

**ARM Cortex® -M0**  
**32-bit Microcontroller****NuMicro® Family**  
**NM1230 Series**  
**Datasheet**

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## 1 GENERAL DESCRIPTION

The NuMicro® NM1230 series 32-bit microcontrollers are embedded with ARM® Cortex®-M0 core for industrial applications which need 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 NM1230 series can run up to 48(72) MHz and operate at 2.2V(3.3V) ~ 5.5V, -40°C ~ 105°C, and thus can support a variety of industrial control applications which need high CPU performance. The NM1230 offers 64 Kbytes embedded program Flash, size configurable Data Flash (shared with program flash), 7.5 Kbytes Flash for the ISP, 1.5 Kbytes SPROM for security, and 16Kbytes SRAM.

Many system level peripheral functions, such as I/O Port, Timer, UART, SPI, I<sup>2</sup>C, PWM, ADC, OP, PGA, Watchdog Timer, Analog Comparator and Brown-out Detector, have been incorporated into the NM1230 to reduce component count, board space and system cost. These useful functions make the NM1230 powerful for a wide range of applications.

Additionally, the NM1230 series is equipped with ISP (In-System Programming) and ICP (In-Circuit Programming) functions, which allow the user to update the program memory without removing the chip from the actual end product.

## 2 FEATURES

- Core
  - ARM® Cortex®-M0 core running up to 48/72 MHz by internal RC oscillator optioned from ROMMAP
  - One 24-bit system timer
  - Supports low power Idle mode
  - A single-cycle 32-bit hardware multiplier
  - NVIC for the 32 interrupt inputs, each with 4-level of priority
  - Supports Serial Wire Debug (SWD) interface and two watch points/four breakpoints
- Built-in LDO for wide operating voltage ranged: 2.2 V to 5.5 V
- Memory
  - 64 Kbytes Flash memory for program memory (APROM)
  - Configurable Flash memory for data memory (Data Flash)
  - 7.5 KB Flash memory for loader (LDROM)
  - Three 0.5 KB Flash memory for security protection (SPROM0, 1, 2)
  - 16 KB SRAM for internal scratch-pad RAM (SRAM)
- Clock Control
  - Programmable system clock source
    - ◆ Switch clock sources on-the-fly
  - 4 ~ 24 MHz external crystal input (HXT)
  - 32.768 kHz external crystal input (LXT) for idle wake-up and system operation clock
  - 48(72) MHz internal oscillator (HIRC) (1% accuracy at 25°C, 5V)
  - 10 kHz internal low-power oscillator (LIRC) for Watchdog Timer and idle wake-up
- I/O Port
  - Up to 44 general-purpose I/O (GPIO) pads and 1 Reset pad
  - Four I/O modes:
    - ◆ Quasi-bidirectional input/output
    - ◆ Push-Pull output
    - ◆ Open-Drain output
    - ◆ Input only with high impedance
  - Optional TTL/Schmitt trigger input
  - I/O pin can be configured as interrupt source with edge/level setting
  - Supports high driver and high sink I/O mode
  - GPIO built-in Pull-up/Pull-low resistor for selection.
- Timer

- Provides four channel 32-bit Timers; one 8-bit pre-scalar counter with 24-bit up-timer for each timer
- Independent clock source for each timer
- Provides One-shot, Periodic, Toggle and Continuous operation modes
- 24-bit up counter value is readable through TDR (Timer Data Register)
- Provides trigger counting/free counting/counter reset function triggered by external capture pin or internal comparator signal
- Supports event counter function
- Supports Toggle Output mode
- Supports wake-up from Idle or Power-down mode
- Continuous Capture
  - Timer0, Timer1, Timer2, Timer3 and SysTick provided with continuous capture function to capture at most 4 edges continuously on one signal
- ECAP (Enhanced Input Capture)
  - One units of 24-bit input capture counter
  - Capture source:
    - ◆ I/O inputs: ECAP ports(ECAP0, ECAP1 and ECAP2)
    - ◆ ACMP Trigger
    - ◆ ADC Trigger
- QEI (Quadrature Encoder Interface)
  - One unit of Quadrature Encoder Interface with 3 inputs QEI\_A, QEI\_B and IDX
- WDT (Watchdog Timer)
  - Programmable clock source and time-out period
  - Supports wake-up function in Power-down mode and Idle mode
  - Interrupt or reset selectable on watchdog time-out
- EPWM
  - Supports a built-in 16-bit PWM clock generators, providing SIX PWM outputs or three complementary paired PWM outputs
  - Shared same as clock source, clock divider, period and dead-zone generator
  - Supports group/independent/complementary modes
  - Supports One-shot or Auto-reload mode
  - Supports Edge-aligned and Center-aligned type
  - Supports Asymmetric mode
  - Programmable dead-zone insertion between complementary channels
  - Each output has independent polarity setting control
  - Hardware fault brake and software brake protections
  - Support three of hardware Brake pin
  - Supports rising, falling, central, period, and fault break interrupts

- Supports duty/period trigger A/D 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
- BPWM
  - One 16-bit PWM generator which supports one 8-bit pre-scalar, one clock divider, two PWM timers (down counter) and one dead-zone generator
  - Two independent outputs or one complementary paired outputs.
  - PWM Interrupt request synchronized with PWM period
  - Edge-aligned type or Center-aligned type option
- USCI (Universal Serial Control Interface Controller)
  - ◆ Three USCI devices
  - ◆ USC10 & USC11 Supports to be configured as UART, SPI or I<sup>2</sup>C individually
  - ◆ USC12 Supports to be configured as UART and I<sup>2</sup>C individually
  - ◆ Supports programmable baud-rate generator
- ADC (Analog-to-Digital Converter)
  - 12-bit ADC with 1us conversion time
  - Supports 2 sample/hold
  - Up to 16-ch single-end input from I/O and one internal input from band-gap.
  - Conversion started either by software trigger, PWM trigger, ACMP trigger or external pin trigger
  - Supports temperature sensor for measurement chip temperature
  - Supports Simultaneous and Sequential function to continuous conversion 4 channels maximum.
- Programmable Gain Amplifier (PGA)
  - Supports 8 level gain selects from 1, 2, 3, 5, 7, 9, 11 and 13.
  - Unity gain frequency up to 6 MHz
- OP Amplifier
  - Rail-to-rail OPA x 3
- DAC
  - Built-in two of 12-bit DAC,
  - Be the reference voltage for ACMP, PGA, ADC or output to pins.
- Analog Comparator
  - Two analog comparators with 4 reference voltage source
    - Programmable 16-level resistor ladders (CRV)
    - Built-in 12-bit DAC for comparator reference voltage

- Band-gap voltage
  - External voltage from port pin
  - Supports Hysteresis function 0/20/90/150mV at  $V_{DD} = 5V$
  - Interrupt when compared results changed
- Hardware Divider
  - 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
  - Waiting for calculation ready automatically when reading quotient and remainder
  - Support 3 group of independent dividend, divisor, quotient and remainder registers for three times of calculation capacity
- ISP (In-System Programming) and ICP (In-Circuit Programming)
- BOD (Brown-out Detector)
  - 8 programmable threshold levels: 4.3V/4.0V/3.7V/3.0V/2.7V/2.4V/2.2V/2.0V
  - Supports Brown-out interrupt and reset option
- 96-bit unique ID
- LVR (Low Voltage Reset)
- Operating Temperature:  $-40^{\circ}C \sim 105^{\circ}C$
- Reliability: EFT  $> \pm 4KV$ , ESD HBM pass 4KV
- Packages:
  - 48-pin LQFP(7x7mm), 48-pin QFN(7x7mm)
  - Package is Halogen-free, RoHS-compliant and TSCA-compliant.

### 3 ABBREVIATIONS

#### 3.1 Abbreviations

| Acronym | Description                                      |
|---------|--|
| ACMP    | Analog Comparator Controller                     |
| ADC     | Analog-to-Digital Converter                      |
| AHB     | Advanced High-Performance Bus                    |
| APB     | Advanced Peripheral Bus                          |
| BOD     | Brown-out Detection                              |
| DAC     | Digital -to-Analog Converter                     |
| DAP     | Debug Access Port                                |
| EPWM    | Enhanced Pulse Width Modulation                  |
| FIFO    | First In, First Out                              |
| FMC     | Flash Memory Controller                          |
| GPIO    | General-Purpose Input/Output                     |
| HCLK    | The Clock of Advanced High-Performance Bus       |
| HIRC    | 48 MHz Internal High Speed RC Oscillator         |
| HXT     | 4~24 MHz External High Speed Crystal Oscillator  |
| ICP     | In Circuit Programming                           |
| ISP     | In System Programming                            |
| ISR     | Interrupt Service Routine                        |
| LDO     | Low Dropout Regulator                            |
| 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             |
| PWM     | Pulse Width Modulation                           |
| QEI     | Quadrature Encoder Interface                     |
| SPI     | Serial Peripheral Interface                      |
| SPS     | Samples per Second                               |
| TMR     | Timer Controller                                 |
| UART    | Universal Asynchronous Receiver/Transmitter      |
| UCID    | Unique Customer ID                               |
| WDT     | Watchdog Timer                                   |

Table 3.1-1 List of Abbreviations

## 4 PARTS INFORMATION LIST AND PIN CONFIGURATION

### 4.1 Selection Guide

#### 4.1.1 NuMicro® NM1230 Series Selection Guide

Note: LQFP48: 7x7mm, QFN48: 7x7mm

| Part Number | Flash (KB) | SRAM (KB) | ISP Loader ROM (KB) | Data Flash | I/O | Timer | Connectivity |                  |     | IRC 48/72 MHz | PWM | BPWM | Analog Comp. | PGA | OPA | ADC (12-bit) | DAC (12-bit)   | Temperature Sensor | ICP/ISPI/AP | Package |
|-------------|------------|-----------|---------------------|------------|-----|-------|--------------|------------------|-----|---------------|-----|------|--------------|-----|-----|--------------|----------------|--------------------|-------------|---------|
|             |            |           |                     |            |     |       | USCI         |                  |     |               |     |      |              |     |     |              |                |                    |             |         |
|             |            |           |                     |            |     |       | UART         | I <sup>2</sup> C | SPI |               |     |      |              |     |     |              |                |                    |             |         |
| NM1234D     | 64         | 16        | 7.5                 | √          | 44  | 4     | 3            | 3                | 2   | 1             | 6   | 2    | 2            | 1   | 3   | 16           | 2 <sup>a</sup> | 1                  | √           | LQFP48  |
| NM1234Y     | 64         | 16        | 7.5                 | √          | 44  | 4     | 3            | 3                | 2   | 1             | 6   | 2    | 2            | 1   | 3   | 16           | 2 <sup>a</sup> | 1                  | √           | QFN48   |

Table 4.1-1 NuMicro® NM1230 Base Series Selection Guide

Note:

- a. DAC0 outputs through PGO by software configuration.

## 4.2 Pin Configuration

### 4.2.1 NuMicro® NM1230 Series LQFP48 (7x7mm) Pin Diagram

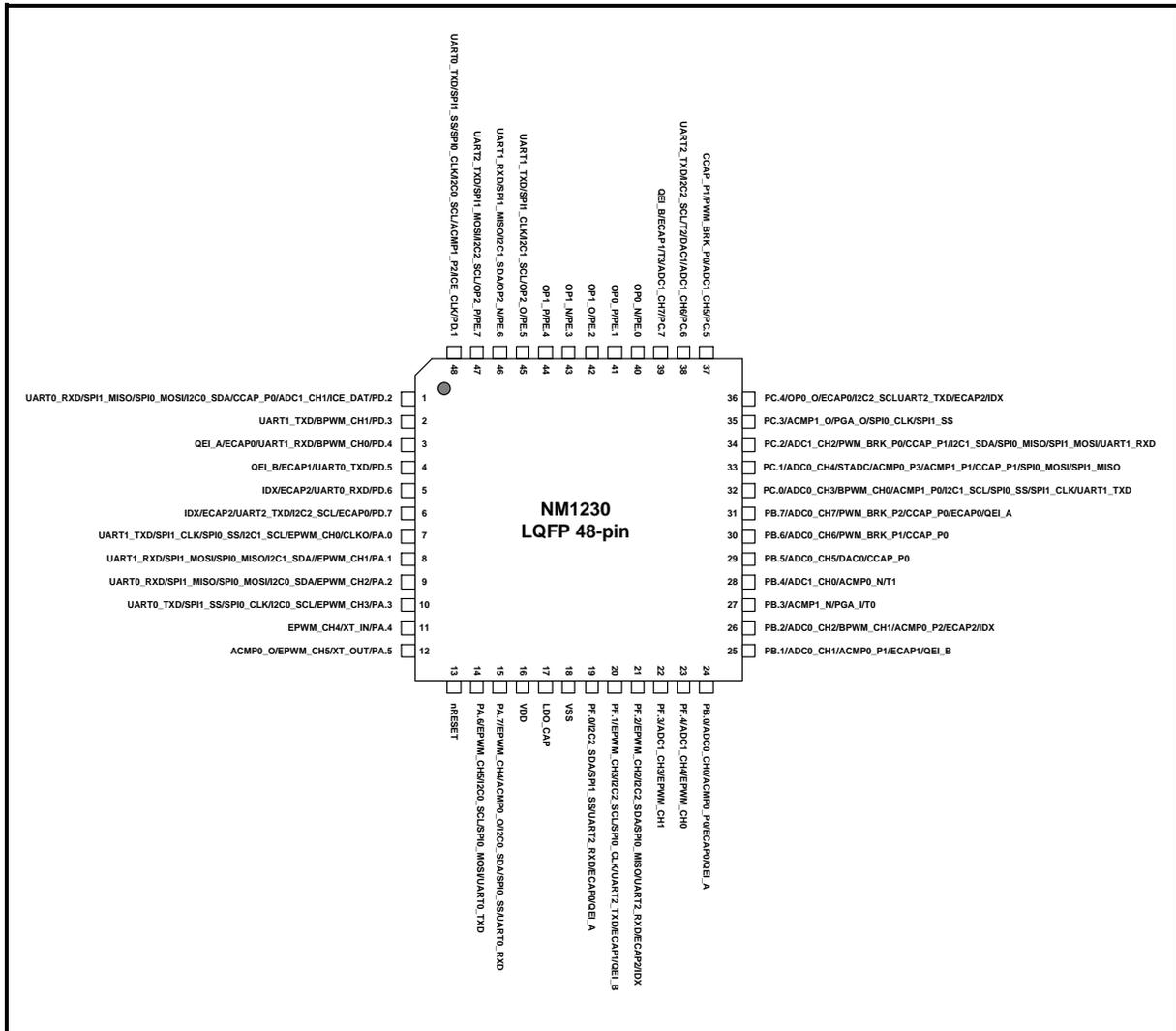


Figure 4.2-1 NuMicro® NM1230 Base Series LQFP 48-pin Diagram

4.2.2 NuMicro® NM1230 Series QFN48 (7x7mm) Pin Diagram

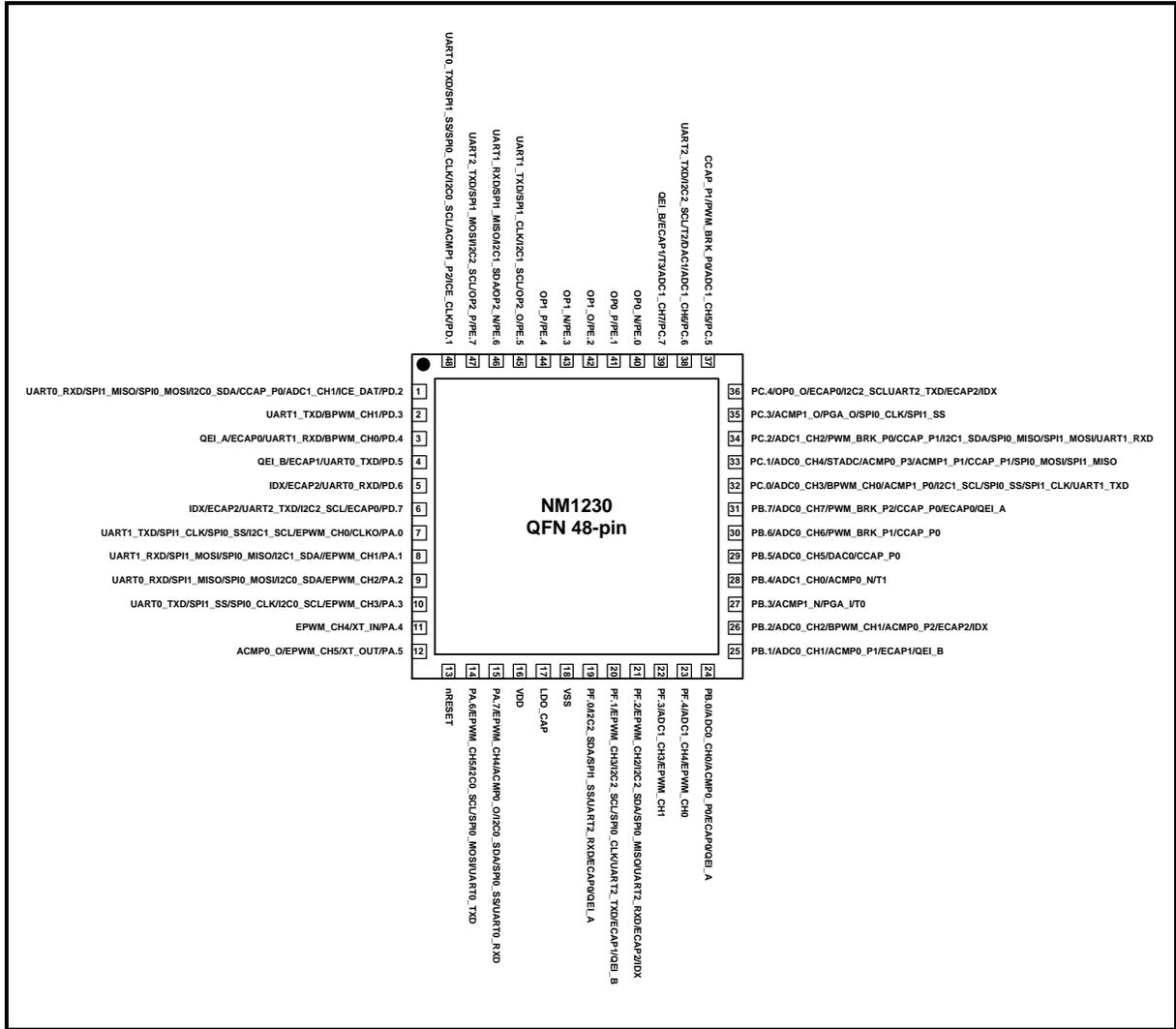


Figure 4.2-2 NuMicro® NM1230 Base Series QFN 48-pin Diagram

### 4.3 Pin Description

#### 4.3.1 NM1230 Series Pin Description Overview

| GPIO MFP0 | ICE XTAL MFP1 | ADC MFP2 | PWM MFP3 | ACMP0 MFP4 | ACMP1 MFP5 | PGA(OP) MFP6 | TIMER MFP7 | I2C MFP8 | SPI0 MFP9 | SPI1 MFPA | UART MFPB | ECAP MFPC | QEI MFPD |           |    |       |   |       |   |
|-----------|---------------|----------|----------|------------|------------|--------------|------------|----------|-----------|-----------|-----------|-----------|----------|-----------|----|-------|---|-------|---|
| GPA0      | CLKO          | O        | EPWM_CH0 | O          |            |              |            | PC1_SCL  | IO        | SPI0_SS   | IO        | SPI1_CLK  | IO       | UART1_TXD | O  |       |   |       |   |
| GPA1      |               |          | EPWM_CH1 | O          |            |              |            | PC1_SDA  | IO        | SPI0_MISO | IO        | SPI1_MOSI | IO       | UART1_RXD | I  |       |   |       |   |
| GPA2      |               |          | EPWM_CH2 | O          |            |              |            | PC0_SDA  | IO        | SPI0_MOSI | IO        | SPI1_MISO | IO       | UART0_RXD | I  |       |   |       |   |
| GPA3      |               |          | EPWM_CH3 | O          |            |              |            | PC0_SCL  | IO        | SPI0_CLK  | IO        | SPI1_SS   | IO       | UART0_TXD | O  |       |   |       |   |
| GPA4      | XT_IN         | A        | EPWM_CH4 | O          |            |              |            |          |           |           |           |           |          |           |    |       |   |       |   |
| GPA5      | XT_OUT        | A        | EPWM_CH5 | O          | ACMP0_O    | O            |            |          |           |           |           |           |          |           |    |       |   |       |   |
| GPA6      |               |          | EPWM_CH5 | O          |            |              |            | PC0_SCL  | IO        | SPI0_MOSI | IO        |           |          | UART0_TXD | IO |       |   |       |   |
| GPA7      |               |          | EPWM_CH4 | O          | ACMP0_O    | O            |            | PC0_SDA  | IO        | SPI0_SS   | IO        |           |          | UART0_RXD | IO |       |   |       |   |
| GPB0      |               | ADC0_CH0 | A        | ACMP0_P0   | A          |              |            | ECAP0    | I         |           |           |           |          |           |    | ECAP0 | I | QEI_A | I |
| GPB1      |               | ADC0_CH1 | A        | ACMP0_P1   | A          |              |            | ECAP1    | I         |           |           |           |          |           |    | ECAP1 | I | QEI_B | I |
| GPB2      |               | ADC0_CH2 | A        | BPWM_CH1   | O          | ACMP0_P2     | A          | ECAP2    | I         |           |           |           |          |           |    | ECAP2 | I | IDX   | I |
| GPB3      |               |          |          |            |            | ACMP1_N      | A          | PGA_I    | A         | T0        | IO        |           |          |           |    |       |   |       |   |
| GPB4      |               | ADC1_CH0 | A        | ACMP0_N    | A          |              |            | T1       | IO        |           |           |           |          |           |    |       |   |       |   |
| GPB5      |               | ADC0_CH5 | A        | DAC0       | A          |              |            | CCAP_P0  | I         |           |           |           |          |           |    |       |   |       |   |
| GPB6      |               | ADC0_CH6 | A        | PWM_BRK_P1 | I          |              |            | CCAP_P0  | I         |           |           |           |          |           |    |       |   |       |   |
| GPB7      |               | ADC0_CH7 | A        | PWM_BRK_P2 | I          |              |            | CCAP_P0  | I         |           |           |           |          |           |    | ECAP0 | I | QEI_A | I |
| GPC0      |               | ADC0_CH3 | A        | BPWM_CH0   | O          | ACMP1_P0     | A          | PC1_SCL  | IO        | SPI0_SS   | IO        | SPI1_CLK  | IO       | UART1_TXD | O  |       |   |       |   |
| GPC1      |               | ADC0_CH4 | A        | STADC      | I          | ACMP0_P3     | A          | CCAP_P1  | I         | SPI0_MOSI | IO        | SPI1_MISO | IO       |           |    |       |   |       |   |
| GPC2      |               | ADC1_CH2 | A        | PWM_BRK_P0 | I          | ACMP1_P1     | A          | CCAP_P1  | I         | PC1_SDA   | IO        | SPI0_MISO | IO       | UART1_RXD | I  |       |   |       |   |
| GPC3      |               |          |          |            |            | ACMP1_O      | O          | PGA_O    | A         | SPI0_CLK  | IO        | SPI1_SS   | IO       |           |    |       |   |       |   |
| GPC4      |               |          |          |            |            | OP0_O        | A          | ECAP0    | I         | PC2_SCL   | IO        |           |          | UART2_TXD | IO | ECAP2 | I | IDX   | I |
| GPC5      |               | ADC1_CH5 | A        | PWM_BRK_P0 | I          |              |            | CCAP_P1  | I         |           |           |           |          |           |    |       |   |       |   |
| GPC6      |               | ADC1_CH6 | A        |            |            | DAC1         | A          | T2       | IO        | PC2_SCL   | IO        |           |          | UART2_TXD | IO |       |   |       |   |
| GPC7      |               | ADC1_CH7 | A        |            |            |              |            | T3       | IO        |           |           |           |          |           |    | ECAP1 | I | QEI_B | I |
| nRESET    |               |          |          |            |            |              |            |          |           |           |           |           |          |           |    |       |   |       |   |
| GPD1      | ICE_CLK       | I        |          |            | ACMP1_P2   | A            |            | PC0_SCL  | IO        | SPI0_CLK  | IO        | SPI1_SS   | IO       | UART0_TXD | O  |       |   |       |   |
| GPD2      | ICE_DAT       | IO       | ADC1_CH1 | A          |            |              |            | CCAP_P0  | I         | PC0_SDA   | IO        | SPI0_MOSI | IO       | UART0_RXD | I  |       |   |       |   |
| GPD3      |               |          | BPWM_CH1 | O          |            |              |            |          |           |           |           |           |          | UART1_TXD | O  |       |   |       |   |
| GPD4      |               |          | BPWM_CH0 | O          |            |              |            |          |           |           |           |           |          | UART1_RXD | I  | ECAP0 | I | QEI_A | I |
| GPD5      |               |          |          |            |            |              |            |          |           |           |           |           |          | UART0_TXD | IO | ECAP1 | I | QEI_B | I |
| GPD6      |               |          |          |            |            |              |            |          |           |           |           |           |          | UART0_RXD | IO | ECAP2 | I | IDX   | I |
| GPD7      |               |          |          |            |            |              |            | ECAP0    | I         | PC2_SCL   | IO        |           |          | UART2_TXD | IO | ECAP2 | I | IDX   | I |
| GPE0      |               |          |          |            |            | OP0_N        | A          |          |           |           |           |           |          |           |    |       |   |       |   |
| GPE1      |               |          |          |            |            | OP0_P        | A          |          |           |           |           |           |          |           |    |       |   |       |   |
| GPE2      |               |          |          |            |            | OP1_O        | A          |          |           |           |           |           |          |           |    |       |   |       |   |
| GPE3      |               |          |          |            |            | OP1_N        | A          |          |           |           |           |           |          |           |    |       |   |       |   |
| GPE4      |               |          |          |            |            | OP1_P        | A          |          |           |           |           |           |          |           |    |       |   |       |   |
| GPE5      |               |          |          |            |            | OP2_O        | A          | PC1_SCL  | IO        |           |           | SPI1_CLK  | IO       | UART1_TXD | O  |       |   |       |   |
| GPE6      |               |          |          |            |            | OP2_N        | A          | PC1_SDA  | IO        |           |           | SPI1_MISO | IO       | UART1_RXD | I  |       |   |       |   |
| GPE7      |               |          |          |            |            | OP2_P        | A          | PC2_SCL  | IO        |           |           | SPI1_MOSI | IO       | UART2_TXD | IO |       |   |       |   |
| GPF0      |               |          |          |            |            |              |            | PC2_SDA  | IO        |           |           | SPI1_SS   | IO       | UART2_RXD | IO | ECAP0 | I | QEI_A | I |
| GPF1      |               |          | EPWM_CH3 | O          |            |              |            | PC2_SCL  | IO        | SPI0_CLK  | IO        |           |          | UART2_TXD | IO | ECAP1 | I | QEI_B | I |
| GPF2      |               |          | EPWM_CH2 | O          |            |              |            | PC2_SDA  | IO        | SPI0_MISO | IO        |           |          | UART2_RXD | IO | ECAP2 | I | IDX   | I |
| GPF3      |               | ADC1_CH3 | A        | EPWM_CH1   | O          |              |            |          |           |           |           |           |          |           |    |       |   |       |   |
| GPF4      |               | ADC1_CH4 | A        | EPWM_CH0   | O          |              |            |          |           |           |           |           |          |           |    |       |   |       |   |

**4.3.2 NM1230 Series Pin Description**

MFP\* = Multi-function pin. (Refer to section SYS\_GP<sub>x</sub>\_MFP)

PA.0 MFP0 means SYS\_GPA\_MFP[3:0]=0x0.

PA.4 MFP5 means SYS\_GPA\_MFP[19:16]=0x5.

MFP only configures the output data or input data of PAD, the direction of PAD were configured by PMD.

The priority of MFP in the same multi-function was GPA > GPB > GPC > GPD > GPE > GPF.

The type A of multi-function needs to be configured to be input port.

