

**ARM® Cortex®-M0  
32-bit Microcontroller**

**NuMicro® Family  
NUC029 Series  
Technical Reference Manual**

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## 1 GENERAL DESCRIPTION

The NuMicro® NUC029 series 32-bit microcontroller is embedded with ARM® Cortex®-M0 core for industrial control and applications which need rich communication interfaces or require high performance, high integration, and low cost. The Cortex®-M0 is the newest ARM® embedded processor with 32-bit performance at a cost equivalent to the traditional 8-bit microcontroller. The NuMicro® NUC029 series includes four part numbers: NUC029LAN, NUC029NAN, NUC029ZAN, NUC029TAN and NUC029FAE.

The NUC029LAN/NUC029NAN/NUC029ZAN/NUC029TAN can run up to 50 MHz and operate at 2.5V ~ 5.5V, -40°C ~ 85°C, and the NUC029FAE can run up to 24 MHz and operate at 2.5V ~ 5.5V, -40°C ~ 105°C. Therefore, the NUC029 series can afford to support a variety of industrial control and applications which need high CPU performance.

The NUC029LAN/NUC029NAN/NUC029ZAN/NUC029TAN offers 64K/64K/32K bytes flash, 4 Kbytes Data Flash, 4 Kbytes flash for the ISP, and 4 Kbytes SRAM. The NUC029FAE offers 16 Kbytes flash, size configurable Data Flash (shared with program flash), 2 Kbytes flash for the ISP, and 2K-bytes SRAM.

Many system level peripheral functions, such as I/O Port, EBI (External Bus Interface), Timer, UART, SPI, I<sup>2</sup>C, PWM, ADC, WDT (Watchdog Timer), WWDT (Window Watchdog Timer), Analog Comparator and Brown-out Detector, have been incorporated into the NUC029 series in order to reduce component count, board space and system cost. These useful functions make the NUC029 series powerful for a wide range of applications.

Additionally, the NuMicro® NUC029 series is equipped with ISP (In-System Programming) and ICP (In-Circuit Programming) functions, and IAP (In-Application Programming), which allow the user to update the program memory without removing the chip from the actual end product.

Item	NUC029LAN/NUC029NAN/ NUC029ZAN/NUC029TAN	NUC029FAE
Core	Up to 50 MHz	Up to 24 MHz
Operating Temp.	-40°C ~ +85°C	-40°C ~ +105°C
Hardware Divider	√	-
Clock Control	Supports PLL as clock source	-
	-	Supports external 32.768 kHz crystal oscillator as clock source
Window WDT	√	-
PWM	PWM Generator and Capture Timer	Enhanced PWM Generator
ADC	12-bit SAR ADC with 760 kSPS (Supports Single, Burst, Single-Cycle, and Continuous Scan mode)	10-bit SAR ADC with 300 kSPS (Only supports Single mode)
EBI	√	-
Built-in Temp.Sensor	√	-

Table 1-1 NuMicro® NUC029 Series Difference List

## 2 FEATURES

- ARM® Cortex®-M0 core
  - Runs up to 50 MHz
  - One 24-bit system timer
  - Supports Low Power Sleep mode
  - A single-cycle 32-bit hardware multiplier
  - NVIC for the 32 interrupt inputs, each with 4-levels of priority
  - Supports Serial Wire Debug (SWD) interface and two watchpoints/four breakpoints
  - Provides hardware divider and supports signed 32-bit dividend, 16-bit divisor operation(NUC029xAN only)
- Operating voltage ranges from 2.5 V to 5.5 V
- Memory
  - 16/32/64 KB Flash for program memory (APROM)
  - Up to 4 KB Flash for loader (LDROM)
  - Up to 4 KB SRAM for internal scratch-pad RAM (SRAM)
  - 4 KB Flash for data memory (Data Flash) (NUC029xAN only)
  - Configurable Data Flash (NUC029FAE only)
- Clock Control
  - Programmable system clock source
  - 22.1184 MHz internal oscillator
    - ◆ Dynamically calibrating the HIRC OSC to 22.1184 MHz  $\pm 3\%$  from -40°C to 105°C by external 32.768 kHz crystal oscillator (LXT) (NUC029FAE only)
  - 4~24 MHz external crystal input
  - 10 kHz low-power oscillator for Watchdog Timer and wake-up in Sleep mode
  - PLL allows CPU operation up to the maximum 50 MHz (NUC029xAN only)
  - 32.768 kHz external crystal input (LXT) for Power-down wake-up and system operation clock (NUC029FAE only)
- GPIO
  - Up to 40 general-purpose I/O (GPIO) pins for LQFP/QFN 48-pin package
  - Four I/O modes:
    - ◆ Quasi-bidirectional
    - ◆ Push-pull output
    - ◆ Open-drain output
    - ◆ Input only with high impedance
  - TTL/Schmitt trigger input selectable
  - I/O pin can be configured as interrupt source with edge/level setting
  - Supports high driver and high sink I/O mode
  - Configurable I/O mode after POR
- Timer
  - Up to four sets of 32-bit timers with 24-bit up counter and one 8-bit prescale counter
  - Independent clock source for each timer
  - Provides up to four timer counting modes: one-shot, periodic, toggle and continuous counting
  - 24-bit up counter value is readable through TDR (Timer Data Register)
  - Supports event counting function to count the input event from external counter pin
  - 24-bit capture value is readable through TCAP (Timer Capture Data Register)
  - Supports external capture pin for interval measurement
    - ◆ Supports external capture pin to reset 24-bit up counter
    - ◆ Supports chip wake-up from Idle/Power-down mode if a timer interrupt signal is generated
  - Supports internal capture triggered while internal ACMP output signal transition

- (NUC029xAN only)
- Supports Inter-Timer trigger mode (NUC029xAN only)
- Supports internal signal (CPO0, CPO1) for interval measurement (NUC029FAE only)
- WDT (Watchdog Timer)
  - Multiple clock sources
  - Supports wake-up from Power-down or Sleep mode
  - Interrupt or reset selectable on watchdog time-out
  - Time-out reset delay period can be selected to 3/18/130/1026 \* WDT\_CLK (NUC029xAN only)
- WWDT (Window Watchdog Timer) (NUC029xAN only)
  - 6-bit down counter with 11-bit pre-scale for wide range window selected
- PWM Generator and Capture Timer (NUC029xAN only)
  - Up to four built-in 16-bit PWM generators, providing eight PWM outputs or four complementary paired PWM outputs
  - Individual clock source, clock divider, 8-bit pre-scalar and dead-zone generator for each PWM generator
  - PWM interrupt synchronized to PWM period
  - 16-bit digital Capture timers with rising/falling capture inputs
  - Supports capture interrupt
  - Internal 10 kHz to PWM clock source
  - Polar inverse function
  - Center-aligned type function
  - Timer duty interrupt enable function
  - Two kinds of PWM interrupt period type selection
  - Two kinds of PWM interrupt duty type selection
  - Period/duty trigger ADC function
  - PWM Timer synchronous start function
- Enhanced PWM Generator (NUC029FAE only)
  - Independent 16-bit PWM duty control units with maximum three outputs
  - Supports group/synchronous/independent/ complementary modes
  - Supports One-shot or Auto-reload mode
  - Supports Edge-aligned and Center-aligned type
  - Programmable dead-zone insertion between complementary channels
  - Each output has independent polarity setting control
  - Hardware fault brake protections
  - Supports duty, period, and fault break interrupts
  - Supports duty/period trigger ADC conversion
  - Timer comparing matching event trigger PWM to do phase change
  - Supports comparator event trigger PWM to force PWM output low for current period
  - Provides interrupt accumulation function
- UART
  - Up to two sets of UART devices
  - Programmable baud-rate generator
  - Buffered receiver and transmitter, each with 16 bytes FIFO
  - Optional flow control function (CTS and RTS)
  - Supports IrDA(SIR) function
  - Supports RS-485 function
  - Supports LIN function (NUC029xAN only)
- SPI
  - Up to two sets of SPI devices
  - Supports Master/Slave mode

- Full-duplex synchronous serial data transfer
- Provides 3 wire function
- Variable length of transfer data from 8 to 32 bits
- MSB or LSB first data transfer
- Rx latching data can be either at rising edge or at falling edge of serial clock
- Tx sending data can be either at rising edge or at falling edge of serial clock
- Supports Byte Suspend mode in 32-bit transmission
- 4-level depth FIFO buffer
- PLL clock source (NUC029xAN only)
- I<sup>2</sup>C
  - Up to two sets of I<sup>2</sup>C modules
  - Supports Master/Slave mode
  - Bi-directional data transfer between masters and slaves
  - Multi-master bus (no central master)
  - Arbitration between simultaneously transmitting masters without corruption of serial data on the bus
  - Serial clock synchronization allows devices with different bit rates to communicate via one serial bus
  - Serial clock synchronization can be used as a handshake mechanism to suspend and resume serial transfer
  - Programmable clocks allow versatile rate control
  - Supports 7-bit addressing mode
  - Supports multiple address recognition (four slave addresses with mask option)
  - Supports Power-down wake-up function
  - Supports FIFO function (NUC029FAE only)
- ADC
  - 12-bit SAR ADC with 760 kSPS for NUC029xAN, and 10-bit SAR ADC with 300 kSPS for NUC029FAE
  - Up to eight single-end analog input channels
    - ◆ Or four differential analog input channels (NUC029xAN only)
  - Four operation modes (NUC029FAE only support Single mode)
    - ◆ Single mode: A/D conversion is performed one time on a specified channel
    - ◆ Burst mode: A/D converter samples and converts the specified single channel and sequentially stores the result in FIFO
    - ◆ Single-cycle Scan mode: A/D conversion is performed only one cycle on all specified channels with the sequence from the smallest numbered channel to the largest numbered channel
    - ◆ Continuous Scan mode: A/D converter continuously performs Single-cycle Scan mode until software stops A/D conversion
  - An A/D conversion can be started by:
    - ◆ Software Write 1 to ADST bit
    - ◆ External pin (STADC)
    - ◆ PWM trigger with optional start delay period
  - Each conversion result is held in data register with valid and overrun indicators
  - Each channel has individual data register (NUC029xAN only)
  - Conversion result can be compared with specified value and user can select whether to generate an interrupt when conversion result matches the compare register setting
  - Internal temperature sensor output (NUC029xAN only)
- Analog Comparator
  - Up to four sets of Comparator analog modules
  - External input or internal band-gap voltage selectable at negative node
  - Interrupt when compared results change
  - Power-down wake-up

- EBI (External Bus Interface) for external memory-mapped device access (NUC029LAN/ NUC029NAN only)
  - Accessible space: 64 KB in 8-bit mode or 128 KB in 16-bit mode
  - Supports 8-bit or 16-bit data width
  - Supports byte-write in 16-bit data width
- ISP (In-System Programming) and ICP (In-Circuit Programming)
- IAP (In-Application Programming)
- One built-in temperature sensor with 1°C resolution (NUC029xAN only)
- BOD (Brown-out Detector)
  - With 4 levels: 4.4V/3.7V/2.7V/2.2V
  - Supports Brown-out interrupt and reset option
- 96-bit unique ID (UID)
- LVR (Low Voltage Reset)
  - Threshold voltage level: 2.0V
- Operating Temperature:
  - NUC029LAN/NUC029NAN/NUC029ZAN/NUC029TAN: -40°C ~85°C
  - NUC029FAE:-40°C ~105°C
- Reliability: EFT > ± 4 KV, ESD HBM pass 4 KV
- Packages:
  - All Green package (RoHS)
  - 48-pin LQFP, 48-pin QFN, 33-pin QFN, 20-pin TSSOP

### 3 ABBREVIATIONS

Acronym	Description
ACMP	Analog Comparator Controller
ADC	Analog-to-Digital Converter
APB	Advanced Peripheral Bus
AHB	Advanced High-Performance Bus
BOD	Brown-out Detection
EBI	External Bus Interface
FIFO	First In, First Out
FMC	Flash Memory Controller
GPIO	General-Purpose Input/Output
HCLK	The Clock of Advanced High-Performance Bus
HIRC	22.1184 MHz Internal High Speed RC Oscillator
HXT	4~24 MHz External High Speed Crystal Oscillator
IAP	In Application Programming
ICP	In Circuit Programming
ISP	In System Programming
LDO	Low Dropout Regulator
LIN	Local Interconnect Network
LIRC	10 kHz internal low speed RC oscillator (LIRC)
LXT	32.768 kHz External Low Speed Crystal Oscillator
NVIC	Nested Vectored Interrupt Controller
PCLK	The Clock of Advanced Peripheral Bus
PLL	Phase-Locked Loop
PWM	Pulse Width Modulation
SPI	Serial Peripheral Interface
SPS	Samples per Second
TMR	Timer Controller
UART	Universal Asynchronous Receiver/Transmitter
UCID	Unique Customer ID
USB	Universal Serial Bus
WDT	Watchdog Timer
WWDT	Window Watchdog Timer

Table 3-1 List of Abbreviations

## 4 PARTS INFORMATION LIST AND PIN CONFIGURATION

### 4.1 NuMicro® NUC029 Series Selection Guide

Part Number	Connectivity												Package	Operating Temperature Range(°C)							
	UART	SPI	I <sup>2</sup> C	PWM (16-bit)	ADC (12-bit)	ADC (10-bit)	Comparator	WDT	WWDT	EBI	PLL	32.768 kHz Crystal Oscillator									
NUC029LAN	64	4	4	4	40	4	2	2	2	8	8	-	4	✓	✓	✓	-	✓	LQFP48	-40 to +85	
NUC029NAN	64	4	4	4	40	4	2	2	2	8	8	-	4	✓	✓	✓	-	✓	QFN48	-40 to +85	
NUC029ZAN	64	4	4	4	24	4	2	1	2	5	5	-	3*	✓	✓	-	✓	-	✓	QFN33 (5x5)	-40 to +85
NUC029TAN	32	4	4	4	24	4	2	1	2	5	5	-	3*	✓	✓	-	✓	-	✓	QFN33 (4x4)	-40 to +85
NUC029FAE	16	2	Config.	2	17	2	1	1	1	3	-	4	2**	✓	-	-	-	✓	✓	TSSOP20	-40 to +105

Table 4-1 NuMicro® NUC029 Series Selection Guide

**Note:**

\*: ACMP3 only has positive and negative input.

\*\*: ACMP0 only has positive and negative input, and ACMP1 only has positive input.

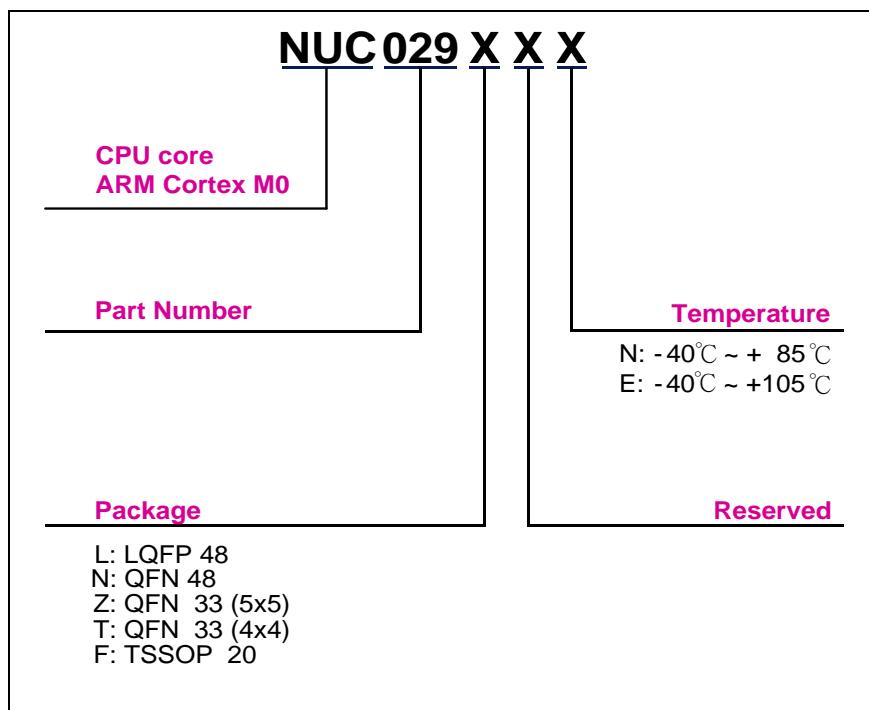


Figure 4-1 NuMicro® NUC029 Series Selection Code

## 4.2 Pin Configuration

### 4.2.1 NuMicro® NUC029 Pin Diagram

#### 4.2.1.1 NuMicro® NUC029LAN LQFP 48 pin

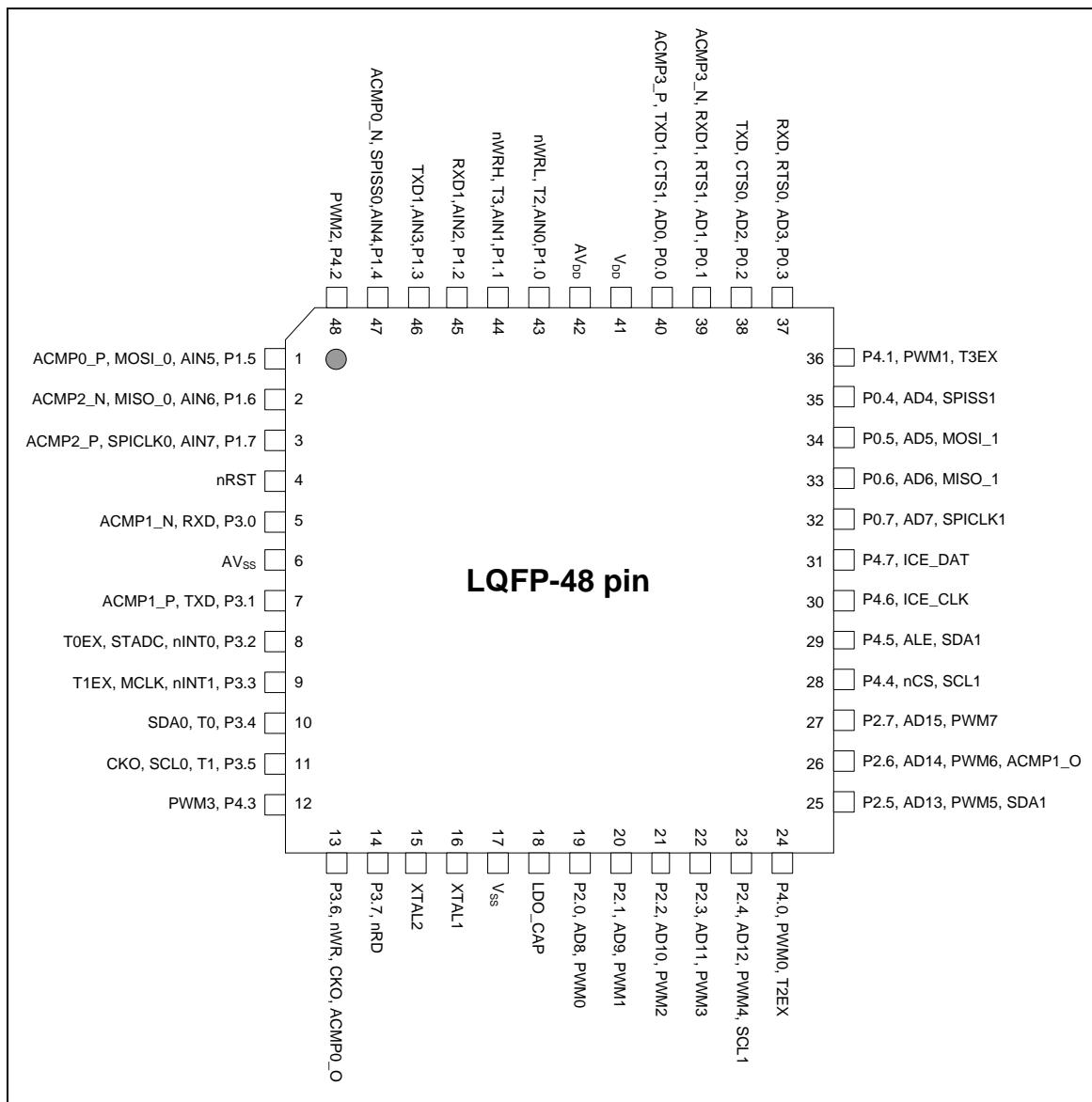


Figure 4-2 NuMicro® NUC029LAN LQFP 48-pin Diagram

## 4.2.1.2 NuMicro® NUC029NAN QFN 48 pin

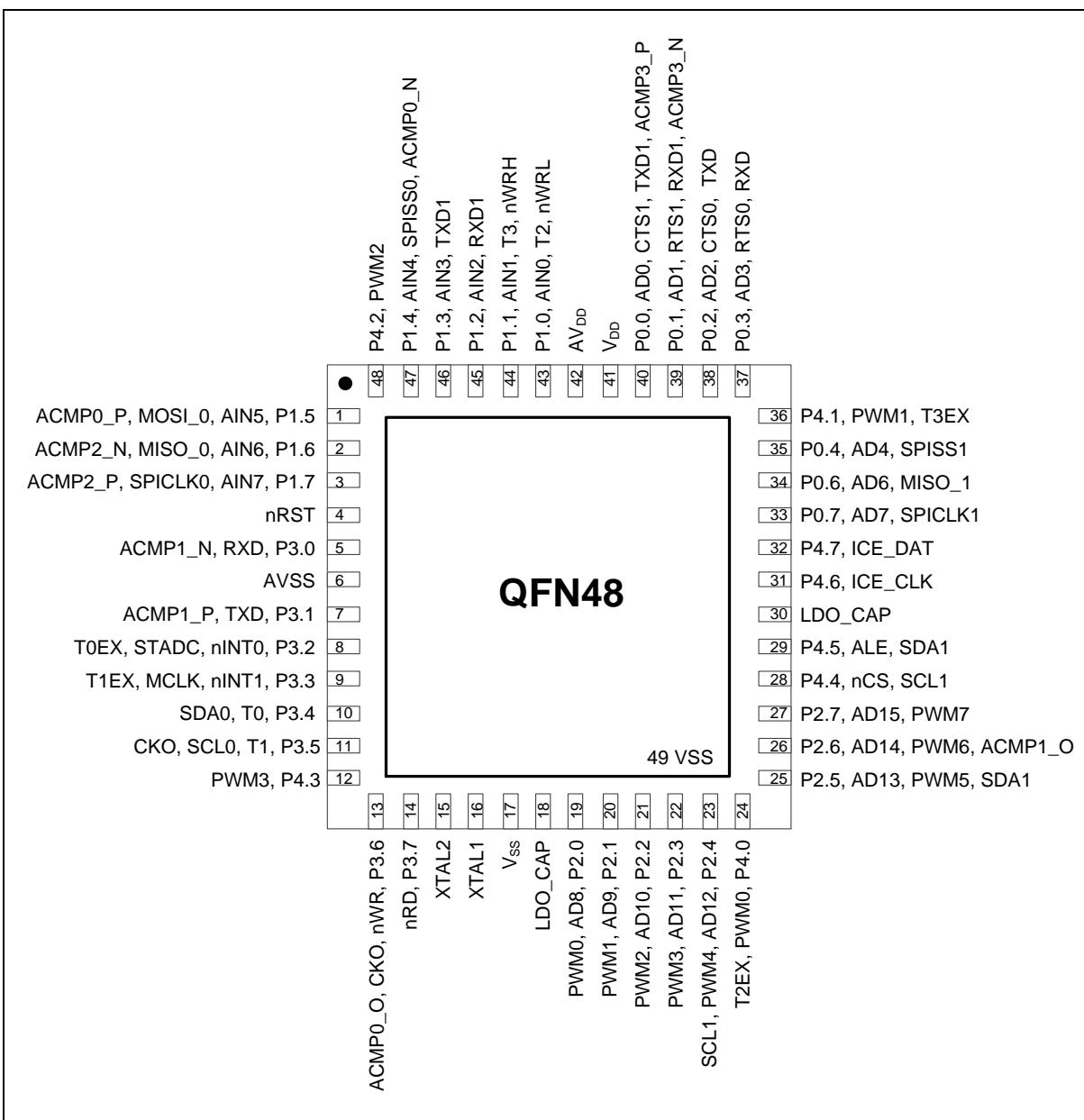


Figure 4-3 NuMicro® NUC029NAN QFN 48-pin Diagram

## 4.2.1.3 NuMicro® NUC029ZAN/NUC029TAN QFN 33 pin

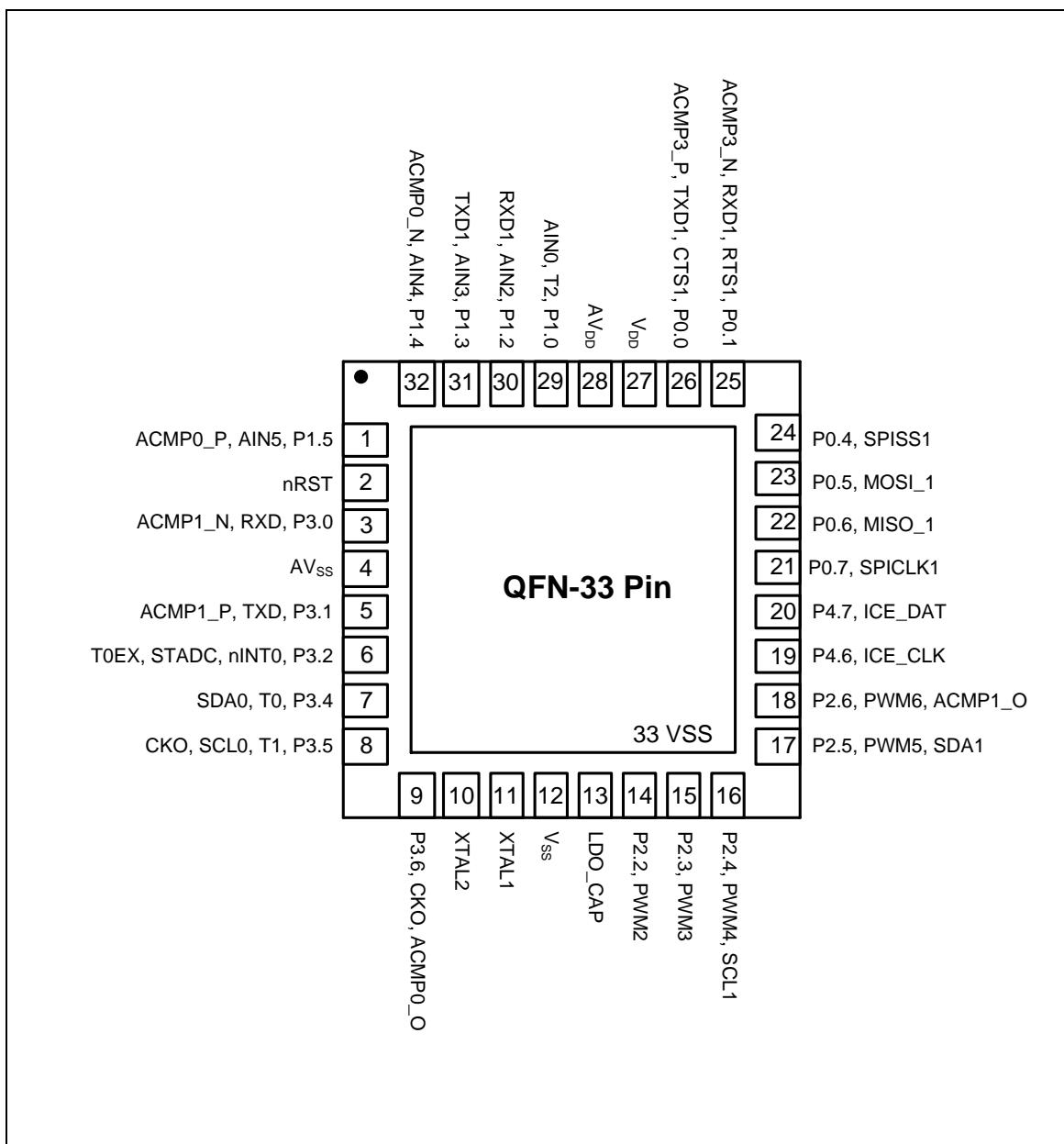


Figure 4-4 NuMicro® NUC029ZAN/NUC029TAN QFN 33-pin Diagram

## 4.2.1.4 NuMicro® NUC029FAE TSSOP 20 pin

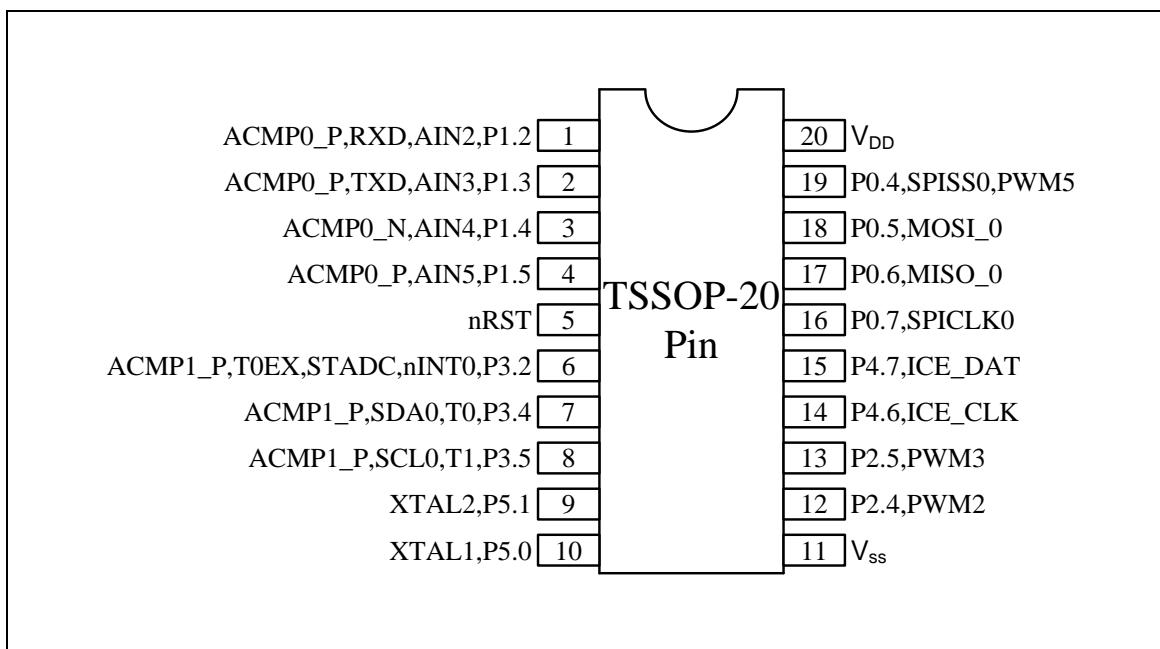


Figure 4-5 NuMicro® NUC029FAE TSSOP 20-pin Diagram

## 4.3 Pin Description

### 4.3.1 NuMicro® NUC029 Pin Description

Pin No.		Pin Name	Pin Type	Description
LQFP/QFN 48-pin	QFN 33-pin			
1	1	P1.5	I/O	General purpose digital I/O pin.
		AIN5	AI	ADC5 analog input.
		ACMP0_P	AI	Comparator0 positive input pin.
	—	MOSI_0	I/O	SPI0 MISO (Master Out, Slave In) pin.
2	—	P1.6	I/O	General purpose digital I/O pin.
		AIN6	AI	ADC6 analog input.
		MISO_0	I/O	SPI0 MISO (Master In, Slave Out) pin.
		ACMP2_N	AI	Comparator2 negative input pin.
3	—	P1.7	I/O	General purpose digital I/O pin.
		AIN7	AI	ADC7 analog input.
		SPICLK0	I/O	SPI0 serial clock pin.
		ACMP2_P	AI	Comparator2 positive input pin.
4	2	nRST	I (ST)	External reset input: active LOW, with an internal pull-up. Set this pin low reset chip to initial state.
5	3	P3.0	I/O	General purpose digital I/O pin.
		RXD <sup>[2]</sup>	I	Data receiver input pin for UART0.
		ACMP1_N	AI	Comparator1 negative input pin.
6	4	AV <sub>ss</sub>	AP	Ground pin for analog circuit.
7	5	P3.1	I/O	General purpose digital I/O pin.
		TXD <sup>[2]</sup>	O	Data transmitter output pin for UART0.
		ACMP1_P	AI	Comparator1 positive input pin
8	6	P3.2	I/O	General purpose digital I/O pin.
		nINT0	I	External interrupt0 input pin.
		STADC	I	ADC external trigger input.
		T0EX	I	Timer0 external capture/reset trigger input pin.
9	—	P3.3	I/O	General purpose digital I/O pin.
		nINT1	I	External interrupt1 input pin.
		MCLK	O	EBI external clock output pin.
		TIEX	I	Timer1 external capture/reset trigger input pin.
10	7	P3.4	I/O	General purpose digital I/O pin.

Pin No.		Pin Name	Pin Type	Description
LQFP/QFN 48-pin	QFN 33-pin			
		T0	I/O	Timer0 external event counter input pin
		SDA0	I/O	I <sup>2</sup> C0 data input/output pin.
11	8	P3.5	I/O	General purpose digital I/O pin.
		T1	I/O	Timer1 external event counter input pin.
		SCL0	I/O	I <sup>2</sup> C0 clock I/O pin.
		CKO <sup>[2]</sup>	O	Frequency divider output pin.
12	—	P4.3	I/O	General purpose digital I/O pin.
		PWM3 <sup>[2]</sup>	I/O	PWM3 output/Capture input.
13	9 —	P3.6	I/O	General purpose digital I/O pin.
		CKO <sup>[2]</sup>	O	Frequency divider output pin.
		ACMP0_O	O	Analog comparator0 output pin.
		nWR	O	EBI write enable output pin.
14	—	P3.7	I/O	General purpose digital I/O pin.
		nRD	O	EBI read enable output pin.
15	10	XTAL2	O	External 4~24 MHz (high speed) crystal output pin.
16	11	XTAL1	I (ST)	External 4~24 MHz (high speed) crystal input pin.
17	12	V <sub>ss</sub>	P	Ground pin for digital circuit.
	33			
18	13	LDO_CAP	P	LDO output pin.
19	—	P2.0	I/O	General purpose digital I/O pin.
		AD8	I/O	EBI Address/Data bus bit8
		PWM0 <sup>[2]</sup>	I/O	PWM0 output/Capture input.
20	—	P2.1	I/O	General purpose digital I/O pin.
		AD9	I/O	EBI Address/Data bus bit9
		PWM1 <sup>[2]</sup>	I/O	PWM1 output/Capture input.
21	14	P2.2	I/O	General purpose digital I/O pin.
		PWM2 <sup>[2]</sup>	I/O	PWM2 output/Capture input.
	—	AD10	I/O	EBI Address/Data bus bit10.
22	15	P2.3	I/O	General purpose digital I/O pin.
		PWM3 <sup>[2]</sup>	I/O	PWM3 output/Capture input.
	—	AD11	I/O	EBI Address/Data bus bit11.
23	16	P2.4	I/O	General purpose digital I/O pin.

Pin No.		Pin Name	Pin Type	Description
LQFP/QFN 48-pin	QFN 33-pin			
—	—	PWM4	I/O	PWM4 output/Capture input.
		SCL1 <sup>[2]</sup>	I/O	I <sup>2</sup> C1 clock I/O pin.
		AD12	I/O	EBI Address/Data bus bit12.
24	—	P4.0	I/O	General purpose digital I/O pin.
		PWM0 <sup>[2]</sup>	I/O	PWM0 output/Capture input.
		T2EX	I	Timer2 external capture/reset trigger input pin.
25	17	P2.5	I/O	General purpose digital I/O pin.
		PWM5	I/O	PWM5 output/Capture input.
		SDA1 <sup>[2]</sup>	i/O	I2C1 data input/output pin.
		AD13	I/O	EBI Address/Data bus bit13.
26	18	P2.6	I/O	General purpose digital I/O pin.
		PWM6	I/O	PWM6 output/Capture input.
		ACMP1_O	O	Analog comparator1 output pin.
		AD14	I/O	EBI Address/Data bus bit14.
27	—	P2.7	I/O	General purpose digital I/O pin.
		AD15	I/O	EBI Address/Data bus bit15.
		PWM7	I/O	PWM7 output/Capture input.
28	—	P4.4	I/O	General purpose digital I/O pin.
		nCS	O	EBI chip select enable output pin.
		SCL1 <sup>[2]</sup>	I/O	I <sup>2</sup> C1 clock I/O pin.
29	—	P4.5	I/O	General purpose digital I/O pin.
		ALE	O	EBI address latch enable output pin.
		SDA1 <sup>[2]</sup>	i/O	I2C1 data input/output pin.
30	19	P4.6	I/O	General purpose digital I/O pin.
		ICE_CLK	I	Serial Wired Debugger Clock pin.
31	20	P4.7	I/O	General purpose digital I/O pin.
		ICE_DAT	I/O	Serial Wired Debugger Data pin.
32	21	P0.7	I/O	General purpose digital I/O pin.
		SPICLK1	I/O	SPI1 serial clock pin.
		AD7	I/O	EBI Address/Data bus bit7.
33	22	P0.6	I/O	General purpose digital I/O pin.
		MISO_1	I/O	SPI1 MISO (Master In, Slave Out) pin.

Pin No.		Pin Name	Pin Type	Description
LQFP/QFN 48-pin	QFN 33-pin			
	—	AD6	I/O	EBI Address/Data bus bit6.
34	23	P0.5	I/O	General purpose digital I/O pin.
		MOSI_1	I/O	SPI1 MISO (Master Out, Slave In) pin.
	—	AD5	I/O	EBI Address/Data bus bit5.
35	24	P0.4	I/O	General purpose digital I/O pin.
		SPISS1	I/O	SPI1 slave select pin.
	—	AD4	I/O	EBI Address/Data bus bit4.
36	—	P4.1	I/O	General purpose digital I/O pin.
		PWM1 <sup>[2]</sup>	I/O	PWM1 output/Capture input.
		T3EX	I	Timer3 external capture/reset trigger input pin.
37	—	P0.3	I/O	General purpose digital I/O pin.
		AD3	I/O	EBI Address/Data bus bit3.
		RTS0	O	Request to Send output pin for UART0.
		RXD <sup>[2]</sup>	I	Data receiver input pin for UART0.
38	—	P0.2	I/O	General purpose digital I/O pin.
		AD2	I/O	EBI Address/Data bus bit2.
		CTS0	I	Clear to Send input pin for UART0.
		TXD <sup>[2]</sup>	O	Data transmitter output pin for UART0.
39	25	P0.1	I/O	General purpose digital I/O pin.
		RTS1	O	Request to Send output pin for UART1.
		RXD1 <sup>[2]</sup>	I	Data receiver input pin for UART1.
		ACMP3_N	AI	Comparator3 negative input pin.
		AD1	I/O	EBI Address/Data bus bit1.
40	26	P0.0	I/O	General purpose digital I/O pin.
		CTS1	I	Clear to Send input pin for UART1.
		TXD1 <sup>[2]</sup>	O	Data transmitter output pin for UART1.
		ACMP3_P	AI	Comparator3 positive input pin.
		AD0	I/O	EBI Address/Data bus bit0.
41	27	V <sub>DD</sub>	P	Power supply for I/O ports and LDO source for internal PLL and digital circuit.
42	28	AV <sub>DD</sub>	AP	Power supply for internal analog circuit.
43	29	P1.0	I/O	General purpose digital I/O pin.

Pin No.		Pin Name	Pin Type	Description
LQFP/QFN 48-pin	QFN 33-pin			
		AIN0	AI	ADC0 analog input.
		T2	I/O	Timer2 external event counter input pin.
		—	O	EBI low byte write enable output pin.
44		—	P1.1	General purpose digital I/O pin.
			AIN1	ADC1 analog input.
			T3	Timer3 external event counter input pin.
			nWRH	EBI high byte write enable output pin.
45	30	P1.2	I/O	General purpose digital I/O pin.
		AIN2	AI	ADC2 analog input.
		RXD1 <sup>[2]</sup>	I	Data receiver input pin for UART1.
46	31	P1.3	I/O	General purpose digital I/O pin.
		AIN3	AI	ADC3 analog input.
		TXD1 <sup>[2]</sup>	O	Data transmitter output pin for UART1.
47	32	P1.4	I/O	General purpose digital I/O pin.
		AIN4	AI	ADC4 analog input.
		ACMP0_N	AI	Comparator0 negative input pin.
		—	SPISS0	SPI0 slave select pin.
48	—	P4.2	I/O	General purpose digital I/O pin.
		PWM2 <sup>[2]</sup>	I/O	PWM2 output/Capture input.

**Note1:** Pin Type I = Digital Input, O = Digital Output; AI = Analog Input; P = Power Pin; AP = Analog Power; ST = Schmitt trigger

**Note2:** The PWM0 ~ PWM3, RXD, TXD, RxD1, TxD1, SCL1, SDA1 and CKO can be assigned to different pins. However, a pin function can only be assigned to a pin at the same time, i.e. software cannot assign RXD to P0.3 and P3.0 at the same time.

Pin No.	Pin Name	Pin Type	Description
TSSOP 20-pin			
1	P1.2	I/O	General purpose digital I/O pin.
	AIN2	AI	ADC2 analog input.
	RXD	I	Data receiver input pin for UART0.
	ACMP0_P	AI	Comparator0 positive input pin.
2	P1.3	I/O	General purpose digital I/O pin.
	AIN3	AI	ADC3 analog input.
	TXD	O	Data transmitter output pin for UART0.
	ACMP0_P	AI	Comparator0 positive input pin.
3	P1.4	I/O	General purpose digital I/O pin.
	AIN4	AI	ADC4 analog input.
	ACMP0_N	AI	Comparator0 negative input pin.
4	P1.5	I/O	General purpose digital I/O pin.
	AIN5	AI	ADC5 analog input.
	ACMP0_P	AI	Comparator0 positive input pin.
	AV <sub>ss</sub>	AP	Ground pin for analog circuit.
5	nRST	I (ST)	External reset input: active LOW, with an internal pull-up. Set this pin low reset chip to initial state.
6	P3.2	I/O	General purpose digital I/O pin.
	nINT0	I	External interrupt0 input pin.
	STADC	I	ADC external trigger input.
	T0EX	I	Timer0 external capture/reset trigger input pin.
	ACMP1_P	AI	Comparator1 positive input pin
7	P3.4	I/O	General purpose digital I/O pin.
	T0	I/O	Timer0 external event counter input pin
	SDA0	i/O	I <sup>2</sup> C0 data input/output pin.
	ACMP1_P	AI	Comparator1 positive input pin
8	P3.5	I/O	General purpose digital I/O pin.
	T1	I/O	Timer1 external event counter input pin.
	SCL0	I/O	I <sup>2</sup> C0 clock I/O pin.
	ACMP1_P	AI	Comparator1 positive input pin
9	P5.1	I/O	General purpose digital I/O pin.
	XTAL2	O	External 4~24 MHz (high speed) crystal output pin.
10	P5.0	I/O	General purpose digital I/O pin.

Pin No.	Pin Name	Pin Type	Description
	XTAL1	I (ST)	External 4~24 MHz (high speed) crystal input pin.
11	V <sub>SS</sub>	P	Ground pin for digital circuit.
12	P2.4	I/O	General purpose digital I/O pin.
	PWM2	I/O	PWM0 output.
13	P2.5	I/O	General purpose digital I/O pin.
	PWM3	I/O	PWM3 output.
14	P4.6	I/O	General purpose digital I/O pin.
	ICE_CLK	I	Serial Wired Debugger Clock pin.
15	P4.7	I/O	General purpose digital I/O pin.
	ICE_DAT	I/O	Serial Wired Debugger Data pin.
16	P0.7	I/O	General purpose digital I/O pin.
	SPICLK0	I/O	SPI0 serial clock pin.
17	P0.6	I/O	General purpose digital I/O pin.
	MISO_0	I/O	SPI0 MISO (Master In, Slave Out) pin.
18	P0.5	I/O	General purpose digital I/O pin.
	MOSI_0	I/O	SPI0 MISO (Master Out, Slave In) pin.
19	P0.4	I/O	General purpose digital I/O pin.
	SPISS0	I/O	SPI1 slave select pin.
	PWM5	I/O	PWM5 output.
20	V <sub>DD</sub>	P	Power supply for I/O ports and LDO source for internal PLL and digital circuit.

**Note1:** Pin Type I = Digital Input, O = Digital Output; AI = Analog Input; P = Power Pin; AP = Analog Power; ST = Schmitt trigger

## 5 FUNCTIONAL DESCRIPTION

### 5.1 ARM® Cortex®-M0 Core

The Cortex®-M0 processor is a configurable, multistage, 32-bit RISC processor, which has an AMBA AHB-Lite interface and includes an NVIC component. It also has optional hardware debug functionality. The processor can execute Thumb code and is compatible with other Cortex®-M profile processor. The profile supports two modes -Thread mode and Handler mode. Handler mode is entered as a result of an exception. An exception return can only be issued in Handler mode. Thread mode is entered on Reset, and can be entered as a result of an exception return. Figure 5-1 shows the functional controller of processor.

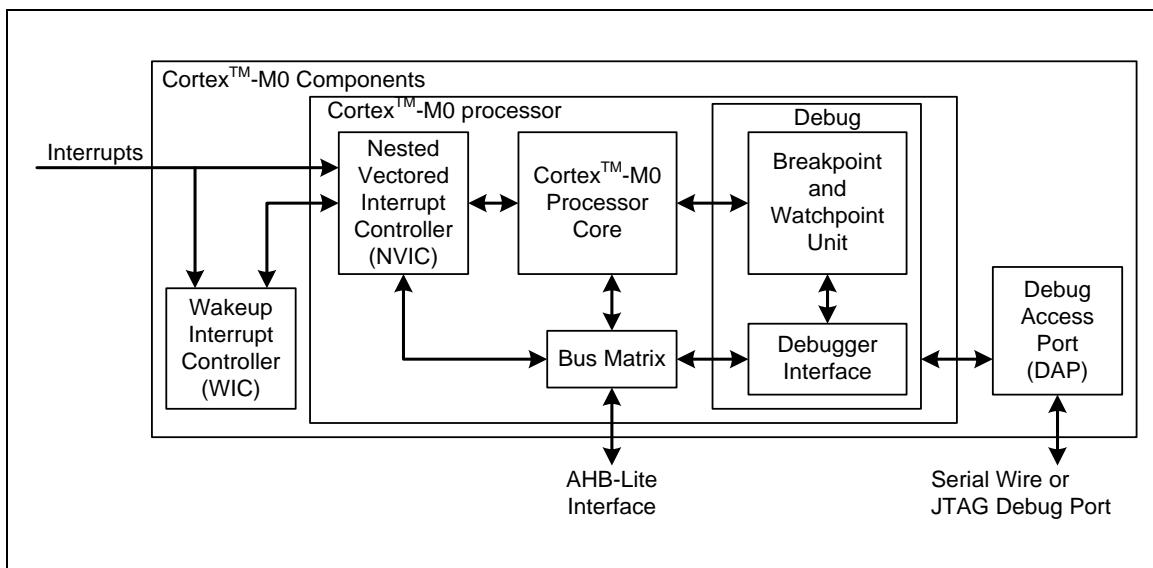


Figure 5-1 Functional Controller Diagram

The implemented device provides the following components and features:

- A low gate count processor:
  - ARMv6-M Thumb® instruction set
  - Thumb-2 technology
  - ARMv6-M compliant 24-bit SysTick timer
  - A 32-bit hardware multiplier
  - System interface supported with little-endian data accesses
  - Ability to have deterministic, fixed-latency, interrupt handling
  - Load/store-multiples and multicycle-multiplies that can be abandoned and restarted to facilitate rapid interrupt handling
  - C Application Binary Interface compliant exception model. This is the ARMv6-M, C Application Binary Interface (C-ABI) compliant exception model that enables the use of pure C functions as interrupt handlers
  - Low Power Sleep mode entry using Wait For Interrupt (WFI), Wait For Event (WFE) instructions, or the return from interrupt sleep-on-exit feature
- NVIC:

- 32 external interrupt inputs, each with four levels of priority
- Dedicated Non-maskable Interrupt (NMI) input
- Supports for both level-sensitive and pulse-sensitive interrupt lines
- Supports Wake-up Interrupt Controller (WIC) and, providing Ultra-low Power Sleep mode
- Debug support
  - Four hardware breakpoints
  - Two watchpoints
  - Program Counter Sampling Register (PCSR) for non-intrusive code profiling
  - Single step and vector catch capabilities
- Bus interfaces:
  - Single 32-bit AMBA-3 AHB-Lite system interface that provides simple integration to all system peripherals and memory
  - Single 32-bit slave port that supports the DAP (Debug Access Port)

## 5.2 System Manager

### 5.2.1 Overview

System management includes the following sections:

- System Resets
- System Power Architecture
- System Memory Map
- System management registers for Part Number ID, chip reset and on-chip controllers reset , multi-functional pin control
- System Timer (SysTick)
- Nested Vectored Interrupt Controller (NVIC)
- System Control registers

### 5.2.2 System Reset

The system reset can be issued by one of the following listed events. For these reset event flags can be read by RSTSRC register.

- Hardware Reset
  - Power-on Reset (POR)
  - Low level on the RESET pin (nRST)
  - Watchdog Time-out Reset (WDT)
  - Low Voltage Reset (LVR)
  - Brown-out Detector Reset (BOD)
- Software Reset
  - MCU Reset - SYSRESETREQ(AIRCR[2])
  - Cortex<sup>®</sup>-M0 Core One-shot Reset - CPU\_RST(IPRSTC1[1])
  - Chip One-shot Reset - Chip\_RST(IPRSTC1[0])

**Note:** ISPCON.BS keeps the original value after MCUReset and CPU Reset.

### 5.2.3 System Power Distribution

In this chip, the power distribution is divided into three segments.

- Analog power from  $AV_{DD}$  and  $AV_{SS}$  provides the power for analog components operation.  $AV_{DD}$  must be equal to  $V_{DD}$  to avoid leakage current.
- Digital power from  $V_{DD}$  and  $V_{SS}$  supplies the power to the I/O pins and internal regulator which provides a fixed 1.8 V power for digital operation.
- Build-in a capacitor for internal voltage regulator. (NUC029FAE only)

The output of internal voltage regulator, LDO\_CAP, requires an external capacitor which should be located close to the corresponding pin. Analog power ( $AV_{DD}$ ) should be the same voltage level with the digital power ( $V_{DD}$ ). Figure 5-2 shows the NuMicro® NUC029xAN power distribution and Figure 5-3 shows the NuMicro® NUC029FAE power distribution.

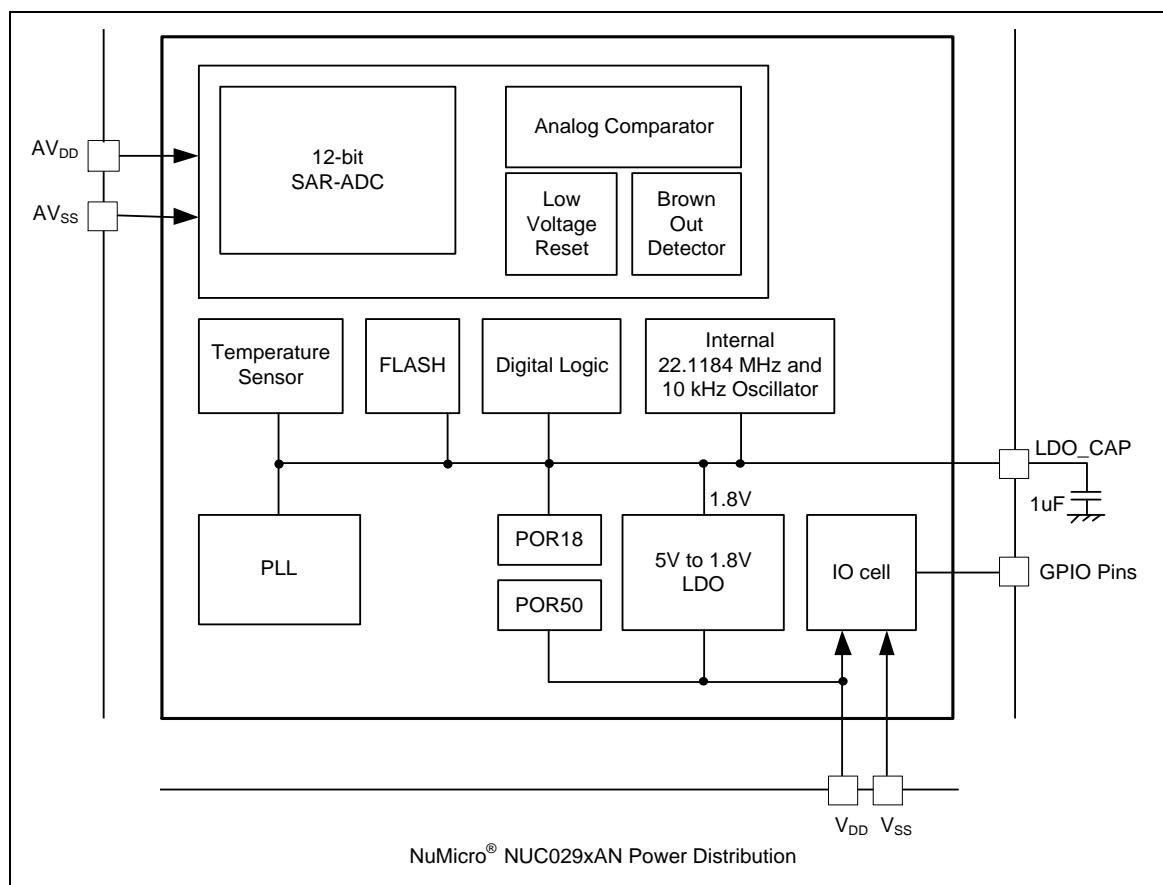


Figure 5-2 NuMicro® NUC029xAN Power Distribution Diagram

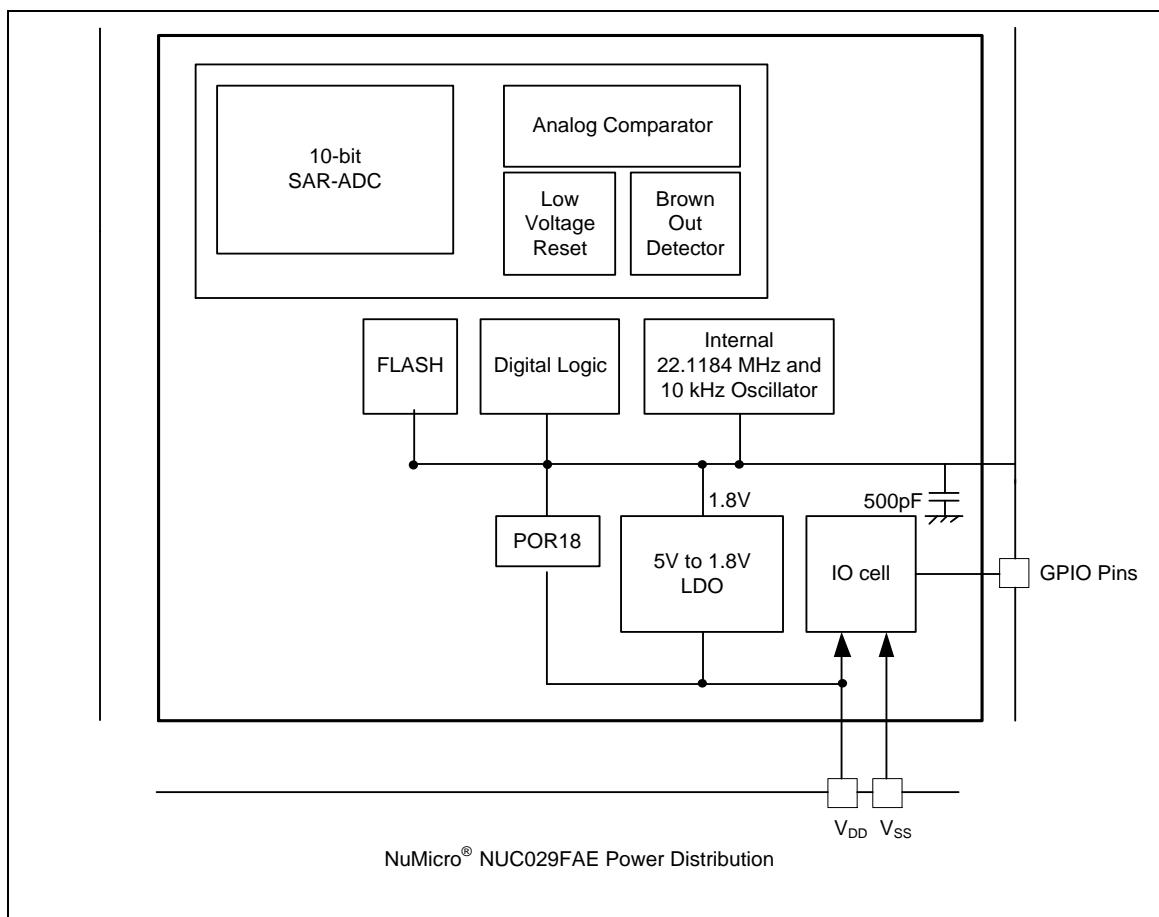


Figure 5-3 NuMicro® NUC029FAE Power Distribution Diagram

#### 5.2.4 System Memory Map

The NuMicro® NUC029 series provides 4G-byte addressing space. The memory locations assigned to each on-chip controllers are shown in the following table. The detailed register definition, addressing space, and programming detailed will be described in the following sections for each on-chip peripheral. The NuMicro® NUC029 series only supports little-endian data format.

Address Space	Token	Controllers
<b>Flash and SRAM Memory Space</b>		
0x0000_0000 – 0x0000_FFFF	FLASH_BA	FLASH Memory Space (64 KB)
0x2000_0000 – 0x2000_0FFF	SRAM_BA	SRAM Memory Space (4 KB)
<b>EBI Space (0x6000_0000 ~ 0x6001_FFFF) (NUC029LAN/NUC029NAN Only)</b>		
0x6000_0000 – 0x6001_FFFF	EBI_BA	External Memory Space (128 KB )
<b>AHB Controllers Space (0x5000_0000 ~ 0x501F_FFFF)</b>		
0x5000_0000 – 0x5000_01FF	GCR_BA	System Global Control Registers

0x5000_0200 – 0x5000_02FF	CLK_BA	Clock Control Registers
0x5000_0300 – 0x5000_03FF	INT_BA	Interrupt Multiplexer Control Registers
0x5000_4000 – 0x5000_7FFF	GPIO_BA	GPIO (P0 ~ P4) Control Registers
0x5000_C000 – 0x5000_FFFF	FMC_BA	Flash Memory Control Registers
0x5001_0000 – 0x5001_03FF	EBI_CTL_BA	EBI Control Registers (NUC029LAN/NUC029NAN only)
0x5001_4000 – 0x5001_7FFF	HDIV_BA	Hardware Divider Register (NUC029xAN only)
<b>APB Controllers Space (0x4000_0000 ~ 0x400F_FFFF)</b>		
0x4000_4000 – 0x4000_40FF	WDT_BA	Watchdog Timer Control Registers
0x4000_4100 – 0x4000_7FFF	WWDT_BA	Window Watchdog Timer Control Registers (NUC029xAN only)
0x4001_0000 – 0x4001_3FFF	TMR01_BA	Timer0/Timer1 Control Registers
0x4002_0000 – 0x4002_3FFF	I2C0_BA	I <sup>2</sup> C0 Interface Control Registers
0x4003_0000 – 0x4003_3FFF	SPI0_BA	SPI0 with master/slave function Control Registers
0x4003_4000 – 0x4003_7FFF	SPI1_BA	SPI1 with master/slave function Control Registers
0x4004_0000 – 0x4004_3FFF	PWMA_BA	PWM0/1/2/3 Control Registers
0x4005_0000 – 0x4005_3FFF	UART0_BA	UART0 Control Registers
0x400D_0000 – 0x400D_3FFF	ACMP01_BA	Analog Comparator0/ Analog Comparator1 Control Registers
0x400E_0000 – 0x400E_FFFF	ADC_BA	Analog-Digital-Converter (ADC) Control Registers
0x4011_0000 – 0x4011_3FFF	TMR23_BA	Timer2/Timer3 Control Registers
0x4012_0000 – 0x4012_3FFF	I2C1_BA	I <sup>2</sup> C1 Interface Control Registers (Nuc029xAN only)
0x4014_0000 – 0x4014_3FFF	PWMB_BA	PWM4/5/6/7 Control Registers
0x4015_0000 – 0x4015_3FFF	UART1_BA	UART1 Control Registers
0x401D_0000 – 0x401D_3FFF	ACMP23_BA	Analog Comparator2/ Analog Comparator3 Control Registers
<b>System Controllers Space (0xE000_E000 ~ 0xE000_EFFF)</b>		
0xE000_E010 – 0xE000_E0FF	SYST_BA	System Timer Control Registers
0xE000_E100 – 0xE000_ECFF	NVIC_BA	External Interrupt Controller Control Registers
0xE000_ED00 – 0xE000_ED8F	SCB_BA	System Control Registers

Table 5-1 NuMicro® NUC029xAN Address Space Assignments for On-Chip Controllers

Address Space	Token	Controllers
<b>Flash and SRAM Memory Space</b>		
0x0000_0000 – 0x0000_3FFF	FLASH_BA	FLASH Memory Space (16 KB)
0x2000_0000 – 0x2000_0FFF	SRAM_BA	SRAM Memory Space (2 KB)
<b>AHB Controllers Space (0x5000_0000 ~ 0x501F_FFFF)</b>		
0x5000_0000 – 0x5000_01FF	GCR_BA	System Global Control Registers
0x5000_0200 – 0x5000_02FF	CLK_BA	Clock Control Registers

0x5000_0300 – 0x5000_03FF	INT_BA	Interrupt Multiplexer Control Registers
0x5000_4000 – 0x5000_7FFF	GP_BA	GPIO (P0 ~ P5) Control Registers
0x5000_C000 – 0x5000_FFFF	FMC_BA	Flash Memory Control Registers
<b>APB Controllers Space (0x4000_0000 ~ 0x401F_FFFF)</b>		
0x4000_4000 – 0x4000_7FFF	WDT_BA	Watchdog Timer Control Registers
0x4001_0000 – 0x4001_3FFF	TMR_BA	Timer0/Timer1 Control Registers
0x4002_0000 – 0x4002_3FFF	I2C_BA	I <sup>2</sup> C Interface Control Registers
0x4003_0000 – 0x4003_3FFF	SPI_BA	SPI with master/slave function Control Registers
0x4004_0000 – 0x4004_3FFF	PWMA_BA	PWM Control Registers
0x4005_0000 – 0x4005_3FFF	UART_BA	UART Control Registers
0x400D_0000 – 0x400D_3FFF	ACMP_BA	Analog Comparator Control Registers
0x400E_0000 – 0x400E_3FFF	ADC_BA	Analog-Digital-Converter (ADC) Control Registers
<b>System Controllers Space (0xE000_E000 ~ 0xE000_EFFF)</b>		
0xE000_E010 – 0xE000_E0FF	SCS_BA	System Timer Control Registers
0xE000_E100 – 0xE000_ECFF	SCS_BA	External Interrupt Controller Control Registers
0xE000_ED00 – 0xE000_ED8F	SCB_BA	System Control Registers

Table 5-2 NuMicro® NUC029FAE Address Space Assignments for On-Chip Controllers

### 5.2.5 Whole System Memory Mapping

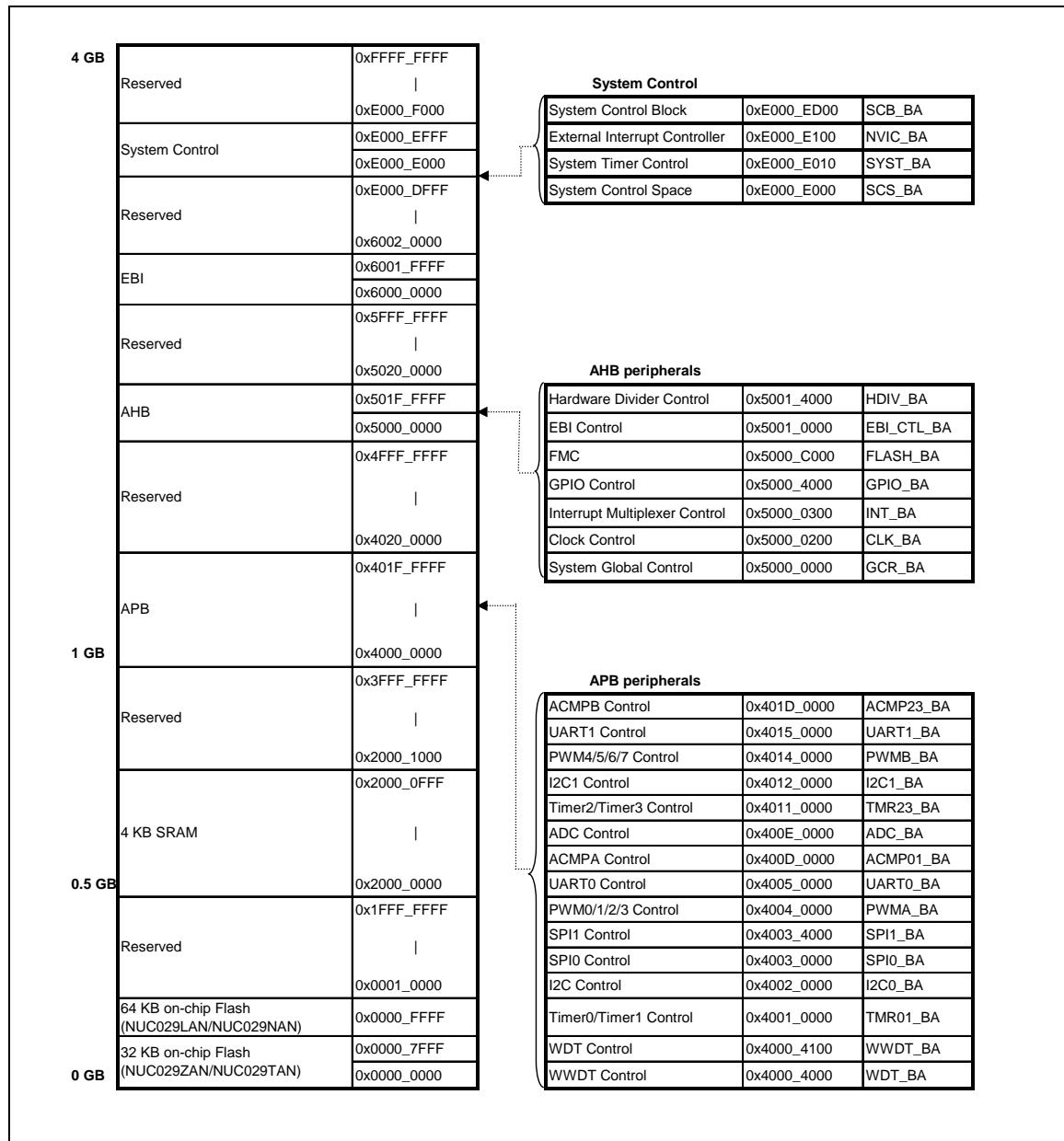


Figure 5-4 NuMicro® NUC029xAN Whole System Memory Mapping

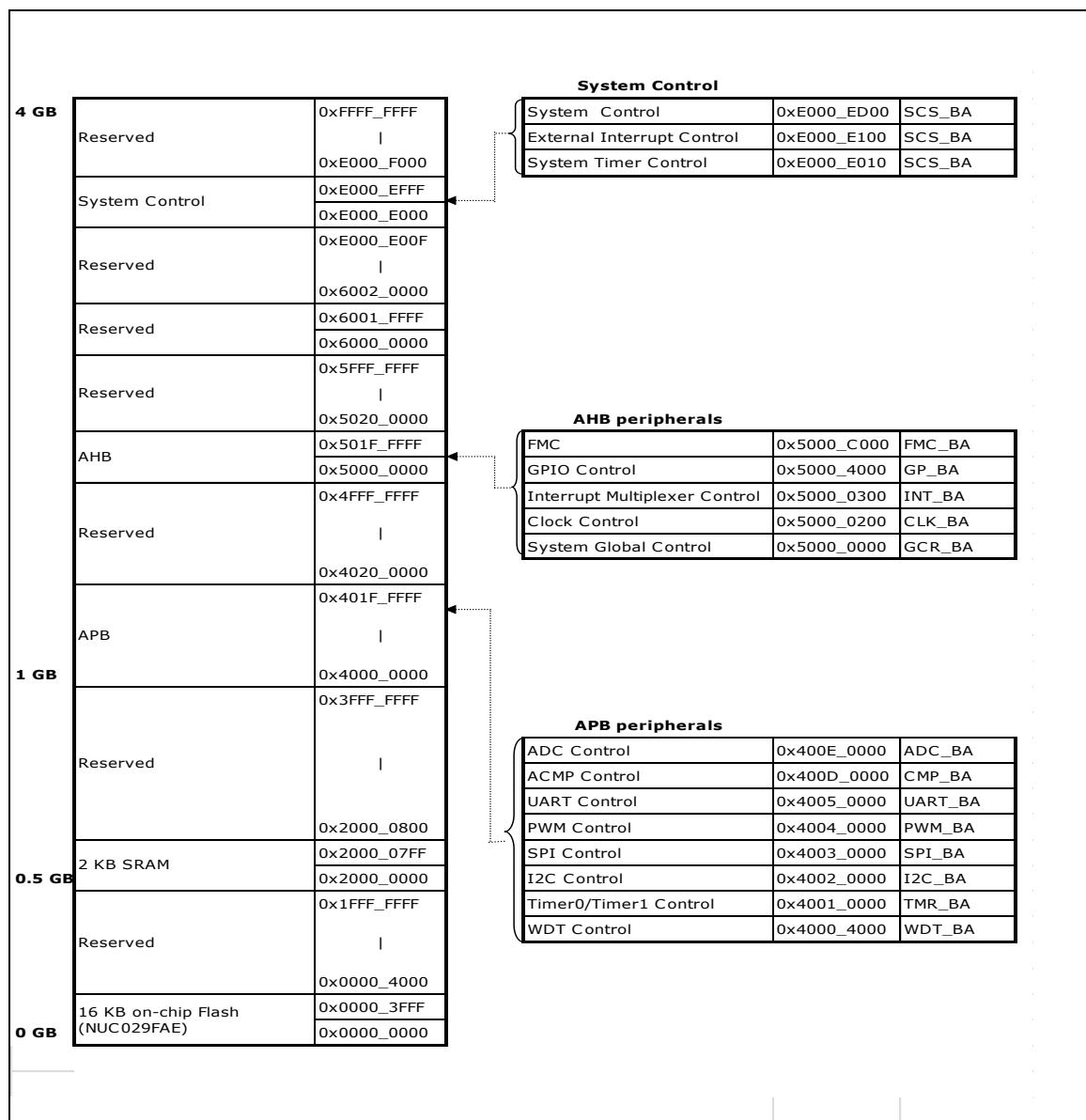


Figure 5-5 NuMicro® NUC029FAE Whole System Memory Mapping

### 5.2.6 System Manager Controller Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>GCR Base Address:</b>				
<b>GCR_BA = 0x5000_0000</b>				
<b>PDID</b>	GCR_BA+0x00	R	Part Device Identification Number Register	0xFFFF_FFFF
<b>RSTSRC</b>	GCR_BA+0x04	R/W	System Reset Source Register	0x0000_00XX
<b>IPRSTC1</b>	GCR_BA+0x08	R/W	Peripheral Reset Control Register 1	0x0000_0000
<b>IPRSTC2</b>	GCR_BA+0x0C	R/W	Peripheral Reset Control Register 2	0x0000_0000
<b>BODCR</b>	GCR_BA+0x18	R/W	Brown-out Detector Control Register	0x0000_008X
<b>TEMPCR</b>	GCR_BA+0x1C	R/W	Temperature Sensor Control Register	0x0000_0000
<b>PORCR</b>	GCR_BA+0x24	R/W	Power-on Reset Controller Register	0x0000_00XX
<b>P0_MFP</b>	GCR_BA+0x30	R/W	P0 Multiple Function and Input Type Control Register	0x0000_0000
<b>P1_MFP</b>	GCR_BA+0x34	R/W	P1 Multiple Function and Input Type Control Register	0x0000_0000
<b>P2_MFP</b>	GCR_BA+0x38	R/W	P2 Multiple Function and Input Type Control Register	0x0000_0000
<b>P3_MFP</b>	GCR_BA+0x3C	R/W	P3 Multiple Function and Input Type Control Register	0x0000_0000
<b>P4_MFP</b>	GCR_BA+0x40	R/W	P4 Multiple Function and Input Type Control Register	0x0000_00C0
<b>REGWRPROT</b>	GCR_BA+0x100	R/W	Register Write-Protection Control Register	0x0000_0000

**Part Device ID Code Register (PDID)**

Register	Offset	R/W	Description				Reset Value
PDID	GCR_BA+0x00	R	Part Device Identification Number Register				0xFFFF_FFFF <sup>[1]</sup>

[1] Every part number has a unique default reset value.

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

Bits	Description	
[31:0]	PDID	<b>Part Device Identification Number</b> This register reflects the device part number code. Software can read this register to identify which device is used.

NuMicro® NUC029xAN	Part Device Identification Number
NUC029LAN	0x0029_5A00
NUC029NAN	0x0029_5A06
NUC029ZAN	0x0029_5A03
NUC029TAN	0x0029_5804

### System Reset Source Register (RSTSRC)

This register provides specific information for software to identify this chip's reset source from the last operation.

Register	Offset	R/W	Description				Reset Value
RSTSRC	GCR_BA+0x04	R/W	System Reset Source Register				0x0000_00XX

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
RSTS_CPU	Reserved	RSTS MCU	RSTS_BOD	RSTS_LVR	RSTS_WDT	RSTS_RESET	RSTS_POR

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	RSTS_CPU	<b>CPU Reset Flag</b> The RSTS_CPU flag is set by hardware if software writes CPU_RST (IPRSTC1[1]) 1 to reset Cortex®-M0 core and Flash memory controller (FMC). 0 = No reset from CPU. 1 = Cortex®-M0 core and FMC are reset by software setting CPU_RST to 1. <b>Note:</b> Write 1 to clear this bit to 0.
[6]	Reserved	Reserved.
[5]	RSTS MCU	<b>MCU Reset Flag</b> The RSTS MCU flag is set by the “reset signal” from the Cortex®-M0 core to indicate the previous reset source. 0 = No reset from Cortex®-M0. 1 = The Cortex®-M0 had issued the reset signal to reset the system by writing 1 to bit SYSRESETREQ (AIRCR[2], Application Interrupt and Reset Control Register, address = 0xE000ED0C) in system control registers of Cortex®-M0 core. <b>Note:</b> Write 1 to clear this bit to 0.
[4]	RSTS_BOD	<b>Brown-out Detector Reset Flag</b> The RSTS_BOD flag is set by the “reset signal” from the Brown-out Detector to indicate the previous reset source. 0 = No reset from BOD. 1 = The BOD had issued the reset signal to reset the system. <b>Note:</b> Write 1 to clear this bit to 0.
[3]	RSTS_LVR	<b>Low Voltage Reset Flag</b> The RSTS_LVR flag is set by the “reset signal” from the Low-Voltage-Reset controller to indicate the previous reset source.

		0 = No reset from LVR. 1 = The LVR controller had issued the reset signal to reset the system. <b>Note:</b> Write 1 to clear this bit to 0.
[2]	RSTS_WDT	<b>Watchdog Reset Flag</b> The RSTS_WDT flag is set by the “reset signal” from the watchdog timer to indicate the previous reset source. 0 = No reset from watchdog timer. 1 = The watchdog timer had issued the reset signal to reset the system. <b>Note:</b> Write 1 to clear this bit to 0.
[1]	RSTS_RESET	<b>Reset Pin Reset Flag</b> The RSTS_RESET flag is set by the “reset signal” from the nRST pin to indicate the previous reset source. 0 = No reset from the nRST pin. 1 = The nRST pin had issued the reset signal to reset the system. <b>Note:</b> Write 1 to clear this bit to 0.
[0]	RSTS_POR	<b>Power-on Reset Flag</b> The RSTS_POR flag is set by the “reset signal” from the Power-on Reset (POR) controller or bit CHIP_RST (IPRSTC1[0]) to indicate the previous reset source. 0 = No reset from POR or CHIP_RST. 1 = The Power-on Reset (POR) or CHIP_RST had issued the reset signal to reset the system. <b>Note:</b> Write 1 to clear this bit to 0.

### Peripheral Reset Control Register1 (IPRSTC1)

Register	Offset	R/W	Description					Reset Value
IPRSTC1	GCR_BA+0x08	R/W	Peripheral Reset Control Register 1					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			HDIV_RST	EBI_RST	Reserved	CPU_RST	CHIP_RST

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	HDIV_RST	<p><b>HDIV Controller Reset (Write Protect)</b>  Set this bit to 1 will generate a reset signal to the hardware divider. User need to set this bit to 0 to release from the reset state.  0 = Hardware divider controller normal operation.  1 = Hardware divider controller reset.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>
[3]	EBI_RST	<p><b>EBI Controller Reset (Write Protect)</b>  Set this bit to 1 will generate a reset signal to the EBI. User needs to set this bit to 0 to release from the reset state.  0 = EBI controller normal operation.  1 = EBI controller reset.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>
[2]	Reserved	Reserved.
[1]	CPU_RST	<p><b>Cortex-m0 Core One-shot Reset (Write Protect)</b>  Setting this bit will only reset the Cortex-M0 core and Flash Memory Controller (FMC), and this bit will automatically return 0 after the two clock cycles.  0 = Cortex-M0 core normal operation.  1 = Cortex-M0 core one-shot reset.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>
[0]	CHIP_RST	<p><b>Chip One-shot Reset (Write Protect)</b>  Setting this bit will reset the whole chip, including Cortex®-M0 core and all peripherals, and this bit will automatically return to 0 after the 2 clock cycles.</p> <p>The CHIP_RST is the same as the POR reset. All the chip controllers are reset and the chip</p>

		<p>setting from CONFIG0 are also reload.</p> <p>0 = Chip normal operation.</p> <p>1 = Chip one-shot reset.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>
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### Peripheral Reset Control Register2 (IPRSTC2)

Setting these bits “1” will generate asynchronous reset signal to the corresponding module. User needs to set these bits to “0” to release the module from the reset state.

Register	Offset	R/W	Description				Reset Value
IPRSTC2	GCR_BA+0x0C	R/W	Peripheral Reset Control Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved			ADC_RST	Reserved			
23	22	21	20	19	18	17	16
ACMP23_RST	ACMP01_RST	PWM47_RST	PWM03_RST	Reserved		UART1_RST	UART0_RST
15	14	13	12	11	10	9	8
Reserved		SPI1_RST	SPI0_RST	Reserved		I2C1_RST	I2C0_RST
7	6	5	4	3	2	1	0
Reserved		TMR3_RST	TMR2_RST	TMR1_RST	TMR0_RST	GPIO_RST	Reserved

Bits	Description	
[31:29]	Reserved	Reserved.
[28]	ADC_RST	<b>ADC Controller Reset</b> 0 = ADC controller normal operation. 1 = ADC controller reset.
[27:24]	Reserved	Reserved.
[23]	ACMP23_RST	<b>Analog Comparator B Controller Reset</b> 0 = Analog Comparator B controller normal operation. 1 = Analog Comparator B controller reset.
[22]	ACMP01_RST	<b>Analog Comparator A Controller Reset</b> 0 = Analog Comparator A controller normal operation. 1 = Analog Comparator A controller reset.
[21]	PWM47_RST	<b>PWM47 Controller Reset</b> 0 = PWM47 controller normal operation. 1 = PWM47 controller reset.
[20]	PWM03_RST	<b>PWM03 Controller Reset</b> 0 = PWM03 controller normal operation. 1 = PWM03 controller reset.
[19:18]	Reserved	Reserved.
[17]	UART1_RST	<b>UART1 Controller Reset</b> 0 = UART1 controller normal operation. 1 = UART1 controller reset.

[16]	<b>UART0_RST</b>	<b>UART0 Controller Reset</b> 0 = UART0 controller normal operation. 1 = UART0 controller reset.
[15:14]	<b>Reserved</b>	Reserved.
[13]	<b>SPI1_RST</b>	<b>SPI1 Controller Reset</b> 0 = SPI1 controller normal operation. 1 = SPI1 controller reset.
[12]	<b>SPI0_RST</b>	<b>SPI0 Controller Reset</b> 0 = SPI0 controller normal operation. 1 = SPI0 controller reset.
[11:10]	<b>Reserved</b>	Reserved.
[9]	<b>I2C1_RST</b>	<b>I<sup>2</sup>C1 Controller Reset</b> 0= I <sup>2</sup> C1 controller normal operation. 1= I <sup>2</sup> C1 controller reset.
[8]	<b>I2C0_RST</b>	<b>I<sup>2</sup>C Controller Reset</b> 0= I <sup>2</sup> C0 controller normal operation. 1= I <sup>2</sup> C0 controller reset.
[7:6]	<b>Reserved</b>	Reserved.
[5]	<b>TMR3_RST</b>	<b>Timer3 Controller Reset</b> 0 = Timer3 controller normal operation. 1 = Timer3 controller reset.
[4]	<b>TMR2_RST</b>	<b>Timer2 Controller Reset</b> 0 = Timer2 controller normal operation. 1 = Timer2 controller reset.
[3]	<b>TMR1_RST</b>	<b>Timer1 Controller Reset</b> 0 = Timer1 controller normal operation. 1 = Timer1 controller reset.
[2]	<b>TMR0_RST</b>	<b>Timer0 Controller Reset</b> 0 = Timer0 controller normal operation. 1 = Timer0 controller reset.
[1]	<b>GPIO_RST</b>	<b>GPIO (P0~P4) Controller Reset</b> 0 = GPIO controller normal operation. 1 = GPIO controller reset.
[0]	<b>Reserved</b>	Reserved.

### Brown-out Detector Control Register (BODCR)

Partial values of the BODCR control registers are initiated by the flash configuration and partial bits are write-protected. Programming the write-protected bits needs to write “59h”, “16h”, and “88h” to address 0x5000\_0100 to disable register protection. Refer to the REGWRPROT register at address GCR\_BA+0x100.

Register	Offset	R/W	Description				Reset Value
BODCR	GCR_BA+0x18	R/W	Brown-out Detector Control Register				0x0000_008X

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
LVR_EN	BOD_OUT	BOD_LPM	BOD_INTF	BOD_RSTEN	BOD_VL		BOD_EN

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	LVR_EN	<b>Low Voltage Reset Enable Control (Write Protect)</b> The LVR function reset the chip when the input power voltage is lower than LVR circuit setting. LVR function is enabled by default. 0 = Low Voltage Reset function Disabled. 1 = Low Voltage Reset function Enabled – After enabling the bit, the LVR function will be active with 100us delay for LVR output stable (default). <b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.
[6]	BOD_OUT	<b>Brown-out Detector Output Status</b> 0 = Brown-out Detector output status is 0, which means the detected voltage is higher than BOD_VL setting or BOD_EN is 0. 1 = Brown-out Detector output status is 1, which means the detected voltage is lower than BOD_VL setting. If the BOD_EN is 0, BOD function disabled, this bit always responds to 0.
[5]	BOD_LPM	<b>Brown-out Detector Low Power Mode (Write Protect)</b> 0 = BOD operated in Normal mode (default). 1 = BOD Low Power mode Enabled. <b>Note1:</b> The BOD consumes about 100 uA in Normal mode, and the low power mode can reduce the current to about 1/10 but slow the BOD response. <b>Note2:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.
[4]	BOD_INTF	<b>Brown-out Detector Interrupt Flag</b> 0 = Brown-out Detector does not detect any voltage draft at V <sub>DD</sub> down through or up through

		<p>the voltage of BOD_VL setting.</p> <p>1 = When Brown-out Detector detects the V<sub>DD</sub> is dropped down through the voltage of BOD_VL setting or the V<sub>DD</sub> is raised up through the voltage of BOD_VL setting, this bit is set to 1 and the Brown-out interrupt is requested if Brown-out interrupt is enabled.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>															
[3]	<b>BOD_RSTEN</b>	<p><b>Brown-out Reset Enable Control (Write Protect)</b></p> <p>0 = Brown-out "INTERRUPT" function Enabled.</p> <p>While the BOD function is enabled (BOD_EN high) and BOD interrupt function is enabled (BOD_RSTEN low), BOD will assert an interrupt if BOD_OUT is high. BOD interrupt will keep till to the BOD_EN set to 0. BOD interrupt can be blocked by disabling the NVIC BOD interrupt or disabling BOD function (set BOD_EN low).</p> <p>1 = Brown-out "RESET" function Enabled.</p> <p><b>Note1:</b> While the Brown-out Detector function is enabled (BOD_EN high) and BOD reset function is enabled (BOD_RSTEN high), BOD will assert a signal to reset chip when the detected voltage is lower than the threshold (BOD_OUT high).</p> <p><b>Note2:</b> The default value is set by flash controller user configuration register config0 bit[20].</p> <p><b>Note3:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>															
[2:1]	<b>BOD_VL</b>	<p><b>Brown-out Detector Threshold Voltage Select (Write Protect)</b></p> <p>The default value is set by flash controller user configuration register config0 bit[22:21]</p> <table border="1"> <thead> <tr> <th>BOV_VL[1]</th> <th>BOV_VL[0]</th> <th>Brown-out voltage</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>4.4V</td> </tr> <tr> <td>1</td> <td>0</td> <td>3.7V</td> </tr> <tr> <td>0</td> <td>1</td> <td>2.7V</td> </tr> <tr> <td>0</td> <td>0</td> <td>2.2V</td> </tr> </tbody> </table> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>	BOV_VL[1]	BOV_VL[0]	Brown-out voltage	1	1	4.4V	1	0	3.7V	0	1	2.7V	0	0	2.2V
BOV_VL[1]	BOV_VL[0]	Brown-out voltage															
1	1	4.4V															
1	0	3.7V															
0	1	2.7V															
0	0	2.2V															
[0]	<b>BOD_EN</b>	<p><b>Brown-out Detector Enable Control (Write Protect)</b></p> <p>The default value is set by flash controller user configuration register config0 bit[23]</p> <p>0 = Brown-out Detector function Disabled.</p> <p>1 = Brown-out Detector function Enabled.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>															

**Temperature Sensor Control Register (TEMPCR)**

Register	Offset	R/W	Description					Reset Value
TEMPCR	GCR_BA+0x1C	R/W	Temperature Sensor Control Register					0x0000_0000

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

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	VTEMP_EN	<p><b>Temperature Sensor Enable Control</b></p> <p>This bit is used to enable/disable temperature sensor function. 0 = Temperature sensor function Disabled (default). 1 = Temperature sensor function Enabled.</p> <p><b>Note:</b> After this bit is set to 1, the value of temperature sensor output can be obtained from the ADC conversion result. Please refer to the ADC chapter for detailed ADC conversion functional description.</p>

**Power-on Reset Control Register (PORCR)**

Register	Offset	R/W	Description				Reset Value
PORCR	GCR_BA+0x24	R/W	Power-on Reset Controller Register				0x0000_00XX

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

Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	POR_DIS_CODE	<p><b>Power-on Reset Enable Control (Write Protect)</b></p> <p>When powered on, the POR circuit generates a reset signal to reset the whole chip function, but noise on the power may cause the POR active again. User can disable internal POR circuit to avoid unpredictable noise to cause chip reset by writing 0x5AA5 to this field.</p> <p>The POR function will be active again when this field is set to another value or chip is reset by other reset source, including:</p> <p>nRST, Watchdog reset, LVR reset, BOD reset, ICE reset command and the software-chip reset function.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>

**Multiple Function Port0 Control Register (P0\_MFP)**

Register	Offset	R/W	Description					Reset Value
P0_MFP	GCR_BA+0x30	R/W	P0 Multiple Function and Input Type Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
Reserved						P0_ALT1		
23	22	21	20	19	18	17	16	
P0_TYPE								
15	14	13	12	11	10	9	8	
P0_ALT								
7	6	5	4	3	2	1	0	
P0_MFP								

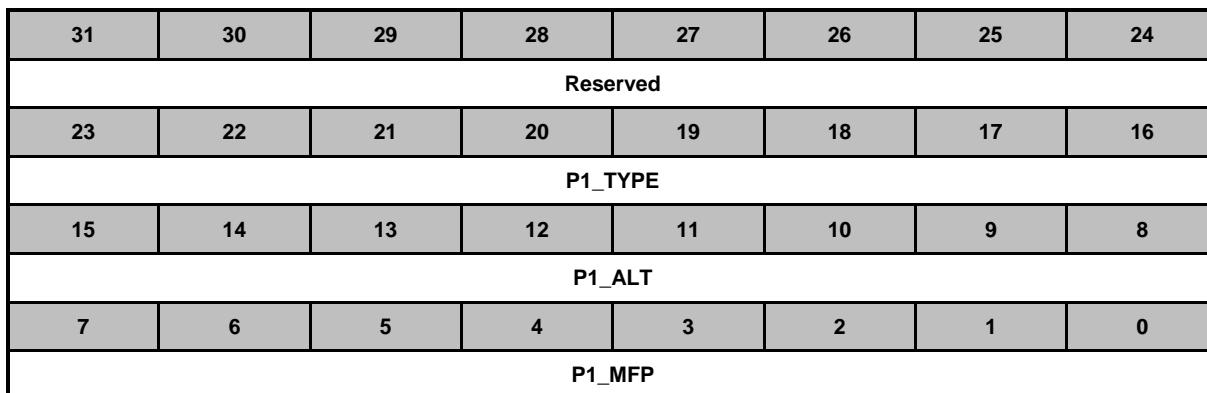
Bits	Description																
[31:26]	<b>Reserved</b>	Reserved.															
[25]	<b>P0_ALT1[1]</b>	<b>P0.1 Alternate Function Selection1</b> The pin function of P0.1 depends on P0_MFP[1], P0_ALT[1], and P0_ALT1[1]. Refer to P0_ALT[1] for detailed description.															
[24]	<b>P0_ALT1[0]</b>	<b>P0.0 Alternate Function Selection1</b> The pin function of P0.0 depends on P0_MFP[0], P0_ALT[0], and P0_ALT1[0]. Refer to P0_ALT[0] for detailed description.															
[23:16]	<b>P0_TYPE[n]</b>	<b>P0[7:0] Input Schmitt Trigger Function Enable Control</b> 0 = P0[7:0] I/O input Schmitt Trigger function Disabled. 1 = P0[7:0] I/O input Schmitt Trigger function Enabled.															
[15]	<b>P0_ALT[7]</b>	<b>P0.7 Alternate Function Selection</b> The pin function of P0.7 depends on P0_MFP[7] and P0_ALT[7]. <table border="1"> <thead> <tr> <th>P0_ALT[7]</th> <th>P0_MFP[7]</th> <th>P0.7 function</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>P0.7</td> </tr> <tr> <td>0</td> <td>1</td> <td>AD7(EBI)</td> </tr> <tr> <td>1</td> <td>0</td> <td>SPICLK1(SPI1)</td> </tr> <tr> <td>1</td> <td>1</td> <td>Reserved</td> </tr> </tbody> </table>	P0_ALT[7]	P0_MFP[7]	P0.7 function	0	0	P0.7	0	1	AD7(EBI)	1	0	SPICLK1(SPI1)	1	1	Reserved
P0_ALT[7]	P0_MFP[7]	P0.7 function															
0	0	P0.7															
0	1	AD7(EBI)															
1	0	SPICLK1(SPI1)															
1	1	Reserved															
[14]	<b>P0_ALT[6]</b>	<b>P0.6 Alternate Function Selection</b> The pin function of P0.6 depends on P0_MFP[6] and P0_ALT[6]. <table border="1"> <thead> <tr> <th>P0_ALT[6]</th> <th>P0_MFP[6]</th> <th>P0.6 function</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>P0.6</td> </tr> </tbody> </table>	P0_ALT[6]	P0_MFP[6]	P0.6 function	0	0	P0.6									
P0_ALT[6]	P0_MFP[6]	P0.6 function															
0	0	P0.6															

		<table border="1"> <tr><td>0</td><td>1</td><td>AD6(EBI)</td></tr> <tr><td>1</td><td>0</td><td>MISO_1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </table>	0	1	AD6(EBI)	1	0	MISO_1(SPI1)	1	1	Reserved						
0	1	AD6(EBI)															
1	0	MISO_1(SPI1)															
1	1	Reserved															
[13]	<b>P0_ALT[5]</b>	<p><b>P0.5 Alternate Function Selection</b></p> <p>The pin function of P0.5 depends on P0_MFP[5] and P0_ALT[5].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[5]</b></th><th><b>P0_MFP[5]</b></th><th><b>P0.5 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.5</td></tr> <tr><td>0</td><td>1</td><td>AD5(EBI)</td></tr> <tr><td>1</td><td>0</td><td>MOSI_1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>	0	0	P0.5	0	1	AD5(EBI)	1	0	MOSI_1(SPI1)	1	1	Reserved
<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>															
0	0	P0.5															
0	1	AD5(EBI)															
1	0	MOSI_1(SPI1)															
1	1	Reserved															
<p><b>P0.4 Alternate Function Selection</b></p> <p>The pin function of P0.4 depends on P0_MFP[4] and P0_ALT[4].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[4]</b></th><th><b>P0_MFP[4]</b></th><th><b>P0.4 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.4</td></tr> <tr><td>0</td><td>1</td><td>AD4(EBI)</td></tr> <tr><td>1</td><td>0</td><td>SPISS1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>	0	0	P0.4	0	1	AD4(EBI)	1	0	SPISS1(SPI1)	1	1	Reserved		
<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>															
0	0	P0.4															
0	1	AD4(EBI)															
1	0	SPISS1(SPI1)															
1	1	Reserved															
<p><b>P0.3 Alternate Function Selection</b></p> <p>The pin function of P0.3 depends on P0_MFP[3] and P0_ALT[3].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[3]</b></th><th><b>P0_MFP[3]</b></th><th><b>P0.3 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.3</td></tr> <tr><td>0</td><td>1</td><td>AD3(EBI)</td></tr> <tr><td>1</td><td>0</td><td>RTS0(UART0)</td></tr> <tr><td>1</td><td>1</td><td>RXD</td></tr> </tbody> </table>	<b>P0_ALT[3]</b>	<b>P0_MFP[3]</b>	<b>P0.3 function</b>	0	0	P0.3	0	1	AD3(EBI)	1	0	RTS0(UART0)	1	1	RXD		
<b>P0_ALT[3]</b>	<b>P0_MFP[3]</b>	<b>P0.3 function</b>															
0	0	P0.3															
0	1	AD3(EBI)															
1	0	RTS0(UART0)															
1	1	RXD															
<p><b>P0.2 Alternate Function Selection</b></p> <p>The pin function of P0.2 depends on P0_MFP[2] and P0_ALT[2].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[2]</b></th><th><b>P0_MFP[2]</b></th><th><b>P0.2 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.2</td></tr> <tr><td>0</td><td>1</td><td>AD2(EBI)</td></tr> <tr><td>1</td><td>0</td><td>CTS0(UART0)</td></tr> <tr><td>1</td><td>1</td><td>TXD</td></tr> </tbody> </table>	<b>P0_ALT[2]</b>	<b>P0_MFP[2]</b>	<b>P0.2 function</b>	0	0	P0.2	0	1	AD2(EBI)	1	0	CTS0(UART0)	1	1	TXD		
<b>P0_ALT[2]</b>	<b>P0_MFP[2]</b>	<b>P0.2 function</b>															
0	0	P0.2															
0	1	AD2(EBI)															
1	0	CTS0(UART0)															
1	1	TXD															
		<table border="1"> <tr><td>0</td><td>1</td><td>AD6(EBI)</td></tr> <tr><td>1</td><td>0</td><td>MISO_1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </table>	0	1	AD6(EBI)	1	0	MISO_1(SPI1)	1	1	Reserved						
0	1	AD6(EBI)															
1	0	MISO_1(SPI1)															
1	1	Reserved															
[13]	<b>P0_ALT[5]</b>	<p><b>P0.5 Alternate Function Selection</b></p> <p>The pin function of P0.5 depends on P0_MFP[5] and P0_ALT[5].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[5]</b></th><th><b>P0_MFP[5]</b></th><th><b>P0.5 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.5</td></tr> <tr><td>0</td><td>1</td><td>AD5(EBI)</td></tr> <tr><td>1</td><td>0</td><td>MOSI_1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>	0	0	P0.5	0	1	AD5(EBI)	1	0	MOSI_1(SPI1)	1	1	Reserved
<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>															
0	0	P0.5															
0	1	AD5(EBI)															
1	0	MOSI_1(SPI1)															
1	1	Reserved															
<p><b>P0.4 Alternate Function Selection</b></p> <p>The pin function of P0.4 depends on P0_MFP[4] and P0_ALT[4].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[4]</b></th><th><b>P0_MFP[4]</b></th><th><b>P0.4 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.4</td></tr> <tr><td>0</td><td>1</td><td>AD4(EBI)</td></tr> <tr><td>1</td><td>0</td><td>SPISS1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>	0	0	P0.4	0	1	AD4(EBI)	1	0	SPISS1(SPI1)	1	1	Reserved		
<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>															
0	0	P0.4															
0	1	AD4(EBI)															
1	0	SPISS1(SPI1)															
1	1	Reserved															
<p><b>P0.3 Alternate Function Selection</b></p> <p>The pin function of P0.3 depends on P0_MFP[3] and P0_ALT[3].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[3]</b></th><th><b>P0_MFP[3]</b></th><th><b>P0.3 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.3</td></tr> <tr><td>0</td><td>1</td><td>AD3(EBI)</td></tr> <tr><td>1</td><td>0</td><td>RTS0(UART0)</td></tr> <tr><td>1</td><td>1</td><td>RXD</td></tr> </tbody> </table>	<b>P0_ALT[3]</b>	<b>P0_MFP[3]</b>	<b>P0.3 function</b>	0	0	P0.3	0	1	AD3(EBI)	1	0	RTS0(UART0)	1	1	RXD		
<b>P0_ALT[3]</b>	<b>P0_MFP[3]</b>	<b>P0.3 function</b>															
0	0	P0.3															
0	1	AD3(EBI)															
1	0	RTS0(UART0)															
1	1	RXD															
<p><b>P0.2 Alternate Function Selection</b></p> <p>The pin function of P0.2 depends on P0_MFP[2] and P0_ALT[2].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[2]</b></th><th><b>P0_MFP[2]</b></th><th><b>P0.2 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.2</td></tr> <tr><td>0</td><td>1</td><td>AD2(EBI)</td></tr> <tr><td>1</td><td>0</td><td>CTS0(UART0)</td></tr> <tr><td>1</td><td>1</td><td>TXD</td></tr> </tbody> </table>	<b>P0_ALT[2]</b>	<b>P0_MFP[2]</b>	<b>P0.2 function</b>	0	0	P0.2	0	1	AD2(EBI)	1	0	CTS0(UART0)	1	1	TXD		
<b>P0_ALT[2]</b>	<b>P0_MFP[2]</b>	<b>P0.2 function</b>															
0	0	P0.2															
0	1	AD2(EBI)															
1	0	CTS0(UART0)															
1	1	TXD															
		<table border="1"> <tr><td>0</td><td>1</td><td>AD6(EBI)</td></tr> <tr><td>1</td><td>0</td><td>MISO_1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </table>	0	1	AD6(EBI)	1	0	MISO_1(SPI1)	1	1	Reserved						
0	1	AD6(EBI)															
1	0	MISO_1(SPI1)															
1	1	Reserved															
[13]	<b>P0_ALT[5]</b>	<p><b>P0.5 Alternate Function Selection</b></p> <p>The pin function of P0.5 depends on P0_MFP[5] and P0_ALT[5].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[5]</b></th><th><b>P0_MFP[5]</b></th><th><b>P0.5 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.5</td></tr> <tr><td>0</td><td>1</td><td>AD5(EBI)</td></tr> <tr><td>1</td><td>0</td><td>MOSI_1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>	0	0	P0.5	0	1	AD5(EBI)	1	0	MOSI_1(SPI1)	1	1	Reserved
<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>															
0	0	P0.5															
0	1	AD5(EBI)															
1	0	MOSI_1(SPI1)															
1	1	Reserved															
<p><b>P0.4 Alternate Function Selection</b></p> <p>The pin function of P0.4 depends on P0_MFP[4] and P0_ALT[4].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[4]</b></th><th><b>P0_MFP[4]</b></th><th><b>P0.4 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.4</td></tr> <tr><td>0</td><td>1</td><td>AD4(EBI)</td></tr> <tr><td>1</td><td>0</td><td>SPISS1(SPI1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>	0	0	P0.4	0	1	AD4(EBI)	1	0	SPISS1(SPI1)	1	1	Reserved		
<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>															
0	0	P0.4															
0	1	AD4(EBI)															
1	0	SPISS1(SPI1)															
1	1	Reserved															
<p><b>P0.3 Alternate Function Selection</b></p> <p>The pin function of P0.3 depends on P0_MFP[3] and P0_ALT[3].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[3]</b></th><th><b>P0_MFP[3]</b></th><th><b>P0.3 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.3</td></tr> <tr><td>0</td><td>1</td><td>AD3(EBI)</td></tr> <tr><td>1</td><td>0</td><td>RTS0(UART0)</td></tr> <tr><td>1</td><td>1</td><td>RXD</td></tr> </tbody> </table>	<b>P0_ALT[3]</b>	<b>P0_MFP[3]</b>	<b>P0.3 function</b>	0	0	P0.3	0	1	AD3(EBI)	1	0	RTS0(UART0)	1	1	RXD		
<b>P0_ALT[3]</b>	<b>P0_MFP[3]</b>	<b>P0.3 function</b>															
0	0	P0.3															
0	1	AD3(EBI)															
1	0	RTS0(UART0)															
1	1	RXD															
<p><b>P0.2 Alternate Function Selection</b></p> <p>The pin function of P0.2 depends on P0_MFP[2] and P0_ALT[2].</p> <table border="1"> <thead> <tr><th><b>P0_ALT[2]</b></th><th><b>P0_MFP[2]</b></th><th><b>P0.2 function</b></th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P0.2</td></tr> <tr><td>0</td><td>1</td><td>AD2(EBI)</td></tr> <tr><td>1</td><td>0</td><td>CTS0(UART0)</td></tr> <tr><td>1</td><td>1</td><td>TXD</td></tr> </tbody> </table>	<b>P0_ALT[2]</b>	<b>P0_MFP[2]</b>	<b>P0.2 function</b>	0	0	P0.2	0	1	AD2(EBI)	1	0	CTS0(UART0)	1	1	TXD		
<b>P0_ALT[2]</b>	<b>P0_MFP[2]</b>	<b>P0.2 function</b>															
0	0	P0.2															
0	1	AD2(EBI)															
1	0	CTS0(UART0)															
1	1	TXD															

[9]	<b>P0_ALT[1]</b>	<b>P0.1 Alternate Function Selection</b> The pin function of P0.1 depends on P0_MFP[1], P0_ALT[1] and P0_ALT1[1].			
		<b>P0_ALT1[1]</b>	<b>P0_ALT[1]</b>	<b>P0_MFP[1]</b>	<b>P0.1 function</b>
		0	0	0	P0.1
		0	0	1	AD1(EBI)
		0	1	0	RTS1(UART1)
		0	1	1	RXD1
[8]	<b>P0_ALT[0]</b>	<b>P0.0 Alternate Function Selection</b> The pin function of P0.0 depends on P0_MFP[0], P0_ALT[0] and P0_ALT1[0].			
		<b>P0_ALT1[0]</b>	<b>P0_ALT[0]</b>	<b>P0_MFP[0]</b>	<b>P0.0 function</b>
		0	0	0	P0.0
		0	0	1	AD0(EBI)
		0	1	0	CTS1(UART1)
		0	1	1	TXD1
[7:0]	<b>P0_MFP[7:0]</b>	<b>P0 Multiple Function Selection</b> The pin function of P0 depends on P0_MFP and P0_ALT. Refer to P0_ALT for detailed description.			

**Multiple Function Port1 Control Register (P1\_MFP)**

Register	Offset	R/W	Description					Reset Value
P1_MFP	GCR_BA+0x34	R/W	P1 Multiple Function and Input Type Control Register					0x0000_0000



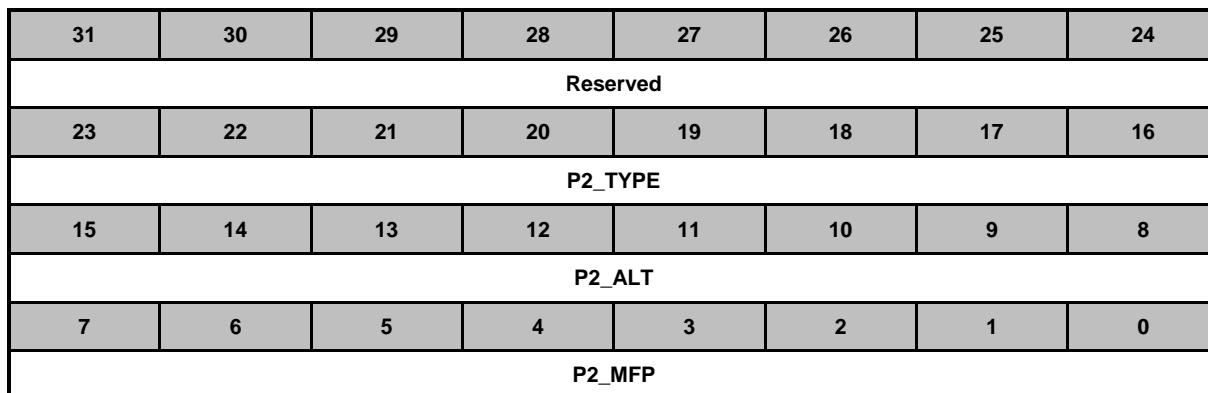
Bits	Description		
[31:24]	Reserved	Reserved.	
[23:16]	P1_TYPE[n]	<b>P1[7:0] Input Schmitt Trigger Function Enable Control</b> 0 = P1[7:0] I/O input Schmitt Trigger function Disabled. 1 = P1[7:0] I/O input Schmitt Trigger function Enabled.	
[15]	P1_ALT[7]	<b>P1.7 Alternate Function Selection</b> The pin function of P1.7 depends on P1_MFP[7] and P1_ALT[7].	
		P1_ALT[7]	P1_MFP[7]
		0	0
		0	1
		1	0
		1	1
[14]	P1_ALT[6]	<b>P1.6 Alternate Function Selection</b> The pin function of P1.6 depends on P1_MFP[6] and P1_ALT[6].	
		P1_ALT[6]	P1_MFP[6]
		0	0
		0	1
		1	0
		1	1
[13]	P1_ALT[5]	<b>P1.5 Alternate Function Selection</b> The pin function of P1.5 depends on P1_MFP[5] and P1_ALT[5].	
		P1_ALT[5]	P1_MFP[5]
		0	0

		0	1	AIN5(ADC)	
		1	0	MOSI_0(SPI0)	
		1	1	ACMP0_P	
[12]	<b>P1_ALT[4]</b>	<b>P1.4 Alternate Function Selection</b> The pin function of P1.4 depends on P1_MFP[4] and P1_ALT[4].			
		<b>P1_ALT[4]</b>	<b>P1_MFP[4]</b>	<b>P1.4 function</b>	
		0	0	P1.4	
		0	1	AIN4(ADC)	
		1	0	SPISS0(SPI0)	
		1	1	ACMP0_N	
[11]	<b>P1_ALT[3]</b>	<b>P1.3 Alternate Function Selection</b> The pin function of P1.3 depends on P1_MFP[3] and P1_ALT[3].			
		<b>P1_ALT[3]</b>	<b>P1_MFP[3]</b>	<b>P1.3 function</b>	
		0	0	P1.3	
		0	1	AIN3(ADC)	
		1	0	TXD1(UART1)	
		1	1	Reserved	
[10]	<b>P1_ALT[2]</b>	<b>P1.2 Alternate Function Selection</b> The pin function of P1.2 depends on P1_MFP[2] and P1_ALT[2].			
		<b>P1_ALT[2]</b>	<b>P1_MFP[2]</b>	<b>P1.2 function</b>	
		0	0	P1.2	
		0	1	AIN2(ADC)	
		1	0	RXD1(UART1)	
		1	1	Reserved	
[9]	<b>P1_ALT[1]</b>	<b>P1.1 Alternate Function Selection</b> The pin function of P1.1 depends on P1_MFP[1] and P1_ALT[1].			
		<b>P1_ALT[1]</b>	<b>P1_MFP[1]</b>	<b>P1.1 function</b>	
		0	0	P1.1	
		0	1	AIN1(ADC)	
		1	0	T3(Timer3)	
		1	1	nWRH	
[8]	<b>P1_ALT[0]</b>	<b>P1.0 Alternate Function Selection</b> The pin function of P1.0 depends on P1_MFP[0] and P1_ALT[0].			
		<b>P1_ALT[0]</b>	<b>P1_MFP[0]</b>	<b>P1.0 function</b>	
		0	0	P1.0	
		0	1	AIN0(ADC)	
		1	0	T2(Timer2)	

		1	1	nWRL
[7:0]	<b>P1_MFP[7:0]</b>	<b>P1 Multiple Function Selection</b> The pin function of P1 depends on P1_MFP and P1_ALT. Refer to P1_ALT for detailed description.		

### Multiple Function Port2 Control Register (P2\_MFP)

Register	Offset	R/W	Description					Reset Value
P2_MFP	GCR_BA+0x38	R/W	P2 Multiple Function and Input Type Control Register					0x0000_0000



Bits	Description																
[31:24]	<b>Reserved</b>		Reserved.														
[23:16]	<b>P2_TYPE[n]</b>		<b>P2[7:0] Input Schmitt Trigger Function Enable Control</b> 0 = P2[7:0] I/O input Schmitt Trigger function Disabled. 1 = P2[7:0] I/O input Schmitt Trigger function Enabled.														
[15]	<b>P2_ALT[7]</b>		<b>P2.7 Alternate Function Selection</b> The pin function of P2.7 depends on P2_MFP[7] and P2_ALT[7].														
	<table border="1"> <thead> <tr> <th>P2_ALT[7]</th> <th>P2_MFP[7]</th> <th>P2.7 function</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.7</td></tr> <tr><td>0</td><td>1</td><td>AD15(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM7(PWMB channel 3)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>		P2_ALT[7]	P2_MFP[7]	P2.7 function	0	0	P2.7	0	1	AD15(EBI)	1	0	PWM7(PWMB channel 3)	1	1	Reserved
P2_ALT[7]	P2_MFP[7]	P2.7 function															
0	0	P2.7															
0	1	AD15(EBI)															
1	0	PWM7(PWMB channel 3)															
1	1	Reserved															
[14]	<b>P2_ALT[6]</b>		<b>P2.6 Alternate Function Selection</b> The pin function of P2.6 depends on P2_MFP[6] and P2_ALT[6].														
	<table border="1"> <thead> <tr> <th>P2_ALT[6]</th> <th>P2_MFP[6]</th> <th>P2.6 function</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.6</td></tr> <tr><td>0</td><td>1</td><td>AD14(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM6(PWMB channel 2)</td></tr> <tr><td>1</td><td>1</td><td>ACMP1_O</td></tr> </tbody> </table>		P2_ALT[6]	P2_MFP[6]	P2.6 function	0	0	P2.6	0	1	AD14(EBI)	1	0	PWM6(PWMB channel 2)	1	1	ACMP1_O
P2_ALT[6]	P2_MFP[6]	P2.6 function															
0	0	P2.6															
0	1	AD14(EBI)															
1	0	PWM6(PWMB channel 2)															
1	1	ACMP1_O															
[13]	<b>P2_ALT[5]</b>		<b>P2.5 Alternate Function Selection</b> The pin function of P2.5 depends on P2_MFP[5] and P2_ALT[5].														
	<table border="1"> <thead> <tr> <th>P2_ALT[5]</th> <th>P2_MFP[5]</th> <th>P2.5 function</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.5</td></tr> </tbody> </table>		P2_ALT[5]	P2_MFP[5]	P2.5 function	0	0	P2.5									
P2_ALT[5]	P2_MFP[5]	P2.5 function															
0	0	P2.5															

		<table border="1"> <tr><td>0</td><td>1</td><td>AD13(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM5(PWMB channel 1)</td></tr> <tr><td>1</td><td>1</td><td>SDA1(I2C1)</td></tr> </table>	0	1	AD13(EBI)	1	0	PWM5(PWMB channel 1)	1	1	SDA1(I2C1)						
0	1	AD13(EBI)															
1	0	PWM5(PWMB channel 1)															
1	1	SDA1(I2C1)															
[12]	P2_ALT[4]	<p><b>P2.4 Alternate Function Selection</b></p> <p>The pin function of P2.4 depends on P2_MFP[4] and P2_ALT[4].</p> <table border="1"> <thead> <tr><th>P2_ALT[4]</th><th>P2_MFP[4]</th><th>P2.4 function</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.4</td></tr> <tr><td>0</td><td>1</td><td>AD12(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM4(PWMB channel 0)</td></tr> <tr><td>1</td><td>1</td><td>SCL1(I2C1)</td></tr> </tbody> </table>	P2_ALT[4]	P2_MFP[4]	P2.4 function	0	0	P2.4	0	1	AD12(EBI)	1	0	PWM4(PWMB channel 0)	1	1	SCL1(I2C1)
P2_ALT[4]	P2_MFP[4]	P2.4 function															
0	0	P2.4															
0	1	AD12(EBI)															
1	0	PWM4(PWMB channel 0)															
1	1	SCL1(I2C1)															
[11]	P2_ALT[3]	<p><b>P2.3 Alternate Function Selection</b></p> <p>The pin function of P2.3 depends on P2_MFP[3] and P2_ALT[3].</p> <table border="1"> <thead> <tr><th>P2_ALT[3]</th><th>P2_MFP[3]</th><th>P2.3 function</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.3</td></tr> <tr><td>0</td><td>1</td><td>AD11(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM3(PWMA channel 3)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	P2_ALT[3]	P2_MFP[3]	P2.3 function	0	0	P2.3	0	1	AD11(EBI)	1	0	PWM3(PWMA channel 3)	1	1	Reserved
P2_ALT[3]	P2_MFP[3]	P2.3 function															
0	0	P2.3															
0	1	AD11(EBI)															
1	0	PWM3(PWMA channel 3)															
1	1	Reserved															
[10]	P2_ALT[2]	<p><b>P2.2 Alternate Function Selection</b></p> <p>The pin function of P2.2 depends on P2_MFP[2] and P2_ALT[2].</p> <table border="1"> <thead> <tr><th>P2_ALT[2]</th><th>P2_MFP[2]</th><th>P2.2 function</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.2</td></tr> <tr><td>0</td><td>1</td><td>AD10(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM2(PWMA channel 2)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	P2_ALT[2]	P2_MFP[2]	P2.2 function	0	0	P2.2	0	1	AD10(EBI)	1	0	PWM2(PWMA channel 2)	1	1	Reserved
P2_ALT[2]	P2_MFP[2]	P2.2 function															
0	0	P2.2															
0	1	AD10(EBI)															
1	0	PWM2(PWMA channel 2)															
1	1	Reserved															
[9]	P2_ALT[1]	<p><b>P2.1 Alternate Function Selection</b></p> <p>The pin function of P2.1 depends on P2_MFP[1] and P2_ALT[1].</p> <table border="1"> <thead> <tr><th>P2_ALT[1]</th><th>P2_MFP[1]</th><th>P2.1 function</th></tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P2.1</td></tr> <tr><td>0</td><td>1</td><td>AD9(EBI)</td></tr> <tr><td>1</td><td>0</td><td>PWM1(PWMA channel 1)</td></tr> <tr><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	P2_ALT[1]	P2_MFP[1]	P2.1 function	0	0	P2.1	0	1	AD9(EBI)	1	0	PWM1(PWMA channel 1)	1	1	Reserved
P2_ALT[1]	P2_MFP[1]	P2.1 function															
0	0	P2.1															
0	1	AD9(EBI)															
1	0	PWM1(PWMA channel 1)															
1	1	Reserved															
[8]	P2_ALT[0]	<p><b>P2.0 Alternate Function Selection</b></p> <p>The pin function of P2.0 depends on P2_MFP[0] and P2_ALT[0].</p> <table border="1"> <thead> <tr><th>P2_ALT[0]</th><th>P2_MFP[0]</th><th>P2.0 function</th></tr> </thead> </table>	P2_ALT[0]	P2_MFP[0]	P2.0 function												
P2_ALT[0]	P2_MFP[0]	P2.0 function															

		0	0	P2.0
		0	1	AD8(EBI)
		1	0	PWM0(PWMA channel 0)
		1	1	Reserved
[7:0]	<b>P2_MFP[7:0]</b>	<b>P2 Multiple Function Selection</b> The pin function of P2 depends on P2_MFP and P2_ALT. Refer to P2_ALT for detailed description.		

Multiple Function Port3 Control Register (P3\_MFP)

Register	Offset	R/W	Description				Reset Value
P3_MFP	GCR_BA+0x3C	R/W	P3 Multiple Function and Input Type Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
P3_TYPE							
15	14	13	12	11	10	9	8
P3_ALT							
7	6	5	4	3	2	1	0
P3_MFP							

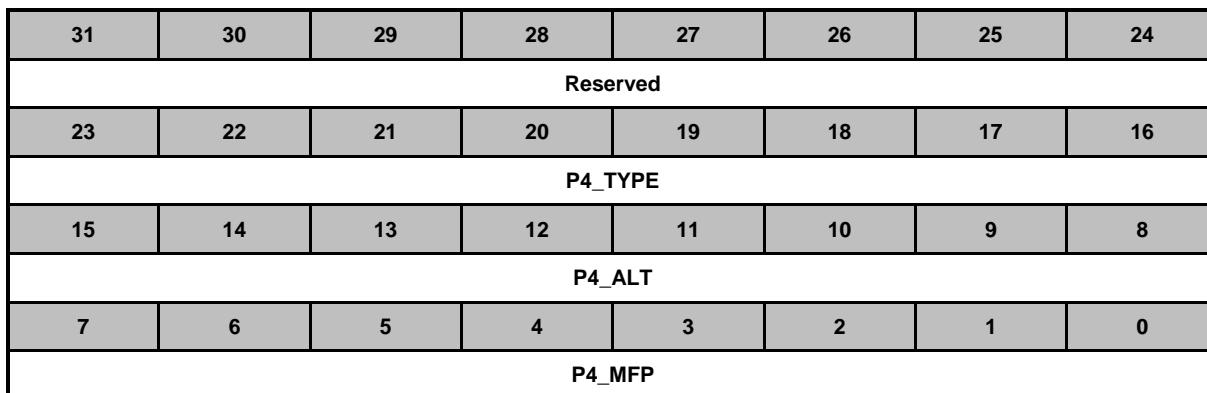
Bits	Description																
[31:24]	Reserved	Reserved.															
[23:16]	P3_TYPE[n]	<b>P3[7:0] Input Schmitt Trigger Function Enable</b> 0 = P3[7:0] I/O input Schmitt Trigger function Disabled. 1 = P3[7:0] I/O input Schmitt Trigger function Enabled.															
[15]	P3_ALT[7]	<b>P3.7 Alternate Function Selection</b> The pin function of P3.7 depends on P3_MFP[7] and P3_ALT[7]. <table border="1" style="margin-top: 5px;"> <tr> <th>P3_ALT[7]</th> <th>P3_MFP[7]</th> <th>P3.7 function</th> </tr> <tr><td>0</td><td>0</td><td>P3.7</td></tr> <tr><td>0</td><td>1</td><td>nRD(EBI)</td></tr> <tr><td>1</td><td>x</td><td>Reserved</td></tr> </table>	P3_ALT[7]	P3_MFP[7]	P3.7 function	0	0	P3.7	0	1	nRD(EBI)	1	x	Reserved			
P3_ALT[7]	P3_MFP[7]	P3.7 function															
0	0	P3.7															
0	1	nRD(EBI)															
1	x	Reserved															
[14]	P3_ALT[6]	<b>P3.6 Alternate Function Selection</b> The pin function of P3.6 depends on P3_MFP[6] and P3_ALT[6]. <table border="1" style="margin-top: 5px;"> <tr> <th>P3_ALT[6]</th> <th>P3_MFP[6]</th> <th>P3.6 function</th> </tr> <tr><td>0</td><td>0</td><td>P3.6</td></tr> <tr><td>0</td><td>1</td><td>nWR(EBI)</td></tr> <tr><td>1</td><td>0</td><td>CKO(Clock Driver output)</td></tr> <tr><td>1</td><td>1</td><td>ACMP0_O</td></tr> </table>	P3_ALT[6]	P3_MFP[6]	P3.6 function	0	0	P3.6	0	1	nWR(EBI)	1	0	CKO(Clock Driver output)	1	1	ACMP0_O
P3_ALT[6]	P3_MFP[6]	P3.6 function															
0	0	P3.6															
0	1	nWR(EBI)															
1	0	CKO(Clock Driver output)															
1	1	ACMP0_O															
[13]	P3_ALT[5]	<b>P3.5 Alternate Function Selection</b> The pin function of P3.5 depends on P3_MFP[5] and P3_ALT[5]. <table border="1" style="margin-top: 5px;"> <tr> <th>P3_ALT[5]</th> <th>P3_MFP[5]</th> <th>P3.5 function</th> </tr> <tr><td>0</td><td>0</td><td>P3.5</td></tr> <tr><td>0</td><td>1</td><td>T1(Timer1 External Event Counter)</td></tr> </table>	P3_ALT[5]	P3_MFP[5]	P3.5 function	0	0	P3.5	0	1	T1(Timer1 External Event Counter)						
P3_ALT[5]	P3_MFP[5]	P3.5 function															
0	0	P3.5															
0	1	T1(Timer1 External Event Counter)															

		1	0	SCL0(I <sup>2</sup> C)	
		1	1	ACMP1_P (ACMP)	
[12]	P3_ALT[4]	<b>P3.4 Alternate Function Selection</b> The pin function of P3.4 depends on P3_MFP[4] and P3_ALT[4].			
		P3_ALT[4]	P3_MFP[4]	P3.4 function	
		0	0	P3.4	
		0	1	T0(Timer0)	
		1	0	SDA0(I <sup>2</sup> C0)	
[11]	P3_ALT[3]	<b>P3.3 Alternate Function Selection</b> The pin function of P3.3 depends on P3_MFP[3] and P3_ALT[3].			
		P3_ALT[3]	P3_MFP[3]	P3.3 function	
		0	0	P3.3	
		0	1	nINT1	
		1	0	MCLK(EBI)	
[10]	P3_ALT[2]	<b>P3.2 Alternate Function Selection</b> The pin function of P3.2 depends on P3_MFP[2] and P3_ALT[2].			
		P3_ALT[2]	P3_MFP[2]	P3.2 function	
		0	0	P3.2	
		0	1	nINT0	
		1	0	T0EX	
[9]	P3_ALT[1]	<b>P3.1 Alternate Function Selection</b> The pin function of P3.1 depends on P3_MFP[1] and P3_ALT[1].			
		P3_ALT[1]	P3_MFP[1]	P3.1 function	
		0	0	P3.1	
		0	1	TXD(UART0)	
		1	0	ACMP1_P	
[8]	P3_ALT[0]	<b>P3.0 Alternate Function Selection</b> The pin function of P3.0 depends on P3_MFP[0] and P3_ALT[0].			
		P3_ALT[0]	P3_MFP[0]	P3.0 function	
		0	0	P3.0	
		0	1	RXD(UART0)	
		1	0	ACMP1_N	
		1	1	Reserved	

[7:0]	<b>P3_MFP[7:0]</b>	<b>P3 Multiple Function Selection</b> The pin function of P3 depends on P3_MFP and P3_ALT. Refer to P3_ALT for detailed description.
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### Multiple Function Port4 Control Register (P4\_MFP)

Register	Offset	R/W	Description					Reset Value
P4_MFP	GCR_BA+0x40	R/W	P4 Multiple Function and Input Type Control Register					0x0000_00C0



Bits	Description		
[31:24]	Reserved	Reserved.	
[23:16]	P4_TYPE[n]	<b>P4[7:0] Input Schmitt Trigger Function Enable Control</b> 0= P4[7:0] I/O input Schmitt Trigger function Disabled. 1= P4[7:0] I/O input Schmitt Trigger function Enabled.	
[15]	P4_ALT[7]	<b>P4.7 Alternate Function Selection</b> The pin function of P4.7 depends on P4_MFP[7] and P4_ALT[7].	
		P4_ALT[7]	P4_MFP[7]
		0	0
		0	1
		1	x
		P4.7 function	
[14]	P4_ALT[6]	<b>P4.6 Alternate Function Selection</b> The pin function of P4.6 depends on P4_MFP[6] and P4_ALT[6].	
		P4_ALT[6]	P4_MFP[6]
		0	0
		0	1
		1	x
		P4.6 function	
[13]	P4_ALT[5]	<b>P4.5 Alternate Function Selection</b> The pin function of P4.5 depends on P4_MFP[5] and P4_ALT[5].	
		P4_ALT[5]	P4_MFP[5]
		0	0
		0	1
		1	0
		P4.5 function	

		1	1	Reserved	
		<b>P4.4 Alternate Function Selection</b> The pin function of P4.4 depends on P4_MFP[4] and P4_ALT[4].			
[12]	<b>P4_ALT[4]</b>	<b>P4_ALT[4]</b>	<b>P4_MFP[4]</b>	<b>P4.4 function</b>	
		0	0	P4.4	
		0	1	nCS (EBI)	
		1	0	SCL1(I <sup>2</sup> C1)	
		1	1	Reserved	
[11]	<b>P4_ALT[3]</b>	<b>P4.3 Alternate Function Selection</b> The pin function of P4.3 depends on P4_MFP[3] and P4_ALT[3].			
		<b>P4_ALT[3]</b>	<b>P4_MFP[3]</b>	<b>P4.3 function</b>	
		0	0	P4.3	
		0	1	PWM3(PWM generator 2)	
		1	x	Reserved	
[10]	<b>P4_ALT[2]</b>	<b>P4.2 Alternate Function Selection</b> The pin function of P4.2 depends on P4_MFP[2] and P4_ALT[2].			
		<b>P4_ALT[2]</b>	<b>P4_MFP[2]</b>	<b>P4.2 function</b>	
		0	0	P4.2	
		0	1	PWM2(PWM generator 2)	
		1	x	Reserved	
[9]	<b>P4_ALT[1]</b>	<b>P4.1 Alternate Function Selection</b> The pin function of P4.1 depends on P4_MFP[1] and P4_ALT[1].			
		<b>P4_ALT[1]</b>	<b>P4_MFP[1]</b>	<b>P4.1 function</b>	
		0	0	P4.1	
		0	1	PWM1(PWM generator 0)	
		1	0	T3EX	
[8]	<b>P4_ALT[0]</b>	<b>P4.0 Alternate Function Selection</b> The pin function of P4.0 depends on P4_MFP[0] and P4_ALT[0].			
		<b>P4_ALT[0]</b>	<b>P4_MFP[0]</b>	<b>P4.0 function</b>	
		0	0	P4.0	
		0	1	PWM0(PWM generator 0)	
		1	0	T2EX	
[7:0]	<b>P4_MFP[7:0]</b>	<b>P4 Multiple Function Selection</b> The pin function of P4 depends on P4_MFP and P4_ALT. Refer to P4_ALT for detailed description.			

### Register Write-Protection Control Register (REGWRPROT)

Some of the system control registers need to be protected to avoid inadvertent write and disturb the chip operation. These system control registers are protected after the power on reset till user to disable register protection. For user to program these protected registers, a register protection disable sequence needs to be followed by a special programming. The register protection disable sequence is writing the data “59h”, “16h” “88h” to the register REGWRPROT address at 0x5000\_0100 continuously. Any different data value, different sequence or any other write to other address during these three data writing will abort the whole sequence.

After the protection is disabled, user can check the protection disable bit at address 0x5000\_0100 bit0, “1” is protection disable, “0” is protection enable. Then user can update the target protected register value and then write any data to the address “0x5000\_0100” to enable register protection.

Write this register to disable/enable register protection, and reading it to get the REGPROTDIS status.

Register	Offset	R/W	Description					Reset Value
REGWRPROT	GCR_BA+0x100	R/W	Register Write-Protection Control Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
REGWRPROT[7:1]							REGWRPROT [0] REGPROTDIS

Bits	Description							
[31:16]	Reserved	Reserved.						
[7:0]	REGWRPROT	<b>Register Write-protection Code (Write Only)</b> Some registers have write-protection function. Writing these registers have to disable the protected function by writing the sequence value “59h”, “16h”, “88h” to this field. After this sequence is completed, the REGPROTDIS bit will be set to 1 and write-protection registers can be normal write.						
[0]	REGPROTDIS	<b>Register Write-protection Disable Index (Read Only)</b> 0 = Write-protection Enabled for writing protected registers. Any write to the protected register is ignored. 1 = Write-protection Disabled for writing protected registers.  The Protected registers are: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Registers</th> <th>Address</th> <th>Note</th> </tr> </thead> <tbody> <tr> <td>IPRSTC1</td> <td>0x5000_0008</td> <td>Peripheral Reset Control Register 1</td> </tr> </tbody> </table>	Registers	Address	Note	IPRSTC1	0x5000_0008	Peripheral Reset Control Register 1
Registers	Address	Note						
IPRSTC1	0x5000_0008	Peripheral Reset Control Register 1						

	<b>BODCR</b>	0x5000_0018	Brown-out Detector Control Register
	<b>PORCR</b>	0x5000_0024	Power-on Reset Controller Register
	<b>PWRCON</b>	0x5000_0200	Bit[6] is not protected for power wake-up interrupt clear.
	<b>APBCLK bit[0]</b>	0x5000_0208	Bit[0] is watchdog clock enable.
	<b>CLKSEL0</b>	0x5000_0210	HCLK and CPU STCLK clock source select.
	<b>CLKSEL1 bit[1:0]</b>	0x5000_0214	Watchdog clock source select.
	<b>NMI_SEL bit[8]</b>	0x5000_0380	NMI interrupt enable.
	<b>ISPCON</b>	0x5000_C000	Flash ISP Control.
	<b>ISPTRG</b>	0x5000_C010	ISP Trigger Control.
	<b>WTCR</b>	0x4000_4000	Watchdog Timer Control.
	<b>FATCON</b>	0x5000_C018	Flash Access Time Control.
	<b>Note:</b> The bits which are write-protected will be noted as " <b>(Write Protect)</b> " beside the description.		

### 5.2.7 System Manager Controller Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>GCR Base Address:</b>				
<b>GCR_BA = 0x5000_0000</b>				
<b>PDID</b>	GCR_BA+0x00	R	Part Device Identification Number Register	0x0029_5415
<b>RSTSRC</b>	GCR_BA+0x04	R/W	System Reset Source Register	0x0000_00XX
<b>IPRSTC1</b>	GCR_BA+0x08	R/W	Peripheral Reset Control Register 1	0x0000_0000
<b>IPRSTC2</b>	GCR_BA+0x0C	R/W	Peripheral Reset Control Register 2	0x0000_0000
<b>BODCR</b>	GCR_BA+0x18	R/W	Brown-out Detector Control Register	0x0000_000X
<b>P0_MFP</b>	GCR_BA+0x30	R/W	P0 Multiple Function and Input Type Control Register	0x0000_0000
<b>P1_MFP</b>	GCR_BA+0x34	R/W	P1 Multiple Function and Input Type Control Register	0x0000_0000
<b>P2_MFP</b>	GCR_BA+0x38	R/W	P2 Multiple Function and Input Type Control Register	0x0000_0000
<b>P3_MFP</b>	GCR_BA+0x3C	R/W	P3 Multiple Function and Input Type Control Register	0x0000_0000
<b>P4_MFP</b>	GCR_BA+0x40	R/W	P4 Multiple Function and Input Type Control Register	0x0000_00C0
<b>P5_MFP</b>	GCR_BA+0x44	R/W	P5 Multiple Function and Input Type Control Register	0x0000_0000
<b>IRCTRIMCTL</b>	GCR_BA+0x80	R/W	HIRC Trim Control Register	0x0000_0000
<b>IRCTRIMEN</b>	GCR_BA+0x84	R/W	HIRC Trim Interrupt Enable Control Register	0x0000_0000
<b>IRCTRIMINT</b>	GCR_BA+0x88	R/W	HIRC Trim Interrupt Status Register	0x0000_0000
<b>REGWRPROT</b>	GCR_BA+0x100	R/W	Register Write-Protection Control Register	0x0000_0000

**Part Device ID Code Register (PDID)**

Register	Offset	R/W	Description	Reset Value
PDID	GCR_BA+0x00	R	Part Device Identification Number Register	0x0029_5415 <sup>[1]</sup>

[1] Every part number has a unique default reset value.

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

Bits	Description	
[31:0]	PDID	<b>Part Device Identification Number</b> This register reflects the device part number code. Software can read this register to identify which device is used.

NuMicro® NUC029FAE	Part Device Identification Number
NUC029FAE	0x0029_5415

### System Reset Source Register (RSTSRC)

This register provides specific information for software to identify this chip's reset source from the last operation.

Register	Offset	R/W	Description				Reset Value
RSTSRC	GCR_BA+0x04	R/W	System Reset Source Register				0x0000_00XX

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
RSTS_CPU	Reserved	RSTS MCU	RSTS_BOD	Reserved	RSTS_WDT	RSTS_RESET	RSTS_POR

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	RSTS_CPU	<b>CPU Reset Flag</b> The RSTS_CPU flag is set by hardware if software writes CPU_RST (IPRSTC1[1]) 1 to reset Cortex®-M0 core and Flash memory controller (FMC). 0 = No reset from CPU. 1 = Cortex®-M0 core and FMC are reset by software setting CPU_RST to 1. <b>Note:</b> Write 1 to clear this bit to 0.
[6]	Reserved	Reserved.
[5]	RSTS MCU	<b>MCU Reset Flag</b> The RSTS MCU flag is set by the “reset signal” from the Cortex®-M0 core to indicate the previous reset source. 0 = No reset from Cortex®-M0. 1 = The Cortex®-M0 had issued the reset signal to reset the system by writing 1 to bit SYSRESETREQ (AIRCR[2], Application Interrupt and Reset Control Register, address = 0xE000ED0C) in system control registers of Cortex®-M0 core. <b>Note:</b> Write 1 to clear this bit to 0.
[4]	RSTS_BOD	<b>Brown-out Detector Reset Flag</b> The RSTS_BOD flag is set by the “reset signal” from the Brown-out Detector to indicate the previous reset source. 0 = No reset from BOD. 1 = The BOD had issued the reset signal to reset the system. <b>Note:</b> Write 1 to clear this bit to 0.
[3]	Reserved	Reserved.
[2]	RSTS_WDT	<b>Watchdog Reset Flag</b>

		<p>The RSTS_WDT flag is set by the “reset signal” from the watchdog timer to indicate the previous reset source.</p> <p>0 = No reset from watchdog timer.</p> <p>1 = The watchdog timer had issued the reset signal to reset the system.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[1]	<b>RSTS_RESET</b>	<p><b>Reset Pin Reset Flag</b></p> <p>The RSTS_RESET flag is set by the “reset signal” from the nRST pin to indicate the previous reset source.</p> <p>0 = No reset from the nRST pin.</p> <p>1 = The nRST pin had issued the reset signal to reset the system.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[0]	<b>RSTS_POR</b>	<p><b>Power-on Reset Flag</b></p> <p>The RSTS_POR flag is set by the “reset signal” from the Power-on Reset (POR) controller or bit CHIP_RST (IPRSTC1[0]) to indicate the previous reset source.</p> <p>0 = No reset from POR or CHIP_RST.</p> <p>1 = The Power-on Reset (POR) or CHIP_RST had issued the reset signal to reset the system.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>

Peripheral Reset Control Register1 (IPRSTC1)

Register	Offset	R/W	Description				Reset Value
IPRSTC1	GCR_BA+0x08	R/W	Peripheral Reset Control Register 1				0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1]	CPU_RST	<p><b>Cortex-m0 Core One-shot Reset (Write Protect)</b>  Setting this bit will only reset the Cortex-M0 core and Flash Memory Controller (FMC), and this bit will automatically return 0 after the two clock cycles.  0 = Cortex-M0 core normal operation.  1 = Cortex-M0 core one-shot reset.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>
[0]	CHIP_RST	<p><b>Chip One-shot Reset (Write Protect)</b>  Setting this bit will reset the whole chip, including Cortex®-M0 core and all peripherals, and this bit will automatically return to 0 after the 2 clock cycles.  The CHIP_RST is the same as the POR reset. All the chip controllers are reset and the chip setting from CONFIG0 are also reload.  0 = Chip normal operation.  1 = Chip one-shot reset.</p> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>

**Peripheral Reset Control Register2 (IPRSTC2)**

Setting these bits “1” will generate asynchronous reset signal to the corresponding module. User needs to set these bits to “0” to release the module from the reset state.

Register	Offset	R/W	Description				Reset Value
IPRSTC2	GCR_BA+0x0C	R/W	Peripheral Reset Control Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved			ADC_RST	Reserved			
23	22	21	20	19	18	17	16
Reserved	ACMP_RST	Reserved	PWM_RST	Reserved			UART_RST
15	14	13	12	11	10	9	8
Reserved			SPI_RST	Reserved			I2C_RST
7	6	5	4	3	2	1	0
Reserved				TMR1_RST	TMR0_RST	GPIO_RST	Reserved

Bits	Description	
[31:29]	Reserved	Reserved.
[28]	ADC_RST	<b>ADC Controller Reset</b> 0 = ADC controller normal operation. 1 = ADC controller reset.
[27:23]	Reserved	Reserved.
[22]	ACMP_RST	<b>Analog Comparator Controller Reset</b> 0 = Analog Comparator controller normal operation. 1 = Analog Comparator controller reset.
[21]	Reserved	Reserved.
[20]	PWM_RST	<b>PWM Controller Reset</b> 0 = PWM controller normal operation. 1 = PWM controller reset.
[19:17]	Reserved	Reserved.
[16]	UART_RST	<b>UART Controller Reset</b> 0 = UART controller normal operation. 1 = UART controller reset.
[15:13]	Reserved	Reserved.
[12]	SPI_RST	<b>SPI Controller Reset</b> 0 = SPI controller normal operation. 1 = SPI controller reset.
[11:9]	Reserved	Reserved.

[8]	<b>I2C_RST</b>	<b>I<sup>2</sup>C Controller Reset</b> 0= I <sup>2</sup> C controller normal operation. 1= I <sup>2</sup> C controller reset.
[7:4]	<b>Reserved</b>	Reserved.
[3]	<b>TMR1_RST</b>	<b>Timer1 Controller Reset</b> 0 = Timer1 controller normal operation. 1 = Timer1 controller reset.
[2]	<b>TMR0_RST</b>	<b>Timer0 Controller Reset</b> 0 = Timer0 controller normal operation. 1 = Timer0 controller reset.
[1]	<b>GPIO_RST</b>	<b>GPIO (P0–P5) Controller Reset</b> 0 = GPIO controller normal operation. 1 = GPIO controller reset.
[0]	<b>Reserved</b>	Reserved.

### Brown-out Detector Control Register (BODCR)

Partial values of the BODCR control registers are initiated by the flash configuration and partial bits are write-protected. Programming the write-protected bits needs to write “59h”, “16h”, and “88h” to address 0x5000\_0100 to disable register protection. Refer to the REGWRPROT register at address GCR\_BA+0x100.

After the unlocked sequence, user can check the lock bit at address 0x5000\_0100 bit 0, where 1 is unlocked and 0 is locked. Then user can update the write-protected registers. Write any data to the address 0x5000\_0100 to re-lock the write-protected register again.

Register	Offset	R/W	Description				Reset Value
BODCR	GCR_BA+0x18	R/W	Brown-out Detector Control Register				0x0000_000X

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	BOD_OUT	BOD_LPM	BOD_INTF	BOD_RSTEN	BOD_VL		BOD_VL_EXT

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	BOD_OUT	<b>Brown-out Detector Output Status</b> 0 = Brown-out Detector output status is 0, which means the detected voltage is higher than BOD_VL setting. 1 = Brown-out Detector output status is 1, which means the detected voltage is lower than BOD_VL setting.
[5]	BOD_LPM	<b>Brown-out Detector Low Power Mode (Write Protect)</b> 0 = BOD operated in Normal mode (default). 1 = BOD Low Power mode Enabled. <b>Note1:</b> The BOD consumes about 100 uA in Normal mode, and the low power mode can reduce the current to about 1/10 but slow the BOD response. <b>Note2:</b> This bit is the protected bit, and programming it needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.
[4]	BOD_INTF	<b>Brown-out Detector Interrupt Flag</b> 0 = Brown-out Detector does not detect any voltage draft at V <sub>DD</sub> down through or up through the voltage of BOD_VL setting. 1 = When Brown-out Detector detects the V <sub>DD</sub> is dropped down through the voltage of BOD_VL setting or the V <sub>DD</sub> is raised up through the voltage of BOD_VL setting, this bit is set to 1 and the Brown-out interrupt is requested if Brown-out interrupt is enabled. <b>Note:</b> Write 1 to clear this bit to 0.
[3]	BOD_RSTEN	<b>Brown-out Reset Enable Control (Write Protect)</b>

		<p>0 = Brown-out "INTERRUPT" function Enabled. While the BOD function is enabled and BOD interrupt function is enabled (BOD_RSTEN low), BOD will assert an interrupt if BOD_OUT is high. BOD interrupt will keep till to the BOD function is Dabled. BOD interrupt can be blocked by disabling the NVIC BOD interrupt or disabling BOD function.</p> <p>1 = Brown-out "RESET" function Enabled.</p> <p><b>Note1:</b> While the Brown-out Detector function is enabled and BOD reset function is enabled, BOD will assert a signal to reset chip when the detected voltage is lower than the threshold (BOD_OUT high).</p> <p><b>Note2:</b> The default value is set by flash controller user configuration register config0 bit[20].</p> <p><b>Note3:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>															
[2:1]	BOD_VL	<p><b>Brown-out Detector Threshold Voltage Select (Write Protect)</b> The default value is set by flash controller user configuration register config0 bit[22:21]</p> <table border="1"> <thead> <tr> <th>BOV_VL[1]</th><th>BOV_VL[0]</th><th>Brown-out voltage</th></tr> </thead> <tbody> <tr> <td>1</td><td>1</td><td>Disable 2.7V and 3.7V</td></tr> <tr> <td>1</td><td>0</td><td>3.7V</td></tr> <tr> <td>0</td><td>1</td><td>2.7V</td></tr> <tr> <td>0</td><td>0</td><td>Reserved</td></tr> </tbody> </table> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>	BOV_VL[1]	BOV_VL[0]	Brown-out voltage	1	1	Disable 2.7V and 3.7V	1	0	3.7V	0	1	2.7V	0	0	Reserved
BOV_VL[1]	BOV_VL[0]	Brown-out voltage															
1	1	Disable 2.7V and 3.7V															
1	0	3.7V															
0	1	2.7V															
0	0	Reserved															
[0]	BOD_VL_EXT	<p><b>Brown-out Detector Enable Control (Write Protect)</b> The default value is set by flash controller user configuration register config0 bit[23] CBOVEXT.</p> <p>If config0 bit[23] is set to 1, default value of BOD_VL_EXT is 0.</p> <p>If config0 bit[23] is set to 0, default value of BOD_VL_EXT is 1.</p> <p>0 = Brown-out Detector function Disabled.</p> <p>1 = Brown-out Detector function Enabled.</p> <table border="1"> <thead> <tr> <th>BOD_VL[1]</th><th>BOD_VL[0]</th><th>Brown-out voltage</th></tr> </thead> <tbody> <tr> <td>1</td><td>1</td><td>4.4V</td></tr> <tr> <td>1</td><td>0</td><td>3.7V</td></tr> <tr> <td>0</td><td>1</td><td>2.7V</td></tr> <tr> <td>0</td><td>0</td><td>2.2V</td></tr> </tbody> </table> <p><b>Note:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>	BOD_VL[1]	BOD_VL[0]	Brown-out voltage	1	1	4.4V	1	0	3.7V	0	1	2.7V	0	0	2.2V
BOD_VL[1]	BOD_VL[0]	Brown-out voltage															
1	1	4.4V															
1	0	3.7V															
0	1	2.7V															
0	0	2.2V															

**Multiple Function Port0 Control Register (P0\_MFP)**

Register	Offset	R/W	Description				Reset Value
P0_MFP	GCR_BA+0x30	R/W	P0 Multiple Function and Input Type Control Register				0x0000_0000

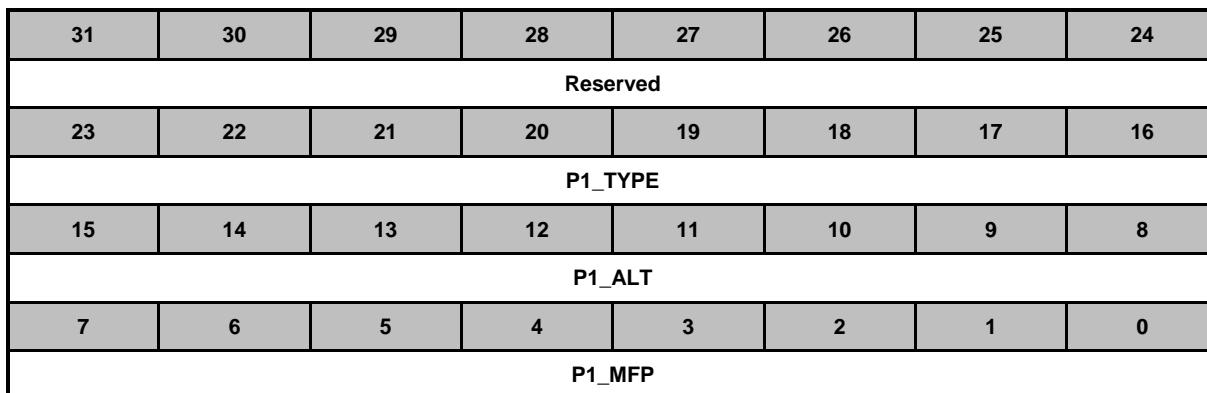
31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
P0_TYPE							
15	14	13	12	11	10	9	8
P0_ALT							
7	6	5	4	3	2	1	0
P0_MFP							

Bits	Description		
[31:24]	Reserved	Reserved.	
[23:16]	P0_TYPE[n]	<b>P0[7:0] TTL Or Schmitt Trigger Function Enable Control</b> 0 = P0[7:0]Select I/O input as TTL function. 1 = P0[7:0] Select I/O input as Schmitt Trigger function .	
[15]	P0_ALT[7]	<b>P0.7 Alternate Function Selection</b> The pin function of P0.7 depends on P0_MFP[7] and P0_ALT[7].	
		P0_ALT[7]	P0_MFP[7]
		0	0
		0	1
		1	0
		1	1
[14]	P0_ALT[6]	<b>P0.6 Alternate Function Selection</b> The pin function of P0.6 depends on P0_MFP[6] and P0_ALT[6].	
		P0_ALT[6]	P0_MFP[6]
		0	0
		0	1
		1	0
		1	1
[13]	P0_ALT[5]	<b>P0.5 Alternate Function Selection</b> The pin function of P0.5 depends on P0_MFP[5] and P0_ALT[5].	

		<b>P0_ALT[5]</b>	<b>P0_MFP[5]</b>	<b>P0.5 function</b>
		0	0	P0.5
		0	1	Reserved
		1	0	MOSI_0(SPI)
		1	1	Reserved
[12]	<b>P0_ALT[4]</b>	<b>P0.4 Alternate Function Selection</b> The pin function of P0.4 depends on P0_MFP[4] and P0_ALT[4].		
		<b>P0_ALT[4]</b>	<b>P0_MFP[4]</b>	<b>P0.4 function</b>
		0	0	P0.4
		0	1	Reserved
		1	0	SPISS0(SPI)
		1	1	PWM5 (PWM)
[11:8]	<b>Reserved</b>	Reserved.		
[7:0]	<b>P0_MFP[7:0]</b>	<b>P0 Multiple Function Selection</b> The pin function of P0 depends on P0_MFP and P0_ALT. Refer to P0_ALT for detailed description.		

**Multiple Function Port1 Control Register (P1\_MFP)**

Register	Offset	R/W	Description					Reset Value
P1_MFP	GCR_BA+0x34	R/W	P1 Multiple Function and Input Type Control Register					0x0000_0000

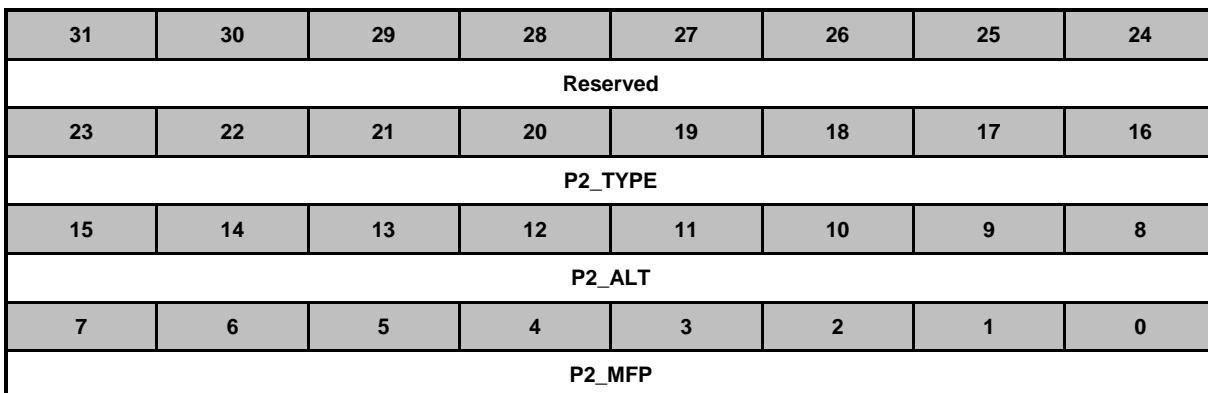


Bits	Description																	
[31:24]	Reserved		Reserved.															
[23:16]	P1_TYPE[n]		<b>P1[7:0] TTL Or Schmitt Trigger Function Enable Control</b> 0 = P1[7:0]Select I/O input as TTL function. 1 = P1[7:0] Select I/O input as Schmitt Trigger function .															
[15:14]	Reserved		Reserved.															
[13]	P1_ALT[5]		<b>P1.5 Alternate Function Selection</b> The pin function of P1.5 depends on P1_MFP[5] and P1_ALT[5]. <table border="1" style="margin-top: 5px;"> <tr> <th>P1_ALT[5]</th> <th>P1_MFP[5]</th> <th>P1.5 function</th> </tr> <tr><td>0</td><td>0</td><td>P1.5</td></tr> <tr><td>0</td><td>1</td><td>AIN5(ADC)</td></tr> <tr><td>1</td><td>0</td><td>Reserved</td></tr> <tr><td>1</td><td>1</td><td>ACMP0_P(ACMP)</td></tr> </table>	P1_ALT[5]	P1_MFP[5]	P1.5 function	0	0	P1.5	0	1	AIN5(ADC)	1	0	Reserved	1	1	ACMP0_P(ACMP)
P1_ALT[5]	P1_MFP[5]	P1.5 function																
0	0	P1.5																
0	1	AIN5(ADC)																
1	0	Reserved																
1	1	ACMP0_P(ACMP)																
[12]	P1_ALT[4]		<b>P1.4 Alternate Function Selection</b> The pin function of P1.4 depends on P1_MFP[4] and P1_ALT[4]. <table border="1" style="margin-top: 5px;"> <tr> <th>P1_ALT[4]</th> <th>P1_MFP[4]</th> <th>P1.4 function</th> </tr> <tr><td>0</td><td>0</td><td>P1.4</td></tr> <tr><td>0</td><td>1</td><td>AIN4(ADC)</td></tr> <tr><td>1</td><td>0</td><td>Reserved</td></tr> <tr><td>1</td><td>1</td><td>ACMP0_N(ACMP)</td></tr> </table>	P1_ALT[4]	P1_MFP[4]	P1.4 function	0	0	P1.4	0	1	AIN4(ADC)	1	0	Reserved	1	1	ACMP0_N(ACMP)
P1_ALT[4]	P1_MFP[4]	P1.4 function																
0	0	P1.4																
0	1	AIN4(ADC)																
1	0	Reserved																
1	1	ACMP0_N(ACMP)																
[11]	P1_ALT[3]		<b>P1.3 Alternate Function Selection</b> The pin function of P1.3 depends on P1_MFP[3] and P1_ALT[3]. <table border="1" style="margin-top: 5px;"> <tr> <th>P1_ALT[3]</th> <th>P1_MFP[3]</th> <th>P1.3 function</th> </tr> </table>	P1_ALT[3]	P1_MFP[3]	P1.3 function												
P1_ALT[3]	P1_MFP[3]	P1.3 function																

		0	0	P1.3
		0	1	AIN3(ADC)
		1	0	TXD(UART)
		1	1	ACMP0_P(ACMP)
[10]	<b>P1_ALT[2]</b>	<b>P1.2 Alternate Function Selection</b> The pin function of P1.2 depends on P1_MFP[2] and P1_ALT[2].		
		<b>P1_ALT[2]</b>	<b>P1_MFP[2]</b>	<b>P1.2 function</b>
		0	0	P1.2
		0	1	AIN2(ADC)
		1	0	RXD(UART)
[9:8]	<b>Reserved</b>	Reserved.		
[7:0]	<b>P1_MFP[7:0]</b>	<b>P1 Multiple Function Selection</b> The pin function of P1 depends on P1_MFP and P1_ALT. Refer to P1_ALT for detailed description.		

**Multiple Function Port2 Control Register (P2\_MFP)**

Register	Offset	R/W	Description					Reset Value
P2_MFP	GCR_BA+0x38	R/W	P2 Multiple Function and Input Type Control Register					0x0000_0000



Bits	Description		
[31:24]	Reserved	Reserved.	
[23:16]	P2_TYPE[n]	<b>P2[7:0] TTL Or Schmitt Trigger Function Enable Control</b> 0 = P2[7:0]Select I/O input as TTL function. 1 = P2[7:0] Select I/O input as Schmitt Trigger function .	
[15:14]	Reserved	Reserved.	
[13]	P2_ALT[5]	<b>P2.5 Alternate Function Selection</b> The pin function of P2.5 depends on P2_MFP[5] and P2_ALT[5].	
		P2_ALT[5]	P2_MFP[5]
		0	0
		0	1
		1	0
		1	1
[12]	P2_ALT[4]	<b>P2.4 Alternate Function Selection</b> The pin function of P2.4 depends on P2_MFP[4] and P2_ALT[4].	
		P2_ALT[4]	P2_MFP[4]
		0	0
		0	1
		1	0
		1	1

[11:8]	<b>Reserved</b>	Reserved.
[7:0]	<b>P2_MFP[7:0]</b>	<b>P2 Multiple Function Selection</b> The pin function of P2 depends on P2_MFP and P2_ALT. Refer to P2_ALT for detailed description.

**Multiple Function Port3 Control Register (P3\_MFP)**

Register	Offset	R/W	Description					Reset Value
P3_MFP	GCR_BA+0x3C	R/W	P3 Multiple Function and Input Type Control Register					0x0000_0000

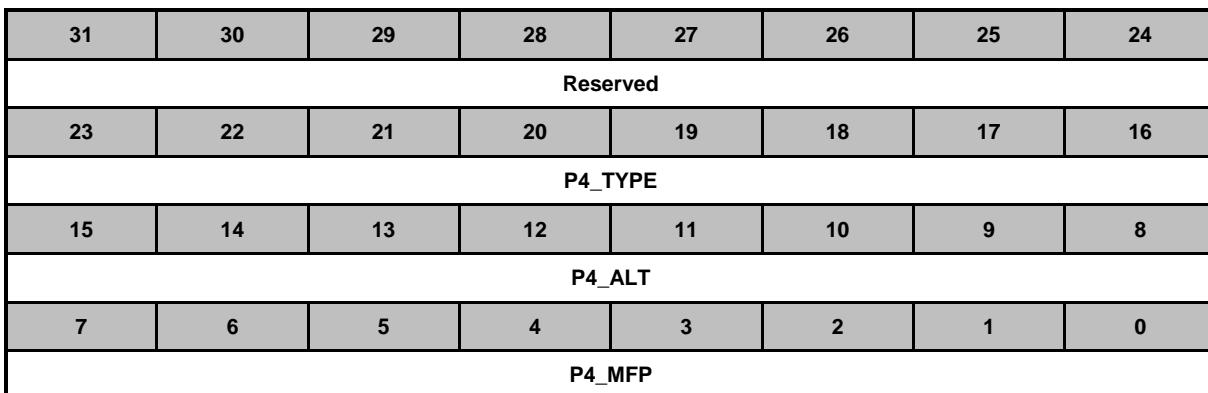
31	30	29	28	27	26	25	24	
Reserved								P32CPP1
23	22	21	20	19	18	17	16	
P3_TYPE								
15	14	13	12	11	10	9	8	
P3_ALT								
7	6	5	4	3	2	1	0	
P3_MFP								

Bits	Description																
[31:25]	Reserved	Reserved.															
[24]	P32CPP1	<b>P3.2 Alternate Function Selection Extension</b> 0 = P3.2 is set by P3_ALT[2] and P3_MFP[2]. 1 = P3.2 is set to CPP1 of ACMP1.															
[23:16]	P3_TYPE[n]	<b>P3[7:0] TTL Or Schmitt Trigger Function Enable Control</b> 0 = P3[7:0]Select I/O input as TTL function. 1 = P3[7:0] Select I/O input as Schmitt Trigger function .															
[15:14]	Reserved	Reserved.															
[13]	P3_ALT[5]	<p><b>P3.5 Alternate Function Selection</b> The pin function of P3.5 depends on P3_MFP[5] and P3_ALT[5].</p> <table border="1"> <thead> <tr> <th>P3_ALT[5]</th> <th>P3_MFP[5]</th> <th>P3.5 function</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>P3.5</td> </tr> <tr> <td>0</td> <td>1</td> <td>T1(Timer1)</td> </tr> <tr> <td>1</td> <td>0</td> <td>SCL0(I<sup>2</sup>C0)</td> </tr> <tr> <td>1</td> <td>1</td> <td>ACMP1_P (ACMP)</td> </tr> </tbody> </table>	P3_ALT[5]	P3_MFP[5]	P3.5 function	0	0	P3.5	0	1	T1(Timer1)	1	0	SCL0(I <sup>2</sup> C0)	1	1	ACMP1_P (ACMP)
P3_ALT[5]	P3_MFP[5]	P3.5 function															
0	0	P3.5															
0	1	T1(Timer1)															
1	0	SCL0(I <sup>2</sup> C0)															
1	1	ACMP1_P (ACMP)															
[12]	P3_ALT[4]	<p><b>P3.4 Alternate Function Selection</b> The pin function of P3.4 depends on P3_MFP[4] and P3_ALT[4].</p> <table border="1"> <thead> <tr> <th>P3_ALT[4]</th> <th>P3_MFP[4]</th> <th>P3.4 function</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>P3.4</td> </tr> <tr> <td>0</td> <td>1</td> <td>T0(Timer0 external event counter)</td> </tr> <tr> <td>1</td> <td>0</td> <td>SDA0(I<sup>2</sup>C)</td> </tr> <tr> <td>1</td> <td>1</td> <td>ACMP1_P (ACMP)</td> </tr> </tbody> </table>	P3_ALT[4]	P3_MFP[4]	P3.4 function	0	0	P3.4	0	1	T0(Timer0 external event counter)	1	0	SDA0(I <sup>2</sup> C)	1	1	ACMP1_P (ACMP)
P3_ALT[4]	P3_MFP[4]	P3.4 function															
0	0	P3.4															
0	1	T0(Timer0 external event counter)															
1	0	SDA0(I <sup>2</sup> C)															
1	1	ACMP1_P (ACMP)															
[11]	Reserved	Reserved.															

[10]	<b>P3_ALT[2]</b>	<b>P3.2 Alternate Function Selection</b>		
		The pin function of P3.2 depends on P3_MFP[2] and P3_ALT[2].		
		<b>Note:</b> If P32CPP1 is set to 1, P3_ALT[2] and P3_MFP[2] settings will be ignored and pin P3.2 function will be CPP1 of ACMP1.		
		<b>P3_ALT[2]</b>	<b>P3_MFP[2]</b>	<b>P3.2 function</b>
		0	0	P3.2
[9:8]	<b>Reserved</b>	Reserved.		
[7:0]	<b>P3_MFP[7:0]</b>	<b>P3 Multiple Function Selection</b> The pin function of P3 depends on P3_MFP and P3_ALT. Refer to P3_ALT for detailed description.		

**Multiple Function Port4 Control Register (P4\_MFP)**

Register	Offset	R/W	Description					Reset Value
P4_MFP	GCR_BA+0x40	R/W	P4 Multiple Function and Input Type Control Register					0x0000_00C0



Bits	Description														
[31:24]	Reserved		Reserved.												
[23:16]	P4_TYPE[n]		<b>P4[7:0] TTL Or Schmitt Trigger Function Enable Control</b> 0 = P4[7:0]Select I/O input as TTL function. 1 = P4[7:0] Select I/O input as Schmitt Trigger function .												
[15]	P4_ALT[7]		<b>P4.7 Alternate Function Selection</b> The pin function of P4.7 depends on P4_MFP[7] and P4_ALT[7]. <table border="1" style="margin-left: 20px;"> <tr> <th>P4_ALT[7]</th> <th>P4_MFP[7]</th> <th>P4.7 function</th> </tr> <tr><td>0</td><td>0</td><td>P4.7</td></tr> <tr><td>0</td><td>1</td><td>ICE_DAT(ICE)</td></tr> <tr><td>1</td><td>x</td><td>Reserved</td></tr> </table>	P4_ALT[7]	P4_MFP[7]	P4.7 function	0	0	P4.7	0	1	ICE_DAT(ICE)	1	x	Reserved
P4_ALT[7]	P4_MFP[7]	P4.7 function													
0	0	P4.7													
0	1	ICE_DAT(ICE)													
1	x	Reserved													
[14]	P4_ALT[6]		<b>P4.6 Alternate Function Selection</b> The pin function of P4.6 depends on P4_MFP[6] and P4_ALT[6]. <table border="1" style="margin-left: 20px;"> <tr> <th>P4_ALT[6]</th> <th>P4_MFP[6]</th> <th>P4.6 function</th> </tr> <tr><td>0</td><td>0</td><td>P4.6</td></tr> <tr><td>0</td><td>1</td><td>ICE_CLK(ICE)</td></tr> <tr><td>1</td><td>x</td><td>Reserved</td></tr> </table>	P4_ALT[6]	P4_MFP[6]	P4.6 function	0	0	P4.6	0	1	ICE_CLK(ICE)	1	x	Reserved
P4_ALT[6]	P4_MFP[6]	P4.6 function													
0	0	P4.6													
0	1	ICE_CLK(ICE)													
1	x	Reserved													
[13:8]	Reserved.														
[7:0]	P4_MFP[7:0]														
	<b>P4 Multiple Function Selection</b> The pin function of P4 depends on P4_MFP and P4_ALT. Refer to P4_ALT for detailed description.														

**Multiple Function Port5 Control Register (P5\_MFP)**

Register	Offset	R/W	Description					Reset Value
P5_MFP	GCR_BA+0x44	R/W	P5 Multiple Function and Input Type Control Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
P4_TYPE							
15	14	13	12	11	10	9	8
P4_ALT							
7	6	5	4	3	2	1	0
P4_MFP							

Bits	Description													
[31:24]	<b>Reserved</b>	Reserved.												
[23:16]	<b>P5_TYPE[n]</b>	<b>P5[7:0] TTL Or Schmitt Trigger Function Enable Control</b> 0 = P5[7:0]Select I/O input as TTL function. 1 = P5[7:0] Select I/O input as Schmitt Trigger function .												
[15:10]	<b>Reserved</b>	Reserved.												
[9]	<b>P5_ALT[1]</b>	<b>P5.1 Alternate Function Selection</b> The pin function of P5.1 depends on P5_MFP[1] and P5_ALT[1].  <table border="1"> <thead> <tr> <th>P5_ALT[1]</th> <th>P5_MFP[1]</th> <th>P5.1 function</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P5.1</td></tr> <tr><td>0</td><td>1</td><td>XTAL2 (Output pin)</td></tr> <tr><td>1</td><td>x</td><td>Reserved</td></tr> </tbody> </table> <b>Note:</b> To enable external XTAL function, XTLCLK_EN (PWRCON[1:0]) bit, the external Crystal HXT or LXT enable control register must also be set.	P5_ALT[1]	P5_MFP[1]	P5.1 function	0	0	P5.1	0	1	XTAL2 (Output pin)	1	x	Reserved
P5_ALT[1]	P5_MFP[1]	P5.1 function												
0	0	P5.1												
0	1	XTAL2 (Output pin)												
1	x	Reserved												
[8]	<b>P5_ALT[0]</b>	<b>P5.0 Alternate Function Selection</b> The pin function of P5.0 depends on P5_MFP[0] and P5_ALT[0].  <table border="1"> <thead> <tr> <th>P5_ALT[0]</th> <th>P5_MFP[0]</th> <th>P5.0 function</th> </tr> </thead> <tbody> <tr><td>0</td><td>0</td><td>P5.0</td></tr> <tr><td>0</td><td>1</td><td>XTAL1 (Input pin)</td></tr> <tr><td>1</td><td>x</td><td>Reserved</td></tr> </tbody> </table> <b>Note:</b> To enable external XTAL function, XTLCLK_EN (PWRCON[1:0]) bit, the external Crystal HXT or LXT enable register must also be set.	P5_ALT[0]	P5_MFP[0]	P5.0 function	0	0	P5.0	0	1	XTAL1 (Input pin)	1	x	Reserved
P5_ALT[0]	P5_MFP[0]	P5.0 function												
0	0	P5.0												
0	1	XTAL1 (Input pin)												
1	x	Reserved												
[7:0]	<b>P5_MFP[7:0]</b>	<b>P5 Multiple Function Selection</b> The pin function of P4 depends on P5_MFP and P5_ALT. Refer to P5_ALT for detailed description.												

