus-matrix.

### PDMA Channel

There are 6 unidirectional PDMA channels used to support data transfer between the peripherals and the memory. The configuration and operation of each PDMA channel is independent. For a bidirectional transfer application, two PDMA channels are required. Each PDMA channel is designed to support the dedicated multiple peripherals with the same registers. Therefore, one PDMA channel only can service one peripheral at the same time. The related registers of the PDMA channel are limited to be accessed with 32-bit operation; otherwise a system hard fault event will occur.

### PDMA Request Mapping

The multiple requests from the peripherals (ADC, SPI, I<sup>2</sup>C, USART and so on) are simply logically ANDed before entering the PDMA, that means that only one request must be enabled at a time in each PDMA channel. Refer to Figure 184: PDMA request mapping architecture and detail peripheral IP requests mapping table is show as the Table 1. The peripheral DMA requests can be independently activated/de-activated by programming the DMA control bit in the registers of the corresponding peripheral.



**Figure 184. PDMA Request Mapping Architecture**

**Table 67. PDMA Channel Assignments**

| IP<br>(x=0,1)    | PDMA Channel Number |                    |                     |                    |                    |                     |
|------------------|---------------------|--------------------|---------------------|--------------------|--------------------|---------------------|
|                  | CH0                 | CH1                | CH2                 | CH3                | CH4                | CH5                 |
| ADC              | ADC                 |                    |                     |                    |                    |                     |
| SPIx             | SPI0_RX             | SPI0_TX            |                     |                    | SPI1_RX            | SPI1_TX             |
| USARTx           | USR0_RX             | USR0_TX            | USR1_RX             | USR1_TX            |                    |                     |
| UARTx            |                     |                    | UR0_RX              | UR0_TX             | UR1_RX             | UR1_TX              |
| SCIx             |                     |                    | SCI1_RX             | SCI1_TX            | SCI0_RX            | SCI0_TX             |
| I2Cx             |                     |                    | I2C0_RX             | I2C1_RX            | I2C0_TX            | I2C1_TX             |
| MCTM             | MT_CH0              | MT_TRIG            | MT_CH1              | MT_CH2             | MT_CH3<br>MT_UEV2  | MT_UEV1             |
| GPTMx            | GT0_CH1<br>GT0_CH3  | GT0_CH2<br>GT0_UEV | GT0_CH0<br>GT0_TRIG | GT1_CH0<br>GT1_CH3 | GT1_CH1<br>GT1_UEV | GT1_CH2<br>GT1_TRIG |
| I <sup>2</sup> S |                     | I2S_RX             | I2S_TX              |                    |                    |                     |

## Channel transfer

A PDMA channel transfer is split into multiple block transactions with PDMA arbitration occurring at the end of each block transaction. Although these channel transfers can all be activated, there is only one block transaction being transferred through the bus at a time. The channel transfer sequence depends upon the channel priority setting of each PDMA channel. The total transfer size is calculated from the block transaction count and block size. The block size is equal to the product of the block length and data bit width. For an efficient transfer, it is recommended that the block length is set as a multiple of 4.

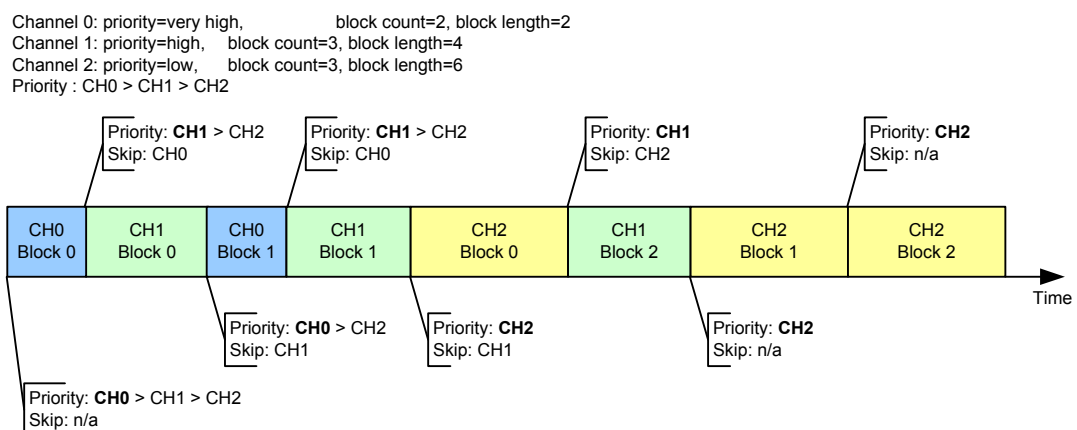
The total transfer data size calculation is shown as below equation:

A PDMA channel total transfer data size = Block transaction count x (Block length x Data width)

## Channel Priority

The PDMA provides four priority levels, known as very high, high, medium and low, which can be configured by the application software. The PDMA also provides two methods to determine the channel priority. One is determined by application software configuration and the other is determined by the fixed hardware channel number. The PDMA arbitration processor will first check the software configuring channel priority level used to request the PDMA to provide the data transfer services. If more than one channel has the same priority, the channel with a smaller channel number will have priority over one with a larger channel number after arbitration.

Note that the highest priority channel will not occupy the PDMA service all the time when other lower priority channel requests are pending. The highest priority channel will be skipped for one block transaction time duration after one block transaction is complete. Then a block transaction requested by the second priority channel will be performed. After a block transaction of the second priority channel is complete, the PDMA arbitration processor will re-check all of the requested channel priority with the exception of the second priority channel since the second priority channel will be excluded after the end of a block transaction. Therefore, a block data transaction of the higher priority channel will be serviced and this channel will be excluded from the priority arbitration at the end of the block transaction. The PDMA will keep transferring the data using the method described above until all of the requested channel data transfer is complete. Refer to the accompanying figure for an example which shows the PDMA channel arbitration and scheduling.



**Figure 185. PDMA Channel Arbitration and Scheduling Example**

## Transfer Request

For a peripheral-to-memory or memory-to-peripheral transfer, one peripheral hardware request will trigger one block transaction of the dedicated PDMA channel. However, a complete data transfer of the relevant dedicated PDMA channel will be triggered when a software request occurs. It is recommended that the PDMA channel is configured to have a lower priority level and a smaller block length which is requested by the software for memory-to-memory data copy applications.

## Address Mode

The PDMA provides three kinds of address modes which are the linear address, circular address and fixed address modes. These different address modes are used to support different kinds of source and destination address arrangements. The following table shows the detailed address mode combinations.

**Table 68. PDMA Address Modes**

| Source Address Mode                    | Destination Address Mode               |
|----------------------------------------|----------------------------------------|
| Linear Increment / Decrement Address   | Linear Increment / Decrement Address   |
| Linear Increment / Decrement Address   | Circular Increment / Decrement Address |
| Linear Increment / Decrement Address   | Fixed Address                          |
| Circular Increment / Decrement Address | Linear Increment / Decrement Address   |
| Circular Increment / Decrement Address | Circular Increment / Decrement Address |
| Fixed Address                          | Linear Increment / Decrement Address   |
| Fixed Address                          | Fixed Address                          |

### Linear Address Mode

After data is transferred, the current address will be increased or decreased by 1, 2 or 4 depending upon the data bit width setting.

### Circular Address Mode

After data is transferred, the current address will be increased or decreased by 1, 2 or 4 depending upon the data bit width setting. When a block transaction is complete, the current address is loaded with the configured start address.

### Fixed Address Mode

After data is transferred, the current address remains unchanged.

## Auto-Reload

When the auto-reload control bit, AUTORLn, in the PDMA channel n control register PDMACHnCR is set, both the channel n current address stored in the PDMACHnCADR register and the channel n current transfer size in the PDMACHnCTSR register will be automatically reloaded with the corresponding start value after the current PDMA channel data transfer has totally completed. The channel n will still be activated and the next relative PDMA request can be serviced without any re-configuration using the application software.

## Transfer Interrupt

There are five transfer events during which the interrupts can be asserted for each PDMA channel. These are the block transaction end (BE), half-transfer (HT), transfer complete (TC), transfer error (TE) and global transfer event (GE). Setting the corresponding control bits in the PDMA interrupt enable register PDMAIER will enable the relevant interrupt events. The global interrupt event, GE, will be generated if any of the four interrupt events including the BE, HT, TC or TE occurs. Clearing the BE, HT, TC or TE event flags will also clear the GE flag. Clearing the GE flag will automatically clear all other event flags. The TE interrupt event will occur when the PDMA accesses a system reserved address space or the PDMA receives a request but when the corresponding transfer size setting is equal to zero.

## Register Map

The following table shows the PDMA registers and the reset values.

**Table 69. PDMA Register Map**

| Register                               | Offset | Description                                   | Reset Value |
|----------------------------------------|--------|-----------------------------------------------|-------------|
| <b>PDMA Base Address = 0x4009_0000</b> |        |                                               |             |
| <b>PDMA Channel 0 Registers</b>        |        |                                               |             |
| PDMACH0CR                              | 0x000  | PDMA Channel 0 Control Register               | 0x0000_0000 |
| PDMACH0SADR                            | 0x004  | PDMA Channel 0 Source Address Register        | 0x0000_0000 |
| PDMACH0DADR                            | 0x008  | PDMA Channel 0 Destination Address Register   | 0x0000_0000 |
| PDMACH0TSR                             | 0x010  | PDMA Channel 0 Transfer Size Register         | 0x0000_0000 |
| PDMACH0CTSR                            | 0x014  | PDMA Channel 0 Current Transfer Size Register | 0x0000_0000 |
| <b>PDMA Channel 1 Registers</b>        |        |                                               |             |
| PDMACH1CR                              | 0x018  | PDMA Channel 1 Control Register               | 0x0000_0000 |
| PDMACH1SADR                            | 0x01C  | PDMA Channel 1 Source Address Register        | 0x0000_0000 |
| PDMACH1DADR                            | 0x020  | PDMA Channel 1 Destination Address Register   | 0x0000_0000 |
| PDMACH1TSR                             | 0x028  | PDMA Channel 1 Transfer Size Register         | 0x0000_0000 |
| PDMACH1CTSR                            | 0x02C  | PDMA Channel 1 Current Transfer Size Register | 0x0000_0000 |
| <b>PDMA Channel 2 Registers</b>        |        |                                               |             |
| PDMACH2CR                              | 0x030  | PDMA Channel 2 Control Register               | 0x0000_0000 |
| PDMACH2SADR                            | 0x034  | PDMA Channel 2 Source Address Register        | 0x0000_0000 |
| PDMACH2DADR                            | 0x038  | PDMA Channel 2 Destination Address Register   | 0x0000_0000 |
| PDMACH2TSR                             | 0x040  | PDMA Channel 2 Transfer Size Register         | 0x0000_0000 |
| PDMACH2CTSR                            | 0x044  | PDMA Channel 2 Current Transfer Size Register | 0x0000_0000 |
| <b>PDMA Channel 3 Registers</b>        |        |                                               |             |
| PDMACH3CR                              | 0x048  | PDMA Channel 3 Control Register               | 0x0000_0000 |
| PDMACH3SADR                            | 0x04C  | PDMA Channel 3 Source Address Register        | 0x0000_0000 |
| PDMACH3DADR                            | 0x050  | PDMA Channel 3 Destination Address Register   | 0x0000_0000 |
| PDMACH3TSR                             | 0x058  | PDMA Channel 3 Transfer Size Register         | 0x0000_0000 |
| PDMACH3CTSR                            | 0x05C  | PDMA Channel 3 Current Transfer Size Register | 0x0000_0000 |
| <b>PDMA Channel 4 Registers</b>        |        |                                               |             |
| PDMACH4CR                              | 0x060  | PDMA Channel 4 Control Register               | 0x0000_0000 |
| PDMACH4SADR                            | 0x064  | PDMA Channel 4 Source Address Register        | 0x0000_0000 |
| PDMACH4DADR                            | 0x068  | PDMA Channel 4 Destination Address Register   | 0x0000_0000 |
| PDMACH4TSR                             | 0x070  | PDMA Channel 4 Transfer Size Register         | 0x0000_0000 |

| Register                               | Offset | Description                                   | Reset Value |
|----------------------------------------|--------|-----------------------------------------------|-------------|
| <b>PDMA Base Address = 0x4009_0000</b> |        |                                               |             |
| PDMACH4CTSR                            | 0x074  | PDMA Channel 4 Current Transfer Size Register | 0x0000_0000 |
| <b>PDMA Channel 5 Registers</b>        |        |                                               |             |
| PDMACH5CR                              | 0x078  | PDMA Channel 5 Control Register               | 0x0000_0000 |
| PDMACH5SADR                            | 0x07C  | PDMA Channel 5 Source Address Register        | 0x0000_0000 |
| PDMACH5DADR                            | 0x080  | PDMA Channel 5 Destination Address Register   | 0x0000_0000 |
| PDMACH5TSR                             | 0x088  | PDMA Channel 5 Transfer Size Register         | 0x0000_0000 |
| PDMACH5CTSR                            | 0x08C  | PDMA Channel 5 Current Transfer Size Register | 0x0000_0000 |
| <b>PDMA Global Register</b>            |        |                                               |             |
| PDMAISR                                | 0x120  | PDMA Interrupt Status Register                | 0x0000_0000 |
| PDMAICLR                               | 0x128  | PDMA Interrupt Status Clear Register          | 0x0000_0000 |
| PDMAIER                                | 0x130  | PDMA Interrupt Enable Register                | 0x0000_0000 |

## Register Descriptions

### PDMA Channel n Control Register – PDMACHnCR, n = 0 ~ 5

This register is used to specify the PDMA channel n data transfer configuration.

Offset: 0x000 (0), 0x018 (1), 0x030 (2), 0x048 (3), 0x060 (4), 0x078 (5)

Reset value: 0x0000\_0000

|            |          |          |          |          |         |         |         |       |
|------------|----------|----------|----------|----------|---------|---------|---------|-------|
|            | 31       | 30       | 29       | 28       | 27      | 26      | 25      | 24    |
| Type/Reset | Reserved |          |          |          |         |         |         |       |
|            | 23       | 22       | 21       | 20       | 19      | 18      | 17      | 16    |
| Type/Reset | Reserved |          |          |          |         |         |         |       |
|            | 15       | 14       | 13       | 12       | 11      | 10      | 9       | 8     |
| Type/Reset | Reserved |          |          |          | AUTORLn | FIXAENn | CHnPRI  |       |
|            |          |          |          |          | RW      | 0       | RW      | 0     |
|            | 7        | 6        | 5        | 4        | 3       | 2       | 1       | 0     |
| Type/Reset | SRCAMODn | SRCAINCn | DSTAMODn | DSTAINCn | DWIDTHn |         | SWTRIGn | CHnEN |
|            | RW       | 0        | RW       | 0        | RW      | 0       | RW      | 0     |

| Bits  | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11]  | AUTORLn | Channel n Auto Reload Enable Control<br>0: Disable Auto Reload function<br>1: Enable Auto Reload function<br>If this bit is set to 1 to enable the auto-reload function, the PDMACHnCADR and PDMACHnCTSR registers will be reloaded with the relevant start value and the PDMA channel n will be activated when a transfer is complete. If this bit is cleared to 0, the PDMACHnCADR and PDMACHnCTSR registers will remain unchanged and the PDMA channel n will be disabled after a transfer completion.                                                                                                                                                                              |
| [10]  | FIXAENn | Channel n Fixed Address Enable control<br>0: Disable fixed address function in the circular address mode<br>1: Enable fixed address function in the circular address mode<br>Note that this bit is only available when the source or destination address mode is set to be in the circular address mode. For example, the source address mode is set as in the linear address mode and the destination address mode is set as in the circular mode. If this bit is set to enable the fixed address function, then the source address mode will still be in the linear address but the destination address mode will be in the fixed address mode instead of the circular address mode. |
| [9:8] | CHnPRI  | Channel n Priority<br>00: Low<br>01: Medium<br>10: High<br>11: Very high<br>The CHnPRI field is used to configure the channel priority using the application program. If there are more than one channel which have the same software configured priority level, the channel with the smaller channel number will have priority to transfer one block of data after the arbitration.                                                                                                                                                                                                                                                                                                   |

| Bits  | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7]   | SRCAMODn | Channel n Source Address Mode selection<br>0: Linear address mode<br>1: Circular address mode<br>In the linear address mode, the current source address field value, CSADR, in the PDMACHnCADR register can be incremented or decremented, determined by the SRCAINCn bit value during a complete transfer. In the circular address mode, the CSADR field value can be incremented or decremented which is also determined by the SRCAINCn bit value during a block transfer and will be loaded with the lower 16-bit value of the PDMACHnSADR register when a block transaction has completed.    |
| [6]   | SRCAINCn | Channel n Source Address Increment control<br>0: Increment<br>1: Decrement<br>This bit is used to determine whether the current source address in the CSADR field is increased or decreased during a complete transfer in the linear address mode or a block transfer in the circular address mode.                                                                                                                                                                                                                                                                                                |
| [5]   | DSTAMODn | Channel n Destination Address Mode selection<br>0: Linear address mode<br>1: Circular address mode<br>In linear address mode, the current destination address field value, CDADR, in the PDMACHnCADR register can be incremented or decremented, determined by the DSTAINCn bit value during a complete transfer. In the circular address mode, the CDADR field value can be incremented or decremented which is also determined by the DSTAINCn bit value during a block transfer and will be loaded with the lower 16-bit value of the PDMACHnDADR register when a block transfer has completed. |
| [4]   | DSTAINCn | Channel n Destination Address Increment Control<br>0: Increment<br>1: Decrement<br>This bit is used to determine if the current destination address in the CDADR field is increased or decreased during a complete transfer in the linear address mode or a block transfer in the circular address mode.                                                                                                                                                                                                                                                                                           |
| [3:2] | DWIDTHn  | Data Bit Width selection<br>00: 8-bit<br>01: 16-bit<br>10: 32-bit<br>11: Reserved<br>The field is used to select the data bit width of the corresponding PDMA channel n.                                                                                                                                                                                                                                                                                                                                                                                                                           |
| [1]   | SWTRIGn  | Software Trigger control<br>0: No operation<br>1: Software triggered transfer request<br>Setting this bit will generate a memory-to-memory software transfer request on the corresponding PDMA channel n. It is automatically cleared when a transfer has completely finished.                                                                                                                                                                                                                                                                                                                     |
| [0]   | CHnEN    | Channel n Enable control<br>0: Disable the PDMA channel n<br>1: Enable the PDMA channel n<br>Setting this bit will enable a software or hardware transfer request on the PDMA channel n. It is automatically cleared by hardware when a transfer has completed with the auto-reload function being disabled. However, if the AUTORLn bit is set to 1 to enable the auto-reload function, this bit will remain high to enable the PDMA channel n function for the next transfer request instead of automatically being cleared by hardware after a transfer has finished.                           |

## PDMA Channel n Source Address Register – PDMACHnSADR, n = 0 ~ 5

This register specifies the source address of the PDMA channel n.