**4.3.2.1 NM1230 Series LQFP48/QFN48 Pin Description**

| Pin No. | Pin Name  | Type | MFP* | Description                              |
|---------|-----------|------|------|--|
| 1       | PD.2      | I/O  | MFP0 | General purpose digital I/O pin.         |
|         | ICE_DAT   | I/O  | MFP1 | Serial wired debugger data pin           |
|         | ADC1_CH1  | A    | MFP2 | ADC1 channel analog input.               |
|         | CCAP_P0   | I    | MFP7 | Timer Continuous Capture input pin       |
|         | I2C0_SDA  | I/O  | MFP8 | I <sup>2</sup> C0 data input/output pin. |
|         | SPI0_MOSI | I/O  | MFP9 | SPI0 MOSI (Master Out, Slave In) pin.    |
|         | SPI1_MISO | I/O  | MFPA | SPI1 MISO (Master In, Slave Out) pin.    |
|         | UART0_RXD | I    | MFPB | Data receiver input pin for UART0.       |
| 2       | PD.3      | I/O  | MFP0 | General purpose digital I/O pin.         |
|         | BPWM_CH1  | I/O  | MFP3 | PWM channel1 output/capture input.       |
|         | UART1_TXD | O    | MFPB | Data transmitter output pin for UART1.   |
| 3       | PD.4      | I/O  | MFP0 | General purpose digital I/O pin.         |
|         | BPWM_CH0  | I/O  | MFP3 | PWM channel0 output/capture input.       |
|         | UART1_RXD | I    | MFPB | Data receiver input pin for UART1.       |
|         | ECAP0     | I    | MFPC | Enhanced Input Capture input pin         |
|         | QEI_A     | I    | MFPD | Quadrature Encoder input pin             |
| 4       | PD.5      | I/O  | MFP0 | General purpose digital I/O pin.         |
|         | UART0_TXD | O    | MFPB | Data transmitter output pin for UART0.   |
|         | ECAP1     | I    | MFPC | Enhanced Input Capture input pin         |
|         | QEI_B     | I    | MFPD | Quadrature Encoder input pin             |
| 5       | PD.6      | I/O  | MFP0 | General purpose digital I/O pin.         |
|         | UART0_RXD | I    | MFPB | Data receiver input pin for UART0.       |
|         | ECAP2     | I    | MFPC | Enhanced Input Capture input pin         |
|         | IDX       | I    | MFPD | Quadrature Encoder input pin             |
| 6       | PD.7      | I/O  | MFP0 | General purpose digital I/O pin.         |

| Pin No. | Pin Name  | Type | MFP* | Description                                       |
|---------|-----------|------|------|---|
|         | ECAP_P0   | I    | MFP7 | Enhanced Input Capture input pin                  |
|         | I2C2_SCL  | I/O  | MFP8 | I <sup>2</sup> C2 clock pin.                      |
|         | UART2_TXD | O    | MFPB | Data transmitter output pin for UART0.            |
|         | ECAP2     | I    | MFPC | Enhanced Input Capture input pin                  |
|         | IDX       | I    | MFPD | Quadrature Encoder input pin                      |
| 7       | PA.0      | I/O  | MFP0 | General purpose digital I/O pin.                  |
|         | CLKO      | O    | MFP1 | Clock Out   |
|         | EPWM_CH0  | I/O  | MFP3 | PWM channel0 output/capture input.                |
|         | I2C1_SCL  | I/O  | MFP8 | I <sup>2</sup> C1 clock pin.                      |
|         | SPI0_SS   | I/O  | MFP9 | SPI0 slave select pin.                            |
|         | SPI1_CLK  | I/O  | MFPA | SPI1 serial clock pin                             |
|         | UART1_TXD | O    | MFPB | Data transmitter output pin for UART1.            |
| 8       | PA.1      | I/O  | MFP0 | General purpose digital I/O pin.                  |
|         | EPWM_CH1  | I/O  | MFP3 | PWM channel1 output/capture input.                |
|         | I2C1_SDA  | I/O  | MFP8 | I <sup>2</sup> C1 data input/output pin.          |
|         | SPI0_MISO | I/O  | MFP9 | SPI0 1st MISO (Master In, Slave Out) pin.         |
|         | SPI1_MOSI | I/O  | MFPA | SPI1 MOSI (Master Out, Slave In) pin.             |
|         | UART1_RXD | I    | MFPB | Data receiver input pin for UART1.                |
| 9       | PA.2      | I/O  | MFP0 | General purpose digital I/O pin.                  |
|         | EPWM_CH2  | I/O  | MFP3 | PWM channel2 output/capture input.                |
|         | I2C0_SDA  | I/O  | MFP8 | I <sup>2</sup> C0 data input/output pin.          |
|         | SPI0_MOSI | I/O  | MFP9 | SPI0 1st MOSI (Master Out, Slave In) pin.         |
|         | SPI1_MISO | I/O  | MFPA | SPI1 MISO (Master In, Slave Out) pin.             |
|         | UART0_RXD | I    | MFPB | Data receiver input pin for UART0.                |
| 10      | PA.3      | I/O  | MFP0 | General purpose digital I/O pin.                  |
|         | EPWM_CH3  | I/O  | MFP3 | PWM channel3 output/capture input.                |
|         | I2C0_SCL  | I/O  | MFP8 | I <sup>2</sup> C0 clock pin.                      |
|         | SPI0_CLK  | I/O  | MFP9 | SPI0 serial clock pin.                            |
|         | SPI1_SS   | I/O  | MFPA | SPI1 slave select pin                             |
|         | UART0_TXD | O    | MFPB | Data transmitter output pin for UART0.            |
| 11      | PA.4      | I/O  | MFP0 | General purpose digital I/O pin.                  |
|         | XT_IN     | I    | MFP1 | External 4~24 MHz (high speed) crystal input pin. |
|         | EPWM_CH4  | I/O  | MFP3 | PWM channel4 output/capture input.                |

| Pin No. | Pin Name        | Type | MFP* | Description  |
|---------|-----------------|------|------|--|
| 12      | PA.5            | I/O  | MFP0 | General purpose digital I/O pin.   |
|         | XT_OUT          | O    | MFP1 | External 4~24 MHz (high speed) crystal output pin.   |
|         | EPWM_CH5        | I/O  | MFP3 | PWM channel5 output/capture input.   |
|         | ACMP0_O         | O    | MFP4 | Analog comparator0 output.   |
| 13      | nRESET          | I    |      | External reset input: active LOW, with an internal pull-up. Set this pin low reset to initial state. |
| 14      | PA.6            | I/O  | MFP0 | General purpose digital I/O pin.   |
|         | EPWM_CH5        | I/O  | MFP3 | PWM channel5 output/capture input.   |
|         | I2C0_SCL        | I/O  | MFP8 | I <sup>2</sup> C0 clock pin.   |
|         | SPI0_MOSI       | I/O  | MFP9 | SPI0 1st MOSI (Master Out, Slave In) pin.  |
|         | UART0_TXD       | O    | MFPB | Data transmitter output pin for UART0.   |
| 15      | PA.7            | I/O  | MFP0 | General purpose digital I/O pin.   |
|         | EPWM_CH4        | I/O  | MFP3 | PWM channel5 output/capture input.   |
|         | ACMP0_O         | O    | MFP4 | Analog comparator0 output.   |
|         | I2C0_SDA        | I/O  | MFP8 | I <sup>2</sup> C0 data input/output pin.   |
|         | SPI0_SS         | I/O  | MFP9 | SPI0 slave select pin  |
|         | UART0_RXD       | I    | MFPB | Data receiver input pin for UART0.   |
| 16      | V <sub>DD</sub> | PWR  | --   | Ground pin for digital circuit.  |
| 17      | LDO_CAP         | A    | --   | LDO output pin.<br><b>Note:</b> Recommend to connect a 1uF CAP to the pin.                           |
| 18      | V <sub>SS</sub> | PWR  | --   | Ground pin for digital circuit.  |
| 19      | PF.0            | I/O  | MFP0 | General purpose digital I/O pin.   |
|         | I2C2_SDA        | I/O  | MFP8 | I <sup>2</sup> C2 data input/output pin.   |
|         | SPI1_SS         | I/O  | MFPA | SPI1 slave select pin  |
|         | UART2_RXD       | I    | MFPB | Data receiver input pin for UART2.   |
|         | ECAP0           | I    | MFPC | Enhanced Input Capture input pin   |
|         | QE1_A           | I    | MFPD | Quadrature Encoder input pin   |
| 20      | PF.1            | I/O  | MFP0 | General purpose digital I/O pin.   |
|         | EPWM_CH3        | I/O  | MFP3 | PWM channel3 output/capture input.   |
|         | I2C2_SCL        | I/O  | MFP8 | I <sup>2</sup> C2 clock pin.   |
|         | SPI0_CLK        | I/O  | MFP9 | SPI0 serial clock pin.   |
|         | UART2_TXD       | O    | MFPB | Data transmitter output pin for UART2.   |
|         | ECAP1           | I    | MFPC | Enhanced Input Capture input pin   |
|         | QE1_B           | I    | MFPD | Quadrature Encoder input pin   |

| Pin No. | Pin Name  | Type | MFP* | Description                               |
|---------|-----------|------|------|---|
| 21      | PF.2      | I/O  | MFP0 | General purpose digital I/O pin.          |
|         | EPWM_CH2  | I/O  | MFP3 | PWM channel2 output/capture input.        |
|         | I2C2_SDA  | I/O  | MFP8 | I <sup>2</sup> C2 data input/output pin.  |
|         | SPI0_MISO | I/O  | MFP9 | SPI0 1st MISO (Master In, Slave Out) pin. |
|         | UART2_RXD | I    | MFPB | Data receiver input pin for UART2.        |
|         | ECAP2     | I    | MFPC | Enhanced Input Capture input pin          |
|         | IDX       | I    | MFPD | Quadrature Encoder input pin              |
| 22      | PF.3      | I/O  | MFP0 | General purpose digital I/O pin.          |
|         | ADC1_CH3  | A    | MFP2 | ADC1 channel analog input.                |
|         | EPWM_CH1  | I/O  | MFP3 | PWM channel1 output/capture input.        |
| 23      | PF.4      | I/O  | MFP0 | General purpose digital I/O pin.          |
|         | ADC1_CH4  | A    | MFP2 | ADC1 channel analog input.                |
|         | EPWM_CH0  | I/O  | MFP3 | PWM channel0 output/capture input.        |
| 24      | PB.0      | I/O  | MFP0 | General purpose digital I/O pin.          |
|         | ADC0_CH0  | A    | MFP2 | ADC0 channel analog input.                |
|         | ACMP0_P0  | A    | MFP4 | Analog comparator0 positive input pin.    |
|         | ECAP0     | I    | MFP7 | Enhanced Input Capture input pin          |
|         | ECAP0     | I    | MFPC | Enhanced Input Capture input pin          |
|         | QEI_A     | I    | MFPD | Quadrature Encoder input pin              |
| 25      | PB.1      | I/O  | MFP0 | General purpose digital I/O pin.          |
|         | ADC0_CH1  | A    | MFP2 | ADC0 channel analog input.                |
|         | ACMP0_P1  | A    | MFP4 | Analog comparator0 positive input pin.    |
|         | ECAP1     | I    | MFP7 | Enhanced Input Capture input pin          |
|         | ECAP1     | I    | MFPC | Enhanced Input Capture input pin          |
|         | QEI_B     | I    | MFPD | Quadrature Encoder input pin              |
| 26      | PB.2      | I/O  | MFP0 | General purpose digital I/O pin.          |
|         | ADC0_CH2  | A    | MFP2 | ADC0 channel analog input.                |
|         | BPWM_CH1  | I/O  | MFP3 | PWM channel1 output/capture input.        |
|         | ACMP0_P2  | A    | MFP4 | Analog comparator0 positive input pin.    |
|         | ECAP2     | I    | MFP7 | Enhanced Input Capture input pin          |
|         | ECAP2     | I    | MFPC | Enhanced Input Capture input pin          |
|         | IDX       | I    | MFPD | Quadrature Encoder input pin              |
| 27      | PB.3      | I/O  | MFP0 | General purpose digital I/O pin.          |

| Pin No. | Pin Name   | Type | MFP* | Description                                |
|---------|------------|------|------|--|
|         | ACMP1_N    | A    | MFP5 | Analog comparator1 negative input pin.     |
|         | PGA_I      | A    | MFP6 | PGA input pin                              |
|         | T0         | I/O  | MFP7 | Timer0event counter input / toggle output  |
| 28      | PB.4       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC1_CH0   | A    | MFP2 | ADC1 channel analog input.                 |
|         | ACMP0_N    | A    | MFP4 | Analog comparator0 negative input pin.     |
|         | T1         | I/O  | MFP7 | Timer1 event counter input / toggle output |
| 29      | PB.5       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC0_CH5   | A    | MFP2 | ADC0 channel analog input.                 |
|         | DAC0       | A    | MFP4 | DAC0 analog output.                        |
|         | CCAP_P0    | I    | MFP7 | Timer Continuous Capture input pin         |
| 30      | PB.6       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC0_CH6   | A    | MFP2 | ADC0 channel analog input.                 |
|         | PWM_BRK_P1 | I    | MFP3 | Brake input pin of EPWM.                   |
|         | CCAP_P0    | I    | MFP7 | Timer Continuous Capture input pin         |
| 31      | PB.7       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC0_CH7   | A    | MFP2 | ADC0 channel analog input.                 |
|         | PWM_BRK_P2 | I    | MFP3 | Brake input pin of EPWM.                   |
|         | CCAP_P0    | I    | MFP7 | Timer Continuous Capture input pin         |
|         | ECAP0      | I    | MFPC | Enhanced Input Capture input pin           |
|         | QEI_A      | I    | MFPD | Quadrature Encoder input pin               |
| 32      | PC.0       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC0_CH3   | A    | MFP2 | ADC0 channel analog input.                 |
|         | BPWM_CH0   | O    | MFP3 | BPWM channel1 output input.                |
|         | ACMP1_P0   | A    | MFP5 | Analog comparator1 positive input pin.     |
|         | I2C1_SCL   | I/O  | MFP8 | I <sup>2</sup> C1 clock pin.               |
|         | SPI0_SS    | I/O  | MFP9 | SPI1 slave select pin                      |
|         | SPI1_CLK   | I/O  | MFPA | SPI1 serial clock pin                      |
|         | UART1_TXD  | O    | MFPB | Data transmitter output pin for UART1.     |
| 33      | PC.1       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC0_CH4   | A    | MFP2 | ADC0 channel analog input.                 |
|         | STADC      | I    | MFP3 | ADC external trigger input.                |
|         | ACMP0_P3   | A    | MFP4 | Analog comparator0 positive input pin.     |

| Pin No. | Pin Name   | Type | MFP* | Description                                |
|---------|------------|------|------|--|
|         | ACMP1_P1   | A    | MFP5 | Analog comparator1 positive input pin.     |
|         | CCAP_P1    | I    | MFP7 | Timer Continuous Capture input pin         |
|         | SPI0_MOSI  | I/O  | MFP9 | SPI0 1st MOSI (Master Out, Slave In) pin.  |
|         | SPI1_MISO  | I/O  | MFPA | SPI1 MISO (Master In, Slave Out) pin.      |
| 34      | PC.2       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC1_CH2   | A    | MFP2 | ADC1 channel analog input.                 |
|         | PWM_BRK_P0 | I    | MFP3 | Brake input pin of EPWM.                   |
|         | CCAP_P1    | I    | MFP7 | Timer Continuous Capture input pin         |
|         | I2C1_SDA   | I/O  | MFP8 | I <sup>2</sup> C1 data input/output pin.   |
|         | SPI0_MISO  | I/O  | MFP9 | SPI0 1st MISO (Master In, Slave Out) pin.  |
|         | SPI1_MOSI  | I/O  | MFPA | SPI1 MOSI (Master Out, Slave In) pin.      |
|         | UART1_RXD  | I    | MFPB | Data receiver input pin for UART1.         |
| 35      | PC.3       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ACMP1_O    | O    | MFP5 | Analog comparator1 output.                 |
|         | PGA_O      | A    | MFP6 | PGA output pin                             |
|         | SPI0_CLK   | I/O  | MFP9 | SPI0 serial clock pin.                     |
|         | SPI1_SS    | I/O  | MFPA | SPI1 slave select pin                      |
| 36      | PC.4       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP0_O      | A    | MFP6 | Operational Amplifier output pin           |
|         | ECAP0      | I    | MFP7 | Enhanced Input Capture input pin           |
|         | I2C2_SCL   | I/O  | MFP8 | I <sup>2</sup> C2 clock pin.               |
|         | UART2_TXD  | O    | MFPB | Data transmitter output pin for UART2.     |
|         | ECAP2      | I    | MFPC | Enhanced Input Capture input pin           |
| 37      | IDX        | I    | MFPD | Quadrature Encoder input pin               |
|         | PC.5       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC1_CH5   | A    | MFP2 | ADC1 channel analog input.                 |
|         | PWM_BRK_P0 | I    | MFP3 | Brake input pin of EPWM.                   |
| 38      | CCAP_P1    | I    | MFP7 | Timer Continuous Capture input pin         |
|         | PC.6       | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC1_CH6   | A    | MFP2 | ADC1 channel analog input.                 |
|         | DAC1       | A    | MFP5 | DAC1 analog output.                        |
|         | T2         | I/O  | MFP7 | Timer2 event counter input / toggle output |
|         | I2C2_SCL   | I/O  | MFP8 | I <sup>2</sup> C2 clock pin.               |

| Pin No. | Pin Name  | Type | MFP* | Description                                |
|---------|-----------|------|------|--|
|         | UART2_TXD | O    | MFPB | Data transmitter output pin for UART2.     |
| 39      | PC.7      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ADC1_CH7  | A    | MFP2 | ADC1 channel analog input.                 |
|         | T3        | I/O  | MFP7 | Timer3 event counter input / toggle output |
|         | ECAP1     | I    | MFPC | Enhanced Input Capture input pin           |
|         | QEI_B     | I    | MFPD | Quadrature Encoder input pin               |
| 40      | PE.0      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP0_N     | A    | MFP7 | Operational Amplifier Negative input pin   |
| 41      | PE.1      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP0_P     | A    | MFP7 | Operational Amplifier Positive input pin   |
| 42      | PE.2      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP1_O     | A    | MFP7 | Operational Amplifier output pin           |
| 43      | PE.3      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP1_N     | A    | MFP7 | Operational Amplifier Negative input pin   |
| 44      | PE.4      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP1_P     | A    | MFP7 | Operational Amplifier Positive input pin   |
| 45      | PE.5      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP2_O     | A    | MFP7 | Operational Amplifier output pin           |
|         | I2C1_SCL  | I/O  | MFP8 | I <sup>2</sup> C1 clock pin.               |
|         | SPI1_CLK  | I/O  | MFPA | SPI1 serial clock pin                      |
|         | UART1_TXD | O    | MFPB | Data transmitter output pin for UART1.     |
| 46      | PE.6      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP2_N     | A    | MFP7 | Operational Amplifier Negative input pin   |
|         | I2C1_SDA  | I/O  | MFP8 | I <sup>2</sup> C1 data input/output pin.   |
|         | SPI1_MISO | I/O  | MFPA | SPI0 1st MISO (Master In, Slave Out) pin.  |
|         | UART1_RXD | I    | MFPB | Data receiver input pin for UART1.         |
| 47      | PE.7      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | OP2_P     | A    | MFP7 | Operational Amplifier Positive input pin   |
|         | I2C2_SCL  | I/O  | MFP8 | I <sup>2</sup> C1 clock pin.               |
|         | SPI1_MOSI | I/O  | MFPA | SPI1 MOSI (Master Out, Slave In) pin.      |
|         | UART2_TXD | O    | MFPB | Data transmitter output pin for UART2.     |
| 48      | PD.1      | I/O  | MFP0 | General purpose digital I/O pin.           |
|         | ICE_CLK   | I    | MFP1 | Serial wired debugger clock pin            |

| Pin No. | Pin Name  | Type | MFP* | Description                            |
|---------|-----------|------|------|--|
|         | ACMP1_P2  | A    | MFP5 | Analog comparator1 positive input pin. |
|         | I2C0_SCL  | I/O  | MFP8 | I <sup>2</sup> C0 clock pin.           |
|         | SPI0_CLK  | I/O  | MFP9 | SPI0 serial clock pin.                 |
|         | SPI1_SS   | I/O  | MFPA | SPI1 slave select pin                  |
|         | UART0_TXD | O    | MFPB | Data transmitter output pin for UART0. |

Table 4.3-1 LQFP48/QFN48 Pin Description

**Note:**

1. Do not leave the pins ICE\_CLK and ICE\_DAT in floating when MCU is in operatoin. User may refer to one of the following methods
  - a. Add external pull-up or pull-low resistors at pins.
  - b. Set the 2 pins in Quasi-mode and output high to be equivelant to internal pull high.
  - c. Enable intenal pull-up by setting PD\_PHEN[2:1] = 11b.
  - d. Be wired to other deivce without floating at pins.

### 4.3.3 GPIO Multi-function Pin Summary

MFP\* = Multi-function pin. (Refer to section SYS\_GPx\_MFP)

PA.0 MFP0 means SYS\_GPA\_MFP[3:0]=0x0.

PA.4 MFP5 means SYS\_GPA\_MFP[19:16]=0x5.

| Group | Pin Name | GPIO | MFP* | Type | Description                     |
|-------|----------|------|------|------|---------------------------------|
| ACMP0 | ACMP0_P0 | PB.0 | MFP4 | A    | Comparator0 positive input pin. |
|       | ACMP0_P1 | PB.1 | MFP4 | A    | Comparator0 positive input pin. |
|       | ACMP0_P2 | PB.2 | MFP4 | A    | Comparator0 positive input pin. |
|       | ACMP0_P3 | PC.1 | MFP4 | A    | Comparator0 positive input pin. |
|       | ACMP0_N  | PB.4 | MFP4 | A    | Comparator0 negative input pin. |
|       | ACMP0_O  | PA.7 | MFP4 | O    | Comparator0 output pin.         |
|       | ACMP0_O  | PA.5 | MFP4 | O    | Comparator0 output pin.         |
| ACMP1 | ACMP1_P0 | PC.0 | MFP5 | A    | Comparator1 positive input pin. |
|       | ACMP1_P1 | PC.1 | MFP5 | A    | Comparator1 positive input pin. |
|       | ACMP1_P2 | PD.1 | MFP5 | A    | Comparator1 positive input pin. |
|       | ACMP1_N  | PB.3 | MFP5 | A    | Comparator1 negative input pin. |
|       | ACMP1_O  | PC.3 | MFP5 | O    | Comparator1 output pin.         |
| STADC | STADC    | PC.1 | MFP3 | I    | External ADC trigger input pin. |
| ADC0  | ADC0_CH0 | PB.0 | MFP2 | A    | ADC0 analog input channel 0.    |
|       | ADC0_CH1 | PB.1 | MFP2 | A    | ADC0 analog input channel 1.    |
|       | ADC0_CH2 | PB.2 | MFP2 | A    | ADC0 analog input channel 2.    |
|       | ADC0_CH3 | PC.0 | MFP2 | A    | ADC0 analog input channel 3.    |
|       | ADC0_CH4 | PC.1 | MFP2 | A    | ADC0 analog input channel 4.    |
|       | ADC0_CH5 | PB.5 | MFP2 | A    | ADC0 analog input channel 5.    |
|       | ADC0_CH6 | PB.6 | MFP2 | A    | ADC0 analog input channel 6.    |
|       | ADC0_CH7 | PB.7 | MFP2 | A    | ADC0 analog input channel 7.    |
| ADC1  | ADC1_CH0 | PB.4 | MFP2 | A    | ADC1 analog input channel 0.    |
|       | ADC1_CH1 | PD.2 | MFP2 | A    | ADC1 analog input channel 1.    |
|       | ADC1_CH2 | PC.2 | MFP2 | A    | ADC1 analog input channel 2.    |
|       | ADC1_CH3 | PF.3 | MFP2 | A    | ADC1 analog input channel 3.    |
|       | ADC1_CH4 | PF.4 | MFP2 | A    | ADC1 analog input channel 4.    |
|       | ADC1_CH5 | PC.5 | MFP2 | A    | ADC1 analog input channel 5.    |
|       | ADC1_CH6 | PC.6 | MFP2 | A    | ADC1 analog input channel 6.    |
|       | ADC1_CH7 | PC.7 | MFP2 | A    | ADC1 analog input channel 7.    |
| CLKO  | CLKO     | PA.0 | MFP1 | O    | Clock output pin.               |

|         |          |      |           |                         |                            |
|---------|----------|------|-----------|-------------------------|----------------------------|
| BPWM    | BPWM_CH0 | PC.0 | MFP3      | O                       | Basic PWM channel 0 output |
|         | BPWM_CH0 | PD.4 | MFP3      | O                       | Basic PWM channel 0 output |
|         | BPWM_CH1 | PB.2 | MFP3      | O                       | Basic PWM channel 1 output |
|         | BPWM_CH1 | PD.3 | MFP3      | O                       | Basic PWM channel 1 output |
| CCAP    | CCAP_P0  | PB.5 | MFP7      | I                       | Continuous Capture Input   |
|         | CCAP_P0  | PB.6 | MFP7      | I                       | Continuous Capture Input   |
|         | CCAP_P0  | PB.7 | MFP7      | I                       | Continuous Capture Input   |
|         | CCAP_P0  | PD.2 | MFP7      | I                       | Continuous Capture Input   |
|         | CCAP_P1  | PC.1 | MFP7      | I                       | Continuous Capture Input   |
|         | CCAP_P1  | PC.2 | MFP7      | I                       | Continuous Capture Input   |
| ECAP    | ECAP_P0  | PB.0 | MFP7,MFPC | I                       | Input capture channel 0    |
|         | ECAP_P0  | PB.7 | MFPC      | I                       | Input capture channel 0    |
|         | ECAP_P0  | PC.4 | MFP7      | I                       | Input capture channel 0    |
|         | ECAP_P0  | PD.4 | MFPC      | I                       | Input capture channel 0    |
|         | ECAP_P0  | PD.7 | MFP7      | I                       | Input capture channel 0    |
|         | ECAP_P0  | PF.0 | MFPC      | I                       | Input capture channel 0    |
|         | ECAP_P1  | PB.1 | MFP7,MFPC | I                       | Input capture channel 1    |
|         | ECAP_P1  | PC.7 | MFPC      | I                       | Input capture channel 1    |
|         | ECAP_P1  | PD.5 | MFPC      | I                       | Input capture channel 1    |
|         | ECAP_P1  | PF.1 | MFPC      | I                       | Input capture channel 1    |
|         | ECAP_P2  | PB.2 | MFP7,MFPC | I                       | Input capture channel 2    |
|         | ECAP_P2  | PC.4 | MFPC      | I                       | Input capture channel 2    |
|         | ECAP_P2  | PD.6 | MFPC      | I                       | Input capture channel 2    |
|         | ECAP_P2  | PD.7 | MFPC      | I                       | Input capture channel 2    |
| ECAP_P2 | PF.2     | MFPC | I         | Input capture channel 2 |                            |
| QEI     | QEI_A    | PB.0 | MFPD      | I                       | QEI channel input          |
|         | QEI_A    | PB.7 | MFPD      | I                       | QEI channel input          |
|         | QEI_A    | PD.4 | MFPD      | I                       | QEI channel input          |
|         | QEI_A    | PF.0 | MFPD      | I                       | QEI channel input          |
|         | QEI_B    | PB.1 | MFPD      | I                       | QEI channel input          |
|         | QEI_B    | PC.7 | MFPD      | I                       | QEI channel input          |
|         | QEI_B    | PD.5 | MFPD      | I                       | QEI channel input          |
|         | QEI_B    | PF.1 | MFPD      | I                       | QEI channel input          |

|        |            |      |      |     |   |
|--------|------------|------|------|-----|---|
|        | IDX        | PB.2 | MFPD | I   | QEI channel input                       |
|        | IDX        | PC.4 | MFPD | I   | QEI channel input                       |
|        | IDX        | PD.6 | MFPD | I   | QEI channel input                       |
|        | IDX        | PD.7 | MFPD | I   | QEI channel input                       |
|        | IDX        | PF.2 | MFPD | I   | QEI channel input                       |
| EPWM   | PWM_BRK_P0 | PC.2 | MFP3 | I   | EPWM brake pin.                         |
|        | PWM_BRK_P0 | PC.5 | MFP3 | I   | EPWM brake pin.                         |
|        | PWM_BRK_P1 | PB.6 | MFP3 | I   | EPWM brake pin.                         |
|        | PWM_BRK_P2 | PB.7 | MFP3 | I   | EPWM brake pin.                         |
|        | EPWM_CH5   | PA.5 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH5   | PA.6 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH4   | PA.4 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH4   | PA.7 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH3   | PA.3 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH3   | PF.1 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH2   | PA.2 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH2   | PF.2 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH1   | PA.1 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH1   | PF.3 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH0   | PA.0 | MFP3 | O   | Enhanced PWM output pin.                |
|        | EPWM_CH0   | PF.4 | MFP3 | O   | Enhanced PWM output pin.                |
| nRESET | nRESET     | --   | --   | I   | External reset pin, internal pull-high. |
| I2C0   | I2C0_SCL   | PA.3 | MFP8 | I/O | I <sup>2</sup> C0 clock pin.            |
|        | I2C0_SCL   | PA.6 | MFP8 | I/O | I <sup>2</sup> C0 clock pin.            |
|        | I2C0_SCL   | PD.1 | MFP8 | I/O | I <sup>2</sup> C0 clock pin.            |
|        | I2C0_SDA   | PA.2 | MFP8 | I/O | I <sup>2</sup> C0 data pin.             |
|        | I2C0_SDA   | PA.7 | MFP8 | I/O | I <sup>2</sup> C0 data pin.             |
|        | I2C0_SDA   | PD.2 | MFP8 | I/O | I <sup>2</sup> C0 data pin.             |
| I2C1   | I2C1_SCL   | PA.0 | MFP8 | I/O | I <sup>2</sup> C1 clock pin.            |
|        | I2C1_SCL   | PC.0 | MFP8 | I/O | I <sup>2</sup> C1 clock pin.            |
|        | I2C1_SCL   | PE.5 | MFP8 | I/O | I <sup>2</sup> C1 clock pin.            |
|        | I2C1_SDA   | PA.1 | MFP8 | I/O | I <sup>2</sup> C1 data pin.             |
|        | I2C1_SDA   | PC.2 | MFP8 | I/O | I <sup>2</sup> C1 data pin.             |
|        | I2C1_SDA   | PE.6 | MFP8 | I/O | I <sup>2</sup> C1 data pin.             |

