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# 8-Bit

# XC87xCLM

## 8-Bit Single-Chip Microcontroller

## Data Sheet

V1.5 2011-03

Microcontrollers

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## Data Sheet

V1.5 2011-03

Microcontrollers

**XC87x Data Sheet**

**Revision History: V1.5 2011-03**

| Previous Versions: V1.4 | |
|---|---|
| Page | Subjects (major changes since last revision) |
| Changes from V1.4 2010-08 to V1.5 2011-03 | |
| **Page 3** | A new variant, SAF-XC874CM-13FVA 5V, has been added in Table 2. |

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**mcdocu.comments@infineon.com**

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# 1 Summary of Features

The XC87x has the following features:

- High-performance XC800 Core
  - compatible with standard 8051 processor
  - two clocks per machine cycle architecture (for memory access without wait state)
  - two data pointers
- On-chip memory
  - 8 Kbytes of Boot ROM
  - 256 bytes of RAM
  - 3 Kbytes of XRAM
  - 64/52 Kbytes of Flash; (includes memory protection strategy)
- I/O port supply at 3.3 V or 5.0 V and core logic supply at 2.5 V (generated by embedded voltage regulator)

(more features on next page)

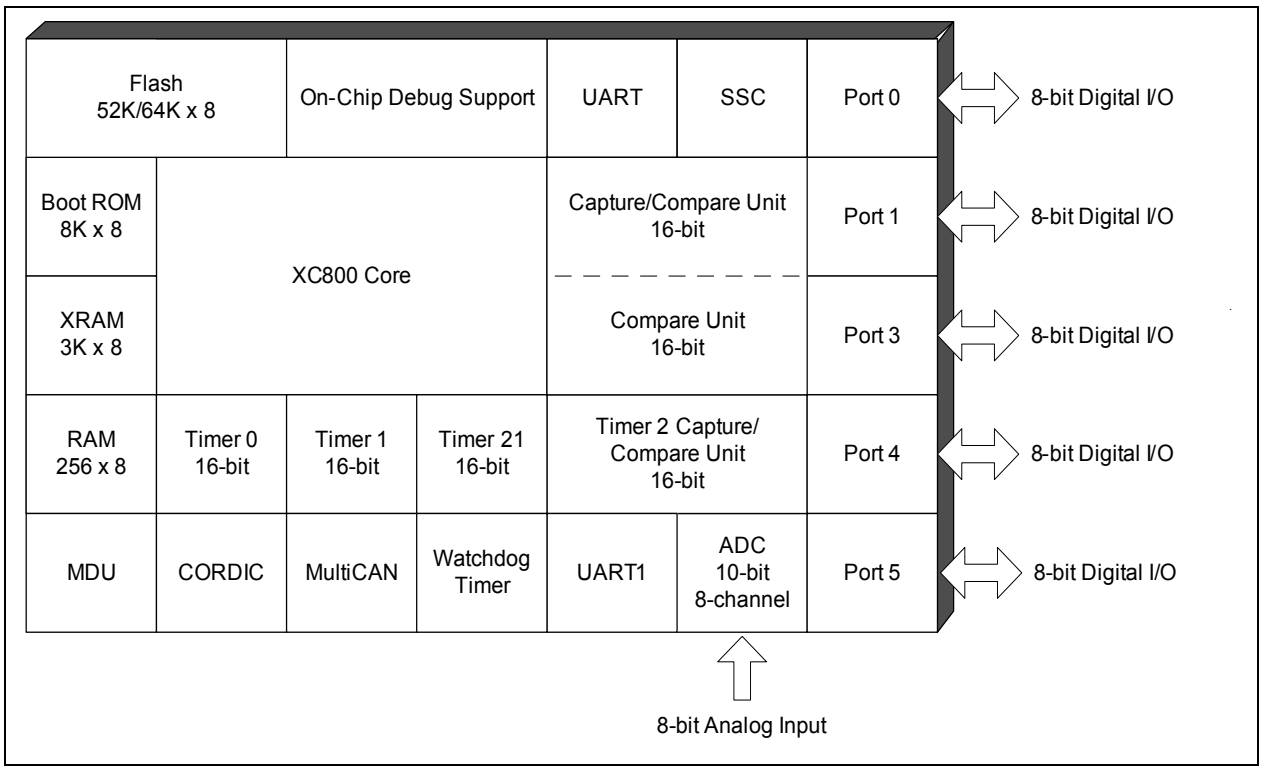



**Figure 1 XC87x Functional Units**

Features: (continued)

- Power-on reset generation
- Brownout detection for core logic supply
- On-chip OSC and PLL for clock generation
  - Loss-of-Clock detection
- Power saving modes
  - slow-down mode
  - idle mode
  - power-down mode with wake-up capability via RXD or EXINT0[1)]
  - clock gating control to each peripheral
- Programmable 16-bit Watchdog Timer (WDT)
- Five ports
  - Up to 40 pins as digital I/O
  - 8 dedicated analog inputs used as A/D converter input
- 8-channel, 10-bit ADC
- Four 16-bit timers
  - Timer 0 and Timer 1 (T0 and T1)
  - Timer 2 and Timer 21 (T2 and T21)
- Multiplication/Division Unit for arithmetic operations (MDU)
- CORDIC Coprocessor for computation of trigonometric, hyperbolic and linear functions
- MultiCAN with 2 nodes, 32 message objects
- Two Capture/compare units
  - Capture/compare unit 6 for PWM signal generation (CCU6)
  - Timer 2 Capture/compare unit for vaious digital signal generation (T2CCU)
- Two full-duplex serial interfaces (UART and UART1)
- Synchronous serial channel (SSC)
- On-chip debug support
  - 1 Kbyte of monitor ROM (part of the 8-Kbyte Boot ROM)
  - 64 bytes of monitor RAM
- Packages:
  - PG-LQFP-64
  - PG-VQFN-48
- Temperature range $T_A$:
  - SAF (-40 to 85 °C)
  - SAX (-40 to 105 °C)
  - SAK (-40 to 125 °C)

1) SAK product variant does not support power-down mode.

### XC87x Variant Devices

The XC87x product family features devices with different configurations, program memory sizes, package options, power supply voltage, temperature and quality profiles (Automotive or Industrial), to offer cost-effective solutions for different application requirements.

The list of XC87x device configurations are summarized in **Table 1**. 2 types of packages are available :

- PG-LQFP-64, which is denoted by XC878 and;
- PG-VQFN-48, which is denoted by XC874

**Table 1 Device Configuration**

| Device Name | CAN Module | LIN BSL Support | MDU Module |
|---|---|---|---|
| XC87x | No | No | No |
| XC87xM | No | No | Yes |
| XC87xCM | Yes | No | Yes |
| XC87xLM | No | Yes | Yes |
| XC87xCLM | Yes | Yes | Yes |

From these 5 different combinations of configuration, each are further made available in many sales types, which are grouped according to device type, program memory sizes, power supply voltage, temperature and quality profiles (Automotive or Industrial), as shown in **Table 2**.

**Table 2 Device Profile**

| Sales Type | Device Type | Program Memory (Kbytes) | Power Supply (V) | Temp-erature (°C) | Quality Profile |
|---|---|---|---|---|---|
| SAF-XC878-13FFI 5V | Flash | 52 | 5.0 | -40 to 85 | Industrial |
| SAF-XC878M-13FFI 5V | Flash | 52 | 5.0 | -40 to 85 | Industrial |
| SAF-XC878CM-13FFI 5V | Flash | 52 | 5.0 | -40 to 85 | Industrial |
| SAF-XC878-16FFI 5V | Flash | 64 | 5.0 | -40 to 85 | Industrial |
| SAF-XC878M-16FFI 5V | Flash | 64 | 5.0 | -40 to 85 | Industrial |
| SAF-XC878CM-16FFI 5V | Flash | 64 | 5.0 | -40 to 85 | Industrial |
| SAF-XC878-13FFI 3V3 | Flash | 52 | 3.3 | -40 to 85 | Industrial |
| SAF-XC878M-13FFI 3V3 | Flash | 52 | 3.3 | -40 to 85 | Industrial |