Offset: 0x004 (0), 0x01C (1), 0x034 (2), 0x04C (3), 0x064 (4), 0x07C (5)

Reset value: 0x0000\_0000

|            |       |    |    |    |    |    |    |    |    |
|------------|-------|----|----|----|----|----|----|----|----|
|            | 31    | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | SADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | SADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15    | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | SADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7     | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | SADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                 |
|--------|-------|--------------------------------------------------------------------------------------------------------------|
| [31:0] | SADRn | Channel n Source Address<br>The register is used to specify the 32-bit source address of the PDMA channel n. |

## PDMA Channel n Destination Address Register – PDMAChnDADR, n=0~5

This register specifies the destination address of the PDMA channel n.

Offset: 0x008 (0), 0x020 (1), 0x038 (2), 0x050 (3), 0x068 (4), 0x080 (5)

Reset value: 0x0000\_0000

|            |       |    |    |    |    |    |    |    |    |
|------------|-------|----|----|----|----|----|----|----|----|
|            | 31    | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | DADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23    | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | DADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15    | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | DADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 7     | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | DADRn |    |    |    |    |    |    |    |    |
| Type/Reset | RW    | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                           |
|--------|-------|------------------------------------------------------------------------------------------------------------------------|
| [31:0] | DADRn | Channel n Destination Address<br>The register is used to specify the 32-bit destination address of the PDMA channel n. |

## PDMA Channel n Transfer Size Register – PDMACHnTSR, n = 0 ~ 5

This register is used to specify the block transaction count and block transaction length.

Offset: 0x010 (0), 0x028 (1), 0x040 (2), 0x058 (3), 0x070 (4), 0x088 (5)

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | BLKCNTn  |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | BLKCNTn  |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | Reserved |    |    |    |    |    |    |    |    |
| Type/Reset |          |    |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | BLKLENn  |    |    |    |    |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW | 0  | RW | 0  | RW |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                           |
|---------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | BLKCNTn | Channel n Block Transaction Count<br>BLKCNTn represents the number of block transactions for a channel n complete transfer. The capacity of a complete transfer is the product of the BLKCNTn and BLKLENn values. The maximum BLKCNTn value is 65,535. |
| [7:0]   | BLKLENn | Channel n Block Length<br>The BLKLENn represents the length of a data block. The data width is defined by the DWIDTHn field in the PDMACHnCR register. The maximum BLKLENn value is 255.                                                               |

## PDMA Channel n Current Transfer Size Register – PDMACHnCTSR, n=0~5

This register is used to indicate the current block transaction count.

Offset: 0x014 (0), 0x02C (1), 0x044 (2), 0x05C (3), 0x074 (4), 0x08C (5)

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|------------|----------|----|----|----|----|----|----|----|----|---|----|---|----|---|----|---|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |   |    |   |    |   |    |   |
|            | CBLKCNTn |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
| Type/Reset | RO       | 0  | RO | 0  | RO | 0  | RO | 0  | RO | 0 | RO | 0 | RO | 0 | RO | 0 |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |   |    |   |    |   |    |   |
|            | CBLKCNTn |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
| Type/Reset | RO       | 0  | RO | 0  | RO | 0  | RO | 0  | RO | 0 | RO | 0 | RO | 0 | RO | 0 |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |   |    |   |    |   |    |   |
|            | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
| Type/Reset |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |   |    |   |    |   |    |   |
|            | Reserved |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |
| Type/Reset |          |    |    |    |    |    |    |    |    |   |    |   |    |   |    |   |

| Bits    | Field    | Descriptions                                                                                                                                                                                                                                                                                                                                              |
|---------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:16] | CBLKCNTn | Channel n Current Block Count<br>The CBLKCNTn field is a 16-bit read-only value indicating the number of data blocks that remain to be transferred. After a data block has transferred completely, the CBLKCNTn value will be decremented by 1. Writing a new value to the BLKCNTn field in the PDMACHnTSR register will update the CBLKCNTn field value. |

## PDMA Interrupt Status Register – PDMAISR

This register is used to indicate the corresponding interrupt status of the PDMA channel 0 ~ 5.

Offset: 0x120

Reset value: 0x0000\_0000

|            |          |         |         |         |         |         |         |         |    |
|------------|----------|---------|---------|---------|---------|---------|---------|---------|----|
|            | 31       | 30      | 29      | 28      | 27      | 26      | 25      | 24      |    |
|            | Reserved |         | TEISTA5 | TCISTA5 | HTISTA5 | BEISTA5 | GEISTA5 | TEISTA4 |    |
| Type/Reset |          |         | RO      | 0       | RO      | 0       | RO      | 0       | RO |
|            | 23       | 22      | 21      | 20      | 19      | 18      | 17      | 16      |    |
|            | TCISTA4  | HTISTA4 | BEISTA4 | GEISTA4 | TEISTA3 | TCISTA3 | HTISTA3 | BEISTA3 |    |
| Type/Reset | RO       | 0       | RO      | 0       | RO      | 0       | RO      | 0       | RO |
|            | 15       | 14      | 13      | 12      | 11      | 10      | 9       | 8       |    |
|            | GEISTA3  | TEISTA2 | TCISTA2 | HTISTA2 | BEISTA2 | GEISTA2 | TEISTA1 | TCISTA1 |    |
| Type/Reset | RO       | 0       | RO      | 0       | RO      | 0       | RO      | 0       | RO |
|            | 7        | 6       | 5       | 4       | 3       | 2       | 1       | 0       |    |
|            | HTISTA1  | BEISTA1 | GEISTA1 | TEISTA0 | TCISTA0 | HTISTA0 | BEISTA0 | GEISTA0 |    |
| Type/Reset | RO       | 0       | RO      | 0       | RO      | 0       | RO      | 0       | RO |

| Bits                             | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [29], [24], [19], [14], [9], [4] | TEISTAn | Channel n Transfer Error Interrupt Status (n = 0 ~ 5)<br>0: No Transfer Error occurs<br>1: Transfer Error occurs<br>This bit is set by hardware and is cleared by writing a “1” into the corresponding interrupt status clear bit in the PDMAISR register. A Transfer error will occur when the PDMA accesses a system reserved address space or the PDMA receives a request but when the corresponding transfer capacity is equal to zero. |
| [28], [23], [18], [13], [8], [3] | TCISTAn | Channel n Transfer Complete Interrupt Status (n= 0 ~ 5)<br>0: No Transfer Completion Occurs<br>1: Transfer Completion Occurs<br>This bit is set by hardware and is cleared by writing a “1” into the corresponding interrupt status clear bit in the PDMAISR register. The Transfer Completion event will occur when the PDMA has completed a data transfer task.                                                                           |
| [27], [22], [17], [12], [7], [2] | HTISTAn | Channel n Half Transfer Interrupt Status (n= 0 ~ 5)<br>0: No Half Transfer Event Occurs<br>1: Half Transfer Event Occurs<br>This bit is set by hardware and is cleared by writing a “1” into the corresponding interrupt status clear bit in the PDMAISR register. A Half Transfer event will occur when the PDMA has completed half of the data transfer task.                                                                             |
| [26], [21], [16], [11], [6], [1] | BEISTAn | Channel n Block Transaction End Interrupt Status (n= 0 ~ 5)<br>0: No Block Transaction End Event Occurs<br>1: Block Transaction End Event Occurs<br>This bit is set by hardware and is cleared by writing a “1” into the corresponding interrupt status clear bit in the PDMAISR register. A Block Transaction End event will occur when the PDMA completes a data block transaction task.                                                  |

| Bits                             | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [25], [20], [15], [10], [5], [0] | GEISTAn | <p>Channel n Global Transfer Interrupt Status (n= 0 ~ 5)</p> <p>0: No TE, TC, HT or BE event occurs<br/>1: TE, TC, HT, or BE event occurs</p> <p>This bit is set by hardware and is cleared by writing a “1” into the corresponding interrupt status clear bit, GEICLRn, in the PDMAISR register. A Global Transfer Event will occur if any of the BE, HT, TC or TE events occur. Also clearing any of the BE, HT, TC or TE event interrupt flags will clear the GE interrupt flag. Note that if a “1” is written into the GEICLRn bit in the PDMAISR register to clear the GE interrupt flag, the BE, HT, TC and TE event interrupt flags will also be cleared to 0 together with the GE interrupt status flag.</p> |

### PDMA Interrupt Status Clear Register – PDMAISCR

This register is used to clear the corresponding interrupt status bits in the PDMAISR Register.

Offset: 0x128

Reset value: 0x0000\_0000

|            |          |  |         |  |         |  |         |  |         |  |         |  |         |  |         |  |    |  |   |  |
|------------|----------|--|---------|--|---------|--|---------|--|---------|--|---------|--|---------|--|---------|--|----|--|---|--|
|            | 31       |  | 30      |  | 29      |  | 28      |  | 27      |  | 26      |  | 25      |  | 24      |  |    |  |   |  |
|            | Reserved |  |         |  | TEICLR5 |  | TCICLR5 |  | HTICLR5 |  | BEICLR5 |  | GEICLR5 |  | TEICLR4 |  |    |  |   |  |
| Type/Reset | RW       |  |         |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW      |  | 0  |  |   |  |
|            | 23       |  | 22      |  | 21      |  | 20      |  | 19      |  | 18      |  | 17      |  | 16      |  |    |  |   |  |
|            | TCICLR4  |  | HTICLR4 |  | BEICLR4 |  | GEICLR4 |  | TEICLR3 |  | TCICLR3 |  | HTICLR3 |  | BEICLR3 |  |    |  |   |  |
| Type/Reset | RW       |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW |  | 0 |  |
|            | 15       |  | 14      |  | 13      |  | 12      |  | 11      |  | 10      |  | 9       |  | 8       |  |    |  |   |  |
|            | GEICLR3  |  | TEICLR2 |  | TCICLR2 |  | HTICLR2 |  | BEICLR2 |  | GEICLR2 |  | TEICLR1 |  | TCICLR1 |  |    |  |   |  |
| Type/Reset | RW       |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW |  | 0 |  |
|            | 7        |  | 6       |  | 5       |  | 4       |  | 3       |  | 2       |  | 1       |  | 0       |  |    |  |   |  |
|            | HTICLR1  |  | BEICLR1 |  | GEICLR1 |  | TEICLR0 |  | TCICLR0 |  | HTICLR0 |  | BEICLR0 |  | GEICLR0 |  |    |  |   |  |
| Type/Reset | RW       |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW      |  | 0       |  | RW |  | 0 |  |

| Bits                             | Field    | Descriptions                                                                                                                                                                                                                                                                                                                             |
|----------------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [29], [24], [19], [14], [9], [4] | TEICLRn  | <p>Channel n Transfer Error Interrupt Status Clear (n = 0 ~ 5)</p> <p>0: No Operation<br/>1: Clear the corresponding TEISTAn bit in the PDMAISR register</p> <p>Writing a “1” into the TEICLRn bit will clear the TEISTAn status bit in the PDMAISR register. This bit will be automatically cleared to 0 after a “1” is written.</p>    |
| [28], [23], [18], [13], [8], [3] | TCICLRn  | <p>Channel n Transfer Complete Interrupt Status Clear (n = 0 ~ 5)</p> <p>0: No Operation<br/>1: Clear the corresponding TCISTAn bit in the PDMAISR register</p> <p>Writing a “1” into the TCICLRn bit will clear the TCISTAn status bit in the PDMAISR register. This bit will be automatically cleared to 0 after a “1” is written.</p> |
| [27], [22], [17], [12], [7], [2] | HTRICLRn | <p>Channel n Half Transfer Interrupt Status Clear (n = 0 ~ 5)</p> <p>0: No Operation<br/>1: Clear the corresponding HTISTAn bit in the PDMAISR register</p> <p>Writing a “1” into the HTRICLRn bit will clear the HTISTAn status bit in the PDMAISR register. This bit will be automatically cleared to 0 after a “1” is written.</p>    |

| Bits                             | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [26], [21], [16], [11], [6], [1] | BEICLRn | Channel n Block Transaction End Interrupt Status Clear (n = 0 ~ 5)<br>0: No Operation<br>1: Clear the corresponding BEISTAn bit in the PDMAISR register<br>Writing a "1" into the BEICLRn bit will clear the BEISTAn status bit in the PDMAISR register. This bit will automatically cleared to 0 after a data "1" is written.                                                                                                  |
| [25], [20], [15], [10], [5], [0] | GEICLRn | Channel n Global Transfer Event Interrupt Status Clear (n = 0 ~ 5)<br>0: No Operation<br>1: Clear the corresponding TEISTAn, TCISTAn, HTISTAn, BEISTAn, and GEISTAn bits in the PDMAISR register<br>Writing a "1" into the GEICLRn bit will clear the GEISTAn status bit together with the TEISTAn, TCISTAn, HTISTAn, BEISTAn bits in the PDMAISR register. This bit will be automatically cleared to 0 after a "1" is written. |

## PDMA Interrupt Enable Register – PDMAIER

This register is used to enable or disable the related interrupts of the PDMA channel 0 ~ 5.

Offset: 0x130

Reset value: 0x0000\_0000

|            |          |       |       |       |       |       |       |       |  |
|------------|----------|-------|-------|-------|-------|-------|-------|-------|--|
|            | 31       | 30    | 29    | 28    | 27    | 26    | 25    | 24    |  |
|            | Reserved |       | TEIE5 | TCIE5 | HTIE5 | BEIE5 | GEIE5 | TEIE4 |  |
| Type/Reset |          |       | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  |  |
|            | 23       | 22    | 21    | 20    | 19    | 18    | 17    | 16    |  |
|            | TCIE4    | HTIE4 | BEIE4 | GEIE4 | TEIE3 | TCIE3 | HTIE3 | BEIE3 |  |
| Type/Reset | RW 0     | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  |  |
|            | 15       | 14    | 13    | 12    | 11    | 10    | 9     | 8     |  |
|            | GEIE3    | TEIE2 | TCIE2 | HTIE2 | BEIE2 | GEIE2 | TEIE1 | TCIE1 |  |
| Type/Reset | RW 0     | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  |  |
|            | 7        | 6     | 5     | 4     | 3     | 2     | 1     | 0     |  |
|            | HTIE1    | BEIE1 | GEIE1 | TEIE0 | TCIE0 | HTIE0 | BEIE0 | GEIE0 |  |
| Type/Reset | RW 0     | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  | RW 0  |  |

| Bits                             | Field             | Descriptions                                                                                                                                                                                                        |
|----------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [29], [24], [19], [14], [9], [4] | TEIE <sub>n</sub> | Channel n Transfer Error Interrupt Enable control (n = 0 ~ 5)<br>0: Transfer Error interrupt is disabled<br>1: Transfer Error interrupt is enabled<br>This bit is set and cleared by software.                      |
| [28], [23], [18], [13], [8], [3] | TCIE <sub>n</sub> | Channel n Transfer Complete Interrupt Enable control (n = 0 ~ 5)<br>0: Transfer Completion interrupt is disabled<br>1: Transfer Completion interrupt is enabled<br>This bit is set and cleared by software.         |
| [27], [22], [17], [12], [7], [2] | HTIE <sub>n</sub> | Channel n Half Transfer Interrupt Enable control (n = 0 ~ 5)<br>0: Half Transfer interrupt is disabled<br>1: Half Transfer interrupt is enabled<br>This bit is set and cleared by software.                         |
| [26], [21], [16], [11], [6], [1] | BEIE <sub>n</sub> | Channel n Block Transaction End Interrupt Enable control (n = 0 ~ 5)<br>0: Block Transaction End interrupt is disabled<br>1: Block Transaction End interrupt is enabled<br>This bit is set and cleared by software. |
| [25], [20], [15], [10], [5], [0] | GEIE <sub>n</sub> | Channel n Global Transfer Event Interrupt Enable control (n = 0 ~ 5)<br>0: Global Transfer Event interrupt is disabled<br>1: Global Transfer Event interrupt is enabled<br>This bit is set and cleared by software. |

# 27 **Extend Bus Interface (EBI)**

## Introduction

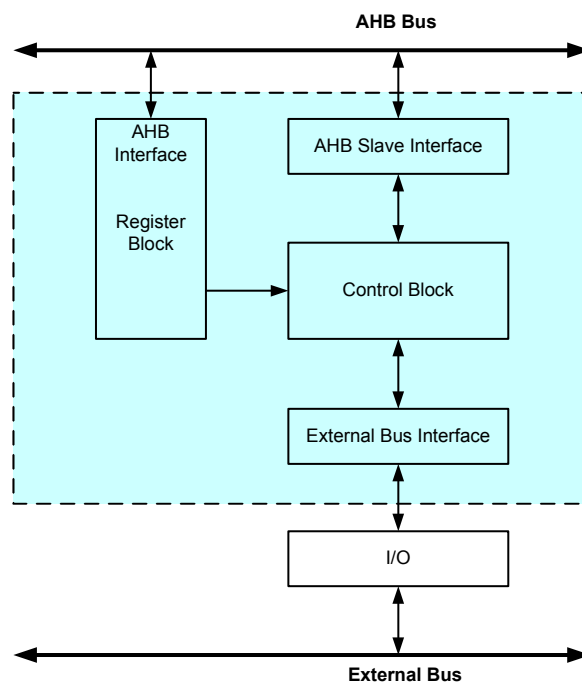
The external bus interface is able to access external parallel interface devices such as SRAM, Flash and LCD modules. The interface is memory mapped into the internal address bus of the CPU. The data and address lines can be multiplexed in order to reduce the number of pins required to connect to external devices. The bus read/write timing can be adjusted to meet the timing specifications of the external devices. Note that the interface only supports asynchronous 8 or 16-bit bus interfaces.

## Features

- Programmable interface for various memory types
  - Asynchronous static random access memory – SRAM
  - Read-only memory – ROM
  - NOR Flash memory
  - 8-bit or 16-bit parallel bus CPU interface device
- Translates AHB transactions into appropriate external device protocol
- Up to 4 memory bank regions and independent chip select control for each memory bank
- Programmable timings to support a wide range of devices
  - Programmable wait states
  - Programmable bus turnaround cycles
  - Programmable output enable and write enable cycles extension
  - Programmable active high or low setting of interface control signal
- Automatic translation when AHB transaction width and external memory interface width is different
- Write buffer to decrease stalling of the AHB write burst transactions
- Supports multiplexed and non-multiplexed address and data line configurations
  - Up to 21 address lines
  - 8-bit or 16-bit data bus width

## Function Descriptions

An overview of the EBI module is shown in Figure 186. The EBI enables internal CPU and other bus matrix master peripherals to access external memories or devices. The EBI automatically translates the internal AHB transactions into the external device protocol. In particular, if the selected external memory is 16 or 8 bits width, then 32-bit wide transactions on the AHB are auto split into consecutive 16 or 8-bit accesses.