|      |           |      |      |     |                                       |
|------|-----------|------|------|-----|---------------------------------------|
| I2C2 | I2C2_SCL  | PC.4 | MFP8 | I/O | I <sup>2</sup> C2 clock pin.          |
|      | I2C2_SCL  | PC.6 | MFP8 | I/O | I <sup>2</sup> C2 clock pin.          |
|      | I2C2_SCL  | PD.7 | MFP8 | I/O | I <sup>2</sup> C2 clock pin.          |
|      | I2C2_SCL  | PE.7 | MFP8 | I/O | I <sup>2</sup> C2 clock pin.          |
|      | I2C2_SCL  | PF.1 | MFP8 | I/O | I <sup>2</sup> C2 clock pin.          |
|      | I2C2_SDA  | PF.0 | MFP8 | I/O | I <sup>2</sup> C2 data pin.           |
|      | I2C2_SDA  | PF.2 | MFP8 | I/O | I <sup>2</sup> C2 data pin.           |
| PGA  | PGA_I     | PB.3 | MFP6 | A   | PGA analog input pin.                 |
|      | PGA_O     | PC.3 | MFP6 | A   | PGA analog output pin.                |
| DAC  | DAC0      | PB.5 | MFP4 | A   | DAC0 analog output pin.               |
|      | DAC1      | PC.6 | MFP5 | A   | DAC1 analog output pin.               |
| OP   | OP0_O     | PC.4 | MFP6 | A   | OP0 analog output pin.                |
|      | OP0_N     | PE.0 | MFP6 | A   | OP0 analog input pin.                 |
|      | OP0_P     | PE.1 | MFP6 | A   | OP0 analog input pin.                 |
|      | OP1_O     | PE.2 | MFP6 | A   | OP1 analog output pin.                |
|      | OP1_N     | PE.3 | MFP6 | A   | OP1 analog input pin.                 |
|      | OP1_P     | PE.4 | MFP6 | A   | OP1 analog input pin.                 |
|      | OP2_O     | PE.5 | MFP6 | A   | OP2 analog output pin.                |
|      | OP2_N     | PE.6 | MFP6 | A   | OP2 analog input pin.                 |
|      | OP2_P     | PE.7 | MFP6 | A   | OP2 analog input pin.                 |
| SPI0 | SPI0_MOSI | PA.2 | MFP9 | I/O | SPI0 MOSI (Master Out, Slave In) pin. |
|      | SPI0_MOSI | PA.6 | MFP9 | I/O | SPI0 MOSI (Master Out, Slave In) pin. |
|      | SPI0_MOSI | PC.1 | MFP9 | I/O | SPI0 MOSI (Master Out, Slave In) pin. |
|      | SPI0_MOSI | PD.2 | MFP9 | I/O | SPI0 MOSI (Master Out, Slave In) pin. |
|      | SPI0_MISO | PA.1 | MFP9 | I/O | SPI0 MISO (Master In, Slave Out) pin. |
|      | SPI0_MISO | PC.2 | MFP9 | I/O | SPI0 MISO (Master In, Slave Out) pin. |
|      | SPI0_MISO | PF.2 | MFP9 | I/O | SPI0 MISO (Master In, Slave Out) pin. |
|      | SPI0_CLK  | PA.3 | MFP9 | I/O | SPI0 clock pin.                       |
|      | SPI0_CLK  | PC.3 | MFP9 | I/O | SPI0 clock pin.                       |
|      | SPI0_CLK  | PD.1 | MFP9 | I/O | SPI0 clock pin.                       |
|      | SPI0_CLK  | PF.1 | MFP9 | I/O | SPI0 clock pin.                       |
|      | SPI0_SS   | PA.0 | MFP9 | I   | SPI0 slave selection pin.             |
|      | SPI0_SS   | PA.7 | MFP9 | I   | SPI0 slave selection pin.             |
|      | SPI0_SS   | PC.0 | MFP9 | I   | SPI0 slave selection pin.             |

|       |           |      |      |     |  |
|-------|-----------|------|------|-----|--|
| SPI1  | SPI1_MOSI | PA.1 | MFPA | I/O | SPI1 MOSI (Master Out, Slave In) pin.      |
|       | SPI1_MOSI | PC.2 | MFPA | I/O | SPI1 MOSI (Master Out, Slave In) pin.      |
|       | SPI1_MOSI | PE.7 | MFPA | I/O | SPI1 MOSI (Master Out, Slave In) pin.      |
|       | SPI1_MISO | PA.2 | MFPA | I/O | SPI1 MISO (Master In, Slave Out) pin       |
|       | SPI1_MISO | PC.1 | MFPA | I/O | SPI1 MISO (Master In, Slave Out) pin       |
|       | SPI1_MISO | PD.2 | MFPA | I/O | SPI1 MISO (Master In, Slave Out) pin       |
|       | SPI1_MISO | PE.6 | MFPA | I/O | SPI1 MISO (Master In, Slave Out) pin       |
|       | SPI1_CLK  | PA.0 | MFPA | I/O | SPI1 clock pin.                            |
|       | SPI1_CLK  | PC.0 | MFPA | I/O | SPI1 clock pin.                            |
|       | SPI1_CLK  | PE.5 | MFPA | I/O | SPI1 clock pin.                            |
|       | SPI1_SS   | PA.3 | MFPA | I/O | SPI1 Slave Select                          |
|       | SPI1_SS   | PC.3 | MFPA | I/O | SPI1 Slave Select                          |
|       | SPI1_SS   | PD.1 | MFPA | I/O | SPI1 Slave Select                          |
|       | SPI1_SS   | PF.0 | MFPA | I/O | SPI1 Slave Select                          |
| TM0   | TM0       | PB.3 | MFP7 | I   | Timer0 event counter input / toggle output |
| TM1   | TM1       | PB.4 | MFP7 | I   | Timer1 event counter input / toggle output |
| TM2   | TM2       | PC.6 | MFP7 | I   | Timer2 event counter input / toggle output |
| TM3   | TM3       | PC.7 | MFP7 | I   | Timer3 event counter input / toggle output |
| XTAL  | XT_OUT    | PA.5 | MPF1 | A   | External crystal output pin.               |
|       | XT_IN     | PA.4 | MFP1 | A   | External crystal input pin.                |
| UART0 | UART0_TXD | PA.3 | MFPB | O   | UART0 data transmitter output pin.         |
|       | UART0_TXD | PA.6 | MFPB | O   | UART0 data transmitter output pin.         |
|       | UART0_TXD | PD.1 | MFPB | O   | UART0 data transmitter output pin.         |
|       | UART0_TXD | PD.5 | MFPB | O   | UART0 data transmitter output pin.         |
|       | UART0_RXD | PA.2 | MFPB | I   | UART0 data receiver input pin.             |
|       | UART0_RXD | PA.7 | MFPB | I   | UART0 data receiver input pin.             |
|       | UART0_RXD | PD.2 | MFPB | I   | UART0 data receiver input pin.             |
| UART1 | UART1_TXD | PA.0 | MFPB | O   | UART1 data transmitter output pin.         |
|       | UART1_TXD | PC.0 | MFPB | O   | UART1 data transmitter output pin.         |
|       | UART1_TXD | PD.3 | MFPB | O   | UART1 data transmitter output pin.         |
|       | UART1_TXD | PE.5 | MFPB | O   | UART1 data transmitter output pin.         |
|       | UART1_RXD | PA.1 | MFPB | I   | UART1 data receiver input pin.             |
|       | UART1_RXD | PC.2 | MFPB | I   | UART1 data receiver input pin.             |

|       |           |      |      |     |                                    |
|-------|-----------|------|------|-----|------------------------------------|
|       | UART1_RXD | PD.4 | MFPB | I   | UART1 data receiver input pin.     |
|       | UART1_RXD | PE.6 | MFPB | I   | UART1 data receiver input pin.     |
| UART2 | UART2_TXD | PC.4 | MFPB | O   | UART2 data transmitter output pin. |
|       | UART2_TXD | PC.6 | MFPB | O   | UART2 data transmitter output pin. |
|       | UART2_TXD | PD.7 | MFPB | O   | UART2 data transmitter output pin. |
|       | UART2_TXD | PE.7 | MFPB | O   | UART2 data transmitter output pin. |
|       | UART2_TXD | PF.1 | MFPB | O   | UART2 data transmitter output pin. |
|       | UART2_RXD | PF.0 | MFPB | I   | UART2 data receiver input pin.     |
|       | UART2_RXD | PF.2 | MFPB | I   | UART2 data receiver input pin.     |
| ICE   | ICE_DAT   | PD.2 | MFP1 | I/O | Serial wired debugger data pin     |
|       | ICE_CLK   | PD.1 | MFP1 | I   | Serial wired debugger clock pin    |

Table 4.3-2 LQFP48 Multi-function Pin Summary

5 BLOCK DIAGRAM

5.1 NuMicro® NM1230 Block Diagram

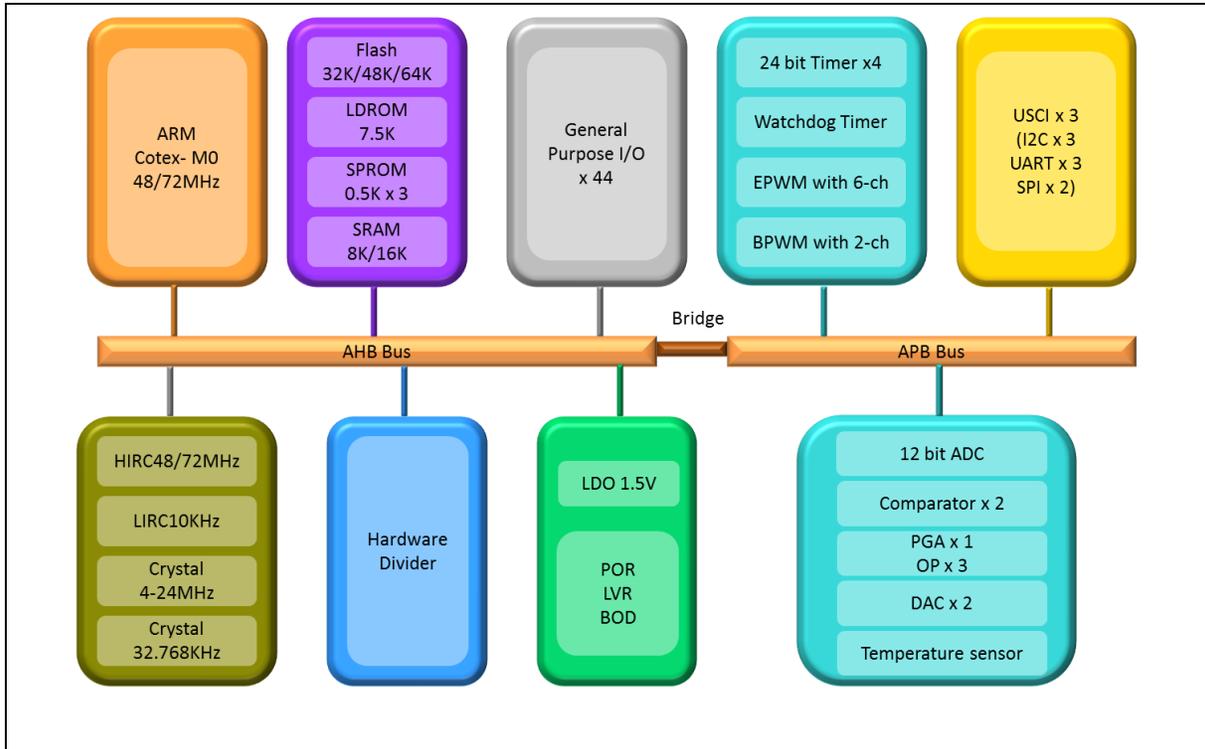


Figure 5.1-1 NuMicro® NM1230 Block Diagram

## 6 FUNCTIONAL DESCRIPTION

### 6.1 ARM® Cortex®-M0 Core

#### 6.1.1 Overview

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 6.1-1 shows the functional controller of processor.

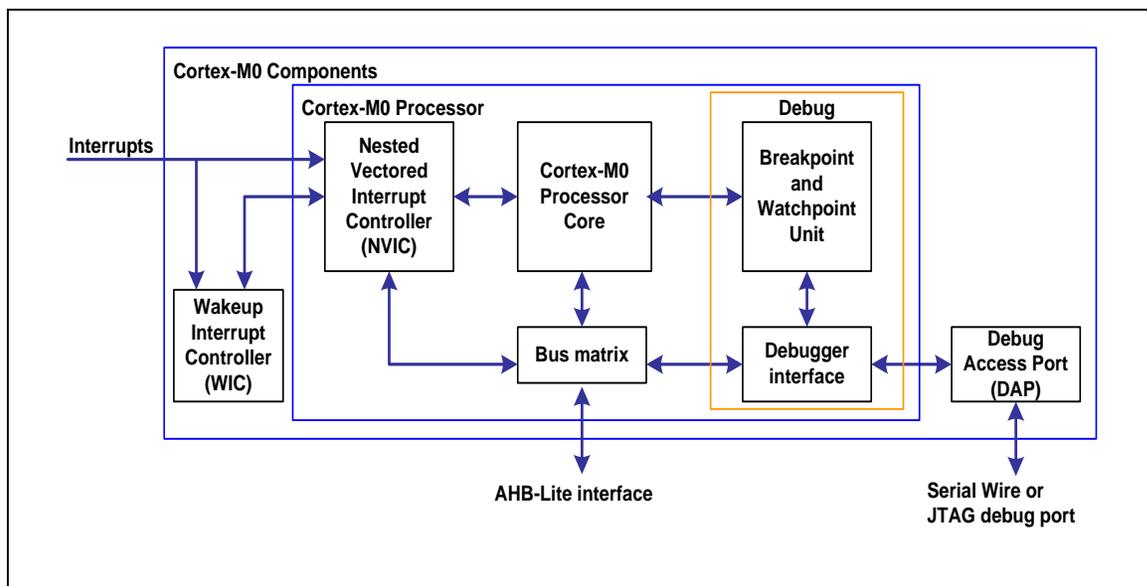


Figure 6.1-1 Functional Block Diagram

#### 6.1.2 Features

The implemented device provides:

- 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 the Wait For Interrupt (WFI), Wait For Event (WFE) instructions, or 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)

## 6.2 System Manager

### 6.2.1 Overview

System management includes the following sections:

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

### 6.2.2 System Reset

The system reset can be issued by one of the events listed below. These reset event flags can be read from SYS\_RSTSTS register to determine the reset source. Hardware reset can reset chip through peripheral reset signals. Software reset can trigger reset through control registers.

- Hardware Reset Sources
  - Power-on Reset (POR)
  - Low level on the nRESET pin
  - Watchdog Timer Time-out Reset (WDT)
  - Low Voltage Reset (LVR)
  - Brown-out Detector Reset (BOD Reset)
- Software Reset Sources
  - CHIP Reset will reset whole chip by writing 1 to CHIPRST (SYS\_IPRST0[0])
  - MCU Reset to reboot but keeping the booting setting from APROM or LDROM by writing 1 to SYSRESETREQ (SCS\_AIRCR[2], Application Interrupt and Reset Control Register, address = 0xE00ED0C) in system control registers of Cortex®-M0 core.
  - CPU Reset for Cortex®-M0 core Only by writing 1 to CPURST (SYS\_IPRST0[1])

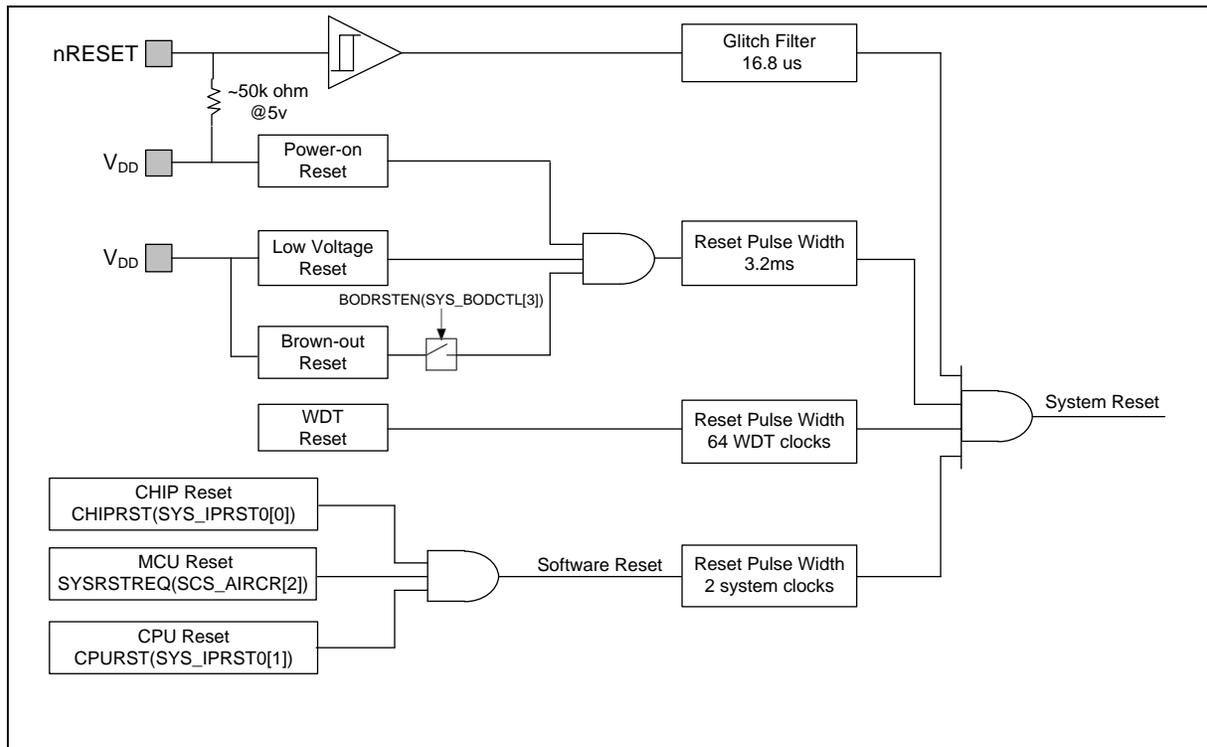


Figure 6.2-1 System Reset Resources

There are a total of 9 reset sources in the NuMicro® family. In general, CPU reset is used to reset Cortex®-M0 only; the other reset sources will reset Cortex®-M0 and all peripherals. However, there are small differences between each reset source and they are listed in Table 6.2-1.

| Reset Sources<br>Register   | POR                 | nRESET              | WDT                 | LVR                 | BOD       | CHIP                | MCU                 | CPU       |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|-----------|---------------------|---------------------|-----------|
| SYS_RSTSTS                  | 0x001               | Bit 1 = 1           | Bit 2 = 1           | Bit 3 = 1           | Bit 4 = 1 | Bit 0 = 1           | Bit 5 = 1           | Bit 7 = 1 |
| CHIPRST<br>(SYS_IPRST0[0])  | 0x0                 | -                   | -                   | -                   | -         | -                   | -                   | -         |
| BODEN<br>(SYS_BODCTL[0])    | Reload from CONFIG0 | Reload from CONFIG0 | Reload from CONFIG0 | Reload from CONFIG0 | -         | Reload from CONFIG0 | Reload from CONFIG0 | -         |
| BODVL<br>(SYS_BODCTL[3:1])  |                     |                     |                     |                     |           |                     |                     |           |
| BODRSTEN<br>(SYS_BODCTL[4]) |                     |                     |                     |                     |           |                     |                     |           |
| XTLEN<br>(CLK_PWRCTL[1:0])  | 0x0                 | 0x0                 | 0x0                 | 0x0                 | 0x0       | 0x0                 | 0x0                 |           |
| WDTCKEN<br>(CLK_APBCLK0[0]) | 0x1                 | -                   | 0x1                 | -                   | -         | 0x1                 | -                   | -         |
| HCLKSEL                     | 0x8                 | 0x8                 | 0x8                 | 0x8                 | 0x8       | 0x8                 | 0x8                 | -         |

|  |                           |                           |                           |                           |                           |                           |   |   |   |
|--|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---|---|---|
| (CLK_CLKSEL0[1:0])   |                           |                           |                           |                           |                           |                           |   |   |   |
| WDTSEL<br>(CLK_CLKSEL1[1:0])                                       | 0x3                       | 0x3                       | -                         | -                         | -                         | -                         | - | - | - |
| XLTSTB<br>(CLK_STATUS[0])  | 0x0                       | -                         | -                         | -                         | -                         | -                         | - | - | - |
| LIRCSTB<br>(CLK_STATUS[3])   | 0x0                       |                           |                           |                           |                           |                           |   |   |   |
| HIRCSTB<br>(CLK_STATUS[4])   | 0x0                       | -                         | -                         | -                         | -                         | -                         | - | - | - |
| CLKSFAL<br>(CLK_STATUS[7])   | 0x0                       | 0x0                       | -                         | -                         | -                         | -                         | - | - | - |
| WDT_CTL  | 0x0700                    | 0x0700                    | 0x0700                    | 0x0700                    | 0x0700                    | 0x0700                    | - | - | - |
| WDT_ALTCTL   | 0x0000                    | 0x0000                    | 0x0000                    | 0x0000                    | 0x0000                    | 0x0000                    | - | - | - |
| BS<br>(FMC_ISPCTL[1])  | Reload from<br>CONFIG0    | - | - | - |
| ISPEN<br>(FMC_ISPCTL[16])  |                           |                           |                           |                           |                           |                           |   |   |   |
| FMC_DFBA   | Reload from<br>CONFIG1    | - | - | - |
| CBS<br>(FMC_ISPSTS[2:1])   | Reload from<br>CONFIG0    | - | - | - |
| VECMAP<br>(FMC_ISPSTS[20:9])                                       | Reload base<br>on CONFIG0 | - | - | - |
| Other Peripheral Registers   | Reset Value               |                           |                           |                           |                           |                           |   |   |   |
| FMC Registers  | Reset Value               |                           |                           |                           |                           |                           |   |   |   |
| Note: '-' means that the value of register keeps original setting. |                           |                           |                           |                           |                           |                           |   |   |   |

Table 6.2-1 Reset Value of Registers

6.2.2.1 nRESET Reset

The nRESET reset means to generate a reset signal by pulling low nRESET pin, which is an asynchronous reset input pin and can be used to reset system at any time. When the nRESET voltage is lower than 0.2 V<sub>DD</sub> and the state keeps longer than 16.8 us (glitch filter), chip will be reset. The nRESET reset will control the chip in reset state until the nRESET voltage rises above 0.7 V<sub>DD</sub> and the state keeps longer than 36 us (glitch filter). The PINRF (SYS\_RSTSTS[1]) will be set to 1 if the previous reset source is nRESET reset. Figure 6.2-2 shows the nRESET reset waveform.

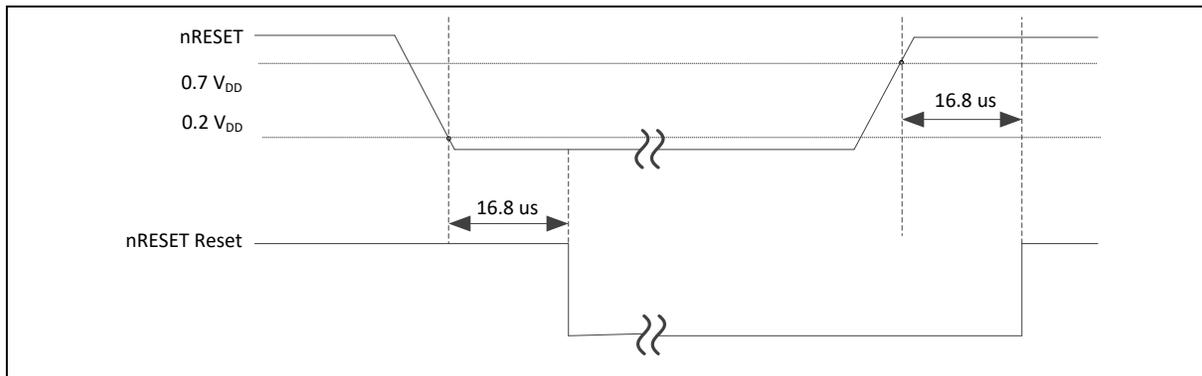


Figure 6.2-2 nRESET Reset Waveform

6.2.2.2 Power-On Reset (POR)

The Power-on reset (POR) is used to generate a stable system reset signal and forces the system to be reset when power-on to avoid unexpected behavior of MCU. When applying the power to MCU, the POR module will detect the rising voltage and generate reset signal to system until the voltage is ready for MCU operation. At POR reset, the PORF (SYS\_RSTSTS[0]) will be set to 1 to indicate there is a POR reset event. The PORF (SYS\_RSTSTS[0]) bit can be cleared by writing 1 to it. Figure 6.2-3 shows the waveform of Power-On reset.

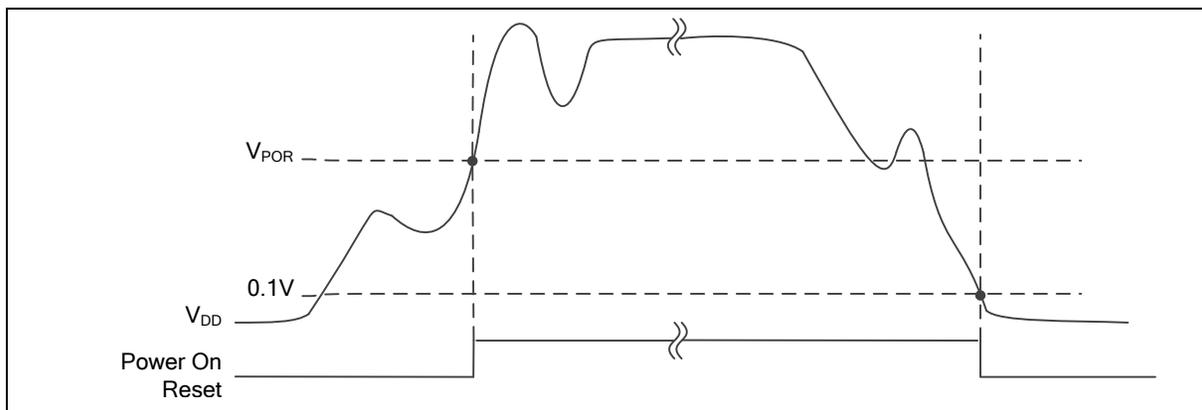


Figure 6.2-3 Power-on Reset (POR) Waveform

6.2.2.3 Low Voltage Reset (LVR)

Low Voltage Reset detects  $AV_{DD}$  during system operation. When the  $AV_{DD}$  voltage is lower than  $V_{LVR}$  and the state keeps longer than De-glitch time ( $16 \cdot HCLK$  cycles), chip will be reset. The LVR reset will control the chip in reset state until the  $AV_{DD}$  voltage rises above  $V_{LVR}$  and the state keeps longer than De-glitch time. Figure 6.2-4 shows the Low Voltage Reset waveform.

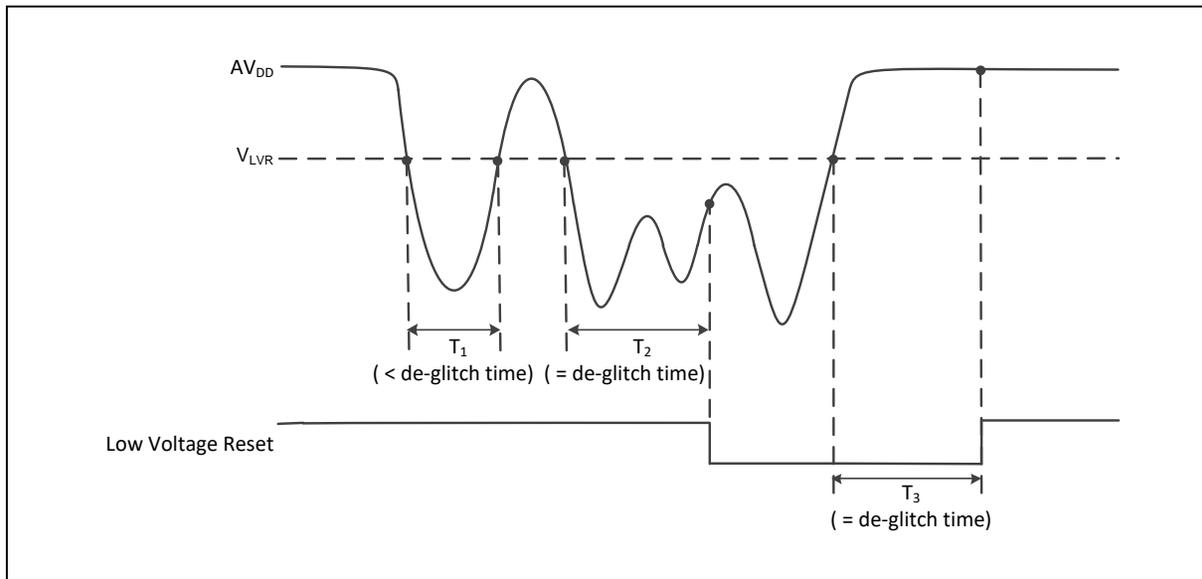


Figure 6.2-4 Low Voltage Reset (LVR) Waveform

#### 6.2.2.4 Brown-out Detector Reset (BOD Reset)

If the Brown-out Detector (BOD) function is enabled by setting the Brown-out Detector Enable Bit BODEN (SYS\_BODCTL[0]), Brown-Out Detector function will detect  $AV_{DD}$  during system operation. When the  $AV_{DD}$  voltage is lower than  $V_{BOD}$  which is decided by BODEN (SYS\_BODCTL[0]) and BODVL (SYS\_BODCTL[3:1]) and the state keeps longer than De-glitch time (Max( $20 \cdot HCLK$  cycles,  $1 \cdot LIRC$  cycle)), chip will be reset. The BOD reset will control the chip in reset state until the  $AV_{DD}$  voltage rises above  $V_{BOD}$  and the state keeps longer than De-glitch time. The default value of BODEN, BODVL and BODRSTEN is set by Flash controller user configuration register CBODEN (CONFIG0[11]), CBOV (CONFIG0[15:13]) and CBORST (CONFIG0[12]) respectively. User can determine the initial BOD setting by setting the CONFIG0 register. Figure 6.2-5 shows the Brown-Out Detector waveform.