**Table 2 Device Profile** (cont'd)

| Sales Type | Device Type | Program Memory (Kbytes) | Power Supply (V) | Temp-erature (°C) | Quality Profile |
|---|---|---|---|---|---|
| SAF-XC878CM-13FFI 3V3 | Flash | 52 | 3.3 | -40 to 85 | Industrial |
| SAF-XC878-16FFI 3V3 | Flash | 64 | 3.3 | -40 to 85 | Industrial |
| SAF-XC878M-16FFI 3V3 | Flash | 64 | 3.3 | -40 to 85 | Industrial |
| SAF-XC878CM-16FFI 3V3 | Flash | 64 | 3.3 | -40 to 85 | Industrial |
| SAF-XC878-13FFA 5V | Flash | 52 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878CM-13FFA 5V | Flash | 52 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878LM-13FFA 5V | Flash | 52 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878CLM-13FFA 5V | Flash | 52 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878-16FFA 5V | Flash | 64 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878CM-16FFA 5V | Flash | 64 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878LM-16FFA 5V | Flash | 64 | 5.0 | -40 to 85 | Automotive |
| SAF-XC878CLM-16FFA 5V | Flash | 64 | 5.0 | -40 to 85 | Automotive |
| SAX-XC878-13FFA 5V | Flash | 52 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878CM-13FFA 5V | Flash | 52 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878LM-13FFA 5V | Flash | 52 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878CLM-13FFA 5V | Flash | 52 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878-16FFA 5V | Flash | 64 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878CM-16FFA 5V | Flash | 64 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878LM-16FFA 5V | Flash | 64 | 5.0 | -40 to 105 | Automotive |
| SAX-XC878CLM-16FFA 5V | Flash | 64 | 5.0 | -40 to 105 | Automotive |
| SAK-XC878-13FFA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878CM-13FFA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878LM-13FFA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878CLM-13FFA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878-16FFA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878CM-16FFA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878LM-16FFA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAK-XC878CLM-16FFA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAF-XC874LM-16FVA 5V | Flash | 64 | 5.0 | -40 to 85 | Automotive |

**Table 2 Device Profile** (cont'd)

| Sales Type | Device Type | Program Memory (Kbytes) | Power Supply (V) | Temp-erature (°C) | Quality Profile |
|---|---|---|---|---|---|
| SAF-XC874CM-16FVA 5V | Flash | 64 | 5.0 | -40 to 85 | Automotive |
| SAF-XC874CM-13FVA 5V | Flash | 52 | 5.0 | -40 to 85 | Automotive |
| SAK-XC874LM-16FVA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAK-XC874CM-16FVA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAK-XC874-16FVA 5V | Flash | 64 | 5.0 | -40 to 125 | Automotive |
| SAK-XC874LM-13FVA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |
| SAK-XC874CM-13FVA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |
| SAK-XC874-13FVA 5V | Flash | 52 | 5.0 | -40 to 125 | Automotive |

As this document refers to all the derivatives, some description may not apply to a specific product. For simplicity, all versions are referred to by the term XC87x throughout this document.

### Ordering Information

The ordering code for Infineon Technologies microcontrollers provides an exact reference to the required product. This ordering code identifies:

- The derivative itself, i.e. its function set, the temperature range, and the supply voltage
- The package and the type of delivery

For the available ordering codes for the XC87x, please refer to your responsible sales representative or your local distributor.

# 2 General Device Information

**Chapter 2** contains the block diagram, pin configurations, definitions and functions of the XC87x.

## 2.1 Block Diagram

The block diagram of the XC87x is shown in **Figure 2**.

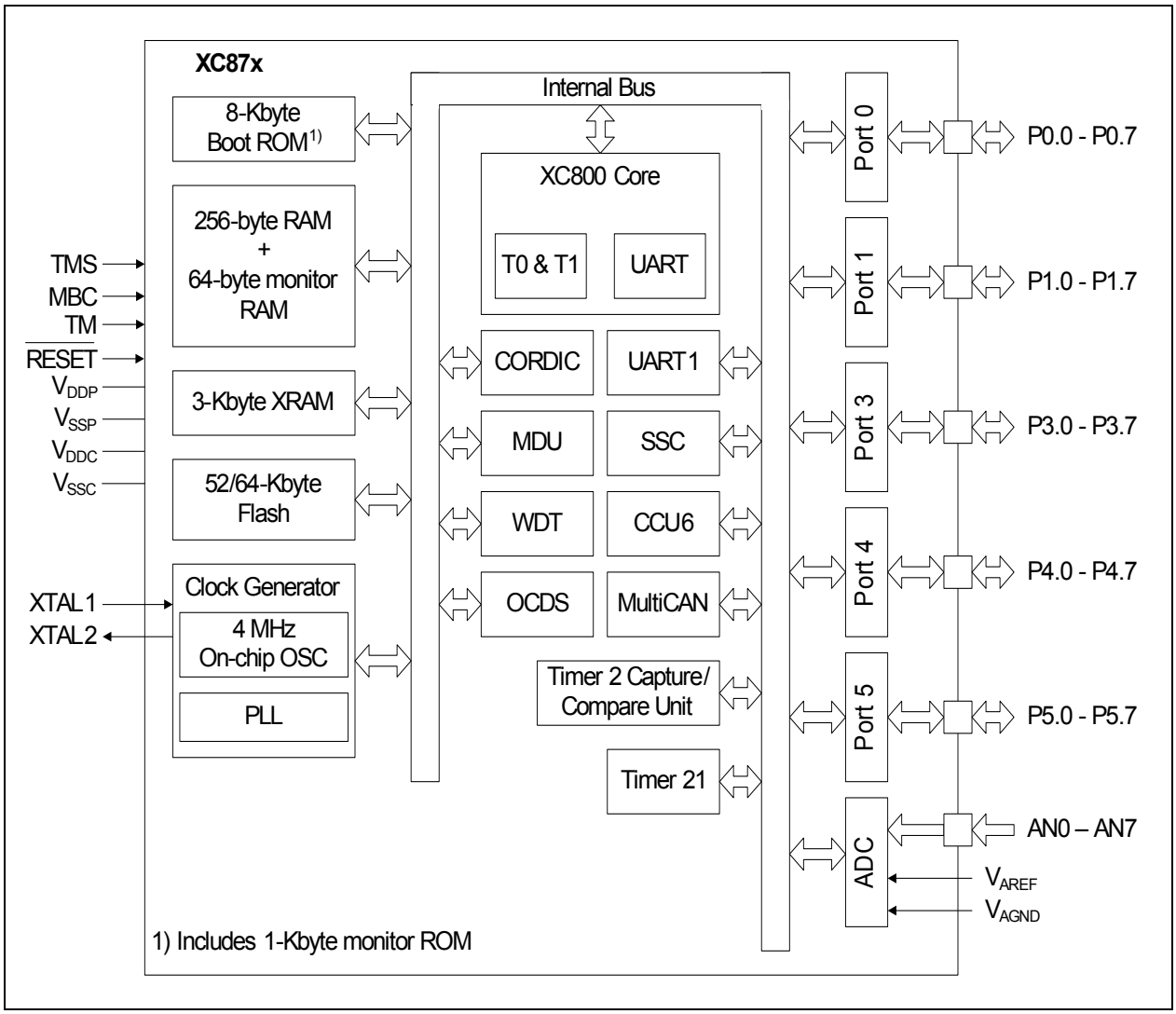



**Figure 2 XC87x Block Diagram**

## 2.2 Logic Symbol

The logic symbols of the XC878 and XC874 are shown in **Figure 3**.