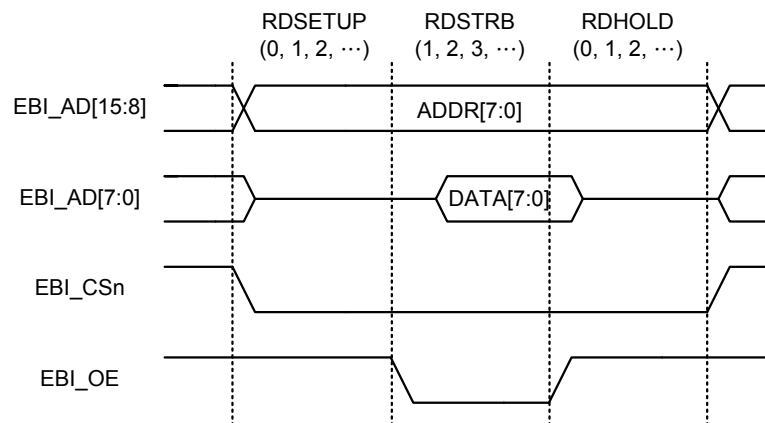


**Figure 186. EBI Block Diagram**

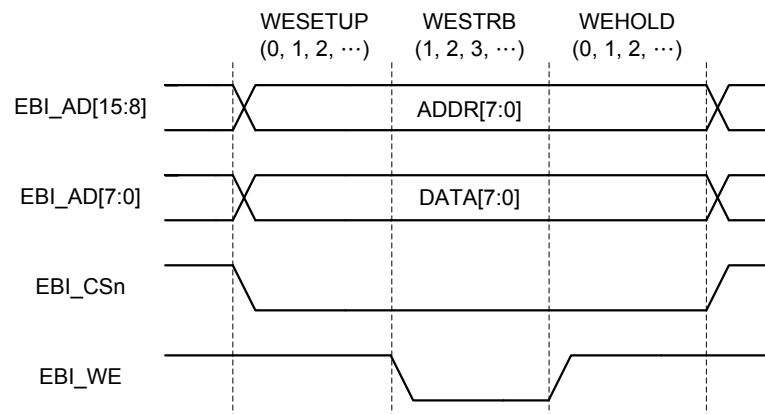
The EBI supports multiplexed and non-multiplexed addressing modes. The non-multiplexed addressing mode can be operated more efficiently and faster but it requires a higher number of pins. The multiplexed addressing modes are slower and require an external address latch device and a lower number of pins. The functionality of the 16 EBI\_AD pins depends on what kind of the multiplexed addressing mode is used. They are used for both address and data in the multiplexed modes. Also for the non-multiplexed 8-bit address mode, both the address and data fit into these 16 EBI\_AD pins. If more address bits or data bits are needed, an external latch can be used to support up to 20-bit addresses or 16-bit data in the multiplexed addressing modes using only the 16 EBI\_AD pins. Furthermore, independent of the addressing mode, up to 21 non-multiplexed address lines can be enabled on the EBI\_A pin connections. The detailed operation in the supported modes is presented in the following sections. The AHB clock (HCLK) is the reference clock for the EBI.

## Non-multiplexed 8-bit Data 8-bit Address Mode

In this mode, 8-bit address and 8-bit data is supported. The address is located on the higher 8 bits of the EBI\_AD lines and the data uses the lower 8 bits. This mode is set by programming the MODE field in the EBICR register to D8A8. Read and write timing in the 8-bit mode are shown in Figure 187 and Figure 188.



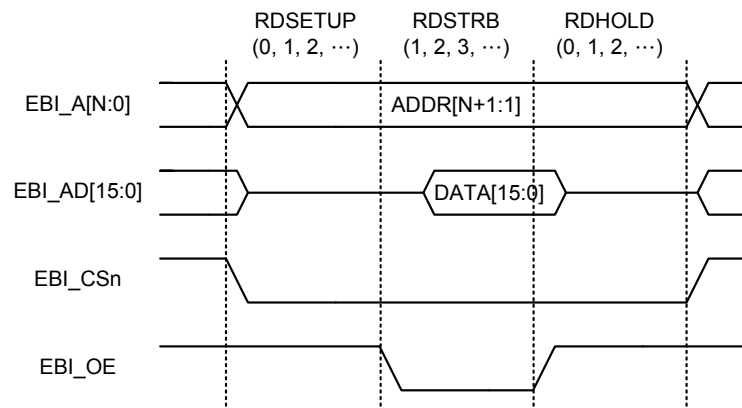
**Figure 187. EBI Non-multiplexed 8-bit Data, 8-bit Address Read Operation**



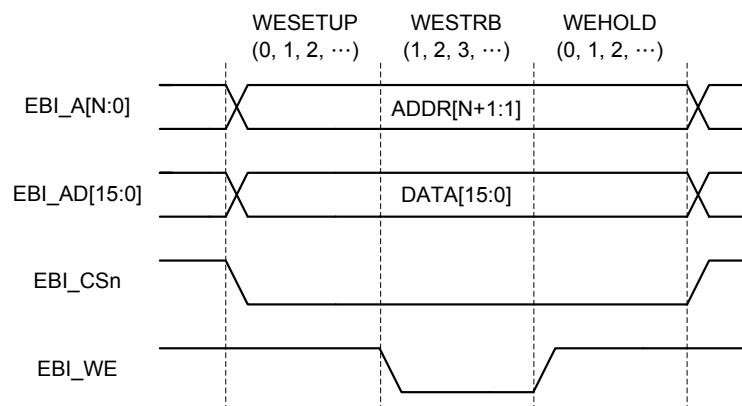
**Figure 188. EBI Non-multiplexed 8-bit Data, 8-bit Address Write Operation**

## Non-multiplexed 16-bit Data N-bit Address Mode

In this non-multiplexed mode 16-bit data is provided on the 16 EBI\_AD lines. The addresses are provided on the EBI\_A lines. This mode is set by programming the MODE field in the EBICR register to D16. Read and write signals are shown in Figure 189 and Figure 190 for the case in which N address lines on EBI\_A have been enabled.



**Figure 189. EBI Non-multiplexed 16-bit Data, N-bit Address Read Operation**



**Figure 190. EBI Non-multiplexed 16-bit Data, N-bit Address Write Operation**

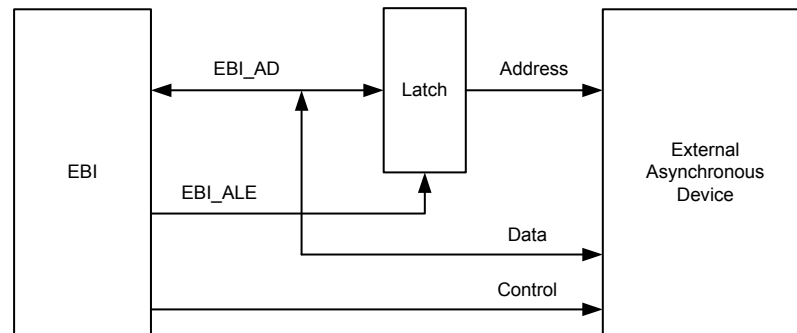
Since the internal AHB address (HADDR) is a byte (8-bit) address whereas the 16-bit width of external device is addressed in words (16-bit), the address actually issued to the external device varies according to the data width as shown in the following table.

| Memory width | Data address issued to the EBI |
|--------------|--------------------------------|
| 8-bit        | HADDR[N:0] → EBI_A[N:0]        |
| 16-bit       | HADDR[N+1:1] → EBI_A[N:0]      |

In case of a 16-bit external device width, the EBI will internally use HADDR[N+1:1] to generate the address EBI\_A[N:0] for external device. Whatever the external memory width (16-bit or 8-bit), EBI\_A[0] should be connected to external device address A[0].

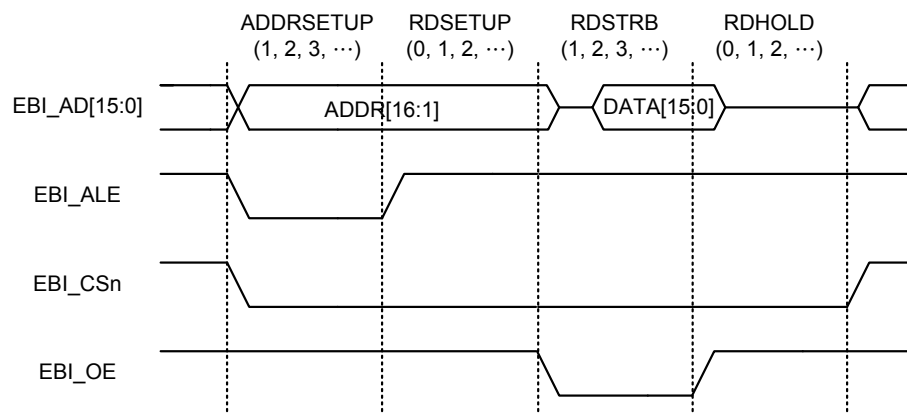
## Multiplexed 16-bit Data, 16-bit Address Mode

In this mode, 16-bit address and 16-bit data is supported, but the utilization of an external latch and an extra signal EBI\_ALE is required. The 16-bit address and 16-bit data bits are multiplexed on the EBI\_AD pins. An EBI address latch setup diagram is shown in Figure 191. This mode is set by programming the MODE field in the EBICR register to D16A16ALE.

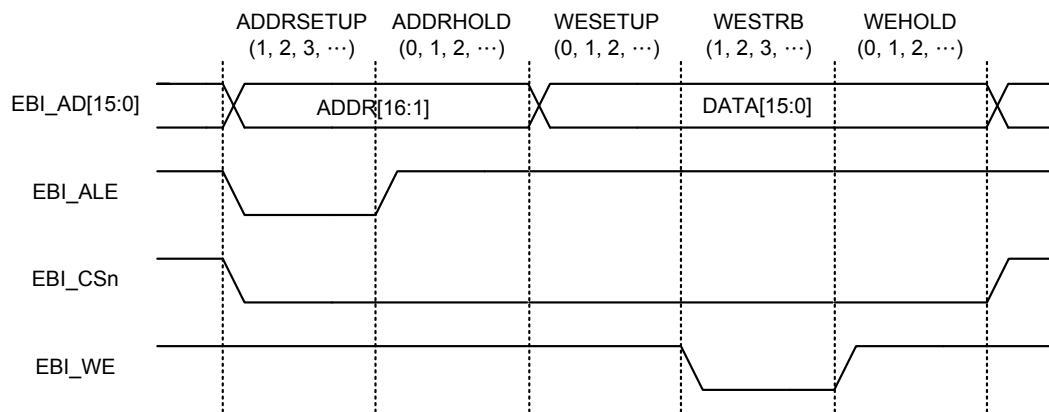


**Figure 191. An EBI Address Latch Setup Diagram**

At the start of the transaction the address is output on the EBI\_AD lines. The external address latch is controlled by the EBI\_ALE signal and stores the address. Then the data is read or written according to operation. Read and write signals are shown in Figure 192 and Figure 193.



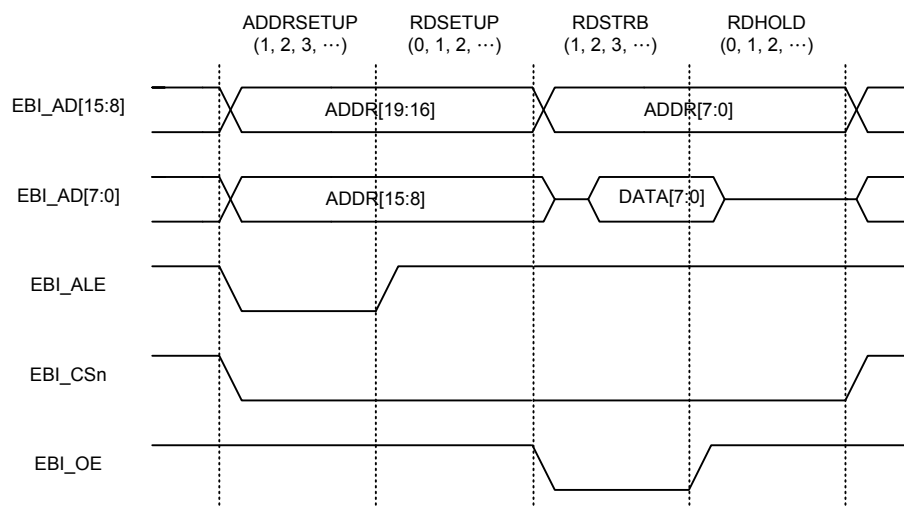
**Figure 192. EBI Multiplexed 16-bit Data, 16-bit Address Read Operation**



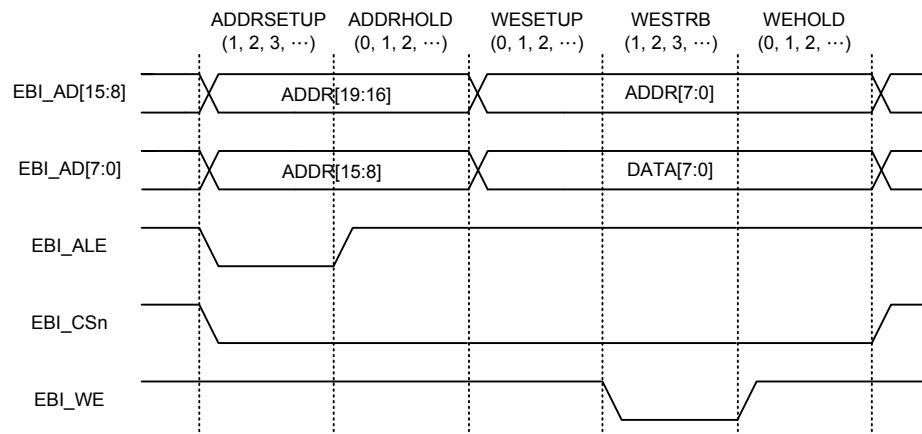
**Figure 193. EBI Multiplexed 16-bit Data, 16-bit Address Write Operation**

### Multiplexed 8-bit Data, 20-bit Address Mode

This mode allows 20-bit address with 8-bit data multiplexed on the EBI\_AD[15:0] lines to reduce the pins utilization and uses the EBI\_ALE signal to decode 8-bit data and 20-bit address. The upper 8 bits of the EBI\_AD lines (EBI\_AD[15:8]) are consecutively used for the highest 4 bits and the lowest 8 bits of the address. The lower 8 bits of the EBI\_AD lines (EBI\_AD[7:0]) are used for the middle 8 address bits and 8-bit data. This mode is set by programming the MODE field in the EBICR register to D8A24ALE. Read and write signals are shown in Figure 194 and Figure 195 respectively.



**Figure 194. EBI Multiplexed 8-bit Data, 20-bit Address Read Operation**



**Figure 195. EBI Multiplexed 8-bit Data, 20-bit Address Write Operation**

## Write Buffer and EBI Status

The EBI has a 32-bit wide write buffer. The write buffer can be used to limit stalling of an AHB write burst transaction which comes from the CPU or PDMA to a potentially slow external device.

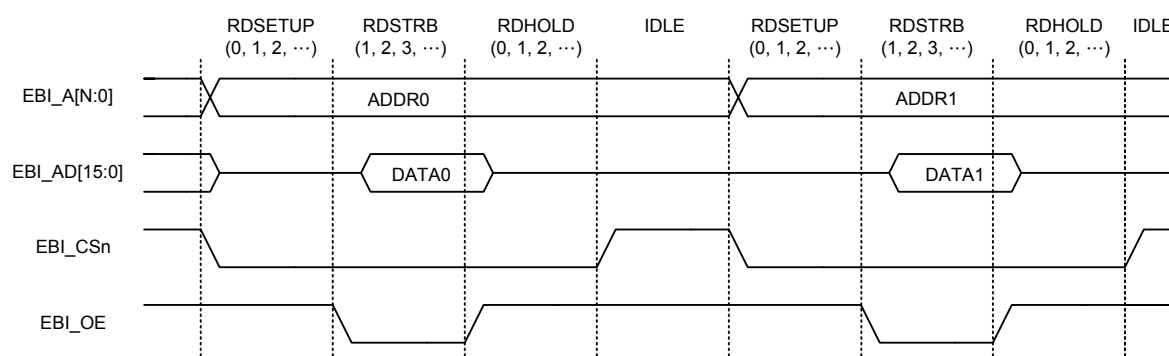
The EBIBUSY status bit in the EBISR register indicates whether an AHB transaction is still active in the EBI or not. When performing an AHB read or write, the EBIBUSY bit stays 1 until the required transaction(s) with the external device has finished.

## Bus Turn-around and Idle Cycles

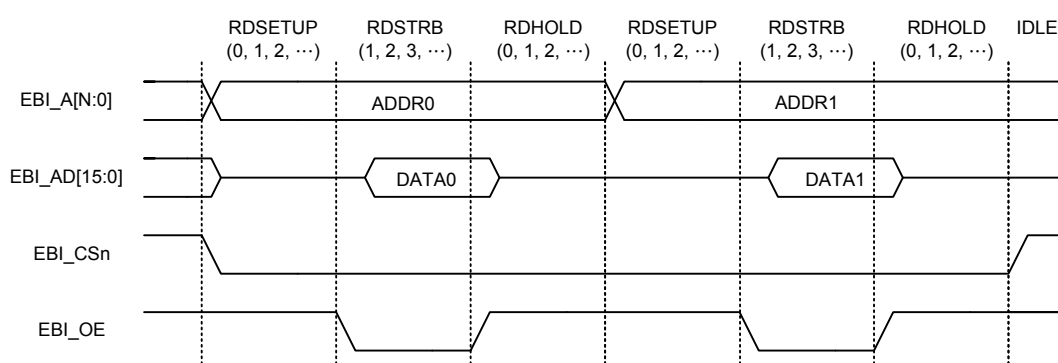
The EBI\_AD lines can be driven by either the EBI or the external device depending on the cycle state of EBI bus. The RDHOLD timing parameter is for the bus turn-around time and should be programmed to ensure enough time for the characteristics of an external device. The default setting for the EBI is to insert an IDLE cycle between EBI transactions to the same bank. The IDLE cycle insertion is shown for two back-to-back read transactions in Figure 196. For cases where the IDLE state can also provide the required bus turn-around time, the RDHOLD parameter can be programmed to 0. For increased EBI access performance, the automatic IDLE state insertion can be disabled by setting the NOIDLEn (n = 0 ~ 3) bits in the EBICR register to 1. This example is shown in Figure 197 for two back-to-back reads in a non-multiplexed address mode.