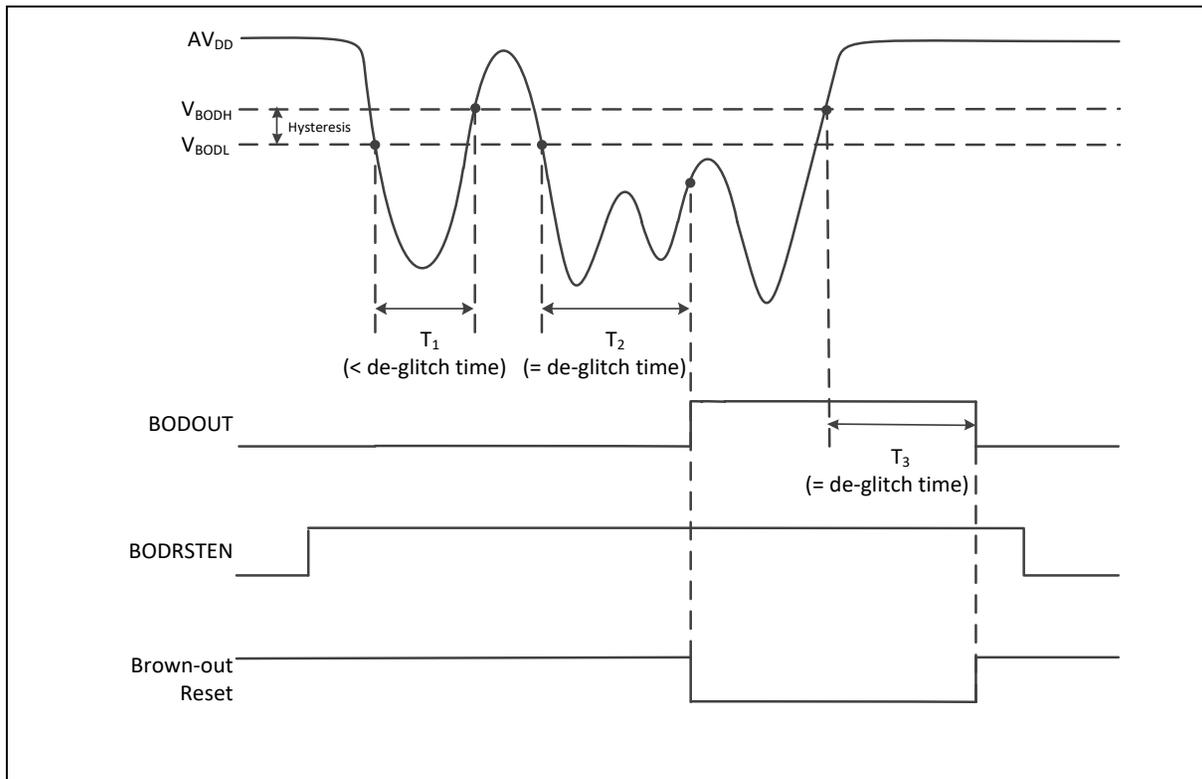


Figure 6.2-5 Brown-out Detector (BOD) Waveform

### 6.2.2.5 Watchdog Timer Reset

In most industrial applications, system reliability is very important. To automatically recover the MCU from failure status is one way to improve system reliability. The watchdog timer (WDT) is widely used to check if the system works fine. If the MCU is crashed or out of control, it may cause the watchdog time-out. User may decide to enable system reset during watchdog time-out to recover the system and take action for the system crash/out-of-control after reset.

Software can check if the reset is caused by watchdog time-out to indicate the previous reset is a watchdog reset and handle the failure of MCU after watchdog time-out reset by checking WDTRF (SYS\_RSTSTS[2]).

### 6.2.2.6 CPU Reset, CHIP Reset and SYSTEM Reset

The CPU Reset means only Cortex®-M0 core is reset and all other peripherals remain the same status after CPU reset. User can set the CPURST (SYS\_IPRST0[1]) to 1 to assert the CPU Reset signal.

The CHIP Reset is same with Power-On Reset. The CPU and all peripherals are reset and BS (FMC\_ISPCTL[1]) bit is automatically reloaded from CONFIG setting. User can set the CHIPRST (SYS\_IPRST0[0]) to 1 to assert the CHIP Reset signal.

The MCU Reset is similar with CHIP Reset. The difference is that BS (FMC\_ISPCTL[1]) will not be reloaded from CONFIG setting and keep its original software setting for booting from APROM or LDROM. User can set the SYSRESETREQ (SCS\_AIRCR[2]) to 1 to assert the MCU Reset.

6.2.3 Power Modes and Wake-up Sources

There are several wake-up sources in Idle mode and Power-down mode. Table 6.2-2 lists the available clocks for each power mode.

| Power Mode       | Normal Mode  | Idle Mode                     | Power-Down Mode   |
|------------------|--|-------------------------------|---|
| Definition       | CPU is in active state                             | CPU is in sleep state         | CPU is in sleep state and all clocks stop except LXT and LIRC. SRAM content retained. |
| Entry Condition  | Chip is in normal mode after system reset released | CPU executes WFI instruction. | CPU sets sleep mode enable and power down enable and executes WFI instruction.        |
| Wake-up Sources  | N/A  | All interrupts                | WDT, I <sup>2</sup> C, Timer, UART, SPI, ACMP, BOD and GPIO                           |
| Available Clocks | All  | All except CPU clock          | LXT and LIRC  |
| After Wake-up    | N/A  | CPU back to normal mode       | CPU back to normal mode   |

Table 6.2-2 Power Mode Difference Table

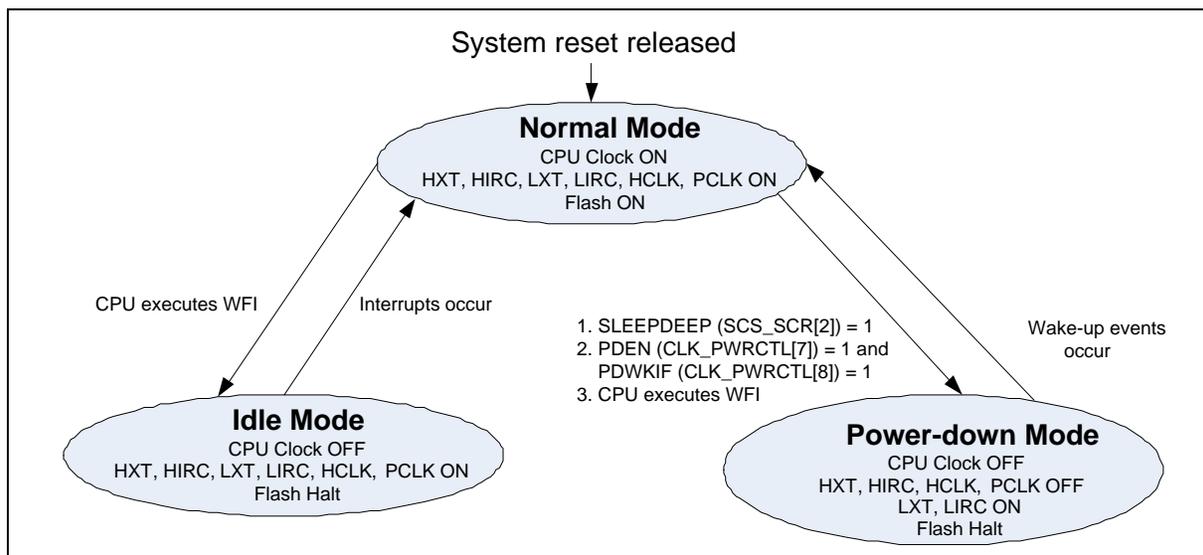


Figure 6.2-6 Power Mode State Machine

1. LXT (32768 Hz XTL) ON or OFF depends on SW setting in run mode.
2. LIRC (10 kHz OSC) ON or OFF depends on SW setting in run mode.
3. If TIMER clock source is selected as LIRC/LXT and LIRC/LXT is on.
4. If WDT clock source is selected as LIRC and LIRC is on.

|                       | Normal Mode | Idle Mode | Power-Down Mode     |
|-----------------------|-------------|-----------|---------------------|
| HXT (4~20 MHz XTL)    | ON          | ON        | Halt                |
| HIRC (48(72) MHz OSC) | ON          | ON        | Halt                |
| LXT (32768 Hz XTL)    | ON          | ON        | ON/OFF <sup>1</sup> |
| LIRC (10 kHz OSC)     | ON          | ON        | ON/OFF <sup>2</sup> |
| LDO                   | ON          | ON        | ON                  |
| CPU                   | ON          | Halt      | Halt                |
| HCLK/PCLK             | ON          | ON        | Halt                |
| SRAM retention        | ON          | ON        | ON                  |
| FLASH                 | ON          | ON        | Halt                |
| GPIO                  | ON          | ON        | Halt                |
| TIMER                 | ON          | ON        | ON/OFF <sup>3</sup> |
| BPWM                  | ON          | ON        | Halt                |
| EPWM                  | ON          | ON        | Halt                |
| WDT                   | ON          | ON        | ON/OFF <sup>4</sup> |
| USCI                  | ON          | ON        | Halt                |
| ADC                   | ON          | ON        | Halt                |
| ACMP                  | ON          | ON        | Halt                |
| ECAP                  | ON          | ON        | Halt                |
| HDIV                  | ON          | ON        | Halt                |
| PGA                   | ON          | ON        | Halt                |

Table 6.2-3 Clocks in Power Modes

**Wake-up sources in Power-down mode:**

WDT, I<sup>2</sup>C, Timer, UART, SPI, BOD, ACMP and GPIO

After chip enters power down, the following wake-up sources can wake chip up to normal mode. Table 6.2-4 lists the condition about how to enter Power-down mode again for each peripheral.

**Note for BOD vs Power-down:**

When the power-down mode is entered to save power consuming, the reference voltage of BOD(Brown-out Detection) will be disabled for saving power, therefore the BOD may incorrectly wake-up power down(if BOD interrupt is enabled) or trigger CPU reset(if BOR, brown-out reset, is enabled). It is a BOD function limitation in Power-down mode.

**Recommended workaround for using BOD and power-down:**

Please make sure that the BOD is disabled before entering Power-down mode. When the chip leaves Power-down mode, the BOD can be enabled again.

\*User needs to wait this condition before setting PDEN (CLK\_PWRCTL[7]) and execute WFI to enter Power-down mode.

| Wake-Up Source        | Wake-Up Condition                       | System Can Enter Power-Down Mode Again Condition*  |
|-----------------------|---|--|
| BOD                   | Brown-Out Detector Interrupt            | After software writes 1 to clear SYS_BODCTL[BODIF].  |
| GPIO                  | GPIO Interrupt                          | After software write 1 to clear the Px_INTSRC[n] bit.  |
| TIMER                 | Timer Interrupt                         | After software writes 1 to clear TWKF (TIMERx_INTSTS[1]) and TIF (TIMERx_INTSTS[0]).                     |
| WDT                   | WDT Interrupt                           | After software writes 1 to clear WKF (WDT_CTL[5]) (Write Protect).                                       |
| USCI UART             | Incoming data wake-up                   | After software writes 1 to clear WKF (UART_WKSTS[0]).  |
| USCI SPI              | SS transaction wake-up                  | After software writes 1 to clear WKF (USPI_WKSTS[0]).  |
| USCI I <sup>2</sup> C | Data toggle                             | After software writes 1 to clear WKF (UI2C_WKSTS[0]).  |
|                       | Address match                           | After software writes 1 to clear WKAKDONE (UI2C_PROTSTS[16], then writes 1 to clear WKF (UI2C_WKSTS[0]). |
| ACMP                  | Comparator Power-down Wake-Up Interrupt | After software writes 1 to clear ACMPF0 (ACMP_STATUS[0]) and ACMPF1 (ACMP_STATUS[1]).                    |

Table 6.2-4 Condition of Entering Power-down Mode Again

### 6.2.4 System Power Architecture

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

- Analog power from  $V_{DD}$  and  $V_{SS}$  provides the power for analog components operation.  $V_{DD}$  must be equal to  $V_{DD}$  to avoid leakage current.
- Digital power from  $V_{DD}$  and  $V_{SS}$  supplies power to the I/O pins and internal regulator which provides a fixed 1.5V power for digital operation.
- A built-in capacitor for internal voltage regulator

The output of internal voltage regulator, LDO, does not require an external capacitor and doesn't bond out to external pin. Analog power ( $V_{DD}$ ) should be the same voltage level of the digital power ( $V_{DD}$ ). Figure 6.2-7 shows the power distribution of the NM1230 series.

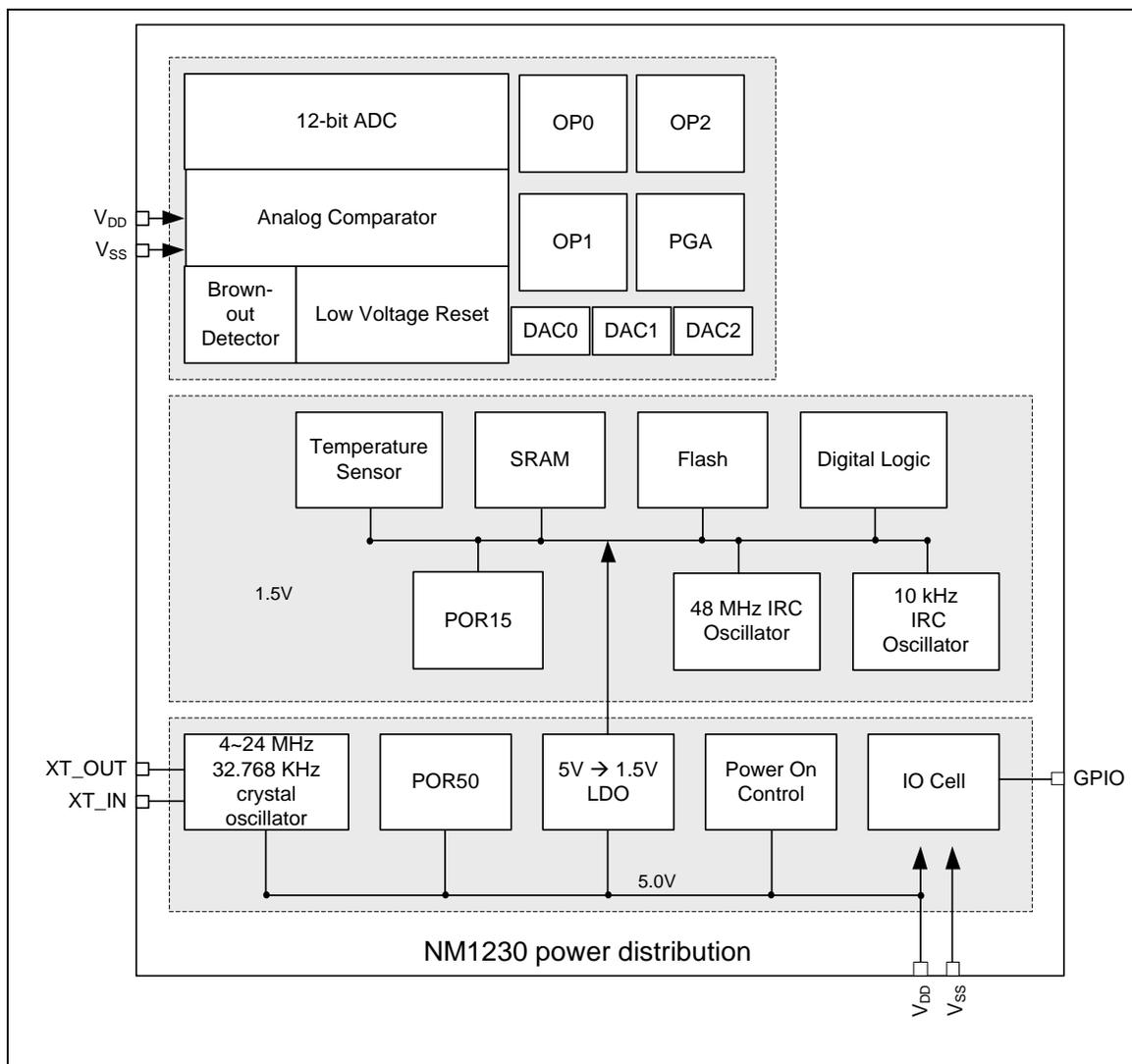


Figure 6.2-7 NuMicro® NM1230 Series Power Architecture Diagram

6.2.5 System Memory Mapping

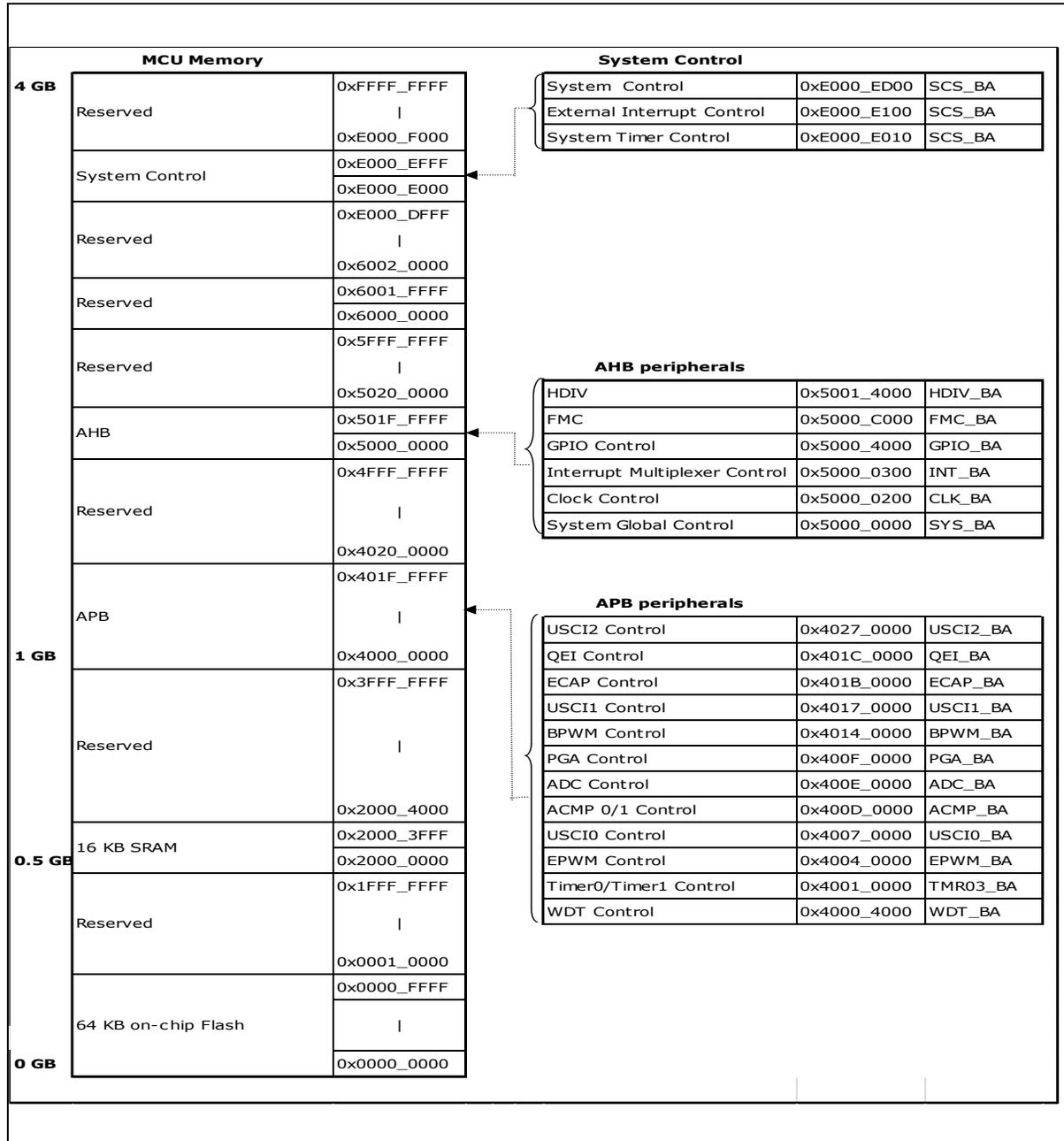


Table 6.2-5 Memory Mapping Table

### 6.2.6 Register Protection

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 SYS\_REGLCTL 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 REGLCTL (SYS\_REGLCTL [0]), “1” is protection disable, “0” is protection enable. Then user can update the target protected register value and then write any data to SYS\_REGLCTL to enable register protection.

The protected registers are listed in Table 6.2-6.

| Register    | Bit             | Description  |
|-------------|-----------------|--|
| SYS_IPRST0  | [1] CPURST      | Processor Core One-shot Reset (Write Protect)                    |
|             | [0] CHIPRST     | Chip One-shot Reset (Write Protect)                              |
| SYS_BODCTL  | [15] LVREN      | Low Voltage Reset Enable Control (Write Protect)                 |
|             | [6] BODLPM      | Brown-out Detector Low Power Mode (Write Protect)                |
|             | [4] BODRSTEN    | Brown-out Reset Enable Control (Write Protect)                   |
|             | [3:1] BODVL     | Brown-out Detector Threshold Voltage Selection (Write Protect)   |
|             | [0] BODEN       | Brown-out Detector Enable Control (Write Protect)                |
| SYS_PORCTL  | [15:0] POROFF   | Power-on Reset Enable Control (Write Protect)                    |
| INT_NMICTL  | [8] NMISELEN    | NMI Interrupt Enable Control (Write Protected)                   |
| CLK_PWRCTL  | [11:10] HXTGAIN | HXT Gain Control (Write Protect)                                 |
|             | [7] PDEN        | System Power-down Enable Control (Write Protect)                 |
|             | [5] PDWKIEN     | Power-down Mode Wake-up Interrupt Enable Control (Write Protect) |
|             | [4] PDWKDLY     | Wake-up Delay Counter Enable Control (Write Protect)             |
|             | [3] LIRCEN      | LIRC Enable Control (Write Protect)                              |
|             | [2] HIRCEN      | HIRC Enable Control (Write Protect)                              |
|             | [1:0] XTLEN     | XTL Enable Control (Write Protect)                               |
| CLK_APBCLK  | [0] WDTCKEN     | Watchdog Timer Clock Enable Control (Write Protect)              |
| CLK_CLKSEL0 | [4:3] STCLKSEL  | Cortex®-M0 SysTick Clock Source Selection (Write Protect)        |
|             | [1:0] HCLKSEL   | HCLK Clock Source Selection (Write Protect)                      |
| CLK_CLKSEL1 | [1:0] WDTSEL    | Watchdog Timer Clock Source Selection (Write Protect)            |
| FMC_ISPCTL  | [6] ISPPFF      | ISP Fail Flag (Write Protect)                                    |
|             | [5] LDUEN       | LDROM Update Enable Control (Write Protect)                      |
|             | [4] CFGUEN      | CONFIG Update Enable Control (Write Protect)                     |

|            |               |  |
|------------|---------------|--|
|            | [3] APUEN     | APROM Update Enable Control (Write Protect)                      |
|            | [2] SPUEN     | SPROM Update Enable Control (Write Protect)                      |
|            | [1] BS        | Boot Select (Write Protect)                                      |
|            | [0] ISPEN     | ISP Enable Control (Write Protect)                               |
| FMC_ISPTRG | [0] ISPGO     | ISP Start Trigger (Write Protect)                                |
| FMC_ISPSTS | [6] ISPPF     | ISP Fail Flag (Write Protect)                                    |
| TIMER0_CTL | [31] ICEDEBUG | ICE Debug Mode Acknowledge Disable Control (Write Protect)       |
| TIMER1_CTL | [31] ICEDEBUG | ICE Debug Mode Acknowledge Disable Control (Write Protect)       |
| TIMER2_CTL | [31] ICEDEBUG | ICE Debug Mode Acknowledge Disable Control (Write Protect)       |
| TIMER3_CTL | [31] ICEDEBUG | ICE Debug Mode Acknowledge Disable Control (Write Protect)       |
| WDT_CTL    | [31] ICEDEBUG | ICE Debug Mode Acknowledge Disable Control (Write Protect)       |
|            | [7] WDTEN     | Watchdog Timer Enable Control (Write Protect)                    |
|            | [6] INTEN     | Watchdog Timer Time-out Interrupt Enable Control (Write Protect) |
|            | [4] WKEN      | Watchdog Timer Time-out Wake-up Function Control (Write Protect) |
|            | [1] RSTEN     | Watchdog Timer Time-out Reset Enable Control (Write Protect)     |
|            | [0] RSTCNT    | Reset Watchdog Timer Up Counter (Write Protect)                  |

Table 6.2-6 Protected Registers

6.2.7 Memory Organization

6.2.7.1 Overview

The NuMicro® NM1230 series provides 4G-byte addressing space. The addressing space assigned to each on-chip controllers is shown in Figure 6.2-8. The detailed register definition, addressing space, and programming details will be described in the following sections for each on-chip peripheral. The NM1230 series only supports little-endian data format.

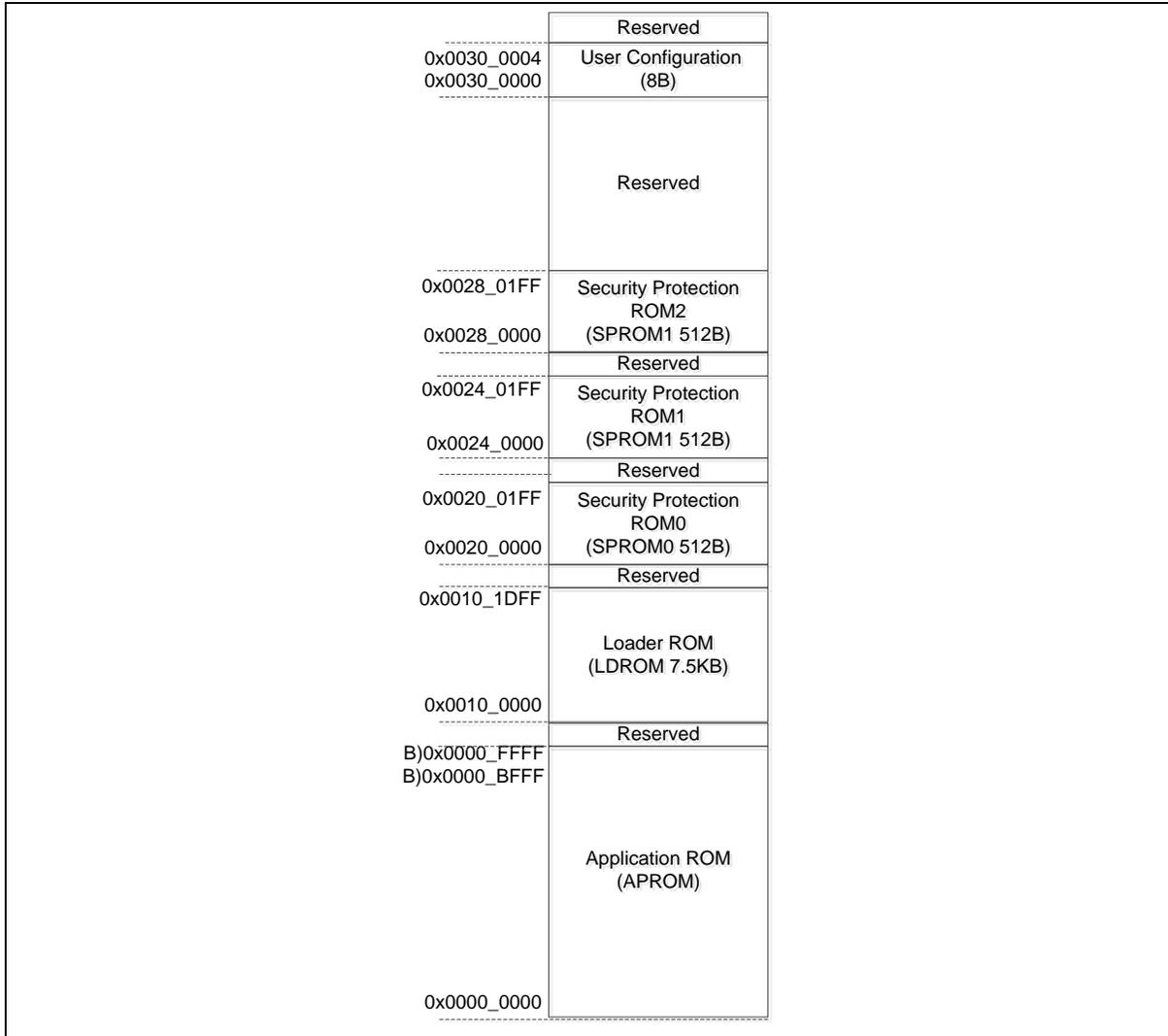


Figure 6.2-8 NuMicro® NM1230 Flash, Security and Configuration Map

6.2.7.2 System Memory Map

The NM1230 series provides 4G-byte addressing space. The memory locations assigned to each on-chip controllers are shown in Table 6.2-7. The detailed register definition, memory space, and programming will be described in the following sections for each on-chip peripheral. The NM1230 series only supports little-endian data format.