**HIRC Trim Control Register (IRCTRIMCTL)**

Register	Offset	R/W	Description				Reset Value
IRCTRIMCTL	GCR_BA+0x80	R/W	HIRC Trim Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
TRIM_RETRY_CNT		TRIM_LOOP		Reserved			TRIM_SEL

Bits	Description	
[31:8]	Reserved	Reserved.
[7:6]	TRIM_RETRY_CNT[1:0]	<p><b>Trim Value Update Limitation Count</b></p> <p>This field defines that how many times the auto trim circuit will try to update the HIRC trim value before the frequency of HIRC locked.</p> <p>Once the HIRC locked, the internal trim value update counter will be reset.</p> <p>If the trim value update counter reached this limitation value and frequency of HIRC still doesn't lock, the auto trim operation will be disabled and TRIM_SEL will be cleared to 00.</p>
	TRIM_RETRY_CNT	Trim Retry Count Limitation
	00	Trim retry count limitation is 64
	01	Trim retry count limitation is 128
	10	Trim retry count limitation is 256
	11	Trim retry count limitation is 512
[5:4]	TRIM_LOOP[1:0]	<p><b>Trim Calculation Loop</b></p> <p>This field defines that trim value calculation is based on how many LXT clocks in.</p> <p>For example, if TRIM_LOOP is set as 00, auto trim circuit will calculate trim value based on the average frequency difference in 4 LXT clock.</p> <p>00 = Trim value calculation is based on average difference in 4 LXT clocks.      01 = Trim value calculation is based on average difference in 8 LXT clocks.      10 = Trim value calculation is based on average difference in 16 LXT clocks.      11 = Trim value calculation is based on average difference in 32 LXT clocks.</p>
[3:1]	Reserved	Reserved.

Bits	Description
[0]	<b>TRIM_SEL</b> <b>Trim Frequency Selection</b> This bit is to enable the HIRC auto trim. When setting this bit to 1, the HIRC auto trim function will trim HIRC to 22.1184 MHz automatically based on the LXT reference clock. During auto trim operation, if LXT clock error is detected or trim retry limitation count reached, this field will be cleared to 0 automatically. 0 = HIRC auto trim function Disabled. 1 = HIRC auto trim function Enabled and HIRC trimmed to 22.1184 MHz.

**HIRC Trim Interrupt Enable Control Register (IRCTRIMIEN)**

Register	Offset	R/W	Description				Reset Value
IRCTRIMIEN	GCR_BA+0x84	R/W	HIRC Trim Interrupt Enable Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					32K_ERR_IEN	TRIM_FAIL_IE_N	Reserved

Bits	Description	
[31:3]	Reserved	Reserved.
[2]	32K_ERR_IEN	<p><b>LXT Clock Error Interrupt Enable Control</b>            This bit controls if CPU could get an interrupt while LXT clock is inaccurate during auto trim operation.            If this bit is high, and 32K_ERR_INT is set during auto trim operation, an interrupt will be triggered to notify the LXT clock frequency is inaccurate.            0 = 32K_ERR_INT status Disabled to trigger an interrupt to CPU.            1 = 32K_ERR_INT status Enabled to trigger an interrupt to CPU.</p>
[1]	TRIM_FAIL_IEN	<p><b>Trim Failure Interrupt Enable Control</b>            This bit controls if an interrupt will be triggered while HIRC trim value update limitation count is reached and HIRC frequency is still not locked on target frequency set by TRIM_SEL.            If this bit is high and TRIM_FAIL_INT is set during auto trim operation, an interrupt will be triggered to notify that HIRC trim value update limitation count is reached.            0 = TRIM_FAIL_INT status Disabled to trigger an interrupt to CPU.            1 = TRIM_FAIL_INT status Enabled to trigger an interrupt to CPU.</p>
[0]	Reserved	Reserved.

**HIRC Trim Interrupt Status Register (IRCTRIMINT)**

Register	Offset	R/W	Description				Reset Value
IRCTRIMINT	GCR_BA+0x88	R/W	HIRC Trim Interrupt Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					32K_ERR_INT	TRIM_FAIL_I NT	FREQ_LOCK

Bits	Description	
[31:3]	Reserved	Reserved.
[2]	32K_ERR_INT	<p><b>LXT Clock Error Interrupt Status</b>            This bit indicates that LXT clock frequency is inaccuracy. Once this bit is set, the auto trim operation stopped and TRIM_SEL will be cleared to 0 by hardware automatically.            If this bit is set and 32K_ERR_IEN is high, an interrupt will be triggered to notify the LXT clock frequency is inaccuracy. Software can write 1 to clear this bit to 0.            0 = LXT clock frequency is accuracy.            1 = LXT clock frequency is inaccuracy.</p>
[1]	TRIM_FAIL_INT	<p><b>Trim Failure Interrupt Status</b>            This bit indicates that HIRC trim value update limitation count reached and HIRC clock frequency still doesn't lock. Once this bit is set, the auto trim operation stopped and TRIM_SEL will be cleared to 0 by hardware automatically.            If this bit is set and TRIM_FAIL_IEN is high, an interrupt will be triggered to notify that HIRC trim value update limitation count was reached. Software can write 1 to clear this bit to 0.            0 = Trim value update limitation count is not reached.            1 = Trim value update limitation count is reached and HIRC frequency is still not locked.</p>
[0]	FREQ_LOCK	<p><b>HIRC Frequency Lock Status</b>            This bit indicates the HIRC frequency locked in 22.1184 MHz.            This is a read only status bit and doesn't trigger any interrupt.</p>

### Register Write-Protection Control Register (REGWRPROT)

Some of the system control registers need to be protected to avoid inadvertent write and disturb the chip operation. These system control registers are protected after the power on reset till user to disable register protection. For user to program these protected registers, a register protection disable sequence needs to be followed by a special programming. The register protection disable sequence is writing the data “59h”, “16h” “88h” to the register REGWRPROT address at 0x5000\_0100 continuously. Any different data value, different sequence or any other write to other address during these three data writing will abort the whole sequence.

After the protection is disabled, user can check the protection disable bit at address 0x5000\_0100 bit0, “1” is protection disable, “0” is protection enable. Then user can update the target protected register value and then write any data to the address “0x5000\_0100” to enable register protection.

Write this register to disable/enable register protection, and reading it to get the REGPROTDIS status.

Register	Offset	R/W	Description					Reset Value
REGWRPROT	GCR_BA+0x100	R/W	Register Write-Protection Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
Reserved								
23	22	21	20	19	18	17	16	
Reserved								
15	14	13	12	11	10	9	8	
Reserved								
7	6	5	4	3	2	1	0	
REGWRPROT[7:1]							REGWRPROT [0] REGPROTDIS	

Bits	Description							
[31:16]	Reserved	Reserved.						
[7:0]	REGWRPROT	<b>Register Write-protection Code (Write Only)</b> Some registers have write-protection function. Writing these registers have to disable the protected function by writing the sequence value “59h”, “16h”, “88h” to this field. After this sequence is completed, the REGPROTDIS bit will be set to 1 and write-protection registers can be normal write.						
[0]	REGPROTDIS	<b>Register Write-protection Disable Index (Read Only)</b> 0 = Write-protection Enabled for writing protected registers. Any write to the protected register is ignored. 1 = Write-protection Disabled for writing protected registers.  The Protected registers are: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Registers</th> <th>Address</th> <th>Note</th> </tr> </thead> <tbody> <tr> <td>IPRSTC1</td> <td>0x5000_0008</td> <td>Peripheral Reset Control Register 1</td> </tr> </tbody> </table>	Registers	Address	Note	IPRSTC1	0x5000_0008	Peripheral Reset Control Register 1
Registers	Address	Note						
IPRSTC1	0x5000_0008	Peripheral Reset Control Register 1						

	<b>BODCR</b>	0x5000_0018	Brown-out Detector Control Register
	<b>PWRCON</b>	0x5000_0200	Bit[6] is not protected for power wake-up interrupt clear.
	<b>APBCLK bit[0]</b>	0x5000_0208	Bit[0] is watchdog clock enable.
	<b>CLKSEL0</b>	0x5000_0210	HCLK and SysTick clock source select.
	<b>CLKSEL1 bit[1:0]</b>	0x5000_0214	Watchdog clock source select.
	<b>NMI_SEL bit[8]</b>	0x5000_0380	NMI interrupt enable.
	<b>ISPCON</b>	0x5000_C000	Flash ISP Control.
	<b>ISPTRG</b>	0x5000_C010	ISP Trigger Control.
	<b>WTCR</b>	0x4000_4000	Watchdog Timer Control.
<b>Note:</b> The bits which are write-protected will be noted as " <b>(Write Protect)</b> " beside the description.			

### 5.2.8 System Timer (SysTick)

The Cortex<sup>®</sup>-M0 includes an integrated system timer, SysTick, which provides a simple, 24-bit clear-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism. The counter can be used as a Real Time Operating System (RTOS) tick timer or as a simple counter.

When system timer is enabled, it will count down from the value in the SysTick Current Value Register (SYST\_CVR) to 0, and reload (wrap) to the value in the SysTick Reload Value Register (SYST\_RVR) on the next clock cycle, then decrement on subsequent clocks. When the counter transitions to 0, the COUNTFLAG status bit is set. The COUNTFLAG bit clears on reads.

The SYST\_CVR value is UNKNOWN on reset. Software should write to the register to clear it to 0 before enabling the feature. This ensures the timer will count from the SYST\_RVR value rather than an arbitrary value when it is enabled.

If the SYST\_RVR is 0, the timer will be maintained with a current value of 0 after it is reloaded with this value. This mechanism can be used to disable the feature independently from the timer enable bit.

For more detailed information, please refer to the “ARM<sup>®</sup> Cortex<sup>®</sup>-M0 Technical Reference Manual” and “ARM<sup>®</sup> v6-M Architecture Reference Manual”.

### 5.2.9 System Timer Control Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SYST Base Address:</b>				
<b>SYST_BA = 0xE000_E010</b>				
<b>SYST_CSR</b>	SYST_BA+0x00	R/W	SysTick Control and Status Register	0x0000_0000
<b>SYST_RVR</b>	SYST_BA+0x04	R/W	SysTick Reload Value Register	0xFFFF_FFFF
<b>SYST_CVR</b>	SYST_BA+0x08	R/W	SysTick Current Value Register	0xFFFF_FFFF

**SysTick Control and Status (SYST\_CSR)**

Register	Offset	R/W	Description				Reset Value
SYST_CSR	SYST_BA+0x00	R/W	SysTick Control and Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					CLKSRC	TICKINT	ENABLE

Bits	Description	
[31:17]	Reserved	Reserved.
[16]	COUNTFLAG	<b>System Tick Counter Flag</b> Returns 1 if timer counted to 0 since last time this register was read. COUNTFLAG is set by a count transition from 1 to 0. COUNTFLAG is cleared on read or by a write to the Current Value register.
[15:3]	Reserved	Reserved.
[2]	CLKSRC	<b>System Tick Clock Source Selection</b> 0 = Clock source is optional, refer to STCLK_S(CLKSEL0[5:3]). 1 = Core clock used for SysTick timer.
[1]	TICKINT	<b>System Tick Interrupt Enabled</b> 0 = Counting down to 0 does not cause the SysTick exception to be pended. Software can use COUNTFLAG to determine if a count to 0 has occurred. 1 = Counting down to 0 will cause the SysTick exception to be pended. Clearing the SysTick Current Value register by a register write in software will not cause SysTick to be pended.
[0]	ENABLE	<b>System Tick Counter Enabled</b> 0 = Counter Disabled. 1 = Counter Enabled and will operate in a multi-shot manner.

**SysTick Reload Value Register (SYST\_RVR)**

Register	Offset	R/W	Description				Reset Value
SYST_RVR	SYST_BA+0x04	R/W	SysTick Reload Value Register				0xFFFF_FFFF

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

Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	RELOAD	<b>System Tick Reload Value</b> Value to load into the Current Value register when the counter reaches 0.

**SysTick Current Value Register (SYST\_CVR)**

Register	Offset	R/W	Description				Reset Value
SYST_CVR	SYST_BA+0x08	R/W	SysTick Current Value Register				0XXXXX_XXXX

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

Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	CURRENT	<b>System Tick Current Value</b> Current counter value. This is the value of the counter at the time it is sampled. The counter does not provide read-modify-write protection. The register is write-clear. A software write of any value will clear the register to 0. Unsupported bits RAZ (see SysTick Reload Value register).

### 5.2.10 System Timer Control Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SCS Base Address:</b>				
<b>SCS_BA = 0xE000_E000</b>				
<b>SYST_CSR</b>	SCS_BA+0x10	R/W	SysTick Control and Status Register	0x0000_0000
<b>SYST_RVR</b>	SCS_BA+0x14	R/W	SysTick Reload Value Register	0xFFFF_FFFF
<b>SYST_CVR</b>	SCS_BA+0x18	R/W	SysTick Current Value Register	0xFFFF_FFFF

**SysTick Control and Status (SYST\_CSR)**

Register	Offset	R/W	Description				Reset Value
SYST_CSR	SCS_BA+0x10	R/W	SysTick Control and Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					CLKSRC	TICKINT	ENABLE

Bits	Description	
[31:17]	<b>Reserved</b>	Reserved.
[16]	<b>COUNTFLAG</b>	<p><b>System Tick Counter Flag</b>            Returns 1 if timer counted to 0 since last time this register was read.            COUNTFLAG is set by a count transition from 1 to 0.            COUNTFLAG is cleared on read or by a write to the Current Value register.</p>
[15:3]	<b>Reserved</b>	Reserved.
[2]	<b>CLKSRC</b>	<p><b>System Tick Clock Source Selection</b>            0 = Clock source is optional, refer to STCLK_S(CLKSEL0[5:3]).            1 = Core clock used for SysTick timer.</p>
[1]	<b>TICKINT</b>	<p><b>System Tick Interrupt Enabled</b>            0 = Counting down to 0 does not cause the SysTick exception to be pended. Software can use COUNTFLAG to determine if a count to 0 has occurred.            1 = Counting down to 0 will cause the SysTick exception to be pended. Clearing the SysTick Current Value register by a register write in software will not cause SysTick to be pended.</p>
[0]	<b>ENABLE</b>	<p><b>System Tick Counter Enabled</b>            0 = Counter Disabled.            1 = Counter Enabled and will operate in a multi-shot manner.</p>

**SysTick Reload Value Register (SYST\_RVR)**

Register	Offset	R/W	Description				Reset Value
SYST_RVR	SCS_BA+0x14	R/W	SysTick Reload Value Register				0xFFFF_FFFF

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

Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	RELOAD	<b>System Tick Reload Value</b> Value to load into the Current Value register when the counter reaches 0.

**SysTick Current Value Register (SYST\_CVR)**

Register	Offset	R/W	Description				Reset Value
SYST_CVR	SCS_BA+0x18	R/W	SysTick Current Value Register				0XXXXX_XXXX

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

Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	CURRENT	<p><b>System Tick Current Value</b></p> <p>Current counter value. This is the value of the counter at the time it is sampled. The counter does not provide read-modify-write protection. The register is write-clear. A software write of any value will clear the register to 0. Unsupported bits RAZ (see SysTick Reload Value register).</p>

### 5.2.11 Nested Vectored Interrupt Controller (NVIC)

The Cortex<sup>®</sup>-M0 provides an interrupt controller as an integral part of the exception mode, named as “Nested Vectored Interrupt Controller (NVIC)”, which is closely coupled to the processor core and provides following features:

- Nested and Vectored interrupt support
- Automatic processor state saving and restoration
- Reduced and deterministic interrupt latency

The NVIC prioritizes and handles all supported exceptions. All exceptions are handled in “Handler Mode”. This NVIC architecture supports 32 (IRQ[31:0]) discrete interrupts with 4 levels of priority. All of the interrupts and most of the system exceptions can be configured to different priority levels. When an interrupt occurs, the NVIC will compare the priority of the new interrupt to the current running one’s priority. If the priority of the new interrupt is higher than the current one, the new interrupt handler will override the current handler.

When an interrupt is accepted, the starting address of the interrupt service routine (ISR) is fetched from a vector table in memory. There is no need to determine which interrupt is accepted and branch to the starting address of the correlated ISR by software. While the starting address is fetched, NVIC will also automatically save processor state including the registers “PC, PSR, LR, R0~R3, R12” to the stack. At the end of the ISR, the NVIC will restore the mentioned registers from stack and resume the normal execution. Thus it will take less and deterministic time to process the interrupt request.

The NVIC supports “Tail Chaining” which handles back-to-back interrupts efficiently without the overhead of states saving and restoration and therefore reduces delay time in switching to pending ISR at the end of current ISR. The NVIC also supports “Late Arrival” which improves the efficiency of concurrent ISRs. When a higher priority interrupt request occurs before the current ISR starts to execute (at the stage of state saving and starting address fetching), the NVIC will give priority to the higher one without delay penalty. Thus it advances the real-time capability.

For more detailed information, please refer to the “ARM<sup>®</sup> Cortex<sup>®</sup>-M0 Technical Reference Manual” and “ARM<sup>®</sup> v6-M Architecture Reference Manual”.

#### 5.2.11.1 Exception Model and System Interrupt Map

The following table lists the exception model supported by NuMicro<sup>®</sup> NUC029 series. Software can set four levels of priority on some of these exceptions as well as on all interrupts. The highest user-configurable priority is denoted as “0” and the lowest priority is denoted as “3”. The default priority of all the user-configurable interrupts is “0”. Note that priority “0” is treated as the fourth priority on the system, after three system exceptions “Reset”, “NMI” and “Hard Fault”.

Exception Name	Vector Number	Priority
Reset	1	-3
NMI	2	-2
Hard Fault	3	-1
Reserved	4 ~ 10	Reserved
SVCall	11	Configurable
Reserved	12 ~ 13	Reserved
PendSV	14	Configurable
SysTick	15	Configurable

Interrupt (IRQ0 ~ IRQ31)	16 ~ 47	Configurable
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Table 5-3 Exception Model

Vector Number	Interrupt Number (Bit In Interrupt Registers)	Interrupt Name	Source Module	Interrupt Description	Power-Down Wake-Up
1 ~ 15	-	-	-	System exceptions	-
16	0	<b>BOD_INT</b>	Brown-out	Brown-out low voltage detected interrupt	Yes
17	1	<b>WDT_INT</b>	WDT	Watchdog Timer interrupt	Yes
18	2	<b>EINT0</b>	GPIO	External signal interrupt from P3.2 pin	Yes
19	3	<b>EINT1</b>	GPIO	External signal interrupt from P3.3 pin	Yes
20	4	<b>P0/1_INT</b>	GPIO	External signal interrupt from P0[7:0]/P1[7:0]	Yes
21	5	<b>P2/3/4_INT</b>	GPIO	External signal interrupt from P2[7:0]/P3[7:0]/P4[7:0], except P3.2 and P3.3	Yes
22	6	<b>PWMA_INT</b>	PWM0~3	PWM0, PWM1, PWM2 and PWM3 interrupt	No
23	7	<b>PWMB_INT</b>	PWM4~7	PWM4, PWM5, PWM6 and PWM7 interrupt	No
24	8	<b>TMR0_INT</b>	TMR0	Timer0 interrupt	Yes
25	9	<b>TMR1_INT</b>	TMR1	Timer1 interrupt	Yes
26	10	<b>TMR2_INT</b>	TMR2	Timer2 interrupt	Yes
27	11	<b>TMR3_INT</b>	TMR3	Timer3 interrupt	Yes
28	12	<b>UART0_INT</b>	UART0	UART0 interrupt	Yes
29	13	<b>UART1_INT</b>	UART1	UART1 interrupt	Yes
30	14	<b>SPI0_INT</b>	SPI0	SPI0 interrupt	No
31	15	<b>SPI1_INT</b>	SPI1	SPI1 interrupt	No
32 ~ 33	16 ~ 17	-	-	Reserved	-
34	18	<b>I2C0_INT</b>	I <sup>2</sup> C0	I <sup>2</sup> C0 interrupt	Yes
35	19	<b>I2C1_INT</b>	I <sup>2</sup> C1	I <sup>2</sup> C1 interrupt	Yes
36 ~ 40	20 ~ 24	-	-	Reserved	-
41	25	<b>ACMP01_INT</b>	ACMP0/1	Analog Comparator0 or Comparator1 interrupt	Yes
42	26	<b>ACMP23_INT</b>	ACMP2/3	Analog Comparator2 or Comparator3 interrupt	Yes
43	27	-	-	Reserved	-
44	28	<b>PWRWU_INT</b>	CLKC	Clock controller interrupt for chip wake-up from Power-down state	Yes
45	29	<b>ADC_INT</b>	ADC	ADC interrupt	No
46 ~ 47	30 ~ 31	-	-	Reserved	-

Table 5-4 NuMicro® NUC029xAN System Interrupt Map

Vector Number	Interrupt Number (Bit In Interrupt Registers)	Interrupt Name	Source Module	Interrupt Description	Power-Down Wake-Up
1 ~ 15	-	-	-	System exceptions	-
16	0	<b>BOD_INT</b>	Brown-out	Brown-out low voltage detected interrupt	Yes
17	1	<b>WDT_INT</b>	WDT	Watchdog Timer interrupt	Yes
18	2	<b>EINT0</b>	GPIO	External signal interrupt from P3.2 pin	Yes
19	3	-	-	Reserved	-
20	4	<b>P0/1_INT</b>	GPIO	External signal interrupt from P0[7:0]/P1[7:0]	Yes
21	5	<b>P2/3/4_INT</b>	GPIO	External signal interrupt from P2[7:0]/P3[7:0]/P4[7:0], except P3.2	Yes
22	6	<b>PWM_INT</b>	PWM	PWM interrupt	No
23	7	<b>BRAKE_INT</b>	PWM	PWM interrupt	No
24	8	<b>TMR0_INT</b>	TMR0	Timer0 interrupt	Yes
25	9	<b>TMR1_INT</b>	TMR1	Timer1 interrupt	Yes
26 ~ 27	10 ~ 11	-	-	Reserved	-
28	12	<b>UART_INT</b>	UART	UART interrupt	Yes
29	13	-	-	Reserved	-
30	14	<b>SPI_INT</b>	SPI	SPI interrupt	No
31	15	-	-	Reserved	-
32	16	<b>GP5_INT</b>	GPIO	External signal interrupt from P5	Yes
33	17	<b>HIRC_TRIM_INT</b>	HIRC	HIRC trim interrupt	NO
34	18	<b>I2C_INT</b>	I <sup>2</sup> C	I <sup>2</sup> C interrupt	Yes
35 ~ 40	19 ~ 24	-	-	Reserved	-
41	25	<b>ACMP_INT</b>	ACMP	Analog Comparator interrupt	Yes
42 ~ 43	26 ~ 27	-	-	Reserved	-
44	28	<b>PWRWU_INT</b>	CLKC	Clock controller interrupt for chip wake-up from Power-down state	Yes
45	29	<b>ADC_INT</b>	ADC	ADC interrupt	No
46 ~ 47	30 ~ 31	-	-	Reserved	-

Table 5-5 NuMicro® NUC029FAE System Interrupt Map

### 5.2.11.2 Vector Table

When an interrupt is accepted, the processor will automatically fetch the starting address of the interrupt service routine (ISR) from a vector table in memory. For ARMv6-M, the vector table base address is fixed at 0x00000000. The vector table contains the initialization value for the stack pointer on reset, and the entry point addresses for all exception handlers. The vector number on previous page defines the order of entries in the vector table associated with exception handler entry as illustrated in previous section.

Vector Table Word Offset	Description
0	SP_main – The Main stack pointer
Vector Number	Exception Entry Pointer using that Vector Number

Table 5-6 Vector Table Format

### 5.2.11.3 Operation Description

NVIC interrupts can be enabled and disabled by writing to their corresponding Interrupt Set-Enable or Interrupt Clear-Enable register bit-field. The registers use a write-1-to-enable and write-1-to-clear policy, both registers reading back the current enabled state of the corresponding interrupts. When an interrupt is disabled, interrupt assertion will cause the interrupt to become Pending, however, the interrupt will not activate. If an interrupt is Active when it is disabled, it remains in its Active state until cleared by reset or an exception return. Clearing the enable bit prevents new activations of the associated interrupt.

NVIC interrupts can be pended/un-pended using a complementary pair of registers to those used to enable/disable the interrupts, named the Set-Pending Register and Clear-Pending Register respectively. The registers use a write-1-to-enable and write-1-to-clear policy, both registers reading back the current pended state of the corresponding interrupts. The Clear-Pending Register has no effect on the execution status of an Active interrupt.

NVIC interrupts are prioritized by updating an 8-bit field within a 32-bit register (each register supporting four interrupts).

The general registers associated with the NVIC are all accessible from a block of memory in the System Control Space and will be described in next section.

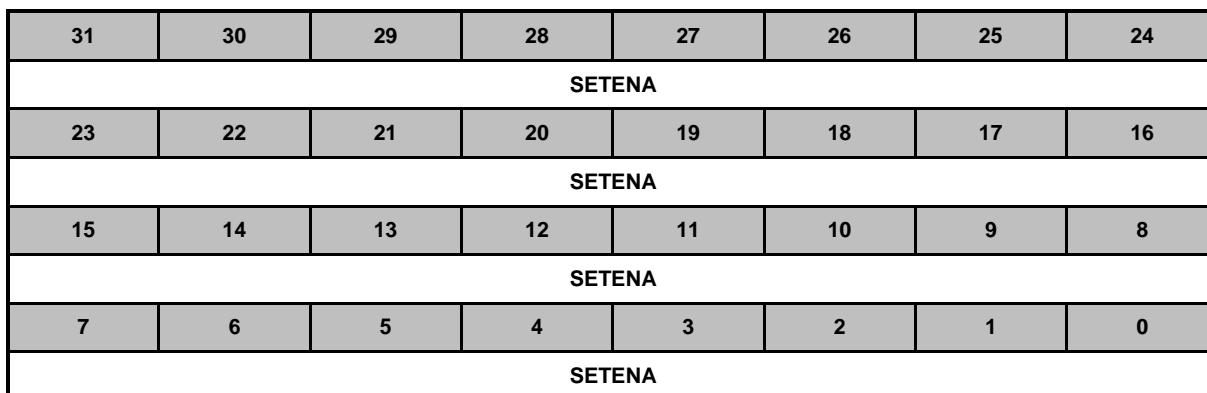
### 5.2.12 NVIC Control Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>NVIC Base Address:</b>				
<b>NVIC_BA = 0xE000_E100</b>				
<b>NVIC_ISER</b>	NVIC_BA+0x000	R/W	IRQ0 ~ IRQ31 Set-Enable Control Register	0x0000_0000
<b>NVIC_ICER</b>	NVIC_BA+0x080	R/W	IRQ0 ~ IRQ31 Clear-Enable Control Register	0x0000_0000
<b>NVIC_ISPR</b>	NVIC_BA+0x100	R/W	IRQ0 ~ IRQ31 Set-Pending Control Register	0x0000_0000
<b>NVIC_ICPR</b>	NVIC_BA+0x180	R/W	IRQ0 ~ IRQ31 Clear-Pending Control Register	0x0000_0000
<b>NVIC_IPR0</b>	NVIC_BA+0x300	R/W	IRQ0 ~ IRQ3 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR1</b>	NVIC_BA+0x304	R/W	IRQ4 ~ IRQ7 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR2</b>	NVIC_BA+0x308	R/W	IRQ8 ~ IRQ11 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR3</b>	NVIC_BA+0x30C	R/W	IRQ12 ~ IRQ15 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR4</b>	NVIC_BA+0x310	R/W	IRQ16 ~ IRQ19 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR5</b>	NVIC_BA+0x314	R/W	IRQ20 ~ IRQ23 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR6</b>	NVIC_BA+0x318	R/W	IRQ24 ~ IRQ27 Interrupt Priority Control Register	0x0000_0000
<b>NVIC_IPR7</b>	NVIC_BA+0x31C	R/W	IRQ28 ~ IRQ31 Interrupt Priority Control Register	0x0000_0000

IRQ0 ~ IRQ31 Set-Enable Control Register (NVIC\_ISER)

Register	Offset	R/W	Description				Reset Value
NVIC_ISER	NVIC_BA+0x000	R/W	IRQ0 ~ IRQ31 Set-Enable Control Register				0x0000_0000



Bits	Description	
[31:0]	<b>SETENA</b>	<p><b>Interrupt Enable Register</b></p> <p>Enable one or more interrupts. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Write:</p> <p>0 = No effect. 1 = Write 1 to enable associated interrupt.</p> <p>Read:</p> <p>0 = Associated interrupt status is Disabled. 1 = Associated interrupt status is Enabled.</p> <p>Read value indicates the current enable status.</p>

IRQ0 ~ IRQ31 Clear-Enable Control Register (NVIC\_ICER)

Register	Offset	R/W	Description					Reset Value
NVIC_ICER	NVIC_BA+0x080	R/W	IRQ0 ~ IRQ31 Clear-Enable Control Register					0x0000_0000

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

Bits	Description	
[31:0]	CLRENA	<p><b>Interrupt Disable Register</b></p> <p>Disable one or more interrupts. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to disable associated interrupt.</p> <p>Read:</p> <p>0 = Associated interrupt status is Disabled.</p> <p>1 = Associated interrupt status is Enabled.</p> <p>Read value indicates the current enable status.</p>

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC\_ISPR)

Register	Offset	R/W	Description				Reset Value
NVIC_ISPR	NVIC_BA+0x100	R/W	IRQ0 ~ IRQ31 Set-Pending Control Register				0x0000_0000

31	30	29	28	27	26	25	24
<b>SETPEND</b>							
23	22	21	20	19	18	17	16
<b>SETPEND</b>							
15	14	13	12	11	10	9	8
<b>SETPEND</b>							
7	6	5	4	3	2	1	0
<b>SETPEND</b>							

Bits	Description	
[31:0]	<b>SETPEND</b>	<p><b>Set Interrupt Pending Register</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to set pending state. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Read:</p> <p>0 = Associated interrupt is not in pending status.</p> <p>1 = Associated interrupt is in pending status.</p> <p>Read value indicates the current pending status.</p>

IRQ0 ~ IRQ31 Clear-Pending Control Register (NVIC\_ICPR)

Register	Offset	R/W	Description					Reset Value
NVIC_ICPR	NVIC_BA+0x180	R/W	IRQ0 ~ IRQ31 Clear-Pending Control Register					0x0000_0000

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

Bits	Description	
[31:0]	CLRPEND	<p><b>Clear Interrupt Pending Register</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to clear pending state. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Read:</p> <p>0 = Associated interrupt is not in pending status.</p> <p>1 = Associated interrupt is in pending status.</p> <p>Read value indicates the current pending status.</p>

IRQ0 ~ IRQ3 Interrupt Priority Register (NVIC\_IPR0)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR0	NVIC_BA+0x300	R/W	IRQ0 ~ IRQ3 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_3								Reserved
23	22	21	20	19	18	17	16	
PRI_2								Reserved
15	14	13	12	11	10	9	8	
PRI_1								Reserved
7	6	5	4	3	2	1	0	
PRI_0								Reserved

Bits	Description	
[31:30]	<b>PRI_3</b>	<b>Priority Of IRQ3</b> “0” denotes the highest priority and “3” denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_2</b>	<b>Priority Of IRQ2</b> “0” denotes the highest priority and “3” denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_1</b>	<b>Priority Of IRQ1</b> “0” denotes the highest priority and “3” denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_0</b>	<b>Priority Of IRQ0</b> “0” denotes the highest priority and “3” denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ4 ~ IRQ7 Interrupt Priority Register (NVIC\_IPR1)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR1	NVIC_BA+0x304	R/W	IRQ4 ~ IRQ7 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_7								Reserved
23	22	21	20	19	18	17	16	
PRI_6								Reserved
15	14	13	12	11	10	9	8	
PRI_5								Reserved
7	6	5	4	3	2	1	0	
PRI_4								Reserved

Bits	Description	
[31:30]	<b>PRI_7</b>	<b>Priority Of IRQ7</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_6</b>	<b>Priority Of IRQ6</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_5</b>	<b>Priority Of IRQ5</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_4</b>	<b>Priority Of IRQ4</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ8 ~ IRQ11 Interrupt Priority Register (NVIC\_IPR2)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR2	NVIC_BA+0x308	R/W	IRQ8 ~ IRQ11 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_11								Reserved
23	22	21	20	19	18	17	16	
PRI_10								Reserved
15	14	13	12	11	10	9	8	
PRI_9								Reserved
7	6	5	4	3	2	1	0	
PRI_8								Reserved

Bits	Description	
[31:30]	<b>PRI_11</b>	<b>Priority Of IRQ11</b> “0” denotes the highest priority and “3” denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_10</b>	<b>Priority Of IRQ10</b> “0” denotes the highest priority and “3” denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_9</b>	<b>Priority Of IRQ9</b> “0” denotes the highest priority and “3” denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_8</b>	<b>Priority Of IRQ8</b> “0” denotes the highest priority and “3” denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ12 ~ IRQ15 Interrupt Priority Register (NVIC\_IPR3)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR3	NVIC_BA+0x30C	R/W	IRQ12 ~ IRQ15 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_15								Reserved
23	22	21	20	19	18	17	16	
PRI_14								Reserved
15	14	13	12	11	10	9	8	
PRI_13								Reserved
7	6	5	4	3	2	1	0	
PRI_12								Reserved

Bits	Description	
[31:30]	<b>PRI_15</b>	<b>Priority Of IRQ15</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_14</b>	<b>Priority Of IRQ14</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_13</b>	<b>Priority Of IRQ13</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_12</b>	<b>Priority Of IRQ12</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ16 ~ IRQ19 Interrupt Priority Register (NVIC\_IPR4)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR4	NVIC_BA+0x310	R/W	IRQ16 ~ IRQ19 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24
PRI_19						Reserved	
23	22	21	20	19	18	17	16
PRI_18						Reserved	
15	14	13	12	11	10	9	8
PRI_17						Reserved	
7	6	5	4	3	2	1	0
PRI_16						Reserved	

Bits	Description	
[31:30]	<b>PRI_19</b>	<b>Priority Of IRQ19</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_18</b>	<b>Priority Of IRQ18</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_17</b>	<b>Priority Of IRQ17</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_16</b>	<b>Priority Of IRQ16</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ20 ~ IRQ23 Interrupt Priority Register (NVIC\_IPR5)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR5	NVIC_BA+0x314	R/W	IRQ20 ~ IRQ23 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_23								Reserved
23	22	21	20	19	18	17	16	
PRI_22								Reserved
15	14	13	12	11	10	9	8	
PRI_21								Reserved
7	6	5	4	3	2	1	0	
PRI_20								Reserved

Bits	Description	
[31:30]	<b>PRI_23</b>	<b>Priority Of IRQ23</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_22</b>	<b>Priority Of IRQ22</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_21</b>	<b>Priority Of IRQ21</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_20</b>	<b>Priority Of IRQ20</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ24 ~ IRQ27 Interrupt Priority Register (NVIC\_IPR6)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR6	NVIC_BA+0x318	R/W	IRQ24 ~ IRQ27 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24
PRI_27					Reserved		
23	22	21	20	19	18	17	16
PRI_26					Reserved		
15	14	13	12	11	10	9	8
PRI_25					Reserved		
7	6	5	4	3	2	1	0
PRI_24					Reserved		

Bits	Description	
[31:30]	<b>PRI_27</b>	<b>Priority Of IRQ27</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_26</b>	<b>Priority Of IRQ26</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_25</b>	<b>Priority Of IRQ25</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_24</b>	<b>Priority Of IRQ24</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ28 ~ IRQ31 Interrupt Priority Register (NVIC\_IPR7)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR7	NVIC_BA+0x31C	R/W	IRQ28 ~ IRQ31 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24
PRI_31						Reserved	
23	22	21	20	19	18	17	16
PRI_30						Reserved	
15	14	13	12	11	10	9	8
PRI_29						Reserved	
7	6	5	4	3	2	1	0
PRI_28						Reserved	

Bits	Description	
[31:30]	<b>PRI_31</b>	<b>Priority Of IRQ31</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_30</b>	<b>Priority Of IRQ30</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_29</b>	<b>Priority Of IRQ29</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_28</b>	<b>Priority Of IRQ28</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

### Interrupt Source Control Registers

Besides the interrupt control registers associated with the NVIC, the NuMicro® NUC029xAN also implements some specific control registers to facilitate the interrupt functions, including “interrupt source identification”, “NMI source selection” and “interrupt test mode”, which are described below.

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>INT Base Address:</b>				
<b>INT_BA = 0x5000_0300</b>				
IRQ0_SRC	INT_BA+0x00	R	IRQ0 (BOD) Interrupt Source Identity	0XXXXX_XXXX
IRQ1_SRC	INT_BA+0x04	R	IRQ1 (WDT) Interrupt Source Identity	0XXXXX_XXXX
IRQ2_SRC	INT_BA+0x08	R	IRQ2 (EINT0) Interrupt Source Identity	0XXXXX_XXXX
IRQ3_SRC	INT_BA+0x0C	R	IRQ3 (EINT1) Interrupt Source Identity	0XXXXX_XXXX
IRQ4_SRC	INT_BA+0x10	R	IRQ4 (P0/1) Interrupt Source Identity	0XXXXX_XXXX
IRQ5_SRC	INT_BA+0x14	R	IRQ5 (P2/3/4) Interrupt Source Identity	0XXXXX_XXXX
IRQ6_SRC	INT_BA+0x18	R	IRQ6 (PWMA) Interrupt Source Identity	0XXXXX_XXXX
IRQ7_SRC	INT_BA+0x1C	R	IRQ7 (PWMB) Interrupt Source Identity	0XXXXX_XXXX
IRQ8_SRC	INT_BA+0x20	R	IRQ8 (TMR0) Interrupt Source Identity	0XXXXX_XXXX
IRQ9_SRC	INT_BA+0x24	R	IRQ9 (TMR1) Interrupt Source Identity	0XXXXX_XXXX
IRQ10_SRC	INT_BA+0x28	R	IRQ10 (TMR2) Interrupt Source Identity	0XXXXX_XXXX
IRQ11_SRC	INT_BA+0x2C	R	IRQ11 (TMR3) Interrupt Source Identity	0XXXXX_XXXX
IRQ12_SRC	INT_BA+0x30	R	IRQ12 (UART0) Interrupt Source Identity	0XXXXX_XXXX
IRQ13_SRC	INT_BA+0x34	R	IRQ13 (UART1) Interrupt Source Identity	0XXXXX_XXXX
IRQ14_SRC	INT_BA+0x38	R	IRQ14 (SPI0) Interrupt Source Identity	0XXXXX_XXXX
IRQ15_SRC	INT_BA+0x3C	R	IRQ15 (SPI1) Interrupt Source Identity	0XXXXX_XXXX
IRQ16_SRC	INT_BA+0x40	-	Reserved.	0XXXXX_XXXX
IRQ17_SRC	INT_BA+0x44	-	Reserved.	0XXXXX_XXXX
IRQ18_SRC	INT_BA+0x48	R	IRQ18 (I <sup>2</sup> C0) Interrupt Source Identity	0XXXXX_XXXX
IRQ19_SRC	INT_BA+0x4C	R	IRQ19 (I <sup>2</sup> C1) Interrupt Source Identity	0XXXXX_XXXX
IRQ20_SRC	INT_BA+0x50	-	Reserved.	0XXXXX_XXXX
IRQ21_SRC	INT_BA+0x54	-	Reserved.	0XXXXX_XXXX
IRQ22_SRC	INT_BA+0x58	-	Reserved.	0XXXXX_XXXX
IRQ23_SRC	INT_BA+0x5C	-	Reserved.	0XXXXX_XXXX

<b>IRQ24_SRC</b>	INT_BA+0x60	-	Reserved.	0XXXXX_XXXX
<b>IRQ25_SRC</b>	INT_BA+0x64	R	IRQ25 (ACMP01) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ26_SRC</b>	INT_BA+0x68	R	IRQ26 (ACMP23) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ27_SRC</b>	INT_BA+0x6C	-	Reserved.	0XXXXX_XXXX
<b>IRQ28_SRC</b>	INT_BA+0x70	R	IRQ28 (PWRWU) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ29_SRC</b>	INT_BA+0x74	R	IRQ29 (ADC) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ30_SRC</b>	INT_BA+0x78	-	Reserved.	0XXXXX_XXXX
<b>IRQ31_SRC</b>	INT_BA+0x7C	-	Reserved.	0XXXXX_XXXX
<b>NMI_SEL</b>	INT_BA+0x80	R/W	NMI Source Interrupt Select Control Register	0x0000_0000

**IRQ0 (BOD) Interrupt Source Identity Register (IRQ0\_SRC)**

Register	Offset	R/W	Description					Reset Value
IRQ0_SRC	INT_BA+0x00	R	IRQ0 (BOD) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ0 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ0 source is not from BOD interrupt (BOD_INT). 1 = IRQ0 source is from BOD interrupt (BOD_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ1 (WDT) Interrupt Source Identity Register (IRQ1\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ1_SRC	INT_BA+0x04	R	IRQ1 (WDT) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ1 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ1 source is not from watchdog interrupt (WDT_INT). 1 = IRQ1 source is from watchdog interrupt (WDT_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ2 (EINT0) Interrupt Source Identity Register (IRQ2\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ2_SRC	INT_BA+0x08	R	IRQ2 (EINT0) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ2 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ2 source is not from external signal interrupt 0 – P3.2 (EINT0). 1 = IRQ2 source is from external signal interrupt 0 – P3.2 (EINT0). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ3 (EINT1) Interrupt Source Identity Register (IRQ3\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ3_SRC	INT_BA+0x0C	R	IRQ3 (EINT1) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ3 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ3 source is not from external signal interrupt 1 – P3.3 (EINT1).</p> <p>1 = IRQ3 source is from external signal interrupt 1 – P3.3 (EINT1).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ4 (P0/1) Interrupt Source Identity Register (IRQ4\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ4_SRC	INT_BA+0x10	R	IRQ4 (P0/1) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ4 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1]: 0 = IRQ4 source is not from P1 interrupt (P1_INT). 1 = IRQ4 source is from P1 interrupt (P1_INT). INT_SRC[0]: 0 = IRQ4 source is not from P0 interrupt (P0_INT). 1 = IRQ4 source is from P0 interrupt (P0_INT). <b>Note1:</b> IRQ4 source can be from multiple interrupt sources at the same time. <b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ5 (P2/3/4) Interrupt Source Identity Register (IRQ5\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ5_SRC	INT_BA+0x14	R	IRQ5 (P2/3/4) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ5 Source Identity</b></p> <p>INT_SRC[2]:</p> <p>0 = IRQ5 source is not from P4 interrupt (P4_INT).      1 = IRQ5 source is from P4 interrupt (P4_INT).</p> <p>INT_SRC[1]:</p> <p>0 = IRQ5 source is not from P3 interrupt (P3_INT).      1 = IRQ5 source is from P3 interrupt (P3_INT).</p> <p>INT_SRC[0]:</p> <p>0 = IRQ5 source is not from P2 interrupt (P2_INT).      1 = IRQ5 source is from P2 interrupt (P2_INT).</p> <p><b>Note1:</b> IRQ5 source can be from multiple interrupt sources at the same time.</p> <p><b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ6 (PWMA) Interrupt Source Identity Register (IRQ6\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ6_SRC	INT_BA+0x18	R	IRQ6 (PWMA) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[3:0]	<p><b>INT_SRC</b></p> <p><b>IRQ6 Source Identity</b></p> <p>INT_SRC[3]:</p> <p>0 = IRQ6 source is not from PWM3(PWMA channel 3) interrupt (PWM3_INT). 1 = IRQ6 source is from PWM3(PWMA channel 3) interrupt (PWM3_INT).</p> <p>INT_SRC[2]:</p> <p>0 = IRQ6 source is not from PWM2(PWMA channel 2) interrupt (PWM2_INT). 1 = IRQ6 source is from PWM2(PWMA channel 2) interrupt (PWM2_INT).</p> <p>INT_SRC[1]:</p> <p>0 = IRQ6 source is not from PWM1(PWMA channel 1) interrupt (PWM1_INT). 1 = IRQ6 source is from PWM1(PWMA channel 1) interrupt (PWM1_INT).</p> <p>INT_SRC[0]:</p> <p>0 = IRQ6 source is not from PWM0(PWMA channel 0) interrupt (PWM0_INT). 1 = IRQ6 source is from PWM0(PWMA channel 0) interrupt (PWM0_INT).</p> <p><b>Note1:</b> IRQ6 source can be from multiple interrupt sources at the same time.</p> <p><b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ7 (PWMB) Interrupt Source Identity Register (IRQ7\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ7_SRC	INT_BA+0x1C	R	IRQ7 (PWMB) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[3:0]	<p><b>IRQ7 Source Identity</b></p> <p><b>INT_SRC[3]:</b> 0 = IRQ7 source is not from PWM7(PWMB channel 3) interrupt (PWM7_INT). 1 = IRQ7 source is from PWM7(PWMB channel 3) interrupt (PWM7_INT).</p> <p><b>INT_SRC[2]:</b> 0 = IRQ7 source is not from PWM6(PWMB channel 2) interrupt (PWM6_INT). 1 = IRQ7 source is from PWM6(PWMB channel 2) interrupt (PWM6_INT).</p> <p><b>INT_SRC[1]:</b> 0 = IRQ7 source is not from PWM5(PWMB channel 1) interrupt (PWM5_INT). 1 = IRQ7 source is from PWM5(PWMB channel 1) interrupt (PWM5_INT).</p> <p><b>INT_SRC[0]:</b> 0 = IRQ7 source is not from PWM4(PWMB channel 0) interrupt (PWM4_INT). 1 = IRQ7 source is from PWM4(PWMB channel 0) interrupt (PWM4_INT).</p> <p><b>Note1:</b> IRQ7 source can be from multiple interrupt sources at the same time.</p> <p><b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ8 (TMR0) Interrupt Source Identity Register (IRQ8\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ8_SRC	INT_BA+0x20	R	IRQ8 (TMR0) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ8 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ8 source is not from Timer0 interrupt (TMR0_INT). 1 = IRQ8 source is from Timer0 interrupt (TMR0_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ9 (TMR1) Interrupt Source Identity Register (IRQ9\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ9_SRC	INT_BA+0x24	R	IRQ9 (TMR1) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ9 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ9 source is not from Timer1 interrupt (TMR1_INT). 1 = IRQ9 source is from Timer1 interrupt (TMR1_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ10 (TMR2) Interrupt Source Identity Register (IRQ10\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ10_SRC	INT_BA+0x28	R	IRQ10 (TMR2) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ10 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ10 source is not from Timer2 interrupt (TMR2_INT). 1 = IRQ10 source is from Timer2 interrupt (TMR2_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ11 (TMR3) Interrupt Source Identity Register (IRQ11\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ11_SRC	INT_BA+0x2C	R	IRQ11 (TMR3) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ11 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ11 source is not from Timer3 interrupt (TMR3_INT).</p> <p>1 = IRQ11 source is from Timer3 interrupt (TMR3_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ12 (UART0) Interrupt Source Identity Register (IRQ12\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ12_SRC	INT_BA+0x30	R	IRQ12 (UART0) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ12 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ12 source is not from UART0 interrupt (UART0_INT). 1 = IRQ12 source is from UART0 interrupt (UART0_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ13 (UART1) Interrupt Source Identity Register (IRQ13\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ13_SRC	INT_BA+0x34	R	IRQ13 (UART1) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ13 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ13 source is not from UART1 interrupt (UART1_INT). 1 = IRQ13 source is from UART1 interrupt (UART1_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ14 (SPI0) Interrupt Source Identity Register (IRQ14\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ14_SRC	INT_BA+0x38	R	IRQ14 (SPI0) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ14 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ14 source is not from SPI0 interrupt (SPI0_INT). 1 = IRQ14 source is from SPI0 interrupt (SPI0_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ15 (SPI1) Interrupt Source Identity Register (IRQ15\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ15_SRC	INT_BA+0x3C	R	IRQ15 (SPI1) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ15 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ15 source is not from SPI1 interrupt (SPI1_INT). 1 = IRQ15 source is from SPI1 interrupt (SPI1_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ18 (I<sup>2</sup>C0) Interrupt Source Identity Register (IRQ18\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ18_SRC	INT_BA+0x48	R	IRQ18 (I <sup>2</sup> C0) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ18 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ18 source is not from I <sup>2</sup> C0 interrupt (I2C0_INT). 1 = IRQ18 source is from I <sup>2</sup> C0 interrupt (I2C0_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

**IRQ19 (I<sup>2</sup>C1) Interrupt Source Identity Register (IRQ19\_SRC)**

Register	Offset	R/W	Description				Reset Value
IRQ19_SRC	INT_BA+0x4C	R	IRQ19 (I <sup>2</sup> C1) Interrupt Source Identity				0XXXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ19 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ19 source is not from I<sup>2</sup>C1 interrupt (I2C1_INT).</p> <p>1 = IRQ19 source is from I<sup>2</sup>C1 interrupt (I2C1_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ25 (ACMP01) Interrupt Source Identity Register (IRQ25\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ25_SRC	INT_BA+0x64	R	IRQ25 (ACMP01) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ25 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ25 source is not from ACMP01 interrupt (ACMP01_INT). 1 = IRQ25 source is from ACMP01 interrupt (ACMP01_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

**IRQ26 (ACMP23) Interrupt Source Identity Register (IRQ26\_SRC)**

Register	Offset	R/W	Description					Reset Value
IRQ26_SRC	INT_BA+0x68	R	IRQ26 (ACMP23) Interrupt Source Identity					0XXXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ26 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ26 source is not from ACMP23 interrupt (ACMP23_INT).</p> <p>1 = IRQ26 source is from ACMP23 interrupt (ACMP23_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ28 (PWRWU) Interrupt Source Identity Register (IRQ28\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ28_SRC	INT_BA+0x70	R	IRQ28 (PWRWU) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ28 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ28 source is not from Power-down mode Wake-up interrupt (PWRWU_INT). 1 = IRQ28 source is from Power-down mode Wake-up interrupt interrupt (PWRWU_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ29 (ADC) Interrupt Source Identity Register (IRQ29\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ29_SRC	INT_BA+0x74	R	IRQ29 (ADC) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ29 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ29 source is not from ADC interrupt (ADC_INT). 1 = IRQ29 source is from ADC interrupt (ADC_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

NMI Interrupt Source Select Control Register (NMI\_SEL)

Register	Offset	R/W	Description				Reset Value
NMI_SEL	INT_BA+0x80	R/W	NMI Source Interrupt Select Control Register				0x0000_0000

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

Bits	Description	
[31:9]	Reserved	Reserved.
[8]	NMI_EN	<p><b>NMI Interrupt Enable Control (Write Protect)</b>            1 = NMI interrupt Enabled.            0 = NMI interrupt Disabled.</p> <p><b>Note:</b> This bit is the protected bit and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Reference the register REGWRPROT at address GCR_BA+0x100</p>
[7:5]	Reserved	Reserved.
[4:0]	NMI_SEL	<p><b>NMI Interrupt Source Selection</b>            The NMI interrupt to Cortex®-M0 can be selected from one of the peripheral interrupt by setting NMI_SEL.</p>

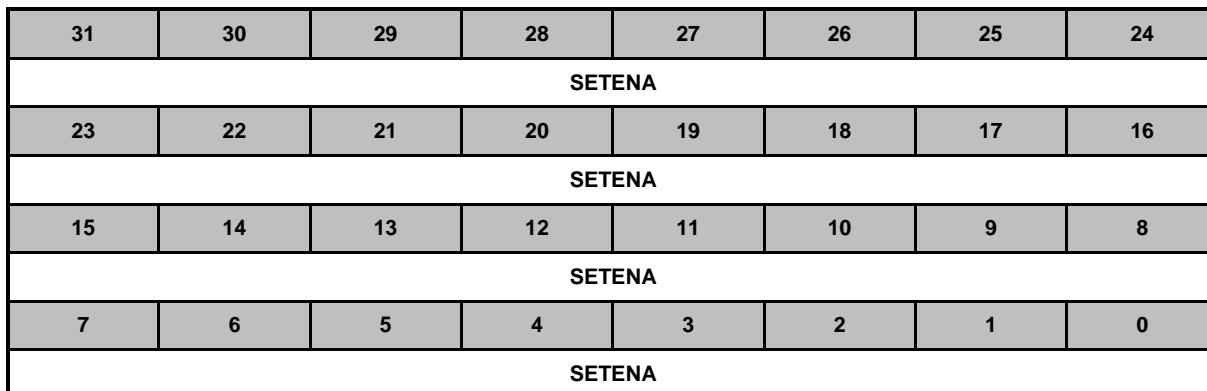
### 5.2.13 NVIC Control Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SCS Base Address:</b>				
<b>SCS_BA = 0xE000_E000</b>				
NVIC_ISER	SCS_BA+0x100	R/W	IRQ0 ~ IRQ31 Set-Enable Control Register	0x0000_0000
NVIC_ICER	SCS_BA+0x180	R/W	IRQ0 ~ IRQ31 Clear-Enable Control Register	0x0000_0000
NVIC_ISPR	SCS_BA+0x200	R/W	IRQ0 ~ IRQ31 Set-Pending Control Register	0x0000_0000
NVIC_ICPR	SCS_BA+0x280	R/W	IRQ0 ~ IRQ31 Clear-Pending Control Register	0x0000_0000
NVIC_IPR0	SCS_BA+0x400	R/W	IRQ0 ~ IRQ3 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR1	SCS_BA+0x404	R/W	IRQ4 ~ IRQ7 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR2	SCS_BA+0x408	R/W	IRQ8 ~ IRQ11 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR3	SCS_BA+0x40C	R/W	IRQ12 ~ IRQ15 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR4	SCS_BA+0x410	R/W	IRQ16 ~ IRQ19 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR5	SCS_BA+0x414	R/W	IRQ20 ~ IRQ23 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR6	SCS_BA+0x418	R/W	IRQ24 ~ IRQ27 Interrupt Priority Control Register	0x0000_0000
NVIC_IPR7	SCS_BA+0x41C	R/W	IRQ28 ~ IRQ31 Interrupt Priority Control Register	0x0000_0000

IRQ0 ~ IRQ31 Set-Enable Control Register (NVIC\_ISER)

Register	Offset	R/W	Description				Reset Value
NVIC_ISER	SCS_BA+0x100	R/W	IRQ0 ~ IRQ31 Set-Enable Control Register				0x0000_0000



Bits	Description	
[31:0]	<b>SETENA</b>	<p><b>Interrupt Enable Register</b></p> <p>Enable one or more interrupts. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to enable associated interrupt.</p> <p>Read:</p> <p>0 = Associated interrupt status is Disabled.</p> <p>1 = Associated interrupt status is Enabled.</p> <p>Read value indicates the current enable status.</p>

IRQ0 ~ IRQ31 Clear-Enable Control Register (NVIC\_ICER)

Register	Offset	R/W	Description					Reset Value
NVIC_ICER	SCS_BA+0x180	R/W	IRQ0 ~ IRQ31 Clear-Enable Control Register					0x0000_0000

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

Bits	Description	
[31:0]	CLRENA	<p><b>Interrupt Disable Register</b></p> <p>Disable one or more interrupts. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to disable associated interrupt.</p> <p>Read:</p> <p>0 = Associated interrupt status is Disabled.</p> <p>1 = Associated interrupt status is Enabled.</p> <p>Read value indicates the current enable status.</p>

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC\_ISPR)

Register	Offset	R/W	Description				Reset Value
NVIC_ISPR	SCS_BA+0x200	R/W	IRQ0 ~ IRQ31 Set-Pending Control Register				0x0000_0000

31	30	29	28	27	26	25	24
<b>SETPEND</b>							
23	22	21	20	19	18	17	16
<b>SETPEND</b>							
15	14	13	12	11	10	9	8
<b>SETPEND</b>							
7	6	5	4	3	2	1	0
<b>SETPEND</b>							

Bits	Description	
[31:0]	<b>SETPEND</b>	<p><b>Set Interrupt Pending Register</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to set pending state. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Read:</p> <p>0 = Associated interrupt is not in pending status.</p> <p>1 = Associated interrupt is in pending status.</p> <p>Read value indicates the current pending status.</p>

IRQ0 ~ IRQ31 Clear-Pending Control Register (NVIC\_ICPR)

Register	Offset	R/W	Description					Reset Value
NVIC_ICPR	SCS_BA+0x280	R/W	IRQ0 ~ IRQ31 Clear-Pending Control Register					0x0000_0000

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

Bits	Description	
[31:0]	CLRPEND	<p><b>Clear Interrupt Pending Register</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Write 1 to clear pending state. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Read:</p> <p>0 = Associated interrupt is not in pending status.</p> <p>1 = Associated interrupt is in pending status.</p> <p>Read value indicates the current pending status.</p>

IRQ0 ~ IRQ3 Interrupt Priority Register (NVIC\_IPR0)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR0	SCS_BA+0x400	R/W	IRQ0 ~ IRQ3 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_3								Reserved
23	22	21	20	19	18	17	16	
PRI_2								Reserved
15	14	13	12	11	10	9	8	
PRI_1								Reserved
7	6	5	4	3	2	1	0	
PRI_0								Reserved

Bits	Description	
[31:30]	<b>PRI_3</b>	<b>Priority Of IRQ3</b> “0” denotes the highest priority and “3” denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_2</b>	<b>Priority Of IRQ2</b> “0” denotes the highest priority and “3” denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_1</b>	<b>Priority Of IRQ1</b> “0” denotes the highest priority and “3” denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_0</b>	<b>Priority Of IRQ0</b> “0” denotes the highest priority and “3” denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ4 ~ IRQ7 Interrupt Priority Register (NVIC\_IPR1)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR1	SCS_BA+0x404	R/W	IRQ4 ~ IRQ7 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_7								Reserved
23	22	21	20	19	18	17	16	
PRI_6								Reserved
15	14	13	12	11	10	9	8	
PRI_5								Reserved
7	6	5	4	3	2	1	0	
PRI_4								Reserved

Bits	Description	
[31:30]	<b>PRI_7</b>	<b>Priority Of IRQ7</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_6</b>	<b>Priority Of IRQ6</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_5</b>	<b>Priority Of IRQ5</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_4</b>	<b>Priority Of IRQ4</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ8 ~ IRQ11 Interrupt Priority Register (NVIC\_IPR2)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR2	SCS_BA+0x408	R/W	IRQ8 ~ IRQ11 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_11								Reserved
23	22	21	20	19	18	17	16	
PRI_10								Reserved
15	14	13	12	11	10	9	8	
PRI_9								Reserved
7	6	5	4	3	2	1	0	
PRI_8								Reserved

Bits	Description	
[31:30]	<b>PRI_11</b>	<b>Priority Of IRQ11</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_10</b>	<b>Priority Of IRQ10</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_9</b>	<b>Priority Of IRQ9</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_8</b>	<b>Priority Of IRQ8</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ12 ~ IRQ15 Interrupt Priority Register (NVIC\_IPR3)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR3	SCS_BA+0x40C	R/W	IRQ12 ~ IRQ15 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_15								Reserved
23	22	21	20	19	18	17	16	
PRI_14								Reserved
15	14	13	12	11	10	9	8	
PRI_13								Reserved
7	6	5	4	3	2	1	0	
PRI_12								Reserved

Bits	Description	
[31:30]	<b>PRI_15</b>	<b>Priority Of IRQ15</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_14</b>	<b>Priority Of IRQ14</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_13</b>	<b>Priority Of IRQ13</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_12</b>	<b>Priority Of IRQ12</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ16 ~ IRQ19 Interrupt Priority Register (NVIC\_IPR4)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR4	SCS_BA+0x410	R/W	IRQ16 ~ IRQ19 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24
PRI_19						Reserved	
23	22	21	20	19	18	17	16
PRI_18						Reserved	
15	14	13	12	11	10	9	8
PRI_17						Reserved	
7	6	5	4	3	2	1	0
PRI_16						Reserved	

Bits	Description	
[31:30]	<b>PRI_19</b>	<b>Priority Of IRQ19</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_18</b>	<b>Priority Of IRQ18</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_17</b>	<b>Priority Of IRQ17</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_16</b>	<b>Priority Of IRQ16</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ20 ~ IRQ23 Interrupt Priority Register (NVIC\_IPR5)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR5	SCS_BA+0x414	R/W	IRQ20 ~ IRQ23 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
PRI_23								Reserved
23	22	21	20	19	18	17	16	
PRI_22								Reserved
15	14	13	12	11	10	9	8	
PRI_21								Reserved
7	6	5	4	3	2	1	0	
PRI_20								Reserved

Bits	Description	
[31:30]	<b>PRI_23</b>	<b>Priority Of IRQ23</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_22</b>	<b>Priority Of IRQ22</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_21</b>	<b>Priority Of IRQ21</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_20</b>	<b>Priority Of IRQ20</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ24 ~ IRQ27 Interrupt Priority Register (NVIC\_IPR6)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR6	SCS_BA+0x418	R/W	IRQ24 ~ IRQ27 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24	
<b>PRI_27</b>		Reserved						
23	22	21	20	19	18	17	16	
<b>PRI_26</b>		Reserved						
15	14	13	12	11	10	9	8	
<b>PRI_25</b>		Reserved						
7	6	5	4	3	2	1	0	
<b>PRI_24</b>		Reserved						

Bits	Description	
[31:30]	<b>PRI_27</b>	<b>Priority Of IRQ27</b> “0” denotes the highest priority and “3” denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_26</b>	<b>Priority Of IRQ26</b> “0” denotes the highest priority and “3” denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_25</b>	<b>Priority Of IRQ25</b> “0” denotes the highest priority and “3” denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_24</b>	<b>Priority Of IRQ24</b> “0” denotes the highest priority and “3” denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

IRQ28 ~ IRQ31 Interrupt Priority Register (NVIC\_IPR7)

Register	Offset	R/W	Description					Reset Value
NVIC_IPR7	SCS_BA+0x41C	R/W	IRQ28 ~ IRQ31 Interrupt Priority Control Register					0x0000_0000

31	30	29	28	27	26	25	24
PRI_31						Reserved	
23	22	21	20	19	18	17	16
PRI_30						Reserved	
15	14	13	12	11	10	9	8
PRI_29						Reserved	
7	6	5	4	3	2	1	0
PRI_28						Reserved	

Bits	Description	
[31:30]	<b>PRI_31</b>	<b>Priority Of IRQ31</b> "0" denotes the highest priority and "3" denotes lowest priority.
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_30</b>	<b>Priority Of IRQ30</b> "0" denotes the highest priority and "3" denotes lowest priority.
[21:16]	<b>Reserved</b>	Reserved.
[15:14]	<b>PRI_29</b>	<b>Priority Of IRQ29</b> "0" denotes the highest priority and "3" denotes lowest priority.
[13:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PRI_28</b>	<b>Priority Of IRQ28</b> "0" denotes the highest priority and "3" denotes lowest priority.
[5:0]	<b>Reserved</b>	Reserved.

### Interrupt Source Control Registers

Besides the interrupt control registers associated with the NVIC, the NuMicro® NUC029xAN also implements some specific control registers to facilitate the interrupt functions, including “interrupt source identification”, “NMI source selection” and “interrupt test mode”, which are described below.

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>INT Base Address:</b>				
<b>INT_BA = 0x5000_0300</b>				
<b>IRQ0_SRC</b>	INT_BA+0x00	R	IRQ0 (BOD) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ1_SRC</b>	INT_BA+0x04	R	IRQ1 (WDT) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ2_SRC</b>	INT_BA+0x08	R	IRQ2 (EINT0) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ3_SRC</b>	INT_BA+0x0C	-	Reserved.	0XXXXX_XXXX
<b>IRQ4_SRC</b>	INT_BA+0x10	R	IRQ4 (P0/1) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ5_SRC</b>	INT_BA+0x14	R	IRQ5 (P2/3/4) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ6_SRC</b>	INT_BA+0x18	R	IRQ6 (PWM) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ7_SRC</b>	INT_BA+0x1C	R	IRQ7 (BRAKE) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ8_SRC</b>	INT_BA+0x20	R	IRQ8 (TMR0) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ9_SRC</b>	INT_BA+0x24	R	IRQ9 (TMR1) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ10_SRC</b>	INT_BA+0x28	-	Reserved.	0XXXXX_XXXX
<b>IRQ11_SRC</b>	INT_BA+0x2C	-	Reserved.	0XXXXX_XXXX
<b>IRQ12_SRC</b>	INT_BA+0x30	R	IRQ12 (UART) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ13_SRC</b>	INT_BA+0x34	-	Reserved.	0XXXXX_XXXX
<b>IRQ14_SRC</b>	INT_BA+0x38	R	IRQ14 (SPI) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ15_SRC</b>	INT_BA+0x3C	-	Reserved.	0XXXXX_XXXX
<b>IRQ16_SRC</b>	INT_BA+0x40	R	IRQ16 (P5) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ17_SRC</b>	INT_BA+0x44	R	IRQ17 (HIRC trim) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ18_SRC</b>	INT_BA+0x48	R	IRQ18 (I <sup>2</sup> C) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ19_SRC</b>	INT_BA+0x4C	-	Reserved.	0XXXXX_XXXX
<b>IRQ20_SRC</b>	INT_BA+0x50	-	Reserved.	0XXXXX_XXXX
<b>IRQ21_SRC</b>	INT_BA+0x54	-	Reserved.	0XXXXX_XXXX
<b>IRQ22_SRC</b>	INT_BA+0x58	-	Reserved.	0XXXXX_XXXX
<b>IRQ23_SRC</b>	INT_BA+0x5C	-	Reserved.	0XXXXX_XXXX

<b>IRQ24_SRC</b>	INT_BA+0x60	-	Reserved.	0XXXXX_XXXX
<b>IRQ25_SRC</b>	INT_BA+0x64	R	IRQ25 (ACMP) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ26_SRC</b>	INT_BA+0x68	-	Reserved.	0XXXXX_XXXX
<b>IRQ27_SRC</b>	INT_BA+0x6C	-	Reserved.	0XXXXX_XXXX
<b>IRQ28_SRC</b>	INT_BA+0x70	R	IRQ28 (PWRWU) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ29_SRC</b>	INT_BA+0x74	R	IRQ29 (ADC) Interrupt Source Identity	0XXXXX_XXXX
<b>IRQ30_SRC</b>	INT_BA+0x78	-	Reserved.	0XXXXX_XXXX
<b>IRQ31_SRC</b>	INT_BA+0x7C	-	Reserved.	0XXXXX_XXXX
<b>NMI_CON</b>	INT_BA+0x80	R/W	NMI Source Interrupt Select Control Register	0x0000_0000
<b>MCU_IRQ</b>	INT_BA+0x84	R/W	MCU IRQ Number Interrupt Identity Register	0x0000_0000

**IRQ0 (BOD) Interrupt Source Identity Register (IRQ0\_SRC)**

Register	Offset	R/W	Description				Reset Value
IRQ0_SRC	INT_BA+0x00	R	IRQ0 (BOD) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description	
[31:3]	Reserved	Reserved.
[2:0]	INT_SRC	<p><b>IRQ0 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ0 source is not from BOD interrupt (BOD_INT).</p> <p>1 = IRQ0 source is from BOD interrupt (BOD_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ1 (WDT) Interrupt Source Identity Register (IRQ1\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ1_SRC	INT_BA+0x04	R	IRQ1 (WDT) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[31:3]	Reserved	Reserved.
[2:0]	INT_SRC	<p><b>IRQ1 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ1 source is not from watchdog interrupt (WDT_INT).</p> <p>1 = IRQ1 source is from watchdog interrupt (WDT_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ2 (EINT0) Interrupt Source Identity Register (IRQ2\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ2_SRC	INT_BA+0x08	R	IRQ2 (EINT0) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ2 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ2 source is not from external signal interrupt 0 – P3.2 (EINT0). 1 = IRQ2 source is from external signal interrupt 0 – P3.2 (EINT0). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ4 (P0/1) Interrupt Source Identity Register (IRQ4\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ4_SRC	INT_BA+0x10	R	IRQ4 (P0/1) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ4 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1]:</p> <p>0 = IRQ4 source is not from P1 interrupt (P1_INT).</p> <p>1 = IRQ4 source is from P1 interrupt (P1_INT).</p> <p>INT_SRC[0]:</p> <p>0 = IRQ4 source is not from P0 interrupt (P0_INT).</p> <p>1 = IRQ4 source is from P0 interrupt (P0_INT).</p> <p><b>Note1:</b> IRQ4 source can be from multiple interrupt sources at the same time.</p> <p><b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ5 (P2/3/4) Interrupt Source Identity Register (IRQ5\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ5_SRC	INT_BA+0x14	R	IRQ5 (P2/3/4) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ5 Source Identity</b></p> <p>INT_SRC[2]:</p> <p>0 = IRQ5 source is not from P4 interrupt (P4_INT).      1 = IRQ5 source is from P4 interrupt (P4_INT).</p> <p>INT_SRC[1]:</p> <p>0 = IRQ5 source is not from P3 interrupt (P3_INT).      1 = IRQ5 source is from P3 interrupt (P3_INT).</p> <p>INT_SRC[0]:</p> <p>0 = IRQ5 source is not from P2 interrupt (P2_INT).      1 = IRQ5 source is from P2 interrupt (P2_INT).</p> <p><b>Note1:</b> IRQ5 source can be from multiple interrupt sources at the same time.</p> <p><b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

**IRQ6 (PWM) Interrupt Source Identity Register (IRQ6\_SRC)**

Register	Offset	R/W	Description					Reset Value
IRQ6_SRC	INT_BA+0x18	R	IRQ6 (PWM) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[3:0]	INT_SRC	<p><b>IRQ6 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ6 source is not from PWM interrupt (PWM_INT).</p> <p>1 = IRQ6 source is from PWM interrupt (PWM_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ7 (BRAKE) Interrupt Source Identity Register (IRQ7\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ7_SRC	INT_BA+0x1C	R	IRQ7 (BRAKE) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[3:0]	<b>INT_SRC</b> <b>IRQ7 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ7 source is not from BRAKE interrupt (BRAKE_INT). 1 = IRQ7 source is from BRAKE interrupt (BRAKE_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ8 (TMR0) Interrupt Source Identity Register (IRQ8\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ8_SRC	INT_BA+0x20	R	IRQ8 (TMR0) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ8 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ8 source is not from Timer0 interrupt (TMR0_INT). 1 = IRQ8 source is from Timer0 interrupt (TMR0_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ9 (TMR1) Interrupt Source Identity Register (IRQ9\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ9_SRC	INT_BA+0x24	R	IRQ9 (TMR1) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ9 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ9 source is not from Timer1 interrupt (TMR1_INT). 1 = IRQ9 source is from Timer1 interrupt (TMR1_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ12 (UART) Interrupt Source Identity Register (IRQ12\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ12_SRC	INT_BA+0x30	R	IRQ12 (UART) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ12 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ12 source is not from UART interrupt (UART_INT).</p> <p>1 = IRQ12 source is from UART interrupt (UART_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ14 (SPI) Interrupt Source Identity Register (IRQ14\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ14_SRC	INT_BA+0x38	R	IRQ14 (SPI) Interrupt Source Identity				0XXXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ14 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ14 source is not from SPI interrupt (SPI_INT). 1 = IRQ14 source is from SPI interrupt (SPI_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

**IRQ16 (P5) Interrupt Source Identity Register (IRQ16\_SRC)**

Register	Offset	R/W	Description				Reset Value
IRQ16_SRC	INT_BA+0x40	R	IRQ16 (P5) Interrupt Source Identity				0XXXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ16 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ16 source is not from P5 interrupt (P5_INT).</p> <p>1 = IRQ16 source is from P5 interrupt (P5_INT).</p> <p><b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

**IRQ17 (HIRC trim) Interrupt Source Identity Register (IRQ17\_SRC)**

Register	Offset	R/W	Description					Reset Value
IRQ17_SRC	INT_BA+0x44	R	IRQ17 (HIRC trim) Interrupt Source Identity					0xFFFF_FFFF

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

Bits	Description	
[2:0]	INT_SRC	<b>IRQ17 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ17 source is not from HIRC trim interrupt (HIRC_TRIM_INT). 1 = IRQ17 source is from HIRC trim interrupt (HIRC_TRIM_INT). <b>Note2:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

IRQ18 (I<sup>2</sup>C) Interrupt Source Identity Register (IRQ18\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ18_SRC	INT_BA+0x48	R	IRQ18 (I <sup>2</sup> C) Interrupt Source Identity				0XXXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ18 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ18 source is not from I <sup>2</sup> C interrupt (I2C_INT). 1 = IRQ18 source is from I <sup>2</sup> C interrupt (I2C_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

**IRQ25 (ACMP) Interrupt Source Identity Register (IRQ25\_SRC)**

Register	Offset	R/W	Description					Reset Value
IRQ25_SRC	INT_BA+0x64	R	IRQ25 (ACMP) Interrupt Source Identity					0xFFFF_FFFF

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ25 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ25 source is not from ACMP interrupt (ACMP_INT).</p> <p>1 = IRQ25 source is from ACMP interrupt (ACMP_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

## IRQ28 (PWRWU) Interrupt Source Identity Register (IRQ28\_SRC)

Register	Offset	R/W	Description					Reset Value
IRQ28_SRC	INT_BA+0x70	R	IRQ28 (PWRWU) Interrupt Source Identity					0XXXX_XXXX

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

Bits	Description	
[2:0]	INT_SRC	<p><b>IRQ28 Source Identity</b></p> <p>INT_SRC[2] = Reserved.</p> <p>INT_SRC[1] = Reserved.</p> <p>INT_SRC[0]:</p> <p>0 = IRQ28 source is not from Power-down mode Wake-up interrupt (PWRWU_INT).</p> <p>1 = IRQ28 source is from Power-down mode Wake-up interrupt interrupt (PWRWU_INT).</p> <p><b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.</p>

IRQ29 (ADC) Interrupt Source Identity Register (IRQ29\_SRC)

Register	Offset	R/W	Description				Reset Value
IRQ29_SRC	INT_BA+0x74	R	IRQ29 (ADC) Interrupt Source Identity				0XXXX_XXXX

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

Bits	Description
[2:0]	<b>INT_SRC</b> <b>IRQ29 Source Identity</b> INT_SRC[2] = Reserved. INT_SRC[1] = Reserved. INT_SRC[0]: 0 = IRQ29 source is not from ADC interrupt (ADC_INT). 1 = IRQ29 source is from ADC interrupt (ADC_INT). <b>Note:</b> When the interrupt flag is cleared, the corresponding bits will be cleared automatically.

**NMI Interrupt Source Select Control Register (NMI\_CON)**

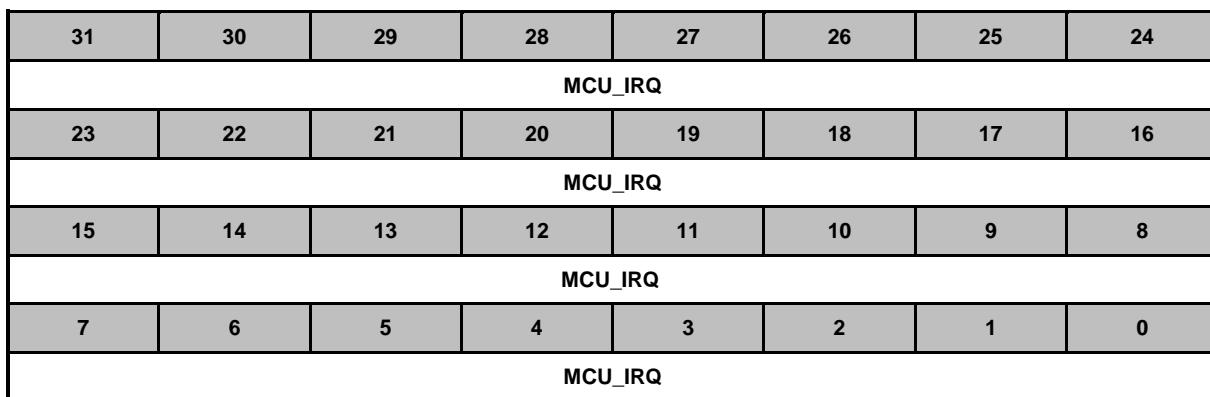
Register	Offset	R/W	Description				Reset Value
NMI_CON	INT_BA+0x80	R/W	NMI Source Interrupt Select Control Register				0x0000_0000

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

Bits	Description	
[31:9]	Reserved	Reserved.
[8]	NMI_SEL_EN	<p><b>NMI Interrupt Enable Control (Write Protect)</b>            1 = NMI interrupt Enabled.            0 = NMI interrupt Disabled.</p> <p><b>Note:</b> This bit is the protected bit and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Reference the register REGWRPROT at address GCR_BA+0x100</p>
[7:5]	Reserved	Reserved.
[4:0]	NMI_SEL	<p><b>NMI Interrupt Source Selection</b>            The NMI interrupt to Cortex®-M0 can be selected from one of the peripheral interrupt by setting NMI_SEL.</p>

**MCU Interrupt Source Control Register (MCU\_IRQ)**

Register	Offset	R/W	Description				Reset Value
MCU_IRQ	INT_BA+0x84	R/W	MCU IRQ Number Interrupt Identity Register				0x0000_0000



Bits	Description
[31:0]	<p><b>MCU IRQ Source</b></p> <p>The MCU_IRQ collects all the interrupts from the peripherals and generates the synchronous interrupt to Cortex®-M0 core. There are two modes to generate interrupt to Cortex®-M0 - the normal mode and test mode.</p> <p><b>MCU_IRQ[31:0]</b> The MCU_IRQ collects all interrupts from each peripheral and synchronizes them then interrupts the Cortex®-M0.</p> <p>When the MCU_IRQ[n] is 0, setting MCU_IRQ[n] to 1 will generate an interrupt to Cortex®-M0 NVIC[n].</p> <p>When the MCU_IRQ[n] is 1 (mean an interrupt is assert), setting 1 to the MCU_bit[n] will clear the interrupt and setting MCU_IRQ[n] 0 has no effect.</p>

### 5.2.14 System Control Block (SCB)

The Cortex®-M0 status and operation mode control are managed by System Control Registers, Including CPUID. Cortex®-M0 interrupt priority and Cortex®-M0 power management can be controlled through these system control registers.

For more detailed information, please refer to the “ARM® Cortex®-M0 Technical Reference Manual” and “ARM® v6-M Architecture Reference Manual”.

### 5.2.15 System Control Block Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SCB Base Address:</b>				
<b>SCB_BA = 0xE000_ED00</b>				
CPUID	SCB_BA+0x000	R	CPUID Register	0x410CC200
ICSR	SCB_BA+0x004	R/W	Interrupt Control State Register	0x0000_0000
AIRCR	SCB_BA+0x00C	R/W	Application Interrupt and Reset Control Register	0xFA05_0000
SCR	SCB_BA+0x010	R/W	System Control Register	0x0000_0000
SHPR2	SCB_BA+0x01C	R/W	System Handler Priority Register 2	0x0000_0000
SHPR3	SCB_BA+0x020	R/W	System Handler Priority Register 3	0x0000_0000

CPUID Base Register (CPUID)

Register	Offset	R/W	Description				Reset Value
CPUID	SCB_BA+0x000	R	CPUID Register				0x410CC200

31	30	29	28	27	26	25	24
<b>IMPLEMENTER</b>							
23	22	21	20	19	18	17	16
Reserved				<b>PART</b>			
15	14	13	12	11	10	9	8
<b>PARTNO</b>				<b>REVISION</b>			
7	6	5	4	3	2	1	0
PARTNO				REVISION			

Bits	Description	
[31:24]	<b>IMPLEMENTER</b>	<b>Implementer Code</b> Implementer code assigned by ARM®. ( ARM® = 0x41).
[23:20]	<b>Reserved</b>	Reserved.
[19:16]	<b>PART</b>	<b>Architecture Of The Processor</b> Read as 0xC for ARMv6-M parts.
[15:4]	<b>PARTNO</b>	<b>Part Number Of The Processor</b> Read as 0xC20.
[3:0]	<b>REVISION</b>	<b>Revision Number</b> Read as 0x0.

Interrupt Control State Register (ICSR)

Register	Offset	R/W	Description				Reset Value
ICSR	SCB_BA+0x004	R/W	Interrupt Control State Register				0x0000_0000

31	30	29	28	27	26	25	24
NMIPENDSET	Reserved		PENDSVSET	PENDSVCLR	PENDSTSET	PENDSTCLR	Reserved
23	22	21	20	19	18	17	16
ISRPREEMPT	ISR PENDING	Reserved				VECTPENDING	
15	14	13	12	11	10	9	8
VECTPENDING				Reserved			
7	6	5	4	3	2	1	0
Reserved		VECTACTIVE					

Bits	Description	
[31]	NMIPENDSET	<p><b>NMI Set-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Changes NMI exception state to pending.</p> <p>Read:</p> <p>0 = NMI exception not pending.</p> <p>1 = NMI exception pending.</p> <p><b>Note:</b> Because NMI is the highest-priority exception, normally the processor enters the NMI exception handler as soon as it detects a write of 1 to this bit. Entering the handler then clears this bit to 0. This means a read of this bit by the NMI exception handler returns 1 only if the NMI signal is reasserted while the processor is executing that handler.</p>
[30:29]	Reserved	Reserved.
[28]	PENDSVSET	<p><b>PendSV Set-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Changes PendSV exception state to pending.</p> <p>Read:</p> <p>0 = PendSV exception is not pending.</p> <p>1 = PendSV exception is pending.</p> <p><b>Note:</b> Writing 1 to this bit is the only way to set the PendSV exception state to pending</p>
[27]	PENDSVCLR	<p><b>PendSV Clear-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Removes the pending state from the PendSV exception.</p> <p><b>Note:</b> This bit is write-only. To clear the PENDSV bit, you must “write 0 to PENDSVSET and write 1 to PENDSVCLR” at the same time.</p>
[26]	PENDSTSET	<p><b>SysTick Exception Set-pending Bit</b></p> <p>Write:</p>

		0 = No effect. 1 = Changes SysTick exception state to pending. <b>Read:</b> 0 = SysTick exception is not pending. 1 = SysTick exception is pending.
[25]	<b>PENDSTCLR</b>	<b>SysTick Exception Clear-pending Bit</b> <b>Write:</b> 0 = No effect. 1 = Removes the pending state from the SysTick exception. <b>Note:</b> This bit is write-only. When you want to clear PENDST bit, you must “write 0 to PENDSTSET and write 1 to PENDSTCLR” at the same time.
[24]	<b>Reserved</b>	Reserved.
[23]	<b>ISRPREEMPT</b>	<b>Interrupt Preempt Bit</b> If set, a pending exception will be serviced on exit from the debug halt state. This bit is read only.
[22]	<b>ISRPENDING</b>	<b>Interrupt Pending Flag, Excluding NMI And Faults (Read Only)</b> 0 = Interrupt not pending. 1 = Interrupt pending.
[21:18]	<b>Reserved</b>	Reserved.
[17:12]	<b>VECTPENDING</b>	<b>Exception Number Of The Highest Priority Pending Enabled Exception</b> 0 = No pending exceptions. Non-zero = Exception number of the highest priority pending enabled exception.
[11:6]	<b>Reserved</b>	Reserved.
[5:0]	<b>VECTACTIVE</b>	<b>Contains The Active Exception Number</b> 0 = Thread mode. Non-zero = Exception number of the currently active exception.

**Application Interrupt and Reset Control Register (AIRCR)**

Register	Offset	R/W	Description					Reset Value
AIRCR	SCB_BA+0x00C	R/W	Application Interrupt and Reset Control Register					0xFA05_0000

31	30	29	28	27	26	25	24
<b>VECTORKEY</b>							
23	22	21	20	19	18	17	16
<b>VECTORKEY</b>							
15	14	13	12	11	10	9	8
<b>Reserved</b>							
7	6	5	4	3	2	1	0
Reserved					SYSRESETREQ	VECTCLRACTIVE	Reserved

Bits	Description	
[31:16]	<b>VECTORKEY</b>	<b>Register Access Key</b> Write: When writing to this register, the VECTORKEY field need to be set to 0x05FA, otherwise the write operation would be ignored. The VECTORKEY filed is used to prevent accidental write to this register from resetting the system or clearing of the exception status. Read: Read as 0xFA05.
[15:3]	<b>Reserved</b>	Reserved.
[2]	<b>SYSRESETREQ</b>	<b>System Reset Request</b> Writing this bit 1 will cause a reset signal to be asserted to the chip to indicate a reset is requested. The bit is a write only bit and self-clears as part of the reset sequence.
[1]	<b>VECTCLRACTIVE</b>	<b>Exception Active Status Clear Bit</b> Reserved for debug use. When writing to the register, user must write 0 to this bit, otherwise behavior is unpredictable.
[0]	<b>Reserved</b>	Reserved.

**System Control Register (SCR)**

Register	Offset	R/W	Description					Reset Value
SCR	SCB_BA+0x010	R/W	System Control Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			SEVONPEN D	Reserved	SLEEPDEEP	SLEEPONEX IT	Reserved

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	SEVONPEND	<p><b>Send Event On Pending Bit</b>            0 = Only enabled interrupts or events can wake-up the processor, disabled interrupts are excluded.            1 = Enabled events and all interrupts, including disabled interrupts, can wake-up the processor.            When an event or interrupt enters pending state, the event signal wakes up the processor from WFE. If the processor is not waiting for an event, the event is registered and affects the next WFE.            The processor also wakes up on execution of an SEV instruction or an external event.</p>
[3]	Reserved	Reserved.
[2]	SLEEPDEEP	<p><b>Processor Deep Sleep And Sleep Mode Selection</b>            Controls whether the processor uses sleep or deep sleep as its low power mode:            0 = Sleep mode.            1 = Deep Sleep mode.</p>
[1]	SLEEPONEXIT	<p><b>Sleep-on-exit Enable Control</b>            This bit indicates sleep-on-exit when returning from Handler mode to Thread mode.            0 = Do not sleep when returning to Thread mode.            1 = Enter Sleep or Deep Sleep when returning from ISR to Thread mode.            Setting this bit to 1 enables an interrupt driven application to avoid returning to an empty main application.</p>
[0]	Reserved	Reserved.

**System Handler Priority Register 2 (SHPR2)**

Register	Offset	R/W	Description					Reset Value
<b>SHPR2</b>	SCB_BA+0x01C	R/W	System Handler Priority Register 2					0x0000_0000

31	30	29	28	27	26	25	24	
<b>PRI_11</b>		Reserved						
23	22	21	20	19	18	17	16	
Reserved								
15	14	13	12	11	10	9	8	
Reserved								
7	6	5	4	3	2	1	0	
Reserved								

Bits	Description	
[31:30]	<b>PRI_11</b>	Priority Of System Handler 11 – SVCall “0” denotes the highest priority and “3” denotes the lowest priority
[29:0]	<b>Reserved</b>	Reserved.

**System Handler Priority Register 3 (SHPR3)**

Register	Offset	R/W	Description				Reset Value
SHPR3	SCB_BA+0x020	R/W	System Handler Priority Register 3				0x0000_0000

31	30	29	28	27	26	25	24
PRI_15				Reserved			
23	22	21	20	19	18	17	16
PRI_14				Reserved			
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved							

Bits	Description	
[31:30]	<b>PRI_15</b>	<b>Priority Of System Handler 15 – SysTick</b> “0” denotes the highest priority and “3” denotes the lowest priority
[29:24]	<b>Reserved</b>	Reserved.
[23:22]	<b>PRI_14</b>	<b>Priority Of System Handler 14 – PendSV</b> “0” denotes the highest priority and “3” denotes the lowest priority
[21:0]	<b>Reserved</b>	Reserved.

### 5.2.16 System Control Block Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SCS Base Address:</b>				
<b>SCS_BA = 0xE000_E000</b>				
CPUID	SCS_BA+0xD00	R	CPUID Register	0x410CC200
ICSR	SCS_BA+0xD04	R/W	Interrupt Control State Register	0x0000_0000
AIRCR	SCS_BA+0xD0C	R/W	Application Interrupt and Reset Control Register	0xFA05_0000
SCR	SCS_BA+0xD10	R/W	System Control Register	0x0000_0000
SHPR2	SCS_BA+0xD1C	R/W	System Handler Priority Register 2	0x0000_0000
SHPR3	SCS_BA+0xD20	R/W	System Handler Priority Register 3	0x0000_0000

CPUID Base Register (CPUID)

Register	Offset	R/W	Description				Reset Value
CPUID	SCS_BA+0xD00	R	CPUID Register				0x410CC200

31	30	29	28	27	26	25	24
<b>IMPLEMENTER</b>							
23	22	21	20	19	18	17	16
Reserved				<b>PART</b>			
15	14	13	12	11	10	9	8
<b>PARTNO</b>				<b>REVISION</b>			
7	6	5	4	3	2	1	0
PARTNO				REVISION			

Bits	Description	
[31:24]	<b>IMPLEMENTER</b>	<b>Implementer Code</b> Implementer code assigned by ARM®. ( ARM® = 0x41).
[23:20]	<b>Reserved</b>	Reserved.
[19:16]	<b>PART</b>	<b>Architecture Of The Processor</b> Read as 0xC for ARMv6-M parts.
[15:4]	<b>PARTNO</b>	<b>Part Number Of The Processor</b> Read as 0xC20.
[3:0]	<b>REVISION</b>	<b>Revision Number</b> Read as 0x0.

Interrupt Control State Register (ICSR)

Register	Offset	R/W	Description				Reset Value
ICSR	SCS_BA+0xD04	R/W	Interrupt Control State Register				0x0000_0000

31	30	29	28	27	26	25	24
NMIPENDSET	Reserved		PENDSVSET	PENDSVCLR	PENDSTSET	PENDSTCLR	Reserved
23	22	21	20	19	18	17	16
ISRPREEMPT	ISR PENDING	Reserve d	VECTPENDING				
15	14	13	12	11	10	9	8
VECTPENDING				Reserved			VECTACTIVE
7	6	5	4	3	2	1	0
VECTACTIVE							

Bits	Description	
[31]	NMIPENDSET	<p><b>NMI Set-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Changes NMI exception state to pending.</p> <p>Read:</p> <p>0 = NMI exception not pending.</p> <p>1 = NMI exception pending.</p> <p><b>Note:</b> Because NMI is the highest-priority exception, normally the processor enters the NMI exception handler as soon as it detects a write of 1 to this bit. Entering the handler then clears this bit to 0. This means a read of this bit by the NMI exception handler returns 1 only if the NMI signal is reasserted while the processor is executing that handler.</p>
[30:29]	Reserved	Reserved.
[28]	PENDSVSET	<p><b>PendSV Set-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Changes PendSV exception state to pending.</p> <p>Read:</p> <p>0 = PendSV exception is not pending.</p> <p>1 = PendSV exception is pending.</p> <p><b>Note:</b> Writing 1 to this bit is the only way to set the PendSV exception state to pending</p>
[27]	PENDSVCLR	<p><b>PendSV Clear-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Removes the pending state from the PendSV exception.</p> <p><b>Note:</b> This bit is write-only. To clear the PENDSV bit, you must “write 0 to PENDSVSET and write 1 to PENDSVCLR” at the same time.</p>
[26]	PENDSTSET	SysTick Exception Set-pending Bit

		<p>Write:</p> <p>0 = No effect.</p> <p>1 = Changes SysTick exception state to pending.</p> <p>Read:</p> <p>0 = SysTick exception is not pending.</p> <p>1 = SysTick exception is pending.</p>
[25]	<b>PENDSTCLR</b>	<p><b>SysTick Exception Clear-pending Bit</b></p> <p>Write:</p> <p>0 = No effect.</p> <p>1 = Removes the pending state from the SysTick exception.</p> <p><b>Note:</b> This bit is write-only. When you want to clear PENDST bit, you must “write 0 to PENDSTSET and write 1 to PENDSTCLR” at the same time.</p>
[24]	<b>Reserved</b>	Reserved.
[23]	<b>ISRPREEMPT</b>	<p><b>Interrupt Preempt Bit</b></p> <p>If set, a pending exception will be serviced on exit from the debug halt state.</p> <p>This bit is read only.</p>
[22]	<b>ISRPENDING</b>	<p><b>Interrupt Pending Flag, Excluding NMI And Faults (Read Only)</b></p> <p>0 = Interrupt not pending.</p> <p>1 = Interrupt pending.</p> <p>This bit is read only.</p>
[21]	<b>Reserved</b>	Reserved.
[20:12]	<b>VECTPENDING</b>	<p><b>Exception Number Of The Highest Priority Pending Enabled Exception</b></p> <p>0 = No pending exceptions.</p> <p>Non-zero = Exception number of the highest priority pending enabled exception.</p> <p>This bit is read only.</p>
[11:6]	<b>Reserved</b>	Reserved.
[5:0]	<b>VECTACTIVE</b>	<p><b>Contains The Active Exception Number</b></p> <p>0 = Thread mode.</p> <p>Non-zero = Exception number of the currently active exception.</p> <p>This bit is read only.</p>

**Application Interrupt and Reset Control Register (AIRCR)**

Register	Offset	R/W	Description					Reset Value
AIRCR	SCS_BA+0xD0C	R/W	Application Interrupt and Reset Control Register					0xFA05_0000

31	30	29	28	27	26	25	24
VECTORKEY							
23	22	21	20	19	18	17	16
VECTORKEY							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					SYSRESETREQ	VECTCLRACTIVE	Reserved

Bits	Description	
[31:16]	<b>VECTORKEY</b>	<b>Register Access Key</b> Write: When writing to this register, the VECTORKEY field need to be set to 0x05FA, otherwise the write operation would be ignored. The VECTORKEY filed is used to prevent accidental write to this register from resetting the system or clearing of the exception status. Read: Read as 0xFA05.
[15:3]	<b>Reserved</b>	Reserved.
[2]	<b>SYSRESETREQ</b>	<b>System Reset Request</b> Writing this bit 1 will cause a reset signal to be asserted to the chip to indicate a reset is requested. The bit is a write only bit and self-clears as part of the reset sequence.
[1]	<b>VECTCLRACTIVE</b>	<b>Exception Active Status Clear Bit</b> Reserved for debug use. When writing to the register, user must write 0 to this bit, otherwise behavior is unpredictable.
[0]	<b>Reserved</b>	Reserved.

**System Control Register (SCR)**

Register	Offset	R/W	Description					Reset Value
SCR	SCS_BA+0xD10	R/W	System Control Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			SEVONPEN D	Reserved	SLEEPDEEP	SLEEPONEX IT	Reserved

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	SEVONPEND	<p><b>Send Event On Pending Bit</b>            0 = Only enabled interrupts or events can wake-up the processor, disabled interrupts are excluded.            1 = Enabled events and all interrupts, including disabled interrupts, can wake-up the processor.            When an event or interrupt enters pending state, the event signal wakes up the processor from WFE. If the processor is not waiting for an event, the event is registered and affects the next WFE.            The processor also wakes up on execution of an SEV instruction or an external event.</p>
[3]	Reserved	Reserved.
[2]	SLEEPDEEP	<p><b>Processor Deep Sleep And Sleep Mode Selection</b>            Controls whether the processor uses sleep or deep sleep as its low power mode:            0 = Sleep mode.            1 = Deep Sleep mode.</p>
[1]	SLEEPONEXIT	<p><b>Sleep-on-exit Enable Control</b>            This bit indicates sleep-on-exit when returning from Handler mode to Thread mode.            0 = Do not sleep when returning to Thread mode.            1 = Enter Sleep or Deep Sleep when returning from ISR to Thread mode.            Setting this bit to 1 enables an interrupt driven application to avoid returning to an empty main application.</p>
[0]	Reserved	Reserved.

**System Handler Priority Register 2 (SHPR2)**

Register	Offset	R/W	Description					Reset Value
<b>SHPR2</b>	SCS_BA+0xD1C	R/W	System Handler Priority Register 2					0x0000_0000

31	30	29	28	27	26	25	24			
PRI_11				Reserved						
23	22	21	20	19	18	17	16			
			Reserved							
15	14	13	12	11	10	9	8			
			Reserved							
7	6	5	4	3	2	1	0			
			Reserved							

Bits	Description	
[31:30]	<b>PRI_11</b>	Priority Of System Handler 11 – SVCall “0” denotes the highest priority and “3” denotes the lowest priority
[29:0]	<b>Reserved</b>	Reserved.

**System Handler Priority Register 3 (SHPR3)**

Register	Offset	R/W	Description				Reset Value
SHPR3	SCS_BA+0xD20	R/W	System Handler Priority Register 3				0x0000_0000

31	30	29	28	27	26	25	24
PRI_15	Reserved						
23	22	21	20	19	18	17	16
PRI_14	Reserved						
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved							

Bits	Description	
[31:30]	PRI_15	Priority Of System Handler 15 – SysTick “0” denotes the highest priority and “3” denotes the lowest priority
[29:24]	Reserved	Reserved.
[23:22]	PRI_14	Priority Of System Handler 14 – PendSV “0” denotes the highest priority and “3” denotes the lowest priority
[21:0]	Reserved	Reserved.

## 5.3 Clock Controller of NuMicro® NUC029xAN

### 5.3.1 Overview

The clock controller generates the clocks for the whole chip, including system clocks and all peripheral clocks. The clock controller also implements the power control function with the individually clock ON/OFF control, clock source selection and clock divider. The chip enters Power-down mode when Cortex®-M0 core executes the WFI instruction only if the PWR\_DOWN\_EN (PWRCON[7]) bit and PD\_WAIT\_CPU (PWRCON[8]) bit are both set to 1. After that, chip enters Power-down mode and wait for wake-up interrupt source triggered to leave Power-down mode. In the Power-down mode, the clock controller turns off the 4~24 MHz external high speed crystal oscillator (HXT) and 22.1184 MHz internal high speed RC oscillator (HIRC) to reduce the overall system power consumption. The following figures show the clock generator and the overview of the clock source control.

The clock generator consists of 4 clock sources as listed below:

- 4~24 MHz external high speed crystal oscillator (HXT)
- Programmable PLL output clock frequency (PLL source can be selected from external 4~24 MHz external high speed crystal oscillator (HXT) or 22.1184 MHz internal high speed RC oscillator (HIRC)) (PLL FOUT)
- 22.1184 MHz internal high speed RC oscillator (HIRC)
- 10 kHz internal low speed RC oscillator (LIRC)

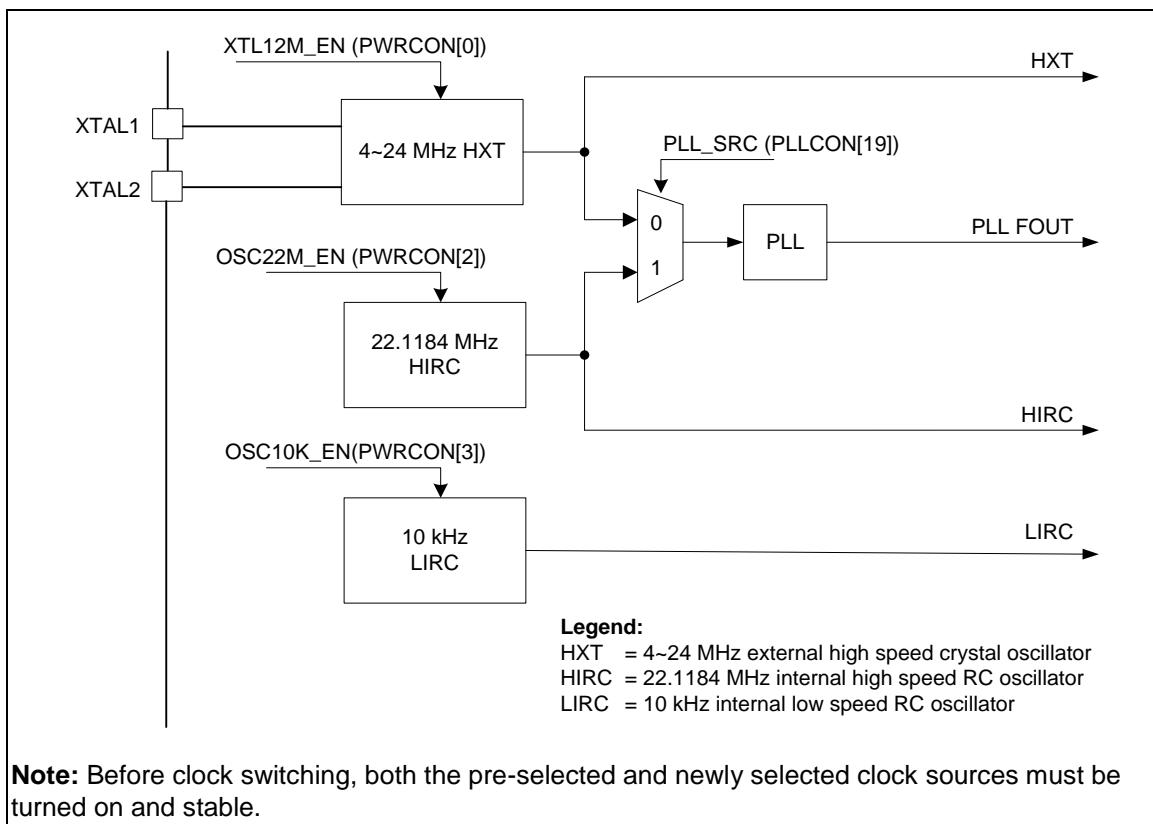


Figure 5-6 NuMicro® NUC029xAN Clock Generator Block Diagram

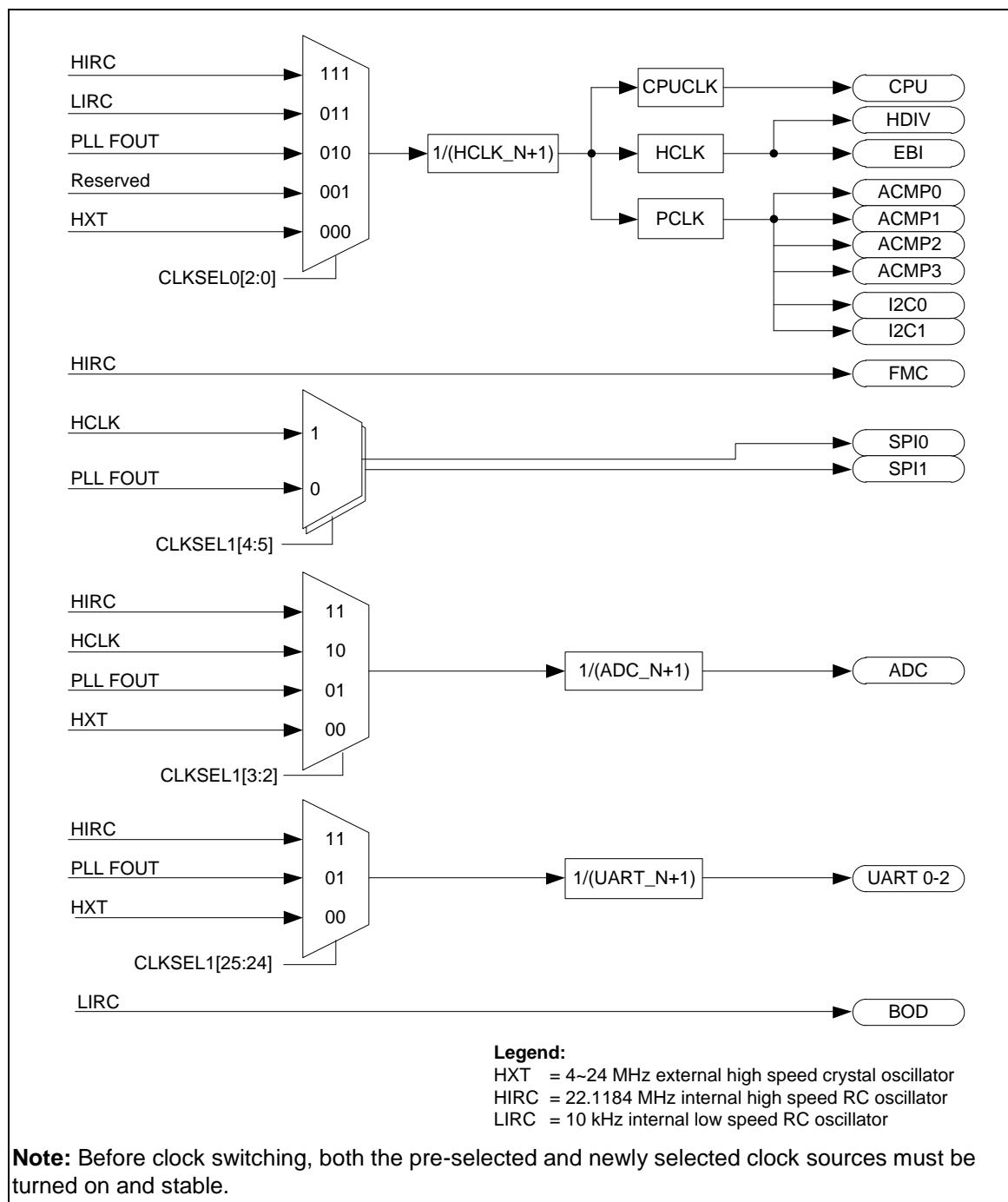


Figure 5-7 NuMicro® NUC029xAN Clock Source Controller Overview (1/2)

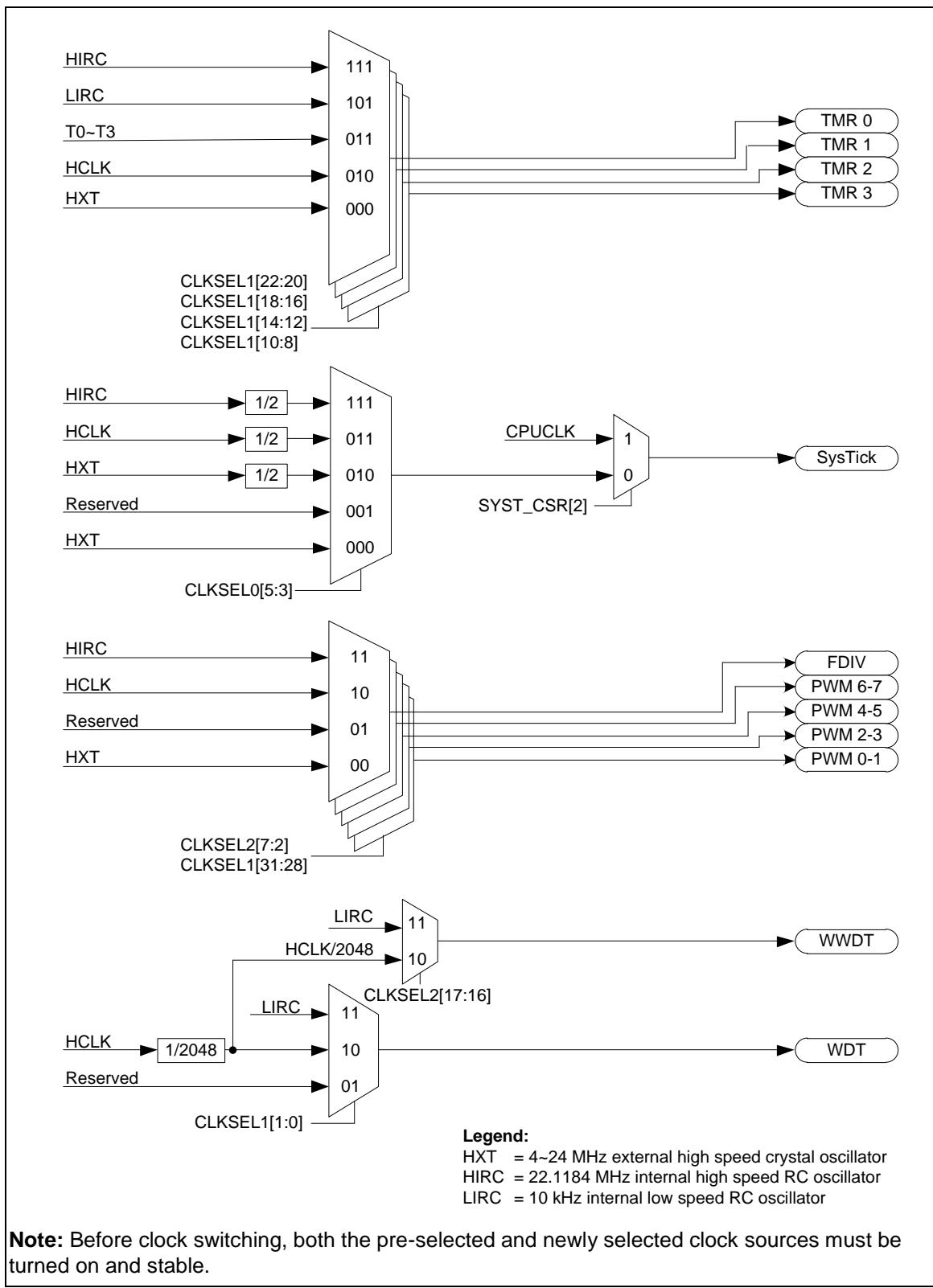


Figure 5-8 NuMicro® NUC029xAN Clock Source Controller Overview (2/2)

### 5.3.2 System Clock and SysTick Clock

The system clock has 4 clock sources which were generated from clock generator block. The clock source switch depends on the register HCLK\_S (CLKSEL0[2:0]). The block diagram is shown in Figure 5-9.

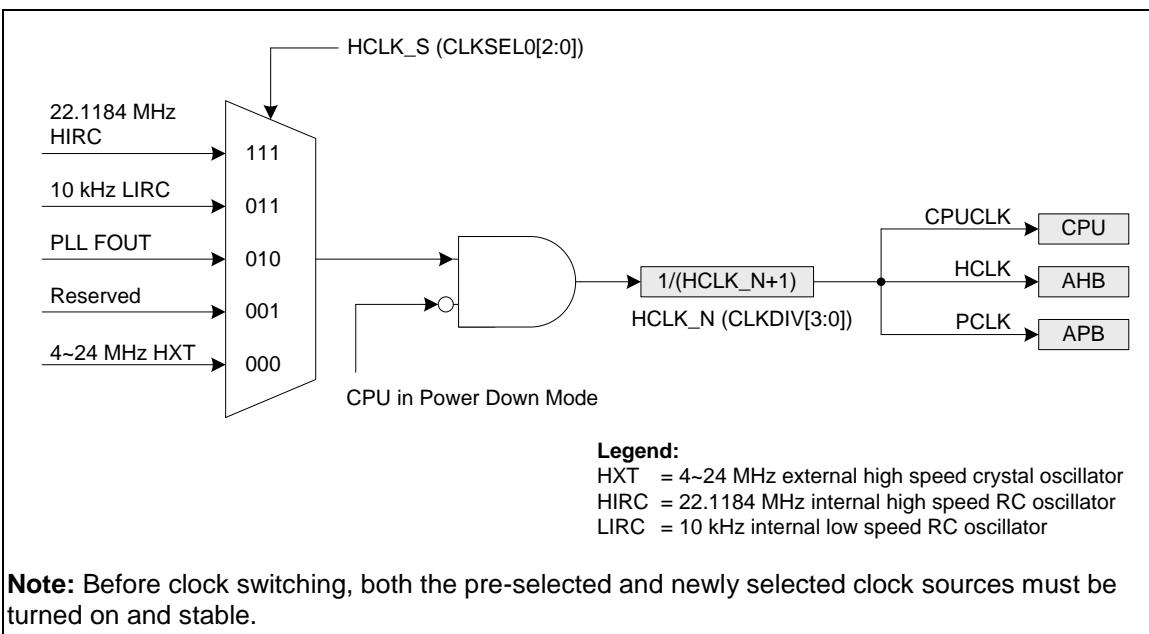


Figure 5-9 NuMicro® NUC029xAN System Clock Block Diagram

The clock source of SysTick in Cortex®-M0 core can use CPU clock or external clock (SYST\_CSR[2]). If using external clock, the SysTick clock (STCLK) has 4 clock sources. The clock source switch depends on the setting of the register STCLK\_S (CLKSEL0[5:3]). The block diagram is shown in Figure 5-10.

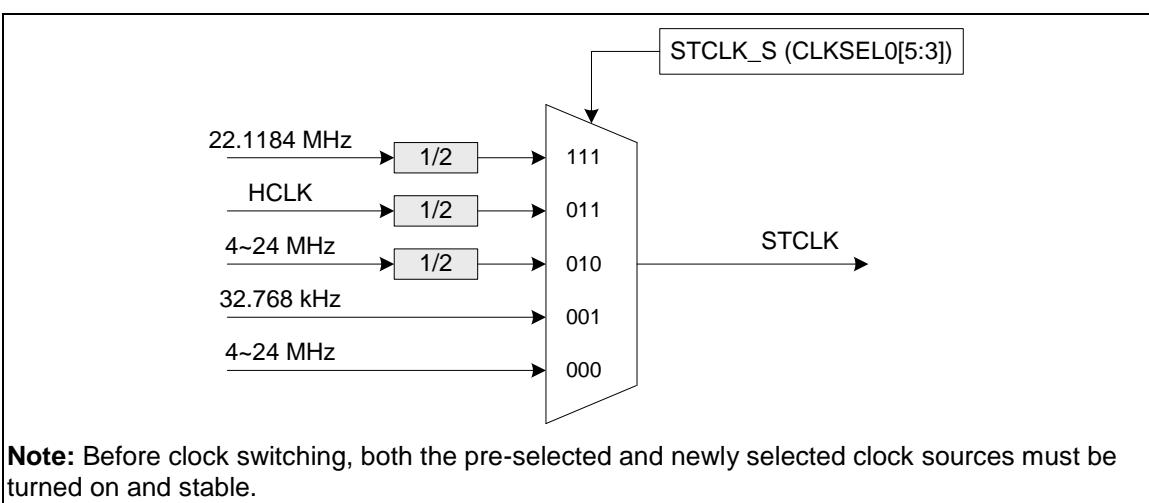


Figure 5-10 NuMicro® NUC029xAN SysTick Clock Control Block Diagram

### 5.3.3 Power-down Mode Clock

When chip enters Power-down mode, system clocks, some clock sources, and some peripheral clocks will be disabled. Some clock sources and peripherals clocks are still active in Power-down mode.

The clocks still kept active are listed below:

- Clock Generator
  - 10 kHz internal low speed RC oscillator clock (LIRC)
- Peripherals Clock (when 10 kHz internal low speed RC oscillator is adopted as clock source)

### 5.3.4 Frequency Divider Output

This device is equipped with a power-of-2 frequency divider which is composed by 16 chained divide-by-2 shift registers. One of the 16 shift register outputs selected by a sixteen to one multiplexer is reflected to CKO pin. Therefore there are 16 options of power-of-2 divided clocks with the frequency from  $F_{in}/2^1$  to  $F_{in}/2^{16}$  where  $F_{in}$  is input clock frequency to the clock divider.

The output formula is  $F_{out} = F_{in}/2^{(N+1)}$ , where  $F_{in}$  is the input clock frequency,  $F_{out}$  is the clock divider output frequency and N is the 4-bit value in FSEL (FRQDIV[3:0]).

When writing 1 to DIVIDER\_EN (FRQDIV[4]), the chained counter starts to count. When writing 0 to DIVIDER\_EN (FRQDIV[4]), the chained counter continuously runs till divided clock reaches low state and stay in low state.

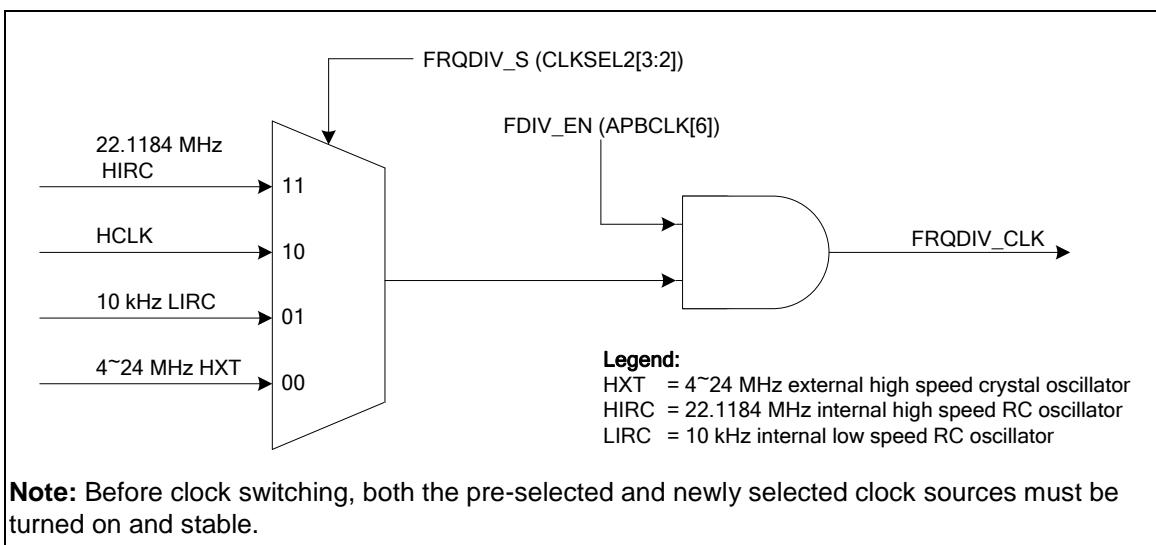


Figure 5-11 NuMicro® NUC029xAN Clock Source of Frequency Divider

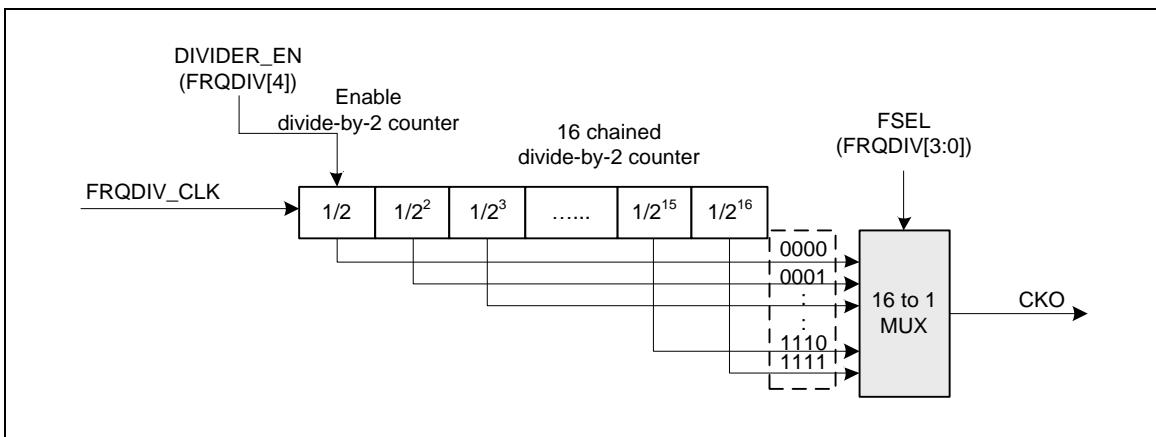


Figure 5-12 NuMicro® NUC029xAN Frequency Divider Block Diagram

### 5.3.5 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>CLK Base Address:</b>				
<b>CLK_BA = 0x5000_0200</b>				
PWRCON	CLK_BA+0x00	R/W	System Power-down Control Register	0x0000_001X
AHBCLK	CLK_BA+0x04	R/W	AHB Devices Clock Enable Control Register	0x0000_000D
APBCLK	CLK_BA+0x08	R/W	APB Devices Clock Enable Control Register	0x0000_000X
CLKSTATUS	CLK_BA+0x0C	R/W	Clock status monitor Register	0x0000_00XX
CLKSEL0	CLK_BA+0x10	R/W	Clock Source Select Control Register 0	0x0000_003X
CLKSEL1	CLK_BA+0x14	R/W	Clock Source Select Control Register 1	0xFFFF_FFFF
CLKDIV	CLK_BA+0x18	R/W	Clock Divider Number Register	0x0000_0000
CLKSEL2	CLK_BA+0x1C	R/W	Clock Source Select Control Register 2	0x0000_00FF
PLLCON	CLK_BA+0x20	R/W	PLL Control Register	0x0005_C22E
FRQDIV	CLK_BA+0x24	R/W	Frequency Divider Control Register	0x0000_0000

### 5.3.6 Register Description

#### Power-down Control Register (PWRCON)

Except the BIT[6], all the other bits are protected, and programming these bits need to write “59h”, “16h”, “88h” to address 0x5000\_0100 to disable register protection. Refer to the REGWRPROT register at address GCR\_BA+0x100.

Register	Offset	R/W	Description				Reset Value
PWRCON	CLK_BA+0x00	R/W	System Power-down Control Register				0x0000_001X

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							PD_WAIT_CPU
7	6	5	4	3	2	1	0
PWR_DOWN_EN	PD_WU_STS	PD_WU_INT_EN	PD_WU_DLY	OSC10K_EN	OSC22M_EN	Reserved	XTL12M_EN

Bits	Description	
[31:9]	Reserved	Reserved.
[8]	PD_WAIT_CPU	<b>Power-down Entry Condition Control (Write Protect)</b> 0 = Chip enters Power-down mode when the PWR_DOWN_EN bit is set to 1. 1 = Chip enters Power-down mode when the both PD_WAIT_CPU and PWR_DOWN_EN bits are set to 1 and CPU run WFI instruction.
[7]	PWR_DOWN_EN	<b>System Power-down Enable Bit (Write Protect)</b> When this bit is set to 1, Power-down mode is enabled and chip Power-down behavior will depend on the PD_WAIT_CPU bit (a) If the PD_WAIT_CPU is 0, then the chip enters Power-down mode immediately after the PWR_DOWN_EN bit set. (b) If the PD_WAIT_CPU is 1, then the chip keeps active till CPU run WFI instruction. When chip wakes up from Power-down mode, this bit is cleared by hardware. User needs to set this bit again for next Power-down. In Power-down mode, 4~24 MHz external high speed crystal oscillator (HXT) and the 22.1184 MHz internal high speed oscillator (HIRC) will be disabled in this mode, and 10 kHz internal low speed RC oscillator (LIRC) are not controlled by Power-down mode. In Power-down mode, the PLL and system clock are disabled, and ignored the clock source selection. The clocks of peripheral are not controlled by Power-down mode, if the peripheral clock source is from 10 kHz internal low speed oscillator. 0 = Chip operating normally or chip in Idle mode because of WFI command. 1 = Chip enters Power-down mode instantly or waits CPU sleep command WFI.
[6]	PD_WU_STS	<b>Power-down Mode Wake-up Interrupt Status</b> Set by “Power-down wake-up event”, which indicates that resume from Power-down mode” The flag is set if the GPIO, UART, WDT, ACMP or BOD wake-up occurred.

		<b>Note:</b> This bit works only if PD_WU_INT_EN (PWRCON[5]) set to 1. Write 1 to clear the bit to 0.
[5]	<b>PD_WU_INT_EN</b>	<p><b>Power-down Mode Wake-up Interrupt Enable Control (Write Protect)</b></p> <p>0 = Disabled. 1 = Enabled.</p> <p><b>Note:</b> The interrupt will occur when both PD_WU_STS and PD_WU_INT_EN are high.</p>
[4]	<b>PD_WU_DLY</b>	<p><b>Wake-up Delay Counter Enable Control (Write Protect)</b></p> <p>When the chip wakes up from Power-down mode, the clock control will delay certain clock cycles to wait system clock stable.</p> <p>The delayed clock cycle is 4096 clock cycles when chip works at 4~24 MHz external high speed crystal (HXT), and 256 clock cycles when chip works at 22.1184 MHz internal high speed RC oscillator (HIRC).</p> <p>0 = Clock cycles delay Disabled. 1 = Clock cycles delay Enabled.</p>
[3]	<b>OSC10K_EN</b>	<p><b>10 KHz Internal Low Speed RC Oscillator (LIRC) Enable Control (Write Protect)</b></p> <p>0 = 10 kHz internal low speed RC oscillator (LIRC) Disabled. 1 = 10 kHz internal low speed RC oscillator (LIRC) Enabled.</p>
[2]	<b>OSC22M_EN</b>	<p><b>22.1184 MHz Internal High Speed RC Oscillator (HIRC) Enable Control (Write Protect)</b></p> <p>0 = 22.1184 MHz internal high speed RC oscillator (HIRC) Disabled. 1 = 22.1184 MHz internal high speed RC oscillator (HIRC) Enabled.</p>
[1]	<b>Reserved</b>	Reserved.
[0]	<b>XTL12M_EN</b>	<p><b>4~24 MHz External High Speed Crystal (HXT) Enable Control (Write Protect)</b></p> <p>The bit default value is set by flash controller user configuration register config0 [26:24]. When the default clock source is from 4~24 MHz external high speed crystal, this bit is set to 1 automatically.</p> <p>0 = 4 ~ 24 MHz external high speed crystal oscillator (HXT) Disabled. 1 = 4 ~ 24 MHz external high speed crystal oscillator (HXT) Enabled.</p>

Register Or Instruction Mode	SLEEPDEEP (SCR[2])	PD_WAIT_CPU (PWRCON[8])	PWR_DOWN_EN (PWRCON[7])	CPU Run WFI Instruction	Clock Disable
Normal operation	0	0	0	NO	All clocks disabled by control register
Idle mode (CPU entering Sleep mode)	0	x	0	YES	Only CPU clock disabled
Power-down mode (CPU entering Deep Sleep mode)	1	1	1	YES	Most clocks are disabled except 10 kHz and only WDT peripheral clock still enable if its peripheral clock source is selected as 10 kHz.

Table 5-7 Power-down Mode Control

When chip enters Power-down mode, user can wake-up chip using some interrupt sources. The related interrupt sources and NVIC IRQ enable bits (NVIC\_ISER) should be enabled before setting PWR\_DOWN\_EN bit in PWRCON[7] to ensure chip can enter Power-down and wake-up successfully.

**AHB Devices Clock Enable Control Register (AHBCLK)**

The bits in this register are used to enable/disable clock for system clock and EBI clock.

Register	Offset	R/W	Description				Reset Value
AHBCLK	CLK_BA+0x04	R/W	AHB Devices Clock Enable Control Register				0x0000_000D

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			HDIV_EN	EBI_EN	ISP_EN	Reserved	Reserved

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	HDIV_EN	<b>Divider Controller Clock Enable Control</b> 0 = Divider controller peripheral clock Disabled. 1 = Divider controller peripheral clock Enabled.
[3]	EBI_EN	<b>EBI Controller Clock Enable Control</b> 0 = EBI peripheral clock Disabled. 1 = EBI peripheral clock Enabled.
[2]	ISP_EN	<b>Flash ISP Controller Clock Enable Control</b> 0 = Flash ISP peripheral clock Disabled. 1 = Flash ISP peripheral clock Enabled.
[1:0]	Reserved	Reserved.

**APB Devices Clock Enable Control Register (APBCLK)**

The bits in this register are used to enable/disable clock for peripheral controller clocks.

Register	Offset	R/W	Description				Reset Value
APBCLK	CLK_BA+0x08	R/W	APB Devices Clock Enable Control Register				0x0000_000X

31	30	29	28	27	26	25	24
ACMP23_EN	ACMP01_EN	Reserved	ADC_EN	Reserved			
23	22	21	20	19	18	17	16
PWM67_EN	PWM45_EN	PWM23_EN	PWM01_EN	Reserved		UART1_EN	UART0_EN
15	14	13	12	11	10	9	8
Reserved		SPI1_EN	SPI0_EN	Reserved		I2C1_EN	I2C0_EN
7	6	5	4	3	2	1	0
Reserved	FDIV_EN	TMR3_EN	TMR2_EN	TMR1_EN	TMR0_EN	Reserved	WDT_EN

Bits	Description	
[31]	ACMP23_EN	<b>Analog Comparator 2/3 Clock Enable Control</b> 0 = Analog Comparator 2/3 clock Disabled. 1 = Analog Comparator 2/3 clock Enabled.
[30]	ACMP01_EN	<b>Analog Comparator 0/1 Clock Enable Control</b> 0 = Analog Comparator 0/1 clock Disabled. 1 = Analog Comparator 0/1 clock Enabled.
[29]	Reserved	Reserved.
[28]	ADC_EN	<b>Analog-digital-converter (ADC) Clock Enable Control</b> 0 = ADC peripheral clock Disabled. 1 = ADC peripheral clock Enabled.
[27:24]	Reserved	Reserved.
[23]	PWM67_EN	<b>PWM_67 Clock Enable Control</b> 0 = PWM67 clock Disabled. 1 = PWM67 clock Enabled.
[22]	PWM45_EN	<b>PWM_45 Clock Enable Control</b> 0 = PWM45 clock Disabled. 1 = PWM45 clock Enabled.
[21]	PWM23_EN	<b>PWM_23 Clock Enable Control</b> 0 = PWM23 clock Disabled. 1 = PWM23 clock Enabled.
[20]	PWM01_EN	<b>PWM_01 Clock Enable Control</b> 0 = PWM01 clock Disabled. 1 = PWM01 clock Enabled.

[19:18]	<b>Reserved</b>	Reserved.
[17]	<b>UART1_EN</b>	<b>UART1 Clock Enable Control</b> 0 = UART1 clock Disabled. 1 = UART1 clock Enabled.
[16]	<b>UART0_EN</b>	<b>UART0 Clock Enable Control</b> 0 = UART0 clock Disabled. 1 = UART0 clock Enabled.
[15:14]	<b>Reserved</b>	Reserved.
[13]	<b>SPI1_EN</b>	<b>SPI1 Peripheral Clock Enable Control</b> 0 = SPI1 peripheral clock Disabled. 1 = SPI1 peripheral clock Enabled.
[12]	<b>SPI0_EN</b>	<b>SPI0 Peripheral Clock Enable Control</b> 0 = SPI0 peripheral clock Disabled. 1 = SPI0 peripheral clock Enabled.
[11:10]	<b>Reserved</b>	Reserved.
[9]	<b>I2C1_EN</b>	<b>I<sup>2</sup>C1 Clock Enable Control</b> 0 = I <sup>2</sup> C clock Disabled. 1 = I <sup>2</sup> C clock Enabled.
[8]	<b>I2C0_EN</b>	<b>I<sup>2</sup>C0 Clock Enable Control</b> 0 = I <sup>2</sup> C clock Disabled. 1 = I <sup>2</sup> C clock Enabled.
[7]	<b>Reserved</b>	Reserved.
[6]	<b>FDIV_EN</b>	<b>Frequency Divider Output Clock Enable Control</b> 0 = FDIV clock Disabled. 1 = FDIV clock Enabled.
[5]	<b>TMR3_EN</b>	<b>Timer3 Clock Enable Control</b> 0 = Timer3 clock Disabled. 1 = Timer3 clock Enabled.
[4]	<b>TMR2_EN</b>	<b>Timer2 Clock Enable Control</b> 0 = Timer2 clock Disabled. 1 = Timer2 clock Enabled.
[3]	<b>TMR1_EN</b>	<b>Timer1 Clock Enable Control</b> 0 = Timer1 clock Disabled. 1 = Timer1 clock Enabled.
[2]	<b>TMR0_EN</b>	<b>Timer0 Clock Enable Control</b> 0 = Timer0 clock Disabled. 1 = Timer0 clock Enabled.
[1]	<b>Reserved</b>	Reserved.
[0]	<b>WDT_EN</b>	<b>Watchdog Timer Clock Enable Control (Write Protect)</b> 0 = Watchdog Timer clock Disabled. 1 = Watchdog Timer clock Enabled. <b>Note:</b> This bit is the protected bit, and programming it needs to write "59h", "16h", and "88h" to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at

		address GCR_BA+0x100.
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### Clock Status Register (CLKSTATUS)

The bits in this register are used to monitor if the chip clock source stable or not, and if clock switching failed.

Register	Offset	R/W	Description				Reset Value
CLKSTATUS	CLK_BA+0x0C	R/W	Clock status monitor Register				0x0000_00XX

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
CLK_SW_FAIL	Reserved		OSC22M_STB	OSC10K_STB	PLL_STB	Reserved	XTL12M_STB

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	CLK_SW_FAIL	<b>Clock Switching Fail Flag</b> 0 = Clock switching success. 1 = Clock switching failed. <b>Note1:</b> This bit is updated when software switches system clock source. If switch target clock is stable, this bit will be set to 0. If switch target clock is not stable, this bit will be set to 1. <b>Note2:</b> This bit is read only. After selected clock source is stable, hardware will switch system clock to selected clock automatically, and CLK_SE_FAIL will be cleared automatically by hardware.
[6:5]	Reserved	Reserved.
[4]	OSC22M_STB	<b>22.1184 MHz Internal High Speed RC Oscillator (HIRC) Stable Flag (Read Only)</b> 0 = 22.1184 MHz internal high speed RC oscillator (HIRC) clock is not stable or disabled. 1 = 22.1184 MHz internal high speed RC oscillator (HIRC) clock is stable.
[3]	OSC10K_STB	<b>10 KHz Internal Low Speed RC Oscillator (LIRC) Stable Flag (Read Only)</b> 0 = 10 kHz internal low speed RC oscillator (LIRC) clock is not stable or disabled. 1 = 10 kHz internal low speed RC oscillator (LIRC) clock is stable.
[2]	PLL_STB	<b>Internal PLL Clock Source Stable Flag (Read Only)</b> 0 = Internal PLL clock is not stable or disabled. 1 = Internal PLL clock is stable.
[1]	Reserved	Reserved.
[0]	XTL12M_STB	<b>4~24 MHz External High Speed Crystal (HXT) Stable Flag (Read Only)</b> 0 = 4~24 MHz external high speed crystal (HXT) clock is not stable or disabled. 1 = 4~24 MHz external high speed crystal (HXT) clock is stable.

**Clock Source Select Control Register 0 (CLKSEL0)**

Register	Offset	R/W	Description				Reset Value
CLKSEL0	CLK_BA+0x10	R/W	Clock Source Select Control Register 0				0x0000_003X

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

Bits	Description	
[31:6]	Reserved	Reserved.
[5:3]	STCLK_S	<p><b>Cortex® -M0 SysTick Clock Source Selection From Reference Clock (Write Protect)</b></p> <p>If SYST_CSR[2] = 1, SysTick clock source is from HCLK.</p> <p>If SYST_CSR[2] = 0, SysTick clock source is defined by below settings.</p> <ul style="list-style-type: none"> <li>000 = Clock source is from HXT.</li> <li>001 = Reserved.</li> <li>010 = Clock source is from HXT/2.</li> <li>011 = Clock source is from HCLK/2.</li> <li>111 = Clock source is from HIRC/2.</li> <li>Others = Reserved.</li> </ul> <p><b>Note1:</b> These bits are protected bits, and programming them needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p> <p><b>Note2:</b> if the SysTick clock source is not from HCLK (i.e. SYST_CSR[2] = 0), SysTick clock source must less than or equal to HCLK/2.</p>
[2:0]	HCLK_S	<p><b>HCLK Clock Source Selection (Write Protect)</b></p> <ul style="list-style-type: none"> <li>000 = Clock source is from HXT.</li> <li>001 = Reserved.</li> <li>010 = Clock source is from PLL.</li> <li>011 = Clock source is from LIRC.</li> <li>111 = Clock source is from HIRC.</li> <li>Others = Reserved.</li> </ul> <p><b>Note1:</b> Before clock switching, the related clock sources (both pre-select and new-select) must be turn-on and stable.</p> <p><b>Note2:</b> The 3-bit default value is reloaded from the value of CFOSC (CONFIG0[26:24]) in user configuration register of Flash controller by any reset. Therefore the default value is either 000b or 111b.</p> <p><b>Note3:</b> These bits are protected bit, and programming them needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register</p>

		REGWRPROT at address GCR_BA+0x100.
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**Clock Source Select Control Register 1 (CLKSEL1)**

Before clock switching, the related clock sources (pre-select and new-select) must be turned on.

Register	Offset	R/W	Description				Reset Value
CLKSEL1	CLK_BA+0x14	R/W	Clock Source Select Control Register 1				0xFFFF_FFFF

31	30	29	28	27	26	25	24
<b>PWM23_S</b>		<b>PWM01_S</b>		<b>Reserved</b>		<b>UART_S</b>	
23	22	21	20	19	18	17	16
Reserved	<b>TMR3_S</b>			Reserved	<b>TMR2_S</b>		
15	14	13	12	11	10	9	8
Reserved	<b>TMR1_S</b>			Reserved	<b>TMR0_S</b>		
7	6	5	4	3	2	1	0
Reserved	<b>SPI1_S</b>	<b>SPI0_S</b>	<b>ADC_S</b>		<b>WDT_S</b>		

Bits	Description
[31:30]	<b>PWM23_S</b> <b>PWM2 And PWM3 Clock Source Selection</b> PWM2 and PWM3 use the same Engine clock source; both of them use the same prescaler. 00 = Clock source is from HXT. 01 = Clock source is from LIRC. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.
[29:28]	<b>PWM01_S</b> <b>PWM0 And PWM1 Clock Source Selection</b> PWM0 and PWM1 use the same Engine clock source; both of them use the same prescaler. 00 = Clock source is from HXT. 01 = Clock source is from LIRC. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.
[27:26]	<b>Reserved</b> Reserved.
[25:24]	<b>UART_S</b> <b>UART Clock Source Selection</b> 00 = Clock source is from HXT. 01 = Clock source is from PLL. 10 = Reserved. 11 = Clock source is from HIRC.
[23]	<b>Reserved</b> Reserved.
[22:20]	<b>TMR3_S</b> <b>TIMER3 Clock Source Selection</b> 000 = Clock source is from HXT. 010 = Clock source is from HCLK. 011 = Clock source is from external trigger T3. 101 = Clock source is from LIRC. 111 = Clock source is from HIRC.

		Others = Reserved.
[19]	<b>Reserved</b>	Reserved.
[18:16]	<b>TMR2_S</b>	<p><b>TIMER2 Clock Source Selection</b></p> <p>000 = Clock source is from HXT. 010 = Clock source is from HCLK. 011 = Clock source is from external trigger T2. 101 = Clock source is from LIRC. 111 = Clock source is from HIRC. Others = Reserved.</p>
[15]	<b>Reserved</b>	Reserved.
[14:12]	<b>TMR1_S</b>	<p><b>TIMER1 Clock Source Selection</b></p> <p>000 = Clock source is from HXT. 010 = Clock source is from HCLK. 011 = Clock source is from external trigger T1. 101 = Clock source is from LIRC. 111 = Clock source is from HIRC. Others = Reserved.</p>
[11]	<b>Reserved</b>	Reserved.
[10:8]	<b>TMR0_S</b>	<p><b>TIMER0 Clock Source Selection</b></p> <p>000 = Clock source is from HXT. 010 = Clock source is from HCLK. 011 = Clock source is from external trigger T0. 101 = Clock source is from LIRC. 111 = Clock source is from HIRC. Others = Reserved.</p>
[7:6]	<b>Reserved</b>	Reserved.
[5]	<b>SPI1_S</b>	<p><b>SPI1 Clock Source Selection</b></p> <p>0 = Clock source is from PLL. 1 = Clock source is from HCLK.</p>
[4]	<b>SPI0_S</b>	<p><b>SPI0 Clock Source Selection</b></p> <p>0 = Clock source is from PLL. 1 = Clock source is from HCLK.</p>
[3:2]	<b>ADC_S</b>	<p><b>ADC Peripheral Clock Source Selection</b></p> <p>00 = Clock source is from HXT. 01 = Clock source is from PLL. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.</p>
[1:0]	<b>WDT_S</b>	<p><b>Watchdog Timer Clock Source Selection (Write Protect)</b></p> <p>00 = Reserved. 01 = Reserved. 10 = Clock source is from HCLK/2048 clock. 11 = Clock source is from LIRC.</p> <p><b>Note:</b> These bits are protected bits, and programming them needs to write “59h”, “16h”, and “88h” to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA+0x100.</p>

**Clock Source Select Control Register (CLKSEL2)**

Before clock switching the related clock sources (pre-select and new-select) must be turned on.

Register	Offset	R/W	Description				Reset Value
CLKSEL2	CLK_BA+0x1C	R/W	Clock Source Select Control Register 2				0x0000_00FF

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved						WWDT_S	
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
PWM67_S	PWM45_S			FRQDIV_S		Reserved	

Bits	Description	
[31:18]	<b>Reserved</b>	Reserved.
[17:16]	<b>WWDT_S</b>	<b>Window Watchdog Timer Clock Source Selection</b> 10 = Clock source is from HCLK/2048 clock. 11 = Clock source is from LIRC.
[31:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>PWM67_S</b>	<b>PWM6 And PWM7 Clock Source Selection</b> PWM6 and PWM7 used the same Engine clock source; both of them used the same prescaler. 00 = Clock source is from HXT. 01 = Clock source is from LIRC. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.
[5:4]	<b>PWM45_S</b>	<b>PWM4 And PWM5 Clock Source Selection</b> PWM4 and PWM5 use the same Engine clock source; both of them used the same prescaler. 00 = Clock source is from HXT. 01 = Clock source is from LIRC. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.
[3:2]	<b>FRQDIV_S</b>	<b>Clock Divider Clock Source Selection</b> 00 = Clock source is from HXT. 01 = Clock source is from LIRC. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.
[1:0]	<b>Reserved</b>	Reserved.

**Clock Divider Register (CLKDIV)**

Register	Offset	R/W	Description				Reset Value
CLKDIV	CLK_BA+0x18	R/W	Clock Divider Number Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
ADC_N							
15	14	13	12	11	10	9	8
Reserved				UART_N			
7	6	5	4	3	2	1	0
Reserved				HCLK_N			

Bits	Description	
[31:24]	<b>Reserved</b>	Reserved.
[23:16]	<b>ADC_N</b>	<b>ADC Peripheral Clock Divide Number From ADC Peripheral Clock Source</b> ADC peripheral clock frequency = (ADC peripheral clock source frequency) / (ADC_N + 1).
[15:12]	<b>Reserved</b>	Reserved.
[11:8]	<b>UART_N</b>	<b>UART Clock Divide Number From UART Clock Source</b> UART clock frequency = (UART clock source frequency) / (UART_N + 1).
[7:4]	<b>Reserved</b>	Reserved.
[3:0]	<b>HCLK_N</b>	<b>HCLK Clock Divide Number From HCLK Clock Source</b> HCLK clock frequency = (HCLK clock source frequency) / (HCLK_N + 1).

**PLL Control Register (PLLCON)**

The PLL reference clock input is from the 4~24 MHz external high speed crystal (HXT) clock input or from the 22.1184 MHz internal high speed RC oscillator (HIRC). These registers are used to control the PLL output frequency and PLL operation mode.

Register	Offset	R/W	Description				Reset Value
PLLCON	CLK_BA+0x20	R/W	PLL Control Register				0x0005_C22E

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved				PLL_SRC	OE	BP	PD
15	14	13	12	11	10	9	8
OUT_DV		IN_DV				FB_DV	
7	6	5	4	3	2	1	0
FB_DV							

Bits	Description	
[19]	<b>PLL_SRC</b>	<b>PLL Source Clock Selection</b> 0 = PLL source clock from HXT. 1 = PLL source clock from HIRC.
[18]	<b>OE</b>	<b>PLL OE (FOUT Enable) Pin Control</b> 0 = PLL FOUT Enabled. 1 = PLL FOUT is fixed low.
[17]	<b>BP</b>	<b>PLL Bypass Control</b> 0 = PLL is in Normal mode (default). 1 = PLL clock output is same as PLL source clock input.
[16]	<b>PD</b>	<b>Power-down Mode</b> If the PWR_DOWN_EN bit is set to 1 in PWRCON register, the PLL will enter Power-down mode too. 0 = PLL is in Normal mode. 1 = PLL is in Power-down mode (default).
[15:14]	<b>OUT_DV</b>	<b>PLL Output Divider Control</b> Refer to the formulas below the table.
[13:9]	<b>IN_DV</b>	<b>PLL Input Divider Control</b> Refer to the formulas below the table.
[8:0]	<b>FB_DV</b>	<b>PLL Feedback Divider Control</b> Refer to the formulas below the table.

PLL Output Clock Frequency Setting:

$$F_{OUT} = F_{IN} \times \frac{NF}{NR} \times \frac{1}{NO}$$

Constrain:

1.  $4\text{MHz} < F_{IN} < 24\text{MHz}$
2.  $800\text{KHz} < \frac{F_{IN}}{2 * NR} < 7.5\text{MHz}$
3.  $100\text{MHz} < F_{CO} = F_{IN} \times \frac{NF}{NR} < 200\text{MHz}$   
 **$120\text{MHz} < F_{CO}$  is preferred**

Symbol	Description
FOUT	Output Clock Frequency
FIN	Input (Reference) Clock Frequency
NR	Input Divider (IN_DV + 2)
NF	Feedback Divider (FB_DV + 2)
NO	OUT_DV = "00" : NO = 1 OUT_DV = "01" : NO = 2 OUT_DV = "10" : NO = 2 OUT_DV = "11" : NO = 4

### Default Frequency Setting

The default value: 0xC22E

$F_{IN} = 12\text{ MHz}$

$NR = (1+2) = 3$

$NF = (46+2) = 48$

$NO = 4$

$F_{OUT} = 12/4 \times 48 \times 1/3 = 48\text{ MHz}$

**Frequency Divider Control Register (FRQDIV)**

Register	Offset	R/W	Description				Reset Value
FRQDIV	CLK_BA+0x24	R/W	Frequency Divider Control Register				0x0000_0000

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

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	DIVIDER_EN	<b>Frequency Divider Enable Control</b> 0 = Frequency Divider Disabled. 1 = Frequency Divider Enabled.
[3:0]	FSEL	<b>Divider Output Frequency Selection</b> The formula of output frequency is: $F_{out} = F_{in}/2^{(N+1)}$ . $F_{in}$ is the input clock frequency. $F_{out}$ is the frequency of divider output clock. N is the 4-bit value of FSEL[3:0].

## 5.4 Clock Controller of NuMicro® NUC029FAE

### 5.4.1 Overview

The clock controller generates the clocks for the whole chip, including system clocks and all peripheral clocks. The clock controller also implements the power control function with the individually clock ON/OFF control, clock source selection and clock divider. The chip enters Power-down mode when Cortex®-M0 core executes the WFI instruction only if the PWR\_DOWN\_EN (PWRCON[7]) bit and PD\_WAIT\_CPU (PWRCON[8]) bit are both set to 1. After that, chip enters Power-down mode and wait for wake-up interrupt source triggered to leave Power-down mode. In the Power-down mode, the clock controller turns off the 4~24 MHz external high speed crystal oscillator (HXT) and 22.1184 MHz internal high speed RC oscillator (HIRC) to reduce the overall system power consumption. The following figures show the clock generator and the overview of the clock source control.

The clock generator consists of 3 clock sources as listed below:

- 4~24 MHz external high speed crystal oscillator (HXT) or 32.768 kHz external low speed crystal oscillator (LXT)
- 22.1184 MHz internal high speed RC oscillator (HIRC)
- 10 kHz internal low speed RC oscillator (LIRC)

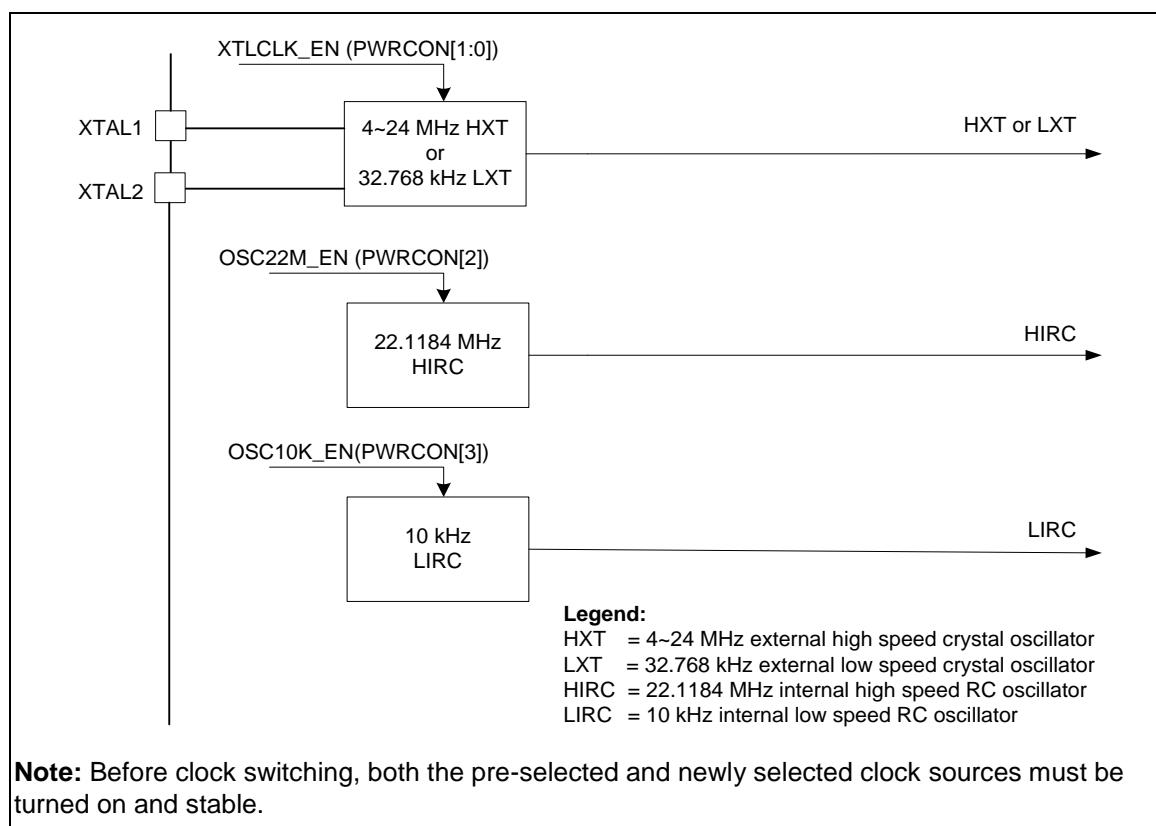


Figure 5-13 NuMicro® NUC029FAE Clock Generator Block Diagram

### 5.4.2 System Clock and SysTick Clock

The system clock has 3 clock sources which were generated from clock generator block. The clock source switch depends on the register HCLK\_S (CLKSEL0[2:0]). The block diagram is shown in Figure 5-14.

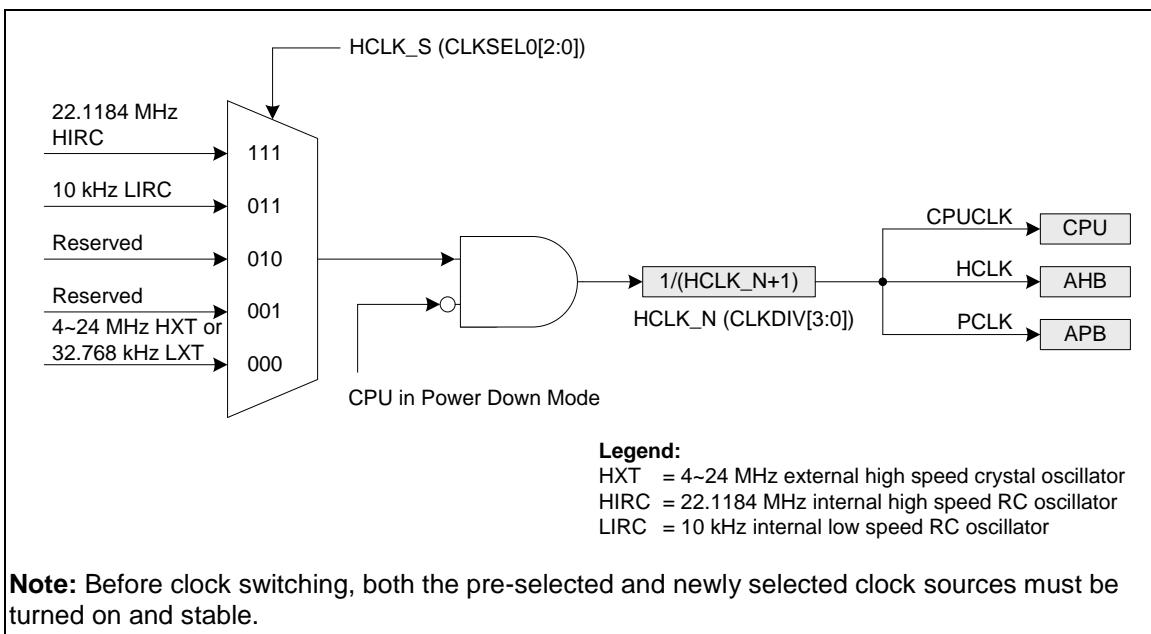


Figure 5-14 NuMicro® NUC029FAE System Clock Block Diagram

The clock source of SysTick in Cortex®-M0 core can use CPU clock or external clock (SYST\_CSR[2]). If using external clock, the SysTick clock (STCLK) has 4 clock sources. The clock source switch depends on the setting of the register STCLK\_S (CLKSEL0[5:3]). The block diagram is shown in Figure 5-15.

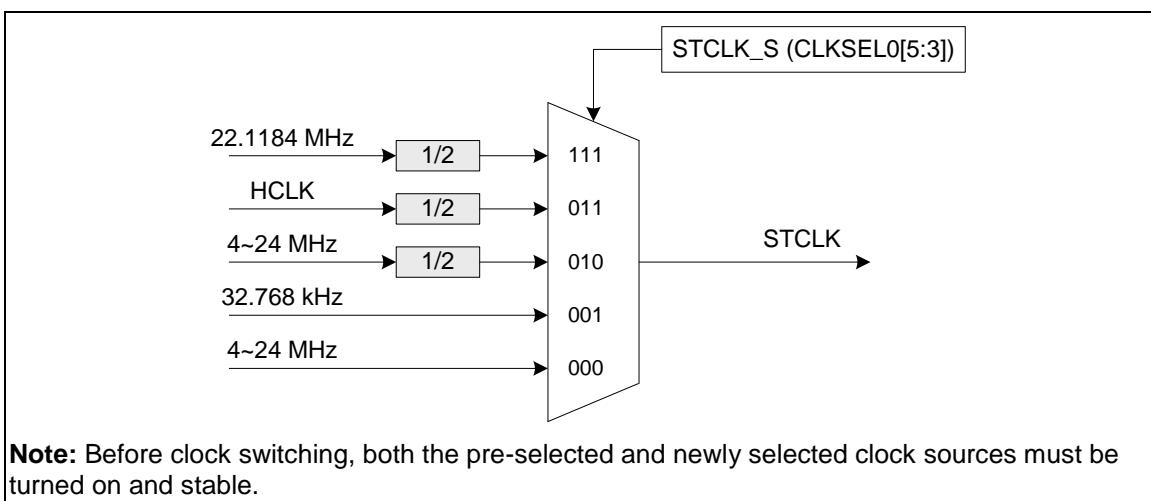


Figure 5-15 NuMicro® NUC029FAE SysTick Clock Control Block Diagram

### 5.4.3 ISP Clock Source Selection

The clock source of ISP is from AHB clock (HCLK). Please refer to the register AHBCLK.

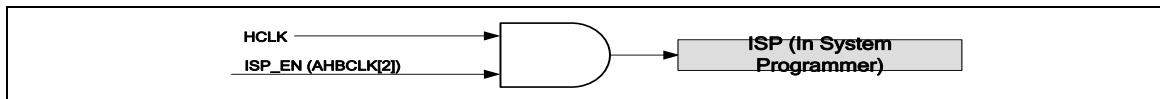


Figure 5-16 NuMicro® NUC029FAE AHB Clock Source for HCLK

### 5.4.4 Module Clock Source Selection

The peripheral clock has different clock source switch settings depending on different peripherals.

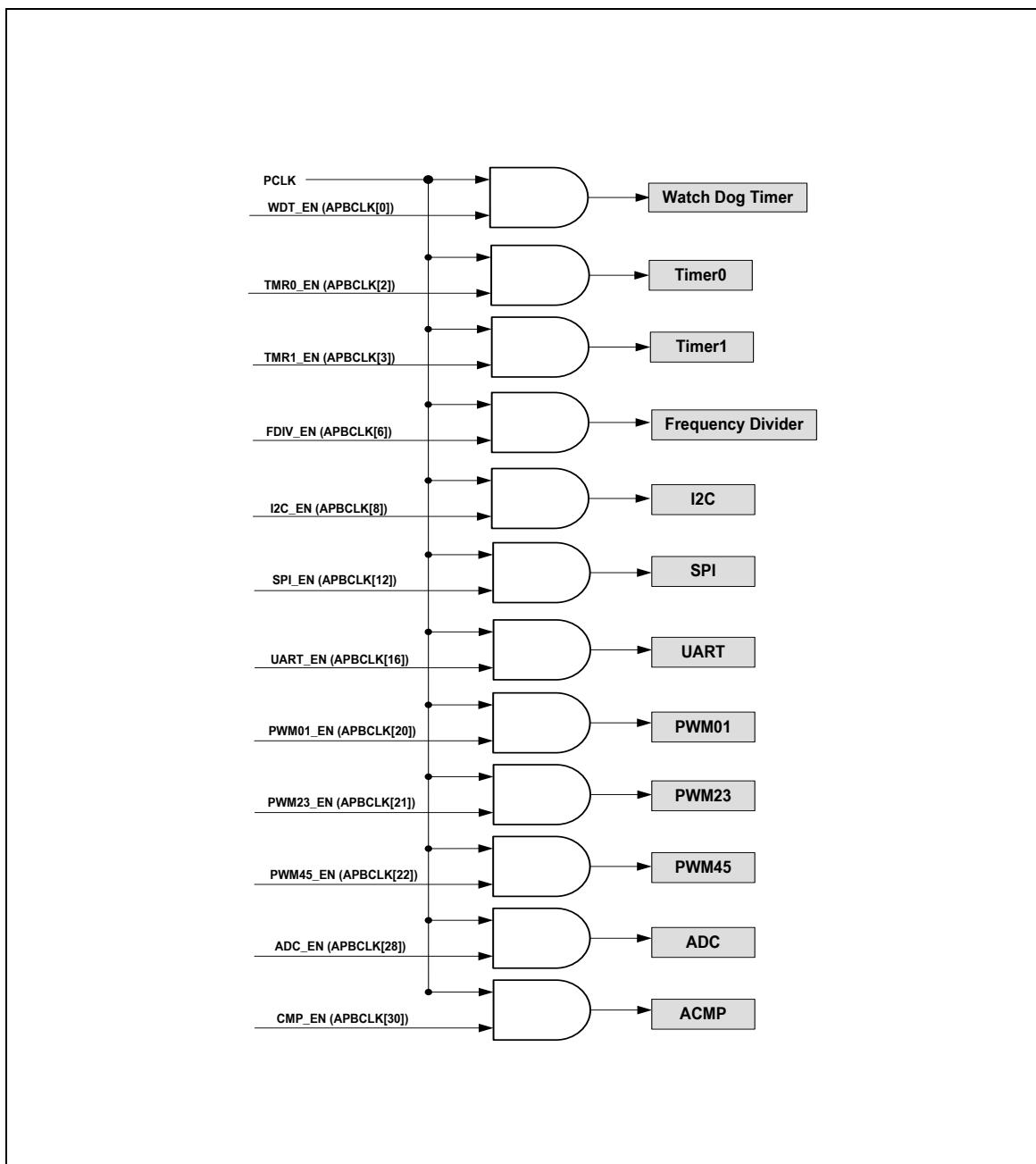


Figure 5-17 NuMicro® NUC029FAE Peripherals Clock Source Selection for PCLK

	Ext. CLK (HXT Or LXT)	HIRC	LIRC	PCLK
WDT	Yes	No	Yes	Yes
Timer0	Yes	Yes	Yes	Yes
Timer1	Yes	Yes	Yes	Yes
I <sup>2</sup> C	No	No	No	Yes
SPI	No	No	No	Yes
UART	Yes	Yes	No	No
PWM	No	No	No	Yes
ADC	Yes	Yes	No	Yes
ACMP	No	No	No	Yes

Table 5-8 NuMicro® NUC029FAE Peripheral Clock Source Selection Table

#### 5.4.5 Power-down Mode Clock

When chip enters Power-down mode, system clocks, some clock sources, and some peripheral clocks will be disabled. Some clock sources and peripherals clocks are still active in Power-down mode.

The clocks still kept active are listed below:

- Clock Generator
  - 10 kHz internal low speed RC oscillator clock (LIRC)
- 32.768 kHz external low speed crystal oscillator (LXT) clock (If PD\_32K = 1 and XTLCLK\_EN[1:0] = 10)
- Peripherals Clock (When 10 kHz low speed oscillator is adopted as clock source)
  - Watchdog Clock
  - Timer 0/1 Clock

#### 5.4.6 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>CLK Base Address:</b>				
<b>CLK_BA = 0x5000_0200</b>				
PWRCON	CLK_BA+0x00	R/W	System Power-down Control Register	0x0000_001C
AHBCLK	CLK_BA+0x04	R/W	AHB Devices Clock Enable Control Register	0x0000_0005
APBCLK	CLK_BA+0x08	R/W	APB Devices Clock Enable Control Register	0x0000_0001
CLKSTATUS	CLK_BA+0x0C	R/W	Clock Status Monitor Register	0x0000_0018
CLKSEL0	CLK_BA+0x10	R/W	Clock Source Select Control Register 0	0x0000_003F
CLKSEL1	CLK_BA+0x14	R/W	Clock Source Select Control Register 1	0xAFFF_FFFF
CLKDIV	CLK_BA+0x18	R/W	Clock Divider Number Register	0x0000_0000
CLKSEL2	CLK_BA+0x1C	R/W	Clock Source Select Control Register 2	0x0000_00EF
FRQDIV	CLK_BA+0x24	R/W	Frequency Divider Control Register	0x0000_0000

### 5.4.7 Register Description

#### Power-down Control Register (PWRCON)

Except the Bit[6], all the other bits are protected, and programming these bits need to write 0x59, 0x16, 0x88 to address 0x5000\_0100 to disable register protection. Refer to the REGWRPROT register at address GCR\_BA + 0x100.

Register	Offset	R/W	Description				Reset Value
PWRCON	CLK_BA+0x00	R/W	System Power-down Control Register				0x0000_001C

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved						PD_32K	Reserved
7	6	5	4	3	2	1	0
PWR_DOWN_EN	PD_WU_STS	PD_WU_INT_EN	PD_WU_DLY	OSC10K_EN	OSC22M_EN	XTLCLK_EN	

Bits	Description	
[31:10]	Reserved	Reserved.
[9]	PD_32K	<b>Enable LXT In Power-down Mode</b> This bit controls the crystal oscillator active or not in Power-down mode. 0 = No effect to Power-down mode. 1 = If XTLCLK_EN[1:0] = 10, LXT is still active in Power-down mode.
[8]	Reserved	Reserved.
[7]	PWR_DOWN_EN	<b>System Power-down Enable Bit (Write Protect)</b> When chip wakes up from Power-down mode, this bit is cleared by hardware. User needs to set this bit again for next Power-down. In Power-down mode, 4~24 MHz external high speed crystal oscillator (HXT), 32.768 kHz external low speed crystal oscillator (LXT), and the 22.1184 MHz internal high speed oscillator (HIRC) will be disabled in this mode, and 10 kHz internal low speed RC oscillator (LIRC) are not controlled by Power-down mode. In Power-down mode, the system clock is disabled, and ignored the clock source selection. The clocks of peripheral are not controlled by Power-down mode, if the peripheral clock source is from 10 kHz internal low speed oscillator. 0 = Chip operating normally or chip in Idle mode because of WFI command. 1 = Chip enters Power-down mode instantly or waits CPU sleep command WFI.
[6]	PD_WU_STS	<b>Power-down Mode Wake-up Interrupt Status</b> Set by "Power-down wake-up event", which indicates that resume from Power-down mode" The flag is set if the GPIO, UART, WDT, I <sup>2</sup> C, ACMP, Timer or BOD wake-up occurred. <b>Note:</b> This bit works only if PD_WU_INT_EN (PWRCON[5]) set to 1. Write 1 to clear the bit to 0.