An IDLE cycle will automatically be inserted for the following cases:

- Between two external device transactions to the same bank when the NOIDLE bit is 0.
- Between two external device transactions to different banks.
- Between a read and a subsequent write on the EBI\_AD lines.
- When no request for an external transaction is available in the EBI.



**Figure 196. EBI Inserts an IDLE Cycle between Transactions in the Same Bank (NOIDLE = 0)**



**Figure 197. EBI De-asserts an IDLE Cycle between Transactions in the Same Bank (NOIDLE = 1)**

## AHB Transaction Width Conversion

The mapping of AHB transactions to an external device depends on the data width of the external device as the byte lanes of the external device are supported in the device. The Table 1 shows the EBI mapping of AHB transactions to external device transactions. The EBI will automatically translate the different AHB transaction width to external device transactions which matches the external bus capabilities of the device.

- If the AHB master (CPU or PDMA) transaction width is larger than the external bus transaction width. The EBI will split and translate the AHB transaction into consecutive multiple external transactions which have consecutively incrementing the address and start with the least significant data from AHB transaction.
- If the AHB master (CPU or PDMA) transaction width is smaller than the external bus transaction width. The EBI will read the data according to the full data bus width of the external device and ignore the superfluous data. For write operation the EBI will automatically perform a read-modify-write sequence to write the data.

**Table 70. EBI Maps AHB Transactions Width to External Device Transactions.**

| AHB Transaction | 8-bit External Device Transaction | 16-bit External Device Transaction                              |
|-----------------|-----------------------------------|-----------------------------------------------------------------|
| 8-bit read      | 1 x 8-bit read                    | 1 x 16-bit read<br>(EBI ignore the superfluous data)            |
| 16-bit read     | 2 x 8-bit read                    | 1 x 16-bit read                                                 |
| 32-bit read     | 4 x 8-bit read                    | 2 x 16-bit read                                                 |
| 8-bit write     | 1 x 8-bit read                    | 1 x 16-bit read;<br>1 x 16-bit write<br>(EBI read-modify-write) |
| 16-bit write    | 2 x 8-bit read                    | 1 x 16-bit write                                                |
| 32-bit write    | 4 x 8-bit read                    | 2 x 16-bit write                                                |

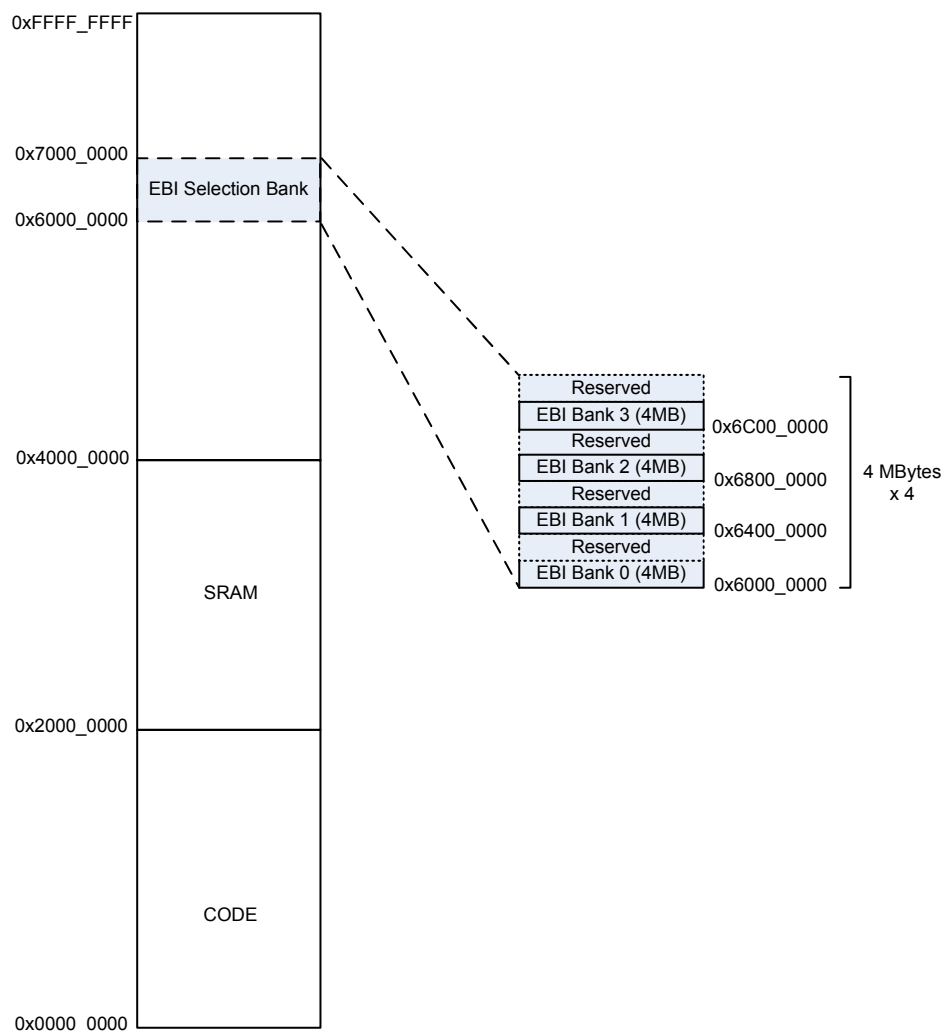
**Table 71. EBI Maps AHB Transactions Width to External Device Transactions Width**

| External Bus Width | Access from AHB Master |                                    | Access to External Bus Interface (EBI) |                              |                            |
|--------------------|------------------------|------------------------------------|----------------------------------------|------------------------------|----------------------------|
|                    | Access type            | Address HADDR[1:0] <sup>Note</sup> | Access split                           | Output value from EBI_A[1:0] | Valid data at EBI_AD[15:0] |
| 8-bit              | Byte (8-bit)           | 0b00                               | No split                               | 0b00                         | EBI_AD[7:0]                |
|                    |                        | 0b01                               | No split                               | 0b01                         |                            |
|                    |                        | 0b10                               | No split                               | 0b10                         |                            |
|                    |                        | 0b11                               | No split                               | 0b11                         |                            |
|                    | Half-word (16-bit)     | 0b00                               | 1/2 access                             | 0b00                         |                            |
|                    |                        |                                    | 2/2 access                             | 0b01                         |                            |
|                    | Half-word (16-bit)     | 0b10                               | 1/2 access                             | 0b10                         |                            |
|                    |                        |                                    | 2/2 access                             | 0b11                         |                            |
|                    | Word (32-bit)          | 0b00                               | 1/4 access                             | 0b00                         |                            |
|                    |                        |                                    | 2/4 access                             | 0b01                         |                            |
|                    |                        |                                    | 3/4 access                             | 0b10                         |                            |
|                    |                        |                                    | 4/4 access                             | 0b11                         |                            |
| 16-bit             | Byte (8-bit)           | 0b00                               | No split                               | 0bx0                         | EBI_AD[7:0]                |
|                    |                        | 0b01                               | No split                               | 0bx0                         | EBI_AD[15:8]               |
|                    |                        | 0b10                               | No split                               | 0bx1                         | EBI_AD[7:0]                |
|                    |                        | 0b11                               | No split                               | 0bx1                         | EBI_AD[15:8]               |
|                    | Half-word (16-bit)     | 0b00                               | No split                               | 0bx0                         | EBI_AD[15:0]               |
|                    |                        | 0b10                               | No split                               | 0bx1                         | EBI_AD[15:0]               |
|                    | Word (32-bit)          | 0b00                               | 1/2 access                             | 0bx0                         | EBI_AD[15:0]               |
|                    |                        |                                    | 2/2 access                             | 0bx1                         | EBI_AD[15:0]               |

**Note:** HADDR is AHB bus address input.

## EBI Bank Access

The EBI is split into 4 different address regions and each owns an individual EBI\_CSn line. When accessing one of the memory regions, the corresponding EBI\_CSn line is asserted. This way up to 4 separate devices can share the EBI lines and be identified by the EBI\_CSn line. Each bank can individually be enabled or disabled in the EBICR register. The data space of each bank can be accessed up to 4MB and is shown as Figure 198.



**Figure 198. EBI Bank Memory Map**

## PDMA Request

The EBI only supports a software trigger for activating a PDMA service.

## Register Map

The following table shows the EBI register and reset value.

**Table 72. EBI Register Map**

| Register                              | Offset | Description                 | Reset Value |
|---------------------------------------|--------|-----------------------------|-------------|
| <b>EBI Base Address = 0x4009_8000</b> |        |                             |             |
| EBICR                                 | 0x000  | EBI Control Register        | 0x0000_0000 |
| EBISR                                 | 0x008  | EBI Status Register         | 0x0000_0010 |
| EBIATR0                               | 0x010  | EBI Address Timing Register | 0x0000_0F0F |
| EBIRTR0                               | 0x014  | EBI Read Timing Register    | 0x000F_3F0F |
| EBIWTR0                               | 0x018  | EBI Write Timing Register   | 0x000F_3F0F |
| EBIPR0                                | 0x01C  | EBI Parity Register         | 0x0000_0000 |

## Register Descriptions

### EBI Control Register – EBICR

This register specifies the control setting for EBI bank.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |         |         |         |          |         |         |         |
|------------|----------|---------|---------|---------|----------|---------|---------|---------|
|            | 31       | 30      | 29      | 28      | 27       | 26      | 25      | 24      |
|            | IDLET    |         |         |         | Reserved |         |         |         |
| Type/Reset | RW       | 0       | RW      | 0       | RW       | 0       | RW      | 0       |
|            | 23       | 22      | 21      | 20      | 19       | 18      | 17      | 16      |
|            | Reserved |         |         |         |          |         |         |         |
| Type/Reset |          |         |         |         |          |         |         |         |
|            | 15       | 14      | 13      | 12      | 11       | 10      | 9       | 8       |
|            | NOIDLE3  | NOIDLE2 | NOIDLE1 | NOIDLE0 | BANKEN3  | BANKEN2 | BANKEN1 | BANKEN0 |
| Type/Reset | RW       | 0       | RW      | 0       | RW       | 0       | RW      | 0       |
|            | 7        | 6       | 5       | 4       | 3        | 2       | 1       | 0       |
|            | Mode3    |         | Mode2   |         | Mode1    |         | Mode0   |         |
| Type/Reset | RW       | 0       | RW      | 0       | RW       | 0       | RW      | 0       |

| Bits    | Field   | Descriptions                                                                                                                                                           |
|---------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:28] | IDLET   | IDLE Time<br>Sets the number of cycles between EBI transactions. If set to 0, one cycle is inserted by the hardware. The cycle unit is based on the HCLK clock period. |
| [15]    | NOIDLE3 | No IDLE 3<br>0: Enable IDLE state insertion<br>1: Disable IDLE state insertion<br>Enable or disable the insertion of an idle state between transactions for bank 3.    |

| Bits  | Field   | Descriptions                                                                                                                                                        |
|-------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [14]  | NOIDLE2 | No IDLE 2<br>0: Enable IDLE state insertion<br>1: Disable IDLE state insertion<br>Enable or disable the insertion of an idle state between transactions for bank 2. |
| [13]  | NOIDLE1 | No IDLE 1<br>0: Enable IDLE state insertion<br>1: Disable IDLE state insertion<br>Enable or disable the insertion of an idle state between transactions for bank 1. |
| [12]  | NOIDLE0 | No IDLE 0<br>0: Enable IDLE state insertion<br>1: Disable IDLE state insertion<br>Enable or disable the insertion of an idle state between transactions for bank 0. |
| [11]  | BANKEN3 | Bank 3 Enable<br>0: Disable<br>1: Enable<br>This bit enables or disables bank 3.                                                                                    |
| [10]  | BANKEN2 | Bank 2 Enable<br>0: Disable<br>1: Enable<br>This bit enables or disables bank 2.                                                                                    |
| [9]   | BANKEN1 | Bank 1 Enable<br>0: Disable<br>1: Enable<br>This bit enables or disables bank 1.                                                                                    |
| [8]   | BANKEN0 | Bank 0 Enable<br>0: Disable<br>1: Enable<br>This bit enables or disables bank 0.                                                                                    |
| [7:6] | MODE3   | Set EBI bank 3 access mode<br>00: D8A8<br>01: D16A16ALE<br>10: D8A24ALE<br>11: D16                                                                                  |
| [5:4] | MODE2   | Set EBI bank 2 access mode<br>00: D8A8<br>01: D16A16ALE<br>10: D8A24ALE<br>11: D16                                                                                  |
| [3:2] | MODE1   | Set EBI bank 1 access mode<br>00: D8A8<br>01: D16A16ALE<br>10: D8A24ALE<br>11: D16                                                                                  |
| [1:0] | MODE0   | Set EBI bank 0 access mode<br>00: D8A8<br>01: D16A16ALE<br>10: D8A24ALE<br>11: D16                                                                                  |

## EBI Status Register – EBISR

This register indicates the EBI status.

Offset: 0x008

Reset value: 0x0000\_0010

|            |          |    |    |    |    |    |    |          |
|------------|----------|----|----|----|----|----|----|----------|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24       |
| Type/Reset | Reserved |    |    |    |    |    |    |          |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16       |
| Type/Reset | Reserved |    |    |    |    |    |    |          |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8        |
| Type/Reset | Reserved |    |    |    |    |    |    | EBISMRST |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0        |
| Type/Reset | Reserved |    |    |    |    |    |    | EBIBUSY  |
|            |          |    |    |    |    |    |    | RO 0     |

| Bits | Field    | Descriptions                                                                                                                                                                            |
|------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8]  | EBISMRST | EBI State Machine Reset<br>0: Normal<br>1: Reset EBI state machine<br>Write a “1” to reset the EBI internal state machine to its initial state and keep the original register settings. |
| [0]  | EBIBUSY  | EBI BUSY<br>0: EBI is idle<br>1: EBI is busy<br>Indicates the EBI is busy with an AHB transaction.                                                                                      |

## EBI Address Timing Register – EBIATR

This register specifies the address timing setting for each bank.

Offset: 0x010

Reset value: 0x0000\_0707

|            |          |    |    |    |    |           |    |    |
|------------|----------|----|----|----|----|-----------|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26        | 25 | 24 |
| Type/Reset | Reserved |    |    |    |    |           |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18        | 17 | 16 |
| Type/Reset | Reserved |    |    |    |    |           |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10        | 9  | 8  |
| Type/Reset | Reserved |    |    |    |    | ADDRHOLD  |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2         | 1  | 0  |
| Type/Reset | Reserved |    |    |    |    | ADDRSETUP |    |    |
|            |          |    |    |    |    | RW        | 1  | RW |
|            |          |    |    |    |    |           | 1  | RW |
|            |          |    |    |    |    |           |    | 1  |

| Bits   | Field     | Descriptions                                                                                                                                                                                                                                    |
|--------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10:8] | ADDRHOLD  | Address Hold Time<br>Sets the number of cycles for which the address should be held on the EBI_AD bus after the EBI_ALE signal is asserted. This field is allowed to be set to 0.                                                               |
| [2:0]  | ADDRSETUP | Address Setup Time<br>Sets the number of cycles for which the address is driven onto the EBI_AD bus before the EBI_ALE signal is asserted. If set to 0, one cycle is inserted by the hardware. The cycle unit is based on an HCLK clock period. |

## EBI Read Timing Register – EBIRTR

This register specifies the read timing setting for each bank

Offset: 0x014

Reset value: 0x0007\_1F07

|            |          |    |    |        |         |    |    |    |
|------------|----------|----|----|--------|---------|----|----|----|
|            | 31       | 30 | 29 | 28     | 27      | 26 | 25 | 24 |
| Type/Reset | Reserved |    |    |        |         |    |    |    |
|            | 23       | 22 | 21 | 20     | 19      | 18 | 17 | 16 |
| Type/Reset | Reserved |    |    |        | RDHOLD  |    |    |    |
|            | 15       | 14 | 13 | 12     | 11      | 10 | 9  | 8  |
| Type/Reset | Reserved |    |    | RDSTRB |         |    |    |    |
|            | 7        | 6  | 5  | 4      | 3       | 2  | 1  | 0  |
| Type/Reset | Reserved |    |    |        | RDSETUP |    |    |    |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                                                                   |
|---------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18:16] | RDHOLD  | Read Hold Time<br>Sets the number of cycles for which the EBI_CSn signal is held active after the EBI_OE signal is de-asserted. This interval is used for bus turnaround.                                                                                                      |
| [12:8]  | RDSTRB  | Read Strobe Time<br>Sets the number of cycles in which the data will be read when the EBI_OE is held active. After the specified number of cycles, the data will be read. If set to 0, one cycle is inserted by the hardware. The cycle unit is based on an HCLK clock period. |
| [2:0]   | RDSETUP | Read Setup Time<br>Sets the number of cycles for which the address is setup before the EBI_OE signal is asserted. The cycle unit is based on an HCLK clock period.                                                                                                             |

## EBI Write Timing Register – EBIWTR

This register specifies the write timing setting for each bank.

Offset: 0x018

Reset value: 0x0007\_1F07

|            |          |    |    |        |    |         |    |    |
|------------|----------|----|----|--------|----|---------|----|----|
|            | 31       | 30 | 29 | 28     | 27 | 26      | 25 | 24 |
|            | Reserved |    |    |        |    |         |    |    |
| Type/Reset |          |    |    |        |    |         |    |    |
|            | 23       | 22 | 21 | 20     | 19 | 18      | 17 | 16 |
|            | Reserved |    |    |        |    | WRHOLD  |    |    |
| Type/Reset |          |    |    |        |    | RW      | 1  | RW |
|            | 15       | 14 | 13 | 12     | 11 | 10      | 9  | 8  |
|            | Reserved |    |    | WRSTRB |    |         |    |    |
| Type/Reset |          |    |    | RW     | 1  | RW      | 1  | RW |
|            | 7        | 6  | 5  | 4      | 3  | 2       | 1  | 0  |
|            | Reserved |    |    |        |    | WRSETUP |    |    |
| Type/Reset |          |    |    |        |    | RW      | 1  | RW |

| Bits    | Field   | Descriptions                                                                                                                                                                                                                 |
|---------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [18:16] | WEHOLD  | Write Hold Time<br>Sets the number of cycles for which the EBI_CSn signal is held active after the EBI_WE signal is de-asserted.                                                                                             |
| [12:8]  | WESTRB  | Write Strobe Time<br>Sets the number of cycles in which the data will be written when the EBI_WE signal is held active. If set to 0, one cycle is inserted by the hardware. The cycle unit is based on an HCLK clock period. |
| [2:0]   | WESETUP | Write Setup Time<br>Sets the number of cycles for which the data is setup before the EBI_WE signal is asserted. The cycle unit is based on an HCLK clock period.                                                             |

## EBI Parity Register – EBIPR

This register specifies the polarity of the EBI control signal for each bank.