The memory locations assigned to each on-chip controllers are shown in Table 6.2-7.

| Address Space  | Token    | Controllers                                     |
|--|----------|---|
| Flash and SRAM Memory Space                          |          |   |
| 0x0000_0000 – 0x0000_FFFF                            | FLASH_BA | FLASH Memory Space (64KB)                       |
| 0x0010_0000 – 0x0010_1DFF                            | LD_BA    | Loader Memory Space (7.5 KB)                    |
| 0x0020_0000 – 0x0020_05FF                            | SP_BA    | Security Program Memory Space (1.5 KB).         |
| 0x0020_0000 – 0x0020_01FF                            | SP0_BA   | Security Program Memory 0 Space (0.5 KB)        |
| 0x0024_0000 – 0x0024_01FF                            | SP1_BA   | Security Program Memory 1 Space (0.5 KB)        |
| 0x0028_0000 – 0x0028_01FF                            | SP2_BA   | Security Program Memory 2 Space (0.5 KB)        |
| 0x0030_0000 – 0x0030_01FF                            | CFG_BA   | CONFIG Program Memory Space (0.5 KB)            |
| 0x2000_0000 – 0x2000_3FFF                            | SRAM_BA  | SRAM Memory Space (16 KB)                       |
| AHB Modules Space (0x5000_0000 – 0x501F_FFFF)        |          |   |
| 0x5000_0000 – 0x5000_01FF                            | SYS_BA   | System 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 Control Registers                          |
| 0x5000_C000 – 0x5000_FFFF                            | FMC_BA   | Flash Memory Control Registers                  |
| 0x5001_4000 – 0x5001_7FFF                            | HDIV_BA  | Hardware Divider and CRC16 Control Register     |
| APB Controllers Space (0x4000_0000 ~ 0x401F_FFFF)    |          |   |
| 0x4000_4000 – 0x4000_7FFF                            | WDT_BA   | Watchdog Timer Control Registers                |
| 0x4001_0000 – 0x4001_3FFF                            | TMR03_BA | Timer0/Timer1/Timer2/Timer3 Control Registers   |
| 0x4004_0000 – 0x4004_3FFF                            | EPWM_BA  | Enhance PWM Control Registers                   |
| 0x4007_0000 – 0x4007_3FFF                            | USCI0_BA | USCI0 Control Registers                         |
| 0x400D_0000 – 0x400D_3FFF                            | ACMP_BA  | Analog Comparator 0/1 Control Registers         |
| 0x400E_0000 – 0x400E_3FFF                            | ADC_BA   | ADC Control Registers                           |
| 0x400F_0000 – 0x400F_3FFF                            | PGA_BA   | Programmable Gain Amplifier Control Register    |
| 0x4014_0000 – 0x4014_3FFF                            | BPWM_BA  | Basic PWM Control Registers                     |
| 0x4017_0000 – 0x4017_3FFF                            | USCI1_BA | USCI1 Control Registers                         |
| 0x401B_0000 – 0x401B_3FFF                            | ECAP_BA  | Enhanced Input Capture Timer Register           |
| 0x401C_0000 – 0x401C_3FFF                            | QEI_BA   | Quadrature Encoder Interface(QEI) Register      |
| 0x4027_0000 – 0x4027_3FFF                            | USCI2_BA | USCI2 Control Registers                         |
| System Controllers Space (0xE000_E000 ~ 0xE000_EFFF) |          |   |
| 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                            | SCS_BA   | System Control Registers                        |

Table 6.2-7 Address Space Assignments for On-Chip Modules

6.2.7.3 SRAM Memory Organization

The NM1230 supports embedded SRAM with total 16 Kbytes size.

- Supports total 16 Kbytes SRAM
- Supports byte / half word / word write
- Supports oversize response error

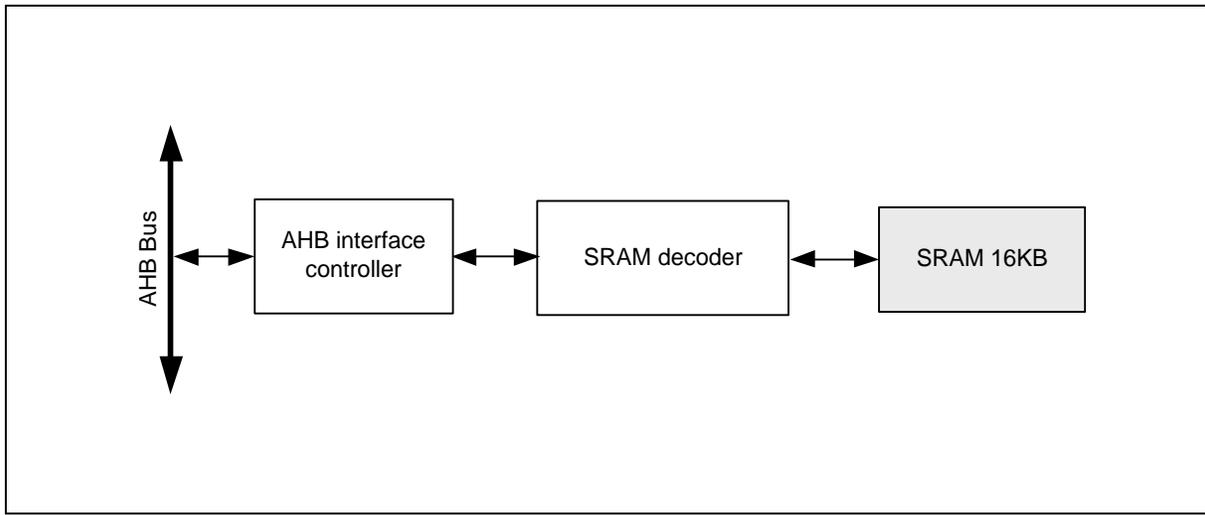


Figure 6.2-9 SRAM Block Diagram

### 6.2.8 System Timer (SysTick)

The Cortex<sup>®</sup>-M0 includes an integrated system timer, SysTick, which provides a simple, 24-bit cleared-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism. The counter can be used in several different ways, for example:

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

A high-speed alarm timer uses Core clock.

A variable rate alarm or signal timer – the duration range is dependent on the reference clock used and the dynamic range of the counter.

A simple counter can be used by software to measure task completion time.

An internal Clock Source control based on missing/meeting durations. The COUNTFLAG bit-field in the control and status register can be used to determine if an action completed within a set duration, as part of a dynamic clock management control loop.

When enabled, the timer 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 edge, and then decrement on subsequent clocks. When the counter transitions to 0, the COUNTFLAG status bit is set. The COUNTFLAG bit clears on read.

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 zero, the timer will be maintained with a current value of zero 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”.

6.2.8.1 System Timer Control Register Map

R: read only, W: write only, R/W: both read and write, W&C: write 1 to clear

| Register                    | Offset      | R/W | Description                    | Reset Value |
|-----------------------------|-------------|-----|--------------------------------|-------------|
| <b>SCS Base Address:</b>    |             |     |                                |             |
| <b>SCS_BA = 0xE000_E000</b> |             |     |                                |             |
| <b>SYST_CTL</b>             | SCS_BA+0x10 | R/W | SysTick Control and Status     | 0x0000_0004 |
| <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 |

6.2.8.2 System Timer Control Register Description

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

| Register | Offset      | R/W | Description                | Reset Value |
|----------|-------------|-----|----------------------------|-------------|
| SYST_CTL | SCS_BA+0x10 | R/W | SysTick Control and Status | 0x0000_0004 |

|          |    |    |    |    |        |         |           |
|----------|----|----|----|----|--------|---------|-----------|
| 31       | 30 | 29 | 28 | 27 | 26     | 25      | 24        |
| Reserved |    |    |    |    |        |         |           |
| 23       | 22 | 21 | 20 | 19 | 18     | 17      | 16        |
| Reserved |    |    |    |    |        |         | COUNTFLAG |
| 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   | <p><b>System Tick Counter Flag</b></p> <p>Return 1 If Timer Counted to 0 Since Last Time this Register Was Read</p> <p>0 = COUNTFLAG is cleared on read or by a write to the Current Value register.</p> <p>1 = COUNTFLAG is set by a count transition from 1 to 0.</p>  |
| [15:3]  | Reserved    | Reserved.  |
| [2]     | CLKSRC      | <p><b>System Tick Clock Source Select Bit</b></p> <p>0 = Clock source is optional, refer to STCLKSEL.</p> <p>1 = Core clock used for SysTick timer.</p>  |
| [1]     | TICKINT     | <p><b>System Tick Interrupt Enable Control</b></p> <p>0 = Counting down to 0 will not cause the SysTick exception to be pended. User can use COUNTFLAG to determine if a count to zero has occurred.</p> <p>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]     | ENABLE      | <p><b>System Tick Counter Enable Control</b></p> <p>0 = System Tick counter Disabled.</p> <p>1 = System Tick counter 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 | 0xXXXX_XXXX |

|          |    |    |    |    |    |    |    |
|----------|----|----|----|----|----|----|----|
| 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><br>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     | <b>System Tick Current Value</b><br>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. |

**6.2.9 Nested Vectored Interrupt Control (NVIC)**

*6.2.9.1 Overview*

The Cortex®-M0 CPU 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.

*6.2.9.2 Features*

- Nested and Vectored interrupt support
- Automatic processor state saving and restoration
- Dynamic priority change
- 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® Cortex®-M0 Technical Reference Manual” and “ARM® v6-M Architecture Reference Manual”.

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

*6.2.9.3 Exception Model and System Interrupt Map*

Table 6.2-8 lists the exception model supported by the NM1230 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 the 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 |

Table 6.2-8 Exception Model

| Vector Number | Interrupt Number (Bit In Interrupt Registers) | Interrupt Name    | Interrupt Description                           |
|---------------|---|-------------------|---|
| 0 ~ 15        | -   | -                 | System exceptions                               |
| 16            | 0   | <b>BOD_OUT</b>    | Brown-Out low voltage detected interrupt        |
| 17            | 1   | <b>WDTPINT</b>    | Watchdog Timer interrupt                        |
| 18            | 2   | <b>USCI0_INT</b>  | USCI0 interrupt                                 |
| 19            | 3   | <b>USCI1_INT</b>  | USCI1 interrupt                                 |
| 20            | 4   | <b>GP_INT</b>     | External interrupt from GPA ~ GPF pins          |
| 21            | 5   | <b>EPWM_INT</b>   | EPWM interrupt                                  |
| 22            | 6   | <b>BRAKE0_INT</b> | EPWM brake interrupt from PWM0 or PWM_BRAKE pin |
| 23            | 7   | <b>BRAKE1_INT</b> | EPWM brake interrupt from PWM1                  |
| 24            | 8   | <b>BPWM0_INT</b>  | BPWM0 interrupt                                 |
| 25            | 9   | <b>BPWM1_INT</b>  | BPWM1 interrupt                                 |
| 26            | 10  | Reserved          | Reserved  |
| 27            | 11  | <b>USCI2_INT</b>  | USCI2 interrupt                                 |
| 28            | 12  | Reserved          | Reserved  |
| 29            | 13  | Reserved          | Reserved  |
| 30            | 14  | Reserved          | Reserved  |
| 31            | 15  | <b>ECAP_INT</b>   | Enhanced Input Capture interrupt                |
| 32            | 16  | <b>CCAP_INT</b>   | Continues Input Capture interrupt               |
| 33            | 17  | Reserved          | Reserved  |
| 34            | 18  | Reserved          | Reserved  |

|    |    |                     |   |
|----|----|---------------------|---|
| 35 | 19 | Reserved            | Reserved                                      |
| 36 | 20 | Reserved            | Reserved                                      |
| 37 | 21 | <b>HIRCTRIM_INT</b> | HIRC TRIM interrupt                           |
| 38 | 22 | <b>TMR0_INT</b>     | Timer 0 interrupt                             |
| 39 | 23 | <b>TMR1_INT</b>     | Timer 1 interrupt                             |
| 40 | 24 | <b>TMR2_INT</b>     | Timer 2 interrupt                             |
| 41 | 25 | <b>TMR3_INT</b>     | Timer 3 interrupt                             |
| 42 | 26 | <b>ACMP_INT</b>     | Analog Comparator 0 or Comparator 1 interrupt |
| 43 | 27 | <b>QEI_INT</b>      | QEI interrupt                                 |
| 44 | 28 | <b>PWRWU_INT</b>    | Chip wake-up from Power-down state interrupt  |
| 45 | 29 | <b>ADC0_INT</b>     | ADC0 interrupt                                |
| 46 | 30 | <b>ADC1_INT</b>     | ADC1 interrupt                                |
| 47 | 31 | <b>ADCWCMP_INT</b>  | ADC Window Compare interrupt                  |

Table 6.2-9 System Interrupt Map Vector Table

6.2.9.4 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 based 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 the exception handler entry as illustrated in previous section.

| Vector Table Word Offset (Bytes) | Description   |
|----------------------------------|---|
| 0x00                             | Initial Stack Pointer Value                         |
| Exception Number * 0x04          | Exception Entry Pointer using that Exception Number |

Table 6.2-10 Vector Table Format

6.2.9.5 Operation Description

The 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.

6.2.9.6 *NVIC Control Registers Map*

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>NVIC_ISER</b>            | SCS_BA+0x100 | R/W | IRQ0 ~ IRQ31 Set-enable Control Register          | 0x0000_0000 |
| <b>NVIC_ICER</b>            | SCS_BA+0x180 | R/W | IRQ0 ~ IRQ31 Clear-enable Control Register        | 0x0000_0000 |
| <b>NVIC_ISPR</b>            | SCS_BA+0x200 | R/W | IRQ0 ~ IRQ31 Set-pending Control Register         | 0x0000_0000 |
| <b>NVIC_ICPR</b>            | SCS_BA+0x280 | R/W | IRQ0 ~ IRQ31 Clear-pending Control Register       | 0x0000_0000 |
| <b>NVIC_IPR0</b>            | SCS_BA+0x400 | R/W | IRQ0 ~ IRQ3 Interrupt Priority Control Register   | 0x0000_0000 |
| <b>NVIC_IPR1</b>            | SCS_BA+0x404 | R/W | IRQ4 ~ IRQ7 Interrupt Priority Control Register   | 0x0000_0000 |
| <b>NVIC_IPR2</b>            | SCS_BA+0x408 | R/W | IRQ8 ~ IRQ11 Interrupt Priority Control Register  | 0x0000_0000 |
| <b>NVIC_IPR3</b>            | SCS_BA+0x40C | R/W | IRQ12 ~ IRQ15 Interrupt Priority Control Register | 0x0000_0000 |
| <b>NVIC_IPR4</b>            | SCS_BA+0x410 | R/W | IRQ16 ~ IRQ19 Interrupt Priority Control Register | 0x0000_0000 |
| <b>NVIC_IPR5</b>            | SCS_BA+0x414 | R/W | IRQ20 ~ IRQ23 Interrupt Priority Control Register | 0x0000_0000 |
| <b>NVIC_IPR6</b>            | SCS_BA+0x418 | R/W | IRQ24 ~ IRQ27 Interrupt Priority Control Register | 0x0000_0000 |
| <b>NVIC_IPR7</b>            | SCS_BA+0x41C | R/W | IRQ28 ~ IRQ31 Interrupt Priority Control Register | 0x0000_0000 |

6.2.9.7 NVIC Control Registers Description

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 |

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

| Bits   | Description  |
|--------|--|
| [31:0] | <p><b>SETENA</b></p> <p><b>Interrupt Enable Register</b><br/>                     Enable one or more interrupts. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).<br/>                     Write operation:<br/>                     0 = No effect.<br/>                     1 = Write 1 to enable associated interrupt.<br/>                     Read operation:<br/>                     0 = Associated interrupt status is Disabled.<br/>                     1 = Associated interrupt status is Enabled.<br/>                     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] | <p><b>CLRENA</b></p> <p><b>Interrupt Disable Register</b><br/>                     Disable one or more interrupts. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).<br/>                     Write operation:<br/>                     0 = No effect.<br/>                     1 = Write 1 to disable associated interrupt.<br/>                     Read operation:<br/>                     0 = Associated interrupt status Disabled.<br/>                     1 = Associated interrupt status Enabled.<br/> <b>Note:</b> 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 |
| SETPEND |    |    |    |    |    |    |    |
| 23      | 22 | 21 | 20 | 19 | 18 | 17 | 16 |
| SETPEND |    |    |    |    |    |    |    |
| 15      | 14 | 13 | 12 | 11 | 10 | 9  | 8  |
| SETPEND |    |    |    |    |    |    |    |
| 7       | 6  | 5  | 4  | 3  | 2  | 1  | 0  |
| SETPEND |    |    |    |    |    |    |    |

| Bits   | Description   |
|--------|---|
| [31:0] | <p><b>SETPEND</b></p> <p><b>Set Interrupt Pending Register</b><br/>                     Write operation:<br/>                     0 = No effect.<br/>                     1 = Write 1 to set pending state. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).<br/>                     Read operation:<br/>                     0 = Associated interrupt in not in pending status.<br/>                     1 = Associated interrupt is in pending status.<br/> <b>Note:</b> 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] | <p><b>Clear Interrupt Pending Register</b></p> <p>Write operation:<br/>0 = No effect.<br/>1 = Write 1 to clear pending state. Each bit represents an interrupt number from IRQ0 ~ IRQ31 (Vector number from 16 ~ 47).</p> <p>Read operation:<br/>0 = Associated interrupt in not in pending status.<br/>1 = Associated interrupt is in pending status.</p> <p><b>Note:</b> 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] | PRI_3       | <b>Priority of IRQ3</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.  |
| [23:22] | PRI_2       | <b>Priority of IRQ2</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.  |
| [15:14] | PRI_1       | <b>Priority of IRQ1</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.  |
| [7:6]   | PRI_0       | <b>Priority of IRQ0</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | 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] | PRI_7       | <b>Priority of IRQ7</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.  |
| [23:22] | PRI_6       | <b>Priority of IRQ6</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.  |
| [15:14] | PRI_5       | <b>Priority of IRQ5</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.  |
| [7:6]   | PRI_4       | <b>Priority of IRQ4</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | 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] | PRI_11      | <b>Priority of IRQ11</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_10      | <b>Priority of IRQ10</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.   |
| [15:14] | PRI_9       | <b>Priority of IRQ9</b><br>0 denotes the highest priority and 3 denotes the lowest priority.  |
| [13:8]  | Reserved    | Reserved.   |
| [7:6]   | PRI_8       | <b>Priority of IRQ8</b><br>0 denotes the highest priority and 3 denotes the lowest priority.  |
| [5:0]   | Reserved    | 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] | PRI_15      | <b>Priority of IRQ15</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_14      | <b>Priority of IRQ14</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.   |
| [15:14] | PRI_13      | <b>Priority of IRQ13</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.   |
| [7:6]   | PRI_12      | <b>Priority of IRQ12</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | 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] | PRI_19      | <b>Priority of IRQ19</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_18      | <b>Priority of IRQ18</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.   |
| [15:14] | PRI_17      | <b>Priority of IRQ17</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.   |
| [7:6]   | PRI_16      | <b>Priority of IRQ16</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | 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] | PRI_23      | <b>Priority of IRQ23</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_22      | <b>Priority of IRQ22</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.   |
| [15:14] | PRI_21      | <b>Priority of IRQ21</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.   |
| [7:6]   | PRI_20      | <b>Priority of IRQ20</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | 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 |
| 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] | PRI_27      | <b>Priority of IRQ27</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_26      | <b>Priority of IRQ26</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.   |
| [15:14] | PRI_25      | <b>Priority of IRQ25</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.   |
| [7:6]   | PRI_24      | <b>Priority of IRQ24</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | 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] | PRI_31      | <b>Priority of IRQ31</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_30      | <b>Priority of IRQ30</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [21:16] | Reserved    | Reserved.   |
| [15:14] | PRI_29      | <b>Priority of IRQ29</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [13:8]  | Reserved    | Reserved.   |
| [7:6]   | PRI_28      | <b>Priority of IRQ28</b><br>0 denotes the highest priority and 3 denotes the lowest priority. |
| [5:0]   | Reserved    | Reserved.   |

6.2.9.8 Interrupt Source Control Registers Map

Besides the interrupt control registers associated with the NVIC, the NM1230 series also implements some specific control registers to facilitate the interrupt functions, including "NMI source selection" and "IRQ number identity", 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><br>INT_BA = 0x5000_0300 |             |     |  |             |
| INT_NMICTL                                       | INT_BA+0x80 | R/W | NMI Source Interrupt Select Control Register | 0x0000_0000 |
| INT_IRQSTS                                       | INT_BA+0x84 | R/W | MCU IRQ Number Identity Register             | 0x0000_0000 |

6.2.9.9 Interrupt Source Control Register Description

**NMI Interrupt Source Select Control Register (INT\_NMICTL)**

| Register   | Offset      | R/W | Description                                  | Reset Value |
|------------|-------------|-----|--|-------------|
| INT_NMICTL | 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 |    |    |    |        |    |    | NMISELEN |
| 7        | 6  | 5  | 4  | 3      | 2  | 1  | 0        |
| Reserved |    |    |    | NMISEL |    |    |          |

| Bits   | Description |  |
|--------|-------------|--|
| [31:9] | Reserved    | Reserved.  |
| [8]    | NMISELEN    | <p><b>NMI Interrupt Enable Control (Write Protected)</b></p> <p>0 = NMI interrupt Disabled.<br/>1 = NMI interrupt Enabled.</p> <p><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 SYS_REGLCTL at address SYS_BA+0x100.</p> |
| [7:5]  | Reserved    | Reserved.  |

| Bits  | Description   |  |
|-------|---------------|--|
| [4:0] | <b>NMISEL</b> | <b>NMI Interrupt Source Selection</b><br>The NMI interrupt to Cortex®-M0 can be selected from one of the peripheral interrupt by setting NMTSEL. |

**MCU Interrupt Request Source Register (INT\_IRQSTS)**

| Register   | Offset      | R/W | Description                      | Reset Value |
|------------|-------------|-----|----------------------------------|-------------|
| INT_IRQSTS | INT_BA+0x84 | R/W | MCU IRQ Number Identity Register | 0x0000_0000 |

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

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

**6.2.10 System Control Registers**

Key control and status features of Cortex®-M0 are managed centrally in a System Control Block within the System Control Registers.

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

*6.2.10.1 System Control Register Memory Map*

**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>SCS_CPUID</b>            | SCS_BA+0xD00 | R   | CPUID Base Register                              | 0x410C_C200 |
| <b>SCS_ICSR</b>             | SCS_BA+0xD04 | R/W | Interrupt Control State Register                 | 0x0000_0000 |
| <b>SCS_AIRCR</b>            | SCS_BA+0xD0C | R/W | Application Interrupt and Reset Control Register | 0xFA05_0000 |
| <b>SCS_SCR</b>              | SCS_BA+0xD10 | R/W | System Control Register                          | 0x0000_0000 |
| <b>SCS_SHPR2</b>            | SCS_BA+0xD1C | R/W | System Handler Priority Register 2               | 0x0000_0000 |
| <b>SCS_SHPR3</b>            | SCS_BA+0xD20 | R/W | System Handler Priority Register 3               | 0x0000_0000 |

6.2.10.2 System Control Register Description

**CPUID Base Register (CPUID)**

| Register  | Offset       | R/W | Description         | Reset Value |
|-----------|--------------|-----|---------------------|-------------|
| SCS_CPUID | SCS_BA+0xD00 | R   | CPUID Base Register | 0x410C_C200 |

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

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

**Interrupt Control State Register (ICSR)**

| Register | Offset       | R/W | Description                      | Reset Value |
|----------|--------------|-----|----------------------------------|-------------|
| SCS_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 | Reserved | VECTPENDING |           |           |           |            |
| 15          | 14          | 13       | 12          | 11        | 10        | 9         | 8          |
| VECTPENDING |             |          |             | Reserved  |           |           | VECTACTIVE |
| 7           | 6           | 5        | 4           | 3         | 2         | 1         | 0          |
| VECTACTIVE  |             |          |             |           |           |           |            |

| Bits    | Description   |
|---------|---|
| [31]    | <p><b>NMIPENDSET</b></p> <p><b>NMI Set-pending Bit</b><br/>Write Operation:<br/>0 = No effect.<br/>1 = Changes NMI exception state to pending.<br/>Read Operation:<br/>0 = NMI exception not pending.<br/>1 = NMI exception pending.<br/><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.   |
| [28]    | <p><b>PENDSVSET</b></p> <p><b>PendSV Set-pending Bit</b><br/>Write Operation:<br/>0 = No effect.<br/>1 = Changes PendSV exception state to pending.<br/>Read Operation:<br/>0 = PendSV exception is not pending.<br/>1 = PendSV exception is pending.<br/><b>Note:</b> Writing 1 to this bit is the only way to set the PendSV exception state to pending</p>   |
| [27]    | <p><b>PENDSVCLR</b></p> <p><b>PendSV Clear-pending Bit</b><br/>Write Operation:<br/>0 = No effect.<br/>1 = Removes the pending state from the PendSV exception.<br/>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]    | <p><b>PENDSTSET</b></p> <p><b>SysTick Exception Set-pending Bit</b></p>   |

|         |                    |   |
|---------|--------------------|---|
|         |                    | <p>Write Operation:<br/>0 = No effect.<br/>1 = Changes SysTick exception state to pending.</p> <p>Read Operation:<br/>0 = SysTick exception is not pending.<br/>1 = SysTick exception is pending.</p>   |
| [25]    | <b>PENDSTCLR</b>   | <p><b>SysTick Exception Clear-pending Bit</b></p> <p>Write Operation:<br/>0 = No effect.<br/>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 toPENDSTSET and write 1 to PENDSTCLR” at the same time.</p> |
| [24]    | <b>Reserved</b>    | Reserved.   |
| [23]    | <b>ISRPREEMPT</b>  | <p><b>Interrupt Preempt Bit(Read Only)</b></p> <p>If set, a pending exception will be serviced on exit from the debug halt state</p>  |
| [22]    | <b>ISRPENDING</b>  | <p><b>Interrupt Pending Flag,Excluding NMI and Faults (Read Only)</b></p> <p>0 = Interrupt not pending.<br/>1 = Interrupt pending.</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.<br/>Non-zero = Exception number of the highest priority pending enabled exception.</p>   |
| [11:9]  | <b>Reserved</b>    | Reserved.   |
| [8:0]   | <b>VECTACTIVE</b>  | <p><b>Contains the Active Exception Number</b></p> <p>0 = Thread mode.<br/>Non-zero = Exception number of the currently active exception.</p>   |

**Application Interrupt and Reset Control Register (SCS\_AIRCR)**

| Register  | Offset       | R/W | Description                                      | Reset Value |
|-----------|--------------|-----|--|-------------|
| SCS_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] | VECTORKEY     | <p><b>Register Access Key</b></p> <p>Write Operation:<br/>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.</p> <p>Read Operation:<br/>Read as 0xFA05.</p> |
| [15:3]  | Reserved      | Reserved.   |
| [2]     | SYSRESETREQ   | <p><b>System Reset Request</b></p> <p>Writing this bit 1 will cause a reset signal to be asserted to the chip to indicate a reset is requested.</p> <p>The bit is a write only bit and self-clears as part of the reset sequence.</p>   |
| [1]     | VECTCLRACTIVE | <p><b>Exception Active Status Clear Bit</b></p> <p>Reserved for debug use. When writing to the register, user must write 0 to this bit, otherwise behavior is unpredictable.</p>  |
| [0]     | Reserved      | Reserved.   |

**System Control Register (SCR)**

| Register | Offset       | R/W | Description             | Reset Value |
|----------|--------------|-----|-------------------------|-------------|
| SCS_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 |    |    | SEVONPEND | Reserved | SLEEPDEEP | SLEEPONEXIT | Reserved |

| Bits   | Description |   |
|--------|-------------|---|
| [31:5] | Reserved    | Reserved.   |
| [4]    | SEVONPEND   | <p><b>Send Event on Pending Bit</b></p> <p>0 = Only enabled interrupts or events can wake-up the processor, disabled interrupts are excluded.</p> <p>1 = Enabled events and all interrupts, including disabled interrupts, can wake-up the processor.</p> <p>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.</p> <p>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></p> <p>Controls whether the processor uses sleep or deep sleep as its low power mode:</p> <p>0 = Sleep mode.</p> <p>1 = Deep Sleep mode.</p>  |
| [1]    | SLEEPONEXIT | <p><b>Sleep-on-exit Enable Control</b></p> <p>This bit indicates sleep-on-exit when returning from Handler mode to Thread mode.</p> <p>0 = Do not sleep when returning to Thread mode.</p> <p>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 |
|-----------|--------------|-----|------------------------------------|-------------|
| SCS_SHPR2 | 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] | PRI_11      | Priority of System Handler 11 – SVCAll<br>"0" denotes the highest priority and "3" denotes the lowest priority. |
| [29:0]  | Reserved    | Reserved.   |

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

| Register  | Offset       | R/W | Description                        | Reset Value |
|-----------|--------------|-----|------------------------------------|-------------|
| SCS_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      | <b>Priority of System Handler 15 – SysTick</b><br>"0" denotes the highest priority and "3" denotes the lowest priority. |
| [29:24] | Reserved    | Reserved.   |
| [23:22] | PRI_14      | <b>Priority of System Handler 14 – PendSV</b><br>"0" denotes the highest priority and "3" denotes the lowest priority.  |
| [21:0]  | Reserved    | Reserved.   |

## 6.3 Clock Controller

### 6.3.1 Overview

The clock controller generates 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 the Cortex<sup>®</sup>-M0 core executes the WFI instruction only if the PDEN (CLK\_PWRCTL[7]) bit set to 1. After that, chip enters Power-down mode and waits for wake-up interrupt source triggered to exit Power-down mode. In Power-down mode, the clock controller turns off the 4~24 MHz external high speed crystal (HXT) and 48(72) MHz internal high speed RC oscillator (HIRC) to reduce the overall system power consumption. Figure 6.3-1 shows the clock generator and the overview of the clock source control.