Bits	Description	
[5]	<b>PD_WU_INT_EN</b>	<p><b>Power-down Mode Wake-up Interrupt Enable Control (Write Protect)</b></p> <p>0 = Disabled. 1 = Enabled.</p> <p><b>Note:</b> The interrupt will occur when both PD_WU_STS and PD_WU_INT_EN are high.</p>
[4]	<b>PD_WU_DLY</b>	<p><b>Wake-up Delay Counter Enable Control (Write Protect)</b></p> <p>When the chip wakes up from Power-down mode, the clock control will delay certain clock cycles to wait system clock stable.</p> <p>The delayed clock cycle is 4096 clock cycles when chip work at 4~24 MHz external high speed crystal (HXT), 4096 clock cycles for 32.768 kHz external low speed crystal (LXT), and 16 clock cycles when chip works at 22.1184 MHz internal high speed RC oscillator (HIRC).</p> <p>0 = Clock cycles delay Disabled. 1 = Clock cycles delay Enabled.</p>
[3]	<b>OSC10K_EN</b>	<p><b>10 KHz Internal Low Speed RC Oscillator (LIRC) Enable Control (Write Protect)</b></p> <p>0 = 10 kHz internal low speed RC oscillator (LIRC) Disabled. 1 = 10 kHz internal low speed RC oscillator (LIRC) Enabled.</p>
[2]	<b>OSC22M_EN</b>	<p><b>22.1184 MHz Internal High Speed RC Oscillator (HIRC) Enable Control (Write Protect)</b></p> <p>0 = 22.1184 MHz internal high speed RC oscillator (HIRC) Disabled. 1 = 22.1184 MHz internal high speed RC oscillator (HIRC) Enabled.</p> <p><b>Note:</b> The default of OSC22M_EN bit is 1.</p>
[1:0]	<b>XTLCLK_EN[1:0]</b>	<p><b>External Crystal HXT Or LXT Enable Control (Write Protect)</b></p> <p>The default clock source is from HIRC. These two bits are default set to “00” and the XTAL1 and XTAL2 pins are GPIO.</p> <p>00 = XTAL1 and XTAL2 are GPIO, disable both LXT &amp; HXT (default). 01 = HXT Enabled. 10 = LXT Enabled. 11 = XTAL1 is external clock input pin, XTAL2 is GPIO.</p> <p><b>Note:</b> To enable the external XTAL function, the P5_ALT[1:0] and P5_MFP[1:0] bits must also be set in P5_MFP.</p>

Mode	Register Or Instruction <b>SLEEPDEEP (SCR[2])</b>	PWR_DOWN_EN (PWRCON[7])	CPU Run WFI Instruction	Clock Disable
Normal operation	0	0	NO	All clocks disabled by control register
Idle mode (CPU entering Sleep mode)	0	0	YES	Only CPU clock disabled
Power-down mode (CPU entering Deep Sleep mode)	1	1	YES	Most clocks are disabled except 10 kHz and only WDT peripheral clock still enable if its peripheral clock source is selected as 10 kHz.

Table 5-9 Power-down Mode Control

When chip enters Power-down mode, user can wake-up this chip using some interrupt sources. The related interrupt sources and NVIC IRQ enable bits (NVIC\_ISER) should be enabled before setting PWR\_DOWN\_EN bit in PWRCON[7] to ensure chip can enter Power-down and wake-up successfully.

**AHB Devices Clock Enable Control Register (AHBCLK)**

The bit in this register is used to enable/disable clock for system clock.

Register	Offset	R/W	Description					Reset Value
AHBCLK	CLK_BA+0x04	R/W	AHB Devices Clock Enable Control Register					0x0000_0005

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

Bits	Description	
[31:3]	Reserved	Reserved.
[2]	ISP_EN	<b>Flash ISP Controller Clock Enable Control</b> 0 = Flash ISP peripheral clock Disabled. 1 = Flash ISP peripheral clock Enabled.
[1]	Reserved	Reserved.
[0]	Reserved	Reserved.

**APB Devices Clock Enable Control Register (APBCLK)**

The bits in this register are used to enable/disable clock for peripheral controller clocks.

Register	Offset	R/W	Description				Reset Value
APBCLK	CLK_BA+0x08	R/W	APB Devices Clock Enable Control Register				0x0000_0001

31	30	29	28	27	26	25	24
Reserved	ACMP_EN	Reserved	ADC_EN	Reserved			
23	22	21	20	19	18	17	16
Reserved	PWM45_EN	PWM23_EN	PWM01_EN	Reserved			UART_EN
15	14	13	12	11	10	9	8
Reserved			SPI_EN	Reserved			I2C_EN
7	6	5	4	3	2	1	0
Reserved	FDIV_EN	Reserved		TMR1_EN	TMR0_EN	Reserved	WDT_EN

Bits	Description	
[31]	Reserved	Reserved.
[30]	ACMP_EN	<b>Analog Comparator Clock Enable Control</b> 0 = Analog Comparator clock Disabled. 1 = Analog Comparator clock Enabled.
[29]	Reserved	Reserved.
[28]	ADC_EN	<b>Analog-digital-converter (ADC) Clock Enable Control</b> 0 = ADC peripheral clock Disabled. 1 = ADC peripheral clock Enabled.
[27:23]	Reserved	Reserved.
[22]	PWM45_EN	<b>PWM_45 Clock Enable Control</b> 0 = PWM45 clock Disabled. 1 = PWM45 clock Enabled.
[21]	PWM23_EN	<b>PWM_23 Clock Enable Control</b> 0 = PWM23 clock Disabled. 1 = PWM23 clock Enabled.
[20]	PWM01_EN	<b>PWM_01 Clock Enable Control</b> 0 = PWM01 clock Disabled. 1 = PWM01 clock Enabled.
[19:17]	Reserved	Reserved.
[16]	UART_EN	<b>UART Clock Enable Control</b> 0 = UART clock Disabled. 1 = UART clock Enabled.
[15:13]	Reserved	Reserved.

Bits	Description	
[12]	<b>SPI_EN</b>	<b>SPI Peripheral Clock Enable Control</b> 0 = SPI peripheral clock Disabled. 1 = SPI peripheral clock Enabled.
[11:9]	<b>Reserved</b>	Reserved.
[8]	<b>I2C_EN</b>	<b>I<sup>2</sup>C Clock Enable Control</b> 0 = I <sup>2</sup> C clock Disabled. 1 = I <sup>2</sup> C clock Enabled.
[7]	<b>Reserved</b>	Reserved.
[6]	<b>FDIV_EN</b>	<b>Frequency Divider Output Clock Enable Control</b> 0 = FDIV clock Disabled. 1 = FDIV clock Enabled.
[5:4]	<b>Reserved</b>	Reserved.
[3]	<b>TMR1_EN</b>	<b>Timer1 Clock Enable Control</b> 0 = Timer1 clock Disabled. 1 = Timer1 clock Enabled.
[2]	<b>TMR0_EN</b>	<b>Timer0 Clock Enable Control</b> 0 = Timer0 clock Disabled. 1 = Timer0 clock Enabled.
[1]	<b>Reserved</b>	Reserved.
[0]	<b>WDT_EN</b>	<b>Watchdog Timer Clock Enable Control (Write Protect)</b> 0 = Watchdog Timer clock Disabled. 1 = Watchdog Timer clock Enabled. <b>Note:</b> This bit is the protected bit, and programming it needs to write 0x59, 0x16, and 0x88 to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA + 0x100.

**Clock Status Register (CLKSTATUS)**

These register bits are used to monitor if the chip clock source is stable or not, and if the clock switch is failed.

Register	Offset	R/W	Description				Reset Value
CLKSTATUS	CLK_BA+0x0C	R/W	Clock Status Monitor Register				0x0000_0018

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
CLK_SW_FAIL	Reserved		OSC22M_STB	OSC10K_STB	Reserved		XTL_STB

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	CLK_SW_FAIL	<p><b>Clock Switch Fail Flag</b>            0 = Clock switching success.            1 = Clock switching failed.</p> <p><b>Note1:</b> This bit is updated when software switches system clock source. If switch target clock is stable, this bit will be set to 0. If switch target clock is not stable, this bit will be set to 1.</p> <p><b>Note2:</b> This bit is read only. After selected clock source is stable, hardware will switch system clock to selected clock automatically, and CLK_SE_FAIL will be cleared automatically by hardware.</p>
[6:5]	Reserved	Reserved.
[4]	OSC22M_STB	<p><b>HIRC Clock Source Stable Flag (Read Only)</b>            0 = HIRC clock is not stable or disabled.            1 = HIRC clock is stable.</p>
[3]	OSC10K_STB	<p><b>LIRC Clock Source Stable Flag (Read Only)</b>            0 = LIRC clock is not stable or disabled.            1 = LIRC clock is stable.</p>
[2:1]	Reserved	Reserved.
[0]	XTL_STB	<p><b>HXT Or LXT Clock Source Stable Flag</b>            0 = HXT or LXT clock is not stable or disabled.            1 = HXT or LXT clock is stable.</p>

**Clock Source Select Control Register 0 (CLKSEL0)**

Register	Offset	R/W	Description				Reset Value
CLKSEL0	CLK_BA+0x10	R/W	Clock Source Select Control Register 0				0x0000_003F

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

Bits	Description	
[31:6]	Reserved	Reserved.
[5:3]	STCLK_S[2:0]	<p><b>Cortex® -M0 SysTick Clock Source Selection From Reference Clock (Write Protect)</b></p> <p>If SYST_CSR[2] = 1, SysTick clock source is from HCLK.  If SYST_CSR[2] = 0, SysTick clock source is defined by below settings.</p> <p>000 = Clock source is from HXT or LXT.  001 = Reserved.  010 = Clock source is from HXT/2 or LXT/2.  011 = Clock source is from HCLK/2.  111 = Clock source is from HIRC /2.  Others = Reserved.</p> <p><b>Note1:</b> These bits are protected bit, and programming them needs to write 0x59, 0x16, and 0x88 to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA + 0x100.</p> <p><b>Note2:</b> If the SysTick clock source is not from HCLK (i.e. SYST_CSR[2] = 0), SysTick clock source must less than or equal to HCLK/2.</p> <p><b>Note3:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.</p>
[2:0]	HCLK_S[2:0]	<p><b>HCLK Clock Source Selection (Write Protect)</b></p> <p>000 = Clock source is from HXT or LXT.  001 = Reserved.  010 = Reserved.  011 = Clock source is from LIRC.  111 = Clock source is from HIRC.  Others = Reserved.</p> <p><b>Note1:</b> Before clock switching, the related clock sources (both pre-select and new-select) must be turn-on and stable.</p> <p><b>Note2:</b> These bits are protected bit, and programming them needs to write 0x59, 0x16, and 0x88 to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA + 0x100.</p> <p><b>Note3:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.</p>

**Clock Source Select Control Register 1 (CLKSEL1)**

Before clock switching, the related clock sources (pre-select and new-select) must be turned on.

Register	Offset	R/W	Description					Reset Value
CLKSEL1	CLK_BA+0x14	R/W	Clock Source Select Control Register 1					0xAFFF_FFFF

31	30	29	28	27	26	25	24
Reserved						UART_S	
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved	TMR1_S			Reserved	TMR0_S		
7	6	5	4	3	2	1	0
Reserved			SPI_S	ADC_S			WDT_S

Bits	Description	
[31:26]	Reserved	Reserved.
[25:24]	UART_S[1:0]	<b>UART Clock Source Selection</b> 00 = Clock source is from HXT or LXT. 01 = Reserved. 10 = Clock source is from HIRC. 11 = Clock source is from HIRC . <b>Note:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.
[23:15]	Reserved	Reserved.
[14:12]	TMR1_S[2:0]	<b>TIMER1 Clock Source Selection</b> 000 = Clock source is from HXT or LXT. 001 = Clock source is from LIRC. 010 = Clock source is from HCLK. 011 = Clock source is from external trigger. 111 = Clock source is from HIRC. Others = Reserved. <b>Note:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.
[11]	Reserved	Reserved.
[10:8]	TMR0_S[2:0]	<b>TIMER0 Clock Source Selection</b> 000 = Clock source is from HXT or LXT. 001 = Clock source is from LIRC. 010 = Clock source is from HCLK. 011 = Clock source is from external trigger. 111 = Clock source is from HIRC. Others = Reserved. <b>Note:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.

Bits	Description	
[7:5]	<b>Reserved</b>	Reserved.
[4]	<b>SPI_S</b>	<p><b>SPI Clock Source Selection</b></p> <p>0 = Clock source is from HXT or LXT. 1 = Clock source is from HCLK.</p> <p><b>Note:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.</p>
[3:2]	<b>ADC_S[1:0]</b>	<p><b>ADC Peripheral Clock Source Selection</b></p> <p>00 = Clock source is from HXT or LXT. 01 = Reserved. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC.</p> <p><b>Note:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.</p>
[1:0]	<b>WDT_S[1:0]</b>	<p><b>WDT CLK Clock Source Selection (Write Protect)</b></p> <p>00 = Clock source is from HXT or LXT. 01 = Reserved. 10 = Clock source is from HCLK/2048 clock. 11 = Clock source is from LIRC.</p> <p><b>Note1:</b> These bits are the protected bit, and programming them needs to write 0x59, 0x16, and 0x88 to address 0x5000_0100 to disable register protection. Refer to the register REGWRPROT at address GCR_BA + 0x100.</p> <p><b>Note2:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.</p>

**Clock Source Select Control Register (CLKSEL2)**

Before clock switching the related clock sources (pre-select and new-select) must be turned on.

Register	Offset	R/W	Description					Reset Value
CLKSEL2	CLK_BA+0x1C	R/W	Clock Source Select Control Register 2					0x0000_00EF

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

Bits	Description	
[31:4]	Reserved	Reserved.
[3:2]	FRQDIV_S[1:0]	<b>Clock Divider Clock Source Selection</b> 00 = Clock source is from HXT or LXT. 01 = Reserved. 10 = Clock source is from HCLK. 11 = Clock source is from HIRC. <b>Note:</b> To set PWRCON[1:0], select HXT or LXT crystal clock.
[1:0]	Reserved	Reserved.

Clock Divider Register (CLKDIV)

Register	Offset	R/W	Description				Reset Value
CLKDIV	CLK_BA+0x18	R/W	Clock Divider Number Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
ADC_N							
15	14	13	12	11	10	9	8
Reserved				UART_N			
7	6	5	4	3	2	1	0
Reserved				HCLK_N			

Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	ADC_N[7:0]	<b>ADC Peripheral Clock Divide Number From ADC Peripheral Clock Source</b> ADC peripheral clock frequency = (ADC peripheral clock source frequency) / (ADC_N + 1).
[15:12]	Reserved	Reserved.
[11:8]	UART_N[3:0]	<b>UART Clock Divide Number From UART Clock Source</b> UART clock frequency = (UART clock source frequency) / (UART_N + 1).
[7:4]	Reserved	Reserved.
[3:0]	HCLK_N[3:0]	<b>HCLK Clock Divide Number From HCLK Clock Source</b> HCLK clock frequency = (HCLK clock source frequency) / (HCLK_N + 1).

**Frequency Divider Control Register (FRQDIV)**

Register	Offset	R/W	Description				Reset Value
FRQDIV	CLK_BA+0x24	R/W	Frequency Divider Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved		DIVIDER1	DIVIDER_EN	FSEL			

Bits	Description	
[31:6]	Reserved	Reserved.
[5]	DIVIDER1	<b>Frequency Divider 1 Enable Control</b> 0 = Divider output frequency is depended on FSEL value. 1 = Divider output frequency is the same as input clock frequency.
[4]	DIVIDER_EN	<b>Frequency Divider Enable Control</b> 0 = Frequency Divider Disabled. 1 = Frequency Divider Enabled.
[3:0]	FSEL[3:0]	<b>Divider Output Frequency Selection</b> The formula of output frequency is $F_{out} = F_{in}/2^{(N+1)}$ , $F_{in}$ is the input clock frequency. $F_{out}$ is the frequency of divider output clock. N is the 4-bit value of FSEL[3:0].

## 5.5 Flash Memory Controller (FMC)

### 5.5.1 Overview

The NuMicro® NUC029 series has 64/32/16K bytes on-chip embedded Flash for application program memory (APROM) that can be updated through ISP procedure. The In-System-Programming (ISP) function enables user to update program memory when chip is soldered on PCB. After chip is powered on, Cortex®-M0 CPU fetches code from APROM or LDROM decided by boot select (CBS) in CONFIG0.

The NuMicro® NUC029 series also provides additional Data Flash for user to store some application dependent data before chip power off. The NUC029xAN provides additional 4 Kbytes DATA Flash, and NUC029FAE provides Data Flash that is shared with APROM and its start address is configurable and defined by user in CONFIG1.

### 5.5.2 Features

- Runs up to 50 MHz with zero wait cycle for continuous address read access
- 64/32/16 KB application program memory (APROM)
- Up to 4KB In-System-Programming (ISP) loader program memory (LDROM)
- Fixed 4KB Data Flash for NUC029xAN
- Configurable Data Flash size and Programmable Data Flash start address for NUC029FAE
- All embedded flash memory supports 512 bytes page erase
- Supports In-Application-Programming (IAP) to switch code between APROM and LDROM without reset
- In-System-Programming (ISP) to update on-chip Flash

### 5.5.3 Block Diagram for NUC029xAN

The flash memory controller consist of AHB slave interface, ISP control logic, writer interface and flash macro interface timing control logic. The block diagram of flash memory controller is shown in the following figure.

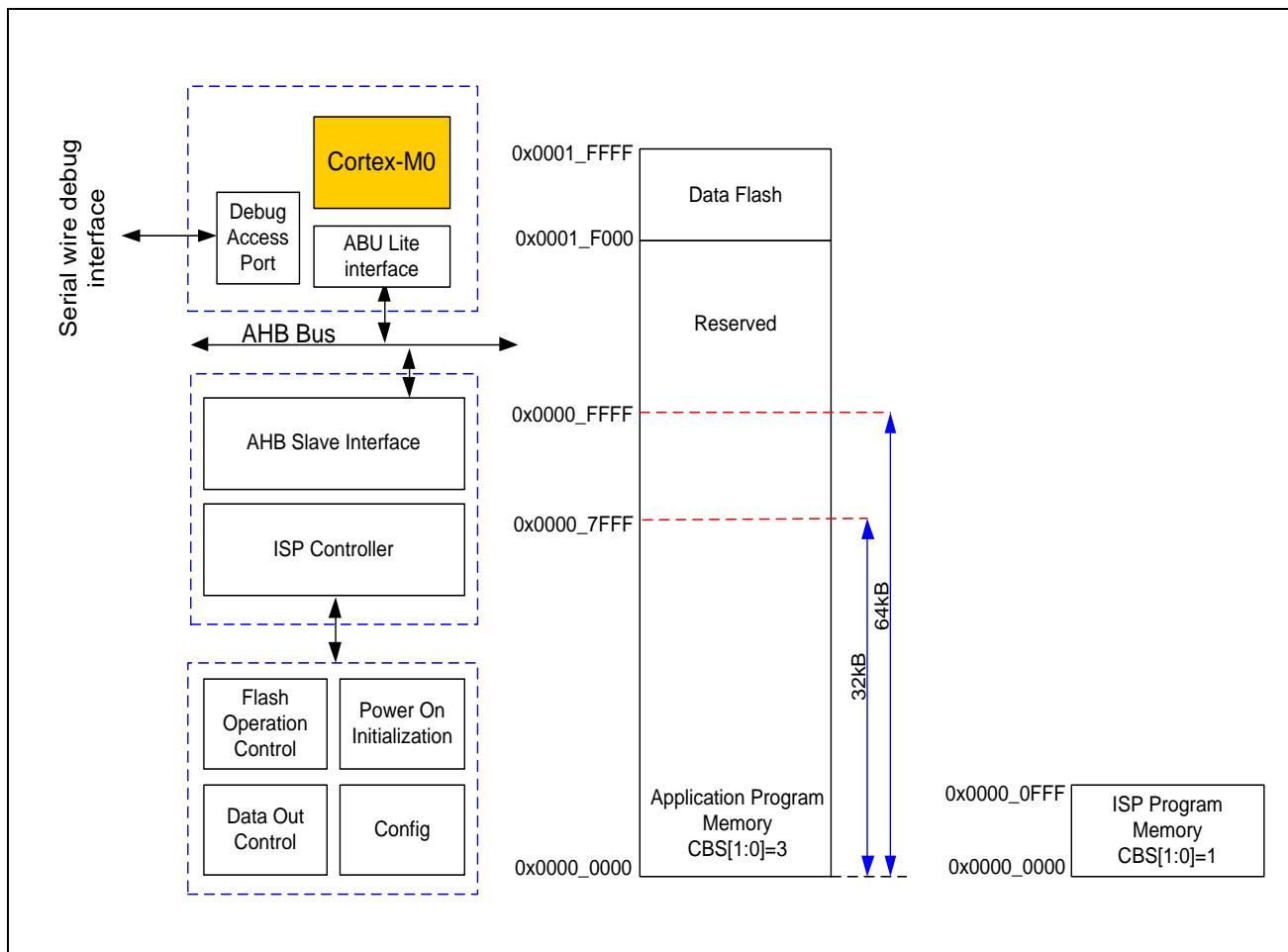


Figure 5-18 Flash Memory Control Block Diagram for NUC029xAN

## 5.5.4

## Block Diagram for NUC029FAE

The flash memory controller consists of ISP control logic, writer interface and flash macro interface timing control logic. The block diagram of flash memory controller is shown in the following figure:

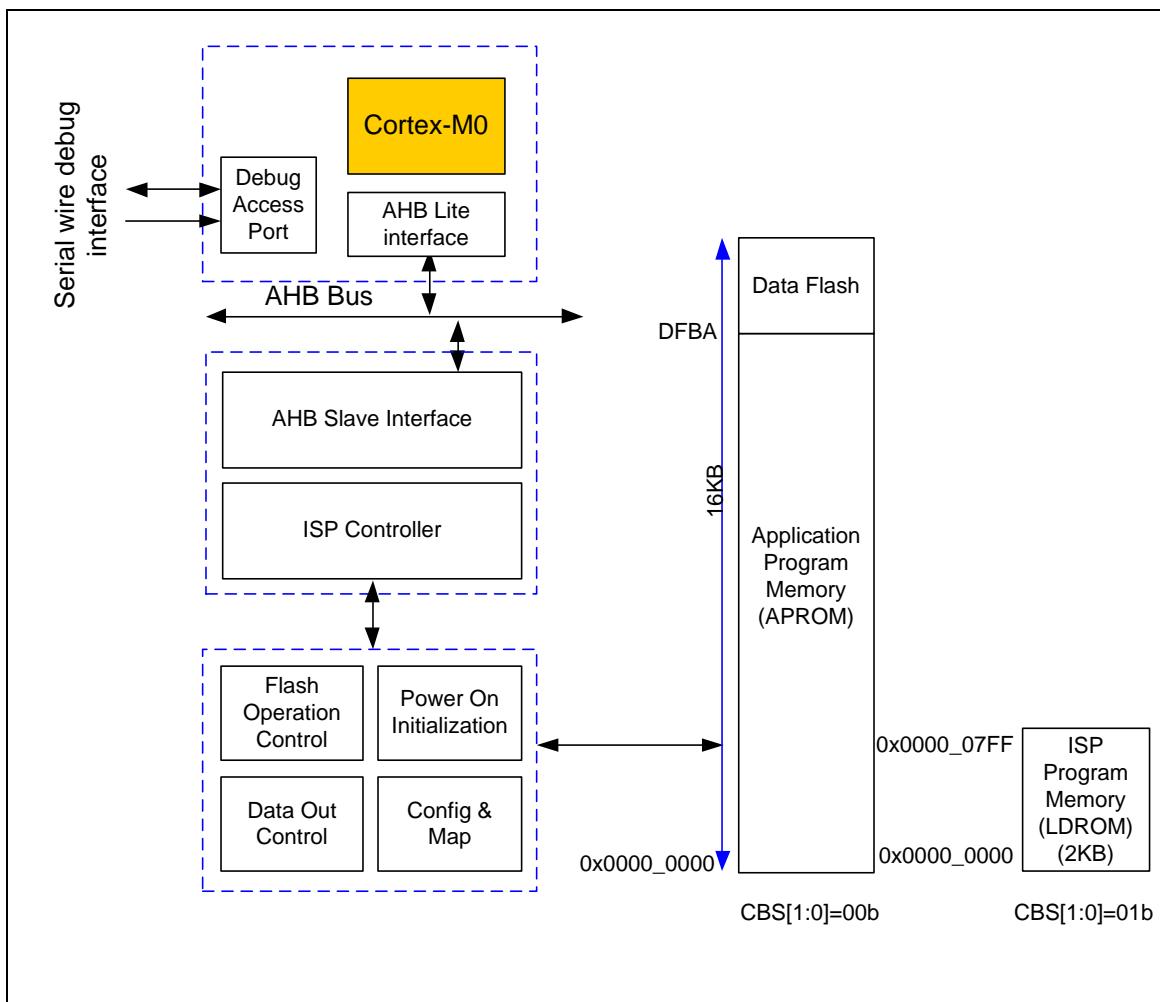


Figure 5-19 Flash Memory Control Block Diagram for NUC029FAE

### 5.5.5 FMC Memory Organization

The NUC029 series flash memory consists of program memory (APROM), Data Flash, ISP loader program memory (LDROM), and user configuration.

Program memory is main memory for user applications and called APROM. User can write their application to APROM and set system to boot from APROM.

ISP loader program memory is designed for a loader to implement In-System-Programming function. LDROM is independent to APROM and system can also be set to boot from LDROM. Therefore, user can use LDROM to avoid system boot fail when code of APROM was corrupted.

Data Flash is used for user to store data. It can be read by ISP read or memory read and programmed through ISP register. The size of each erase unit is 512 bytes. For NUC029xAN, Data Flash size is 4 KB and start address is fixed at 0x0001\_F000; for NUC029xAN, Data Flash is shared with APROM, the size and start address are defined in CONFIG1.

User configuration provides several bytes to control system logic, such as flash security lock, boot select, Brown-out voltage level, Data Flash base address, etc.... User configuration works like a fuse for power on setting and loaded from flash memory to its corresponding control register during chip powered on.

In the NuMicro® Family, the flash memory organization is different to system memory map. Flash memory organization is used when user using ISP command to read, program or erase flash memory. System memory map is used when CPU access flash memory to fetch code or data. For example of NUC029xAN, when system is set to boot from LDROM by CBS[1:0] = 01'b, CPU will be able to fetch code of LDROM from 0x0 ~ 0xFFFF. However, if user want to read LDROM by ISP, they still need to read the address of LDROM as 0x0010\_0000 ~ 0x0010\_0FFF.

The following table and figure show the address mapping information of APROM, LDROM, Data Flash and user configuration.

Block Name	Size	Start Address	End Address
AP-ROM	32/64 Kbytes	0x0000_0000	0x0000_7FFF (32 Kbytes) 0x0000_FFFF (64 Kbytes)
Data Flash	4 Kbytes	0x0001_F000	0x0001_FFFF
LD-ROM	4 Kbytes	0x0010_0000	0x0010_0FFF
User Configuration	1 Words	0x0030_0000	0x0030_0000

Table 5-10 Flash Memory Address Map for NUC029xAN

Block Name	DFEN	Size	Start Address	End Address
AP-ROM	0	(16-0.5*N) Kbytes	0x0000_0000	DFBA-1
AP-ROM	1	16 Kbytes	0x0000_0000	0x0000_3FFF
Data Flash	0	0.5*N Kbytes	DFBA	0x0000_3FFF
Data Flash	1	0 Kbytes	N/A	N/A
LD-ROM	x	2 Kbytes	0x0010_0000	0x0010_07FF
User Configuration	x	2 Words	0x0030_0000	0x0030_0007

Table 5-11 Flash Memory Address Map for NUC029FAE

The Flash memory organization is shown below:

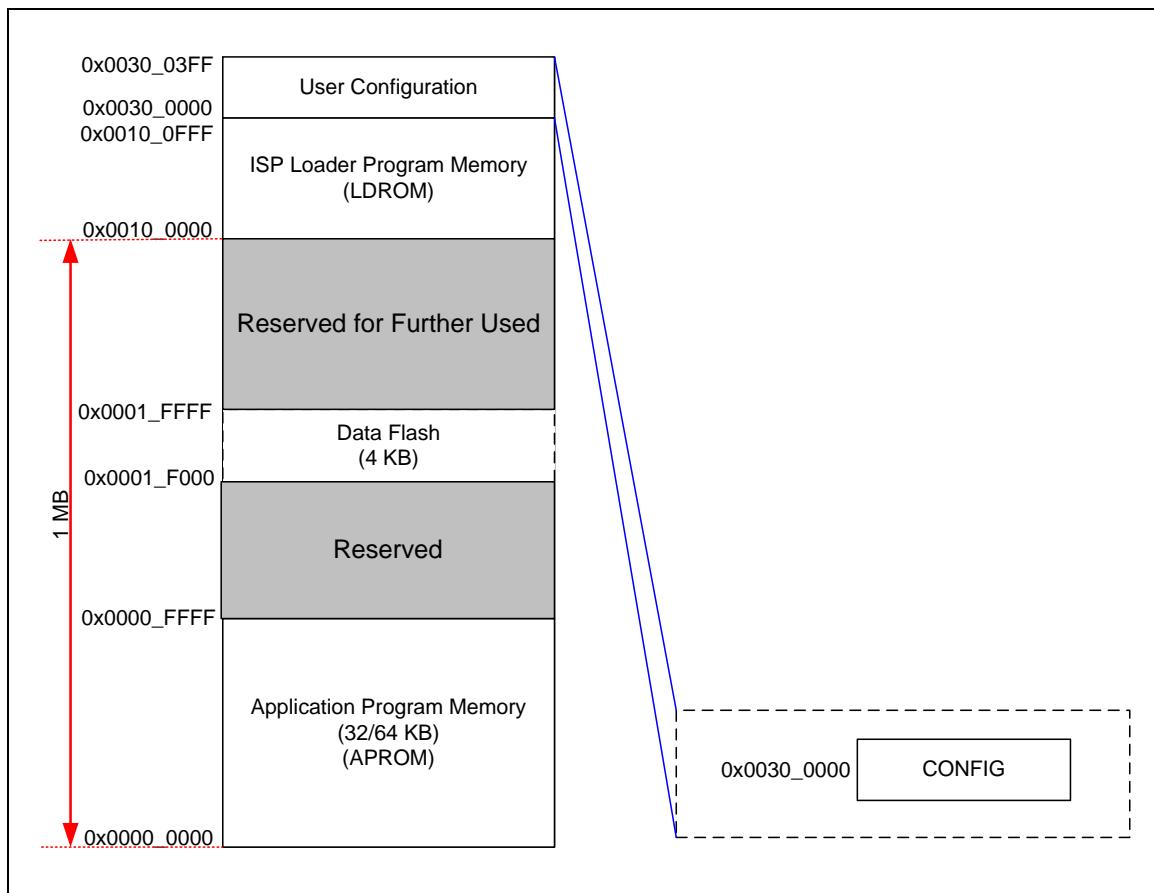


Figure 5-20 Flash Memory Organization for NUC029xAN

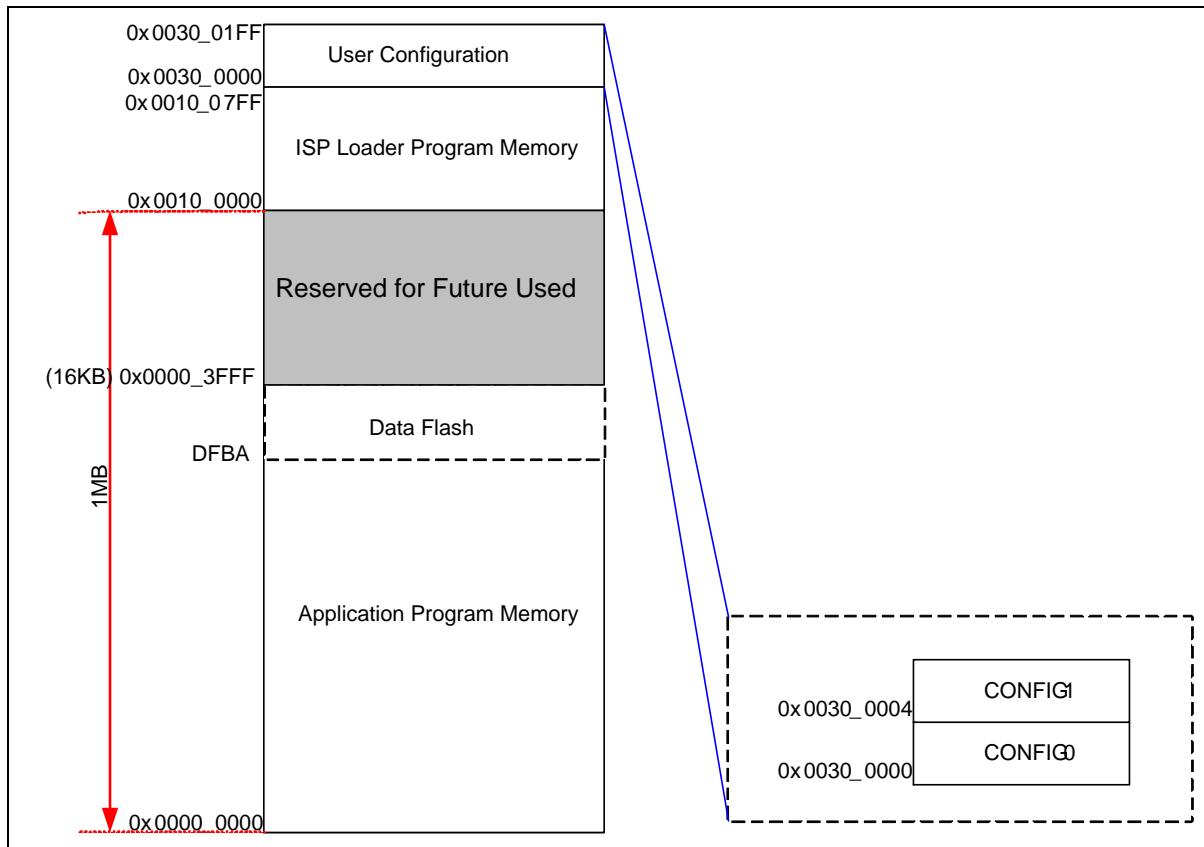


Figure 5-21 Flash Memory Organization for NUC029FAE

### 5.5.6 Data Flash

#### NUC029xAN:

The NUC029xAN provides Data Flash for user to store data. It is read/write thru ISP registers. The erase unit is 512 bytes. When a word will be changed, all 128 words need to be copied to another page or SRAM in advance. For 32/64 Kbytes flash memory device, Data Flash size is 4 Kbytes and start address is fixed at 0x0001\_F000.

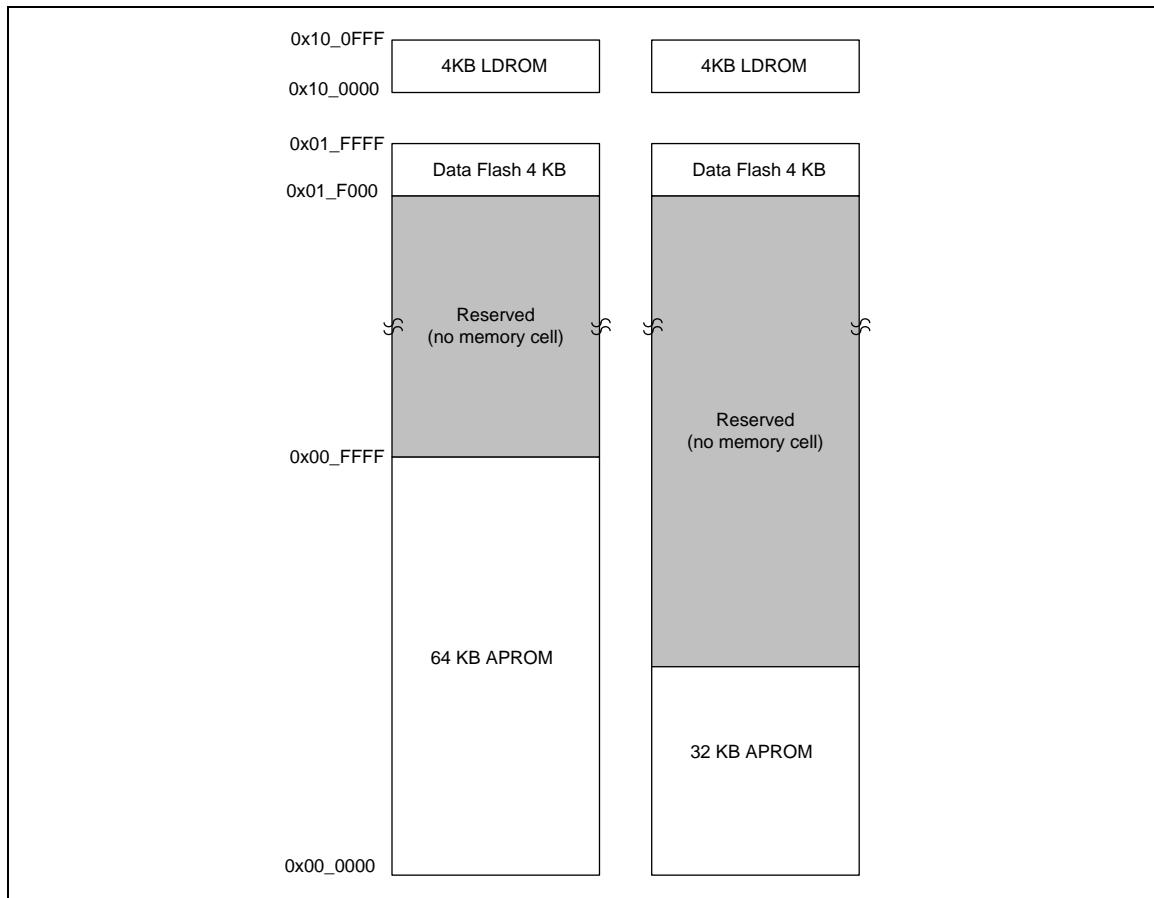


Figure 5-22 Flash Memory Structure for NUC029xAN

**NUC029FAE:**

The NUC029FAE provides Data Flash for user to store data which is read/write thru ISP registers. The Data Flash base address is defined by DFBA(CONFIG0[0]) is enabled. For example for 4K/2K/1K/0KB Data Flash, the DFBA setting value is listed in the following table. The erase unit is 512 bytes. When a word will be changed, all 128 words need to be copied to another page or SRAM in advance.

Data Flash	4KB (DFEN=0)	2KB (DFEN=0)	1KB (DFEN=0)	0KB (DFEN=1)
16K Flash	DFBA=0x0000_3000	DFBA=0x0000_3800	DFBA=0x0000_3C00	DFEN=1

Table 5-12 Data Flash Table for NUC029FAE

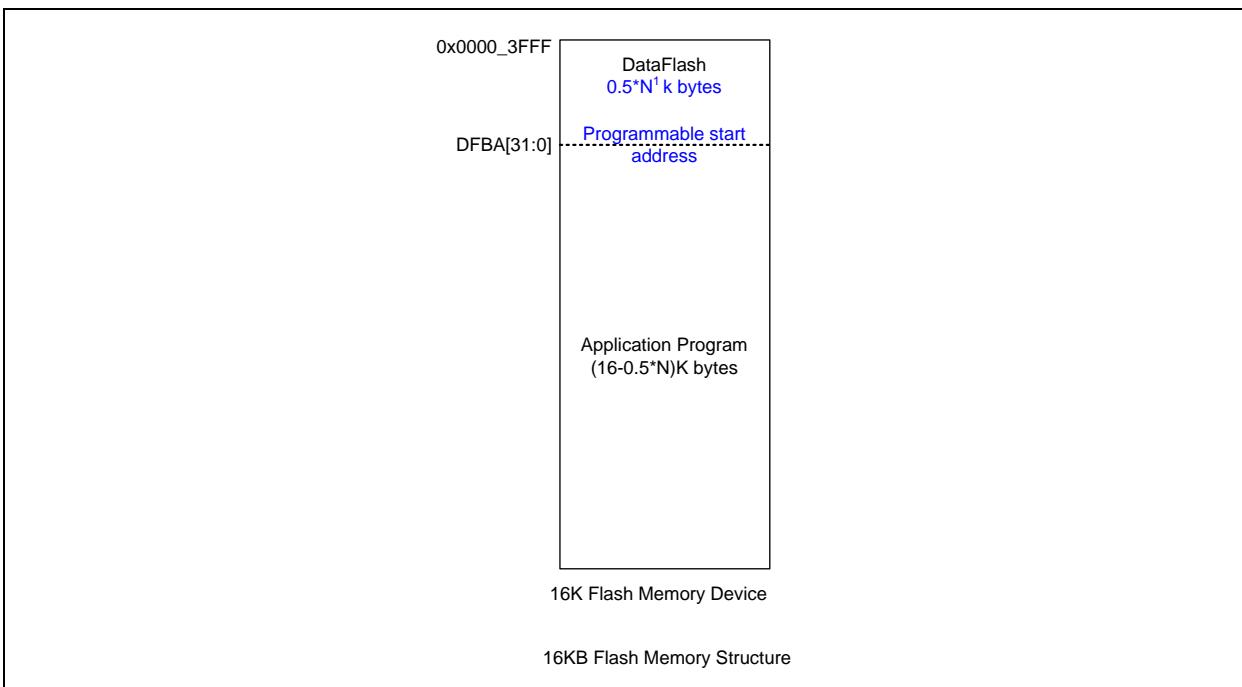


Figure 5-23 Flash Memory Structure for NUC029FAE

### 5.5.7 User Configuration

#### 5.5.7.1 Boot options

User configuration is internal programmable configuration area for boot options. The user configuration is located at 0x300000 of Flash Memory Organization and it is 32 bits word. Any change on user configuration will take effect after system reboot.

**NUC029xAN:**

**CONFIG0 (Address = 0x0030\_0000)**

31	30	29	28	27	26	25	24
CWDTEN	CWDTPDEN	Reserved			CFOSC		
23	22	21	20	19	18	17	16
CBODEN	CBOV		CBORST	Reserved			
15	14	13	12	11	10	9	8
Reserved					CIOINI	Reserved	
7	6	5	4	3	2	1	0
CBS		Reserved				LOCK	Reserved

BIT	Description											
[31]	CWDTEN	<b>Watchdog Enable Control</b> 0 = Watchdog Timer Enabled and force Watchdog Timer clock source as OSC10K after chip powered on. 1 = Watchdog Timer Disabled after chip powered on.										
[30]	CWDTPDEN	<b>Watchdog Clock Power-Down Enable Control</b> 0 = OSC10K Watchdog Timer clock source is forced to be always enabled. 1 = OSC10K Watchdog Timer clock source is controlled by OSC10K_EN (PWRCON[3]) when chip enters Power-Down mode. <b>Note:</b> This bit only works at CWDTEN is set to 0										
[31:27]	Reserved	Reserved.										
[26:24]	CFOSC	<b>CPU Clock Source Selection After Reset</b> <table border="1"> <tr> <td>CFOSC[2:0]</td> <td>Clock Source</td> </tr> <tr> <td>000</td> <td>External crystal clock (4 ~ 24 MHz)</td> </tr> <tr> <td>111</td> <td>Internal RC 22.1184 MHz oscillator clock</td> </tr> <tr> <td>Others</td> <td>Reserved</td> </tr> </table> <p>The value of CFOSC will be load to CLKSEL0.HCLK_S[2:0] in system register after any reset occurs.</p>	CFOSC[2:0]	Clock Source	000	External crystal clock (4 ~ 24 MHz)	111	Internal RC 22.1184 MHz oscillator clock	Others	Reserved		
CFOSC[2:0]	Clock Source											
000	External crystal clock (4 ~ 24 MHz)											
111	Internal RC 22.1184 MHz oscillator clock											
Others	Reserved											
[23]	CBODEN	<b>Brown-out Detector Enable Control</b> 0= Brown-out detect Enabled after powered on. 1= Brown-out detect Disabled after powered on.										
[22:21]	CBOV	<b>Brown-out Voltage Selection</b> <table border="1"> <tr> <td>CBOV</td> <td>Brown-out Voltage</td> </tr> <tr> <td>11</td> <td>4.4V</td> </tr> <tr> <td>10</td> <td>3.7V</td> </tr> <tr> <td>01</td> <td>2.7V</td> </tr> <tr> <td>00</td> <td>2.2V</td> </tr> </table>	CBOV	Brown-out Voltage	11	4.4V	10	3.7V	01	2.7V	00	2.2V
CBOV	Brown-out Voltage											
11	4.4V											
10	3.7V											
01	2.7V											
00	2.2V											
[20]	CBORST	<b>Brown-out Reset Enable Control</b> 0 = Brown-out reset Enabled after powered on.										

		1 = Brown-out reset Disabled after powered on.
[19:11]	<b>Reserved</b>	Reserved.
[10]	<b>CIOINI</b>	<b>I/O Initial State Selection</b> 0 = All GPIO default to be input tri-state mode after powered on. 1 = All GPIO default to be Quasi-bidirectional mode after chip is powered on.
[9:8]	<b>Reserved</b>	Reserved.
[7:6]	<b>CBS</b>	<b>Chip Boot Selection</b> 00 = LDROM with IAP function. 01 = LDROM without IAP function. 10 = APROM with IAP function. 11 = APROM without IAP function. For NUC029xAN, user can set CBS[0] = 0 to support IAP function supported. When CBS[0] = 0, the LDROM is mapping to address 0x100000 and APROM is mapping to address 0x0. User could access them by their address without boot switching. In other words, if IAP function is supported, the code in LDROM and APROM can be called by each other. <b>Note1:</b> BS bit of ISPCON is only can be used to control boot switching when CBS[0] = 1. <b>Note2:</b> VECMAP is only can be used to remap to 0x0~0x1ff when CBS[0] = 0.
[5:2]	<b>Reserved</b>	Reserved.
[1]	<b>LOCK</b>	<b>Security Lock Control</b> 0 = Flash data is locked 1 = Flash data is not locked. When flash data is locked, only device ID, unique ID, user configuration can be read by writer and ICP through serial debug interface. Others data is locked as 0xFFFFFFFF. ISP can read data anywhere regardless of LOCK bit value. To unlock system, user can use ISP command to disable LOCK bit or erase whole chip (Chip Erase) by ICP tool.
[0]	<b>Reserved</b>	Reserved.

**Note:** The reserved bits of user configuration should be kept as '1'.

#### NUC029FAE:

**CONFIG0 (Address = 0x0030\_0000)**

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
CBOVEXT	CBOV		CBORST	Reserved			
15	14	13	12	11	10	9	8
Reserved					CIOINI	Reserved	
7	6	5	4	3	2	1	0
CBS		Reserved				LOCK	DFEN

Config0	Address = 0x0030_0000																									
Bits	Description																									
[31:24]	Reserved	Reserved																								
[23]	CBOVEXT	Brown-out Voltage Selection Extension 0 = Brown-out voltage selection includes 2.2V, 2.7V, 3.7V and 4.4V 1 = Brown-out voltage selection includes BOD disable mode. To disable BOD function, CBOV[1:0] must be 11b. See table in CBOV.																								
[22:21]	CBOV[1:0]	Brown-out Voltage Selection	<table border="1"> <thead> <tr> <th>CBOVEXT</th> <th>CBOV[1:0]</th> <th>Brown-out voltage</th> </tr> </thead> <tbody> <tr><td>0</td><td>00</td><td>2.2V</td></tr> <tr><td>0</td><td>01</td><td>2.7V</td></tr> <tr><td>0</td><td>10</td><td>3.7V</td></tr> <tr><td>0</td><td>11</td><td>4.4V</td></tr> <tr><td>1</td><td>11</td><td>Disable BOD function</td></tr> </tbody> </table>			CBOVEXT	CBOV[1:0]	Brown-out voltage	0	00	2.2V	0	01	2.7V	0	10	3.7V	0	11	4.4V	1	11	Disable BOD function			
CBOVEXT	CBOV[1:0]	Brown-out voltage																								
0	00	2.2V																								
0	01	2.7V																								
0	10	3.7V																								
0	11	4.4V																								
1	11	Disable BOD function																								
[20]	CBORST	Brown-out Reset Enable Control 0 = Brown-out reset Enabled after power on. 1 = Brown-out reset Disabled after power on.																								
[19:11]	Reserved	Reserved																								
[10]	CIOINI	IO Initial State Selection 0 = Quasi bi-direction mode. All GPIO default to be Quasi bi-direction mode after chip power on. 1 = Input tri-state mode. All GPIO default to be input tri-state mode after power on.																								
[9:8]	Reserved	Reserved																								
[7:6]	CBS	Chip Boot Selection 00 = LDROM with IAP function. 01 = LDROM without IAP function. 10 = APROM with IAP function.																								

<b>Config0</b>	<b>Address = 0x0030_0000</b>	
<b>Bits</b>	<b>Description</b>	
		<p>11 = APROM without IAP function.</p> <p>For NUC029FAE, user can set CBS[0] = 0 to support IAP function. When CBS[0] = 0, the LDROM is mapping to address 0x100000 and APROM is mapping to address 0x0. User could access them by their address without boot switching. In other words, if IAP function is supported, the code in LDROM and APROM can be called by each other.</p> <p><b>Note1:</b> BS bit of ISPCON is only can be used to control boot switching when CBS[0] = 1. CBS[0] means bit 6 of this register.</p> <p><b>Note2:</b> VECMAP is only can be used to remap page 0 of APROM or LDROM to 0x0~0x1ff when CBS[0] = 0.</p>
[5:2]	<b>Reserved</b>	Reserved
[1]	<b>LOCK</b>	<p><b>Security Lock</b></p> <p>0 = Flash data locked. 1 = Flash data unlocked.</p> <p>When flash data is locked, only device ID, unique ID, user configuration can be read by writer and ICP through serial debug interface. Others data is locked as 0xFFFFFFFF. ISP can read data anywhere regardless of LOCK bit value.</p>
[0]	<b>DFEN</b>	<p><b>Data Flash Enable Control</b></p> <p>0 = Data Flash Enabled. 1 = Data Flash Disabled.</p>

**Note:** The reserved bits of user configuration should be kept as '1'.

**CONFIG1 (Address = 0x0030\_0004)**

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

Config1	Address = 0x0030_0004	
Bits	Description	
[31:14]	Reserved	Reserved
[13:0]	DFBA[13:0]	Data Flash Base Address The Data Flash base address is defined by user. Since on chip flash erase unit is 512 bytes, it is mandatory to keep bit 8-0 as 0.

**5.5.7.2 Brown-out Detection**

The NUC029 series includes brown-out detection function for monitoring the voltage on V<sub>DD</sub> pin. If V<sub>DD</sub> voltage falls below level setting of CBOV (and CBOVEXT for NUC029FAE only), the BOD event will be triggered when BOD enabled. User can decide to use BOD reset by enable CBORST or just enable BOD interrupt by NVIC when BOD detected. Because BOD reset is issued whenever V<sub>DD</sub> voltage falls below the level setting of CBOV, user must make sure the CBOV setting to avoid BOD reset right after BOD reset enabled. For example, if the V<sub>DD</sub> is 3.3V (and CBOVEXT is 0'b for NUC029FAE only), CBOV could only be 00'b or 01'b. Otherwise, the system will be halted in BOD reset state when BOD reset is enabled and CBOV is 10'b or 11'b.

**5.5.8 Boot Selection**

The NUC029 series provides in system programming (ISP) feature to update APROM when chip is mounted on PCB. A dedicated 2 K/4K bytes LDROM is used to store ISP firmware. Users can select to start program fetch from APROM or LDROM by CBS[1](CONFIG0[7]).

In addition to setting boot from APROM or LDROM, CBS(CONFIG0[7:6]) is also used to control system memory map after booting. The value of CBS[1](CONFIG0[7]) will be loaded to BS(ISPCON[1]) after booting.

In addition to setting boot from APROM or LDROM, CBS(CONFIG0[7:6]) is also used to control system memory map after booting.

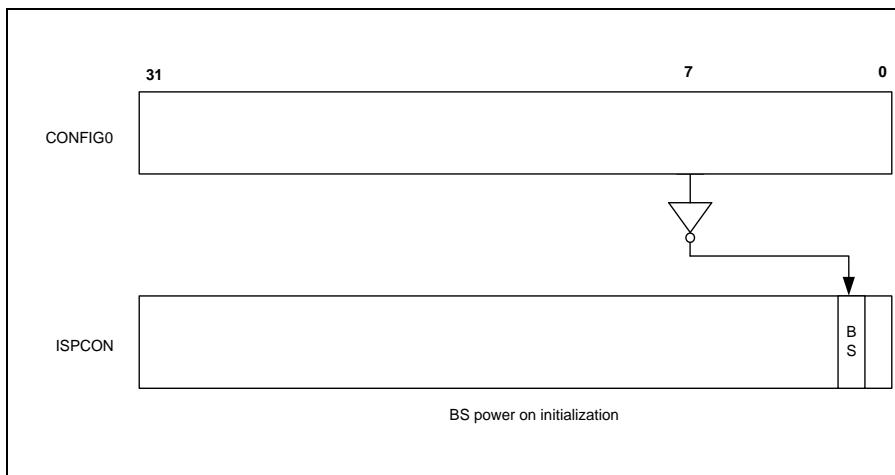


Figure 5-24 Boot Select (BS) for Power-on Action

When CBS[0] = 1 and set CBS[1] = 1 to boot from APROM, the application in APROM will not be able to access LDROM by CPU read. In other words, when CBS[0] = 1 and CBS[1] = 0 are set to boot from LDROM, the software executed in LDROM will not be able to access APROM by memory read. The following figure shows the memory map when booting from APROM and LDROM.

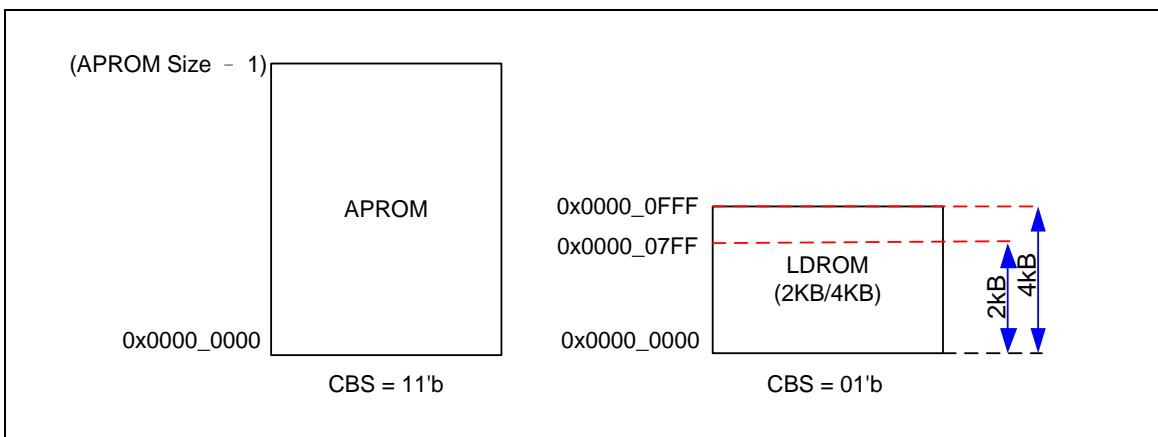


Figure 5-25 Program Executing Range for Booting from APROM and LDROM

For the application that software needs to execute code in APROM and call the functions in LDROM or to execute code in LDROM and call the APROM function without changing boot mode, CBS[0] needs to be set as 0 and this is called In-Application-Programming (IAP).

CBS[1:0]	Boot Selection
00	<b>LDROM with IAP function for NUC029xAN</b> Chip booting from LDROM, program executing range including LDROM and most of APROM (all except first 512 bytes as the first 512 bytes is mapped from LDROM). LDROM address is mapping to 0x0010_0000 ~ 0x0010_0FFF, and also the first 512 bytes of LDROM is mapping to the address 0x0000_0000 ~ 0x0000_01FF. The address 0x0000_0000 ~ 0x0000_01FF can be re-mapping to any other page within executing range though

	ISP command.
	<p><b>LDROM with IAP function for NUC029FAE</b></p> <p>Chip booting from LDROM, program executing range including LDROM and most of APROM (all except first 512 bytes as the first 512 bytes is mapped from LDROM).</p> <p>LDROM address is mapping to 0x0010_0000 ~ 0x0010_07FF, and also the first 512 bytes of LDROM is mapping to the address 0x0000_0000 ~ 0x0000_01FF.</p> <p>The address 0x0000_0000 ~ 0x0000_01FF can be re-mapping to any other page within executing range though ISP command.</p> <p>Both APROM and LDROM are programmable in this mode no matter the code is currently running on LDROM or APROM. Data Flash is meaningless in this mode, because any area of APROM and LDROM can just be used as the Data Flash and DFBA is not functioned in this mode.</p>
01	<p><b>LDROM without IAP function</b></p> <p>Chip booting from LDROM, program executing range only including LDROM; APROM cannot be access by program directly, except by through ISP.</p> <p>LDROM is write-protected in this mode.</p>
10	<p><b>APROM with IAP function for NUC029xAN</b></p> <p>Chip booting from APROM, program executing range including LDROM and APROM</p> <p>LDROM address is mapping to 0x0010_0000~0x0010_0FFF</p> <p>The address 0x0000_0000 ~ 0x0000_01FF can be re-mapping to any other page within executing range though ISP command.</p> <p><b>APROM with IAP function for NUC029FAE</b></p> <p>Chip booting from APROM, program executing range including LDROM and APROM</p> <p>LDROM address is mapping to 0x0010_0000~0x0010_07FF</p> <p>The address 0x0000_0000 ~ 0x0000_01FF can be re-mapping to any other page within executing range though ISP command.</p> <p>Both APROM and LDROM are programmable in this mode no matter the code is currently running on LDROM or APROM. Data Flash is meaningless in this mode, because any area of APROM and LDROM can just be used as the Data Flash and DFBA is not functioned in this mode.</p>
11	<p><b>APROM without IAP function</b></p> <p>Chip booting from APROM and program executing range only including APROM. LDROM cannot be access by program directly, except by through ISP.</p> <p>APROM is write-protected in this mode.</p>

Table 5-13 Supported Boot Selection Options

### 5.5.9 In-Application-Programming (IAP)

The NUC029 series provides In-application-programming (IAP) function for user to switch the code executing between APROM and LDROM without reset. User can enable the IAP function by re-booting chip and setting the chip boot selection bits CBS[1:0](CONFIG0[7:6]) as 10'b or 00'b.

In the case that the chip boots from APROM with the IAP function enabled (CBS[1:0] = 10'b), the executable range of code includes all of APROM and LDROM. The address space of APROM is kept as the original size, but the address space of the 4 KB LDROM is mapped to 0x0010\_0000~0x0010\_0FFF for NUC029xAN and the address space of the 2 KB LDROM is mapped to 0x0010\_0000~ 0x0010\_07FF for NUC029FAE.

In the case that the chip boots from LDROM with the IAP function enabled (CBS[1:0] = 00'b), the executable range of code includes all of LDROM and almost all of APROM except for its first page. User cannot access the first page of APROM because the first page of executable code

range becomes the mirror of the first page of LDROM as set by default. Meanwhile, the address space of 4 KB LDROM is mapped to 0x0010\_0000~0x0010\_0FFF for NUC029xAN and the address space of 2 KB LDROM is mapped to 0x0010\_0000~0x0010\_07FF for NUC029FAE. The first page of LDROM is mapped to 0x0000\_0000~0x0000\_01FF.

Please refer to following figure for the address map while IAP is activating.

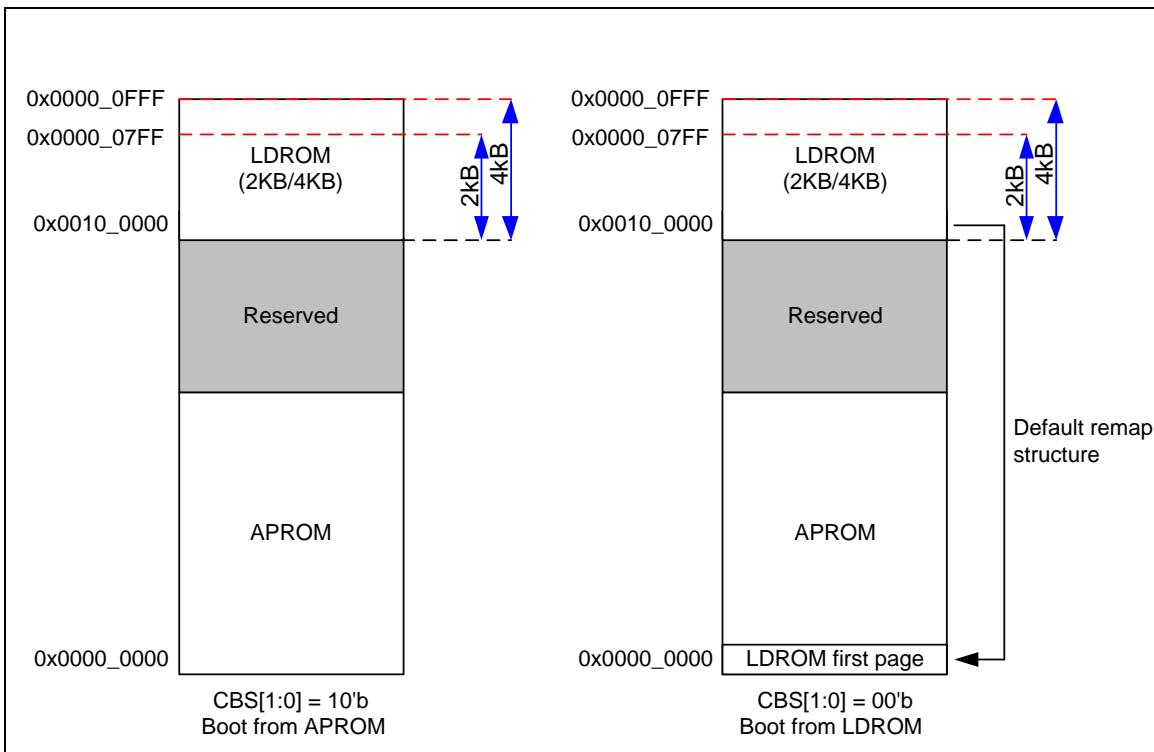


Figure 5-26 Executable Range of Code with IAP Function Enabled

When chip boots with the IAP function enabled, any other page within the executable range of code can be mirrored to the first page of executable code (0x0000\_0000~0x0000\_01FF) any time. User can change the remap address of the first executing page by filling the target remap address to ISPADR and then go through ISP register with the Vector Page Re-map command. After changing the remap address, user can check if the change is successful by reading the VECMAP(ISPSTA[20:9]).

### 5.5.10 In-System-Programming (ISP)

The NUC029 series supports In-System-Programming which allows a device to be reprogrammed under software control and avoids system fail risk when download or programming fail. Furthermore, the capability to update the application firmware makes a wide range of applications possible.

To supports In-System-Programming, NUC029series include LDROM and ISP controller. User can implement their ISP loader programming in LDROM and this loader can programming user application code (APROM) through ISP register. In other words, the loader could provide the ability to update system firmware on board. By ISP loader, various hardware peripheral interfaces make it be easier to receive new program code. The most common method to perform ISP is via

UART along with the ISP loader in LDROM. General speaking, PC transfers the new APROM code through serial port. Then ISP loader receives it and reprograms into APROM through ISP commands.

### 5.5.11 ISP Registers Control Procedure

The NUC029 series supports booting from APROM or LDROM initially defined by user configuration. The change of user configuration needs to reboot system to make it take effect. If user wants to switch between APROM or LDROM mode without changing user configuration with CBS[0] = 1, he needs to control BS(ISPCON[1]) bit, then reset CPU\_RST(IPRSTC1[1])(Not reset I/O and peripherals) or SYSRESETREQ(AIRCR[2])(Reset I/O and peripherals).. The boot switching flow by BS bit is shown in the following figure. Boot switching function by BS bit is only valid when CBS[0] = 1.

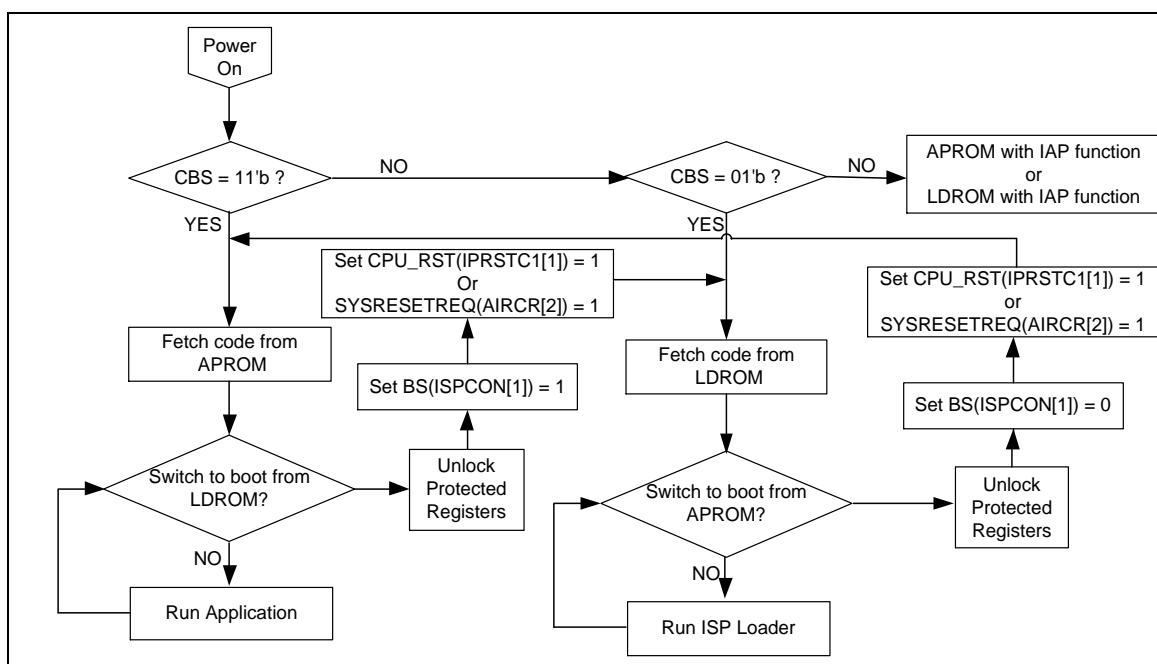


Figure 5-27 Example Flow of Boot Selection by BS Bit when CBS[0] = 1

Updating APROM by software in LDROM or updating LDROM by software in APROM can avoid a system failure when update fails.

The ISP controller supports to read, erase and program embedded flash memory. Several control bits of ISP controller are write-protected, thus it is necessary to unlock before we can set them. To unlock the protected register bits, software needs to write 0x59, 0x16 and 0x88 sequentially to REGWRPROT. If register is unlocked successfully, the value of REGWRPROT will be 1. The unlock sequence must not be interrupted by other access; otherwise it may fail to unlock.

After unlocking the protected register bits, user needs to set the ISPCON control register to decide to update LDROM, User Configuration, APROM and enable ISP controller.

Once the ISPCON register is set properly, user can set ISPCMD for erase, read or programming. Set ISPADR for target flash memory based on flash memory origination. ISPDAT can be used to set the data to program or used to return the read data according to ISPCMD.

Finally, set ISPGO(ISPTRG[0]) bit to perform the relative ISP register function. The ISPGO(ISPTRG[0]) bit is self-cleared when ISP register function has been done. To make sure ISP register function has been finished before CPU goes ahead, ISB instruction is used right after

ISPGO(ISPTRG[0]) setting.

Several error conditions are checked after ISP register function is completed. If an error condition occurs, ISP register operation is not started and the ISP fail flag will be set instead. ISPFF(ISPSTA[6]) flag can only be cleared by software. The next ISP register control procedure can be started even ISPFF bit is kept as 1. Therefore, it is recommended to check the ISPFF(ISPSTA[6]) bit and clear it after each ISP register operation if it is set to 1.

When the ISPGO(ISPTRG[0]) bit is set, CPU will wait for ISP operation to finish during this period; the peripheral still keeps working as usual. If any interrupt request occurs, CPU will not service it till ISP operation is finished. When ISP operation is finished, the ISPGO(ISPTRG[0]) bit will be cleared by hardware automatically. User can check whether ISP operation is finished or not by the ISPGO(ISPTRG[0]) bit. User should add ISB instruction next to the instruction in which the ISPGO bit is set 1 to ensure correct execution of the instructions following ISP operation.

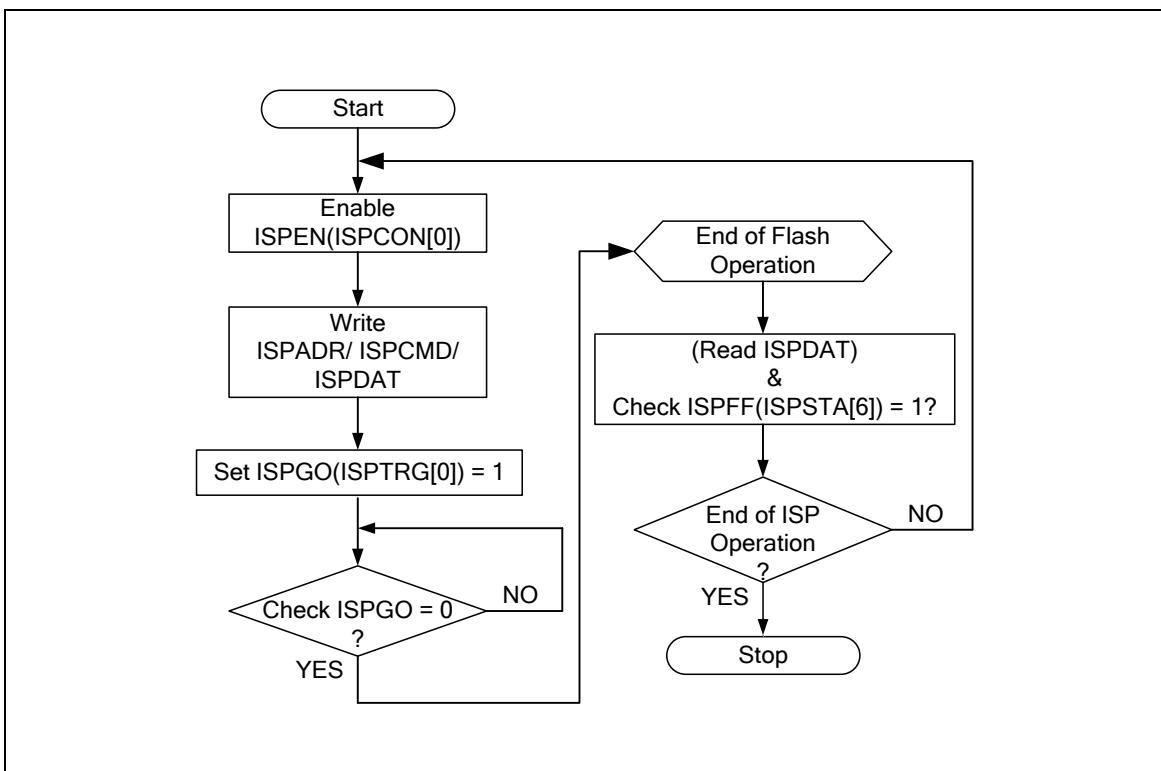


Figure 5-28 ISP Flow Example

The following table lists ISP commands supported by NUC029 series.

ISP Command	ISPCMD	ISPADR	ISPDAT
FLASH Page Erase	0x22	Valid address of flash memory origination. It must be 512 bytes page alignment.	Don't care
FLASH Program	0x21	Valid address of flash memory origination	Programming Data
FLASH Read	0x00	Valid address of flash memory origination	Return Data
Read Unique ID	0x04	0x0000_0000	Unique ID Word 0
		0x0000_0004	Unique ID Word 1
		0x0000_0008	Unique ID Word 2
		0x0000_0014	Unique CID Word 1 (NUC029FAE only)
		0x0000_0018	Unique CID Word 2 (NUC029FAE only)
		0x0000_001C	Unique CID Word 3 (NUC029FAE only)
Read Company ID	0x0B	Don't care	Company ID (0xDA)
Vector Page Re-Map	0x2E	Page in APROM or LDROM It must be 512 bytes page alignment	Don't care

Table 5-14 ISP Command List

### 5.5.12 Multi-booting by Vector Remapping

The NUC029 series can support to boot from different address by vector page remapping function. When CBS[0] = 0, All pages of LDROM and APROM can be remap to vector address 0x0. The remapping address can be got by VECMAP(ISPSTA[20:9]). When CBS[1:0] = 10'b, the remapping address is default to 0x0 when powered on. This means the vector page is mapping from first page of APROM to boot from APROM at power on. When CBS[1:0] = 00'b, the remapping address is 0x10\_0000. This means the vector page is mapping from first page of LDROM to boot from LDROM at power on.

The remapping address can be changed by Vector Page Re-Map command. User may remap specified page to vector page by Vector Page Re-Map command, than using CPU\_RST(IPRSTC1[1]) (Not reset I/O and peripherals) or SYSRESETREQ(AIRCR[2])(Reset I/O and peripherals) to reset system to reboot. The CPU will fetch the stack and reset handler pointer from new vector page, than boot to the specified application.

For example, if user has two independent applications in APROM called App0 and App1. App0 is located at 0x0, and App1 is located at 0x2000. The CBS[1:0] was set to 00'b to boot from LDROM. When power on, the system will execute the code in LDROM. The code in LDROM will decide to boot to App0 or App1. For boot to App0, the code in LDROM will enable ISP and set vector page remapping to 0x0, then reset CPU by CPU\_RST(IPRSTC1[1]) (Not reset I/O and peripherals) or SYSRESETREQ(AIRCR[2]) (Reset I/O and peripherals) to boot to App0. For boot to App1, the code in LDROM will enable ISP and set vector page remapping to 0x2000, then reset CPU by CPU\_RST or SYSRESETREQ to boot to App1. The following figure shows how to use vector page remapping to boot to different applications.

To set vector page remapping, user needs to set new page address to ISPADDR, set remap command code 0x2E to ISPCMD. Then trigger ISP command by set ISPGO(ISPTRG[0]) to 1. User can confirm the new vector page mapping address by VECMAP(ISPSTA[20:9]).

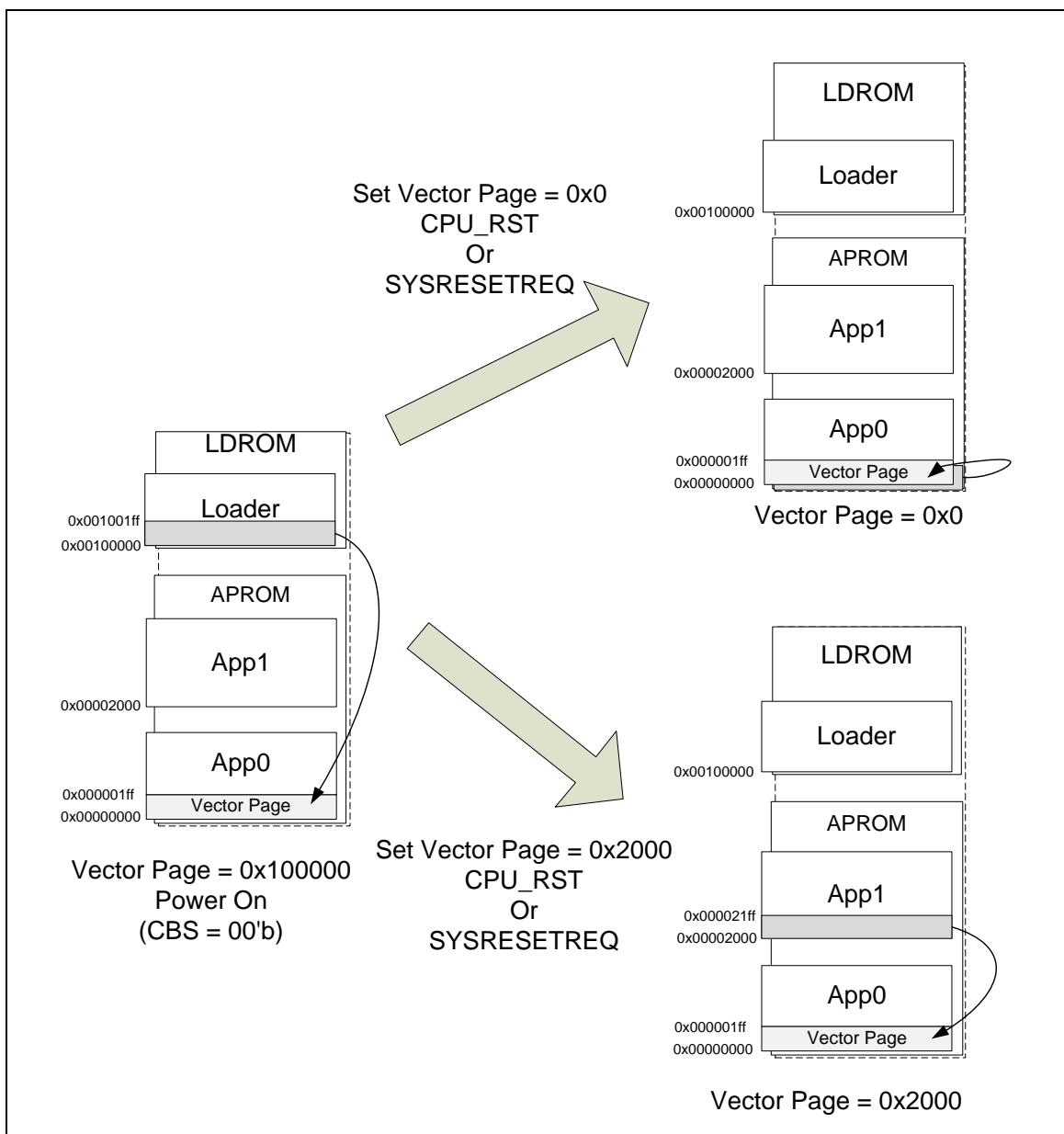


Figure 5-29 Multi-booting by Vector Page Remapping

### 5.5.13 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>FMC Base Address:</b>				
<b>FMC_BA = 0x5000_C000</b>				
ISPCON	FMC_BA+0x00	R/W	ISP Control Register	0x0000_0000
ISPADR	FMC_BA+0x04	R/W	ISP Address Register	0x0000_0000
ISPDAT	FMC_BA+0x08	R/W	ISP Data Register	0x0000_0000
ISPCMD	FMC_BA+0x0C	R/W	ISP Command Register	0x0000_0000
ISPTRG	FMC_BA+0x10	R/W	ISP Trigger Control Register	0x0000_0000
DFBADR	FMC_BA+0x14	R	Data Flash Base Address	0x0001_F000
FATCON	FMC_BA+0x18	R/W	Flash Access Time Control Register	0x0000_0000
ISPSTA	FMC_BA+0x40	R/W	ISP Status Register	0x0000_0000

### 5.5.14 Register Description for NUC029xAN

#### ISP Control Register (ISPCON)

Register	Offset	R/W	Description				Reset Value
ISPCON	FMC_BA+0x00	R/W	ISP Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	ISPFF	LDUEN	CFGUEN	APUEN	Reserved	BS	ISPEN

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	ISPFF	<b>ISP Fail Flag (Write Protect)</b> This bit is set by hardware when a triggered ISP meets any of the following conditions: (1) APROM writes to itself if APUEN is set to 0. (2) LDROM writes to itself. (3) Destination address is illegal, such as over an available range. <b>Note:</b> Write 1 to clear this bit to 0.
[5]	LDUEN	<b>LDROM Update Enable Control (Write Protect)</b> 0 = LDROM cannot be updated. 1 = LDROM can be updated when the MCU runs in APROM.
[4]	CFGUEN	<b>CONFIG Update Enable Control (Write Protect)</b> Writing this bit to 1 enables software to update CONFIG value by ISP register control procedure regardless of program code is running in APROM or LDROM. 0 = ISP update User Configuration Disabled. 1 = ISP update User Configuration Enabled.
[3]	APUEN	<b>APROM Update Enable Control (Write Protect)</b> 0 = APROM cannot be updated when chip runs in APROM. 1 = APROM can be updated when chip runs in APROM.
[2]	Reserved	Reserved.
[1]	BS	<b>Boot Select (Write Protect)</b> Set/clear this bit to select next booting from LDROM/APROM, respectively. This bit also functions as chip booting status flag, which can be used to check where chip booted from. This bit is initiated with the inversed value of CBS in CONFIG0 after any reset is happened except CPU reset (RSTS_CPU is 1) or system reset (RSTS_SYS) is happened. 0 = Boot from APROM. 1 = Boot from LDROM.

[0]	<b>ISPEN</b>	<b>ISP Enable Control (Write Protect)</b> Set this bit to enable ISP function. 0 = ISP function Disabled. 1 = ISP function Enabled.
-----	--------------	--

**ISP Address Register (ISPADR)**

Register	Offset	R/W	Description					Reset Value
ISPADR	FMC_BA+0x04	R/W	ISP Address Register					0x0000_0000

31	30	29	28	27	26	25	24
<b>ISPADR</b>							
23	22	21	20	19	18	17	16
<b>ISPADR</b>							
15	14	13	12	11	10	9	8
<b>ISPADR</b>							
7	6	5	4	3	2	1	0
<b>ISPADR</b>							

Bits	Description	
[31:0]	<b>ISPADR</b>	<b>ISP Address</b> The NUC029xAN has a maximum 16K x 32-bit (64 KB) of embedded Flash, which supports word program only. ISPADR[1:0] must be kept 00'b for ISP operation.

**ISP Data Register (ISPDAT)**

Register	Offset	R/W	Description					Reset Value
ISPDAT	FMC_BA+0x08	R/W	ISP Data Register					0x0000_0000

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

Bits	Description	
[31:0]	ISPDAT	<b>ISP Data</b> Write data to this register before ISP program operation. Read data from this register after ISP read operation.

**ISP Command (ISPCMD)**

Register	Offset	R/W	Description					Reset Value
ISPCMD	FMC_BA+0x0C	R/W	ISP Command Register					0x0000_0000

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

Bits	Description	
[31:6]	Reserved	Reserved.
[5:0]	ISPCMD	<b>ISP Command</b> ISP commands are shown below: 0x00 = Read. 0x04 = Read Unique ID. 0x0B = Read Company ID (0xDA). 0x21 = Program. 0x22 = Page Erase. 0x2E = Set Vector Page Re-Map.

**ISP Trigger Control Register (ISPTRG)**

Register	Offset	R/W	Description					Reset Value
ISPTRG	FMC_BA+0x10	R/W	ISP Trigger Control Register					0x0000_0000

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

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	ISPGO	<p><b>ISP Start Trigger (Write Protect)</b></p> <p>Write 1 to start ISP operation and this bit will be cleared to 0 by hardware automatically when ISP operation is finished.</p> <p>0 = ISP operation is finished. 1 = ISP operation is progressed.</p>

**Data Flash Base Address Register (DFBADR)**

Register	Offset	R/W	Description				Reset Value
DFBADR	FMC_BA+0x14	R	Data Flash Base Address				0x0001_F000

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

Bits	Description	
[31:0]	DFBADR	<b>Data Flash Base Address</b> This register indicates Data Flash start address. It is a read only register. For 32/64 Kbytes flash memory device, the Data Flash size is 4 Kbytes and it start address is fixed at 0x0001_F000 by hardware internally.

**Flash Access Time Control Register (FATCON)**

Register	Offset	R/W	Description				Reset Value
FATCON	FMC_BA+0x18	R/W	Flash Access Time Control Register				0x0000_0000

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

Bits	Description	
[31:8]	<b>Reserved</b>	Reserved.
[7]	<b>Reserved</b>	Reserved.
[6:5]	<b>Reserved</b>	Reserved.
[4]	<b>LFOM</b>	<b>Low Frequency Optimization Mode Control (Write Protect)</b> When chip operation frequency is lower than 25 MHz, chip can work more efficiently by setting this bit to 1 0 = Low frequency optimization mode Disabled. 1 = Low frequency optimization mode Enabled.
[0]	<b>Reserved</b>	Reserved.

**ISP Status Register (ISPSTA)**

Register	Offset	R/W	Description			Reset Value
ISPSTA	FMC_BA+0x40	R/W	ISP Status Register			0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved			VECMAP				
15	14	13	12	11	10	9	8
VECMAP							
7	6	5	4	3	2	1	0
Reserved	ISPFF	Reserved			CBS		ISPGO

Bits	Description	
[31:21]	Reserved	Reserved.
[20:9]	VECMAP	<p><b>Vector Page Mapping Address (Read Only)</b></p> <p>The current flash address space 0x0000_0000~0x0000_01FF is mapping to address {VECMAP[11:0], 9'h000} ~ {VECMAP[11:0], 9'h1FF}</p>
[8:7]	Reserved	Reserved.
[6]	ISPFF	<p><b>ISP Fail Flag (Write Protect)</b></p> <p>This bit is set by hardware when a triggered ISP meets any of the following conditions:</p> <ul style="list-style-type: none"> <li>(1) APROM writes to itself</li> <li>(2) LDROM writes to itself</li> <li>(3) CONFIG is erased/programmed if CFGUEN is set to 0</li> <li>(4) Destination address is illegal, such as over an available range</li> </ul> <p>Write 1 to clear this bit.</p> <p><b>Note:</b> The function of this bit is the same as ISPCON bit 6</p>
[5:3]	Reserved	Reserved.
[2:1]	CBS	<p><b>Chip Boot Select (Read Only)</b></p> <p>This is a mirror of CBS in CONFIG0.</p>
[0]	ISPGO	<p><b>ISP Start Trigger (Read Only)</b></p> <p>Write 1 to start ISP operation and this bit will be cleared to 0 by hardware automatically when ISP operation is finished.</p> <p>1 = ISP operation is progressed. 0 = ISP operation is finished.</p> <p><b>Note:</b> This bit is the same as ISPTRG bit0</p>

### 5.5.15 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>FMC Base Address:</b>				
<b>FMC_BA = 0x5000_C000</b>				
ISPCON	FMC_BA+0x00	R/W	ISP Control Register	0x0000_0000
ISPADR	FMC_BA+0x04	R/W	ISP Address Register	0x0000_0000
ISPDAT	FMC_BA+0x08	R/W	ISP Data Register	0x0000_0000
ISPCMD	FMC_BA+0x0C	R/W	ISP Command Register	0x0000_0000
ISPTRG	FMC_BA+0x10	R/W	ISP Trigger Register	0x0000_0000
DFBA	FMC_BA+0x14	R	Data Flash Start Address	0x0000_3800
ISPSTA	FMC_BA+0x40	R/W	ISP Status Register	0x0000_0000

### 5.5.16 Register Description for NUC029FAE

#### ISP Control Register (ISPCON)

Register	Offset	R/W	Description				Reset Value
ISPCON	FMC_BA+0x00	R/W	ISP Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	ISPFF	LDUEN	CFGUEN	APUEN	Reserved	BS	ISPEN

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	ISPFF	<p><b>ISP Fail Flag (Write Protect)</b>            This bit is set by hardware when a triggered ISP meets any of the following conditions:            (1) APROM writes to itself if APUEN is set to 0 or CBS[0]=1.            (2) LDROM writes to itself if LDUEN is set to 0 or CBS[0]=1.            (3) User Configuration is erased/programmed when CFGUEN is 0.            (4) Destination address is illegal, such as over an available range.  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[5]	LDUEN	<p><b>LDROM Update Enable Control (Write Protect)</b>            0 = LDROM cannot be updated.            1 = LDROM can be updated when the MCU runs in APROM.</p>
[4]	CFGUEN	<p><b>CONFIG Update Enable Control (Write Protect)</b>            Writing this bit to 1 enables software to update CONFIG value by ISP register control procedure regardless of program code is running in APROM or LDROM.            0 = ISP update User Configuration Disabled.            1 = ISP update User Configuration Enabled.</p>
[3]	APUEN	<p><b>APROM Update Enable Control (Write Protect)</b>            0 = APROM cannot be updated when chip runs in APROM.            1 = APROM can be updated when chip runs in APROM.</p>
[2]	Reserved	Reserved.

Bits	Description	
[1]	<b>BS</b>	<b>Boot Select (Write Protect)</b> Set/clear this bit to select next booting from LDROM/APROM, respectively. This bit also functions as chip booting status flag, which can be used to check where chip booted from. This bit is initiated with the inverted value of CBS in CONFIG0 after any reset is happened except CPU reset (RSTS_CPU is 1) or system reset (RSTS_SYS) is happened. 0 = Boot from APROM. 1 = Boot from LDROM.
[0]	<b>ISPEN</b>	<b>ISP Enable Control (Write Protect)</b> Set this bit to enable ISP function. 0 = ISP function Disabled. 1 = ISP function Enabled.

**ISP Address (ISPADR)**

Register	Offset	R/W	Description				Reset Value
ISPADR	FMC_BA+0x04	R/W	ISP Address Register				0x0000_0000

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

Bits	Description	
[31:0]	ISPADR	<b>ISP Address</b> The NUC029FAE supports word program only. ISPADR[1:0] must be kept 00'b for ISP operation.

**ISPDAT (ISP Data Register)**

Register	Offset	R/W	Description				Reset Value
ISPDAT	FMC_BA+0x08	R/W	ISP Data Register				0x0000_0000

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

Bits	Description	
[31:0]	ISPDAT	ISP Data Write data to this register before ISP program operation. Read data from this register after ISP read operation.

**ISP Command (ISPCMD)**

Register	Offset	R/W	Description				Reset Value
ISPCMD	FMC_BA+0x0C	R/W	ISP Command Register				0x0000_0000

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

Bits	Description	
[31:6]	Reserved	Reserved.
[5:0]	ISPCMD	<p><b>ISP Command</b></p> <p>ISP commands are shown below:</p> <p>0x00 = Read.</p> <p>0x04 = Read Unique ID.</p> <p>0x0B = Read Company ID (0xDA).</p> <p>0x21 = Program.</p> <p>0x22 = Page Erase.</p> <p>0x2E = Set Vector Page Re-Map.</p>

**ISP Trigger Control Register (ISPTRG)**

Register	Offset	R/W	Description				Reset Value
ISPTRG	FMC_BA+0x10	R/W	ISP Trigger Register				0x0000_0000

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

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	ISPGO	<p><b>ISP Start Trigger (Write Protect)</b></p> <p>Write 1 to start ISP operation and this bit will be cleared to 0 by hardware automatically when ISP operation is finished.</p> <p>0 = ISP operation is finished. 1 = ISP operation is progressed.</p>

Data Flash Base Address Register (DFBA)

Register	Offset	R/W	Description				Reset Value
DFBA	FMC_BA+0x14	R	Data Flash Start Address				0x0000_3800

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

Bits	Description	
[31:0]	DFBA	<p><b>Data Flash Base Address</b></p> <p>This register indicates Data Flash start address. It is a read only register.</p> <p>The Data Flash start address is defined by user. Since on chip flash erase unit is 512 bytes, it is mandatory to keep bit 8-0 as 0.</p>

**Example:**

Data Flash	4KB (DFEN=0)	2KB (DFEN=0)	1KB (DFEN=0)	0KB (DFEN=1)
16K Flash	DFBA=0x0000_3000	DFBA=0x0000_3800	DFBA=0x0000_3C00	DFEN=1

**ISP Status Register (ISPSTA)**

Register	Offset	R/W	Description			Reset Value
ISPSTA	FMC_BA+0x40	R/W	ISP Status Register			0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved			VECMAP				
15	14	13	12	11	10	9	8
VECMAP							Reserved
7	6	5	4	3	2	1	0
Reserved	ISPFF	Reserved			CBS		ISPGO

Bits	Description	
[31:21]	Reserved	Reserved.
[20:9]	VECMAP	<b>Vector Page Mapping Address (Read Only)</b> The current flash address space 0x0000_0000~0x0000_01FF is mapping to address {VECMAP[11:0], 9'h000} ~ {VECMAP[11:0], 9'h1FF}.
[8:7]	Reserved	Reserved.
[6]	ISPFF	<b>ISP Fail Flag (Write Protect)</b> This bit is set by hardware when a triggered ISP meets any of the following conditions: (1) APROM writes to itself if APUEN is set to 0 or CBS[0]=1. (2) LDROM writes to itself if LDUEN is set to 0 or CBS[0]=1. (3) User Configuration is erased/programmed when CFGUEN is 0. (4) Destination address is illegal, such as over an available range. Write 1 to clear. <b>Note:</b> This bit functions the same as ISPCON bit 6.
[5:3]	Reserved	Reserved.
[2:1]	CBS	<b>Config Boot Selection (Read Only)</b> This is a mirror of CBS in CONFIG0.
[0]	ISPGO	<b>ISP Start Trigger (Read Only)</b> Write 1 to start ISP operation and this bit will be cleared to 0 by hardware automatically when ISP operation is finished. 1 = ISP operation is progressed. 0 = ISP operation is finished. <b>Note:</b> This bit is the same with ISPTRG bit 0.

## 5.6 External Bus Interface (EBI) (NUC029LAN/NUC029NAN Only)

### 5.6.1 Overview

The NuMicro® NUC029LAN/NUC029NAN has an external bus interface (EBI) to access external device. To save the connections between external device and this chip, EBI support address bus and data bus multiplex mode. Also, address latch enable (ALE) signal is used to differentiate the address and data cycle.

### 5.6.2 Features

- Supports external devices with maximum 64 KB size (8-bit data width) / 128 KB (16-bit data width)
- Supports variable external bus base clock (MCLK) which based on HCLK
- Supports 8-bit or 16-bit data width
- Supports variable data access time (tACC), address latch enable time (tALE) and address hold time (tAHD)
- Supports address bus and data bus multiplex mode to save the address pins
- Supports configurable idle cycle for different access condition: Write command finish (W2X), Read-to-Read (R2R)
- Supports zero address hold time with read/write operation and write buffer for write operation to enhance read/write performance

### 5.6.3 Block Diagram

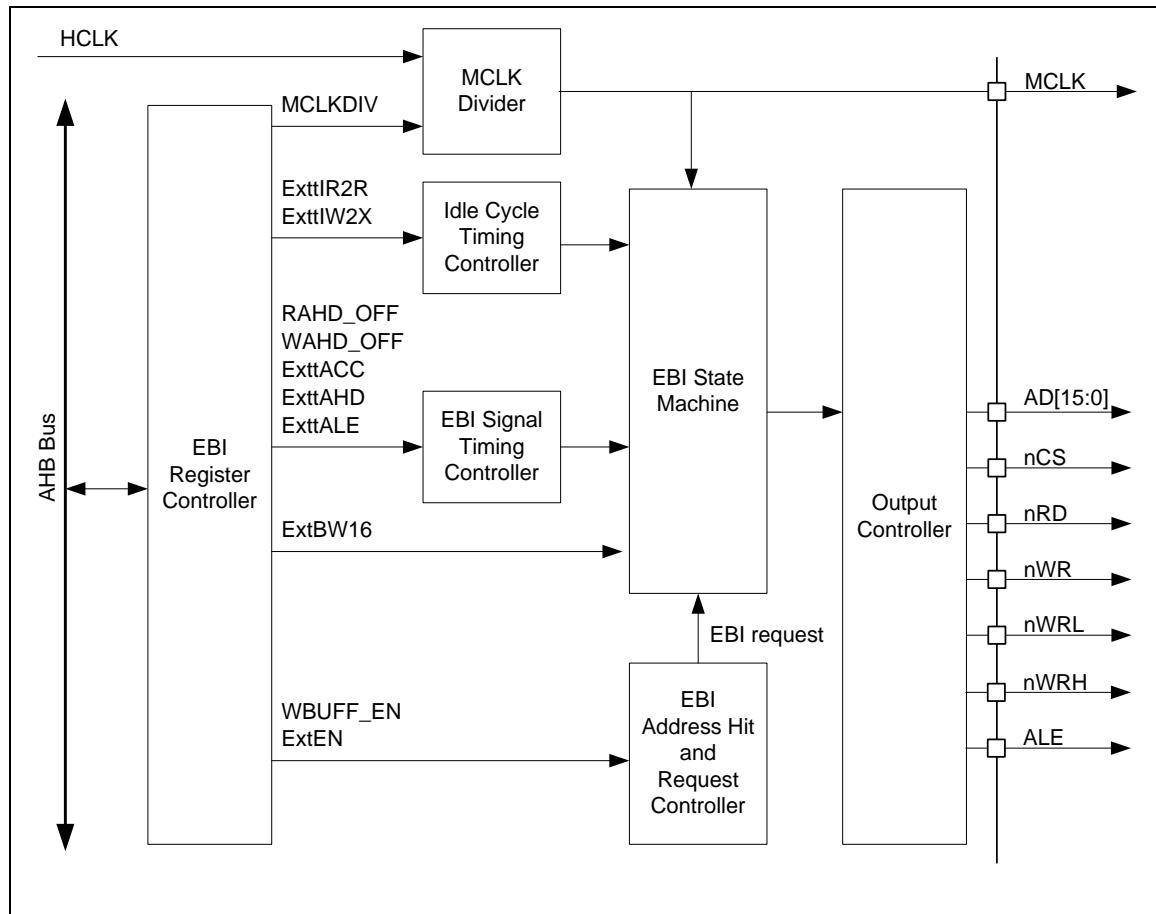


Figure 5-30 EBI Block Diagram

## 5.6.4 Basic Configuration

The basic configurations of EBI are as follows:

- EBI peripheral clock is enabled in AHBCLK[3].
- The AD[15:0] pins functions are configured in P0\_MFP and P2\_MFP registers; nRD, nWR and MCLK pins functions are configured in P3\_MFP register; ALE and nCS pins functions are configured in P4\_MFP register; nWRL and nWRH pins functions are configured in P1\_MFP register.

## 5.6.5 Functional Description

### 5.6.5.1 EBI Area and Address Hit

The EBI mapping address is located at 0x6000\_0000 ~ 0x6001\_FFFF and the maximum available memory space is 128 Kbytes. When the system request address hits EBI's memory space, the corresponding EBI chip select signal (nCS) is assert and EBI state machine operates.

For an 8-bit device (64 Kbytes), EBI mapped this 64 Kbytes device to 0x6000\_0000 ~ 0x6000\_FFFF and 0x6001\_0000 ~ 0x6001\_FFFF simultaneously.

For a 16-bit device (128 Kbytes), EBI mapped this 128 Kbytes device to 0x6000\_0000 ~ 0x6001\_FFFF.

### 5.6.5.2 EBI Data Width Connection

The EBI controller supports to connect the external device whose address bus and data bus are multiplexed. For the external device with separated address and data bus, the connection to device needs additional logic (latch device) to latch the address. In this case, pin ALE is connected to the latch device to latch the address value. Pins AD0 ~ AD15 for 16-bit data width or Pins AD0 ~ AD7 for 8-bit data width are the input pins of the latch device, and the output pins of the latch device are connected to the Addr[15:0] of external device.

For 16-bit device, the AD[15:0] shared by address (Addr[15:0]) and 16-bit data (Data[15:0]). For 8-bit device, only AD[7:0] shared by address (Addr[7:0]) and 8-bit data (Data[7:0]), AD[15:8] is dedicated for address (Addr[15:8]) and could be connected to 8-bit device directly.

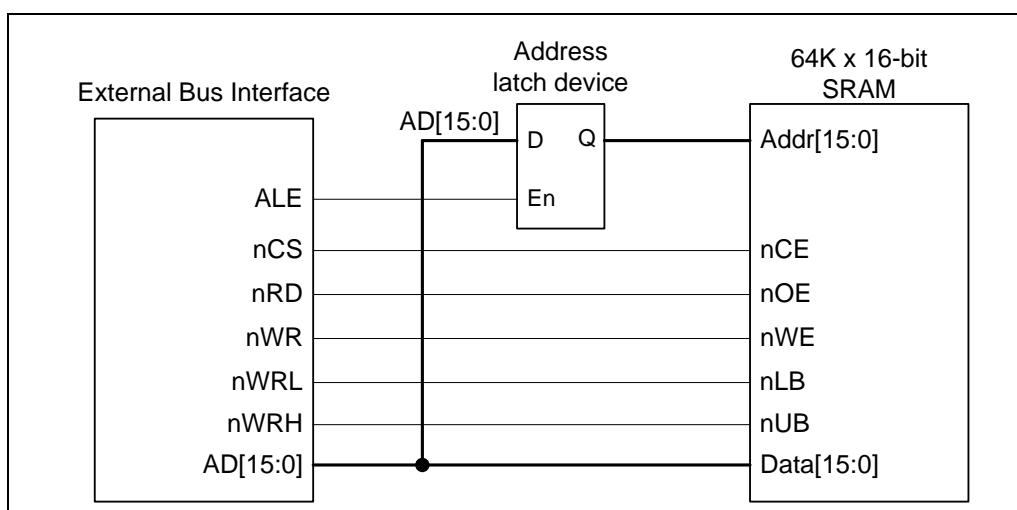


Figure 5-31 Connection of 16-bit EBI Data Width with 16-bit Device

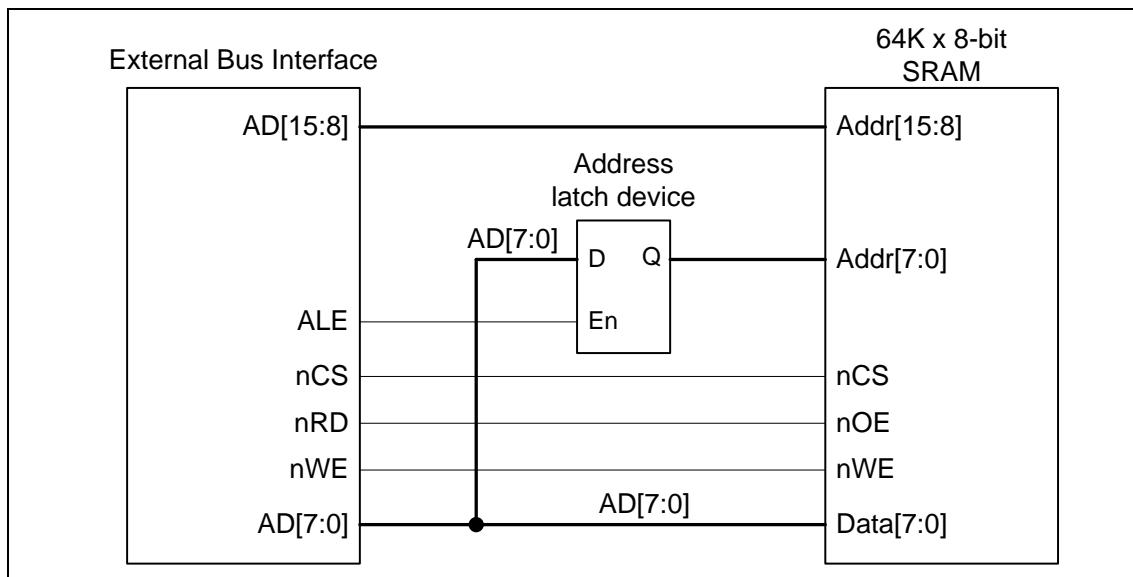


Figure 5-32 Connection of 8-bit EBI Data Width with 8-bit Device

When the system access data width is larger than EBI data width (8-bit / 16 bit data width), the EBI controller will finish a system access command by operating EBI access more than once. For example, if system requests a 32-bit data through EBI device, the EBI controller will operate accessing four times when setting EBI data width with 8-bit data width.

#### 5.6.5.3 EBI Operating Control

##### MCLK Control

In the chip, all EBI signals will be synchronized by MCLK when EBI is operating. When the chip connects to the external device with slower operating frequency, the MCLK can divide most to 32 from HCLK by setting MCLKDIV[2:0]. Therefore, the EBI controller is suitable for a wide frequency range of EBI device. If MCLK frequency is set to the same as HCLK, EBI signals are synchronized by positive edge of MCLK, else by negative edge of MCLK.

##### Operation and Access Timing Control

At the start of EBI access, chip select signal (nCS) asserts to low and waits one MCLK for address setup time (tASU) for address stable. Then address latch enable signal (ALE) asserts to high after address is stable and keeps for a period of time (tALE) for address latch. After latch address, ALE signal asserts to low and waits one MCLK for address latch hold time (tLHD) and another one MCLK cycle (tA2D) that is inserted behind tLHD to be the bus turn-around time for address change to data. Then nRD signal asserts to low when read access or nWR signal asserts to low when write access. Then nRD or nWR signal asserts to high after keeps access time (tACC) for reading output stable or writing finish. After that, EBI signals keep for data access hold time (tAHD) and nCS signal asserts to high then address is released by current access control.

The EBI controller provides a flexible timing control for different external devices, as shown in the following table. In EBI timing control, tASU, tLHD and tA2D are all fixed to 1 MCLK cycle, tAHD can modulate to 1 ~ 8 MCLK cycles by setting ExtAHD(EXTIME[10:8]) or zero tAHD for read/write by setting RAHD\_OFF/WAHD\_OFF bit, tACC can modulate to 1 ~ 32 MCLK cycles by

setting ExttACC(EXTIME[7:3]), and tALE can modulate to 1 ~ 8 MCLK cycles by setting ExttALE(EBICON[18:16]).

Parameter	Value	Unit	Description
tASU	1	MCLK	Address Latch Setup Time.
tALE	1 ~ 8	MCLK	ALE High Period. Controlled by ExttALE(EBICON[18:16]).
tLHD	1	MCLK	Address Latch Hold Time.
tA2D	1	MCLK	Address To Data Delay (Bus Turn-Around Time).
tACC	1 ~ 32	MCLK	Data Access Time. Controlled by ExttACC(EXTIME[7:3]).
tAHD	1 ~ 8	MCLK	Data Access Hold Time. Controlled by ExttAHD(EXTIME[10:8]) to select 1 ~ 8 tAHD.
tAHD	0	MCLK	Setting RAHD_OFF/WAHD_OFF to select zero tAHD.
IDLE	0 ~ 15	MCLK	Idle Cycle. Controlled by ExtIR2R[3:0](EXTIME[27:24]) and ExtIW2X[3:0](EXTIME[15:12]).

Table 5-15 EBI Timing Table

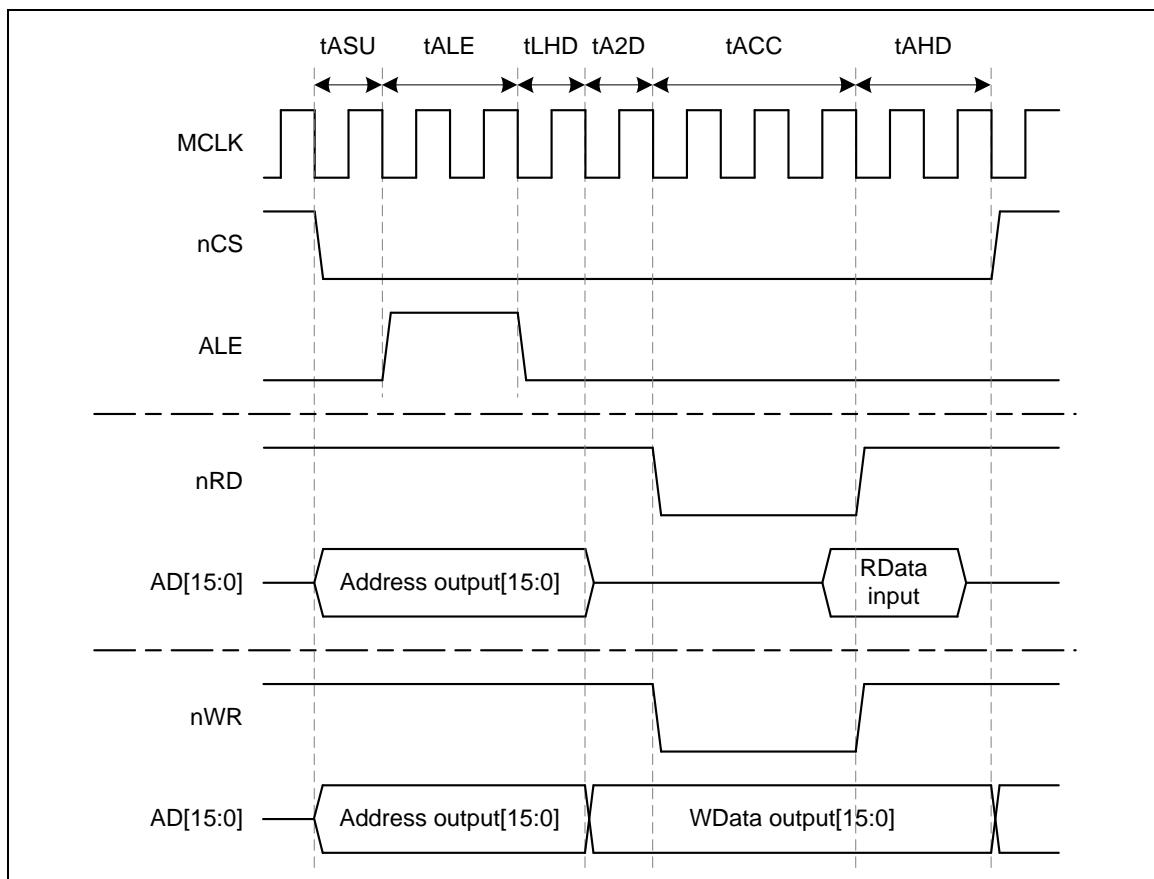


Figure 5-33 EBI Timing Control Waveform for 16-bit Data Width

The figure above shows an example of setting 16-bit data width for EBI application. In this Dec. 11, 2017

example, AD0 ~ AD15 are used to be address[15:0] and data[15:0]. When ALE signal asserts to high, AD0 ~ AD15 are the address output. After address is latched (tLHD), ALE signal asserts to low and the AD[15:0] bus changes to high impedance to wait device output data in read access operation, or it is used to be write data output.

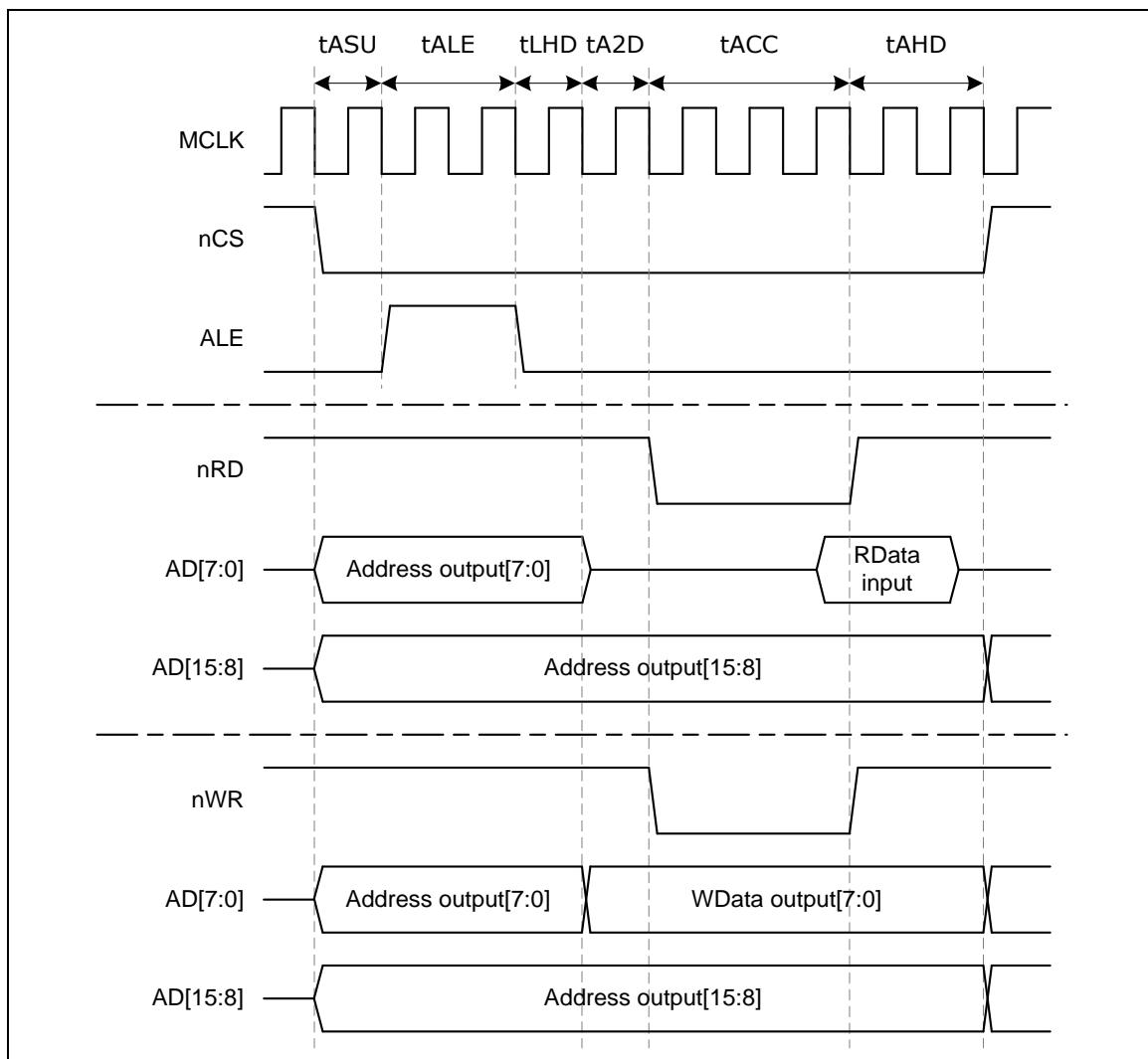


Figure 5-34 EBI Timing Control Waveform for 8-bit Data Width

The figure above shows an example of setting 8-bit data width for EBI application. The difference between 8-bit and 16-bit data width is AD8 ~ AD15. In 8-bit data width setting, and AD8 ~ AD15 are always the address[15:8] output so that the external latch needs only 8-bit width.

### Insert Idle Cycle

When EBI is accessing continuously, bus conflict may occur if the device access time is much longer compared with system clock frequency. The EBI controller supplies additional idle cycle to solve this problem. During idle cycle period, all control signals of EBI bus are inactive. The following figure shows idle cycle.

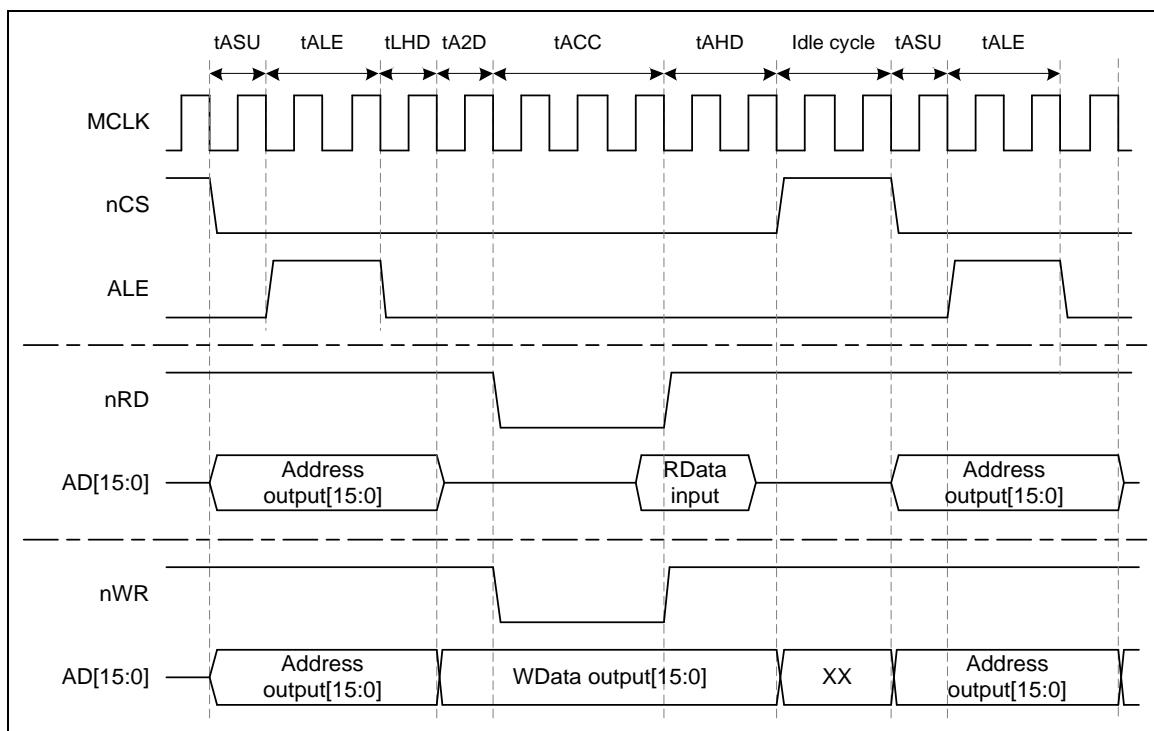


Figure 5-35 EBI Timing Control Waveform for Insert Idle Cycle

There are two conditions that EBI can insert idle cycle by timing control:

1. After write access
2. After read access and before next read access

By setting ExtIW2X(EXTIME [15:12]) and ExtIR2R(EXTIME[27:24]), the time of idle cycle can be specified from 0 ~ 15 MCLK.

### Write Buffer

When software write a data to external device through EBI bus, the EBI controller will start processing the write action immediately and the CPU is held until current EBI write action finish. User can enable write buffer function to improve CPU and EBI access performance. When EBI write buffer function is enabled, the CPU can continuous execute other instruction during EBI controller process the write action to external device. There is one exception condition for this case, if CPU executes another data access through EBI bus when EBI process write action, the CPU will be held.

### 5.6.6 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>EBI Base Address:</b>				
<b>EBI_BA = 0x5001_0000</b>				
<b>EBICON</b>	EBI_BA+0x00	R/W	External Bus Interface General Control Register	0x0000_0000
<b>EXTIME</b>	EBI_BA+0x04	R/W	External Bus Interface Timing Control Register	0x0000_0000
<b>EBICON2</b>	EBI_BA+0x08	R/W	External Bus Interface General Control Register 2	0x0000_0000

### 5.6.7 Register Description

#### External Bus Interface General Control Register (EBICON)

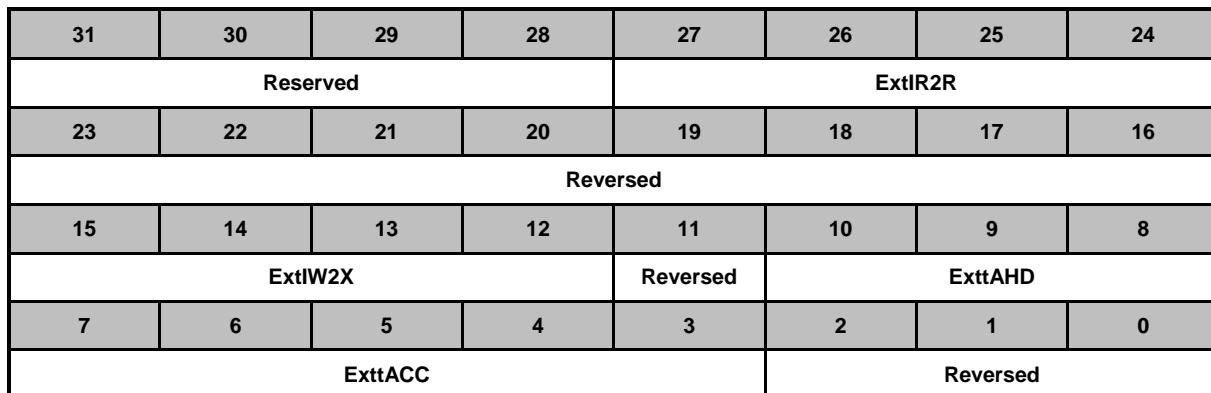
Register	Offset	R/W	Description					Reset Value
EBICON	EBI_BA+0x00	R/W	External Bus Interface General Control Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reversed					ExttALE		
15	14	13	12	11	10	9	8
Reversed					MCLKDIV		
7	6	5	4	3	2	1	0
Reversed					ExtBW16	ExtEN	

Bits	Description	
[31:19]	Reserved	Reserved.
[18:16]	ExttALE	<b>Expand Time Of ALE</b> This field is used to control the ALE pulse width (tALE) for address latch. $tALE = (\text{ExttALE} + 1) * \text{MCLK}$ .
[15:11]	Reserved	Reserved.
[10:8]	MCLKDIV	<b>External Output Clock Divider</b> The frequency of EBI output clock (MCLK) is controlled by MCLKDIV as follows: 000 = MCLK frequency is HCLK/1. 001 = MCLK frequency is HCLK/2. 010 = MCLK frequency is HCLK/4. 011 = MCLK frequency is HCLK/8. 100 = MCLK frequency is HCLK/16. 101 = MCLK frequency is HCLK/32. <b>Note:</b> The default value of output clock is HCLK/1.
[7:2]	Reserved	Reserved.
[1]	ExtBW16	<b>EBI Data Width 16-bit / 8-bit</b> This bit defines if the data bus is 8-bit or 16-bit. 0 = EBI data width is 8 bit. 1 = EBI data width is 16 bit.
[0]	ExtEN	<b>EBI Enable Control</b> This bit is the functional enable bit for EBI. 0 = EBI function Disabled. 1 = EBI function Enabled.

### External Bus Interface Timing Control Register (EXTIME)

Register	Offset	R/W	Description				Reset Value
EXTIME	EBI_BA+0x04	R/W	External Bus Interface Timing Control Register				0x0000_0000



Bits	Description	
[31:28]	Reserved	Reserved.
[27:24]	ExtIR2R	<b>Idle State Cycle Between Read-read</b> When read action is finished and the next action is going to read, idle state is inserted and nCS signal return to high if ExtIR2R is not 0. Idle state cycle = (ExtIR2R * MCLK).
[23:16]	Reserved	Reserved.
[15:12]	ExtIW2X	<b>Idle State Cycle After Write</b> When write action is finished, idle state is inserted and nCS signal return to high if ExtIW2X is not 0. Idle state cycle = (ExtIW2X * MCLK).
[11]	Reserved	Reserved.
[10:8]	ExttAHD	<b>EBI Data Access Hold Time</b> ExttAHD defines data access hold time (tAHD). $tAHD = (\text{ExttAHD} + 1) * \text{MCLK}$ .
[7:3]	ExttACC	<b>EBI Data Access Time</b> ExttACC defines data access time (tACC). $tACC = (\text{ExttACC} + 1) * \text{MCLK}$ .
[2:0]	Reserved	Reserved.

**External Bus Interface General Control Register 2 (EBICON2)**

Register	Offset	R/W	Description				Reset Value
EBICON2	EBI_BA+0x08	R/W	External Bus Interface General Control Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reversed							
15	14	13	12	11	10	9	8
Reversed							
7	6	5	4	3	2	1	0
Reversed					WAHD_OFF	RAHD_OFF	WBUFF_EN

Bits	Description	
[31:3]	Reserved	Reserved.
[2]	WAHD_OFF	<b>Access Hold Time Disable Control When Write</b> 0 = tAHD is controlled by ExttAHD[2:0] when write through EBI. 1 = Zero tAHD when write through EBI.
[1]	RAHD_OFF	<b>Access Hold Time Disable Control When Read</b> 0 = tAHD is controlled by ExttAHD[2:0] when read through EBI. 1 = Zero tAHD when read through EBI.
[0]	WBUFF_EN	<b>EBI Write Buffer Enable Control</b> Enable this function to improve CPU and EBI access performance. 0 = EBI write buffer Disabled. 1 = EBI write buffer Enabled.

## 5.8 General Purpose I/O (GPIO)

### 5.8.1 Overview

The NuMicro® NUC029 series has up to 40 General Purpose I/O pins to be shared with other function pins depending on the chip configuration. These 40 pins are arranged in 6 ports named as P0, P1, P2, P3, P4 and P5. Each port has the maximum of 8 pins. Each of the 40 pins is independent and has the corresponding register bits to control the pin mode function and data.

The I/O type of each of I/O pins can be configured by software individually as Input, Push-pull output, Open-drain output or Quasi-bidirectional mode. Each I/O pin has a very weak individual pull-up resistor which is about 110~300 KΩ for V<sub>DD</sub> is from 5.0 V to 2.5 V.

### 5.8.2 Features

- Four I/O modes:
  - Quasi-bidirectional
  - Push-Pull output
  - Open-Drain output
  - Input only with high impedance
- TTL/Schmitt trigger input selectable by Px\_TYPE[15:0] in Px\_MFP[23:16]
- I/O pin configured as interrupt source with edge/level setting
- Configurable default I/O mode of all pins after reset by CIOINI(CONFIG[10]) setting
  - For NUC029xAN:
    - If CIOINI is 0, all GPIO pins in input tri-state mode after chip reset
    - If CIOINI is 1, all GPIO pins in Quasi-bidirectional mode after chip reset (Default)
  - After reset, the I/O mode of all pins are stay in Quasi-bidirectional mode and each port data register Px\_DOUT[7:0] resets to 0x000\_00FF.
  - For NUC029FAE:
    - If CIOINI is 0, all GPIO pins in Quasi-bidirectional mode after chip reset
    - If CIOINI is 1, all GPIO pins in input tri-state mode after chip reset (Default)
- I/O pin internal pull-up resistor enabled only in Quasi-bidirectional I/O mode
- Enabling the pin interrupt function will also enable the pin wake-up function.

### 5.8.3 Basic Configuration

The GPIO pin functions are configured in P0\_MFP, P1\_MFP, P2\_MFP, P3\_MFP, P4\_MFP and P5\_MFP(NUC029FAE only) registers.

### 5.8.4 Functional Description

#### 5.8.4.1 Input Mode

Set Px\_PMD (PMDn[1:0]) to 00'b as the Px.n pin is in Input mode and the I/O pin is in tri-state (high impedance) without output drive capability. The Px\_PIN value reflects the status of the corresponding port pins.

#### 5.8.4.2 Push-pull Output Mode

Set Px\_PMD (PMDn[1:0]) to 01'b as the Px.n pin is in Push-pull output mode and the I/O pin supports digital output function with source/sink current capability. The bit value in the corresponding Px\_DOUT[n] bit is driven on the pin.

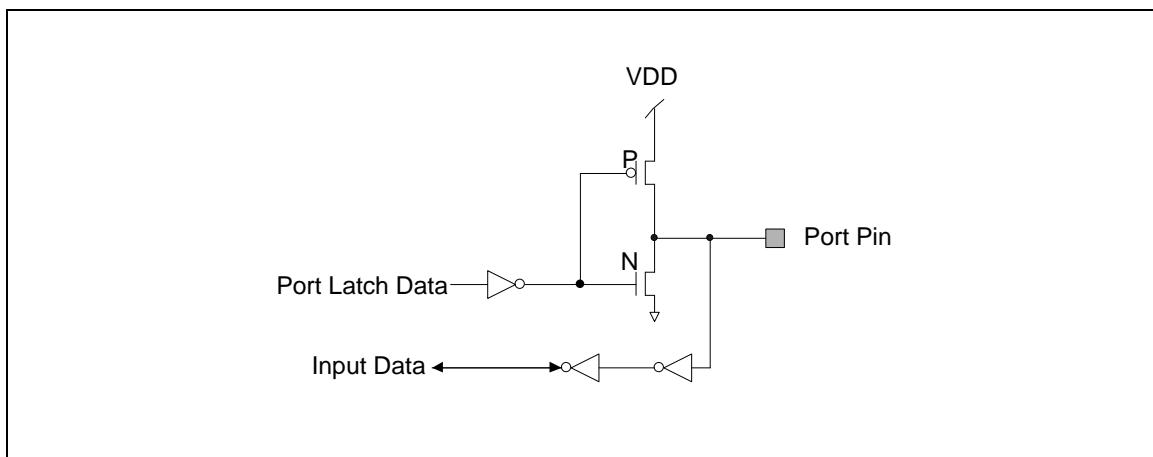


Figure 5-36 Push-Pull Output

#### 5.8.4.3 Open-drain Output Mode

Set Px\_PMD (PMDn[1:0]) to 10'b as the Px.n pin is in Open-drain mode and the digital output function of I/O pin only supports sink current capability, an external pull-up resistor is needed for driving high state. If the bit value in the corresponding Px\_DOUT[n] bit is 0, the pin drive a low output on the pin. If the bit value in the corresponding Px\_DOUT[n] bit is 1, the pin output drives high that is controlled by external pull-up resistor.

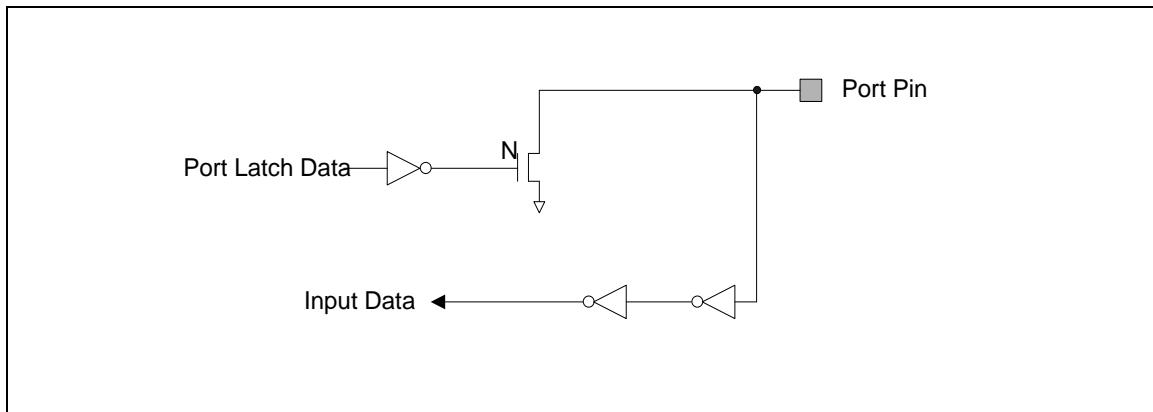


Figure 5-37 Open-Drain Output

#### 5.8.4.4 Quasi-bidirectional Mode

Set Px\_PMD (PMDn[1:0]) to 11'b as the Px.n pin is in Quasi-bidirectional mode and the I/O pin supports digital output and input function at the same time but the source current is only up to hundreds of uA. Before the digital input function is performed the corresponding Px\_DOUT[n] bit must be set to 1. If the bit value in the corresponding Px\_DOUT[n] bit is 0, the pin drive a low output on the pin. If the bit value in the corresponding Px\_DOUT[n] bit is 1, the pin will check the pin value. If pin value is high, no action takes. If pin state is low, then pin will drive strong high with 2 clock cycles on the pin and then disable the strong output drive. Meanwhile, the pin status is controlled by internal pull-up resistor. Note that the source current capability in Quasi-bidirectional mode is only about 200uA to 30uA for V<sub>DD</sub> from 5.0 V to 2.5 V.

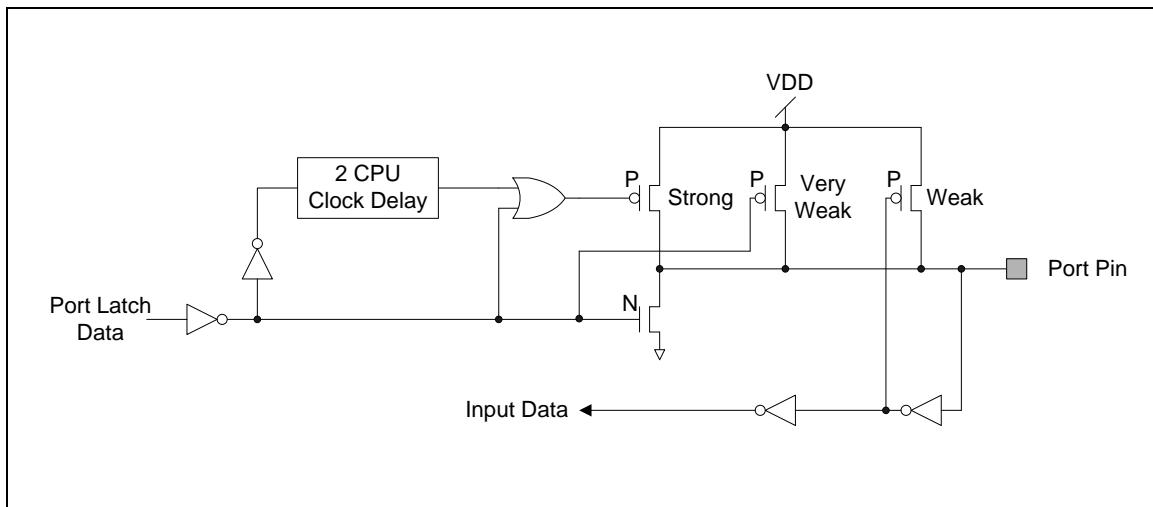


Figure 5-38 Quasi-Bidirectional I/O Mode

#### 5.8.5 GPIO Interrupt and Wake-up Function

Each GPIO pin can be set as chip interrupt source by setting correlative Px\_IEN bit and Px\_IMD. There are five types of interrupt condition can be selected: low level trigger, high level trigger, falling edge trigger, rising edge trigger and both rising and falling edge trigger. For edge trigger condition, user can enable input signal de-bounce function to prevent unexpected interrupt happened which caused by noise. The de-bounce clock source and sampling cycle period can be set through DBNCECON register.

### 5.8.6 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

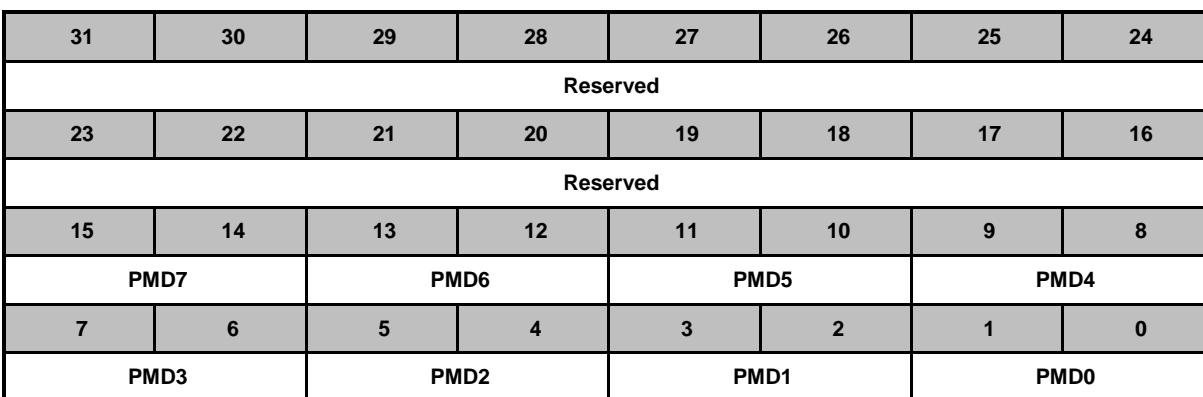
Register	Offset	R/W	Description	Reset Value
<b>GPIO Base Address:</b>				
<b>GP_BA = 0x5000_4000</b>				
<b>P0_PMD</b>	GP_BA+0x000	R/W	P0 I/O Mode Control	0x0000_XXXX
<b>P0_OFFD</b>	GP_BA+0x004	R/W	P0 Digital Input Path Disable Control	0x0000_0000
<b>P0_DOUT</b>	GP_BA+0x008	R/W	P0 Data Output Value	0x0000_00FF
<b>P0_DMASK</b>	GP_BA+0x00C	R/W	P0 Data Output Write Mask	0x0000_0000
<b>P0_PIN</b>	GP_BA+0x010	R	P0 Pin Value	0x0000_00XX
<b>P0_DBEN</b>	GP_BA+0x014	R/W	P0 De-bounce Enable Control	0x0000_0000
<b>P0_IMD</b>	GP_BA+0x018	R/W	P0 Interrupt Mode Control	0x0000_0000
<b>P0_IEN</b>	GP_BA+0x01C	R/W	P0 Interrupt Enable Control	0x0000_0000
<b>P0_ISRC</b>	GP_BA+0x020	R/W	P0 Interrupt Source Flag	0x0000_0000
<b>P1_PMD</b>	GP_BA+0x040	R/W	P1 I/O Mode Control	0x0000_XXXX
<b>P1_OFFD</b>	GP_BA+0x044	R/W	P1 Digital Input Path Disable Control	0x0000_0000
<b>P1_DOUT</b>	GP_BA+0x048	R/W	P1 Data Output Value	0x0000_00FF
<b>P1_DMASK</b>	GP_BA+0x04C	R/W	P1 Data Output Write Mask	0x0000_0000
<b>P1_PIN</b>	GP_BA+0x050	R	P1 Pin Value	0x0000_00XX
<b>P1_DBEN</b>	GP_BA+0x054	R/W	P1 De-bounce Enable Control	0x0000_0000
<b>P1_IMD</b>	GP_BA+0x058	R/W	P1 Interrupt Mode Control	0x0000_0000
<b>P1_IEN</b>	GP_BA+0x05C	R/W	P1 Interrupt Enable Control	0x0000_0000
<b>P1_ISRC</b>	GP_BA+0x060	R/W	P1 Interrupt Source Flag	0x0000_0000
<b>P2_PMD</b>	GP_BA+0x080	R/W	P2 I/O Mode Control	0x0000_XXXX
<b>P2_OFFD</b>	GP_BA+0x084	R/W	P2 Digital Input Path Disable Control	0x0000_0000
<b>P2_DOUT</b>	GP_BA+0x088	R/W	P2 Data Output Value	0x0000_00FF
<b>P2_DMASK</b>	GP_BA+0x08C	R/W	P2 Data Output Write Mask	0x0000_0000
<b>P2_PIN</b>	GP_BA+0x090	R	P2 Pin Value	0x0000_00XX
<b>P2_DBEN</b>	GP_BA+0x094	R/W	P2 De-bounce Enable Control	0x0000_0000
<b>P2_IMD</b>	GP_BA+0x098	R/W	P2 Interrupt Mode Control	0x0000_0000
<b>P2_IEN</b>	GP_BA+0x09C	R/W	P2 Interrupt Enable Control	0x0000_0000

<b>P2_ISRC</b>	GP_BA+0x0A0	R/W	P2 Interrupt Source Flag	0x0000_0000
<b>P3_PMD</b>	GP_BA+0x0C0	R/W	P3 I/O Mode Control	0x0000_XXXX
<b>P3_OFFD</b>	GP_BA+0x0C4	R/W	P3 Digital Input Path Disable Control	0x0000_0000
<b>P3_DOUT</b>	GP_BA+0x0C8	R/W	P3 Data Output Value	0x0000_00FF
<b>P3_DMASK</b>	GP_BA+0x0CC	R/W	P3 Data Output Write Mask	0x0000_0000
<b>P3_PIN</b>	GP_BA+0x0D0	R	P3 Pin Value	0x0000_00XX
<b>P3_DBEN</b>	GP_BA+0x0D4	R/W	P3 De-bounce Enable Control	0x0000_0000
<b>P3_IMD</b>	GP_BA+0x0D8	R/W	P3 Interrupt Mode Control	0x0000_0000
<b>P3_IEN</b>	GP_BA+0x0DC	R/W	P3 Interrupt Enable Control	0x0000_0000
<b>P3_ISRC</b>	GP_BA+0x0E0	R/W	P3 Interrupt Source Flag	0x0000_0000
<b>P4_PMD</b>	GP_BA+0x100	R/W	P4 I/O Mode Control	0x0000_XXXX
<b>P4_OFFD</b>	GP_BA+0x104	R/W	P4 Digital Input Path Disable Control	0x0000_0000
<b>P4_DOUT</b>	GP_BA+0x108	R/W	P4 Data Output Value	0x0000_00FF
<b>P4_DMASK</b>	GP_BA+0x10C	R/W	P4 Data Output Write Mask	0x0000_0000
<b>P4_PIN</b>	GP_BA+0x110	R	P4 Pin Value	0x0000_00XX
<b>P4_DBEN</b>	GP_BA+0x114	R/W	P4 De-bounce Enable Control	0x0000_0000
<b>P4_IMD</b>	GP_BA+0x118	R/W	P4 Interrupt Mode Control	0x0000_0000
<b>P4_IEN</b>	GP_BA+0x11C	R/W	P4 Interrupt Enable Control	0x0000_0000
<b>P4_ISRC</b>	GP_BA+0x120	R/W	P4 Interrupt Source Flag	0x0000_0000
<b>DBNCECON</b>	GP_BA+0x180	R/W	Interrupt De-bounce Control	0x0000_0020
<b>P0n_PDIO n = 0, 1...7</b>	GP_BA+0x200 + 0x04 * n	R/W	GPIO P0.n Pin Data Input/Output	0x0000_000X
<b>P1n_PDIO n = 0, 1...7</b>	GP_BA+0x220 + 0x04 * n	R/W	GPIO P1.n Pin Data Input/Output	0x0000_000X
<b>P2n_PDIO n = 0, 1...7</b>	GP_BA+0x240 + 0x04 * n	R/W	GPIO P2.n Pin Data Input/Output	0x0000_000X
<b>P3n_PDIO n = 0, 1...7</b>	GP_BA+0x260 + 0x04 * n	R/W	GPIO P3.n Pin Data Input/Output	0x0000_000X
<b>P4n_PDIO n = 0, 1...7</b>	GP_BA+0x280 + 0x04 * n	R/W	GPIO P4.n Pin Data Input/Output	0x0000_000X

### 5.8.7 Register Description for NUC029xAN

#### Port 0-4 I/O Mode Control (Px\_PMD)

Register	Offset	R/W	Description				Reset Value
P0_PMD	GP_BA+0x000	R/W	P0 I/O Mode Control				0x0000_XXXX
P1_PMD	GP_BA+0x040	R/W	P1 I/O Mode Control				0x0000_XXXX
P2_PMD	GP_BA+0x080	R/W	P2 I/O Mode Control				0x0000_XXXX
P3_PMD	GP_BA+0x0C0	R/W	P3 I/O Mode Control				0x0000_XXXX
P4_PMD	GP_BA+0x100	R/W	P4 I/O Mode Control				0x0000_XXXX



Bits	Description	
[31:16]	Reserved	Reserved.
[15 :0]	PMDn	<p><b>Port 0-4 I/O Pin [N] Mode Control</b></p> <p>Determine each I/O mode of Px.n pins.</p> <p>00 = Px.n is in Input mode.</p> <p>01 = Px.n is in Push-pull Output mode.</p> <p>10 = Px.n is in Open-drain Output mode.</p> <p>11 = Px.n is in Quasi-bidirectional mode.</p> <p><b>Note 1:</b> x = 0~4, n = 0~7.</p> <p><b>Note 2:</b> The initial value of this field is defined by CIOINI (CONFIG[10]) If CIOINI is set to 1, the default value is 0x0000_FFFF and all pins will be quasi-bidirectional mode after chip powered on. If CIOINI is set to 0, the default value is 0x0000_0000 and all pins will be input tri-state mode after chip powered on.</p>

### Port 0-4 Digital Input Path Disable Control (Px\_OFFD)

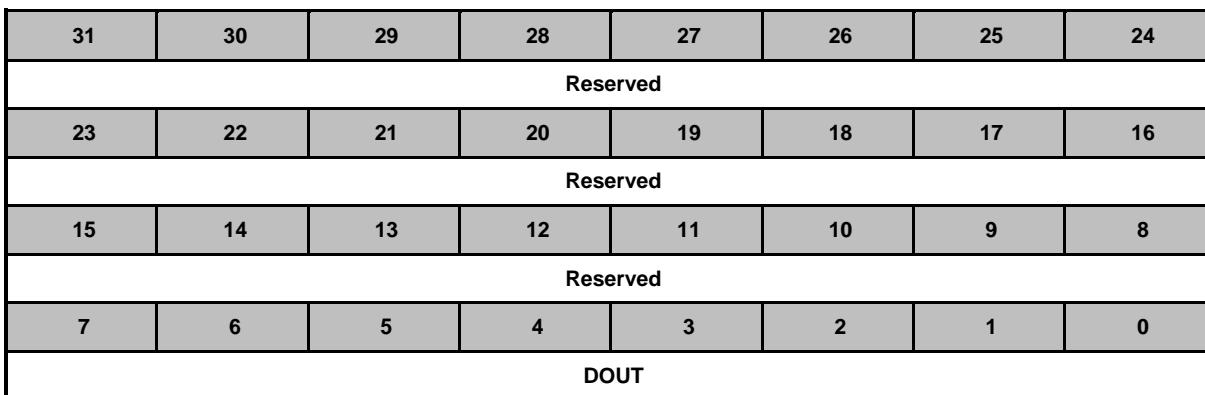
Register	Offset	R/W	Description				Reset Value
P0_OFFD	GP_BA+0x004	R/W	P0 Digital Input Path Disable Control				0x0000_0000
P1_OFFD	GP_BA+0x044	R/W	P1 Digital Input Path Disable Control				0x0000_0000
P2_OFFD	GP_BA+0x084	R/W	P2 Digital Input Path Disable Control				0x0000_0000
P3_OFFD	GP_BA+0x0C4	R/W	P3 Digital Input Path Disable Control				0x0000_0000
P4_OFFD	GP_BA+0x104	R/W	P4 Digital Input Path Disable Control				0x0000_0000

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

Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	OFFD	<p><b>Port 0-4 Pin [N] Digital Input Path Disable Control</b></p> <p>Each of these bits is used to control if the digital input path of corresponding Px.n pin is disabled. If input is analog signal, users can disable Px.n digital input path to avoid input current leakage.</p> <p>0 = Px.n digital input path Enabled. 1 = Px.n digital input path Disabled (digital input tied to low).</p> <p><b>Note:</b> x = 0~4, n = 0~7.</p>
[15:0]	Reserved	Reserved.

**Port 0-4 Data Output Value (Px\_DOUT)**

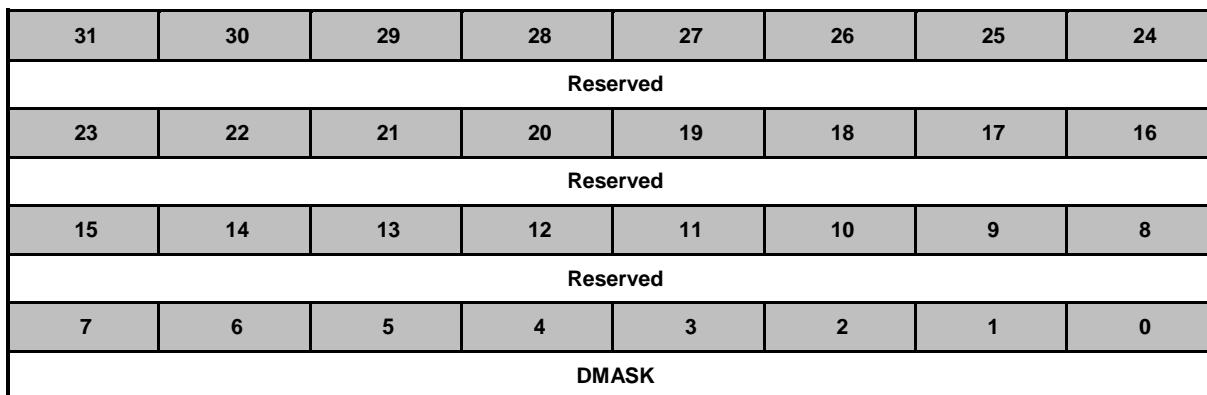
Register	Offset	R/W	Description				Reset Value
P0_DOUT	GP_BA+0x008	R/W	P0 Data Output Value				0x0000_00FF
P1_DOUT	GP_BA+0x048	R/W	P1 Data Output Value				0x0000_00FF
P2_DOUT	GP_BA+0x088	R/W	P2 Data Output Value				0x0000_00FF
P3_DOUT	GP_BA+0x0C8	R/W	P3 Data Output Value				0x0000_00FF
P4_DOUT	GP_BA+0x108	R/W	P4 Data Output Value				0x0000_00FF



Bits	Description	
[31:8]	<b>Reserved</b>	Reserved.
[15:0]	<b>DOUT[n]</b>	<p><b>Port 0-4 Pin [N] Output Value</b></p> <p>Each of these bits controls the status of a Px.n pin when the Px.n is configured as Push-pull output, Open-drain output or Quasi-bidirectional mode.</p> <p>0 = Px.n will drive Low if the Px.n pin is configured as Push-pull output, Open-drain output or Quasi-bidirectional mode.</p> <p>1 = Px.n will drive High if the Px.n pin is configured as Push-pull output or Quasi-bidirectional mode.</p> <p><b>Note:</b> x = 0~4, n = 0~7.</p>

**Port0-4 Data Output Write Mask (Px\_DMASK)**

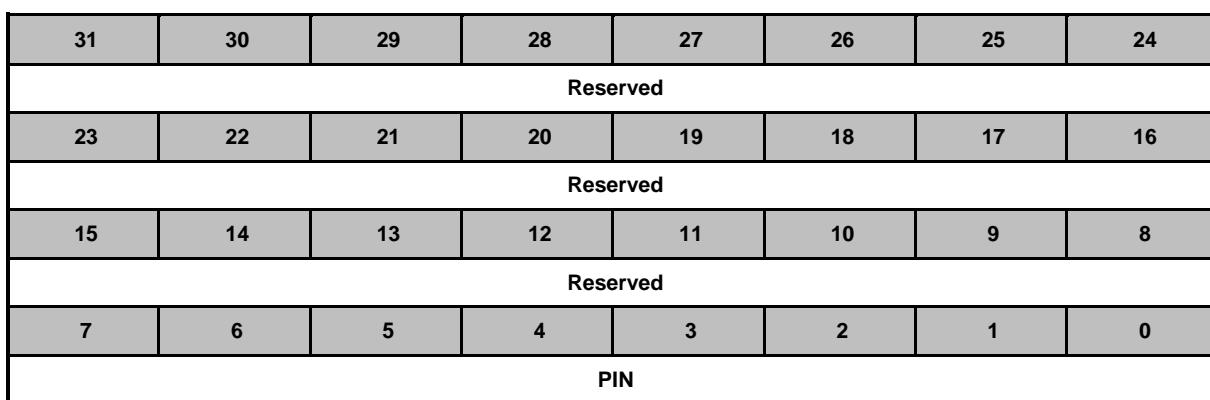
Register	Offset	R/W	Description				Reset Value
P0_DMASK	GP_BA+0x00C	R/W	P0 Data Output Write Mask				0x0000_0000
P1_DMASK	GP_BA+0x04C	R/W	P1 Data Output Write Mask				0x0000_0000
P2_DMASK	GP_BA+0x08C	R/W	P2 Data Output Write Mask				0x0000_0000
P3_DMASK	GP_BA+0x0CC	R/W	P3 Data Output Write Mask				0x0000_0000
P4_DMASK	GP_BA+0x10C	R/W	P4 Data Output Write Mask				0x0000_0000



Bits	Description	
[31:8]	<b>Reserved</b>	Reserved.
[7:0]	<b>DMASK[n]</b>	<p><b>Port 0-4 Pin [N] Data Output Write Mask</b></p> <p>These bits are used to protect the corresponding Px_DOUT[n] bit. When the DMASK[n] bit is set to 1, the corresponding Px_DOUT[n] bit is protected. If the write signal is masked, writing data to the protect bit is ignored.</p> <p>0 = Corresponding Px_DOUT[n] bit can be updated. 1 = Corresponding Px_DOUT[n] bit protected.</p> <p><b>Note 1:</b> x = 0~4, n = 0~7.</p> <p><b>Note 2:</b> This function only protects the corresponding Px_DOUT[n] bit, and will not protect the corresponding Pxn_PDIO bit.</p>

**Port 0-4 Pin Value (Px\_PIN)**

Register	Offset	R/W	Description				Reset Value
P0_PIN	GP_BA+0x010	R	P0 Pin Value				0x0000_00XX
P1_PIN	GP_BA+0x050	R	P1 Pin Value				0x0000_00XX
P2_PIN	GP_BA+0x090	R	P2 Pin Value				0x0000_00XX
P3_PIN	GP_BA+0x0D0	R	P3 Pin Value				0x0000_00XX
P4_PIN	GP_BA+0x110	R	P4 Pin Value				0x0000_00XX



Bits	Description	
[31:8]	Reserved	Reserved.
[15:0]	PIN[n]	<p><b>Port 0-4 Pin [N] Pin Value</b></p> <p>Each bit of the register reflects the actual status of the respective Px.n pin. If the bit is 1, it indicates the corresponding pin status is high; else the pin status is low.</p> <p><b>Note:</b> x = 0~4, n = 0~7.</p>

**Port 0-4 De-bounce Enable (Px\_DBEN)**

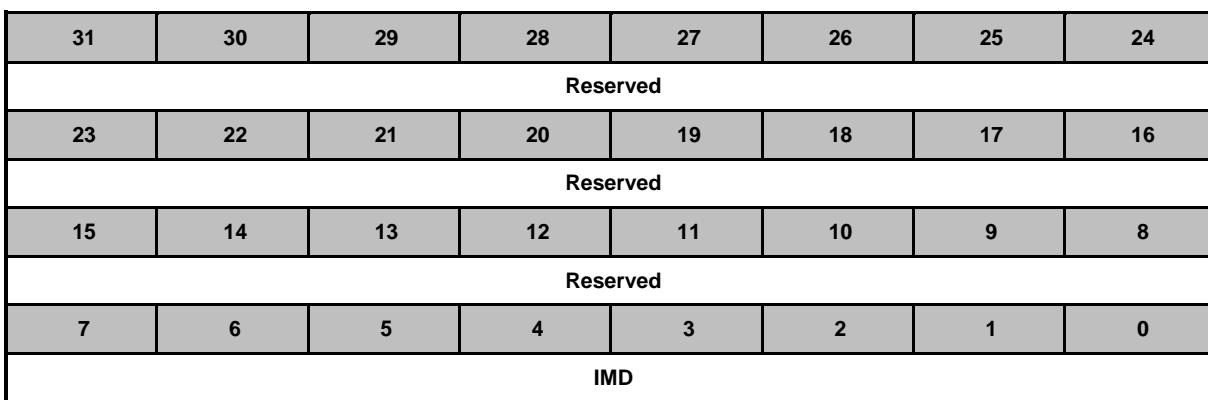
Register	Offset	R/W	Description				Reset Value
P0_DBEN	GP_BA+0x014	R/W	P0 De-bounce Enable Control				0x0000_0000
P1_DBEN	GP_BA+0x054	R/W	P1 De-bounce Enable Control				0x0000_0000
P2_DBEN	GP_BA+0x094	R/W	P2 De-bounce Enable Control				0x0000_0000
P3_DBEN	GP_BA+0x0D4	R/W	P3 De-bounce Enable Control				0x0000_0000
P4_DBEN	GP_BA+0x114	R/W	P4 De-bounce Enable Control				0x0000_0000

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

Bits	Description	
[31:8]	Reserved	Reserved.
[15:0]	DBEN[n]	<p><b>Port 0-4 Pin [N] Input Signal De-bounce Enable Control</b></p> <p>DBEN[n] bit is used to enable the de-bounce function for each corresponding bit. If the input signal pulse width cannot be sampled by continuous two de-bounce sample cycle, the input signal transition is seen as the signal bounce and will not trigger the interrupt. The de-bounce clock source is controlled by DBNCECON[4], one de-bounce sample cycle period is controlled by DBNCECON[3:0].</p> <p>0 = Px.n de-bounce function Disabled. 1 = Px.n de-bounce function Enabled.</p> <p>The de-bounce function is valid only for edge triggered interrupt. If the interrupt mode is level triggered, the de-bounce enable bit is ignored.</p> <p><b>Note 1:</b> x = 0~4, n = 0~7.</p> <p><b>Note 2:</b> If Px.n pin is chosen as Power-down wake-up source, user should be disable the de-bounce function before entering Power-down mode to avoid the second interrupt event occurred after system waken up which caused by Px.n de-bounce function.</p>

## Port 0-4 Interrupt Mode Control (Px\_IMD)

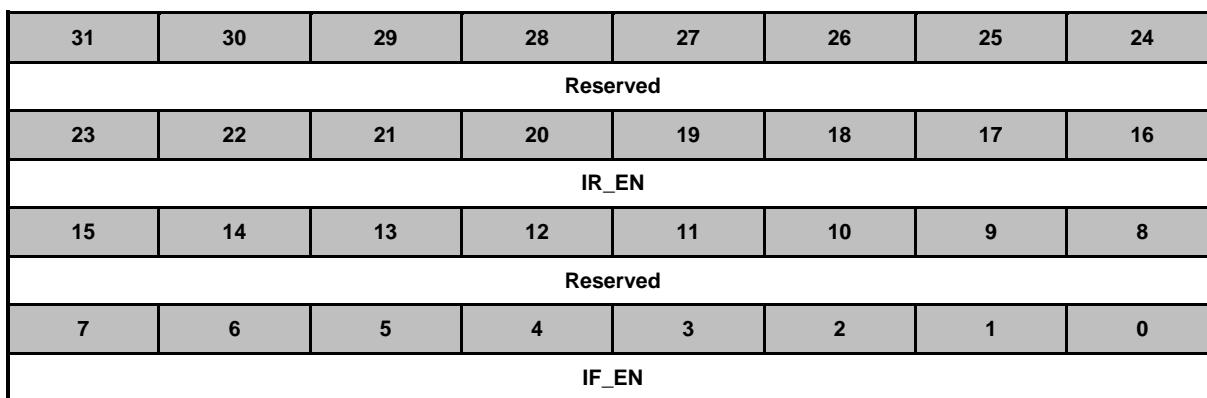
Register	Offset	R/W	Description					Reset Value
P0_IMD	GP_BA+0x018	R/W	P0 Interrupt Mode Control					0x0000_0000
P1_IMD	GP_BA+0x058	R/W	P1 Interrupt Mode Control					0x0000_0000
P2_IMD	GP_BA+0x098	R/W	P2 Interrupt Mode Control					0x0000_0000
P3_IMD	GP_BA+0x0D8	R/W	P3 Interrupt Mode Control					0x0000_0000
P4_IMD	GP_BA+0x118	R/W	P4 Interrupt Mode Control					0x0000_0000



Bits	Description	
[31:8]	Reserved	Reserved.
[15:0]	IMD[n]	<p><b>Port 0-4 Pin [N] Edge Or Level Detection Interrupt Mode Control</b></p> <p>IMD[n] bit is used to control the triggered interrupt is by level trigger or by edge trigger. If the interrupt is by edge trigger, the trigger source can be controlled by de-bounce. If the interrupt is by level trigger, the input source is sampled by one HCLK clock and generates the interrupt.</p> <p>0 = Edge trigger interrupt. 1 = Level trigger interrupt.</p> <p>If the pin is set as the level trigger interrupt, only one level can be set on the registers Px_IEN. If both levels to trigger interrupt are set, the setting is ignored and no interrupt will occur.</p> <p>The de-bounce function is valid only for edge triggered interrupt. If the interrupt mode is level triggered, the de-bounce enable bit is ignored.</p> <p><b>Note:</b> x = 0~4, n = 0~7.</p>

## Port 0-4 Interrupt Enable Control (Px\_IEN)

Register	Offset	R/W	Description				Reset Value
P0_IEN	GP_BA+0x01C	R/W	P0 Interrupt Enable Control				0x0000_0000
P1_IEN	GP_BA+0x05C	R/W	P1 Interrupt Enable Control				0x0000_0000
P2_IEN	GP_BA+0x09C	R/W	P2 Interrupt Enable Control				0x0000_0000
P3_IEN	GP_BA+0x0DC	R/W	P3 Interrupt Enable Control				0x0000_0000
P4_IEN	GP_BA+0x11C	R/W	P4 Interrupt Enable Control				0x0000_0000



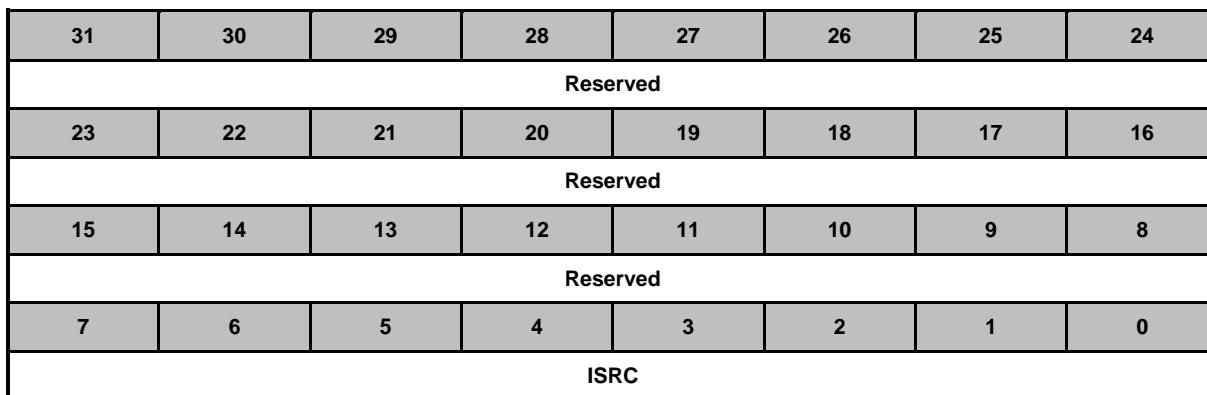
Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	IR_EN[n]	<p><b>Port 0-4 Pin [N] Interrupt Enable By Input Rising Edge Or Input Level High</b></p> <p>IR_EN[n] bit is used to enable the interrupt for each of the corresponding input Px.n pin. Set bit to 1 also enable the pin wake-up function.</p> <p>When setting the IR_EN[n] bit to 1 :</p> <p>If the interrupt is level trigger (IMD[n] is 1), the input Px.n pin will generate the interrupt while this pin state is at high level.</p> <p>If the interrupt is edge trigger (IMD[n] is 0), the input Px.n pin will generate the interrupt while this pin state changed from low to high.</p> <p>0 = Px.n level high or low to high interrupt Disabled. 1 = Px.n level high or low to high interrupt Enabled.</p> <p><b>Note:</b> x = 0~4, n = 0~7.</p>
[15:8]	Reserved	Reserved.
[7:0]	IF_EN[n]	<p><b>Port 0-4 Pin [N] Interrupt Enable By Input Falling Edge Or Input Level Low</b></p> <p>IF_EN[n] bit is used to enable the interrupt for each of the corresponding input Px.n pin. Set bit to 1 also enable the pin wake-up function.</p> <p>When setting the IF_EN[n] bit to 1 :</p> <p>If the interrupt is level trigger (IMD[n] is 1), the input Px.n pin will generate the interrupt while this pin state is at low level.</p> <p>If the interrupt is edge trigger (IMD[n] is 0), the input Px.n pin will generate the interrupt while this pin state changed from high to low.</p> <p>0 = Px.n level low or high to low interrupt Disabled.</p>

		1 = Px.n level low or high to low interrupt Enabled.
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**Note:** x = 0~4, n = 0~7.