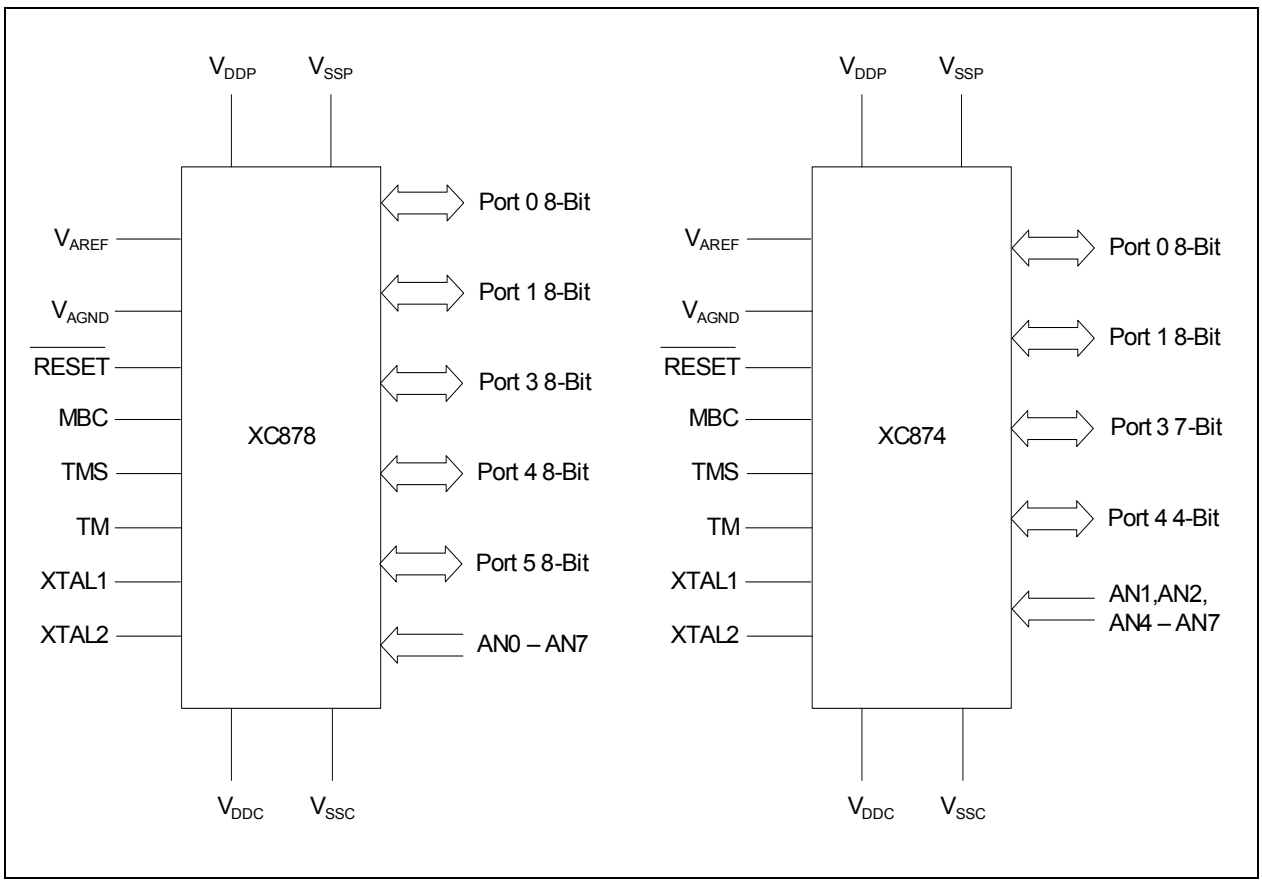



**Figure 3 XC878 and XC874 Logic Symbol**

## 2.3 Pin Configuration

The pin configuration of the XC878, which is based on the PG-LQFP-64, is shown in **Figure 4**, while that of the XC874, which is based on the PG-VQFN-48 package, is shown in **Figure 5**.