6.3.2 Clock Diagram

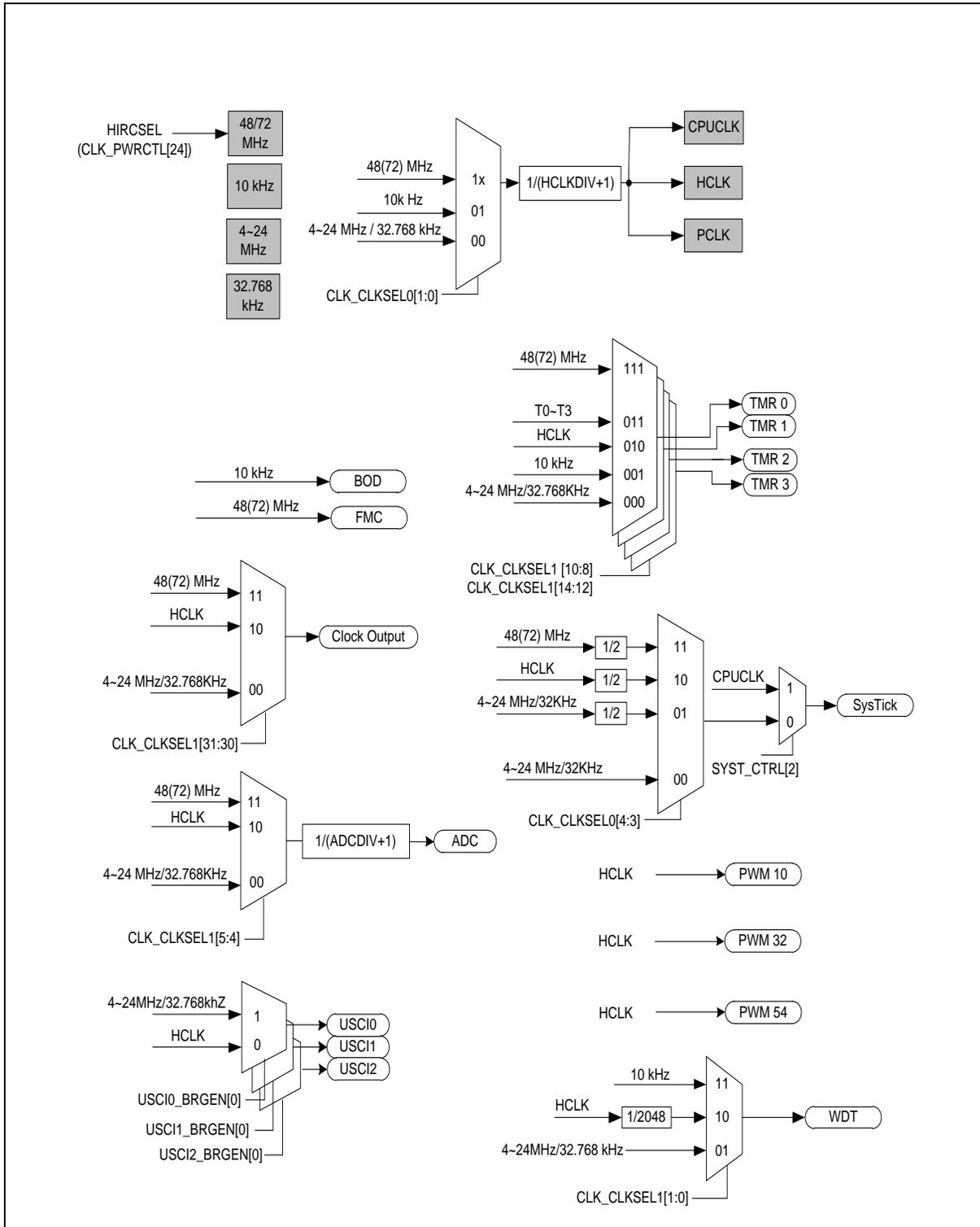


Figure 6.3-1 Clock Generator Global View Diagram

6.3.3 Clock Generator

The clock generator consists of 4 clock sources, which are listed below:

- 32.768 kHz external low speed crystal oscillator (LXT)
- 4~24 MHz external high speed crystal oscillator (HXT)
- 48(72) MHz internal high speed RC oscillator (HIRC)
- 10 kHz internal low speed RC oscillator (LIRC)

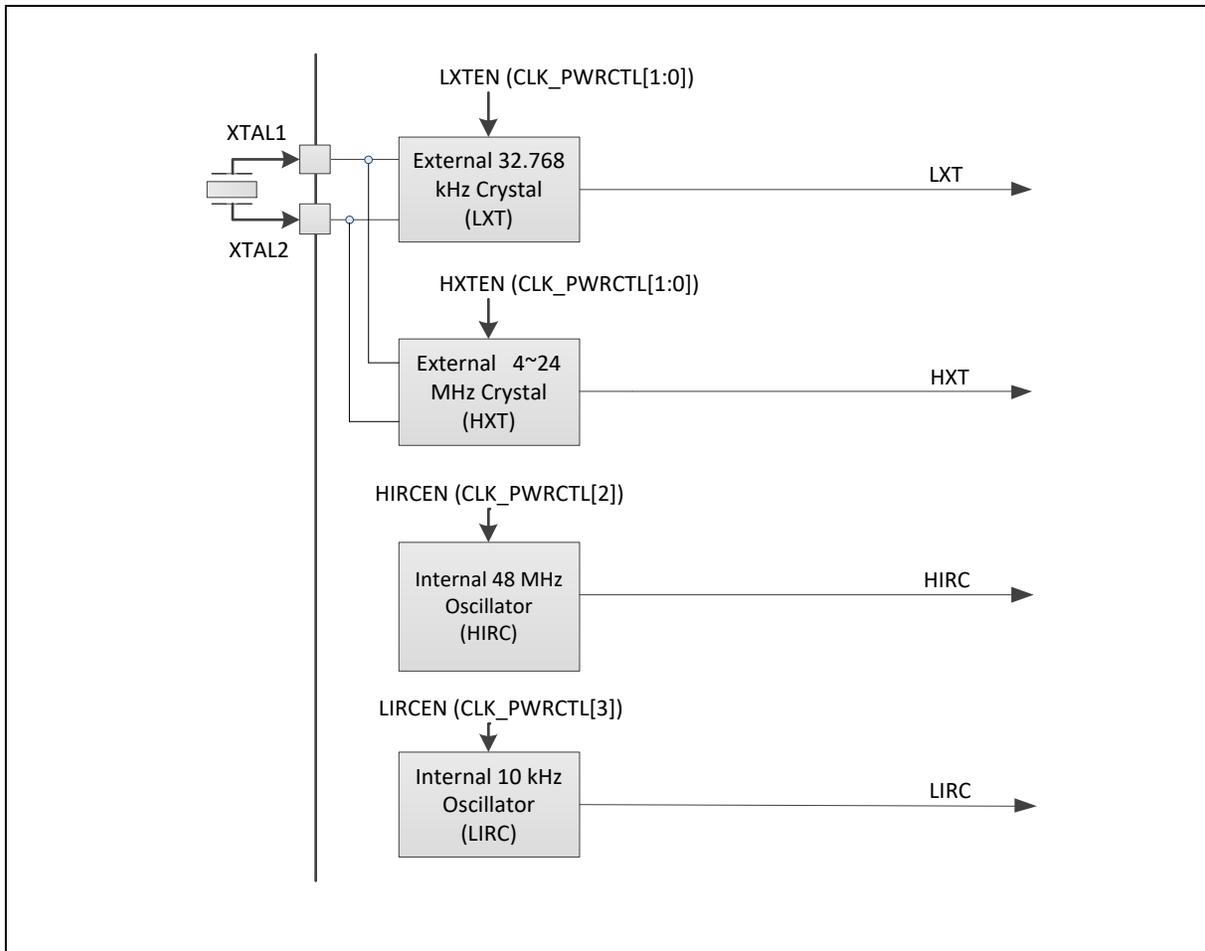


Figure 6.3-2 Clock Generator Block Diagram

The external crystal oscillator and two capacitors are connected to the pad “XT\_IN” and pad “XT\_OUT”. The capacitance value of the two capacitors may be changed for differential crystal oscillator from different vender. The load capacitance values and resistance values must be adjusted according to the selected oscillator. The recommended load capacitance values and resistance values as

| Crystal Oscillator | Capacitance Values | Resistance Values     |
|--------------------|--------------------|-----------------------|
| 12 MHz             | C1:20pF , C2:20pF  | Hi-Z ( Build in Chip) |
| 32.768 kHz         | C1:20pF , C2:20oF  | Hi-Z ( Build in Chip) |

Table 6.3-1 Recommended Load Capacitance Values and Resistance Values

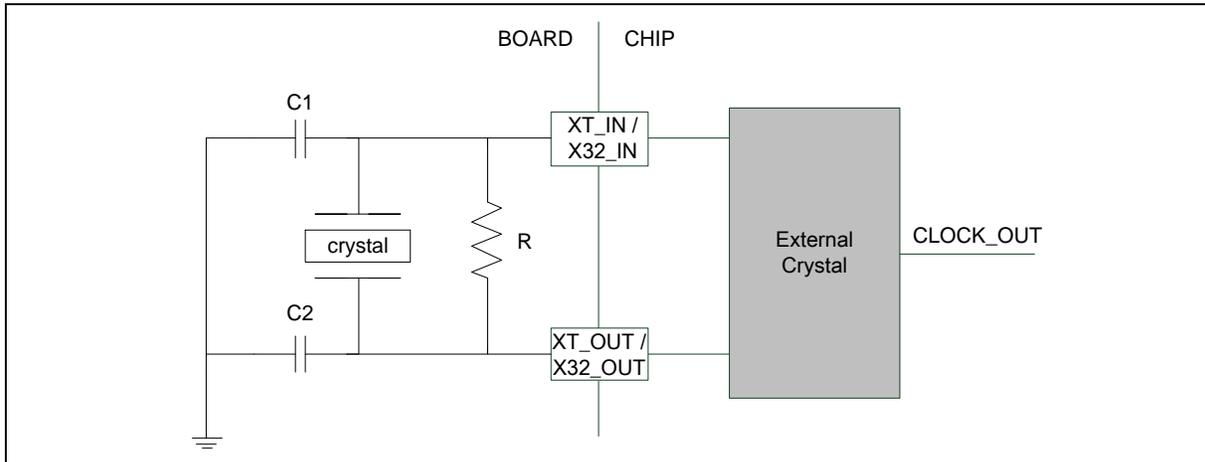


Figure 6.3-3 Crystal Oscillator Circuit

### 6.3.4 System Clock and SysTick Clock

The system clock has three clock sources which were generated from clock generator block. The clock source switch depends on the register HCLKSEL (CLK\_CLKSEL0[1:0]). The block diagram is shown in Figure 6.3-4.

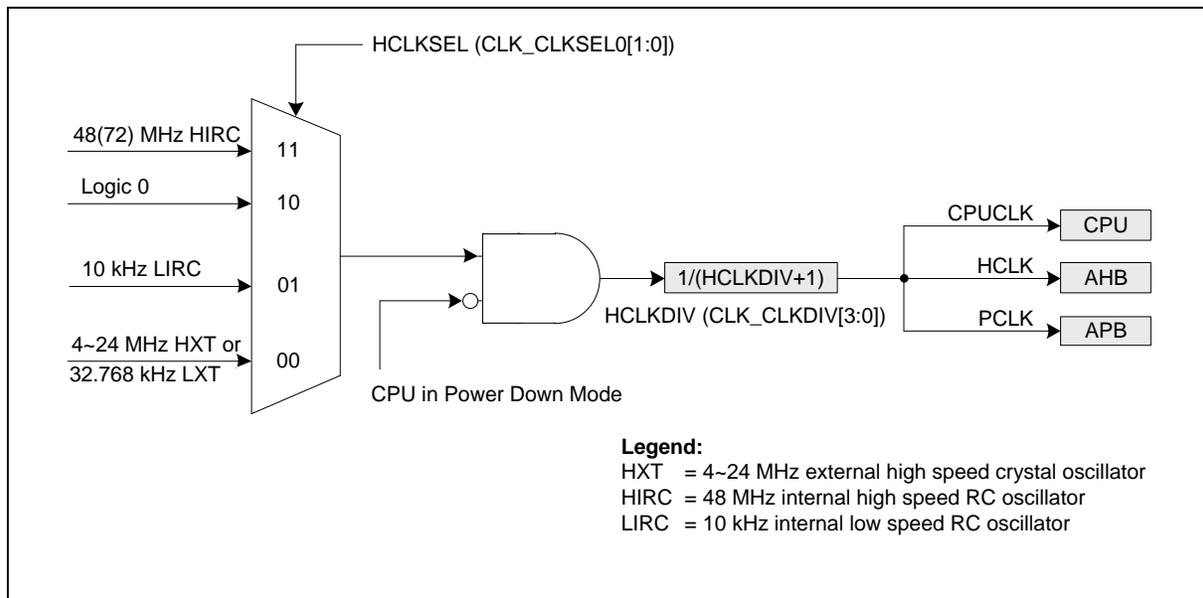


Figure 6.3-4 System Clock Block Diagram

The clock source of SysTick in the Cortex®-M0 core can use CPU clock or external clock (SYST\_CTL[2]). If using external clock, the SysTick clock (STCLK) has 4 clock sources. The clock source switch depends on the setting of the register STCLKSEL (CLK\_CLKSEL0[4:3]). The block diagram is shown in Figure 6.3-5.

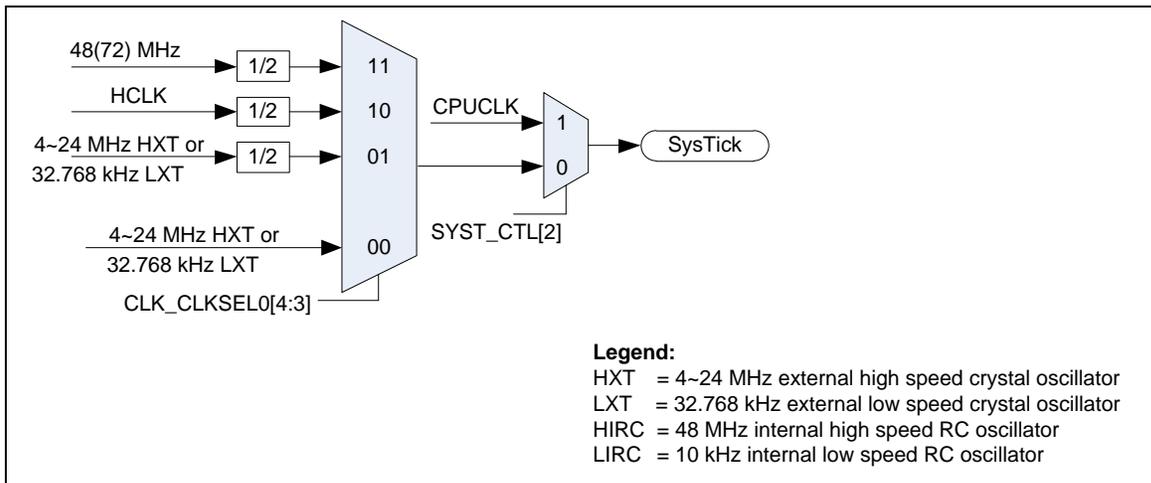


Figure 6.3-5 SysTick Clock Control Block Diagram

### 6.3.5 AHB Clock Source Selection

The clock source of ISP is from AHB clock (HCLK). Please refer to register CLK\_AHBCLK.

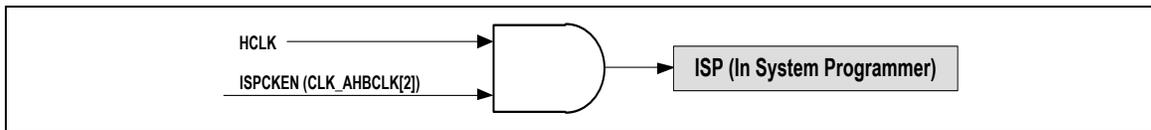


Figure 6.3-6 AHB Clock Source for HCLK

### 6.3.6 Peripherals Clock Source Selection

The peripheral clock has different clock source switch settings depending on different peripherals. Please refer to the CLK\_CLKSEL1 and CLK\_APBCLK register description in section 錯誤! 找不到參照來源。

### 6.3.7 Power-down Mode Clock

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

The clocks still kept active are listed below:

- Clock Generator
- 10 kHz internal low speed oscillator (LIRC) clock
- 32.768 kHz external low speed crystal oscillator (LXT) clock (If PDLXT = 1 and XTLEN[1:0] = 10)
- Peripherals Clock (When 10 kHz low speed oscillator is adopted as clock source)
  - ◆ Watchdog Clock

◆ Timer 0/1 Clock

6.3.8 Frequency Divider Output

This device is equipped with a power-of-2 frequency divider which is composed of 16 chained divide-by-2 shift registers. One of the 16 shift register outputs selected by a sixteen to one multiplexer is reflected to the CLKO 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 FREQSEL (CLK\_CLKOCTL[3:0]).

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

if DIV1EN(CLK\_CLKOCTL[5]) set to 1, the frequency divider clock will bypass power-of-2 frequency divider. The frequency divider clock will be output to CLKO pin directly.

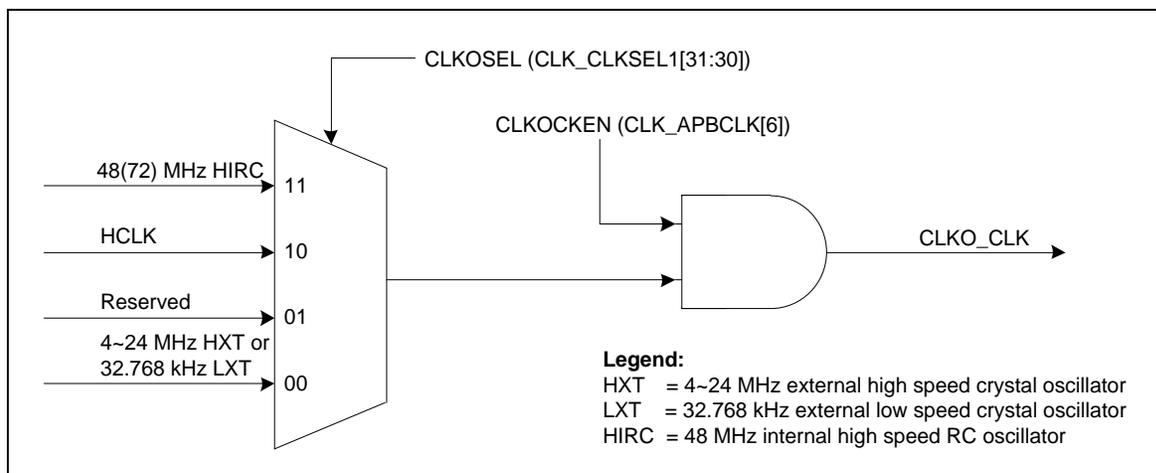


Figure 6.3-7 Clock Source of Frequency Divider

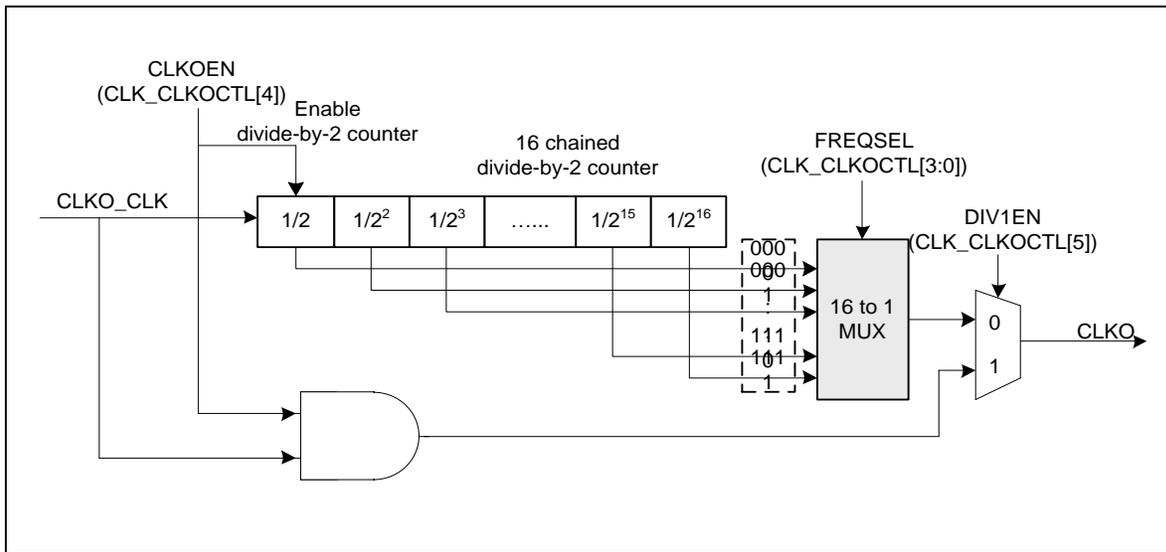


Figure 6.3-8 Block Diagram of Frequency Divider

## 6.4 Flash Memory Controller (FMC)

### 6.4.1 Overview

The NM1230 series is equipped with 48/64 Kbytes on chip embedded Flash EPROM for application program memory (APROM) that can be updated through ISP procedure. In System Programming (ISP) function enables user to update program memory when chip is soldered on PCB. After chip powered on Cortex<sup>®</sup>-M0 CPU fetches code from APROM or LDROM decided by boot select (CBS) in Config0. By the way, the NM1230 series also provides Data Flash Region, where the Data Flash is shared with original program memory and its start address is configurable and defined by user in Config1. The Data Flash size is defined by user depending on the application request. Security program memory (SPROM) provides user to protect any program code within SPROM.

### 6.4.2 Features

- Running up to 48(72) MHz with one wait state and 24 MHz without wait state for discontinuous address read access
- 48/64 Kbytes application program memory (APROM)
- 7.5 Kbytes in system programming (ISP) loader program memory (LDROM)
- Programmable Data Flash start address and memory size with 512 bytes page erase unit
- In System Program (ISP)/In Application Program (IAP) to update on chip Flash EPROM

## 6.5 General Purpose I/O (GPIO)

### 6.5.1 Overview

The NM1230 series has up to 44 General Purpose I/O pins and one input pin. These pins could be shared with other functions depending on the chip configuration. 44 pins are arranged in 6 ports named as PA, PB, PC, PD, PE and PF. Each of the 44 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. After the chip is reset, the I/O mode of all pins are depending on CIOIN (CONFIG0[10]).

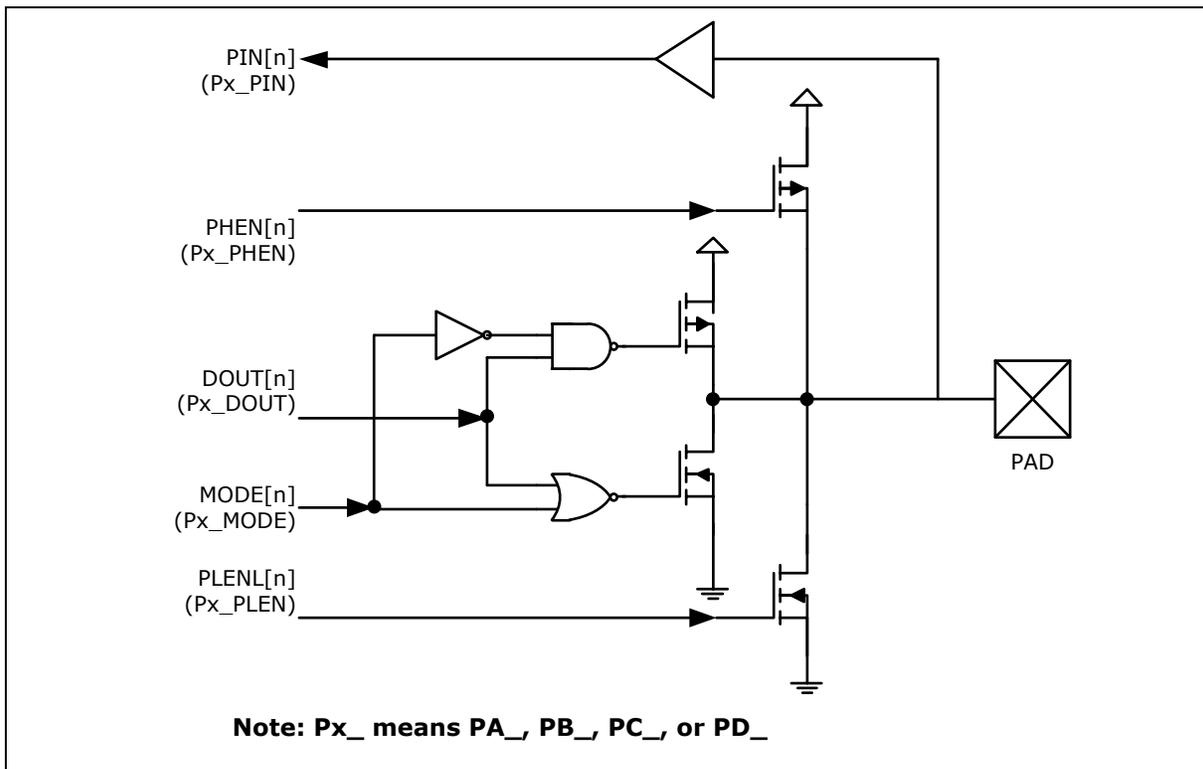


Figure 6.5-1 I/O Pin Block Diagram

### 6.5.2 Features

- Four I/O modes:
  - Quasi-bidirectional mode
  - Push-Pull Output mode
  - Open-Drain Output mode
  - Input only with high impedance mode
- TTL/Schmitt trigger input selectable
- I/O pin can be configured as interrupt source with edge/level setting
- Supports High Drive and High Slew Rate I/O mode
- Configurable default I/O mode of all pins after reset by CIOINI (CONFIG0[10]) setting
  - CIOIN = 0, all GPIO pins in Quasi-bidirectional mode after chip reset
  - CIOIN = 1, all GPIO pins in input mode after chip reset
- All GPIO supports the pull-up and pull-low resistor enabled in four I/O modes

- Enabling the pin interrupt function will also enable the wake-up function

## 6.6 Timer Controller (TIMER)

### 6.6.1 Overview

The Timer Controller includes four 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.

### 6.6.2 Features

- Supports two sets of 32-bit timers with 24-bit up-timer and one 8-bit pre-scale counter
- Supports independent clock source for each channel (TMR0/1/2/3\_CLK)
- Supports four timer counting modes: one-shot, periodic, toggle and continuous counting
- Time-out period = (period of timer clock input) \* (8-bit pre-scale counter + 1) \* (24-bit CMPDAT)
- Supports 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 TIMERx\_CNT (Timer Data Register)
- Supports event counting function to count the event from external pin (TM0/1/2/3)
- Supports internal capture triggered while internal ACMP output signal transition
- Supports chip wake-up from Idle/Power-down mode if a timer interrupt signal is generated

## 6.7 Enhanced Input Capture Timer (ECAP)

### 6.7.1 Overview

This device provides an Input Capture Timer/Counter whose capture function can detect the digital edge-changed signal at channel inputs. This unit has three input capture channels. The timer/counter is equipped with up counting, reload and compare-match capabilities.

### 6.7.2 Features

- Supports the interrupt function
- Each input channel has its own capture counter hold register
- 24-bit Input Capture up-counting timer/counter
- With noise filter in front end of input ports
- Edge detector with three options
  - ◆ Rising edge detection
  - ◆ Falling edge detection
  - ◆ Both edge detection
- Each input channel is supported with one capture counter hold register
- Captured event reset and/or reload capture counter
- Supports compare-match function

## 6.8 Enhanced PWM Generator (EPWM)

### 6.8.1 Overview

The NM1230 has built in one PWM unit which is specially designed for motor driving control applications. The PWM unit supports six PWM generators which can be configured as six independent PWM outputs, PWM0~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 clock divider providing nine divided frequencies (1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256) for each channel. Each PWM output shares one 16-bit counter for PWM period control, and 16-bit comparators for PWM duty control. The six PWM generators provide fourteen 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 up 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 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. To control motor more precisely, some registers are provided to configure not only PWM but also Timer, ADC and ACMP. By doing so, it can save more CPU time and control motor with ease especially in BLDC.

### 6.8.2 Features

- Supports one PWM clock timer and one 9 level Divider (1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256).
- Supports six independent 16-bit PWM duty control units with maximum six port pins:
  - ◆ Six independent PWM outputs – PWM0, PWM1, PWM2, PWM3, PWM4, 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)
- Supports group function.
- Supports one-shot (only edge alignment mode) or auto-reload mode PWM
- Supports 16-bit resolution PWM counter
- Supports Edge-aligned and Center-aligned mode
- Supports Programmable dead-zone insertion between complementary paired PWMs
- Supports hardware fault brake protections
  - ◆ Two Interrupt types, BRK0 and BRK1:
    - BRK0 forces EPWM in brake state and resumed by software
    - BRK1 force EPWM in brake state and auto-resumed by hardware
    - Brake source:
      - ◆ BRK0: ACMP0, ACMP1, EADC and External pins (PWM\_BRK\_Px)

- ◆ BRK1: ACMP0, ACMP1, EADC and External pins (PWM\_BRK\_Px).
- 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 falling CMPDAT matching, central matching (in Center-aligned mode), rising CMPDAT matching (in Center-aligned mode), period matching to trigger EADC conversion
- Supports ACMP output event trigger PWM to force PWM output at most one period low
- Supports interrupt accumulation function

## 6.9 Basic PWM Generator (BPWM)

### 6.9.1 Overview

The NM1230 series has one set of BPWM group supporting one set of PWM generator that can be configured as 2 independent PWM outputs, PWM20~PWM21, or as 1 complementary PWM pairs, (PWM20, PWM21) with programmable Dead-zone generators.

The PWM generator has one 8-bit pre-scalar, 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 up/down-counters for PWM period control, two 16-bit comparators for PWM duty control and one dead-zone generator. The PWM generator provides two independent PWM interrupt flags which are set by hardware when the corresponding PWM period down counter reaches zero. 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 DTCNT01(BPWM\_CTL[4]) is set, PWM20 and PWM21 perform complementary; the paired PWM timing, period, duty and dead-time are determined by PWM0 timer and Dead-zone generator 0. Refer to [錯誤! 找不到參照來源。](#) for the architecture of Basic PWM Timers.

To prevent PWM driving output pin from glitches, 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 zero. The double buffering feature avoids glitch at PWM outputs.

When the 16-bit period down counter reaches zero, the interrupt request is generated. If PWM-timer is set as auto-reload mode, when the down counter reaches zero, it is reloaded with BPWM Counter Register(BPWM\_PERIODx, x=0,1) automatically then start 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 zero.

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.

### 6.9.2 Features

- One PWM generator which supports one 8-bit pre-scalar, one clock divider, two PWM timers (down counter), one dead-zone generator and two PWM outputs.
- Up to 16-bit resolution
- PWM Interrupt request synchronized with PWM period
- One-shot or Auto-reload mode PWM
- Edge-aligned type or Center-aligned type option

## 6.10 Quadrature Encoder Interface (QEI)

### 6.10.1 Overview

There is a 32-bit QEI controllers in this device. The Quadrature Encoder Interface (QEI) decodes speed of rotation and motion sensor information. It can be used in any application that uses a quadrature encoder for feedback.