Offset: 0x01C

Reset value: 0x0000\_0000

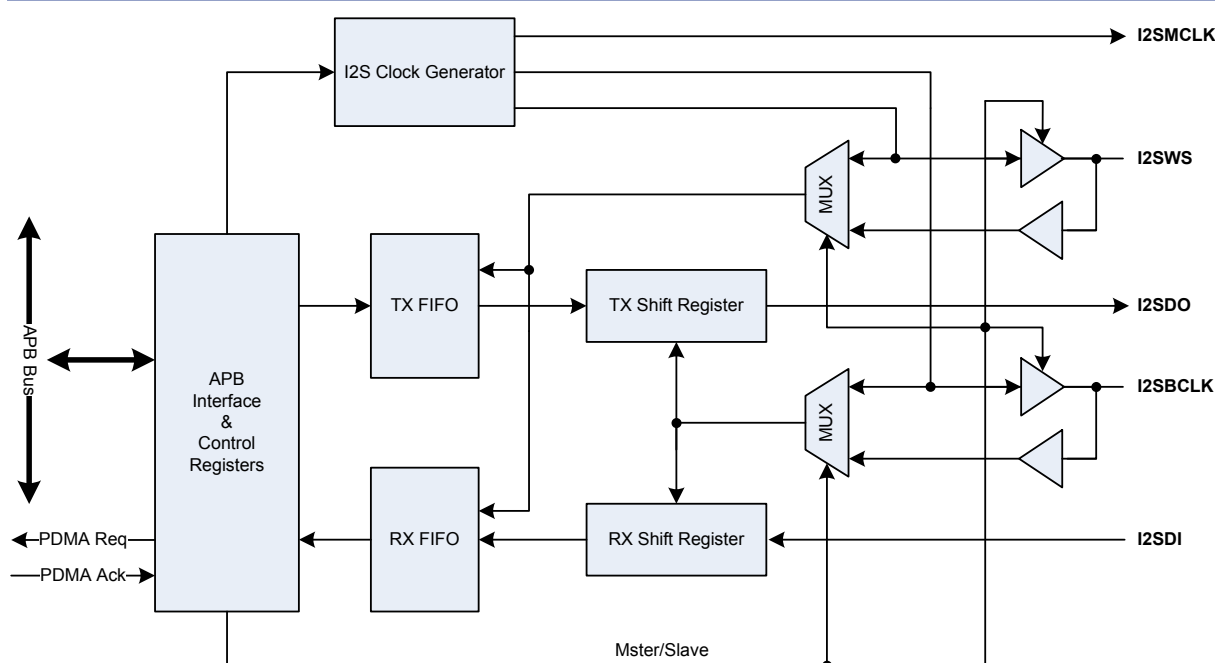
|            |          |    |    |    |        |       |       |       |
|------------|----------|----|----|----|--------|-------|-------|-------|
|            | 31       | 30 | 29 | 28 | 27     | 26    | 25    | 24    |
| Type/Reset | Reserved |    |    |    |        |       |       |       |
|            | 23       | 22 | 21 | 20 | 19     | 18    | 17    | 16    |
| Type/Reset | Reserved |    |    |    |        |       |       |       |
|            | 15       | 14 | 13 | 12 | 11     | 10    | 9     | 8     |
| Type/Reset | Reserved |    |    |    |        |       |       |       |
|            | 7        | 6  | 5  | 4  | 3      | 2     | 1     | 0     |
| Type/Reset | Reserved |    |    |    | ALEPOL | WEPOL | OEPOL | CSPOL |
|            |          |    |    |    | RW     | 0     | RW    | 0     |

| Bits | Field  | Descriptions                                                                                                                        |
|------|--------|-------------------------------------------------------------------------------------------------------------------------------------|
| [3]  | ALEPOL | Address Latch Polarity<br>0: EBI_ALE is active low<br>1: EBI_ALE is active high<br>Set the polarity of the EBI_ALE line             |
| [2]  | WEPOL  | Write Enable Polarity<br>0: EBI_WE is active low<br>1: EBI_WE is active high<br>Set the polarity of the EBI_WE line.                |
| [1]  | OEPOL  | Output Enable Polarity<br>0: EBI_OE is active low<br>1: EBI_OE is active high<br>Set the polarity of the EBI_OE line.               |
| [0]  | CSPOL  | Chip Selection Polarity<br>0: EBI_CS is active low<br>1: EBI_CS is active high<br>Set the polarity of the EBI_CS <sub>n</sub> line. |

## 28 Inter-IC Sound (I<sup>2</sup>S)

## Introduction

The I<sup>2</sup>S is a synchronous communication interface that can be used as a master or slave to exchange data with other audio peripherals, such as ADCs or DACs. The I<sup>2</sup>S supports a variety of data formats. In addition to the stereo I<sup>2</sup>S-justified, Left-justified and Right-justified modes, there are mono PCM modes with 8/16/24/32-bit sample size. When the I<sup>2</sup>S operates in the master mode, then when using the fractional divider, it can provide an accurate sampling frequency output and support the rate control function and fine-tuning of the output frequency to avoid system problems caused by the cumulative frequency error between different devices.



### Figure 199. I<sup>2</sup>S Block Diagram

## Features

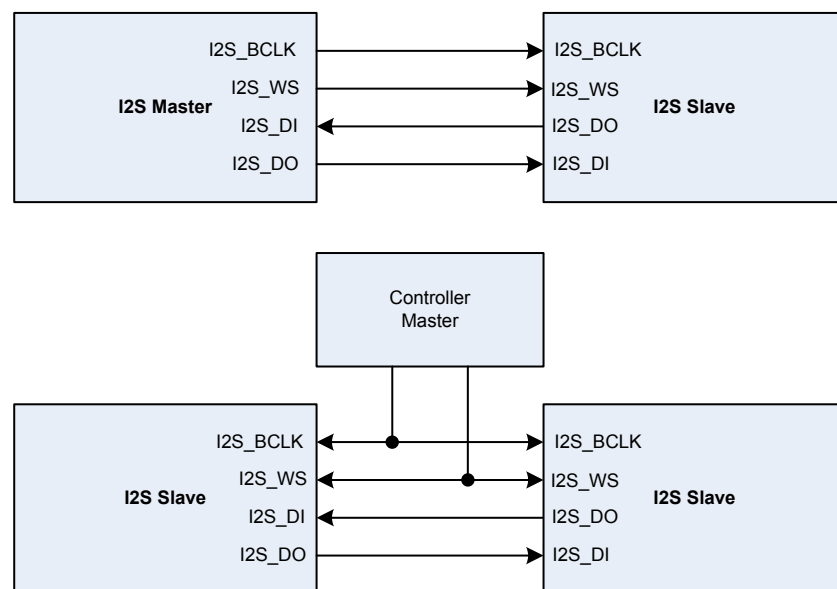
- Master or slave mode
- Mono and stereo
- I<sup>2</sup>S-justified, Left-justified, and Right-justified mode
- 8/16/24/32-bit sample size with 32-bit channel extended
- 8 × 32-bit Tx & Rx FIFO with PDMA supported
- 8-bit Fractional Clock Divider with rate control

## Functional Description

### I<sup>2</sup>S Master and Slave Mode

The I<sup>2</sup>S can operate in slave or master mode. Within the I<sup>2</sup>S module the difference between these modes lies in the word select (WS) signal which determines the timing of data transmissions.

- In the master mode, the word select signal is generated internally by a clock rate generator.
- In the slave mode, the word select signal is input on the I<sup>2</sup>S\_WS pin.
- When an I<sup>2</sup>S bus is enabled, the word select, bit clock signals are sent continuously by the bus master.
- The mute control bit will place the transmit channel in a mute condition. When the mute mode is enabled, the transmit channel FIFO operates normally, but the output data stream is discarded and replaced by zeroes. This bit does not affect the receive channel so data reception can occur normally.



**Figure 200. Simple I<sup>2</sup>S Master/Slave Configuration**

## I<sup>2</sup>S Clock Rate Generator

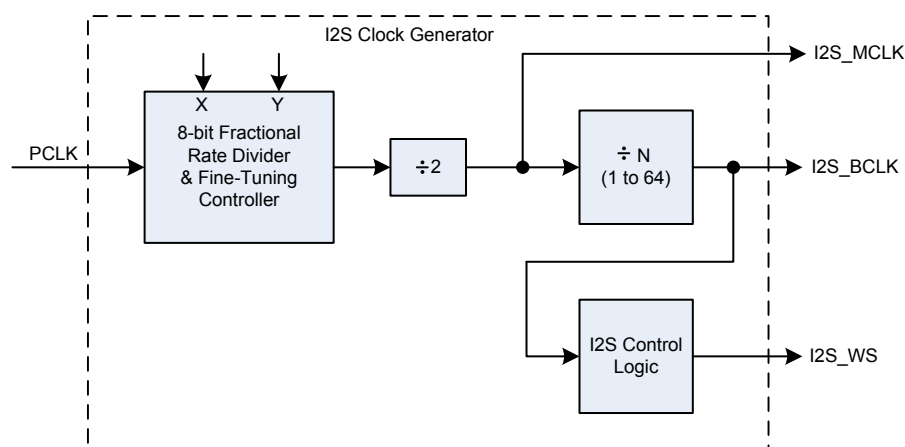
The main (I<sup>2</sup>S\_MCLK) and bit clock (I<sup>2</sup>S\_BCLK) rates for the I<sup>2</sup>S are determined by the values in the I2SCDR register. The required I<sup>2</sup>S bit clock rate setting depends on the desired audio sample rate desired, the format (stereo/mono) used, and the data size. The main clock rate (I<sup>2</sup>S\_MCLK) is generated using a fractional rate divider which is a divided down PCLK frequency of the I<sup>2</sup>S. Values of the numerator (X) and the denominator (Y) must be chosen to produce a frequency twice that of the main clock (I<sup>2</sup>S\_MCLK). The output frequency of the divider is divided by 2 in order to get the duty cycle of the output clock more even. The I<sup>2</sup>S clock generator block diagram is shown in Figure 201. The equation for the fractional rate divider is:

$$I^2S\_MCLK = 1/2 * PCLK * (X/Y), \text{ and } 2X \leq Y, X \neq 0, Y \neq 0$$

$$I^2S\_BCLK = I^2S\_MCLK / N, N = \{1, 2, \dots, 64\}$$

Because the fractional rate divider is a fully digital implementation function, the divider output clock transitions are synchronous with the input source clock. Therefore, the fractional rate divider will generate some jitter with some divider settings. Users should make note of this phenomenon when choosing the X and Y setup values. It is possible to avoid jitter entirely by choosing fractions such that X divides evenly into Y. For example, 2/4, 2/6, 3/9, 1/N, etc.

The tables below show the recommended setup values to reduce clock jitter for different source clocks and sample rates.



**Figure 201. I<sup>2</sup>S Clock Generator Diagram**

**Table 73. Recommend FS List @ 8 MHz PCLK**

|                     | 512 F <sub>s</sub> |   | 384 F <sub>s</sub> |     | 256 F <sub>s</sub> |     | 192 F <sub>s</sub> |     | 128 F <sub>s</sub> |     | 64 F <sub>s</sub> |     | 32 F <sub>s</sub> |     | 16 F <sub>s</sub> |     |
|---------------------|--------------------|---|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|-------------------|-----|-------------------|-----|-------------------|-----|
| F <sub>s</sub> (Hz) | X                  | Y | X                  | Y   | X                  | Y   | X                  | Y   | X                  | Y   | X                 | Y   | X                 | Y   | X                 | Y   |
| 8,000               | —                  | — | 48                 | 125 | 32                 | 125 | 24                 | 125 | 16                 | 125 | 8                 | 125 | 4                 | 125 | 2                 | 125 |
| 11,025              | —                  | — | —                  | —   | 85                 | 241 | 59                 | 223 | 45                 | 255 | 21                | 238 | 9                 | 204 | 3                 | 136 |
| 12,000              | —                  | — | —                  | —   | 48                 | 125 | 36                 | 125 | 24                 | 125 | 12                | 125 | 6                 | 125 | 3                 | 125 |
| 16,000              | —                  | — | —                  | —   | —                  | —   | 48                 | 125 | 32                 | 125 | 16                | 125 | 8                 | 125 | 4                 | 125 |
| 22,050              | —                  | — | —                  | —   | —                  | —   | —                  | —   | 85                 | 241 | 45                | 255 | 21                | 238 | 9                 | 204 |
| 24,000              | —                  | — | —                  | —   | —                  | —   | —                  | —   | 48                 | 125 | 24                | 125 | 12                | 125 | 6                 | 125 |
| 32,000              | —                  | — | —                  | —   | —                  | —   | —                  | —   | —                  | —   | 32                | 125 | 16                | 125 | 8                 | 125 |
| 44,100              | —                  | — | —                  | —   | —                  | —   | —                  | —   | —                  | —   | 85                | 241 | 45                | 255 | 21                | 238 |
| 48,000              | —                  | — | —                  | —   | —                  | —   | —                  | —   | —                  | —   | 48                | 125 | 24                | 125 | 12                | 125 |
| 96,000              | —                  | — | —                  | —   | —                  | —   | —                  | —   | —                  | —   | —                 | —   | 48                | 125 | 24                | 125 |
| 192,000             | —                  | — | —                  | —   | —                  | —   | —                  | —   | —                  | —   | —                 | —   | —                 | —   | 48                | 125 |

**Table 74. Recommend FS List @ 48 MHz PCLK**

|                     | 512 F <sub>s</sub> |     | 384 F <sub>s</sub> |     | 256 F <sub>s</sub> |     | 192 F <sub>s</sub> |     | 128 F <sub>s</sub> |     | 64 F <sub>s</sub> |     | 32 F <sub>s</sub> |     | 16 F <sub>s</sub> |     |
|---------------------|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|-------------------|-----|-------------------|-----|-------------------|-----|
| F <sub>s</sub> (Hz) | X                  | Y   | X                  | Y   | X                  | Y   | X                  | Y   | X                  | Y   | X                 | Y   | X                 | Y   | X                 | Y   |
| 8,000               | 18                 | 211 | 8                  | 125 | 9                  | 211 | 4                  | 125 | 5                  | 234 | 1                 | 94  | 1                 | 188 | -                 | -   |
| 11,025              | 2                  | 17  | 3                  | 34  | 1                  | 17  | 3                  | 68  | 1                  | 34  | 1                 | 68  | 1                 | 136 | -                 | -   |
| 12,000              | 16                 | 125 | 12                 | 125 | 8                  | 125 | 6                  | 125 | 4                  | 125 | 2                 | 125 | 1                 | 125 | 1                 | 250 |
| 16,000              | 43                 | 252 | 16                 | 125 | 18                 | 211 | 8                  | 125 | 9                  | 211 | 5                 | 234 | 1                 | 94  | 1                 | 188 |
| 22,050              | 4                  | 17  | 3                  | 17  | 2                  | 17  | 3                  | 34  | 1                  | 17  | 1                 | 34  | 1                 | 68  | 1                 | 136 |
| 24,000              | 32                 | 125 | 24                 | 125 | 16                 | 125 | 12                 | 125 | 8                  | 125 | 4                 | 125 | 2                 | 125 | 1                 | 125 |
| 32,000              | 71                 | 208 | 32                 | 125 | 43                 | 252 | 16                 | 125 | 18                 | 211 | 9                 | 211 | 5                 | 234 | 1                 | 94  |
| 44,100              | 119                | 253 | 85                 | 241 | 4                  | 17  | 3                  | 17  | 2                  | 17  | 1                 | 17  | 1                 | 34  | 1                 | 68  |
| 48,000              | —                  | —   | 48                 | 125 | 32                 | 125 | 24                 | 125 | 16                 | 125 | 8                 | 125 | 4                 | 125 | 2                 | 125 |
| 96,000              | —                  | —   | —                  | —   | —                  | —   | 48                 | 125 | 32                 | 125 | 16                | 125 | 8                 | 125 | 4                 | 125 |
| 192,000             | —                  | —   | —                  | —   | —                  | —   | —                  | —   | —                  | —   | 32                | 125 | 16                | 125 | 8                 | 125 |

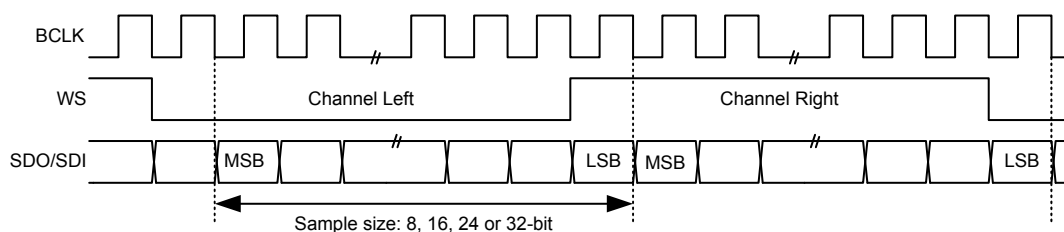
**Table 75. Recommend FS List @ 72 MHz PCLK**

|                     | 512 F <sub>s</sub> |     | 384 F <sub>s</sub> |     | 256 F <sub>s</sub> |     | 192 F <sub>s</sub> |     | 128 F <sub>s</sub> |     | 64 F <sub>s</sub> |     | 32 F <sub>s</sub> |     | 16 F <sub>s</sub> |     |
|---------------------|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|-------------------|-----|-------------------|-----|-------------------|-----|
| F <sub>s</sub> (Hz) | X                  | Y   | X                  | Y   | X                  | Y   | X                  | Y   | X                  | Y   | X                 | Y   | X                 | Y   | X                 | Y   |
| 8,000               | 12                 | 211 | 9                  | 211 | 6                  | 211 | 5                  | 234 | 3                  | 211 | 1                 | 141 | -                 | -   | -                 | -   |
| 11,025              | 4                  | 51  | 1                  | 17  | 2                  | 51  | 1                  | 34  | 1                  | 51  | 1                 | 102 | 1                 | 204 | -                 | -   |
| 12,000              | 18                 | 211 | 8                  | 125 | 9                  | 211 | 4                  | 125 | 5                  | 234 | 1                 | 94  | 1                 | 188 | -                 | -   |
| 16,000              | 19                 | 167 | 18                 | 211 | 12                 | 211 | 9                  | 211 | 6                  | 211 | 3                 | 211 | 1                 | 141 | -                 | -   |
| 22,050              | 37                 | 236 | 2                  | 17  | 4                  | 51  | 1                  | 17  | 2                  | 51  | 1                 | 51  | 1                 | 102 | 1                 | 204 |
| 24,000              | 43                 | 252 | 16                 | 125 | 18                 | 211 | 8                  | 125 | 9                  | 211 | 5                 | 234 | 1                 | 94  | 1                 | 188 |
| 32,000              | 38                 | 167 | 43                 | 252 | 19                 | 167 | 18                 | 211 | 12                 | 211 | 6                 | 211 | 3                 | 211 | 1                 | 141 |
| 44,100              | 53                 | 169 | 4                  | 17  | 37                 | 236 | 2                  | 17  | 4                  | 51  | 2                 | 51  | 1                 | 51  | 1                 | 102 |
| 48,000              | 71                 | 208 | 32                 | 125 | 43                 | 252 | 16                 | 125 | 18                 | 211 | 9                 | 211 | 5                 | 234 | 1                 | 94  |
| 96,000              | —                  | —   | —                  | —   | 71                 | 208 | 32                 | 125 | 43                 | 252 | 18                | 211 | 9                 | 211 | 5                 | 234 |
| 192,000             | —                  | —   | —                  | —   | —                  | —   | —                  | —   | 71                 | 208 | 43                | 252 | 18                | 211 | 9                 | 211 |

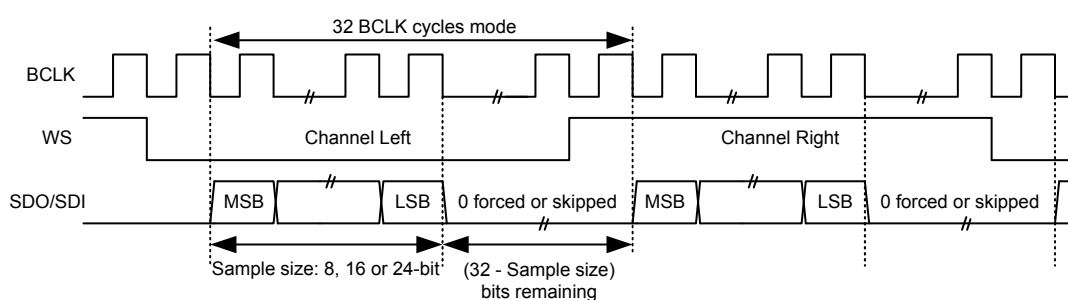
## I<sup>2</sup>S Interface Format

### I<sup>2</sup>S-justified Stereo Mode

The standard I<sup>2</sup>S-justified mode is where the Most Significant Bit (MSB) of the stereo audio sample data is available on the second rising edge of the BCLK clock following a WS signal transition. In the stereo mode, a low WS state indicates left channel data and a high state indicates right channel data. Figure 202 and Figure 203 show the standard I<sup>2</sup>S-justified stereo mode format.