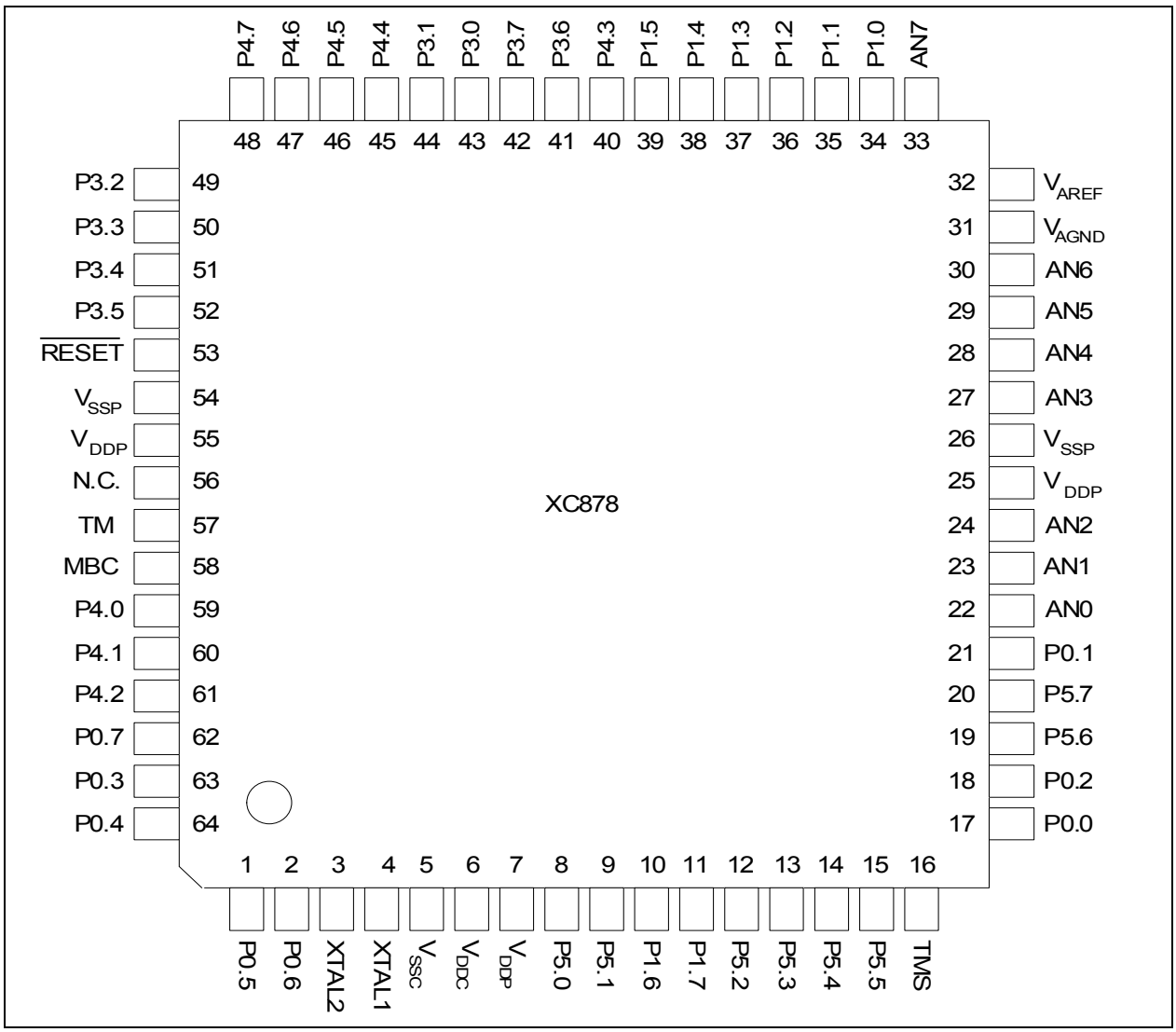



**Figure 4 XC878 Pin Configuration, PG-LQFP-64 Package** (top view)

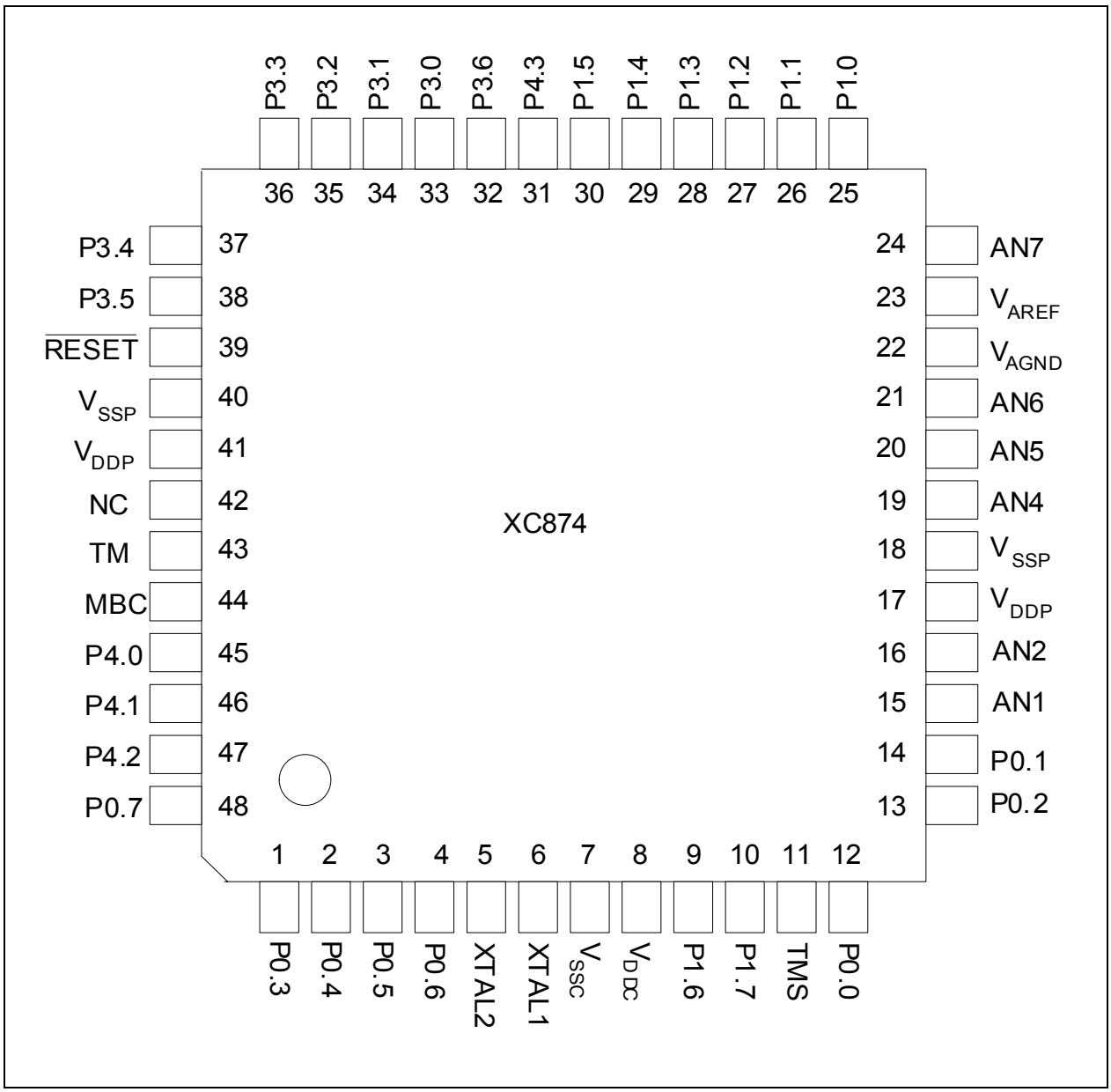



**Figure 5 XC874 Pin Configuration, PG-VQFN-48 Package** (top view)

## 2.4 Pin Definitions and Functions

The functions and default states of the XC87x external pins are provided in **Table 3**.