### 6.10.2 Features

- Two QEI phase inputs, QEI\_A and QEI\_B; One Index input IDX.
- One QEI control register (QEI\_CTL) and one QEI Status Register (QEI\_STATUS)
- Four Quadrature encoder pulse counter operation modes:
- Mode0: x4 free-counting mode
- Mode1: x2 free-counting mode
- Mode2: x4 compare-counting mode
- Mode3: x2 compare-counting mode
- Encoder Pulse Width measurement mode

## 6.11 Watchdog Timer (WDT)

### 6.11.1 Overview

The Watchdog Timer is used to perform a system reset when system runs into an unknown state. This prevents system from hanging for an infinite period of time. Besides, the Watchdog Timer supports the function to wake-up system from Idle/Power-down mode.

### 6.11.2 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 time-out wake-up function only if WDT clock source is selected as 10 kHz

## 6.12 USCI – Universal Serial Control Interface Controller

### 6.12.1 Overview

The Universal Serial Control Interface (USCI) is a flexible interface module covering several serial communication protocols. The user can configure this controller as UART, SPI, or I<sup>2</sup>C functional protocol.

**Note:** For detailed USCI UART, I<sup>2</sup>C and SPI information, please refer to section 6.13, 6.14, and 6.15.

### 6.12.2 Features

The controller can be individually configured to match the application needs. The following protocols are supported:

- UART
- SPI
- I<sup>2</sup>C

## 6.13 USCI – UART Mode

### 6.13.1 Overview

The asynchronous serial channel UART covers the reception and the transmission of asynchronous data frames. It performs a serial-to-parallel conversion on data received from the peripheral, and a parallel-to-serial conversion on data transmitted from the controller. The receiver and transmitter being independent, frames can start at different points in time for transmission and reception.

The UART controller also provides the LIN function. There is incoming data to wake up the system.

### 6.13.2 Features

- Supports one transmit buffer and two receive buffer for data payload
- Supports programmable baud-rate generator
- Supports 9-Bit Data Transfer
- Supports LIN function
- Baud rate detection possible by built-in capture event of baud rate generator
- Supports Wake-up function

## 6.14 USCI – SPI Mode

### 6.14.1 Overview

The SPI protocol of USCI controller applies to synchronous serial data communication and allows full duplex transfer. It supports both master and Slave operation mode with the 4-wire bi-direction interface. SPI mode of USCI controller performs 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. The SPI mode is selected by FUNMODE (USPI\_CTL[2:0]) = 0x1.

The SPI protocol can operate as master or Slave mode by setting the SLAVE (USPI\_PROTCTL[0]) to communicate with the off-chip SPI Slave or master device. The application block diagrams in master and Slave mode are shown as Figure 6.14-1 and Figure 6.14-2.

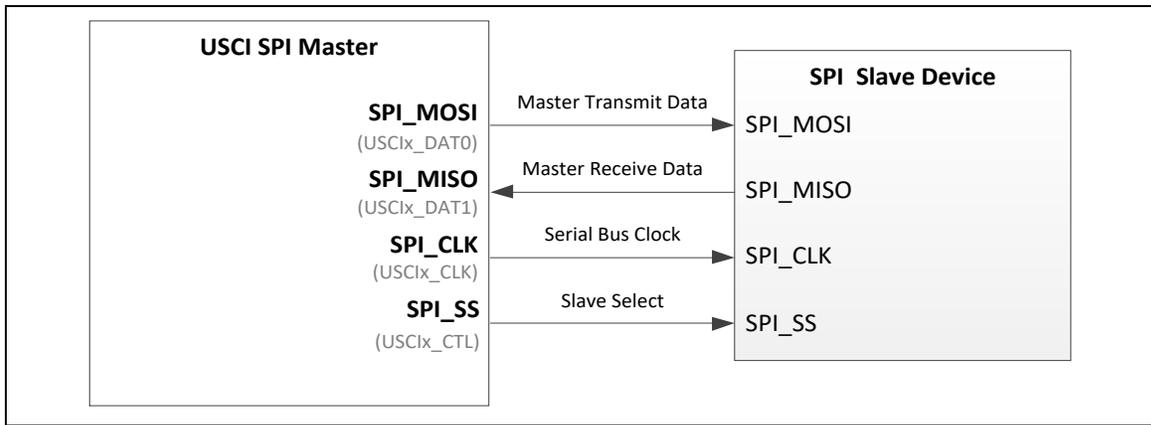


Figure 6.14-1 SPI Master Mode Application Block Diagram (x=0, 1)

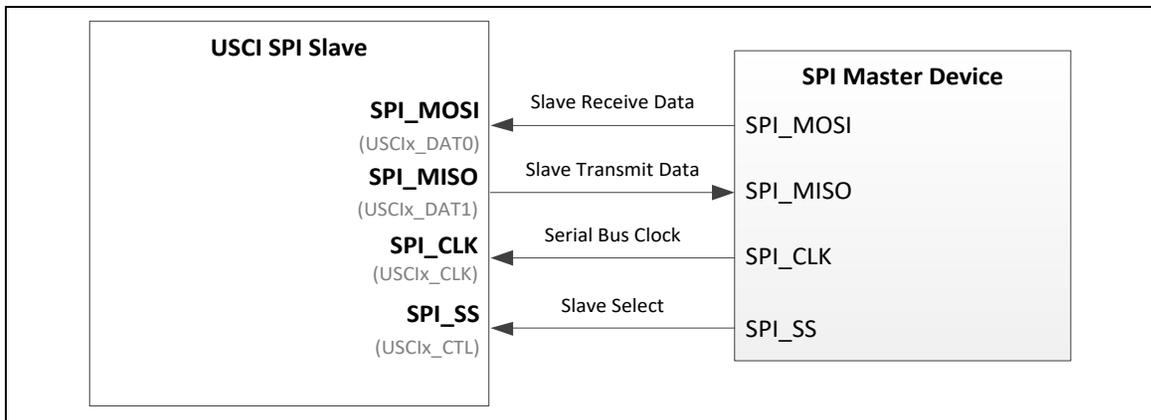


Figure 6.14-2 SPI Slave Mode Application Block Diagram (x=0, 1)

### 6.14.2 Features

- Supports Master or Slave mode operation (the maximum frequency -- Master =  $f_{PCLK}/2$ , Slave <  $f_{PCLK}/5$ )
- Configurable bit length of a transfer word from 4 to 16-bit
- Supports one transmit buffer and two receive buffers for data payload

- Supports MSB first or LSB first transfer sequence
- Supports Word Suspend function
- Supports 3-wire, no slave select signal, bi-direction interface
- Supports wake-up function by slave select signal in Slave mode

## 6.15 USCI – I<sup>2</sup>C Mode

### 6.15.1 Overview

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. 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 Figure 6.15-1 for more detailed I<sup>2</sup>C BUS Timing.

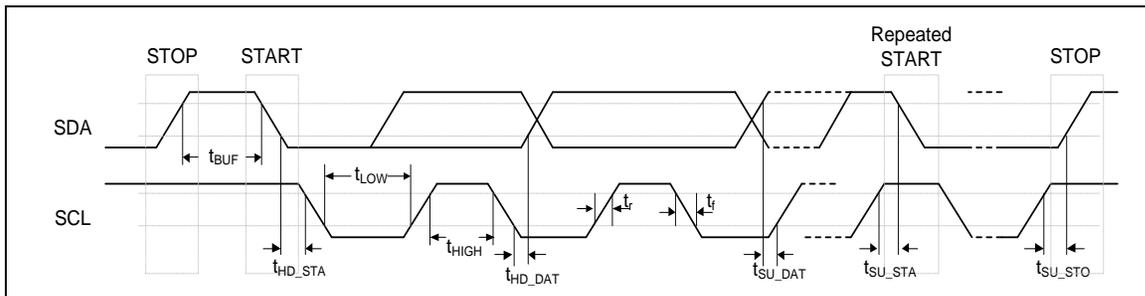


Figure 6.15-1 I<sup>2</sup>C Bus Timing

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. The I<sup>2</sup>C mode is selected by FUNMODE (UI2C\_CTL [2:0]) = 0100B. When this port is enabled, the USCI 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:** A pull-up resistor is needed for I<sup>2</sup>C operation because the SDA and SCL are set to open-drain pins when USCI is selected to I<sup>2</sup>C operation mode.

### 6.15.2 Features

- Full master and slave device capability
- Supports of 7-bit addressing, as well as 10-bit addressing
- Communication in standard mode (100 kBit/s) or in fast mode (up to 400 kBit/s)
- Supports multi-master bus
- Supports one transmit buffer and two receive buffer for data payload
- Supports 10-bit bus time-out capability
- Supports Power down wake-up by data toggle or address match
- Supports setup/hold time programmable

## 6.16 Hardware Divider (HDIV)

### 6.16.1 Overview

The hardware divider (HDIV) is useful to the high performance application. The hardware divider is a signed, integer divider with both quotient and remainder outputs.

### 6.16.2 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)
- Support 3 group of dividends, divisor, quotients and remainders for three times of independent calculation capacity
- 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



## 6.17 Analog to Digital Converter (ADC)

### 6.17.1 Overview

The NM1230 series contains one 12-bit successive approximation analog-to-digital converter (SAR A/D converter). The A/D converter can be started by software, external pin (STADC/PC.1) or PWM trigger.

### 6.17.2 Features

- Analog input voltage range: 0~V<sub>DD</sub>.
- 12-bit resolution and 10-bit accuracy guaranteed.
- Up to 16+16 single-end analog input channels.
- Configurable ADC internal sampling time.

## 6.18 Analog Comparator (ACMP)

### 6.18.1 Overview

The NM1230 series contains two comparators which can be used in a number of different configurations. The comparator output is logic 1 when positive input greater than negative input, otherwise the output is 0. Each comparator can be configured to generate interrupt when the comparator output value changes.

### 6.18.2 Features

- Analog input voltage range: 0 ~  $V_{DD}$
- Supports Hysteresis function
- Optional internal reference voltage source for each comparator negative input

## 6.19 OP and Programmable Gain Amplifier (PGA)

### 6.19.1 Overview

The NM1230 series contains a programmable gain amplifier (PGA) which can be enabled through the PGAEN bit. User can measure the outputs of the programmable gain amplifier as the programmable gain amplifier output to the integrated A/D converter channel, where digital results can be taken. Furthermore, user can adjust gain to 1, 2, 3, 5, 7, 9, 11,13

**Note:** The analog input port pins must be configured as input type before the PGA function is enabled.

### 6.19.2 Features

#### 6.19.2.1 PGA Features

- Supports analog input voltage range: 0~  $V_{DD}$ .
- Supports programmable gain: 1, 2, 3, 5, 7, 9, 11,13
- Supports PGA output as input of ADC and ACMP

#### 6.19.2.2 OP Features

- Supports analog input voltage range: 0~  $V_{DD}$ .
- 3 rail-to-rail OP amplifiers

## **7 ELECTRICAL CHARACTERISTICS**

For information on the NM1230 series electrical characteristics, please refer to NuMicro® NM1230 Series Datasheet.

7.1 Absolute Maximum Ratings

| Symbol            | Parameter                                 | Min            | Max            | Unit |
|-------------------|---|----------------|----------------|------|
| $V_{DD} - V_{SS}$ | DC Power Supply                           | -0.3           | +7.0           | V    |
| $V_{IN}$          | Input Voltage                             | $V_{SS} - 0.3$ | $V_{DD} + 0.3$ | V    |
| $1/t_{CLCL}$      | Oscillator Frequency                      | 4              | 24             | MHz  |
| $T_A$             | Operating Temperature                     | -40            | +105           | °C   |
| $T_{ST}$          | Storage Temperature                       | -55            | +150           | °C   |
| $I_{DD}$          | Maximum Current into $V_{DD}$             | -              | 120            | mA   |
| $I_{SS}$          | Maximum Current out of $V_{SS}$           | -              | 120            | mA   |
| $I_{IO}$          | Maximum Current sunk by an I/O pin        | -              | 35             | mA   |
|                   | Maximum Current sourced by an I/O pin     | -              | 35             | mA   |
|                   | Maximum Current sunk by total I/O pins    | -              | 100            | mA   |
|                   | Maximum Current sourced by total I/O pins | -              | 100            | mA   |

**Note:** Exposure to conditions beyond those listed under absolute maximum ratings may adversely affects the life and reliability of the device.

7.2 DC Electrical Characteristics

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ )

| Symbol    | Parameter                            | Min  | Typ  | Max  | Unit | Test Conditions  |        |        |                     |
|-----------|--------------------------------------|------|------|------|------|--|--------|--------|---------------------|
| $V_{DD}$  | Operation voltage                    | 2.2  | -    | 5.5  | V    | $V_{DD} = 2.2\text{V} \sim 5.5\text{V}$ up to 48 MHz<br>$V_{DD} = 3.3\text{V} \sim 5.5\text{V}$ up to 72 MHz |        |        |                     |
| $V_{SS}$  | Power Ground                         | -0.3 | -    | -    | V    |  |        |        |                     |
| $V_{LDO}$ | LDO Output Voltage                   |      | 1.5  |      | V    |  |        |        |                     |
| $V_{BG}$  | Band-gap Voltage <sup>3</sup>        | 1.17 | 1.23 | 1.28 | V    | $V_{DD} = 3.0\text{V} \sim 5.5\text{V}$ ,<br>$T_A = -40^\circ\text{C} \sim 105^\circ\text{C}$                |        |        |                     |
| $I_{DD}$  | Operating Current<br>Normal Run Mode | -    | 14.9 | -    | mA   | $V_{DD}$   | HXT    | HIRC   | All Digital Modules |
|           |                                      |      |      |      |      | 5.5V   | X      | 72 MHz | V                   |
| $I_{DD}$  | HCLK = 72 MHz<br>while(1){}          | -    | 10.3 | -    | mA   | 5.5V   | X      | 72 MHz | X                   |
| $I_{DD}$  | Executed from Flash                  | -    | 14.9 | -    | mA   | 3V   | X      | 72 MHz | V                   |
| $I_{DD}$  |                                      | -    | 10.3 | -    | mA   | 3V   | X      | 72 MHz | X                   |
| $I_{DD}$  | Operating Current<br>Normal Run Mode | -    | 10.4 | -    | mA   | $V_{DD}$   | HXT    | HIRC   | All Digital Modules |
|           |                                      |      |      |      |      | 5.5V   | X      | 48 MHz | V                   |
| $I_{DD}$  | HCLK = 48 MHz<br>while(1){}          | -    | 7.3  | -    | mA   | 5.5V   | X      | 48 MHz | X                   |
| $I_{DD}$  | Executed from Flash                  | -    | 10.4 | -    | mA   | 3V   | X      | 48 MHz | V                   |
| $I_{DD}$  |                                      | -    | 7.3  | -    | mA   | 3V   | X      | 48 MHz | X                   |
| $I_{DD}$  | Operating Current<br>Normal Run Mode | -    | 5.4  | -    | mA   | $V_{DD}$   | HXT    | HIRC   | All Digital Modules |
|           |                                      |      |      |      |      | 5.5V   | 24 MHz | X      | V                   |
| $I_{DD}$  | HCLK = 24 MHz<br>while(1){}          | -    | 4.1  | -    | mA   | 5.5V   | 24 MHz | X      | X                   |
| $I_{DD}$  | Executed from Flash                  | -    | 5.4  | -    | mA   | 3V   | 24 MHz | X      | V                   |
| $I_{DD}$  |                                      | -    | 4.1  | -    | mA   | 3V   | 24 MHz | X      | X                   |
| $I_{DD}$  | Operating Current<br>Normal Run Mode | -    | 3.9  | -    | mA   | $V_{DD}$   | HXT    | HIRC   | All Digital Modules |
|           |                                      |      |      |      |      | 5.5V   | 16 MHz | X      | V                   |
| $I_{DD}$  | HCLK = 16 MHz<br>while(1){}          | -    | 3.0  | -    | mA   | 5.5V   | 16 MHz | X      | X                   |
| $I_{DD}$  | Executed from Flash                  | -    | 3.9  | -    | mA   | 3V   | 16 MHz | X      | V                   |

|                   |                                      |   |     |   |    |                 |        |        |                        |
|-------------------|--------------------------------------|---|-----|---|----|-----------------|--------|--------|------------------------|
| I <sub>DD</sub>   |                                      | - | 3.0 | - | mA | 3V              | 16 MHz | X      | X                      |
| I <sub>DD</sub>   | Operating Current<br>Normal Run Mode | - | 3.1 | - | mA | V <sub>DD</sub> | HXT    | HIRC   | All Digital<br>Modules |
|                   |                                      |   |     |   |    | 5.5V            | 12 MHz | X      | V                      |
| I <sub>DD</sub>   | HCLK = 12 MHz<br>while(1){}          | - | 2.5 | - | mA | 5.5V            | 12 MHz | X      | X                      |
| I <sub>DD</sub>   | Executed from Flash                  | - | 3.1 | - | mA | 3V              | 12 MHz | X      | V                      |
| I <sub>DD</sub>   |                                      | - | 2.4 | - | mA | 3V              | 12 MHz | X      | X                      |
| I <sub>DD</sub>   | Operating Current<br>Normal Run Mode | - | 1.5 | - | mA | V <sub>DD</sub> | HXT    | HIRC   | All Digital<br>Modules |
|                   |                                      |   |     |   |    | 5.5V            | 4 MHz  | X      | V                      |
| I <sub>DD</sub>   | HCLK = 4 MHz<br>while(1){}           | - | 1.3 | - | mA | 5.5V            | 4 MHz  | X      | X                      |
| I <sub>DD</sub>   | Executed from Flash                  | - | 1.4 | - | mA | 3V              | 4 MHz  | X      | V                      |
| I <sub>DD</sub>   |                                      | - | 1.2 | - | mA | 3V              | 4 MHz  | X      | X                      |
| I <sub>DD</sub>   | Operating Current<br>Normal Run Mode | - | 154 | - | μA | V <sub>DD</sub> | LXT    | LIRC   | All Digital<br>Modules |
|                   |                                      |   |     |   |    | 5.5V            | 32 KHz | V      | V <sup>(1)</sup>       |
| I <sub>DD</sub>   | HCLK = 32 kHz<br>while(1){}          | - | 152 | - | μA | 5.5V            | 32 KHz | V      | X                      |
| I <sub>DD</sub>   | Executed from Flash                  | - | 134 | - | μA | 3V              | 32 KHz | V      | V <sup>(1)</sup>       |
| I <sub>DD</sub>   |                                      | - | 132 | - | μA | 3V              | 32 KHz | V      | X                      |
| I <sub>DD</sub>   | Operating Current<br>Normal Run Mode | - | 148 | - | μA | V <sub>DD</sub> | HXT    | LIRC   | All Digital<br>Modules |
|                   |                                      |   |     |   |    | 5.5V            | X      | 10 KHz | V <sup>(2)</sup>       |
| I <sub>DD</sub>   | HCLK = 10 kHz<br>while(1){}          | - | 148 | - | μA | 5.5V            | X      | 10 KHz | X                      |
| I <sub>DD</sub>   | Executed from Flash                  | - | 128 | - | μA | 3V              | X      | 10 KHz | V <sup>(2)</sup>       |
| I <sub>DD</sub>   |                                      | - | 128 | - | μA | 3V              | X      | 10 KHz | X                      |
| I <sub>IDLE</sub> | Operating Current<br>Idle Mode       | - | 8.3 | - | mA | V <sub>DD</sub> | HXT    | HIRC   | All Digital<br>Modules |
|                   |                                      |   |     |   |    | 5.5V            | X      | V      | V                      |
| I <sub>IDLE</sub> | HCLK= 72 MHz                         | - | 3.6 | - | mA | 5.5V            | X      | V      | X                      |
| I <sub>IDLE</sub> |                                      | - | 8.3 | - | mA | 3V              | X      | V      | V                      |

|                   |                            |   |     |   |    |                 |        |      |                     |
|-------------------|----------------------------|---|-----|---|----|-----------------|--------|------|---------------------|
| I <sub>IDLE</sub> |                            | - | 3.6 | - | mA | 3V              | X      | V    | X                   |
| I <sub>IDLE</sub> | Operating Current          | - | 5.7 | - | mA | V <sub>DD</sub> | HXT    | HIRC | All Digital Modules |
|                   |                            |   |     |   |    | 5.5V            | X      | V    | V                   |
| I <sub>IDLE</sub> | Idle Mode<br>HCLK= 48 MHz  | - | 2.6 | - | mA | 5.5V            | X      | V    | X                   |
| I <sub>IDLE</sub> |                            | - | 5.7 | - | mA | 3V              | X      | V    | V                   |
| I <sub>IDLE</sub> |                            | - | 2.6 | - | mA | 3V              | X      | V    | X                   |
| I <sub>IDLE</sub> | Operating Current          | - | 2.9 | - | mA | V <sub>DD</sub> | HXT    | HIRC | All Digital Modules |
|                   |                            |   |     |   |    | 5.5V            | 24 MHz | X    | V                   |
| I <sub>IDLE</sub> | Idle Mode<br>HCLK = 24 MHz | - | 1.6 | - | mA | 5.5V            | 24 MHz | X    | X                   |
| I <sub>IDLE</sub> |                            | - | 2.9 | - | mA | 3V              | 24 MHz | X    | V                   |
| I <sub>IDLE</sub> |                            | - | 1.6 | - | mA | 3V              | 24 MHz | X    | X                   |
| I <sub>IDLE</sub> | Operating Current          | - | 2.2 | - | mA | V <sub>DD</sub> | HXT    | HIRC | All Digital Modules |
|                   |                            |   |     |   |    | 5.5V            | V      | X    | V                   |
| I <sub>IDLE</sub> | Idle Mode<br>HCLK = 16 MHz | - | 1.3 | - | mA | 5.5V            | V      | X    | X                   |
| I <sub>IDLE</sub> |                            | - | 2.1 | - | mA | 3V              | V      | X    | V                   |
| I <sub>IDLE</sub> |                            | - | 1.3 | - | mA | 3V              | V      | X    | X                   |
| I <sub>IDLE</sub> | Operating Current          | - | 1.8 | - | mA | V <sub>DD</sub> | HXT    | HIRC | All Digital Modules |
|                   |                            |   |     |   |    | 5.5V            | V      | X    | V                   |
| I <sub>IDLE</sub> | Idle Mode<br>HCLK = 12 MHz | - | 1.1 | - | mA | 5.5V            | V      | X    | X                   |
| I <sub>IDLE</sub> |                            | - | 1.7 | - | mA | 3V              | V      | X    | V                   |
| I <sub>IDLE</sub> |                            | - | 1.1 | - | mA | 3V              | V      | X    | X                   |
| I <sub>IDLE</sub> | Operating Current          | - | 1.0 | - | mA | V <sub>DD</sub> | HXT    | HIRC | All Digital Modules |
|                   |                            |   |     |   |    | 5.5V            | V      | X    | V                   |
| I <sub>IDLE</sub> | Idle Mode<br>HCLK = 4 MHz  | - | 0.8 | - | mA | 5.5V            | V      | X    | X                   |
| I <sub>IDLE</sub> |                            | - | 1.0 | - | mA | 3V              | V      | X    | V                   |

|                                 |  |                    |      |                       |    |   |     |      |                     |
|---------------------------------|--|--------------------|------|-----------------------|----|---|-----|------|---------------------|
| I <sub>IDLE</sub>               |  | -                  | 0.7  | -                     | mA | 3V  | V   | X    | X                   |
| I <sub>IDLE</sub>               | Operating Current                                | -                  | 150  | -                     | μA | V <sub>DD</sub>   | HXT | LIRC | All Digital Modules |
|                                 |  |                    |      |                       |    | 5.5V  | X   | V    | V <sup>(1)</sup>    |
| I <sub>IDLE</sub>               | Idle Mode<br>HCLK = 32 kHz                       | -                  | 148  | -                     | μA | 5.5V  | X   | V    | X                   |
| I <sub>IDLE</sub>               |  | -                  | 129  | -                     | μA | 3V  | X   | V    | V <sup>(1)</sup>    |
| I <sub>IDLE</sub>               |  |                    |      |                       |    | 3V  | X   | V    | X                   |
| I <sub>IDLE</sub>               | Operating Current                                | -                  | 147  | -                     | μA | V <sub>DD</sub>   | HXT | LIRC | All Digital Modules |
|                                 |  |                    |      |                       |    | 5.5V  | X   | V    | V <sup>(2)</sup>    |
| I <sub>IDLE</sub>               | Idle Mode<br>HCLK = 10 kHz                       | -                  | 147  | -                     | μA | 5.5V  | X   | V    | X                   |
| I <sub>IDLE</sub>               |  | -                  | 127  | -                     | μA | 3V  | X   | V    | V <sup>(2)</sup>    |
| I <sub>IDLE</sub>               |  |                    |      |                       |    | 3V  | X   | V    | X                   |
| I <sub>PWD</sub>                | Standby Current                                  | -                  | 3.6  | -                     | μA | V <sub>DD</sub> = 5.5 V, All oscillators and analog blocks turned off.                          |     |      |                     |
| I <sub>PWD</sub>                | Power-down Mode<br>(Deep Sleep Mode)             | -                  | 2.4  | -                     | μA | V <sub>DD</sub> = 3 V, All oscillators and analog blocks turned off.                            |     |      |                     |
| I <sub>LK</sub>                 | Input Leakage Current                            | -1                 | -    | +1                    | μA | V <sub>DD</sub> = 5.5 V, 0 < V <sub>IN</sub> < V <sub>DD</sub><br>Open-drain or input only mode |     |      |                     |
| V <sub>IL1</sub>                | Input Low Voltage (TTL Input)                    | -0.3               | 1.33 |                       | V  | V <sub>DD</sub> = 5.5 V   |     |      |                     |
|                                 |  | -0.3               | 1    |                       |    | V <sub>DD</sub> = 3.3 V   |     |      |                     |
| V <sub>IH1</sub>                | Input High Voltage (TTL Input)                   |                    | 1.47 | V <sub>DD</sub> + 0.3 | V  | V <sub>DD</sub> = 5.5 V   |     |      |                     |
|                                 |  |                    | 1.08 | V <sub>DD</sub> + 0.3 |    | V <sub>DD</sub> = 3.3 V   |     |      |                     |
| V <sub>ILS</sub>                | Negative-going Threshold (Schmitt Input), nRESET | -                  | -    | 0.3V <sub>DD</sub>    | V  | -   |     |      |                     |
| V <sub>IHS</sub>                | Positive-going Threshold (Schmitt Input), nRESET | 0.7V <sub>DD</sub> | -    | -                     | V  | -   |     |      |                     |
| R <sub>UP</sub> <sup>[3]</sup>  | Internal Pull-up Resistor (PA/PB/PC/PD/PE/PF)    |                    | 51   |                       | kΩ | V <sub>DD</sub> = 5.0V  |     |      |                     |
| R <sub>LOW</sub> <sup>[3]</sup> | Internal Pull-low Resistor (PA/PB/PC/PD/PE/PF)   |                    | 51   |                       | kΩ | V <sub>DD</sub> = 5.0V  |     |      |                     |
| R <sub>RST</sub>                | Internal nRESET Pin Pull-up Resistor             | 48                 |      | 148                   | kΩ | V <sub>DD</sub> = 2.2 V ~ 5.5V  |     |      |                     |
| V <sub>ILS</sub>                | Negative-going Threshold (Schmitt input)         | -                  | -    | 0.3V <sub>DD</sub>    | V  | -   |     |      |                     |
| V <sub>IHS</sub>                | Positive-going Threshold (Schmitt input)         | 0.7V <sub>DD</sub> | -    | -                     | V  | -   |     |      |                     |

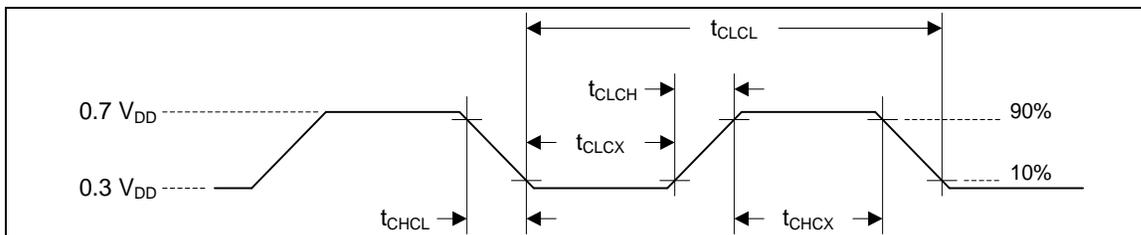
|            |   |   |        |   |         |                                  |
|------------|---|---|--------|---|---------|----------------------------------|
| $I_{IL}$   | Logic 0 Input Current (Quasi-bidirectional Mode)                              | - | -63.65 |   | $\mu A$ | $V_{DD} = 5.5 V, V_{IN} = 0V$    |
| $I_{TL}$   | Logic 1 to 0 Transition Current   | - | -566.7 | - | $\mu A$ | $V_{DD} = 5.5 V$                 |
| $I_{SR}$   | Source Current (Quasi-bidirectional Mode)                                     | - | -372   | - | $\mu A$ | $V_{DD} = 4.5 V, V_{IN} = 2.4 V$ |
| $I_{SR}$   |   | - | -76.8  | - | $\mu A$ | $V_{DD} = 2.7 V, V_{IN} = 2.2 V$ |
| $I_{SR}$   |   | - | -37.3  | - | $\mu A$ | $V_{DD} = 2.2 V, V_{IN} = 1.8 V$ |
| $I_{SR}$   | Source Current (Push-pull Mode)   | - | -19.2  | - | $mA$    | $V_{DD} = 4.5 V, V_{IN} = 2.4 V$ |
| $I_{SR}$   |   | - | -4     | - | $mA$    | $V_{DD} = 2.7 V, V_{IN} = 2.2 V$ |
| $I_{SR}$   |   | - | -2     | - | $mA$    | $V_{DD} = 2.2 V, V_{IN} = 1.8 V$ |
| $I_{SK}$   | Sink Current PA/PB/PC/PD (Quasi-bidirectional, Open-Drain and Push-pull Mode) | - | 12.8   | - | $mA$    | $V_{DD} = 4.5 V, V_{IN} = 0.4 V$ |
| $I_{SK}$   |   | - | 8.1    | - | $mA$    | $V_{DD} = 2.7 V, V_{IN} = 0.4 V$ |
| $I_{SK13}$ |   | - | 6      | - | $mA$    | $V_{DD} = 2.2 V, V_{IN} = 0.4 V$ |

**Notes:**

1. Only enable modules, which support 32 kHz LIRC clock source
2. Only enable modules, which support 10 kHz LIRC clock source
3. Guaranteed by design, not test in production.