**Port 0-4 Interrupt Source Flag (Px\_ISRC)**

Register	Offset	R/W	Description				Reset Value
P0_ISRC	GP_BA+0x020	R/W	P0 Interrupt Source Flag				0x0000_0000
P1_ISRC	GP_BA+0x060	R/W	P1 Interrupt Source Flag				0x0000_0000
P2_ISRC	GP_BA+0x0A0	R/W	P2 Interrupt Source Flag				0x0000_0000
P3_ISRC	GP_BA+0x0E0	R/W	P3 Interrupt Source Flag				0x0000_0000
P4_ISRC	GP_BA+0x120	R/W	P4 Interrupt Source Flag				0x0000_0000



Bits	Description	
[31:8]	<b>Reserved</b>	Reserved.
[7:0]	<b>ISRC[n]</b>	<p><b>Port 0-4 Pin [N] Interrupt Source Flag</b></p> <p>Write :</p> <p>0 = No action.</p> <p>1 = Clear the corresponding pending interrupt.</p> <p>Read :</p> <p>0 = No interrupt at Px.n.</p> <p>1 = Px.n generates an interrupt.</p> <p><b>Note:</b> x = 0~4, n = 0~7.</p>

**Interrupt De-bounce Cycle Control (DBNCECON)**

Register	Offset	R/W	Description					Reset Value
DBNCECON	GP_BA+0x180	R/W	Interrupt De-bounce Control					0x0000_0020

31	30	29	28	27	26	25	24	
Reserved								
23	22	21	20	19	18	17	16	
Reserved								
15	14	13	12	11	10	9	8	
Reserved								
7	6	5	4	3	2	1	0	
Reserved		ICLK_ON	DBCLKSRC	DBCLKSEL				

Bits	Description	
[31:6]	Reserved	Reserved.
[5]	ICLK_ON	<p><b>Interrupt Clock On Mode</b></p> <p>0 = Edge detection circuit is active only if I/O pin corresponding Px_IEN bit is set to 1.            1 = All I/O pins edge detection circuit is always active after reset.</p> <p><b>Note:</b> It is recommended to turn off this bit to save system power if no special application concern.</p>
[4]	DBCLKSRC	<p><b>De-bounce Counter Clock Source Selection</b></p> <p>0 = De-bounce counter clock source is the HCLK.            1 = De-bounce counter clock source is the 10 kHz internal low speed oscillator.</p>
[3:0]	DBCLKSEL	<p><b>De-bounce Sampling Cycle Selection</b></p> <p>0000 = Sample interrupt input once per 1 clocks.            0001 = Sample interrupt input once per 2 clocks.            0010 = Sample interrupt input once per 4 clocks.            0011 = Sample interrupt input once per 8 clocks.            0100 = Sample interrupt input once per 16 clocks.            0101 = Sample interrupt input once per 32 clocks.            0110 = Sample interrupt input once per 64 clocks.            0111 = Sample interrupt input once per 128 clocks.            1000 = Sample interrupt input once per 256 clocks.            1001 = Sample interrupt input once per 2*256 clocks.            1010 = Sample interrupt input once per 4*256 clocks.            1011 = Sample interrupt input once per 8*256 clocks.            1100 = Sample interrupt input once per 16*256 clocks.            1101 = Sample interrupt input once per 32*256 clocks.            1110 = Sample interrupt input once per 64*256 clocks.            1111 = Sample interrupt input once per 128*256 clocks.</p>

**GPIO Px.n Pin Data Input/Outut (Px<sub>n</sub>\_PDIO)**

Register	Offset	R/W	Description	Reset Value
<b>P0n_PDIO</b> <b>n = 0,1...7</b>	GP_BA+0x200 + 0x04 * n	R/W	GPIO P0.n Pin Data Input/Output	0x0000_000X
<b>P1n_PDIO</b> <b>n = 0,1...7</b>	GP_BA+0x220 + 0x04 * n	R/W	GPIO P1.n Pin Data Input/Output	0x0000_000X
<b>P2n_PDIO</b> <b>n = 0,1...7</b>	GP_BA+0x240 + 0x04 * n	R/W	GPIO P2.n Pin Data Input/Output	0x0000_000X
<b>P3n_PDIO</b> <b>n = 0,1...7</b>	GP_BA+0x260 + 0x04 * n	R/W	GPIO P3.n Pin Data Input/Output	0x0000_000X
<b>P4n_PDIO</b> <b>n = 0,1...7</b>	GP_BA+0x280 + 0x04 * n	R/W	GPIO P4.n Pin Data Input/Output	0x0000_000X

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved							<b>Px<sub>n</sub>_PDIO</b>

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	<b>Px<sub>n</sub>_PDIO</b>	<p><b>GPIO Px.N Pin Data Input/Output</b>  Writing this bit can control one GPIO pin output value.  0 = Corresponding GPIO pin set to low.  1 = Corresponding GPIO pin set to high.  Read this register to get GPIO pin status.  0 = Corresponding GPIO pin status is low.  1 = Corresponding GPIO pin status is high.</p> <p>For example, writing P00_PDIO will reflect the written value to bit P0_DOUT[0], reading P00_PDIO will return the value of P0_PIN[0].</p> <p><b>Note 1:</b> x = 0~4, n = 0~7.</p> <p><b>Note 2:</b> The writing operation will not be affected by register Px_DMASK[n].</p>

### 5.8.8 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>GPIO Base Address:</b>				
<b>GP_BA = 0x5000_4000</b>				
<b>P0_PMD</b>	GP_BA+0x000	R/W	P0 I/O Mode Control	0x0000_XXXX
<b>P0_OFFD</b>	GP_BA+0x004	R/W	P0 Digital Input Path Disable Control	0x0000_0000
<b>P0_DOUT</b>	GP_BA+0x008	R/W	P0 Data Output Value	0x0000_00F3
<b>P0_DMASK</b>	GP_BA+0x00C	R/W	P0 Data Output Write Mask	0x0000_0000
<b>P0_PIN</b>	GP_BA+0x010	R	P0 Pin Value	0x0000_00XX
<b>P0_DBEN</b>	GP_BA+0x014	R/W	P0 De-bounce Enable Control	0x0000_0000
<b>P0_IMD</b>	GP_BA+0x018	R/W	P0 Interrupt Mode Control	0x0000_0000
<b>P0_IEN</b>	GP_BA+0x01C	R/W	P0 Interrupt Enable Control	0x0000_0000
<b>P0_ISRC</b>	GP_BA+0x020	R/W	P0 Interrupt Source Flag	0x0000_0000
<b>P1_PMD</b>	GP_BA+0x040	R/W	P1 I/O Mode Control	0x0000_XXXX
<b>P1_OFFD</b>	GP_BA+0x044	R/W	P1 Digital Input Path Disable Control	0x0000_0000
<b>P1_DOUT</b>	GP_BA+0x048	R/W	P1 Data Output Value	0x0000_003D
<b>P1_DMASK</b>	GP_BA+0x04C	R/W	P1 Data Output Write Mask	0x0000_0000
<b>P1_PIN</b>	GP_BA+0x050	R	P1 Pin Value	0x0000_00XX
<b>P1_DBEN</b>	GP_BA+0x054	R/W	P1 De-bounce Enable Control	0x0000_0000
<b>P1_IMD</b>	GP_BA+0x058	R/W	P1 Interrupt Mode Control	0x0000_0000
<b>P1_IEN</b>	GP_BA+0x05C	R/W	P1 Interrupt Enable Control	0x0000_0000
<b>P1_ISRC</b>	GP_BA+0x060	R/W	P1 Interrupt Source Flag	0x0000_0000
<b>P2_PMD</b>	GP_BA+0x080	R/W	P2 I/O Mode Control	0x0000_XXXX
<b>P2_OFFD</b>	GP_BA+0x084	R/W	P2 Digital Input Path Disable Control	0x0000_0000
<b>P2_DOUT</b>	GP_BA+0x088	R/W	P2 Data Output Value	0x0000_007C
<b>P2_DMASK</b>	GP_BA+0x08C	R/W	P2 Data Output Write Mask	0x0000_0000
<b>P2_PIN</b>	GP_BA+0x090	R	P2 Pin Value	0x0000_00XX
<b>P2_DBEN</b>	GP_BA+0x094	R/W	P2 De-bounce Enable Control	0x0000_0000
<b>P2_IMD</b>	GP_BA+0x098	R/W	P2 Interrupt Mode Control	0x0000_0000
<b>P2_IEN</b>	GP_BA+0x09C	R/W	P2 Interrupt Enable Control	0x0000_0000

<b>P2_ISRC</b>	GP_BA+0x0A0	R/W	P2 Interrupt Source Flag	0x0000_0000
<b>P3_PMD</b>	GP_BA+0x0C0	R/W	P3 I/O Mode Control	0x0000_XXXX
<b>P3_OFFD</b>	GP_BA+0x0C4	R/W	P3 Digital Input Path Disable Control	0x0000_0000
<b>P3_DOUT</b>	GP_BA+0x0C8	R/W	P3 Data Output Value	0x0000_0077
<b>P3_DMASK</b>	GP_BA+0x0CC	R/W	P3 Data Output Write Mask	0x0000_0000
<b>P3_PIN</b>	GP_BA+0x0D0	R	P3 Pin Value	0x0000_00XX
<b>P3_DBEN</b>	GP_BA+0x0D4	R/W	P3 De-bounce Enable Control	0x0000_0000
<b>P3_IMD</b>	GP_BA+0x0D8	R/W	P3 Interrupt Mode Control	0x0000_0000
<b>P3_IEN</b>	GP_BA+0x0DC	R/W	P3 Interrupt Enable Control	0x0000_0000
<b>P3_ISRC</b>	GP_BA+0x0E0	R/W	P3 Interrupt Source Flag	0x0000_0000
<b>P4_PMD</b>	GP_BA+0x100	R/W	P4 I/O Mode Control	0x0000_XXXX
<b>P4_OFFD</b>	GP_BA+0x104	R/W	P4 Digital Input Path Disable Control	0x0000_0000
<b>P4_DOUT</b>	GP_BA+0x108	R/W	P4 Data Output Value	0x0000_00C0
<b>P4_DMASK</b>	GP_BA+0x10C	R/W	P4 Data Output Write Mask	0x0000_0000
<b>P4_PIN</b>	GP_BA+0x110	R	P4 Pin Value	0x0000_00XX
<b>P4_DBEN</b>	GP_BA+0x114	R/W	P4 De-bounce Enable Control	0x0000_0000
<b>P4_IMD</b>	GP_BA+0x118	R/W	P4 Interrupt Mode Control	0x0000_0000
<b>P4_IEN</b>	GP_BA+0x11C	R/W	P4 Interrupt Enable Control	0x0000_0000
<b>P4_ISRC</b>	GP_BA+0x120	R/W	P4 Interrupt Source Flag	0x0000_0000
<b>P5_PMD</b>	GP_BA+0x140	R/W	P5 I/O Mode Control	0x0000_XXXX
<b>P5_OFFD</b>	GP_BA+0x144	R/W	P5 Digital Input Path Disable Control	0x0000_0000
<b>P5_DOUT</b>	GP_BA+0x148	R/W	P5 Data Output Value	0x0000_003F
<b>P5_DMASK</b>	GP_BA+0x14C	R/W	P5 Data Output Write Mask	0x0000_0000
<b>P5_PIN</b>	GP_BA+0x150	R	P5 Pin Value	0x0000_00XX
<b>P5_DBEN</b>	GP_BA+0x154	R/W	P5 De-bounce Enable Control	0x0000_0000
<b>P5_IMD</b>	GP_BA+0x158	R/W	P5 Interrupt Mode Control	0x0000_0000
<b>P5_IEN</b>	GP_BA+0x15C	R/W	P5 Interrupt Enable Control	0x0000_0000
<b>P5_ISRC</b>	GP_BA+0x160	R/W	P5 Interrupt Source Flag	0x0000_0000
<b>DBNCECON</b>	GP_BA+0x180	R/W	Interrupt De-bounce Control	0x0000_0020
<b>P5_OFFD</b>	GP_BA+0x144	R/W	P5 Digital Input Path Disable Control	0x0000_0000
<b>P5_DOUT</b>	GP_BA+0x148	R/W	P5 Data Output Value	0x0000_003F

<b>P5_DMASK</b>	GP_BA+0x14C	R/W	P5 Data Output Write Mask	0x0000_0000
<b>P5_PIN</b>	GP_BA+0x150	R	P5 Pin Value	0x0000_00XX
<b>P5_DBEN</b>	GP_BA+0x154	R/W	P5 De-bounce Enable Control	0x0000_0000
<b>P5_IMD</b>	GP_BA+0x158	R/W	P5 Interrupt Mode Control	0x0000_0000
<b>P5_IEN</b>	GP_BA+0x15C	R/W	P5 Interrupt Enable Control	0x0000_0000
<b>P5_ISRC</b>	GP_BA+0x160	R/W	P5 Interrupt Source Flag	0x0000_0000
<b>DBNCECON</b>	GP_BA+0x180	R/W	Interrupt De-bounce Control	0x0000_0020
<b>P04_PDIO</b>	GP_BA+0x210	R/W	GPIO P0.4 Pin Data Input/Output	0x0000_0001
<b>P05_PDIO</b>	GP_BA+0x214	R/W	GPIO P0.5 Pin Data Input/Output	0x0000_0001
<b>P06_PDIO</b>	GP_BA+0x218	R/W	GPIO P0.6 Pin Data Input/Output	0x0000_0001
<b>P07_PDIO</b>	GP_BA+0x21C	R/W	GPIO P0.7 Pin Data Input/Output	0x0000_0001
<b>P12_PDIO</b>	GP_BA+0x228	R/W	GPIO P1.2 Pin Data Input/Output	0x0000_0001
<b>P13_PDIO</b>	GP_BA+0x22C	R/W	GPIO P1.3 Pin Data Input/Output	0x0000_0001
<b>P14_PDIO</b>	GP_BA+0x230	R/W	GPIO P1.4 Pin Data Input/Output	0x0000_0001
<b>P15_PDIO</b>	GP_BA+0x234	R/W	GPIO P1.5 Pin Data Input/Output	0x0000_0001
<b>P24_PDIO</b>	GP_BA+0x250	R/W	GPIO P2.4 Pin Data Input/Output	0x0000_0001
<b>P25_PDIO</b>	GP_BA+0x254	R/W	GPIO P2.5 Pin Data Input/Output	0x0000_0001
<b>P32_PDIO</b>	GP_BA+0x268	R/W	GPIO P3.2 Pin Data Input/Output	0x0000_0001
<b>P34_PDIO</b>	GP_BA+0x270	R/W	GPIO P3.4 Pin Data Input/Output	0x0000_0001
<b>P35_PDIO</b>	GP_BA+0x274	R/W	GPIO P3.5 Pin Data Input/Output	0x0000_0001
<b>P46_PDIO</b>	GP_BA+0x298	R/W	GPIO P4.6 Pin Data Input/Output	0x0000_0001
<b>P47_PDIO</b>	GP_BA+0x29C	R/W	GPIO P4.7 Pin Data Input/Output	0x0000_0001
<b>P50_PDIO</b>	GP_BA+0x2A0	R/W	GPIO P5.0 Pin Data Input/Output	0x0000_0001
<b>P51_PDIO</b>	GP_BA+0x2A4	R/W	GPIO P5.1 Pin Data Input/Output	0x0000_0001

### 5.8.9 Register Description for NUC029FAE

#### Port 0-5 I/O Mode Control (Px\_PMD)

Register	Offset	R/W	Description				Reset Value
P0_PMD	GP_BA+0x000	R/W	P0 I/O Mode Control				0x0000_XXXX
P1_PMD	GP_BA+0x040	R/W	P1 I/O Mode Control				0x0000_XXXX
P2_PMD	GP_BA+0x080	R/W	P2 I/O Mode Control				0x0000_XXXX
P3_PMD	GP_BA+0x0C0	R/W	P3 I/O Mode Control				0x0000_XXXX
P4_PMD	GP_BA+0x100	R/W	P4 I/O Mode Control				0x0000_XXXX
P5_PMD	GP_BA+0x140	R/W	P5 I/O Mode Control				0x0000_XXXX

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
PMD7		PMD6		PMD5		PMD4	
7	6	5	4	3	2	1	0
PMD3		PMD2		PMD1		PMD0	

Bits	Description	
[31:16]	Reserved	Reserved.
[15 : 0]	PMDn	<p><b>Port 0-5 I/O Pin [N] Mode Control</b></p> <p>Determine each I/O mode of Px.n pins. Default mode is controlled by CIOINI (CONFIG0[10]).</p> <p>00 = Px.n is in Input mode.      01 = Px.n is in Push-pull Output mode.      10 = Px.n is in Open-drain Output mode.      11 = Px.n is in Quasi-bidirectional mode.</p> <p><b>Note 1:</b> x = 0~4, n = 0~7.</p> <p><b>Note 2:</b></p> <p>P0_PMD[7:0] are reserved.      P1_PMD[15:12], [3:0] are reserved.      P2_PMD[15:12], [7:0] are reserved.      P3_PMD[15:12], [7:6], [3:0] are reserved.      P4_PMD[11:0] are reserved.      P5_PMD[15:4] are reserved.</p>

## Port 0-5 Digital Input Path Disable Control (Px\_OFFD)

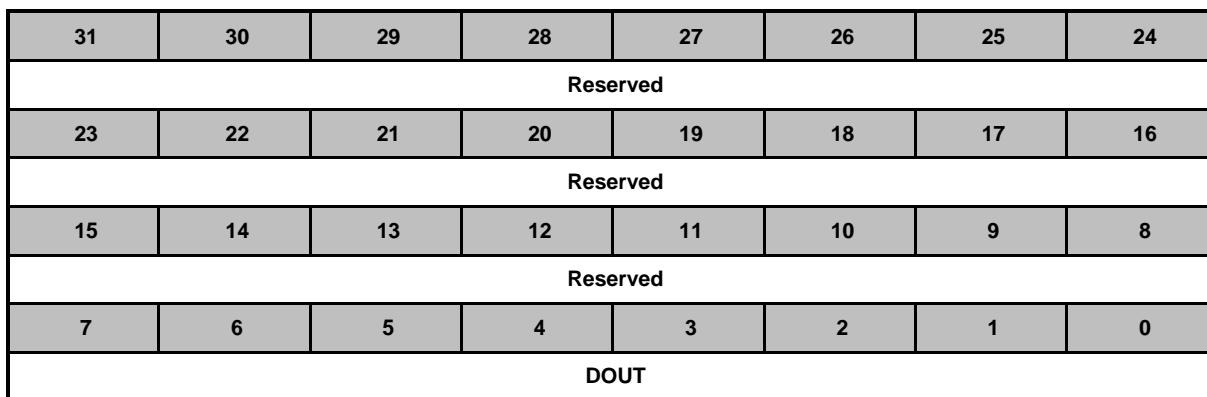
Register	Offset	R/W	Description				Reset Value
P0_OFFD	GP_BA+0x004	R/W	P0 Digital Input Path Disable Control				0x0000_0000
P1_OFFD	GP_BA+0x044	R/W	P1 Digital Input Path Disable Control				0x0000_0000
P2_OFFD	GP_BA+0x084	R/W	P2 Digital Input Path Disable Control				0x0000_0000
P3_OFFD	GP_BA+0x0C4	R/W	P3 Digital Input Path Disable Control				0x0000_0000
P4_OFFD	GP_BA+0x104	R/W	P4 Digital Input Path Disable Control				0x0000_0000
P5_OFFD	GP_BA+0x144	R/W	P5 Digital Input Path Disable Control				0x0000_0000

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

Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	OFFD	<p><b>Port 0-5 Pin [N] Digital Input Path Disable Control</b></p> <p>Each of these bits is used to control if the digital input path of corresponding Px.n pin is disabled. If input is analog signal, users can disable Px.n digital input path to avoid input current leakage.</p> <p>0 = Px.n digital input path Enabled. 1 = Px.n digital input path Disabled (digital input tied to low).</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <ul style="list-style-type: none"> <li>P0_OFFD[19:16] are reserved.</li> <li>P1_OFFD [23:22], [17:16] are reserved.</li> <li>P2_OFFD [23:22], [19:16] are reserved.</li> <li>P3_OFFD [23:22], [19], [17:16] are reserved.</li> <li>P4_OFFD [21:16] are reserved.</li> <li>P5_OFFD [23:18] are reserved.</li> </ul>
[15:0]	Reserved	Reserved.

**Port 0-5 Data Output Value (Px\_DOUT)**

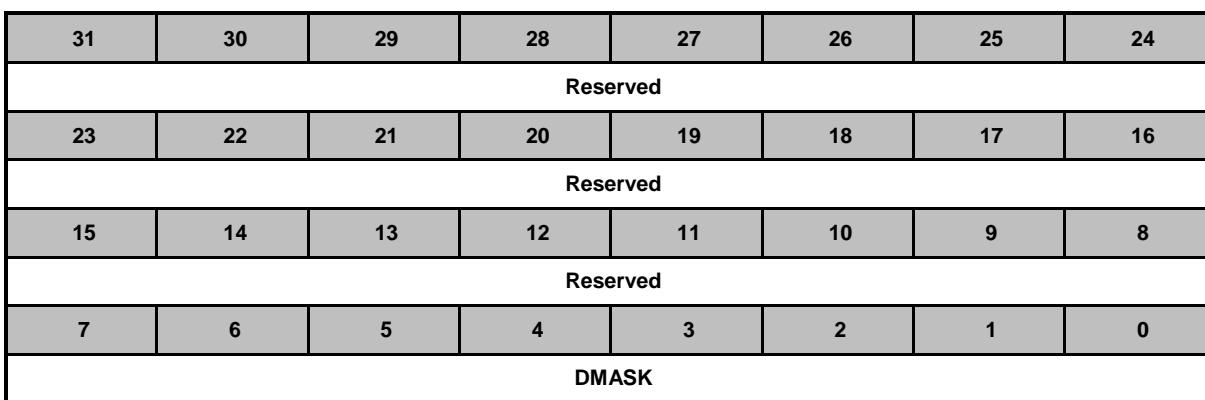
Register	Offset	R/W	Description				Reset Value
P0_DOUT	GP_BA+0x008	R/W	P0 Data Output Value				0x0000_00F3
P1_DOUT	GP_BA+0x048	R/W	P1 Data Output Value				0x0000_003D
P2_DOUT	GP_BA+0x088	R/W	P2 Data Output Value				0x0000_007C
P3_DOUT	GP_BA+0x0C8	R/W	P3 Data Output Value				0x0000_0077
P4_DOUT	GP_BA+0x108	R/W	P4 Data Output Value				0x0000_00C0
P5_DOUT	GP_BA+0x148	R/W	P5 Data Output Value				0x0000_003F



Bits	Description	
[31:8]	<b>Reserved</b>	Reserved.
[7:0]	<b>DOUT[n]</b>	<p><b>Port 0-5 Pin [N] Output Value</b></p> <p>Each of these bits controls the status of a Px.n pin when the Px.n is configured as Push-pull output, Open-drain output or Quasi-bidirectional mode.</p> <p>0 = Px.n will drive Low if the Px.n pin is configured as Push-pull output, Open-drain output or Quasi-bidirectional mode.</p> <p>1 = Px.n will drive High if the Px.n pin is configured as Push-pull output or Quasi-bidirectional mode.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <ul style="list-style-type: none"> <li>P0_DOUT[3:0] are reserved.</li> <li>P1_DOUT[7:6], [1:0] are reserved.</li> <li>P2_DOUT[7:6], [3:0] are reserved.</li> <li>P3_DOUT[7:6], [3], [1:0] are reserved.</li> <li>P4_DOUT[5:0] are reserved.</li> <li>P5_DOUT[7:2] are reserved.</li> </ul>

**Port0-5 Data Output Write Mask (Px\_DMASK)**

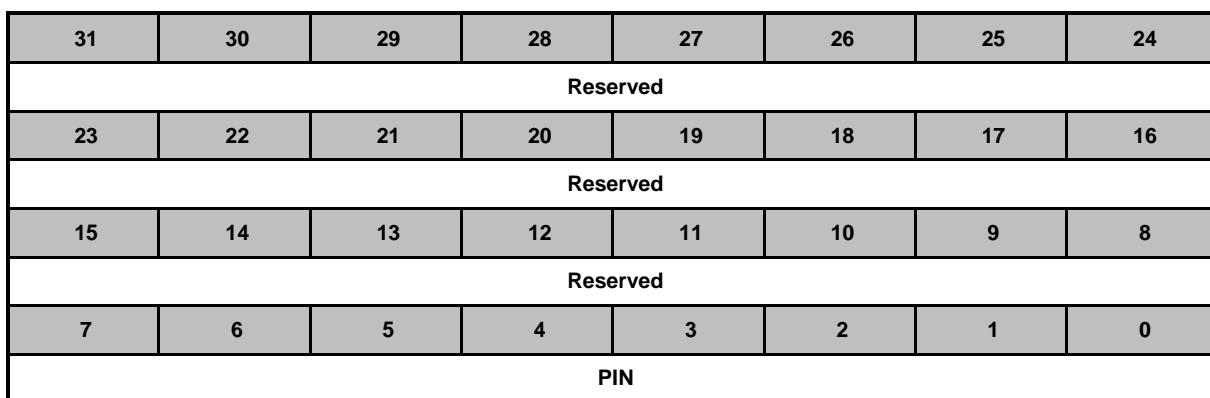
Register	Offset	R/W	Description				Reset Value
P0_DMASK	GP_BA+0x00C	R/W	P0 Data Output Write Mask				0x0000_0000
P1_DMASK	GP_BA+0x04C	R/W	P1 Data Output Write Mask				0x0000_0000
P2_DMASK	GP_BA+0x08C	R/W	P2 Data Output Write Mask				0x0000_0000
P3_DMASK	GP_BA+0x0CC	R/W	P3 Data Output Write Mask				0x0000_0000
P4_DMASK	GP_BA+0x10C	R/W	P4 Data Output Write Mask				0x0000_0000
P5_DMASK	GP_BA+0x14C	R/W	P5 Data Output Write Mask				0x0000_0000



Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	DMASK[n]	<p><b>Port 0-5 Pin [N] Data Output Write Mask</b></p> <p>These bits are used to protect the corresponding Px_DOUT[n] bit. When the DMASK[n] bit is set to 1, the corresponding Px_DOUT[n] bit is protected. If the write signal is masked, writing data to the protect bit is ignored.</p> <p>0 = Corresponding Px_DOUT[n] bit can be updated. 1 = Corresponding Px_DOUT[n] bit protected.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b> This function only protects the corresponding Px_DOUT[n] bit, and will not protect the corresponding Pxn_PDIO bit.</p> <p><b>Note 3:</b></p> <ul style="list-style-type: none"> <li>P0_DMASK[3:0] are reserved.</li> <li>P1_DMASK[7:6], [1:0] are reserved.</li> <li>P2_DMASK[7:6], [3:0] are reserved.</li> <li>P3_DMASK[7:6], [3], [1:0] are reserved.</li> <li>P4_DMASK[5:0] are reserved.</li> <li>P5_DMASK[7:2] are reserved.</li> </ul>

**Port 0-5 Pin Value (Px\_PIN)**

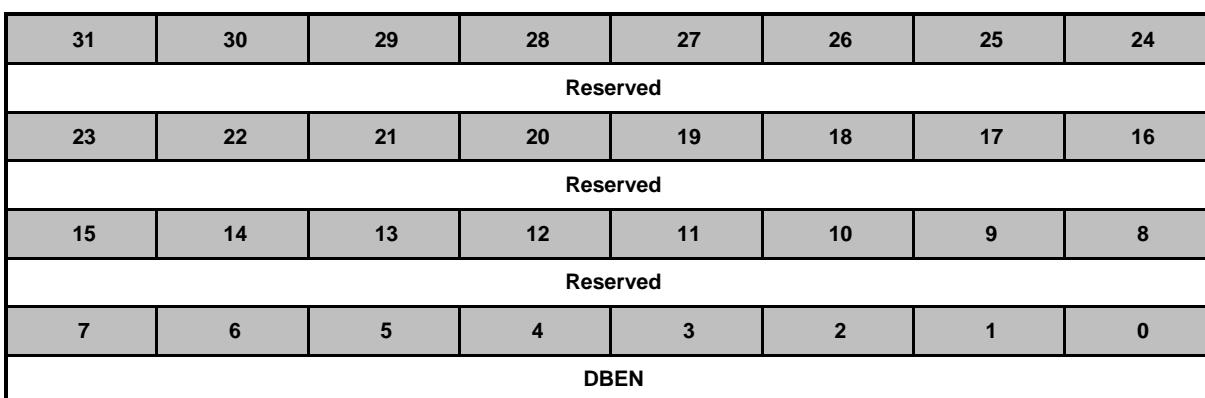
Register	Offset	R/W	Description				Reset Value
P0_PIN	GP_BA+0x010	R	P0 Pin Value				0x0000_00XX
P1_PIN	GP_BA+0x050	R	P1 Pin Value				0x0000_00XX
P2_PIN	GP_BA+0x090	R	P2 Pin Value				0x0000_00XX
P3_PIN	GP_BA+0x0D0	R	P3 Pin Value				0x0000_00XX
P4_PIN	GP_BA+0x110	R	P4 Pin Value				0x0000_00XX
P5_PIN	GP_BA+0x150	R	P5 Pin Value				0x0000_00XX



Bits	Description	
[31:8]	Reserved	Reserved.
[15:0]	PIN[n]	<p><b>Port 0-5 Pin [N] Pin Value</b></p> <p>Each bit of the register reflects the actual status of the respective Px.n pin. If the bit is 1, it indicates the corresponding pin status is high; else the pin status is low.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <ul style="list-style-type: none"> <li>P0_PIN[3:0] are reserved.</li> <li>P1_PIN[7:6], [1:0] are reserved.</li> <li>P2_PIN[7:6], [3:0] are reserved.</li> <li>P3_PIN[7:6], [3], [1:0] are reserved.</li> <li>P4_PIN[5:0] are reserved.</li> <li>P5_PIN[7:2] are reserved.</li> </ul>

**Port 0-5 De-bounce Enable (Px\_DBEN)**

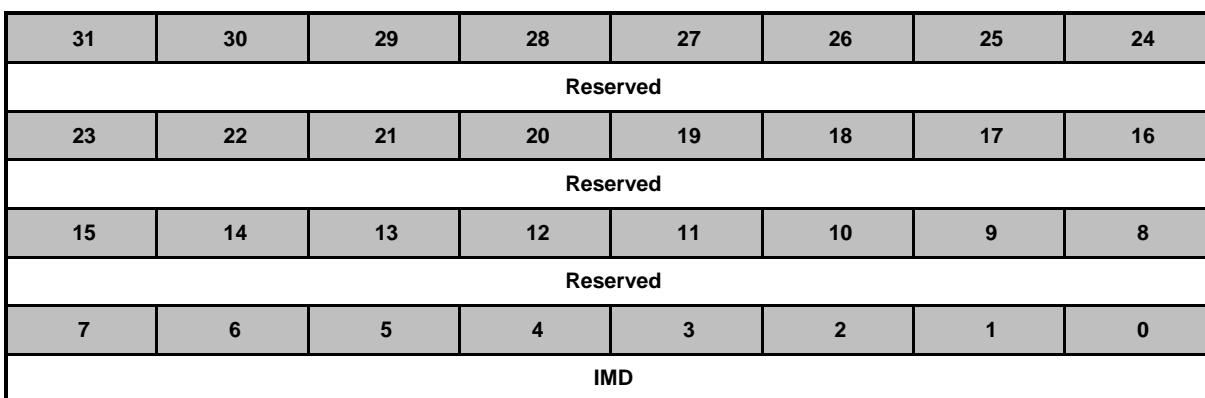
Register	Offset	R/W	Description				Reset Value
P0_DBEN	GP_BA+0x014	R/W	P0 De-bounce Enable Control				0x0000_0000
P1_DBEN	GP_BA+0x054	R/W	P1 De-bounce Enable Control				0x0000_0000
P2_DBEN	GP_BA+0x094	R/W	P2 De-bounce Enable Control				0x0000_0000
P3_DBEN	GP_BA+0xD4	R/W	P3 De-bounce Enable Control				0x0000_0000
P4_DBEN	GP_BA+0x114	R/W	P4 De-bounce Enable Control				0x0000_0000
P5_DBEN	GP_BA+0x154	R/W	P5 De-bounce Enable Control				0x0000_0000



Bits	Description	
[31:8]	Reserved	Reserved.
[15:0]	DBEN[n]	<p><b>Port 0-5 Pin [N] Input Signal De-bounce Enable Control</b></p> <p>DBEN[n] bit is used to enable the de-bounce function for each corresponding bit. If the input signal pulse width cannot be sampled by continuous two de-bounce sample cycle, the input signal transition is seen as the signal bounce and will not trigger the interrupt. The de-bounce clock source is controlled by DBNCECON[4], one de-bounce sample cycle period is controlled by DBNCECON[3:0].</p> <p>0 = Px.n de-bounce function Disabled. 1 = Px.n de-bounce function Enabled.</p> <p>The de-bounce function is valid only for edge triggered interrupt. If the interrupt mode is level triggered, the de-bounce enable bit is ignored.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b> If Px.n pin is chosen as Power-down wake-up source, user should be disable the de-bounce function before entering Power-down mode to avoid the second interrupt event occurred after system waken up which caused by Px.n de-bounce function.</p> <p><b>Note 3:</b></p> <ul style="list-style-type: none"> <li>P0_DBEN[3:0] are reserved.</li> <li>P1_DBEN[7:6], [1:0] are reserved.</li> <li>P2_DBEN[7:6], [3:0] are reserved.</li> <li>P3_DBEN[7:6], [3], [1:0] are reserved.</li> <li>P4_DBEN[5:0] are reserved.</li> <li>P5_DBEN[7:2] are reserved.</li> </ul>

## Port 0-5 Interrupt Mode Control (Px\_IMD)

Register	Offset	R/W	Description				Reset Value
P0_IMD	GP_BA+0x018	R/W	P0 Interrupt Mode Control				0x0000_0000
P1_IMD	GP_BA+0x058	R/W	P1 Interrupt Mode Control				0x0000_0000
P2_IMD	GP_BA+0x098	R/W	P2 Interrupt Mode Control				0x0000_0000
P3_IMD	GP_BA+0x0D8	R/W	P3 Interrupt Mode Control				0x0000_0000
P4_IMD	GP_BA+0x118	R/W	P4 Interrupt Mode Control				0x0000_0000
P5_IMD	GP_BA+0x158	R/W	P5 Interrupt Mode Control				0x0000_0000



Bits	Description	
[31:8]	Reserved	Reserved.
[15:0]	IMD[n]	<p><b>Port 0-5 Pin [N] Edge Or Level Detection Interrupt Mode Control</b></p> <p>IMD[n] bit is used to control the triggered interrupt is by level trigger or by edge trigger. If the interrupt is by edge trigger, the trigger source can be controlled by de-bounce. If the interrupt is by level trigger, the input source is sampled by one HCLK clock and generates the interrupt.</p> <p>0 = Edge trigger interrupt. 1 = Level trigger interrupt.</p> <p>If the pin is set as the level trigger interrupt, only one level can be set on the registers Px_IEN. If both levels to trigger interrupt are set, the setting is ignored and no interrupt will occur.</p> <p>The de-bounce function is valid only for edge triggered interrupt. If the interrupt mode is level triggered, the de-bounce enable bit is ignored.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <ul style="list-style-type: none"> <li>P0_IMD[3:0] are reserved.</li> <li>P1_IMD[7:6], [1:0] are reserved.</li> <li>P2_IMD[7:6], [3:0] are reserved.</li> <li>P3_IMD[7:6], [3], [1:0] are reserved.</li> <li>P4_IMD[5:0] are reserved.</li> <li>P5_IMD[7:2] are reserved.</li> </ul>

## Port 0-5 Interrupt Enable Control (Px\_IEN)

Register	Offset	R/W	Description				Reset Value
P0_IEN	GP_BA+0x01C	R/W	P0 Interrupt Enable Control				0x0000_0000
P1_IEN	GP_BA+0x05C	R/W	P1 Interrupt Enable Control				0x0000_0000
P2_IEN	GP_BA+0x09C	R/W	P2 Interrupt Enable Control				0x0000_0000
P3_IEN	GP_BA+0x0DC	R/W	P3 Interrupt Enable Control				0x0000_0000
P4_IEN	GP_BA+0x11C	R/W	P4 Interrupt Enable Control				0x0000_0000
P5_IEN	GP_BA+0x15C	R/W	P5 Interrupt Enable Control				0x0000_0000

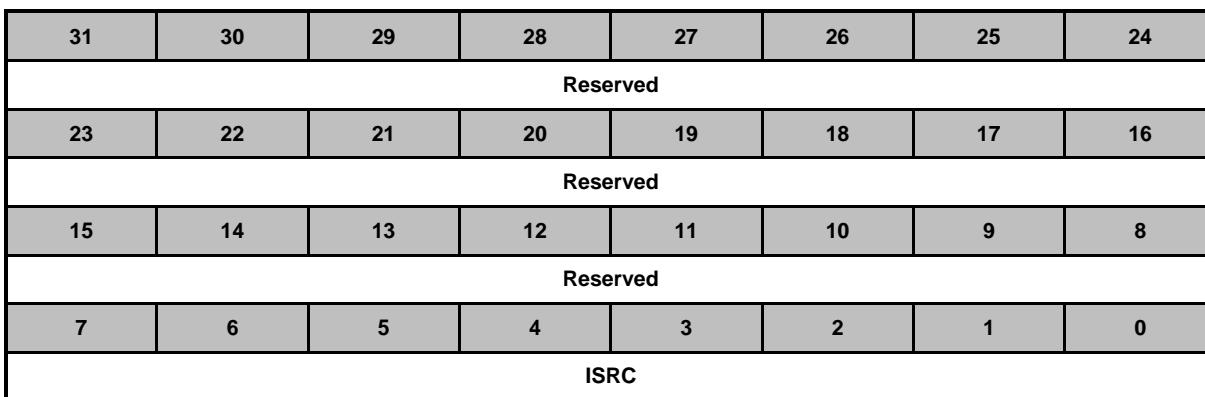
31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
IR_EN							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
IF_EN							

Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	IR_EN[n]	<p><b>Port 0-5 Pin [N] Interrupt Enable By Input Rising Edge Or Input Level High</b></p> <p>IR_EN[n] bit is used to enable the interrupt for each of the corresponding input Px.n pin. Set bit to 1 also enable the pin wake-up function.</p> <p>When setting the IR_EN[n] bit to 1 :</p> <p>If the interrupt is level trigger (IMD[n] is 1), the input Px.n pin will generate the interrupt while this pin state is at high level.</p> <p>If the interrupt is edge trigger (IMD[n] is 0), the input Px.n pin will generate the interrupt while this pin state changed from low to high.</p> <p>0 = Px.n level high or low to high interrupt Disabled.</p> <p>1 = Px.n level high or low to high interrupt Enabled.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <p>P0_IEN[19:16] are reserved.</p> <p>P1_IEN[23:22], [17:16] are reserved.</p> <p>P2_IEN[23:22], [19:16] are reserved.</p> <p>P3_IEN[23:22], [19], [17:16] are reserved.</p> <p>P4_IEN[21:16] are reserved.</p> <p>P5_IEN[23:18] are reserved.</p>
[15:8]	Reserved	Reserved.

[7:0]	<b>IF_EN[n]</b>	<p><b>Port 0-5 Pin [N] Interrupt Enable By Input Falling Edge Or Input Level Low</b></p> <p>IF_EN[n] bit is used to enable the interrupt for each of the corresponding input Px.n pin. Set bit to 1 also enable the pin wake-up function.</p> <p>When setting the IF_EN[n] bit to 1 :</p> <p>If the interrupt is level trigger (IMD[n] is 1), the input Px.n pin will generate the interrupt while this pin state is at low level.</p> <p>If the interrupt is edge trigger (IMD[n] is 0), the input Px.n pin will generate the interrupt while this pin state changed from high to low.</p> <p>0 = Px.n level low or high to low interrupt Disabled.</p> <p>1 = Px.n level low or high to low interrupt Enabled.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <p>P0_IEN[3:0] are reserved.</p> <p>P1_IEN[7:6], [1:0] are reserved.</p> <p>P2_IEN[7:6], [3:0] are reserved.</p> <p>P3_IEN[7:6], [3], [1:0] are reserved.</p> <p>P4_IEN[5:0] are reserved.</p> <p>P5_IEN[7:2] are reserved.</p>
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**Port 0-5 Interrupt Source Flag (Px\_ISRC)**

Register	Offset	R/W	Description				Reset Value
P0_ISRC	GP_BA+0x020	R/W	P0 Interrupt Source Flag				0x0000_0000
P1_ISRC	GP_BA+0x060	R/W	P1 Interrupt Source Flag				0x0000_0000
P2_ISRC	GP_BA+0x0A0	R/W	P2 Interrupt Source Flag				0x0000_0000
P3_ISRC	GP_BA+0x0E0	R/W	P3 Interrupt Source Flag				0x0000_0000
P4_ISRC	GP_BA+0x120	R/W	P4 Interrupt Source Flag				0x0000_0000
P5_ISRC	GP_BA+0x160	R/W	P5 Interrupt Source Flag				0x0000_0000



Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	ISRC[n]	<p><b>Port 0-5 Pin [N] Interrupt Source Flag</b></p> <p>Write :</p> <p>0 = No action.</p> <p>1 = Clear the corresponding pending interrupt.</p> <p>Read :</p> <p>0 = No interrupt at Px.n.</p> <p>1 = Px.n generates an interrupt.</p> <p><b>Note 1:</b> x = 0~5, n = 0~7.</p> <p><b>Note 2:</b></p> <p>P0_ISRC[3:0] are reserved.</p> <p>P1_ISRC[7:6], [1:0] are reserved.</p> <p>P2_ISRC[7:6], [3:0] are reserved.</p> <p>P3_ISRC[7:6], [3], [1:0] are reserved.</p> <p>P4_ISRC[5:0] are reserved.</p> <p>P5_ISRC[7:2] are reserved.</p>

**Interrupt De-bounce Cycle Control (DBNCECON)**

Register	Offset	R/W	Description					Reset Value
DBNCECON	GP_BA+0x180	R/W	Interrupt De-bounce Control					0x0000_0020

31	30	29	28	27	26	25	24	
Reserved								
23	22	21	20	19	18	17	16	
Reserved								
15	14	13	12	11	10	9	8	
Reserved								
7	6	5	4	3	2	1	0	
Reserved		ICLK_ON	DBCLKSRC	DBCLKSEL				

Bits	Description	
[31:6]	Reserved	Reserved.
[5]	ICLK_ON	<p><b>Interrupt Clock On Mode</b></p> <p>0 = Edge detection circuit is active only if I/O pin corresponding Px_IEN bit is set to 1.            1 = All I/O pins edge detection circuit is always active after reset.</p> <p><b>Note:</b> It is recommended to turn off this bit to save system power if no special application concern.</p>
[4]	DBCLKSRC	<p><b>De-bounce Counter Clock Source Selection</b></p> <p>0 = De-bounce counter clock source is the HCLK.            1 = De-bounce counter clock source is the 10 kHz internal low speed oscillator.</p>
[3:0]	DBCLKSEL	<p><b>De-bounce Sampling Cycle Selection</b></p> <p>0000 = Sample interrupt input once per 1 clocks.            0001 = Sample interrupt input once per 2 clocks.            0010 = Sample interrupt input once per 4 clocks.            0011 = Sample interrupt input once per 8 clocks.            0100 = Sample interrupt input once per 16 clocks.            0101 = Sample interrupt input once per 32 clocks.            0110 = Sample interrupt input once per 64 clocks.            0111 = Sample interrupt input once per 128 clocks.            1000 = Sample interrupt input once per 256 clocks.            1001 = Sample interrupt input once per 2*256 clocks.            1010 = Sample interrupt input once per 4*256 clocks.            1011 = Sample interrupt input once per 8*256 clocks.            1100 = Sample interrupt input once per 16*256 clocks.            1101 = Sample interrupt input once per 32*256 clocks.            1110 = Sample interrupt input once per 64*256 clocks.            1111 = Sample interrupt input once per 128*256 clocks.</p>

**GPIO Px.n Pin Data Input/Outut (Pxn\_PDIO)**

P[x][n]\_PDIO: x = 0~5, n = 0~7

Register	Offset	R/W	Description	Reset Value
P04_PDIO	GP_BA+0x210	R/W	GPIO P0.4 Pin Data Input/Output	0x0000_0001
P05_PDIO	GP_BA+0x214	R/W	GPIO P0.5 Pin Data Input/Output	0x0000_0001
P06_PDIO	GP_BA+0x218	R/W	GPIO P0.6 Pin Data Input/Output	0x0000_0001
P07_PDIO	GP_BA+0x21C	R/W	GPIO P0.7 Pin Data Input/Output	0x0000_0001
P12_PDIO	GP_BA+0x228	R/W	GPIO P1.2 Pin Data Input/Output	0x0000_0001
P13_PDIO	GP_BA+0x22C	R/W	GPIO P1.3 Pin Data Input/Output	0x0000_0001
P14_PDIO	GP_BA+0x230	R/W	GPIO P1.4 Pin Data Input/Output	0x0000_0001
P15_PDIO	GP_BA+0x234	R/W	GPIO P1.5 Pin Data Input/Output	0x0000_0001
P24_PDIO	GP_BA+0x250	R/W	GPIO P2.4 Pin Data Input/Output	0x0000_0001
P25_PDIO	GP_BA+0x254	R/W	GPIO P2.5 Pin Data Input/Output	0x0000_0001
P32_PDIO	GP_BA+0x268	R/W	GPIO P3.2 Pin Data Input/Output	0x0000_0001
P34_PDIO	GP_BA+0x270	R/W	GPIO P3.4 Pin Data Input/Output	0x0000_0001
P35_PDIO	GP_BA+0x274	R/W	GPIO P3.5 Pin Data Input/Output	0x0000_0001
P46_PDIO	GP_BA+0x298	R/W	GPIO P4.6 Pin Data Input/Output	0x0000_0001
P47_PDIO	GP_BA+0x29C	R/W	GPIO P4.7 Pin Data Input/Output	0x0000_0001
P50_PDIO	GP_BA+0x2A0	R/W	GPIO P5.0 Pin Data Input/Output	0x0000_0001
P51_PDIO	GP_BA+0x2A4	R/W	GPIO P5.1 Pin Data Input/Output	0x0000_0001

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

Bits	Description		
[31:1]	Reserved	Reserved.	

[0]	Pxn_PDIO	<p><b>GPIO Px.N Pin Data Input/Output</b></p> <p>Writing this bit can control one GPIO pin output value.</p> <p>0 = Corresponding GPIO pin set to low.</p> <p>1 = Corresponding GPIO pin set to high.</p> <p>Read this register to get GPIO pin status.</p> <p>0 = Corresponding GPIO pin status is low.</p> <p>1 = Corresponding GPIO pin status is high.</p> <p>For example, writing P04_PDIO will reflect the written value to bit P0_DOUT[4], reading P04_PDIO will return the value of P0_PIN[4].</p> <p><b>Note1:</b> x = 0~5, n = 0~7.</p> <p><b>Note2:</b> The writing operation will not be affected by register Px_DMASK[n].</p>
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## 5.9 Timer Controller (TIMER)

### 5.9.1 Overview

The timer controller includes up to 4 sets 32-bit timers, TIMER0 ~ TIMER3, allowing user to easily implement a timer control for applications. The timer can perform functions, such as frequency measurement, delay timing, clock generation, and event counting by external input pins, and interval measurement by external capture pins.

### 5.9.2 Features

- Up to 4 sets of 32-bit timers with 24-bit up counter and one 8-bit prescale counter
- Independent clock source for each timer
- Provides four timer counting modes: one-shot, periodic, toggle and continuous counting
- Time-out period = (Period of timer clock input) \* (8-bit prescale counter + 1) \* (24-bit TCMP)
- Maximum counting cycle time =  $(1 / T \text{ MHz}) * (2^8) * (2^{24})$ , T is the period of timer clock
- 24-bit up counter value is readable through TDR (Timer Data Register)
- Supports event counting function to count the event from external counter pin (T0~T3)
- 24-bit capture value is readable through TCAP (Timer Capture Data Register)
- Supports external pin capture (T0EX~T3EX) for interval measurement
- Supports external pin capture (T0EX~T3EX) for reset 24-bit up counter
- Supports chip wake-up from Idle/Power-down mode if a timer interrupt signal is generated
- Supports internal capture triggered while internal ACMP output signal transition (NUC029xAN only)
- Supports Inter-Timer trigger mode (NUC029xAN only)
- Supports internal signal (CPO0, CPO1) for interval measurement (NUC029FAE only)

### 5.9.3 Block Diagram

The Timer Controller block diagram and clock control are shown as follows.

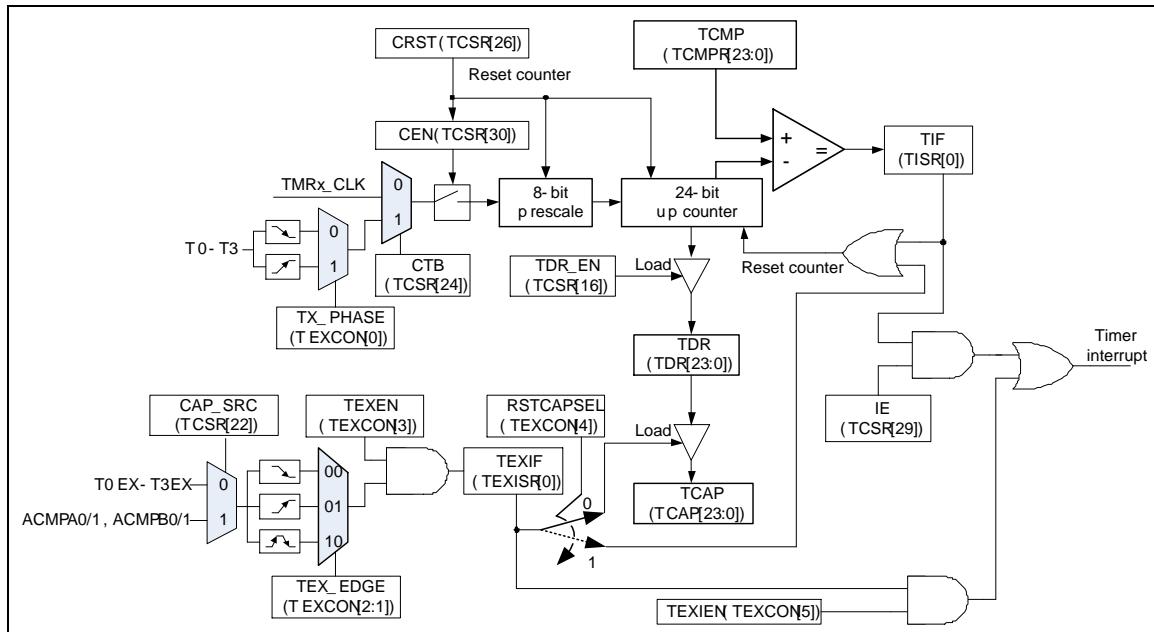


Figure 5-39 Timer Controller Block Diagram for NUC029xAN

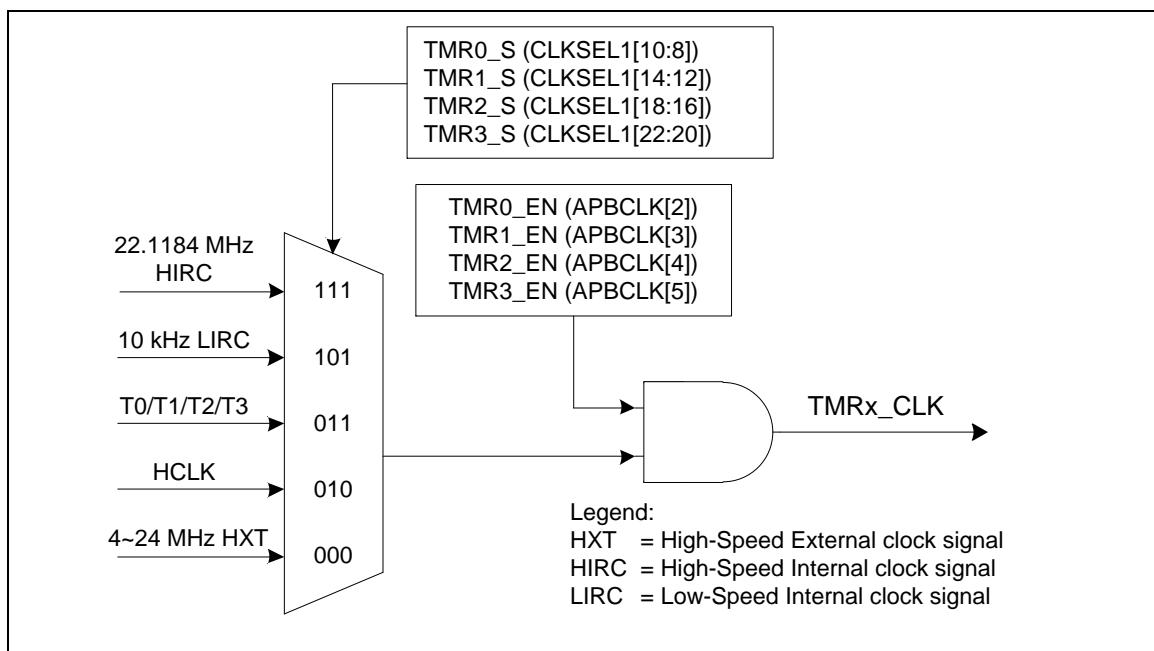


Figure 5-40 Clock Source of Timer Controller for NUC029xAN

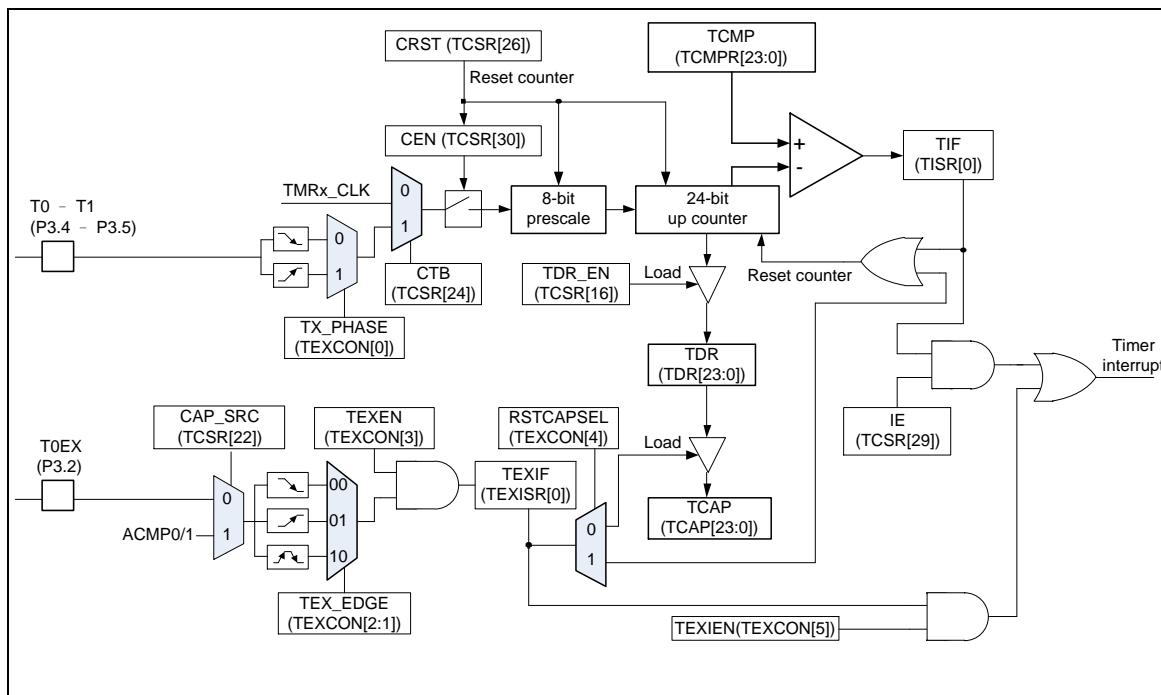


Figure 5-41 Timer Controller Block Diagram for NUC029FAE

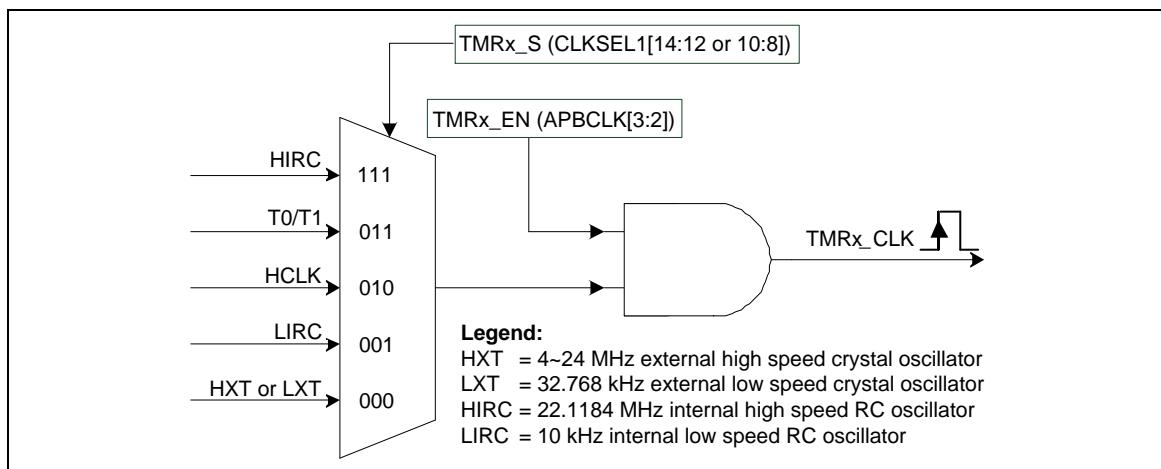


Figure 5-42 Clock Source of Timer Controller for NUC029FAE

### 5.9.4 Basic Configuration

#### NUC029xAN:

The peripheral clock source of Timer0 ~ Timer3 can be enabled in TMRx\_EN(APBCLK[5:2]) and selected as different frequency in TMR0\_S(CLKSEL1[10:8]) for Timer0, TMR1\_S(CLKSEL1[14:12]) for Timer1, TMR2\_S(CLKSEL1[18:16]) for Timer2 and TMR0\_S(CLKSEL1[22:20]) for Timer3.

#### NUC029FAE:

The peripheral clock source of Timer0 ~ Timer1 can be enabled in TMRx\_EN(APBCLK[3:2]) and selected as different frequency in TMR0\_S(CLKSEL1[10:8]) for Timer0, TMR1\_S(CLKSEL1[14:12]) for Timer1.

## 5.9.5 Functional Description

### 5.9.5.1 Timer Interrupt Flag

Timer controller supports two interrupt flags; one is TIF(I2CTOC[0]) flag and its set while timer counter value (TDR) matches the timer compared value (TCMP(TCMPR[23:0])), the other is TEXIF(TEXISR[0]) flag and its set when the transition on the TxEX pin associated TEX\_EDGE(TEXCONx[2:1]) setting.

### 5.9.5.2 Timer Counting Operation Mode

Timer controller provides four timer counting modes: one-shot, periodic, toggle-output and continuous counting operation modes:

#### 5.9.5.2.1 One-shot Mode

If timer controller is configured at one-shot mode (TCSR<sub>x</sub>[28:27] is 00'b) and CEN(TCSR[30]) bit is set, the timer counter starts up counting. Once the TDR value reaches TCMP value, the TIF flag will be set to 1, TDR value and CEN bit is cleared by timer controller then timer counting operation stops. In the meantime, if the IE(TCSR[29]) bit is enabled, the timer interrupt signal is generated and sent to NVIC to inform CPU also.

#### 5.9.5.2.2 Periodic Mode

If timer controller is configured at periodic mode (TCSR<sub>x</sub>[28:27] is 01'b) and CEN(TCSR[30]) bit is set, the timer counter starts up counting. Once the TDR value reaches TCMP value, the TIF flag will be set to 1, TDR value will be cleared by timer controller and timer counter operates counting again. In the meantime, if the IE bit is enabled, the timer interrupt signal is generated and sent to NVIC to inform CPU also. In this mode, timer controller operates counting and compares with TCMP value periodically until the CEN bit is cleared by software.

#### 5.9.5.2.3 Toggle-output Mode

If timer controller is configured at toggle-out mode (TCSR<sub>x</sub>[28:27] is 10'b) and CEN bit is set, the timer counter starts up counting. The counting operation of toggle-out mode is almost the same as periodic mode, except toggle-out mode has associated output pin to output signal while specify TIF bit is set. Thus, the toggle-output signal on T0~T3 pin is changing back and forth with 50% duty cycle.

For NUC029FAE, the output pin could be either Tx or TxEX depending on the TOUT\_PIN(TCSR[18]) bit of TCSR register.

#### 5.9.5.2.4 Continuous Counting Mode

If timer controller is configured at continuous counting mode (TCSR<sub>x</sub>[28:27] is 11'b) and CEN bit is set, the timer counter starts up counting. Once the TDR value reaches TCMP value, the TIF

flag will be set to 1 and TDR value keeps up counting. In the meantime, if the IE bit is enabled, the timer interrupt signal is generated and sent to NVIC to inform CPU also. User can change different TCMP value immediately without disabling timer counting and restarting timer counting in this mode.

For example, TCMP value is set as 80, first. The TIF flag will set to 1 when TDR value is equal to 80, timer counter is kept counting and TDR value will not goes back to 0, it continues to count 81, 82, 83, ... to  $2^{24}$  -1, 0, 1, 2, 3, ... to  $2^{24}$  -1 again and again. Next, if software programs TCMP value as 200 and clears TIF flag, the TIF flag will set to 1 again when TDR value reaches to 200. At last, software programs TCMP as 500 and clears TIF flag, the TIF flag will set to 1 again when TDR value reaches to 500.

In this mode, the timer counting is continuous. So, this operation mode is called as continuous counting mode.

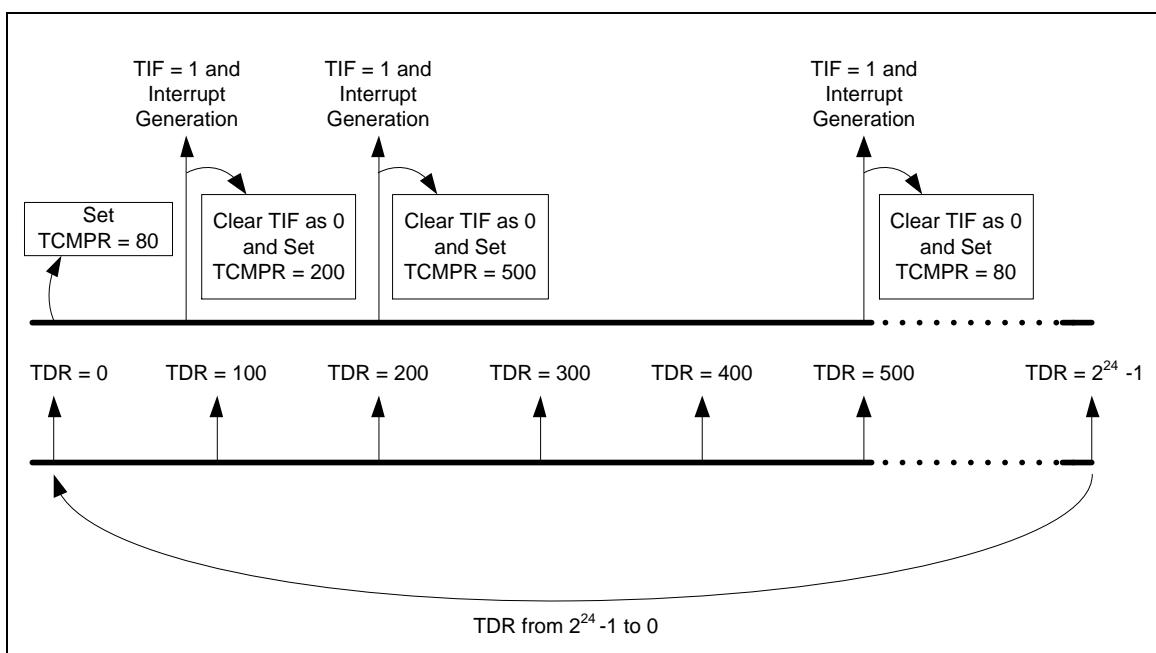


Figure 5-43 Continuous Counting Mode

#### 5.9.5.3 Event Counting Mode

Timer controller also provides an application which can count the input event from Tx pin ( $x=0\sim 3$ ) and the number of event will reflect to TDR value. It is also called as event counting function. In this function, CTB(TCSR[24]) bit should be set and the timer peripheral clock source should be set as HCLK.

Software can enable or disable Tx pin de-bounce circuit by TCDB(TEXCON[7]) bit. The input event frequency should be less than 1/3 HCLK if Tx pin de-bounce disabled or less than 1/8 HCLK if Tx pin de-bounce enabled to assure the returned TDR value is incorrect, and software can also select edge detection phase of Tx pin by TX\_PHASE(TEXCON[0]) bit.

In event counting mode, the timer counting operation mode can be selected as one-shot, periodic and continuous counting mode to counts the TDR value by input event from Tx pin.

#### 5.9.5.4 Event Function (NUC029xAN only)

### **Event Capture Mode**

The event capture function is used to capture TDR value to TCAP value while edge transition detected on TxEX pin ( $x= 0\sim 3$ ). In this mode, RSTCAPSEL(TEXCON[4]) bit should be as 0 for select TxEX transition is using as the event capture function and the timer peripheral clock source should be set as HCLK.

Software can enable or disable TxEX pin de-bounce circuit by TEXDB(TEXCON[6]) bit. The transition frequency of TxEX pin should be less than 1/3 HCLK if TxEX pin de-bounce disabled or less than 1/8 HCLK if TxEX pin de-bounce enabled to assure the capture function can be work normally, and software can also select edge transition detection of TxEX pin by TEX\_EDGE (TEXCON[2:1]) bits.

In event capture mode, software does not consider what timer counting operation mode is selected, the capture event occurred only if edge transition on TxEX pin is detected.

### **Event Reset Counter Mode**

It also provides reset counter function to reset TDR value while edge transition detected on TxEX pin ( $x= 0\sim 3$ ). In this mode, most the settings are the same as event capture function except RSTCAPSEL(TEXCON[4]) bit should be as 1 for select TxEX transition is using as the event reset counter.

#### **5.9.5.5 Input Capture Function (NUC029FAE only)**

The input capture or reset function is provided to capture or reset timer counter value. The capture function with free-counting capture mode and trigger-counting capture mode are configured by CAP\_MODE(TEXCON[8]). The free-counting capture mode, reset mode, trigger-counting capture mode are described as follows: The input source could be either TxEX or comparator output CPOx depending on CAP\_SRC(TCSR[19]) bit.

### **Free-Counting Capture Mode**

If CAP\_MODE is cleared to 0, TEXEN(TEXCON[3]) is set to 1 and RSTCAPSEL(TEXCON[4]) is set to 0, the TDR will be captured into TCAP register when TEX(Timer External Pin) pin trigger condition occurred. The TEX trigger edge can be chosen by TEX\_EDGE.

### **Reset Mode**

If CAP\_MODE is cleared to 0, TEXEN(TEXCON[3]) is set to 1 and RSTCAPSEL is set to 1, the TDR will be reset to 0 when TEX pin trigger condition happened. The TEX trigger edge can be chosen by TEX\_EDGE(TEXCON[2:1]). The detail operation method is described in Table 5-16.

### **Trigger-Counting Capture Mode**

If CAP\_MODE is set to 1, TEXEN(TEXCON[3]) is set to 1 and RSTCAPSEL is set to 0, the TDR will be reset to 0 then captured into TCAP register when TEX(Timer External Pin) pin trigger condition occurred. The TEX trigger edge can be chosen by TEX\_EDGE. The detailed operation method is described in Table 5-16.

When TEX trigger occurred, TEXIF(Timer External Interrupt Flag) is set to 1, and the interrupt signal is generated, then, sent to NVIC to inform CPU if TEXIEN(Timer External Interrupt Enable Bit) is 1. And, the TEX source operating frequency should be less than 1/3 HCLK frequency if disable TEX de-bounce or less than 1/8 HCLK frequency if enabling TEX de-bounce. It also provides T0EX enabled or disabled capture de-bounce function by TEXDB (TEXCON[6]).

Function	CAP_MODE (TEXCON[8])	RSTCAPN (TEXCON[4])	TEX_EDGE (TEXCON[2:1])	Operation Description
Free-counting Capture Mode	0	0	00	The high to zero transition on Timer External Input Pin is detected. TDR is captured to TCAP.
	0	0	01	The zero to high transition on Timer External Input Pin is detected. TDR is captured to TCAP.
	0	0	10	Either high to zero or zero to high transition on Timer External Input Pin is detected. TDR is captured to TCAP.
	0	0	11	Reserved
Reset Mode	0	1	00	The high to zero transition on Timer External Input Pin is detected. TDR is reset to 0.
	0	1	01	The zero to high transition on Timer External Input Pin is detected. TDR is reset to 0.
	0	1	10	Either high to zero or zero to high transition on Timer External Input Pin is detected. TDR is reset to 0.
	0	1	11	Reserved
Trigger-Counting Capture Mode	1	0	00	Falling Edge Trigger: The 1st high to zero transition on Timer External Input Pin is detected to reset TDR as 0 and then starts counting, while the 2nd high to zero transition stops counting.
	1	0	01	Rising Edge Trigger: The 1st zero to high transition to on Timer External Input Pin is detected to reset TDR as 0 and then starts counting, while the 2nd zero to high transition stops counting.
	1	0	10	Level Change Trigger: The high to zero transition on Timer External Input Pin is detected to reset TDR as 0 and then starts counting, while zero to high transition stops counting.
	1	0	11	Level Change Trigger: The zero to high transition on Timer External Input Pin is detected to reset TDR as 0 and then starts counting, while high to zero transition stops counting.

Table 5-16 Input Capture Mode Operation

#### 5.9.5.6 Inter-Timer Trigger Capture Mode (NUC029xAN only)

In this mode, the Timer0/2 will be forced in counter mode, counting with external event, and will generate an internal signal (INTR\_TMR\_TRG) to trigger Timer1/3 start or stop counting. Also, the Timer1/3 will be forced in capture mode and start/stop trigger-counting by Timer0/2 counter status.

Setting Timer0 Inter-timer Trigger Capture enabled, trigger-counting capture function is forced on Timer1. Setting Timer2 Inter-Timer Trigger enabled, trigger-counting capture function is forced on

Timer3.

### **Start Trigger**

While INTR\_TRG\_EN bit in Timer0/2 is set, the Timer0/2 will make a rising-edge transition of INTR\_TMR\_TRG while Timer0/2 24-bit counter value (TDR) is counting from 0x0 to 0x1 and Timer1/3 counter will start counting immediately and automatically.

### **Stop Trigger**

When Timer0/2 TDR reaches the Timer0/2 TCMPR value, the Timer0/2 will make a falling-edge transition of INTR\_TMR\_TRG. Then Timer0/2 counter mode function will be disabled and INTR\_TRG\_EN bit will be cleared by hardware then Timer1/3 will stop counting also. At the same time, the Timer1/3 TDR value will be saved into Timer1/3 TCAP register.

User can use inter-timer trigger mode to measure the period of external event (Tx) more precisely. Figure 5-45 shows the sample flow of Inter-Timer Trigger Capture Mode for Timer0 as event counter mode and Timer1 as trigger-counting capture mode.

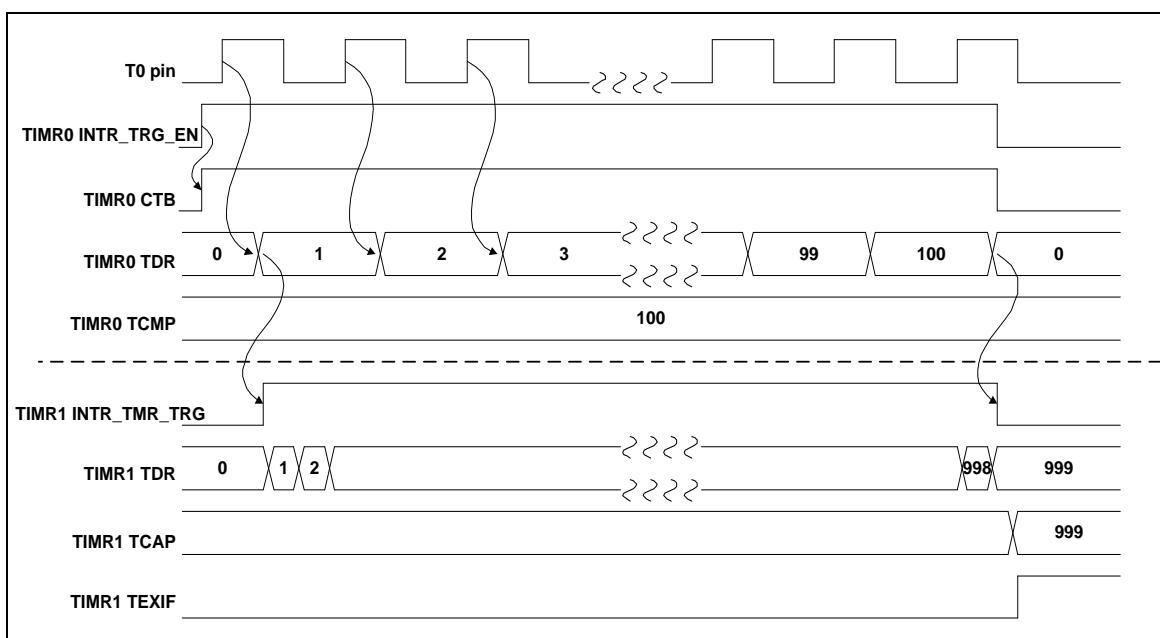


Figure 5-44 Inter-Timer Trigger Capture Timing

#### **5.9.5.7 Internal Capture Trigger from ACMP (NUC029xAN only)**

The event capture function also can be triggered by internal output signal transition on ACMPA0(Timer0), ACMPA1(Timer1), ACMPB0(Timer2) or ACMPB1(Timer3) output. The detail setting of capture function is the same as previous descriptions in Event Capture Mode.

### 5.9.6 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>TIMER Base Address:</b>				
<b>TMR01_BA = 0x4001_0000</b>				
<b>TMR23_BA = 0x4011_0000</b>				
<b>TCSR0</b>	TMR01_BA+0x00	R/W	Timer0 Control and Status Register	0x0000_0005
<b>TCMPR0</b>	TMR01_BA+0x04	R/W	Timer0 Compare Register	0x0000_0000
<b>TISR0</b>	TMR01_BA+0x08	R/W	Timer0 Interrupt Status Register	0x0000_0000
<b>TDR0</b>	TMR01_BA+0x0C	R	Timer0 Data Register	0x0000_0000
<b>TCAP0</b>	TMR01_BA+0x10	R	Timer0 Capture Data Register	0x0000_0000
<b>TEXCON0</b>	TMR01_BA+0x14	R/W	Timer0 External Control Register	0x0000_0000
<b>TEXISR0</b>	TMR01_BA+0x18	R/W	Timer0 External Interrupt Status Register	0x0000_0000
<b>TCSR1</b>	TMR01_BA+0x20	R/W	Timer1 Control and Status Register	0x0000_0005
<b>TCMPR1</b>	TMR01_BA+0x24	R/W	Timer1 Compare Register	0x0000_0000
<b>TISR1</b>	TMR01_BA+0x28	R/W	Timer1 Interrupt Status Register	0x0000_0000
<b>TDR1</b>	TMR01_BA+0x2C	R	Timer1 Data Register	0x0000_0000
<b>TCAP1</b>	TMR01_BA+0x30	R	Timer1 Capture Data Register	0x0000_0000
<b>TEXCON1</b>	TMR01_BA+0x34	R/W	Timer1 External Control Register	0x0000_0000
<b>TEXISR1</b>	TMR01_BA+0x38	R/W	Timer1 External Interrupt Status Register	0x0000_0000
<b>TCSR2</b>	TMR23_BA+0x00	R/W	Timer2 Control and Status Register	0x0000_0005
<b>TCMPR2</b>	TMR23_BA+0x04	R/W	Timer2 Compare Register	0x0000_0000
<b>TISR2</b>	TMR23_BA+0x08	R/W	Timer2 Interrupt Status Register	0x0000_0000
<b>TDR2</b>	TMR23_BA+0x0C	R	Timer2 Data Register	0x0000_0000
<b>TCAP2</b>	TMR23_BA+0x10	R	Timer2 Capture Data Register	0x0000_0000
<b>TEXCON2</b>	TMR23_BA+0x14	R/W	Timer2 External Control Register	0x0000_0000
<b>TEXISR2</b>	TMR23_BA+0x18	R/W	Timer2 External Interrupt Status Register	0x0000_0000
<b>TCSR3</b>	TMR23_BA+0x20	R/W	Timer3 Control and Status Register	0x0000_0005
<b>TCMPR3</b>	TMR23_BA+0x24	R/W	Timer3 Compare Register	0x0000_0000
<b>TISR3</b>	TMR23_BA+0x28	R/W	Timer3 Interrupt Status Register	0x0000_0000
<b>TDR3</b>	TMR23_BA+0x2C	R	Timer3 Data Register	0x0000_0000
<b>TCAP3</b>	TMR23_BA+0x30	R	Timer3 Capture Data Register	0x0000_0000

TEXCON3	TMR23_BA+0x34	R/W	Timer3 External Control Register	0x0000_0000
TEXISR3	TMR23_BA+0x38	R/W	Timer3 External Interrupt Status Register	0x0000_0000

### 5.9.7 Register Description for NUC029xAN

#### Timer Control and Status Register (TCSR)

Register	Offset	R/W	Description				Reset Value
TCSR0	TMR01_BA+0x00	R/W	Timer0 Control and Status Register				0x0000_0005
TCSR1	TMR01_BA+0x20	R/W	Timer1 Control and Status Register				0x0000_0005
TCSR2	TMR23_BA+0x00	R/W	Timer2 Control and Status Register				0x0000_0005
TCSR3	TMR23_BA+0x20	R/W	Timer3 Control and Status Register				0x0000_0005

31	30	29	28	27	26	25	24
DBGACK_TMR	CEN	IE	MODE		CRST	CACT	CTB
23	22	21	20	19	18	17	16
WAKE_EN	CAP_SRC	TOUT_SEL	PERIODIC_SEL	INTR_TRG_EN	Reserved		TDR_EN
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
PRESCALE							

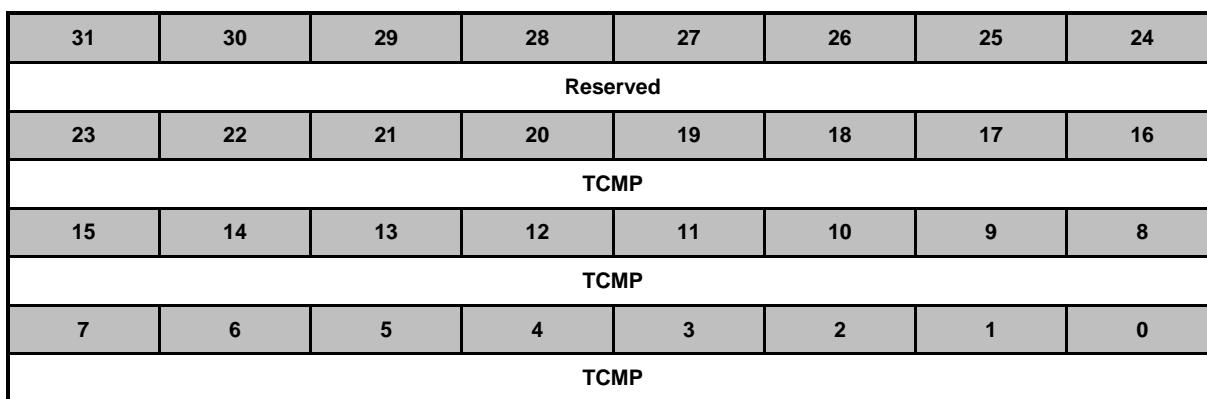
Bits	Description	
[31]	DBGACK_TMR	<b>ICE Debug Mode Acknowledge Disable (Write Protect)</b> 0 = ICE debug mode acknowledgement effects TIMER counting. Timer counter will be held while CPU is held by ICE. 1 = ICE debug mode acknowledgement Disabled. Timer counter will keep going no matter CPU is held by ICE or not.
[30]	CEN	<b>Timer Enable Control</b> 0 = Stops/Suspends counting. 1 = Starts counting. <b>Note1:</b> In stop status, and then set CEN to 1 will enable the 24-bit up counter to keep counting from the last stop counting value. <b>Note2:</b> This bit is auto-cleared by hardware in one-shot mode (TCSR[28:27] = 00) when the timer interrupt flag (TIF) is generated.
[29]	IE	<b>Interrupt Enable Control</b> 0 = Timer Interrupt function Disabled. 1 = Timer Interrupt function Enabled. If this bit is enabled, when the timer interrupt flag (TIF) is set to 1, the timer interrupt signal is generated and inform to CPU.
[28:27]	MODE	<b>Timer Operating Mode</b> 00 = The Timer controller is operated in One-shot mode. 01 = The Timer controller is operated in Periodic mode.

		10 = The Timer controller is operated in Toggle-output mode. 11 = The Timer controller is operated in Continuous Counting mode.
[26]	<b>CRST</b>	<b>Timer Reset</b> 0 = No effect. 1 = Reset 8-bit prescale counter, 24-bit up counter value and CEN bit if CACT is 1.
[25]	<b>CACT</b>	<b>Timer Active Status (Read Only)</b> This bit indicates the 24-bit up counter status. 0 = 24-bit up counter is not active. 1 = 24-bit up counter is active.
[24]	<b>CTB</b>	<b>Counter Mode Enable Control</b> This bit is for external counting pin function enabled. When timer is used as an event counter, this bit should be set to 1 and select HCLK as timer clock source. Please refer to section 5.9.5.3 for detail description. 0 = External event counter mode Disabled. 1 = External event counter mode Enabled.
[23]	<b>WAKE_EN</b>	<b>Wake-up Function Enable Control</b> 0 = Wake-up trigger event Disabled. 1 = Wake-up trigger event Enabled.
[22]	<b>CAP_SRC</b>	<b>Capture Pin Source Selection</b> 0 = Capture Function source is from TxEx pin. 1 = Capture Function source is from internal ACMPx output signal.
[21]	<b>TOUT_SEL</b>	<b>Toggle-output Pin Selection</b> 0 = Toggle-output pin is from Tx pin. 1 = Toggle-output pin is from TxEx pin.
[20]	<b>PERIODIC_SEL</b>	<b>Periodic Mode Behavior Selection Enable</b> 0 = The behavior selection in periodic mode is Disabled. When user updates TCMP while timer is running in periodic mode, TDR will be reset to default value. 1 = The behavior selection in periodic mode is Enabled. When user update TCMP while timer is running in periodic mode, the limitations as bellows list, If updated TCMP value > TDR, TCMP will be updated and TDR keep running continually. If updated TCMP value = TDR, timer time-out interrupt will be asserted immediately. If updated TCMP value < TDR, TDR will be reset to default value.
[19]	<b>INTR_TRG_EN</b>	<b>Inter-timer Trigger Mode Enable Control</b> Setting this bit will enable the inter-timer trigger capture function. The Timer0/2 will be in counter mode and counting with external clock source or event. Also, Timer1/3 will be in trigger-counting mode of capture function. 0 = Inter-Timer Trigger Capture mode Disabled. 1 = Inter-Timer Trigger Capture mode Enabled. <b>Note:</b> For Timer1/3, this bit is ignored and the read back value is always 0.
[18:17]	<b>Reserved</b>	Reserved.
[16]	<b>TDR_EN</b>	<b>Data Load Enable Control</b> When TDR_EN is set, TDR (Timer Data Register) will be updated continuously with the 24-bit up-timer value as the timer is counting. 0 = Timer Data Register update Disabled. 1 = Timer Data Register update Enabled while Timer counter is active.

[15:8]	Reserved	Reserved.
[7:0]	<b>PRESCALE</b>	<b>Prescale Counter</b> Timer input clock source is divided by (PRESCALE+1) before it is fed to the Timer up counter. If this field is 0 (PRESCALE = 0), then there is no scaling.

**Timer Compare Register (TCMPR)**

Register	Offset	R/W	Description	Reset Value
TCMPR0	TMR01_BA+0x04	R/W	Timer0 Compare Register	0x0000_0000
TCMPR1	TMR01_BA+0x24	R/W	Timer1 Compare Register	0x0000_0000
TCMPR2	TMR23_BA+0x04	R/W	Timer2 Compare Register	0x0000_0000
TCMPR3	TMR23_BA+0x24	R/W	Timer3 Compare Register	0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	TCMP	<p><b>Timer Compared Value</b></p> <p>TCMP is a 24-bit compared value register. When the internal 24-bit up counter value is equal to TCMP value, the TIF flag will set to 1.</p> <p>Time-out period = (Period of Timer clock source) * (8-bit PRESCALE + 1) * (24-bit TCMP).</p> <p><b>Note1:</b> Never write 0x0 or 0x1 in TCMP field, or the core will run into unknown state.</p> <p><b>Note2:</b> When Timer is operating at Continuous Counting mode, the 24-bit up counter will keep counting continuously even if software writes a new value into TCMP field. But if Timer is operating at other modes except Periodic mode, the 24-bit up counter will restart counting and using newest TCMP value to be the timer compared value if software writes a new value into TCMP field.</p>

**Timer Interrupt Status Register (TISR)**

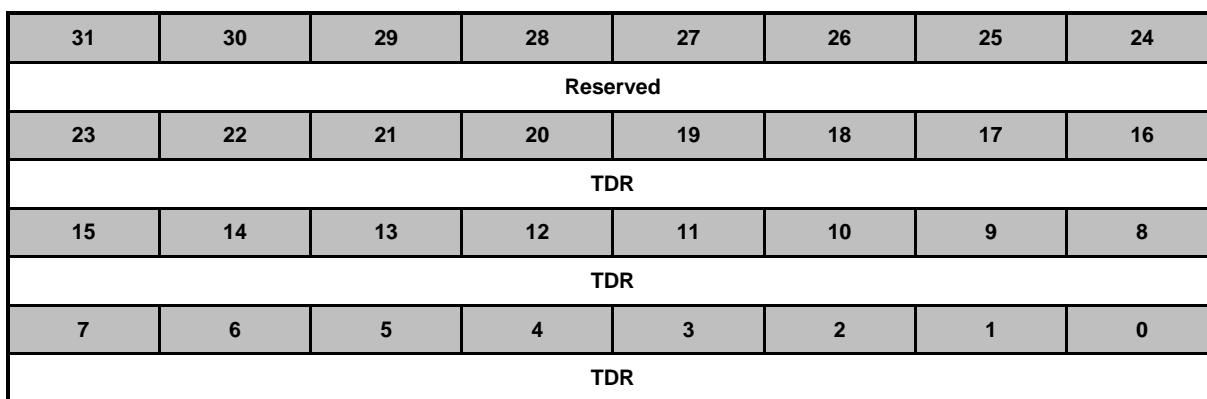
Register	Offset	R/W	Description					Reset Value
TISR0	TMR01_BA+0x08	R/W	Timer0 Interrupt Status Register					0x0000_0000
TISR1	TMR01_BA+0x28	R/W	Timer1 Interrupt Status Register					0x0000_0000
TISR2	TMR23_BA+0x08	R/W	Timer2 Interrupt Status Register					0x0000_0000
TISR3	TMR23_BA+0x28	R/W	Timer3 Interrupt Status Register					0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1]	TWF	<p><b>Timer Wake-up Flag</b>            This bit indicates the interrupt wake-up flag status of Timer.            0 = Timer does not cause chip wake-up.            1 = Chip wake-up from Idle or Power-down mode if Timer time-out interrupt signal generated.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>
[0]	TIF	<p><b>Timer Interrupt Flag</b>            This bit indicates the interrupt flag status of Timer while TDR value reaches to TCMP value.            0 = No effect.            1 = TDR value matches the TCMP value.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>

**Timer Data Register (TDR)**

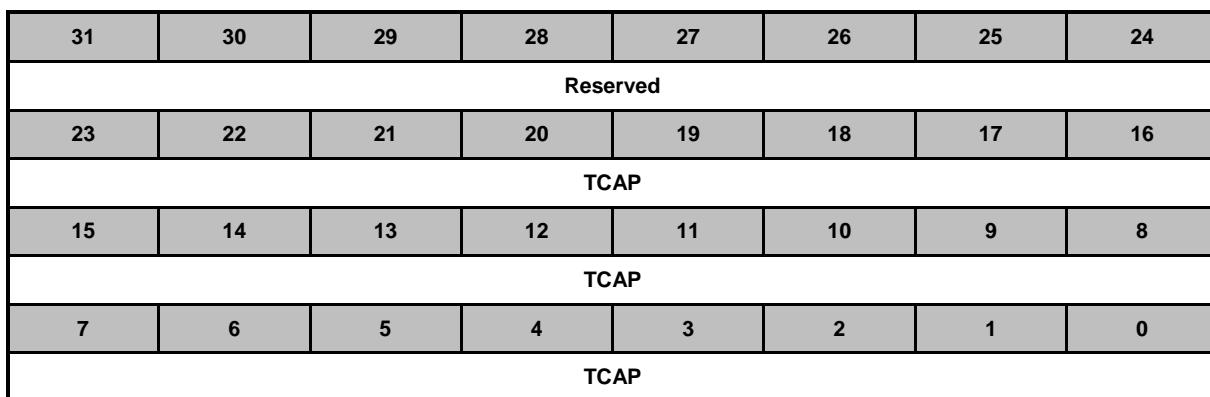
Register	Offset	R/W	Description	Reset Value
TDR0	TMR01_BA+0x0C	R	Timer0 Data Register	0x0000_0000
TDR1	TMR01_BA+0x2C	R	Timer1 Data Register	0x0000_0000
TDR2	TMR23_BA+0x0C	R	Timer2 Data Register	0x0000_0000
TDR3	TMR23_BA+0x2C	R	Timer3 Data Register	0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	TDR	Timer Data Register If TDR_EN is set to 1, TDR register value will be updated continuously to monitor 24-bit up counter value.

**Timer Capture Data Register (TCAP)**

Register	Offset	R/W	Description	Reset Value
TCAP0	TMR01_BA+0x10	R	Timer0 Capture Data Register	0x0000_0000
TCAP1	TMR01_BA+0x30	R	Timer1 Capture Data Register	0x0000_0000
TCAP2	TMR23_BA+0x10	R	Timer2 Capture Data Register	0x0000_0000
TCAP3	TMR23_BA+0x30	R	Timer3 Capture Data Register	0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	TCAP	<b>Timer Capture Data Register</b> When TEXIF flag is set to 1, the current TDR value will be auto-loaded into this TCAP filed immediately.

**Timer External Control Register (TEXCON)**

Register	Offset	R/W	Description				Reset Value
TEXCON0	TMR01_BA+0x14	R/W	Timer0 External Control Register				0x0000_0000
TEXCON1	TMR01_BA+0x34	R/W	Timer1 External Control Register				0x0000_0000
TEXCON2	TMR23_BA+0x14	R/W	Timer2 External Control Register				0x0000_0000
TEXCON3	TMR23_BA+0x34	R/W	Timer3 External Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
TCDB	TEXDB	TEXIEN	RSTCAPSEL	TEXEN	TEX_EDGE		TX_PHASE

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	TCDB	<b>Timer External Counter Input Pin De-bounce Enable Control</b> 0 = Tx pin de-bounce Disabled. 1 = Tx pin de-bounce Enabled. If this bit is enabled, the edge detection of Tx pin is detected with de-bounce circuit.
[6]	TEXDB	<b>Timer External Capture Input Pin De-bounce Enable Control</b> 0 = TxEX pin de-bounce Disabled. 1 = TxEX pin de-bounce Enabled. If this bit is enabled, the edge detection of TxEX pin is detected with de-bounce circuit.
[5]	TEXIEN	<b>Timer External Capture Interrupt Enable Control</b> 0 = TxEX pin detection Interrupt Disabled. 1 = TxEX pin detection Interrupt Enabled. If TEXIEN enabled, Timer will raise an external capture interrupt signal and inform to CPU while TEXIF flag is set to 1.
[4]	RSTCAPSEL	<b>Timer External Reset Counter / Timer External Capture Mode Selection</b> 0 = Transition on TxEX pin is using to save the TDR value into TCAP value if TEXIF flag is set to 1. 1 = Transition on TxEX pin is using to reset the 24-bit up counter.
[3]	TEXEN	<b>Timer External Pin Function Enable</b> This bit enables the RSTCAPSEL function on the TxEX pin. 0 = RSTCAPSEL function of TxEX pin will be ignored. 1 = RSTCAPSEL function of TxEX pin is active.

[2:1]	<b>TEX_EDGE</b>	<b>Timer External Capture Pin Edge Detect Selection</b> 00 = A 1 to 0 transition on TxEX pin will be detected. 01 = A 0 to 1 transition on TxEX pin will be detected. 10 = Either 1 to 0 or 0 to 1 transition on TxEX pin will be detected. 11 = Reserved.
[0]	<b>TX_PHASE</b>	<b>Timer External Count Pin Phase Detect Selection</b> This bit indicates the detection phase of Tx pin. 0 = A falling edge of Tx pin will be counted. 1 = A rising edge of Tx pin will be counted.

**Timer External Interrupt Status Register (TEXISR)**

Register	Offset	R/W	Description				Reset Value
<b>TEXISR0</b>	TMR01_BA+0x18	R/W	Timer0 External Interrupt Status Register				0x0000_0000
<b>TEXISR1</b>	TMR01_BA+0x38	R/W	Timer1 External Interrupt Status Register				0x0000_0000
<b>TEXISR2</b>	TMR23_BA+0x18	R/W	Timer2 External Interrupt Status Register				0x0000_0000
<b>TEXISR3</b>	TMR23_BA+0x38	R/W	Timer3 External Interrupt Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved							<b>TEXIF</b>

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	<b>TEXIF</b>	<p><b>Timer External Capture Interrupt Flag</b></p> <p>This bit indicates the external capture interrupt flag status.</p> <p>When TEXEN enabled, TxEX pin selected as external capture function, and a transition on TxEX pin matched the TEX_EDGE setting, this flag will set to 1 by hardware.</p> <p>1 = TxEX pin interrupt occurred. 0 = TxEX pin interrupt did not occur.</p> <p><b>Note:</b> This bit is cleared by writing 1 to it.</p>

### 5.9.8 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>TMR Base Address</b>				
<b>TMR_BA = 0x4001_0000</b>				
<b>TCSR0</b>	TMR_BA+0x00	R/W	Timer0 Control and Status Register	0x0000_0005
<b>TCMPR0</b>	TMR_BA+0x04	R/W	Timer0 Compare Register	0x0000_0000
<b>TISR0</b>	TMR_BA+0x08	R/W	Timer0 Interrupt Status Register	0x0000_0000
<b>TDR0</b>	TMR_BA+0x0C	R	Timer0 Data Register	0x0000_0000
<b>TCAP0</b>	TMR_BA+0x10	R	Timer0 Capture Data Register	0x0000_0000
<b>TEXCON0</b>	TMR_BA+0x14	R/W	Timer0 External Control Register	0x0000_0000
<b>TEXISR0</b>	TMR_BA+0x18	R/W	Timer0 External Interrupt Status Register	0x0000_0000
<b>TCSR1</b>	TMR_BA+0x20	R/W	Timer1 Control and Status Register	0x0000_0005
<b>TCMPR1</b>	TMR_BA+0x24	R/W	Timer1 Compare Register	0x0000_0000
<b>TISR1</b>	TMR_BA+0x28	R/W	Timer1 Interrupt Status Register	0x0000_0000
<b>TDR1</b>	TMR_BA+0x2C	R	Timer1 Data Register	0x0000_0000
<b>TCAP1</b>	TMR_BA+0x30	R	Timer1 Capture Data Register	0x0000_0000
<b>TEXCON1</b>	TMR_BA+0x34	R/W	Timer1 External Control Register	0x0000_0000
<b>TEXISR1</b>	TMR_BA+0x38	R/W	Timer1 External Interrupt Status Register	0x0000_0000

### 5.9.9 Register Description for NUC029FAE

#### Timer Control Register (TCSR)

Register	Offset	R/W	Description			Reset Value
TCSR0	TMR_BA+0x00	R/W	Timer0 Control and Status Register			0x0000_0005
TCSR1	TMR_BA+0x20	R/W	Timer1 Control and Status Register			0x0000_0005

31	30	29	28	27	26	25	24
DBGACK_TMR	CEN	IE	MODE		CRST	CACT	CTB
23	22	21	20	19	18	17	16
WAKE_EN	Reserved			CAP_SRC	TOUT_PIN	PERIODIC_SEL	TDR_EN
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
PRESCALE							

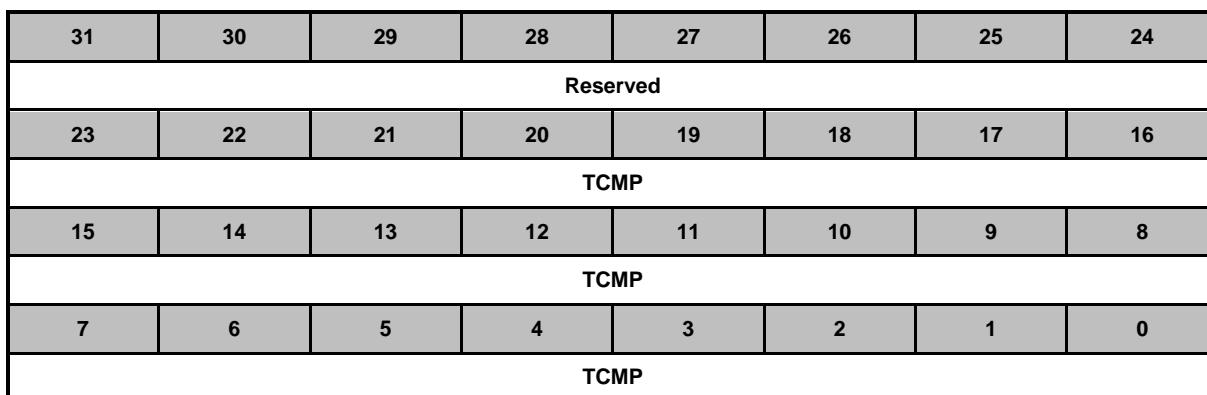
Bits	Description							
[31]	DBGACK_TMR	<b>ICE Debug Mode Acknowledge Disable Control (Write Protect)</b> 0 = ICE debug mode acknowledgement effects TIMER counting. Timer counter will be held while CPU is held by ICE. 1 = ICE debug mode acknowledgement Disabled. Timer counter will keep going no matter CPU is held by ICE or not.						
[30]	CEN	<b>Timer Enable Control</b> 0 = Stops/Suspends counting. 1 = Starts counting. <b>Note1:</b> In stop status, and then set CEN to 1 will enable the 24-bit up counter to keep counting from the last stop counting value. <b>Note2:</b> This bit is auto-cleared by hardware in one-shot mode (MODE (TCSR <sub>x</sub> [28:27]) = 00) when the timer interrupt flag (TIF) is generated.						
[29]	IE	<b>Interrupt Enable Control</b> 0 = Timer Interrupt function Disabled. 1 = Timer Interrupt function Enabled. If this bit is enabled, when the timer interrupt flag (TIF) is set to 1, the timer interrupt signal is generated and inform to CPU.						
[28:27]	MODE[1:0]	<b>Timer Operating Mode</b> <table border="1" style="width: 100%;"> <tr> <th>MODE</th> <th>Timer Operating Mode</th> </tr> <tr> <td>00</td> <td>The timer is operating in the One-shot mode. The associated interrupt signal is generated once (if IE is enabled) and CEN is automatically cleared by hardware.</td> </tr> <tr> <td>01</td> <td>The timer is operating in Periodic mode. The associated interrupt signal is generated periodically (if IE is enabled).</td> </tr> </table>	MODE	Timer Operating Mode	00	The timer is operating in the One-shot mode. The associated interrupt signal is generated once (if IE is enabled) and CEN is automatically cleared by hardware.	01	The timer is operating in Periodic mode. The associated interrupt signal is generated periodically (if IE is enabled).
MODE	Timer Operating Mode							
00	The timer is operating in the One-shot mode. The associated interrupt signal is generated once (if IE is enabled) and CEN is automatically cleared by hardware.							
01	The timer is operating in Periodic mode. The associated interrupt signal is generated periodically (if IE is enabled).							

Bits	Description
	<p>10      The timer is operating in Toggle mode. The interrupt signal is generated periodically (if IE is enabled). The associated signal (tout) is changing back and forth with 50% duty cycle.</p>
	<p>11      The timer is operating in Continuous Counting mode. The associated interrupt signal is generated when TDR = TCMPR (if IE is enabled). However, the 24-bit up-timer counts continuously. Please refer to 5.9.5.2.4 for detailed description about Continuous Counting mode operation.</p>
[26]	<p><b>CRST</b>  <b>Timer Reset</b>            0 = No effect.            1 = Reset 8-bit prescale counter, 24-bit up counter value and CEN bit if CACT is 1.</p>
[25]	<p><b>CACT</b>  <b>Timer Active Status (Read Only)</b>            This bit indicates the 24-bit up counter status.            0 = 24-bit up counter is not active.            1 = 24-bit up counter is active.</p>
[24]	<p><b>CTB</b>  <b>Counter Mode Enable Control</b>            This bit is for external counting pin function enabled. When timer is used as an event counter, this bit should be set to 1 and select HCLK as timer clock source. Please refer to section 5.9.5.3 for detail description.            0 = External event counter mode Disabled.            1 = External event counter mode Enabled.</p>
[23]	<p><b>WAKE_EN</b>  <b>Wake-up Enable Control</b>            When WAKE_EN (UA_IER[6]) is set and the TIF or TEXIF (TEXISR[0]) is set, the timer controller will generator a wake-up trigger event to CPU.            0 = Wake-up trigger event Disabled.            1 = Wake-up trigger event Enabled.</p>
[22:20]	Reserved
[19]	<p><b>CAP_SRC</b>  <b>Capture Pin Source Selection</b>  <b>For TCSR0:</b>            0 = Capture Function source is from T0EX pin.            1 = Capture Function source is from ACMP0 output signal.  <b>For TCSR1:</b>            0 = Reserved.            1 = Capture Function source is from ACMP1 output signal.</p>
[18]	<p><b>TOUT_PIN</b>  <b>Toggle Out Pin Selection</b>  <b>For TCSR0:</b>            When Timer is set to toggle mode,            0 = Time0 toggle output pin is T0 pin.            1 = Time0 toggle output pin is T0EX pin.  <b>For TCSR1:</b>            When Timer is set to toggle mode,            0 = Time1 toggle output pin is T1 pin.            1 = Reserved.</p>
[17]	<p><b>PERIODIC_SEL</b>  <b>Periodic Mode Behavior Selection</b>            0 = In One-shot or Periodic mode, when write new TCMP, timer counter will reset.            1 = In One-shot or Periodic mode, when write new TCMP if new TCMP &gt; TDR(current counter), timer counter keep counting and will not reset. If new TCMP &lt;= TDR(current</p>

Bits	Description	
	counter) , timer counter will reset.	
[16]	<b>TDR_EN</b>	<b>Data Load Enable Control</b> When TDR_EN is set, TDR (Timer Data Register) will be updated continuously with the 24-bit up-timer value as the timer is counting. 0 = Timer Data Register update Disabled. 1 = Timer Data Register update Enabled while Timer counter is active.
[15:8]	<b>Reserved</b>	Reserved.
[7:0]	<b>PRESCALE [7:0]</b>	<b>Prescale Counter</b> Timer input clock source is divided by (PRESCALE+1) before it is fed to the Timer up counter. If this field is 0 (PRESCALE = 0), then there is no scaling.

**Timer Compare Register (TCMPR)**

Register	Offset	R/W	Description			Reset Value
TCMPR0	TMR_BA+0x04	R/W	Timer0 Compare Register			0x0000_0000
TCMPR1	TMR_BA+0x24	R/W	Timer1 Compare Register			0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	TCMP[23:0]	<p><b>Timer Compared Value</b>            TCMP is a 24-bit compared value register. When the internal 24-bit up counter value is equal to TCMP value, the TIF flag will set to 1.</p> <p>Time-out period = (Period of Timer clock source) * (8-bit PRESCALE + 1) * (24-bit TCMP).</p> <p><b>Note1:</b> Never write 0x0 or 0x1 in TCMP field, or the core will run into unknown state.</p>

**Timer Interrupt Status Register (TISR)**

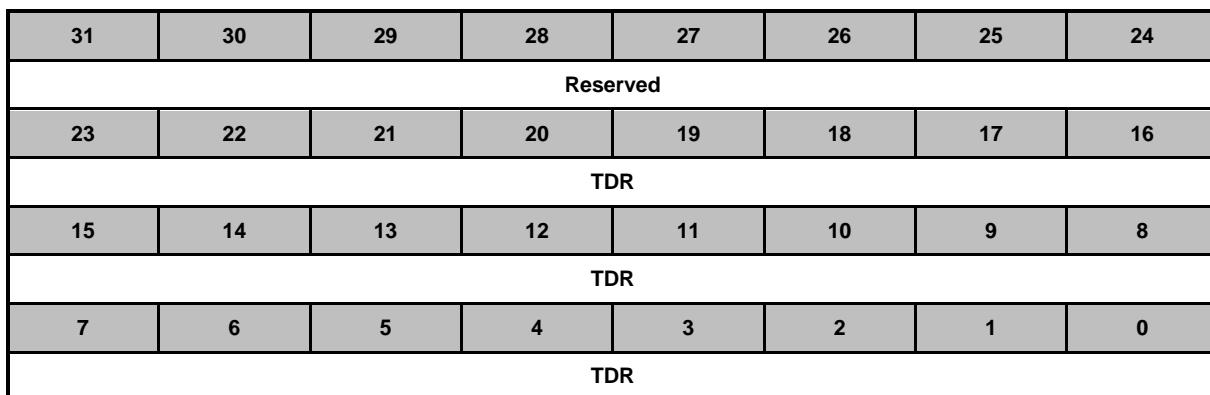
Register	Offset	R/W	Description				Reset Value
TISR0	TMR_BA+0x08	R/W	Timer0 Interrupt Status Register				0x0000_0000
TISR1	TMR_BA+0x28	R/W	Timer1 Interrupt Status Register				0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1]	TWF	<p><b>Timer Wake-up Flag</b>  This bit indicates the interrupt wake-up flag status of Timer.  0 = Timer does not cause chip wake-up.  1 = Chip wake-up from Idle or Power-down mode if Timer time-out interrupt signal generated.</p> <p><b>Note:</b> This bit is cleared by writing 1 to it.</p>
[0]	TIF	<p><b>Timer Interrupt Flag</b>  This bit indicates the interrupt flag status of Timer while TDR value reaches to TCMP value.  0 = No effect.  1 = TDR value matches the TCMP value.</p> <p><b>Note:</b> This bit is cleared by writing 1 to it.</p>

Timer Data Register (TDR)

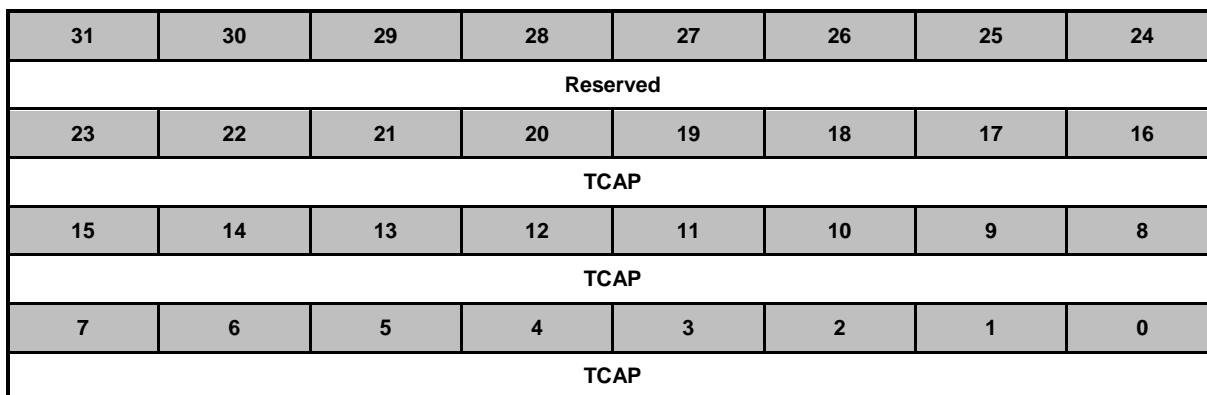
Register	Offset	R/W	Description			Reset Value
TDR0	TMR_BA+0x0C	R	Timer0 Data Register			0x0000_0000
TDR1	TMR_BA+0x2C	R	Timer1 Data Register			0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	TDR[23:0]	Timer Data Register If TDR_EN (TCSRx[16]) is set to 1, TDR register value will be updated continuously to monitor 24-bit up counter value.

**Timer Capture Data Register (TCAP)**

Register	Offset	R/W	Description			Reset Value
TCAP0	TMR_BA+0x10	R	Timer0 Capture Data Register			0x0000_0000
TCAP1	TMR_BA+0x30	R	Timer1 Capture Data Register			0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:0]	TCAP[23:0]	<b>Timer Capture Data Register</b> When TEXIF flag is set to 1, the current TDR value will be auto-loaded into this TCAP filed immediately.

**Timer External Control Register (TEXCON)**

Register	Offset	R/W	Description			Reset Value
TEXCON0	TMR_BA+0x14	R/W	Timer0 External Control Register			0x0000_0000
TEXCON1	TMR_BA+0x34	R/W	Timer1 External Control Register			0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
TCDB	TEXDB	TEXIEN	RSTCAPSEL	TEXEN	TEX_EDGE		TX_PHASE

Bits	Description	
[31:9]	Reserved	Reserved.
[8]	CAP_MODE	<b>Capture Mode Selection</b> 0 = Timer counter reset function or free-counting mode of timer capture function. 1 = Trigger-counting mode of timer capture function.
[7]	TCDB	<b>Timer External Counter Input Pin De-bounce Enable Control</b> 0 = Tx (x = 0~1) pin de-bounce Disabled. 1 = Tx (x = 0~1) pin de-bounce Enabled. If this bit is enabled, the edge detection of Tx (x = 0~1) pin is detected with de-bounce circuit.
[6]	TEXDB	<b>Timer External Capture Input Pin De-bounce Enable Control</b> <b>For TEXCON0:</b> 0 = T0EX pin de-bounce Disabled. 1 = T0EX pin de-bounce Enabled. If this bit is enabled, the edge detection of T0EX pin is detected with de-bounce circuit. <b>For TEXCON1:</b> Reserved.
[5]	TEXIEN	<b>Timer External Capture Interrupt Enable Control</b> <b>For TEXCON0:</b> 0 = T0EX pin detection Interrupt Disabled. 1 = T0EX pin detection Interrupt Enabled. If TEXIEN enabled, Timer will raise an external capture interrupt signal and inform to CPU while TEXIF flag is set to 1. <b>For TEXCON1:</b> Reserved.
[4]	RSTCAPSEL	Timer External Reset Counter / Timer External Capture Mode Selection

Bits	Description
	<p><b>For TEXCON0:</b> 0 = Transition on T0EX pin is using to save the TDR value into TCAP value if TEXIF flag is set to 1. 1 = Transition on T0EX pin is using to reset the 24-bit up counter.</p> <p><b>For TEXCON1:</b> Reserved.</p>
[3]	<p><b>Timer External Pin Function Enable Control</b></p> <p><b>For TEXCON0:</b> This bit enables the RSTCAPSEL function on the T0EX pin. 0 = RSTCAPSEL function of T0EX pin will be ignored. 1 = RSTCAPSEL function of T0EX pin is active.</p> <p><b>For TEXCON1:</b> Reserved.</p>
[2:1]	<p><b>Timer External Pin Edge Detection</b></p> <p><b>For TEXCON0:</b> 00 = A 1 to 0 transition on T0EX will be detected. 01 = A 0 to 1 transition on T0EX will be detected. 10 = Either 1 to 0 or 0 to 1 transition on T0EX will be detected. 11 = Reserved.</p> <p><b>For TEXCON1:</b> Reserved.</p>
[0]	<p><b>Timer External Count Pin Phase Detect Selection</b></p> <p>This bit indicates the detection phase of Tx (x = 0~1) pin. 0 = A falling edge of Tx (x = 0~1) pin will be counted. 1 = A rising edge of Tx (x = 0~1) pin will be counted.</p>

Timer External Interrupt Status Register (TEXISR)

Register	Offset	R/W	Description			Reset Value
TEXISR0	TMR_BA+0x18	R/W	Timer0 External Interrupt Status Register			0x0000_0000
TEXISR1	TMR_BA+0x38	R/W	Timer1 External Interrupt Status Register			0x0000_0000

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

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	TEXIF	<p><b>Timer External Interrupt Flag</b></p> <p><b>For TEXISR0:</b></p> <p>This bit indicates the external capture interrupt flag status</p> <p>When TEXEN enabled, T0EX pin selected as external capture function, and a transition on T0EX pin matched the TEX_EDGE setting, this flag will set to 1 by hardware</p> <p>0 = T0EX pin interrupt did not occur. 1 = T0EX pin interrupt occurred.</p> <p><b>Note:</b> This bit is cleared by writing 1 to it</p> <p><b>For TEXISR1:</b></p> <p>Reserved.</p>

## 5.10 PWM Generator and Capture Timer (PWM) (NUC029xAN Only)

### 5.10.1 Overview

The NuMicro® NUC029xAN has 2 sets of PWM group supporting a total of 4 sets of PWM generators that can be configured as 8 independent PWM outputs, PWM0~PWM7, or as 4 complementary PWM pairs, (PWM0, PWM1), (PWM2, PWM3), (PWM4, PWM5) and (PWM6, PWM7) with 4 programmable Dead-zone generators.

Each PWM generator has one 8-bit prescaler, one clock divider with 5 divided frequencies (1, 1/2, 1/4, 1/8, 1/16), two PWM Timers including two clock selectors, two 16-bit PWM counters for PWM period control, two 16-bit comparators for PWM duty control and one Dead-zone generator. The 4 sets of PWM generators provide 8 independent PWM interrupt flags set by hardware when the corresponding PWM period down counter reaches 0. Each PWM interrupt source with its corresponding enable bit can cause CPU to request PWM interrupt. The PWM generators can be configured as one-shot mode to produce only one PWM cycle signal or auto-reload mode to output PWM waveform continuously.

When DZEN01 (PCR[4]) is set, PWM0 and PWM1 perform complementary PWM paired function; the paired PWM period, duty and Dead-time are determined by PWM0 timer and Dead-zone generator 0. Similarly, the complementary PWM pairs of (PWM2, PWM3), (PWM4, PWM5) and (PWM6, PWM7) are controlled by PWM2, PWM4 and PWM6 timers and Dead-zone generator 2, 4 and 6, respectively.

To prevent PWM driving output pin with unsteady waveform, the 16-bit period down counter and 16-bit comparator are implemented with double buffer. When user writes data to counter/comparator buffer registers, the updated value will be load into the 16-bit down counter/comparator at the time down counter reaching 0. The double buffering feature avoids glitch at PWM outputs.

When the 16-bit period down counter reaches 0, the interrupt request is generated. If PWM-timer is set as auto-reload mode, when the down counter reaches 0, it is reloaded with PWM Counter Register (CNRx) automatically then starts decreasing, repeatedly. If the PWM-timer is set as one-shot mode, the down counter will stop and generate one interrupt request when it reaches 0.

The value of PWM counter comparator is used for pulse high width modulation. The counter control logic changes the output to high level when down-counter value matches the value of compare register.

The alternate feature of the PWM-timer is digital input Capture function. If Capture function is enabled the PWM output pin is switched as capture input mode. The Capture0 and PWM0 share one timer which is included in PWM0 and the Capture1 and PWM1 share PWM1 timer, and etc. Therefore user must setup the PWM-timer before enable Capture feature. After capture feature is enabled, the capture always latched PWM-counter to Capture Rising Latch Register (CRLR) when input channel has a rising transition and latched PWM-counter to Capture Falling Latch Register (CFLR) when input channel has a falling transition. Capture channel 0 interrupt is programmable by setting CRL\_IE0 (CCR0[1]) (Rising latch Interrupt enable) and CFLIE0 (CCR0[2]) (Falling latch Interrupt enable) to decide the condition of interrupt occur. Capture channel 1 has the same feature by setting CRLIE1 (CCR0[17]) and CFLIE1 (CCR0[18]). And capture channel 2 to channel 3 on each group have the same feature by setting the corresponding control bits in CCR2. For each group, whenever Capture issues Interrupt 0/1/2/3, the PWM counter 0/1/2/3 will be reload at this moment.

The maximum captured frequency that PWM can capture is confined by the capture interrupt latency. When capture interrupt occurred, software will do at least three steps, including: Read PIIR to get interrupt source and Read CRLRx/CFLRx(x=0~3) to get capture value and finally write 1 to clear PIIR to 0. If interrupt latency will take time T0 to finish, the capture signal mustn't transition during this interval (T0). In this case, the maximum capture frequency will be 1/T0.

## 5.10.2 Features

### 5.10.2.1 PWM Function:

- Up to 2 PWM groups (PWMA/PWMB) to support 8 PWM channels or 4 complementary PWM paired channels
- Each PWM group has two PWM generators with each PWM generator supporting one 8-bit prescaler, one clock divider, two PWM-timers, one Dead-zone generator and two PWM outputs.
- Up to 16-bit resolution
- One-shot or Auto-reload mode
- Edge-aligned type or Center-aligned type option
- PWM trigger ADC start-to-conversion

### 5.10.2.2 Capture Function:

- Timing control logic shared with PWM Generators
- Supports 8 Capture input channels shared with 8 PWM output channels
- Each channel supports one rising latch register (CRLRx), one falling latch register (CFLRx) and Capture interrupt flag (CAPIFx)

### 5.10.3 Block Diagram

The following figures illustrate the architecture of PWM in pair (e.g. PWM-Timer 0/1 are in one pair and PWM-Timer 2/3 are in another one, and so on.).

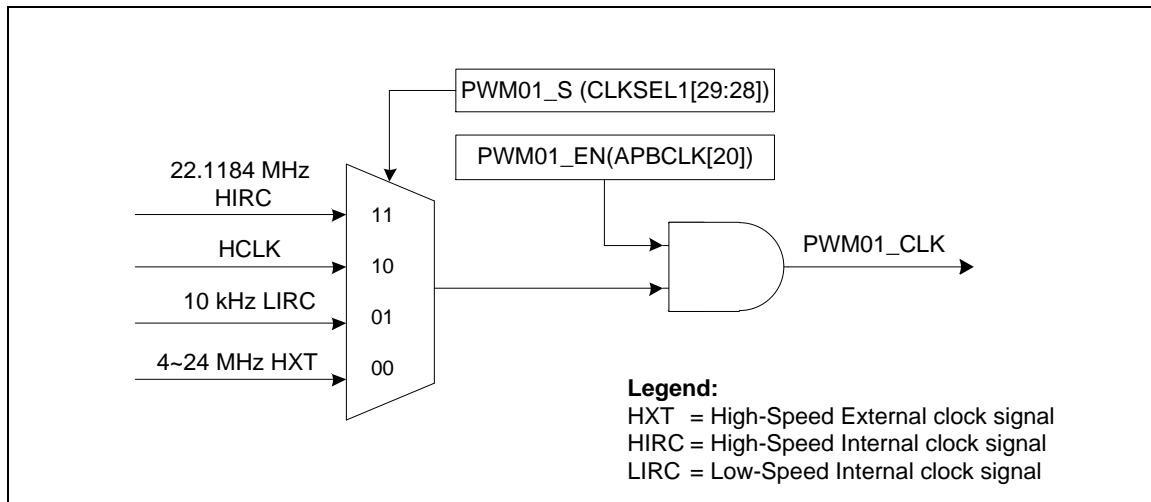


Figure 5-45 PWM Generator 0 Clock Source Control

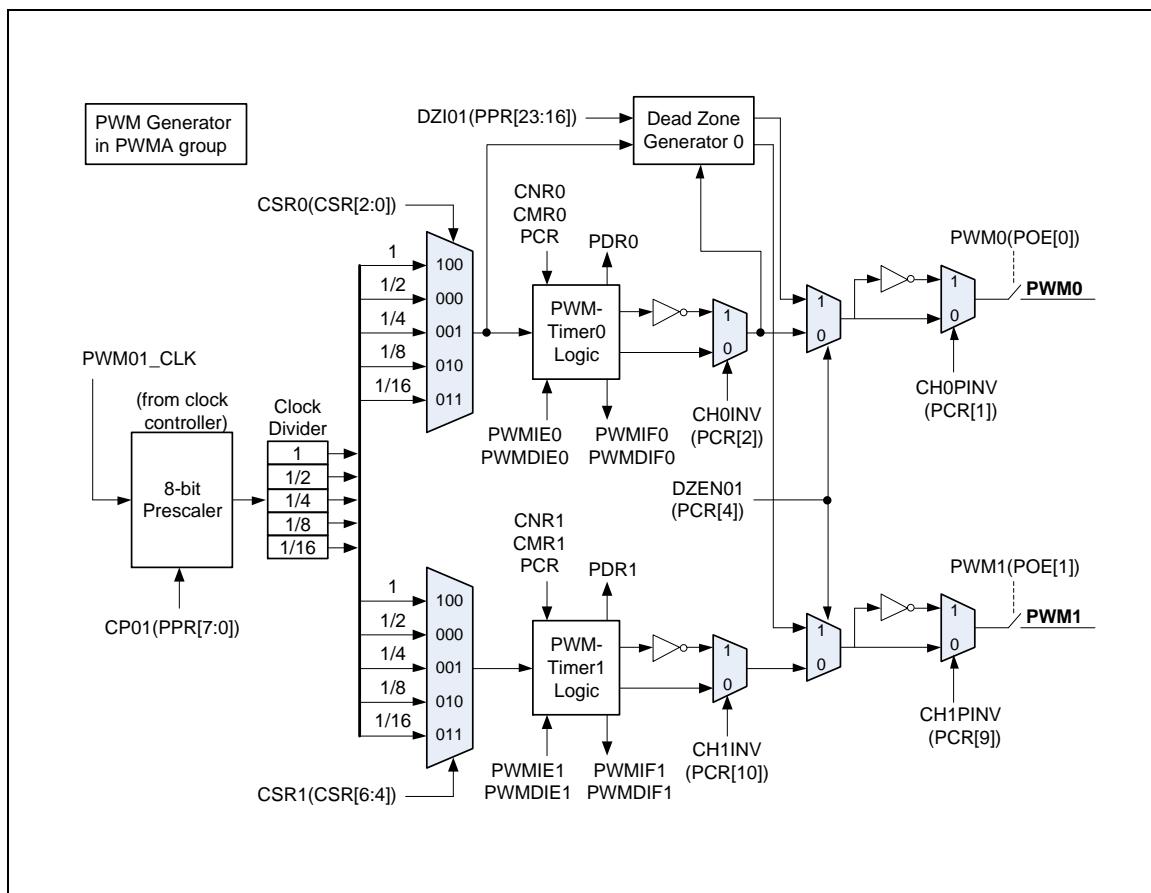


Figure 5-46 PWM Generator 0 Architecture Diagram

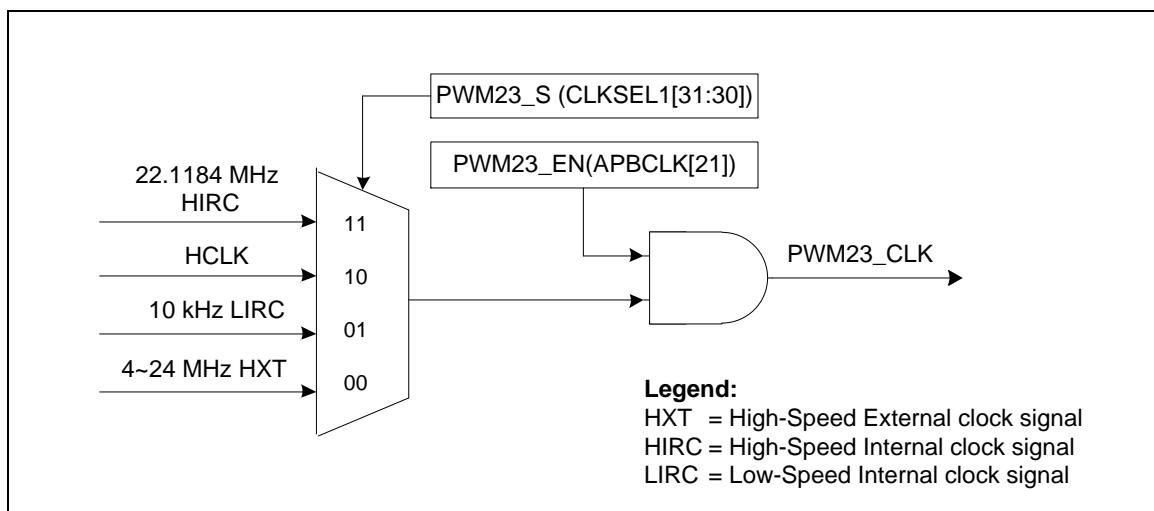


Figure 5-47 PWM Generator 2 Clock Source Control

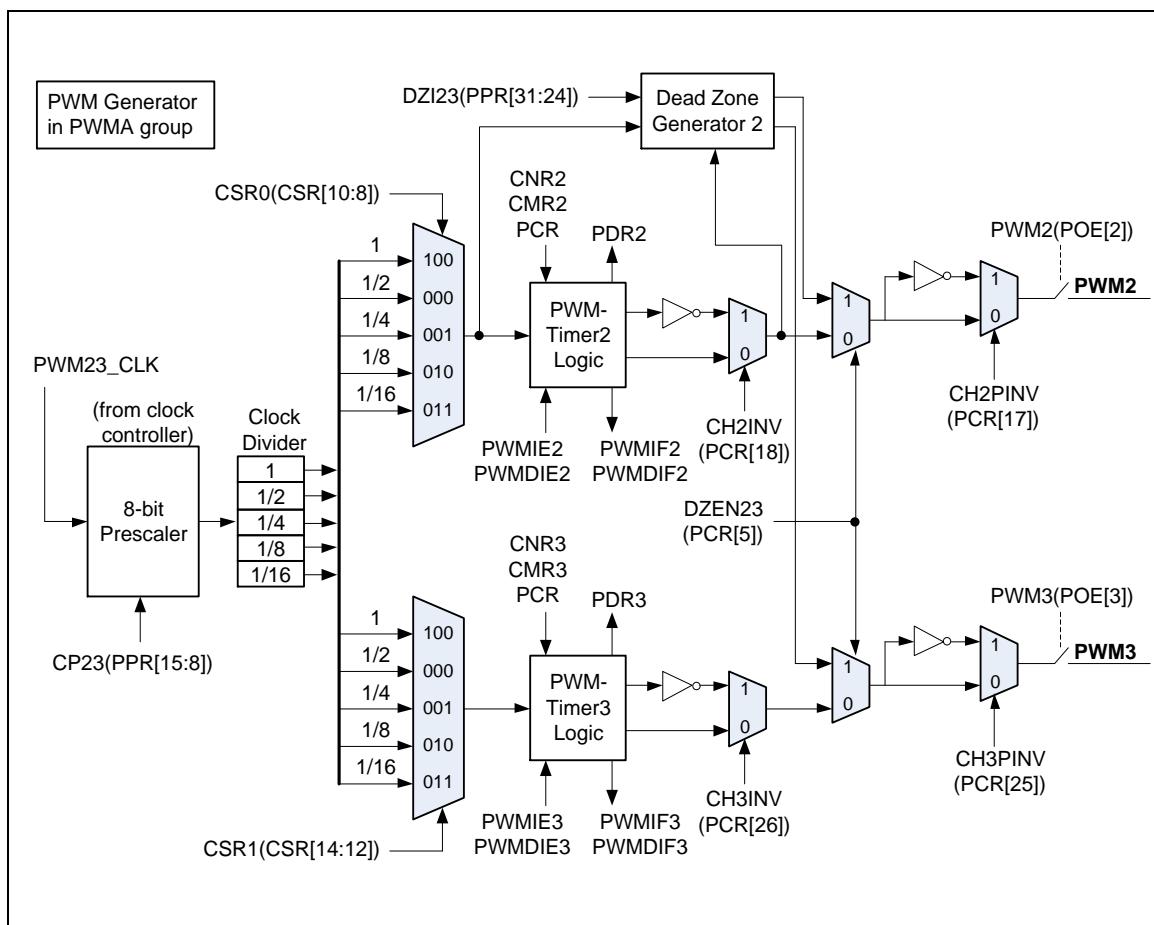


Figure 5-48 PWM Generator 2 Architecture Diagram

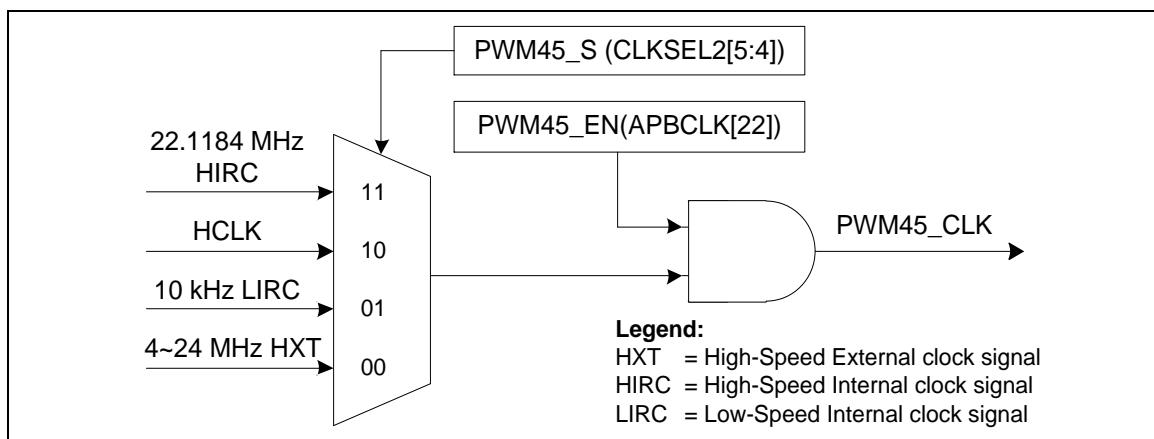


Figure 5-49 PWM Generator 4 Clock Source Control

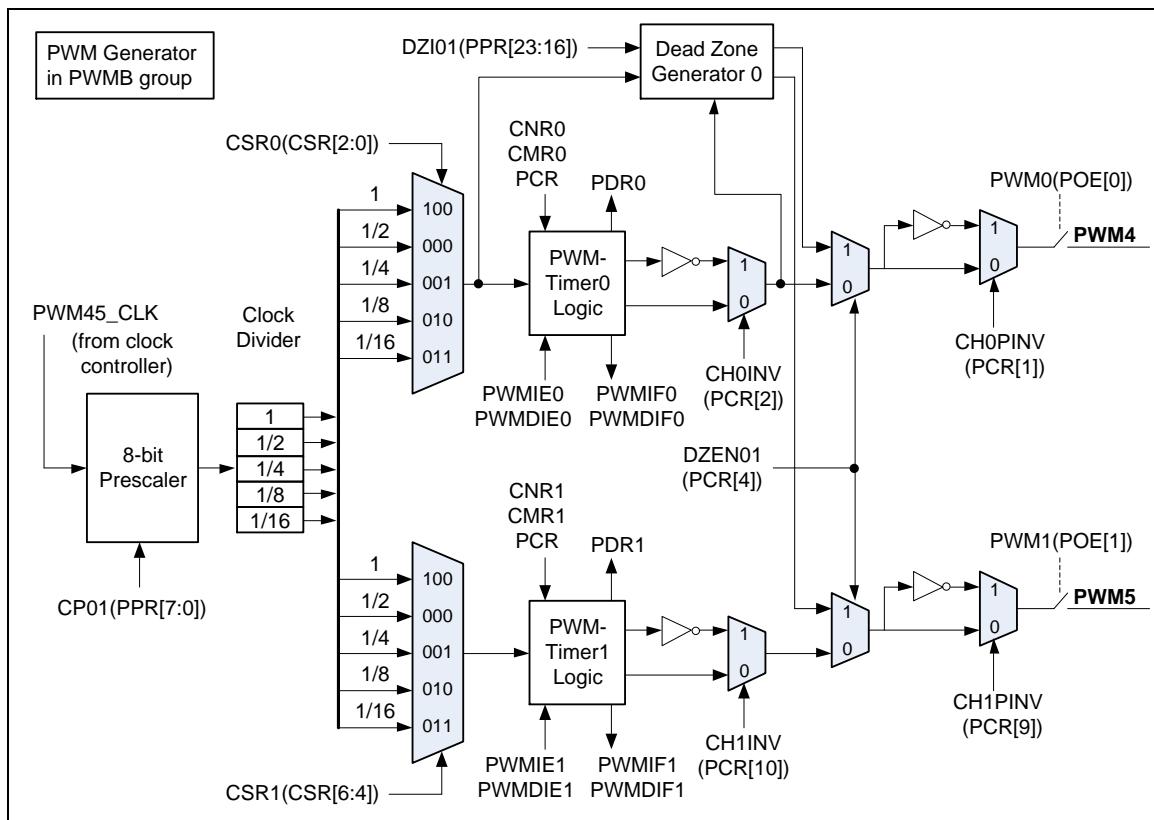


Figure 5-50 PWM Generator 4 Architecture Diagram

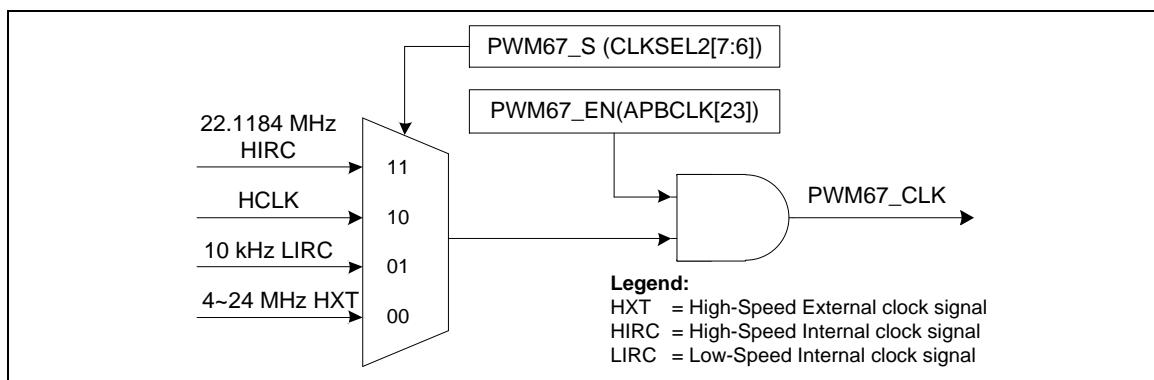


Figure 5-51 PWM Generator 6 Clock Source Control

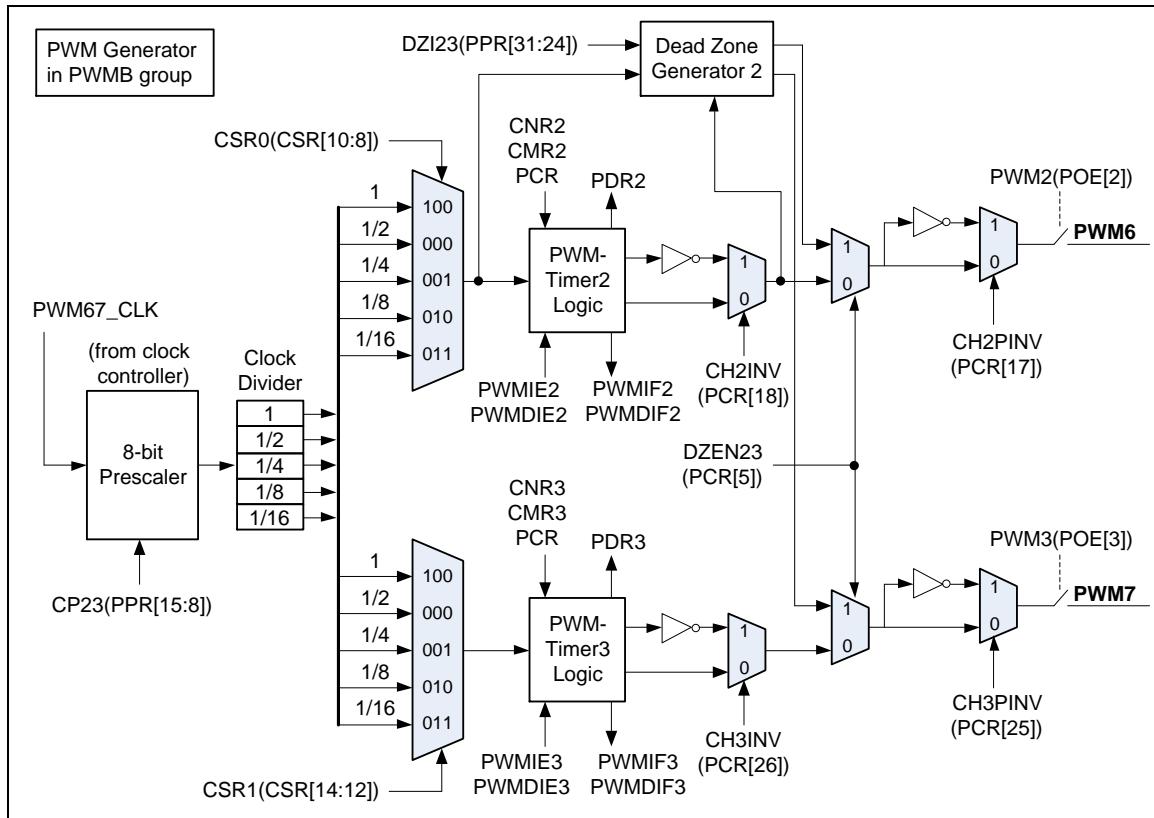


Figure 5-52 PWM Generator 6 Architecture Diagram

### 5.10.4 Basic Configuration

The PWM pin functions are configured in P2\_MFP and P4\_MFP registers.

The PWM clock can be enabled in APBCLK[23:20]. The PWM clock source is selected by CLKSEL1[31:28] and CLKSEL2[7:4].

### 5.10.5 Functional Description

#### 5.10.5.1 PWM-Timer Operation

The PWM controller supports 2 operation types: Edge-aligned and Center-aligned.

##### Edge-aligned PWM (Down-counter)

In Edge-aligned PWM Output mode, the 16 bits PWM counter will starts down-counting from CNRx to match with the value of the duty cycle CMRx (old), when this happened it will toggle the PWMx generator output to low. The counter will continue down-counting to zero, at this moment, it toggles the PWMx generator output to high and CMRx(new) and CNRx(new) are updated with CHxMODE=1 and request the PWM interrupt if PWM interrupt is enabled(PIERx=1).

The PWM period and duty control are configured by PWM down-counter register (CNR) and PWM comparator register (CMR). The PWM-Timer timing operation is shown below. The pulse width modulation follows the formula as shown below and the legend of PWM-Timer Comparator is shown in the note that the corresponding GPIO pins must be configured as PWM function (enable POE and disable CAPENR) for the corresponding PWM channel.

- PWM frequency =  $\text{PWMxy\_CLK}/[(\text{prescale}+1)*(\text{clock divider})*(\text{CNR}+1)]$ ; where xy, could be 01, 23, 45 or 67, depends on selected PWM channel.
- Duty ratio =  $(\text{CMR}+1)/(\text{CNR}+1)$
- CMR  $\geq$  CNR: PWM output is always high
- CMR < CNR: PWM low width =  $(\text{CNR}-\text{CMR})$  unit<sup>[1]</sup>; PWM high width =  $(\text{CMR}+1)$  unit
- CMR = 0: PWM low width =  $(\text{CNR})$  unit; PWM high width = 1 unit

Note [1]: unit = one PWM clock cycle.

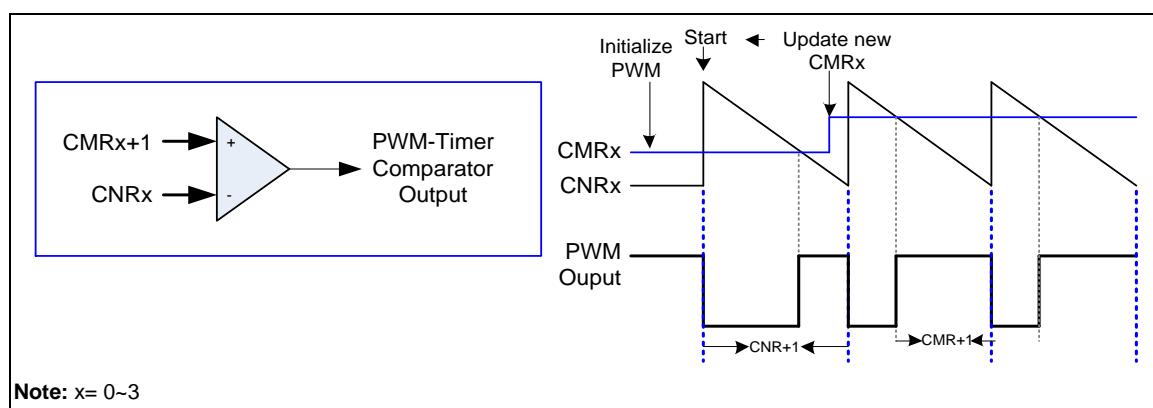


Figure 5-53 Legend of Internal Comparator Output of PWM-Timer

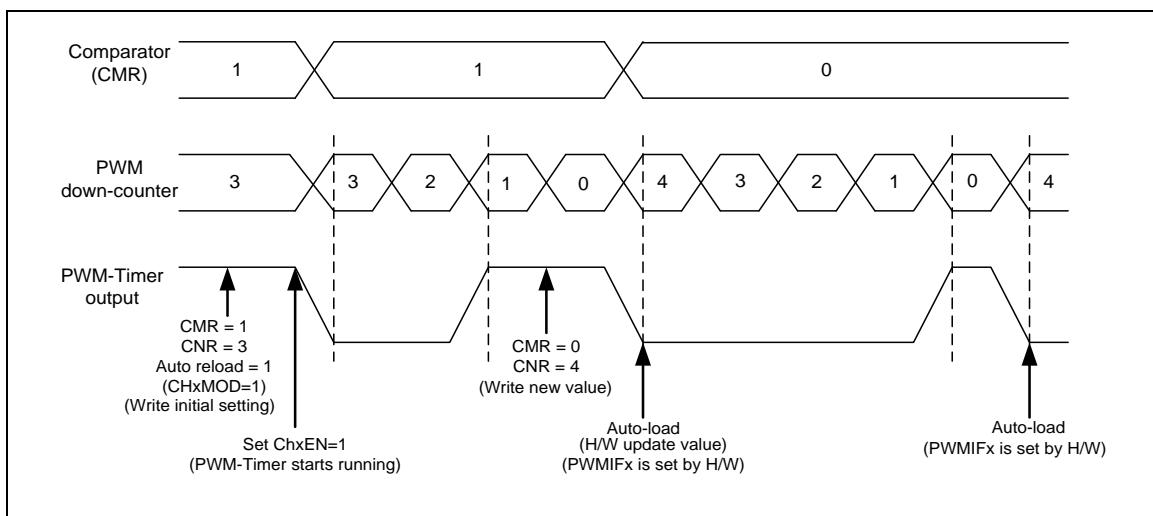


Figure 5-54 PWM Timer Operation Timing

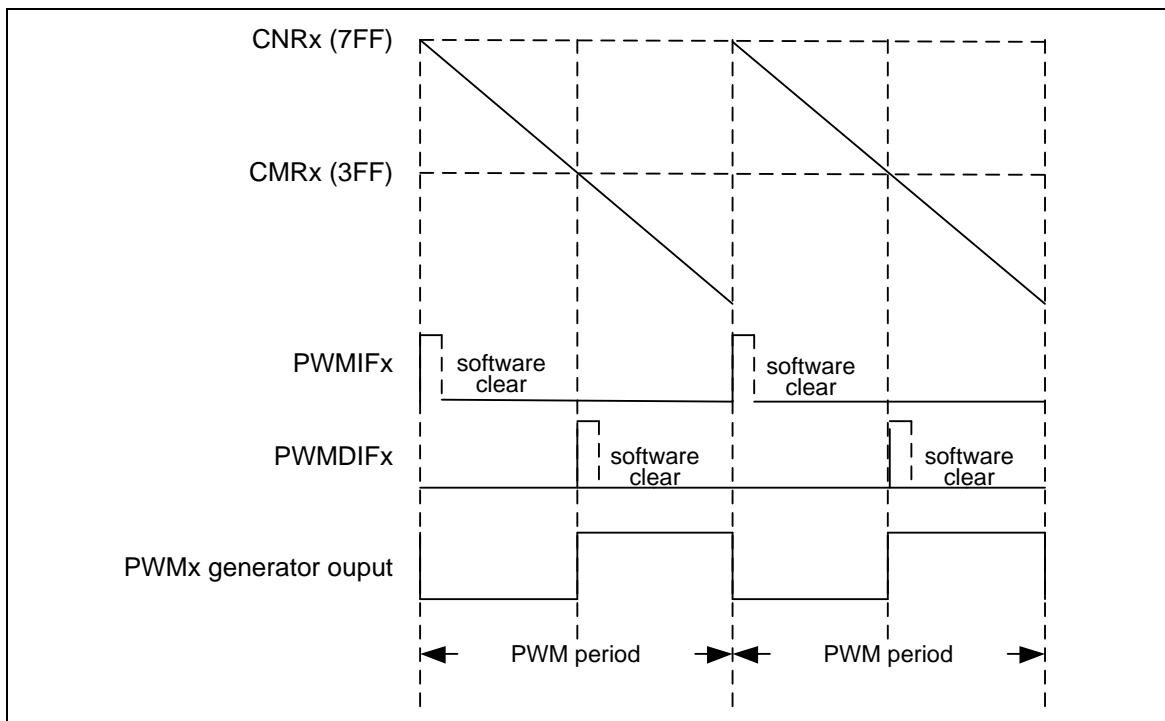


Figure 5-55 PWM Period Interrupt Generate Timing Waveform

### Center-aligned PWM (Up/Down-counter)

The center-aligned PWM signals are produced by the module when the PWM time base is configured in an Up/Down Counting mode. The PWM counter will start counting-up from 0 to match the value of CMRx (old); this will cause the toggling of the PWMx generator output to low. The counter will continue counting to match with the CNRx (old). Upon reaching this state counter is configured automatically to down counting, when PWM counter matches the CMRx (old) value again the PWMx generator output toggles to high. Once the PWM counter underflows it will update the PWM period register CNRx(new) and duty cycle register CMRx(new) with CHxMODE = 1.

- PWM frequency =  $\text{PWMxy\_CLK}/[(\text{prescale}+1)*(\text{clock divider})*(\text{CNR}+1)]$ ; where xy, could be 01, 23, 45 or 67, depends on selected PWM channel.
- Duty ratio =  $[(2 \times \text{CMR}) + 1]/[2 \times (\text{CNR}+1)]$
- CMR > CNR: PWM output is always high
- CMR <= CNR: PWM low width=  $2 \times (\text{CNR}-\text{CMR}) + 1$  unit<sup>[1]</sup>; PWM high width =  $(2 \times \text{CMR}) + 1$  unit
- CMR = 0: PWM low width =  $2 \times \text{CNR} + 1$  unit; PWM high width = 1 unit

**Note [1]:** unit = one PWM clock cycle.

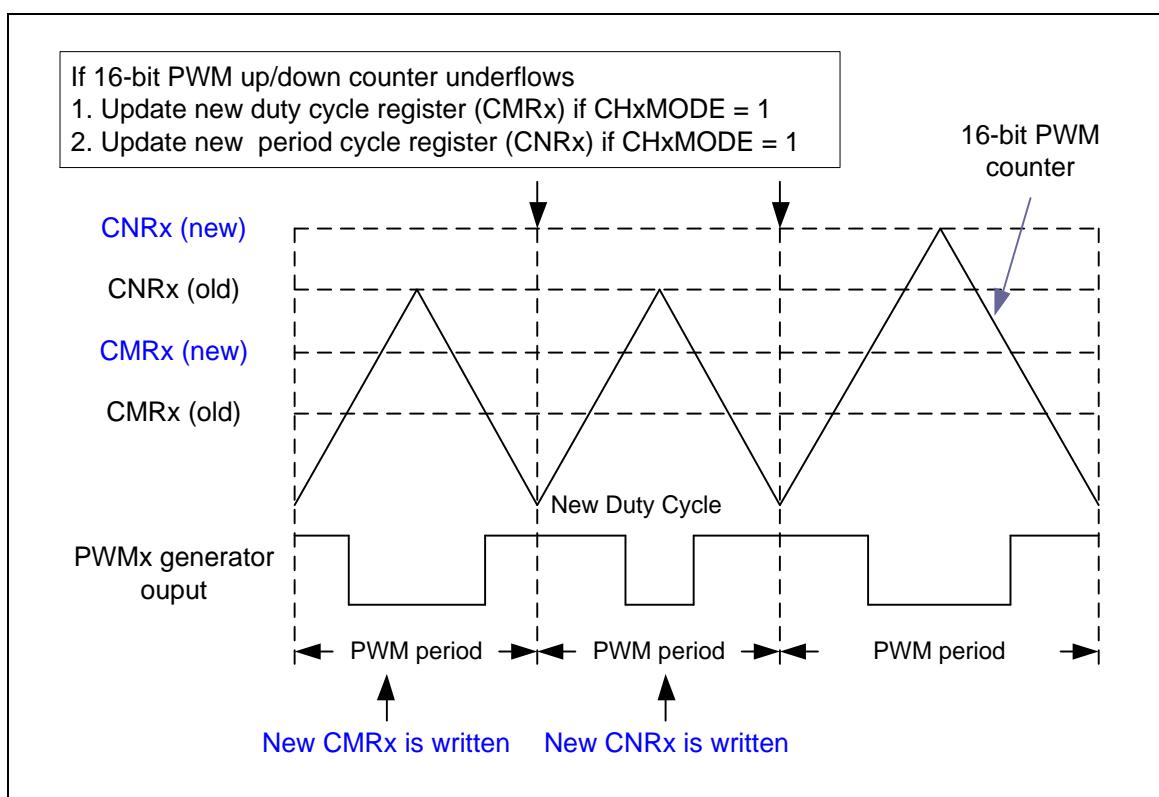


Figure 5-56 Center-aligned type Output Waveform

In Center-aligned type, system can generate two kinds of interrupt, period interrupt and duty interrupt, at four specified timings. PWM period interrupt is generated at counter equals zero on down-count if INTxxTYPE (PIER[17:16]) = 0 or at counter equals CNRx on up-count if INTxxTYPE (PIER[17:16]) = 1, i.e. at center point of PWM cycle. PWM duty interrupt is requested at counter equals CMR on down-count if INTxxDTYPE (PIER[25:24] = 0) or at counter equals CMR on up-count if INTxxDTYPE (PIER[25:24] = 1)

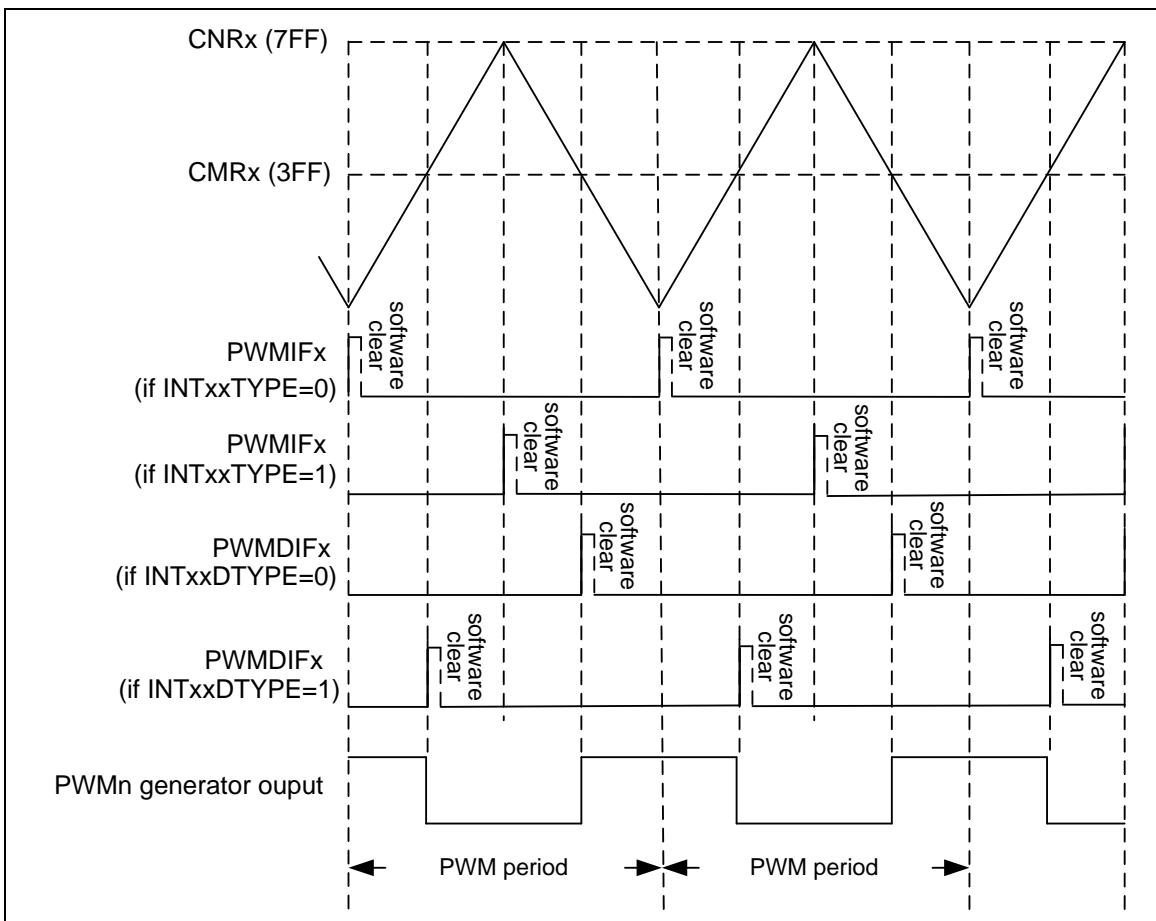


Figure 5-57 PWM Center-aligned Interrupt Generate Timing Waveform

#### 5.10.5.2 PWM Double Buffering, Auto-reload and One-shot Operation

PWM Timers have double buffering function and the reload value is updated at the start of next period without affecting current timer operation. The PWM counter value can be written into CNRx and current PWM counter value can be read from PDRx.

PWM0 will operate in One-shot mode if CH0MOD bit is set to 0, and operate in Auto-reload mode if CH0MOD bit is set to 1. It is recommend that switch PWM0 operating mode before set CH0EN bit to 1 to enable PWM0 counter start running because the content of CNR0 and CMR0 will be cleared to 0 to reset the PWM0 period and duty setting when PWM0 operating mode is changed. As PWM0 operate in One-shot mode, CMR0 and CNR0 should be written first and then set CH0EN bit to 1 to enable PWM0 counter start running. After PWM0 counter down count from CNR0 value to 0, CNR0 and CMR0 will be cleared to 0 by hardware and PWM counter will be held. Software need to write new CMR0 and CNR0 value to set next one-shot period and duty.

When re-start next one-shot operation, the CMR0 should be written first because PWM0 counter will auto re-start counting when CNR0 is written a non-zero value. As PWM0 operates at auto-reload mode, CMR0 and CNR0 should be written first and then set CH0EN bit to 1 to enable PWM0 counter start running. The value of CNR0 will reload to PWM0 counter when it down count reaches 0. If CNR0 is set to 0, PWM0 counter will be held. PWM1~PWM7 performs the same function as PWM0.

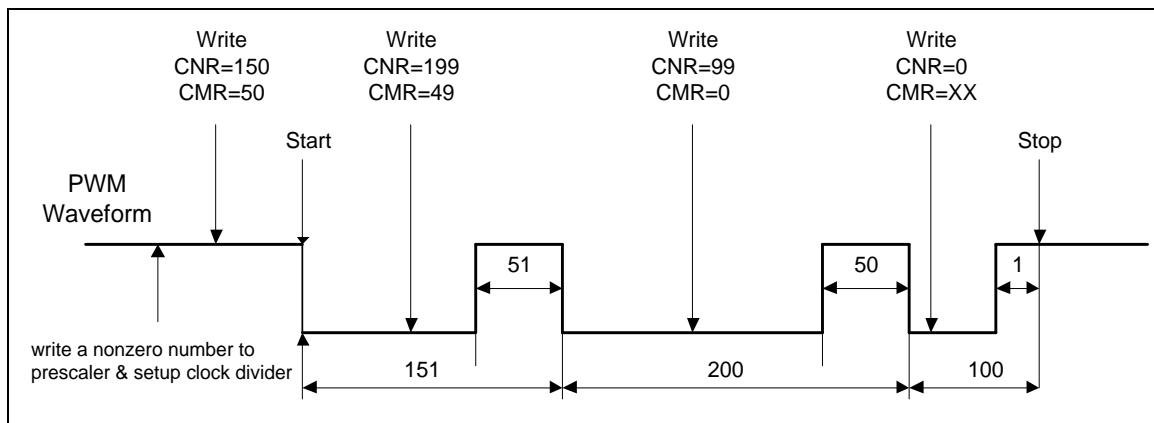


Figure 5-58 PWM Double Buffering Illustration

#### 5.10.5.3 Modulate Duty Ratio

The double buffering function allows CMRx to be written at any point in current cycle. The loaded value will take effect from the next cycle.

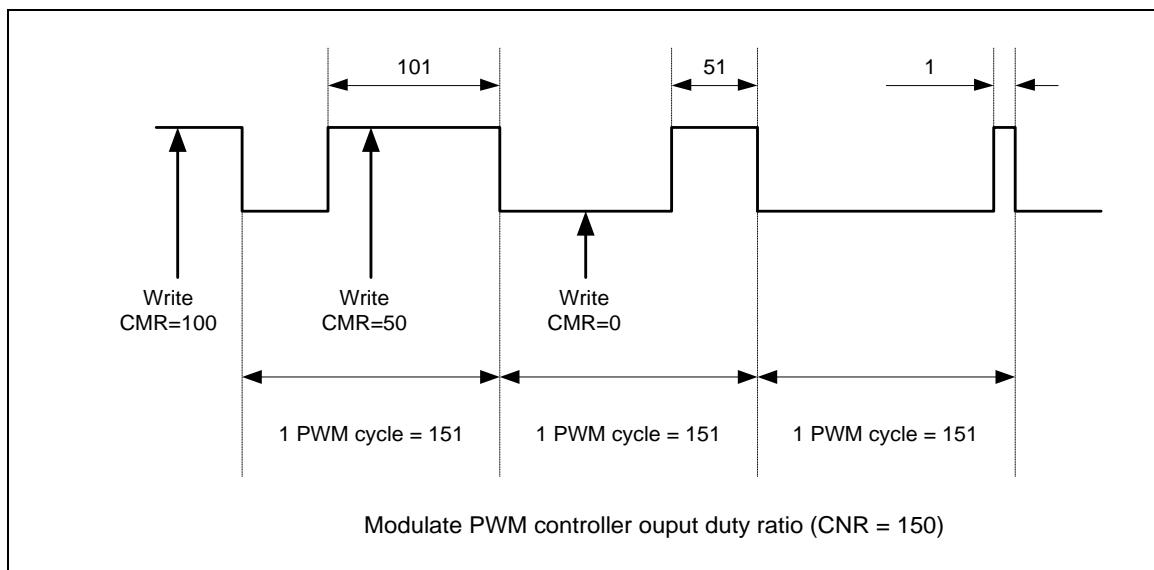


Figure 5-59 PWM Controller Output Duty Ratio

#### 5.10.5.4 Dead-Zone Generator

The PWM controller is implemented with Dead-zone generator. They are built for power device protection. This function generates a programmable time gap to delay PWM rising output. User

can program PPRx.DZI to determine the Dead-zone interval.

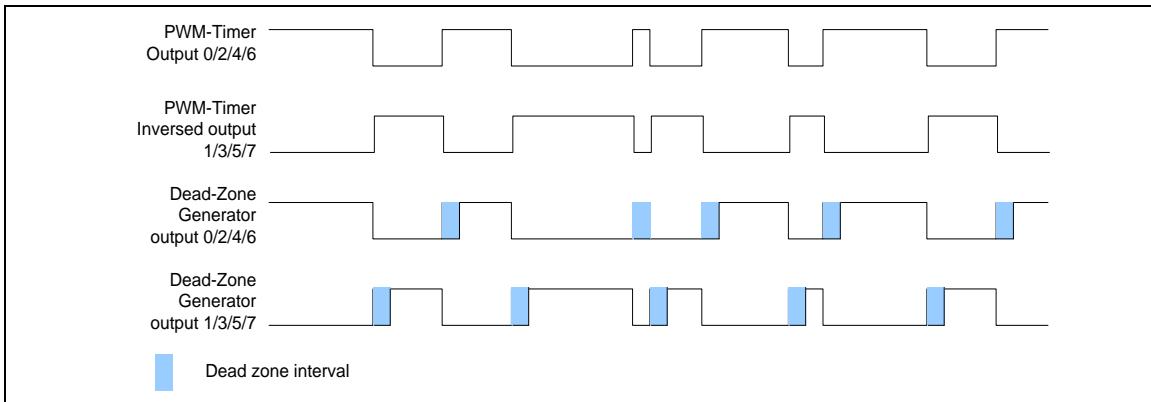


Figure 5-60 Paired-PWM Output with Dead-zone Generation Operation

##### 5.10.5.5 PWM-Timer Trigger ADC to Start Conversion

PWM can be one of the ADC conversion trigger source. When PWM operating at center aligned type, four PWM trigger ADC-to-Conversion timings can be selected. When PWM operating at edge-aligned type, two PWM trigger ADC-to-Conversion timings can be selected.

For Center-aligned type, PWM can trigger ADC to start conversion in different timings by setting INTxxDTYPE/ INTxxTYPE and PWMxDTEN/ PWMxTEN. Trigger ADC timings and settings as shown below.

INTxxTEN	INTxxTYPE	Description
1	0	PWM counter equals to 0 at down-counting
1	1	PWM counter equal to CNRx + 1 at up-counting

INTxxDTEN	INTxxDTYPE	Description
1	0	PWM counter equals CMRx at down-counting
1	1	PWM counter equals CMRx at up-counting

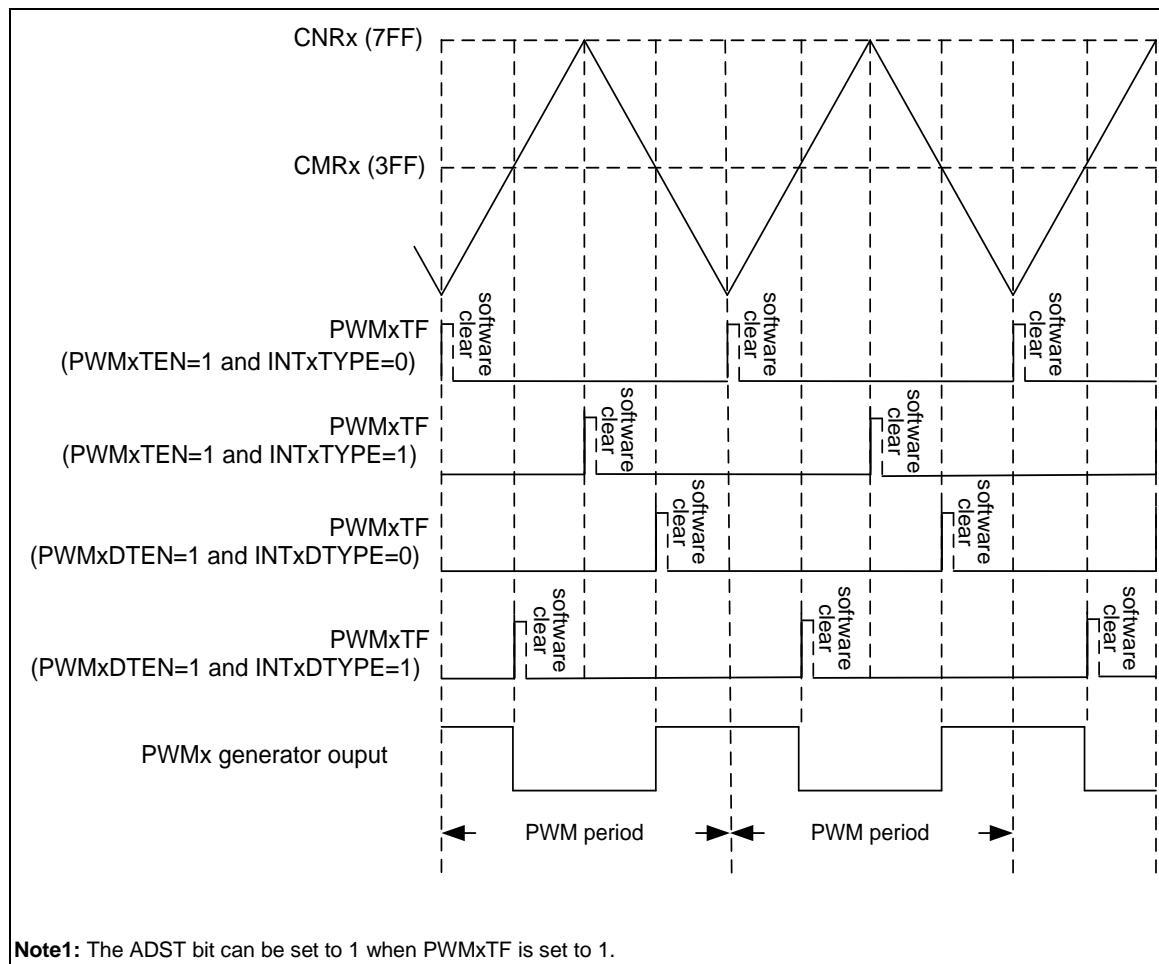


Figure 5-61 PWM Trigger ADC Flag (PWMxTF) in Center-aligned Type Timing Waveform

For Edge-aligned type, PWM can trigger ADC to start conversion in different timings by setting PWMxDTEN/ PWMxTEN. Trigger ADC timings and settings as shown below.