**Table 3 Pin Definitions and Functions**

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function |
|---|---|---|---|---|
| **P0** | | I/O | | **Port 0**<br>Port 0 is an 8-bit bidirectional general purpose I/O port. It can be used as alternate functions for the JTAG, CCU6, UART, UART1, T2CCU, Timer 21, MultiCAN, SSC and External Bus Interface.<br>*Note: External Bus Interface is not available in XC874.* |
| P0.0 | 17/12 | | Hi-Z | TCK_0 JTAG Clock Input<br>T12HR_1 CCU6 Timer 12 Hardware Run Input<br>CC61_1 Input/Output of Capture/Compare channel 1<br>CLKOUT_0 Clock Output<br>RXDO_1 UART Transmit Data Output |
| P0.1 | 21/14 | | Hi-Z | TDI_0 JTAG Serial Data Input<br>T13HR_1 CCU6 Timer 13 Hardware Run Input<br>RXD_1 UART Receive Data Input<br>RXDC1_0 MultiCAN Node 1 Receiver Input<br>COUT61_1 Output of Capture/Compare channel 1<br>EXF2_1 Timer 2 External Flag Output |
| P0.2 | 18/13 | | PU | $\overline{\text{CTRAP}}$_2 CCU6 Trap Input<br>TDO_0 JTAG Serial Data Output<br>TXD_1 UART Transmit Data Output/Clock Output<br>TXDC1_0 MultiCAN Node 1 Transmitter Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| P0.3 | 63/1 | | Hi-Z | SCK_1<br>COUT63_1<br><br>RXDO1_0<br>A17 | SSC Clock Input/Output<br>Output of Capture/Compare channel 3<br>UART1 Transmit Data Output<br>Address Line 17 Output |
| P0.4 | 64/2 | | Hi-Z | MTSR_1<br><br>CC62_1<br><br>TXD1_0<br><br>A18 | SSC Master Transmit Output/ Slave Receive Input<br>Input/Output of Capture/Compare channel 2<br>UART1 Transmit Data Output/Clock Output<br>Address Line 18 Output |
| P0.5 | 1/3 | | Hi-Z | MRST_1<br><br>EXINT0_0<br>T2EX1_1<br>RXD1_0<br>COUT62_1<br><br>A19 | SSC Master Receive Input/Slave Transmit Output<br>External Interrupt Input 0<br>Timer 21 External Trigger Input<br>UART1 Receive Data Input<br>Output of Capture/Compare channel 2<br>Address Line 19 Output |
| P0.6 | 2/4 | | PU | $\overline{\text{T2CC4_1}}$<br>$\overline{\text{WR}}$ | Compare Output Channel 4<br>External Data Write Control Output |
| P0.7 | 62/48 | | PU | CLKOUT_1<br>$\overline{\text{T2CC5_1}}$<br>$\overline{\text{RD}}$ | Clock Output<br>Compare Output Channel 5<br>External Data Read Control Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| **P1** | | I/O | | **Port 1**<br>Port 1 is an 8-bit bidirectional general purpose I/O port. It can be used as alternate functions for the JTAG, CCU6, UART, Timer 0, Timer 1, T2CCU, Timer 21, MultiCAN, SSC and External Bus Interface.<br>*Note: External Bus Interface is not available in XC874.* | |
| P1.0 | 34/25 | | PU | RXD_0<br>T2EX_0<br>RXDC0_0<br>A8 | UART Receive Data Input<br>Timer 2 External Trigger Input<br>MultiCAN Node 0 Receiver Input<br>Address Line 8 Output |
| P1.1 | 35/26 | | PU | EXINT3_0<br>T0_1<br>TXD_0<br><br>TXDC0_0<br><br>A9 | External Interrupt Input 3<br>Timer 0 Input<br>UART Transmit Data Output/Clock Output<br>MultiCAN Node 0 Transmitter Output<br>Address Line 9 Output |
| P1.2 | 36/27 | | PU | SCK_0<br>A10 | SSC Clock Input/Output<br>Address Line 10 Output |
| P1.3 | 37/28 | | PU | MTSR_0<br><br>SCK_2<br>TXDC1_3<br><br>A11 | SSC Master Transmit Output/Slave Receive Input<br>SSC Clock Input/Output<br>MultiCAN Node 1 Transmitter Output<br>Address Line 11 Output |
| P1.4 | 38/29 | | PU | MRST_0<br><br>EXINT0_1<br>RXDC1_3<br>MTSR_2<br><br>A12 | SSC Master Receive Input/ Slave Transmit Output<br>External Interrupt Input 0<br>MultiCAN Node 1 Receiver Input<br>SSC Master Transmit Output/Slave Receive Input<br>Address Line 12 Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| P1.5 | 39/30 | | PU | CCPOS0_1<br>EXINT5_0<br>T1_1<br>MRST_2<br><br>EXF2_0<br>RXDO_0 | CCU6 Hall Input 0<br>External Interrupt Input 5<br>Timer 1 Input<br>SSC Master Receive Input/ Slave Transmit Output<br>Timer 2 External Flag Output<br>UART Transmit Data Output |
| P1.6 | 10/9 | | PU | CCPOS1_1<br>T12HR_0<br><br>EXINT6_0<br>RXDC0_2<br>T21_1 | CCU6 Hall Input 1<br>CCU6 Timer 12 Hardware Run Input<br>External Interrupt Input 6<br>MultiCAN Node 0 Receiver Input<br>Timer 21 Input |
| P1.7 | 11/10 | | PU | CCPOS2_1<br>T13HR_0<br><br>T2_1<br>TXDC0_2<br><br>P1.5 and P1.6 can be used as a software chip select output for the SSC. | CCU6 Hall Input 2<br>CCU6 Timer 13 Hardware Run Input<br>Timer 2 Input<br>MultiCAN Node 0 Transmitter Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function |
|---|---|---|---|---|
| **P3** | | I/O | | **Port 3**<br>Port 3 is an 8-bit bidirectional general purpose I/O port. It can be used as alternate functions for CCU6, UART1, T2CCU, Timer 21, MultiCAN and External Bus Interface.<br>*Note: External Bus Interface is not available in XC874.* |
| P3.0 | 43/33 | | Hi-Z | CCPOS1_2 CCU6 Hall Input 1<br>CC60_0 Input/Output of Capture/Compare channel 0<br>RXDO1_1 UART1 Transmit Data Output<br>T2CC0_1/ EXINT3_2 External Interrupt Input 3/T2CCU Capture/Compare Channel 0 |
| P3.1 | 44/34 | | Hi-Z | CCPOS0_2 CCU6 Hall Input 0<br>CC61_2 Input/Output of Capture/Compare channel 1<br>COUT60_0 Output of Capture/Compare channel 0<br>TXD1_1 UART1 Transmit Data Output/Clock Output |
| P3.2 | 49/35 | | Hi-Z | CCPOS2_2 CCU6 Hall Input 2<br>RXDC1_1 MultiCAN Node 1 Receiver Input<br>RXD1_1 UART1 Receive Data Input<br>CC61_0 Input/Output of Capture/Compare channel 1<br>T2CC1_1/ EXINT4_2 External Interrupt Input 4/T2CCU Capture/Compare Channel 1 |
| P3.3 | 50/36 | | Hi-Z | COUT61_0 Output of Capture/Compare channel 1<br>TXDC1_1 MultiCAN Node 1 Transmitter Output<br>T2CC2_1/ EXINT5_2 External Interrupt Input 5/T2CCU Capture/Compare Channel 2<br>A13 Address Line 13 Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| P3.4 | 51/37 | | Hi-Z | CC62_0 | Input/Output of Capture/Compare channel 2 |
| | | | | RXDC0_1 | MultiCAN Node 0 Receiver Input |
| | | | | T2EX1_0 | Timer 21 External Trigger Input |
| | | | | T2CC3_1/ EXINT6_3 | External Interrupt Input 6/T2CCU Capture/Compare Channel 3 |
| | | | | A14 | Address Line 14 Output |
| P3.5 | 52/38 | | Hi-Z | COUT62_0 | Output of Capture/Compare channel 2 |
| | | | | EXF21_0 | Timer 21 External Flag Output |
| | | | | TXDC0_1 | MultiCAN Node 0 Transmitter Output |
| | | | | A15 | Address Line 15 Output |
| P3.6 | 41/32 | | PU | $\overline{\text{CTRAP_0}}$ | CCU6 Trap Input |
| P3.7 | 42/- | | Hi-Z | EXINT4_0 | External Interrupt Input 4 |
| | | | | COUT63_0 | Output of Capture/Compare channel 3 |
| | | | | A16 | Address Line 16 Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function |
|---|---|---|---|---|
| **P4** | | I/O | | **Port 4**<br>Port 4 is an 8-bit bidirectional general purpose I/O port. It can be used as alternate functions for CCU6, Timer 0, Timer 1, T2CCU, Timer 21, MultiCAN and External Bus Interface.<br>*Note: External Bus Interface is not available in XC874.* |
| P4.0 | 59/45 | | Hi-Z | RXDC0_3 MultiCAN Node 0 Receiver Input<br>CC60_1 Output of Capture/Compare channel 0<br>T2CC0_0/ EXINT3_1 External Interrupt Input 3/T2CCU Capture/Compare Channel 0<br>D0 Data Line 0 Input/Output |
| P4.1 | 60/46 | | Hi-Z | TXDC0_3 MultiCAN Node 0 Transmitter Output<br>COUT60_1 Output of Capture/Compare channel 0<br>T2CC1_0/ EXINT4_1 External Interrupt Input 4/T2CCU Capture/Compare Channel 1<br>D1 Data Line 1 Input/Output |
| P4.2 | 61/47 | | PU | EXINT6_1 External Interrupt Input 6<br>T21_0 Timer 21 Input<br>D2 Data Line 2 Input/Output |
| P4.3 | 40/31 | | Hi-Z | T2EX_1 Timer 2 External Trigger Input<br>EXF21_1 Timer 21 External Flag Output<br>COUT63_2 Output of Capture/Compare channel 3<br>D3 Data Line 3 Input/Output |
| P4.4 | 45/- | | Hi-Z | CCPOS0_3 CCU6 Hall Input 0<br>T0_0 Timer 0 Input<br>CC61_4 Output of Capture/Compare channel 1<br>T2CC2_0/ EXINT5_1 External Interrupt Input 5/T2CCU Capture/Compare Channel 2<br>D4 Data Line 4 Input/Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| P4.5 | 46/- | | Hi-Z | CCPOS1_3<br>T1_0<br>COUT61_2<br><br>T2CC3_0/<br>EXINT6_2<br>D5 | CCU6 Hall Input 1<br>Timer 1 Input<br>Output of Capture/Compare channel 1<br>External Interrupt Input 6/T2CCU Capture/Compare Channel 3<br>Data Line 5 Input/Output |
| P4.6 | 47/- | | Hi-Z | CCPOS2_3<br>T2_0<br>CC62_2<br><br>T2CC4_0<br>D6 | CCU6 Hall Input 2<br>Timer 2 Input<br>Output of Capture/Compare channel 2<br>Compare Output Channel 4<br>Data Line 6 Input/Output |
| P4.7 | 48/- | | Hi-Z | $\overline{\text{CTRAP}}$_3<br>COUT62_2<br><br>T2CC5_0<br>D7 | CCU6 Trap Input<br>Output of Capture/Compare channel 2<br>Compare Output Channel 5<br>Data Line 7 Input/Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| **P5** | | I/O | | **Port 5**<br>Port 5 is an 8-bit bidirectional general purpose I/O port. It can be used as alternate functions for UART, UART1, T2CCU, JTAG and External Interface. | |
| P5.0 | 8/- | | PU | EXINT1_1<br>A0 | External Interrupt Input 1<br>Address Line 0 Output |
| P5.1 | 9/- | | PU | EXINT2_1<br>A1 | External Interrupt Input 2<br>Address Line 1 Output |
| P5.2 | 12/- | | PU | RXD_2<br>T2CC2_2/<br>EXINT5_3<br>A2 | UART Receive Data Input<br>External Interrupt Input 5/T2CCU Capture/Compare Channel 2<br>Address Line 2 Output |
| P5.3 | 13/- | | PU | CCPOS0_0<br>EXINT1_0<br>T12HR_2<br>CC61_3<br>TXD_2<br>T2CC5_2<br>A3 | CCU6 Hall Input 0<br>External Interrupt Input 1<br>CCU6 Timer 12 Hardware Run Input<br>Input of Capture/Compare channel 1<br>UART Transmit Data Output/Clock Output<br>Compare Output Channel 5<br>Address Line 3 Output |
| P5.4 | 14/- | | PU | CCPOS1_0<br>EXINT2_0<br>T13HR_2<br>CC62_3<br>RXDO_2<br>T2CC4_2<br>A4 | CCU6 Hall Input 1<br>External Interrupt Input 2<br>CCU6 Timer 13 Hardware Run Input<br>Input of Capture/Compare channel 2<br>UART Transmit Data Output<br>Compare Output Channel 4<br>Address Line 4 Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function | |
|---|---|---|---|---|---|
| P5.5 | 15/- | | PU | CCPOS2_0<br>CTRAP_1<br>CC60_3<br><br>TDO_1<br>TXD1_2<br><br>T2CC0_2/<br>EXINT3_3<br>A5 | CCU6 Hall Input 2<br>CCU6 Trap Input<br>Input of Capture/Compare channel 0<br>JTAG Serial Data Output<br>UART1 Transmit Data Output/ Clock Output<br>External Interrupt Input 3/T2CCU Capture/Compare Channel 0<br>Address Line 5 Output |
| P5.6 | 19/- | | PU | TCK_1<br>RXDO1_2<br>T2CC1_2/<br>EXINT4_3<br>A6 | JTAG Clock Input<br>UART1 Transmit Data Output<br>External Interrupt Input 4/T2CCU Capture/Compare Channel 1<br>Address Line 6 Output |
| P5.7 | 20/- | | PU | TDI_1<br>RXD1_2<br>T2CC3_2/<br>EXINT6_4<br>A7 | JTAG Serial Data Input<br>UART1 Receive Data Input<br>External Interrupt Input 6/T2CCU Capture/Compare Channel 3<br>Address Line 7 Output |