### 7.3 AC Electrical Characteristics

#### 7.3.1 External Input Clock



Note: Duty cycle is 50%.

| Symbol            | Parameter       | Min | Typ | Max | Unit | Test Conditions |
|-------------------|-----------------|-----|-----|-----|------|-----------------|
| t <sub>CHCX</sub> | Clock High Time | 10  | -   | -   | ns   | -               |
| t <sub>CLCX</sub> | Clock Low Time  | 10  | -   | -   | ns   | -               |
| t <sub>CLCH</sub> | Clock Rise Time | 2   | -   | 15  | ns   | -               |
| t <sub>CHCL</sub> | Clock Fall Time | 2   | -   | 15  | ns   | -               |

#### 7.3.2 External 4~24 MHz High Speed Crystal (HXT)

| Symbol           | Parameter         | Min. | Typ. | Max | Unit | Test Conditions                |
|------------------|-------------------|------|------|-----|------|--------------------------------|
| V <sub>HXT</sub> | Operation Voltage | 2.2  | -    | 5.5 | V    | -                              |
| T <sub>A</sub>   | Temperature       | -40  | -    | 105 | °C   | -                              |
| I <sub>HXT</sub> | Operating Current | -    | 414  | -   | uA   | 12 MHz, V <sub>DD</sub> = 5.5V |
| f <sub>HXT</sub> | Clock Frequency   | 4    | -    | 24  | MHz  | -                              |

#### 7.3.3 Typical Crystal Application Circuits

| Crystal        | C1      | C2      |
|----------------|---------|---------|
| 4 MHz ~ 24 MHz | 8~12 pF | 8~12 pF |

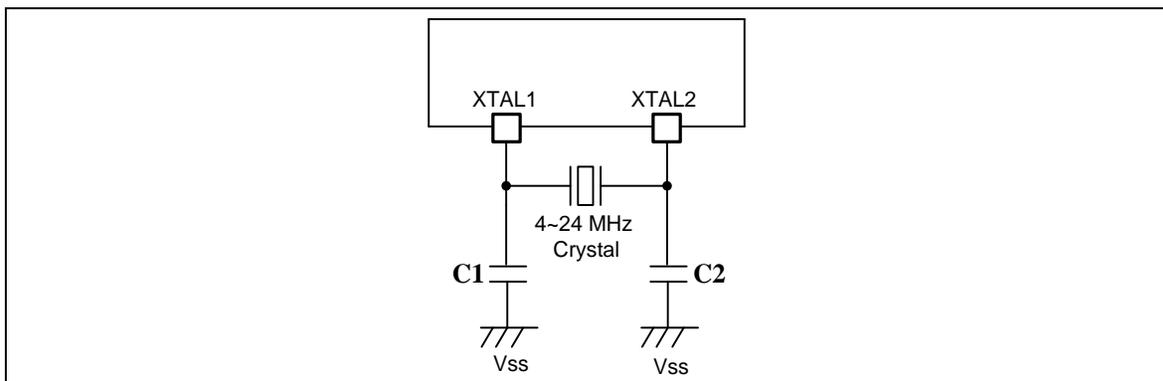


Figure 7.3-1 Typical Crystal Application Circuit

### 7.3.4 48/72 MHz Internal High Speed RC Oscillator (HIRC)

| Symbol      | Parameter                                | Min  | Typ | Max  | Unit  | Test Conditions  |
|-------------|--|------|-----|------|---|--|
| $V_{HRC}$   | Supply Voltage                           | -    | 1.5 | -    | V   | -  |
| $f_{HRC72}$ | Center Frequency                         | -    | 72  | -    | MHz   | -  |
|             | Calibrated Internal Oscillator Frequency | -1.5 | -   | +1.5 | %   | $T_A = 25^\circ\text{C}$<br>$V_{DD}=4.5\text{ V}\sim 5.5\text{ V}$ |
| 2.5%        |  | -    | -   | %    | $T_A = -40^\circ\text{C}\sim 105^\circ\text{C}$<br>$V_{DD}=3.0\text{ V}\sim 5.5\text{ V}$ |  |
| $I_{HRC72}$ | Operating Current                        | -    | 300 | -    | $\mu\text{A}$   | $T_A = 25^\circ\text{C}, V_{DD} = 5\text{ V}$                      |
| $f_{HRC48}$ | Center Frequency                         | -    | 48  | -    | MHz   | -  |
|             | Calibrated Internal Oscillator Frequency | -1   | -   | +1   | %   | $T_A = 25^\circ\text{C}$<br>$V_{DD} = 5.5\text{ V}$                |
| 2%          |  | -    | -   | %    | $T_A = -40^\circ\text{C}\sim 105^\circ\text{C}$<br>$V_{DD}=2.5\text{ V}\sim 5.5\text{ V}$ |  |
| $I_{HRC48}$ | Operating Current                        | -    | 280 | -    | $\mu\text{A}$   | $T_A = 25^\circ\text{C}, V_{DD} = 5\text{ V}$                      |

### 7.3.5 10 kHz Internal Low Speed RC Oscillator (LIRC)

| Symbol    | Parameter        | Min | Typ  | Max | Unit | Test Conditions |
|-----------|------------------|-----|------|-----|------|-----------------|
| $V_{LRC}$ | Supply Voltage   | -   | 1.5V | -   | V    | -               |
| $f_{LRC}$ | Center Frequency | -   | 10   | -   | kHz  | -               |

|                  |                      |                    |     |                    |    |  |
|------------------|----------------------|--------------------|-----|--------------------|----|--|
|                  | Oscillator Frequency | -20 <sup>[1]</sup> | -   | +20 <sup>[1]</sup> | %  | V <sub>DD</sub> = 2.2 V ~ 5.5 V<br>T <sub>A</sub> = -40°C ~ +105°C |
| I <sub>LRC</sub> | Operating Current    | -                  | 0.4 | -                  | μA | T <sub>A</sub> = 25 °C, V <sub>DD</sub> = 5 V                      |

**Note1:** These parameters are characterized but not tested.

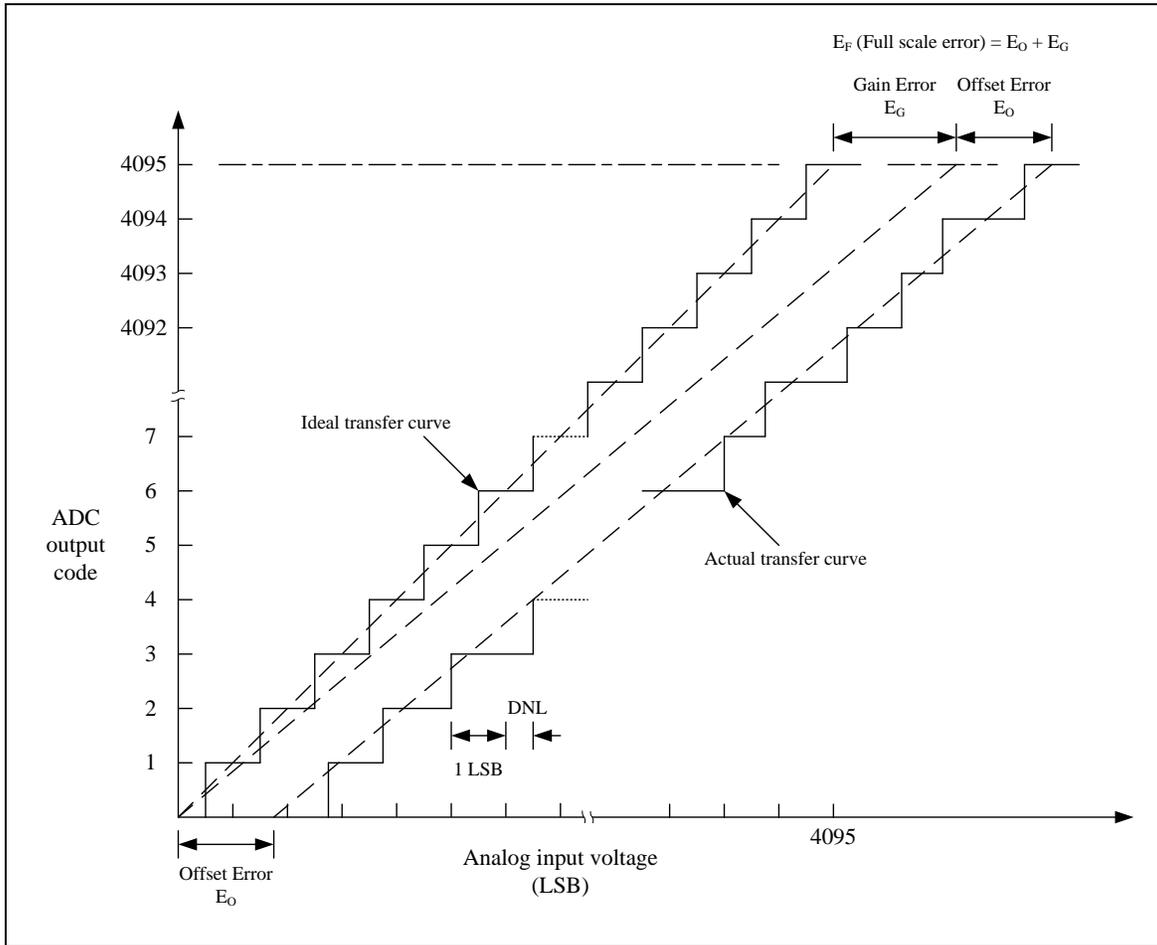
## 7.4 Analog Characteristics

### 7.4.1 12-bit SAR ADC

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Symbol     | Parameter                       | Min        | Typ     | Max      | Unit        | Test Condition  |
|------------|---------------------------------|------------|---------|----------|-------------|---|
| -          | Resolution                      | -          | -       | 12       | Bit         | -   |
| DNL        | Differential Nonlinearity Error | -          | 2       | -        | LSB         | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| INL        | Integral Nonlinearity Error     | -          | $\pm 2$ | -        | LSB         | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| $E_O$      | Offset Error                    | -          | $\pm 1$ | -        | LSB         | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| $E_G$      | Gain Error (Transfer Gain)      | -          | -1      | -        | LSB         | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| $E_A$      | Absolute Error                  | -          | $\pm 3$ | -        | LSB         | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| -          | Monotonic                       | Guaranteed |         |          | -           | -   |
| $T_{ACQ}$  | Acquisition Time (Sample Stage) | N+1        |         |          | $1/F_{ADC}$ | $V_{DD} = 3.0 \sim 5.5 \text{ V}$<br>N is sampling counter,<br>N=1~1024 |
|            |                                 | 200        |         |          | ns          | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| $T_{CONV}$ | Conversion Time <sup>3</sup>    |            | 1000    | 1250     | ns          | $V_{DD} = 3.0 \sim 5.5 \text{ V}$                                       |
| $I_{DDA}$  | Supply Current (Avg.)           | -          | 1       | -        | mA          | $V_{DD} = 5.5 \text{ V}$  |
| $V_{IN}$   | Analog Input Voltage            | 0          | -       | $V_{DD}$ | V           | -   |
| $C_{IN}$   | Input Capacitance <sup>2</sup>  | -          | 1.6     | -        | pF          | -   |

1. ADC voltage reference is same with  $V_{DD}$ .
2. It's for sample and hold. The maximum value depends on process variation. Basically, the variation of  $C_{IN}$  is less than about 10% of typical value.
3. Guaranteed by design, not test in production. The conversion time is upto auto-completion of analog comparison in ADC IP and the typical value is about 1000ns at  $V_{DD} = 5V$ .



**7.4.2 LDO & Power Management**

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Symbol    | Parameter      | Min  | Typ | Max  | Unit | Test Condition |
|-----------|----------------|------|-----|------|------|----------------|
| $V_{LDO}$ | Output Voltage | 1.35 | 1.5 | 1.65 | V    | -              |

**Notes:**

It is recommended a 0.1 $\mu\text{F}$  bypass capacitor is connected between  $V_{DD}$  and the closest  $V_{SS}$  pin of the device.

**7.4.3 Brown-out Detector**

( $V_{DD} - V_{SS} = 0 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Symbol    | Parameter            | Min  | Typ | Max  | Unit          | Test Condition         |
|-----------|----------------------|------|-----|------|---------------|------------------------|
| $I_{BOD}$ | Quiescent Current    | -    | 40  | -    | $\mu\text{A}$ | $V_{DD} = 5.5\text{V}$ |
| $V_{BOH}$ | Brown-out Hysteresis | 30   | 100 | 150  | mV            |                        |
| $V_{BOD}$ | Brown-out Detector   | 4.15 | 4.3 | 4.45 | V             | BOV_VL [2:0] = 7       |
|           |                      | 3.85 | 4.0 | 4.15 | V             | BOV_VL [2:0] = 6       |
|           |                      | 3.55 | 3.7 | 3.85 | V             | BOV_VL [2:0] = 5       |
|           |                      | 2.85 | 3.0 | 3.15 | V             | BOV_VL [2:0] = 4       |
|           |                      | 2.55 | 2.7 | 2.85 | V             | BOV_VL [2:0] = 3       |
|           |                      | 2.3  | 2.4 | 2.5  | V             | BOV_VL [2:0] = 2       |
|           |                      | 2.1  | 2.2 | 2.3  | V             | BOV_VL [2:0] = 1       |
|           |                      | 1.9  | 2.0 | 2.1  | V             | BOV_VL [2:0] = 0       |

**7.4.4 Power-on Reset**

( $V_{DD} - V_{SS} = 0 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Symbol    | Parameter         | Min  | Typ  | Max  | Unit | Test Condition |
|-----------|-------------------|------|------|------|------|----------------|
| $V_{POR}$ | Threshold Voltage | 1.60 | 1.75 | 1.90 | V    | -              |

**7.4.5 LVR Reset**

( $V_{DD} - V_{SS} = 0 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Symbol    | Parameter         | Min | Typ | Max | Unit | Test Condition |
|-----------|-------------------|-----|-----|-----|------|----------------|
| $V_{LVR}$ | Threshold Voltage | 1.7 | 1.9 | 2.1 | V    | -              |

7.4.6 Comparator

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Symbol    | Parameter               | Min | Typ      | Max            | Unit          | Test Condition       |
|-----------|-------------------------|-----|----------|----------------|---------------|----------------------|
| $I_{CMP}$ | Operation Current       | -   | 48       |                | $\mu\text{A}$ | $V_{DD}=5.5\text{V}$ |
| $V_{OFF}$ | Input Offset Voltage    |     | $\pm 10$ |                | mV            | -                    |
| $V_{SW}$  | Output Swing            | 0   | -        | $V_{DD}$       | V             | -                    |
| $V_{COM}$ | Input Common Mode Range | 0.1 | -        | $V_{DD} - 0.1$ | V             | -                    |
| -         | DC Gain <sup>[1]</sup>  | -   | 60       | -              | dB            | -                    |
| $T_{PGD}$ | Propagation Delay       | -   | 200      | -              | ns            |                      |
| $V_{HYS}$ | Hysteresis              | 10  | 20       | 30             | mV            | ACMPHYSEN = 01       |
| $V_{HYS}$ | Hysteresis              | 60  | 90       | 120            | mV            | ACMPHYSEN = 10       |
| $V_{HYS}$ | Hysteresis              | 95  | 150      | 200            | mV            | ACMPHYSEN = 11       |
| $T_{STB}$ | Stable time             | -   | 1.06     | -              | $\mu\text{s}$ |                      |

Notes:

Guaranteed by design, not test in production.

7.4.7 PGA

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 \text{ V}$ ,  $T_A = -40 \sim 105^\circ\text{C}$ )

| Parameter                  | Min        | Typ | Max                     | Unit                         | Test Condition  |
|----------------------------|------------|-----|-------------------------|------------------------------|---|
| Operating Current          |            |     | 5                       | mA                           | $V_{DD}5\text{V}=5\text{V}$ , $T=125^\circ\text{C}$                   |
| Input Offset               |            |     | +2                      | mV                           | $V_{CM}=V_{DD}/2$ , $T=25^\circ\text{C}$                              |
| Input Offset Average Drift |            |     | 3.5                     | $\mu\text{V}/^\circ\text{C}$ |   |
| Output Swing               | 0.1        |     | $V_{DD}5\text{V} - 0.1$ | V                            |   |
| PGA gain accuracy          | -1         |     | +1                      | %                            |   |
| Input Common Mode Range    | 0          |     | $V_{DD}5\text{V} - 1.5$ | V                            |   |
| DC Gain                    | 50         | 80  |                         | dB                           |   |
| Unity Gain Frequency       | 6          | 7   | 8.2                     | MHz                          | $V_{DD} = 5\text{V}$  |
| Phase Margin               | $50^\circ$ |     |                         | $^\circ$                     |   |
| PSRR+                      | 49         | 90  |                         | dB                           | $V_{DD} = 5\text{V}$  |
| CMRR                       | 69         | 90  |                         | dB                           | $V_{DD} = 5\text{V}$  |
| Slew Rate+                 | 6.0        | -   | -                       | V/us                         | $V_{DD}=5\text{V}$ , $R_{load}=33\text{K}$ ,<br>$C_{load}=50\text{p}$ |
| Wake Up Time               |            |     | 20                      | $\mu\text{s}$                |   |

|  |  |     |  |    |                       |
|--|--|-----|--|----|-----------------------|
| Maximum output voltage swing from rail |  | 40  |  | mV | $V_{DD}=5.5, R_L=50K$ |
|  |  | 200 |  | mV | $V_{DD}=5.5, R_L=10K$ |

**Notes:**

Guaranteed by design, not test in production.

**7.4.8 OP Amplifier**

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 V, T_A = -40 \sim 105^\circ C$ )

| Parameter                              | Min | Typ        | Max          | Unit             | Test Condition                          |
|--|-----|------------|--------------|------------------|---|
| Input offset voltage                   | -   | 2          | 5            | mV               |   |
| Input offset average drift             | -   | -          | 1            | $\mu V/^\circ C$ |   |
| Output swing                           | 0.1 | -          | $V_{DD}-0.1$ | V                |   |
| Input common mode range                | 0.1 | -          | $V_{DD}-0.1$ | V                |   |
| DC gain                                | -   | 80         | -            | dB               |   |
| Phase margin                           | -   | $50^\circ$ | -            | $^\circ$         |   |
| PSRR+                                  | -   | 90         | -            | dB               | $V_{DD}=5V$                             |
| CMRR                                   | -   | 90         | -            | dB               | $V_{DD}=5V$                             |
| Slew rate                              | 6.0 | -          | -            | V/us             | $V_{DD}=5V, R_{LOAD}=33K, C_{LOAD}=50p$ |
| Wake up time                           | -   | -          | 1            | us               |   |
| Quiescent current                      | -   | 0.7        | 1.4          | mA               |   |
| Maximum output voltage swing from rail |     | 20         |              | mV               | $V_{DD}=5.5, R_L=10K$                   |
|  |     | 100        |              | mV               | $V_{DD}=5.5, R_L=2K$                    |

**7.4.9 Temperature Sensor**

( $V_{DD} - V_{SS} = 2.2 \sim 5.5 V, T_A = -40 \sim 105^\circ C$ )

| Symbol | Parameter             | Min | Typ   | Max | Unit          | Test Condition    |
|--------|-----------------------|-----|-------|-----|---------------|-------------------|
| TA     | Temperature           | -40 | -     | 105 | $^\circ C$    |                   |
| -      | Gain <sup>1</sup> ,   | -   | -1.81 | -   | $mV/^\circ C$ |                   |
| -      | Offset <sup>1,2</sup> | -   | 715   | -   | mV            | $T_A = 0^\circ C$ |

**Note:**

- The temperature sensor formula for the output voltage ( $V_{temp}$ ) is list as below equation.  

$$V_{temp} (mV) = \text{Gain} (mV/^\circ C) \times \text{Temperature} (^\circ C) + \text{Offset} (mV)$$
- The Gain and Offset may have some drift for different chips. Register SYS\_TSOFFSET is a reference data measured by ADC in factory test.

**7.4.10 ESD Characteristics**

| Symbol           | Ratings                                       | Condition    | Package | Maximum Value | Unit |
|------------------|---|--------------|---------|---------------|------|
| V <sub>ESD</sub> | Electrostatic discharge (Human body mode)     | TA = + 25 °C | LQFP 48 | 6000          | V    |
|                  | Electrostatic discharge (Charged Device mode) |              |         | 500           | V    |

**7.4.11 EFT Characteristics**

| Symbol | Condition        | Package | Pass Level | Unit |
|--------|------------------|---------|------------|------|
|        | F <sub>sys</sub> |         |            |      |
|        | HIRC             | LQFP 48 | +/- 4000   | V    |

7.5 Flash DC Electrical Characteristics

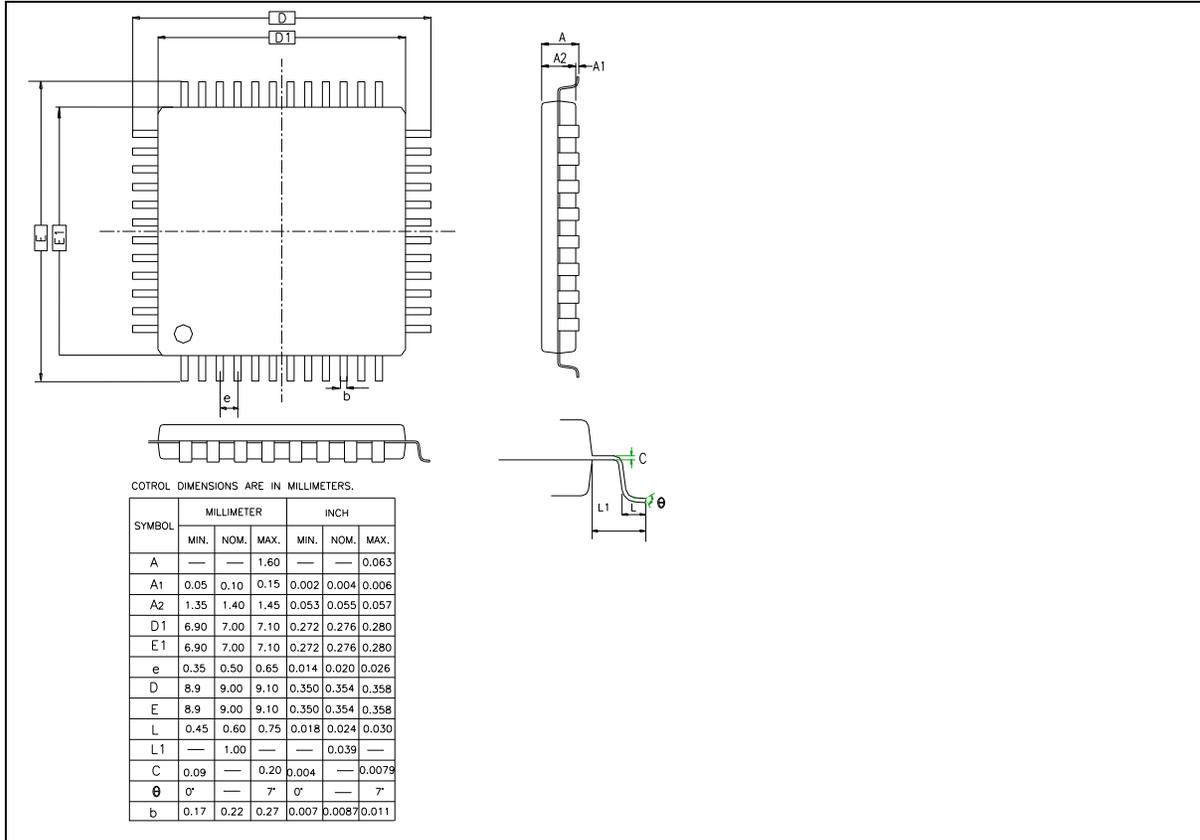
| Symbol                          | Parameter         | Min    | Typ | Max  | Unit                  | Test Condition       |
|---------------------------------|-------------------|--------|-----|------|-----------------------|----------------------|
| V <sub>FLA</sub> <sup>[2]</sup> | Supply Voltage    | 1.35   | 1.5 | 1.65 | V                     |                      |
| N <sub>ENDUR</sub>              | Endurance         | 20,000 | -   | -    | cycles <sup>[1]</sup> |                      |
| T <sub>RET</sub>                | Data Retention    | 10     | -   | -    | year                  | T <sub>A</sub> =85°C |
| T <sub>ERASE</sub>              | Sector Erase Time | -      |     | 5    | ms                    |                      |
| T <sub>PROG</sub>               | Program Time      | -      | 5   | 6.5  | us                    | Per Byte             |
| I <sub>DD1</sub>                | Read Current      | -      | 4   | 5.5  | mA                    | @50MHz               |
| I <sub>DD2</sub>                | Program Current   | -      | -   | 3.5  | mA                    |                      |
| I <sub>DD3</sub>                | Erase Current     | -      | -   | 2    | mA                    |                      |

Notes:

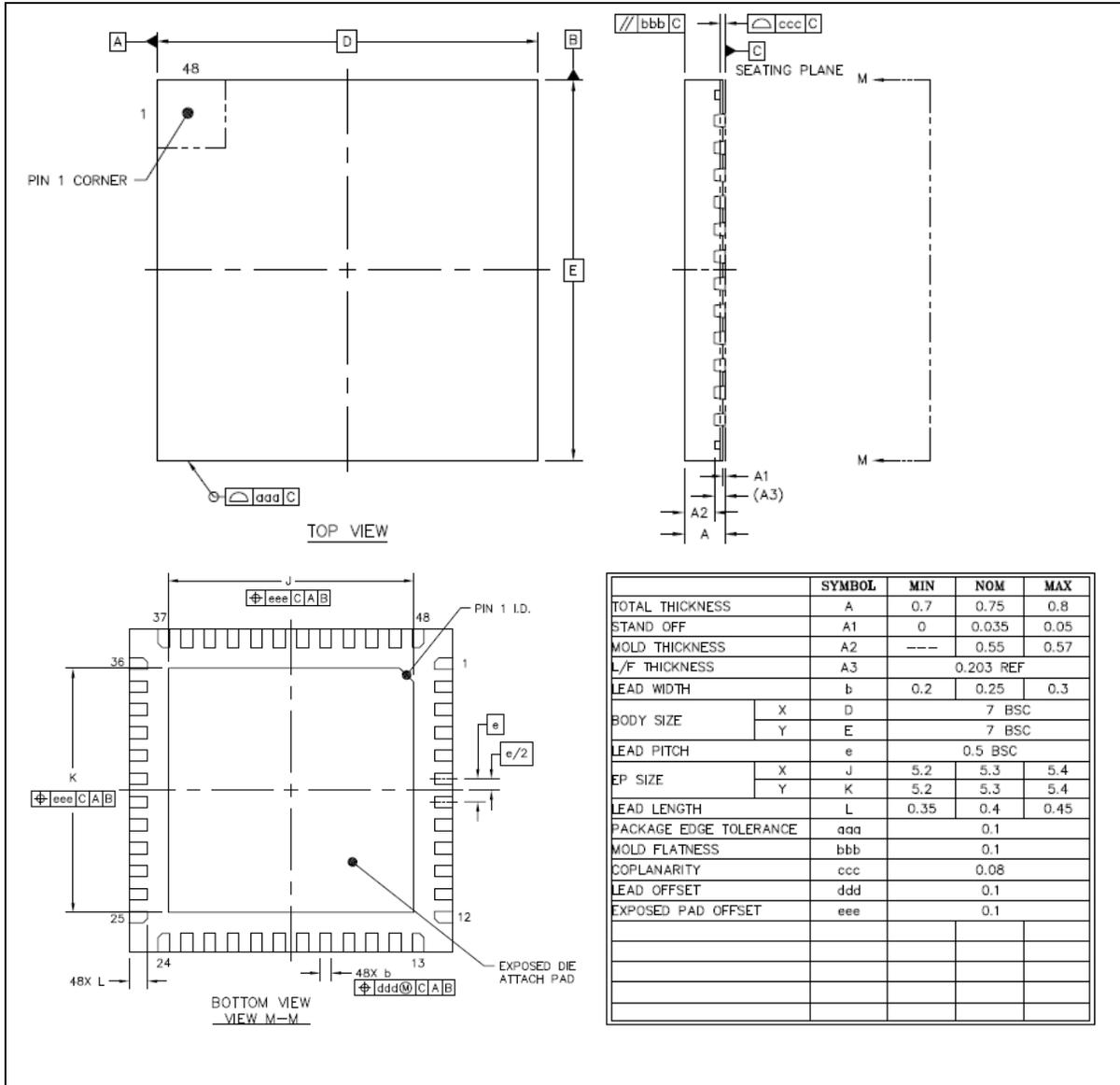
1. Number of program/erase cycles.
2. V<sub>FLA</sub> is source from chip LDO output voltage.  
Guaranteed by design, not test in production.

## 8 PACKAGE DIMENSIONS

### 8.1 48-Pin LQFP 7x7mm



8.2 48-Pin QFN 7x7mm



**9 REVISION HISTORY**

| Date       | Revision | Description  |
|------------|----------|--|
| 2020.06.16 | 0.1      | Preliminary version.   |
| 2020.09.28 | 0.1      | Add an explanation for BOD and Power-down mode: Note for BOD vs Power-down |
| 2020.12.08 | 0.1      | Remove some parts including NM1233D, NM1233Y, NM1232D and NM1232Y.         |
| 2021.10.01 | 0.1      | 1. Update the ESD and EFT characteristics                                  |
| 2022.11.08 | 0.1      | 1. Add compliance statement of International Environmental Regulations.    |

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