INTxDTEN	Description
1	PWM counter equals CMRx at down-counting
INTxTEN	Description
1	PWM counter equals to 0 at down-counting

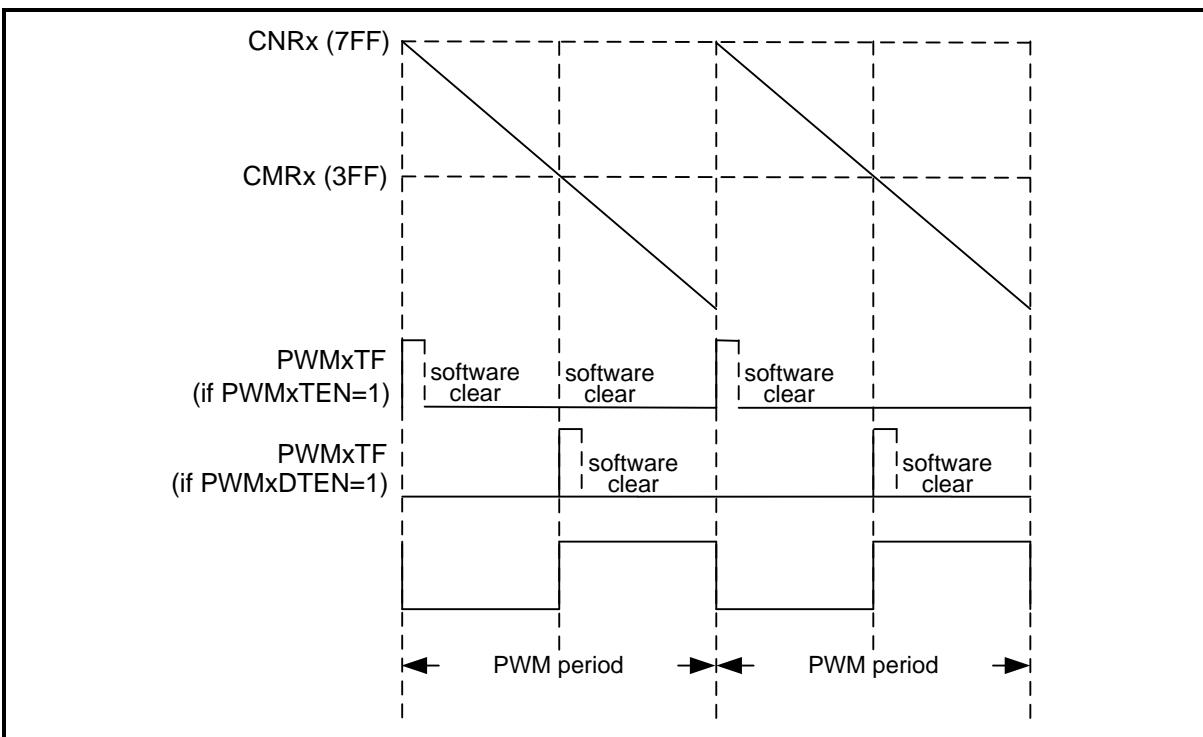


Figure 5-62 PWM Trigger ADC Flag (PWMxTF) in Edge-aligned Type Timing Waveform

#### 5.10.5.6 PWM trigger ADC start-of-conversion procedure

1. Configure prescaler register (PPRx) for setting clock prescaler (CPxx).
2. Configure clock select register (CSR<sub>x</sub>) for setting clock source divider selection (CSR<sub>x</sub>).
3. Configure PWM control register (PCR<sub>x</sub>) for setting auto-reload mode (CH<sub>x</sub>MOD = 1), PWM aligned type (PWM<sub>xx</sub>TYPE) and DISABLE PWM-Timer (CH<sub>x</sub>EN = 0).
4. Configure PWM control register (PCR<sub>x</sub>) for setting inverter on/off (CH<sub>x</sub>INV), polar inverse on/off (CH<sub>x</sub>PINV) and Dead-zone generator on/off (DZEN<sub>xx</sub>). (optional)
5. Configure PWM interrupt enable register (PIER) for setting PWM period interrupt type (INT<sub>xx</sub>TYPE) and PWM duty interrupt type (INT<sub>xx</sub>DTYPE).
6. Configure PWM trigger control register (TCON) to enable/disable PWM period trigger ADC (PWM<sub>x</sub>TEN) and PWM duty trigger ADC (PWM<sub>x</sub>DTEN).
7. Configure comparator register (CMRx) for setting PWM duty (CMRx).
8. Configure PWM counter register (CNRx) for setting PWM-Timer loaded value (CNRx).
9. Configure PWM output enable register (POE) to enable PWM output channel (PWM<sub>x</sub> = 1)
10. Configure ADC trigger delay control register (ADTDCR) in ADC controller registers for setting PWM trigger delay time (PTDT) (optional)
11. Configure ADC channel enable register (ADCHER) in ADC controller registers to enable analog input channel (CHEN<sub>x</sub> = 1)
12. Configure ADC control register (ADCR) in ADC controller registers for setting hardware trigger source is from PWM trigger (TRGS = 3), external trigger enable (TRGEN = 1), A/D converter operation mode (ADMD = 0,2,3) and A/D converter enable (ADEN = 1)
13. Configure PWM control register (PCR) to enable PWM timer start running (CH<sub>x</sub>EN = 1)

14. ADST (ADCR[11]) bit will be set to 1 by hardware when PWM trigger flag (PWMxTF) is set to 1 by hardware.
15. Software can poll A/D conversion end flag – ADF (ADSR[0]) to check if the conversion is finished or not.
16. ADST (ADCR[11]) bit will be cleared to 0 automatically in single mode and single cycle scan mode. In continuous scan mode, the ADST bit will keep 1 until software clears it.

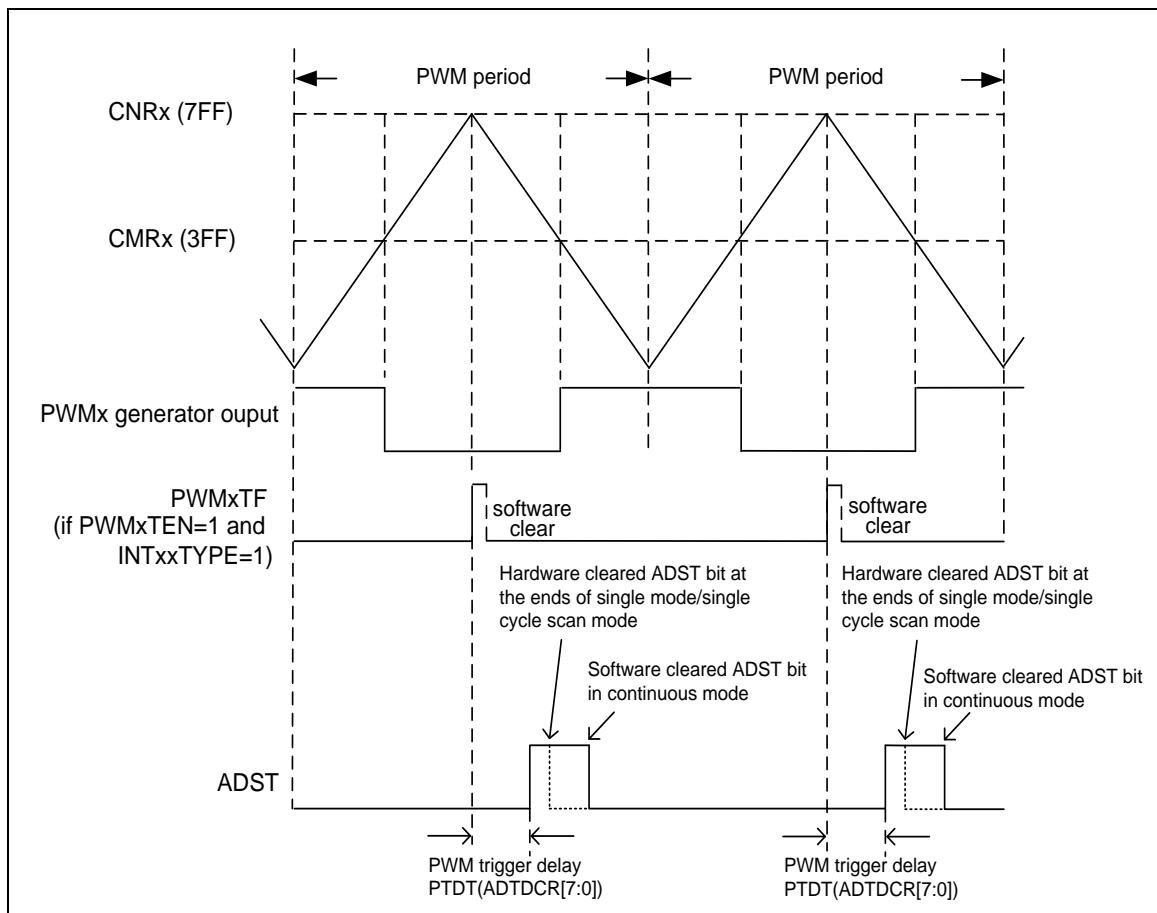


Figure 5-63 PWM Trigger ADC Start-of-Conversion in Center-aligned Type

#### 5.10.5.7 Capture Operation

The Capture 0 and PWM 0 share one timer that included in PWM 0; and the Capture 1 and PWM 1 share another timer, and etc. The capture always latches PWM-counter to CRLRx when input channel has a rising transition and latches PWM-counter to CFLRx when input channel has a falling transition. Capture channel 0 interrupt is programmable by setting CCR0[1] (Rising latch Interrupt enable) and CCR0[2] (Falling latch Interrupt enable) to decide the condition of interrupt occur. Capture channel 1 has the same feature by setting CCR0[17] and CCR0[18], and etc. Whenever the Capture controller issues a capture interrupt, the corresponding PWM counter will be reloaded with CNRx at this moment. Note that the corresponding GPIO pins must be configured as capture function (POE disabled and CAPENR enabled) for the corresponding capture channel.

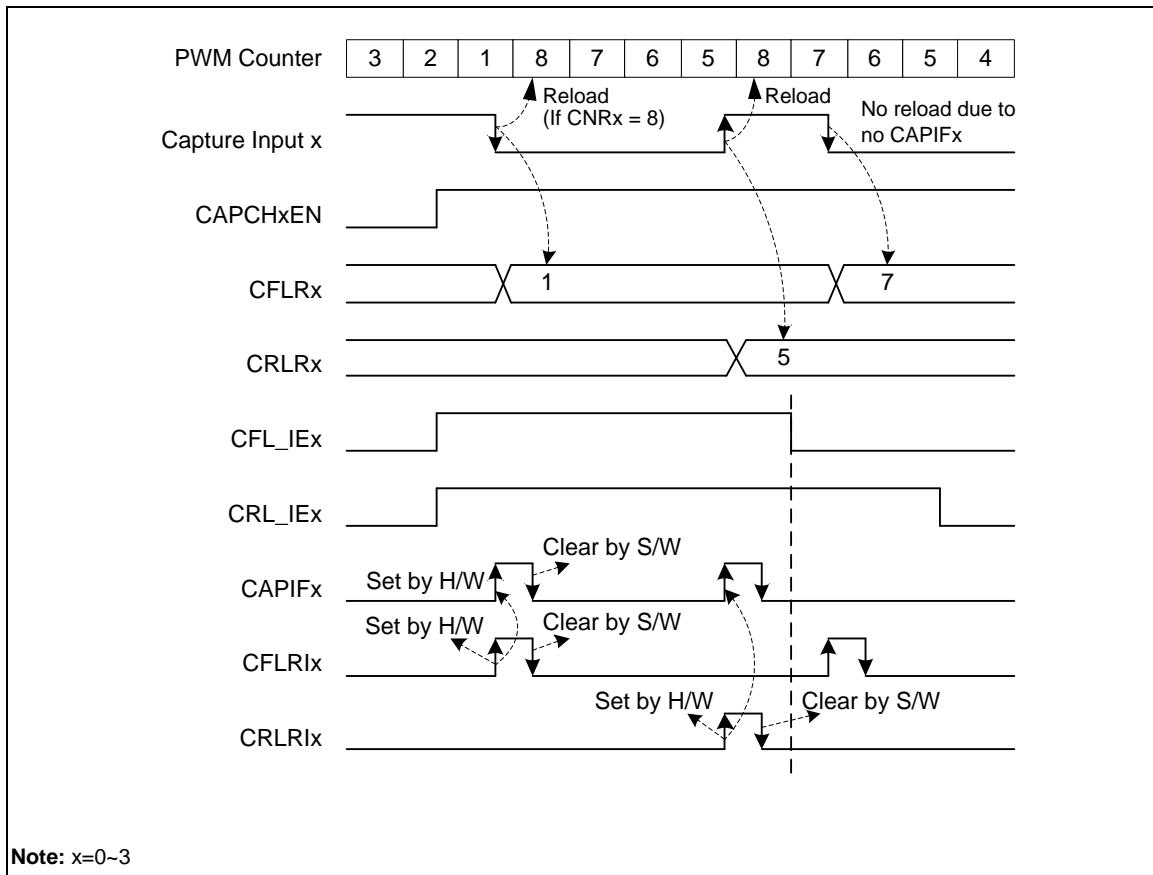


Figure 5-64 Capture Operation Timing

In this case, the CNR is 8:

1. The PWM counter will be reloaded with CNRx when a capture interrupt flag (CAPIFx) is set.
2. The channel low pulse width is (CNR + 1 – CRLR).
3. The channel high pulse width is (CNR + 1 – CFLR).

#### 5.10.5.8 PWM-Timer Interrupt Architecture

There are eight PWM interrupts, PWM0\_INT~PWM7\_INT, which are divided into PWMA\_INT and PWMB\_INT for Advanced Interrupt Controller (AIC). PWM 0 and Capture 0 share one interrupt, PWM1 and Capture 1 share the same interrupt and so on. Therefore, PWM function and Capture function in the same channel cannot be used at the same time. The following figure demonstrates the architecture of PWM-Timer interrupts.

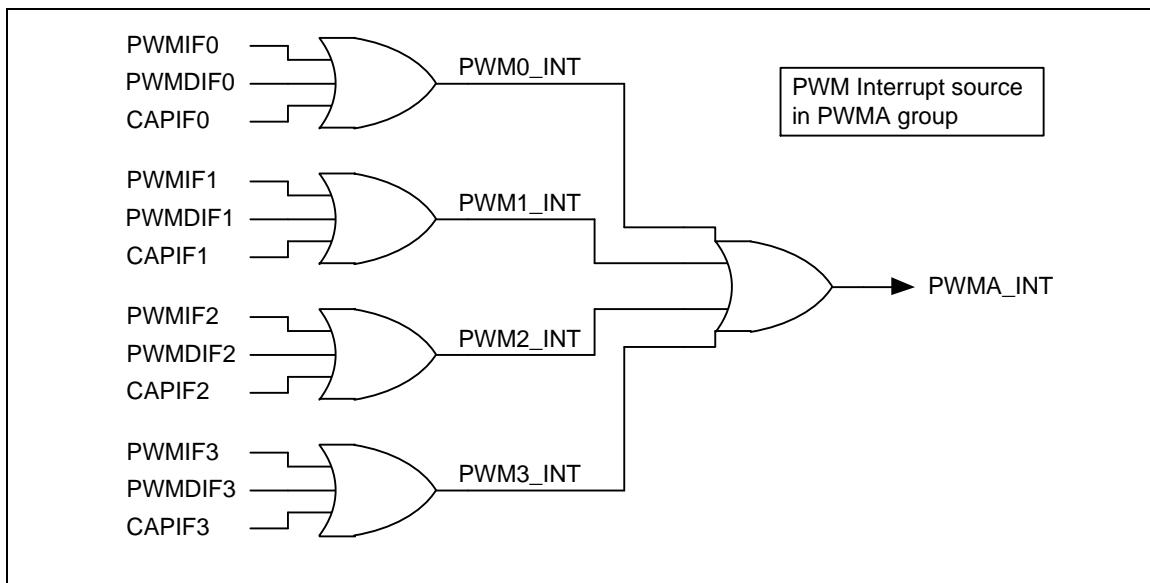


Figure 5-65 PWM Group A PWM-Timer Interrupt Architecture Diagram

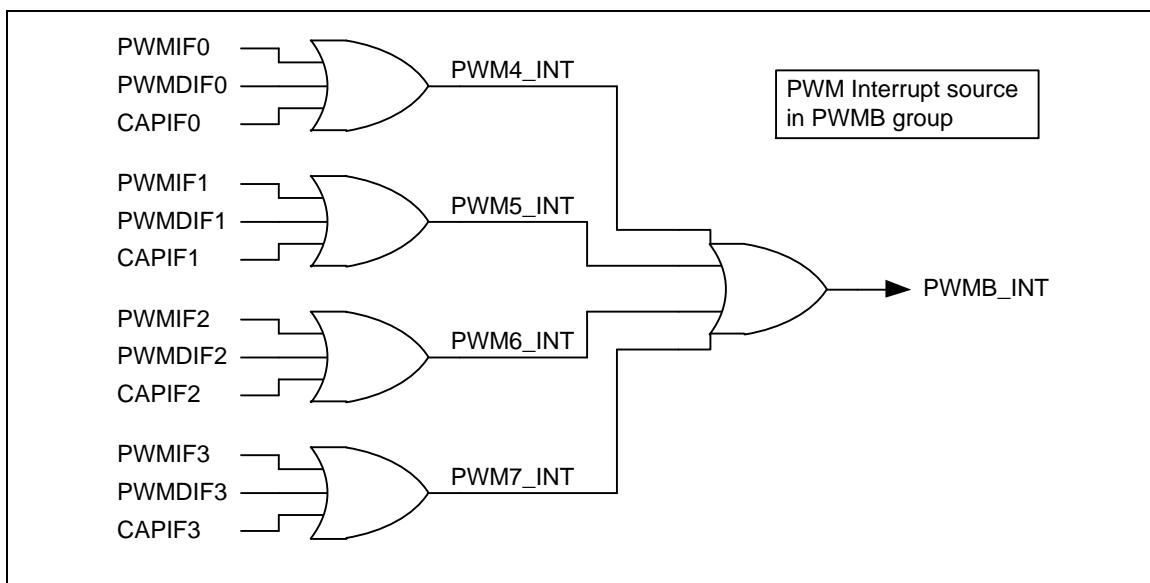


Figure 5-66 PWM Group B PWM-Timer Interrupt Architecture Diagram

#### 5.10.5.9 PWM-Timer Start Procedure

The following procedure is recommended for starting a PWM drive.

1. Configure prescaler register (PPR) for setting clock prescaler (CPxx).
2. Configure clock select register (CSR) for setting clock source select (CSRx).
3. Configure PWM control register (PCR) for setting auto-reload mode (CHxMOD = 1) and DISABLE PWM-Timer (CHxEN = 0).
4. Configure PWM control register (PCR) for setting inverter on/off (CHxINV) and Dead-zone generator on/off (DZENxx). (optional)

5. Configure comparator register (CMRx) for setting PWM duty (CMRx).
6. Configure PWM counter register (CNRx) for setting PWM-Timer loaded value (CNRx).
7. Configure PWM interrupt enable register (PIER) for setting PWM period interrupt enable bit (PWMIEx). (optional)
8. Configure PWM output enable register (POE) to enable PWM output channel (PWMx = 1)
9. Configure PWM control register (PCR) to enable PWM timer start running (CHxEN = 1)

#### 5.10.5.10 PWM-Timer Re-Start Procedure in One-shot mode

After PWM waveform is generated once in PWM One-shot mode, PWM-Timer will be stopped automatically and both of CNRx and CMRx will be cleared by hardware. Software must fill CMRx and CNRx value again to re-start another PWM one-shot waveform. The following procedure is recommended for re-starting PWM one-shot waveform.

1. Configure comparator register (CMRx) for setting PWM duty (CMRx).
2. Configure PWM counter register (CNRx) for setting PWM period (CNRx). After setup CNRx, PWM wave will be generated.

#### 5.10.5.11 PWM-Timer Stop Procedure

##### Method 1:

Set 16-bit counter register (CNRx) as 0, and monitor data register (PDRx, current value of 16-bit down-counter). When PDRx reaches to 0, disable PWM-Timer (CHxEN in PCR). (*Recommended*)

##### Method 2:

Set 16-bit counter register (CNRx) as 0. When interrupt request happened, disable PWM-Timer (CHxEN in PCR). (*Recommended*)

##### Method 3:

Disable PWM-Timer directly (CHxEN in PCR) (*Not recommended*)

The reason why method 3 is not recommended is that disabling CHxEN will immediately stop PWM output signal and lead to change the duty of the PWM output, this may cause damage to the control circuit of motor.

#### 5.10.5.12 PWM-Timer Synchronous Start Procedure

Group a PWM-Timer1~3 and group B PWM-Timer0~3 can synchronous start with group A PWM-Time0. The following procedure is recommended for PWM-Timer synchronous start

1. Configure prescaler register (PPR) for setting clock prescaler (CPxx).
2. Configure clock select register (CSR) for setting clock source select (CSRx).
3. Configure PWM control register (PCR) for setting inverter auto-reload mode (CHxMOD = 1), PWM aligned type (PWMxxTYPE) and DISABLE PWM-Timer (CHxEN = 0).
4. Configure PWM control register (PCR) for setting inverter on/off (CHxINV), polar inverse on/off (CHxPINV) and Dead-zone generator on/off (DZENn). (optional)
5. Configure comparator register (CMRx) for setting PWM duty (CMRx).
6. Configure PWM counter register (CNRx) for setting PWM-Timer loaded value (CNRx).
7. Configure PWM interrupt enable register (PIER) for setting PWM period interrupt type

(INTxxTYPE), PWM duty interrupt type (INTxxDTYPE), PWM period interrupt enable bit (PWMIEx) and PWM duty interrupt enable bit (PWMDIEx). (optional)

8. Configure PWM output enable register (POE) to enable PWM output channel (PWMx)
9. Configure PWM synchronous control register (PSCR) to enable PWM synchronous start bit (PSSEN<sub>x</sub> = 1)
10. Configure group A PWM control register (PCR) to enable group A PWM-Timer0 start running (CH0EN = 1 in group A PCR). All of specified PWM-Timers will synchronous start with group A PWM-Timer0.

#### 5.10.5.13 Capture Start Procedure

1. Configure prescaler register (PPR) for setting clock prescaler (CPxx).
2. Configure clock select register (CSR) for setting clock source select (CSR<sub>x</sub>)
3. Configure PWM control register (PCR) for setting auto-reload mode (CHxMOD = 1) and DISABLE PWM-Timer (CHxEN = 0).
4. Configure PWM capture control register (CCR<sub>x</sub>) for setting rising interrupt enable (CRL\_IEx), falling interrupt enable (CFL\_IEx) and input signal inverter on/off (INV<sub>x</sub>)
5. Configure PWM counter register (CNR<sub>x</sub>) for setting PWM-Timer loaded value (CNR<sub>x</sub>)
6. Configure PWM control register (PCR) to enable PWM timer start running (CHxEN = 1)
7. Configure the capture input channel enable register (CAPENR) to enable the corresponding GPIO pins as capture function.

### 5.10.6 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>PWM Base Address:</b>				
<b>PWM group A</b>				
<b>PWMA_BA = 0x4004_0000</b>				
<b>PWM group B</b>				
<b>PWMB_BA = 0x4014_0000</b>				
<b>PPR</b>	PWMA_BA+0x00 PWMB_BA+0x00	R/W	PWM Prescaler Register	0x0000_0000
<b>CSR</b>	PWMA_BA+0x04 PWMB_BA+0x04	R/W	PWM Clock Source Divider Select Register	0x0000_0000
<b>PCR</b>	PWMA_BA+0x08 PWMB_BA+0x08	R/W	PWM Control Register	0x0000_0000
<b>CNR0</b>	PWMA_BA+0x0C PWMB_BA+0x0C	R/W	PWM Counter Register 0	0x0000_0000
<b>CMR0</b>	PWMA_BA+0x10 PWMB_BA+0x10	R/W	PWM Comparator Register 0	0x0000_0000
<b>PDR0</b>	PWMA_BA+0x14 PWMB_BA+0x14	R	PWM Data Register 0	0x0000_0000
<b>CNR1</b>	PWMA_BA+0x18 PWMB_BA+0x18	R/W	PWM Counter Register 1	0x0000_0000
<b>CMR1</b>	PWMA_BA+0x1C PWMB_BA+0x1C	R/W	PWM Comparator Register 1	0x0000_0000
<b>PDR1</b>	PWMA_BA+0x20 PWMB_BA+0x20	R	PWM Data Register 1	0x0000_0000
<b>CNR2</b>	PWMA_BA+0x24 PWMB_BA+0x24	R/W	PWM Counter Register 2	0x0000_0000
<b>CMR2</b>	PWMA_BA+0x28 PWMB_BA+0x28	R/W	PWM Comparator Register 2	0x0000_0000
<b>PDR2</b>	PWMA_BA+0x2C PWMB_BA+0x2C	R	PWM Data Register 2	0x0000_0000
<b>CNR3</b>	PWMA_BA+0x30 PWMB_BA+0x30	R/W	PWM Counter Register 3	0x0000_0000
<b>CMR3</b>	PWMA_BA+0x34 PWMB_BA+0x34	R/W	PWM Comparator Register 3	0x0000_0000
<b>PDR3</b>	PWMA_BA+0x38 PWMB_BA+0x38	R	PWM Data Register 3	0x0000_0000
<b>PIER</b>	PWMA_BA+0x40 PWMB_BA+0x40	R/W	PWM Interrupt Enable Register	0x0000_0000
<b>PIIR</b>	PWMA_BA+0x44	R/W	PWM Interrupt Indication Register	0x0000_0000

	PWMB_BA+0x44			
<b>CCR0</b>	PWMA_BA+0x50 PWMB_BA+0x50	R/W	PWM Capture Control Register 0	0x0000_0000
<b>CCR2</b>	PWMA_BA+0x54 PWMB_BA+0x54	R/W	PWM Capture Control Register 2	0x0000_0000
<b>CRLR0</b>	PWMA_BA+0x58 PWMB_BA+0x58	R	PWM Capture Rising Latch Register (Channel 0)	0x0000_0000
<b>CFLR0</b>	PWMA_BA+0x5C PWMB_BA+0x5C	R	PWM Capture Falling Latch Register (Channel 0)	0x0000_0000
<b>CRLR1</b>	PWMA_BA+0x60 PWMB_BA+0x60	R	PWM Capture Rising Latch Register (Channel 1)	0x0000_0000
<b>CFLR1</b>	PWMA_BA+0x64 PWMB_BA+0x64	R	PWM Capture Falling Latch Register (Channel 1)	0x0000_0000
<b>CRLR2</b>	PWMA_BA+0x68 PWMB_BA+0x68	R	PWM Capture Rising Latch Register (Channel 2)	0x0000_0000
<b>CFLR2</b>	PWMA_BA+0x6C PWMB_BA+0x6C	R	PWM Capture Falling Latch Register (Channel 2)	0x0000_0000
<b>CRLR3</b>	PWMA_BA+0x70 PWMB_BA+0x70	R	PWM Capture Rising Latch Register (Channel 3)	0x0000_0000
<b>CFLR3</b>	PWMA_BA+0x74 PWMB_BA+0x74	R	PWM Capture Falling Latch Register (Channel 3)	0x0000_0000
<b>CAPENR</b>	PWMA_BA+0x78 PWMB_BA+0x78	R/W	PWM Capture Input 0~3 Enable Register	0x0000_0000
<b>POE</b>	PWMA_BA+0x7C PWMB_BA+0x7C	R/W	PWM Output Enable Register for Channel 0~3	0x0000_0000
<b>TCON</b>	PWMA_BA+0x80 PWMB_BA+0x80	R/W	PWM Trigger Control Register for Channel 0~3	0x0000_0000
<b>TSTATUS</b>	PWMA_BA+0x84 PWMB_BA+0x84	R/W	PWM Trigger Status Register	0x0000_0000
<b>PSCR</b>	PWMA_BA+0x98 PWMB_BA+0x98	R/W	PWM Synchronous Control Register	0x0000_0000

### 5.10.7 Register Description

#### PWM Prescaler Register (PPR)

Register	Offset	R/W	Description	Reset Value
PPR	PWMA_BA+0x00 PWMB_BA+0x00	R/W	PWM Prescaler Register	0x0000_0000

31	30	29	28	27	26	25	24
DZI23							
23	22	21	20	19	18	17	16
DZI01							
15	14	13	12	11	10	9	8
CP23							
7	6	5	4	3	2	1	0
CP01							

Bits	Description	
[31:24]	DZI23	<b>Dead-zone Interval For Pair Of Channel 2 And Channel 3 (PWM2 And PWM3 Pair For PWM Group A, PWM6 And PWM7 Pair For PWM Group B)</b> These 8-bit determine the Dead-zone length. The unit time of Dead-zone length = [(prescale+1)*(clock source divider)]/ PWMxy_CLK (where xy could be 23 or 67, depends on selected PWM channel.).
[23:16]	DZI01	<b>Dead-zone Interval For Pair Of Channel 0 And Channel 1 (PWM0 And PWM1 Pair For PWM Group A, PWM4 And PWM5 Pair For PWM Group B)</b> These 8-bit determine the Dead-zone length. The unit time of Dead-zone length = [(prescale+1)*(clock source divider)]/ PWMxy_CLK (where xy could be 01 or 45, depends on selected PWM channel.).
[15:8]	CP23	<b>Clock Prescaler 2 (PWM-timer 2 / 3 For Group A And PWM-timer 6 / 7 For Group B)</b> Clock input is divided by (CP23 + 1) before it is fed to the corresponding PWM-Timer. If CP23=0, then the clock prescaler 2 output clock will be stopped. So corresponding PWM-Timer will also be stopped.
[7:0]	CP01	<b>Clock Prescaler 0 (PWM-timer 0 / 1 For Group A And PWM-timer 4 / 5 For Group B)</b> Clock input is divided by (CP01 + 1) before it is fed to the corresponding PWM-Timer. If CP01=0, then the clock prescaler 0 output clock will be stopped. So corresponding PWM-Timer will also be stopped.

**PWM Clock Selector Register (CSR)**

Register	Offset	R/W	Description					Reset Value
CSR	PWMA_BA+0x04 PWMB_BA+0x04	R/W	PWM Clock Source Divider Select Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved	CSR3			Reserved	CSR2		
7	6	5	4	3	2	1	0
Reserved	CSR1			Reserved	CSR0		

Bits	Description													
[31:15]	Reserved	Reserved.												
[14:12]	CSR3	<b>PWM Timer 3 Clock Source Divider Selection (PWM Timer 3 For Group A And PWM Timer 7 For Group B)</b> Select clock source divider for PWM timer 3. <table border="1" style="margin-left: 20px;"> <tr> <th>CSR3 [14:12]</th> <th>Input Clock Divided by</th> </tr> <tr> <td>000</td> <td>2</td> </tr> <tr> <td>001</td> <td>4</td> </tr> <tr> <td>010</td> <td>8</td> </tr> <tr> <td>011</td> <td>16</td> </tr> <tr> <td>100</td> <td>1</td> </tr> </table>	CSR3 [14:12]	Input Clock Divided by	000	2	001	4	010	8	011	16	100	1
CSR3 [14:12]	Input Clock Divided by													
000	2													
001	4													
010	8													
011	16													
100	1													
[11]	Reserved	Reserved.												
[10:8]	CSR2	<b>PWM Timer 2 Clock Source Divider Selection (PWM Timer 2 For Group A And PWM Timer 6 For Group B)</b> Select clock source divider for PWM timer 2. (Table is the same as CSR3)												
[7]	Reserved	Reserved.												
[6:4]	CSR1	<b>PWM Timer 1 Clock Source Divider Selection (PWM Timer 1 For Group A And PWM Timer 5 For Group B)</b> Select clock source divider for PWM timer 1. (Table is the same as CSR3)												
[3]	Reserved	Reserved.												
[2:0]	CSR0	<b>PWM Timer 0 Clock Source Divider Selection (PWM Timer 0 For Group A And PWM Timer 4 For Group B)</b>												

		Select clock source divider for PWM timer 0. (Table is the same as CSR3)
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**PWM Control Register (PCR)**

Register	Offset	R/W	Description				Reset Value
PCR	PWMA_BA+0x08 PWMB_BA+0x08	R/W	PWM Control Register				0x0000_0000

31	30	29	28	27	26	25	24
PWM23TYPE	PWM01TYPE	Reserved		CH3MOD	CH3INV	CH3PINV	CH3EN
23	22	21	20	19	18	17	16
		Reserved		CH2MOD	CH2INV	CH2PINV	CH2EN
15	14	13	12	11	10	9	8
		Reserved		CH1MOD	CH1INV	CH1PINV	CH1EN
7	6	5	4	3	2	1	0
	Reserved		DZEN23	DZEN01	CH0MOD	CH0INV	CH0PINV
							CH0EN

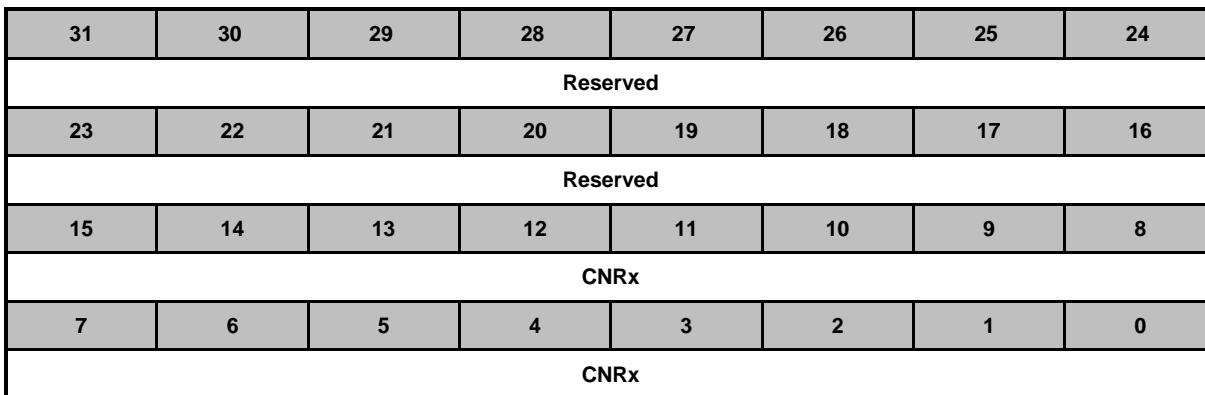
Bits	Description
[31]	<b>PWM23TYPE</b> <b>PWM23 Aligned Type Selection Bit (PWM2 And PWM3 Pair For PWM Group A, PWM6 And PWM7 Pair For PWM Group B)</b> 0 = Edge-aligned type. 1 = Center-aligned type.
[30]	<b>PWM01TYPE</b> <b>PWM01 Aligned Type Selection Bit (PWM0 And PWM1 Pair For PWM Group A, PWM4 And PWM5 Pair For PWM Group B)</b> 0 = Edge-aligned type. 1 = Center-aligned type.
[29:28]	<b>Reserved</b> Reserved.
[27]	<b>CH3MOD</b> <b>PWM-timer 3 Auto-reload/One-shot Mode Control (PWM Timer 3 For Group A And PWM Timer 7 For Group B)</b> 0 = One-shot mode. 1 = Auto-reload mode. <b>Note:</b> If there is a transition at this bit, it will cause CNR3 and CMR3 be cleared.
[26]	<b>CH3INV</b> <b>PWM-timer 3 Output Inverter Enable Control (PWM Timer 3 For Group A And PWM Timer 7 For Group B)</b> 0 = Inverter Disabled. 1 = Inverter Enabled.
[25]	<b>CH3PINV</b> <b>PWM-timer 3 Output Polar Inverse Enable Control (PWM Timer 3 For Group A And PWM Timer 7 For Group B)</b> 0 = Polar Inverter Disabled. 1 = Polar Inverter Enabled.
[24]	<b>CH3EN</b> <b>PWM-timer 3 Enable Control (PWM Timer 3 For Group A And PWM Timer 7 For Group B)</b> 0 = Corresponding PWM-Timer Stopped. 1 = Corresponding PWM-Timer Start Running.

[23:20]	<b>Reserved</b>	Reserved.
[19]	<b>CH2MOD</b>	<p><b>PWM-timer 2 Auto-reload/One-shot Mode Control (PWM Timer 2 For Group A And PWM Timer 6 For Group B)</b>            0 = One-shot mode.            1 = Auto-reload mode.</p> <p><b>Note:</b> If there is a transition at this bit, it will cause CNR2 and CMR2 be cleared.</p>
[18]	<b>CH2INV</b>	<p><b>PWM-timer 2 Output Inverter Enable Control (PWM Timer 2 For Group A And PWM Timer 6 For Group B)</b>            0 = Inverter Disabled.            1 = Inverter Enabled.</p>
[17]	<b>CH2PINV</b>	<p><b>PWM-timer 2 Output Polar Inverse Enable (PWM Timer 2 For Group A And PWM Timer 6 For Group B)</b>            0 = Polar Inverter Disabled.            1 = Polar Inverter Enabled.</p>
[16]	<b>CH2EN</b>	<p><b>PWM-timer 2 Enable (PWM Timer 2 For Group A And PWM Timer 6 For Group B)</b>            0 = Corresponding PWM-Timer Stopped.            1 = Corresponding PWM-Timer Start Running.</p>
[15:12]	<b>Reserved</b>	Reserved.
[11]	<b>CH1MOD</b>	<p><b>PWM-timer 1 Auto-reload/One-shot Mode (PWM Timer 1 For Group A And PWM Timer 5 For Group B)</b>            0 = One-shot mode.            1 = Auto-reload mode.</p> <p><b>Note:</b> If there is a transition at this bit, it will cause CNR1 and CMR1 be cleared.</p>
[10]	<b>CH1INV</b>	<p><b>PWM-timer 1 Output Inverter Enable (PWM Timer 1 For Group A And PWM Timer 5 For Group B)</b>            0 = Inverter Disabled.            1 = Inverter Enabled.</p>
[9]	<b>CH1PINV</b>	<p><b>PWM-timer 1 Output Polar Inverse Enable (PWM Timer 1 For Group A And PWM Timer 5 For Group B)</b>            0 = Polar Inverter Disabled.            1 = Polar Inverter Enabled.</p>
[8]	<b>CH1EN</b>	<p><b>PWM-timer 1 Enable (PWM Timer 1 For Group A And PWM Timer 5 For Group B)</b>            0 = Corresponding PWM-Timer Stopped.            1 = Corresponding PWM-Timer Start Running.</p>
[7:6]	<b>Reserved</b>	Reserved.
[5]	<b>DZEN23</b>	<p><b>Dead-zone 2 Generator Enable (PWM2 And PWM3 Pair For PWM Group A, PWM6 And PWM7 Pair For PWM Group B)</b>            0 = Disabled.            1 = Enabled.</p> <p><b>Note:</b> When Dead-zone generator is enabled, the pair of PWM2 and PWM3 becomes a complementary pair for PWM group A and the pair of PWM6 and PWM7 becomes a complementary pair for PWM group B.</p>
[4]	<b>DZEN01</b>	<p><b>Dead-zone 0 Generator Enable Control (PWM0 And PWM1 Pair For PWM Group A, PWM4 And PWM5 Pair For PWM Group B)</b>            0 = Disabled.            1 = Enabled.</p> <p><b>Note:</b> When Dead-zone generator is enabled, the pair of PWM0 and PWM1 becomes a complementary pair for PWM group A and the pair of PWM4 and PWM5 becomes a complementary</p>

		pair for PWM group B.
[3]	<b>CH0MOD</b>	<b>PWM-timer 0 Auto-reload/One-shot Mode Control (PWM Timer 0 For Group A And PWM Timer 4 For Group B)</b> 0 = One-shot mode. 1 = Auto-reload mode. <b>Note:</b> If there is a transition at this bit, it will cause CNR0 and CMR0 be cleared.
[2]	<b>CH0INV</b>	<b>PWM-timer 0 Output Inverter Enable Control (PWM Timer 0 For Group A And PWM Timer 4 For Group B)</b> 0 = Inverter Disabled. 1 = Inverter Enabled.
[1]	<b>CH0PINV</b>	<b>PWM-timer 0 Output Polar Inverse Enable Control (PWM Timer 0 For Group A And PWM Timer 4 For Group B)</b> 0 = Polar Inverter Disabled. 1 = Polar Inverter Enabled.
[0]	<b>CHOEN</b>	<b>PWM-timer 0 Enable Control (PWM Timer 0 For Group A And PWM Timer 4 For Group B)</b> 0 = The corresponding PWM-Timer stops running. 1 = The corresponding PWM-Timer starts running.

**PWM Counter Register 3-0 (CNR3-0)**

Register	Offset	R/W	Description	Reset Value
CNR0	PWMA_BA+0x0C PWMB_BA+0x0C	R/W	PWM Counter Register 0	0x0000_0000
CNR1	PWMA_BA+0x18 PWMB_BA+0x18	R/W	PWM Counter Register 1	0x0000_0000
CNR2	PWMA_BA+0x24 PWMB_BA+0x24	R/W	PWM Counter Register 2	0x0000_0000
CNR3	PWMA_BA+0x30 PWMB_BA+0x30	R/W	PWM Counter Register 3	0x0000_0000

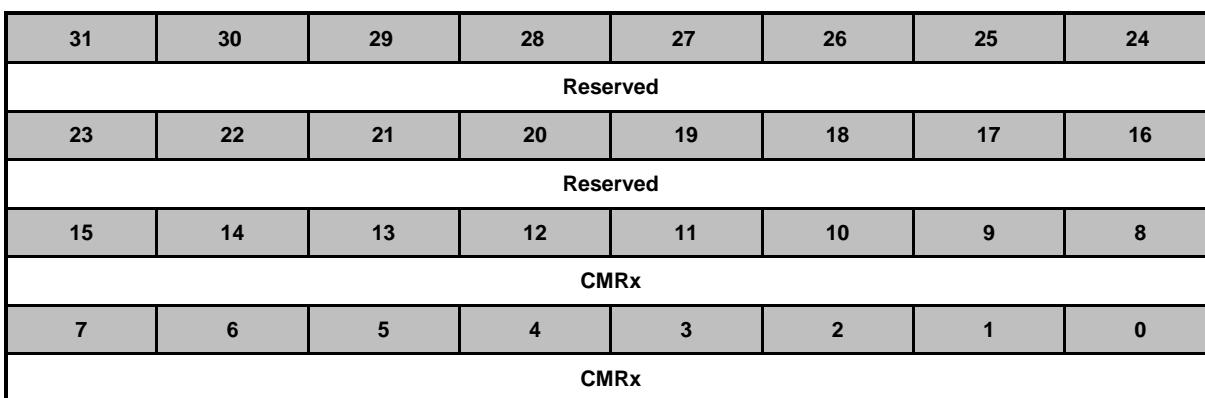


Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	CNRx	<p><b>PWM Timer Loaded Value</b>            CNR determines the PWM period.            PWM frequency = <math>\text{PWM}_{xy\_CLK}/[(\text{prescale}+1) * (\text{clock divider}) * (\text{CNR}+1)]</math>; where xy, could be 01, 23, 45 or 67, depends on selected PWM channel.</p> <p><b>For Edge-aligned Type:</b></p> <ul style="list-style-type: none"> <li>• Duty ratio = <math>(\text{CMR}+1)/(\text{CNR}+1)</math>.</li> <li>• <math>\text{CMR} \geq \text{CNR}</math>: PWM output is always high.</li> <li>• <math>\text{CMR} &lt; \text{CNR}</math>: PWM low width = <math>(\text{CNR}-\text{CMR})</math> unit; PWM high width = <math>(\text{CMR}+1)</math> unit.</li> <li>• <math>\text{CMR} = 0</math>: PWM low width = <math>(\text{CNR})</math> unit; PWM high width = 1 unit.</li> </ul> <p><b>For Center-aligned Type :</b></p> <ul style="list-style-type: none"> <li>• Duty ratio = <math>[(2 \times \text{CMR}) + 1]/[2 \times (\text{CNR}+1)]</math>.</li> <li>• <math>\text{CMR} &gt; \text{CNR}</math>: PWM output is always high.</li> <li>• <math>\text{CMR} \leq \text{CNR}</math>: PWM low width = <math>2 \times (\text{CNR}-\text{CMR}) + 1</math> unit; PWM high width = <math>(2 \times \text{CMR}) + 1</math> unit.</li> <li>• <math>\text{CMR} = 0</math>: PWM low width = <math>2 \times \text{CNR} + 1</math> unit; PWM high width = 1 unit.            (Unit = one PWM clock cycle).</li> </ul>

		<p><b>Note1:</b> Any write operation to CNR will take effect in next PWM cycle.</p> <p><b>Note2:</b> When CNR value is set to 0, PWM output is always high.</p> <p><b>Note3:</b> When PWM operating at center-aligned type, CNR value should be set between 0x0001 to 0xFFFF. If CNR equal to 0x0000 or 0xFFFF, the PWM will work unpredictable.</p>
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**PWM Comparator Register 3-0 (CMR3-0)**

Register	Offset	R/W	Description	Reset Value
CMR0	PWMA_BA+0x10 PWMB_BA+0x10	R/W	PWM Comparator Register 0	0x0000_0000
CMR1	PWMA_BA+0x1C PWMB_BA+0x1C	R/W	PWM Comparator Register 1	0x0000_0000
CMR2	PWMA_BA+0x28 PWMB_BA+0x28	R/W	PWM Comparator Register 2	0x0000_0000
CMR3	PWMA_BA+0x34 PWMB_BA+0x34	R/W	PWM Comparator Register 3	0x0000_0000

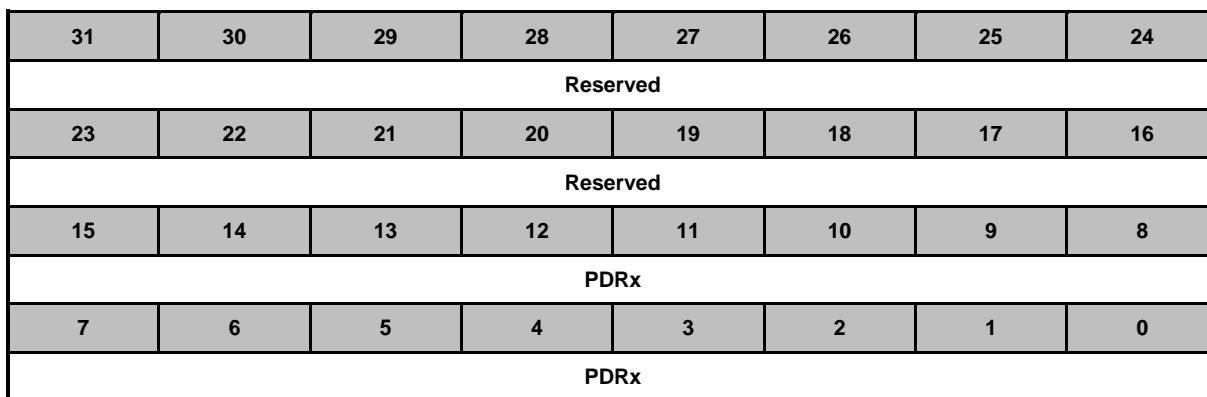


Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	CMRx	<p><b>PWM Comparator Register</b>            CMR determines the PWM duty.            PWM frequency = PWMxy_CLK/[(prescale+1)*(clock divider)*(CNR+1)]; where xy, could be 01, 23, 45 or 67, depends on selected PWM channel.</p> <p><b>For Edge-aligned Type:</b></p> <ul style="list-style-type: none"> <li>• Duty ratio = (CMR+1)/(CNR+1).</li> <li>• CMR &gt;= CNR: PWM output is always high.</li> <li>• CMR &lt; CNR: PWM low width = (CNR-CMR) unit; PWM high width = (CMR+1) unit.</li> <li>• CMR = 0: PWM low width = (CNR) unit; PWM high width = 1 unit.</li> </ul> <p>In Center-aligned Type :</p> <ul style="list-style-type: none"> <li>• Duty ratio = [(2 x CMR) + 1]/[2 x (CNR+1)].</li> <li>• CMR &gt; CNR: PWM output is always high.</li> <li>• CMR &lt;= CNR: PWM low width = 2 x (CNR-CMR) + 1 unit; PWM high width = (2 x CMR) + 1 unit.</li> <li>• CMR = 0: PWM low width = 2 x CNR + 1 unit; PWM high width = 1 unit.            (Unit = one PWM clock cycle).</li> </ul>

		<b>Note:</b> Any write operation to CMR will take effect in next PWM cycle.
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**PWM Data Register 3-0 (PDR 3-0)**

Register	Offset	R/W	Description	Reset Value
<b>PDR0</b>	PWMA_BA+0x14 PWMB_BA+0x14	R	PWM Data Register 0	0x0000_0000
<b>PDR1</b>	PWMA_BA+0x20 PWMB_BA+0x20	R	PWM Data Register 1	0x0000_0000
<b>PDR2</b>	PWMA_BA+0x2C PWMB_BA+0x2C	R	PWM Data Register 2	0x0000_0000
<b>PDR3</b>	PWMA_BA+0x38 PWMB_BA+0x38	R	PWM Data Register 3	0x0000_0000



Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	PDRx	<b>PWM Data Register</b> User can monitor PDR to know the current value in 16-bit counter.

**PWM Interrupt Enable Register (PIER)**

Register	Offset	R/W	Description				Reset Value
PIER	PWMA_BA+0x40 PWMB_BA+0x40	R/W	PWM Interrupt Enable Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved						INT23DTYPE	INT01DTYPE
23	22	21	20	19	18	17	16
Reserved						INT23TYPE	INT01TYPE
15	14	13	12	11	10	9	8
Reserved				PWMDIE3	PWMDIE2	PWMDIE1	PWMDIE0
7	6	5	4	3	2	1	0
Reserved				PWMIE3	PWMIE2	PWMIE1	PWMIE0

Bits	Description	
[31:26]	Reserved	Reserved.
[25]	INT23DTYPE	<p><b>PWM23 Duty Interrupt Type Selection (PWM2 And PWM3 Pair For PWM Group A, PWM6 And PWM7 Pair For PWM Group B)</b></p> <p>0 = PWMDIFx will be set if PWM counter down count and matches CMRx register. PWM will trigger ADC to conversion when PWM counter down count and matches CMRx register if correlate PWM trigger enable bit (PWMDTEN) is set to 1.</p> <p>1 = PWMDIFx will be set when PWM counter up count and matches CMRx register. PWM will trigger ADC to conversion when PWM counter up count and matches CMRx register if correlate PWM trigger enable bit (PWMDTEN) is set to 1.</p> <p><b>Note:</b> Set INT23DTYPE to 1 only work when PWM operating in center aligned type.</p>
[24]	INT01DTYPE	<p><b>PWM01 Duty Interrupt Type Selection (PWM0 And PWM1 Pair For PWM Group A, PWM4 And PWM5 Pair For PWM Group B)</b></p> <p>0 = PWMDIFx will be set if PWM counter down count and matches CMRx register. PWM will trigger ADC to conversion when PWM counter down count and matches CMRx register if correlate PWM trigger enable bit (PWMDTEN) is set to 1.</p> <p>1 = PWMDIFx will be set when PWM counter up count and matches CMRx register. PWM will trigger ADC to conversion when PWM counter up count and matches CMRx register if correlate PWM trigger enable bit (PWMDTEN) is set to 1.</p> <p><b>Note:</b> Set INT01DTYPE to 1 only work when PWM operating in center aligned type.</p>
[23:18]	Reserved	Reserved.
[17]	INT23TYPE	<p><b>PWM23 Interrupt Period Type Selection (PWM2 And PWM3 Pair For PWM Group A, PWM6 And PWM7 Pair For PWM Group B)</b></p> <p>0 = PWMIFx will be set if PWM counter underflow. PWM will trigger ADC to conversion when PWM counter underflow if correlate PWM trigger enable bit (PWMTEN) is set to 1.</p> <p>1 = PWMIFx will be set if PWM counter matches CNRx register. PWM will trigger ADC to conversion when PWM counter matches CNRx register if correlate PWM trigger enable bit (PWMTEN) is set to 1.</p> <p><b>Note:</b> Setting INT23TYPE to 1 only works when PWM operating is in center-aligned type.</p>
[16]	INT01TYPE	<b>PWM01 Interrupt Period Type Selection (PWM0 And PWM1 Pair For PWM Group A,</b>

		<b>PWM4 And PWM5 Pair For PWM Group B)</b> 0 = PWMIFx will be set if PWM counter underflow. PWM will trigger ADC to conversion when PWM counter underflow if correlate PWM trigger enable bit (PWMxTEN) is set to 1. 1 = PWMIFx will be set if PWM counter matches CNRx register. PWM will trigger ADC to conversion when PWM counter matches CNRx register if correlate PWM trigger enable bit (PWMxTEN) is set to 1. <b>Note:</b> Setting INT01TYPE to 1 only works when PWM operating is in center-aligned type.
[15:12]	<b>Reserved</b>	Reserved.
[11]	<b>PWMDIE3</b>	<b>PWM Channel 3 Duty Interrupt Enable Control</b> 0 = PWM channel 3 duty interrupt Disabled. 1 = PWM channel 3 duty interrupt Enabled.
[10]	<b>PWMDIE2</b>	<b>PWM Channel 2 Duty Interrupt Enable Control</b> 0 = PWM channel 2 duty interrupt Disabled. 1 = PWM channel 2 duty interrupt Enabled.
[9]	<b>PWMDIE1</b>	<b>PWM Channel 1 Duty Interrupt Enable Control</b> 0 = PWM channel 1 duty interrupt Disabled. 1 = PWM channel 1 duty interrupt Enabled.
[8]	<b>PWMDIE0</b>	<b>PWM Channel 0 Duty Interrupt Enable Control</b> 0 = PWM channel 0 duty interrupt Disabled. 1 = PWM channel 0 duty interrupt Enabled.
[3]	<b>PWMIE3</b>	<b>PWM Channel 3 Period Interrupt Enable Control</b> 0 = PWM channel 3 period interrupt Disabled. 1 = PWM channel 3 period interrupt Enabled.
[2]	<b>PWMIE2</b>	<b>PWM Channel 2 Period Interrupt Enable Control</b> 0 = PWM channel 2 period interrupt Disabled. 1 = PWM channel 2 period interrupt Enabled.
[1]	<b>PWMIE1</b>	<b>PWM Channel 1 Period Interrupt Enable Control</b> 0 = PWM channel 1 period interrupt Disabled. 1 = PWM channel 1 period interrupt Enabled.
[0]	<b>PWMIE0</b>	<b>PWM Channel 0 Period Interrupt Enable Control</b> 0 = PWM channel 0 period interrupt Disabled. 1 = PWM channel 0 period interrupt Enabled.

**PWM Interrupt Indication Register (PIIR)**

Register	Offset	R/W	Description				Reset Value
PIIR	PWMA_BA+0x44 PWMB_BA+0x44	R/W	PWM Interrupt Indication Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				PWMDIF3	PWMDIF2	PWMDIF1	PWMDIFO
7	6	5	4	3	2	1	0
Reserved				PWMIF3	PWMIF2	PWMIF1	PWMIFO

Bits	Description	
[31:12]	Reserved	Reserved.
[11]	PWMDIF3	<p><b>PWM Channel 3 Duty Interrupt Status</b></p> <p>When INTDTYPE23 = 0, this bit is set by hardware when channel 3 PWM counter equals CMR3 on down-count.</p> <p>When INTDTYPE23 = 1, this bit is set by hardware when channel 3 PWM counter equals CMR3 on up-count.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[10]	PWMDIF2	<p><b>PWM Channel 2 Duty Interrupt Status</b></p> <p>When INTDTYPE23 = 0, this bit is set by hardware when channel 2 PWM counter equals CMR2 on down-count.</p> <p>When INTDTYPE23 = 1, this bit is set by hardware when channel 2 PWM counter equals CMR2 on up-count.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[9]	PWMDIF1	<p><b>PWM Channel 1 Duty Interrupt Status</b></p> <p>When INTDTYPE01 = 0, this bit is set by hardware when channel 1 PWM counter equals CMR1 on down-count.</p> <p>When INTDTYPE01 = 1, this bit is set by hardware when channel 1 PWM counter equals CMR1 on up-count.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[8]	PWMDIFO	<p><b>PWM Channel 0 Duty Interrupt Status</b></p> <p>When INTDTYPE01 = 0, this bit is set by hardware when channel 0 PWM counter equals CMR0 on down-count.</p> <p>When INTDTYPE01 = 1, this bit is set by hardware when channel 0 PWM counter equals CMR0 on up-count.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[7:4]	Reserved	Reserved.
[3]	PWMIF3	<b>PWM Channel 3 Period Interrupt Status</b>

		When INTTYPE23 = 0, this bit is set by hardware when channel 3 PWM counter equals 0. When INTTYPE23 = 1, this bit is set by hardware when channel 3 PWM counter equals CNR3. <b>Note:</b> Write 1 to clear this bit to 0.
[2]	<b>PWMIF2</b>	<b>PWM Channel 2 Period Interrupt Status</b> When INTTYPE23 = 0, this bit is set by hardware when channel 2 PWM counter equals 0. When INTTYPE23 = 1, this bit is set by hardware when channel 2 PWM counter equals CNR2. <b>Note:</b> Write 1 to clear this bit to 0.
[1]	<b>PWMIF1</b>	<b>PWM Channel 1 Period Interrupt Status</b> When INTTYPE01 = 0, this bit is set by hardware when channel 1 PWM counter equals 0. When INTTYPE01 = 1, this bit is set by hardware when channel 1 PWM counter equals CNR1. <b>Note:</b> Write 1 to clear this bit to 0.
[0]	<b>PWMIF0</b>	<b>PWM Channel 0 Period Interrupt Status</b> When INTTYPE01 = 0, this bit is set by hardware when channel 0 PWM counter equals 0. When INTTYPE01 = 1, this bit is set by hardware when channel 0 PWM counter equals CNR0. <b>Note:</b> Write 1 to clear this bit to 0.

Capture Control Register (CCR0)

Register	Offset	R/W	Description				Reset Value
CCR0	PWMA_BA+0x50 PWMB_BA+0x50	R/W	PWM Capture Control Register 0				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
CFLRI1	CRLRI1	Reserved	CAPIF1	CAPCH1EN	CFL_IE1	CRL_IE1	INV1
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
CFLRI0	CRLRI0	Reserved	CAPIF0	CAPCH0EN	CFL_IE0	CRL_IE0	INV0

Bits	Description	
[31:24]	Reserved	Reserved.
[23]	CFLRI1	<p><b>CFLR1 Latched Indicator</b>  When PWM group input channel 1 has a falling transition, CFLR1 was latched with the value of PWM down-counter and this bit is set by hardware.  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[22]	CRLRI1	<p><b>CRLR1 Latched Indicator</b>  When PWM group input channel 1 has a rising transition, CRLR1 was latched with the value of PWM down-counter and this bit is set by hardware.  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[21]	Reserved	Reserved.
[20]	CAPIF1	<p><b>Channel 1 Capture Interrupt Indication Flag</b>  If PWM group channel 1 rising latch interrupt is enabled (CRL_IE1 = 1), a rising transition occurs at PWM group channel 1 will result in CAPIF1 to high; Similarly, a falling transition will cause CAPIF1 to be set high if PWM group channel 1 falling latch interrupt is enabled (CFL_IE1 = 1).  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[19]	CAPCH1EN	<p><b>Channel 1 Capture Function Enable Control</b>  0 = Capture function on PWM group channel 1 Disabled.  1 = Capture function on PWM group channel 1 Enabled.  <b>Note1:</b> When Enabled, Capture latched the PWM-counter and saved to CRLR (Rising latch) and CFLR (Falling latch).  <b>Note2:</b> When Disabled, Capture does not update CRLR and CFLR, and disable PWM group channel 1 Interrupt.</p>
[18]	CFL_IE1	<p><b>Channel 1 Falling Latch Interrupt Enable Control</b>  0 = Falling latch interrupt Disabled.  1 = Falling latch interrupt Enabled.  <b>Note:</b> When Enabled, if Capture detects PWM group channel 1 has falling transition,</p>

		Capture will issue an Interrupt.
[17]	<b>CRL_IE1</b>	<p><b>Channel 1 Rising Latch Interrupt Enable Control</b>            0 = Rising latch interrupt Disabled.            1 = Rising latch interrupt Enabled.</p> <p><b>Note:</b> When Enabled, if Capture detects PWM group channel 1 has rising transition, Capture will issue an Interrupt.</p>
[16]	<b>INV1</b>	<p><b>Capture Channel 1 Inverter Enable Control</b>            0 = Inverter Disabled.            1 = Inverter Enabled. Reverse the input signal from GPIO before fed to Capture timer.</p>
[15:8]	<b>Reserved</b>	Reserved.
[7]	<b>CFLRI0</b>	<p><b>CFLR0 Latched Indicator Control</b>            When PWM group input channel 0 has a falling transition, CFLR0 was latched with the value of PWM down-counter and this bit is set by hardware.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[6]	<b>CRLRI0</b>	<p><b>CRLR0 Latched Indicator</b>            When PWM group input channel 0 has a rising transition, CRLR0 was latched with the value of PWM down-counter and this bit is set by hardware.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[5]	<b>Reserved</b>	Reserved.
[4]	<b>CAPIF0</b>	<p><b>Channel 0 Capture Interrupt Indication Flag</b>            If PWM group channel 0 rising latch interrupt is enabled (CRLIE0 = 1), a rising transition occurs at PWM group channel 0 will result in CAPIF0 to high; Similarly, a falling transition will cause CAPIF0 to be set high if PWM group channel 0 falling latch interrupt is enabled (CFLIE0 = 1).</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[3]	<b>CAPCH0EN</b>	<p><b>Channel 0 Capture Function Enable Control</b>            0 = Capture function on PWM group channel 0 Disabled.            1 = Capture function on PWM group channel 0 Enabled.</p> <p><b>Note1:</b> When Enabled, Capture latches the PWM-counter value and saved to CRLR (Rising latch) and CFLR (Falling latch).</p> <p><b>Note2:</b> When Disabled, Capture does not update CRLR and CFLR, and disable PWM group channel 0 Interrupt.</p>
[2]	<b>CFLIE0</b>	<p><b>Channel 0 Falling Latch Interrupt Enable Control</b>            0 = Falling latch interrupt Disabled.            1 = Falling latch interrupt Enabled.</p> <p><b>Note:</b> When Enabled, if Capture detects PWM group channel 0 has falling transition, and Capture will issue an Interrupt.</p>
[1]	<b>CRLIE0</b>	<p><b>Channel 0 Rising Latch Interrupt Enable Control</b>            0 = Rising latch interrupt Disabled.            1 = Rising latch interrupt Enabled.</p> <p><b>Note:</b> When Enabled, if Capture detects PWM group channel 0 has rising transition, Capture will issue an Interrupt.</p>
[0]	<b>INV0</b>	<p><b>Capture Channel 0 Inverter Enable Control</b>            0 = Inverter Disabled.            1 = Inverter Enabled. Reverse the input signal from GPIO before fed to Capture timer.</p>

**Capture Control Register (CCR2)**

Register	Offset	R/W	Description				Reset Value
CCR2	PWMA_BA+0x54 PWMB_BA+0x54	R/W	PWM Capture Control Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
CFLRI3	CRLRI3	Reserved	CAPIF3	CAPCH3EN	CFL_IE3	CRLIE3	INV3
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
CFLRI2	CRLRI2	Reserved	CAPIF2	CAPCH2EN	CFLIE2	CRLIE2	INV2

Bits	Description	
[31:24]	Reserved	Reserved.
[23]	CFLRI3	<b>CFLR3 Latched Indicator</b> When PWM group input channel 3 has a falling transition, CFLR3 was latched with the value of PWM down-counter and this bit is set by hardware. <b>Note:</b> Write 1 to clear this bit to 0.
[22]	CRLRI3	<b>CRLR3 Latched Indicator</b> When PWM group input channel 3 has a rising transition, CRLR3 was latched with the value of PWM down-counter and this bit is set by hardware. <b>Note:</b> Write 1 to clear this bit to 0.
[21]	Reserved	Reserved.
[20]	CAPIF3	<b>Channel 3 Capture Interrupt Indication Flag</b> If PWM group channel 3 rising latch interrupt is enabled (CRLIE3=1), a rising transition occurs at PWM group channel 3 will result in CAPIF3 to high; Similarly, a falling transition will cause CAPIF3 to be set high if PWM group channel 3 falling latch interrupt is enabled (CFLIE3=1). <b>Note:</b> Write 1 to clear this bit to 0.
[19]	CAPCH3EN	<b>Channel 3 Capture Function Enable Control</b> 0 = Capture function on PWM group channel 3 Disabled. 1 = Capture function on PWM group channel 3 Enabled. <b>Note1:</b> When Enabled, Capture latched the PWM-counter and saved to CRLR (Rising latch) and CFLR (Falling latch). <b>Note2:</b> When Disabled, Capture does not update CRLR and CFLR, and disable PWM group channel 3 Interrupt.
[18]	CFLIE3	<b>Channel 3 Falling Latch Interrupt Enable Control</b> 0 = Falling latch interrupt Disabled. 1 = Falling latch interrupt Enabled.

		<b>Note:</b> When Enabled, if Capture detects PWM group channel 3 has falling transition, Capture will issue an Interrupt.
[17]	CRL_IE3	<p><b>Channel 3 Rising Latch Interrupt Enable Control</b>            0 = Rising latch interrupt Disabled.            1 = Rising latch interrupt Enabled.</p> <p><b>Note:</b> When Enabled, if Capture detects PWM group channel 3 has rising transition, Capture will issue an Interrupt.</p>
[16]	INV3	<p><b>Capture Channel 3 Inverter Enable Control</b>            0 = Inverter Disabled.            1 = Inverter Enabled. Reverse the input signal from GPIO before fed to Capture timer.</p>
[15:8]	Reserved	Reserved.
[7]	CFLRI2	<p><b>CFLR2 Latched Indicator</b>            When PWM group input channel 2 has a falling transition, CFLR2 was latched with the value of PWM down-counter and this bit is set by hardware.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[6]	CRLRI2	<p><b>CRLR2 Latched Indicator</b>            When PWM group input channel 2 has a rising transition, CRLR2 was latched with the value of PWM down-counter and this bit is set by hardware.</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[5]	Reserved	Reserved.
[4]	CAPIF2	<p><b>Channel 2 Capture Interrupt Indication Flag</b>            If PWM group channel 2 rising latch interrupt is enabled (CRLIE2=1), a rising transition occurs at PWM group channel 2 will result in CAPIF2 to high; Similarly, a falling transition will cause CAPIF2 to be set high if PWM group channel 2 falling latch interrupt is enabled (CFLIE2=1).</p> <p><b>Note:</b> Write 1 to clear this bit to 0.</p>
[3]	CAPCH2EN	<p><b>Channel 2 Capture Function Enable Control</b>            1 = Capture function on PWM group channel 2 Enabled.            0 = Capture function on PWM group channel 2 Disabled.</p> <p><b>Note1:</b> When Enabled, Capture latched the PWM-counter value and saved to CRLR (Rising latch) and CFLR (Falling latch).</p> <p><b>Note2:</b> When Disabled, Capture does not update CRLR and CFLR, and disable PWM group channel 2 Interrupt.</p>
[2]	CFLIE2	<p><b>Channel 2 Falling Latch Interrupt Enable Control</b>            0 = Falling latch interrupt Disabled.            1 = Falling latch interrupt Enabled.</p> <p><b>Note:</b> When Enabled, if Capture detects PWM group channel 2 has falling transition, Capture will issue an Interrupt.</p>
[1]	CRLIE2	<p><b>Channel 2 Rising Latch Interrupt Enable Control</b>            0 = Rising latch interrupt Disabled.            1 = Rising latch interrupt Enabled.</p> <p><b>Note:</b> When Enabled, if Capture detects PWM group channel 2 has rising transition, Capture will issue an Interrupt.</p>
[0]	INV2	<p><b>Capture Channel 2 Inverter Enable Control</b>            0 = Inverter Disabled.            1 = Inverter Enabled. Reverse the input signal from GPIO before fed to Capture timer.</p>

**Capture Rising Latch Register3-0 (CRLR3-0)**

Register	Offset	R/W	Description	Reset Value
CRLR0	PWMA_BA+0x58 PWMB_BA+0x58	R	PWM Capture Rising Latch Register (Channel 0)	0x0000_0000
CRLR1	PWMA_BA+0x60 PWMB_BA+0x60	R	PWM Capture Rising Latch Register (Channel 1)	0x0000_0000
CRLR2	PWMA_BA+0x68 PWMB_BA+0x68	R	PWM Capture Rising Latch Register (Channel 2)	0x0000_0000
CRLR3	PWMA_BA+0x70 PWMB_BA+0x70	R	PWM Capture Rising Latch Register (Channel 3)	0x0000_0000

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

Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	CRLRx	<b>Capture Rising Latch Register</b> Latch the PWM counter value when Channel 0/1/2/3 has rising transition.

Capture Falling Latch Register3-0 (CFLR3-0)

Register	Offset	R/W	Description	Reset Value
CFLR0	PWMA_BA+0x5C PWMB_BA+0x5C	R	PWM Capture Falling Latch Register (Channel 0)	0x0000_0000
CFLR1	PWMA_BA+0x64 PWMB_BA+0x64	R	PWM Capture Falling Latch Register (Channel 1)	0x0000_0000
CFLR2	PWMA_BA+0x6C PWMB_BA+0x6C	R	PWM Capture Falling Latch Register (Channel 2)	0x0000_0000
CFLR3	PWMA_BA+0x74 PWMB_BA+0x74	R	PWM Capture Falling Latch Register (Channel 3)	0x0000_0000

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

Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	CFLRx	<b>Capture Falling Latch Register</b> Latch the PWM counter value when Channel 0/1/2/3 has Falling transition.

**Capture Input Enable Register (CAPENR)**

Register	Offset	R/W	Description				Reset Value
CAPENR	PWMA_BA+0x78 PWMB_BA+0x78	R/W	PWM Capture Input 0~3 Enable Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved				<b>CAPENR</b>			

Bits	Description	
[31:4]	<b>Reserved</b>	Reserved.
[3:0]	<b>CAPENR</b>	<p><b>Capture Input Enable Register</b></p> <p>0 = Capture input Disabled. (PWMx multi-function pin input does not affect input capture function.)</p> <p>1 = Capture input Enabled. (PWMx multi-function pin input will affect its input capture function.)</p> <p><b>CAPENR</b></p> <p><b>Bit 3210 for PWM group A</b></p> <p>Bit xxx1 → Capture channel 0 enabled. Capture input channel can be from P2.0 or P4.0. User can only select one of pins by setting multi-function pin register.</p> <p>Bit xx1x → Capture channel 1 enabled. Capture input channel can be from P2.1 or P4.1. User can only select one of pins by setting multi-function pin register.</p> <p>Bit x1xx → Capture channel 2 enabled. Capture input channel can be from P2.2 or P4.2. User can only select one of pins by setting multi-function pin register.</p> <p>Bit 1xxx → Capture channel 3 enabled. Capture input channel can be from P2.3 or P4.3. User can only select one of pins by setting multi-function pin register.</p> <p><b>Bit 3210 for PWM group B</b></p> <p>Bit xxx1 → Capture channel 0 enabled. Capture input channel can be from P2.4 by setting multi-function pin register.</p> <p>Bit xx1x → Capture channel 1 enabled. Capture input channel can be from P2.5 by setting multi-function pin register.</p> <p>Bit x1xx → Capture channel 2 enabled. Capture input channel can be from P2.6 by setting multi-function pin register.</p> <p>Bit 1xxx → Capture channel 3 enabled. Capture input channel can be from P2.7 by setting multi-function pin register.</p>

**PWM Output Enable Register (POE)**

Register	Offset	R/W	Description				Reset Value
POE	PWMA_BA+0x7C PWMB_BA+0x7C	R/W	PWM Output Enable Register for Channel 0~3				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved				PWM3	PWM2	PWM1	PWM0

Bits	Description	
[31:4]	Reserved	Reserved.
[3]	PWM3	<b>Channel 3 Output Enable Register</b> 0 = PWM channel 3 output to pin Disabled. 1 = PWM channel 3 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must also be switched to PWM function.
[2]	PWM2	<b>Channel 2 Output Enable Register</b> 0 = PWM channel 2 output to pin Disabled. 1 = PWM channel 2 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must also be switched to PWM function.
[1]	PWM1	<b>Channel 1 Output Enable Register</b> 0 = PWM channel 1 output to pin Disabled. 1 = PWM channel 1 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must also be switched to PWM function.
[0]	PWM0	<b>Channel 0 Output Enable Register</b> 0 = PWM channel 0 output to pin Disabled. 1 = PWM channel 0 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must also be switched to PWM function.

**PWM Trigger Control Register (TCON)**

Register	Offset	R/W	Description				Reset Value
TCON	PWMA_BA+0x80 PWMB_BA+0x80	R/W	PWM Trigger Control Register for Channel 0~3				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				PWM3DTEN	PWM2DTEN	PWM1DTEN	PWM0DTEN
7	6	5	4	3	2	1	0
Reserved				PWM3TEN	PWM2TEN	PWM1TEN	PWM0TEN

Bits	Description	
[31:12]	Reserved	Reserved.
[11]	PWM3DTEN	<p><b>Channel 3 PWM Duty Trigger ADC Enable Control</b>            0 = PWM channel 3 duty trigger ADC function Disabled.            1 = PWM channel 3 duty trigger ADC function Enabled.</p> <p>As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 3 counter down count to match CMR3.</p> <p>As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 3 counter up count or down count to match CMR3 based on INT23DTYPE setting.</p>
[10]	PWM2DTEN	<p><b>Channel 2 PWM Duty Trigger ADC Enable Control</b>            0 = PWM channel 2 duty trigger ADC function Disabled.            1 = PWM channel 2 duty trigger ADC function Enabled.</p> <p>As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 2 counter down count to match CMR2.</p> <p>As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 2 counter up count or down count to match CMR2 based on INT23DTYPE setting.</p>
[9]	PWM1DTEN	<p><b>Channel 1 PWM Duty Trigger ADC Enable Control</b>            0 = PWM channel 1 duty trigger ADC function Disabled.            1 = PWM channel 1 duty trigger ADC function Enabled.</p> <p>As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 1 counter down count to match CMR1.</p> <p>As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 1 counter up count or down count to match CMR1 based on INT01DTYPE setting.</p>
[8]	PWM0DTEN	<b>Channel 0 PWM Duty Trigger ADC Enable Control</b> 0 = PWM channel 0 duty trigger ADC function Disabled.

		1 = PWM channel 0 duty trigger ADC function Enabled. As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 0 counter down count to match CMR0. As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 0 counter up count or down count to match CMR0 based on INT01PTYPE setting.
[7:4]	<b>Reserved</b>	Reserved.
[3]	<b>PWM3TEN</b>	<b>Channel 3 PWM Period Trigger ADC Enable Control</b> 0 = PWM channel 3 period trigger ADC function Disabled. 1 = PWM channel 3 period trigger ADC function Enabled. As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 3 counter down count to underflow. As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 3 counter up count to (CNR3 + 1) or down count to underflow based on INT23PTYPE setting.
[2]	<b>PWM2TEN</b>	<b>Channel 2 PWM Period Trigger ADC Enable Control</b> 0 = PWM channel 2 period trigger ADC function Disabled. 1 = PWM channel 2 period trigger ADC function Enabled. As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 2 counter down count to underflow. As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 2 counter up count to (CNR2 + 1) or down count to underflow based on INT23PTYPE setting.
[1]	<b>PWM1TEN</b>	<b>Channel 1 PWM Period Trigger ADC Enable Control</b> 0 = PWM channel 1 period trigger ADC function Disabled. 1 = PWM channel 1 period trigger ADC function Enabled. As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 1 counter down count to underflow. As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 1 counter up count to (CNR1 + 1) or down count to underflow based on INT01PTYPE setting.
[0]	<b>PWM0TEN</b>	<b>Channel 0 PWM Period Trigger ADC Enable Control</b> 0 = PWM channel 0 period trigger ADC function Disabled. 1 = PWM channel 0 period trigger ADC function Enabled. As PWM operating at edge-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 0 counter down count to underflow. As PWM operating at center-aligned type, enable this bit can make PWM trigger ADC to start conversion when PWM channel 0 counter up count to (CNR0 + 1) or down count to underflow based on INT01PTYPE setting.

**PWM Trigger Status Register (TSTATUS)**

Register	Offset	R/W	Description				Reset Value
TSTATUS	PWMA_BA+0x84 PWMB_BA+0x84	R/W	PWM Trigger Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved				PWM3TF	PWM2TF	PWM1TF	PWM0TF

Bits	Description	
[31:4]	Reserved	Reserved.
[3]	PWM3TF	<p><b>Channel 3 PWM Trigger ADC Flag</b>  This bit is set to 1 by hardware when PWM channel 3 trigger ADC condition matched. ADC will start conversion if ADC triggered source is selected by PWM while this bit is set to 1.  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[2]	PWM2TF	<p><b>Channel 2 PWM Trigger ADC Flag</b>  This bit is set to 1 by hardware when PWM channel 2 trigger ADC condition matched. ADC will start conversion if ADC triggered source is selected by PWM while this bit is set to 1.  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[1]	PWM1TF	<p><b>Channel 1 PWM Trigger ADC Flag</b>  This bit is set to 1 by hardware when PWM channel 1 trigger ADC condition matched. ADC will start conversion if ADC triggered source is selected by PWM while this bit is set to 1.  <b>Note:</b> Write 1 to clear this bit to 0.</p>
[0]	PWM0TF	<p><b>Channel 0 PWM Trigger ADC Flag</b>  This bit is set to 1 by hardware when PWM channel 0 trigger ADC condition matched. ADC will start conversion if ADC triggered source is selected by PWM while this bit is set to 1.  <b>Note:</b> Write 1 to clear this bit to 0.</p>

**PWM Synchronous Control Register (PSCR)**

Register	Offset	R/W	Description				Reset Value
PSCR	PWMA_BA+0x98 PWMB_BA+0x98	R/W	PWM Synchronous Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							PSSEN3
23	22	21	20	19	18	17	16
Reserved							PSSEN2
15	14	13	12	11	10	9	8
Reserved							PSSEN1
7	6	5	4	3	2	1	0
Reserved							PSSEN0

Bits	Description	
[31:25]	Reserved	Reserved.
[24]	PSSEN3	<b>Channel 3 PWM-timer Synchronous Start Enable Control</b> 0 = Channel 3 PWM-Timer Synchronous Start Disabled. 1 = Channel 3 PWM-Timer Synchronous Start Enabled. If this bit is set to 1, the PWM-Timer channel 3 of specified PWM group will synchronously start with PWM-Timer channel 0 of PWM group A when SW writes 1 to CHOEN(PCR[0]) in PWM group A.
[23:17]	Reserved	Reserved.
[16]	PSSEN2	<b>Channel 2 PWM-timer Synchronous Start Enable Control</b> 0 = Channel 2 PWM-Timer Synchronous Start Disabled. 1 = Channel 2 PWM-Timer Synchronous Start Enabled. If this bit is set to 1, the PWM-Timer channel 2 of specified PWM group will synchronously start with PWM-Timer channel 0 of PWM group A when SW writes 1 to CHOEN(PCR[0]) in PWM group A.
[15:9]	Reserved	Reserved.
[8]	PSSEN1	<b>Channel 1 PWM-timer Synchronous Start Enable Control</b> 0 = Channel 1 PWM-Timer Synchronous Start Disabled. 1 = Channel 1 PWM-Timer Synchronous Start Enabled. If this bit is set to 1, the PWM-Timer channel 1 of specified PWM group will synchronously start with PWM-Timer channel 0 of PWM group A when SW writes 1 to CHOEN(PCR[0]) in PWM group A.
[7:1]	Reserved	Reserved.
[0]	PSSEN0	<b>Channel 0 PWM-timer Synchronous Start Enable Control</b> 0 = Channel 0 PWM-Timer Synchronous Start Disabled. 1 = Channel 0 PWM-Timer Synchronous Start Enabled. If this bit is set to 1, the PWM-Timer channel 0 of specified PWM group will

		synchronously start with PWM-Timer channel 0 of PWM group A when SW writes 1 to CH0EN(PCR[0]) in PWM group A.
--	--	---

## 5.11 Enhanced PWM Generator (NUC029FAE Only)

### 5.11.1 Overview

The NuMicro® NUC029FAE has built one PWM unit which is specially designed for motor driving control applications. The PWM unit supports six PWM generators which can be configured as three independent PWM outputs, PWM2, PWM3 and PWM5, or as three complementary PWM pairs, (PWM0, PWM1), (PWM2, PWM3) and (PWM4, PWM5) with three programmable dead-zone generators.

Every complementary PWM pairs share one 8-bit prescaler. There are six clock dividers providing five divided frequencies (1, 1/2, 1/4, 1/8, 1/16) for each channel. Each PWM output has independent 16-bit counter for PWM period control, and 16-bit comparators for PWM duty control. The six PWM generators provide twelve independent PWM interrupt flags which are set by hardware when the corresponding PWM period counter comparison matched period and duty. Each PWM interrupt source with its corresponding enable bit can request PWM interrupt. The PWM generators can be configured as One-shot mode to produce only one PWM cycle signal or Auto-reload mode to output PWM waveform continuously.

To prevent PWM driving output pin with unsteady waveform, the 16-bit period down counter and 16-bit comparator are implemented with double buffer. When user writes data to counter/comparator buffer registers, the updated value will be loaded into the 16-bit down counter/ comparator at the end of current period. The double buffering feature avoids glitch at PWM outputs.

Besides PWM, Motor controlling also need Timer, ACMP and ADC to work together. In order to control motor more precisely, we provide some registers that not only configure PWM but also Timer, ADC and ACMP, by doing so, it can save more CPU time and control motor with ease especially in BLDC.

### 5.11.2 Features

The PWM unit supports the following features:

- Independent 16-bit PWM duty control units with maximum six port pins:
  - Three independent PWM outputs –PWM2, PWM3 and PWM5
  - Three complementary PWM pairs, with each pin in a pair mutually complement to each other and capable of programmable dead-zone insertion – (PWM0, PWM1), (PWM2, PWM3) and (PWM4, PWM5)
- Group control bit – PWM2 and PWM4 are synchronized with PWM0, PWM3 and PWM5 are synchronized with PWM1
- One-shot (only support edge alignment mode) or Auto-reload mode PWM
- Up to 16-bit resolution
- Supports Edge-aligned and Center-aligned mode
- Programmable dead-zone insertion between complementary paired PWMs
- Each pin of PWM0 to PWM5 has independent polarity setting control
- Hardware fault brake protections
  - Two Interrupt source types:

- Synchronously requested at PWM frequency when down counter comparison matched (edge- and center-aligned mode) or underflow (edge-aligned mode)
- Requested when external fault brake asserted
  - ◆ BKP0: EINT0 or CPO1
- The PWM signals before polarity control stage are defined in the view of positive logic. The PWM ports is active high or active low are controlled by polarity control register
- Supports independently rising CMR matching (in Center-aligned mode), CNR matching (in Center-aligned mode), falling CMR matching, period matching to trigger ADC conversion
- Timer comparing matching event trigger PWM to do phase change in BLDC application
- Supports ACMP output event trigger PWM to force PWM output at most one period low, this feature is usually for step motor control
- Provides interrupt accumulation function

### 5.11.3 Block Diagram

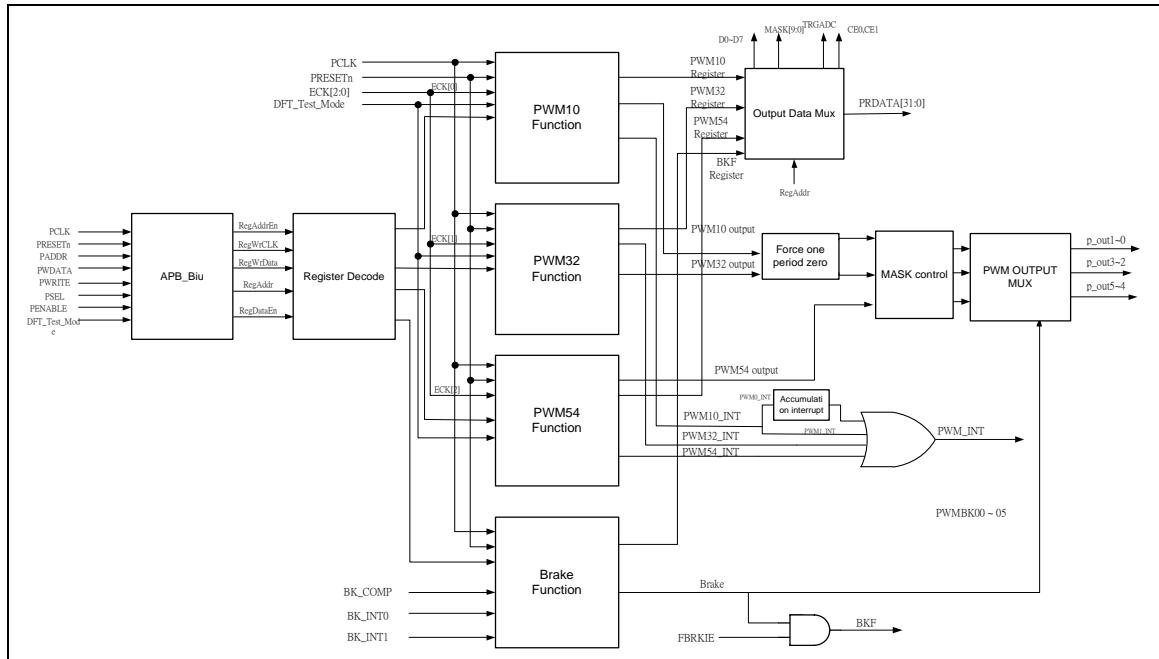


Figure 5-67 PWM Block Diagram

The following figures illustrate the architecture of PWM in pair (e.g. PWM-Timer 0/1 are in one pair and PWM-Timer 2/3 are in another one, and so on.).

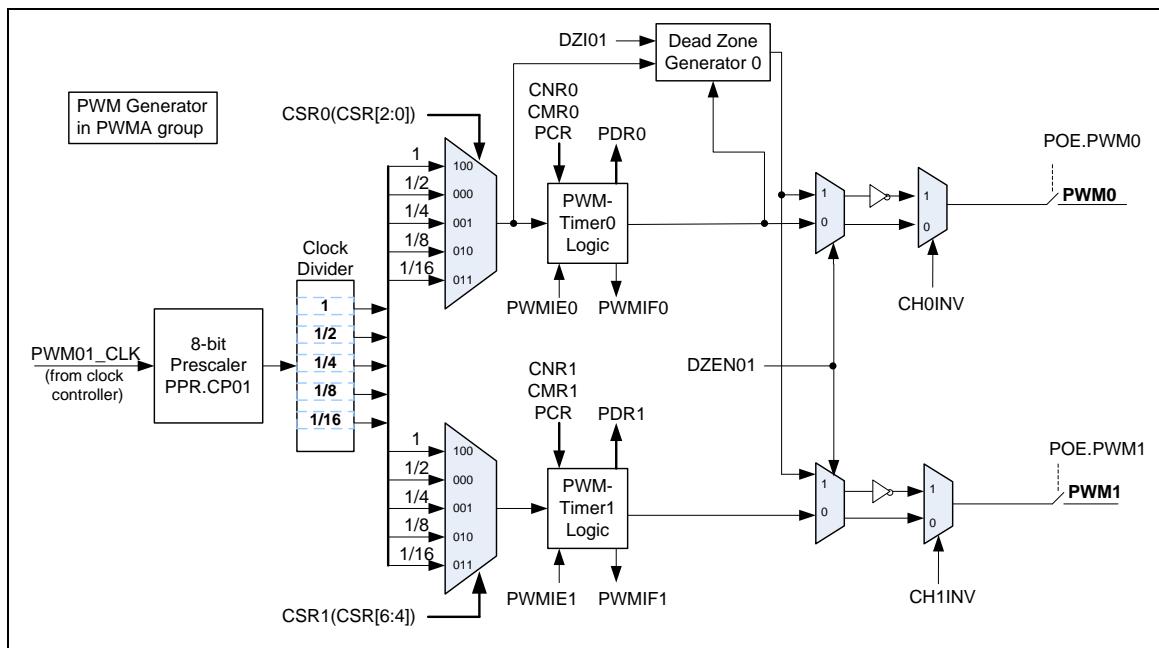


Figure 5-68 PWM Generator 0 Architecture Diagram

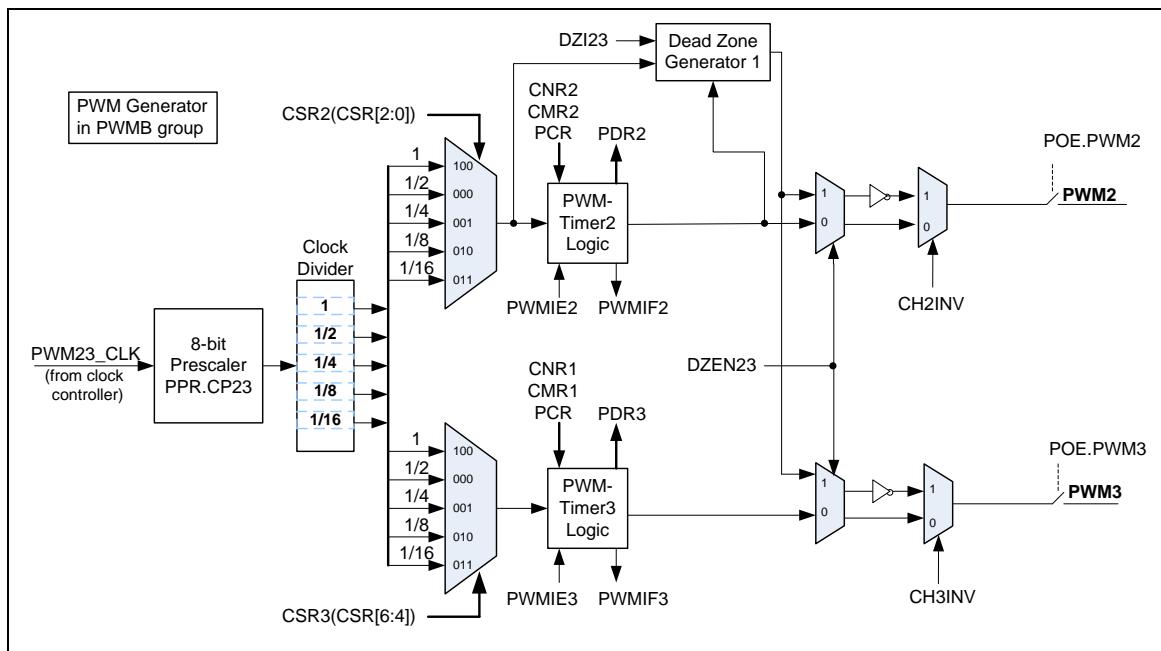


Figure 5-69 PWM Generator 2 Architecture Diagram

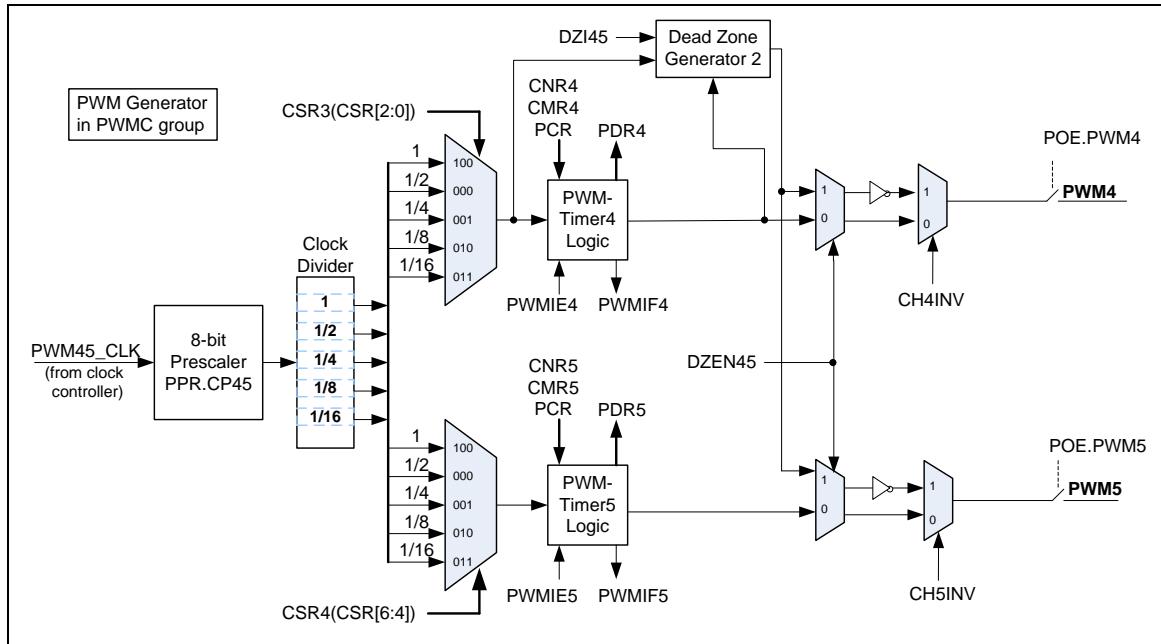


Figure 5-70 PWM Generator 4 Architecture Diagram

#### 5.11.4 Basic Configuration

The PWM pin functions are configured in P0\_MFP and P2\_MFP registers.

The PWM clock can be enabled in APBCLK[22:20]. The PWM clock source must be HCLK.

## 5.11.5 Functional Description

### 5.11.5.1 PWM-Timer Operation

This device supports two operation modes: Edge-aligned and Center-aligned mode.

Following equations show the formula for period and duty for each PWM operation mode:

#### Edge aligned (Down counter)

$$\text{Duty ratio} = (\text{CMR}+1) / (\text{CNR}+1)$$

$$\text{Duty} = (\text{CMR}+1) * (\text{clock period})$$

$$\text{Period} = (\text{CNR}+1) * (\text{clock period})$$

#### Center aligned (Up and Down Counter):

$$\text{Duty ratio} = (\text{CNR} - \text{CMR}) / (\text{CNR}+1)$$

$$\text{Duty} = (\text{CNR} - \text{CMR}) * 2 * (\text{clock period})$$

$$\text{Period} = (\text{CNR}+1) * 2 * (\text{clock period})$$

#### Edge aligned PWM (Down-counter)

In Edge-aligned PWM Output mode, the 16-bit PWM counter will start counting-down from CNRn to match with the value of the duty cycle CMRn (old); when this happens it will toggle the PWMn generator output to high. The counter will continue counting-down to 0; at this moment, it toggles the PWMn generator output to low and CMRn (new) and CNRn (new) are updated with CHnMODE=1 and requests the PWM interrupt if PWM interrupt is enabled (PIER.n=1).

The following figures describe the Edge-aligned PWM timing and operation flow.

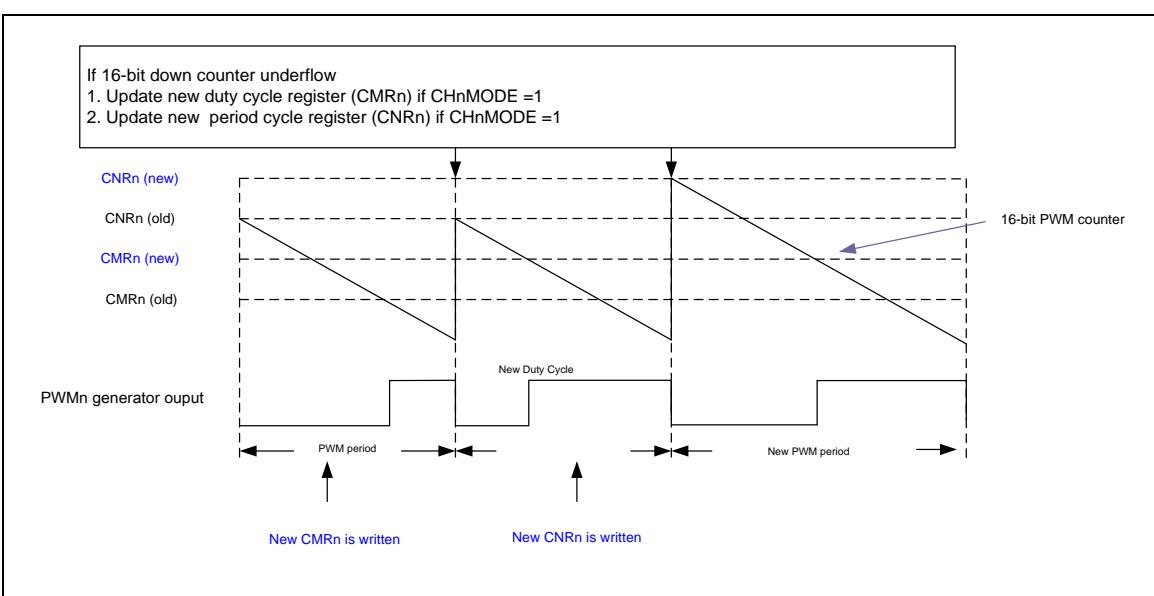


Figure 5-71 Edge-aligned PWM

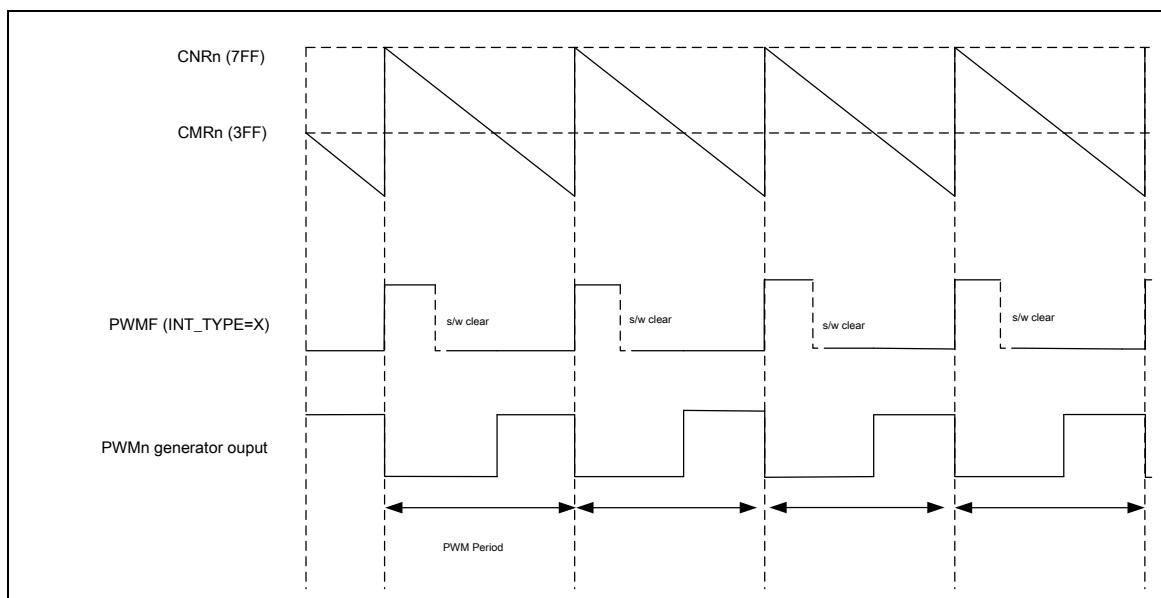


Figure 5-72 PWM Edge-aligned Waveform Output

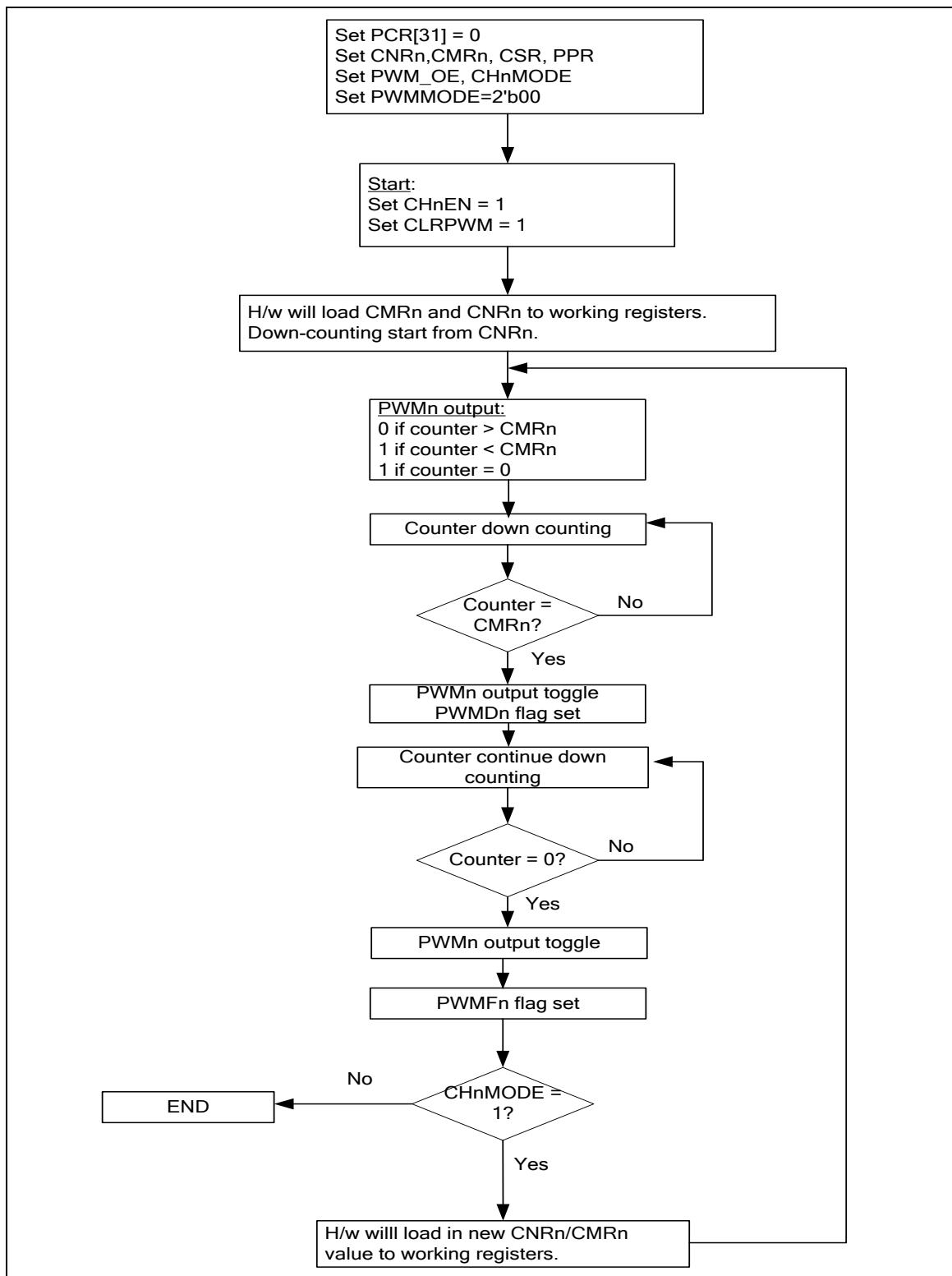


Figure 5-73 Edge-aligned Flow Diagram

The PWM period and duty control are decided by PWM down-counter register (CNRn) and PWM comparator register (CMRn). The following figures show the pulse width modulation follows the

formula below and the legend of PWM-Timer Comparator and the PWM-Timer timing operation. Note that the corresponding GPIO pins must be configured as PWM function (enable PWMPOE) for the corresponding PWM channel.

PWM frequency =  $HCLK/((\text{prescale}+1)*(\text{clock divider})/(\text{CNR}+1))$ ; where xy, could be 01, 23 or 45 depending on the selected PWM channel

Duty ratio =  $(\text{CMR}+1)/(\text{CNR}+1)$

$\text{CMR} \geq \text{CNR}$ : PWM output is always high

$\text{CMR} < \text{CNR}$ : PWM low width=  $(\text{CNR}-\text{CMR})$  unit[1]; PWM high width =  $(\text{CMR}+1)$  unit

$\text{CMR} = 0$ : PWM low width =  $(\text{CNR})$  unit; PWM high width = 1 unit

**Note:** 1. Unit = one PWM clock cycle.

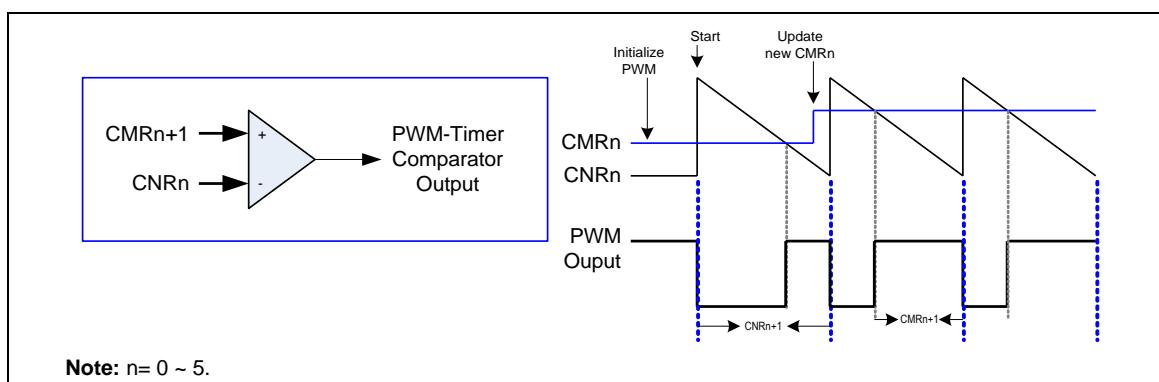


Figure 5-74 Legend of Internal Comparator Output of PWM-Timer

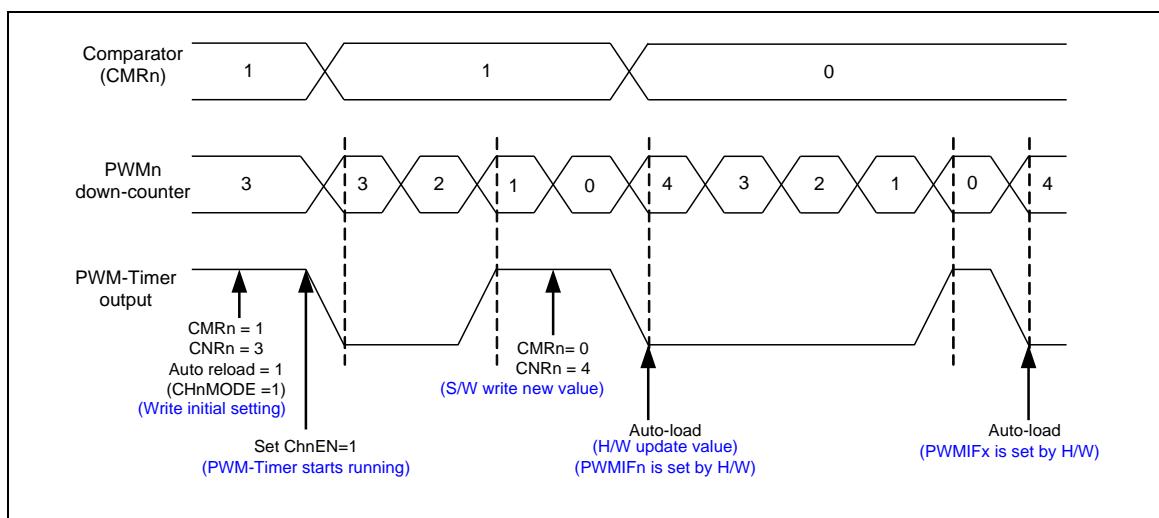


Figure 5-75 PWM-Timer Operation Timing

### Center-Aligned PWM (up/down counter)

The center-aligned PWM signals are produced by the module when the PWM time base is configured in an Up/Down Counting mode. The PWM counter will start counting-up from 0 to match the value of CMR<sub>n</sub> (old); this will cause the toggling of the PWM<sub>n</sub> generator output to high. The counter will continue counting to match with the CNR<sub>n</sub> (old). Upon reaching this state counter is configured automatically to down counting, when PWM counter matches the CMR<sub>n</sub> (old) value again the PWM<sub>n</sub> generator output toggles to low. Once the PWM counter underflows it will update the PWM period register CNR<sub>n</sub> (new) and duty cycle register CMR<sub>n</sub> (new) with CHnMODE = 1.

In Center-aligned mode, the PWM period interrupt is requested at down-counter underflow if INT\_TYPE (PIER[17]) = 0, i.e. at start (end) of each PWM cycle or at up-counter matching with CNR<sub>n</sub> if INT\_TYPE (PIER[17]) = 1, i.e. at center point of PWM cycle.

PWM frequency = HCLK/((prescale+1)\*(clock divider))/(CNR+1); where xy, could be 01, 23 or 45 depending on the selected PWM channel

Duty ratio = (CNR - CMR) / (CNR+1)

CNR >= CMR: PWM output is always low

CMR < CNR: PWM low width= (CNR - CMR) \* 2 units[1]; PWM high width = (CMR+1) \* 2 units

CMR = 0: PWM low width = CNR \* 2 units; PWM high width = 2 units

**Note:** 1. Unit = one PWM clock cycle.

The following figures descript the Center-aligned PWM timing and operation flow.

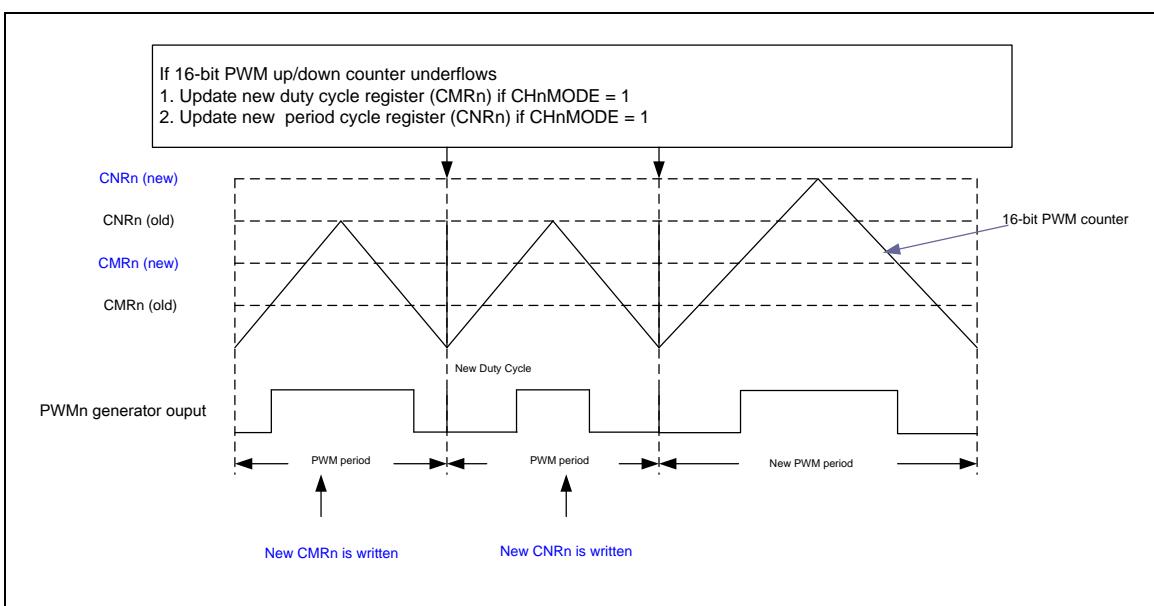


Figure 5-76 Center-aligned Mode

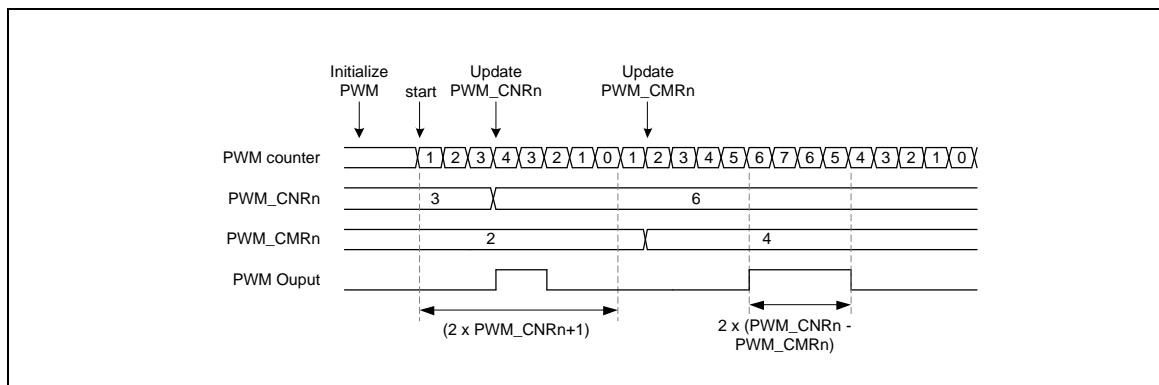


Figure 5-77 Center-aligned Mode Operation Timing

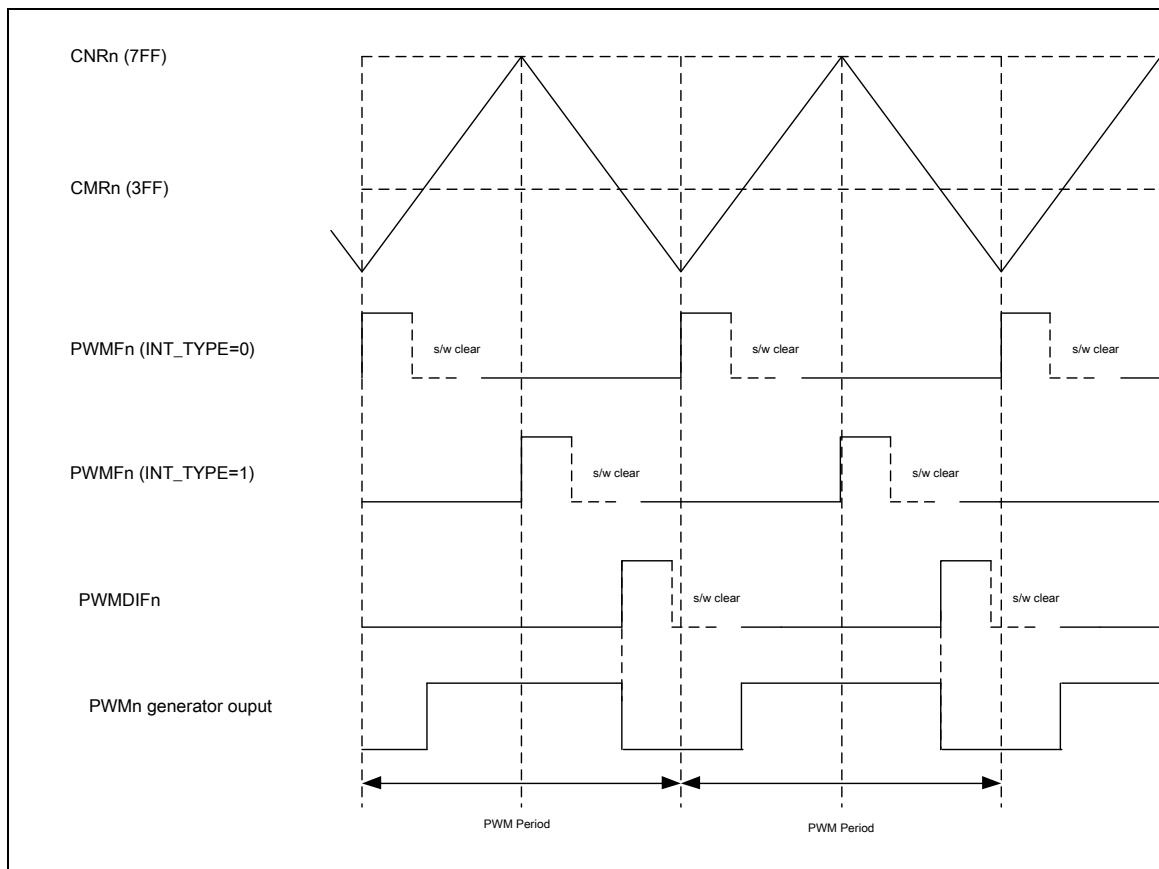


Figure 5-78 PWM Center-aligned Waveform Output

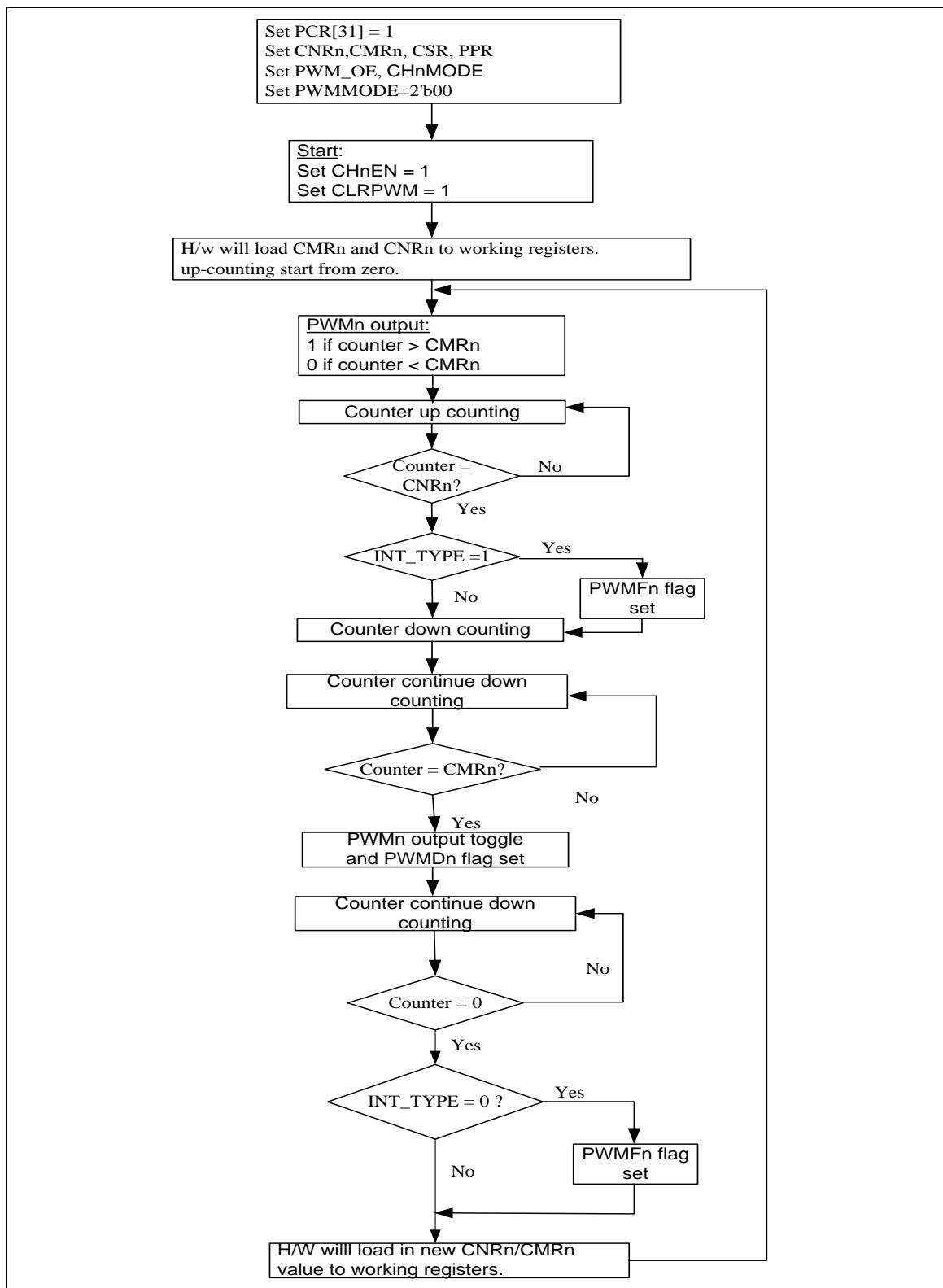


Figure 5-79 Center-aligned Flow Diagram (INT\_TYPE = 0)

### 5.11.5.2 PWM Double Buffering, Auto-reload and One-shot Operation

The NuMicro® NUC029FAE PWM Timers have double buffering function the reload value is updated at the start of next period without affecting current timer operation. The PWM counter value can be written into CNRn.

PWM0 will operate in One-shot mode if CH0MOD bit is set to 0, and operate in Auto-reload mode if CH0MOD bit is set to 1. It is recommend that switch PWM0 operating mode before set CH0EN bit to 1 to enable PWM0 counter start running because the content of CNR0 and CMR0 will be cleared to 0 to reset the PWM0 period and duty setting when PWM0 operating mode is changed. As PWM0 operate in One-shot mode, CMR0 and CNR0 should be written first and then set CH0EN bit to 1 to enable PWM0 counter start running. After PWM0 counter down count from CNR0 value to 0, CNR0 and CMR0 will be cleared to 0 by hardware and PWM counter will be held. Software need to write new CMR0 and CNR0 value to set next one-shot period and duty. When re-start next one-shot operation, the CMR0 should be written first because PWM0 counter will auto re-start counting when CNR0 is written a non-zero value. As PWM0 operates at auto-reload mode, CMR0 and CNR0 should be written first and then set CH0EN bit to 1 to enable PWM0 counter start running. The value of CNR0 will reload to PWM0 counter when it down count reaches 0. If CNR0 is set to 0, PWM0 counter will be held. PWM1~PWM5 performs the same function as PWM0

**Note:** One-shot operation only support edge alignment mode.

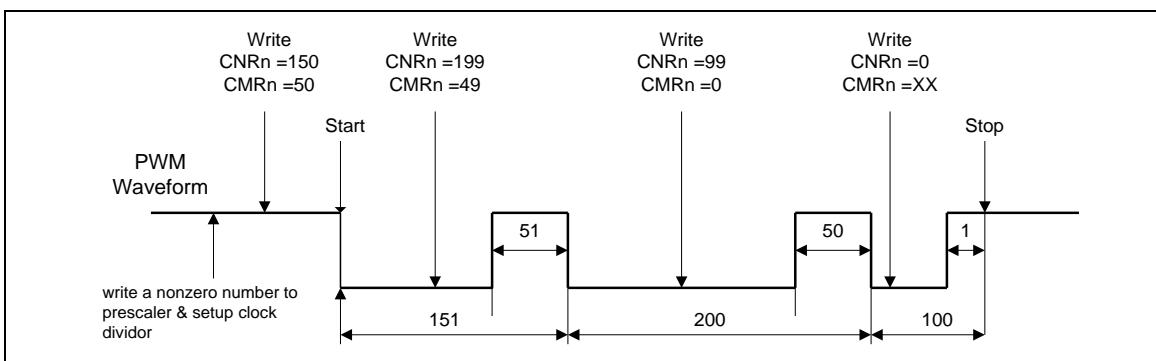


Figure 5-80 PWM Double Buffering Illustration

### 5.11.5.3 Modulate Duty Ratio

The double buffering function allows CMRn to be written at any point in current cycle. The loaded value will take effect from next cycle.

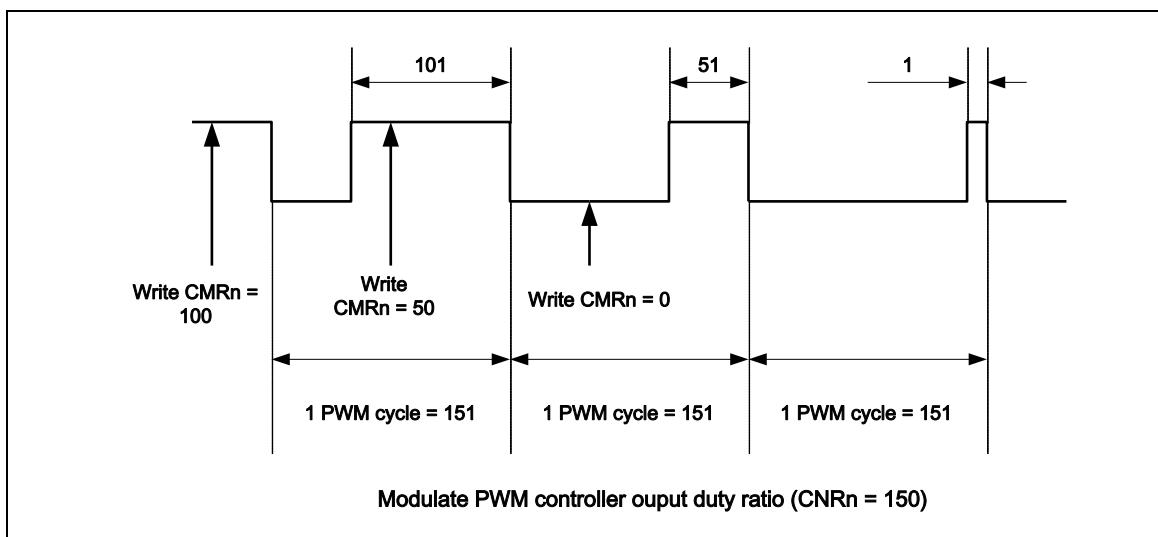


Figure 5-81 PWM Controller Output Duty Ratio

#### 5.11.5.4 PWM Operation Modes

This powerful PWM unit supports independent mode which may be applied to DC or BLDC motor system, Complementary mode with dead-zone insertion which may be used in the application of AC induction motor and synchronous motor, and Synchronous mode that makes both pins of each pair are in phase. Besides, the Group mode, which forces the PWM2 and PWM4 synchronous with PWM0 generator, may simplify updating duty control in DC and BLDC motor applications.

#### 5.11.5.5 Independent mode

Independent mode is enabled when PWMMOD[1:0] = 00.

By default, the PWM is operated in independent mode, with six PWM channels outputs. Each channel is running off its own duty-cycle generator module.

#### 5.11.5.6 Complementary mode

Complementary mode is enabled when PWMMOD[1:0] = 01.

In this module there are three duty-cycle generators utilized for complementary mode, with total of three PWM output pair pins in this module. The total six PWM outputs are grouped into output pairs of even and odd numbered outputs. In complimentary modes, the internal odd PWM signal PG<sub>n</sub>, always be the complement of the corresponding even PWM signal. For example, PG1 will be the complement of PG0. PG3 will be the complement of PG2 and PG5 will be the complement of PG4. The time base for the PWM module is provided by its own 16-bit timer, which also incorporates selectable pre-scalar options.

#### 5.11.5.7 Dead-zone insertion

The dead-zone generator inserts an “off” period called “dead-zone” between the turnings off of one pin to the turning on of the complementary pin of the paired pins. This is to prevent damage to the power switching devices that will be connected to the PWM output pins. The complementary output pair mode has an 8-bit down counter used to produce the dead-zone insertion. The complementary outputs are delayed until the timer counts down to 0.

The dead-zone can be calculated from the following formula:

$$\text{dead-zone} = \text{PWM\_CLK} * (\text{DZI}_{xy}[7:0]+1), \text{ where } xy, \text{ could be } 01, 23, 45$$

The timing diagram below indicates the dead-zone insertion for one pair of PWM signals.

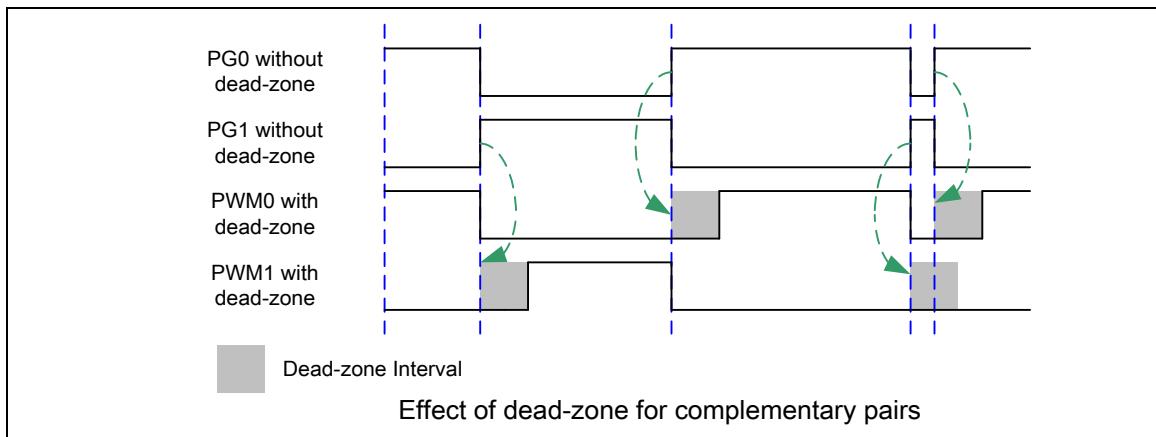


Figure 5-82 Dead-zone Insertion

In Power inverter applications, a dead-zone insertion avoids the upper and lower switches of the half bridge from being active at the same time. Hence the dead-zone control is crucial to proper operation of a system. Some amount of time must be provided between turning off of one PWM output in a complementary pair and turning on the other transistor as the power output devices cannot switch instantaneously.

#### 5.11.5.8 Synchronous mode

Synchronous mode is enabled when PWMMOD[1:0] = 10.

In the synchronization mode the PWM pair signals from PWM Generator are in-phase.

PG1=PG0, PG3=PG2 and PG5=PG4.

#### 5.11.5.9 Group mode

Group mode is enabled when GRP (PCR[30]) = 1.

This device supports Group mode control. This control allows all even PWM channels output to be duty controllable by PWM0 duty register.

If GRP = 1, both (PG2, PG3) and (PG4, PG5) pairs will follow (PG0, PG1), which imply;

PG4 = PG2 = PG0;

PG5 = PG3 = PG1 = invert (PG0) if Complementary mode is enabled (PWMMOD[1:0] = 01)

For Application, please do not use Group and Synchronous mode simultaneously because the Synchronous mode will be inactive.

#### 5.11.5.10 Polarity Control

Each PWM port of PWM0 ~ PWM5 has independent polarity control to configure the polarity of active state of PWM output. By default, the PWM output is active high.

The following diagram shows the initial state before PWM starts with different polarity settings.

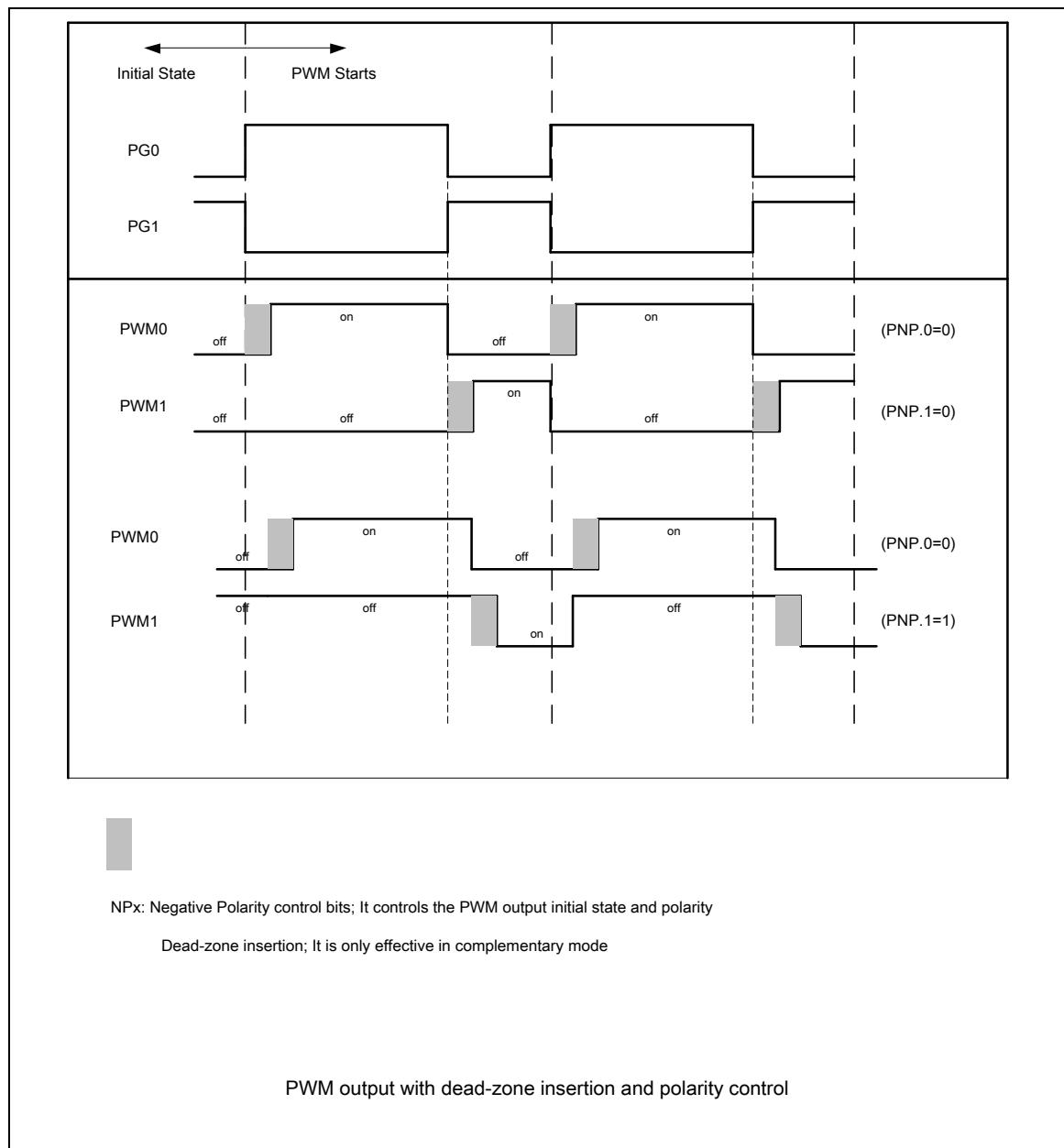


Figure 5-83 Initial State and Polarity Control with Rising Edge Dead-zone Insertion

### 5.11.6 PWM for Motor Control Interrupt Architecture

There are four interrupt sources for a PWM unit, which are PWM period flag (PWMPIF), PWM duty interrupt (PWMDIF), Brake0 flag (BKF0) and Brake1 flag (BKF1). The bit BRKIE (PIER[16]) controls the brake interrupt enable; the bit PWMPIEn (PIER[0] ~ PIER[5]) controls the PWM periodic interrupt enable; and the bit PWMDIEn (PIER[8] ~ PIER[13]) controls the PWM duty interrupt enable. Note that all the interrupt flags are set by hardware and must be cleared by software.

The following figure demonstrates the architecture of Motor Control PWM interrupts.

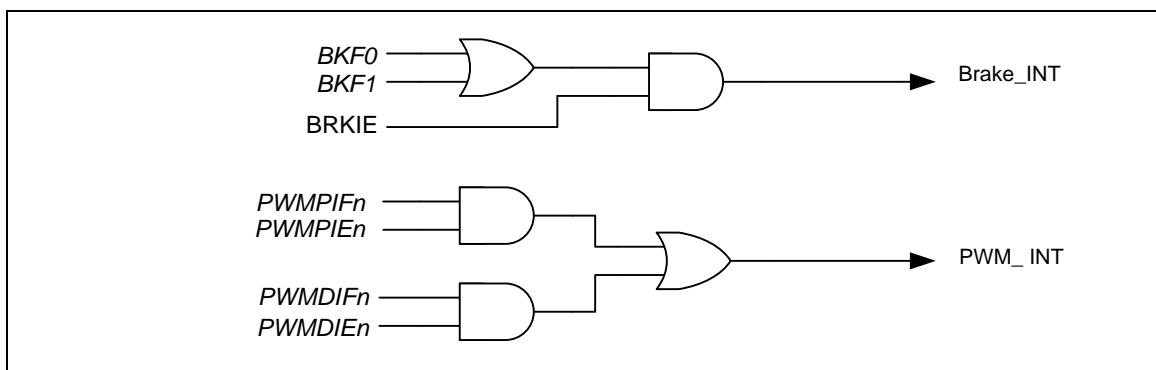


Figure 5-84 Motor Control PWM Architecture

#### 5.11.6.1 PWM Brake Function

This device supported two external brake pins: BKP0 and BKP1 pins. The Brake function is controlled by the contents of the PFBCON registers.

Since the both brake conditions being asserted will automatically raise the BKF flag, user program can poll these brake flag bits or enable PWM's brake interrupt to determine which condition causes a brake to occur.

**Note:** When a brake happens, the PWM0 ~ PWM5 enable bits will be disabled by hardware. User program must clear fault brake event flag (BKF) first, then write the PWM enable bits again to release PWM Brake state.

#### 5.11.6.2 PWM Phase Change Function

PWM supports phase change function, by configuring both PHCHG and PHCHG\_NXT register, each time when time-out event coming, PHCHG's value will be updated by PHCHG\_NXT's value automatically, PHCHG's bit field is identical with PHCHG\_NXT's, each time when PHCHG updated, the related function will also change,

#### 5.11.7 PWM Timer Start Procedure

The following procedure is recommended for PWM-Timer start

1. Configure prescaler register (PPR) for setting clock prescaler (CPxx).
2. Configure clock select register (CSR) for setting clock source select (CSRx).
3. Configure PWM control register (PCR) for setting auto-reload mode (CHxMOD = 1), PWM aligned type (PWMTYPE) and DISABLE PWM-Timer (CHxEN = 0).
4. Configure PWM control register (PCR) for setting inverter on/off (CHxINV), and Dead-zone generator on/off (DZENn). (Optional)
5. Configure PDZIR register to set dead-zone interval. (Optional)
6. Configure comparator register (CMRx) for setting PWM duty (CMRx).
7. Configure PWM counter register (CNRx) for setting PWM-Timer loaded value (CNRx).
8. Configure PWM interrupt enable register (PIER) for setting PWM period interrupt type (INTTYPE), PWM period interrupt enable bit (PWMPIE) and PWM duty interrupt enable bit (PWMDIE). (Optional)
9. Configure PWM output enable register (POE) to enable PWM output channel (PWMx)
10. Configure PWM control register (PCR) to enable PWM-Timer (CHxEN = 1)

### 5.11.8 PWM Timer Stop Procedure

**Method 1:**

Set 16-bit counter register (CNRx) as 0. When interrupt request happened, disable PWM-Timer (CHxEN in PCR). (Recommended)

**Method 2:**

Disable PWM-Timer directly (CHxEN in PCR). (Not recommended)

The reason why this method is not recommended is that disabling CHxEN will immediately stop PWM output signal and lead to change the duty of the PWM output, this may cause damage to the motor control circuit.

### 5.11.9 Register Map

R: read only, W: write only, R/W: both read and write

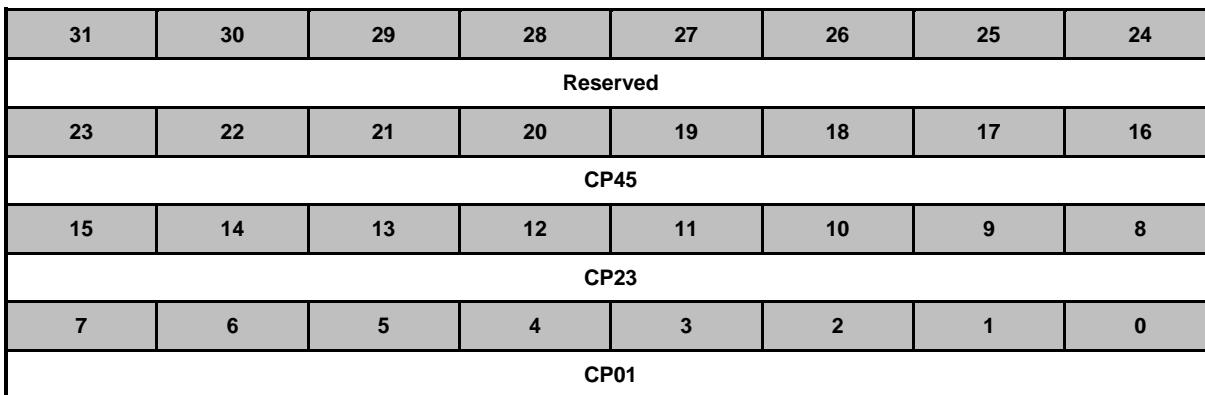
Register	Offset	R/W	Description	Reset Value
<b>PWM Base Address:</b>				
<b>PWM_BA = 0x4004_0000</b>				
PPR	PWM_BA+0x00	R/W	PWM Pre-scale Register	0x0000_0000
CSR	PWM_BA+0x04	R/W	PWM Clock Select Register	0x0000_0000
PCR	PWM_BA+0x08	R/W	PWM Control Register	0x0000_0000
CNR0	PWM_BA+0x0C	R/W	PWM Counter Register 0	0x0000_0000
CNR1	PWM_BA+0x10	R/W	PWM Counter Register 1	0x0000_0000
CNR2	PWM_BA+0x14	R/W	PWM Counter Register 2	0x0000_0000
CNR3	PWM_BA+0x18	R/W	PWM Counter Register 3	0x0000_0000
CNR4	PWM_BA+0x1C	R/W	PWM Counter Register 4	0x0000_0000
CNR5	PWM_BA+0x20	R/W	PWM Counter Register 5	0x0000_0000
CMR0	PWM_BA+0x24	R/W	PWM Comparator Register 0	0x0000_0000
CMR1	PWM_BA+0x28	R/W	PWM Comparator Register 1	0x0000_0000
CMR2	PWM_BA+0x2C	R/W	PWM Comparator Register 2	0x0000_0000
CMR3	PWM_BA+0x30	R/W	PWM Comparator Register 3	0x0000_0000
CMR4	PWM_BA+0x34	R/W	PWM Comparator Register 4	0x0000_0000
CMR5	PWM_BA+0x38	R/W	PWM Comparator Register 5	0x0000_0000
PIER	PWM_BA+0x54	R/W	PWM Interrupt Enable Control Register	0x0000_0000
PIIR	PWM_BA+0x58	R/W	PWM Interrupt Indication Register	0x0000_0000
PWMPOE	PWM_BA+0x5C	R/W	PWM Output Enable for Channel 0~5	0x0000_0000
PFBCON	PWM_BA+0x60	R/W	PWM Fault Brake Control Register	0x0000_0000
PDZIR	PWM_BA+0x64	R/W	PWM Dead-zone Interval Register	0x0000_0000
TRGCON0	PWM_BA+0x68	R/W	PWM Trigger Control Register 0	0x0000_0000
TRGCON1	PWM_BA+0x6C	R/W	PWM Trigger Control Register 1	0x0000_0000
TRGSTS0	PWM_BA+0x70	R/W	PWM Trigger Status Register 0	0x0000_0000
TRGSTS1	PWM_BA+0x74	R/W	PWM Trigger Status Register 1	0x0000_0000
PHCHG	PWM_BA+0x78	R/W	Phase Change Register	0x0000_3F00
PHCHGNXT	PWM_BA+0x7C	R/W	Next Phase Change Register	0x0000_3F00

<b>PHCHGMASK</b>	PWM_BA+0x80	R/W	Phase Change MASK Register	0x0000_0000
<b>INTACCCTL</b>	PWM_BA+0x84	R/W	Period Interrupt Accumulation Control Register	0x0000_00F0

### 5.11.10 Register Description

#### PWM Pre-Scale Register (PPR)

Register	Offset	R/W	Description				Reset Value
PPR	PWM_BA+0x00	R/W	PWM Pre-scale Register				0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	CP45[7:0]	<b>Clock Prescaler 4 For PWM Counter 4 And 5</b> Clock input is divided by (CP45 + 1) before it is fed to the corresponding PWM counter. If CP45 = 0, the clock prescaler 4 output clock will be stopped. So the corresponding PWM counter will also be stopped.
[15:8]	CP23[7:0]	<b>Clock Prescaler 2 For PWM Counter 2 And 3</b> Clock input is divided by (CP23 + 1) before it is fed to the corresponding PWM counter. If CP23 = 0, the clock prescaler 2 output clock will be stopped. So the corresponding PWM counter will also be stopped.
[7:0]	CP01[7:0]	<b>Clock Prescaler 0 For PWM Counter 0 And 1</b> Clock input is divided by (CP01 + 1) before it is fed to the corresponding PWM counter. If CP01 = 0, the clock prescaler 0 output clock will be stopped. So the corresponding PWM counter will also be stopped.

**PWM Clock Selector Register (CSR)**

Register	Offset	R/W	Description				Reset Value
CSR	PWM_BA+0x04	R/W	PWM Clock Select Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved	CSR5			Reserved	CSR4		
15	14	13	12	11	10	9	8
Reserved	CSR3			Reserved	CSR2		
7	6	5	4	3	2	1	0
Reserved	CSR1			Reserved	CSR0		

Bits	Description	
[31:23]	Reserved	Reserved.
[22:20]	CSR5[2:0]	<b>Timer 5 Clock Source Selection</b> Select clock input for PWM timer. 000 = Input Clock Divided by 2. 001 = Input Clock Divided by 4. 010 = Input Clock Divided by 8. 011 = Input Clock Divided by 16. 100 = Input Clock Divided by 1.
[19]	Reserved	Reserved.
[18:16]	CSR4[2:0]	<b>Timer 4 Clock Source Selection</b> Select clock input for PWM timer. (Table is the same as CSR5.)
[15]	Reserved	Reserved.
[14:12]	CSR3[2:0]	<b>Timer 3 Clock Source Selection</b> Select clock input for PWM timer. (Table is the same as CSR5.)
[11]	Reserved	Reserved.
[10:8]	CSR2[2:0]	<b>Timer 2 Clock Source Selection</b> Select clock input for PWM timer. (Table is the same as CSR5.)
[7]	Reserved	Reserved.
[6:4]	CSR1[2:0]	<b>Timer 1 Clock Source Selection</b> Select clock input for PWM timer. (Table is the same as CSR5.)

Bits	Description	
[3]	<b>Reserved</b>	Reserved.
[2:0]	<b>CSR0[2:0]</b>	<b>Timer 0 Clock Source Selection</b> Select clock input for PWM timer. (Table is the same as CSR5.)

PWM Control Register (PCR)

Register	Offset	R/W	Description				Reset Value
PCR	PWM_BA+0x08	R/W	PWM Control Register				0x0000_0000

31	30	29	28	27	26	25	24
<b>PWMTYPE</b>	<b>GRP</b>	<b>PWMMOD</b>		<b>CLRPWM</b>	<b>DZEN45</b>	<b>DZEN23</b>	<b>DZEN01</b>
23	22	21	20	19	18	17	16
<b>CH5MOD</b>	<b>CH5INV</b>	<b>Reserved</b>	<b>CH5EN</b>	<b>CH4MOD</b>	<b>CH4INV</b>	<b>Reserved</b>	<b>CH4EN</b>
15	14	13	12	11	10	9	8
<b>CH3MOD</b>	<b>CH3INV</b>	<b>Reserved</b>	<b>CH3EN</b>	<b>CH2MOD</b>	<b>CH2INV</b>	<b>Reserved</b>	<b>CH2EN</b>
7	6	5	4	3	2	1	0
<b>CH1MOD</b>	<b>CH1INV</b>	<b>Reserved</b>	<b>CH1EN</b>	<b>CH0MOD</b>	<b>CH0INV</b>	<b>DB_MODE</b>	<b>CH0EN</b>

Bits	Description	
[31]	<b>PWMTYPE</b>	<b>PWM Aligned Type Selection Bit</b> 0 = Edge-aligned type. 1 = Center-aligned type.
[30]	<b>GRP</b>	<b>Group Bit</b> 0 = The signals timing of all PWM channels are independent. 1 = Unify the signals timing of PWM0, PWM2 and PWM4 in the same phase which is controlled by PWM0 and also unify the signals timing of PWM1, PWM3 and PWM5 in the same phase which is controlled by PWM1.
[29:28]	<b>PWMMOD[1:0]</b>	<b>PWM Operating Mode Selection</b> 00 = Independent mode. 01 = Complementary mode. 10 = Synchronized mode. 11 = Reserved.
[27]	<b>CLRPWM</b>	<b>Clear PWM Counter Control Bit</b> 0 = Do not clear PWM counter. 1 = All 16-bit PWM counters cleared to 0x0000. <b>Note:</b> It is automatically cleared by hardware.
[26]	<b>DZEN45</b>	<b>Dead-zone 4 Generator Enable Control (PWM4 And PWM5 Pair For PWM Group)</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> When the dead-zone generator is enabled, the pair of PWM4 and PWM5 becomes a complementary pair for PWM group.
[25]	<b>DZEN23</b>	<b>Dead-zone 2 Generator Enable Control (PWM2 And PWM3 Pair For PWM Group)</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> When the dead-zone generator is enabled, the pair of PWM2 and PWM3 becomes a complementary pair for PWM group.

Bits	Description	
[24]	<b>DZEN01</b>	<p><b>Dead-zone 0 Generator Enable Control (PWM0 And PWM1 Pair For PWM Group)</b></p> <p>0 = Disabled. 1 = Enabled.</p> <p><b>Note:</b> When the dead-zone generator is enabled, the pair of PWM0 and PWM1 becomes a complementary pair for PWM group.</p>
[23]	<b>CH5MOD</b>	<p><b>PWM-timer 5 Auto-reload/One-shot Mode</b></p> <p>0 = One-shot mode. 1 = Auto-reload mode.</p> <p><b>Note:</b> If there is a rising transition at this bit, it will cause CNR5 and CMR5 cleared.</p>
[22]	<b>CH5INV</b>	<p><b>PWM-timer 5 Output Inverter Enable Control</b></p> <p>0 = Inverter Disabled. 1 = Inverter Enabled.</p>
[21]	<b>Reserved</b>	Reserved.
[20]	<b>CH5EN</b>	<p><b>PWM-timer 5 Enable/Disable Start Run</b></p> <p>0 = Corresponding PWM-timer running Stopped. 1 = Corresponding PWM-timer start run Enabled.</p>
[19]	<b>CH4MOD</b>	<p><b>PWM-timer 4 Auto-reload/One-shot Mode</b></p> <p>0 = One-shot mode. 1 = Auto-reload mode.</p> <p><b>Note:</b> If there is a rising transition at this bit, it will cause CNR4 and CMR4 cleared.</p>
[18]	<b>CH4INV</b>	<p><b>PWM-timer 4 Output Inverter Enable Control</b></p> <p>0 = Inverter Disabled. 1 = Inverter Enabled.</p>
[17]	<b>Reserved</b>	Reserved.
[16]	<b>CH4EN</b>	<p><b>PWM-timer 4 Enable/Disable Start Run</b></p> <p>0 = Corresponding PWM-timer running Stopped. 1 = Corresponding PWM-timer start run Enabled.</p>
[15]	<b>CH3MOD</b>	<p><b>PWM-timer 3 Auto-reload/One-shot Mode</b></p> <p>0 = One-shot mode. 1 = Auto-reload mode.</p> <p><b>Note:</b> If there is a rising transition at this bit, it will cause CNR3 and CMR3 cleared.</p>
[14]	<b>CH3INV</b>	<p><b>PWM-timer 3 Output Inverter Enable Control</b></p> <p>0 = Inverter Disabled. 1 = Inverter Enabled.</p>
[13]	<b>Reserved</b>	Reserved.
[12]	<b>CH3EN</b>	<p><b>PWM-timer 3 Enable/Disable Start Run</b></p> <p>0 = Corresponding PWM-timer running Stopped. 1 = Corresponding PWM-timer start run Enabled.</p>
[11]	<b>CH2MOD</b>	<p><b>PWM-timer 2 Auto-reload/One-shot Mode</b></p> <p>0 = One-shot mode. 1 = Auto-reload mode.</p> <p><b>Note:</b> If there is a rising transition at this bit, it will cause CNR2 and CMR2 cleared.</p>

Bits	Description	
[10]	<b>CH2INV</b>	<b>PWM-timer 2 Output Inverter Enable Control</b> 0 = Inverter Disabled. 1 = Inverter Enabled.
[9]	<b>Reserved</b>	Reserved.
[8]	<b>CH2EN</b>	<b>PWM-timer 2 Enable/Disable Start Run</b> 0 = Corresponding PWM-timer running Stopped. 1 = Corresponding PWM-timer start run Enabled.
[7]	<b>CH1MOD</b>	<b>PWM-timer 1 Auto-reload/One-shot Mode</b> 0 = One-shot mode. 1 = Auto-reload mode. <b>Note:</b> If there is a rising transition at this bit, it will cause CNR1 and CMR1 cleared.
[6]	<b>CH1INV</b>	<b>PWM-timer 1 Output Inverter ON/OFF</b> 0 = Inverter OFF. 1 = Inverter ON.
[5]	<b>Reserved</b>	Reserved.
[4]	<b>CH1EN</b>	<b>PWM-timer 1 Enable/Disable Start Run</b> 0 = Corresponding PWM-timer running Stopped. 1 = Corresponding PWM-timer start run Enabled.
[3]	<b>CH0MOD</b>	<b>PWM-timer 0 Auto-reload/One-shot Mode</b> 0 = One-shot mode. 1 = Auto-reload mode. <b>Note:</b> If there is a rising transition at this bit, it will cause CNR0 and CMR0 cleared.
[2]	<b>CH0INV</b>	<b>PWM-timer 0 Output Inverter Enable Control</b> 0 = Inverter Disabled. 1 = Inverter Enabled.
[1]	<b>DB_MODE</b>	<b>PWM Debug Mode Configuration Bit (Available In DEBUG Mode Only)</b> 0 = Safe mode: The timer is frozen and PWM outputs are shut down Safe state for the inverter. The timer can still be re-started from where it stops. 1 = Normal mode: The timer continues to operate normally May be dangerous in some cases since a constant duty cycle is applied to the inverter (no more interrupts serviced).
[0]	<b>CH0EN</b>	<b>PWM-timer 0 Enable/Disable Start Run</b> 0 = Corresponding PWM-timer running Stopped. 1 = Corresponding PWM-timer start run Enabled.

**PWM Counter Register 0-5 (CNR0-5)**

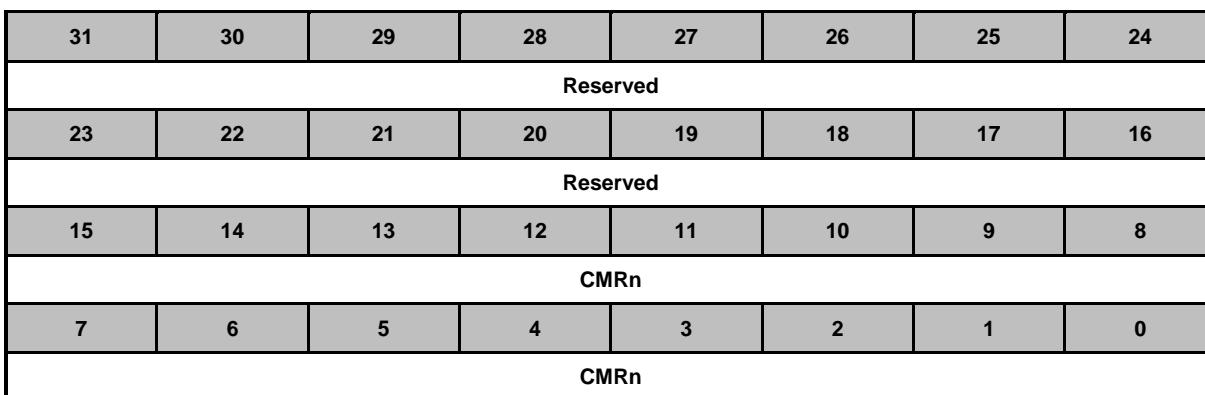
Register	Offset	R/W	Description	Reset Value
CNR0	PWM_BA+0x0C	R/W	PWM Counter Register 0	0x0000_0000
CNR1	PWM_BA+0x10	R/W	PWM Counter Register 1	0x0000_0000
CNR2	PWM_BA+0x14	R/W	PWM Counter Register 2	0x0000_0000
CNR3	PWM_BA+0x18	R/W	PWM Counter Register 3	0x0000_0000
CNR4	PWM_BA+0x1C	R/W	PWM Counter Register 4	0x0000_0000
CNR5	PWM_BA+0x20	R/W	PWM Counter Register 5	0x0000_0000

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

Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	CNRn	<p><b>PWM Counter/Timer Loaded Value</b>            CNRn determines the PWM period. n = 0, 1..5.            Edge-aligned mode:  <math>\text{PWM frequency} = \text{HCLK}/((\text{prescale}+1) * (\text{clock divider})) / (\text{CNRn}+1)</math>; where xy, could be 01, 23, 45 depending on the selected PWM channel.  <math>\text{Duty ratio} = (\text{CMRn}+1)/(\text{CNRn}+1)</math>.  <math>\text{CMRn} \geq \text{CNRn}</math>: PWM output is always high.  <math>\text{CMRn} &lt; \text{CNRn}</math>: PWM low width = (CNRn-CMRn) unit; PWM high width = (CMRn+1) unit.  <math>\text{CMRn} = 0</math>: PWM low width = (CNRn) unit; PWM high width = 1 unit.            Center-aligned mode:  <math>\text{PWM frequency} = \text{HCLK}/((\text{prescale}+1) * (\text{clock divider})) / (2*\text{CNRn}+1)</math>; where xy, could be 01, 23, 45 depending on the selected PWM channel.  <math>\text{Duty ratio} = (\text{CNRn} - \text{CMRn})/(\text{CNRn}+1)</math>.  <math>\text{CMRn} \geq \text{CNRn}</math>: PWM output is always low.  <math>\text{CMRn} &lt; \text{CNRn}</math>: PWM low width = (CMRn + 1) * 2 unit; PWM high width = (CNRn - CMRn) * 2 unit.  <math>\text{CMRn} = 0</math>: PWM low width = 2 unit; PWM high width = (CNRn) * 2 unit.            (Unit = One PWM clock cycle).  <b>Note:</b> Any write to CNRn will take effect in next PWM cycle.         </p>

**PWM Comparator Register 0-5 (CMR0-5)**

Register	Offset	R/W	Description				Reset Value
<b>CMR0</b>	PWM_BA+0x24	R/W	PWM Comparator Register 0				0x0000_0000
<b>CMR1</b>	PWM_BA+0x28	R/W	PWM Comparator Register 1				0x0000_0000
<b>CMR2</b>	PWM_BA+0x2C	R/W	PWM Comparator Register 2				0x0000_0000
<b>CMR3</b>	PWM_BA+0x30	R/W	PWM Comparator Register 3				0x0000_0000
<b>CMR4</b>	PWM_BA+0x34	R/W	PWM Comparator Register 4				0x0000_0000
<b>CMR5</b>	PWM_BA+0x38	R/W	PWM Comparator Register 5				0x0000_0000



Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	CMRn	<p><b>PWM Comparator Bits</b></p> <p>CMR determines the PWM duty. n = 0, 1..5.</p> <p>Edge-aligned mode:</p> <p>PWM frequency = HCLK/((prescale+1)*(clock divider))/(CNRn+1); where xy, could be 01, 23, 45 depending on the selected PWM channel.</p> <p>Duty ratio = (CMRn+1)/(CNRn+1).</p> <p>CNRn &gt;= CMRn: PWM output is always high.</p> <p>CNRn &lt; CMRn: PWM low width = (CNRn-CMRn) unit; PWM high width = (CMRn+1) unit.</p> <p>CMRn = 0: PWM low width = (CNRn) unit; PWM high width = 1 unit.</p> <p>Center-aligned mode:</p> <p>PWM frequency = HCLK/((prescale+1)*(clock divider)) /(2*CNRn+1); where xy, could be 01, 23, 45 depending on the selected PWM channel.</p> <p>Duty ratio = (CNRn - CMRn)/(CNRn+1).</p> <p>CNRn &gt;= CMRn: PWM output is always low.</p> <p>CNRn &lt; CMRn: PWM low width = (CMRn + 1) * 2 unit; PWM high width = (CNRn - CMRn) * 2 unit.</p> <p>CMRn = 0: PWM low width = 2 unit; PWM high width = (CNRn) * 2 unit.</p> <p>(Unit = One PWM clock cycle).</p> <p><b>Note:</b> Any write to CMRn will take effect in next PWM cycle.</p>

**PWM Interrupt Enable Control Register (PIER)**

Register	Offset	R/W	Description				Reset Value
PIER	PWM_BA+0x54	R/W	PWM Interrupt Enable Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved						INT_TYPE	BRKIE
15	14	13	12	11	10	9	8
Reserved		PWMDIE5	PWMDIE4	PWMDIE3	PWMDIE2	PWMDIE1	PWMDIE0
7	6	5	4	3	2	1	0
Reserved		PWMPIE5	PWMPIE4	PWMPIE3	PWMPIE2	PWMPIE1	PWMPIE0

Bits	Description	
[31:18]	Reserved	Reserved.
[17]	INT_TYPE	<b>PWM Interrupt Type Selection Bit</b> 0 = PWMPIFn will be set if PWM counter underflows. 1 = PWMPIFn will be set if PWM counter matches CNRn register. <b>Note:</b> This bit is effective when PWM in central align mode only.
[16]	BRKIE	<b>Fault Brake0 And 1 Interrupt Enable Control</b> 0 = Disabling flags BKF0 and BKF1 to trigger PWM interrupt. 1 = Enabling flags BKF0 and BKF1 can trigger PWM interrupt.
[15:14]	Reserved	Reserved.
[13]	PWMDIE5	<b>PWM Channel 5 Duty Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[12]	PWMDIE4	<b>PWM Channel 4 Duty Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[11]	PWMDIE3	<b>PWM Channel 3 Duty Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[10]	PWMDIE2	<b>PWM Channel 2 Duty Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[9]	PWMDIE1	<b>PWM Channel 1 Duty Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.

Bits	Description	
[8]	<b>PWMDIE0</b>	<b>PWM Channel 0 Duty Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[7:6]	<b>Reserved</b>	Reserved.
[5]	<b>PWMPIE5</b>	<b>PWM Channel 5 Period Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[4]	<b>PWMPIE4</b>	<b>PWM Channel 4 Period Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[3]	<b>PWMPIE3</b>	<b>PWM Channel 3 Period Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[2]	<b>PWMPIE2</b>	<b>PWM Channel 2 Period Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[1]	<b>PWMPIE1</b>	<b>PWM Channel 1 Period Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.
[0]	<b>PWMPIE0</b>	<b>PWM Channel 0 Period Interrupt Enable Control</b> 0 = Disabled. 1 = Enabled.

**PWM Interrupt Indication Register (PIIR)**

Register	Offset	R/W	Description				Reset Value
PIIR	PWM_BA+0x58	R/W	PWM Interrupt Indication Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved						BKF1	BKF0
15	14	13	12	11	10	9	8
Reserved		PWMDIF5	PWMDIF4	PWMDIF3	PWMDIF2	PWMDIF1	PWMDIF0
7	6	5	4	3	2	1	0
Reserved		PWMPIF5	PWMPIF4	PWMPIF3	PWMPIF2	PWMPIF1	PWMPIF0

Bits	Description	
[31:18]	Reserved	Reserved.
[17]	BKF1	<b>PWM Brake1 Flag</b> 0 = PWM Brake does not recognize a falling signal at BKP1. 1 = When PWM Brake detects a falling signal at pin BKP1, this flag will be set to high. <b>Note:</b> Software can write 1 to clear this bit.
[16]	BKF0	<b>PWM Brake0 Flag</b> 0 = PWM Brake does not recognize a falling signal at BKP0. 1 = When PWM Brake detects a falling signal at pin BKP0, this flag will be set to high. <b>Note:</b> Software can write 1 to clear this bit.
[15:14]	Reserved	Reserved.
[13]	PWMDIF5	<b>PWM Channel 5 Duty Interrupt Flag</b> Flag is set by hardware when a channel 5 PWM counter reaches CMR5 in down-count direction. <b>Note:</b> Software can write 1 to clear this bit.
[12]	PWMDIF4	<b>PWM Channel 4 Duty Interrupt Flag</b> Flag is set by hardware when a channel 4 PWM counter reaches CMR4 in down-count direction. <b>Note:</b> Software can write 1 to clear this bit.
[11]	PWMDIF3	<b>PWM Channel 3 Duty Interrupt Flag</b> Flag is set by hardware when a channel 3 PWM counter reaches CMR3 in down-count direction. <b>Note:</b> Software can write 1 to clear this bit.
[10]	PWMDIF2	<b>PWM Channel 2 Duty Interrupt Flag</b> Flag is set by hardware when a channel 2 PWM counter reaches CMR2 in down-count direction. <b>Note:</b> Software can write 1 to clear this bit.

Bits	Description	
[9]	<b>PWMDIF1</b>	<p><b>PWM Channel 1 Duty Interrupt Flag</b>  Flag is set by hardware when a channel 1 PWM counter reaches CMR1 in down-count direction.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[8]	<b>PWMDIF0</b>	<p><b>PWM Channel 0 Duty Interrupt Flag</b>  Flag is set by hardware when a channel 0 PWM counter reaches CMR0 in down-count direction.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[7:6]	<b>Reserved</b>	Reserved.
[5]	<b>PWMPIF5</b>	<p><b>PWM Channel 5 Period Interrupt Flag</b>  Flag is set by hardware when PWM5 down counter reaches zero.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[4]	<b>PWMPIF4</b>	<p><b>PWM Channel 4 Period Interrupt Flag</b>  Flag is set by hardware when PWM4 down counter reaches zero.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[3]	<b>PWMPIF3</b>	<p><b>PWM Channel 3 Period Interrupt Flag</b>  Flag is set by hardware when PWM3 down counter reaches zero.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[2]	<b>PWMPIF2</b>	<p><b>PWM Channel 2 Period Interrupt Flag</b>  Flag is set by hardware when PWM2 down counter reaches zero.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[1]	<b>PWMPIF1</b>	<p><b>PWM Channel 1 Period Interrupt Flag</b>  Flag is set by hardware when PWM1 down counter reaches zero.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>
[0]	<b>PWMPIF0</b>	<p><b>PWM Channel 0 Period Interrupt Flag</b>  Flag is set by hardware when PWM0 down counter reaches zero.</p> <p><b>Note:</b> Software can write 1 to clear this bit.</p>

**Note:** User can clear each interrupt flag by writing 1 to corresponding bit in PIIR.

PWM Output Control Register (PWMPOE)

Register	Offset	R/W	Description				Reset Value
PWMPOE	PWM_BA+0x5C	R/W	PWM Output Enable for Channel 0~5				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved		PWM5	Reserved	PWM3	PWM2	Reserved	

Bits	Description	
[31:6]	Reserved	Reserved.
[5]	PWM5	<b>PWM Channel 5 Output Enable Control</b> 0 = PWM channel 5 output to pin Disabled. 1 = PWM channel 5 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must be switched to PWM function.
[4]	Reserved	Reserved.
[3]	PWM3	<b>PWM Channel 3 Output Enable Control</b> 0 = PWM channel 3 output to pin Disabled. 1 = PWM channel 3 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must be switched to PWM function.
[2]	PWM2	<b>PWM Channel 2 Output Enable Control</b> 0 = PWM channel 2 output to pin Disabled. 1 = PWM channel 2 output to pin Enabled. <b>Note:</b> The corresponding GPIO pin must be switched to PWM function.
[1:0]	Reserved	Reserved.