**Table 3 Pin Definitions and Functions** (cont'd)

| Symbol | Pin Number (LQFP-64 / VQFN-48) | Type | Reset State | Function |
|---|---|---|---|---|
| $V_{DDP}$ | 7, 25, 55/ 17, 41 | – | – | **I/O Port Supply (3.3 or 5.0 V)** Also used by EVR and analog modules. All pins must be connected. |
| $V_{SSP}$ | 26, 54/ 18, 40 | – | – | **I/O Ground** All pins must be connected. |
| $V_{DDC}$ | 6/8 | – | – | **Core Supply Monitor (2.5 V)** |
| $V_{SSC}$ | 5/7 | – | – | **Core Supply Ground** |
| $V_{AREF}$ | 32/23 | – | – | **ADC Reference Voltage** |
| $V_{AGND}$ | 31/22 | – | – | **ADC Reference Ground** |
| **AN0** | 22/- | I | Hi-Z | **Analog Input 0** |
| **AN1** | 23/15 | I | Hi-Z | **Analog Input 1** |
| **AN2** | 24/16 | I | Hi-Z | **Analog Input 2** |
| **AN3** | 27/- | I | Hi-Z | **Analog Input 3** |
| **AN4** | 28/19 | I | Hi-Z | **Analog Input 4** |
| **AN5** | 29/20 | I | Hi-Z | **Analog Input 5** |
| **AN6** | 30/21 | I | Hi-Z | **Analog Input 6** |
| **AN7** | 33/24 | I | Hi-Z | **Analog Input 7** |
| **XTAL1** | 4/6 | I | Hi-Z | **External Oscillator Input (Feedback resistor required, normally NC)** |
| **XTAL2** | 3/5 | O | Hi-Z | **External Oscillator Output (Feedback resistor required, normally NC)** |
| **TMS** | 16/11 | I | PD | **JTAG Test Mode Select** |
| **$\overline{\text{RESET}}$** | 53/39 | I | PU | **Reset Input** |
| **MBC** | 58/44 | I | PU | **Monitor & BootStrap Loader Control** |
| **TM** | 57/43 | – | – | **Test Mode (External pull down device required)** |
| **NC** | 56/42 | – | – | **No Connection** |

# 3 Functional Description

**Chapter 3** provides an overview of the XC87x functional description.

## 3.1 Processor Architecture

The XC87x is based on a high-performance 8-bit Central Processing Unit (CPU) that is compatible with the standard 8051 processor. While the standard 8051 processor is designed around a 12-clock machine cycle, the XC87x CPU uses a 2-clock machine cycle. This allows fast access to ROM or RAM memories without wait state. The instruction set consists of 45% one-byte, 41% two-byte and 14% three-byte instructions.

The XC87x CPU provides a range of debugging features, including basic stop/start, single-step execution, breakpoint support and read/write access to the data memory, program memory and Special Function Registers (SFRs).

**Figure 6** shows the CPU functional blocks.

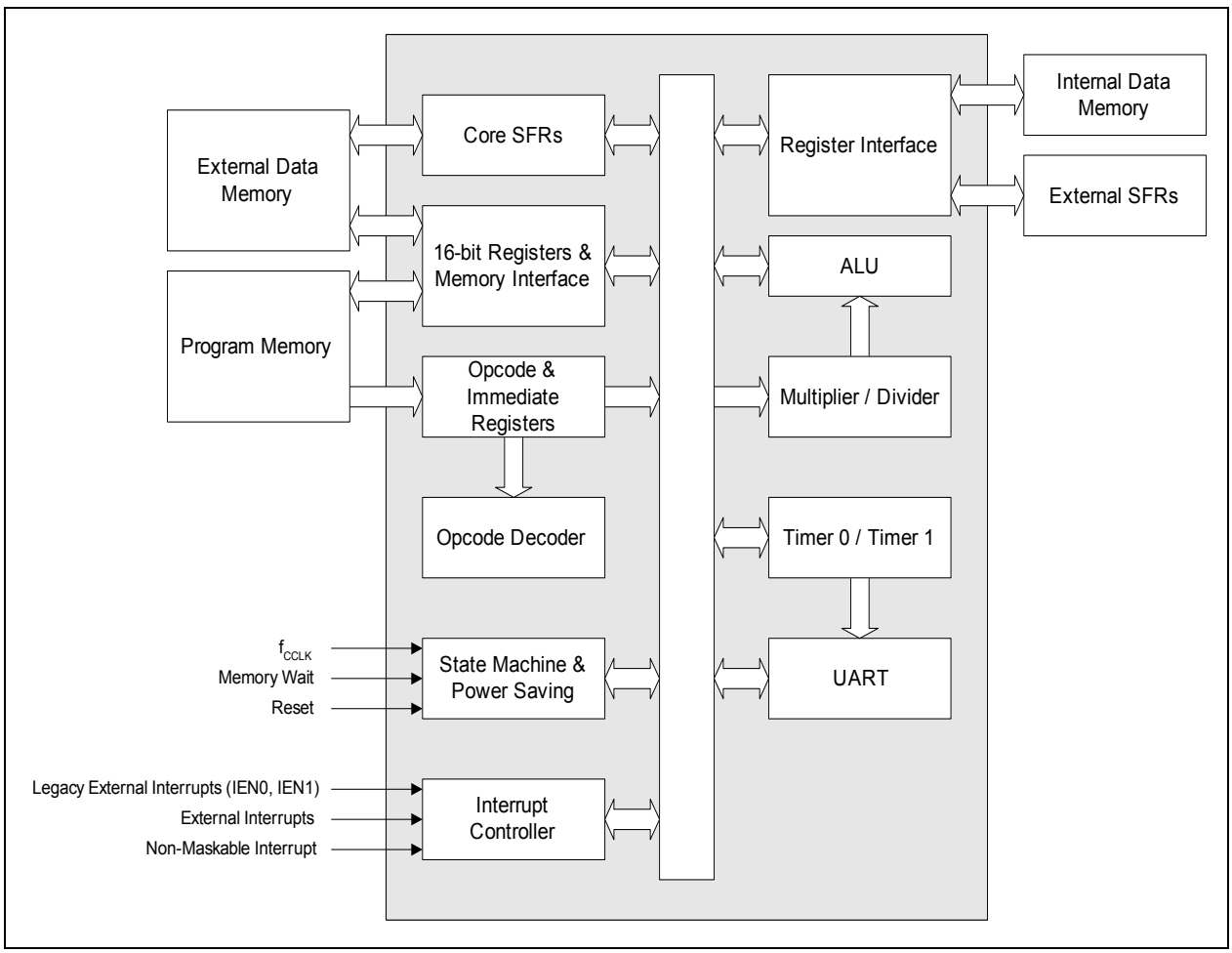



**Figure 6 CPU Block Diagram**

## 3.2 Memory Organization

The XC87x CPU operates in the following address spaces:

- 8 Kbytes of Boot ROM program memory
- 256 bytes of internal RAM data memory
- 3 Kbytes of XRAM memory
  (XRAM can be read/written as program memory or external data memory)
- A 128-byte Special Function Register area
- 64/52 Kbytes of Flash program memory (Flash devices)

**Figure 7** and **Figure 8** illustrate the memory address spaces of the XC87x with 64Kbytes and 52Kbytes embedded Flash respectively.