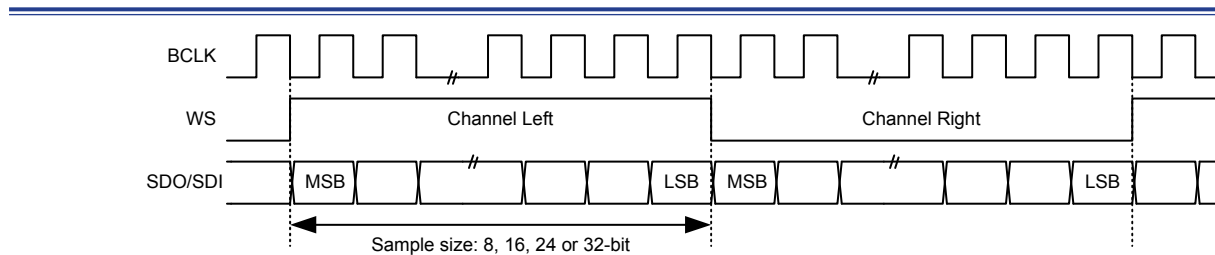
**Figure 202. I<sup>2</sup>S-justified Stereo Mode Waveforms**



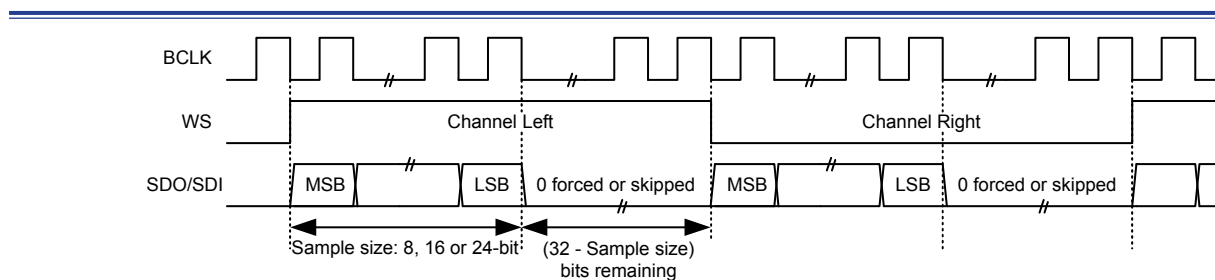
**Figure 203. I<sup>2</sup>S-justified Stereo Mode Waveforms (32-bit Channel Enabled)**

### Left-justified Stereo Mode

Left-Justified mode is where the Most Significant Bit (MSB) of the stereo audio sample data is available on the first rising edge of BCLK following a WS transition. Figure 204 and Figure 205 are shown with a left I<sup>2</sup>S-justified stereo mode format.



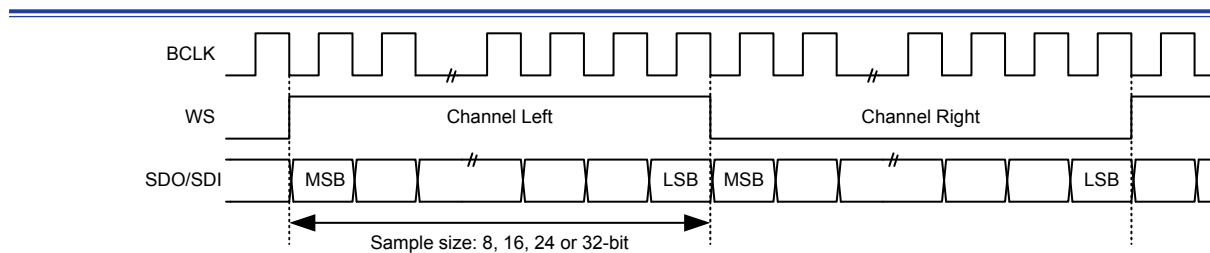
**Figure 204. Left-justified Stereo Mode Waveforms**



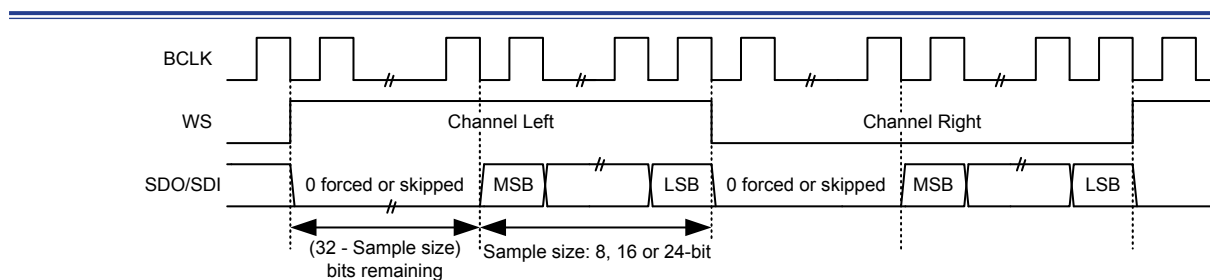
**Figure 205. Left-justified Stereo Mode Waveforms (32-bit Channel Enabled)**

### Right-justified Stereo Mode

Right-Justified mode is where the Least Significant Bit (LSB) of the stereo audio sample data is available on the rising edge of BCLK preceding a WS transition and where the MSB is transmitted first. Figure 206 and Figure 207 show a right I<sup>2</sup>S-justified stereo mode format.



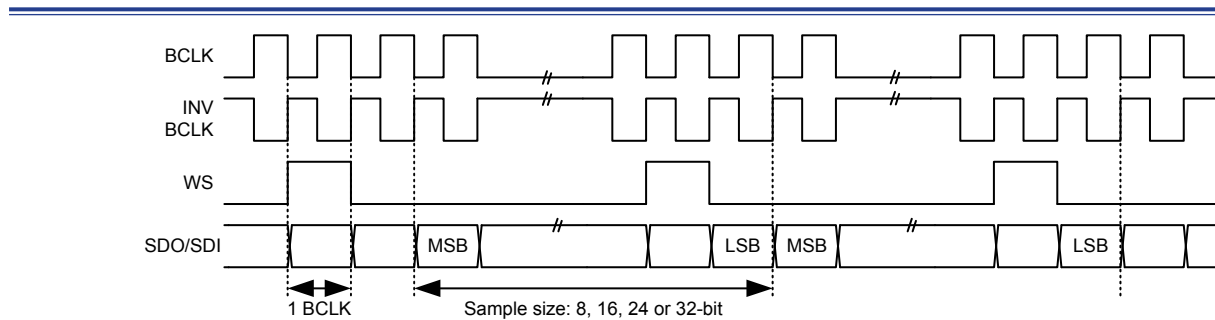
**Figure 206. Right-justified Stereo Mode Waveforms**



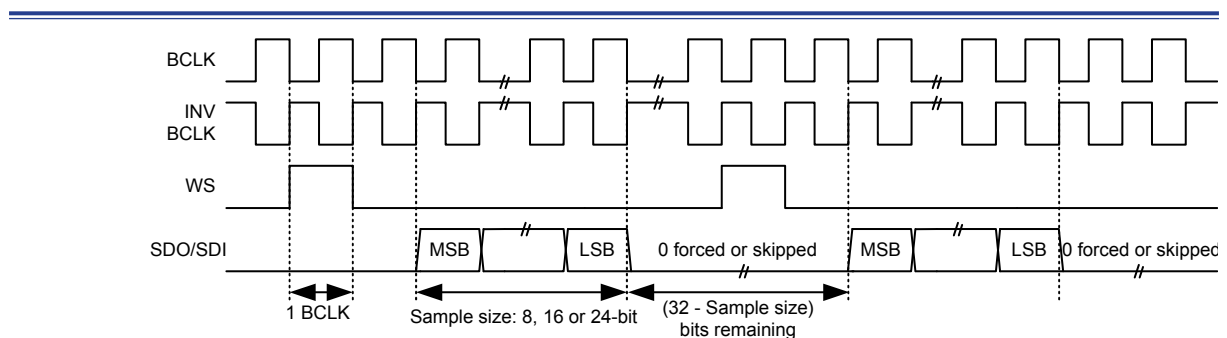
**Figure 207. Right-justified Stereo Mode Waveforms (32-bit Channel Enabled)**

### I<sup>2</sup>S-justified Mono Mode

In the I<sup>2</sup>S-justified mono mode, the Most Significant Bit (MSB) of the mono audio sample data is available on the second rising edge of the BCLK clock following a falling edge on the WS signal. Figure 208 and Figure 209 show an I<sup>2</sup>S-justified mono mode format.



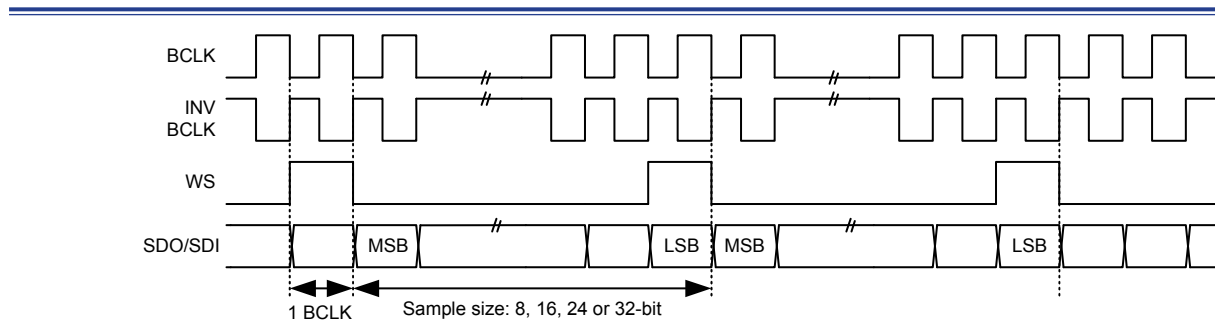
**Figure 208. I<sup>2</sup>S-justified Mono Mode Waveforms**



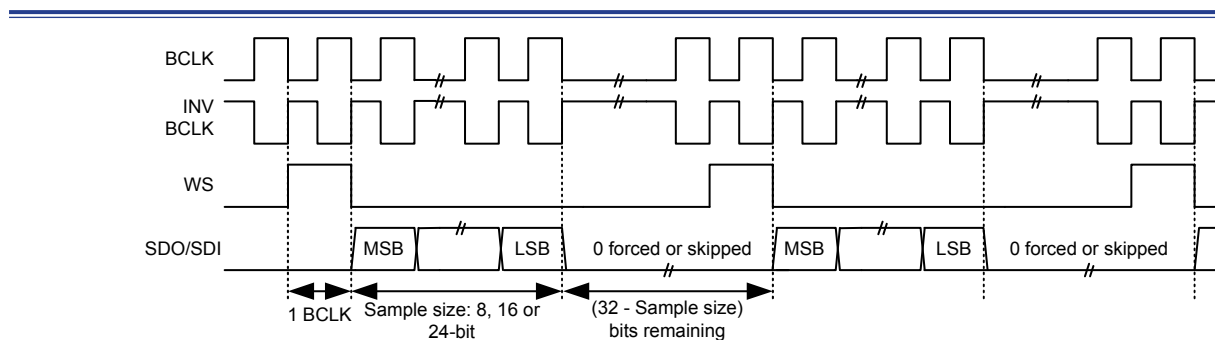
**Figure 209. I<sup>2</sup>S-justified Mono Mode Waveforms (32-bit Channel Enabled)**

### Left-justified Mono Mode

In the left-justified mono mode, the Most Significant Bit (MSB) of the mono audio sample data is available on the first rising edge of the BCLK clock following a falling edge on the WS signal. Figure 210 and Figure 211 show a left-justified mono mode format.



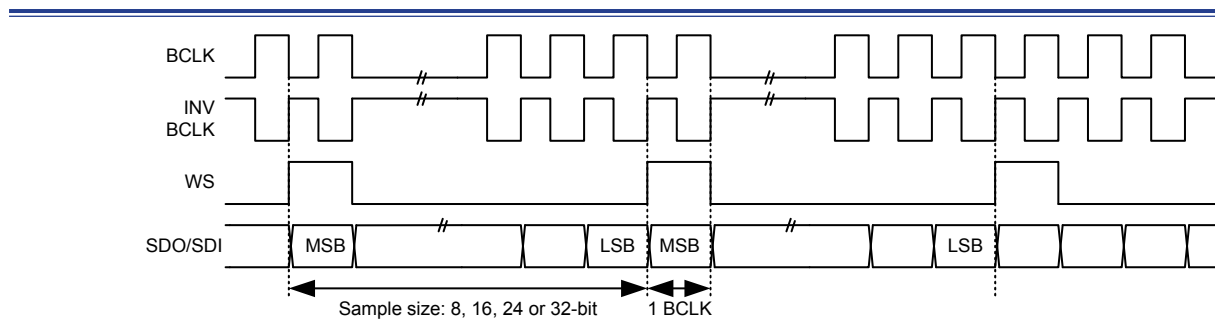
**Figure 210. Left-justified Mono Mode Waveforms**



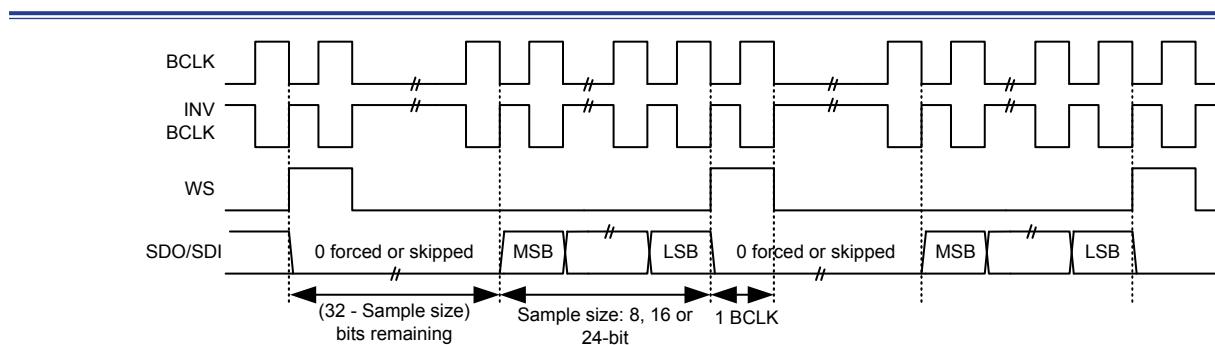
**Figure 211. Left-justified Mono Mode Waveforms (32-bit Channel Enabled)**

### Right-justified Mono Mode

In the right-justified mono mode, the Least Significant Bit (LSB) of the mono audio sample data is available on the last rising edge of the BCLK clock preceding a rising edge on the WS signal. Figure 212 and Figure 213 show the right-justified mono mode format.



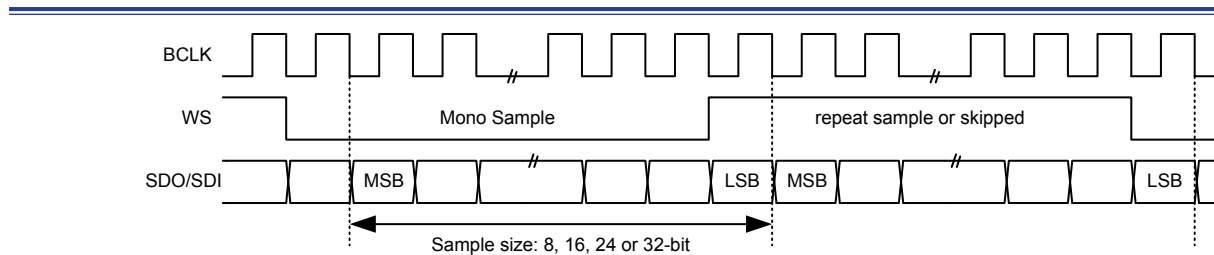
**Figure 212. Right-justified Mono Mode Waveforms**



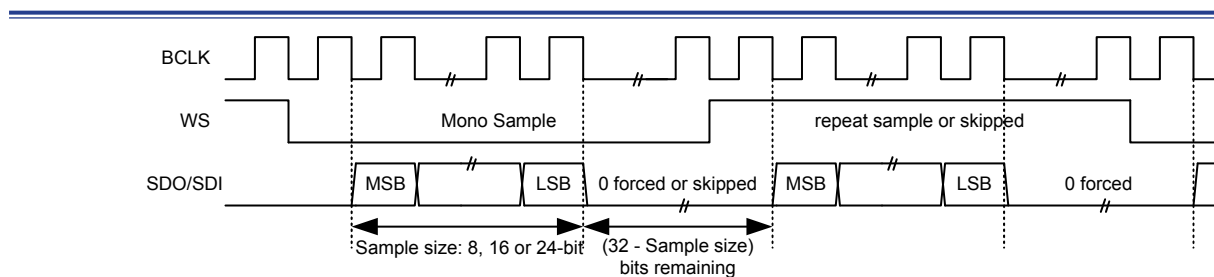
**Figure 213. Right-justified Mono Mode Waveforms (32-bit Channel Enabled)**

### I<sup>2</sup>S-justified Repeat Mode

In the I<sup>2</sup>S-justified repeat mode, the Most Significant Bit (MSB) of the mono audio sample data is available on the second rising edge of the BCLK clock following a WS signal transition. In this mode the same data is transmitted twice, once when WS is low and again when WS is high. Figure 214 and Figure 215 show the I<sup>2</sup>S-justified repeat mode format.