**PWM Fault Brake Control Register (PFBCON)**

Register	Offset	R/W	Description				Reset Value
PFBCON	PWM_BA+0x60	R/W	PWM Fault Brake Control Register				0x0000_0000

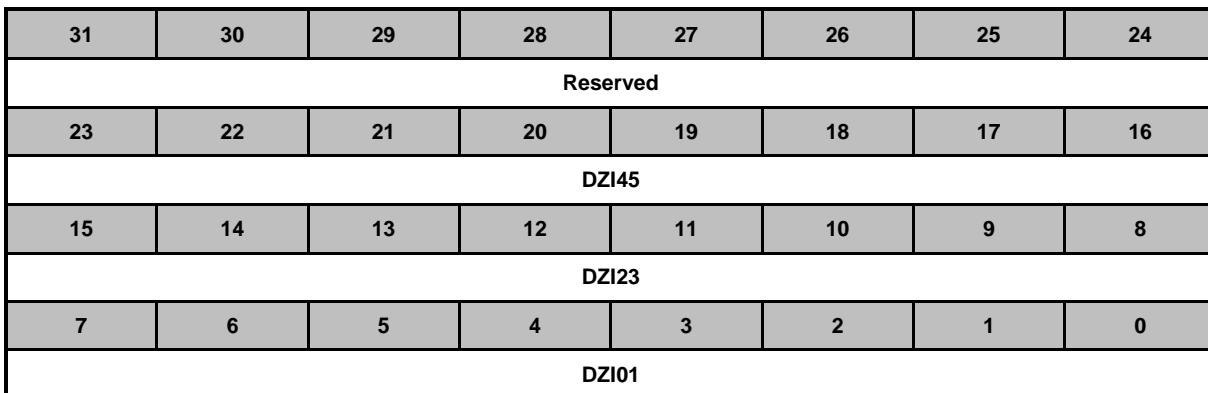
31	30	29	28	27	26	25	24
D7BKO7	D6BKO6	PWMBKO5	Reserved	PWMBKO3	PWMBKO2	Reserved	
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
BKF	Reserved				CPO0BKEN	Reserved	BKEN0

Bits	Description	
[31]	D7BKO7	<b>D7 Brake Output Select Bit</b> 0 = D7 output low when fault brake conditions asserted. 1 = D7 output high when fault brake conditions asserted.
[30]	D6BKO6	<b>D6 Brake Output Select Bit</b> 0 = D6 output low when fault brake conditions asserted. 1 = D6 output high when fault brake conditions asserted.
[29]	PWMBKO5	<b>PWM Channel 5 Brake Output Select Bit</b> 0 = PWM output low when fault brake conditions asserted. 1 = PWM output high when fault brake conditions asserted.
[28]	Reserved	Reserved.
[27]	PWMBKO3	<b>PWM Channel 3 Brake Output Select Bit</b> 0 = PWM output low when fault brake conditions asserted. 1 = PWM output high when fault brake conditions asserted.
[26]	PWMBKO2	<b>PWM Channel 2 Brake Output Select Bit</b> 0 = PWM output low when fault brake conditions asserted. 1 = PWM output high when fault brake conditions asserted.
[25:8]	Reserved	Reserved.
[7]	BKF	<b>PWM Fault Brake Event Flag (Write 1 Clear)</b> 0 = PWM output initial state when fault brake conditions asserted. 1 = PWM output fault brake state when fault brake conditions asserted. Software can write 1 to clear this bit and must clear this bit before restart PWM counter.
[6:3]	Reserved	Reserved.
[2]	CPO0BKEN	<b>BKP1 Fault Brake Function Source Selection</b> 0 = EINT1 as one brake source in BKP1. 1 = CPO0 as one brake source in BKP1.

Bits	Description	
[1]	<b>Reserved</b>	Reserved.
[0]	<b>BKEN0</b>	<b>Enable BKP0 Pin Trigger Fault Brake Function 0</b> 0 = Disabling BKP0 pin can trigger brake function 0 (EINT0 or CPO1). 1 = Enabling a falling at BKP0 pin can trigger brake function 0.

**PWM Dead-Zone Interval Register (PDZIR)**

Register	Offset	R/W	Description				Reset Value
PDZIR	PWM_BA+0x64	R/W	PWM Dead-zone Interval Register				0x0000_0000



Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	DZI45[7:0]	<b>Dead-zone Interval Register For Pair Of Channel4 And Channel5 (PWM4 And PWM5 Pair)</b> These 8 bits determine dead-zone length. The unit time of dead-zone length is received from corresponding CSR bits.
[15:8]	DZI23[7:0]	<b>Dead-zone Interval Register For Pair Of Channel2 And Channel3 (PWM2 And PWM3 Pair)</b> These 8 bits determine dead-zone length. The unit time of dead-zone length is received from corresponding CSR bits.
[7:0]	DZI01[7:0]	<b>Dead-zone Interval Register For Pair Of Channel0 And Channel1 (PWM0 And PWM1 Pair)</b> These 8 bits determine dead-zone length. The unit time of dead-zone length is received from corresponding CSR bits.

**PWM Trigger ADC Control Register (TRGCON0)**

Register	Offset	R/W	Description				Reset Value
TRGCON0	PWM_BA+0x68	R/W	PWM Trigger Control Register 0				0x0000_0000

31	30	29	28	27	26	25	24
Reserved				P3TRGEN	CM3TRGFEN	CNT3TRGEN	CM3TRGREN
23	22	21	20	19	18	17	16
Reserved				P2TRGEN	CM2TRGFEN	CNT2TRGEN	CM2TRGREN
15	14	13	12	11	10	9	8
Reserved				P1TRGEN	CM1TRGFEN	CNT1TRGEN	CM1TRGREN
7	6	5	4	3	2	1	0
Reserved				P0TRGEN	CM0TRGFEN	CNT0TRGEN	CM0TRGREN

Bits	Description	
[31:28]	Reserved	Reserved.
[27]	P3TRGEN	<b>Enable PWM Trigger ADC Function While Channel3's Counter Matching 0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[26]	CM3TRGFEN	<b>Enable PWM Trigger ADC Function While Channel3's Counter Matching CMR3 In Down-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[25]	CNT3TRGEN	<b>Enable PWM Trigger ADC Function While Channel3's Counter Matching CNR3</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[24]	CM3TRGREN	<b>Enable PWM Trigger ADC Function While Channel3's Counter Matching CMR3 In Up-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[23:20]	Reserved	Reserved.
[19]	P2TRGEN	<b>Enable PWM Trigger ADC Function While Channel2's Counter Matching 0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.

Bits	Description
[18]	<b>CM2TRGFEN</b> <b>Enable PWM Trigger ADC Function While Channel2's Counter Matching CMR2 In Down-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[17]	<b>CNT2TRGEN</b> <b>Enable PWM Trigger ADC Function While Channel2's Counter Matching CNR2</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[16]	<b>CM2TRGREN</b> <b>Enable PWM Trigger ADC Function While Channel2's Counter Matching CMR2 In Up-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[15:12]	Reserved
[11]	<b>P1TRGEN</b> <b>Enable PWM Trigger ADC Function While Channel1's Counter Matching 0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[10]	<b>CM1TRGFEN</b> <b>Enable PWM Trigger ADC Function While Channel1's Counter Matching CMR1 In Down-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[9]	<b>CNT1TRGEN</b> <b>Enable PWM Trigger ADC Function While Channel1's Counter Matching CNR1</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[8]	<b>CM1TRGREN</b> <b>Enable PWM Trigger ADC Function While Channel1's Counter Matching CMR1 In Up-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[7:4]	Reserved
[3]	<b>P0TRGEN</b> <b>Enable PWM Trigger ADC Function While Channel0's Counter Matching 0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.

Bits	Description	
[2]	<b>CM0TRGFEN</b>	<b>Enable PWM Trigger ADC Function While Channel0's Counter Matching CMR0 In Down-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[1]	<b>CNT0TRGEN</b>	<b>Enable PWM Trigger ADC Function While Channel0's Counter Matching CNR0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[0]	<b>CM0TRGREN</b>	<b>Enable PWM Trigger ADC Function While Channel0's Counter Matching CMR0 In Up-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.

**PWM Trigger ADC Control Register (TRGCON1)**

Register	Offset	R/W	Description				Reset Value
TRGCON1	PWM_BA+0x6C	R/W	PWM Trigger Control Register 1				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				P5TRGEN	CM5TRGFEN	CNT5TRGEN	CM5TRGREN
7	6	5	4	3	2	1	0
Reserved				P4TRGEN	CM4TRGFEN	CNT4TRGEN	CM4TRGREN

Bits	Description	
[31:12]	Reserved	Reserved.
[11]	P5TRGEN	<b>Enable PWM Trigger ADC Function While Channel5's Counter Matching 0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[10]	CM5TRGFEN	<b>Enable PWM Trigger ADC Function While Channel5's Counter Matching CMR5 In Down-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[9]	CNT5TRGEN	<b>Enable PWM Trigger ADC Function While Channel5's Counter Matching CNR5</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[8]	CM5TRGREN	<b>Enable PWM Trigger ADC Function While Channel5's Counter Matching CMR5 In Up-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[7:4]	Reserved	Reserved.
[3]	P4TRGEN	<b>Enable PWM Trigger ADC Function While Channel4's Counter Matching 0</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.

Bits	Description	
[2]	<b>CM4TRGFEN</b>	<b>Enable PWM Trigger ADC Function While Channel4's Counter Matching CMR4 In Down-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is valid for both center aligned mode and edged aligned mode.
[1]	<b>CNT4TRGEN</b>	<b>Enable PWM Trigger ADC Function While Channel4's Counter Matching CNR4</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.
[0]	<b>CM4TRGREN</b>	<b>Enable PWM Trigger ADC Function While Channel4's Counter Matching CMR4 In Up-count Direction</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit is only valid for PWM in center aligned mode. When PWM is in edged aligned mode, setting this bit is meaningless and will not take any effect.

**PWM Trigger Status Register (TRGSTS0)**

Register	Offset	R/W	Description				Reset Value
TRGSTS0	PWM_BA+0x70	R/W	PWM Trigger Status Register 0				0x0000_0000

31	30	29	28	27	26	25	24
Reserved				PERID3FLAG	CMR3FLAG_F	CNT3FLAG	CMR3FLAG_R
23	22	21	20	19	18	17	16
Reserved				PERID2FLAG	CMR2FLAG_F	CNT2FLAG	CMR2FLAG_R
15	14	13	12	11	10	9	8
Reserved				PERID1FLAG	CMR1FLAG_F	CNT1FLAG	CMR1FLAG_R
7	6	5	4	3	2	1	0
Reserved				PERID0FLAG	CMR0FLAG_F	CNT0FLAG	CMR0FLAG_R

Bits	Description	
[31:28]	Reserved	Reserved.
[27]	PERID3FLAG	<b>When Counter Counting To Period, This Bit Will Be Set For Trigger ADC</b> <b>Note:</b> Software can write 1 to clear this bit.
[26]	CMR3FLAG_F	<b>When Counter Counting Down To CMR, This Bit Will Be Set For Trigger ADC</b> <b>Note:</b> Software can write 1 to clear this bit.
[25]	CNT3FLAG	<b>When Counter Counting To CNR, This Bit Will Be Set For Trigger ADC</b> <b>Note:</b> Software can write 1 to clear this bit.
[24]	CMR3FLAG_R	<b>When Counter Counting Up To CMR, This Bit Will Be Set For Trigger ADC</b> <b>Note:</b> Software can write 1 to clear this bit.
[23:20]	Reserved	Reserved.
[19]	PERID2FLAG	<b>ADC Trigger Flag By Period</b> <b>Note:</b> Software can write 1 to clear this bit.
[18]	CMR2FLAG_F	<b>ADC Trigger Flag By Counting Down To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[17]	CNT2FLAG	<b>ADC Trigger Flag By Counting To CNR</b> <b>Note:</b> Software can write 1 to clear this bit.
[16]	CMR2FLAG_R	<b>ADC Trigger Flag By Counting Up To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[15:12]	Reserved	Reserved.
[11]	PERID1FLAG	<b>ADC Trigger Flag By Period</b> <b>Note:</b> Software can write 1 to clear this bit.
[10]	CMR1FLAG_F	<b>ADC Trigger Flag By Counting Down To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.

Bits	Description	
[9]	CNT1FLAG	<b>ADC Trigger Flag By Counting To CNR</b> <b>Note:</b> Software can write 1 to clear this bit.
[8]	CMR1FLAG_R	<b>ADC Trigger Flag By Counting Up To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[7:4]	Reserved	Reserved.
[3]	PERID0FLAG	<b>ADC Trigger Flag By Period</b> <b>Note:</b> Software can write 1 to clear this bit.
[2]	CMR0FLAG_F	<b>ADC Trigger Flag By Counting Down To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[1]	CNT0FLAG	<b>ADC Trigger Flag By Counting To CNR</b> <b>Note:</b> Software can write 1 to clear this bit.
[0]	CMR0FLAG_R	<b>ADC Trigger Flag By Counting Up To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.

**PWM Trigger Status Register (TRGSTS1)**

Register	Offset	R/W	Description				Reset Value
TRGSTS1	PWM_BA+0x74	R/W	PWM Trigger Status Register 1				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				PERID5FLAG	CMR5FLAG_F	CNT5FLAG	CMR5FLAG_R
7	6	5	4	3	2	1	0
Reserved				PERID4FLAG	CMR4FLAG_F	CNT4FLAG	CMR4FLAG_R

Bits	Description	
[31:12]	Reserved	Reserved.
[11]	PERID5FLAG	<b>ADC Trigger Flag By Period</b> <b>Note:</b> Software can write 1 to clear this bit.
[10]	CMR5FLAG_F	<b>ADC Trigger Flag By Counting Down To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[9]	CNT5FLAG	<b>ADC Trigger Flag By Counting To CNR</b> <b>Note:</b> Software can write 1 to clear this bit.
[8]	CMR5FLAG_R	<b>ADC Trigger Flag By Counting Up To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[7:4]	Reserved	Reserved.
[3]	PERID4FLAG	<b>ADC Trigger Flag By Period</b> <b>Note:</b> Software can write 1 to clear this bit.
[2]	CMR4FLAG_F	<b>ADC Trigger Flag By Counting Down To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.
[1]	CNT4FLAG	<b>ADC Trigger Flag By Counting To CNR</b> <b>Note:</b> Software can write 1 to clear this bit.
[0]	CMR4FLAG_R	<b>ADC Trigger Flag By Counting Up To CMR</b> <b>Note:</b> Software can write 1 to clear this bit.

### Phase Change Register (PHCHG)

Register	Offset	R/W	Description				Reset Value
PHCHG	PWM_BA+0x78	R/W	Phase Change Register				0x0000_3F00

31	30	29	28	27	26	25	24
CE0	T0	<b>CMP0SEL</b>		CH31TOFF0	CH21TOFF0	Reserved	
23	22	21	20	19	18	17	16
CE1	T1	<b>CMP1SEL</b>		CH31TOFF1	CH21TOFF1	Reserved	
15	14	13	12	11	10	9	8
ACCNT1	ACCNT0	PWM5	Reserved	PWM3	PWM2	Reserved	
7	6	5	4	3	2	1	0
D7	D6	D5	Reserved	D3	D2	Reserved	

Bits	Description	
[31]	<b>CE0</b>	<b>ACMP0 Trigger Function Enable Control</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit will be auto cleared when ACMP0 trigger PWM if ACCNT0 is set.
[30]	<b>T0</b>	<b>Timer0 Trigger PWM Function Enable Control</b> 0 = Disabled. 1 = Enabled. When this bit is set, timer0 time-out event will update PHCHG with PHCHG_NXT register.
[29:28]	<b>CMP0SEL[1:0]</b>	<b>CMP0SEL</b> Select the positive input source of ACMP0. 00 = Select P1.5 as the input of ACMP0. 01 = Select P1.0 as the input of ACMP0. 10 = Select P1.2 as the input of ACMP0. 11 = Select P1.3 as the input of ACMP0.
[27]	<b>CH31TOFF0</b>	<b>Setting This Bit Will Force PWM3 To Output Low Lasting For At Most One Period Cycle As Long As ACMP0 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[26]	<b>CH21TOFF0</b>	<b>Setting This Bit Will Force PWM2 To Output Low Lasting For At Most One Period Cycle As Long As ACMP0 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[25:24]	<b>Reserved</b>	Reserved.

Bits	Description	
[23]	<b>CE1</b>	<b>ACMP1 Trigger Function Enable Control</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit will be auto cleared when ACMP1 trigger PWM if ACCNT1 is set.
[22]	<b>T1</b>	<b>Timer1 Trigger PWM Function Enable Control</b> 0 = Disabled. 1 = Enabled. When this bit is set, timer1 time-out event will update PHCHG with PHCHG_NXT register.
[21:20]	<b>CMP1SEL[1:0]</b>	<b>CMP1SEL</b> Select the positive input source of ACMP1. 00 = Select P3.1 as the input of ACMP1. 01 = Select P3.2 as the input of ACMP1. 10 = Select P3.3 as the input of ACMP1. 11 = Select P3.4 as the input of ACMP1.
[19]	<b>CH31TOFF1</b>	<b>Setting This Bit Will Force PWM3 To Output Low Lasting For At Most One Period Cycle As Long As ACMP1 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[18]	<b>CH21TOFF1</b>	<b>Setting This Bit Will Force PWM2 To Output Low Lasting For At Most One Period Cycle As Long As ACMP1 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[17:16]	<b>Reserved</b>	Reserved.
[15]	<b>ACCNT1</b>	<b>Hardware Auto Clear CE1 When ACMP1 Trigger It</b> 0 = Enabled. 1 = Disabled.
[14]	<b>ACCNT0</b>	<b>Hardware Auto Clear CE0 When ACMP0 Trigger It</b> 0 = Enabled. 1 = Disabled.
[13]	<b>PWM5</b>	<b>PWM Channel 5 Output Enable Control</b> 0 = Output D5 specified in bit 5 of PHCHG register. 1 = Output the original channel 5 waveform.
[12]	<b>Reserved</b>	Reserved.
[11]	<b>PWM3</b>	<b>PWM Channel 3 Output Enable Control</b> 0 = Output D3 specified in bit 3 of PHCHG register. 1 = Output the original channel 3 waveform.
[10]	<b>PWM2</b>	<b>PWM Channel 2 Output Enable Control</b> 0 = Output D2 specified in bit 2 of PHCHG register. 1 = Output the original channel 2 waveform.
[9:8]	<b>Reserved</b>	Reserved.

Bits	Description	
[7]	<b>D7</b>	<b>D7: When MASK7 Is 1, Channel 7's Output Waveform Is D7</b> 0 = Output low. 1 = Output high.
[6]	<b>D6</b>	<b>D6: When MASK6 Is 1, Channel 6's Output Waveform Is D6</b> 0 = Output low. 1 = Output high.
[5]	<b>D5</b>	<b>D5: When PWM5 Is Zero, Channel 5's Output Waveform Is D5</b> 0 = Output low. 1 = Output high.
[4]	<b>Reserved</b>	Reserved.
[3]	<b>D3</b>	<b>D3: When PWM3 Is Zero, Channel 3's Output Waveform Is D3</b> 0 = Output low. 1 = Output high.
[2]	<b>D2</b>	<b>D2: When PWM2 Is Zero, Channel 2's Output Waveform Is D2</b> 0 = Output low. 1 = Output high.
[1:0]	<b>Reserved</b>	Reserved.

Next Phase Change Register (PHCHGNXT)

Register	Offset	R/W	Description				Reset Value
PHCHGNXT	PWM_BA+0x7C	R/W	Next Phase Change Register				0x0000_3F00

31	30	29	28	27	26	25	24
CE0	T0	CMP0SEL		CH31TOFF0	CH21TOFF0	Reserved	
23	22	21	20	19	18	17	16
CE1	T1	CMP1SEL		CH31TOFF1	CH21TOFF1	Reserved	
15	14	13	12	11	10	9	8
ACCNT1	ACCNT0	PWM5	Reserved	PWM3	PWM2	Reserved	
7	6	5	4	3	2	1	0
D7	D6	D5	Reserved	D3	D2	Reserved	

Bits	Description	
[31]	CE0	<b>ACMP0 Trigger Function Enable Control</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit will be auto cleared when ACMP0 trigger PWM if ACCNT0 is set.
[30]	T0	<b>Timer0 Trigger PWM Function Enable Control</b> 0 = Disabled. 1 = Enabled. When this bit is set, timer0 time-out event will update PHCHG with PHCHG_NXT register.
[29:28]	CMP0SEL[1:0]	<b>CMP0SEL</b> Select the positive input source of ACMP0. 00 = Select P1.5 as the input of ACMP0. 01 = Select P1.0 as the input of ACMP0. 10 = Select P1.2 as the input of ACMP0. 11 = Select P1.3 as the input of ACMP0.
[27]	CH31TOFF0	<b>Setting This Bit Will Force PWM3 To Output Low Lasting For At Most One Period Cycle As Long As ACMP0 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[26]	CH21TOFF0	<b>Setting This Bit Will Force PWM2 To Output Low Lasting For At Most One Period Cycle As Long As ACMP0 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[25:24]	Reserved	Reserved.

Bits	Description	
[23]	<b>CE1</b>	<b>ACMP1 Trigger Function Enable Control</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> This bit will be auto cleared when ACMP1 trigger PWM if ACCNT1 is set.
[22]	<b>T1</b>	<b>Timer1 Trigger PWM Function Enable Control</b> 0 = Disabled. 1 = Enabled. When this bit is set, timer1 time-out event will update PHCHG with PHCHG_NXT register.
[21:20]	<b>CMP1SEL[1:0]</b>	<b>CMP1SEL</b> Select the positive input source of ACMP1. 00 = Select P3.1 as the input of ACMP1. 01 = Select P3.2 as the input of ACMP1. 10 = Select P3.3 as the input of ACMP1. 11 = Select P3.4 as the input of ACMP1.
[19]	<b>CH31TOFF1</b>	<b>Setting This Bit Will Force PWM3 To Output Low Lasting For At Most One Period Cycle As Long As ACMP1 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[18]	<b>CH21TOFF1</b>	<b>Setting This Bit Will Force PWM2 To Output Low Lasting For At Most One Period Cycle As Long As ACMP1 Trigger It; This Feature Is Usually In Step Motor Application</b> 0 = Disabled. 1 = Enabled. <b>Note:</b> Only for PWM2, PWM3.
[17:16]	<b>Reserved</b>	Reserved.
[15]	<b>ACCNT1</b>	<b>Hardware Auto Clear CE1 When ACMP1 Trigger It</b> 0 = Enabled. 1 = Disabled.
[14]	<b>ACCNT0</b>	<b>Hardware Auto Clear CE0 When ACMP0 Trigger It</b> 0 = Enabled. 1 = Disabled.
[13]	<b>PWM5</b>	<b>PWM Channel 5 Output Enable Control</b> 0 = Output D5 specified in bit 5 of PHCHG register. 1 = Output the original channel 5 waveform.
[12]	<b>Reserved</b>	Reserved.
[11]	<b>PWM3</b>	<b>PWM Channel 3 Output Enable Control</b> 0 = Output D3 specified in bit 3 of PHCHG register. 1 = Output the original channel 3 waveform.
[10]	<b>PWM2</b>	<b>PWM Channel 2 Output Enable Control</b> 0 = Output D2 specified in bit 2 of PHCHG register. 1 = Output the original channel 2 waveform.
[9:8]	<b>Reserved</b>	Reserved.

Bits	Description	
[7]	D7	<b>D7: When MASK7 Is 1, Channel 7's Output Waveform Is D7</b> 0 = Output low. 1 = Output high.
[6]	D6	<b>D6: When MASK6 Is 1, Channel 6's Output Waveform Is D6</b> 0 = Output low. 1 = Output high.
[5]	D5	<b>D5: When PWM5 Is Zero, Channel 5's Output Waveform Is D5</b> 0 = Output low. 1 = Output high.
[4]	Reserved	Reserved.
[3]	D3	<b>D3: When PWM3 Is Zero, Channel 3's Output Waveform Is D3</b> 0 = Output low. 1 = Output high.
[2]	D2	<b>D2: When PWM2 Is Zero, Channel 2's Output Waveform Is D2</b> 0 = Output low. 1 = Output high.
[1:0]	Reserved	Reserved.

### Phase Change Mask Register (PHCHGMASK)

Register	Offset	R/W	Description				Reset Value
PHCHGMASK	PWM_BA+0x80	R/W	Phase Change MASK Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved						<b>CMPMASK</b>	
7	6	5	4	3	2	1	0
MASK7	MASK6	Reserved					

Bits	Description	
[31:10]	Reserved	Reserved.
[9]	CMPMASK[1]	<b>MASK For ACMP1</b> 0 = The input of ACMP is controlled by CMP_CR1 register. 1 = The input of ACMP is controlled by CMP1SEL of PHCHG register.
[8]	CMPMASK[0]	<b>MASK For ACMP0</b> 0 = The input of ACMP is controlled by CMP_CR0 register. 1 = The input of ACMP is controlled by CMP0SEL of PHCHG register.
[7]	MASK7	<b>MASK For D7</b> 0 = Original GPIO P0.0. 1 = D7.
[6]	MASK6	<b>MASK For D6</b> 0 = Original GPIO P0.1. 1 = D6.
[5:0]	Reserved	Reserved.

Interrupt Accumulation Control Register (INTACCUCTL)

Register	Offset	R/W	Description				Reset Value
INTACCUCTL	PWM_BA+0x84	R/W	Period Interrupt Accumulation Control Register				0x0000_00F0

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
PERIODCNT				Reserved			INTACCUEN0

Bits	Description	
[31:8]	Reserved	Reserved.
[7:4]	PERIODCNT[3:0]	<b>Interrupt Accumulation Bits</b> When INTACCUEN0 is set, PERIODCNT will decrease when every PWMPIFO flag is set and when PERIODCNT reach to zero, the PWM0 interrupt will occurred and PERIODCNT will reload itself.
[3:1]	Reserved	Reserved.
[0]	INTACCUEN0	<b>Interrupt Accumulation Function Enable Control</b> 0 = Disabled. 1 = Enabled.

## 5.12 Watchdog Timer (WDT)

### 5.12.1 Overview

The purpose of Watchdog Timer is to perform a system reset when system runs into an unknown state. This prevents system from hanging for an infinite period of time. Besides, this Watchdog Timer supports the function to wake-up system from Idle/Power-down mode.

### 5.12.2 Features

- 18-bit free running up counter for Watchdog Timer time-out interval.
- Selectable time-out interval ( $2^4 \sim 2^{18}$ ) WDT\_CLK cycle and the time-out interval period is 104 ms ~ 26.3168 s if WDT\_CLK = 10 kHz.
- System kept in reset state for a period of  $(1 / \text{WDT\_CLK}) * 63$
- Supports Watchdog Timer reset delay period (NUC029xAN only)
  - Selectable it includes (1026、130、18 or 3) \* WDT\_CLK reset delay period
- Supports to force Watchdog Timer enabled after chip powered on or reset while CWDTEN (CONFIG0[31] Watchdog Enable) bit is set to 0 (NUC029xAN only)
- Supports Watchdog Timer time-out wake-up function only if WDT clock source is selected as 10 kHz

### 5.12.3 Block Diagram

The Watchdog Timer clock control and block diagram are shown as follows.

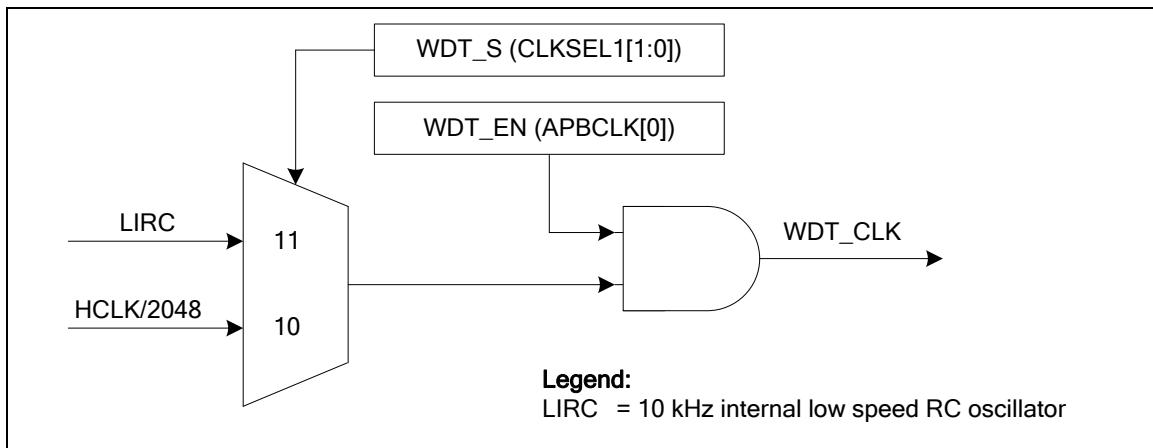


Figure 5-85 Watchdog Timer Clock Control

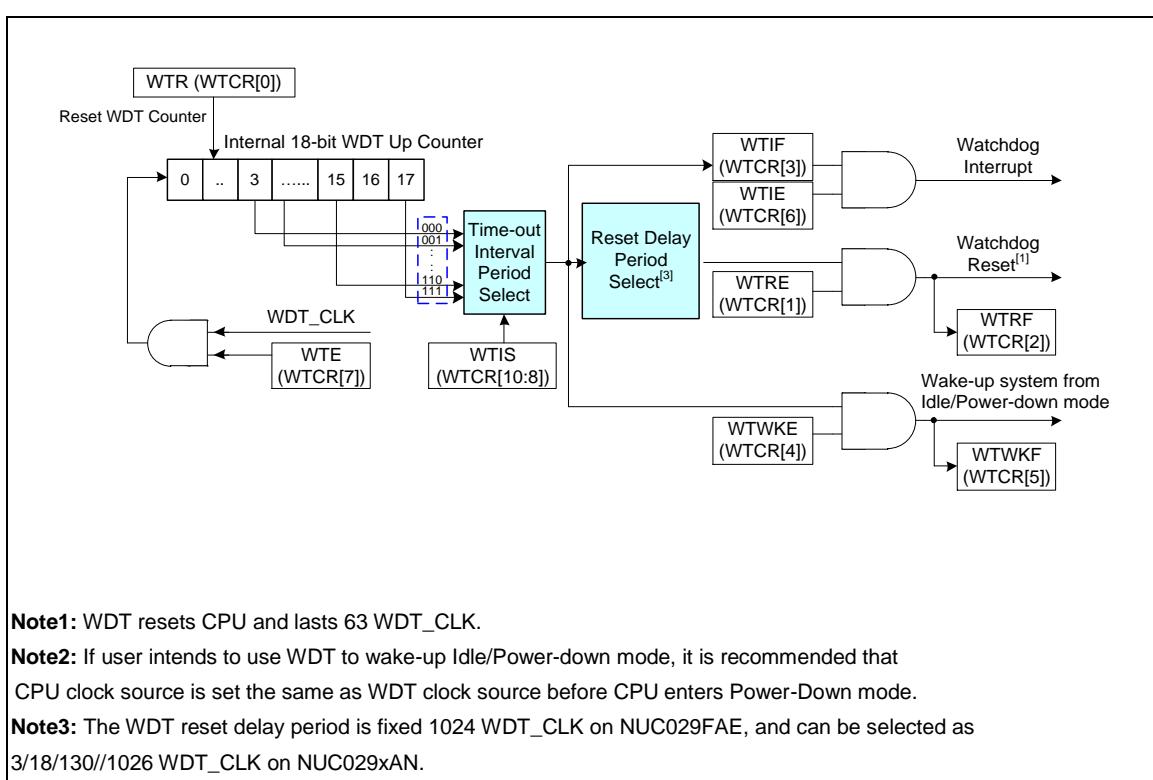


Figure 5-86 Watchdog Timer Block Diagram

### 5.12.4 Basic Configuration

The WDT peripheral clock is enabled in WDT\_EN(APBCLK[0]) and clock source can be selected in WDT\_S(CLKSEL1[1:0]).

Or user can setting CONFIG[31] 0 to force Watchdog Timer enabled and active in 10 kHz after chip powered on or reset on NUC029xAN.

### 5.12.5 Functional Description

The Watchdog Timer (WDT) includes an 18-bit free running up counter with programmable time-out intervals. Table 5-17 shows the WDT time-out interval period selection and Figure 5-87 shows the WDT time-out interval and reset period timing.

#### 5.12.5.1.1 WDT Time-out Interrupt

Setting WTE(WTCR[7]) bit to 1 will enable the WDT function and the WDT counter to start counting up. There are eight time-out interval period can be selected by setting WTIS(WTCR[10:8]). When the WDT up counter reaches the WTIS settings, WDT time-out interrupt will occur then WTIF(WTCR[3]) flag will be set to 1 immediately.

#### 5.12.5.1.2 WDT Reset Delay Period and Reset System

There is a specified  $T_{RSTD}$  delay period follows the WTIF(WTCR[3]) flag is setting to 1. User should set WTR(WTCR[0]) bit to reset the 18-bit WDT up counter value to avoid generate WDT time-out reset signal before the  $T_{RSTD}$  delay period expires. If the WDT up counter value has not been cleared after the specific  $T_{RSTD}$  delay period expires, the WDT control will set WTRF(WTCR[2]) flag to 1 if WTRE(WTCR[1]) bit is enabled, then chip enters to reset state immediately. Refer to Figure 5-87, the  $T_{RST}$  reset period will keep last 63 WDT clocks then chip restart executing program from reset vector (0x0000\_0000). The WTRF(WTCR[2]) flag will keep 1 after WDT time-out reset the chip, user can check WTRF(WTCR[2]) flag by software to recognize the system has been reset by WDT time-out reset or not.

#### 5.12.5.1.3 WDT Wake-up

If WDT clock source is selected to 10 kHz, system can be waken-up from Power-down mode while WDT time-out interrupt signal is generated and WTWKE(WTCR[4]) bit enabled. In the meanwhile, the WTWKF(WTCR[5]) flag will set to 1 automatically, user can check WTWKF(WTCR[5]) flag by software to recognize the system has been waken-up by WDT time-out interrupt or not.

WTIS	Time-Out Interval Period $T_{TIS}$	Reset Delay Period (NUC029xAN)	
		$T_{RSTD}$	$T_{RSTD}$
000	$2^4 * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
001	$2^6 * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
010	$2^8 * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
011	$2^{10} * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
100	$2^{12} * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
101	$2^{14} * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
110	$2^{16} * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$
111	$2^{18} * T_{WDT}$	$(3/18/130/1026) * T_{WDT}$	$1024 * T_{WDT}$

Table 5-17 Watchdog Timer Time-out Interval Period Selection

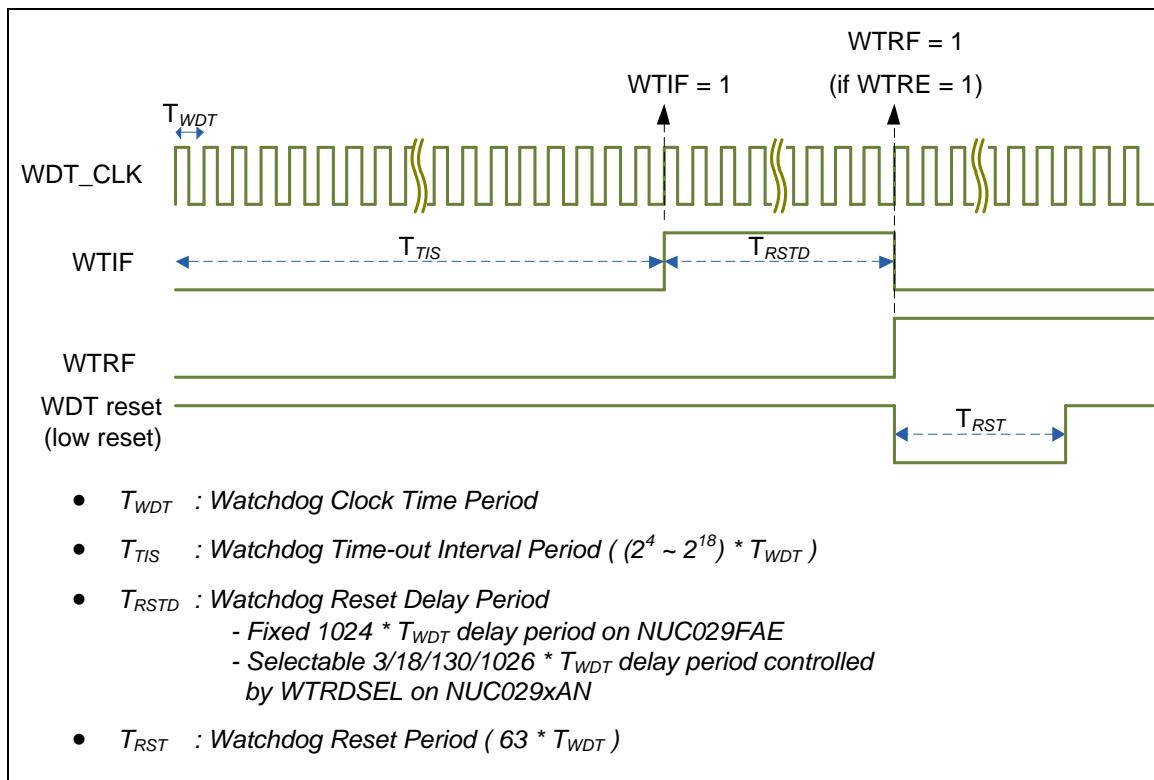


Figure 5-87 Watchdog Timer Time-out Interval and Reset Period Timing

### 5.12.6 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>WDT Base Address:</b> <b>WDT_BA = 0x4000_4000</b>				
WTCR	WDT_BA+0x00	R/W	Watchdog Timer Control Register	0x0000_0700
WTCRALT	WDT_BA+0x04	R/W	Watchdog Timer Alternative Control Register (NUC029xAN only)	0x0000_0000

### 5.12.7 Register Description

#### Watchdog Timer Control Register (WTCR)

Register	Offset	R/W	Description	Reset Value
WTCR	WDT_BA+0x00	R/W	Watchdog Timer Control Register	0x0000_0700

**Note:** To program write-protected bits in this register, an open lock sequence is needed, by sequentially writing 0x59, 0x16, and 0x88 to register REGWRPROT at address GCR\_BA + 0x100.

31	30	29	28	27	26	25	24
DBGACK_WDT	Reserved						
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved					WTIS		
7	6	5	4	3	2	1	0
WTE	WTIE	WTWKF	WTWKE	WTIF	WTRF	WTRE	WTR

Bits	Description	
[31]	DBGACK_WDT	<b>ICE Debug Mode Acknowledge Disable Control (Write Protect)</b> 0 = ICE debug mode acknowledgement effects WDT counting. WDT up counter will be held while CPU is held by ICE. 1 = ICE debug mode acknowledgement Disabled. WDT up counter will keep going no matter CPU is held by ICE or not.
[30:11]	Reserved	Reserved.
[10:8]	WTIS	<b>Watchdog Timer Time-out Interval Selection (Write Protect)</b> These three bits select the time-out interval period for the WDT. 000 = $2^4 * T_{WDT}$ . 001 = $2^6 * T_{WDT}$ . 010 = $2^8 * T_{WDT}$ . 011 = $2^{10} * T_{WDT}$ . 100 = $2^{12} * T_{WDT}$ . 101 = $2^{14} * T_{WDT}$ . 110 = $2^{16} * T_{WDT}$ . 111 = $2^{18} * T_{WDT}$ .
[7]	WTE	<b>Watchdog Timer Enable Control (Write Protect)</b> 0 = WDT Disabled. (This action will reset the internal up counter value.) 1 = WDT Enabled.
[6]	WTIE	<b>Watchdog Timer Time-out Interrupt Enable Control (Write Protect)</b> If this bit is enabled, the WDT time-out interrupt signal is generated and inform to CPU. 0 = WDT time-out interrupt Disabled. 1 = WDT time-out interrupt Enabled.

[5]	<b>WTWKF</b>	<b>Watchdog Timer Time-out Wake-up Flag</b> This bit indicates the interrupt wake-up flag status of WDT. 0 = WDT does not cause chip wake-up. 1 = Chip wake-up from Idle or Power-down mode if WDT time-out interrupt signal generated. <b>Note:</b> This bit is cleared by writing 1 to it.
[4]	<b>WTWKE</b>	<b>Watchdog Timer Time-out Wake-up Function Control (Write Protect)</b> If this bit is set to 1, while WTIF is generated to 1 and WTIE enabled, the WDT time-out interrupt signal will generate a wake-up trigger event to chip. 0 = Wake-up trigger event Disabled if WDT time-out interrupt signal generated. 1 = Wake-up trigger event Enabled if WDT time-out interrupt signal generated. <b>Note:</b> Chip can be woken-up by WDT time-out interrupt signal generated only if WDT clock source is selected to 10 kHz oscillator.
[3]	<b>WTIF</b>	<b>Watchdog Timer Time-out Interrupt Flag</b> This bit will set to 1 while WDT up counter value reaches the selected WDT time-out interval. 0 = WDT time-out interrupt did not occur. 1 = WDT time-out interrupt occurred. <b>Note:</b> This bit is cleared by writing 1 to it.
[2]	<b>WTRF</b>	<b>Watchdog Timer Time-out Reset Flag</b> This bit indicates the system has been reset by WDT time-out reset or not. 0 = WDT time-out reset did not occur. 1 = WDT time-out reset occurred. <b>Note:</b> This bit is cleared by writing 1 to it.
[1]	<b>WTRE</b>	<b>Watchdog Timer Time-out Reset Enable Control (Write Protect)</b> Setting this bit will enable the WDT time-out reset function If the WDT up counter value has not been cleared after the specific WDT reset delay period expires. 0 = WDT time-out reset function Disabled. 1 = WDT time-out reset function Enabled. <b>Note:</b> Fixed $1024 * T_{WDT}$ delay period on NUC029FAE. Selectable 3/18/130/1026 * TWDT delay period controlled by WTRDSEL on NUC029xAN.
[0]	<b>WTR</b>	<b>Reset Watchdog Timer Up Counter (Write Protect)</b> 0 = No effect. 1 = Reset the internal 18-bit WDT up counter value. <b>Note:</b> This bit will be automatically cleared by hardware.

Watchdog Timer Alternative Control Register (WTCRALT)

Register	Offset	R/W	Description				Reset Value
WTCRALT	WDT_BA+0x04	R/W	Watchdog Timer Alternative Control Register (NUC029xAN only)				0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1:0]	WTRDSEL	<p><b>Watchdog Timer Reset Delay Selection (Write Protect)</b></p> <p>When WDT time-out happened, software has a time named WDT Reset Delay Period to clear WDT counter to prevent WDT time-out reset happened. Software can select a suitable value of WDT Reset Delay Period for different WDT time-out period.</p> <p>00 = Watchdog Timer Reset Delay Period is 1026 * WDT_CLK.      01 = Watchdog Timer Reset Delay Period is 130* WDT_CLK.      10 = Watchdog Timer Reset Delay Period is 18 * WDT_CLK.      11 = Watchdog Timer Reset Delay Period is 3 * WDT_CLK.</p> <p><b>Note:</b> This register will be reset to 0 if WDT time-out reset happened.</p>

## 5.13 Window Watchdog Timer (WWDT) (NUC029xAN Only)

### 5.13.1 Overview

The NuMicro® NUC029xAN supports The Window Watchdog Timer (WWDT). WWDT is used to perform a system reset within a specified window period to prevent software run to uncontrollable status by any unpredictable condition.

### 5.13.2 Features

- 6-bit down counter value WWDTVAL (WWDTVAL[5:0]) and 6-bit compare window value WINCMP (WWDTCR[21:16]) to make the WWDT time-out window period flexible
- Supports 4-bit value to programmable maximum 11-bit prescale counter period of WWDT counter

### 5.13.3 Block Diagram

The Window Watchdog Timer clock control and block diagram are shown as follows.

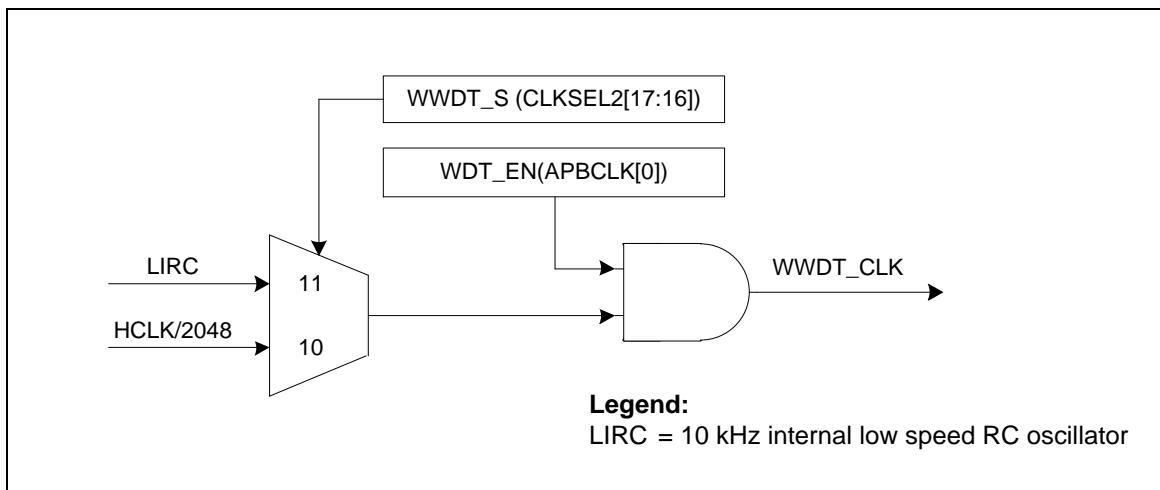


Figure 5-88 Window Watchdog Timer Clock Control

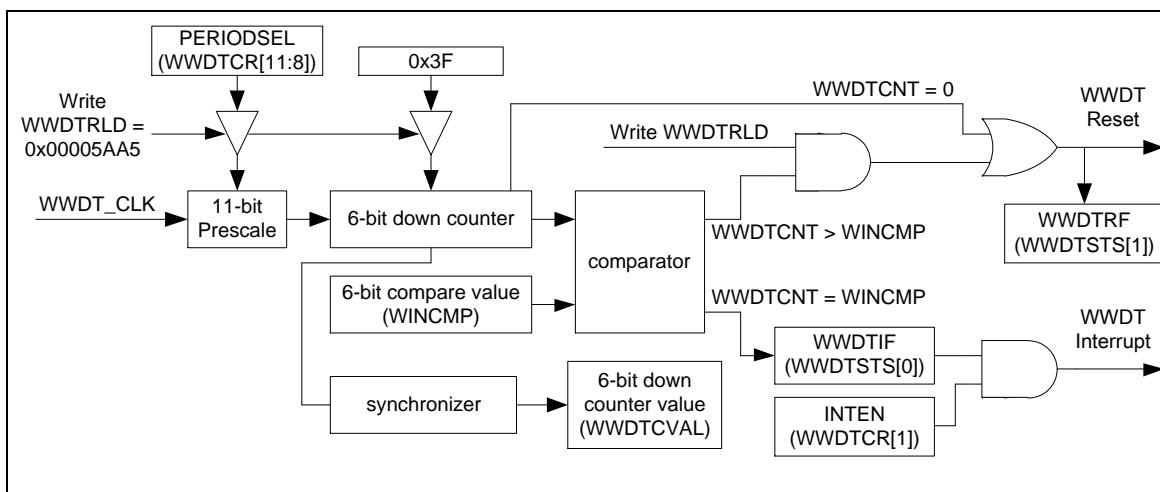


Figure 5-89 Window Watchdog Timer Block Diagram

### 5.13.4 Basic Configuration

The WWDT peripheral clock is enabled in APBCLK[0] and clock source can be selected in CLKSEL2[17:16].

### 5.13.5 Functional Description

The Window Watchdog Timer (WWDT) includes a 6-bit down counter with programmable prescale value to define different WWDT time-out intervals.

The clock source of 6-bit WWDT is based on system clock divide 2048 (HCLK/2048) or internal

10 kHz oscillator with a programmable 11-bit prescale counter value which controlled by PERIODSEL setting. Also, the correlate of PERIODSEL and prescale value are listed in the following table.

PERIODSEL	Prescale Value	Max. Time-Out Period	Max. Time-Out Interval (WWDT_CLK=10 KHz)
0000	1	$1 * 64 * T_{WWDT}$	6.4 ms
0001	2	$2 * 64 * T_{WWDT}$	12.8 ms
0010	4	$4 * 64 * T_{WWDT}$	25.6 ms
0011	8	$8 * 64 * T_{WWDT}$	51.2 ms
0100	16	$16 * 64 * T_{WWDT}$	102.4 ms
0101	32	$32 * 64 * T_{WWDT}$	204.8 ms
0110	64	$64 * 64 * T_{WWDT}$	409.6 ms
0111	128	$128 * 64 * T_{WWDT}$	819.2 ms
1000	192	$192 * 64 * T_{WWDT}$	1.2288 s
1001	256	$256 * 64 * T_{WWDT}$	1.6384 s
1010	384	$384 * 64 * T_{WWDT}$	2.4576 s
1011	512	$512 * 64 * T_{WWDT}$	3.2768 s
1100	768	$768 * 64 * T_{WWDT}$	4.9152 s
1101	1024	$1024 * 64 * T_{WWDT}$	6.5536 s
1110	1536	$1536 * 64 * T_{WWDT}$	9.8304 s
1111	2048	$2048 * 64 * T_{WWDT}$	13.1072 s

Table 5-18 Window Watchdog Timer Prescale Value Selection

#### 5.13.5.1.1 WWDT Counting

When the WWDTEN bit is set, WWDT down counter will start counting from 0x3F to 0. To prevent program runs to disable WWDT counter counting unexpected, the WWDT control register WWDTCR can only be written once after chip is powered on or reset. User cannot disable WWDT counter counting (WWDTEN), change counter prescale period (PERIODSEL) or change window compare value (WINCMP) while WWDTEN bit has been enabled by software unless chip is reset.

#### 5.13.5.1.2 WWDT Compare Match Interrupt

During down counting by the WWDT counter, the WWDTIF is set to 1 while the WWDT counter value (WWDTVAL) is equal to WINCMP value and WWDTIF can be cleared by software; if WWDTIE is also set to 1 by software, the WWDT compare match interrupt signal is generated also while WWDTIF is set to 1 by hardware.

#### 5.13.5.1.3 WWDT Reset System

When WWDTIF is generated, user must reload WWDT internal counter value to 0x3F by writing

0x00005AA5 to WWDTRLD, and also to prevent WWDT counter value reached to 0 and generate WWDT reset system signal to info system reset.

If current WWDTVAL value is larger than WINCMP value and user writes 0x00005AA5 to the WWDTRLD register, the WWDT reset system signal will be generated immediately to cause chip reset also.

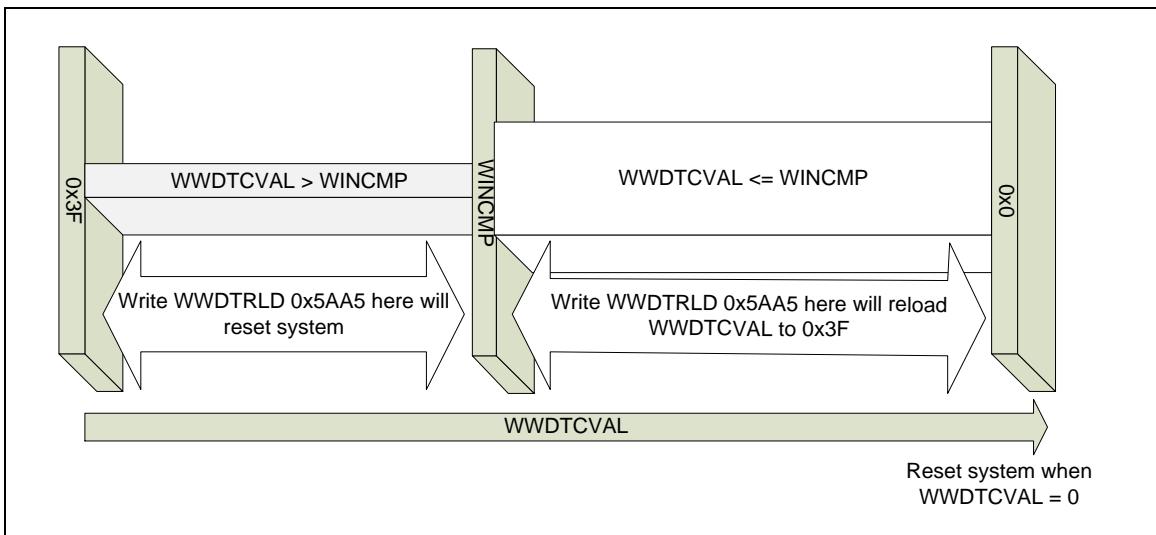


Figure 5-90 Window Watchdog Timer Reset and Reload Behavior

#### 5.13.5.1.4 WWDT Window Setting Limitation

When user writes 0x00005AA5 to WWDTRLD to reload WWDT counter value to 0x3F, it needs 3 WWDT clocks to sync the reload command to actually perform reload action. This means if user set PERIODSEL to 0000, the counter prescale value should be as 1, and the WINCMP value must be larger than 2; otherwise, writing WWDTRLD to reload WWDT counter value to 0x3F is unavailable while WWDTIF is generated and WWDT reset system event always happened.

PERIODSEL	Prescale Value	Valid WINCMP Value
0000	1	0x3 ~ 0x3F
0001	2	0x2 ~ 0x3F
Others	Others	0x0 ~ 0x3F

Table 5-19 WINCMP Setting Limitation

### 5.13.6 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>WWDT Base Address:</b>				
<b>WWDT_BA = 0x4000_4100</b>				
WWDTRLD	WWDT_BA+0x00	W	Window Watchdog Timer Reload Counter Register	0x0000_0000
WWDTCSR	WWDT_BA+0x04	R/W	Window Watchdog Timer Control Register	0x003F_0800
WWDTSR	WWDT_BA+0x08	R/W	Window Watchdog Timer Status Register	0x0000_0000
WWDTCVR	WWDT_BA+0x0C	R	Window Watchdog Timer Counter Value Register	0x0000_003F

### 5.13.7 Register Description

#### Window Watchdog Timer Reload Counter Register (WWDTRLD)

Register	Offset	R/W	Description					Reset Value
WWDTRLD	WWDT_BA+0x00	W	Window Watchdog Timer Reload Counter Register					0x0000_0000

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

Bits	Description	
[31:0]	WWDTRLD	<p><b>WWDT Reload Counter Register</b></p> <p>Writing 0x00005AA5 to this register will reload the WWDT counter value to 0x3F.</p> <p><b>Note:</b> Software can only write WWDTRLD to reload WWDT counter value when current WWDT counter value between 0 and WINCMP. If software writes WWDTRLD when current WWDT counter value is larger than WINCMP, WWDT reset signal will generate immediately.</p>

Window Watchdog Timer Control Register (WWDTCR)

Register	Offset	R/W	Description					Reset Value
WWDTCR	WWDT_BA+0x04	R/W	Window Watchdog Timer Control Register					0x003F_0800

**Note:** This register can be written only one time after chip is powered on or reset.

31	30	29	28	27	26	25	24	
DBGACK_WWDT	Reserved							
23	22	21	20	19	18	17	16	
Reserved		WINCMP						
15	14	13	12	11	10	9	8	
Reserved				PERIODSEL				
7	6	5	4	3	2	1	0	
Reserved						WWDTIE	WWDTEN	

Bits	Description	
[31]	DBGACK_WWDT	<b>ICE Debug Mode Acknowledge Disable Control</b> 0 = ICE debug mode acknowledgement effects WWDT counting. WWDT down counter will be held while CPU is held by ICE. 1 = ICE debug mode acknowledgement Disabled. WWDT down counter will keep going no matter CPU is held by ICE or not.
[30:22]	Reserved	Reserved.
[21:16]	WINCMP	<b>WWDT Window Compare Register</b> Set this register to adjust the valid reload window. <b>Note:</b> Software can only write WWDTRLD to reload WWDT counter value when current WWDT counter value between 0 and WINCMP. If Software writes WWDTRLD when current WWDT counter value larger than WINCMP, WWDT reset signal will generate immediately.
[15:12]	Reserved	Reserved.
[11:8]	PERIODSEL	<b>WWDT Counter Prescale Period Selection</b> 0000 = Pre-scale is 1; Max time-out period is $1 * 64 * T_{WWDT}$ . 0001 = Pre-scale is 2; Max time-out period is $2 * 64 * T_{WWDT}$ . 0010 = Pre-scale is 4; Max time-out period is $4 * 64 * T_{WWDT}$ . 0011 = Pre-scale is 8; Max time-out period is $8 * 64 * T_{WWDT}$ . 0100 = Pre-scale is 16; Max time-out period is $16 * 64 * T_{WWDT}$ . 0101 = Pre-scale is 32; Max time-out period is $32 * 64 * T_{WWDT}$ . 0110 = Pre-scale is 64; Max time-out period is $64 * 64 * T_{WWDT}$ . 0111 = Pre-scale is 128; Max time-out period is $128 * 64 * T_{WWDT}$ . 1000 = Pre-scale is 192; Max time-out period is $192 * 64 * T_{WWDT}$ . 1001 = Pre-scale is 256; Max time-out period is $256 * 64 * T_{WWDT}$ . 1010 = Pre-scale is 384; Max time-out period is $384 * 64 * T_{WWDT}$ . 1011 = Pre-scale is 512; Max time-out period is $512 * 64 * T_{WWDT}$ . 1100 = Pre-scale is 768; Max time-out period is $768 * 64 * T_{WWDT}$ .

		1101 = Pre-scale is 1024; Max time-out period is $1024 * 64 * T_{WWDT}$ . 1110 = Pre-scale is 1536; Max time-out period is $1536 * 64 * T_{WWDT}$ . 1111 = Pre-scale is 2048; Max time-out period is $2048 * 64 * T_{WWDT}$ .
[7:2]	<b>Reserved</b>	Reserved.
[1]	<b>WWDTIE</b>	<b>WWDT Interrupt Enable Control</b> If this bit is enabled, the WWDT counter compare match interrupt signal is generated and inform to CPU. 0 = WWDT counter compare match interrupt Disabled. 1 = WWDT counter compare match interrupt Enabled.
[0]	<b>WWDTEN</b>	<b>WWDT Enable Control</b> 0 = WWDT counter is stopped. 1 = WWDT counter is starting counting.

Window Watchdog Timer Status Register (WWDTSR)

Register	Offset	R/W	Description					Reset Value
WWDTSR	WWDT_BA+0x08	R/W	Window Watchdog Timer Status Register					0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1]	WWDTRF	<p><b>WWDT Timer-out Reset Flag</b>  This bit indicates the system has been reset by WWDT time-out reset or not.  0 = WWDT time-out reset did not occur.  1 = WWDT time-out reset occurred.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>
[0]	WWDTIF	<p><b>WWDT Compare Match Interrupt Flag</b>  This bit indicates the interrupt flag status of WWDT while WWDT counter value matches WINCMP value.  0 = No effect.  1 = WWDT counter value matches WINCMP value.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>

Window Watchdog Timer Counter Value Register (WWDTCSR)

Register	Offset	R/W	Description					Reset Value
WWDTCSR	WWDT_BA+0x0C	R	Window Watchdog Timer Counter Value Register					0x0000_003F

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

Bits	Description	
[31:6]	Reserved	Reserved.
[5:0]	WWDTCSR	<b>WWDT Counter Value</b> WWDTCSR will be updated continuously to monitor 6-bit down counter value.

## 5.14 UART Interface Controller (UART)

### 5.14.1 Overview

The NuMicro® NUC029 series provides up to 2 channels of Universal Asynchronous Receiver/Transmitters (UART). UART Controller performs Normal Speed UART, and supports flow control function. The UART Controller performs a serial-to-parallel conversion on data received from the peripheral, and a parallel-to-serial conversion on data transmitted from the CPU. The UART controller also supports IrDA SIR Function and RS-485 function mode. The NUC029xAN also supports LIN master/slave function mode. Each UART Controller channel supports six types of interrupts. NUC029xAN has seventh interrupt, LIN receiver break field detected interrupt (LIN\_RX\_BREAK\_INT).

### 5.14.2 Features

- Full duplex, asynchronous communications
- Separates receive / transmit 16/16 bytes entry FIFO for data payloads
- Supports hardware auto flow control/flow control function (CTS, RTS) and programmable RTS flow control trigger level
- Programmable receiver buffer trigger level
- Supports programmable baud-rate generator for each channel individually
- Supports CTS wake-up function
- Supports 8-bit receiver buffer time-out detection function
- Programmable transmitting data delay time between the last stop and the next start bit by setting DLY (UA\_TOR [15:8]) register
- Supports break error, frame error, parity error and receive / transmit buffer overflow detect function
- Fully programmable serial-interface characteristics
  - Programmable data bit length, 5-, 6-, 7-, 8-bit character
  - Programmable parity bit, even, odd, no parity or stick parity bit generation and detection
  - Programmable stop bit length, 1, 1.5, or 2 stop bit generation
- Supports IrDA SIR function mode
  - Supports 3-/16-bit duration for normal mode
- Supports RS-485 function mode.
  - Supports RS-485 9-bit mode
  - Supports hardware or software enable to control RS-485 transmission direction by programming RTS pin
- Supports LIN function mode (NUC029xAN only)
  - Supports LIN master/slave mode
  - Supports programmable break generation function for transmitter
  - Supports break detect function for receiver

### 5.14.3 Block Diagram

The UART clock control and block diagram are shown below.

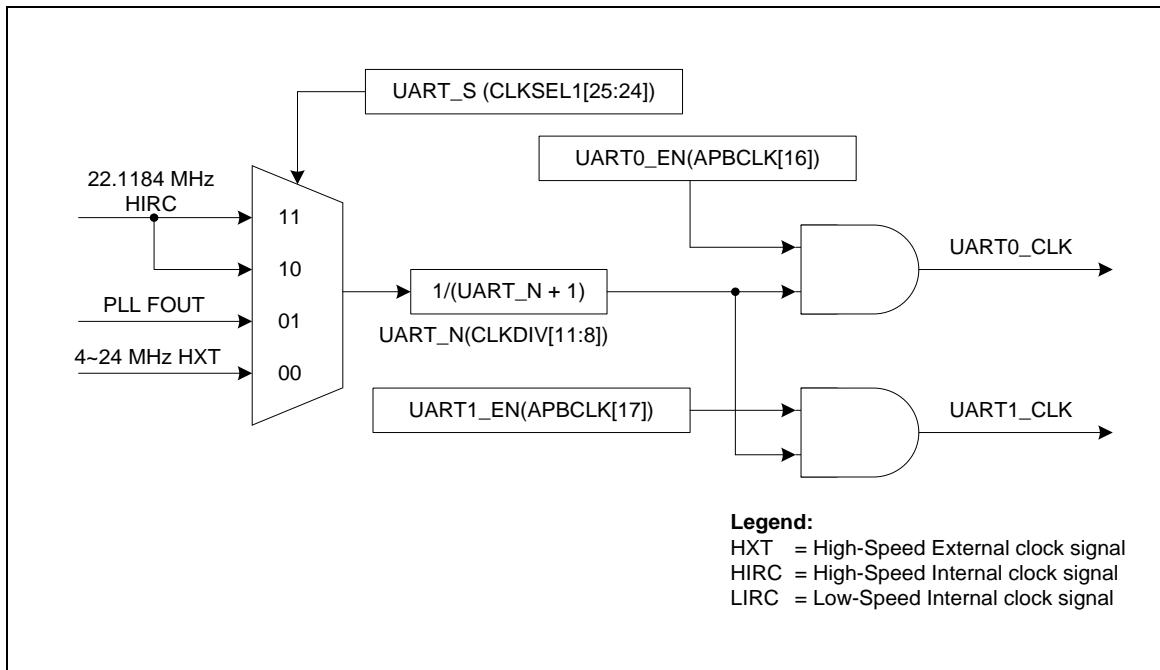


Figure 5-91 UART Controller Clock Control for NUC029xAN

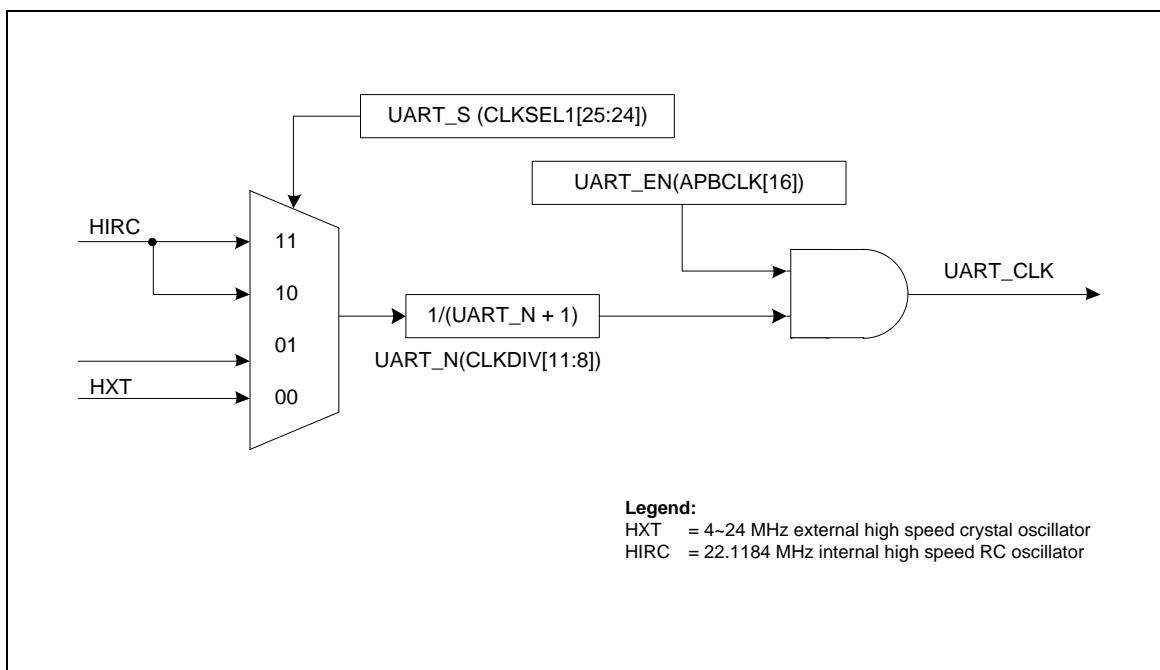


Figure 5-92 UART Controller Clock Control for NUC029FAE

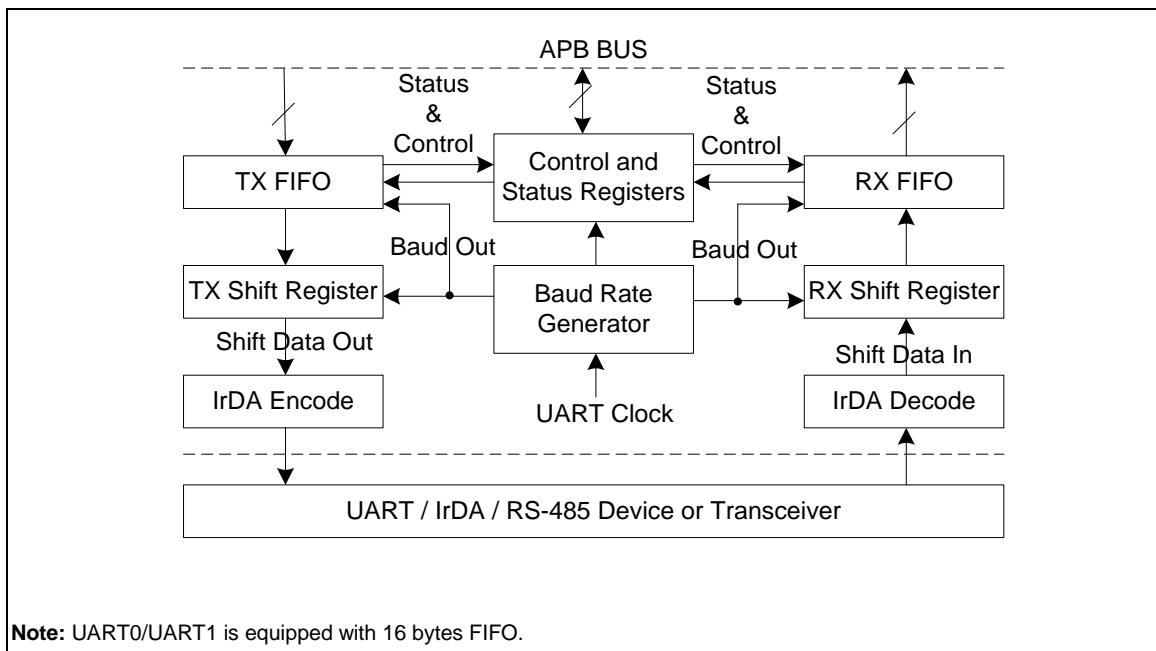


Figure 5-93 UART Controller Block Diagram

Each block is described in detail as follows:

#### **TX\_FIFO**

The transmitter is buffered with a 16 bytes FIFO to reduce the number of interrupts presented to the CPU.

#### **RX\_FIFO**

The receiver is buffered with a 16 bytes FIFO (plus three error bits per byte) to reduce the number of interrupts presented to the CPU.

#### **TX Shift Register**

This block is the shifting the transmitting data out serially control block.

#### **RX Shift Register**

This block is the shifting the receiving data in serially control block.

#### **Baud Rate Generator**

Divide the external clock by the divisor to get the desired baud rate clock. Refer to baud rate equation.

#### **IrDA Encode**

This block is IrDA encode control block.

#### **IrDA Decode**

This block is IrDA decode control block.

#### **Control and Status Register**

This field is register set that including the FIFO control registers (UA\_FCR), FIFO status registers (UA\_FSR), and line control register (UA\_LCR) for transmitter and receiver. The time-out control register (UA\_TOR) identifies the condition of time-out interrupt. This register set also includes the interrupt enable register (UA\_IER) and interrupt status register (UA\_ISR) to enable or disable the

responding interrupt and to identify the occurrence of the responding interrupt. There are six types of interrupts, transmitter FIFO empty interrupt(THRE\_INT), receiver threshold level reaching interrupt (RDA\_INT), line status interrupt (parity error or framing error or break interrupt) (RLS\_INT), time-out interrupt (TOUT\_INT), Buffer error interrupt (BUF\_ERR\_INT). NUC029xAN also have MODEM/Wake-up status interrupt (MODEM\_INT), LIN receiver break field detected interrupt (LIN\_RX\_BREAK\_INT).

In addition, the block diagram of auto-flow control is demonstrated in the following diagram.

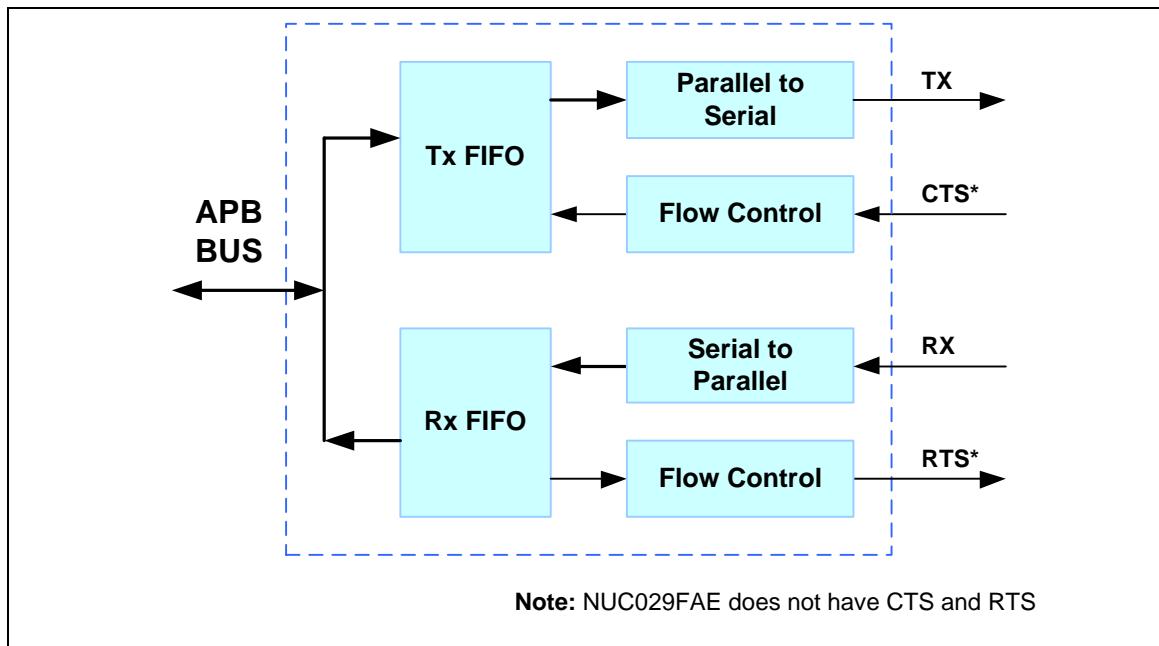


Figure 5-94 Auto Flow Control Block Diagram

#### 5.14.4 Basic Configuration

##### NUC029xAN:

The UART Controller function pins are configured in P0\_MFP registers for UART0 and P3\_MFP registers for UART1.

The UART Controller clock are enabled in UART0\_EN(APBCLK[16]) for UART0 and UART1\_EN (APBCLK[17]) for UART1.

The UART Controller clock source is selected by UART\_S(CLKSEL[25:24]).

The UART Controller clock prescaler is determined by UART\_N(CLKDIV[11:8]).

**NUC029FAE:**

The UART Controller function pins are configured in P1\_MFP registers for UART.

The UART Controller clock are enabled in UART\_EN(APBCLK[16]) for UART.

The UART Controller clock source is selected by UART\_S(CLKSEL[25:24]).

The UART Controller clock prescaler is determined by UART\_N(CLKDIV[11:8]).

### 5.14.5 Functional Description

The UART Controller supports four function modes including UART, IrDA and RS-485 mode. NUC029xAN also supports LIN mode. User can select a function by setting the UA\_FUN\_SEL register.

#### 5.14.5.1 UART Controller Baud Rate Generator

The UART Controller includes a programmable baud rate generator capable of dividing clock input by divisors to produce the serial clock that transmitter and receiver need. The baud rate equation is  $\text{Baud Rate} = \text{UART\_CLK} / M * [\text{BRD} + 2]$ , where M and BRD are defined in Baud Rate Divider Register (UA\_BAUD). The following tables list the UART baud rate equations in the various conditions and UART baud rate parameter settings. There is no error for the baud rate results calculated through the baud rate parameter and register setting below. In IrDA function mode, the baud rate generator must be set in Mode 0.

Mode	DIV_X_EN	DIV_X_ONE	Divider X	BRD	M	Baud Rate Equation
Mode 0	0	0	B	A	16	$\text{UART\_CLK} / [16 * (A+2)]$
Mode 1	1	0	B	A	B+1	$\text{UART\_CLK} / [(B+1) * (A+2)]$ , B must $\geq 8$
Mode 2	1	1	Don't care	A	1	$\text{UART\_CLK} / (A+2)$ , A must $\geq 8$

Table 5-20 UART Controller Baud Rate Equation Table

UART Peripheral Clock = 22.1184 MHz					
Baud Rate	Mode 0	Mode 1		Mode 2	
921600	Not support	A=0, B=11	0x2B00_0000	A=22	0x3000_0016
460800	A=1	A=1, B=15 A=2, B=11	0x2F00_0001 0x2B00_0002	A=46	0x3000_002E
230400	A=4	A=4, B=15 A=6, B=11	0x2F00_0004 0x2B00_0006	A=94	0x3000_005E
115200	A=10	A=10, B=15 A=14, B=11	0x2F00_000A 0x2B00_000E	A=190	0x3000_00BE
57600	A=22	A=22, B=15 A=30, B=11	0x2F00_0016 0x2B00_001E	A=382	0x3000_017E
38400	A=34	A=62, B=8 A=46, B=11 A=34, B=15	0x2800_003E 0x2B00_002E 0x2F00_0022	A=574	0x3000_023E
19200	A=70	A=126, B=8	0x2800_007E	A=1150	0x3000_047E

		A=94, B=11 A=70, B=15	0x2B00_005E 0x2F00_0046		
9600	A=142	A=254, B=8 A=190, B=11 A=142, B=15	0x2800_00FE 0x2B00_00BE 0x2F00_008E	A=2302	0x3000_08FE
4800	A=286	A=510, B=8 A=382, B=11 A=286, B=15	0x2800_01FE 0x2B00_017E 0x2F00_011E	A=4606	0x3000_11FE

Table 5-21 UART Controller Baud Rate Parameter and Register Setting Table

#### 5.14.5.2 UART Controller FIFO Control and Status

The UART Controller is built-in with a 16 bytes transmitter FIFO (TX\_FIFO) and a 16 bytes receiver FIFO (RX\_FIFO) that reduces the number of interrupts presented to the CPU. The CPU can read the status of the UART at any time during operation. The reported status information includes the interrupts and condition of the transfer operations being performed by the UART, as well as 3 error conditions (parity error, framing error, break interrupt) probably occur while receiving data. This FIFO control and status also support all of UART, IrDA, RS-485 and LIN(NUC029xAN only) function mode.

#### 5.14.5.3 UART Controller Wake-up Function

When the chip is in Power-down mode, an external CTS change will wake-up chip from Power-down mode. This wake-up function is available in every function mode. User must enable the MODEN\_INT interrupt to use the wake-up function.

#### 5.14.5.4 UART Controller Interrupt and Status

Each UART Controller supports five types of interrupts including:

- Receiver threshold level reached interrupt (RDA\_INT)
- Transmitter FIFO empty interrupt (THRE\_INT)
- Line status interrupt (parity error, frame error or break interrupt) (RLS\_INT)
- Receiver buffer time-out interrupt (TOUT\_INT)
- Buffer error interrupt (BUF\_ERR\_INT)

NUC029xAN also supports other two types of interrupts including:

- MODEM/Wake-up status interrupt (MODEM\_INT)
- LIN receiver break field detected interrupt (LIN\_RX\_BREAK\_INT)

The following tables describe the interrupt sources and flags. The interrupt is generated when the interrupt flag is generated and the interrupt enable bit is set. User must clear the interrupt flag after the interrupt is generated.

Interrupt Source	Interrupt Indicator	Interrupt Enable Bit	Interrupt Flag	Flag Cleared By
------------------	---------------------	----------------------	----------------	-----------------

Receive Data Available Interrupt	RDA_INT	RDA_IEN	<b>RDA_IF</b>	Read UA_RBR
Transmit Holding Register Empty Interrupt	THRE_INT	THRE_IEN	<b>THRE_IF</b>	Write UA_THR
Receive Line Status Interrupt	RLS_INT	RLS_IEN	<b>RLS_IF</b> = BIF or FEF or PEF	Writing '1' to BIF/FEF/PEF
			<b>RLS_IF</b> = NUC029xAN: RS485_ADD_DETF NUC029FAE BIF or FEF or PEF or RS485_ADD_DETF	Writing '1' to NUC029xAN: RS485_ADD_DETF NUC029FAE BIF/FEF/PEF/ RS485_ADD_DETF
Modem Status Interrupt (NUC029xAN only)	MODEM_INT	MODEM_IEN	<b>MODEM_IF</b> = DCTS	Write '1' to DCTS
RX Time-out Interrupt	TOUT_INT	RTO_IEN	<b>TOUT_IF</b>	Read UA_RBR
Buffer Error Interrupt	BUF_ERR_INT	BUF_ERR_IEN	<b>BUF_ERR_IF</b> = (TX_OVER_IF or RX_OVER_IF)	Writing '1' to TX_OVER_IF / RX_OVER_IF
LIN RX Break Field Detected interrupt (NUC029xAN only)	LIN_RX_BREAK_INT	LIN_RX_BRK_IEN	<b>LIN_RX_BREAK_IF</b>	Write '1' to LIN_RX_BREAK_IF

Table 5-22 UART Controller Interrupt Source and Flag List

#### 5.14.5.5 *UART Function Mode*

The UART Controller provides UART function (user must set UA\_FUN\_SEL[1:0] to '00' to enable UART function mode). The UART baud rate is up to 1 Mbps.

The UART provides full-duplex and asynchronous communications. The transmitter and receiver contain 16-bytes FIFO for payloads. User can program receiver buffer trigger level and receiver buffer time-out detection for receiver. The transmitting data delay time between the last stop and the next start bit can be programmed by setting DLY(UA\_TOR [15:8]) register. The UART supports hardware auto-flow control and flow control function (CTS, RTS), programmable RTS flow control trigger level and fully programmable serial-interface characteristics.

#### UART Line Control Function

The UART Controller supports fully programmable serial-interface characteristics by setting the UA\_LCR register. Software can use the UA\_LCR register to program the word length, stop bit and parity bit. The following tables list the UART word and stop bit length settings and the UART parity bit settings.

NSB (UA_LCR[2])	WLS (UA_LCR[1:0])	Word Length (Bit)	Stop Length (Bit)
0	00	5	1
0	01	6	1
0	10	7	1
0	11	8	1
1	00	5	1.5
1	01	6	2
1	10	7	2
1	11	8	2

Table 5-23 UART Line Control of Word and Stop Length Setting

Parity Type	SPE (UA_LCR[5])	EPE (UA_LCR[4])	PBE (UA_LCR[3])	Description
No Parity	x	x	0	No parity bit output.
Odd Parity	0	0	1	Odd Parity is calculated by adding all the "1's" in a data stream and adding a parity bit to the total bits, to make the total count an odd number.
Even Parity	0	1	1	Even Parity is calculated by adding all the "1's" in a data stream and adding a parity bit to the total bits, to make the count an even number.
Forced Mask Parity	1	0	1	Parity bit always logic 1. Parity bit on the serial byte is set to "1" regardless of total number of "1's" (even or odd counts).
Forced Space Parity	1	1	1	Parity bit always logic 0. Parity bit on the serial byte is set to "0" regardless of total number of "1's" (even or odd counts).

Table 5-24 UART Line Control of Parity Bit Setting

**Note:** User cannot change line controller setting when TE\_FLAG(UA\_FSR[28]) is not empty

#### UART Auto-Flow Control Function (NUC029xAN only)

The UART supports auto-flow control function that uses two signals, CTS (clear-to-send) and RTS (request-to-send), to control the flow of data transfer between the UART and external devices (e.g. Modem). When auto flow is enabled, the UART is not allowed to receive data until the UART asserts RTS to external device. When the number of bytes in the RX FIFO equals the value of RTS\_TRI\_LEV(UA\_FCR [19:16]), the RTS is de-asserted. The UART sends data out when UART detects CTS is asserted from external device. If the valid asserted CTS is not detected, the UART will not send data out.

The following diagram demonstrates the CTS auto flow control of UART function mode. User must set AUTO\_CTS\_EN (UA\_IER [13]) to enable CTS auto flow control function. The LEV\_CTS (UA\_MCR [8]) can set CTS pin input active state. The DCTS(UA\_MSR [0]) is set when any state change of CTS pin input has occurred, and then TX data will be automatically transmitted from TX FIFO.

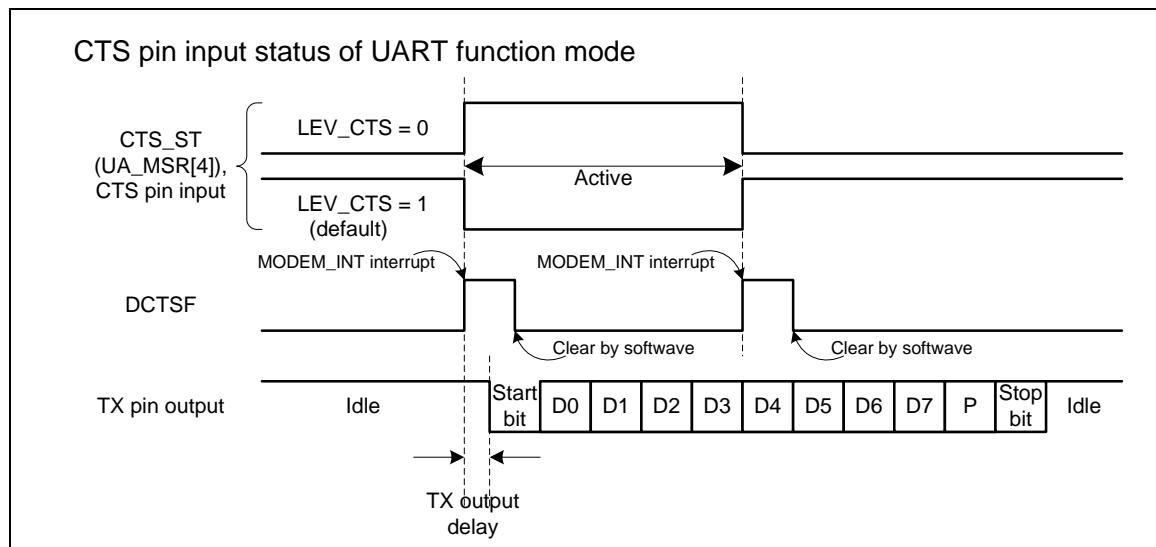


Figure 5-95 UART CTS Auto Flow Control Enabled

As shown in the following figure, in UART RTS Auto Flow control mode (AUTO\_RTS\_EN(UA\_IER[12])=1), the nRTS internal signal is controlled by UART FIFO controller with RTS\_RTI\_lev(UA\_FCR[19:16]) trigger level.

Setting LEV\_RTS(UA\_MCR[9]) can control the RTS pin output is inverse or non-inverse from nRTS signal. User can read the RTS\_ST(UA\_MCR[13]) bit to get real RTS pin output voltage logic status.

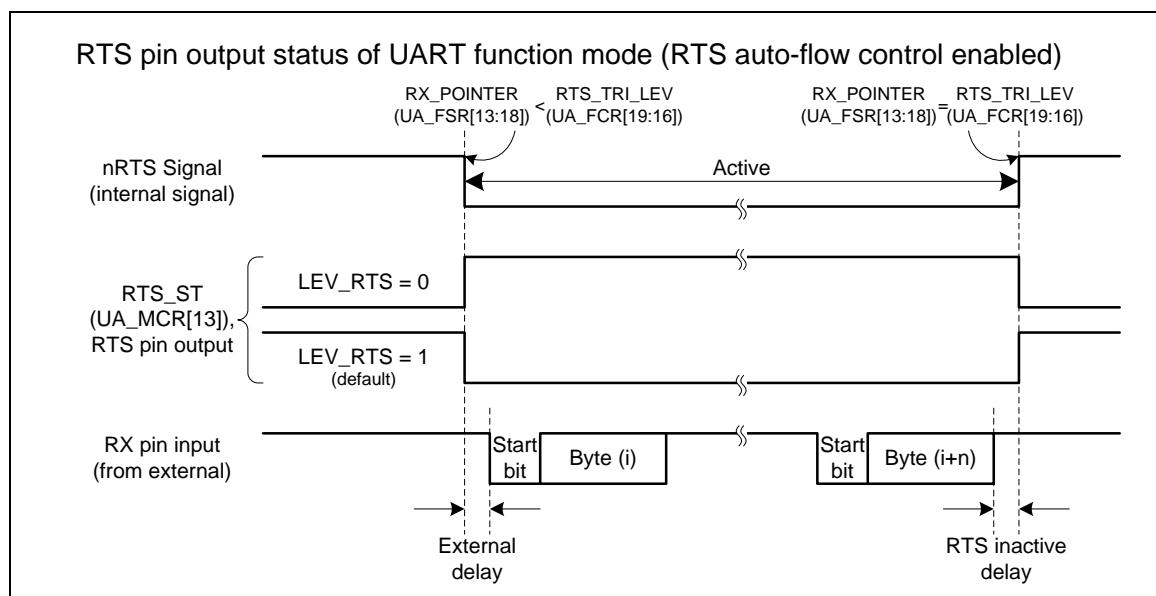


Figure 5-96 UART RTS Auto Flow Control Enabled

As shown in the following figure, in software mode (AUTO\_RTS\_EN(UA\_IER[12])=0) the RTS flow is directly controlled by software programming of RTS(UA\_MCR[1]) control bit.

Setting LEV\_RTS(UA\_MCR[9]) can control the RTS pin output is inverse or non-inverse from RTS(UA\_MCR[1]) control bit. User can read the RTS\_ST(UA\_MCR[13]) bit to get real RTS pin output voltage logic status.

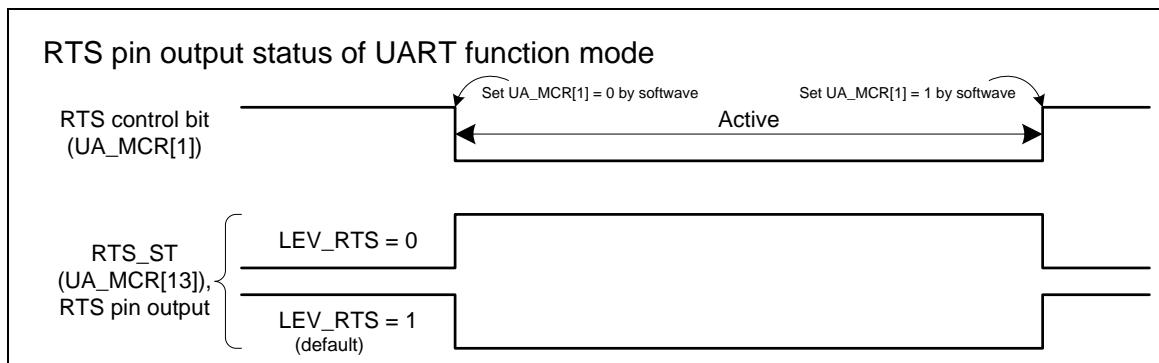


Figure 5-97 UART RTS Flow with Software Control

#### 5.14.5.6 IrDA Function Mode

The UART Controller also provides Serial IrDA (SIR, Serial Infrared) function (user must set IrDA\_EN(UA\_FUN\_SEL [1:0]) to 10'b to enable the IrDA function). The SIR specification defines a short-range infrared asynchronous serial transmission mode with one start bit, 8 data bits, and 1 stop bit. The maximum data rate is 115.2 kbps. The IrDA SIR block contains an IrDA SIR protocol encoder/decoder. The IrDA SIR protocol is half-duplex only. So it cannot transmit and receive data at the same time. The IrDA SIR physical layer specifies a minimum 10 ms transfer delay between transmission and reception, and this delay feature must be implemented by software.

In IrDA mode, the DIV\_X\_EN (UA\_BAUD [29]) register must be disabled.

**Baud Rate = Clock / (16 \* BRD)**, where BRD is Baud Rate Divider in UA\_BAUD register.

The following diagram demonstrates the IrDA control block diagram.

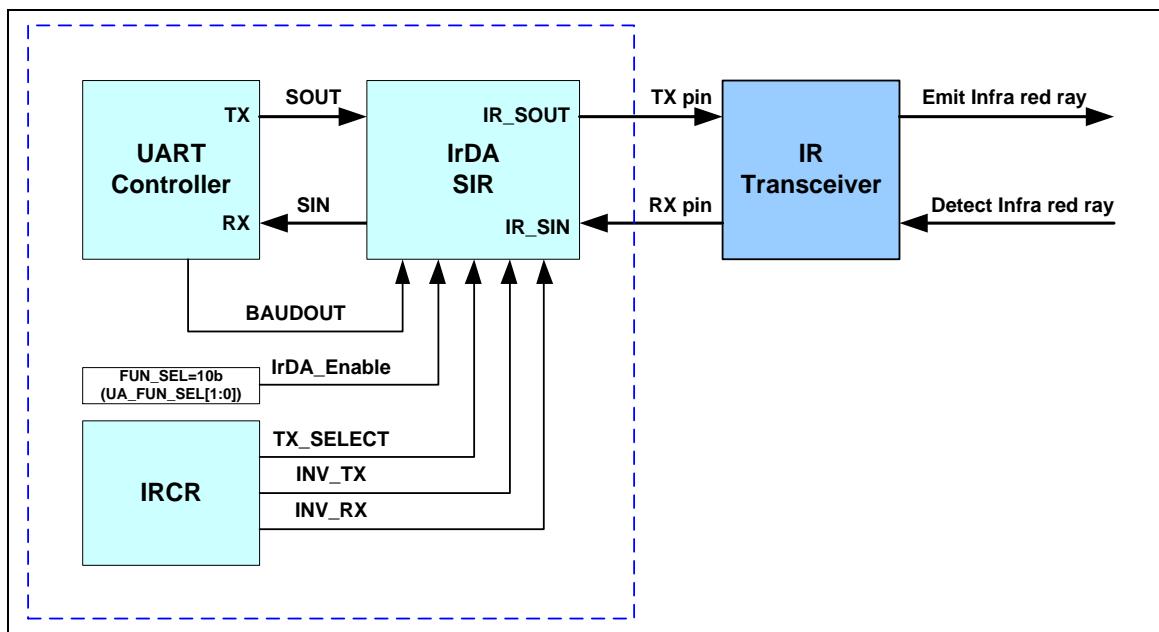


Figure 5-98 IrDA Control Block Diagram

#### IrDA SIR Transmit Encoder

The IrDA SIR Transmit Encoder modulates Non-Return-to Zero (NRZ) transmit bit stream output from UART. The IrDA SIR physical layer specifies the use of Return-to-Zero, Inverted (RZI)

modulation scheme which represents logic 0 as an infra light pulse. The modulated output pulse stream is transmitted to an external output driver and infrared light emitting diode.

In Normal mode, the transmitted pulse width is specified as 3/16 period of baud rate.

### IrDA SIR Receive Decoder

The IrDA SIR Receive Decoder demodulates the Return-to-Zero bit stream from the input detector and outputs the NRZ serial bits stream to the UART received data input. The decoder input is normally high in idle state. (Because of this, IRCR(INV\_RX [6]) should be set as 1 by default).

A start bit is detected when the decoder input is LOW.

### IrDA SIR Operation

The IrDA SIR encoder/decoder provides functionality which converts between UART data stream and half-duplex serial SIR interface. The following diagram is IrDA encoder/decoder waveform.

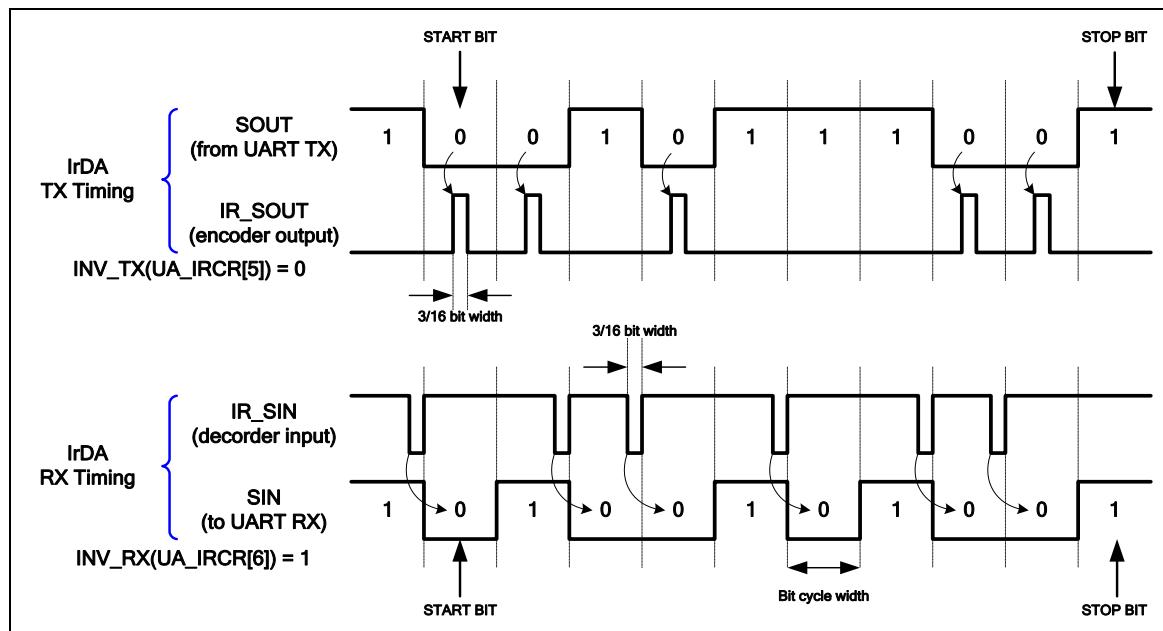


Figure 5-99 IrDA TX/RX Timing Diagram

#### 5.14.5.7 RS-485 Function Mode

Another alternate function of UART Controller is RS-485 function (user must set UA\_FUN\_SEL [1:0] to 11'b to enable RS-485 function). The RS-485 transceiver control is implemented by using the RTS control signal from an asynchronous serial port to enable the RS-485 driver. Many characteristics of the RX and TX are same as UART in RS-485 mode

For NUC029xAN, direction control can be provided by RTS pin or programming GPIO (P0.3 for RTS0 and P0.1 for RTS1) to implement the function by software. For NUC029FAE, user must control RTS(UA\_MCR[1]) by software to directly control RTS signal..

The controller can configuration of it as an RS-485 addressable slave and the RS-485 master transmitter will identify an address character by setting the parity (9-th bit) to 1. For data characters, the parity is set to 0. Software can use UA\_LCR register to control the 9-th bit (When the PBE, EPE and SPE are set, the 9-th bit is transmitted 0 and when PBE and SPE are set and

EPE is cleared, the 9-th bit is transmitted 1).

The controller supports three operation modes: RS-485 Normal Multi-drop Operation Mode (NMM), RS-485 Auto Address Detection Operation Mode (AAD) and RS-485 Auto Direction Control Operation Mode (AUD). Software can choose any operation mode by programming the UA\_ALT\_CSR register, and drive the transfer delay time between the last stop bit leaving the TX FIFO and the de-assertion of by setting DL(UA\_TOR [15:8]) bit.

#### **RS-485 Normal Multi-drop Operation Mode (NMM)**

In RS-485 Normal Multi-drop Operation Mode, in first, software must decide the data which before the address byte be detected will be stored in RX FIFO or not. If software wants to ignore any data before address byte detected, the flow is set RX\_DIS(UA\_FCR [8]) then enable RS485\_NMM(UA\_ALT\_CSR [8]) and the receiver will ignore any data until an address byte is detected (bit 9 = 1) and the address byte data will be stored in the RX FIFO. If software wants to receive any data before address byte detected, the flow is disables RX\_DIS(UA\_FCR [8]) then enable RS485\_NMM(UA\_ALT\_CSR [8]) and the receiver will received any data.

If an address byte is detected (bit 9 = 1), it will generate an interrupt to CPU and RX\_DIS(UA\_FCR [8]) can decide whether accepting the following data bytes are stored in the RX FIFO. If software disables receiver by setting RX\_DIS(UA\_FCR [8]) register, when a next address byte is detected, the controller will clear the RX\_DIS(UA\_FCR [8]) bit and the address byte data will be stored in the RX FIFO.

#### **RS-485 Auto Address Detection Operation Mode (AAD)**

In RS-485 Auto Address Detection Operation Mode, the receiver will ignore any data until an address byte is detected (bit 9 = 1) and the address byte data matches the ADDR\_MATCH (UA\_ALT\_CSR[31:24]) value. The address byte data will be stored in the RX FIFO. The all received byte data will be accepted and stored in the RX FIFO until and address byte data not match the ADDR\_MATCH(UA\_ALT\_CSR[31:24]) value.

#### **RS-485 Auto Direction Mode (AUD)**

Another option function of RS-485 controllers is **RS-485 auto direction control function**. User must set RS485\_AUD(UA\_ALT\_CSR[10]) to 1 to enabled RS-485 auto direction mode. The RS-485 transceiver control is implemented using the RTS control signal from an asynchronous serial port. The RTS line is connected to the RS-485 transceiver enable pin such that setting the RTS line to high (logic 1) enables the RS-485 transceiver. Setting the RTS line to low (logic 0) puts the transceiver into the tri-state condition to disabled. User can set LEV\_RTS in UA\_MCR register to change the RTS driving level.

The following diagram demonstrates the RS-485 RTS driving level in AUD mode. The RTS pin will be automatically driven during TX data transmission.

Setting LEV\_RTS(UA\_MCR[9]) can control RTS pin output driving level. User can read the RTS\_ST(UA\_MCR[13]) bit to get real RTS pin output voltage logic status.

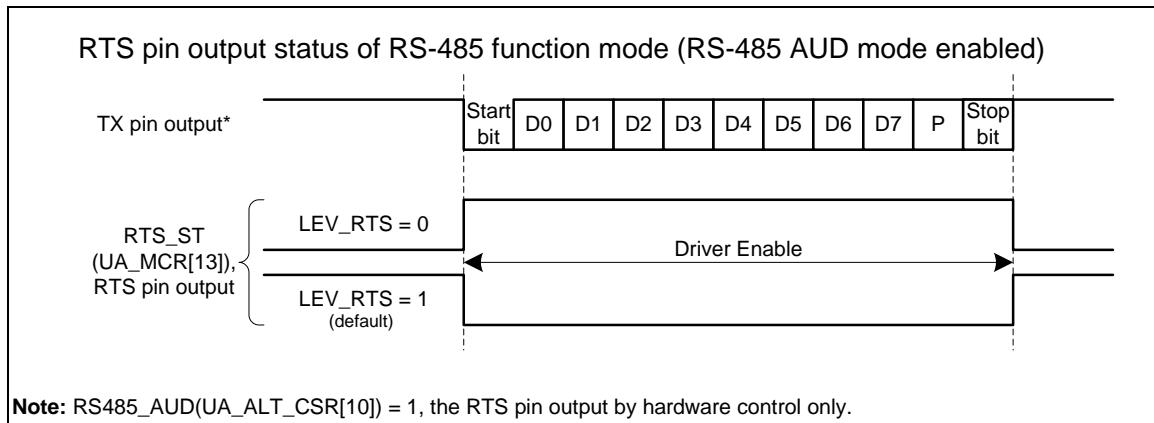


Figure 5-100 RS-485 RTS Driving Level in Auto Direction Mode

The following diagram demonstrates the RS-485 RTS driving level in software control (RS485\_AUD(UA\_ALT\_CSR[10])=0). The RTS driving level is controlled by programming the RTS(UA\_MCR[1]) control bit.

Setting LEV\_RTS(UA\_MCR[9]) can control the RTS pin output is inverse or non-inverse from RTS(UA\_MCR[1]) control bit. User can read the RTS\_ST(UA\_MCR[13]) bit to get real RTS pin output voltage logic status.

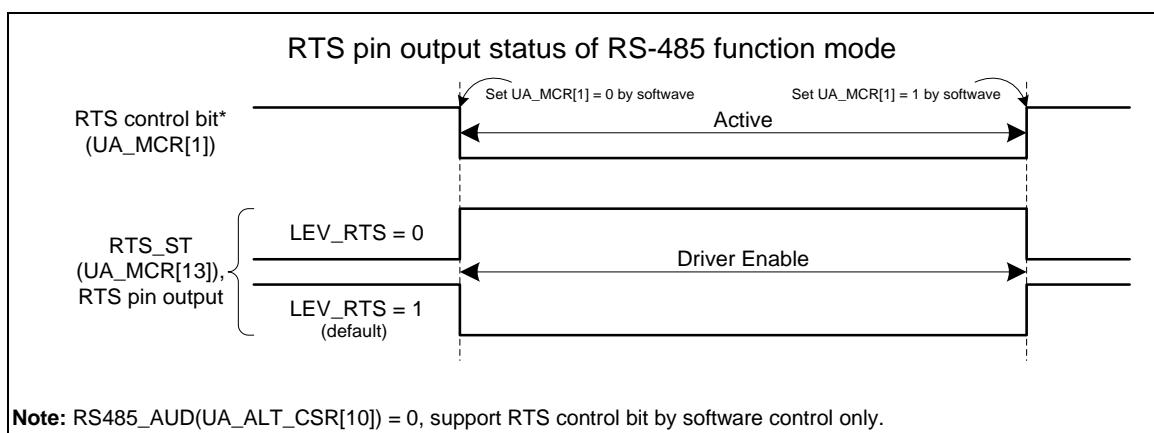


Figure 5-101 RS-485 RTS Driving Level with Software Control

#### Program Sequence Example:

1. Program FUN\_SEL(UA\_FUN\_SEL[1:0]) to select RS-485 function.
2. Program the RX\_DIS(UA\_FCR[8]) bit to determine enable or disable the receiver RS-485 receiver
3. Program the RS485\_NMM or RS485\_AAD mode.
4. If the RS485\_AAD(UA\_ALT\_CSR[9]) mode is selected, the ADDR\_MATCH(UA\_ALT\_CSR[31:24]) is programmed for auto address match value.
5. Determine auto direction control by programming RS485\_AUD(UA\_ALT\_CSR[10]).

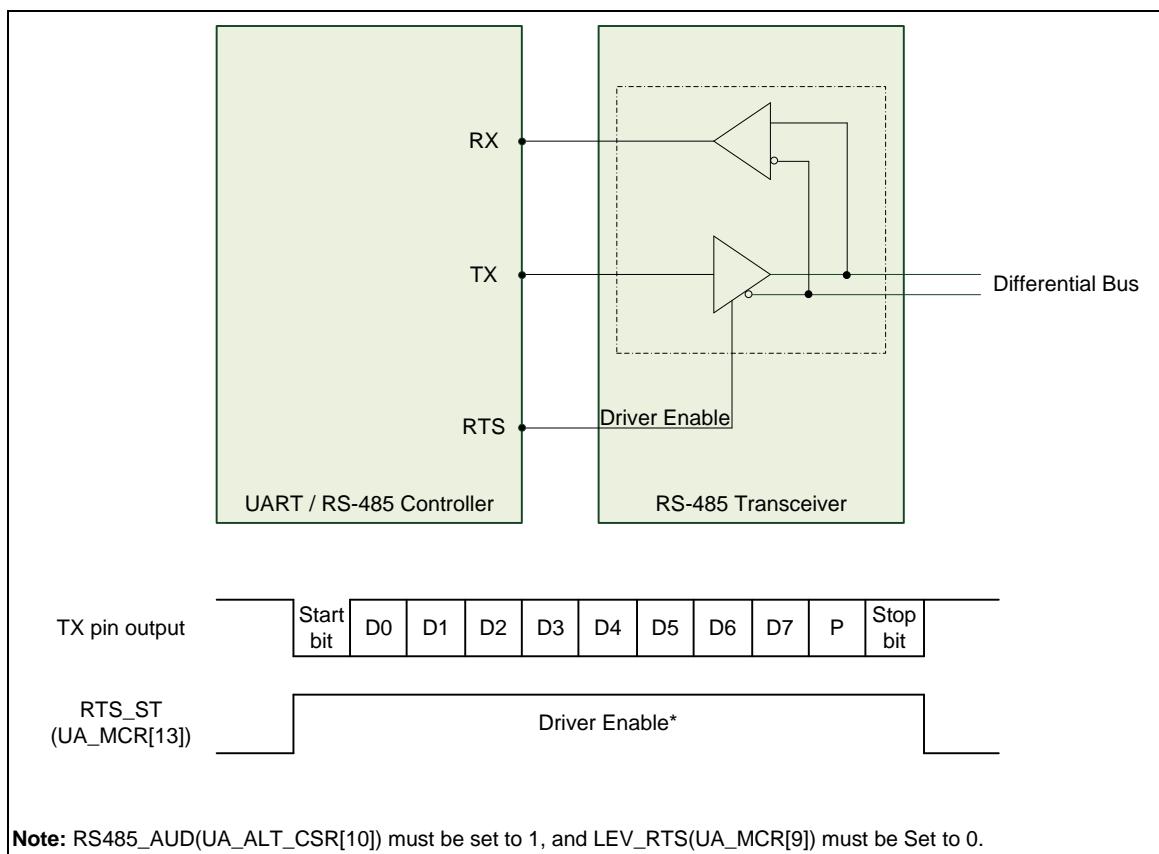


Figure 5-102 Structure of RS-485 Frame

#### 5.14.5.8 LIN (Local Interconnection Network) Function Mode (NUC029xAN only)

The UART Controller supports LIN function mode (user must set UA\_FUN\_SEL[1:0] to 01'b to enable LIN function). In LIN function mode, each byte field is initiated by a start bit with value 0 (dominant), followed by 8 data bits (LSB is first) and ended by 1 stop bit with value one (recessive) in accordance with the LIN standard. The following diagram is the structure of LIN function mode:

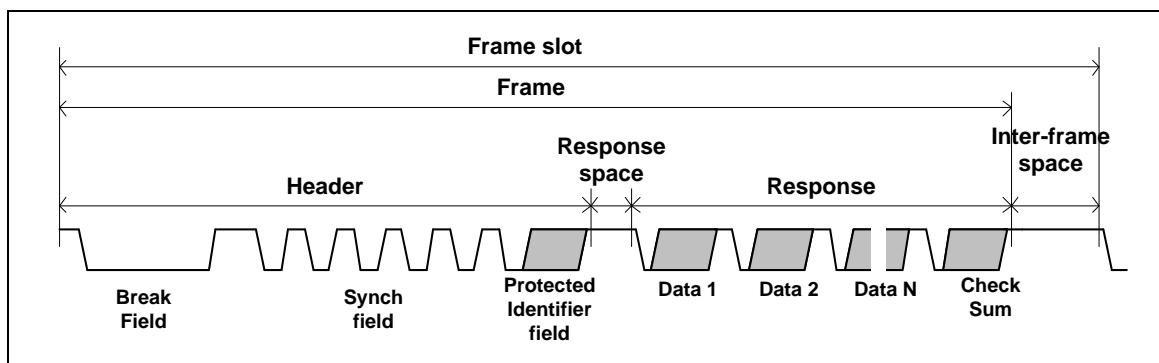


Figure 5-103 Structure of LIN Frame

The program flow of LIN bus transmit transfer (TX) is shown as follows:

1. Setting the UA\_FUN\_SEL[1:0] to 01'b to enable LIN bus mode.

2. Fill UA\_LIN\_BKFL(UA\_ALT\_CSR[3:0]) to choose break field length. (The break field length is UA\_LIN\_BKFL + 2).
3. Fill 0x55 to THR(UA\_THR[7:0]) to request synch field transmission.
4. Request identifier field transmission by writing the protected identifier value in the UA\_THR
5. Setting the LIN\_TX\_EN(UA\_ALT\_CSR[7]) bit to start transmission. (When break filed operation is finished, LIN\_TX\_EN(UA\_ALT\_CSR[7]) will be cleared automatically).
6. When the STOP bit of the last byte THR has been sent to bus, hardware will set flag TE\_FLAG in UA\_FSR to 1.
7. Fill N bytes data and checksum to THR(UA\_THR[7:0]) then repeat step 5 and 6 to transmit the data.

The program flow of LIN bus receiver transfer (RX) is show as follows:

1. Setting the UA\_FUN\_SEL[1:0] to 01'b to enable LIN bus mode.
2. Setting the LIN\_RX\_EN(UA\_ALT\_CSR[6]) bit to enable LIN RX mode.
3. Waiting for the flag LIN\_RX\_BREAK\_IF(UA\_ISR[7]) to check RX received break field or not.
4. Waiting for the flag RDA\_IF(UA\_ISR[0]) and read back the RBR(UA\_RBR[7:0]) register.

### 5.14.6 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>UART Base Address:</b>				
<b>UART0_BA = 0x4005_0000</b>				
<b>UART1_BA = 0x4015_0000</b>				
<b>UA_RBR</b> <i>x = 0, 1</i>	UARTx_BA+0x00	R	UART Receive Buffer Register	Undefined
<b>UA_THR</b> <i>x = 0, 1</i>	UARTx_BA+0x00	W	UART Transmit Holding Register	Undefined
<b>UA_IER</b> <i>x = 0, 1</i>	UARTx_BA+0x04	R/W	UART Interrupt Enable Register	0x0000_0000
<b>UA_FCR</b> <i>x = 0, 1</i>	UARTx_BA+0x08	R/W	UART FIFO Control Register	0x0000_0101
<b>UA_LCR</b> <i>x = 0, 1</i>	UARTx_BA+0x0C	R/W	UART Line Control Register	0x0000_0000
<b>UA_MCR</b> <i>x = 0, 1</i>	UARTx_BA+0x10	R/W	UART Modem Control Register	0x0000_0200
<b>UA_MSR</b> <i>x = 0, 1</i>	UARTx_BA+0x14	R/W	UART Modem Status Register	0x0000_0110
<b>UA_FSR</b> <i>x = 0, 1</i>	UARTx_BA+0x18	R/W	UART FIFO Status Register	0x1040_4000
<b>UA_ISR</b> <i>x = 0, 1</i>	UARTx_BA+0x1C	R/W	UART Interrupt Status Register	0x0000_0002
<b>UA_TOR</b> <i>x = 0, 1</i>	UARTx_BA+0x20	R/W	UART Time-out Register	0x0000_0000
<b>UA_BAUD</b> <i>x = 0, 1</i>	UARTx_BA+0x24	R/W	UART Baud Rate Divisor Register	0x0F00_0000
<b>UA_IRCR</b> <i>x = 0, 1</i>	UARTx_BA+0x28	R/W	UART IrDA Control Register	0x0000_0040
<b>UA_ALT_CSR</b> <i>x = 0, 1</i>	UARTx_BA+0x2C	R/W	UART Alternate Control/Status Register	0x0000_0000
<b>UA_FUN_SEL</b> <i>x = 0, 1</i>	UARTx_BA+0x30	R/W	UART Function Select Register	0x0000_0000

### 5.14.7 Register Description for NUC029xAN

#### UART Receive Buffer Register (UA\_RBR)

Register	Offset	R/W	Description				Reset Value
UA_RBR x = 0, 1	UARTx_BA+0x00	R	UART Receive Buffer Register				Undefined

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	RBR	<b>Receive Buffer Register (Read Only)</b> By reading this register, the UART Controller will return an 8-bit data received from UART_RX pin (LSB first).

UART Transmit Holding Register (UA\_THR)

Register	Offset	R/W	Description				Reset Value
UA_THR x=0,1	UARTx_BA+0x00	W	UART Transmit Holding Register				Undefined

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	THR	<b>Transmit Holding Register</b> By writing to this register, the UART Controller will send out an 8-bit data through the UART_TX pin (LSB first).

**UART Interrupt Enable Register (UA\_IER)**

Register	Offset	R/W	Description				Reset Value
UA_IER x=0,1	UARTx_BA+0x04	R/W	UART Interrupt Enable Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved		AUTO_CTS_EN	AUTO_RTS_EN	TIME_OUT_EN	Reserved		LIN_RX_BRK_IEN
7	6	5	4	3	2	1	0
Reserved	WAKE_EN	BUF_ERR_IEN	RTO_IEN	MODEM_IEN	RLS_IEN	THRE_IEN	RDA_IEN

Bits	Description	
[31:14]	Reserved	Reserved.
[13]	AUTO_CTS_EN	<p><b>CTS Auto-flow Control Enable Control</b>            0 = CTS auto-flow control Disabled.            1 = CTS auto-flow control Enabled.</p> <p><b>Note:</b> When CTS auto-flow is enabled, the UART will send data to external device when CTS input assert (UART will not send data to device until CTS is asserted).</p>
[12]	AUTO_RTS_EN	<p><b>RTS Auto-flow Control Enable Control</b>            0 = RTS auto-flow control Disabled.            1 = RTS auto-flow control Enabled.</p> <p><b>Note:</b> When RTS auto-flow is enabled, if the number of bytes in the RX FIFO equals the RTS_TRILEV (UA_FCR [19:16]), the UART will reassert RTS signal.</p>
[11]	TIME_OUT_EN	<p><b>Time-out Counter Enable Control</b>            0 = Time-out counter Disabled.            1 = Time-out counter Enabled.</p>
[10:9]	Reserved	Reserved.
[8]	LIN_RX_BRK_IEN	<p><b>LIN RX Break Field Detected Interrupt Enable Control</b>            0 = LIN bus RX break filed interrupt Disabled.            1 = LIN bus RX break filed interrupt Enabled.</p> <p><b>Note:</b> This bit is used for LIN function mode.</p>
[7]	Reserved	Reserved.
[6]	WAKE_EN	<p><b>UART Wake-up Function Enable Control</b>            0 = UART wake-up function Disabled.            1 = UART wake-up function Enabled.</p> <p><b>Note:</b> when the chip is in Power-down mode, an external CTS change will wake-up chip from Power-down mode.</p>

[5]	<b>BUF_ERR_IEN</b>	<b>Buffer Error Interrupt Enable Control</b> 0 = BUF_ERR_INT Masked off. 1 = BUF_ERR_INT Enabled.
[4]	<b>RTO_IEN</b>	<b>RX Time-out Interrupt Enable Control</b> 0 = TOUT_INT Masked off. 1 = TOUT_INT Enabled.
[3]	<b>MODEM_IEN</b>	<b>Modem Status Interrupt Enable Control</b> 0 = MODEM_INT Masked off. 1 = MODEM_INT Enabled.
[2]	<b>RLS_IEN</b>	<b>Receive Line Status Interrupt Enable Control</b> 0 = RLS_INT Masked off. 1 = RLS_INT Enabled.
[1]	<b>THRE_IEN</b>	<b>Transmit Holding Register Empty Interrupt Enable Control</b> 0 = THRE_INT Masked off. 1 = THRE_INT Enabled.
[0]	<b>RDA_IEN</b>	<b>Receive Data Available Interrupt Enable Control</b> 0 = RDA_INT Masked off. 1 = RDA_INT Enabled.

**UART FIFO Control Register (UA\_FCR)**

Register	Offset	R/W	Description					Reset Value
UA_FCR x=0,1	UARTx_BA+0x08	R/W	UART FIFO Control Register					0x0000_0101

31	30	29	28	27	26	25	24	
Reserved								
23	22	21	20	19	18	17	16	
Reserved				RTS_TRI_LEV				
15	14	13	12	11	10	9	8	
Reserved								RX_DIS
7	6	5	4	3	2	1	0	
RFITL				Reserved	TFR	RFR	Reserved	

Bits	Description	
[31:20]	Reserved	Reserved.
[19:16]	RTS_TRI_LEV	<p><b>RTS Trigger Level (For Auto-flow Control Use)</b></p> <p>0000 = RTS Trigger Level is 1 byte.      0001 = RTS Trigger Level is 4 bytes.      0010 = RTS Trigger Level is 8 bytes.      0011 = RTS Trigger Level is 14 bytes.      Other = Reserved.</p> <p><b>Note:</b> This field is used for RTS auto-flow control.</p>
[15:9]	Reserved	Reserved.
[8]	RX_DIS	<p><b>Receiver Disable Register</b></p> <p>The receiver is disabled or not (set 1 to disable receiver)      1 = Receiver Disabled.      0 = Receiver Enabled.</p> <p><b>Note:</b> This field is used for RS-485 Normal Multi-drop mode. It should be programmed before RS-485_NMM (UA_ALT_CSR [8]) is programmed.</p>
[7:4]	RFITL	<p><b>RX FIFO Interrupt (RDA_INT) Trigger Level</b></p> <p>When the number of bytes in the receive FIFO equals the RFITL then the RDA_IF will be set (if RDA_IEN in UA_IER register is enable, an interrupt will generated).</p> <p>0000 = RX FIFO Interrupt Trigger Level is 1 byte.      0001 = RX FIFO Interrupt Trigger Level is 4 bytes.      0010 = RX FIFO Interrupt Trigger Level is 8 bytes.      0011 = RX FIFO Interrupt Trigger Level is 14 bytes.      Other = Reserved.</p>
[3]	Reserved	Reserved.
[2]	TFR	<p><b>TX Field Software Reset</b></p> <p>When TX_RST is set, all the byte in the transmit FIFO and TX internal state machine are</p>

		cleared. 0 = No effect. 1 = Reset the TX internal state machine and pointers. <b>Note:</b> This bit will automatically clear at least 3 UART Controller peripheral clock cycles.
[1]	<b>RFR</b>	<b>RX Field Software Reset</b> When RX_RST is set, all the byte in the receiver FIFO and RX internal state machine are cleared. 0 = No effect. 1 = Reset the RX internal state machine and pointers. <b>Note:</b> This bit will automatically clear at least 3 UART Controller peripheral clock cycles.
[0]	<b>Reserved</b>	Reserved.

**UART Line Control Register (UA\_LCR)**

Register	Offset	R/W	Description				Reset Value
UA_LCR x=0,1	UARTx_BA+0x0C	R/W	UART Line Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	BCB	SPE	EPE	PBE	NSB	WLS	

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	BCB	<p><b>Break Control Bit</b>  When this bit is set to logic 1, the serial data output (TX) is forced to the Spacing State (logic 0). This bit acts only on TX and has no effect on the transmitter logic.  0 = Break control Disabled.  1 = Break control Enabled.</p>
[5]	SPE	<p><b>Stick Parity Enable Control</b>  0 = Stick parity Disabled.  1 = If PBE (UA_LCR[3]) and EBE (UA_LCR[4]) are logic 1, the parity bit is transmitted and checked as logic 0. If PBE (UA_LCR[3]) is 1 and EBE (UA_LCR[4]) is 0 then the parity bit is transmitted and checked as 1.</p>
[4]	EPE	<p><b>Even Parity Enable Control</b>  0 = Odd number of logic 1's is transmitted and checked in each word.  1 = Even number of logic 1's is transmitted and checked in each word.  This bit has effect only when PBE (UA_LCR[3]) is set.</p>
[3]	PBE	<p><b>Parity Bit Enable Control</b>  0 = No parity bit.  1 = Parity bit is generated on each outgoing character and is checked on each incoming data.</p>
[2]	NSB	<p><b>Number Of “STOP Bit”</b>  0 = One “STOP bit” is generated in the transmitted data.  1 = When select 5-bit word length, 1.5 “STOP bit” is generated in the transmitted data.  When select 6-, 7- and 8-bit word length, 2 “STOP bit” is generated in the transmitted data.</p>
[1:0]	WLS	<p><b>Word Length Selection</b>  00 = Word length is 5-bit.  01 = Word length is 6-bit.  10 = Word length is 7-bit.</p>

		11 = Word length is 8-bit.
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**UART Modem Control Register (UA\_MCR)**

Register	Offset	R/W	Description	Reset Value
UA_MCR x=0,1	UARTx_BA+0x10	R/W	UART Modem Control Register	0x0000_0200

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved		RTS_ST	Reserved			LEV_RTS	Reserved
7	6	5	4	3	2	1	0
Reserved						RTS	Reserved

Bits	Description	
[31:14]	<b>Reserved</b>	Reserved.
[13]	<b>RTS_ST</b>	<p><b>RTS Pin Status (Read Only)</b></p> <p>This bit mirror from RTS pin output of voltage logic status.            0 = RTS pin output is low level voltage logic state.            1 = RTS pin output is high level voltage logic state.</p>
[12:10]	<b>Reserved</b>	Reserved.
[9]	<b>LEV_RTS</b>	<p><b>RTS Pin Active Level</b></p> <p>This bit defines the active level state of RTS pin output.            0 = RTS pin output is high level active.            1 = RTS pin output is low level active.</p> <p><b>Note1:</b> Refer to Figure 5-96 and Figure 5-97 for UART function mode.  <b>Note2:</b> Refer to Figure 5-100 and Figure 5-101 for RS-485 function mode.</p>
[8:2]	<b>Reserved</b>	Reserved.
[1]	<b>RTS</b>	<p><b>RTS (Request-to-send) Signal Control</b></p> <p>This bit is direct control internal RTS signal active or not, and then drive the RTS pin output with LEV_RTS bit configuration.            0 = RTS signal is active.            1 = RTS signal is inactive.</p> <p><b>Note1:</b> This RTS signal control bit is not effective when RTS auto-flow control is enabled in UART function mode.  <b>Note2:</b> This RTS signal control bit is not effective when RS-485 auto direction mode (AUD) is enabled in RS-485 function mode.</p>
[0]	<b>Reserved</b>	Reserved.

**UART Modem Status Register (UA\_MSR)**

Register	Offset	R/W	Description				Reset Value
UA_MSR x=0,1	UARTx_BA+0x14	R/W	UART Modem Status Register				0x0000_0110

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

Bits	Description	
[31:9]	<b>Reserved</b>	Reserved.
[8]	<b>LEV_CTS</b>	<p><b>CTS Pin Active Level</b>            This bit defines the active level state of CTS pin input.            0 = CTS pin input is high level active.            1 = CTS pin input is low level active.  <b>Note:</b> Refer to Figure 5-95 for more information.</p>
[7:5]	<b>Reserved</b>	Reserved.
[4]	<b>CTS_ST</b>	<p><b>CTS Pin Status (Read Only)</b>            This bit mirror from CTS pin input of voltage logic status.            0 = CTS pin input is low level voltage logic state.            1 = CTS pin input is high level voltage logic state.  <b>Note:</b> This bit echoes when UART Controller peripheral clock is enabled, and CTS multi-function port is selected.</p>
[3:1]	<b>Reserved</b>	Reserved.
[0]	<b>DCTSF</b>	<p><b>Detect CTS State Change Flag</b>            This bit is set whenever CTS input has change state, and it will generate Modem interrupt to CPU when MODEM_IEN (UA_IER [3]) is set to 1.            0 = CTS input has not change state.            1 = CTS input has change state.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>

## UART FIFO Status Register (UA\_FSR)

Register	Offset	R/W	Description				Reset Value
UA_FSR x=0,1	UARTx_BA+0x18	R/W	UART FIFO Status Register				0x1040_4000

31	30	29	28	27	26	25	24
Reserved			TE_FLAG	Reserved			TX_OVER_IF
23	22	21	20	19	18	17	16
TX_FULL	TX_EMPTY	TX_POINTER					
15	14	13	12	11	10	9	8
RX_FULL	RX_EMPTY	RX_POINTER					
7	6	5	4	3	2	1	0
Reserved	BIF	FEF	PEF	RS485_ADD_DETF	Reserved		RX_OVER_IF

Bits	Description	
[31:29]	Reserved	Reserved.
[28]	TE_FLAG	<p><b>Transmitter Empty Flag (Read Only)</b>  This bit is set by hardware when TX FIFO (UA_THR) is empty and the STOP bit of the last byte has been transmitted.  0 = TX FIFO is not empty.  1 = TX FIFO is empty.  <b>Note:</b> This bit is cleared automatically when TX FIFO is not empty or the last byte transmission has not completed.</p>
[27:25]	Reserved	Reserved.
[24]	TX_OVER_IF	<p><b>TX Overflow Error Interrupt Flag</b>  If TX FIFO (UA_THR) is full, an additional write to UA_THR will cause this bit to logic 1.  0 = TX FIFO is not overflow.  1 = TX FIFO is overflow.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>
[23]	TX_FULL	<p><b>Transmitter FIFO Full (Read Only)</b>  This bit indicates TX FIFO full or not.  0 = TX FIFO is not full.  1 = TX FIFO is full.  <b>Note:</b> This bit is set when the number of usage in TX FIFO Buffer is equal to 16, otherwise is cleared by hardware.</p>
[22]	TX_EMPTY	<p><b>Transmitter FIFO Empty (Read Only)</b>  This bit indicates TX FIFO empty or not.  0 = TX FIFO is not empty.  1 = TX FIFO is empty.  <b>Note:</b> When the last byte of TX FIFO has been transferred to Transmitter Shift Register, hardware sets this bit high. It will be cleared when writing data into THR (TX FIFO not</p>

		empty).
[21:16]	<b>TX_POINTER</b>	<p><b>TX FIFO Pointer (Read Only)</b></p> <p>This field indicates the TX FIFO Buffer Pointer. When CPU writes one byte into UA_THR, TX_POINTER increases one. When one byte of TX FIFO is transferred to Transmitter Shift Register, TX_POINTER decreases one.</p> <p>The Maximum value shown in TX_POINTER is 15. When the using level of TX FIFO Buffer equal to 16, the TX_FULL bit is set to 1 and TX_POINTER will show 0. As one byte of TX FIFO is transferred to Transmitter Shift Register, the TX_FULL bit is cleared to 0 and TX_POINTER will show 15.</p>
[15]	<b>RX_FULL</b>	<p><b>Receiver FIFO Full (Read Only)</b></p> <p>This bit initiates RX FIFO full or not.</p> <p>0 = RX FIFO is not full. 1 = RX FIFO is full.</p> <p><b>Note:</b> This bit is set when the number of usage in RX FIFO Buffer is equal to 16, otherwise is cleared by hardware.</p>
[14]	<b>RX_EMPTY</b>	<p><b>Receiver FIFO Empty (Read Only)</b></p> <p>This bit initiate RX FIFO empty or not.</p> <p>0 = RX FIFO is not empty. 1 = RX FIFO is empty.</p> <p><b>Note:</b> When the last byte of RX FIFO has been read by CPU, hardware sets this bit high. It will be cleared when UART receives any new data.</p>
[13:8]	<b>RX_POINTER</b>	<p><b>RX FIFO Pointer (Read Only)</b></p> <p>This field indicates the RX FIFO Buffer Pointer. When UART receives one byte from external device, RX_POINTER increases one. When one byte of RX FIFO is read by CPU, RX_POINTER decreases one.</p> <p>The Maximum value shown in RX_POINTER is 15. When the using level of RX FIFO Buffer equal to 16, the RX_FULL bit is set to 1 and RX_POINTER will show 0. As one byte of RX FIFO is read by CPU, the RX_FULL bit is cleared to 0 and RX_POINTER will show 15.</p>
[7]	<b>Reserved</b>	Reserved.
[6]	<b>BIF</b>	<p><b>Break Interrupt Flag (Read Only)</b></p> <p>This bit is set to logic 1 whenever the received data input (RX) is held in the “spacing state” (logic 0) for longer than a full word transmission time (that is, the total time of “start bit” + data bits + parity + stop bits).</p> <p>0 = No Break interrupt is generated. 1 = Break interrupt is generated.</p> <p><b>Note1:</b> This bit is read only, but can be cleared by writing ‘1’ to it or RFR (UA_FCR [1]).</p>
[5]	<b>FEF</b>	<p><b>Framing Error Flag (Read Only)</b></p> <p>This bit is set to logic 1 whenever the received character does not have a valid “stop bit” (that is, the stop bit following the last data bit or parity bit is detected as logic 0).</p> <p>0 = No framing error is generated. 1 = Framing error is generated.</p> <p><b>Note1:</b> This bit is read only, but can be cleared by writing ‘1’ to it or RFR (UA_FCR [1]).</p>
[4]	<b>PEF</b>	<p><b>Parity Error Flag (Read Only)</b></p> <p>This bit is set to logic 1 whenever the received character does not have a valid “parity bit”.</p> <p>0 = No parity error is generated. 1 = Parity error is generated.</p> <p><b>Note1:</b> This bit is read only, but can be cleared by writing ‘1’ to it or RFR (UA_FCR [1]).</p>
[3]	<b>RS485_ADD_DETF</b>	<b>RS-485 Address Byte Detection Flag</b> This bit is set to 1 while RS485_ADD_EN (UA_ALT_CSR[15]) is set to 1 to enable

		Address detection mode and receive detect a data with an address bit (bit 9 = 1). <b>Note1:</b> This field is used for RS-485 function mode. <b>Note2:</b> This bit is cleared by writing 1 to it.
[2:1]	<b>Reserved</b>	Reserved.
[0]	<b>RX_OVER_IF</b>	<b>RX Overflow Error Interrupt Flag</b> This bit is set when RX FIFO overflow. If the number of bytes of received data is greater than RX_FIFO (UA_RBR) size, 16 bytes this bit will be set. 0 = RX FIFO is not overflow. 1 = RX FIFO is overflow. <b>Note:</b> This bit is cleared by writing 1 to it.

**UART Interrupt Status Control Register (UA\_ISR)**

Register	Offset	R/W	Description				Reset Value
UA_ISR x=0,1	UARTx_BA+0x1C	R/W	UART Interrupt Status Register				0x0000_0002

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
LIN_RX_BRE AK_INT	Reserved	BUF_ERR_IN T	TOUT_INT	MODEM_INT	RLS_INT	THRE_INT	RDA_INT
7	6	5	4	3	2	1	0
LIN_RX_BRE AK_IF	Reserved	BUF_ERR_IF	TOUT_IF	MODEM_IF	RLS_IF	THRE_IF	RDA_IF

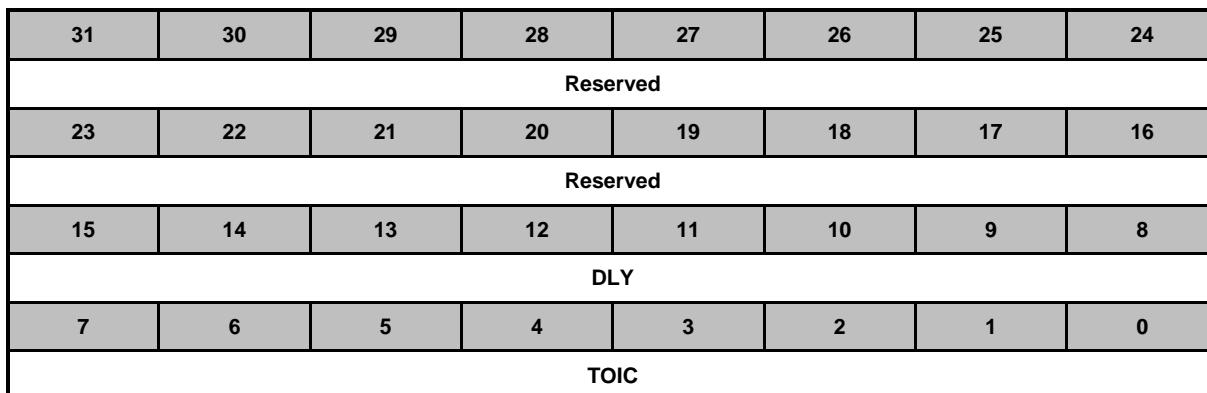
Bits	Description	
[31:14]	Reserved	Reserved.
[15]	LIN_RX_BREAK_INT	<b>LIN Bus RX Break Field Detected Interrupt Indicator (Read Only)</b> This bit is set if LIN_RX_BRK_IEN and LIN_RX_BREAK_IF are both set to 1. 0 = No LIN RX Break interrupt is generated. 1 = LIN RX Break interrupt is generated.
[14]	Reserved	Reserved.
[13]	BUF_ERR_INT	<b>Buffer Error Interrupt Indicator (Read Only)</b> This bit is set if BUF_ERR_IEN and BUF_ERR_IF are both set to 1. 0 = No buffer error interrupt is generated. 1 = buffer error interrupt is generated.
[12]	TOUT_INT	<b>Time-out Interrupt Indicator (Read Only)</b> This bit is set if RTO_IEN and TOUT_IF are both set to 1. 0 = No Time-out interrupt is generated. 1 = Time-out interrupt is generated.
[11]	MODEM_INT	<b>MODEM Status Interrupt Indicator (Read Only)</b> This bit is set if MODEM_IEN and MODEM_IF are both set to 1. 0 = No Modem interrupt is generated. 1 = Modem interrupt is generated.
[10]	RLS_INT	<b>Receive Line Status Interrupt Indicator (Read Only)</b> This bit is set if RLS_IEN and RLS_IF are both set to 1. 0 = No RLS interrupt is generated. 1 = RLS interrupt is generated.
[9]	THRE_INT	<b>Transmit Holding Register Empty Interrupt Indicator (Read Only)</b> This bit is set if THRE_IEN and THRE_IF are both set to 1.

		0 = No THRE interrupt is generated. 1 = THRE interrupt is generated.
[8]	<b>RDA_INT</b>	<b>Receive Data Available Interrupt Indicator (Read Only)</b> This bit is set if RDA_IEN and RDA_IF are both set to 1. 0 = No RDA interrupt is generated. 1 = RDA interrupt is generated.
[7]	<b>LIN_RX_BREAK_IF</b>	<b>LIN Bus RX Break Field Detected Flag</b> This bit is set when RX received LIN Break Field. If LIN_RX_BRK_IEN (UA_IER [8]) is enabled the LIN RX Break interrupt will be generated. 0 = No LIN RX Break received. 1 = LIN RX Break received. <b>Note:</b> This bit is cleared by writing 1 to it.
[6]	<b>Reserved</b>	Reserved.
[5]	<b>BUF_ERR_IF</b>	<b>Buffer Error Interrupt Flag (Read Only)</b> This bit is set when the TX/RX FIFO overflow flag (TX_OVER_IF or RX_OVER_IF) is set. When BUF_ERR_IF is set, the transfer is not correct. If BUF_ERR_IEN (UA_IER [5]) is enabled, the buffer error interrupt will be generated. 0 = No buffer error interrupt flag is generated. 1 = Buffer error interrupt flag is generated. <b>Note1:</b> This bit is read only and reset to 0 when all bits of TX_OVER_IF and RX_OVER_IF are cleared.
[4]	<b>TOUT_IF</b>	<b>Time-out Interrupt Flag (Read Only)</b> This bit is set when the RX FIFO is not empty and no activities occurred in the RX FIFO and the time-out counter equal to TOIC. If RTO_IEN (UA_IER [4]) is enabled, the Tout interrupt will be generated. 0 = No Time-out interrupt flag is generated. 1 = Time-out interrupt flag is generated. <b>Note:</b> This bit is read only and user can read UA_RBR (RX is in active) to clear it.
[3]	<b>MODEM_IF</b>	<b>MODEM Interrupt Flag (Read Only)</b> This bit is set when the CTS pin has state change (DCTSF = 1). If UA_IER [MODEM_IEN] is enabled, the Modem interrupt will be generated. 0 = No Modem interrupt flag is generated. 1 = Modem interrupt flag is generated. <b>Note:</b> This bit is read only and reset to 0 when bit DCTSF is cleared by a write 1 on DCTSF.
[2]	<b>RLS_IF</b>	<b>Receive Line Interrupt Flag (Read Only)</b> This bit is set when the RX receive data have parity error, framing error or break error (at least one of 3 bits, BIF, FEF and PEF, is set). If RLS_IEN (UA_IER [2]) is enabled, the RLS interrupt will be generated. 0 = No RLS interrupt flag is generated. 1 = RLS interrupt flag is generated. <b>Note1:</b> In RS-485 function mode, this field is set including "receiver detect and received address byte character (bit 9 = 1) bit". At the same time, the bit of RS485_ADD_DETF (UA_FSR[3]) is also set. <b>Note2:</b> This bit is read only and reset to 0 when all bits of BIF, FEF, PEF and RS485_ADD_DETF are cleared.
[1]	<b>THRE_IF</b>	<b>Transmit Holding Register Empty Interrupt Flag (Read Only)</b> This bit is set when the last data of TX FIFO is transferred to Transmitter Shift Register. If THRE_IEN (UA_IER [1]) is enabled, the THRE interrupt will be generated. 0 = No THRE interrupt flag is generated.

		1 = THRE interrupt flag is generated. <b>Note:</b> This bit is read only and it will be cleared when writing data into THR (TX FIFO not empty).
[0]	<b>RDA_IF</b>	<b>Receive Data Available Interrupt Flag (Read Only)</b> When the number of bytes in the RX FIFO equals the RFITL then the RDA_IF will be set. If RDA_IEN (UA_IER [0]) is enabled, the RDA interrupt will be generated. 0 = No RDA interrupt flag is generated. 1 = RDA interrupt flag is generated. <b>Note:</b> This bit is read only and it will be cleared when the number of unread bytes of RX FIFO drops below the threshold level (RFITL).

UART Time-out Register (UA\_TOR)

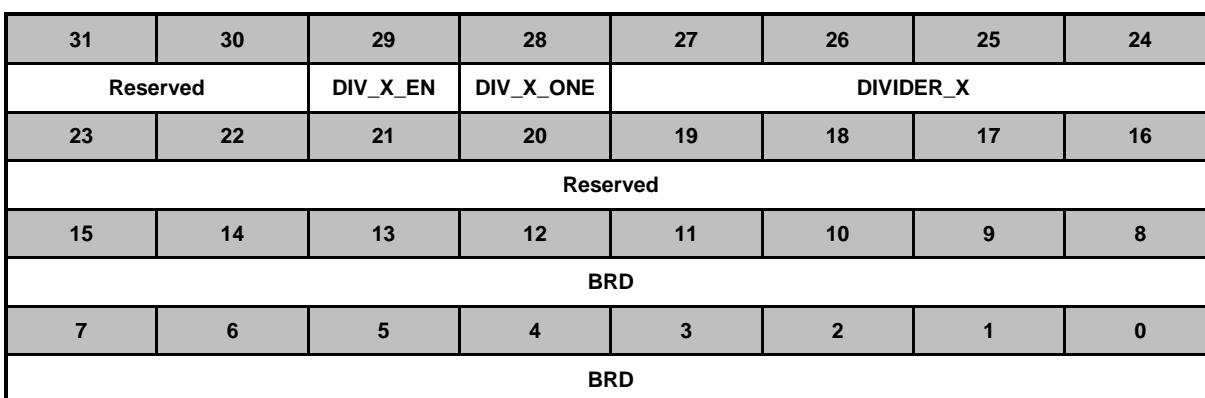
Register	Offset	R/W	Description	Reset Value
UA_TOR x=0,1	UARTx_BA+0x20	R/W	UART Time-out Register	0x0000_0000



Bits	Description	
[31:16]	Reserved	Reserved.
[15:8]	DLY	<p><b>TX Delay Time Value</b>            This field is used to program the transfer delay time between the last stop bit and next start bit.</p> <p>The diagram illustrates the timing sequence for two bytes, Byte (i) and Byte (i+1), transmitted over a serial link. The TX signal starts at a low level, transitions to high at the 'Start' of Byte (i), remains high during the byte transmission, and then transitions back to low at the 'Stop'. A dashed double-headed arrow labeled 'DLY' indicates the duration between the Stop of Byte (i) and the Start of Byte (i+1).</p>
[7:0]	TOIC	<p><b>Time-out Interrupt Comparator</b>            The time-out counter resets and starts counting (the counting clock = baud rate) whenever the RX FIFO receives a new data word. Once the content of time-out counter (TOUT_CNT) is equal to that of time-out interrupt comparator (TOIC), a receiver time-out interrupt (TOUT_INT) is generated if RTO_IEN (UA_IER [4]). A new incoming data word or RX FIFO empty clears TOUT_INT. In order to avoid receiver time-out interrupt generation immediately during one character is being received, TOIC value should be set between 40 and 255. So, for example, if TOIC is set with 40, the time-out interrupt is generated after four characters are not received when 1 stop bit and no parity check is set for UART transfer.</p>

**UART Baud Rate Divider Register (UA\_BAUD)**

Register	Offset	R/W	Description	Reset Value
UA_BAUD x=0,1	UARTx_BA+0x24	R/W	UART Baud Rate Divisor Register	0x0F00_0000



Bits	Description	
[31:30]	Reserved	Reserved.
[29]	DIV_X_EN	<p><b>Divider X Enable Control</b>            The BRD = Baud Rate Divider, and the baud rate equation is Baud Rate = Clock / [M * (BRD + 2)]; The default value of M is 16.            0 = Divider X Disabled (the equation of M = 16).            1 = Divider X Enabled (the equation of M = X+1, but DIVIDER_X[27:24] must &gt;= 8).  <b>Note1:</b> Refer to the section 5.14.5.1 for more information.  <b>Note2:</b> In IrDA function mode, this bit must disable.</p>
[28]	DIV_X_ONE	<p><b>Divider X Equal 1</b>            0 = Divider M = X (the equation of M = X+1, but DIVIDER_X[27:24] must &gt;= 8).            1 = Divider M = 1 (the equation of M = 1, but BRD [15:0] must &gt;= 8).  <b>Note1:</b> Refer to the section 5.14.5.1 for more information.</p>
[27:24]	DIVIDER_X	<p><b>Divider X</b>            The baud rate divider M = X+1.</p>
[23:16]	Reserved	Reserved.
[15:0]	BRD	<p><b>Baud Rate Divider</b>            The field indicated the baud rate divider.</p>

UART IrDA Control Register (UART\_IRCR)

Register	Offset	R/W	Description				Reset Value
UA_IRCR x=0,1	UARTx_BA+0x28	R/W	UART IrDA Control Register				0x0000_0040

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	INV_RX	INV_TX	Reserved			TX_SELECT	Reserved

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	INV_RX	<b>Inverse RX Input Control</b> 0 = No inversion. 1 = Inverse RX input signal.
[5]	INV_TX	<b>Inverse RX Output Control</b> 0 = No inversion. 1 = Inverse TX output signal.
[4:2]	Reserved	Reserved.
[1]	TX_SELECT	<b>IrDA Receiver Enable Control</b> 0 = IrDA receiver Enabled. 1 = IrDA transmitter Enabled.
[0]	Reserved	Reserved.

**UART Alternate Control/Status Register (UA\_ALT\_CSR)**

Register	Offset	R/W	Description				Reset Value
UA_ALT_CSR x=0,1	UARTx_BA+0x2C	R/W	UART Alternate Control/Status Register				0x0000_0000

31	30	29	28	27	26	25	24
ADDR_MATCH							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
RS485_ADD_EN	Reserved				RS485_AUD	RS485_AAD	RS485_NMM
7	6	5	4	3	2	1	0
LIN_TX_EN	LIN_RX_EN	Reserved		UA_LIN_BKFL			

Bits	Description	
[31:24]	ADDR_MATCH	<b>Address Match Value Register</b> This field contains the RS-485 address match values. <b>Note:</b> This field is used for RS-485 auto address detection mode.
[23:16]	Reserved	Reserved.
[15]	RS485_ADD_EN	<b>RS-485 Address Detection Enable Control</b> This bit is use to enable RS-485 Address Detection mode. 0 = RS-485 address detection mode Disabled. 1 = RS-485 address detection mode Enabled. <b>Note:</b> This field is used for RS-485 any operation mode.
[14:11]	Reserved	Reserved.
[10]	RS485_AUD	<b>RS-485 Auto Direction Mode (AUD) Control</b> 0 = RS-485 Auto Direction Operation Mode (AUD) Disabled. 1 = RS-485 Auto Direction Operation Mode (AUD) Enabled. <b>Note:</b> It can be active with RS485_AAD or RS485_NMM operation mode.
[9]	RS485_AAD	<b>RS-485 Auto Address Detection Operation Mode (AAD) Control</b> 0 = RS-485 Auto Address Detection Operation Mode (AAD) Disabled. 1 = RS-485 Auto Address Detection Operation Mode (AAD) Enabled. <b>Note:</b> It cannot be active with RS485_NMM operation mode.
[8]	RS485_NMM	<b>RS-485 Normal Multi-drop Operation Mode (NMM) Control</b> 0 = RS-485 Normal Multi-drop Operation Mode (NMM) Disabled. 1 = RS-485 Normal Multi-drop Operation Mode (NMM) Enabled. <b>Note:</b> It cannot be active with RS485_AAD operation mode.
[7]	LIN_TX_EN	<b>LIN TX Break Mode Enable Control</b> 0 = LIN TX Break Mode Disabled.

		1 = LIN TX Break Mode Enabled. <b>Note:</b> When TX break field transfer operation finished, this bit will be cleared automatically.
[6]	<b>LIN_RX_EN</b>	<b>LIN RX Enable Control</b> 0 = LIN RX mode Disabled. 1 = LIN RX mode Enabled.
[5:4]	<b>Reserved</b>	Reserved.
[3:0]	<b>UA_LIN_BKFL</b>	<b>UART LIN Break Field Length</b> This field indicates a 4-bit LIN TX break field count. <b>Note:</b> This break field length is UA_LIN_BKFL + 2.

**UART Function Select Register (UA\_FUN\_SEL)**

Register	Offset	R/W	Description				Reset Value
UA_FUN_SEL x=0,1	UARTx_BA+0x30	R/W	UART Function Select Register				0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1:0]	FUN_SEL	<b>Function Select</b> UART Controller function mode selection. 00 = UART function mode. 01 = LIN function mode. 10 = IrDA function mode. 11 = RS-485 function mode.

### 5.14.8 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>UART Base Address:</b>				
<b>UART_BA = 0x4005_0000</b>				
UA_RBR	UART_BA+0x00	R	UART Receive Buffer Register	Undefined
UA_THR	UART_BA+0x00	W	UART Transmit Holding Register	Undefined
UA_IER	UART_BA+0x04	R/W	UART Interrupt Enable Control Register	0x0000_0000
UA_FCR	UART_BA+0x08	R/W	UART FIFO Control Register	0x0000_0101
UA_LCR	UART_BA+0x0C	R/W	UART Line Control Register	0x0000_0000
UA_MCR	UART_BA+0x10	R/W	UART Modem Control Register	0x0000_0200
UA_FSR	UART_BA+0x18	R/W	UART FIFO Status Register	0x1040_4000
UA_ISR	UART_BA+0x1C	R/W	UART Interrupt Status Register	0x0000_0002
UA_TOR	UART_BA+0x20	R/W	UART Time-out Register	0x0000_0000
UA_BAUD	UART_BA+0x24	R/W	UART Baud Rate Divisor Register	0x0F00_0000
UA_IRCR	UART_BA+0x28	R/W	UART IrDA Control Register	0x0000_0040
UA_ALT_CSR	UART_BA+0x2C	R/W	UART Alternate Control/Status Register	0x0000_0000
UA_FUN_SEL	UART_BA+0x30	R/W	UART Function Select Register	0x0000_0000

### 5.14.9 Register Description for NUC029FAE

#### Receive Buffer Register (UA\_RBR)

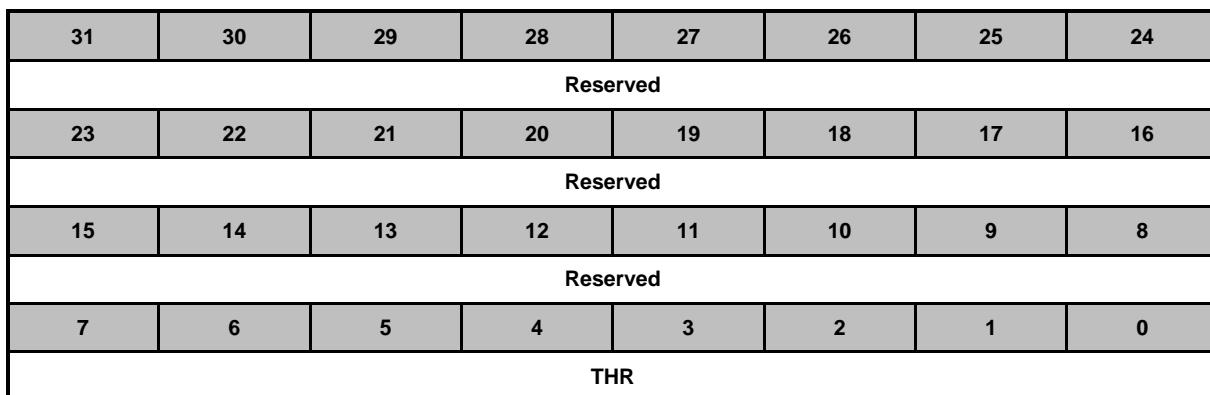
Register	Offset	R/W	Description			Reset Value
UA_RBR	UART_BA+0x00	R	UART Receive Buffer Register			Undefined

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	RBR[7:0]	<b>Receive Buffer Bits (Read Only)</b> By reading this register, the UART Controller will return an 8-bit data received from RX pin (LSB first).

Transmit Holding Register (UA\_THR)

Register	Offset	R/W	Description			Reset Value
UA_THR	UART_BA+0x00	W	UART Transmit Holding Register			Undefined



Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	THR	<b>Transmit Holding Bits</b> By writing to this register, the UART sends out an 8-bit data through the TX pin (LSB first).

**Interrupt Enable Control Register (UA\_IER)**

Register	Offset	R/W	Description				Reset Value
UA_IER	UART_BA+0x04	R/W	UART Interrupt Enable Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				TIME_OUT_EN	Reserved		
7	6	5	4	3	2	1	0
Reserved		BUF_ERR_IEN	RTO_IEN	MODEM_IEN	RLS_IEN	THRE_IEN	RDA_IEN

Bits	Description	
[31:12]	Reserved	Reserved.
[11]	TIME_OUT_EN	<b>Time-out Counter Enable Control</b> 0 = Time-out counter Disabled. 1 = Time-out counter Enabled.
[10:6]	Reserved	Reserved.
[5]	BUF_ERR_IEN	<b>Buffer Error Interrupt Enable Control</b> 0 = INT_BUF_ERR Masked Disabled. 1 = INT_BUF_ERR Enabled.
[4]	RTO_IEN	<b>RX Time-out Interrupt Enable Control</b> 0 = TOUT_INT Masked off. 1 = TOUT_INT Enabled.
[3]	MODEM_IEN	<b>Modem Status Interrupt Enable Control</b> 0 = MODEM_INT Masked off. 1 = MODEM_INT Enabled.
[2]	RLS_IEN	<b>Receive Line Status Interrupt Enable Control</b> 0 = RLS_INT Masked off. 1 = RLS_INT Enabled.
[1]	THRE_IEN	<b>Transmit Holding Register Empty Interrupt Enable Control</b> 0 = THRE_INT Masked off. 1 = THRE_INT Enabled.
[0]	RDA_IEN	<b>Receive Data Available Interrupt Enable Control</b> 0 = RDA_INT Masked off. 1 = RDA_INT Enabled.

**FIFO Control Register (UA\_FCR)**

Register	Offset	R/W	Description				Reset Value
UA_FCR	UART_BA+0x08	R/W	UART FIFO Control Register				0x0000_0101

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
RFITL				Reserved	TFR	RFR	Reserved

Bits	Description	
[31:16]	Reserved	Reserved.
[15:9]	Reserved	Reserved.
[8]	RX_DIS	<p><b>Receiver Disable Control</b>  The receiver is disabled or not (setting 1 to disable the receiver).  0 = Receiver Enabled.  1 = Receiver Disabled.</p> <p><b>Note1:</b> This field is only used for RS-485 Normal Multi-drop mode. It should be programmed firstly to avoid receiving unknown data before RS-485_NMM (UA_ALT_CSR[8]) is programmed.</p> <p><b>Note2:</b> After RS-485 receives an address byte in RS-485 Normal Multi-drop mode, this bit (RX_DIS) will be cleared to "0" by hardware.</p>
[7:4]	RFITL[3:0]	<p><b>RX FIFO Interrupt (RDA_INT) Trigger Level</b>  When the number of bytes in the receive FIFO equals the RFITL then the RDA_IF will be set (if RDA_IEN in UA_IER register is enable, an interrupt will generated).</p> <p>0000 = RX FIFO Interrupt Trigger Level is 1 byte.  0001 = RX FIFO Interrupt Trigger Level is 4 bytes.  0010 = RX FIFO Interrupt Trigger Level is 8 bytes.  0011 = RX FIFO Interrupt Trigger Level is 14 bytes.  Other = Reserved.</p>
[3]	Reserved	Reserved.
[2]	TFR	<p><b>TX Field Software Reset</b>  When TX_RST is set, all the byte in the transmit FIFO and TX internal state machine are cleared.  0 = No effect.  1 = The TX internal state machine and pointers reset.</p> <p><b>Note:</b> This bit will auto clear needs at least 3 UART Controller peripheral clock cycles.</p>
[1]	RFR	<b>RX Field Software Reset</b> When RX_RST is set, all the byte in the receiver FIFO and RX internal state machine are

Bits	Description	
		cleared. 0 = No effect. 1 = The RX internal state machine and pointers reset. <b>Note:</b> This bit will auto clear needs at least 3 UART Controller peripheral clock cycles.
[0]	<b>Reserved</b>	Reserved.

**Line Control Register (UA\_LCR)**

Register	Offset	R/W	Description			Reset Value
UA_LCR	UART_BA+0x0C	R/W	UART Line Control Register			0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	BCB	SPE	EPE	PBE	NSB	WLS	

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	BCB	<b>Break Control Bit</b> When this bit is set to logic 1, the serial data output (TX) is forced to the Spacing State (logic 0). This bit acts only on TX and has no effect on the transmitter logic. 0 = Break control Disabled. 1 = Break control Enabled.
[5]	SPE	<b>Stick Parity Enable Control</b> 0 = Stick parity Disabled. 1 = If PBE (UA_LCR[3]) and EBE (UA_LCR[4]) are logic 1, the parity bit is transmitted and checked as logic 0. If PBE (UA_LCR[3]) is 1 and EBE (UA_LCR[4]) is 0 then the parity bit is transmitted and checked as 1.
[4]	EPE	<b>Even Parity Enable Control</b> 0 = Odd number of logic 1's is transmitted and checked in each word. 1 = Even number of logic 1's is transmitted and checked in each word. This bit has effect only when PBE (UA_LCR[3]) is set.
[3]	PBE	<b>Parity Bit Enable Control</b> 0 = No parity bit. 1 = Parity bit is generated on each outgoing character and is checked on each incoming data.
[2]	NSB	<b>Number Of “STOP Bit”</b> 0 = One “STOP bit” is generated in the transmitted data. 1 = When select 5-bit word length, 1.5 “STOP bit” is generated in the transmitted data. When select 6-, 7- and 8-bit word length, 2 “STOP bit” is generated in the transmitted data.
[1:0]	WLS[1:0]	<b>Word Length Selection</b> 00 = Word length is 5-bit. 01 = Word length is 6-bit. 10 = Word length is 7-bit.

Bits	Description
	11 = Word length is 8-bit.

**MODEM Control Register (UA\_MCR)**

Register	Offset	R/W	Description				Reset Value
UA_MCR	UART_BA+0x10	R/W	UART Modem Control Register				0x0000_0200

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved		RTS_ST	Reserved			LEV_RTS	Reserved
7	6	5	4	3	2	1	0
Reserved						RTS	Reserved

Bits	Description	
[31:14]	Reserved	Reserved.
[13]	RTS_ST	<p><b>RTS Pin State (Read Only)</b></p> <p>This bit mirror from RTS pin output of voltage logic status. 0 = RTS pin output is low level voltage logic state. 1 = RTS pin output is high level voltage logic state.</p>
[12:10]	Reserved	Reserved.
[9]	LEV_RTS	<p><b>RTS Pin Active Level</b></p> <p>This bit defines the active level state of RTS pin output. 0 = RTS pin output is high level active. 1 = RTS pin output is low level active.</p> <p><b>Note1:</b> Refer to UART function mode. <b>Note2:</b> Refer to RS-485 function mode.</p>
[8:2]	Reserved	Reserved.
[1]	RTS	<p><b>RTS (Request-to-send) Signal Control</b></p> <p>This bit is direct control internal RTS signal active or not, and then drive the RTS pin output with LEV_RTS bit configuration. 0 = RTS signal is active. 1 = RTS signal is inactive.</p>
[0]	Reserved	Reserved.

**FIFO Status Register (UA\_FSR)**

Register	Offset	R/W	Description			Reset Value
UA_FSR	UART_BA+0x18	R/W	UART FIFO Status Register			0x1040_4000

31	30	29	28	27	26	25	24
Reserved			TE_FLAG	Reserved			TX_OVER_IF
23	22	21	20	19	18	17	16
TX_FULL	TX_EMPTY	TX_POINTER					
15	14	13	12	11	10	9	8
RX_FULL	RX_EMPTY	RX_POINTER					
7	6	5	4	3	2	1	0
Reserved	BIF	FEF	PEF	RS-485_ADD_DETF	Reserved		RX_OVER_IF

Bits	Description	
[31:29]	Reserved	Reserved.
[28]	TE_FLAG	<p><b>Transmitter Empty Flag (Read Only)</b>  This bit is set by hardware when TX FIFO (UA_THR) is empty and the STOP bit of the last byte has been transmitted.  0 = TX FIFO is not empty.  1 = TX FIFO is empty and the STOP bit of the last byte has been transmitted.  <b>Note:</b> This bit is cleared automatically when TX FIFO is not empty or the last byte transmission has not completed.</p>
[27:25]	Reserved	Reserved.
[24]	TX_OVER_IF	<p><b>TX Overflow Error Interrupt Flag</b>  If TX FIFO (UA_THR) is full, an additional write to UA_THR will cause this bit to logic 1.  0 = TX FIFO is not overflow.  1 = TX FIFO is overflow.  <b>Note:</b> This bit is cleared by writing 1 to it.</p>
[23]	TX_FULL	<p><b>Transmitter FIFO Full (Read Only)</b>  This bit indicates TX FIFO full or not.  0 = TX FIFO is not full.  1 = TX FIFO is full.  <b>Note:</b> This bit is set when the number of usage in TX FIFO Buffer is equal to 16, otherwise is cleared by hardware.</p>
[22]	TX_EMPTY	<p><b>Transmitter FIFO Empty (Read Only)</b>  This bit indicates TX FIFO is empty or not.  0 = TX FIFO is not empty.  1 = TX FIFO is empty.  <b>Note:</b> When the last byte of TX FIFO has been transferred to Transmitter Shift Register, hardware sets this bit high. It will be cleared when writing data into THR (TX FIFO not</p>

Bits	Description	
	(empty).	
[21:16]	<b>TX_POINTER [5:0]</b>	<p><b>TX FIFO Pointer (Read Only)</b></p> <p>This field indicates the TX FIFO Buffer Pointer. When CPU writes one byte into UA THR, TX_POINTER increases one. When one byte of TX FIFO is transferred to Transmitter Shift Register, TX_POINTER decreases one.</p> <p>The Maximum value shown in TX_POINTER is 15. When the using level of TX FIFO Buffer equal to 16, the TX_FULL bit is set to 1 and TX_POINTER will show 0. As one byte of TX FIFO is transferred to Transmitter Shift Register, the TX_FULL bit is cleared to 0 and TX_POINTER will show 15.</p>
[15]	<b>RX_FULL</b>	<p><b>Receiver FIFO Full (Read Only)</b></p> <p>This bit initiates RX FIFO full or not.</p> <p>0 = RX FIFO is not full. 1 = RX FIFO is full.</p> <p><b>Note:</b> This bit is set when the number of usage in RX FIFO Buffer is equal to 16, otherwise is cleared by hardware.</p>
[14]	<b>RX_EMPTY</b>	<p><b>Receiver FIFO Empty (Read Only)</b></p> <p>This bit initiate RX FIFO empty or not.</p> <p>0 = RX FIFO is not empty. 1 = RX FIFO is empty.</p> <p><b>Note:</b> When the last byte of RX FIFO has been read by CPU, hardware sets this bit high. It will be cleared when UART receives any new data.</p>
[13:8]	<b>RX_POINTER [5:0]</b>	<p><b>RX FIFO Pointer (Read Only)</b></p> <p>This field indicates the RX FIFO Buffer Pointer. When UART receives one byte from external device, RX_POINTER increases one. When one byte of RX FIFO is read by CPU, RX_POINTER decreases one.</p> <p>The Maximum value shown in RX_POINTER is 15. When the using level of RX FIFO Buffer equal to 16, the RX_FULL bit is set to 1 and RX_POINTER will show 0. As one byte of RX FIFO is read by CPU, the RX_FULL bit is cleared to 0 and RX_POINTER will show 15.</p>
[7]	<b>Reserved</b>	Reserved.
[6]	<b>BIF</b>	<p><b>Break Interrupt Flag (Read Only)</b></p> <p>This bit is set to logic 1 whenever the received data input (RX) is held in the “spacing state” (logic 0) for longer than a full word transmission time (that is, the total time of “start bit” + data bits + parity + stop bits).</p> <p>0 = No Break interrupt is generated. 1 = Break interrupt is generated.</p> <p><b>Note:</b> This bit is read only, but software can write 1 to clear it.</p>
[5]	<b>FEF</b>	<p><b>Framing Error Flag (Read Only)</b></p> <p>This bit is set to logic 1 whenever the received character does not have a valid “stop bit” (that is, the stop bit follows the last data bit or parity bit is detected as logic 0).</p> <p>0 = No framing error is generated. 1 = Framing error is generated.</p> <p><b>Note:</b> This bit is read only, but can be cleared by writing ‘1’ to it .</p>
[4]	<b>PEF</b>	<p><b>Parity Error Flag (Read Only)</b></p> <p>This bit is set to logic 1 whenever the received character does not have a valid “parity bit”.</p> <p>0 = No parity error is generated. 1 = Parity error is generated.<b>Note:</b> This bit is read only, but can be cleared by writing ‘1’ to it .</p>
[3]	<b>RS-485_</b>	<b>RS-485 Address Byte Detection Flag</b>

Bits	Description	
	<b>ADD_DETF</b>	This bit is set to 1 while RS485_ADD_EN (UA_ALT_CSR[15]) is set to 1 to enable Address detection mode and receive detect a data with an address bit (bit 9 = 1). <b>Note1:</b> This field is used for RS-485 function mode. <b>Note2:</b> This bit is cleared by writing 1 to it.
[2:1]	<b>Reserved</b>	Reserved.
[0]	<b>RX_OVER_IF</b>	<b>RX Overflow Error Interrupt Flag</b> This bit is set when RX FIFO overflow. If the number of bytes of received data is greater than RX_FIFO (UA_RBR) size 16 bytes, this bit will be set. 0 = RX FIFO is not overflow. 1 = RX FIFO is overflow. <b>Note:</b> This bit is cleared by writing 1 to it.