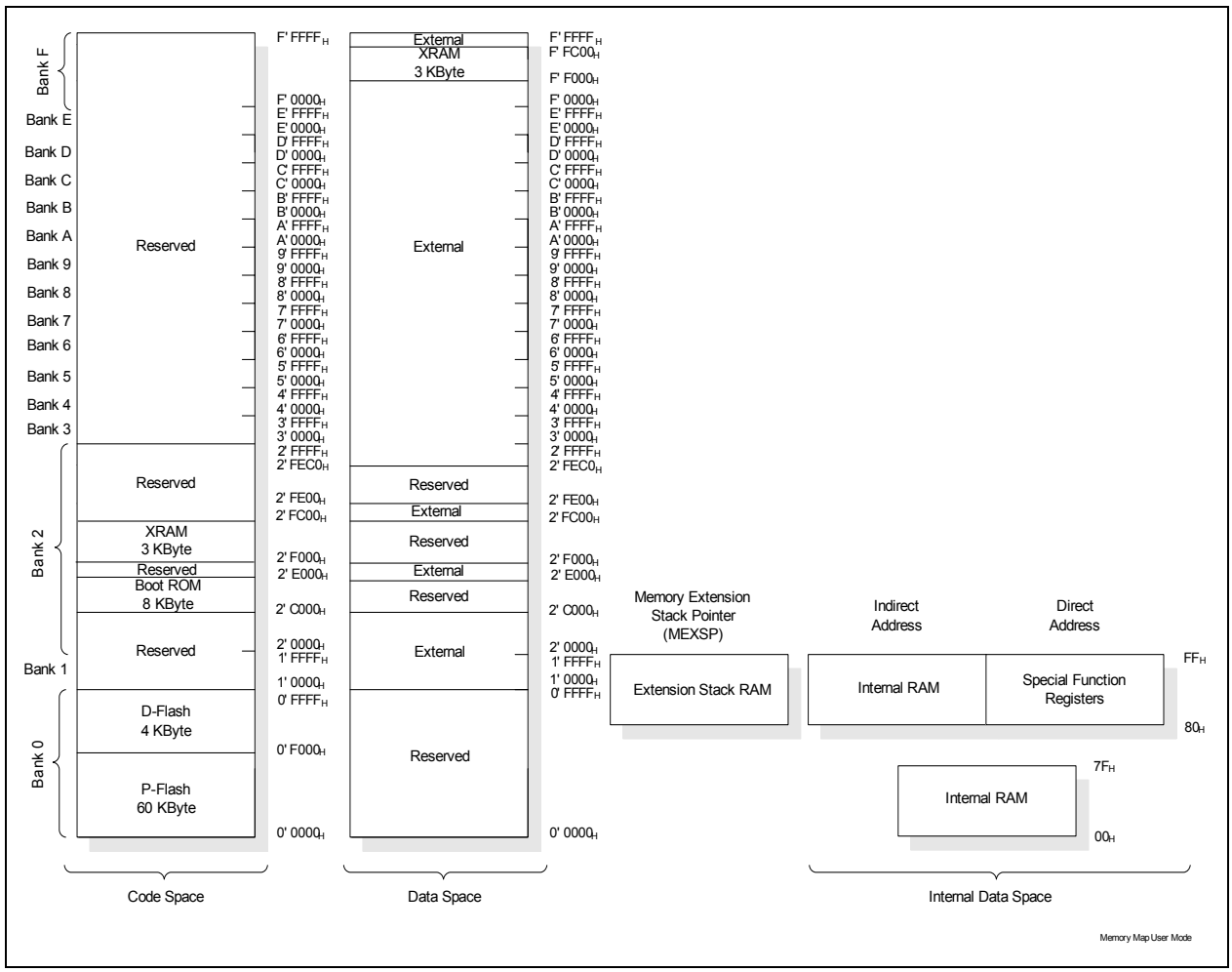



**Figure 7 Memory Map of XC87x with 64K Flash Memory in user mode**

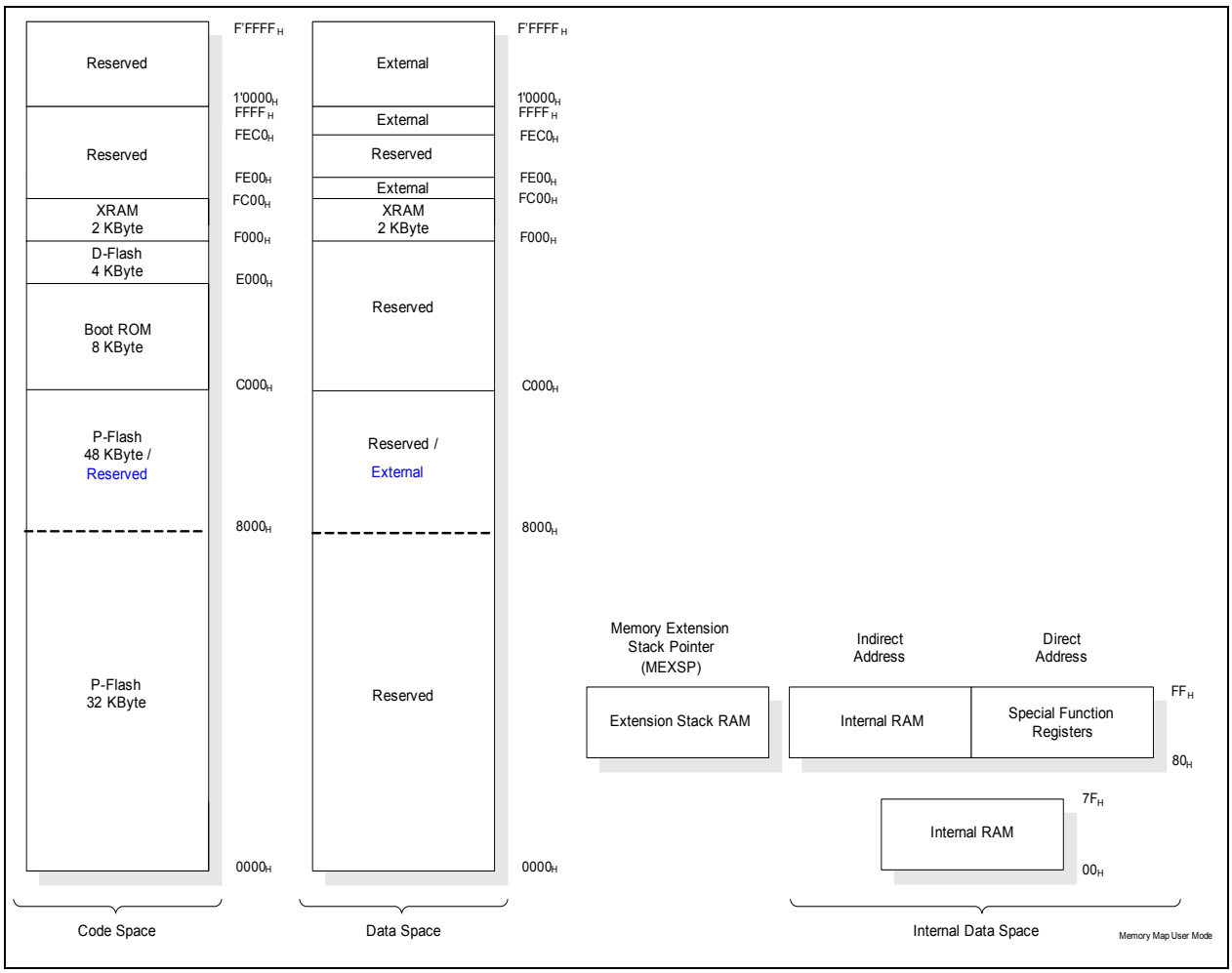



**Figure 8 Memory Map of XC87x with 52K Flash Memory in user mode**

### 3.2.1 Memory Protection Strategy

The XC87x memory protection strategy includes:

- Basic protection: The user is able to block any external access via the boot option to any memory
- Read-out protection: The user is able to protect the contents in the Flash
- Flash program and erase protection

These protection strategies are enabled by programming a valid password (16-bit non-one value) via Bootstrap Loader (BSL) mode 6.

#### 3.2.1.1 Flash Memory Protection

As long as a valid password is available, all external access to the device, including the Flash, will be blocked.

For additional security, the Flash hardware protection can be enabled to implement a second layer of read-out protection, as well as to enable program and erase protection.

Flash hardware protection is available only for Flash devices and comes in two modes:

- Mode 0: Only the P-Flash is protected; the D-Flash is unprotected
- Mode 1: Both the P-Flash and D-Flash are protected

The selection of each protection mode and the restrictions imposed are summarized in Table 4.