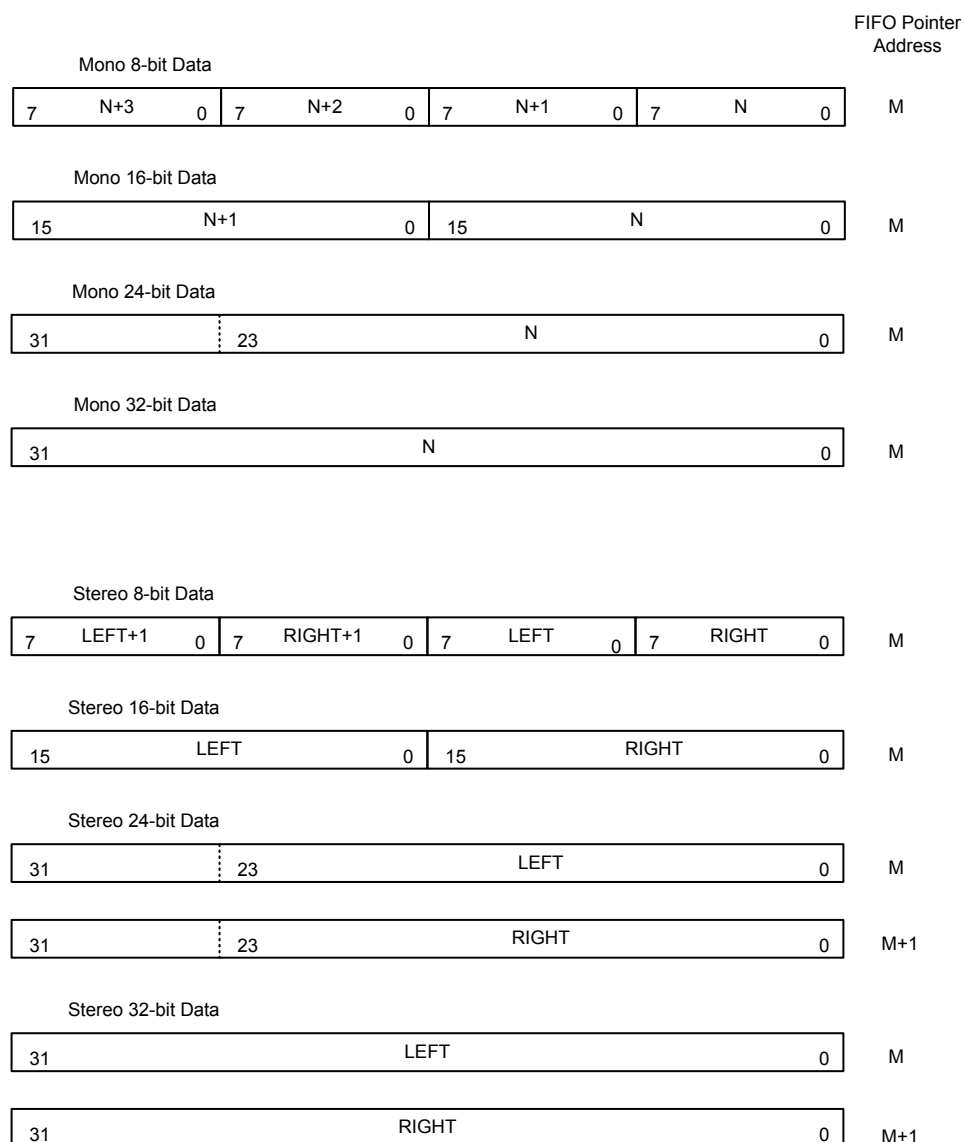
**Figure 214. I<sup>2</sup>S-justified Repeat Mode Waveforms**



**Figure 215. I<sup>2</sup>S-justified Repeat Mode Waveforms (32-bit Channel Enabled)**

## FIFO Control and Arrangement

The I<sup>2</sup>S handles audio data for transmission and reception and is performed via the FIFO controller. Each transmitted or received FIFO has a depth of 8 words ( $8 \times 32$ -bit) and can buffer the data. The format is dependent upon the stereo/mono mode and sample size setting. The detailed FIFO data content format is shown in Figure 216. The FIFO controller consists of comparators which compare the current FIFO levels with configurable depth settings. The current level of the TX or RX FIFO status can be seen in the TXFS and RXFS fields of the I<sup>2</sup>S status register (I2SSR).



**Figure 216. FIFO Data Content Arrangement for Various Modes**

## PDMA and Interrupt

When the level of received data in the RX FIFO is equal to or greater than the level defined by the RXFTLS field in the I<sup>2</sup>S FIFO control register (I2SFCR), the relative RXFTL flag will be set and then an I<sup>2</sup>S RX PDMA request will be generated. A CPU interrupt will be generated if the enable bit of the I<sup>2</sup>S RX PDMA request or the RX FIFO trigger level interrupt is asserted. When the level of transmitted data in the TX FIFO is equal to or less than the level defined by the TXFTLS field in the I<sup>2</sup>S FIFO control register (I2SFCR), the relative TXFTL flag will be set and a I<sup>2</sup>S TX PDMA request will be generated. A CPU interrupt will be generated if the enable bit of the I<sup>2</sup>S TX PDMA request or TX FIFO trigger level interrupt is asserted.

The I<sup>2</sup>S transmitter and receiver have separate PDMA requests and can be assigned to two different PDMA channels. When a PDMA request is enabled for the I<sup>2</sup>S transmitter (TXDMAEN = 1) then this will automatically request that data is transferred to the assigned I<sup>2</sup>S TX PDMA channel whenever TX FIFO space is available and TXFTL is active. When a PDMA request is enabled for the receiver (RXDMAEN = 1) then this will automatically request the data transfers to the I<sup>2</sup>S RX PDMA channel whenever data is present in the receive FIFO and when RXFTL is active.

## Register Map

The following table shows the I<sup>2</sup>S registers and reset values.

**Table 76. I<sup>2</sup>S Register Map**

| Register | Offset | Description                                  | Reset Value |
|----------|--------|----------------------------------------------|-------------|
| I2SCR    | 0x000  | I <sup>2</sup> S Control Register            | 0x0000_0000 |
| I2SIER   | 0x004  | I <sup>2</sup> S Interrupt Enable Register   | 0x0000_0000 |
| I2SCDR   | 0x008  | I <sup>2</sup> S Clock Divider Register      | 0x0000_0000 |
| I2STXDR  | 0x00C  | I <sup>2</sup> S Tx Data Register            | 0x0000_0000 |
| I2SRXDR  | 0x010  | I <sup>2</sup> S Rx Data Register            | 0x0000_0000 |
| I2SFCR   | 0x014  | I <sup>2</sup> S FIFO Control Register       | 0x0000_0000 |
| I2SSR    | 0x018  | I <sup>2</sup> S Status Register             | 0x0000_0809 |
| I2SRCNTR | 0x01C  | I <sup>2</sup> S Rate Counter Value Register | 0x0000_0000 |

## Register Descriptions

### I<sup>2</sup>S Control Register – I2SCR

This register specifies the corresponding I<sup>2</sup>S function enable control.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |         |         |        |         |        |        |        |
|------------|----------|---------|---------|--------|---------|--------|--------|--------|
|            | 31       | 30      | 29      | 28     | 27      | 26     | 25     | 24     |
| Type/Reset | Reserved |         |         |        |         |        |        |        |
|            | 23       | 22      | 21      | 20     | 19      | 18     | 17     | 16     |
| Type/Reset | Reserved |         |         |        | MCKINV  | BCKINV | RCSEL  | RCEN   |
|            |          |         |         |        | RW      | 0      | RW     | 0      |
|            | 15       | 14      | 13      | 12     | 11      | 10     | 9      | 8      |
| Type/Reset | CLKDEN   | RXDMAEN | TXDMAEN | TXMUTE | CHANNEL | REPEAT | MCLKEN | BITEXT |
|            | RW       | 0       | RW      | 0      | RW      | 0      | RW     | 0      |
|            | 7        | 6       | 5       | 4      | 3       | 2      | 1      | 0      |
| Type/Reset | FORMAT   |         | SMPSIZE |        | MS      | RXEN   | TXEN   | I2SEN  |
|            | RW       | 0       | RW      | 0      | RW      | 0      | RW     | 0      |

| Bits | Field   | Descriptions                                                                                                                                                                          |
|------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [19] | MCKINV  | MCLK Inverse Enable<br>0: Disable<br>1: Enable                                                                                                                                        |
| [18] | BCKINV  | BCLK Inverse Enable<br>0: Disable<br>1: Enable                                                                                                                                        |
| [17] | RCSEL   | Rate Control Select (master only)<br>0: slower<br>1: faster                                                                                                                           |
| [16] | RCEN    | Rate Control Enable (master only)<br>0: Disable<br>1: Enable                                                                                                                          |
| [15] | CLKDEN  | Clock Divider Enable (master only)<br>0: Disable<br>1: Enable<br>The clock divider can be used to generate the MCLK and BCLK clock of the I <sup>2</sup> S interface for master mode. |
| [14] | RXDMAEN | RX PDMA Request Enable<br>0: Disable<br>1: Enable                                                                                                                                     |
| [13] | TXDMAEN | TX PDMA Request Enable<br>0: Disable<br>1: Enable                                                                                                                                     |
| [12] | TXMUTE  | TX Mute Enable<br>0: Disable<br>1: Enable                                                                                                                                             |

| Bits  | Field   | Descriptions                                                                                                                                                                                                                                                                                                                                                                   |
|-------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [11]  | CHANNEL | Stereo or Mono<br>0: Stereo<br>1: Mono<br>Note: This bit should be configured when I <sup>2</sup> S is disabled.                                                                                                                                                                                                                                                               |
| [10]  | REPEAT  | Repeat Mode<br>0: Disable<br>1: Enable<br>This mode is for I <sup>2</sup> S-justified stereo configuration only, transmitting the mono data on both channels and receiving just the left channel data and ignoring the right. Enabling the repeat mode will reset the CHANNEL bit automatically.<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled. |
| [9]   | MCLKEN  | MCLK Output Enable (master only)<br>0: Disable<br>1: Enable<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled.                                                                                                                                                                                                                                      |
| [8]   | BITEXT  | 32-bit Channel Enable<br>0: Disable<br>1: Enable<br>Setting this bit will force the channel size to 32-bits. If the sample size is 8/16/24-bits, the remaining bits will be forced to 0 in the TX and ignored in the RX.<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled.                                                                         |
| [7:6] | FORMAT  | Data Format<br>00: I <sup>2</sup> S-justified<br>01: Left-justified<br>10: Right-justified<br>11: reserved<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled.                                                                                                                                                                                       |
| [5:4] | SMPSIZE | Sample Size<br>00: 8-bit<br>01: 16-bit<br>10: 24-bit<br>11: 32-bit<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled.                                                                                                                                                                                                                               |
| [3]   | MS      | Master or Slave Mode<br>0: Master<br>1: Slave<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled.                                                                                                                                                                                                                                                    |
| [2]   | RXEN    | RX Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                                                                                                                                                           |
| [1]   | TXEN    | TX Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                                                                                                                                                           |
| [0]   | I2SEN   | I <sup>2</sup> S Enable<br>0: Disable<br>1: Enable                                                                                                                                                                                                                                                                                                                             |

## I<sup>2</sup>S Interrupt Enable Register – I2SIER

This register contains the corresponding I<sup>2</sup>S interrupt enable bits.

Offset: 0x004

Reset value: 0x0000\_0000

|            |          |         |         |         |          |         |         |         |
|------------|----------|---------|---------|---------|----------|---------|---------|---------|
|            | 31       | 30      | 29      | 28      | 27       | 26      | 25      | 24      |
| Type/Reset | Reserved |         |         |         |          |         |         |         |
|            | 23       | 22      | 21      | 20      | 19       | 18      | 17      | 16      |
| Type/Reset | Reserved |         |         |         |          |         |         |         |
|            | 15       | 14      | 13      | 12      | 11       | 10      | 9       | 8       |
| Type/Reset | Reserved |         |         |         |          |         |         |         |
|            | 7        | 6       | 5       | 4       | 3        | 2       | 1       | 0       |
| Type/Reset | Reserved | RXOVLEN | RXUDLEN | RXFTLEN | Reserved | TXOVLEN | TXUDLEN | TXFTLEN |
|            |          | RW      | 0       | RW      | 0        | RW      | 0       | RW      |
|            |          |         |         |         |          |         |         |         |

| Bits | Field   | Descriptions                                                      |
|------|---------|-------------------------------------------------------------------|
| [6]  | RXOVLEN | RX FIFO Overflow Interrupt Enable<br>0: Disable<br>1: Enable      |
| [5]  | RXUDLEN | RX FIFO Underflow Interrupt Enable<br>0: Disable<br>1: Enable     |
| [4]  | RXFTLEN | RX FIFO Trigger Level Interrupt Enable<br>0: Disable<br>1: Enable |
| [2]  | TXOVLEN | TX FIFO Overflow Interrupt Enable<br>0: Disable<br>1: Enable      |
| [1]  | TXUDLEN | TX FIFO Underflow Interrupt Enable<br>0: Disable<br>1: Enable     |
| [0]  | TXFTLEN | TX FIFO Trigger Level Interrupt Enable<br>0: Disable<br>1: Enable |

## I<sup>2</sup>S Clock Divider Register – I2SCDR

This register specifies the I<sup>2</sup>S clock divider ratio.

Offset: 0x008

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |  |
|------------|----------|----|----|----|----|----|----|----|--|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |  |
| Type/Reset | Reserved |    |    |    |    |    |    |    |  |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |  |
| Type/Reset | N_DIV    |    |    |    |    |    |    |    |  |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |  |
| Type/Reset | X_DIV    |    |    |    |    |    |    |    |  |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |  |
| Type/Reset | Y_DIV    |    |    |    |    |    |    |    |  |

| Bits    | Field | Descriptions                                                                                                                                                   |
|---------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [23:16] | N_DIV | N divider for BCLK<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled.                                                               |
| [15:8]  | X_DIV | X divider for MCLK<br>(X != 0) && (Y != 0) && (X/Y >= 1/255) && (X/Y <= 127/255)<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled. |
| [7:0]   | Y_DIV | Y divider for MCLK<br>(X != 0) && (Y != 0) && (X/Y >= 1/255) && (X/Y <= 127/255)<br>Note: This bit should be configured when the I <sup>2</sup> S is disabled. |

## I<sup>2</sup>S Tx Data Register – I2STXDR

This register is used to specify the I<sup>2</sup>S transmitted data.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |      |    |    |    |    |    |    |    |    |
|------------|------|----|----|----|----|----|----|----|----|
|            | 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | TXDR |    |    |    |    |    |    |    |    |
| Type/Reset | WO   | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 23   | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | TXDR |    |    |    |    |    |    |    |    |
| Type/Reset | WO   | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | TXDR |    |    |    |    |    |    |    |    |
| Type/Reset | WO   | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 7    | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | TXDR |    |    |    |    |    |    |    |    |
| Type/Reset | WO   | 0  | WO | 0  | WO | 0  | WO | 0  | WO |

| Bits   | Field | Descriptions     |
|--------|-------|------------------|
| [31:0] | TXDR  | TX Data Register |

## I<sup>2</sup>S Rx Data Register – I2SRXDR

This register is used to store the I<sup>2</sup>S received data.

Offset: 0x010

Reset value: 0x0000\_0000

|            |      |    |    |    |    |    |    |    |    |
|------------|------|----|----|----|----|----|----|----|----|
|            | 31   | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | RXDR |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 23   | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | RXDR |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 15   | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | RXDR |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 7    | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | RXDR |    |    |    |    |    |    |    |    |
| Type/Reset | RO   | 0  | RO | 0  | RO | 0  | RO | 0  | RO |

| Bits   | Field | Descriptions     |
|--------|-------|------------------|
| [31:0] | RXDR  | RX Data Register |

## I<sup>2</sup>S FIFO Control Register – I2SFCR

This register contains the related I<sup>2</sup>S FIFO control bits.

Offset: 0x014

Reset value: 0x0000\_0000

|            |          |    |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
| Type/Reset | Reserved |    |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
| Type/Reset | Reserved |    |    |    |    |    | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
| Type/Reset | RW       |    |    |    | 0  |    |    |    |    |

| Bits  | Field  | Descriptions                                                                                                                                                                                                                                                                                 |
|-------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [9]   | RXFRST | RX FIFO Reset<br>Set this bit to reset the Rx FIFO.                                                                                                                                                                                                                                          |
| [8]   | TXFRST | TX FIFO Reset<br>Set this bit to reset the Tx FIFO.                                                                                                                                                                                                                                          |
| [7:4] | RXFTLS | RX FIFO Trigger Level Select<br>0000: Trigger level is 0<br>0001: Trigger level is 1<br>...<br>0111: Trigger level is 7<br>1xxx: Trigger level is 8<br>When the data contained in the Rx FIFO is equal to or greater than the level defined by the RXFTLS field, the RXFTL flag will be set. |
| [3:0] | TXFTLS | TX FIFO Trigger Level Select<br>0000: Trigger level is 0<br>0001: Trigger level is 1<br>...<br>0111: Trigger level is 7<br>1xxx: Trigger level is 8<br>When the data contained in the Tx FIFO is equal to or less than the level defined by the TXFTLS field, the TXFTL flag will be set.    |

## I<sup>2</sup>S Status Register – I2SSR

This register contains the relevant I<sup>2</sup>S status.