**Interrupt Status Control Register (UA\_ISR)**

Register	Offset	R/W	Description			Reset Value
UA_ISR	UART_BA+0x1C	R/W	UART Interrupt Status Register			0x0000_0002

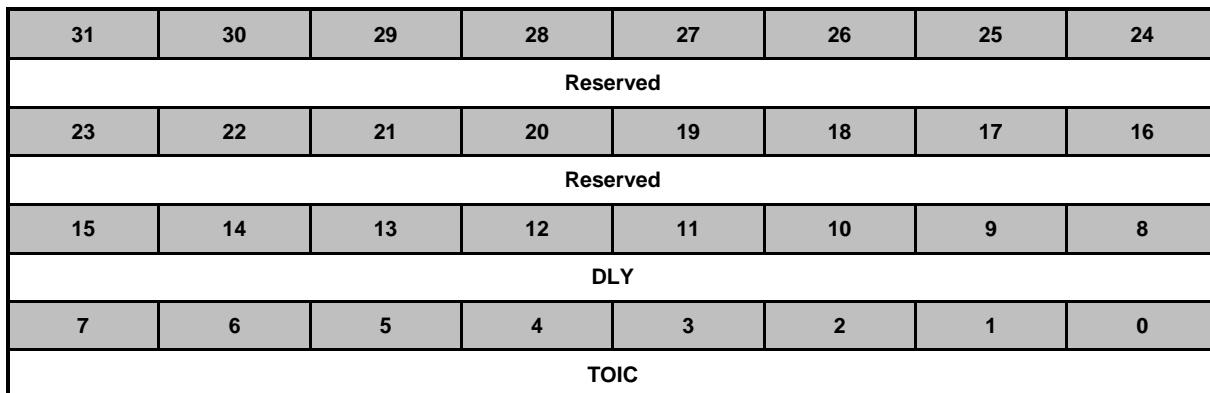
31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved		BUF_ERR_IN T	TOUT_INT	Reserved	RLS_INT	THRE_INT	RDA_INT
7	6	5	4	3	2	1	0
Reserved		BUF_ERR_IF	TOUT_IF	Reserved	RLS_IF	THRE_IF	RDA_IF

Bits	Description	
[31:14]	Reserved	Reserved.
[13]	BUF_ERR_INT	<p><b>Buffer Error Interrupt Indicator (Read Only)</b></p> <p>This bit is set if BUF_ERR_IEN and BUF_ERR_IF are both set to 1.            0 = No buffer error interrupt is generated.            1 = buffer error interrupt is generated.</p>
[12]	TOUT_INT	<p><b>Time-out Interrupt Indicator (Read Only)</b></p> <p>This bit is set if RTO_IEN and TOUT_IF are both set to 1.            0 = No Time-out interrupt is generated.            1 = Time-out interrupt is generated.</p>
[11]	Reserved	Reserved.
[10]	RLS_INT	<p><b>Receive Line Status Interrupt (Read Only)</b></p> <p>This bit is set if RLS_IEN and RLS_IF are both set to 1.            0 = No RLS interrupt is generated.            1 = RLS interrupt is generated.</p>
[9]	THRE_INT	<p><b>Transmit Holding Register Empty Interrupt Indicator (Read Only)</b></p> <p>This bit is set if THRE_IEN and THRE_IF are both set to 1.            0 = No THRE interrupt is generated.            1 = THRE interrupt is generated.</p>
[8]	RDA_INT	<p><b>Receive Data Available Interrupt Indicator (Read Only)</b></p> <p>This bit is set if RDA_IEN and RDA_IF are both set to 1.            This bit is set if RDA_IEN and RDA_IF are both set to 1.            0 = No RDA interrupt is generated.            1 = RDA interrupt is generated.</p>
[7:6]	Reserved	Reserved.

Bits	Description	
[5]	BUF_ERR_IF	<p><b>Buffer Error Interrupt Flag (Read Only)</b>            This bit is set when the TX/RX FIFO overflow flag (TX_OVER_IF or RX_OVER_IF) is set. When BUF_ERR_IF is set, the transfer is not correct. If BUF_ERR_IEN (UA_IER [5]) is enabled, the buffer error interrupt will be generated.            0 = No buffer error interrupt flag is generated.            1 = Buffer error interrupt flag is generated.</p> <p><b>Note:</b> This bit is read only and reset to 0 when all bits of TX_OVER_IF and RX_OVER_IF are cleared.</p>
[4]	TOUT_IF	<p><b>Time-out Interrupt Flag (Read Only)</b>            This bit is set when the RX FIFO is not empty and no activities occurred in the RX FIFO and the time-out counter equal to TOIC. If RTO_IEN (UA_IER [4]) is enabled, the Tout interrupt will be generated.            0 = No Time-out interrupt flag is generated.            1 = Time-out interrupt flag is generated.</p> <p><b>Note:</b> This bit is read only and user can read UA_RBR (RX is in active) to clear it.</p>
[3]	Reserved	Reserved.
[2]	RLS_IF	<p><b>Receive Line Interrupt Flag (Read Only)</b>            This bit is set when the RX receive data have parity error, framing error or break error (at least one of 3 bits, BIF, FEF and PEF, is set). If RLS_IEN (UA_IER [2]) is enabled, the RLS interrupt will be generated.            0 = No RLS interrupt flag is generated.            1 = RLS interrupt flag is generated.</p> <p><b>Note1:</b> In RS-485 function mode, this field is set including "receiver detect and received address byte character (bit 9 = 1) bit". At the same time, the bit of RS485_ADD_DETF (UA_FSR[3]) is also set.</p> <p><b>Note2:</b> This bit is read only and reset to 0 when all bits of BIF, FEF, PEF and RS485_ADD_DETF are cleared.</p>
[1]	THRE_IF	<p><b>Transmit Holding Register Empty Interrupt Flag (Read Only)</b>            This bit is set when the last data of TX FIFO is transferred to Transmitter Shift Register. If THRE_IEN (UA_IER [1]) is enabled, the THRE interrupt will be generated.            0 = No THRE interrupt flag is generated.            1 = THRE interrupt flag is generated.</p> <p><b>Note:</b> This bit is read only and it will be cleared when writing data into THR (TX FIFO not empty).</p>
[0]	RDA_IF	<p><b>Receive Data Available Interrupt Flag (Read Only)</b>            When the number of bytes in the RX FIFO equals the RFITL then the RDA_IF will be set. If RDA_IEN (UA_IER [0]) is enabled, the RDA interrupt will be generated.            0 = No RDA interrupt flag is generated.            1 = RDA interrupt flag is generated.</p> <p><b>Note:</b> This bit is read only and it will be cleared when the number of unread bytes of RX FIFO drops below the threshold level (RFITL).</p>

**Time-out Register (UA\_TOR)**

Register	Offset	R/W	Description				Reset Value
UA_TOR	UART_BA+0x20	R/W	UART Time-out Register				0x0000_0000



Bits	Description	
[31:16]	Reserved	Reserved.
[15:8]	DLY[7:0]	<p><b>TX Delay Time Value</b></p> <p>This field is used to program the transfer delay time between the last stop bit and next start bit.</p> <pre>     TX [Start] Byte (i) [Stop] ----- [Start] Byte (i+1)   -----  DLY   </pre>
[7:0]	TOIC[7:0]	<p><b>Time-out Interrupt Comparator</b></p> <p>The time-out counter resets and starts counting (the counting clock = baud rate) whenever the RX FIFO receives a new data word. Once the content of time-out counter (TOUT_CNT) is equal to that of time-out interrupt comparator (TOIC), a receiver time-out interrupt (TOUT_INT) is generated if RTO_IEN (UA_IER [4]). A new incoming data word or RX FIFO empty clears TOUT_INT. In order to avoid receiver time-out interrupt generation immediately during one character is being received, TOIC value should be set between 40 and 255. So, for example, if TOIC is set with 40, the time-out interrupt is generated after four characters are not received when 1 stop bit and no parity check is set for UART transfer.</p>

**Baud Rate Divider Register (UA\_BAUD)**

Register	Offset	R/W	Description				Reset Value
UA_BAUD	UART_BA+0x24	R/W	UART Baud Rate Divisor Register				0x0F00_0000

31	30	29	28	27	26	25	24
Reserved		DIV_X_EN	DIV_X_ONE	DIVIDER_X			
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
BRD							
7	6	5	4	3	2	1	0
BRD							

Bits	Description	
[31:30]	Reserved	Reserved.
[29]	DIV_X_EN	<p><b>Divider X Enable Control</b></p> <p>The BRD = Baud Rate Divider, and the baud rate equation is: Baud Rate = Clock / [M * (BRD + 2)], The default value of M is 16.</p> <p>0 = Divider X Disabled (the equation of M = 16).</p> <p>1 = Divider X Enabled (the equation of M = X+1, but DIVIDER_X [27:24] must <math>\geq 8</math>).</p> <p><b>Note:</b> When in IrDA mode, this bit must be disabled.</p>
[28]	DIV_X_ONE	<p><b>Divider X Equal 1</b></p> <p>0 = Divider M = X (the equation of M = X+1, but DIVIDER_X[27:24] must <math>\geq 8</math>).</p> <p>1 = Divider M = 1 (the equation of M = 1, but BRD [15:0] must <math>\geq 8</math>).</p> <p>Refer to section “UART Controller Baud Rate Generator” for more information.</p>
[27:24]	DIVIDER_X[3:0]	<p><b>Divider X</b></p> <p>The baud rate divider M = X+1.</p>
[23:16]	Reserved	Reserved.
[15:0]	BRD[15:0]	<p><b>Baud Rate Divider</b></p> <p>The field indicates the baud rate divider.</p>

IrDA Control Register (IRCR)

Register	Offset	R/W	Description				Reset Value
UA_IRCR	UART_BA+0x28	R/W	UART IrDA Control Register				0x0000_0040

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	INV_RX	INV_TX	Reserved			TX_SELECT	Reserved

Bits	Description	
[31:7]	Reserved	Reserved.
[6]	INV_RX	<b>INV_RX</b> 0 = No inversion. 1 = Inverse RX input signal.
[5]	INV_TX	<b>INV_TX</b> 0 = No inversion. 1 = Inverse TX output signal.
[4:2]	Reserved	Reserved.
[1]	TX_SELECT	<b>TX_SELECT</b> 0 = IrDA receiver Enabled. 1 = IrDA transmitter Enabled.
[0]	Reserved	Reserved.

**UART Alternate Control/Status Register (UA\_ALT\_CSR)**

Register	Offset	R/W	Description			Reset Value
UA_ALT_CSR	UART_BA+0x2C	R/W	UART Alternate Control/Status Register			0x0000_0000

31	30	29	28	27	26	25	24
ADDR_MATCH							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
RS485_ADD_EN	Reserved			RS485_AUD	RS485_AAD	RS485_NMM	
7	6	5	4	3	2	1	0
Reserved							

Bits	Description	
[31:24]	ADDR_MATCH [7:0]	<b>Address Match Value</b> This field contains the RS-485 address match values. <b>Note:</b> This field is used for RS-485 auto address detection mode.
[23:16]	Reserved	Reserved.
[15]	RS485_ADD_EN	<b>RS-485 Address Detection Enable Control</b> This bit is used to enable RS-485 Address Detection mode. 0 = RS-485 address detection mode Disabled. 1 = RS-485 address detection mode Enabled. <b>Note:</b> This field is used for RS-485 any operation mode.
[14:11]	Reserved	Reserved.
[10]	RS485_AUD	<b>RS-485 Auto Direction Mode (AUD) Control</b> 0 = RS-485 Auto Address Detection Operation Mode (AAD) Disabled. 1 = RS-485 Auto Address Detection Operation Mode (AAD) Enabled. <b>Note:</b> This bit cannot be active with RS485_NMM operation mode.
[9]	RS485_AAD	<b>RS-485 Auto Address Detection Operation Mode (AAD)</b> 0 = RS-485 Auto Address Detection Operation Mode (AAD) Disabled. 1 = RS-485 Auto Address Detection Operation Mode (AAD) Enabled. <b>Note:</b> This bit cannot be active with RS485_NMM operation mode.
[8]	RS485_NMM	<b>RS-485 Normal Multi-drop Operation Mode (NMM) Control</b> 0 = RS-485 Normal Multi-drop Operation Mode (NMM) Disabled. 1 = RS-485 Normal Multi-drop Operation Mode (NMM) Enabled. <b>Note:</b> This bit cannot be active with RS485_AAD operation mode.
[7:0]	Reserved	Reserved.

UART Function Select Register (UA\_FUN\_SEL)

Register	Offset	R/W	Description				Reset Value
UA_FUN_SEL	UART_BA+0x30	R/W	UART Function Select Register				0x0000_0000

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

Bits	Description	
[31:2]	Reserved	Reserved.
[1:0]	FUN_SEL	<b>Function Selection</b> 00 = UART function mode. 01 = Reserved. 10 = IrDA function mode. 11 = RS-485 function mode.

## 5.15 I<sup>2</sup>C Serial Interface Controller (I<sup>2</sup>C)

### 5.15.1 Overview

I<sup>2</sup>C is a two-wire, bi-directional serial bus that provides a simple and efficient method of data exchange between devices. The I<sup>2</sup>C standard is a true multi-master bus including collision detection and arbitration that prevents data corruption if two or more masters attempt to control the bus simultaneously.

### 5.15.2 Features

The I<sup>2</sup>C bus uses two wires (SDA and SCL) to transfer information between devices connected to the bus. The main features of the I<sup>2</sup>C bus include:

- Supports up to two I<sup>2</sup>C serial interface controller
- Master/Slave mode
- Bidirectional data transfer between masters and slaves
- Multi-master bus (no central master)
- Arbitration between simultaneously transmitting masters without corruption of serial data on the bus
- Serial clock synchronization allow devices with different bit rates to communicate via one serial bus
- Serial clock synchronization used as a handshake mechanism to suspend and resume serial transfer
- Built-in a 14-bit time-out counter requesting the I<sup>2</sup>C interrupt if the I<sup>2</sup>C bus hangs up and timer-out counter overflows.
- Programmable clocks allow for versatile rate control
- Supports 7-bit addressing mode
- Supports multiple address recognition ( four slave address with mask option)
- Supports Power-down wake-up function
- Support FIFO function (NUC029FAE only)

### 5.15.3 Basic Configuration

#### NUC029xAN:

The basic configurations of I<sup>2</sup>C0 are as follows:

- I<sup>2</sup>C0 pins are configured on P3\_MFP [13:12] register.
- Enable I<sup>2</sup>C0 clock (I2C0\_EN) on APBCLK [8] register.
- Reset I<sup>2</sup>C0 controller (I2C0\_RST) on IPRSTC2 [8] register.

The basic configurations of I<sup>2</sup>C1 are as follows:

- I<sup>2</sup>C1 pins are configured on P2\_MFP [5:4] or P4\_MFP[5:4] registers.
- Enable I<sup>2</sup>C1 clock (I2C1\_EN) on APBCLK [9] register.
- Reset I<sup>2</sup>C1 controller (I2C1\_RST) on IPRSTC2 [9] register.

#### NUC029FAAE:

The basic configurations of I<sup>2</sup>C are as follows:

- I<sup>2</sup>C pins are configured on P3\_MFP [7:6] register.
- Enable I<sup>2</sup>C clock (I2C\_EN) on APBCLK [8] register.
- Reset I<sup>2</sup>C controller (I2C\_RST) on IPRSTC2 [8] register.

### 5.15.4 Functional Description

On I<sup>2</sup>C bus, data is transferred between a Master and a Slave. Data bits transfer on the SCL and SDA lines are synchronously on a byte-by-byte basis. Each data byte is 8-bit long. There is one SCL clock pulse for each data bit with the MSB being transmitted first, and an acknowledge bit follows each transferred byte. Each bit is sampled during the high period of SCL; therefore, the SDA line may be changed only during the low period of SCL and must be held stable during the high period of SCL. A transition on the SDA line while SCL is high is interpreted as a command (START or STOP). Please refer to the following figure for more detailed I<sup>2</sup>C BUS Timing.

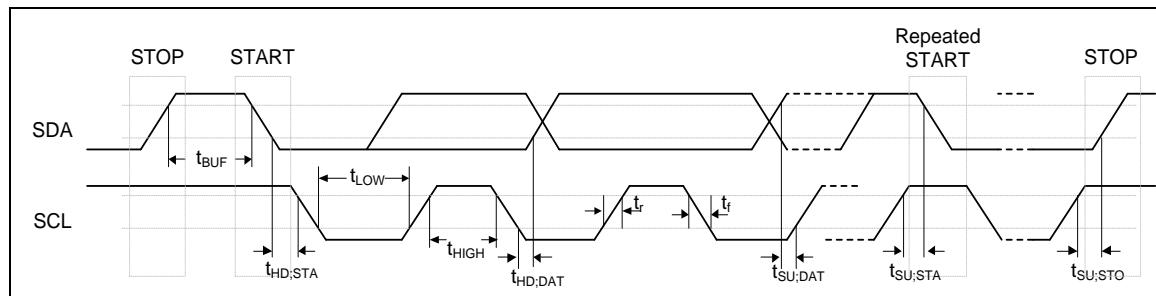


Figure 5-104 I<sup>2</sup>C Bus Timing

The device on-chip I<sup>2</sup>C provides the serial interface that meets the I<sup>2</sup>C bus standard mode specification. The I<sup>2</sup>C port handles byte transfers autonomously. To enable this port, the bit ENS1

in I2CON should be set to '1'. The I<sup>2</sup>C hardware interfaces to the I<sup>2</sup>C bus via two pins: SDA and SCL. When I/O pins are used as I<sup>2</sup>C ports, user must set the pins function to I<sup>2</sup>C in advance.

**Note:** Pull-up resistor is needed for I<sup>2</sup>C operation as the SDA and SCL are open-drain pins.

#### 5.15.4.1.1 Two-level FIFO Mode (NUC029FAE only)

For NUC029FAE, there is two-level FIFO to improve the performance of I<sup>2</sup>C bus. In two-level FIFO mode, the next transmitted or the last received data can be active even if the current data is transmitted or the last received isn't read back yet.

The I<sup>2</sup>C SCL bus is stretched low when there is SI event. The NOSTRETCH control bit is used to force the I<sup>2</sup>C SCL bus is no stretched under the SI event.

There are under run or over run interrupt when the two-level FIFO mode is enabled and the interrupt event enable is set.

### 5.15.5 I<sup>2</sup>C Protocol

The following figure shows the typical I<sup>2</sup>C protocol. Normally, a standard communication consists of four parts:

- 1) START or Repeated START signal generation
- 2) Slave address and R/W bit transfer
- 3) Data transfer
- 4) STOP signal generation

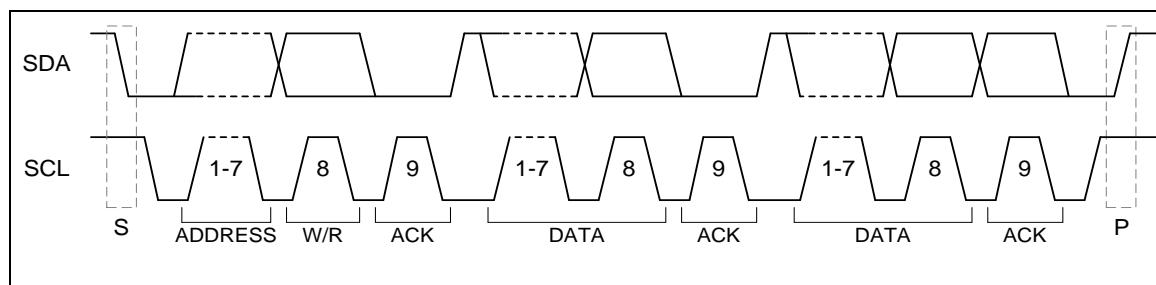


Figure 5-105 I<sup>2</sup>C Protocol

#### 5.15.5.1 START or Repeated START signal

When the bus is free/idle, meaning no master device is engaging the bus (both SCL and SDA lines are high), a master can initiate a transfer by sending a START signal. A START signal, usually referred to as the "S" bit, is defined as a HIGH to LOW transition on the SDA line while SCL is HIGH. The START signal denotes the beginning of a new data transmission.

A Repeated START is not a STOP signal between two START signals and usually referred to as the "Sr" bit. The master uses this method to communicate with another slave or the same slave in a different transfer direction (e.g. from writing to a device to reading from a device) without releasing the bus.

### 5.15.5.2 STOP signal

The master can terminate the communication by generating a STOP signal. A STOP signal, usually referred to as the "P" bit, is defined as a LOW to HIGH transition on the SDA line while SCL is HIGH.

The following figure shows the waveform of START, Repeat START and STOP.

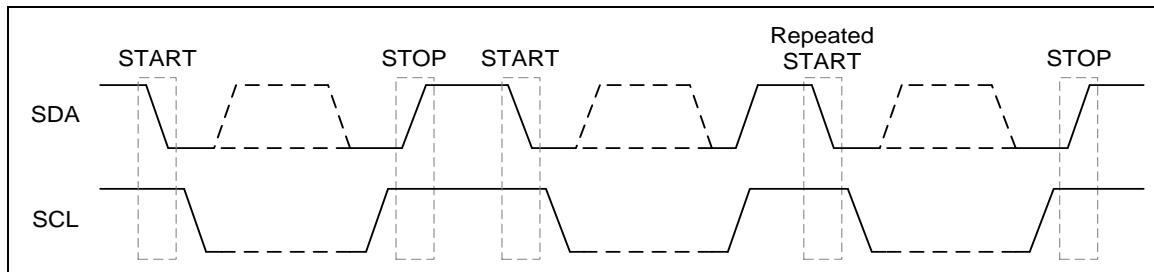


Figure 5-106 START and STOP Conditions

### 5.15.5.3 Slave Address Transfer

The first byte of data transferred by the master immediately after the START signal is the Slave address (SLA). This is a 7-bit calling address followed by a Read/Write (R/W) bit. The R/W bit signals of the slave indicate the data transfer direction. No two slaves in the system can have the same address. Only the slave with an address that matches the one transmitted by the master will respond by returning an acknowledge bit by pulling the SDA low at the 9th SCL clock cycle.

### 5.15.5.4 Data Transfer

When a slave receives a correct address with an R/W bit, the data will follow R/W bit specified to transfer. Each transferred byte is followed by an acknowledge bit on the 9th SCL clock cycle. If the slave signals a Not Acknowledge (NACK), the master can generate a STOP signal to abort the data transfer or generate a Repeated START signal and start a new transfer cycle.

If the master, as a receiving device, does Not Acknowledge (NACK) the slave, the slave releases the SDA line for the master to generate a STOP or Repeated START signal.

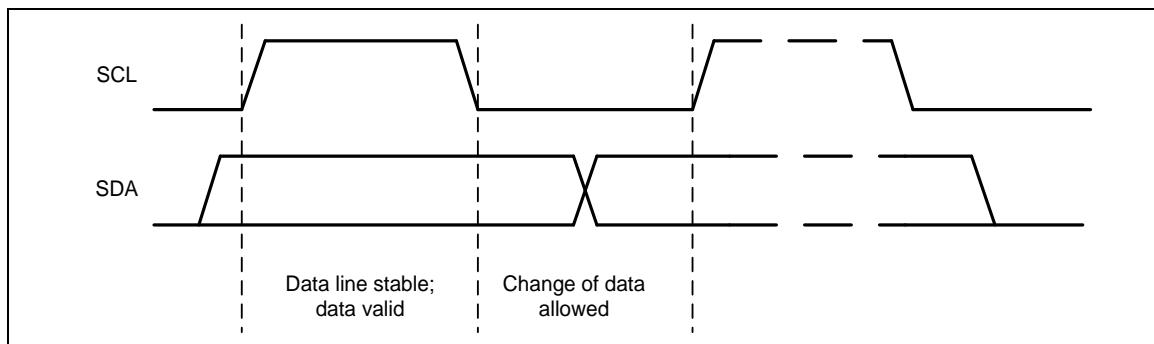
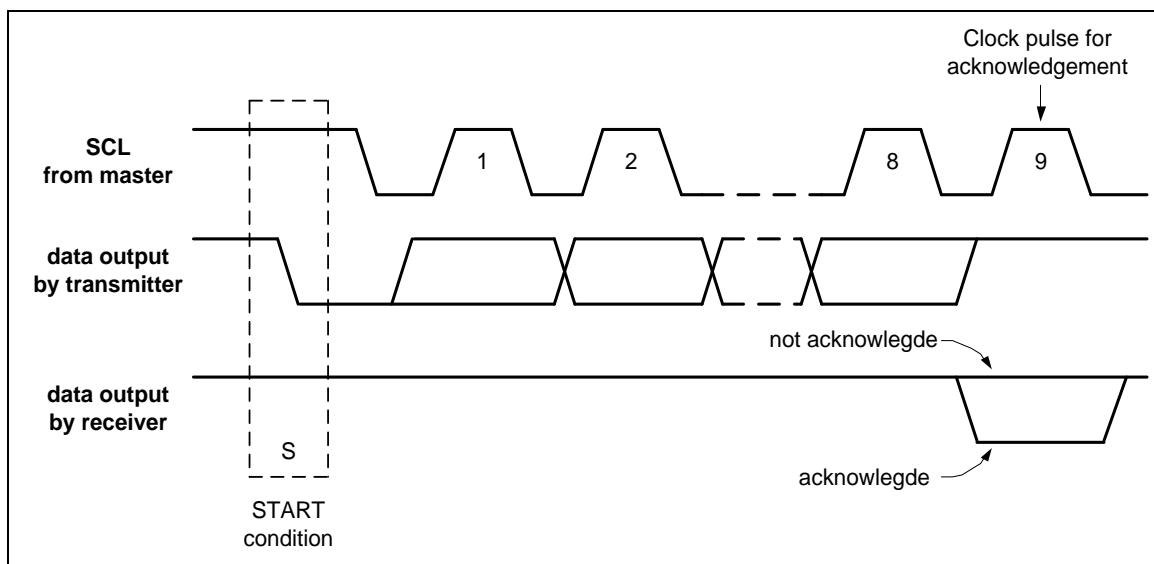


Figure 5-107 Bit Transfer on the I<sup>2</sup>C Bus

Figure 5-108 Acknowledge on the I<sup>2</sup>C Bus

#### 5.15.5.5 Data transfer on the I<sup>2</sup>C bus

The following figure shows a master transmits data to slave. A master addresses a slave with a 7-bit address and 1-bit write index to denote that the master wants to transmit data to the slave. The master keeps transmitting data after the slave returns acknowledge to the master.

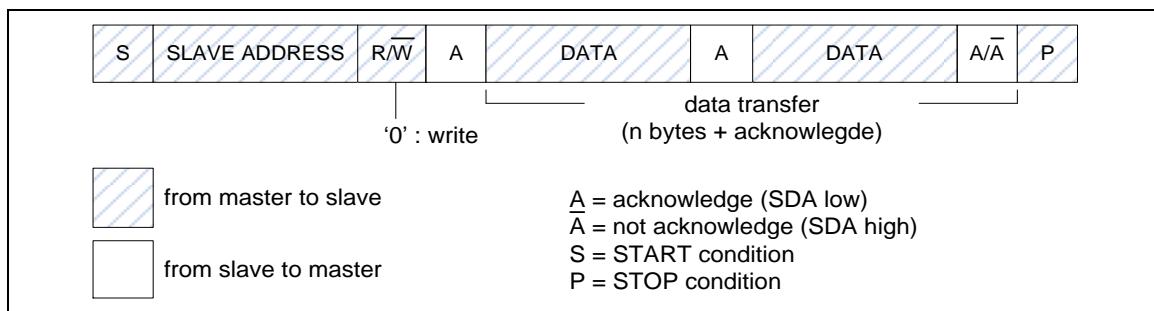


Figure 5-109 Master Transmits Data to Slave

The following figure shows a master read data from slave. A master addresses a slave with a 7-bit address and 1-bit read index to denote that the master wants to read data from the slave. The slave will start transmitting data after the slave returns acknowledge to the master.

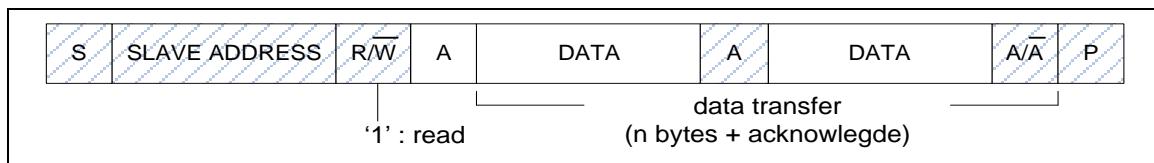


Figure 5-110 Master Reads Data from Slave

#### 5.15.5.6 Two Level FIFO Mode on I<sup>2</sup>C bus (NUC029FAE only)

Set to enable the two-level FIFO for I<sup>2</sup>C transmitted or received buffer. It is used to improve the

performance of the I<sup>2</sup>C bus. If this TWOFF\_EN bit is set = 1, the control bit of STA for repeat start or STO bit should be set after the current SI is clear.

For example: if there are 4 data shall be transmitted and then stop it. The STO bit shall be set after the 3rd data's SI event being clear. In this time, the 4th data can be transmitted and the I<sup>2</sup>C stop after the 4th data transmission done.

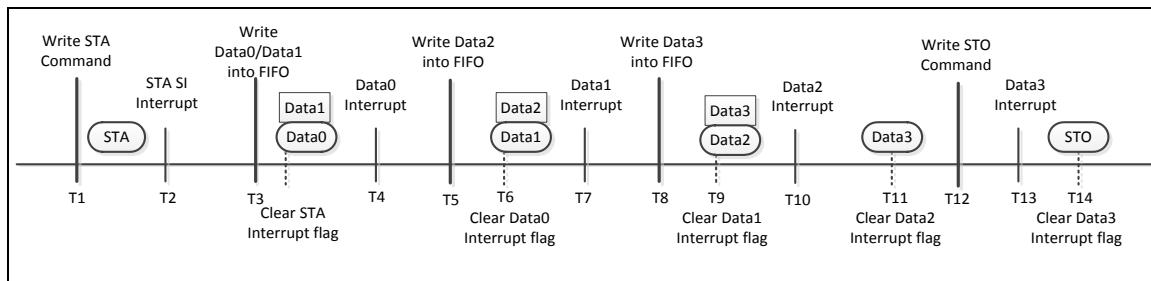


Figure 5-111 Timing of Two Level FIFO Transmit in Master Write

For example: if there are 4 data shall be received in Slave mode. The controller can receives the 2nd data in the I<sup>2</sup>C bus after the 1st data had been loaded into the received buffer and the user can read the 1st data after the 1st interrupt status be cleared.

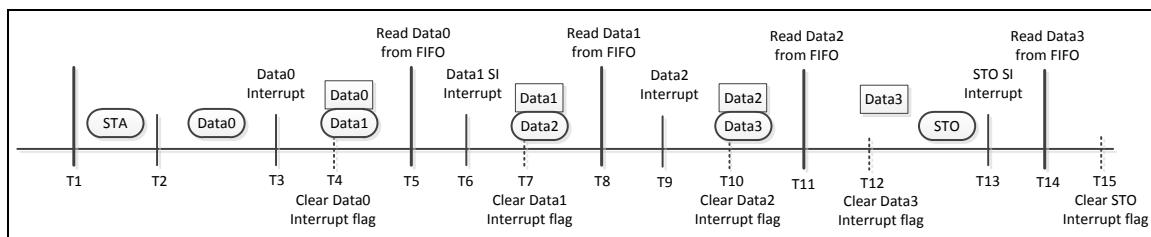


Figure 5-112 Timing of Two Level FIFO Transmit in Slave Read

### 5.15.6 I<sup>2</sup>C Protocol Registers

To control I<sup>2</sup>C port through the following fifteen special function registers: I2CON (control register), I2CSTATUS (status register), I2CDAT (data register), I2CADDRn (address registers, n=0~3), I2CADMn (address mask registers, n=0~3), I2CLK (clock rate register), I2CTOC (Time-out counter register), I2CWKUPCON(wake-up control register) and I2CWKUPSTS(wake-up status register).

#### Address Registers (I2CADDR)

The I<sup>2</sup>C port is equipped with four slave address registers, I2CADDRn (n=0~3). The contents of the register are irrelevant when I<sup>2</sup>C is in Master mode. In Slave mode, the bit field I2CADDRn[7:1] must be loaded with the chip's own slave address. The I<sup>2</sup>C hardware will react if the contents of I2CADDRn are matched with the received slave address.

The I<sup>2</sup>C ports support the “General Call” function. If the GC bit (I2CADDRn[0]) is set the I<sup>2</sup>C port hardware will respond to General Call address (00H). Clear GC bit to disable general call

function.

When the GC bit is set and the I<sup>2</sup>C is in Slave mode, it can receive the general call address by 00H after Master send general call address to I<sup>2</sup>C bus, then it will follow status of GC mode.

### **Slave Address Mask Registers (I2CADM)**

The I<sup>2</sup>C bus controller supports multiple address recognition with four address mask registers I2CADM<sub>n</sub> (n=0~3). When the bit in the address mask register is set to 1, it means the received corresponding address bit is "Don't care". If the bit is set to 0, it means the received corresponding register bit should be exactly the same as address register.

### **Data Register (I2CDAT)**

This register contains a byte of serial data to be transmitted or a byte which just has been received. The CPU can be read from or written to the 8-bit (I2CDAT[7:0]) directly while it is not in the process of shifting a byte. When I<sup>2</sup>C is in a defined state and the serial interrupt flag (SI) is set, data in I2CDAT[7:0] remains stable. While data is being shifted out, data on the bus is simultaneously being shifted in; I2CDAT[7:0] always contains the last data byte presented on the bus.

The acknowledge bit is controlled by the I<sup>2</sup>C hardware and cannot be accessed by the CPU. Serial data is shifted into I2CDAT[7:0] on the rising edges of serial clock pulses on the SCL line. When a byte has been shifted into I2CDAT[7:0], the serial data is available in I2CDAT[7:0], and the acknowledge bit (ACK or NACK) is returned by the control logic during the ninth clock pulse. In order to monitor bus status while sending data, the bus date will be shifted to I2CDATA[7:0] when sending I2CDATA[7:0] to bus. In the case of sending data, serial data bits are shifted out from I2CDAT[7:0] on the falling edge of SCL clocks, and is shifted to I2CDAT[7:0] on the rising edge of SCL clocks.

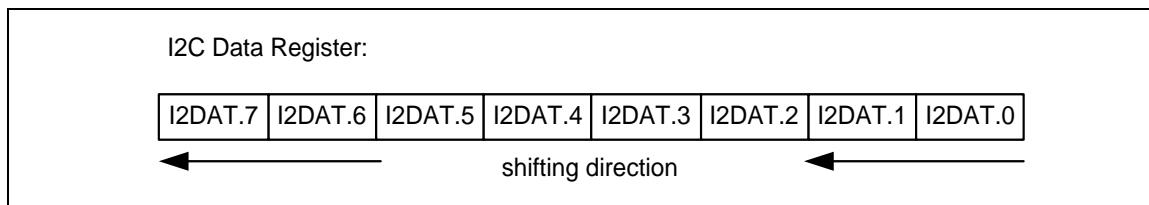


Figure 5-113 I<sup>2</sup>C Data Shifting Direction

### **Control Register (I2CON)**

The CPU can be read from and written to I2CON[7:0] directly. When the I<sup>2</sup>C port is enabled by setting ENS1(I2CON[6]) to high, the internal states will be controlled by I2CON and I<sup>2</sup>C logic hardware.

There are two bits are affected by hardware: the SI bit is set when the I<sup>2</sup>C hardware requests a serial interrupt, and the STO bit is cleared when a STOP condition is present on the bus. The STO bit is also cleared when ENS1 = 0.

Once a new status code is generated and stored in I2CSTATUS, the I<sup>2</sup>C Interrupt Flag bit SI (I2CON[3]) will be set automatically. If the Enable Interrupt bit EI(I2CON[7]) is set at this time, the I<sup>2</sup>C interrupt will be generated. The bit field I2CSTATUS[7:0] stores the internal state code, the

content keeps stable until SI is cleared by software.

### Status Register (I2CSTATUS)

I2CSTATUS[7:0] is an 8-bit read-only register. The bit field I2CSTATUS[7:0] contains the status code and there are 26 possible status codes. All states are listed in 0When I2CSTATUS[7:0] is F8H, no serial interrupt is requested. All other I2CSTATUS[7:0] values correspond to the defined I<sup>2</sup>C states. When each of these states is entered, a status interrupt is requested (SI = 1). A valid status code is present in I2CSTATUS[7:0] one cycle after SI set by hardware and is still present one cycle after SI reset by software.

In addition, the state 00H stands for a Bus Error, which occurs when a START or STOP condition is present at an incorrect position in the I<sup>2</sup>C format frame. A Bus Error may occur during the serial transfer of an address byte, a data byte or an acknowledge bit. To recover I<sup>2</sup>C from bus error, STO should be set and SI should be cleared to enter Not Addressed Slave mode. Then STO is cleared to release bus and to wait for a new communication. The I<sup>2</sup>C bus cannot recognize stop condition during this action when a bus error occurs.

<b>Master Mode</b>		<b>Slave Mode</b>	
<b>STATUS</b>	<b>Description</b>	<b>STATUS</b>	<b>Description</b>
0x08	Start	0xA0	Slave Transmit Repeat Start or Stop
0x10	Master Repeat Start	0xA8	Slave Transmit Address ACK
0x18	Master Transmit Address ACK	0xB0	Slave Transmit Arbitration Lost
0x20	Master Transmit Address NACK	0xB8	Slave Transmit Data ACK
0x28	Master Transmit Data ACK	0xC0	Slave Transmit Data NACK
0x30	Master Transmit Data NACK	0xC8	Slave Transmit Last Data ACK
0x38	Master Arbitration Lost	0x60	Slave Receive Address ACK
0x40	Master Receive Address ACK	0x68	Slave Receive Arbitration Lost
0x48	Master Receive Address NACK	0x80	Slave Receive Data ACK
0x50	Master Receive Data ACK	0x88	Slave Receive Data NACK
0x58	Master Receive Data NACK	0x70	GC mode Address ACK
0x00	Bus error	0x78	GC mode Arbitration Lost
		0x90	GC mode Data ACK
		0x98	GC mode Data NACK
0xF8	Bus Released <b>Note:</b> Status "0xF8" exists in both master/slave modes, and it won't raise interrupt.		

Table 5-25 I<sup>2</sup>C Status Code Description

### Clock Baud Rate Bits (I2CLK)

The data baud rate of I<sup>2</sup>C is determined by I2CLK[7:0] register when I<sup>2</sup>C is in Master Mode, and it is not necessary in a Slave mode. In the Slave mode, I<sup>2</sup>C will automatically synchronize it with any clock frequency from master I<sup>2</sup>C device.

The data baud rate of I<sup>2</sup>C setting is Data Baud Rate of I<sup>2</sup>C = (system clock) / (4x (I2CLK [7:0] +1)). If system clock = 16 MHz, the I2CLK[7:0] = 40 (28H), the data baud rate of I<sup>2</sup>C = 16 MHz/ (4x (40 +1)) = 97.5 Kbits/sec.

### Time-out Counter Register (I2CTOC)

There is a 14-bit time-out counter which can be used to deal with the I<sup>2</sup>C bus hang-up. If the time-out counter is enabled, the counter starts up counting until it overflows (TIF=1) and generates I<sup>2</sup>C interrupt to CPU or stops counting by clearing ENTI to 0. When time-out counter is enabled, writing 1 to the SI flag will reset counter and re-start up counting after SI is cleared. If I<sup>2</sup>C bus hangs up, it causes the I2CSTATUS and flag SI are not updated for a period, the 14-bit time-out counter may overflow and acknowledge CPU the I<sup>2</sup>C interrupt. Refer to the following figure for the 14-bit time-out counter. User may write 1 to clear TIF to 0.

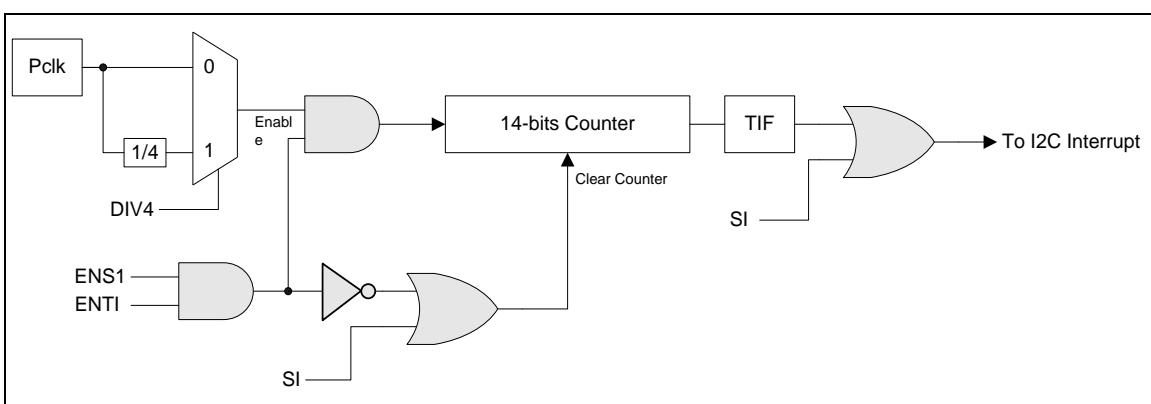


Figure 5-114 I<sup>2</sup>C Time-out Count Block Diagram

### Wake-up Control Register (I2WKUPCON) (NUC029xAN) / I<sup>2</sup>C Control Register 2 (I2CON2) (NUC029FAE)

When chip enters Power-down mode, other I<sup>2</sup>C master can wake-up our chip by addressing our I<sup>2</sup>C device, user must configure the related setting before entering Sleep mode. When the chip is woken-up by address match with one of the four address register, the following data will be abandoned at this time.

### Wake-up Status Register (I2WKUPSTS) (NUC029xAN) / I<sup>2</sup>C Status Register 2 (I2CSTATUS2) (NUC029FAE)

When system is woken up by other I<sup>2</sup>C master device, WKUPIF is set to indicate this event. User needs write "1" to clear this bit.

The other status bits are used to indicate the current FIFO status when the TWOFF\_EN is set. (NUC029FAE only)

### 5.15.7 Operation Modes

The on-chip I<sup>2</sup>C ports support three operation modes, Master, Slave, and General Call Mode.

In a given application, I<sup>2</sup>C port may operate as a master or as a slave. In Slave mode, the I<sup>2</sup>C port hardware looks for its own slave address and the general call address. If one of these addresses

is detected, and if the slave is willing to receive or transmit data from/to master(by setting the AA bit), acknowledge pulse will be transmitted out on the 9th clock, hence an interrupt is requested on both master and slave devices if interrupt is enabled. When the microcontroller wishes to become the bus master, hardware waits until the bus is free before entering Master mode so that a possible slave action is not be interrupted. If bus arbitration is lost in Master mode, I<sup>2</sup>C port switches to Slave mode immediately and can detect its own slave address in the same serial transfer.

To control the I<sup>2</sup>C bus transfer in each mode, user needs to set I2CON, I2CDAT registers according to current status code of I2CSTATUS register. In other words, for each I<sup>2</sup>C bus action, user needs to check current status by I2CSTATUS register, and then set I2CON, I2CDAT registers to take bus action. Finally, check the response status by I2CSTATUS.

The bits, STA, STO and AA in I2CON register are used to control the next state of the I<sup>2</sup>C hardware after SI flag of I2CON [3] register is cleared. Upon completion of the new action, a new status code will be updated in I2CSTATUS register and the SI flag of I2CON register will be set. If the I<sup>2</sup>C interrupt control bit EI (I2CON [7]) is set, appropriate action or software branch of the new status code can be performed in the Interrupt service routine.

The following figure shows the current I<sup>2</sup>C status code is 0x08, and then set I2CDATA=SLA+W and (STA,STO,SI,AA) = (0,0,1,x) to send the address to I<sup>2</sup>C bus. If a slave on the bus matches the address and response ACK, the I2CSTATUS will be updated by status code 0x18.

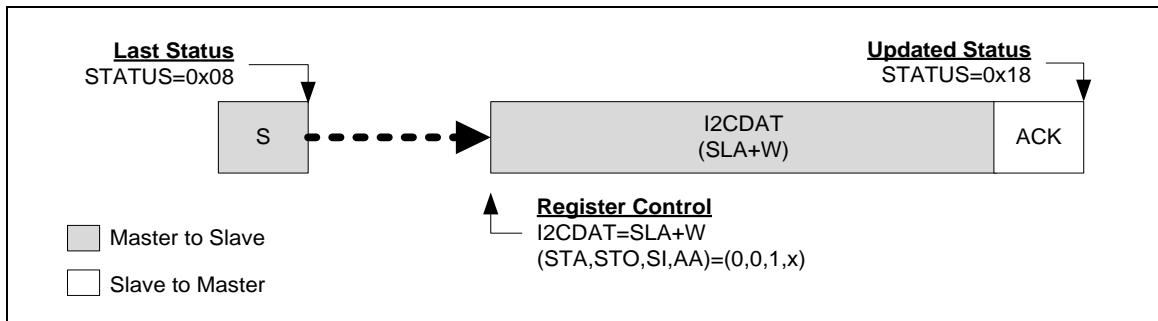


Figure 5-115 Control I<sup>2</sup>C Bus according to Current I<sup>2</sup>C Status

### 5.15.7.1 Master Mode

In the following figures, all possible protocols for I<sup>2</sup>C master are shown. User needs to follow proper path of the flow to implement required I<sup>2</sup>C protocol.

In other words, user can send a START signal to bus and I<sup>2</sup>C will be in Master Transmitter mode or Master receiver mode after START signal has been sent successfully and new status code would be 0x08. Followed by START signal, user can send slave address, read/write bit, data and Repeat START, STOP to perform I<sup>2</sup>C protocol.

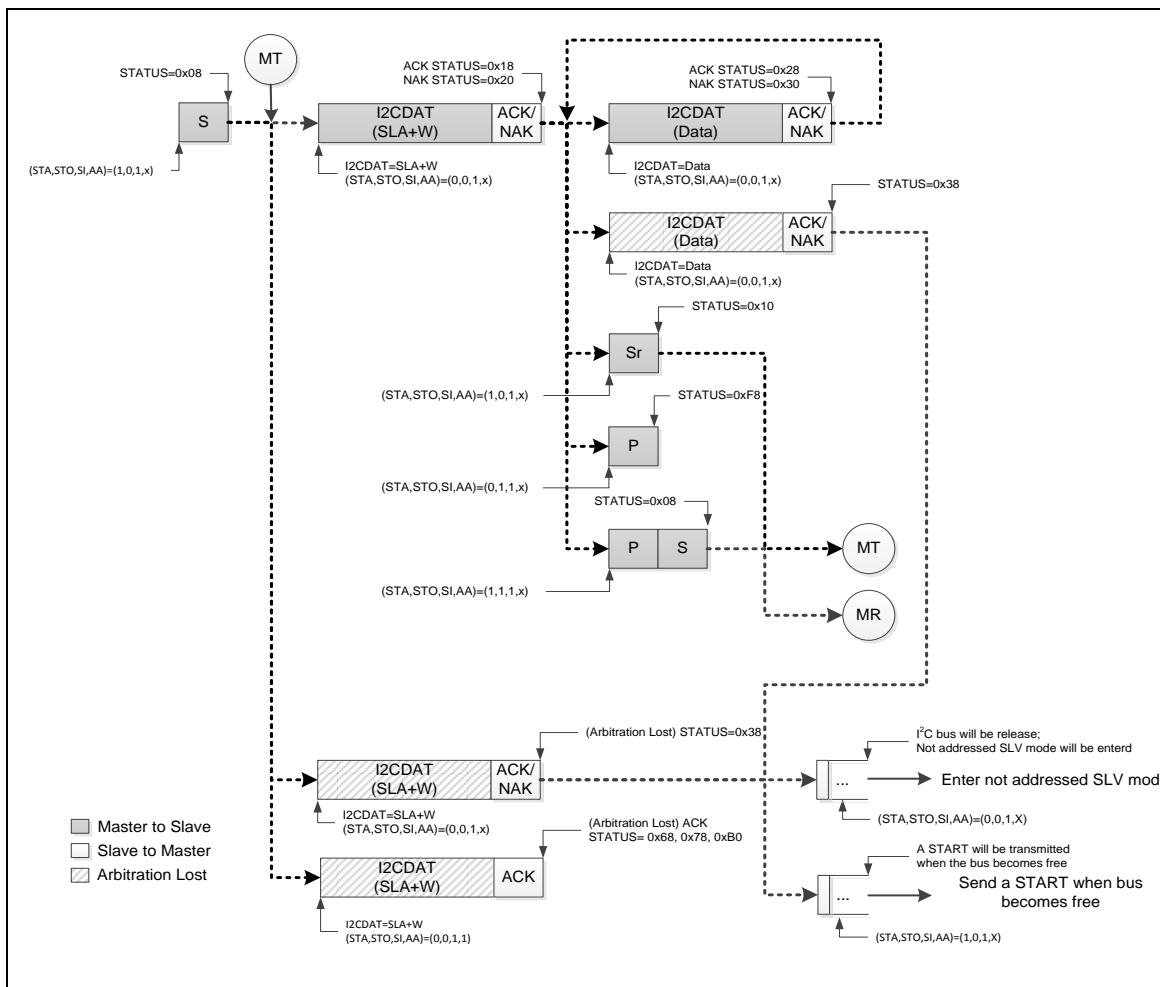


Figure 5-116 Master Transmitter Mode Control Flow

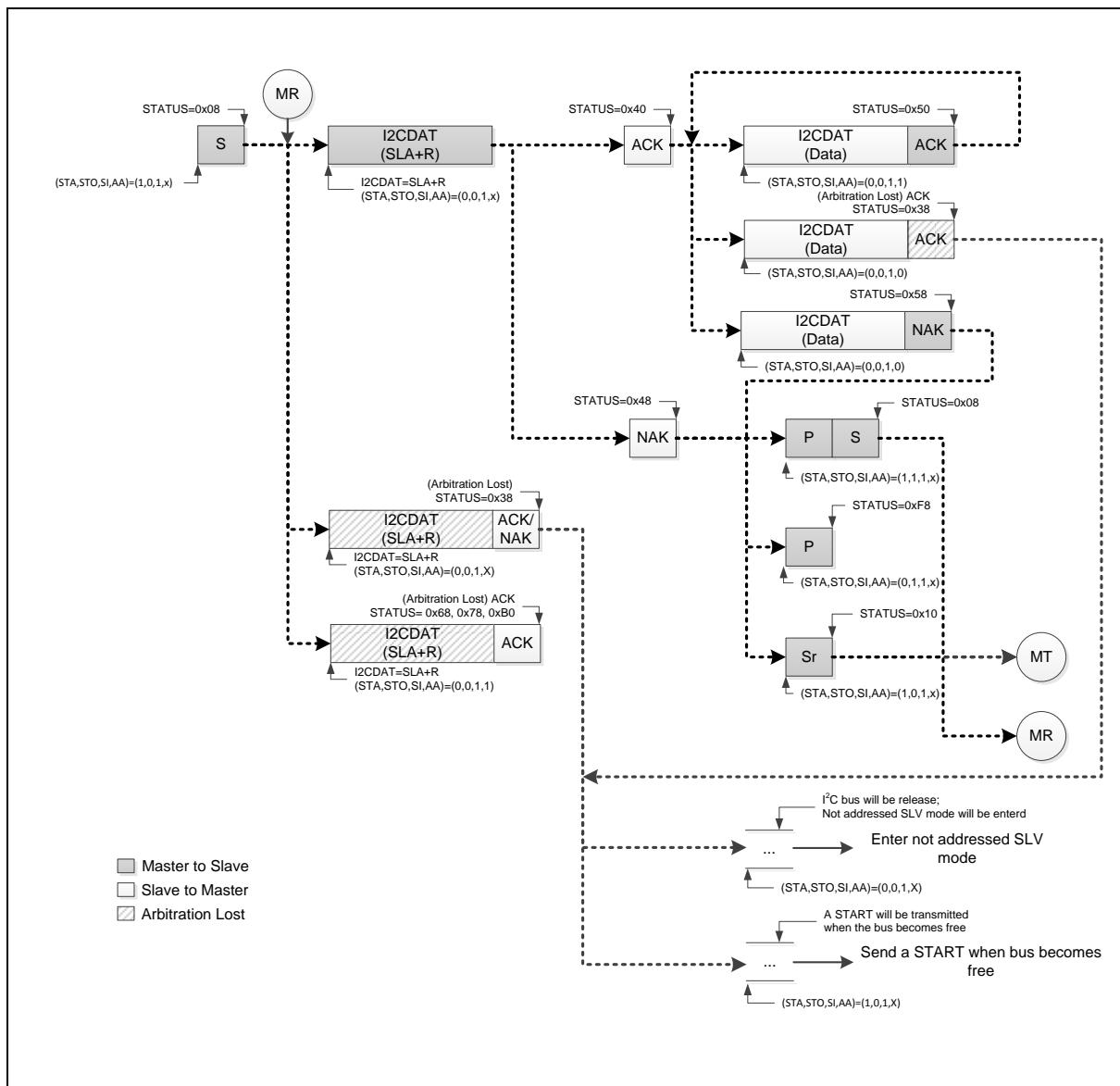


Figure 5-117 Master Receiver Mode Control Flow

If the I<sup>2</sup>C is in Master mode and gets arbitration lost, the status code will be 0x38. In status 0x38, user may set (STA, STO, SI, AA) = (1, 0, 1, X) to send START to re-start Master operation when bus become free. Otherwise, user may set (STA, STO, SI, AA) = (0, 0, 1, X) to release I<sup>2</sup>C bus and enter not addressed Slave mode.

#### 5.15.7.2 Slave Mode

When reset default, I<sup>2</sup>C is not addressed and will not recognize the address on I<sup>2</sup>C bus. User can set slave address by I2CADDRx and set (STA, STO, SI, AA) = (0, 0, 1, 1) to let I<sup>2</sup>C recognize the address sent by master. Figure 5-118 shows all the possible flow for I<sup>2</sup>C in Slave mode. Users need to follow a proper flow (as shown in Figure 5-118 to implement their own I<sup>2</sup>C protocol).

If bus arbitration is lost in Master mode, I<sup>2</sup>C port switches to Slave mode immediately and can detect its own slave address in the same serial transfer. If the detected address is SLA+W

(Master want to write data to Slave) after arbitration lost, the status code is 0x68. If the detected address is SLA+R (Master want to read data from Slave) after arbitration lost, the status code is 0xB0.

**Note:** During I<sup>2</sup>C communication, the SCL clock will be released when writing '1' to clear SI flag in Slave mode.

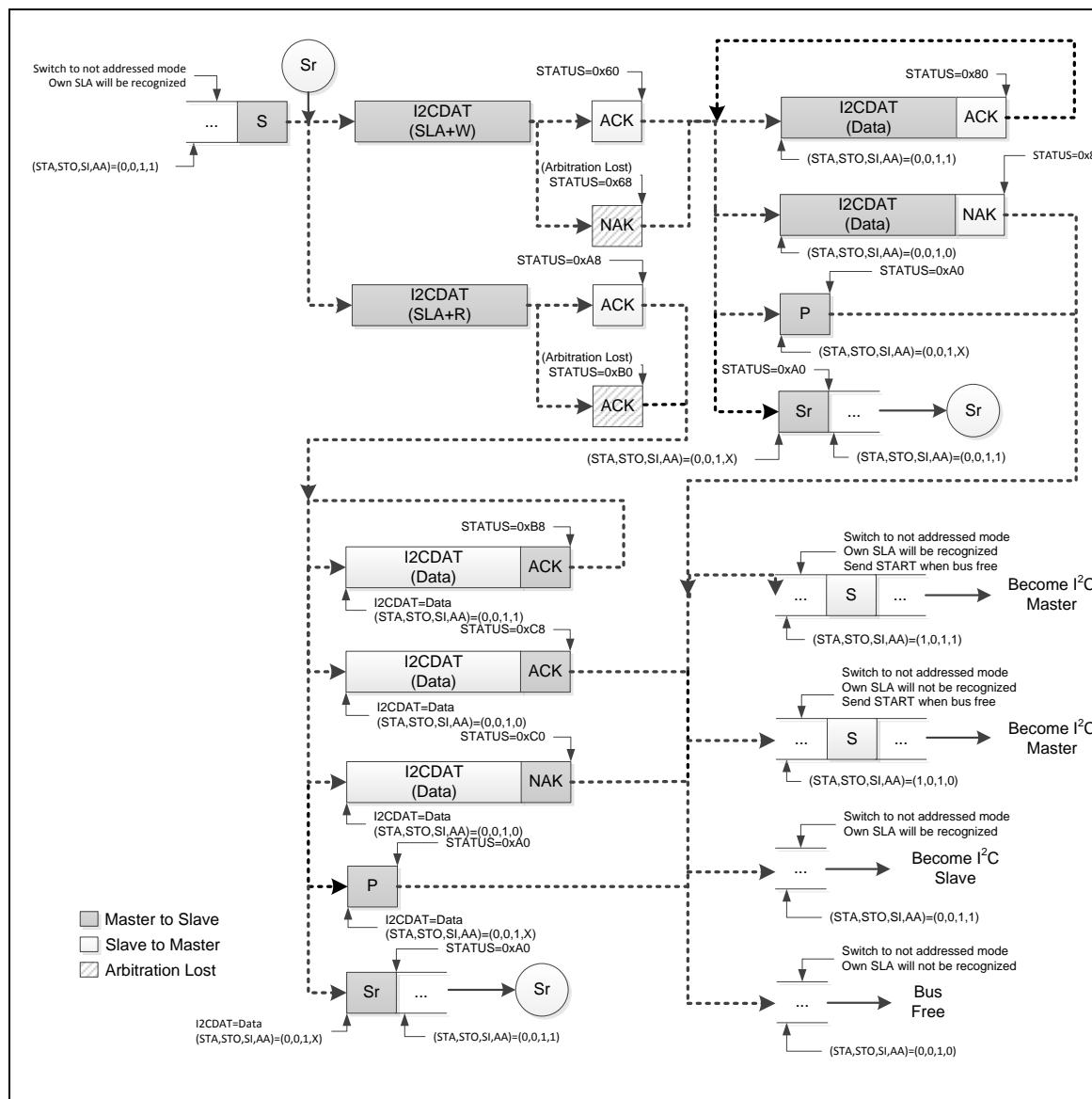


Figure 5-118 Save Mode Control Flow

If I<sup>2</sup>C is still receiving data in addressed Slave mode but got a STOP or Repeat START, the status code will be 0xA0. User could follow the action for status code 0x88 as shown in the above figure when getting 0xA0 status.

If I<sup>2</sup>C is still transmitting data in addressed Slave mode but got a STOP or Repeat START, the status code will be 0xA0. User could follow the action for status code 0xC8 as shown in the above

figure when getting 0xA0 status.

**Note:** After slave gets status of 0x88, 0xC8, 0xC0 and 0xA0, slave can switch to not address mode and own SLA will not be recognized. If entering this status, slave will not receive any I<sup>2</sup>C signal or address from master. At this status, I<sup>2</sup>C should be reset to leave this status.

#### 5.15.7.3 General Call (GC) Mode

If the GC bit (I2CADDRn[0]) is set, the I<sup>2</sup>C port hardware will respond to General Call address (00H). User can clear GC bit to disable general call function. When the GC bit is set and the I<sup>2</sup>C is in Slave mode, it can receive the general call address by 0x00 after master send general call address to I<sup>2</sup>C bus, then it will follow status of GC mode.

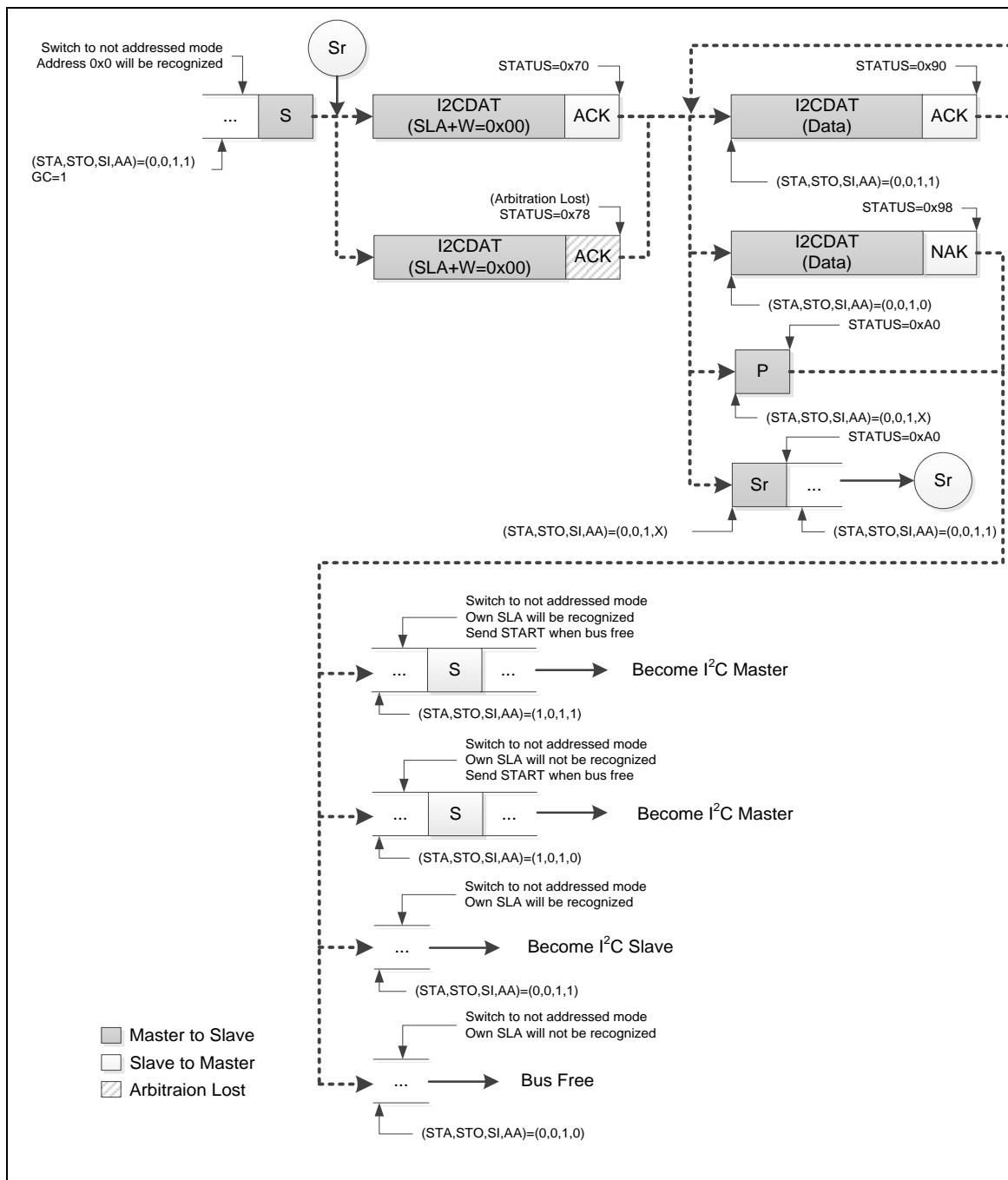


Figure 5-119 GC Mode

If I<sup>2</sup>C is still receiving data in GC mode but got a STOP or Repeat START, the status code will be 0xA0. User could follow the action for status code 0x98 in above figure when getting 0xA0 status.

**Note:** After slave gets status of 0x98 and 0xA0, slave can switch to not address mode and own SLA will not be recognized. If entering this status, slave will not receive any I<sup>2</sup>C signal or address from master. At this time, I<sup>2</sup>C controller should be reset to leave this status.

#### 5.15.7.4 Multi-Master

In some applications, there are two or more masters on the same I<sup>2</sup>C bus to access slaves, and the masters may transmit data simultaneously. The I<sup>2</sup>C supports multi-master by including collision detection and arbitration to prevent data corruption.

- When I2CSTATUS = 0x38, an “Arbitration Lost” is received. Arbitration lost event maybe occur during the send START bit, data bits or STOP bit. User could set (STA, STO, SI, AA) = (1, 0, 1, X) to send START again when bus free, or set (STA, STO, SI, AA) = (0, 0, 1, X) to send STOP to back to not addressed Slave mode.
- When I2CSTATUS = 0x00, a “Bus Error” is received. To recover I<sup>2</sup>C bus from a bus error, STO should be set and SI should be cleared, and then STO is cleared to release bus.
  - Set (STA, STO, SI, AA) = (0, 1, 1, X) to stop current transfer
  - Set (STA, STO, SI, AA) = (0, 0, 1, X) to release bus

#### 5.15.7.5 Example for Random Read on EEPROM

The following steps are used to configure the I<sup>2</sup>C related registers when using I<sup>2</sup>C to read data from EEPROM.

1. Set the multi-function pin in the “P3\_MFP” and “P3\_ALT” registers as SCL and SDA pins.
2. Enable I<sup>2</sup>C APB clock, I2C\_EN=1 in the “APBCLK” register.
3. Set I2C\_RST=1 to reset I<sup>2</sup>C controller then set I<sup>2</sup>C controller to normal operation, I2C\_RST=0 in the “IPRSTC2” register.
4. Set ENS1=1 to enable I<sup>2</sup>C controller in the “I2CON” register.
5. Give I<sup>2</sup>C clock a divided register value for I<sup>2</sup>C clock rate in the “I2CLK”.
6. Set SETENA=0x00040000 in the “NVIC\_ISER” register to set I<sup>2</sup>C IRQ.
7. Set EI=1 to enable I<sup>2</sup>C Interrupt in the “I2CON” register.
8. Set I<sup>2</sup>C address registers which are “I2CADDR0~I2CADDR3”.

Random read operation is one of the methods of access EEPROM. The method allows the master to access any address of EEPROM space. The following figure shows the EEPROM random read operation.

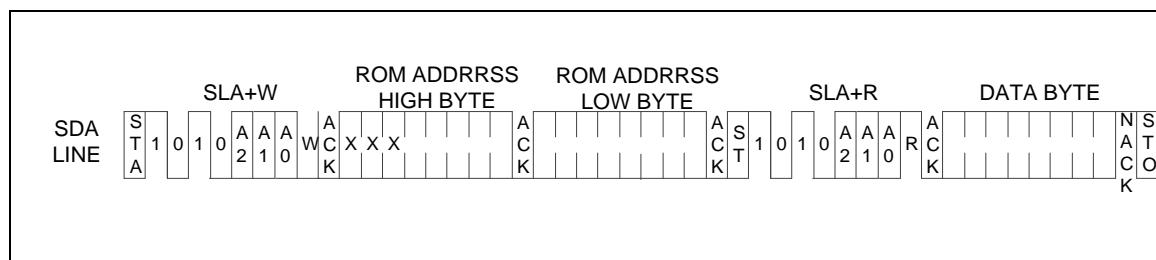


Figure 5-120 EEPROM Random Read

The following figure shows how to use I<sup>2</sup>C controller to implement the protocol of EEPROM random read.

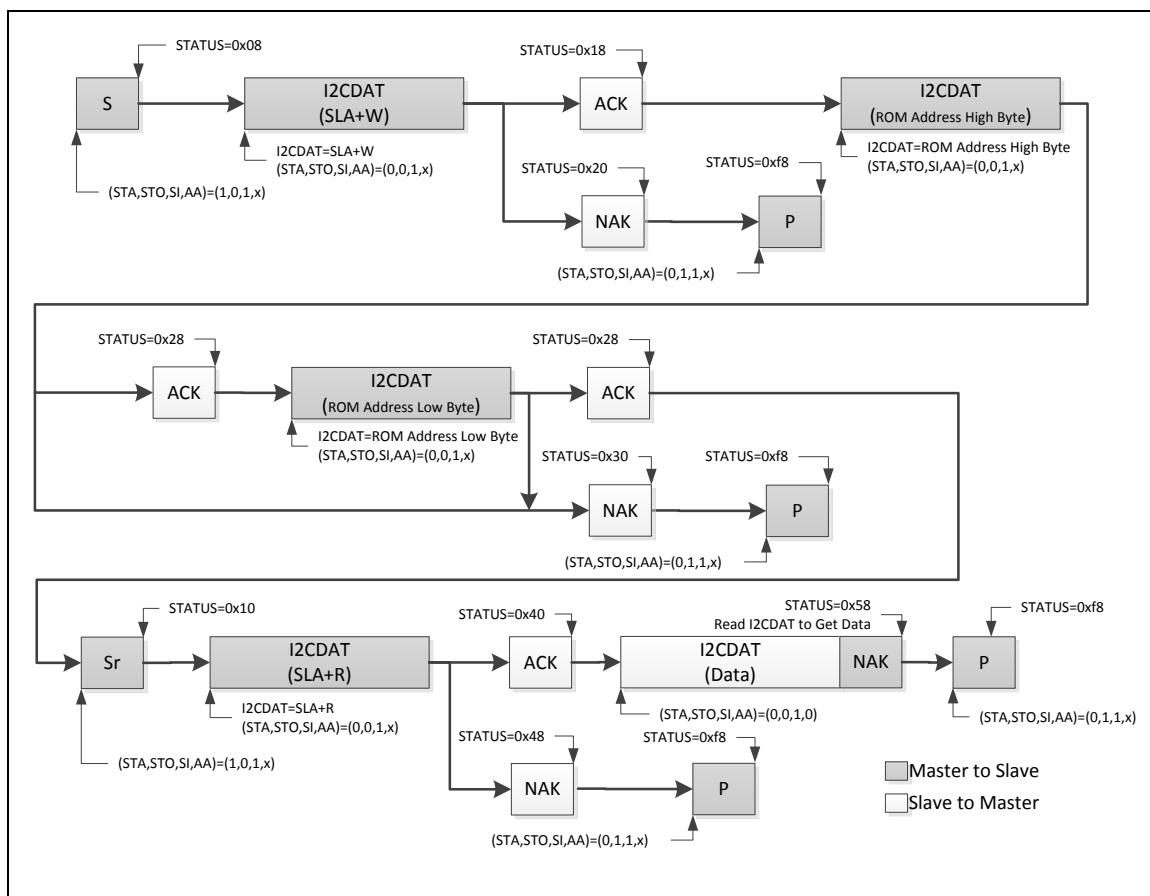


Figure 5-121 Protocol of EEPROM Random Read

The I<sup>2</sup>C controller sends START to bus to be a master. Then it sends a SLA+W (Slave address + Write bit) to EEPROM followed by two bytes data address to set the EEPROM address to read. Finally, a Repeat START followed by SLA+R is sent to read the data from EEPROM.

### 5.15.8 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>I<sup>2</sup>C Base Address:</b>				
I2C0_BA = 0x4002_0000				
I2C1_BA = 0x4012_0000				
I2CON x=0,1	I2Cx_BA+0x00	R/W	I <sup>2</sup> C Control Register	0x0000_0000
I2CADDR0 x=0,1	I2Cx_BA+0x04	R/W	I <sup>2</sup> C Slave Address Register0	0x0000_0000
I2CDAT x=0,1	I2Cx_BA+0x08	R/W	I <sup>2</sup> C Data Register	0x0000_0000
I2CSTATUS x=0,1	I2Cx_BA+0x0C	R	I <sup>2</sup> C Status Register	0x0000_00F8
I2CLK x=0,1	I2Cx_BA+0x10	R/W	I <sup>2</sup> C Clock Divided Register	0x0000_0000
I2CTOC x=0,1	I2Cx_BA+0x14	R/W	I <sup>2</sup> C Time-out Counter Register	0x0000_0000
I2CADDR1 x=0,1	I2Cx_BA+0x18	R/W	I <sup>2</sup> C Slave Address Register1	0x0000_0000
I2CADDR2 x=0,1	I2Cx_BA+0x1C	R/W	I <sup>2</sup> C Slave Address Register2	0x0000_0000
I2CADDR3 x=0,1	I2Cx_BA+0x20	R/W	I <sup>2</sup> C Slave Address Register3	0x0000_0000
I2CADM0 x=0,1	I2Cx_BA+0x24	R/W	I <sup>2</sup> C Slave Address Mask Register0	0x0000_0000
I2CADM1 x=0,1	I2Cx_BA+0x28	R/W	I <sup>2</sup> C Slave Address Mask Register1	0x0000_0000
I2CADM2 x=0,1	I2Cx_BA+0x2C	R/W	I <sup>2</sup> C Slave Address Mask Register2	0x0000_0000
I2CADM3 x=0,1	I2Cx_BA+0x30	R/W	I <sup>2</sup> C Slave Address Mask Register3	0x0000_0000
I2CWKUPCON x=0,1	I2Cx_BA+0x3C	R/W	I <sup>2</sup> C Wake-up Control Register	0x0000_0000
I2CWKUPSTS x=0,1	I2Cx_BA+0x40	R/W	I <sup>2</sup> C Wake-up Status Register	0x0000_0000

### 5.15.9 Register Description for NUC029xAN

#### I<sup>2</sup>C Control Register (I2CON)

Register	Offset	R/W	Description				Reset Value
I2CON	I2Cx_BA+0x00	R/W	I <sup>2</sup> C Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
EI	ENS1	STA	STO	SI	AA	Reserved	

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	EI	<b>I<sup>2</sup>C Interrupt Enable Control</b> 0 = I <sup>2</sup> C interrupt Disabled. 1 = I <sup>2</sup> C interrupt Enabled.
[6]	ENS1	<b>I<sup>2</sup>C Controller Enable Control</b> 0 = I <sup>2</sup> C Controller Disabled. 1 = I <sup>2</sup> C Controller Enabled. Set to enable I <sup>2</sup> C serial function controller. When ENS1=1 the I <sup>2</sup> C serial function enables. The function of multi-function pins must be set to I <sup>2</sup> C first.
[5]	STA	<b>I<sup>2</sup>C START Control</b> Setting STA to logic 1 to enter Master mode, the I <sup>2</sup> C hardware sends a START or repeat START condition to bus when the bus is free.
[4]	STO	<b>I<sup>2</sup>C STOP Control</b> In master mode, setting STO to transmit a STOP condition to bus then I <sup>2</sup> C hardware will check the bus condition if a STOP condition is detected this bit will be cleared by hardware automatically. In Slave mode, setting STO resets I <sup>2</sup> C hardware to the defined "not addressed" Slave mode. This means it is NO LONGER in the slave receiver mode to receive data from the master transmit device.
[3]	SI	<b>I<sup>2</sup>C Interrupt Flag</b> When a new I <sup>2</sup> C state is present in the I2CSTATUS register, the SI flag is set by hardware, and if bit EI (I2CON [7]) is set, the I <sup>2</sup> C interrupt is requested. SI must be cleared by software. Clear SI by writing 1 to it.
[2]	AA	<b>Assert Acknowledge Control</b> When AA=1 prior to address or data received, an acknowledged (low level to SDA) will be returned during the acknowledge clock pulse on the SCL line when 1.) A slave is acknowledging the address sent from master, 2.) The receiver devices are acknowledging the data sent by transmitter. When AA=0 prior to address or data received, a Not acknowledged (high level to SDA) will be returned during the acknowledge clock pulse on

		the SCL line.
[1:0]	<b>Reserved</b>	Reserved.

**I<sup>2</sup>C Data Register (I2CDAT)**

Register	Offset	R/W	Description				Reset Value
I2CDAT	I2Cx_BA+0x08	R/W	I <sup>2</sup> C Data Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CDAT							

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	I2CDAT	<b>I<sup>2</sup>C Data Register</b> Bit [7:0] is located with the 8-bit transferred data of I <sup>2</sup> C serial port.

**I<sup>2</sup>C Status Register (I2CSTATUS )**

Register	Offset	R/W	Description					Reset Value
I2CSTATUS	I2Cx_BA+0x0C	R	I <sup>2</sup> C Status Register					0x0000_00F8

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CSTATUS							

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	I2CSTATUS	<p><b>I<sup>2</sup>C Status</b></p> <p>The three least significant bits are always 0. The five most significant bits contain the status code. There are 26 possible status codes. When I2CSTATUS contains F8H, no serial interrupt is requested. All other I2CSTATUS values correspond to defined I<sup>2</sup>C states. When each of these states is entered, a status interrupt is requested (SI = 1). A valid status code is present in I2CSTATUS one cycle after SI is set by hardware and is still present one cycle after SI has been reset by software. In addition, states 00H stands for a Bus Error. A Bus Error occurs when a START or STOP condition is present at an incorrect position in the formation frame. A bus error may occur during the serial transfer of an address byte, a data byte or an acknowledge bit.</p>

**I<sup>2</sup>C Clock Divided Register (I2CLK)**

Register	Offset	R/W	Description				Reset Value
I2CLK	I2Cx_BA+0x10	R/W	I <sup>2</sup> C Clock Divided Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CLK							

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	I2CLK	<b>I<sup>2</sup>C Clock Divided</b> The I <sup>2</sup> C clock rate bits: Data Baud Rate of I <sup>2</sup> C = PCLK / (4x (I2CLK+1)). <b>Note:</b> The minimum value of I2CLK is 4.

**I<sup>2</sup>C Time-out Control Register (I2CTOC)**

Register	Offset	R/W	Description	Reset Value
I2CTOC	I2Cx_BA+0x14	R/W	I <sup>2</sup> C Time-out Counter Register	0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					ENTI	DIV4	TIF

Bits	Description	
[31:3]	Reserved	Reserved.
[2]	ENTI	<b>Time-out Counter Enable Control</b> 0 = Time-out counter Disabled. 1 = Time-out counter Enabled. <b>Note:</b> When the 14 bit Time-out counter is enabled, it will start counting when SI is cleared. Writing 1 to the Si flag will reset the counter and re-start up counting after SI is cleared.
[1]	DIV4	<b>Time-out Counter Input Clock Divided By 4</b> 0 = Time-out counter input clock divided by 4 Disabled. 1 = Time-out counter input clock divided by 4 Enabled. <b>Note:</b> When Enabled, the time-out period is extended 4 times.
[0]	TIF	<b>Time-out Flag</b> This bit is set by hardware when I <sup>2</sup> C time-out happened and it can interrupt CPU if I <sup>2</sup> C interrupt enable bit (EI) is set to 1. <b>Note:</b> Software can write 1 to clear this bit.

**I<sup>2</sup>C Slave Address Register (I2CADDRx)**

Register	Offset	R/W	Description				Reset Value
I2CADDR0	I2Cx_BA+0x04	R/W	I <sup>2</sup> C Slave Address Register0				0x0000_0000
I2CADDR1	I2Cx_BA+0x18	R/W	I <sup>2</sup> C Slave Address Register1				0x0000_0000
I2CADDR2	I2Cx_BA+0x1C	R/W	I <sup>2</sup> C Slave Address Register2				0x0000_0000
I2CADDR3	I2Cx_BA+0x20	R/W	I <sup>2</sup> C Slave Address Register3				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CADDR							GC

Bits	Description	
[31:8]	Reserved	Reserved.
[7:1]	I2CADDR	<b>I<sup>2</sup>C Address Register</b> The content of this register is irrelevant when I <sup>2</sup> C is in Master mode. In Slave mode, the seven most significant bits must be loaded with the chip's own address. The I <sup>2</sup> C hardware will react if one of the addresses is matched.
[0]	GC	<b>General Call Function Enable Control</b> 0 = General Call function Disabled. 1 = General Call Function Enabled.

**I<sup>2</sup>C Slave Address Mask Register (I2CADMx)**

Register	Offset	R/W	Description				Reset Value
I2CADM0	I2Cx_BA+0x24	R/W	I <sup>2</sup> C Slave Address Mask Register0				0x0000_0000
I2CADM1	I2Cx_BA+0x28	R/W	I <sup>2</sup> C Slave Address Mask Register1				0x0000_0000
I2CADM2	I2Cx_BA+0x2C	R/W	I <sup>2</sup> C Slave Address Mask Register2				0x0000_0000
I2CADM3	I2Cx_BA+0x30	R/W	I <sup>2</sup> C Slave Address Mask Register3				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CADM							Reserved

Bits	Description	
[31:8]	Reserved	Reserved.
[7:1]	I2CADM	<b>I<sup>2</sup>C Address Mask</b> 0 = I <sup>2</sup> C address mask Disabled (the received corresponding register bit should be exactly the same as address register). 1 = I <sup>2</sup> C address mask Enabled (the received corresponding address bit is “Don’t care”).
[0]	Reserved	Reserved.

**I<sup>2</sup>C Wake-up Control Register (I2CWKUPCON)**

Register	Offset	R/W	Description					Reset Value
I2CWKUPCON	I2Cx_BA+0x3C	R/W	I <sup>2</sup> C Wake-up Control Register					0x0000_0000

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

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	WKUPEN	<b>I<sup>2</sup>C Wakeup Function Enable Control</b> 1 = I <sup>2</sup> C wake-up function Enabled. 0 = I <sup>2</sup> C wake-up function Disabled.

**I<sup>2</sup>C Wake-up Status Register (I2CWKUPSTS)**

Register	Offset	R/W	Description					Reset Value
I2CWKUPSTS	I2Cx_BA+0x40	R/W	I <sup>2</sup> C Wake-up Status Register					0x0000_0000

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

Bits	Description	
[31:1]	Reserved	Reserved.
[0]	WKUPIF	<b>I<sup>2</sup>C Wake-up Interrupt Flag</b> When chip is woken up from Power-Down mode by I <sup>2</sup> C, this bit is set to 1. Software can write 1 to clear this bit.

### 5.15.10 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>I<sup>2</sup>C Base Address:</b>				
<b>I2C_BA = 0x4002_0000</b>				
I2CON	I2C_BA+0x00	R/W	I <sup>2</sup> C Control Register	0x0000_0000
I2CADRR0	I2C_BA+0x04	R/W	I <sup>2</sup> C Slave Address Register 0	0x0000_0000
I2CDAT	I2C_BA+0x08	R/W	I <sup>2</sup> C DATA Register	0x0000_0000
I2CSTATUS	I2C_BA+0x0C	R	I <sup>2</sup> C Status Register	0x0000_00F8
I2CLK	I2C_BA+0x10	R/W	I <sup>2</sup> C Clock Divided Register	0x0000_0000
I2CTOC	I2C_BA+0x14	R/W	I <sup>2</sup> C Time-Out Counter Register	0x0000_0000
I2CADDR0	I2C_BA+0x04	R/W	I <sup>2</sup> C Slave Address Register 0	0x0000_0000
I2CADDR1	I2C_BA+0x18	R/W	I <sup>2</sup> C Slave Address Register 1	0x0000_0000
I2CADDR2	I2C_BA+0x1C	R/W	I <sup>2</sup> C Slave Address Register 2	0x0000_0000
I2CADDR3	I2C_BA+0x20	R/W	I <sup>2</sup> C Slave Address Register 3	0x0000_0000
I2CADM0	I2C_BA+0x24	R/W	I <sup>2</sup> C Slave Address Mask Register 0	0x0000_0000
I2CADM1	I2C_BA+0x28	R/W	I <sup>2</sup> C Slave Address Mask Register 1	0x0000_0000
I2CADM2	I2C_BA+0x2C	R/W	I <sup>2</sup> C Slave Address Mask Register 2	0x0000_0000
I2CADM3	I2C_BA+0x30	R/W	I <sup>2</sup> C Slave Address Mask Register 3	0x0000_0000
I2CCON2	I2C_BA+0x3C	R/W	I <sup>2</sup> C Control Register 2	0x0000_0000
I2CSTATUS2	I2C_BA+0x40	R/W	I <sup>2</sup> C Status Register 2	0x0000_0000

### 5.15.11 Register Description for NUC029FAE

#### I<sup>2</sup>C Control Register (I2CON)

Register	Offset	R/W	Description				Reset Value
I2CON	I2C_BA+0x00	R/W	I <sup>2</sup> C Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
EI	ENS1	STA	STO	SI	AA	Reserved	

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	EI	<b>Interrupt Enable Control</b> 0 = I <sup>2</sup> C interrupt Disabled. 1 = I <sup>2</sup> C interrupt Enabled.
[6]	ENS1	<b>I<sup>2</sup>C Controller Enable Control</b> 0 = I <sup>2</sup> C Controller Disabled. 1 = I <sup>2</sup> C Controller Enabled. Set to enable I <sup>2</sup> C serial function controller. When ENS1=1 the I <sup>2</sup> C serial function enables. The function of multi-function pin must be set to I <sup>2</sup> C first.
[5]	STA	<b>I<sup>2</sup>C START Control Bit</b> Setting STA to logic 1 to enter Master mode. I <sup>2</sup> C hardware sends a START or repeats the START condition to bus when the bus is free.
[4]	STO	<b>I<sup>2</sup>C STOP Control Bit</b> In Master mode, setting STO to transmit a STOP condition to bus then I <sup>2</sup> C hardware will check the bus condition if a STOP condition is detected this bit will be cleared by hardware automatically. In Slave mode, setting STO resets I <sup>2</sup> C hardware to the defined "not addressed" Slave mode. This means it is NO LONGER in the Slave receiver mode to receive data from the master transmit device.
[3]	SI	<b>I<sup>2</sup>C Interrupt Flag</b> When a new I <sup>2</sup> C state is present in the I2CSTATUS register, the SI flag is set by hardware, and if bit EI (I2CON[7]) is set, the I <sup>2</sup> C interrupt is requested. SI must be cleared by software. Software can write 1 to clear this bit.
[2]	AA	<b>Assert Acknowledge Control Bit</b> When AA=1 is prior to address or data received, an acknowledged (low level to SDA) will be returned during the acknowledge clock pulse on the SCL line when 1.) A slave is acknowledging the address sent from master, 2.) The receiver devices are acknowledging the data sent by transmitter. When AA=0 prior to address or data received, a Not acknowledged (high level to SDA) will be returned during the acknowledge clock pulse on the SCL line.

Bits	Description	
[1:0]	<b>Reserved</b>	Reserved.

**I<sup>2</sup>C DATA REGISTER (I2CDAT)**

Register	Offset	R/W	Description				Reset Value
I2CDAT	I2C_BA+0x08	R/W	I <sup>2</sup> C DATA Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CDAT							

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	I2CDAT[7:0]	<b>I<sup>2</sup>C Data Bits</b> Bit [7:0] is located with the 8-bit transferred data of the I <sup>2</sup> C serial port.

**I<sup>2</sup>C STATUS REGISTER ( I2CSTATUS )**

Register	Offset	R/W	Description				Reset Value
I2CSTATUS	I2C_BA+0x0C	R	I <sup>2</sup> C Status Register				0x0000_00F8

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CSTATUS							

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	I2CSTATUS[7:0]	<p><b>I<sup>2</sup>C Status Bits</b></p> <p>The three least significant bits are always 0. The five most significant bits contain the status code. There are 26 possible status codes. When I2CSTATUS contains F8H, no serial interrupt is requested. All the other I2CSTATUS values correspond to defined I<sup>2</sup>C states. When each of these states is entered, a status interrupt is requested (SI = 1). A valid status code is present in I2CSTATUS one cycle after SI is set by hardware and is still present one cycle after SI has been reset by software. In addition, the states 00H stands for a Bus Error. A Bus Error occurs when a START or STOP condition is present at an illegal position in the formation frame. Examples of illegal position are during the serial transfer of an address byte, a data byte or an acknowledge bit.</p>

**I<sup>2</sup>C BAUD RATE CONTROL REGISTER (I2CLK)**

Register	Offset	R/W	Description	Reset Value
I2CLK	I2C_BA+0x10	R/W	I <sup>2</sup> C Clock Divided Register	0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CLK							

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	I2CLK[7:0]	<b>I<sup>2</sup>C Clock Divided Bits</b> The I <sup>2</sup> C clock rate bits: Data Baud Rate of I <sup>2</sup> C = (system clock) / (4x (I2CLK+1)). <b>Note:</b> The minimum value of I2CLK is 4.

**I<sup>2</sup>C TIME-OUT COUNTER REGISTER (I2CTOC)**

Register	Offset	R/W	Description				Reset Value
I2CTOC	I2C_BA+0x14	R/W	I <sup>2</sup> C Time-Out Counter Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved					ENTI	DIV4	TIF

Bits	Description	
[31:3]	Reserved	Reserved.
[2]	ENTI	<b>Time-out Counter Enable Control</b> 0 = Time-out counter Disabled. 1 = Time-out counter Enabled. <b>Note:</b> When the 14-bit time-out counter is enabled, it will start counting when SI is clear. Setting 1to the SI flag will reset counter and re-start up counting after SI is cleared.
[1]	DIV4	<b>Time-out Counter Input Clock Divided By 4</b> 0 = Time-out counter input clock divided by 4 Disabled. 1 = Time-out counter input clock divided by 4 Enabled. <b>Note:</b> When enabled, the time-out period is extended 4 times.
[0]	TIF	<b>Time-out Flag</b> This bit is set by hardware when I <sup>2</sup> C time-out happened and it can interrupt CPU if I <sup>2</sup> C interrupt enable bit (EI) is set to 1. <b>Note:</b> Software can write 1 to clear this bit.

**I<sup>2</sup>C SLAVE ADDRESS REGISTER (I2CADDRx)**

Register	Offset	R/W	Description	Reset Value
I2CADDR0	I2C_BA+0x04	R/W	I <sup>2</sup> C Slave Address Register 0	0x0000_0000
I2CADDR1	I2C_BA+0x18	R/W	I <sup>2</sup> C Slave Address Register 1	0x0000_0000
I2CADDR2	I2C_BA+0x1C	R/W	I <sup>2</sup> C Slave Address Register 2	0x0000_0000
I2CADDR3	I2C_BA+0x20	R/W	I <sup>2</sup> C Slave Address Register 3	0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CADDR							GC

Bits	Description	
[31:8]	Reserved	Reserved.
[7:1]	I2CADDR	<b>I<sup>2</sup>C Address Bits</b> The content of this register is irrelevant when I <sup>2</sup> C is in Master mode. In Slave mode, the seven most significant bits must be loaded with the MCU's own address. The I <sup>2</sup> C hardware will react if either of the address is matched.
[0]	GC	<b>General Call Function</b> 0 = General Call Function Disabled. 1 = General Call Function Enabled.

**I<sup>2</sup>C SLAVE ADDRESS MASK REGISTER (I2CADMx)**

Register	Offset	R/W	Description				Reset Value
I2CADM0	I2C_BA+0x24	R/W	I <sup>2</sup> C Slave Address Mask Register 0				0x0000_0000
I2CADM1	I2C_BA+0x28	R/W	I <sup>2</sup> C Slave Address Mask Register 1				0x0000_0000
I2CADM2	I2C_BA+0x2C	R/W	I <sup>2</sup> C Slave Address Mask Register 2				0x0000_0000
I2CADM3	I2C_BA+0x30	R/W	I <sup>2</sup> C Slave Address Mask Register 3				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
I2CADM							Reserved

Bits	Description	
[31:8]	Reserved	Reserved.
[7:1]	I2CADM	<b>I<sup>2</sup>C Address Mask Bits</b> 0 = I <sup>2</sup> C address mask Disabled (the received corresponding register bit should be exactly the same as address register). 1 = I <sup>2</sup> C address mask Enabled (the received corresponding address bit is “Don’t care”).
[0]	Reserved	Reserved.

**I<sup>2</sup>C CONTROL REGISTER 2 (I2CCON2)**

Register	Offset	R/W	Description				Reset Value
I2CCON2	I2C_BA+0x3C	R/W	I <sup>2</sup> C Control Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			UNDER_INTE N	OVER_INTEN	NOSTRETCH	TWOFF_EN	WAKEUPEN

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	UNDER_INTEN	<p><b>I<sup>2</sup>C UNDER RUN Interrupt Control Bit</b></p> <p>Setting UNDER_INTEN to enable will send a interrupt to system when the TWOFF bit is enabled and there is under run event happened in transmitted FIFO.</p> <p>0 = Disabled. 1 = Enabled.</p>
[3]	OVER_INTEN	<p><b>I<sup>2</sup>C OVER RUN Interrupt Control Bit</b></p> <p>Setting OVER_INTEN to enable will send a interrupt to system when the TWOFF bit is enabled and there is over run event in received FIFO.</p> <p>0 = Disabled. 1 = Enabled.</p>
[2]	NOSTRETCH	<p><b>NO STRETCH The I<sup>2</sup>C BUS</b></p> <p>0 = The I<sup>2</sup>C SCL bus is stretched by hardware if the SI is not cleared in master mode. 1 = The I<sup>2</sup>C SCL bus is not stretched by hardware if the SI is not cleared in master mode.</p>
[1]	TWOFF_EN	<p><b>TWO LEVEL FIFO Enable Control</b></p> <p>0 = Disabled. 1 = Enabled.</p> <p>Set to enable the two-level FIFO for I<sup>2</sup>C transmitted or received buffer. It is used to improve the performance of the I<sup>2</sup>C bus. If this bit is set = 1, the control bit of STA for repeat start or STO bit should be set after the current SI is clear. For example: if there are 4 data shall be transmitted and then stop it. The STO bit shall be set after the 3<sup>rd</sup> data's SI event being clear. In this time, the 4<sup>th</sup> data can be transmitted and the I<sup>2</sup>C stop after the 4<sup>th</sup> data transmission done.</p>
[0]	WAKEUPEN	<p><b>Wake-up Enable Control</b></p> <p>0 = I<sup>2</sup>C wake-up function Disabled. 1 = I<sup>2</sup>C wake-up function Enabled.</p> <p>The system can be wake-up by I<sup>2</sup>C bus when the system is set into power mode and the received data matched one of the addresses in Address Register.</p>

**I<sup>2</sup>C STATUS REGISTER 2 (I2CSTATUS 2)**

Register	Offset	R/W	Description				Reset Value
I2CSTATUS2	I2C_BA+0x40	R/W	I <sup>2</sup> C Status Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			UNDERUN	OVERUN	EMPTY	FULL	WAKEUPIF

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	UNDERUN	<b>I<sup>2</sup>C UNDER RUN Status Bit</b> This bit indicates the transmitted FIFO is under run when the TWOFF_EN = 1.
[3]	OVERUN	<b>I<sup>2</sup>C OVER RUN Status Bit</b> This bit indicates the received FIFO is over run when the TWOFF_EN = 1.
[2]	EMPTY	<b>I<sup>2</sup>C TWO LEVEL FIFO EMPTY</b> This bit indicates RX FIFO empty or not when the TWOFF_EN = 1.
[1]	FULL	<b>I<sup>2</sup>C TWO LEVEL FIFO FULL</b> This bit indicates TX FIFO full or not when the TWOFF_EN = 1.
[0]	WAKEUPIF	<b>I<sup>2</sup>C Wake-up Interrupt Flag</b> When chip is woken up from Power-Down mode by I <sup>2</sup> C, this bit is set to 1. Software can write 1 to clear this bit.

## 5.16 Serial Peripheral Interface (SPI)

### 5.16.1 Overview

The Serial Peripheral Interface (SPI) is a synchronous serial data communication protocol that operates in full duplex mode. Devices communicate in Master/Slave mode with the 4-wire bi-direction interface. The NuMicro® NUC029 series contains up to 2 sets of SPI controllers performing a serial-to-parallel conversion on data received from a peripheral device, and a parallel-to-serial conversion on data transmitted to a peripheral device. Each set of SPI controller can be configured as a master or a slave device.

### 5.16.2 Features

- Up to 2 sets of SPI controllers
- Supports Master or Slave mode operation
- Configurable bit length of a transaction word from 8 to 32 bits
- Provides separate 4-layer depth transmit and receive FIFO buffers
- Supports MSB first or LSB first transfer sequence
- Supports the Byte Reorder function
- Supports Byte or Word Suspend mode
- Supports Slave 3-wire mode
- Supports PLL clock source (NUC029xAN only)

### 5.16.3 Block Diagram

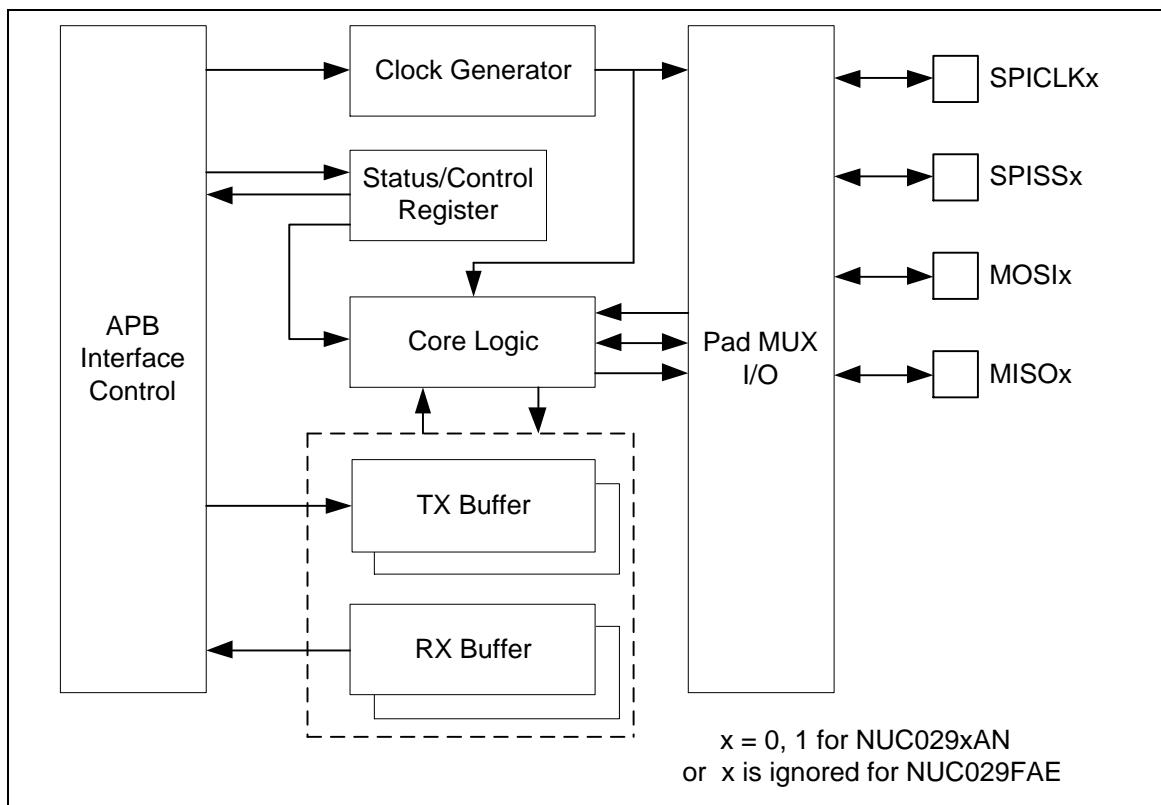


Figure 5-122 SPI Block Diagram

### 5.16.4 Basic Configuration

#### NUC029xAN:

The SPI pin functions are configured in P0\_MFP and P1\_MFP registers. The SPI0 and SPI1 peripheral clock can be enabled in APBCLK[12] and APBCLK[13]. The SPI peripheral clock source is selected in CLKSEL1[4] and CLKSEL1[5].

#### NUC029FAE:

The SPI pin functions are configured in P0\_MFP register. The SPI peripheral clock can be enabled in SPI\_EN(APBCLK[12]) bit and its source can be selected in SPI\_S(CLKSEL1[4]) bit.

### 5.16.5 Functional Description

#### 5.16.5.1 Terminology

##### SPI Peripheral Clock and SPI Bus Clock

The SPI controller needs the SPI peripheral clock to drive the SPI logic unit to perform the data transfer. The SPI bus clock is the clock presented on SPICLKx pin. The SPI peripheral clock frequency is determined by the settings of clock source, BCn(SPI\_CNTRL2[31]) option and clock divisor (DIVIDER(SPI\_DIVIDER[7:0])). The SPIx\_S bit of CLKSEL1 register determines the clock

source of the SPI peripheral clock. Set the BCn bit to 0 for the compatible SPI clock frequency calculation of previous products. The DIVIDER setting of SPI\_DIVIDER register determines the divisor of the clock frequency calculation.

In SPI Master mode, the SPI peripheral clock is equal to the SPI bus clock.

In SPI Slave mode, the SPI bus clock is provided by an off-chip master device. The SPI peripheral clock frequency of slave device must be faster than the bus clock frequency of the master device connected together. The frequency of SPI peripheral clock cannot be faster than the APB clock frequency regardless of Master mode or Slave mode.

### Master/Slave Mode

This SPI controller can be set as Master or Slave mode by setting the SLAVE bit (SPI\_CNTRL[18]) to communicate with the off-chip SPI slave or master device. The application block diagrams in Master or Slave mode are shown below.

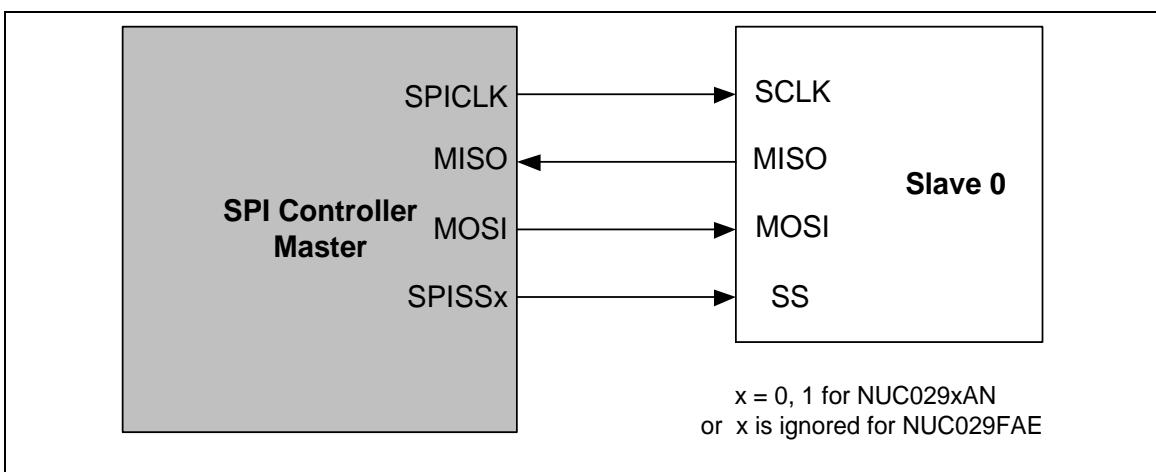


Figure 5-123 SPI Master Mode Application Block Diagram

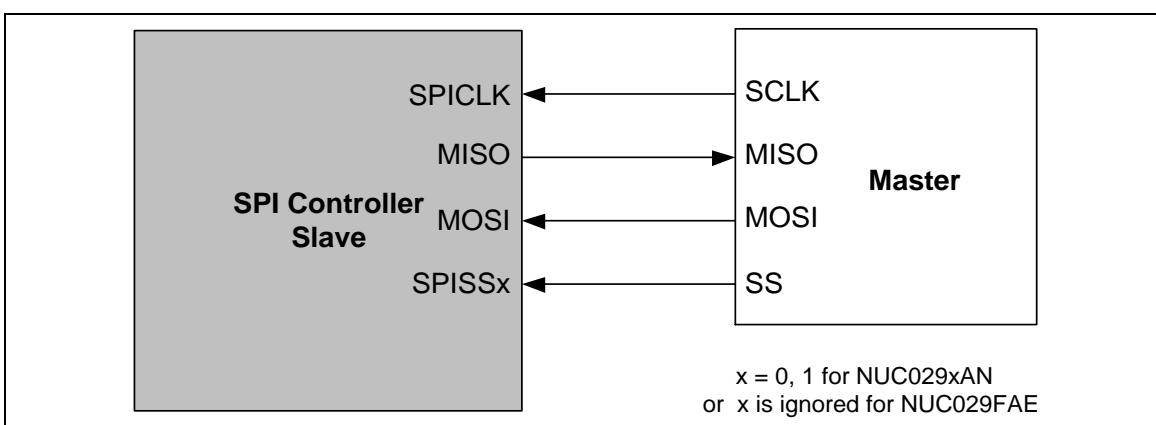


Figure 5-124 SPI Slave Mode Application Block Diagram

### Clock Polarity

The CLKP(SPI\_CNTRL[11]) bit defines the bus clock idle state. If CLKP = 1, the output SPICLK is idle at high state, otherwise it is at low state if CLKP = 0.

### Transmit/Receive Bit Length

The bit length of a transaction word is defined in TX\_BIT\_LEN(SPI\_CNTRL[7:3]) bit. It can be configured up to 32-bit length in a transaction word for transmitting and receiving.

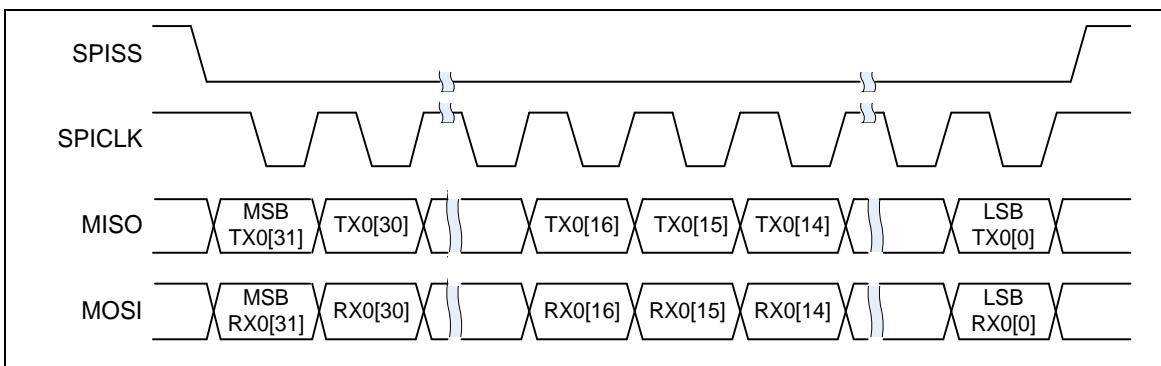


Figure 5-125 32-bit in One Transaction

### LSB First

The LSB bit (SPI\_CNTRL[10]) defines the data transmission either from LSB or MSB firstly to start to transmit/receive data.

### Transmit Edge

The TX\_NEG(SPI\_CNTRL[2]) bit defines the data transmitted out either on negative edge or on positive edge of bus clock SPICLK.

### Receive Edge

The RX\_NEG(SPI\_CNTRL[1]) bit defines the data received in either on negative edge or on positive edge of bus clock SPICLK.

**Note:** The settings of TX\_NEG and RX\_NEG are mutual exclusive. In other words, don't transmit and receive data at the same clock edge.

### Word Suspend

The four bits field of SP\_CYCLE(SPI\_CNTRL[15:12]) provide a configurable suspend interval between two successive transaction words in Master mode. The definition of the suspend interval is the interval between the last clock edge of the preceding transaction word and the first clock edge of the following transaction word. The default value of SP\_CYCLE is 0x3 (3.5 bus clock cycles), and the SP\_CYCLE(SPI\_CNTRL[15:12]) setting will not take effect to the word suspend interval if software disables the FIFO mode.

### Slave Selection

In Master mode, each SPI controller can drive one off-chip slave device through the slave select output pin, SPISSx. In Slave mode, the off-chip master device drives the slave select signal from the SPISSx input pin to this SPI controller. In Master/Slave mode, the active state of slave select signal can be programmed to low active or high active in SS\_LVL(SPI\_SSR[2]) bit, and the SS\_LTRIG(SPI\_SSR[4]) bit defines the slave select signal SPISSx is level trigger or edge trigger.

The selection of trigger condition depends on what type of peripheral slave/master device is connected.

In Slave mode, if the SS\_LTRIG(SPI\_SSR[4]) bit is configured as level trigger, the LTRIG\_FLAG(SPI\_SSR[5]) bit is used to indicate if both the number of received data and the number of received bits meet the requirement which defined in TX\_BIT\_LEN(SPI\_CNTRL[7:3]) among one transaction done (the transaction done means the unit transfer interrupt flag is set to 1 when the slave select signal is inactivated or the SPI controller finishes one data transfer.)

#### **Level-trigger / Edge-trigger**

In Slave mode, the slave select signal can be configured as level-trigger or edge-trigger. In edge-trigger, the data transfer starts from an active edge of the slave select signal and ends on an inactive edge of the slave select signal. The unit-transfer interrupt flag(SPI\_CNTRL[16]) will be set to 1 as an inactive edge is detected. If master does not send an inactive edge to slave, the transfer procedure will not be completed and the unit-transfer interrupt flag of slave will not be set. In level-trigger, the unit-transfer interrupt flag of slave will be set when one of the following two conditions occurs. The first condition is that if the number of transferred bits matches the settings of TX\_BIT\_LEN(SPI\_CNTRL[7:3]), the unit-transfer interrupt flag of slave will be set. The second condition, if master set the slave select pin to inactive level during the transfer in progress, it will force slave device to terminate the current transfer no matter how many bits have been transferred and the unit-transfer interrupt flag will be set. User can read the status of LTRIG\_FLAG(SPI\_SSR[5]) bit to check if the data has been completely transferred.

##### *5.16.5.2 Automatic Slave Selection*

In Master mode, if the AUTOSS(SPI\_SSR[3]) bit is set, the slave select signal will be generated automatically and output to SPISSx pin according to SSR(SPI\_SSR[0]) bit whether be enabled or not. This means that the slave select signal will be asserted by the SPI controller when data transfer is started by setting the GO\_BUSY(SPI\_CNTRL[0]) bit and will be de-asserted after the data transfer is finished. If the AUTOSS(SPI\_SSR[3]) bit is cleared, the slave select output signal will be asserted/de-asserted by setting/clearing the SSR(SPI\_SSR[0]) bit. The active state of the slave select output signal is specified in SS\_LVL(SPI\_SSR[2]) bit.

##### *5.16.5.3 Byte Reorder Function*

When the transfer is set as MSB first (LSB = 0) and the byte reorder function is enabled, the data stored in the TX buffer and RX buffer will be rearranged in the order as [Byte0, Byte1, Byte2, Byte3] when the bit length is configured as 32-bit (TX\_BIT\_LEN(SPI\_CNTRL[7:3]) = 0). The sequence of transmitted/received data will be Byte0, Byte1, Byte2, and then Byte3. If the TX\_BIT\_LEN(SPI\_CNTRL[7:3]) bit field is set to 24, the data in TX buffer and RX buffer will be rearranged as [unknown byte, Byte0, Byte1, Byte2]. The SPI controller will transmit/receive data with the sequence of Byte0, Byte1 and then Byte2. Each byte will be transmitted/received with MSB first. The rule of 16-bit mode is the same as above. Byte reorder function is only available when TX\_BIT\_LEN(SPI\_CNTRL[7:3]) is configured as 16, 24, or 32 bits.

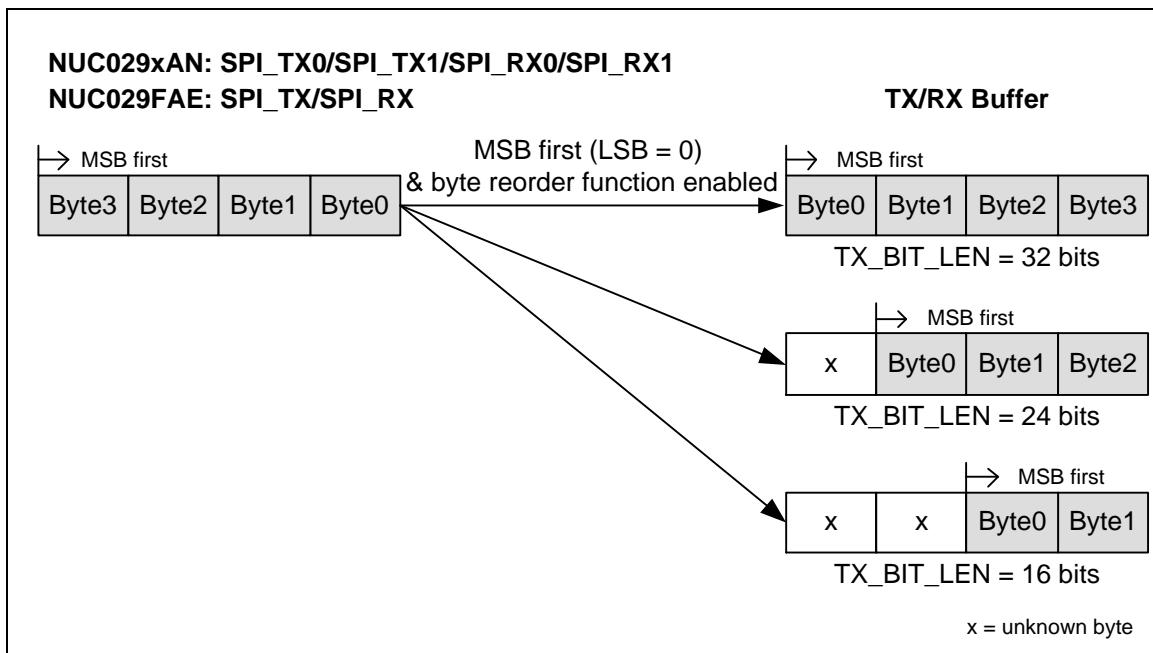


Figure 5-126 Byte Reorder

#### 5.16.5.4 Byte Suspend Function

Both settings of byte suspend interval and word suspend interval are configured in SP\_CYCLE. In Master mode, if the byte reorder function is enabled by setting SPI\_CNTRL[19] to 1, the hardware will insert a suspend interval of 0.5 ~ 15.5 bus clock periods between two successive bytes in a transaction word. The setting of TX\_BIT\_LEN(SPI\_CNTRL[7:3]) can be configured as 16, 24 or 32 bits.

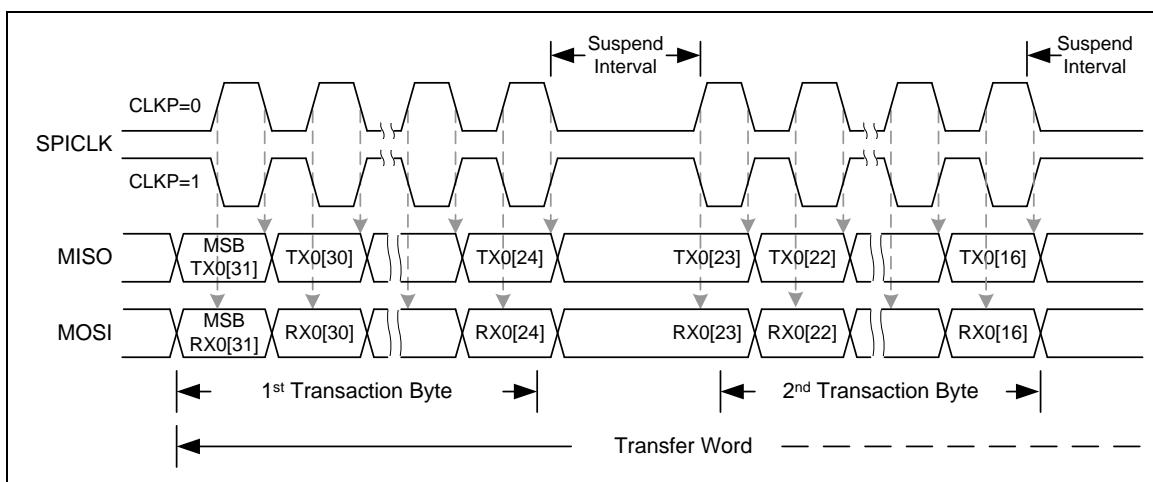


Figure 5-127 Timing Waveform for Byte Suspend

#### 5.16.5.5 Slave 3-wire Mode

When the NOSLVSEL(SPI\_CNTRL2[8]) bit is set by software to enable the Slave 3-wire mode, the SPI controller can work with no slave select signal in Slave mode. The NOSLVSEL(SPI\_CNTRL2[8]) bit only takes effect in Slave mode. Only three pins, SPICLK, MISO, and MOSI, are required to communicate with a SPI master. The SPISS pin can be

configured as a GPIO. When the NOSLVSEL(SPI\_CNTRL2[8]) bit is set to 1, the SPI slave will be ready to transmit/receive data after the GO\_BUSY(SPI\_CNTRL[0]) bit is set to 1. As the number of received bits meets the requirement which defined in TX\_BIT\_LEN(SPI\_CNTRL[7:3]), the unit-transfer interrupt flag, IF(SPI\_CNTRL[16]), will be set to 1.

**Note:** In Slave 3-wire mode, the SS\_LTRIG(SPI\_SSR[4]) bit should be set as 1.

#### 5.16.5.6 FIFO Mode

The SPI controllers support FIFO mode when the FIFO(SPI\_CNTRL[21]) bit is set as 1. The SPI controllers equip with four 32-bit wide transmit and receive FIFO buffers.

The transmit FIFO buffer is a 4-layer depth, 32-bit wide, first-in, first-out register buffer. The software can write data to the transmit FIFO buffer by writing the SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register. The data stored in the transmit FIFO buffer will be read and sent out by the transmission control logic. If the 4-layer transmit FIFO buffer is full, the TX\_FULL(SPI\_STATUS[27]) bit will be set to 1. When the SPI transmission logic unit draws out the last datum of the transmit FIFO buffer, so that the 4-layer transmit FIFO buffer is empty, the TX\_EMPTY(SPI\_STATUS[26]) bit will be set to 1. Note that the TX\_EMPTY(SPI\_STATUS[26]) flag is set to 1 while the last transaction is still in progress.

The received FIFO buffer is also a 4-layer depth, 32-bit wide, first-in, first-out register buffer. The receive control logic will store the received data to this buffer. The software can read the FIFO buffer data from SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register. There are FIFO related status bits, like RX\_EMPTY(SPI\_STATUS[24]) and RX\_FULL(SPI\_STATUS[25]), to indicate the current status of FIFO buffer.

In FIFO mode, the software can set the transmitting and receiving threshold by setting the TX\_THRESHOLD(SPI\_FIFO\_CTL[29:28]) and RX\_THRESHOLD(SPI\_FIFO\_CTL[25:24]) settings. When the count of valid data stored in transmit FIFO buffer is less than or equal to TX\_THRESHOLD(SPI\_FIFO\_CTL[29:28]) setting, the TX\_INTSTS(SPI\_STATUS[4]) bit will be set to 1. When the count of valid data stored in receive FIFO buffer is larger than RX\_THRESHOLD(SPI\_FIFO\_CTL[25:24]) setting, the RX\_INTSTS(SPI\_STATUS[0]) bit will be set to 1.

In FIFO mode, the software can write 4 data to the SPI transmit FIFO buffer in advance. When the SPI controller operates with FIFO mode, the GO\_BUSY(SPI\_CNTRL[0]) bit will be controlled by hardware, software should not modify the content of SPI\_CNTRL register unless clearing the FIFO bit to disable the FIFO mode.

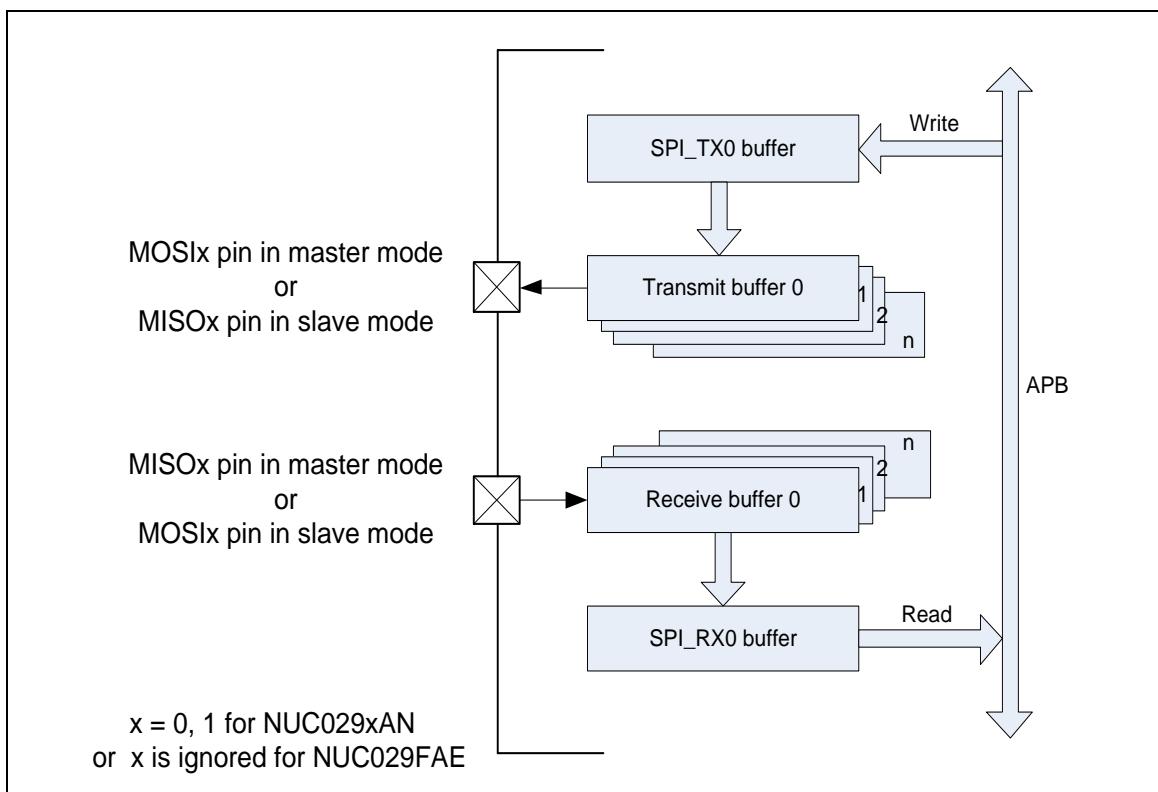


Figure 5-128 FIFO Mode Block Diagram

### SPI Master mode and FIFO mode Enabled

In Master mode transmission operation, the TX\_EMPTY(SPI\_CNTRL[26]) flag will be cleared to 0 when the FIFO bit is set to 1 and the software write the first datum to the SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register. The transmission starts immediately as long as the transmit FIFO buffer is not empty. User can write the next data into SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register immediately. The SPI controller will insert a suspend interval between two successive transactions in FIFO mode and the period of suspend interval is decided by the setting of SP\_CYCLE (SPI\_CNTRL [15:12]). User can write data into SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register as long as the TX\_FULL(SPI\_CNTRL[27]) flag is 0.

The subsequent transactions will be triggered automatically if the transmitted data are updated in time. If the SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register is not updated after all data transfer are done, the transfer will stop.

In Master mode reception operation, the serial data are received from MISOx pin and stored to receive FIFO buffer. The RX\_EMPTY(SPI\_CNTRL[24]) flag will be cleared to 0 while the receive FIFO buffer contain unread data. The software can read the received data from SPI\_RX0(NUC029xAN) or SPI\_RX(NUC029FAE) register as long as the RX\_EMPTY(SPI\_CNTRL[26]) flag is 0. If the receive FIFO buffer contain 4 unread data, the RX\_FULL(SPI\_CNTRL[25]) flag will be set to 1. The SPI controller will stop receiving data until the software read the SPI\_RX0(NUC029xAN) or SPI\_RX(NUC029FAE) register.

### SPI Slave mode and FIFO mode Enabled

In Slave mode, when the FIFO bit is set as 1, the GO\_BUSY(SPI\_CNTRL[0]) bit will be set as 1 by hardware automatically. If user wants to stop the Slave mode SPI data transfer, both the FIFO bit and GO\_BUSY(SPI\_CNTRL[0]) bit must be cleared to 0 by software.

In Slave mode transmission operation, when the software writes data to SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register, the data will be loaded into transmit FIFO buffer and the TX\_EMPTY(SPI\_CNTRL[26]) flag will be set to 0. The transmission will start when the slave device receives clock signal from master. The software can write data to SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register as long as TX\_FULL(SPI\_CNTRL[27]) flag is 0. After all data have been drawn out by the SPI transmission logic unit and the software does not update the SPI\_TX0(NUC029xAN) or SPI\_TX(NUC029FAE) register, the TX\_EMPTY(SPI\_CNTRL[26]) flag will be set to 1.

In Slave mode reception operation, the serial data is received from MOSIx pin and stored to SPI\_RX0(NUC029xAN) or SPI\_RX(NUC029FAE) register. The reception mechanism is similar to Master mode reception operation.

#### 5.16.5.7 Interrupt

##### SPI unit-transfer interrupt

As the SPI controller finishes a unit transfer, the unit-transfer interrupt flag IF(SPI\_CNTRL[16]) will be set to 1. The unit-transfer interrupt event will generate an interrupt to CPU if the unit-transfer interrupt enable bit IE(SPI\_CNTRL[17]) is set. The unit-transfer interrupt flag can be cleared only by writing 1 to it.

##### SPI Slave 3-wire mode start interrupt

In Slave 3-wire mode, the Slave 3-wire mode start interrupt flag, SLV\_START\_INTSTS(SPI\_CNTRL2[11]), will be set to 1 when the slave senses the SPI bus clock signal. The SPI controller will issue an interrupt if the SSTA\_INTEN(SPI\_CNTRL2[10]) bit is set to 1. If the count of the received bits is less than the bit length setting of TX\_BIT\_LEN(SPI\_CNTRL[7:3]) and there is no more SPI bus clock input over the expected time period which is defined by user, user can set the SLV\_ABORT(SPI\_CNTRL2[9]) bit to abort the current transfer. The unit-transfer interrupt flag, IF, will be set to 1 if the SLV\_ABORT(SPI\_CNTRL2[9]) bit is set to 1 by software.

##### Receive FIFO time-out interrupt

In FIFO mode, there is time-out function to inform user. If there is a received data in the FIFO and it does not get read by software over 64 SPI peripheral clock periods in Master mode or over 576 SPI peripheral clock periods in Slave mode, it will send a time-out interrupt to the system if the time-out interrupt enable bit, SPI\_FIFO\_CTL[21], is set to 1.

##### Transmit FIFO interrupt

In FIFO mode, if the valid data count of the transmit FIFO buffer is less than or equal to the setting value of TX\_THRESHOLD(SPI\_FIFO\_CTL[29:28]), the transmit FIFO interrupt flag will be set to 1. The SPI controller will generate a transmit FIFO interrupt to the system if the transmit FIFO interrupt enable bit, SPI\_FIFO\_CTL[3], is set to 1.

##### Receive FIFO interrupt

In FIFO mode, if the valid data count of the receive FIFO buffer is larger than the setting value of RX\_THRESHOLD(SPI\_FIFO\_CTL[25:24]), the receive FIFO interrupt flag will be set to 1. The SPI controller will generate a receive FIFO interrupt to the system if the receive FIFO interrupt enable bit, SPI\_FIFO\_CTL[2], is set to 1.

### 5.16.6 Timing Diagram

The active state of slave select signal can be defined by the settings of SS\_LVL(SPI\_SSR[2]) bit and SS\_LTRIG(SPI\_SSR[4]) bit. The bus clock (SPICLK) idle state can be configured as high state or low state by setting the CLKP(SPI\_CNTRL[11]) bit. It also provides the bit length of a transaction word in TX\_BIT\_LEN(SPI\_CNTRL[7:3]) bit, and transmit/receive data from MSB or LSB first in LSB(SPI\_CNTRL[10]) bit. User also can select which edge of bus clock to transmit/receive data in TX\_NEG/RX\_NEG(SPI\_CNTRL[2]/SPI\_CNTRL[1]) bit. Four SPI timing diagrams for master/slave operations and the related settings are shown below.

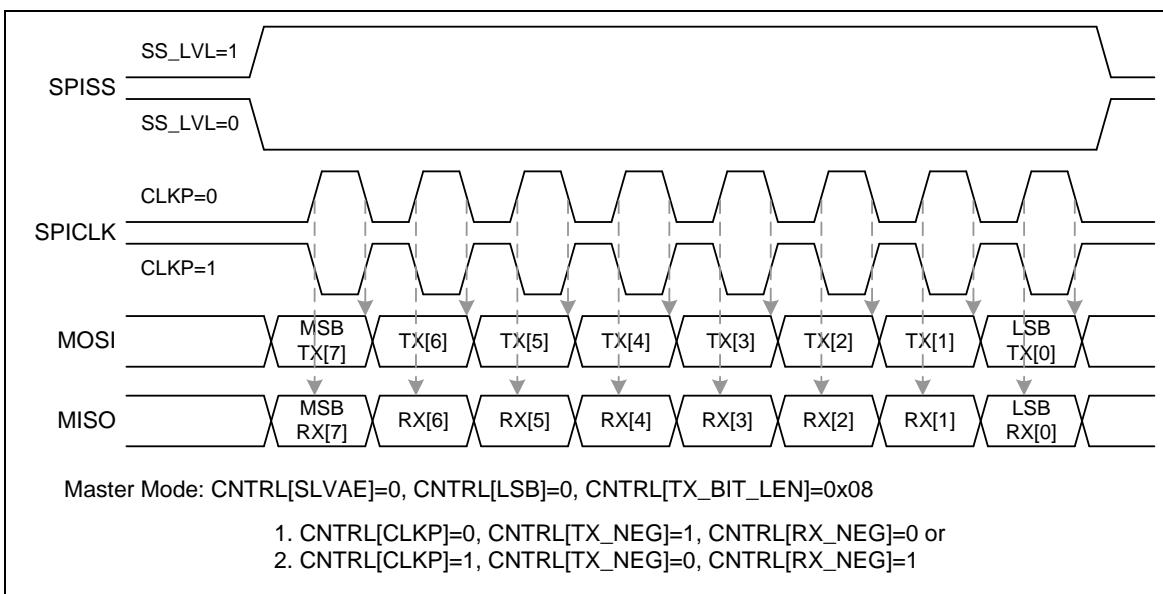


Figure 5-129 SPI Timing in Master Mode

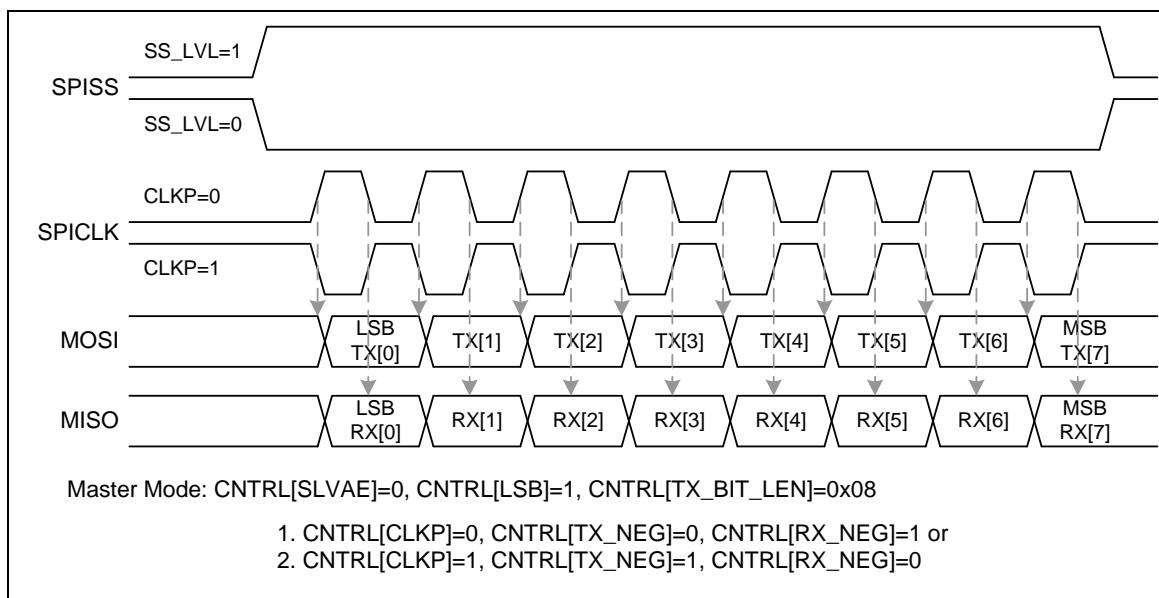


Figure 5-130 SPI Timing in Master Mode (Alternate Phase of SPICLK)

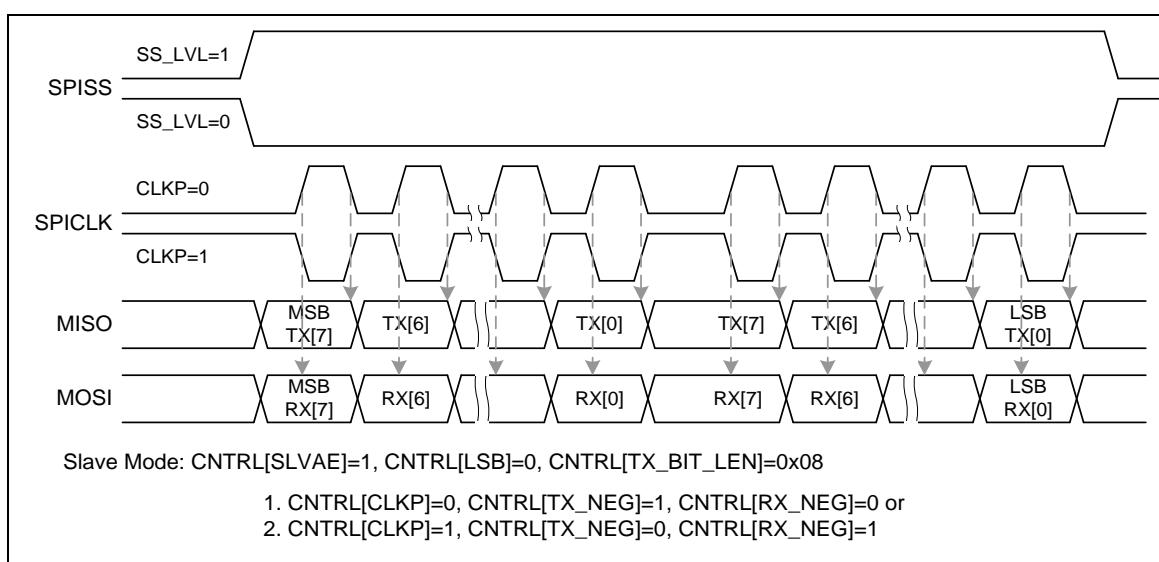


Figure 5-131 SPI Timing in Slave Mode

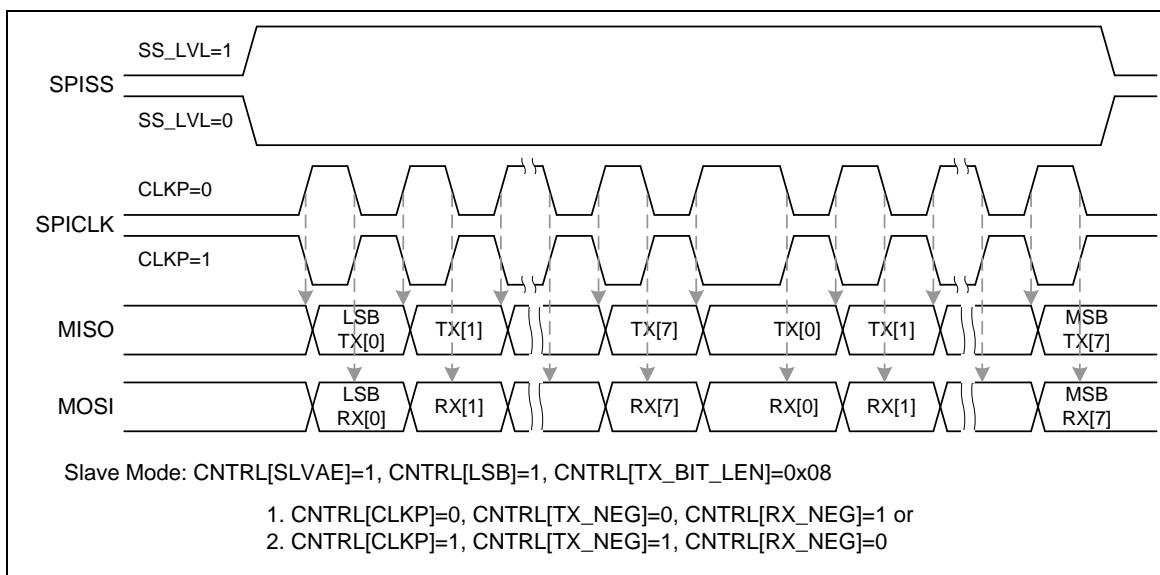


Figure 5-132 SPI Timing in Slave Mode (Alternate Phase of SPICLK)

### 5.16.7 Programming Examples

**Example 1:** SPI controller is set as a master to access an off-chip slave device with following specifications on NUC029xAN:

- Data bit is latched on positive edge of bus clock
- Data bit is driven on negative edge of bus clock
- Data is transferred from MSB first
- Data width is 8 bits
- SPICLK is idle at low state
- Only one byte of data to be transmitted/received in a transaction
- Connect with an off-chip slave device. Slave select signal is active low

The operation flow is described below.

- 1) Set the DIVIDER (SPI\_DIVIDER[7:0]) to determine the output frequency of bus clock.
- 2) Write the related settings into the SPI\_CNTRL register to control the SPI master actions.
  1. Set this SPI controller as master device in SLAVE bit (SPI\_CNTRL[18] = 0).
  2. Force the bus clock idle state at low in CLKP bit (SPI\_CNTRL[11] = 0).
  3. Select data transmitted on negative edge of bus clock in TX\_NEG bit (SPI\_CNTRL[2] = 1).
  4. Select data latched on positive edge of bus clock in RX\_NEG bit (SPI\_CNTRL[1] = 0).
  5. Set the bit length of word transfer as 8-bit in TX\_BIT\_LEN bit field (SPI\_CNTRL[7:3] = 0x08).
  6. Set MSB transfer first in MSB bit (SPI\_CNTRL[10] = 0), and need not to care the SP\_CYCLE bit field (SPI\_CNTRL[15:12]) due to it is not in FIFO mode in this case.

- 3) Write the SPI\_SSR register a proper value for the related settings of Master mode.
  1. Clear the Automatic Slave Select bit AUTOSS(SPI\_SSR[3] = 0).  
Select low level trigger output of slave select signal in the Slave Select Active Level control bit, SS\_LVL (SPI\_SSR[2] = 0).
  2. Set the slave select signal to be active by setting the Slave Select control bit SSR (SPI\_SSR[0]) to active the off-chip slave device.
- 4) If this SPI master attempts to transmit (write) one byte data to the off-chip slave device, write the byte data that will be transmitted into the SPI\_TX0 register.
- 5) If this SPI master just only attempts to receive (read) one byte data from the off-chip slave device and does not care what data will be transmitted, the SPI\_TX0 register does not need to be updated by software.
- 6) Set the GO\_BUSY bit (SPI\_CNTRL[0] = 1) to start the data transfer with the SPI interface.
- 7) Waiting for SPI interrupt (if the Interrupt Enable IE bit was set) or just polling the GO\_BUSY bit till it is cleared to 0 by hardware automatically.
- 8) Read out the received one byte data from SPI\_RX0[7:0].
- 9) Go to 4) to continue another data transfer or set SSR[0] bit to 0 to inactivate the off-chip slave device.

**Example 2:** The SPI controller is set as a slave device and connects with an off-chip master device. The off-chip master device communicates with the on-chip SPI slave controller through the SPI interface with the following specifications on NUC029FAE:

- Data bit is latched on positive edge of bus clock
- Data bit is driven on negative edge of bus clock
- Data is transferred from LSB first
- Data width is 8 bits
- SPICLK is idle at high state
- Only one byte of data to be transmitted/received in a transaction
- Slave select signal is high level trigger

The operation flow is as follows.

- 1) Set the DIVIDER (SPI\_DIVIDER[7:0]) to determine the slave peripheral clock frequency. The slave peripheral clock frequency must be larger than the SPI bus clock frequency.
- 2) Write the SPI\_SSR register a proper value for the related settings of Slave mode.  
Select high level and level trigger for the input of slave select signal by setting the Slave Select Active Level control bit SS\_LVL (SPI\_SSR[2] = 1) and the Slave Select Level Trigger SS\_LTRIG (SPI\_SSR[4] = 1).
- 3) Write the related settings into the SPI\_CNTRL register to control this SPI slave actions
  1. Set this SPI controller as slave device in SLAVE bit (SPI\_CNTRL[18] = 1)
  2. Select the serial clock idle state at high in CLKP bit (SPI\_CNTRL[11] = 1)
  3. Select data transmitted at negative edge of serial clock in TX\_NEG bit (SPI\_CNTRL[2] = 1)
  4. Select data latched at positive edge of serial clock in RX\_NEG bit (SPI\_CNTRL[1] = 0)

5. Set the bit length of word transfer as 8 bits in TX\_BIT\_LEN bit field (SPI\_CNTRL[7:3] = 0x08)
6. Set LSB transfer first in LSB bit (SPI\_CNTRL[10] = 1)
- 4) If this SPI slave attempts to transmit (be read) one byte data to the off-chip master device, write the byte data that will be transmitted into the SPI\_TX register.
- 5) If this SPI slave just only attempts to receive (be written) one byte data from the off-chip master device and does not care what data will be transmitted, the SPI\_TX does not need to update by software.
- 6) Set the GO\_BUSY bit (SPI\_CNTRL[0] = 1) to wait for the slave select trigger input and bus clock input from the off-chip master device to start the data transfer at the SPI interface.
- 7) Waiting for SPI interrupt (if the Interrupt Enable IE bit is set) or just polling the GO\_BUSY bit until it is cleared to 0 by hardware automatically.
- 8) Read out the received one byte data from SPI\_RX [7:0].
- 9) Go to 4) to continue another data transfer or clear the GO\_BUSY bit to stop data transfer.

### 5.16.8 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SPI Base Address:</b>				
<b>SPI0_BA = 0x4003_0000</b>				
<b>SPI1_BA = 0x4003_4000</b>				
<b>SPI_CNTRL x=0,1</b>	SPIx_BA+0x00	R/W	Control and Status Register	0x0500_0004
<b>SPI_DIVIDER x=0,1</b>	SPIx_BA+0x04	R/W	Clock Divider Register	0x0000_0000
<b>SPI_SSR x=0,1</b>	SPIx_BA+0x08	R/W	Slave Select Register	0x0000_0000
<b>SPI_RX x=0,1</b>	SPIx_BA+0x10	R	Data Receive Register	0x0000_0000
<b>SPI_TX x=0,1</b>	SPIx_BA+0x20	W	Data Transmit Register	0x0000_0000
<b>SPI_CNTRL2 x=0,1</b>	SPIx_BA+0x3C	R/W	Control and Status Register 2	0x0000_0000
<b>SPI_FIFO_CTL x=0,1</b>	SPIx_BA+0x40	R/W	SPI FIFO Control Register	0x2200_0000
<b>SPI_STATUS x=0,1</b>	SPIx_BA+0x44	R/W	SPI Status Register	0x0500_0000

### 5.16.9 Register Description for NUC029xAN

#### SPI Control and Status Register (SPI\_CNTRL)

Register	Offset	R/W	Description				Reset Value
SPI_CNTRL	SPIx_BA+0x00	R/W	Control and Status Register				0x0500_0004

31	30	29	28	27	26	25	24
Reserved				TX_FULL	TX_EMPTY	RX_FULL	RX_EMPTY
23	22	21	20	19	18	17	16
Reserved		FIFO	Reserved	REORDER	SLAVE	IE	IF
15	14	13	12	11	10	9	8
SP_CYCLE				CLKP	LSB	Reserved	
7	6	5	4	3	2	1	0
TX_BIT_LEN				TX_NEG	RX_NEG	GO_BUSY	

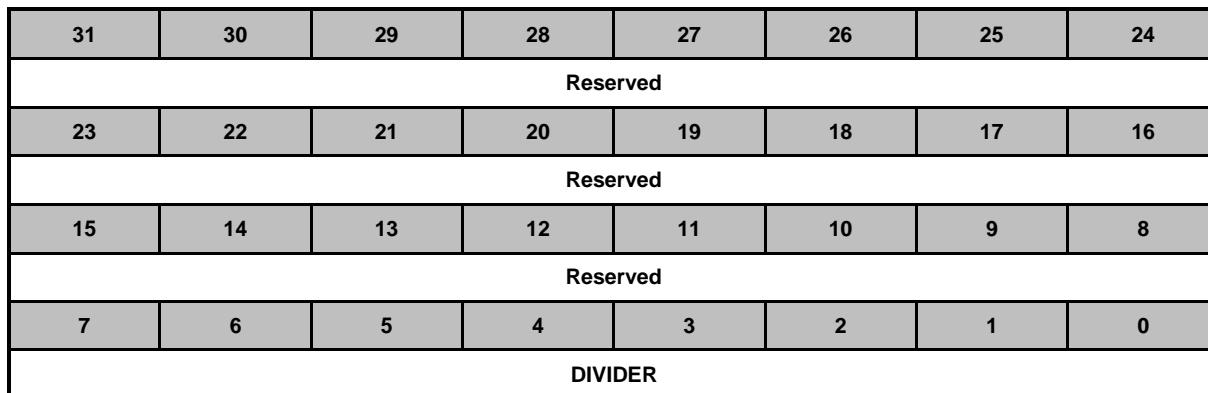
Bits	Description	
[31:28]	Reserved	Reserved.
[27]	TX_FULL	<p><b>Transmit FIFO Buffer Full Indicator (Read Only)</b>            It is a mutual mirror bit of SPI_STATUS[27].            0 = Indicates that the transmit FIFO buffer is not full.            1 = Indicates that the transmit FIFO buffer is full.</p>
[26]	TX_EMPTY	<p><b>Transmit FIFO Buffer Empty Indicator (Read Only)</b>            It is a mutual mirror bit of SPI_STATUS[26].            0 = Indicates that the transmit FIFO buffer is not empty.            1 = Indicates that the transmit FIFO buffer is empty.</p>
[25]	RX_FULL	<p><b>Receive FIFO Buffer Full Indicator (Read Only)</b>            It is a mutual mirror bit of SPI_STATUS[25].            0 = Indicates that the receive FIOF buffer is not full.            1 = Indicates that the receive FIFO buffer is full.</p>
[24]	RX_EMPTY	<p><b>Receive FIFO Buffer Empty Indicator (Read Only)</b>            It is a mutual mirror bit of SPI_CNTRL[24].            0 = Indicates that the receive FIFO buffer is not empty.            1 = Indicates that the receive FIFO buffer is empty.</p>
[23:22]	Reserved	Reserved.
[21]	FIFO	<p><b>FIFO Mode Enable Control</b>            In Master mode, if the FIFO mode is enabled, the GO_BUSY bit will be set to 1 automatically after writing data into the 8-depth transmit FIFO. When all data stored at transmit FIFO buffer are transferred, the GO_BUSY bit will back to 0.            0 = FIFO Mode Disabled.            1 = FIFO Mode Enabled.  <b>Note:</b> Before enabling FIFO mode, the other related settings should be set in advance.</p>

[20:19]	<b>REORDER</b>	<b>Byte Reorder Function And Byte Suspend Function Selection</b> 00 = Byte reorder function and byte suspend function are Disabled. 01 = Byte reorder function Enabled. Byte suspend interval is determined by the setting of SP_CYCLE. Set SP_CYCLE to 0 to disabled byte suspend function. 10 = Reserved. 11 = Reserved. <b>Note:</b> Byte reorder function is only available if TX_BIT_LEN is defined as 16, 24, and 32 bits.
[18]	<b>SLAVE</b>	<b>Slave Mode Control</b> 0 = Master mode. 1 = Slave mode.
[17]	<b>IE</b>	<b>Unit-transfer Interrupt Enable Control</b> 0 = SPI unit-transfer interrupt Disabled. 1 = SPI unit-transfer interrupt Enabled.
[16]	<b>IF</b>	<b>Unit-transfer Interrupt Flag</b> 0 = No transaction has been finished since this bit was cleared to 0. 1 = SPI controller has finished one unit transfer. <b>Note:</b> This bit will be cleared by writing 1 to itself.
[15:12]	<b>SP_CYCLE</b>	<b>Suspend Interval (Master Only)</b> These four bits provide configurable suspend interval between two successive transactions in a transfer. The definition of the suspend interval is the interval between the last clock edge of the preceding transaction word and the first clock edge of the following transaction word. The default value is 0x3. The period of the suspend interval is obtained according to the following equation: $(SP\_CYCLE[3:0] + 0.5) * \text{period of SPICLK clock cycle}$ Example: SP_CYCLE = 0x0 ... 0.5 SPICLK clock cycle. SP_CYCLE = 0x1 ... 1.5 SPICLK clock cycle. ..... SP_CYCLE = 0xE ... 14.5 SPICLK clock cycle. SP_CYCLE = 0xF ... 15.5 SPICLK clock cycle.
[11]	<b>CLKP</b>	<b>Clock Polarity</b> 0 = SPICLK idle low. 1 = SPICLK idle high.
[10]	<b>LSB</b>	<b>LSB First</b> 0 = The MSB is transmitted/received first. 1 = The LSB is transmitted/received first.
[9:8]	<b>Reserved</b>	Reserved.
[7:3]	<b>TX_BIT_LEN</b>	<b>Transfer Bit Length</b> This field specifies how many bits can be transmitted / received in one transaction. The minimum bit length is 8 bits and can up to 32 bits. TX_BIT_LEN = 0x08 ... 8 bit. TX_BIT_LEN = 0x09 ... 9 bits. ..... TX_BIT_LEN = 0x1F ... 31 bits. TX_BIT_LEN = 0x00 ... 32 bits.

[2]	TX_NEG	<b>Transmit On Negative Edge</b> 0 = The transmitted data output signal is driven on the rising edge of SPICLK. 1 = The transmitted data output signal is driven on the falling edge of SPICLK.
[1]	RX_NEG	<b>Receive On Negative Edge</b> 0 = The received data input signal is latched on the rising edge of SPICLK. 1 = The received data input signal is latched on the falling edge of SPICLK.
[0]	GO_BUSY	<b>SPI Transfer Trigger And Busy Status</b> In FIFO mode, this bit will be controlled by hardware. Software cannot modify this bit. If FIFO mode is disabled, during the data transfer, this bit keeps the value of 1. As the transfer is finished, this bit will be cleared automatically. 0 = Writing 0 to this bit to stop data transfer if SPI is transferring. 1 = In Master mode, writing 1 to this bit to start the SPI data transfer; in Slave mode, writing 1 to this bit indicates that the slave is ready to communicate with a master. <b>Note 1:</b> When FIFO mode is disabled, all configurations should be ready before writing 1 to the GO_BUSY bit. <b>Note 2:</b> In SPI Slave mode, if FIFO mode is disabled and the SPI bus clock is kept at idle state during a data transfer, the GO_BUSY bit will not be cleared to 0 when slave select signal goes to inactive state.

**SPI Divider Register (SPI\_DIVIDER)**

Register	Offset	R/W	Description				Reset Value
SPI_DIVIDER	SPIx_BA+0x04	R/W	Clock Divider Register				0x0000_0000



Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	DIVIDER	<p><b>Clock Divider</b></p> <p>The value in this field is the frequency divider to determine the SPI peripheral clock frequency, <math>f_{spi}</math>, and the SPI master's bus clock frequency on the SPICLK output pin. The frequency is obtained according to the following equation.</p> <p>If the bit of BCn, SPI_CNTRL2[31], is set to 0,</p> $f_{spi} = \frac{f_{SPI\_clock\_src}}{(DIVIDER + 1) * 2}$ <p>else if BCn is set to 1,</p> $f_{spi} = \frac{f_{SPI\_clock\_src}}{(DIVIDER + 1)}$ <p>where</p> <p><math>f_{SPI\_clock\_src}</math> is the SPI peripheral clock source which is defined in the CLKSEL1 register.</p>

**SPI Slave Select Register (SPI\_SS\_R)**

Register	Offset	R/W	Description				Reset Value
SPI_SS_R	SPIx_BA+0x08	R/W	Slave Select Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved		LTRIG_FLAG	SS_LTRIG	AUTOSS	SS_LVL	Reserved	SSR

Bits	Description	
[31:6]	Reserved	Reserved.
[5]	LTRIG_FLAG	<p><b>Level Trigger Flag</b>  When the SS_LTRIG bit is set in Slave mode, this bit can be read to indicate the received bit number is met the requirement or not.  0 = The transaction number or the transferred bit length of one transaction does not meet the specified requirements.  1 = The transaction number and the transferred bit length met the specified requirements which defined in TX_BIT_LEN.  <b>Note:</b> This bit is READ only and only available in Slave mode.</p>
[4]	SS_LTRIG	<p><b>Slave Select Level Trigger Enable (Slave Only)</b>  0 = The input slave select signal is edge-trigger. This is the default value. It depends on SS_LVL to decide the signal is active at falling-edge or rising-edge.  1 = The slave select signal will be level-trigger. It depends on SS_LVL to decide the signal is active low or active high.</p>
[3]	AUTOSS	<p><b>Automatic Slave Select Function Enable (Master Only)</b>  0 = If this bit is cleared, slave select signal will be asserted/de-asserted by setting /clearing SSR bit.  1 = If this bit is set, SPISSx signal will be generated automatically, which means that slave select signal will be asserted by the SPI controller when transmit/receive is started by setting GO_BUSY, and will be de-asserted after each transmit/receive is finished.</p>
[2]	SS_LVL	<p><b>Slave Select Active Level</b>  This bit defines the active status of slave select signal (SPISSx).  0 = The slave select signal SPISSx is active at low-level/falling-edge.  1 = The slave select signal SPISSx is active at high-level/rising-edge.</p>
[1]	Reserved	Reserved.
[0]	SSR	<p><b>Slave Select Control (Master Only)</b>  If AUTOSS bit is cleared to 0,  0 = Set the SPISSx line to inactive state.  1 = Set the proper SPISSx line to active state.</p>

		<p>If AUTOSS bit is set to 1, 0 = Keep the SPISSx line at inactive state. 1 = Select the SPISSx line to be automatically driven to active state for the duration of transmission/reception, and will be driven to inactive state for the rest of the time. The active state of SPISSx is specified in SS_LVL bit.</p>
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**SPI Data Receive Register (SPI\_RX)**

Register	Offset	R/W	Description				Reset Value
SPI_RX	SPIx_BA+0x10	R	Data Receive Register				0x0000_0000

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

Bits	Description	
[31:0]	RX	<p><b>Data Receive Register</b></p> <p>The Data Receive Registers hold the value of received data of the last executed transfer. Valid bits depend on the transmit bit length field in the SPI_CNTRL register.</p> <p>For example, if TX_BIT_LEN is set to 0x08 and TX_NUM is set to 0x0, bit RX0[7:0] holds the received data. The values of the other bits are unknown. The Data Receive Registers are read-only registers.</p>

**SPI Data Transmit Register (SPI\_TX)**

Register	Offset	R/W	Description				Reset Value
SPI_TX	SPIx_BA+0x20	W	Data Transmit Register				0x0000_0000

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

Bits	Description	
[31:0]	TX	<p><b>Data Transmit Register</b></p> <p>The Data Transmit Registers hold the data to be transmitted in the next transfer. Valid bits depend on the transmit bit length field in the CNTRL register.</p> <p>For example, if TX_BIT_LEN is set to 0x08 and the TX_NUM is set to 0x0, the bit TX0[7:0] will be transmitted in next transfer. If TX_BIT_LEN is set to 0x00 and TX_NUM is set to 0x1, the SPI controller will perform two 32-bit transmit/receive successive using the same setting. The transmission sequence is TX0[31:0] first and then TX1[31:0].</p>

**SPI Control and Status Register 2 (SPI\_CNTRL2)**

Register	Offset	R/W	Description				Reset Value
SPI_CNTRL2	SPIx_BA+0x3C	R/W	Control and Status Register 2				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				SLV_START_INTSTS	SSTA_INTE_N	SLV_ABORT	NOSLVSEL
7	6	5	4	3	2	1	0
Reserved							

Bits	Description	
[31:17]	Reserved	Reserved.
[16]	SS_INT_OPT	<p><b>Slave Select Inactive Interrupt Option</b>  This setting is only available if the SPI controller is configured as level trigger slave device.  0 = As the slave select signal goes to inactive level, the IF bit will NOT be set to 1.  1 = As the slave select signal goes to inactive level, the IF bit will be set to 1.</p>
[15:12]	Reserved	Reserved.
[11]	SLV_START_INTSTS	<p><b>Slave 3-wire Mode Start Interrupt Status</b>  This bit dedicates if a transaction has started in Slave 3-wire mode. It is a mutual mirror bit of SPI_STATUS[11].  0 = Slave does not detect any SPI bus clock transition since the SSTA_INTEN bit was set to 1.  1 = A transaction has started in Slave 3-wire mode. It will be cleared automatically when a transaction is done or by writing 1 to this bit.</p>
[10]	SSTA_INTEN	<p><b>Slave 3-wire Mode Start Interrupt Enable</b>  It is used to enable interrupt when the transfer has started in Slave 3-wire mode. If there is no transfer done interrupt over the time period which is defined by user after the transfer start, user can set the SLV_ABORT bit to force the transfer done.  0 = Transaction start interrupt Disabled.  1 = Transaction start interrupt Enabled. It will be cleared to 0 as the current transfer is done or the SLV_START_INTSTS bit is cleared to 0.</p>
[9]	SLV_ABORT	<p><b>Slave 3-wire Mode Abort Control</b>  In normal operation, there is an interrupt event when the number of received bits meets the requirement which defined in TX_BIT_LEN.  If the number of received bits is less than the requirement and there is no more bus clock input over one transfer time in Slave 3-wire mode, user can set this bit to force the current transfer done and then user can get a unit transfer interrupt event.  <b>Note:</b> This bit will be cleared to 0 automatically by hardware after it is set to 1 by software.</p>

[8]	<b>NOSLVSEL</b>	<b>Slave 3-wire Mode Enable</b> This is used to ignore the slave select signal in Slave mode. The SPI controller can work with 3-wire interface including SPICLK, SPI_MISO, and SPI_MOSI when this bit is set to 1. 0 = The controller is 4-wire bi-direction interface. 1 = The controller is 3-wire bi-direction interface in Slave mode. When this bit is set to 1, the controller will be ready to transmit/receive data after the GO_BUSY bit is set to 1. <b>Note:</b> In Slave 3-wire mode, the SS_LTRIG bit (SPI_SSR[4]) shall be set as 1.
[7:0]	<b>Reserved</b>	Reserved.

**SPI FIFO Control Register (SPI\_FIFO\_CTL)**

Register	Offset	R/W	Description				Reset Value
SPI_FIFO_CTL	SPIx_BA+0x40	R/W	SPI FIFO Control Register				0x2200_0000

31	30	29	28	27	26	25	24
Reserved		TX_THRESHOLD			Reserved	RX_THRESHOLD	
23	22	21	20	19	18	17	16
Reserved		TIMEOUT_IN_TEN	Reserved				
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	RXOV_INTEN	Reserved		TX_INTEN	RX_INTEN	TX_CLR	RX_CLR

Bits	Description	
[31:30]	Reserved	Reserved.
[29:28]	TX_THRESHOLD	<b>Transmit FIFO Threshold</b> If the valid data count of the transmit FIFO buffer is less than or equal to the TX_THRESHOLD setting, the TX_INTSTS bit will be set to 1, else the TX_INTSTS bit will be cleared to 0.
[27:26]	Reserved	Reserved.
[25:24]	RX_THRESHOLD	<b>Received FIFO Threshold</b> If the valid data count of the receive FIFO buffer is larger than the RX_THRESHOLD setting, the RX_INTSTS bit will be set to 1, else the RX_INTSTS bit will be cleared to 0.
[23:22]	Reserved	Reserved.
[21]	TIMEOUT_INTEN	<b>Receive FIFO Time-out Interrupt Enable Control</b> 0 = Time-out interrupt Disabled. 1 = Time-out interrupt Enabled.
[20:7]	Reserved	Reserved.
[6]	RXOV_INTEN	<b>Receive FIFO Overrun Interrupt Enable Control</b> 0 = Receive FIFO overrun interrupt Disabled. 1 = Receive FIFO overrun interrupt Enabled.
[5:4]	Reserved	Reserved.
[3]	TX_INTEN	<b>Transmit Threshold Interrupt Enable Control</b> 0 = Transmit threshold interrupt Disabled. 1 = Transmit threshold interrupt Enabled.
[2]	RX_INTEN	<b>Receive Threshold Interrupt Enable Control</b> 0 = Receive threshold interrupt Disabled. 1 = Receive threshold interrupt Enabled.

[1]	TX_CLR	<b>Clear Transmit FIFO Buffer</b> 0 = No effect. 1 = Clear transmit FIFO buffer. The TX_FULL flag will be cleared to 0 and the TX_EMPTY flag will be set to 1. This bit will be cleared to 0 by hardware after software sets it to 1 and the transmit FIFO is cleared.
[0]	RX_CLR	<b>Clear Receive FIFO Buffer</b> 0 = No effect. 1 = Clear receive FIFO buffer. The RX_FULL flag will be cleared to 0 and the RX_EMPTY flag will be set to 1. This bit will be cleared to 0 by hardware after software sets it to 1 and the receive FIFO is cleared.

**SPI Status Register (SPI\_STATUS)**

Register	Offset	R/W	Description				Reset Value
SPI_STATUS	SPIx_BA+0x44	R/W	SPI Status Register				0x0500_0000

31	30	29	28	27	26	25	24
TX_FIFO_COUNT			TX_FULL		TX_EMPTY	RX_FULL	RX_EMPTY
23	22	21	20	19	18	17	16
Reserved			TIMEOUT	Reserved			IF
15	14	13	12	11	10	9	8
RX_FIFO_COUNT			SLV_START_INTSTS		Reserved		
7	6	5	4	3	2	1	0
Reserved			TX_INTSTS	Reserved	RX_OVERRUN	Reserved	RX_INTSTS

Bits	Description	
[31:28]	TX_FIFO_COUNT	Transmit FIFO Data Count (Read Only) Indicates the valid data count of transmit FIFO buffer.
[27]	TX_FULL	Transmit FIFO Buffer Full Indicator (Read Only) It is a mutual mirror bit of SPI_CNTRL[27]. 0 = The transmit FIFO buffer is not full. 1 = The transmit FIFO buffer is full.
[26]	TX_EMPTY	Transmit FIFO Buffer Empty Indicator (Read Only) It is a mutual mirror bit of SPI_CNTRL[26]. 0 = The transmit FIFO buffer is not empty. 1 = The transmit FIFO buffer is empty.
[25]	RX_FULL	Receive FIFO Buffer Full Indicator (Read Only) It is a mutual mirror bit of SPI_CNTRL[25]. 0 = The receive FIFO buffer is not full. 1 = The receive FIFO buffer is full.
[24]	RX_EMPTY	Receive FIFO Buffer Empty Indicator (Read Only) It is a mutual mirror bit of SPI_CNTRL[24]. 0 = The receive FIFO buffer is not empty. 1 = The receive FIFO buffer is empty.
[23:21]	Reserved	Reserved.
[20]	TIMEOUT	Time-out Interrupt Flag 0 = No receive FIFO time-out event. 1 = The receive FIFO buffer is not empty and it does not get read over 64 SPI clock periods in Master mode or over 576 SPI peripheral clock periods in Slave mode. When the received FIFO buffer is read by software, the time-out status will be cleared automatically. <b>Note:</b> This bit will be cleared by writing 1 to itself.