Offset: 0x018

Reset value: 0x0000\_0809

|            |          |    |    |    |    |    |    |    |
|------------|----------|----|----|----|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
|            | RXFS     |    |    |    |    |    |    |    |
| Type/Reset | RO       | 0  | RO | 0  | RO | 0  | RO | 0  |
|            | 23       | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset | RO       |    |    |    |    |    |    |    |
|            | 15       | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset | RO       |    |    |    |    |    |    |    |
|            | 7        | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
|            | Reserved |    |    |    |    |    |    |    |
| Type/Reset | RO       |    |    |    |    |    |    |    |

| Bits    | Field  | Descriptions                                                                                                                       |
|---------|--------|------------------------------------------------------------------------------------------------------------------------------------|
| [31:28] | RXFS   | Rx FIFO Status<br>0000: Rx FIFO empty<br>0001: Rx FIFO contains 1 data<br>...<br>1000: Rx FIFO contains 8 data<br>Others: Reserved |
| [27:24] | TXFS   | Tx FIFO Status<br>0000: Tx FIFO empty<br>0001: Tx FIFO contains 1 data<br>...<br>1000: Tx FIFO contains 8 data<br>Others: Reserved |
| [18]    | CLKRDY | Clock Divider Output Ready Flag<br>0: not ready<br>1: ready                                                                        |
| [17]    | TXBUSY | Tx Busy Flag<br>0: not busy<br>1: busy                                                                                             |
| [16]    | CHS    | Channel Status<br>0: left channel<br>1: right channel                                                                              |
| [12]    | RXFFUL | Rx FIFO Full Flag<br>0: Rx FIFO not full<br>1: Rx FIFO full                                                                        |
| [11]    | RXFEMT | Rx FIFO Empty Flag<br>0: Rx FIFO not empty<br>1: Rx FIFO empty                                                                     |

| Bits | Field  | Descriptions                                                                                                                                                                                                        |
|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [10] | RXFOV  | Rx FIFO Overflow Flag<br>0: Rx FIFO not overflow<br>1: Rx FIFO overflow<br>This bit is set by hardware and cleared by writing 1.                                                                                    |
| [9]  | RXFUD  | Rx FIFO Underflow Flag<br>0: Rx FIFO not underflow<br>1: Rx FIFO underflow<br>This bit is set by hardware and cleared by writing 1.                                                                                 |
| [8]  | RXFTL  | Rx FIFO Trigger Level Flag<br>0: Data in the Rx FIFO is less than the trigger level<br>1: Data in the Rx FIFO is equal to or higher than the trigger level<br>This bit is set by hardware and cleared by writing 1. |
| [4]  | TXFFUL | Tx FIFO Full Flag<br>0: Tx FIFO not full<br>1: Tx FIFO full                                                                                                                                                         |
| [3]  | TXFEMT | Tx FIFO Empty Flag<br>0: Tx FIFO not empty<br>1: Tx FIFO empty                                                                                                                                                      |
| [2]  | TXFOV  | Tx FIFO Overflow Flag<br>0: Tx FIFO not overflow<br>1: Tx FIFO overflow<br>This bit is set by hardware and cleared by writing 1.                                                                                    |
| [1]  | TXFUD  | Tx FIFO Underflow Flag<br>0: Tx FIFO not underflow<br>1: Tx FIFO underflow<br>This bit is set by hardware and cleared by writing 1.                                                                                 |
| [0]  | TXFTL  | Tx FIFO Trigger Level Flag<br>0: Data in the Tx FIFO is higher than the trigger level<br>1: Data in the Tx FIFO is equal to or less than the trigger level<br>This bit is set by hardware and cleared by writing 1. |

## I<sup>2</sup>S Rate Counter Value Register – I2SRCNTR

This register specifies the I<sup>2</sup>S rate control counter value.

Offset: 0x01C

Reset value: 0x0000\_0000

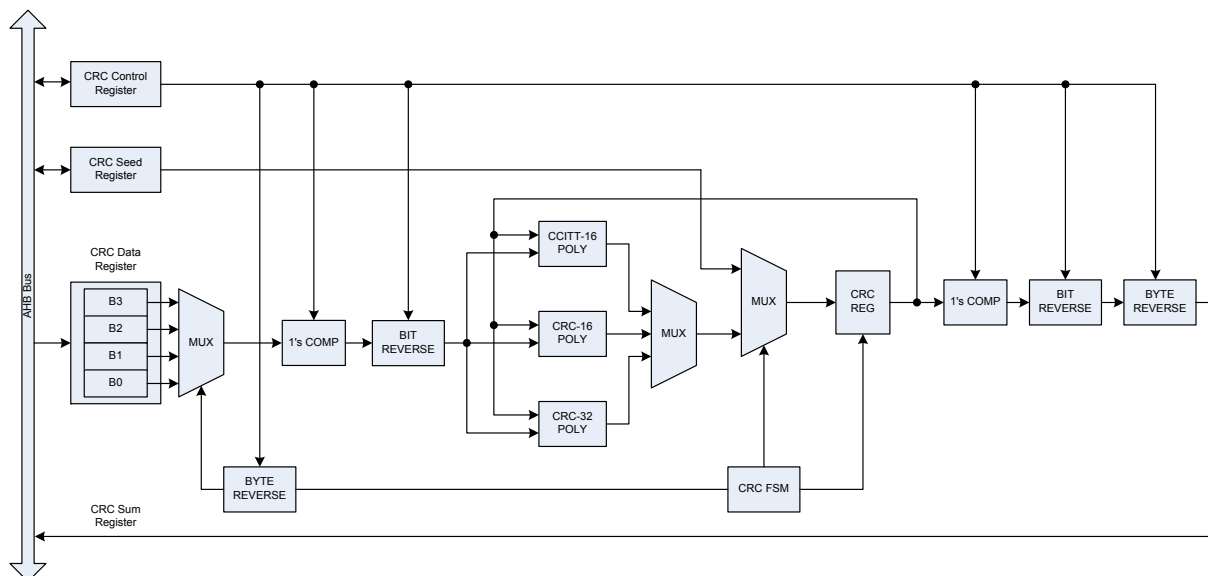
|            |          |    |    |    |       |    |    |    |    |
|------------|----------|----|----|----|-------|----|----|----|----|
|            | 31       | 30 | 29 | 28 | 27    | 26 | 25 | 24 |    |
|            | Reserved |    |    |    |       |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW    | 0  | RW | 0  | RW |
|            | 23       | 22 | 21 | 20 | 19    | 18 | 17 | 16 |    |
|            | Reserved |    |    |    | RCNTR |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW    | 0  | RW | 0  | RW |
|            | 15       | 14 | 13 | 12 | 11    | 10 | 9  | 8  |    |
|            | RCNTR    |    |    |    |       |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW    | 0  | RW | 0  | RW |
|            | 7        | 6  | 5  | 4  | 3     | 2  | 1  | 0  |    |
|            | RCNTR    |    |    |    |       |    |    |    |    |
| Type/Reset | RW       | 0  | RW | 0  | RW    | 0  | RW | 0  | RW |

| Bits   | Field | Descriptions                                                                                                |
|--------|-------|-------------------------------------------------------------------------------------------------------------|
| [19:0] | RCNTR | Rate Counter Value<br>This value must be equal to or higher than Y_DIV for useful rate fine-tuning control. |

# 29 Cyclic Redundancy Check (CRC)

## Introduction

The CRC (Cyclic Redundancy Check) calculation unit is an error detection technique test algorithm and uses to verify data transmission or storage data correctness. A CRC calculation takes a data stream or a block of data as input and generates a 16- or 32-bit output remainder. Ordinarily, a data stream is suffixed by a CRC code and used as a checksum when being sent or stored. Therefore, the received or restored data stream is calculated by the same generator polynomial as described above. If the new CRC code result does not match the one calculated earlier, that means data stream contains a data error.



**Figure 217. CRC Block Diagram**

## Features

- Support CRC16 polynomial:  $0x8005$ ,  $X^{16}+X^{15}+X^2+1$
- Support CCITT CRC16 polynomial:  $0x1021$ ,  $X^{16}+X^{12}+X^5+1$
- Support IEEE-802.3 CRC32 polynomial:  $0x04C11DB7$ ,  $X^{32}+X^{26}+X^{23}+X^{22}+X^{16}+X^{12}+X^{11}+X^{10}+X^8+X^7+X^5+X^4+X^2+X+1$
- Support 1's complement, byte reverse & bit reverse operation on data and checksum
- Support byte, half-word & word data size
- Programmable CRC initial seed value
- CRC computation done in 1 AHB clock cycle for 8-bit data and 4 AHB clock cycles for 32-bit data
- Support PDMA to complete a CRC computation of a block of memory

## Function Descriptions

This unit only enables the calculation in the CRC16, CCITT CRC16 and IEEE-802.3 CRC32 polynomial. In this unit, the generator polynomial is fixed to the numeric values for those modes; therefore, the CRC value based on other generator polynomials cannot be calculated.

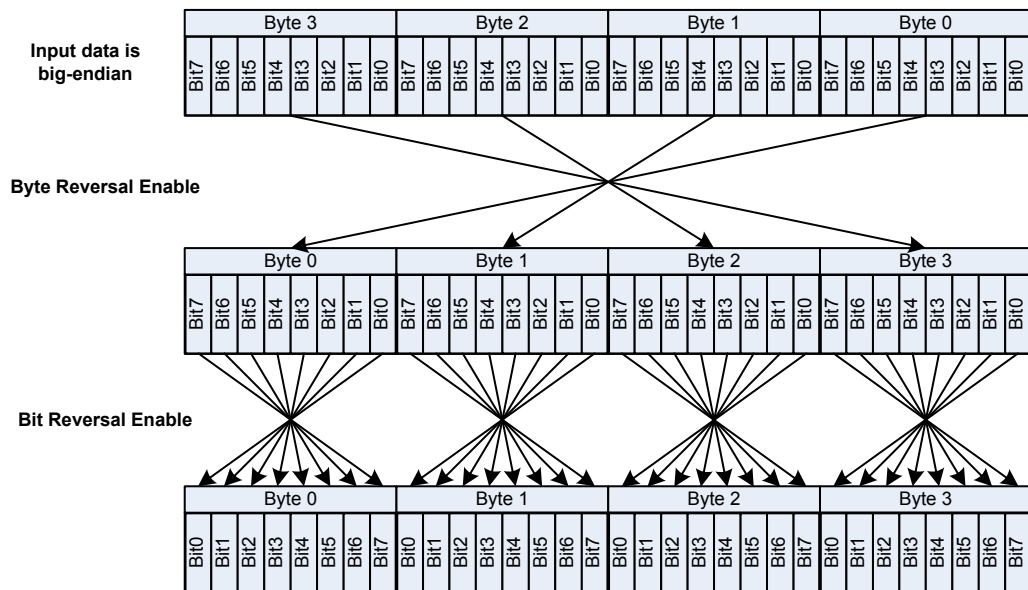
### CRC Computation

The CRC calculation unit has 32-bit write CRC data register (CRCDR) and read CRC checksum register (CRCCSR). The CRCDR register is used to input new data (write access), and the CRCCSR register is used to hold the result of the previous CRC calculation (read access). Each write operation to the CRCDR register creates a combination of the previous CRC value (stored in CRCCSR) and the new one. The CRC block diagram is shown as Figure 217. The CRC unit calculates the CRC data register (CRCDR) value is basic on byte by byte and default byte and bit order is big-endian. The CRCDR register can be accessed write by word, right-aligned half-word and right-aligned byte. For the other registers only 32-bit access is allowed. The duration of the computation depends on data width:

- 4 AHB clock cycles for 32-bit data input
- AHB clock cycles for 16-bit data input
- AHB clock cycles for 8-bit data input

### Byte and Bit Reversal for CRC Computation

The byte reordering and byte-level bit reversal operation can be occurred before the data is used in the CRC calculation or after the CRC checksum output. They are configurable the corresponding setting field of the CRCCR register. These operations occur on word or half words write. The hardware ignores the DATBYRV bit of the CRCCR register with any byte writes but the bit reversal setting DATBIRV are still applied to the byte. The Figure 218 is shown the byte and bit reversal operation example.



**Figure 218. CRC Data Bit and Byte Reversal Example**

## CRC with PDMA

A PDMA channel with software trigger may be used to transfer data into the CRC unit. If a huge block data is needed to calculate. The recommended PDMA model is to use the PDMA to transfer all available words of data and uses software writes to transfer the other remaining bytes. To write data into the CRC unit, the PDMA should be accessed data write by word from the source location of memory to the CRC data register (CRCDR) in non-incrementing address mode. Then software can write any remaining bytes to the CRC data register (CRCDR) and read the CRC calculation result value from the CRC checksum register (CRCCSR).

## Register Map

The following table shows the CRC registers and reset values.

**Table 77. CRC Register Map**

| Register                             | Offset | Description           | Reset Value |
|--------------------------------------|--------|-----------------------|-------------|
| <b>CRC Base Address = 0x4008A000</b> |        |                       |             |
| CRCCR                                | 0x000  | CRC Control Register  | 0x0000_0000 |
| CRCSR                                | 0x004  | CRC Seed Register     | 0x0000_0000 |
| CRCCSR                               | 0x008  | CRC Checksum Register | 0x0000_0000 |
| CRCDR                                | 0x00C  | CRC Data Register     | 0x0000_0000 |

## Register Descriptions

### CRC Control Register – CRCCR

This register specifies the corresponding CRC function enable control.

Offset: 0x000

Reset value: 0x0000\_0000

|            |          |         |         |         |         |         |      |    |
|------------|----------|---------|---------|---------|---------|---------|------|----|
|            | 31       | 30      | 29      | 28      | 27      | 26      | 25   | 24 |
| Type/Reset | Reserved |         |         |         |         |         |      |    |
|            | 23       | 22      | 21      | 20      | 19      | 18      | 17   | 16 |
| Type/Reset | Reserved |         |         |         |         |         |      |    |
|            | 15       | 14      | 13      | 12      | 11      | 10      | 9    | 8  |
| Type/Reset | Reserved |         |         |         |         |         |      |    |
|            | 7        | 6       | 5       | 4       | 3       | 2       | 1    | 0  |
| Type/Reset | SUMCMPL  | SUMBYRV | SUMBIRV | DATCMPL | DATBYRV | DATBIRV | POLY |    |
|            | RW       | 0       | RW      | 0       | RW      | 0       | RW   | 0  |

| Bits  | Field   | Descriptions                                                                               |
|-------|---------|--------------------------------------------------------------------------------------------|
| [7]   | SUMCMPL | 1's Complement operation on Checksum Output<br>0: Disable<br>1: Enable                     |
| [6]   | SUMBYRV | Byte Reverse operation on Checksum Output<br>0: Disable<br>1: Enable                       |
| [5]   | SUMBIRV | Bit Reverse operation on Checksum Output<br>0: Disable<br>1: Enable                        |
| [4]   | DATCMPL | 1's Complement operation on Data<br>0: Disable<br>1: Enable                                |
| [3]   | DATBYRV | Byte Reverse operation on Data<br>0: Disable<br>1: Enable                                  |
| [2]   | DATBIRV | Bit Reverse operation on Data<br>0: Disable<br>1: Enable                                   |
| [1:0] | POLY    | CRC polynomial<br>00: CRC-CCITT (0x1021)<br>01: CRC-16 (0x8005)<br>1X: CRC-32 (0x04C11DB7) |

## CRC Seed Register – CRCSDR

This register is used to specify the CRC seed.

Offset: 0x004

Reset value: 0x0000\_0000

|            |      |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |
|------------|------|---|----|---|----|---|----|---|----|---|----|---|----|---|----|---|
|            | 31   |   | 30 |   | 29 |   | 28 |   | 27 |   | 26 |   | 25 |   | 24 |   |
|            | SEED |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |
| Type/Reset | WO   | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 |
|            | 23   |   | 22 |   | 21 |   | 20 |   | 19 |   | 18 |   | 17 |   | 16 |   |
|            | SEED |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |
| Type/Reset | WO   | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 |
|            | 15   |   | 14 |   | 13 |   | 12 |   | 11 |   | 10 |   | 9  |   | 8  |   |
|            | SEED |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |
| Type/Reset | WO   | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 |
|            | 7    |   | 6  |   | 5  |   | 4  |   | 3  |   | 2  |   | 1  |   | 0  |   |
|            | SEED |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |
| Type/Reset | WO   | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 | WO | 0 |

| Bits   | Field | Descriptions                                                                                                              |
|--------|-------|---------------------------------------------------------------------------------------------------------------------------|
| [31:0] | SEED  | CRC Seed Data<br>Put the 16/32-bit seed value in this register according to the polynomial setting in the CRCCR register. |

## CRC Checksum Register – CRCCSR

This register contains the CRC checksum output.

Offset: 0x008

Reset value: 0x0000\_0000

|            |        |    |    |    |    |    |    |    |    |
|------------|--------|----|----|----|----|----|----|----|----|
|            | 31     | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | CHKSUM |    |    |    |    |    |    |    |    |
| Type/Reset | RO     | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 23     | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | CHKSUM |    |    |    |    |    |    |    |    |
| Type/Reset | RO     | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 15     | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | CHKSUM |    |    |    |    |    |    |    |    |
| Type/Reset | RO     | 0  | RO | 0  | RO | 0  | RO | 0  | RO |
|            | 7      | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | CHKSUM |    |    |    |    |    |    |    |    |
| Type/Reset | RO     | 0  | RO | 0  | RO | 0  | RO | 0  | RO |

| Bits   | Field  | Descriptions                                                                                                                                                                                 |
|--------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | CHKSUM | CRC Checksum Data<br>Get the CRC 16/32-bit checksum result thought this register according to the polynomial setting in the CRCCR register after all data are written to the CRCDR register. |

## CRC Data Register – CRCDR

This register is used to specify the CRC input data.

Offset: 0x00C

Reset value: 0x0000\_0000

|            |         |    |    |    |    |    |    |    |    |
|------------|---------|----|----|----|----|----|----|----|----|
|            | 31      | 30 | 29 | 28 | 27 | 26 | 25 | 24 |    |
|            | CRCDATA |    |    |    |    |    |    |    |    |
| Type/Reset | WO      | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 23      | 22 | 21 | 20 | 19 | 18 | 17 | 16 |    |
|            | CRCDATA |    |    |    |    |    |    |    |    |
| Type/Reset | WO      | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 15      | 14 | 13 | 12 | 11 | 10 | 9  | 8  |    |
|            | CRCDATA |    |    |    |    |    |    |    |    |
| Type/Reset | WO      | 0  | WO | 0  | WO | 0  | WO | 0  | WO |
|            | 7       | 6  | 5  | 4  | 3  | 2  | 1  | 0  |    |
|            | CRCDATA |    |    |    |    |    |    |    |    |
| Type/Reset | WO      | 0  | WO | 0  | WO | 0  | WO | 0  | WO |

| Bits   | Field   | Descriptions                                                                                                                       |
|--------|---------|------------------------------------------------------------------------------------------------------------------------------------|
| [31:0] | CRCDATA | CRC Input Data<br>Byte, half-word & word write are allowed. 1's complement, byte reverse and bit reverse operation can be applied. |

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