[19:17]	<b>Reserved</b>	Reserved.
[16]	<b>IF</b>	<p><b>SPI Unit-transfer Interrupt Flag</b>            It is a mutual mirror bit of SPI_CNTRL[16].            0 = The transfer does not finish yet.            1 = The SPI controller has finished one unit transfer.  <b>Note:</b> This bit will be cleared by writing 1 to itself.</p>
[15:12]	<b>RX_FIFO_COUNT</b>	<p><b>Receive FIFO Data Count (Read Only)</b>            Indicates the valid data count of receive FIFO buffer.</p>
[11]	<b>SLV_START_INTSTS</b>	<p><b>Slave Start Interrupt Status</b>            It is used to dedicate that the transfer has started in Slave 3-wire mode. It's a mutual mirror bit of SPI_CNTRL2[11].            0 = The transfer is not started.            1 = The transfer has started in Slave 3-wire mode. It will be cleared as transfer done or by writing one to this bit.</p>
[10:5]	<b>Reserved</b>	Reserved.
[4]	<b>TX_INTSTS</b>	<p><b>Transmit FIFO Threshold Interrupt Status (Read Only)</b>            0 = The valid data count within the transmit FIFO buffer is larger than the setting value of TX_THRESHOLD.            1 = The valid data count within the transmit FIFO buffer is less than or equal to the setting value of TX_THRESHOLD.  <b>Note:</b> If TX_INTEN = 1 and TX_INTSTS = 1, the SPI controller will generate a SPI interrupt request.</p>
[3]	<b>Reserved</b>	Reserved.
[2]	<b>RX_OVERRUN</b>	<p><b>Receive FIFO Overrun Status</b>            When the receive FIFO buffer is full, the follow-up data will be dropped and this bit will be set to 1.  <b>Note:</b> This bit will be cleared by writing 1 to itself.</p>
[1]	<b>Reserved</b>	Reserved.
[0]	<b>RX_INTSTS</b>	<p><b>Receive FIFO Threshold Interrupt Status (Read Only)</b>            0 = The valid data count within the Rx FIFO buffer is smaller than or equal to the setting value of RX_THRESHOLD.            1 = The valid data count within the receive FIFO buffer is larger than the setting value of RX_THRESHOLD.  <b>Note:</b> If RX_INTEN = 1 and RX_INTSTS = 1, the SPI controller will generate a SPI interrupt request.</p>

### 5.16.10 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>SPI Base Address:</b>				
<b>SPI_BA = 0x4003_0000</b>				
<b>SPI_CNTRL</b>	SPI_BA+0x00	R/W	SPI Control and Status Register	0x0500_3004
<b>SPI_DIVIDER</b>	SPI_BA+0x04	R/W	SPI Clock Divider Register	0x0000_0000
<b>SPI_SSR</b>	SPI_BA+0x08	R/W	SPI Slave Select Register	0x0000_0000
<b>SPI_RX</b>	SPI_BA+0x10	R	SPI Data Receive Register	0x0000_0000
<b>SPI_TX</b>	SPI_BA+0x20	W	SPI Data Transmit Register	0x0000_0000
<b>SPI_CNTRL2</b>	SPI_BA+0x3C	R/W	SPI Control and Status Register 2	0x0000_0000
<b>SPI_FIFO_CTL</b>	SPI_BA+0x40	R/W	SPI FIFO Control Register	0x2200_0000
<b>SPI_STATUS</b>	SPI_BA+0x44	R/W	SPI Status Register	0x0500_0000

### 5.16.11 Register Description for NUC029FAE

#### SPI Control and Status Register (SPI\_CNTRL)

Register	Offset	R/W	Description				Reset Value
SPI_CNTRL	SPI_BA+0x00	R/W	SPI Control and Status Register				0x0500_3004

31	30	29	28	27	26	25	24
Reserved				TX_FULL	TX_EMPTY	RX_FULL	RX_EMPTY
23	22	21	20	19	18	17	16
Reserved		FIFO	Reserved	REORDER	SLAVE	IE	IF
15	14	13	12	11	10	9	8
SP_CYCLE				CLKP	LSB	Reserved	
7	6	5	4	3	2	1	0
TX_BIT_LEN				TX_NEG	RX_NEG	GO_BUSY	

Bits	Description	
[31:28]	Reserved	Reserved.
[27]	TX_FULL	<p><b>Transmit FIFO Buffer Full Indicator (Read Only)</b>            0 = The transmit FIFO buffer is not full.            1 = The transmit FIFO buffer is full.  <b>Note:</b> It's a mutual mirror bit of SPI_STATUS[27].</p>
[26]	TX_EMPTY	<p><b>Transmit FIFO Buffer Empty Indicator (Read Only)</b>            0 = The transmit FIFO buffer is not empty.            1 = The transmit FIFO buffer is empty.  <b>Note:</b> It's a mutual mirror bit of SPI_STAUTS[26].</p>
[25]	RX_FULL	<p><b>Receive FIFO Buffer Full Indicator (Read Only)</b>            0 = The receive FIFO buffer is not full.            1 = The receive FIFO buffer is full.  <b>Note:</b> It's a mutual mirror bit of SPI_STATUS[25]</p>
[24]	RX_EMPTY	<p><b>Receive FIFO Buffer Empty Indicator (Read Only)</b>            0 = The receive FIFO buffer is not empty.            1 = The receive FIFO buffer is empty.  <b>Note:</b> It's a mutual mirror bit of SPI_CNTRL[24].</p>
[23:22]	Reserved	Reserved.
[21]	FIFO	<p><b>FIFO Mode Enable Control</b>            0 = FIFO Mode Disabled.            1 = FIFO Mode Enabled.  <b>Note 1:</b> Before enabling FIFO mode, the other related settings should be set in advance.  <b>Note 2:</b> In Master mode, if the FIFO mode is enabled, the GO_BUSY bit will be set to 1 automatically after writing data into the 4-depth transmit FIFO. When all data stored at transmit FIFO buffer are transferred, the GO_BUSY bit will back to 0.</p>

[20]	<b>Reserved</b>	Reserved.
[19]	<b>REORDER</b>	<p><b>Byte Reorder Function</b>            0 = Byte reorder function Disabled.            1 = Byte reorder function Enabled.</p> <p><b>Note:</b> This setting is only available if TX_BIT_LEN is defined as 16, 24, and 32 bits.</p>
[18]	<b>SLAVE</b>	<p><b>Slave Mode Control</b>            0 = Master mode.            1 = Slave mode.</p>
[17]	<b>IE</b>	<p><b>Unit-transfer Interrupt Enable Control</b>            0 = SPI unit-transfer interrupt Disabled.            1 = SPI unit-transfer interrupt Enabled.</p>
[16]	<b>IF</b>	<p><b>Unit-transfer Interrupt Flag</b>            0 = The transfer does not finish yet.            1 = The SPI controller has finished one unit transfer.</p> <p><b>Note 1:</b> This bit will be cleared by writing 1 to itself.</p> <p><b>Note 2:</b> It's a mutual mirror bit of SPI_STATUS[16].</p>
[15:12]	<b>SP_CYCLE[3:0]</b>	<p><b>Suspend Interval (Master Only)</b>            The four bits provide configurable suspend interval between two successive transactions in a transfer. The definition of the suspend interval is the interval between the last clock edge of the preceding transaction word and the first clock edge of the following transaction word. The default value is 0x3. The period of the suspend interval is obtained according to the following equation:  <math display="block">(SP\_CYCLE[3:0] + 0.5) * \text{period of SPICLK clock cycle}</math>           Example:            SP_CYCLE = 0x0 ... 0.5 SPICLK clock cycle.            SP_CYCLE = 0x1 ... 1.5 SPICLK clock cycle.            .....            SP_CYCLE = 0xE ... 14.5 SPICLK clock cycle.            SP_CYCLE = 0xF ... 15.5 SPICLK clock cycle.</p>
[11]	<b>CLKP</b>	<p><b>Clock Polarity</b>            0 = SPICLK idle low.            1 = SPICLK idle high.</p>
[10]	<b>LSB</b>	<p><b>LSB First</b>            0 = The MSB is transmitted/received first.            1 = The LSB is transmitted/received first.</p>
[9:8]	<b>Reserved</b>	Reserved.
[7:3]	<b>TX_BIT_LEN[4:0]</b>	<p><b>Transmit Bit Length</b>            This field specifies how many bits are transmitted in one transmit/receive. The minimum bit length is 8 bits and can up to 32 bits.            TX_BIT_LEN = 0x08 ... 8 bits.            TX_BIT_LEN = 0x09 ... 9 bits.            .....            TX_BIT_LEN = 0x1F ... 31 bits.            TX_BIT_LEN = 0x00 ... 32 bits.</p>
[2]	<b>TX_NEG</b>	<p><b>Transmit On Negative Edge</b>            0 = The transmitted data output signal is driven on the Rising edge of SPICLK.</p>

		1 = The transmitted data output signal is driven on the Falling edge of SPICLK.
[1]	<b>RX_NEG</b>	<b>Receive On Negative Edge</b> 0 = The received data input signal latched on the Rising edge of SPICLK. 1 = The received data input signal latched on the Falling edge of SPICLK.
[0]	<b>GO_BUSY</b>	<b>SPI Transfer Control Bit And Busy Status</b> If FIFO mode is enabled, this bit will be controlled by hardware and is Read only. If FIFO mode is disabled, during the data transfer, this bit keeps the value of 1. As the transfer is finished, this bit will be cleared automatically. 0 = Writing 0 to this bit to stop data transfer if SPI is transferring. 1 = In Master mode, writing 1 to this bit to start the SPI data transfer; in Slave mode, writing 1 to this bit indicates that the slave is ready to communicate with a master. <b>Note 1:</b> When FIFO mode is disabled, all configurations should be ready before writing 1 to the GO_BUSY bit. <b>Note 2:</b> In SPI Slave mode, if FIFO mode is disabled and the SPI bus clock is kept at idle state during a data transfer, the GO_BUSY bit will not be cleared to 0 when slave select signal goes to inactive state.

**SPI Divider Register (SPI\_DIVIDER)**

Register	Offset	R/W	Description				Reset Value
SPI_DIVIDER	SPI_BA+0x04	R/W	SPI Clock Divider Register				0x0000_0000

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	DIVIDER	<p><b>Clock Divider Bits (Master Only)</b></p> <p>The value in this field is the frequency divider to determine the SPI peripheral clock frequency <math>f_{spi}</math>, and the SPI master's bus clock frequency on the SPICLK output pin. The frequency is obtained according to the following equation:</p> <p>If the bit of BCn, SPI_CNTRL2[31], is set to 0,</p> $f_{spi} = \frac{f_{SPI\_clock\_src}}{(DIVIDER + 1) * 2}$ <p>else if BCn is set to 1,</p> $f_{spi} = \frac{f_{SPI\_clock\_src}}{(DIVIDER + 1)}$ <p>where</p> <p><math>f_{SPI\_clock\_src}</math> is the SPI peripheral clock source which is defined in the CLKSEL1 register.</p>

**SPI Slave Select Register (SPI\_SS\_R)**

Register	Offset	R/W	Description				Reset Value
SPI_SS_R	SPI_BA+0x08	R/W	SPI Slave Select Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved		LTRIG_FLAG	SS_LTRIG	AUTOSS	SS_LVL	Reserved	SSR

Bits	Description	
[31:6]	Reserved	Reserved.
[5]	LTRIG_FLAG	<p><b>Level Trigger Flag (Read Only, Slave Only)</b>  When the SS_LTRIG bit is set in Slave mode, this bit can be read to indicate the received bit number is met the requirement or not.</p> <p>0 = The transaction number or the transferred bit length of one transaction does not meet the specified requirements.</p> <p>1 = The transaction number and the transferred bit length met the specified requirements which defined in TX_BIT_LEN.</p>
[4]	SS_LTRIG	<p><b>Slave Select Level Trigger Enable Bit (Slave Only)</b>  0 = The input slave select signal is edge-trigger.  1 = The input slave select signal is level-trigger.</p>
[3]	AUTOSS	<p><b>Automatic Slave Selection Function Enable Bit (Master Only)</b>  0 = SPISS pin signal will be asserted/de-asserted by setting /clearing SSR bit.  1 = SPISS pin signal will be generated automatically, which means that slave select signal will be asserted by the SPI controller when transmit/receive is started by setting GO_BUSY, and will be de-asserted after each transmit/receive is finished.</p>
[2]	SS_LVL	<p><b>Slave Select Active Level (Slave Only)</b>  It defines the active status of slave select signal (SPISS).  If SS_LTRIG bit is 1:  0 = The slave select signal SPISS is active at Low-level.  1 = The slave select signal SPISS is active at High-level.  If SS_LTRIG bit is 0:  0 = The slave select signal SPISS is active at Falling-edge.  1 = The slave select signal SPISS is active at Rising-edge.</p>
[1]	Reserved	Reserved.
[0]	SSR	<p><b>Slave Select Control Bit (Master Only)</b>  If AUTOSS bit is 0,  0 = Set the SPISS line to inactive state.</p>

		<p>1 = Set the proper SPISS line to active state. If AUTOSS bit is 1, 0 = Keep the SPISS line at inactive state. 1 = Select the SPISS line to be automatically driven to active state for the duration of transmission/reception, and will be driven to inactive state for the rest of the time. The active state of SPISS is specified in SS_LVL bit.</p>
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**SPI Data Receive Register (SPI\_RX)**

Register	Offset	R/W	Description				Reset Value
SPI_RX	SPI_BA+0x10	R	SPI Data Receive Register				0x0000_0000

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

Bits	Description	
[31:0]	RX	<p><b>Data Receive Bits (Read Only)</b></p> <p>The Data Receive Registers hold the value of received data of the last executed transfer. Valid bits depend on the transmit bit length field in the SPI_CNTRL register.</p> <p>For example, if TX_BIT_LEN is set to 0x08, bit RX [7:0] holds the received data. The values of the other bits are unknown.</p>

**SPI Data Transmit Register (SPI\_TX)**

Register	Offset	R/W	Description				Reset Value
SPI_TX	SPI_BA+0x20	W	SPI Data Transmit Register				0x0000_0000

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

Bits	Description	
[31:0]	TX	<p><b>Data Transmit Bits (Write Only)</b></p> <p>The Data Transmit Registers hold the data to be transmitted in the next transfer. Valid bits depend on the transmit bit length field in the CNTRL register.</p> <p>For example, if TX_BIT_LEN is set to 0x08, the bit TX [7:0] will be transmitted in next transfer.</p>

**SPI Control and Status Register 2 (SPI\_CNTRL2)**

Register	Offset	R/W	Description				Reset Value
SPI_CNTRL2	SPI_BA+0x3C	R/W	SPI Control and Status Register 2				0x0000_0000

31	30	29	28	27	26	25	24
BCn	Reserved						
23	22	21	20	19	18	17	16
Reserved							SS_INT_OPT
15	14	13	12	11	10	9	8
Reserved				SLV_START_INTSTS	SSTA_INTE_N	SLV_ABORT	NOSLVSEL
7	6	5	4	3	2	1	0
Reserved							

Bits	Description	
[31]	BCn	<b>Clock Configuration Backward Compatible Option</b> 0 = The clock configuration is backward compatible. 1 = The clock configuration is not backward compatible. <b>Note:</b> Refer to the description of SPI_DIVIDER register for details.
[30:17]	Reserved	Reserved.
[16]	SS_INT_OPT	<b>Slave Select Inactive Interrupt Option (Slave Only)</b> 0 = As the slave select signal goes to inactive level, the IF bit will NOT be set to 1. 1 = As the slave select signal goes to inactive level, the IF bit will be set to 1. <b>Note:</b> This setting is only available if the SPI controller is configured as level trigger in slave device.
[15:12]	Reserved	Reserved.
[11]	SLV_START_INTSTS	<b>Slave 3-wire Mode Start Interrupt Status (Slave Only)</b> This bit dedicates if a transaction has started in slave 3-wire mode. 0 = Slave does not detect any SPI bus clock transfer since the SSTA_INTEN bit was set to 1. 1 = The transfer has started in slave 3-wire mode.. <b>Note 1:</b> It will be cleared automatically when a transaction is done or by writing 1 to this bit. <b>Note 2:</b> It is a mutual mirror bit of SPI_STATUS[11].
[10]	SSTA_INTEN	<b>Slave 3-wire Mode Start Interrupt Enable Control (Slave Only)</b> It is used to enable interrupt when the transfer has started in slave 3-wire mode. If there is no transfer done interrupt over the time period which is defined by user after the transfer start, user can set the SLV_ABORT bit to force the transfer done. 0 = Transaction start interrupt Disabled. 1 = Transaction start interrupt Enabled. <b>Note:</b> It will be cleared to 0 as the current transfer is done or the SLV_START_INTSTS bit is cleared to 0.

[9]	<b>SLV_ABORT</b>	<p><b>Slave 3-wire Mode Abort Control Bit (Slave Only)</b></p> <p>In normal operation, there is an interrupt event when the number of received bits meets the requirement which defined in TX_BIT_LEN.</p> <p>If the number of received bits is less than the requirement and there is no more bus clock input over one transfer time in Slave 3-wire mode, user can set this bit to force the current transfer done and then user can get a unit transfer interrupt event.</p> <p>0 = No force the transfer done when the NOSLVSEL bit is set to 1. 1 = Force the transfer done when the NOSLVSEL bit is set to 1.</p> <p><b>Note:</b> This bit will be cleared to 0 automatically by hardware after it is set to 1 by software.</p>
[8]	<b>NOSLVSEL</b>	<p><b>Slave 3-wire Mode Enable Control (Slave Only)</b></p> <p>The SPI controller work with 3-wire interface including SPICLK, SPI_MISO, and SPI_MOSI</p> <p>0 = The controller is 4-wire bi-direction interface. 1 = The controller is 3-wire bi-direction interface in Slave mode. The controller will be ready to transmit/receive data after the GO_BUSY bit is set to 1.</p> <p><b>Note:</b> In Slave 3-wire mode, the SS_LTRIG bit (SPI_SSR[4]) shall be set as 1.</p>
[7:0]	<b>Reserved</b>	Reserved.

**SPI FIFO Control Register (SPI\_FIFO\_CTL)**

Register	Offset	R/W	Description				Reset Value
SPI_FIFO_CTL	SPI_BA+0x40	R/W	SPI FIFO Control Register				0x2200_0000

31	30	29	28	27	26	25	24
Reserved		TX_THRESHOLD			Reserved	RX_THRESHOLD	
23	22	21	20	19	18	17	16
Reserved		TIMEOUT_IN_TEN	Reserved				
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	RXOV_INTEN	Reserved		TX_INTEN	RX_INTEN	TX_CLR	RX_CLR

Bits	Description	
[31:30]	Reserved	Reserved.
[29:28]	TX_THRESHOLD [1:0]	<b>Transmit FIFO Threshold</b> If the valid data count of the transmit FIFO buffer is less than or equal to the TX_THRESHOLD setting, the TX_INTSTS bit will be set to 1, else the TX_INTSTS bit will be cleared to 0.
[27:26]	Reserved	Reserved.
[25:24]	RX_THRESHOLD [1:0]	<b>Received FIFO Threshold</b> If the valid data count of the receive FIFO buffer is larger than the RX_THRESHOLD setting, the RX_INTSTS bit will be set to 1, else the RX_INTSTS bit will be cleared to 0.
[23:22]	Reserved	Reserved.
[21]	TIMEOUT_INTEN	<b>Receive FIFO Time-out Interrupt Enable Control</b> 0 = Time-out interrupt Disabled. 1 = Time-out interrupt Enabled.
[20:7]	Reserved	Reserved.
[6]	RXOV_INTEN	<b>Receive FIFO Overrun Interrupt Enable Control</b> 0 = Receive FIFO overrun interrupt Disabled. 1 = Receive FIFO overrun interrupt Enabled.
[5:4]	Reserved	Reserved.
[3]	TX_INTEN	<b>Transmit Threshold Interrupt Enable Control</b> 0 = Transmit threshold interrupt Disabled. 1 = Transmit threshold interrupt Enabled.
[2]	RX_INTEN	<b>Receive Threshold Interrupt Enable Control</b> 0 = Receive threshold interrupt Disabled. 1 = Receive threshold interrupt Enabled.

[1]	TX_CLR	<b>Clear Transmit FIFO Buffer</b> 0 = No effect. 1 = Clear transmit FIFO buffer. <b>Note:</b> This bit will be cleared to 0 by hardware after software sets it to 1 and the transmit FIFO is cleared.
[0]	RX_CLR	<b>Clear Receive FIFO Buffer</b> 0 = No effect. 1 = Clear receive FIFO buffer. <b>Note:</b> This bit will be cleared to 0 by hardware after software sets it to 1 and the receive FIFO is cleared.

**SPI Status Register (SPI\_STATUS)**

Register	Offset	R/W	Description				Reset Value
SPI_STATUS	SPI_BA+0x44	R/W	SPI Status Register				0x0500_0000

31	30	29	28	27	26	25	24
TX_FIFO_COUNT				TX_FULL	TX_EMPTY	RX_FULL	RX_EMPTY
23	22	21	20	19	18	17	16
Reserved		TIMEOUT		Reserved			IF
15	14	13	12	11	10	9	8
RX_FIFO_COUNT				SLV_STAR_I NTSTS	Reserved		
7	6	5	4	3	2	1	0
Reserved			TX_INTSTS	Reserved	RX_OVERRUN	Reserved	RX_INTSTS

Bits	Description	
[31:28]	TX_FIFO_COUNT[3:0]	<b>Transmit FIFO Data Count (Read Only)</b> Indicates the valid data count of transmit FIFO buffer.
[27]	TX_FULL	<b>Transmit FIFO Buffer Full Indicator (Read Only)</b> 0 = The transmit FIFO buffer is not full. 1 = The transmit FIFO buffer is full. <b>Note:</b> It's a mutual mirror bit of SPI_CNTRL[27].
[26]	TX_EMPTY	<b>Transmit FIFO Buffer Empty Indicator (Read Only)</b> 0 = The transmit FIFO buffer is not empty. 1 = The transmit FIFO buffer is empty. <b>Note:</b> It's a mutual mirror bit of SPI_CNTRL[26].
[25]	RX_FULL	<b>Receive FIFO Buffer Full Indicator (Read Only)</b> 0 = The receive FIFO buffer is not full. 1 = The receive FIFO buffer is full. <b>Note:</b> It's a mutual mirror bit of SPI_CNTRL[25].
[24]	RX_EMPTY	<b>Receive FIFO Buffer Empty Indicator (Read Only)</b> 0 = The receive FIFO buffer is not empty. 1 = The receive FIFO buffer is empty. <b>Note:</b> It's a mutual mirror bit of SPI_CNTRL[24].
[23:21]	Reserved	Reserved.
[20]	TIMEOUT	<b>Time-out Interrupt Flag</b> 0 = No receive FIFO time-out event. 1 = The receive FIFO buffer is not empty and it does not get read over 64 SPI clock periods in Master mode or over 576 SPI peripheral clock periods in Slave mode. When the received FIFO buffer is read by software, the time-out status will be cleared automatically. <b>Note:</b> This bit will be cleared by writing 1 to itself.

[19:17]	<b>Reserved</b>	Reserved.
[16]	<b>IF</b>	<p><b>SPI Unit-transfer Interrupt Flag</b>            0 = The transfer does not finish yet.            1 = The SPI controller has finished one unit transfer.</p> <p><b>Note 1:</b> This bit will be cleared by writing 1 to itself.  <b>Note 2:</b> It's a mutual mirror bit of SPI_CNTRL[16].</p>
[15:12]	<b>RX_FIFO_COUNT[3:0]</b>	<p><b>Receive FIFO Data Count (Read Only)</b>            Indicates the valid data count of receive FIFO buffer.</p>
[11]	<b>SLV_START_INT_STS</b>	<p><b>Slave Start Interrupt Status (Slave Only)</b>            It is used to dedicate that the transfer has started in slave 3-wire mode.            0 = Slave does not detect any SPI bus clock transfer since the SSTA_INTEN bit was set to 1.            1 = The transfer has started in slave 3-wire mode.</p> <p><b>Note 1:</b> It will be cleared as transfer done or by writing one to this bit.  <b>Note 2:</b> It's a mutual mirror bit of SPI_CNTRL2[11].</p>
[10:5]	<b>Reserved</b>	Reserved.
[4]	<b>TX_INTSTS</b>	<p><b>Transmit FIFO Threshold Interrupt Status (Read Only)</b>            0 = The valid data count within the transmit FIFO buffer is larger than the setting value of TX_THRESHOLD.            1 = The valid data count within the transmit FIFO buffer is less than or equal to the setting value of TX_THRESHOLD.</p> <p><b>Note:</b> If TX_INTEN = 1 and TX_INTSTS = 1, the SPI controller will generate a SPI interrupt request.</p>
[3]	<b>Reserved</b>	Reserved.
[2]	<b>RX_OVERRUN</b>	<p><b>Receive FIFO Overrun Status</b>            When the receive FIFO buffer is full, the follow-up data will be dropped and this bit will be set to 1.            0 = No overrun in receive FIFO.            1 = Overrun in receive FIFO.</p> <p><b>Note:</b> This bit will be cleared by writing 1 to itself.</p>
[1]	<b>Reserved</b>	Reserved.
[0]	<b>RX_INTSTS</b>	<p><b>Receive FIFO Threshold Interrupt Status (Read Only)</b>            0 = The valid data count within the Rx FIFO buffer is smaller than or equal to the setting value of RX_THRESHOLD.            1 = The valid data count within the receive FIFO buffer is larger than the setting value of RX_THRESHOLD.</p> <p><b>Note:</b> If RX_INTEN = 1 and RX_INTSTS = 1, the SPI controller will generate a SPI interrupt request.</p>

## 5.17 Analog-to-Digital Converter (ADC)

### 5.17.1 Overview

The NuMicro® NUC029xAN contains one 12-bit successive approximation analog-to-digital converters (SAR A/D converter) with 8 input channels, and The NuMicro® NUC029FAE contains one 10-bit successive approximation analog-to-digital converters (SAR A/D converter) with 8 input channels.

The A/D converter of NUC029xAN supports four operation modes: Single, Burst, Single-cycle Scan and Continuous Scan mode, and the A/D converter of NUC029xAN only supports Single mode.

The A/D converter can be started by software, PWM trigger and external STADC pin.

### 5.17.2 Features

- Analog input voltage range: 0~AV<sub>DD</sub>
- 12-bit resolution and 10-bit accuracy is guaranteed (NUC029xAN only)
- 10-bit resolution and 8-bit accuracy is guaranteed (NUC029FAE only)
- Up to 8 single-end analog input channels
  - Or 4 differential analog input channels (NUC029xAN only)
- Up to 760 kSPS sample rate for NUC029xAN
- 300 KSPS (V<sub>DD</sub> 4.5V - 5.5V) and 200 KSPS (V<sub>DD</sub> 2.5V - 5.5V) conversion rate for NUC029FAE
- Four operating modes (NUC029FAE only supports Single mode)
  - Single mode: A/D conversion is performed one time on a specified channel
  - Burst mode: A/D converter samples and converts the specified single channel and sequentially stores the result in FIFO.
  - Single-cycle Scan mode: A/D conversion is performed one cycle on all specified channels with the sequence from the smallest numbered channel to the largest numbered channel
  - Continuous Scan mode: A/D converter continuously performs Single-cycle scan mode until software stops A/D conversion
- An A/D conversion can be started by:
  - Writing 1 to ADST bit (ADCR[11]) through software
  - PWM trigger with optional start delay period
  - External pin STADC
- Each conversion result is held in data register with valid and overrun indicators
- Each channel has individual data register (NUC029xAN only)
- The conversion result can be compared with specify value and user can select whether to generate an interrupt when conversion result matches the compare register setting
- Channel 7 supports 3 input sources:
  - external analog voltage
  - internal Band-gap voltage

- internal temperature sensor output (NUC029xAN only)

### 5.17.3 Block Diagram for NUC029xAN

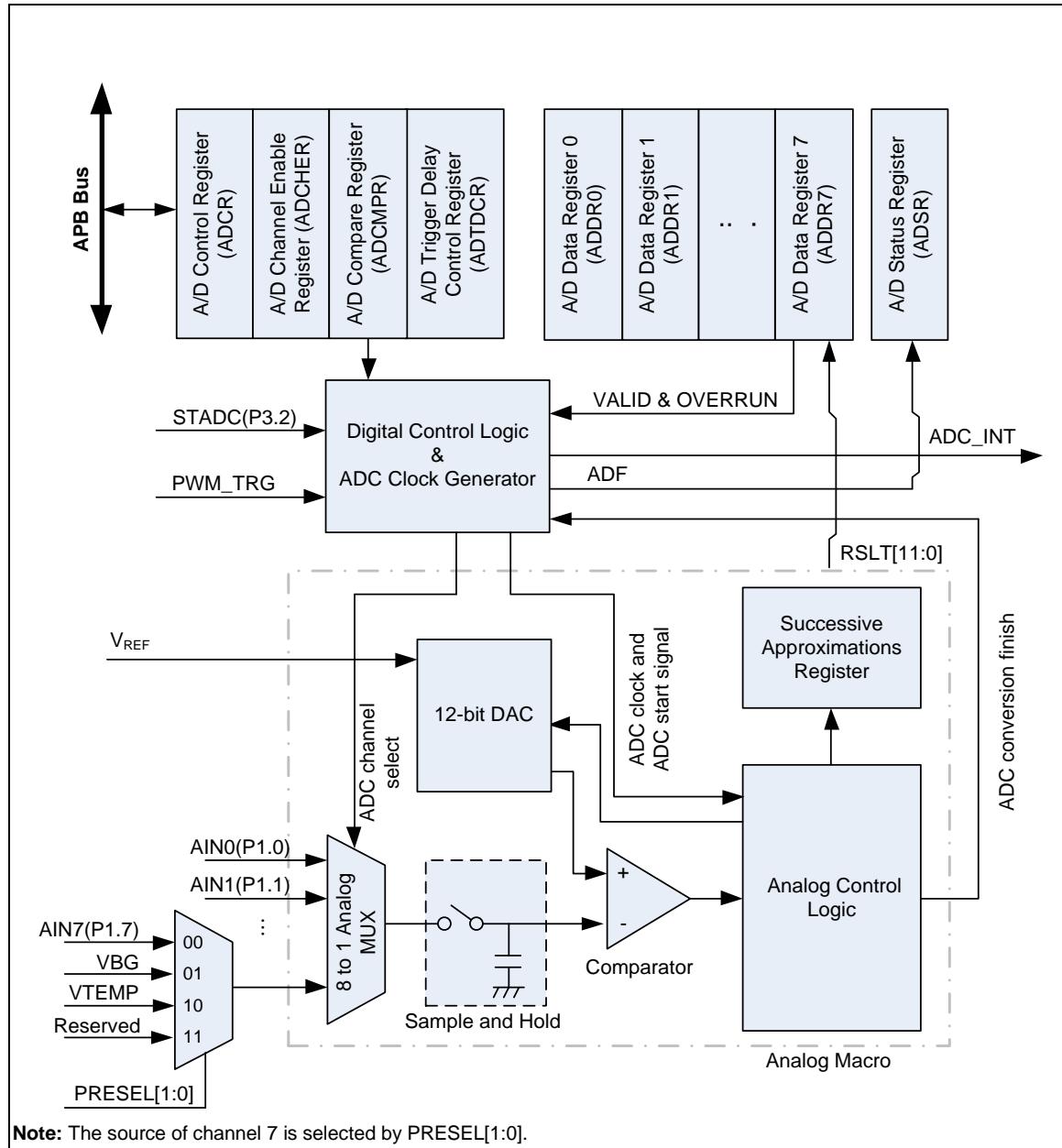


Figure 5-133 A/D Controller Block Diagram for NUC029xAN

#### 5.17.4 Block Diagram for NUC029FAE

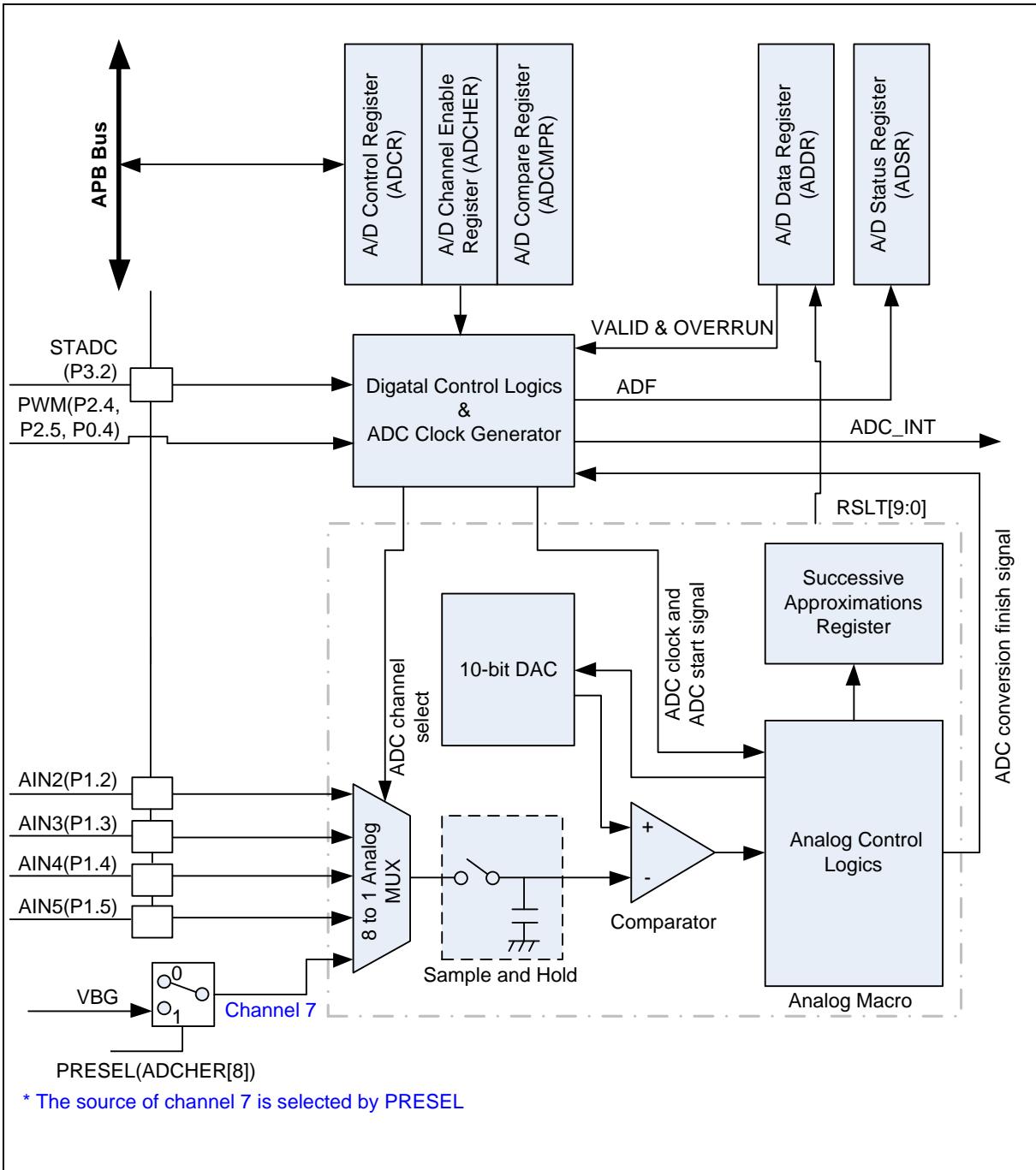


Figure 5-134 A/D Controller Block Diagram for NUC029FAE

#### 5.17.5 Basic Configuration

The ADC pin functions are configured in P1\_MFP register. It is recommended to disable the digital input path of the analog input pins to avoid the leakage current. User can disable the digital input path by configuring P1\_OFFD register.

The ADC peripheral clock can be enabled in ADC\_EN(APBCLK[28]). The ADC peripheral clock source is selected by ADC\_S(CLKSEL1[3:2]). The clock prescalar is determined by ADC\_N(CLKDIV[23:16]).

### 5.17.6 Functional Description

#### NUC029xAN:

The A/D converter operates by successive approximation with 12-bit resolution. The ADC has four operation modes: Single, Burst, Single-cycle Scan mode and Continuous Scan mode. When user wants to change the operation mode or analog input channel, in order to prevent incorrect operation, software must clear ADST(ADCR[11]) bit to 0 in advance.

#### NUC029FAE:

The A/D converter operates by successive approximation with 10-bit resolution. When changing the analog input channel is enabled, in order to prevent incorrect operation, software must clear ADST(ADCR[11]) bit to 0 in the ADCR register. The A/D converter discards the current conversion immediately and enters idle state while ADST bit is cleared.

#### 5.17.6.1 ADC peripheral Clock Generator

##### NUC029xAN:

The maximum sampling rate is up to 760 kSPS. The ADC has four clock sources selected by ADC\_S(CLKSEL1[3:2]), the ADC peripheral clock frequency is divided by an 8-bit pre-scalar with the following formula:

ADC peripheral clock frequency = (ADC peripheral clock source frequency) / (ADC\_N+1); where the 8-bit ADC\_N is located in register CLKDIV[23:16].

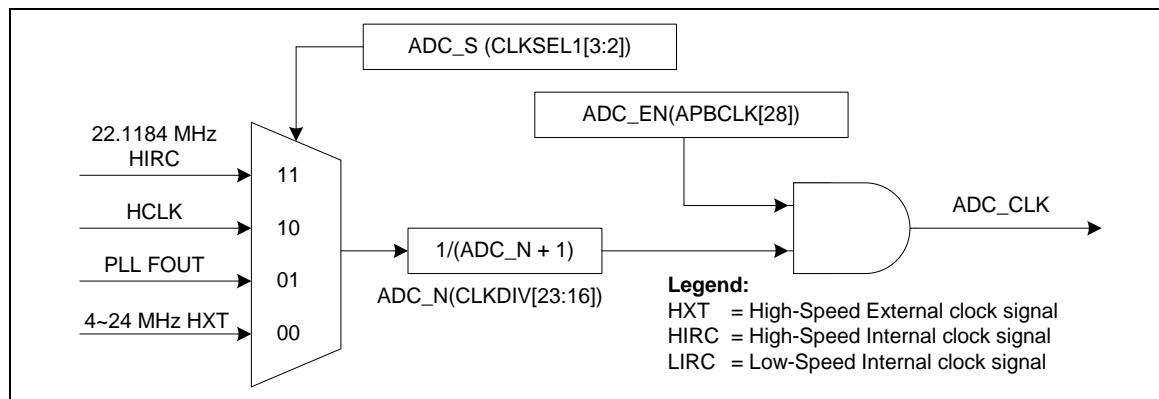


Figure 5-135 ADC Peripheral Clock Control for NUC029xAN

##### NUC029FAE:

The maximum sampling rate is up to 760 kSPS. The ADC engine has four clock sources selected by ADC\_S(CLKSEL1[3:2]), and selected between HXT and LXT by XTLCLK\_EN(PWRCON[1:0]). The ADC clock peripheral frequency is divided by an 8-bit prescaler with the following formula:

ADC peripheral clock frequency = (ADC peripheral clock source frequency) / (ADC\_N+1);

where the 8-bit ADC\_N is located in register CLKDIV[23:16].

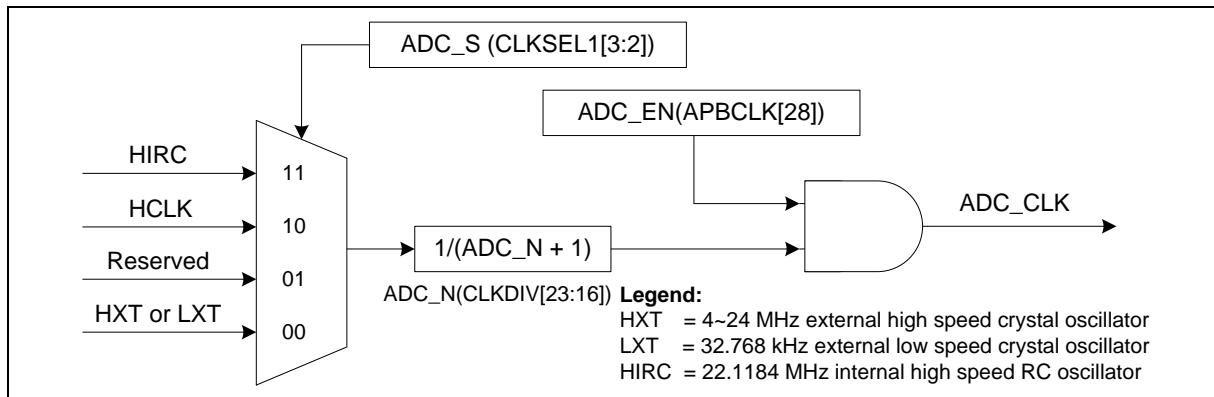


Figure 5-136 ADC Peripheral Clock Control for NUC029FAE

#### 5.17.6.2 Operation Mode

The A/D converter of NUC029xAN supports four operation modes: Single, Burst, Single-cycle Scan and Continuous Scan mode, and the A/D converter of NUC029xAN only supports Single mode.

##### 5.17.6.2.1 Single Mode

In Single mode, A/D conversion is performed only once on the specified single channel. The operations are as follows:

1. A/D conversion will be started when the ADST(ADCR[11]) bit is set to 1 by software or external trigger input.
2. When A/D conversion is finished, the result is stored in the A/D data register corresponding to the channel for NUC029xAN and the result is stored in the A/D data register for NUC029FAE.
3. The ADF(ADSR[0]) bit will be set to 1. If the ADIE(ADCR[1]) bit is set to 1, the ADC interrupt will be asserted.
4. The ADST(ADCR[11]) bit remains 1 during A/D conversion. When A/D conversion ends, the ADST bit is automatically cleared to 0 and the A/D converter enters idle state.

**Note 1:** If software enables more than one channel in Single mode, only the channel with the smallest number will be selected and the other enabled channels will be ignored.

**Note 2:** If ADST bit is cleared to 0 when ADC is in converting, the BUSY bit will be cleared to 0 immediately, ADC cannot finish the current conversion and A/D converter enters idle state directly.

An example timing diagram for Single mode is shown below.

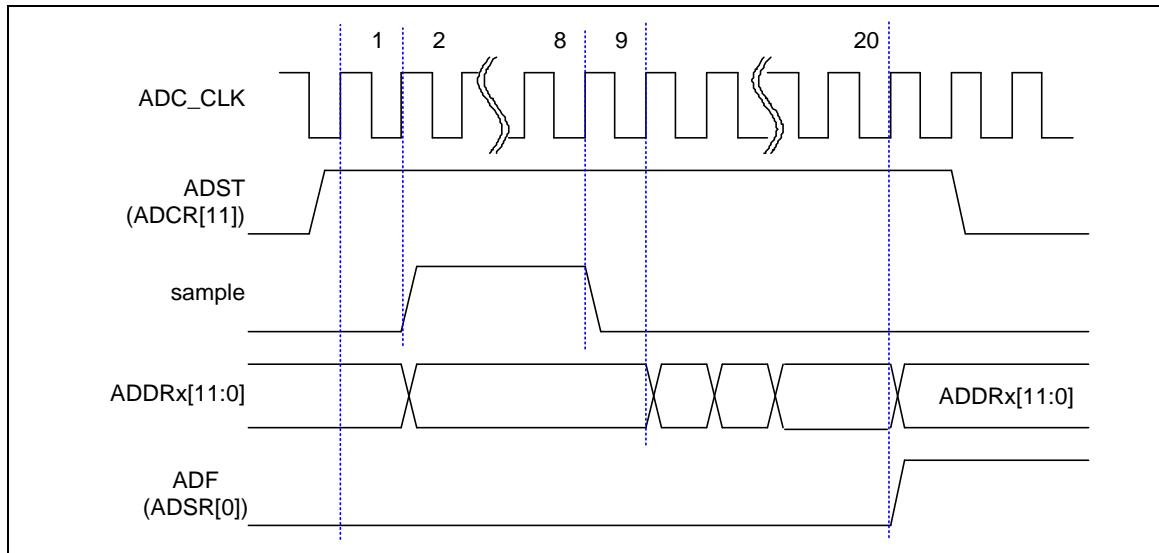


Figure 5-137 Single Mode Conversion Timing Diagram for NUC029xAN

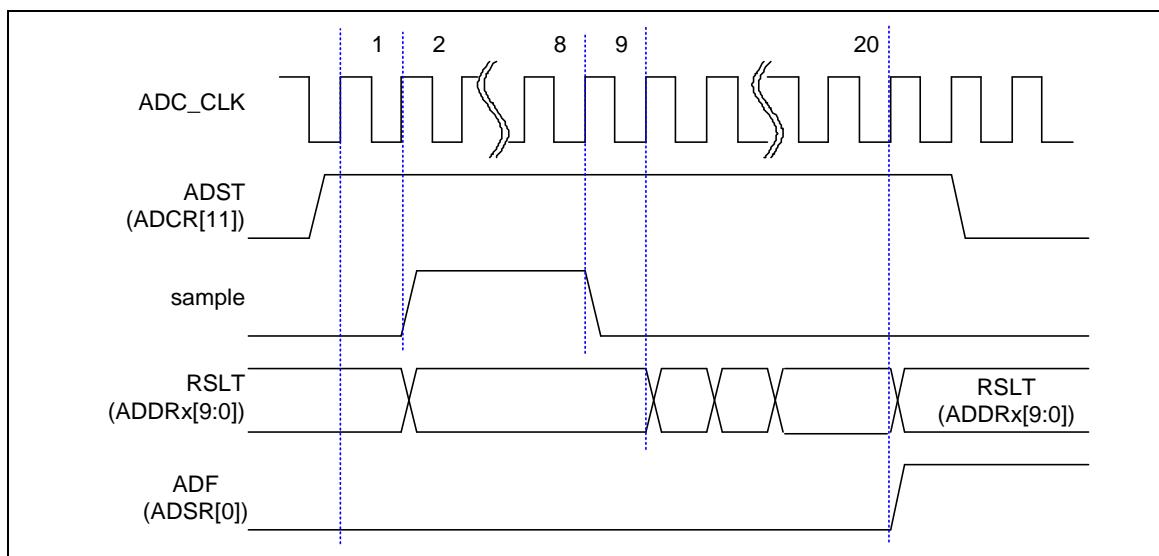


Figure 5-138 Single Mode Conversion Timing Diagram for NUC029FAE

#### 5.17.6.2.2 Burst Mode

In Burst mode, A/D converter samples and converts the specified single channel and sequentially stores the result into FIFO (up to 8 samples). The operations are as follows:

1. When the ADST(ADCR[11]) bit in ADCR is set to 1 by software or external trigger input, A/D conversion is started on the channel with the smallest number.
2. When A/D conversion for the specified channel is completed, the result is sequentially transferred to FIFO and can be accessed only from the A/D data register 0.
3. When more than 4 samples in FIFO, the ADF(ADSR[0]) bit is set to 1. If the ADIE(ADCR[1])

bit is set to 1 at this time, an ADC interrupt is requested after finishing the A/D conversion.

4. Steps 2 to 3 are repeated as long as the ADST(ADCR[11]) bit remains set to 1. When the ADST(ADCR[11]) bit is cleared to 0, ADC cannot finish the current conversion and A/D converter enters idle state directly.

**Note:** If software enables more than one channel in Burst mode, only the channel with the smallest number is converted and other enabled channels will be ignored.

#### 5.17.6.2.3 Single-Cycle Scan Mode

In Single-cycle Scan mode, A/D converter samples and converts all of the specified channels once in the sequence from the smallest number enabled channel to the largest number enabled channel. Operations are as follows:

1. When the ADST(ADCR[11]) bit is set to 1 by software or external trigger input, A/D conversion is started on the channel with the smallest number.
2. When A/D conversion for each enabled channel is completed, the result is sequentially transferred to the A/D data register corresponding to each channel.
3. When the conversions of all the enabled channels are completed, the ADF(ADSR[0]) bit is set to 1. If the ADC interrupt function is enabled, the ADC interrupt occurs.
4. After ADC finishes one cycle conversion, the ADST(ADCR[11]) bit is automatically cleared to 0 and the A/D converter enters idle state. If ADST(ADCR[11]) is cleared to 0 before all enabled ADC channels conversion done, ADC cannot finish the current conversion and A/D converter enters idle state directly.

An example timing diagram for Single-cycle Scan mode on enabled channels (0, 2, 3 and 7) is shown below.

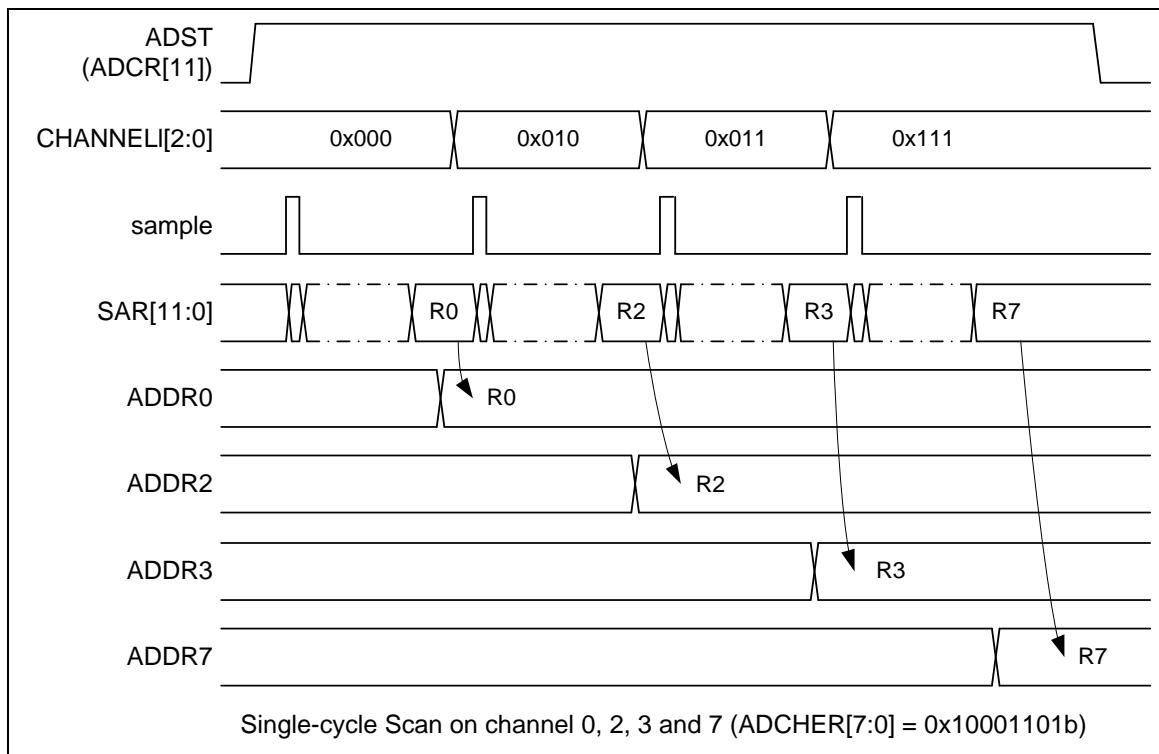


Figure 5-139 Single-Cycle Scan Mode on Enabled Channels Timing Diagram

#### 5.17.6.2.4 Continuous Scan Mode

In Continuous Scan mode, A/D conversion is performed sequentially on the specified channels that enabled by CHEN(ADCR[7:0]) bits (maximum 8 channels for ADC). The operations are as follows:

1. When the ADST(ADCR[11]) bit is set to 1 by software or external trigger input, A/D conversion is started on the channel with the smallest number.
2. When A/D conversion for each enabled channel is completed, the result of each enabled channel is stored in the A/D data register corresponding to each enabled channel.
3. When A/D converter completes the conversions of all enabled channels sequentially, the ADF(ADSR[0]) bit will be set to 1. If the ADC interrupt function is enabled, the ADC interrupt occurs. The conversion of the enabled channel with the smallest number will start again if software does not clear the ADST(ADCR[11]) bit.
4. As long as the ADST(ADCR[11]) bit remains at 1, the step 2 ~ 3 will be repeated. When ADST(ADCR[11]) is cleared to 0, ADC cannot finish the current conversion and A/D converter enters idle state directly.

An example timing diagram for Continuous Scan mode on enabled channels (0, 2, 3 and 7) is shown below.

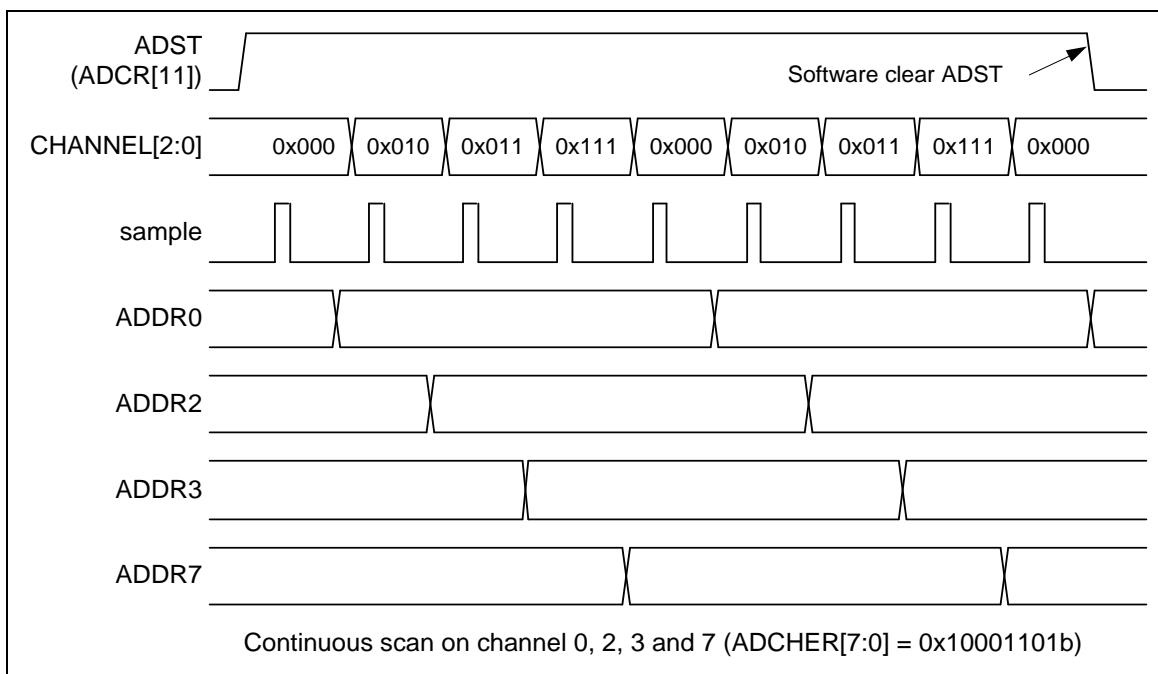


Figure 5-140 Continuous Scan Mode on Enabled Channels Timing Diagram

#### 5.17.6.3 External Trigger Input Sampling and A/D Conversion Time

##### **NUC029xAN:**

In Single-cycle Scan mode, A/D conversion can be triggered by external pin request. When the TRGEN(ADCR[8]) bit is set to 1 to enable ADC external trigger function, setting the TRGS(ADCR[5:4]) bits to 00b is to select external trigger input from the STADC pin. Software can set TRGCOND(ADCR[7:6]) to select trigger condition is falling/rising edge or low/high level. If level trigger condition is selected, the STADC pin must be kept at specified state at least 8 PCLKs. The ADST(ADCR[11]) bit will be set to 1 at the 9<sup>th</sup> PCLK and start to convert. Conversion will keep going if external trigger input is kept at active state in level trigger mode. It is stopped only when external condition trigger condition disappears. If edge trigger condition is selected, the high and low state must be kept at least 4 PLCKs. Pulse that is shorter than this specification will be ignored.

**Note:** User must enable the external trigger function or enable ADC at least 4 PCLKs after enabling ADC peripheral clock.

##### **NUC029FAE:**

A/D conversion can be triggered by external pin request. When the TRGEN(ADCR[8]) bit is set to 1 to enable ADC external trigger function, setting the TRGS(ADCT[5:4]) bits to 00b is to select external trigger input from the STADC pin. Software can set TRGCOND(ADCR[6]) to select trigger condition between falling or rising edge. An 8-bit sampling counter is used to deglitch. If edge trigger condition is selected, the high and low state must be kept at least 4 PLCKs. Pulse that is shorter than this specification will be ignored.

#### 5.17.6.4 PWM trigger

##### **NUC029xAN:**

In Single-cycle Scan mode, A/D conversion can be triggered by PWM request. When the TRGEN(ADCR[8]) bit is set to 1 to enable ADC external hardware trigger function, setting the

TRGS(ADCT[5:4] bits to 11b is to select external hardware trigger input source from PWM trigger. When PWM trigger is enabled, setting PTDT(ADTDCR[7:0]) bits can insert a delay time between PWM trigger condition and ADC start conversion.

#### NUC029FAE:

A/D conversion can also be triggered by PWM request. When the TRGEN(ADCR[8]) is set to high to enable ADC external hardware trigger function, setting the TRGS(ADCT[5:4] bits to 11b is to select external hardware trigger input source from PWM trigger. When PWM trigger is enabled, setting PTDT(ADTDCR[7:0]) bits can insert a delay time between PWM trigger condition and ADC start conversion.

#### 5.17.6.5 Conversion Result Monitor by Compare Mode Function

The NuMicro® NUC029 series ADC controller provides two compare registers, ADCMPR0 and ADCMPR1, to monitor maximum two specified channels. Software can select which channel to be monitored by setting CMPCH(ADCMPRx[5:3]). CMPCOND(ADCMPRx[2]) bit is used to determine the compare condition. If CMPCOND(ADCMPRx[2]) bit is cleared to 0, the internal match counter will increase one when the conversion result is less than the value specified in CMPD[11:0] for NUC029xAN and CMPD[9:0] for NUC029xAN; if CMPCOND(ADCMPRx[2]) bit is set to 1, the internal match counter will increase one when the conversion result is greater than or equal to the value specified in CMPD[11:0] for NUC029xAN and CMPD[9:0] for NUC029xAN. When the conversion of the channel specified by CMPCH(ADCMPRx[5:3]) is completed, the comparing action will be triggered one time automatically. When the compare result meets the setting, compare match counter will increase 1, otherwise, the compare match counter will be clear to 0. When the match counter reaches the setting of (CMPMATCNT+1) then CMPF bit will be set to 1, if CMPIE(ADCMPRx[1]) bit is set then an ADC\_INT interrupt request is generated. Software can use it to monitor the external analog input pin voltage transition in scan mode without imposing a load on software. The detailed logic diagram is shown below.

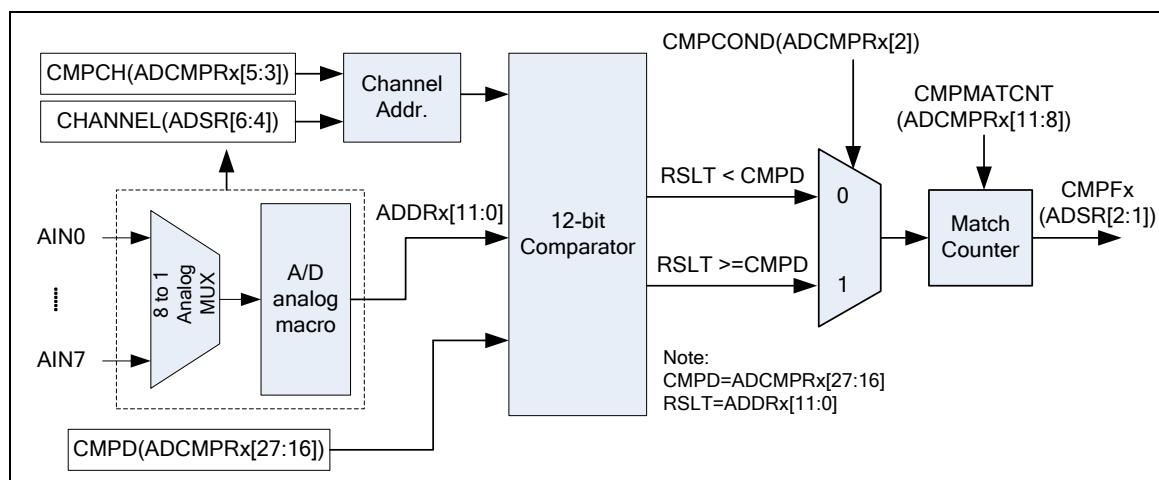


Figure 5-141 A/D Conversion Result Monitor Logic Diagram for NUC029xAN

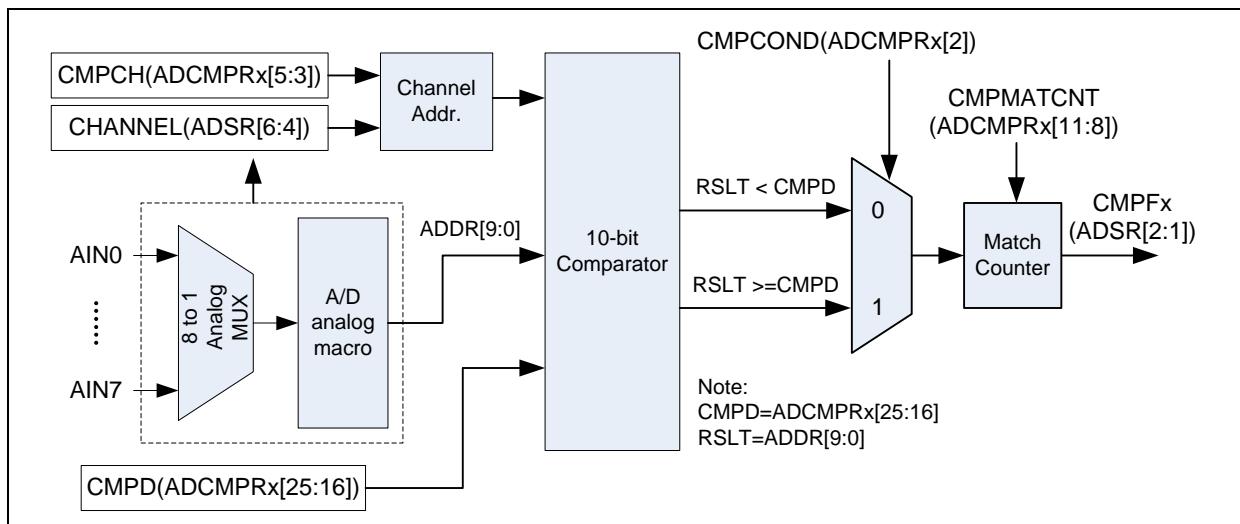


Figure 5-142 A/D Conversion Result Monitor Logic Diagram for NUC029FAE

#### 5.17.6.6 Interrupt Sources

There are three interrupt sources of ADC interrupt. When an ADC operation mode finishes its conversion, the A/D conversion end flag, ADF(ADSR[0]), will be set to 1. The CMPF0(ADSR[1]) and CMPF1(ADSR[2]) are the compare flags of compare function. When the conversion result meets the settings of ADCMP0/1, the corresponding flag will be set to 1. When one of the flags, ADF(ADSR[0]), CMPF0(ADSR[1]) and CMPF1(ADSR[2]), is set to 1 and the corresponding interrupt enable bit, ADIE(ADCR[1]) and CMPIE(ADCMPRx[1]), is set to 1, the ADC interrupt will be asserted. Software can clear these flags to revoke the interrupt request.

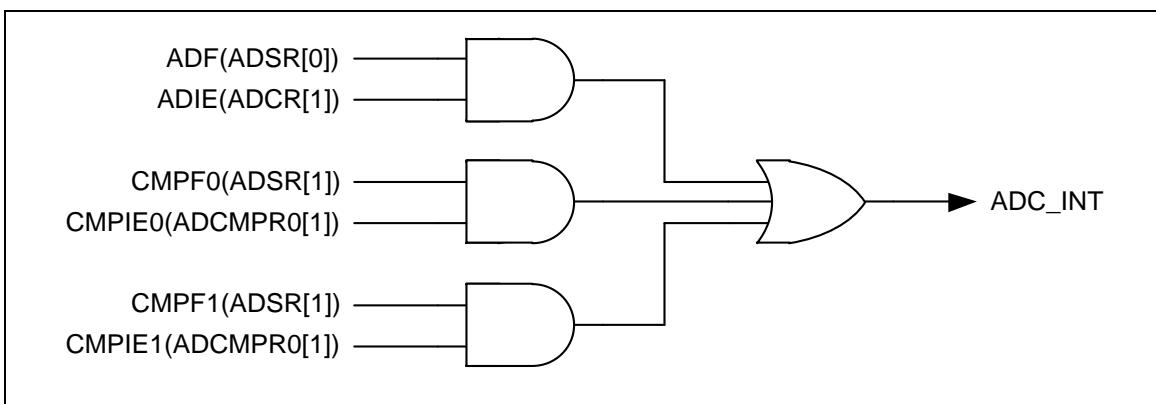


Figure 5-143 A/D Controller Interrupt

### 5.17.7 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write.

Register	Offset	R/W	Description	Reset Value
<b>ADC Base Address:</b>				
<b>ADC_BA = 0x400E_0000</b>				
<b>ADDR0</b>	ADC_BA+0x00	R	ADC Data Register 0	0x0000_0000
<b>ADDR1</b>	ADC_BA+0x04	R	ADC Data Register 1	0x0000_0000
<b>ADDR2</b>	ADC_BA+0x08	R	ADC Data Register 2	0x0000_0000
<b>ADDR3</b>	ADC_BA+0x0C	R	ADC Data Register 3	0x0000_0000
<b>ADDR4</b>	ADC_BA+0x10	R	ADC Data Register 4	0x0000_0000
<b>ADDR5</b>	ADC_BA+0x14	R	ADC Data Register 5	0x0000_0000
<b>ADDR6</b>	ADC_BA+0x18	R	ADC Data Register 6	0x0000_0000
<b>ADDR7</b>	ADC_BA+0x1C	R	ADC Data Register 7	0x0000_0000
<b>ADCR</b>	ADC_BA+0x20	R/W	ADC Control Register	0x0000_0000
<b>ADCHER</b>	ADC_BA+0x24	R/W	ADC Channel Enable Register	0x0000_0000
<b>ADCMR0</b>	ADC_BA+0x28	R/W	ADC Compare Register 0	0x0000_0000
<b>ADCMR1</b>	ADC_BA+0x2C	R/W	ADC Compare Register 1	0x0000_0000
<b>ADSR</b>	ADC_BA+0x30	R/W	ADC Status Register	0x0000_0000
<b>ADTDCR</b>	ADC_BA+0x44	R/W	ADC Trigger Delay Control Register	0x0000_0000

### 5.17.8 Register Description for NUC029xAN

#### ADC Data Registers (ADDR0 ~ ADDR7)

Register	Offset	R/W	Description				Reset Value
ADDR0	ADC_BA+0x00	R	ADC Data Register 0				0x0000_0000
ADDR1	ADC_BA+0x04	R	ADC Data Register 1				0x0000_0000
ADDR2	ADC_BA+0x08	R	ADC Data Register 2				0x0000_0000
ADDR3	ADC_BA+0x0C	R	ADC Data Register 3				0x0000_0000
ADDR4	ADC_BA+0x10	R	ADC Data Register 4				0x0000_0000
ADDR5	ADC_BA+0x14	R	ADC Data Register 5				0x0000_0000
ADDR6	ADC_BA+0x18	R	ADC Data Register 6				0x0000_0000
ADDR7	ADC_BA+0x1C	R	ADC Data Register 7				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved						VALID	OVERRUN
15	14	13	12	11	10	9	8
RSLT							
7	6	5	4	3	2	1	0
RSLT							

Bits	Description	
[31:18]	Reserved	Reserved.
[17]	VALID	<b>Valid Flag</b> 0 = Data in RSLT bits is not valid. 1 = Data in RSLT bits is valid. This bit will be set to 1 when the conversion of the corresponding channel is completed. This bit will be cleared to 0 by hardware after ADDR register is read. This is a read only bit.
[16]	OVERRUN	<b>Overrun Flag (Read Only)</b> 0 = Data in RSLT is not overwrote. 1 = Data in RSLT is overwrote. If converted data in RSLT has not been read before new conversion result is loaded to this register, OVERRUN is set to 1. It is cleared by hardware after ADDR register is read.
[15:0]	RSLT	<b>A/D Conversion Result</b> This field contains conversion result of ADC.

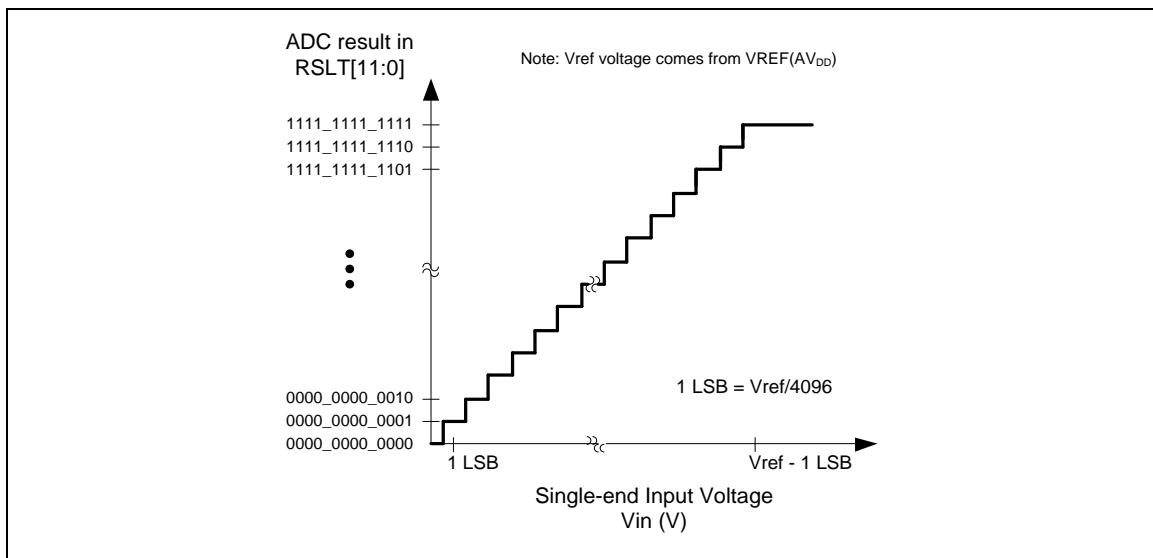


Figure 5-144 Conversion Result Mapping Diagram of ADC Single-end Input

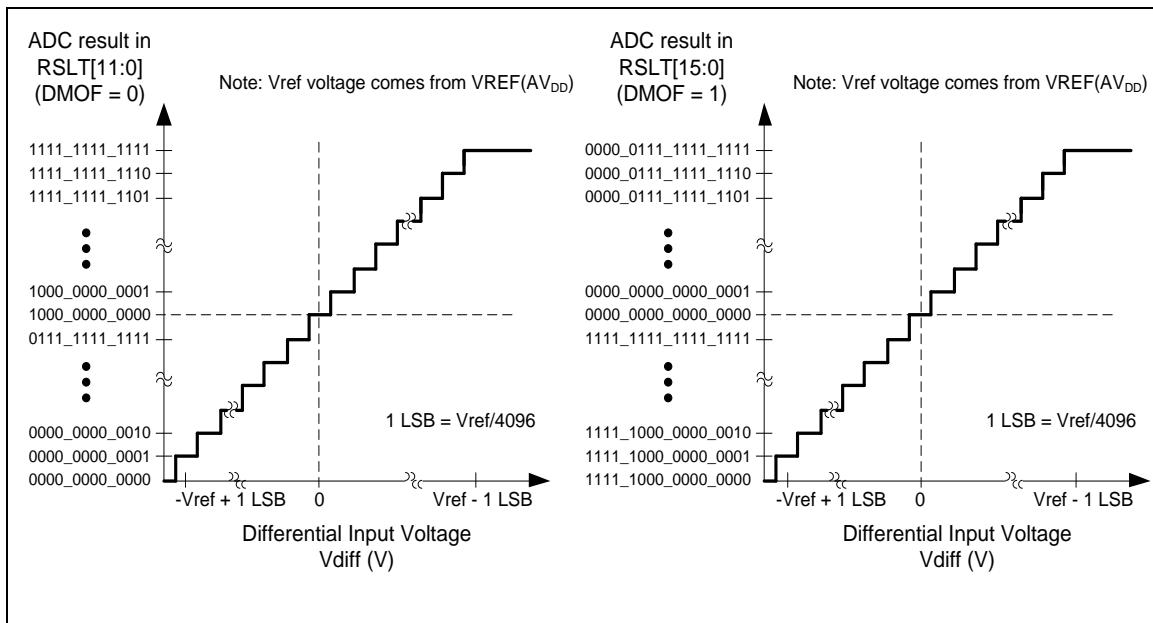


Figure 5-145 Conversion Result Mapping Diagram of ADC Differential Input

**ADC Control Register (ADCR)**

Register	Offset	R/W	Description				Reset Value
ADCR	ADC_BA+0x20	R/W	ADC Control Register				0x0000_0000

31	30	29	28	27	26	25	24
DMOF	Reserved						
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				ADST	DIFFEN	Reserved	TRGEN
7	6	5	4	3	2	1	0
TRGCOND		TRGS		ADMID		ADIE	ADEN

Bits	Description																				
[31]	<b>DMOF</b> <b>Differential Input Mode Output Format</b> 0 = A/D Conversion result will be filled in RSLT at ADDR <sub>x</sub> registers with unsigned format (straight binary format). 1 = A/D Conversion result will be filled in RSLT at ADDR <sub>x</sub> registers with 2's complement format.																				
[30:12]	Reserved.																				
[11]	<b>ADST</b> <b>A/D Conversion Start</b> ADST bit can be set to 1 from two sources: software or external pin STADC. ADST will be cleared to 0 by hardware automatically at the ends of Single mode and Single-cycle Scan mode. In Continuous Scan mode and Burst mode, A/D conversion is continuously performed until software writes 0 to this bit or chip is reset. 0 = Conversion stops and A/D converter enters idle state. 1 = Conversion starts.																				
[10]	<b>DIFFEN</b> <b>Differential Input Mode Control</b> 0 = Single-end analog input mode. 1 = Differential analog input mode.																				
	<table border="1"> <thead> <tr> <th>Differential Input Paired Channel</th> <th colspan="2">ADC Analog Input</th> </tr> </thead> <tbody> <tr> <td></td> <td>V<sub>plus</sub></td> <td>V<sub>minus</sub></td> </tr> <tr> <td>0</td> <td>AIN0</td> <td>AIN1</td> </tr> <tr> <td>1</td> <td>AIN2</td> <td>AIN3</td> </tr> <tr> <td>2</td> <td>AIN4</td> <td>AIN5</td> </tr> <tr> <td>3</td> <td>AIN6</td> <td>AIN7</td> </tr> </tbody> </table> <b>Differential input voltage (V<sub>diff</sub>) = V<sub>plus</sub> - V<sub>minus</sub></b> , where V <sub>plus</sub> is the analog input; V <sub>minus</sub> is the inverted analog input. <b>Note:</b> In Differential Input mode, only the even number of the two corresponding channels needs to be enabled in ADCHER register. The conversion result will be placed to the corresponding data register of the enabled channel.			Differential Input Paired Channel	ADC Analog Input			V <sub>plus</sub>	V <sub>minus</sub>	0	AIN0	AIN1	1	AIN2	AIN3	2	AIN4	AIN5	3	AIN6	AIN7
Differential Input Paired Channel	ADC Analog Input																				
	V <sub>plus</sub>	V <sub>minus</sub>																			
0	AIN0	AIN1																			
1	AIN2	AIN3																			
2	AIN4	AIN5																			
3	AIN6	AIN7																			

[9]	<b>Reserved</b>	Reserved.
[8]	<b>TRGEN</b>	<p><b>External Trigger Enable Control</b></p> <p>Enable or disable triggering of A/D conversion by external STADC pin. If external trigger is enabled, the ADST bit can be set to 1 by the selected hardware trigger source.</p> <p>0= External trigger Disabled. 1= External trigger Enabled.</p> <p><b>Note:</b> The ADC external trigger function is only supported in Single-cycle Scan mode.</p>
[7:6]	<b>TRGCOND</b>	<p><b>External Trigger Condition</b></p> <p>These two bits decide external pin STADC trigger event is level or edge. The signal must be kept at stable state at least 8 PCLKs for level trigger and at least 4 PCLKs for edge trigger.</p> <p>00 = Low level. 01 = High level. 10 = Falling edge. 11 = Rising edge.</p>
[5:4]	<b>TRGS</b>	<p><b>Hardware Trigger Source</b></p> <p>00 = A/D conversion is started by external STADC pin. 11 = A/D conversion is started by PWM trigger.</p> <p>Software should clear TRGEN bit and ADST bit to 0 before changing TRGS.</p>
[3:2]	<b>ADMD</b>	<p><b>A/D Converter Operation Mode Control</b></p> <p>00 = Single conversion. 01 = Burst conversion. 10 = Single-cycle Scan. 11 = Continuous Scan.</p> <p><b>Note1:</b> When changing the operation mode, software should clear ADST bit firstly. <b>Note2:</b> In Burst mode, the A/D result data always at Data Register 0.</p>
[1]	<b>ADIE</b>	<p><b>A/D Interrupt Enable Control</b></p> <p>A/D conversion end interrupt request is generated if ADIE bit is set to 1.</p> <p>0 = A/D interrupt function Disabled. 1 = A/D interrupt function Enabled.</p>
[0]	<b>ADEN</b>	<p><b>A/D Converter Enable</b></p> <p>0 = A/D converter Disabled. 1 = A/D converter Enabled.</p> <p><b>Note:</b> Before starting A/D conversion function, this bit should be set to 1. Clear it to 0 to disable A/D converter analog circuit to save power consumption.</p>

**ADC Channel Enable Register (ADCHER)**

Register	Offset	R/W	Description				Reset Value
ADCHER	ADC_BA+0x24	R/W	ADC Channel Enable Register				0x0000_0000

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

Bits	Description	
[31:10]	Reserved	Reserved.
[9:8]	PRESEL[1:0]	<b>Analog Input Channel 7 Source Selection</b> 00 = External analog input. 01 = Internal band-gap voltage. 10 = Internal temperature sensor. 11 = Reserved. <b>Note:</b> When the band-gap voltage is selected as the analog input source of ADC channel 7, ADC peripheral clock rate needs to be limited to lower than 300 kHz.
[7:0]	CHEN	<b>Analog Input Channel Enable Control</b> Set CHEN[7:0] to enable the corresponding analog input channel 7 ~ 0. If DIFFEN bit is set to 1, only the even number channel needs to be enabled. 0 = Channel Disabled. 1 = Channel Enabled.

**A/D Compare Register 0/1 (ADCMPRO/1)**

Register	Offset	R/W	Description					Reset Value
ADCMPRO	ADC_BA+0x28	R/W	ADC Compare Register 0					0x0000_0000
ADCMP1	ADC_BA+0x2C	R/W	ADC Compare Register 1					0x0000_0000

31	30	29	28	27	26	25	24
Reserved				CMPD			
23	22	21	20	19	18	17	16
CMPD							
15	14	13	12	11	10	9	8
Reserved				CMPPATCNT			
7	6	5	4	3	2	1	0
Reserved		CMPCH			CMPCOND	CMPIE	CMPEN

Bits	Description	
[31:28]	Reserved	Reserved.
[27:16]	CMPD	<b>Comparison Data</b> The 12-bit data is used to compare with conversion result of specified channel.
[15:12]	Reserved	Reserved.
[11:8]	CMPPATCNT	<b>Compare Match Count</b> When the specified A/D channel analog conversion result matches the compare condition defined by CMPCOND[2], the internal match counter will increase 1. When the internal counter reaches the value to (CMPPATCNT +1), the CMPFx bit will be set.
[7:6]	Reserved	Reserved.
[5:3]	CMPCH	<b>Compare Channel Selection</b> 000 = Channel 0 conversion result is selected to be compared. 001 = Channel 1 conversion result is selected to be compared. 010 = Channel 2 conversion result is selected to be compared. 011 = Channel 3 conversion result is selected to be compared. 100 = Channel 4 conversion result is selected to be compared. 101 = Channel 5 conversion result is selected to be compared. 110 = Channel 6 conversion result is selected to be compared. 111 = Channel 7 conversion result is selected to be compared.
[2]	CMPCOND	<b>Compare Condition</b> 0= Set the compare condition as that when a 12-bit A/D conversion result is less than the 12-bit CMPD (ADCMPRx[27:16]), the internal match counter will increase one. 1= Set the compare condition as that when a 12-bit A/D conversion result is greater than or equal to the 12-bit CMPD (ADCMPRx[27:16]), the internal match counter will increase one. <b>Note:</b> When the internal counter reaches to (CMPPATCNT +1), the CMPFx bit will

		be set.
[1]	<b>CMPIE</b>	<b>Compare Interrupt Enable Control</b> If the compare function is enabled and the compare condition matches the setting of CMPCOND and CMPMATCNT, CMPFx bit will be asserted, in the meanwhile, if CMPIE is set to 1, a compare interrupt request is generated. 0 = Compare function interrupt Disabled. 1 = Compare function interrupt Enabled.
[0]	<b>CMPEN</b>	<b>Compare Enable Control</b> Set this bit to 1 to enable ADC controller to compare CMPD[11:0] with specified channel conversion result when converted data is loaded into ADDR register. 0 = Compare function Disabled. 1 = Compare function Enabled.

**A/D Status Register (ADSR)**

Register	Offset	R/W	Description				Reset Value
ADSR	ADC_BA+0x30	R/W	ADC Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
OVERRUN							
15	14	13	12	11	10	9	8
VALID							
7	6	5	4	3	2	1	0
Reserved	CHANNEL			BUSY	CMPF1	CMPF0	ADF

Bits	Description	
[31:24]	Reserved	Reserved.
[23:16]	OVERRUN	<b>Overrun Flag (Read Only)</b> It is a mirror of OVERRUN bit in ADDR <sub>x</sub> register. When ADC is in Burst mode and the FIFO is overrun, all bits of OVERRUN[7:0] will be set to 1.
[15:8]	VALID	<b>Data Valid Flag (Read Only)</b> It is a mirror of VALID bit in ADDR <sub>x</sub> register. When ADC is in Burst mode and any conversion result is valid, all bits of VALID[7:0] will be set to 1.
[7]	Reserved	Reserved.
[6:4]	CHANNEL	<b>Current Conversion Channel</b> When BUSY=1, this field reflects current conversion channel. When BUSY=0, it shows the number of the next converted channel. It is read only.
[3]	BUSY	<b>BUSY/IDLE</b> This bit is a mirror of ADST bit in ADCR register. It is read only. 0 = A/D converter is in idle state. 1 = A/D converter is busy at conversion.
[2]	CMPF1	<b>Compare Flag 1</b> When the A/D conversion result of the selected channel meets setting condition in ADCMPR1 then this bit is set to 1; it is cleared by writing 1 to self. 0 = Conversion result in ADDR does not meet ADCMPR1 setting. 1 = Conversion result in ADDR meets ADCMPR1 setting.
[1]	CMPF0	<b>Compare Flag 0</b> When the A/D conversion result of the selected channel meets setting condition in ADCMPR0 then this bit is set to 1. This bit is cleared by writing 1 to it. 0 = Conversion result in ADDR does not meet ADCMPR0 setting. 1 = Conversion result in ADDR meets ADCMPR0 setting.

[0]	ADF	<p><b>A/D Conversion End Flag</b></p> <p>A status flag that indicates the end of A/D conversion. Software can write 1 to clear this bit.</p> <p>ADF is set to 1 at the following three conditions:</p> <ol style="list-style-type: none"><li>1. When A/D conversion ends in Single mode.</li><li>2. When A/D conversion ends on all specified channels in Single-cycle Scan mode and Continuous Scan mode.</li><li>3. When more than 4 samples in FIFO in Burst mode.</li></ol>
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ADC Trigger Delay Control Register (ADTDCR)

Register	Offset	R/W	Description					Reset Value
ADTDCR	ADC_BA+0x44	R/W	ADC Trigger Delay Control Register					0x0000_0000

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	PTDT	<b>PWM Trigger Delay Time</b> Set this field will delay ADC start conversion time after PWM trigger. PWM trigger delay time is $(4 * \text{PTDT}) * \text{system clock}$

### 5.17.9 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write.

Register	Offset	R/W	Description	Reset Value
<b>ADC Base Address:</b>				
<b>ADC_BA = 0x400E_0000</b>				
ADDR	ADC_BA+0x00	R	ADC Data Register 0	0x0000_0000
ADCR	ADC_BA+0x20	R/W	ADC Control Register	0x0000_0000
ADCHER	ADC_BA+0x24	R/W	ADC Channel Enable Register	0x0000_0000
ADCMR0	ADC_BA+0x28	R/W	ADC Compare Register 0	0x0000_0000
ADCMR1	ADC_BA+0x2C	R/W	ADC Compare Register 1	0x0000_0000
ADSR	ADC_BA+0x30	R/W	ADC Status Register	0x0000_0000
ADTDCR	ADC_BA+0x44	R/W	ADC Trigger Delay Control Register	0x0000_0000
ADSAMP	ADC_BA+0x48	R/W	ADC Sampling Time Counter Register	0x0000_0000

### 5.17.10 Register Description for NUC029FAE

#### ADC Data Registers (ADDR)

Register	Offset	R/W	Description				Reset Value
ADDR	ADC_BA+0x00	R	ADC Data Register 0				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved						VALID	OVERRUN
15	14	13	12	11	10	9	8
RSLT							
7	6	5	4	3	2	1	0
RSLT							

Bits	Description	
[31:18]	Reserved	Reserved.
[17]	VALID	<b>Valid Flag</b> 0 = Data in RSLT bits is not valid. 1 = Data in RSLT bits is valid. This bit will be set to 1 when the conversion of the corresponding channel is completed. This bit will be cleared to 0 by hardware after ADDR register is read. This is a read only bit.
[16]	OVERRUN	<b>Overrun Flag (Read Only)</b> 0 = Data in RSLT is not overwritten. 1 = Data in RSLT is overwritten. If converted data in RSLT has not been read before new conversion result is loaded to this register, OVERRUN is set to 1. It is cleared by hardware after ADDR register is read.
[15:0]	RSLT	<b>A/D Conversion Result</b> This field contains conversion result of ADC.

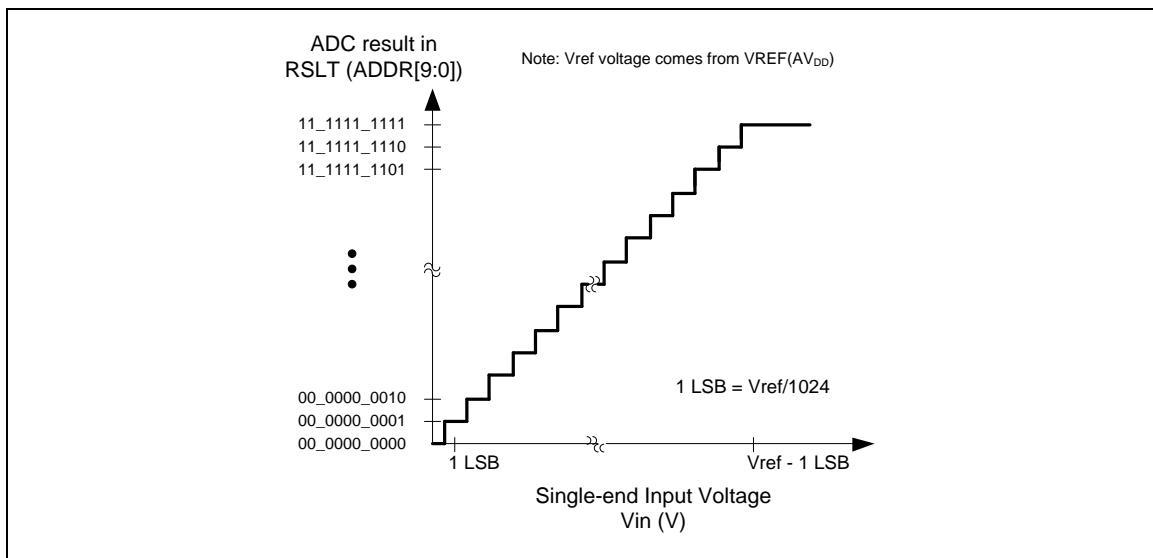


Figure 5-146 Conversion Result Mapping Diagram of ADC Single-end Input

**ADC Control Register (ADCR)**

Register	Offset	R/W	Description				Reset Value
ADCR	ADC_BA+0x20	R/W	ADC Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved				ADST	Reserved		TRGEN
7	6	5	4	3	2	1	0
Reserved	TRGCOND	TRGS		Reserved		ADIE	ADEN

Bits	Description	
[31:12]	Reserved	Reserved.
[11]	ADST	<b>A/D Conversion Start</b> ADST bit can be set to 1 from three sources: software or PWM trigger and external pin STADC. ADST will be cleared to 0 by hardware automatically after conversion complete. 0 = Conversion stops and A/D converter enters idle state. 1 = Conversion starts.
[10:9]	Reserved	Reserved.
[8]	TRGEN	<b>External Trigger Enable Control</b> Enable or disable triggering of A/D conversion by external STADC pin. If external trigger is enabled, the ADST bit can be set to 1 by the selected hardware trigger source. 0= External trigger Disabled. 1= External trigger Enabled.
[7]	Reserved	Reserved.
[6]	TRGCOND	<b>External Trigger Condition</b> This bit decides whether the external pin STADC trigger event is falling or raising edge. The signal must be kept at stable state at least 4 PCLKs at high and low state for edge trigger. 0 = Falling edge. 1 = Raising edge.
[5:4]	TRGS	<b>Hardware Trigger Source</b> 00 = A/D conversion is started by external STADC pin. 11 = A/D conversion is started by PWM trigger. Others = Reserved. <b>Note:</b> Software should disable TRGEN and ADST before change TRGS.
[3:2]	Reserved	Reserved.

[1]	<b>ADIE</b>	<b>A/D Interrupt Enable Control</b> A/D conversion end interrupt request is generated if ADIE bit is set to 1. 0 = A/D interrupt function Disabled. 1 = A/D interrupt function Enabled.
[0]	<b>ADEN</b>	<b>A/D Converter Enable</b> 0 = A/D converter Disabled. 1 = A/D converter Enabled. <b>Note:</b> Before starting A/D conversion function, this bit should be set to 1. Clear it to 0 to disable A/D converter analog circuit to save power consumption.

**ADC Channel Enable Register (ADCHER)**

Register	Offset	R/W	Description				Reset Value
ADCHER	ADC_BA+0x24	R/W	ADC Channel Enable Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved		CHEN5	CHEN4	CHEN3	CHEN2	Reserved	

Bits	Description	
[31:9]	Reserved	Reserved.
[8]	PRESEL	<b>Analog Input Channel 7 Source Selection</b> 0 = Reserved. 1 = Internal band-gap voltage. <b>Note:</b> When the band-gap voltage is selected as the analog input source of ADC channel 7, ADC peripheral clock rate needs to be limited to lower than 300 kHz.
[7:6]	Reserved	Reserved.
[5]	CHEN5	<b>Analog Input Channel 5 Enable Control</b> 0 = Channel 5 Disabled. 1 = Channel 5 Enabled.
[4]	CHEN4	<b>Analog Input Channel 4 Enable Control</b> 0 = Channel 4 Disabled. 1 = Channel 4 Enabled.
[3]	CHEN3	<b>Analog Input Channel 3 Enable Control</b> 0 = Channel 3 Disabled. 1 = Channel 3 Enabled.
[2]	CHEN2	<b>Analog Input Channel 2 Enable Control</b> 0 = Channel 2 Disabled. 1 = Channel 2 Enabled.
[1:0]	Reserved	Reserved.

**A/D Compare Register 0/1 (ADCMPRO/1)**

Register	Offset	R/W	Description					Reset Value
ADCMPRO	ADC_BA+0x28	R/W	ADC Compare Register 0					0x0000_0000
ADCMPR1	ADC_BA+0x2C	R/W	ADC Compare Register 1					0x0000_0000

31	30	29	28	27	26	25	24
Reserved						CMPD	
23	22	21	20	19	18	17	16
CMPD							
15	14	13	12	11	10	9	8
Reserved				CMPPATCNT			
7	6	5	4	3	2	1	0
Reserved		CMPCH			CMPCOND	CMPIE	CMPEN

Bits	Description	
[31:26]	Reserved	Reserved.
[25:16]	CMPD	<b>Comparison Data</b> The 10-bit data is used to compare with conversion result of specified channel.
[15:12]	Reserved	Reserved.
[11:8]	CMPPATCNT	<b>Compare Match Count</b> When the specified A/D channel analog conversion result matches the compare condition defined by CMPCOND, the internal match counter will increase 1. When the internal counter reaches the value to (CMPPATCNT +1), the CMPFx bit will be set.
[7:6]	Reserved	Reserved.
[5:3]	CMPCH	<b>Compare Channel Selection</b> 000 = Reserved. 001 = Reserved. 010 = Channel 2 conversion result is selected to be compared. 011 = Channel 3 conversion result is selected to be compared. 100 = Channel 4 conversion result is selected to be compared. 101 = Channel 5 conversion result is selected to be compared. 110 = Reserved. 111 = Channel 7 conversion result is selected to be compared.
[2]	CMPCOND	<b>Compare Condition</b> 0 = Set the compare condition as that when a 10-bit A/D conversion result is less than the 10-bit CMPD (ADCMPRx[25:16]), the internal match counter will increase one. 1 = Set the compare condition as that when a 10-bit A/D conversion result is greater or equal to the 10-bit CMPD (ADCMPRx[25:16]), the internal match counter will increase one. <b>Note:</b> When the internal counter reaches to (CMPPATCNT +1), the CMPFx bit will

		be set.
[1]	<b>CMPIE</b>	<b>Compare Interrupt Enable Control</b> If the compare function is enabled and the compare condition matches the setting of CMPCOND and CMPMATCNT, CMPFx bit will be asserted, in the meanwhile, if CMPIE is set to 1, a compare interrupt request is generated. 0 = Compare function interrupt Disabled. 1 = Compare function interrupt Enabled.
[0]	<b>CMPEN</b>	<b>Compare Enable Control</b> Set this bit to 1 to enable ADC controller to compare CMPD[9:0] with specified channel conversion result when converted data is loaded into ADDR register. 0 = Compare function Disabled. 1 = Compare function Enabled.

**A/D Status Register (ADSR)**

Register	Offset	R/W	Description				Reset Value
ADSR	ADC_BA+0x30	R/W	ADC Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved	CHANNEL			BUSY	CMPF1	CMPF0	ADF

Bits	Description	
[31:17]	Reserved	Reserved.
[16]	OVERRUN	<b>Overrun Flag (Read Only)</b> It is a mirror to OVERRUN (ADSR[16]) bit in ADDR register.
[15:9]	Reserved	Reserved.
[8]	VALID	<b>Data Valid Flag (Read Only)</b> It is a mirror of VALID bit in ADDRx register.
[7]	Reserved	Reserved.
[6:4]	CHANNEL	<b>Current Conversion Channel (Read Only)</b> This field reflects the current conversion channel when BUSY=1. When BUSY=0, it shows the number of the next converted channel.
[3]	BUSY	<b>BUSY/IDLE (Read Only)</b> This bit is a mirror of ADST bit in ADCR register. 0 = A/D converter is in idle state. 1 = A/D converter is busy at conversion.
[2]	CMPF1	<b>Compare Flag 1</b> When the selected channel A/D conversion result meets the setting condition in ADCMPR1, this bit is set to 1. Software can write 1 to clear this bit to 0. 0 = Conversion result in ADDR does not meet ADCMPR1 setting. 1 = Conversion result in ADDR meets ADCMPR1 setting.
[1]	CMPF0	<b>Compare Flag 0</b> When the selected channel A/D conversion result meets the setting condition in ADCMPR0, this bit is set to 1. Software can write 1 to clear this bit to 0. 0 = Conversion result in ADDR does not meet ADCMPR0 setting. 1 = Conversion result in ADDR meets ADCMPR0 setting.
[0]	ADF	<b>A/D Conversion End Flag</b> A status flag that indicates the end of A/D conversion. ADF is set to 1 When A/D conversion ends.

		Software can write 1 to clear this bit to 0.
--	--	--

ADC Trigger Delay Control Register (ADTDCR)

Register	Offset	R/W	Description					Reset Value
ADTDCR	ADC_BA+0x44	R/W	ADC Trigger Delay Control Register					0x0000_0000

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7:0]	PTDT	<b>PWM Trigger Delay Time</b> Set this field will delay ADC start conversion time after PWM trigger. PWM trigger delay time is $(4 * \text{PTDT}) * \text{system clock}$

ADC Sampling Register (ADSAMP)

Register	Offset	R/W	Description					Reset Value
ADSAMP	ADC_BA+0x48	R/W	ADC Sampling Time Counter Register					0x0000_0000

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

Bits	Description	
[31:4]	Reserved	Reserved.
[3:0]	ADSAMPCNT	<p><b>ADC Sampling Counter</b></p> <p>If the ADC input is unstable, user can set this register to increase the sampling time to get a stable ADC input signal. The default sampling time is 1 ADC clock. The additional clock number will be inserted to lengthen the sampling clock.</p> <p>0000 = 0 additional ADC sample clock.      0001 = 1 additional ADC sample clock.      0010 = 2 additional ADC sample clock.      0011 = 4 additional ADC sample clock.      0100 = 8 additional ADC sample clock.      0101 = 16 additional ADC sample clock.      0110 = 32 additional ADC sample clock.      0111 = 64 additional ADC sample clock.      1000 = 128 additional ADC sample clock.      1001 = 256 additional ADC sample clock.      1010 = 512 additional ADC sample clock.      1011 = 1024 additional ADC sample clock.      1100 = 1024 additional ADC sample clock.      1101 = 1024 additional ADC sample clock.      1110 = 1024 additional ADC sample clock.      1111 = 1024 additional ADC sample clock.</p>

## 5.18 Analog Comparator (ACMP)

### 5.18.1 Overview

The NuMicro® NUC029 series contains up to four sets of comparators which can be used in a number of different configurations. The comparator output is logic 1 when positive input voltage is greater than negative input voltage; otherwise the output is logic 0. Each comparator can be configured to generate interrupt request when the comparator output value changes.

### 5.18.2 Features

- Up to four sets of Comparator analog modules
- Analog input voltage range: 0~  $V_{DD}$
- Supports Hysteresis function
- Optional internal reference voltage source for each comparator negative input
- Two interrupt vectors for the four analog comparators
- External input or internal band-gap voltage selectable at negative node
- Interrupt when compared results change
- Power-down wake-up

### 5.18.3 Block Diagram for NUC029xAN

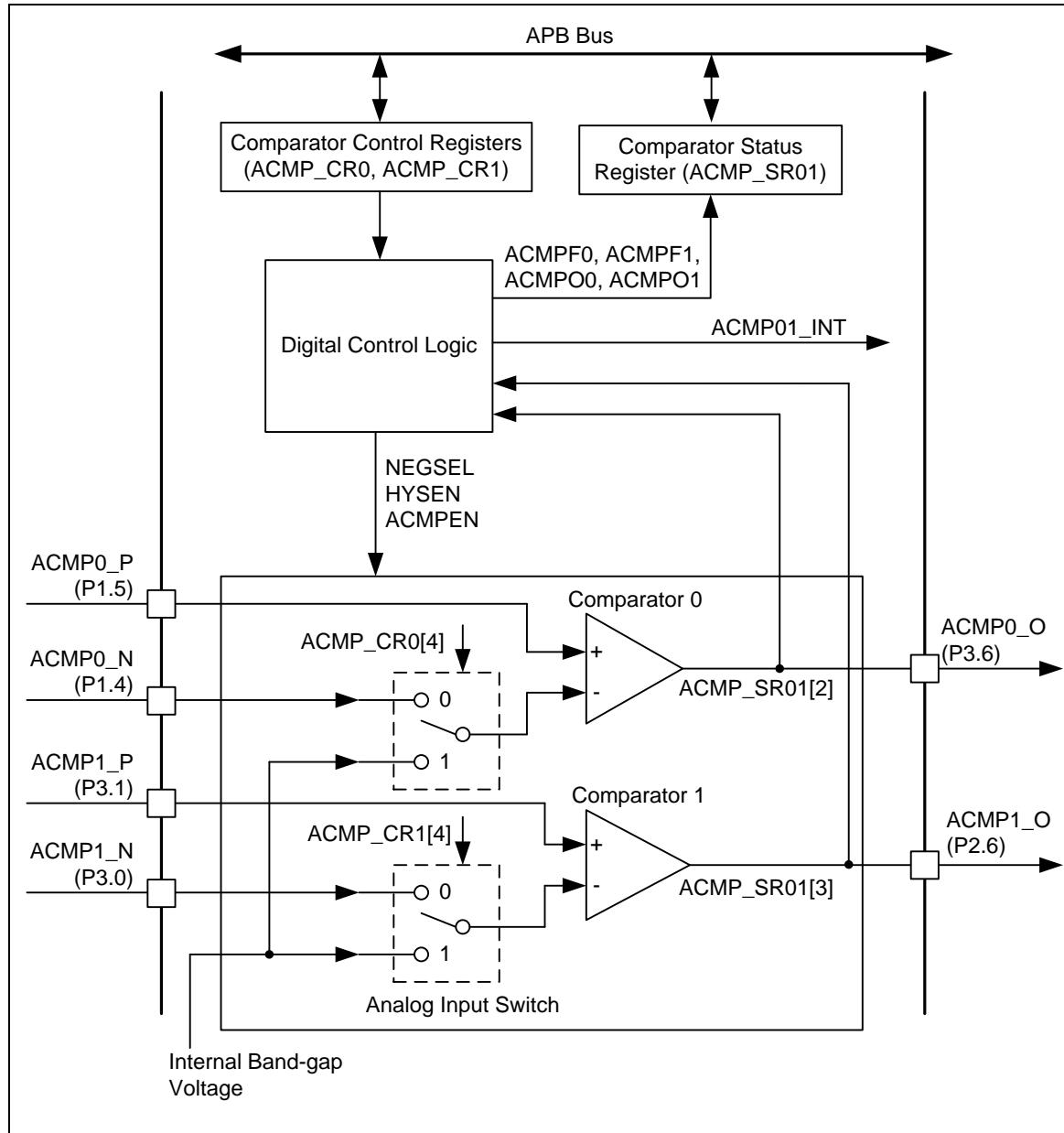


Figure 5-147 Analog Comparator 0/1 Block Diagram for NUC029xAN

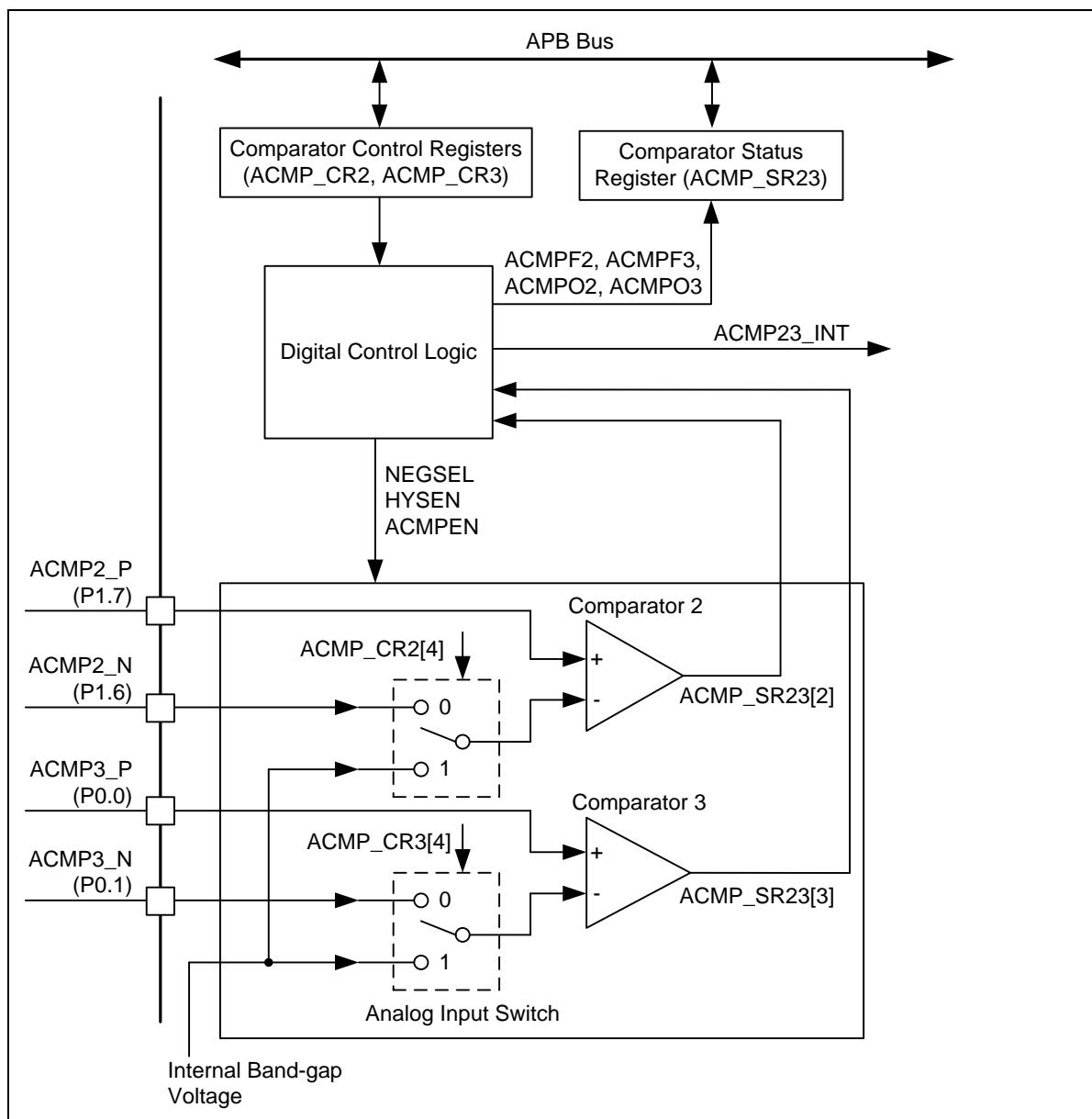


Figure 5-148 Analog Comparator 2/3 Block Diagram for NUC029xAN

## 5.18.4 Block Diagram for NUC029FAE

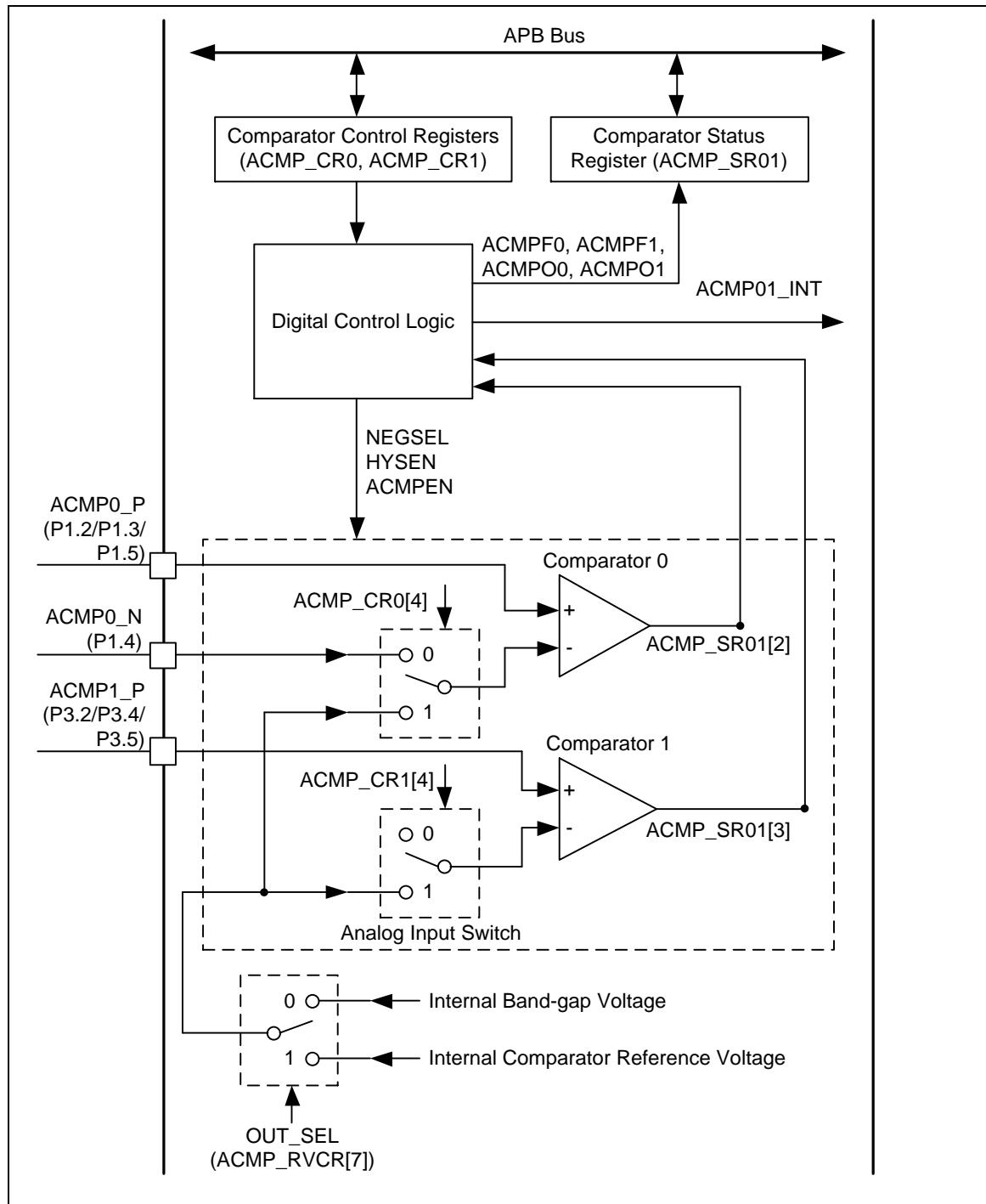


Figure 5-149 Analog Comparator Block Diagram for NUC029FAE

### 5.18.5 Basic Configuration

#### NUC029xAN:

The ACMP pin functions are configured in P0\_MFP, P1\_MFP, P2\_MFP and P3\_MFP registers. It is recommended to disable the digital input path of the analog input pins to avoid the leakage current. The digital input path can be disabled by configuring P0\_OFFD, P1\_OFFD and P3\_OFFD registers.

The ACMP01 and ACMP23 peripheral clocks can be enabled by setting ACMP01\_EN(APBCLK[30]) and ACMP23\_EN(APBCLK[31]) to 1.

#### NUC029FAE:

The ACMP pin functions are configured in P1\_MFP, P2\_MFP and P3\_MFP registers. It is recommended to disable the digital input path of the analog input pins to avoid the leakage current. The digital input path can be disabled by configuring P1\_OFFD and P3\_OFFD registers.

The ACMP peripheral clocks can be enabled by setting ACMP\_EN(APBCLK[30]) to 1.

### 5.18.6 Functional Description

#### 5.18.6.1 Interrupt Sources

#### NUC029xAN:

The output of comparators are sampled by PCLK and reflected at ACMPOx of ACMP\_SR01/23 register. If ACMPIE of ACMP\_CRx register is set to 1, the comparator interrupt will be enabled. As the output state of comparator is changed, the comparator interrupt will be asserted and the corresponding flag, ACMPFx, will be set. Software can clear the flag to 0 by writing 1 to it.

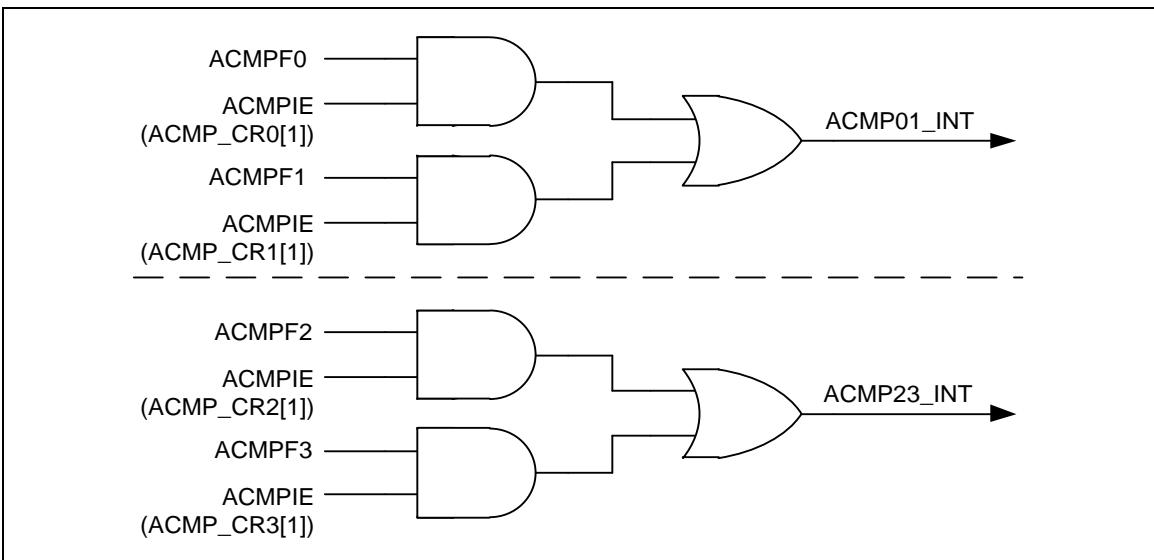


Figure 5-150 Analog Comparator Controller Interrupt Sources for NUC029xAN

#### NUC029FAE:

The output of comparators are sampled by PCLK and reflected at ACMPOx(ACMP\_SR01[3] and ACMP\_SR01[2]). If ACMPIE(ACMP\_CRx[1]) is set to 1, the comparator interrupt will be enabled. As the output state of comparator is changed, the comparator interrupt will be asserted and the corresponding flag, ACMPFx(ACMP\_SR01[1] and ACMP\_SR01[0]), will be set. Software can clear the flag to 0 by writing 1 to it.

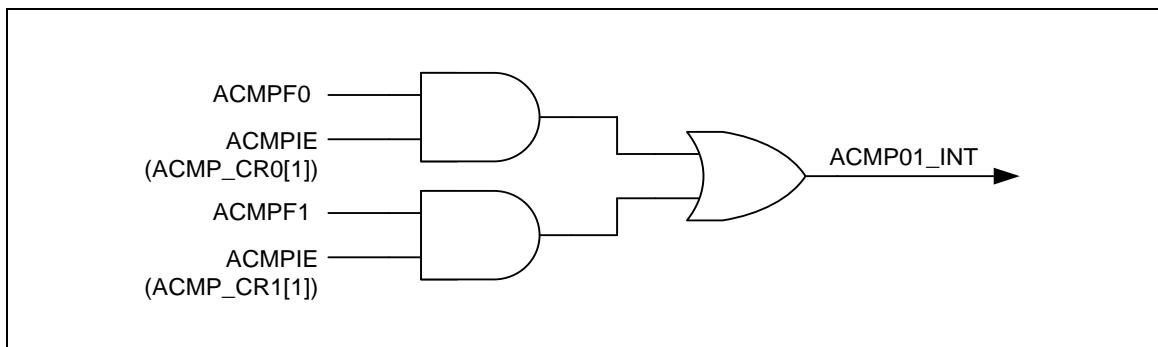


Figure 5-151 Analog Comparator Controller Interrupt Sources for NUC029FAE

#### 5.18.6.2 Hysteresis Function

The analog comparator provides hysteresis function to make the comparator output transition more stable. If comparator output is 0, it will not change to 1 until the positive input voltage exceeds the negative input voltage by a positive hysteresis voltage. Similarly, if comparator output is 1, it will not change to 0 until the positive input voltage drops below the negative input voltage by a negative hysteresis voltage.

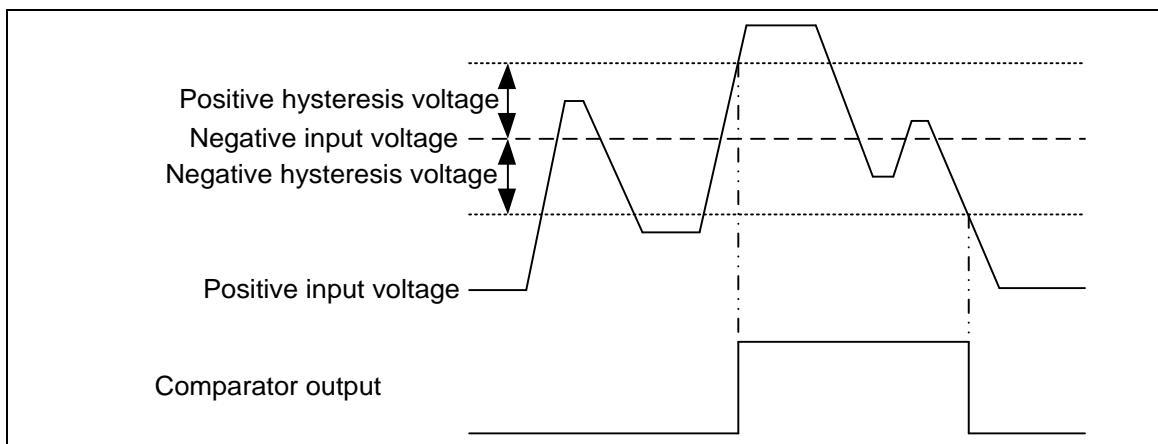


Figure 5-152 Comparator Hysteresis Function

#### 5.18.7 Comparator Reference Voltage (CRV) (NUC029FAE only)

##### 5.18.7.1 Introduction

The comparator reference voltage (CRV) module is responsible for generating reference voltage for comparators. The CRV module consists of resistors ladder and analog switch, and user can set the CRV output voltage using CRVS(ACMP\_RVCR[3:0]) and select the reference voltage to ACMP by setting OUT\_SEL(ACMP\_RVCR[7]).

##### 5.18.7.2 Features

- User selectable references voltage by setting CRVS(ACMP\_RVCR[3:0])
- Automatic disable resistors ladder for reducing power consumption when setting OUT\_SEL(ACMP\_RVCR[7]) = 0 (selecting Band-gap source voltage)

The block diagram of the CRV module is shown below:

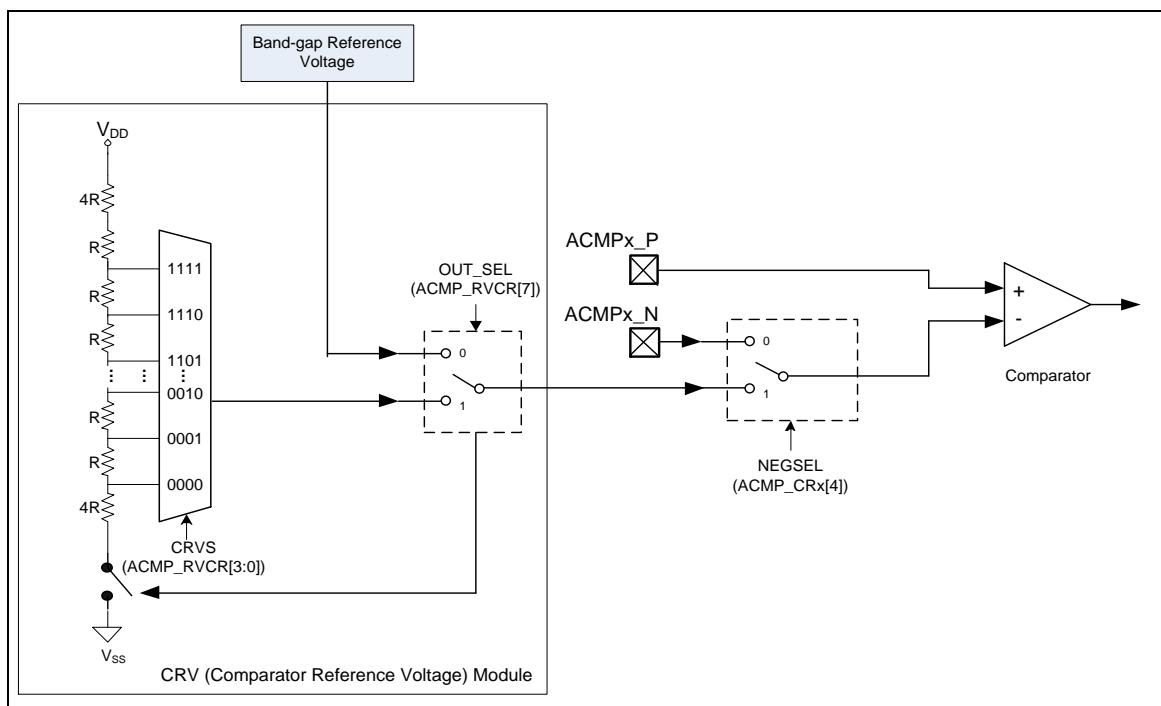


Figure 5-153 Comparator Reference Voltage Block Diagram

### 5.18.8 Register Map for NUC029xAN

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>ACMP Base Address:</b>				
<b>ACMP01_BA = 0x400D_0000</b>				
<b>ACMP23_BA = 0x401D_0000</b>				
<b>ACMP_CR0</b>	ACMP01_BA+0x00	R/W	Analog Comparator 0 Control Register	0x0000_0000
<b>ACMP_CR1</b>	ACMP01_BA+0x04	R/W	Analog Comparator 1 Control Register	0x0000_0000
<b>ACMP_SR01</b>	ACMP01_BA+0x08	R/W	Analog Comparator 0/1 Status Register	0x0000_0000
<b>ACMP_CR2</b>	ACMP23_BA+0x00	R/W	Analog Comparator 2 Control Register	0x0000_0000
<b>ACMP_CR3</b>	ACMP23_BA+0x04	R/W	Analog Comparator 3 Control Register	0x0000_0000
<b>ACMP_SR23</b>	ACMP23_BA+0x08	R/W	Analog Comparator 2/3 Status Register	0x0000_0000

### 5.18.9 Register Description for NUC029xAN

#### Analog Comparator 0 Control Register (ACMP\_CR0)

Register	Offset	R/W	Description				Reset Value
ACMP_CR0	ACMP01_BA+0x00	R/W	Analog Comparator 0 Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			NEGSEL	Reserved	HYSEN	ACMPIE	ACMPEN

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	NEGSEL	<b>Analog Comparator 0 Negative Input Selection</b> 0 = The source of the negative comparator input is from ACMP0_N pin. 1 = The internal band-gap voltage is selected as the source of negative comparator input.
[3]	Reserved	Reserved.
[2]	HYSEN	<b>Analog Comparator 0 Hysteresis Enable Control</b> 0 = Hysteresis function Disabled. 1 = Hysteresis function Enabled.
[1]	ACMPIE	<b>Analog Comparator 0 Interrupt Enable Control</b> 0 = Interrupt function Disabled. 1 = Interrupt function Enabled.
[0]	ACMPEN	<b>Analog Comparator 0 Enable Control</b> 0 = Analog Comparator 0 Disabled. 1 = Analog Comparator 0 Enabled. <b>Note:</b> Analog comparator output needs to wait 2 us stable time after ACMPEN is set.

**Analog Comparator 1 Control Register (ACMP\_CR1)**

Register	Offset	R/W	Description				Reset Value
ACMP_CR1	ACMP01_BA+0x04	R/W	Analog Comparator 1 Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			NEGSEL	Reserved	HYSEN	ACMPIE	ACMPEN

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	NEGSEL	<b>Analog Comparator 1 Negative Input Selection</b> 0 = The source of the negative comparator input is from ACMP1_N pin. 1 = The internal band-gap voltage is selected as the source of negative comparator input.
[3]	Reserved	Reserved.
[2]	HYSEN	<b>Analog Comparator 1 Hysteresis Enable Control</b> 0 = Hysteresis function Disabled. 1 = Hysteresis function Enabled.
[1]	ACMPIE	<b>Analog Comparator 1 Interrupt Enable Control</b> 0 = Interrupt function Disabled. 1 = Interrupt function Enabled.
[0]	ACMPEN	<b>Analog Comparator 1 Enable Control</b> 0 = Analog comparator 1 Disabled. 1 = Analog comparator 1 Enabled. <b>Note:</b> Analog comparator output needs to wait 2 us stable time after ACMPEN is set.

## Analog Comparator 0/1 Status Register (ACMP\_SR01)

Register	Offset	R/W	Description				Reset Value
ACMP_SR01	ACMP01_BA+0x08	R/W	Analog Comparator 0/1 Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved				ACMPO1	ACMPO0	ACMPF1	ACMPF0

Bits	Description	
[31:4]	Reserved	Reserved.
[3]	ACMPO1	<b>Analog Comparator 1 Output</b> Synchronized to the APB clock to allow reading by software. Cleared when the comparator 1 is disabled (ACMP_CR1[0] = 0). 0 = Analog comparator 1 outputs 0. 1 = Analog comparator 1 outputs 1.
[2]	ACMPO0	<b>Analog Comparator 0 Output</b> Synchronized to the APB clock to allow reading by software. Cleared when the comparator 0 is disabled (ACMP_CRO[0] = 0). 0 = Analog comparator 0 outputs 0. 1 = Analog comparator 0 outputs 1.
[1]	ACMPF1	<b>Analog Comparator 1 Flag</b> This bit is set by hardware whenever the comparator 1 output changes state. This will generate an interrupt if ACMP_CR1[1] is set to 1. 0 = Analog comparator 1 output does not change. 1 = Analog comparator 1 output changed since this bit was cleared to 0. <b>Note:</b> Write 1 to clear this bit to 0.
[0]	ACMPF0	<b>Analog Comparator 0 Flag</b> This bit is set by hardware whenever the comparator 0 output changes state. This will generate an interrupt if ACMP_CRO[1] is set to 1. 0 = Analog comparator 0 output does not change. 1 = Analog comparator 0 output changed since this bit was cleared to 0. <b>Note:</b> Write 1 to clear this bit to 0.

**Analog Comparator 2 Control Register (ACMP\_CR2)**

Register	Offset	R/W	Description				Reset Value
ACMP_CR2	ACMP23_BA+0x00	R/W	Analog Comparator 2 Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			NEGSEL	Reserved	HYSEN	ACMPIE	ACMPEN

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	NEGSEL	<b>Analog Comparator 2 Negative Input Selection</b> 0 = The source of the negative comparator input is from ACMP2_N pin. 1 = The internal band-gap voltage is selected as the source of negative comparator input.
[3]	Reserved	Reserved.
[2]	HYSEN	<b>Analog Comparator 2 Hysteresis Enable Control</b> 0 = Hysteresis function Disabled. 1 = Hysteresis function Enabled.
[1]	ACMPIE	<b>Analog Comparator 2 Interrupt Enable Control</b> 0 = Interrupt function Disabled. 1 = Interrupt function Enabled.
[0]	ACMPEN	<b>Analog Comparator 2 Enable Control</b> 0 = Analog Comparator 2 Disabled. 1 = Analog Comparator 2 Enabled. <b>Note:</b> Analog comparator output needs to wait 2 us stable time after ACMPEN is set.

**Analog Comparator 3 Control Register (ACMP\_CR3)**

Register	Offset	R/W	Description				Reset Value
ACMP_CR3	ACMP23_BA+0x04	R/W	Analog Comparator 3 Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved			NEGSEL	Reserved	HYSER	ACMPIE	ACMPEN

Bits	Description	
[31:5]	Reserved	Reserved.
[4]	NEGSEL	<b>Analog Comparator 3 Negative Input Selection</b> 0 = The source of the negative comparator input is from ACMP3_N pin. 1 = The internal band-gap voltage is selected as the source of negative comparator input.
[3]	Reserved	Reserved.
[2]	HYSER	<b>Analog Comparator 3 Hysteresis Enable Control</b> 0 = Hysteresis function Disabled. 1 = Hysteresis function Enabled.
[1]	ACMPIE	<b>Analog Comparator 3 Interrupt Enable Control</b> 0 = Interrupt function Disabled. 1 = Interrupt function Enabled.
[0]	ACMPEN	<b>Analog Comparator 3 Enable Control</b> 0 = Analog comparator 3 Disabled. 1 = Analog comparator 3 Enabled. <b>Note:</b> Analog comparator output needs to wait 2 us stable time after ACMPEN is set.

**Analog Comparator 2/3 Status Register (ACMP\_SR23)**

Register	Offset	R/W	Description					Reset Value
ACMP_SR23	ACMP23_BA+0x08	R/W	Analog Comparator 2/3 Status Register					0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved				ACMPO3	ACMPO2	ACMPF3	ACMPF2

Bits	Description	
[31:4]	Reserved	Reserved.
[3]	ACMPO3	<b>Analog Comparator 3 Output</b> Synchronized to the APB clock to allow reading by software. Cleared when the comparator 3 is disabled (ACMP_CR3[0] = 0). 0 = Analog comparator 3 outputs 0. 1 = Analog comparator 3 outputs 1.
[2]	ACMPO2	<b>Analog Comparator 2 Output</b> Synchronized to the APB clock to allow reading by software. Cleared when the comparator 2 is disabled (ACMP_CR2[0] = 0). 0 = Analog comparator 2 outputs 0. 1 = Analog comparator 2 outputs 1.
[1]	ACMPF3	<b>Analog Comparator 3 Flag</b> This bit is set by hardware whenever the comparator 3 output changes state. This will generate an interrupt if ACMP_CR3[1] is set to 1. 0 = Analog comparator 3 output does not change. 1 = Analog comparator 3 output changed since this bit was cleared to 0. <b>Note:</b> Write 1 to clear this bit to 0.
[0]	ACMPF2	<b>Analog Comparator 2 Flag</b> This bit is set by hardware whenever the comparator 2 output changes state. This will generate an interrupt if ACMP_CR2[1] is set to 1. 0 = Analog comparator 2 output does not change. 1 = Analog comparator 2 output changed since this bit was cleared to 0. <b>Note:</b> Write 1 to clear this bit to 0.

### 5.18.10 Register Map for NUC029FAE

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>ACMP Base Address:</b> <b>ACMP_BA = 0x400D_0000</b>				
<b>ACMP_CR0</b>	ACMP_BA+0x00	R/W	Analog Comparator 0 Control Register	0x0000_0000
<b>ACMP_CR1</b>	ACMP_BA+0x04	R/W	Analog Comparator 1 Control Register	0x0000_0000
<b>ACMP_SR01</b>	ACMP_BA+0x08	R/W	Analog Comparator 0/1 Status Register	0x0000_0000
<b>ACMP_RVCR</b>	ACMP_BA+0x0C	R/W	Analog Comparator Reference Voltage Control Register	0x0000_0000

### 5.18.11 Register Description for NUC029FAE

#### Analog Comparator 0 Control Register (ACMP\_CR0)

Register	Offset	R/W	Description				Reset Value
ACMP_CR0	ACMP_BA+0x00	R/W	Analog Comparator 0 Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved	CPP0SEL		Reserved				
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved						FALLING	RISING
7	6	5	4	3	2	1	0
Reserved			NEGSEL	Reserved	HYSSEN	ACMPIE	ACMPEN

Bits	Description	
[31]	Reserved	Reserved.
[30:29]	CPP0SEL[1:0]	<b>Analog Comparator 0 Positive Input Selection</b> 00 = CPP0 is from P1.5 pin. 01 = CPP0 is from P1.0 pin. 10 = CPP0 is from P1.2 pin. 11 = CPP0 is from P1.3 pin.
[28:10]	Reserved	Reserved.
[9]	FALLING	<b>Analog Comparator 0 Falling Edge Trigger Enable Control</b> 0 = Analog comparator 0 falling edge trigger PWM or Timer Enabled. 1 = Analog comparator 0 falling edge trigger Disabled. <b>Note:</b> The bit is only effective while analog comparator 0 triggers PWM or Timer.
[8]	RISING	<b>Analog Comparator 0 Rising Edge Trigger Enable Control</b> 0 = Analog comparator 0 rising edge trigger PWM or Timer Enabled. 1 = Analog comparator 0 rising edge trigger Disabled. <b>Note:</b> The bit is only effective while analog comparator 0 triggers PWM or Timer.
[7:5]	Reserved	Reserved.
[4]	NEGSEL	<b>Analog Comparator 0 Negative Input Selection</b> 0 = The source of the negative comparator input is from CPN0 pin. 1 = The source of the negative comparator input is from internal band-gap voltage or comparator reference voltage.
[3]	Reserved	Reserved.
[2]	HYSSEN	<b>Analog Comparator 0 Hysteresis Enable Control</b> 0 = Hysteresis function Disabled. 1 = Hysteresis function Enabled.

[1]	<b>ACMPIE</b>	<b>Analog Comparator 0 Interrupt Enable Control</b> 0 = Interrupt function Disabled. 1 = Interrupt function Enabled.
[0]	<b>ACMPEN</b>	<b>Analog Comparator 0 Enable Control</b> 0 = Analog Comparator 0 Disabled. 1 = Analog Comparator 1 Enabled. <b>Note:</b> Analog comparator output needs to wait 2 us stable time after this bit is set.

**Analog Comparator 1 Control Register (ACMP\_CR1)**

Register	Offset	R/W	Description				Reset Value
ACMP_CR1	ACMP_BA+0x04	R/W	Analog Comparator 1 Control Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved	CPP1SEL		Reserved				
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved					FALLING	RISING	
7	6	5	4	3	2	1	0
Reserved			NEGSEL	Reserved	HYSEN	ACMPIE	ACMPEN

Bits	Description	
[31]	Reserved	Reserved.
[30:29]	CPP1SEL[1:0]	<b>Analog Comparator 1 Positive Input Selection</b> 00 = CPP1 is from P3.1 pin. 01 = CPP1 is from P3.2 pin. 10 = CPP1 is from P3.4 pin. 11 = CPP1 is from P3.5 pin.
[28:10]	Reserved	Reserved.
[9]	FALLING	<b>Analog Comparator 1 Falling Edge Trigger Enable Control</b> 0 = Analog comparator 1 falling edge trigger PWM or Timer Enabled. 1 = Analog comparator 1 falling edge trigger Disabled. <b>Note:</b> The bit is only effective while analog comparator 1 triggers PWM or Timer.
[8]	RISING	<b>Analog Comparator 1 Rising Edge Trigger Enable Control</b> 0 = Analog comparator 1 rising edge trigger PWM or Timer Enabled. 1 = Analog comparator 1 rising edge trigger Disabled. <b>Note:</b> The bit is only effective while analog comparator 1 triggers PWM or Timer.
[7:5]	Reserved	Reserved.
[4]	NEGSEL	<b>Analog Comparator 1 Negative Input Selection</b> 0 = The source of the negative comparator input is from CPN1 pin. 1 = The source of the negative comparator input is from internal band-gap voltage or comparator reference voltage.
[3]	Reserved	Reserved.
[2]	HYSEN	<b>Analog Comparator 1 Hysteresis Enable Control</b> 0 = Hysteresis function Disabled. 1 = Hysteresis function Enabled.

[1]	<b>ACMPIE</b>	<b>Analog Comparator 1 Interrupt Enable Control</b> 0 = Interrupt function Disabled. 1 = Interrupt function Enabled.
[0]	<b>ACMPEN</b>	<b>Analog Comparator 1 Enable Control</b> 0 = Analog Comparator 1 Disabled. 1 = Analog Comparator 1 Enabled. <b>Note:</b> Analog comparator output needs to wait 2 us stable time after this bit is set.

## Analog Comparator 0/1 Status Register (ACMP\_SR01)

Register	Offset	R/W	Description				Reset Value
ACMP_SR01	ACMP_BA+0x08	R/W	Analog Comparator 0/1 Status Register				0x0000_0000

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved				ACMPO1	ACMPO0	ACMPF1	ACMPF0

Bits	Description	
[31:4]	Reserved	Reserved.
[3]	ACMPO1	<b>Analog Comparator 1 Output</b> Synchronized to the APB clock to allow reading by software. Cleared when the comparator 1 is disabled ACMPEN(ACMP_CR1[0]) = 0. 0 = Analog comparator 1 outputs 0. 1 = Analog comparator 1 outputs 1.
[2]	ACMPO0	<b>Analog Comparator 0 Output</b> Synchronized to the APB clock to allow reading by software. Cleared when the comparator 0 is disabled ACMPEN(ACMP_CR0[0]) = 0. 0 = Analog comparator 0 outputs 0. 1 = Analog comparator 0 outputs 1.
[1]	ACMPF1	<b>Analog Comparator 1 Flag</b> This bit is set by hardware whenever the comparator 1 output changes state. This will generate an interrupt if ACMPIE(ACMP_CR1[1]) = 1. 0 = Analog comparator 1 output does not change. 1 = Analog comparator 1 output changed. <b>Note:</b> Software can write 1 to clear this bit to 0.
[0]	ACMPF0	<b>Analog Comparator 0 Flag</b> This bit is set by hardware whenever the comparator 0 output changes state. This will generate an interrupt if ACMPIE(ACMP_CR0[1]) = 1. 0 = Analog comparator 0 output does not change. 1 = Analog comparator 0 output changed. <b>Note:</b> Software can write 1 to clear this bit to 0.

Analog Comparator Reference Voltage Control Register (ACMP\_RVCR)

Register	Offset	R/W	Description					Reset Value
ACMP_RVCR	ACMP_BA+0x0C	R/W	Analog Comparator Reference Voltage Control Register					0x0000_0000

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

Bits	Description	
[31:8]	Reserved	Reserved.
[7]	OUT_SEL	<b>CRV Module Output Selection</b> 0 = Band-gap voltage. 1 = Internal comparator reference voltage.
[6:4]	Reserved	Reserved.
[3:0]	CRVS[3:0]	<b>Comparator Reference Voltage Setting</b> Comparator reference voltage = $V_{DD} * (1 / 6 + CRVS[3:0] / 24)$ .

## 5.19 Hardware Divider (HDIV) (NUC029xAN Only)

### 5.19.1 Overview

The NuMicro® NUC029xAN has the hardware divider (HDIV). HDIV is useful to the high performance application. The hardware divider is a signed, integer divider with both quotient and remainder outputs.

### 5.19.2 Features

- Signed (two's complement) integer calculation
- 32-bit dividend with 16-bit divisor calculation capacity
- 32-bit quotient and 32-bit remainder outputs (16-bit remainder with sign extends to 32-bit)
- Divided by zero warning flag
- 6 HCLK clocks taken for one cycle calculation
- Write divisor to trigger calculation
- Waiting for calculation ready automatically when reading quotient and remainder

### 5.19.3 Basic Configuration

Before using the hardware divider, the clock of hardware divider must be enabled. To enable hardware divider, it needs to set HDIV\_EN on AHBCLK[4] to 1.

### 5.19.4 Functional Description

To use hardware divider, it needs to set dividend first. Then set divisor and the hardware divider will trigger calculation automatically after divisor written. The calculation results including the quotient and remainder could be got by reading DIVQUO and DIVREM register. If CPU reads DIVQUO or DIVREM before hardware divider calculation finishing, CPU will be held until hardware divider finishing the calculation. Therefore, CPU can always get valid results after trigger one hardware divider calculation without software delay.

DIV0 flag of DIVSTS will be set if divisor is 0.

The dividend is 32-bit signed integer and divisor is 16-bit signed integer. The quotient is 32-bit signed integer and the remainder is 16-bit signed integer.

The following figure shows the operation flow of hardware divider. To calculate X / Y, CPU needs to write X to DIVIDEND register, and then write Y to DIVISOR. CPU can read DIVQUO and DIVREM registers to get calculation results after DIVISOR been written.

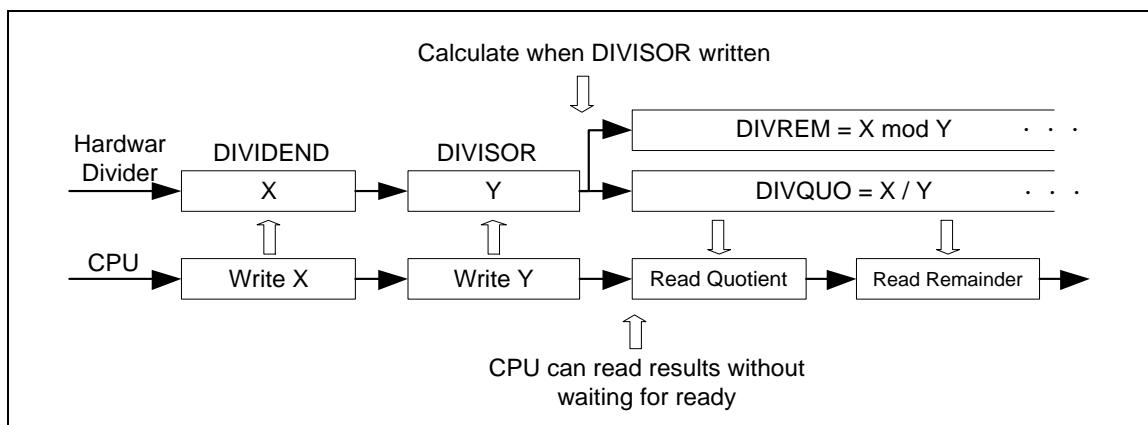


Figure 5-154 Hardware Divider Operation Flow

### 5.19.5 Register Map

R: read only, W: write only, R/W: both read and write

Register	Offset	R/W	Description	Reset Value
<b>HDIV Base Address:</b>				
<b>HDIV_BA = 0x5001_4000</b>				
DIVIDEND	HDIV_BA+0x00	R/W	Dividend Source Register	0x0000_0000
DIVISOR	HDIV_BA+0x04	R/W	Divisor Source Register	0x0000_FFFF
DIVQUO	HDIV_BA+0x08	R/W	Quotient Result Register	0x0000_0000
DIVREM	HDIV_BA+0x0C	R/W	Remainder Result Register	0x0000_0000
DIVSTS	HDIV_BA+0x10	R	Divider Status Register	0x0000_0001

### 5.19.6 Register Description

#### Dividend Source Register (DIVIDEND)

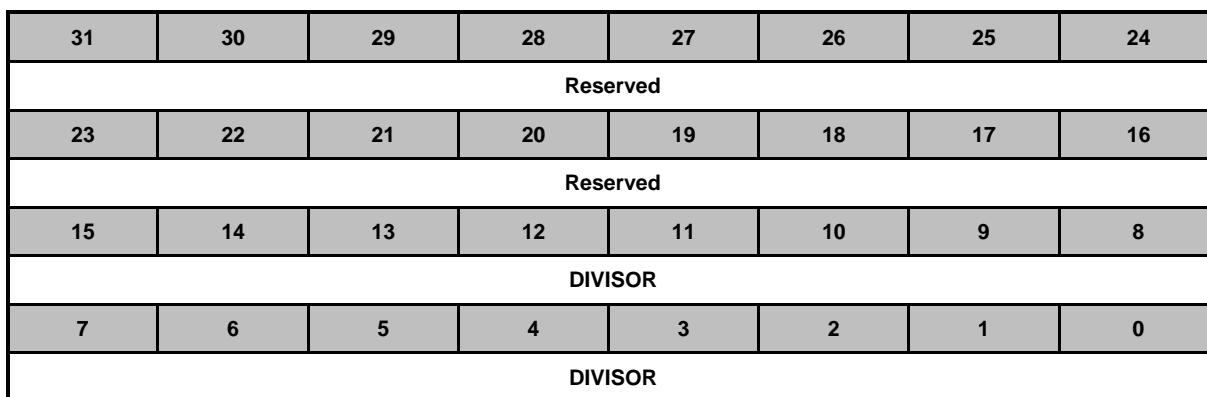
Register	Offset	R/W	Description				Reset Value
DIVIDEND	HDIV_BA+0x00	R/W	Dividend Source Register				0x0000_0000

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

Bits	Description	
[31:0]	DIVIDEND	<b>Dividend Source</b> This register is given the dividend of divider before calculation starting.

Divisor Source Register (DIVISOR)

Register	Offset	R/W	Description				Reset Value
DIVISOR	HDIV_BA+0x04	R/W	Divisor Source Register				0x0000_FFFF



Bits	Description	
[31:16]	Reserved	Reserved.
[15:0]	DIVISOR	<b>Divisor Source</b> This register is given the divisor of divider before calculation starts. <b>Note:</b> When this register is written, hardware divider will start calculate.

Quotient Result Register (DIVQUO)

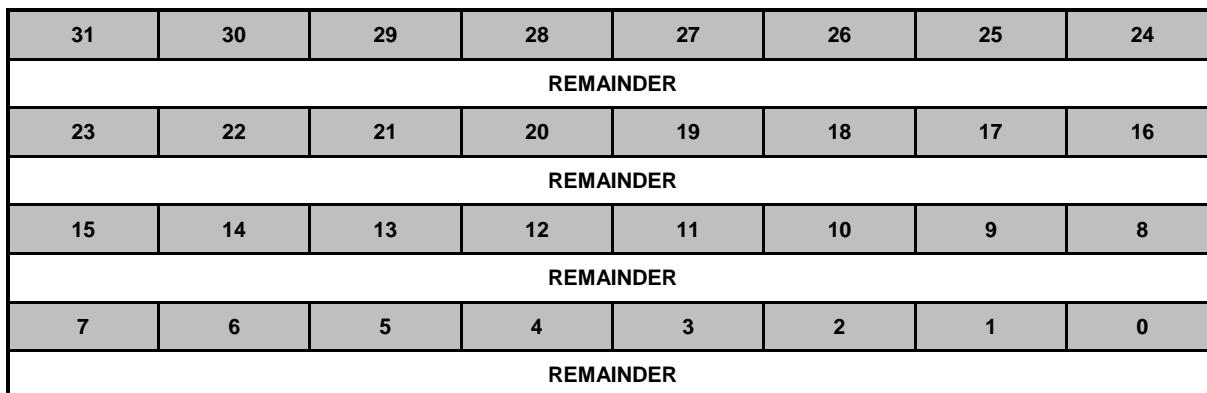
Register	Offset	R/W	Description					Reset Value
DIVQUO	HDIV_BA+0x08	R/W	Quotient Result Register					0x0000_0000

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

Bits	Description	
[31:0]	QUOTIENT	<b>Quotient Result</b> This register holds the quotient result of divider after calculation complete.

**Remainder Result Register (DIVREM)**

Register	Offset	R/W	Description					Reset Value
DIVREM	HDIV_BA+0x0C	R/W	Remainder Result Register					0x0000_0000



Bits	Description	
[31:16]	REMAINDER[31:16]	<b>Sign Extension Of REMAINDER[15:0]</b> The remainder of hardware divider is 16-bit sign integer (REMAINDER[15:0]) with sign extension (REMAINDER[31:16]) to 32-bit integer.
[15:0]	REMAINDER[15:0]	<b>Remainder Result</b> This register holds the remainder result of divider after calculation complete.

**Divider Status Register (DIVSTS)**

Register	Offset	R/W	Description					Reset Value
DIVSTS	HDIV_BA+0x10	R	Divider Status Register					0x0000_0001

31	30	29	28	27	26	25	24
Reserved							
23	22	21	20	19	18	17	16
Reserved							
15	14	13	12	11	10	9	8
Reserved							
7	6	5	4	3	2	1	0
Reserved						DIV0	Reserved

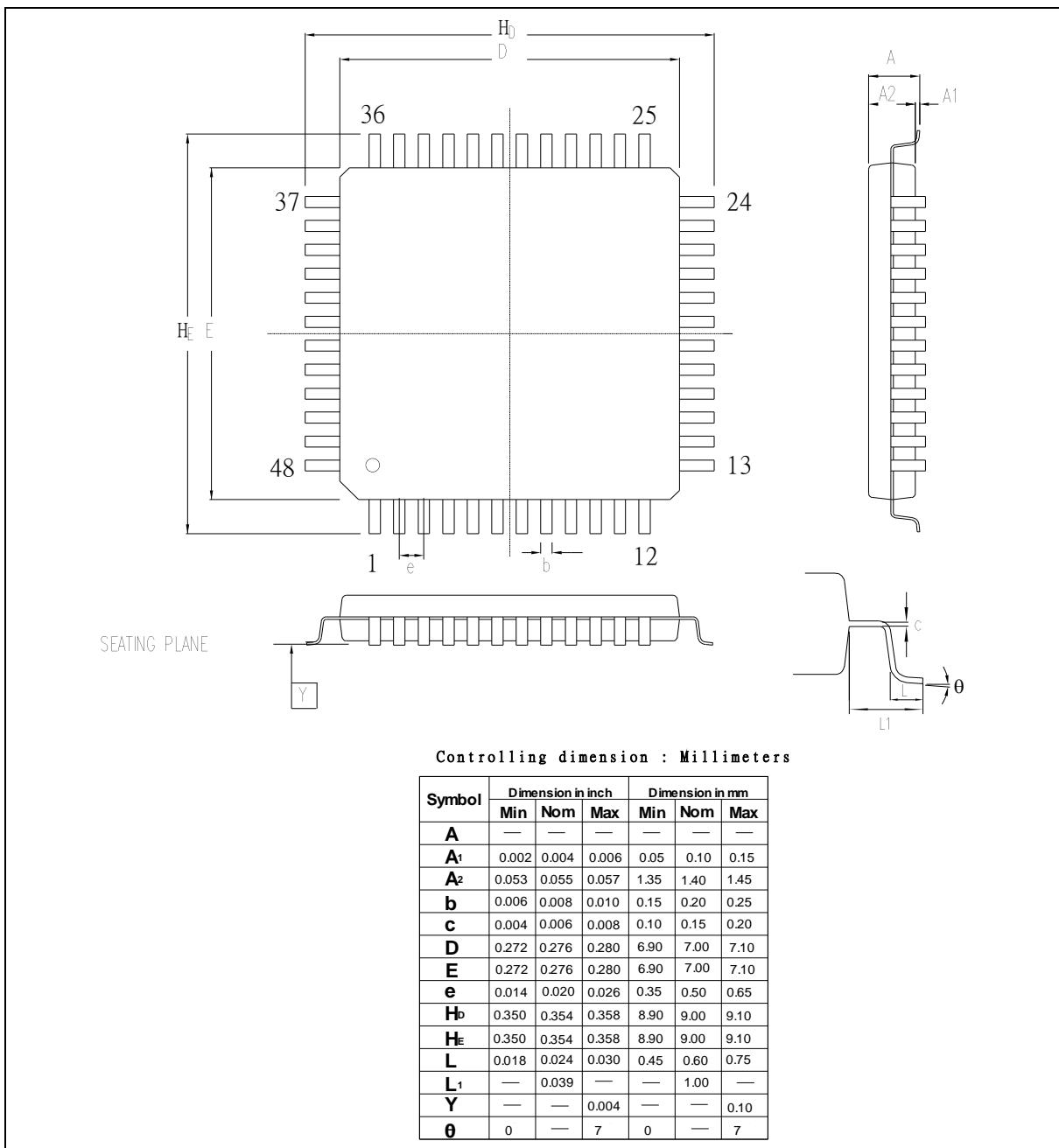
Bits	Description	
[31:2]	Reserved	Reserved.
[1]	DIV0	<b>Divisor Zero Warning</b> 0 = The divisor is not 0. 1 = The divisor is 0. <b>Note:</b> The DIV0 flag is used to indicate divide-by-zero situation and updated whenever DIVISOR is written. This register is read only.
[0]	Reserved	Reserved.

## 6 ELECTRICAL CHARACTERISTICS

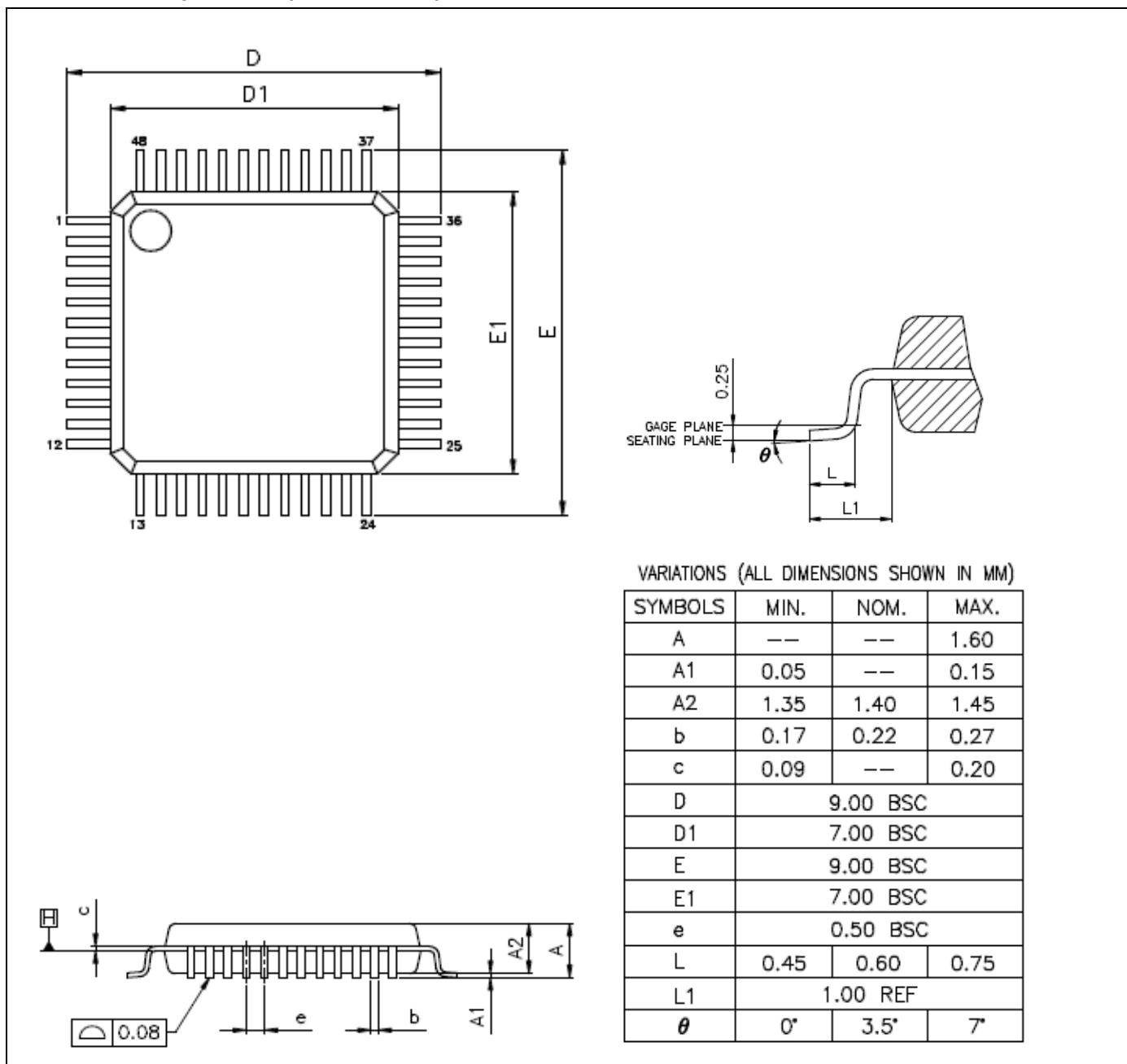
For information on NuMicro® NUC029 series electrical characteristics, please refer to NuMicro® NUC029 Series Datasheet.

## 7 PACKAGE DIMENSIONS

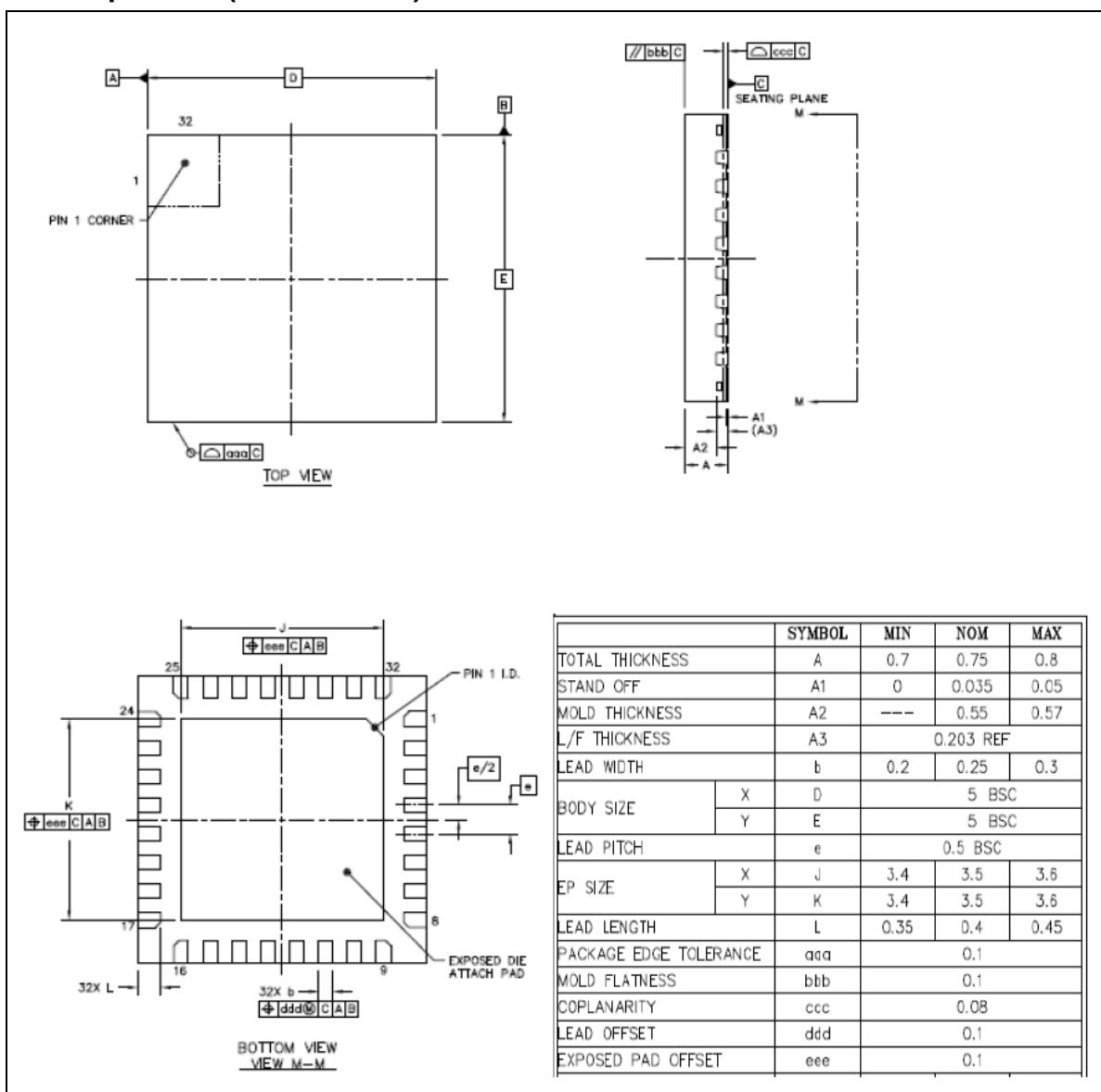
### 7.1 48-pin LQFP (7x7x1.4 mm)



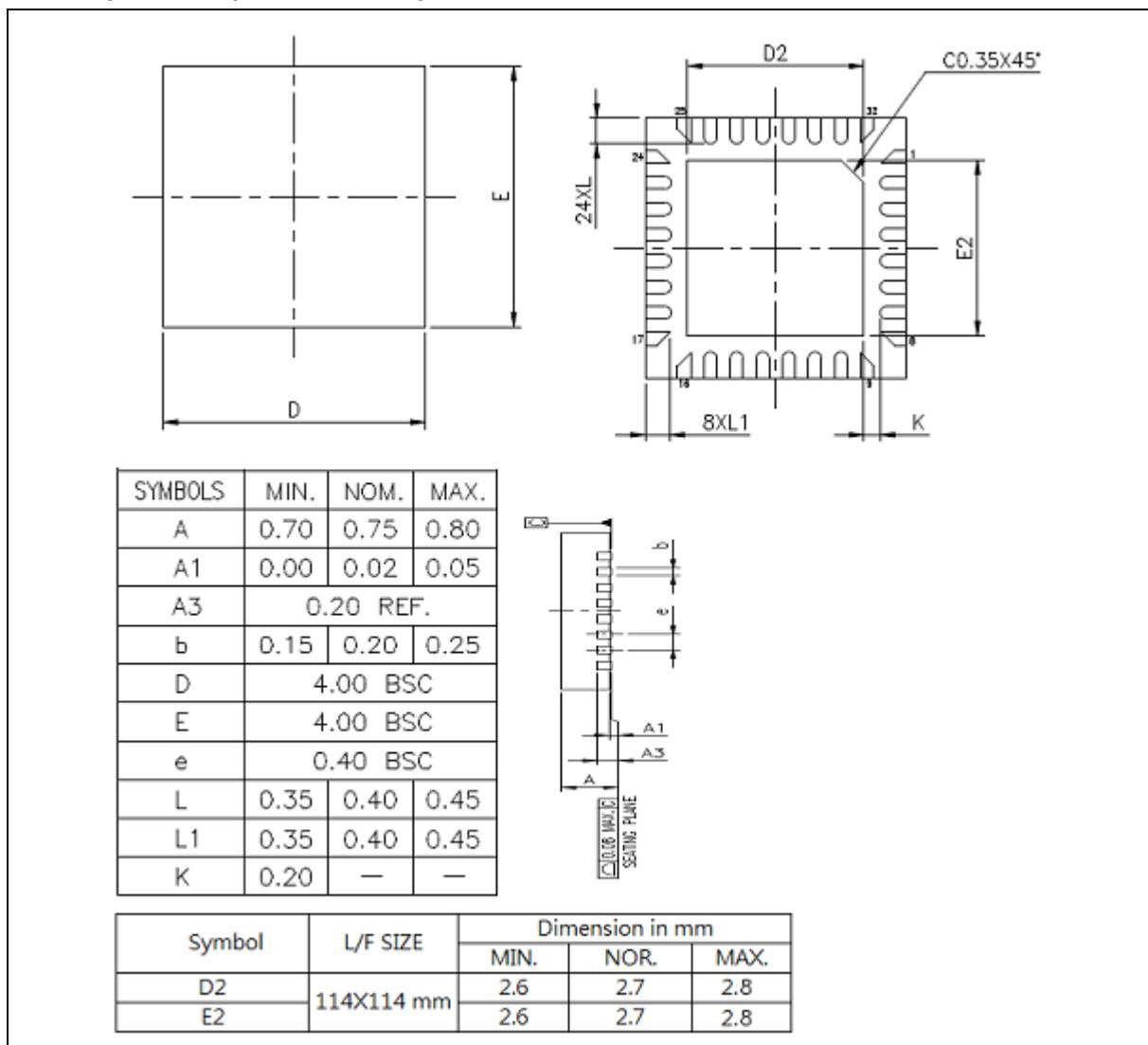
## 7.2 48-pin QFN (7x7x0.8 mm)



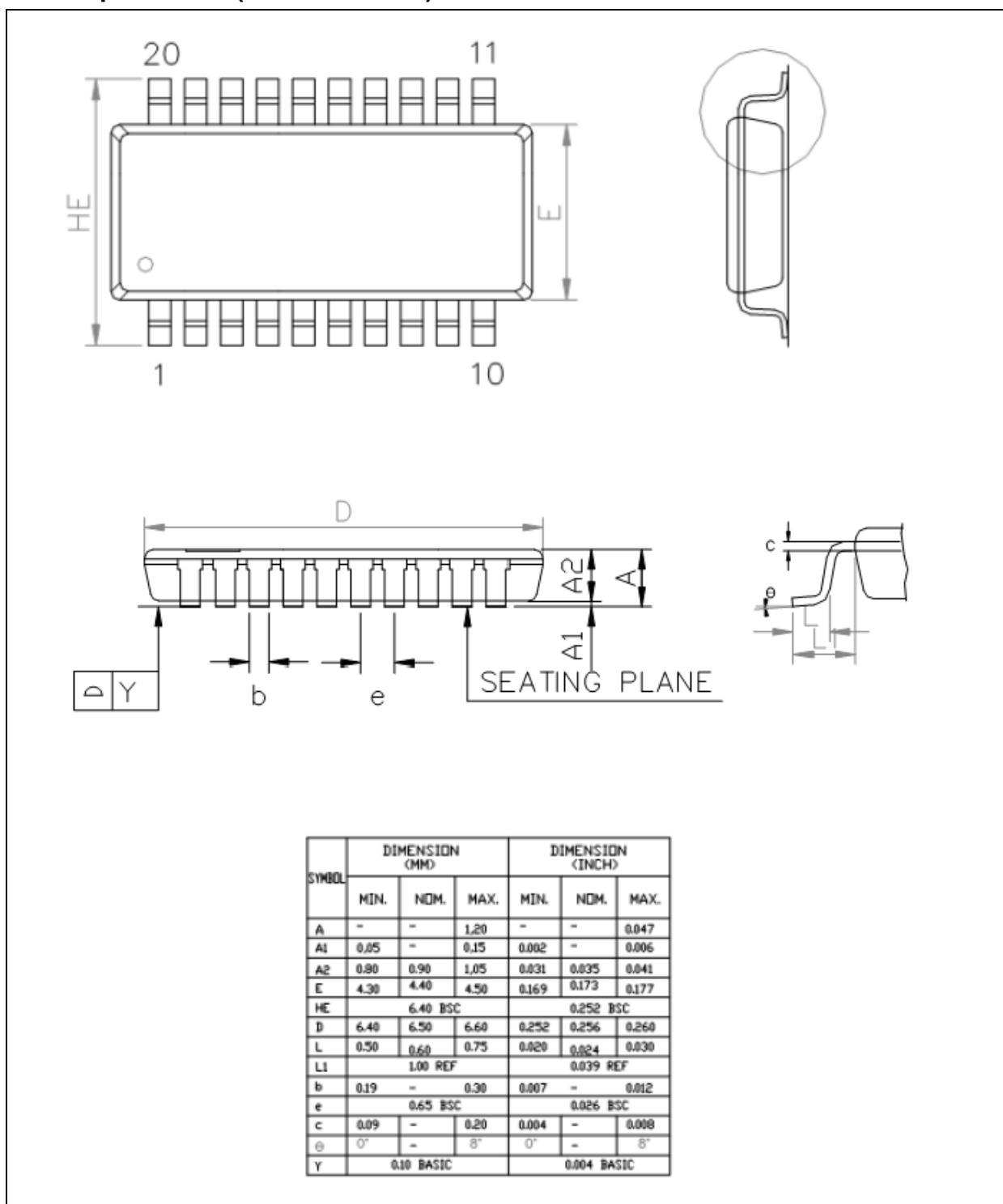
### 7.3 33-pin QFN (5x5x0.75 mm)



## 7.4 33-pin QFN (4x4x0.75 mm)



## 7.5 20-pin TSSOP (6.5x4.4x1.2 mm)



## 8 REVISION HISTORY

Date	Revision	Description
2014.05.27	1.00	<ol style="list-style-type: none"><li>1. Preliminary version.</li></ol>
2014.08.26	1.01	<ol style="list-style-type: none"><li>1. Modified Figure 4-1 NuMicro® NUC029 Series Selection Code.</li><li>2. Fixed the typo of nRD, nWR, nWRH, nWRL, nINT0 and nINT1 in Chapter 5.2.6.</li></ol>
2015.05.18	1.02	<ol style="list-style-type: none"><li>1. Changed the order of Chapter 5 FUNCTIONAL DESCRIPTION.</li><li>2. Fixed typos and obscure description.</li><li>3. Fixed the typo of P3.5 Alternate Function Selection in Chapter 5.2.7 when P3_ALT[5] = 1 and P3_MFP[5] = 1.</li><li>4. Fixed the description about Frequency Divider Output of NUC029xAN series in Chapter 5.3.4.</li><li>5. Added clock switching note in Chapter 5.3 and 5.4.</li><li>6. Added Table 5-16 Input Capture Mode Operation in Chapter 5.9.5.5.</li><li>7. Removed description about ACMP output inverse function available on NUC029xAN series.</li><li>8. Updated 33-pin QFN (4x4) package dimension in Chapter 7.4.</li></ol>
2017.06.23	1.03	<ol style="list-style-type: none"><li>1. Added new part number NUC029ZAN.</li></ol>
2017.12.11	1.04	<ol style="list-style-type: none"><li>1. Added new part number NUC029NAN.</li></ol>

### Important Notice

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