**Table 4 Flash Protection Modes**

| Flash Protection | Without hardware protection | With hardware protection | |
|---|---|---|---|
| **Hardware Protection Mode** | - | 0 | 1 |
| **Activation** | Program a valid password via BSL mode 6 | | |
| **Selection** | Bit 13 of password = 0 | Bit 13 of password = 1<br>MSB of password = 0 | Bit 13 of password = 1<br>MSB of password = 1 |
| **P-Flash contents can be read by** | Read instructions in any program memory | Read instructions in the P-Flash | Read instructions in the P-Flash or D-Flash |
| **External access to P-Flash** | Not possible | Not possible | Not possible |

**Table 4 Flash Protection Modes** (cont'd)

| Flash Protection | Without hardware protection | With hardware protection | |
|---|---|---|---|
| **P-Flash program and erase** | Possible | Possible only on the condition that MSB - 1 of password is set to 1 | Possible only on the condition that MSB - 1 of password is set to 1 |
| **D-Flash contents can be read by** | Read instructions in any program memory | Read instructions in any program memory | Read instructions in the P-Flash or D-Flash |
| **External access to D-Flash** | Not possible | Not possible | Not possible |
| **D-Flash program** | Possible | Possible | Possible, on the condition that MSB - 1 of password is set to 1 |
| **D-Flash erase** | Possible | Possible, on these conditions:<br>• MISC_CON.DFLASHEN bit is set to 1 prior to each erase operation; or<br>• the MSB - 1 of password is set to 1 | Possible, on the condition that MSB - 1 of password is set to 1 |

BSL mode 6, which is used for enabling Flash protection, can also be used for disabling Flash protection. Here, the programmed password must be provided by the user. To disable the flash protection, a password match is required. A password match triggers an automatic erase of the protected P-Flash and D-Flash contents, including the programmed password. With a valid password, the Flash hardware protection is then enabled or disabled upon next reset. For the other protection strategies, no reset is necessary.

Although no protection scheme can be considered infallible, the XC87x memory protection strategy provides a very high level of protection for a general purpose microcontroller.

*Note: If ROM read-out protection is enabled, only read instructions in the ROM memory can target the ROM contents.*

### 3.2.2 Special Function Register

The Special Function Registers (SFRs) occupy direct internal data memory space in the range $80_H$ to $FF_H$. All registers, except the program counter, reside in the SFR area. The SFRs include pointers and registers that provide an interface between the CPU and the on-chip peripherals. As the 128-SFR range is less than the total number of registers required, address extension mechanisms are required to increase the number of addressable SFRs. The address extension mechanisms include:

- Mapping
- Paging

#### 3.2.2.1 Address Extension by Mapping

Address extension is performed at the system level by mapping. The SFR area is extended into two portions: the standard (non-mapped) SFR area and the mapped SFR area. Each portion supports the same address range $80_H$ to $FF_H$, bringing the number of addressable SFRs to 256. The extended address range is not directly controlled by the CPU instruction itself, but is derived from bit RMAP in the system control register SYSCON0 at address $8F_H$. To access SFRs in the mapped area, bit RMAP in SFR SYSCON0 must be set. Alternatively, the SFRs in the standard area can be accessed by clearing bit RMAP. The SFR area can be selected as shown in **Figure 9**.

As long as bit RMAP is set, the mapped SFR area can be accessed. This bit is not cleared automatically by hardware. Thus, before standard/mapped registers are accessed, bit RMAP must be cleared/set, respectively, by software.

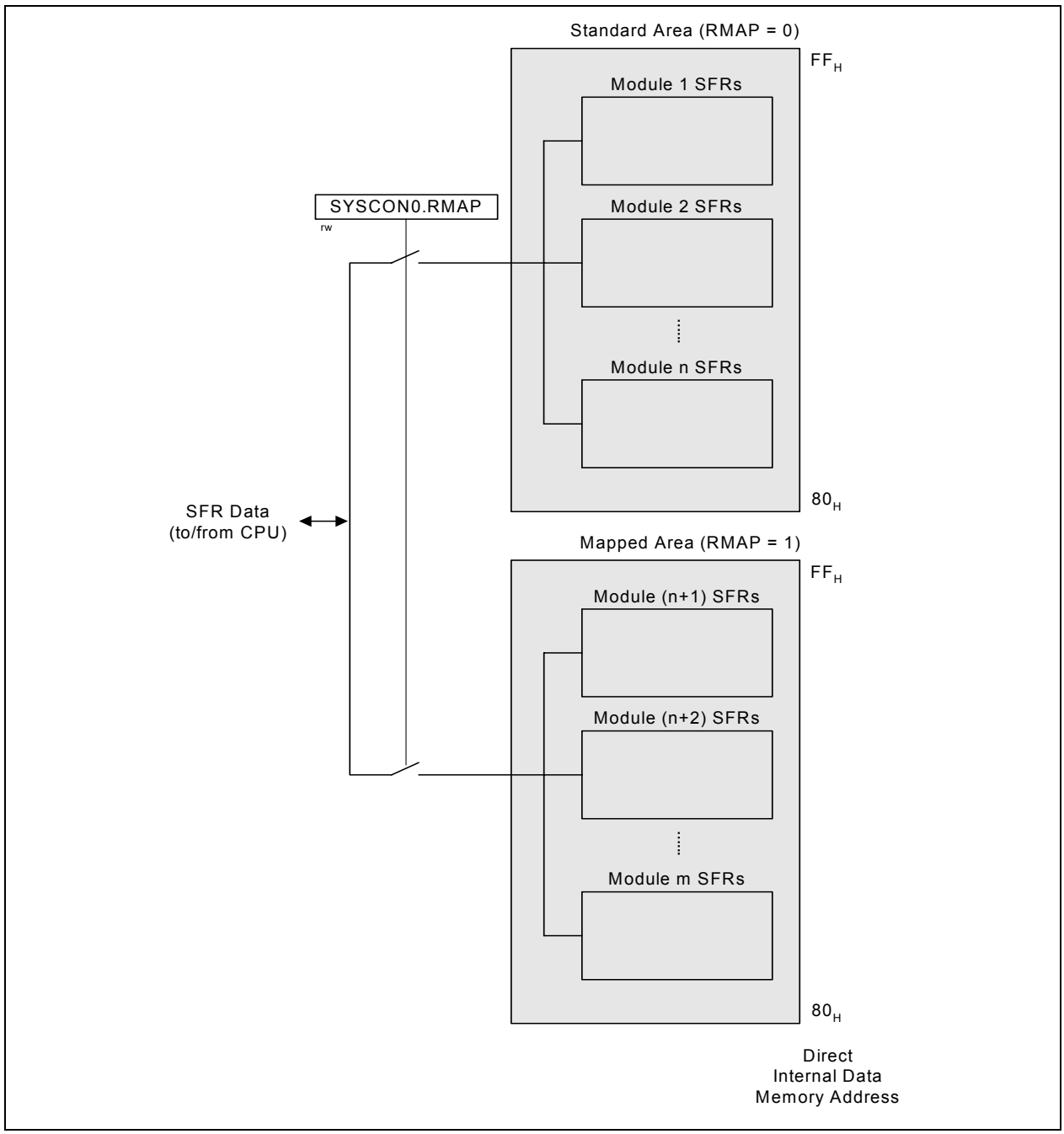



**Figure 9 Address Extension by Mapping**

**SYSCON0**
**System Control Register 0** **Reset Value: $04_H$**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| | **0** | | **IMODE** | **0** | **1** | **0** | **RMAP** |
| | r | | rw | r | r | r | rw |

| Field | Bits | Type | Description |
|---|---|---|---|
| **RMAP** | 0 | rw | **Interrupt Node XINTR0 Enable**<br>0 The access to the standard SFR area is enabled<br>1 The access to the mapped SFR area is enabled |
| **1** | 2 | r | **Reserved**<br>Returns 1 if read; should be written with 1. |
| **0** | [7:5], 3,1 | r | **Reserved**<br>Returns 0 if read; should be written with 0. |

*Note: The RMAP bit should be cleared/set by ANL or ORL instructions.The rest bits of SYSCON0 should not be modified.*

### 3.2.2.2 Address Extension by Paging

Address extension is further performed at the module level by paging. With the address extension by mapping, the XC87x has a 256-SFR address range. However, this is still less than the total number of SFRs needed by the on-chip peripherals. To meet this requirement, some peripherals have a built-in local address extension mechanism for increasing the number of addressable SFRs. The extended address range is not directly controlled by the CPU instruction itself, but is derived from bit field PAGE in the module page register MOD_PAGE. Hence, the bit field PAGE must be programmed before accessing the SFR of the target module. Each module may contain a different number of pages and a different number of SFRs per page, depending on the specific requirement. Besides setting the correct RMAP bit value to select the SFR area, the user must also ensure that a valid PAGE is selected to target the desired SFR. A page inside the extended address range can be selected as shown in **Figure 10**.

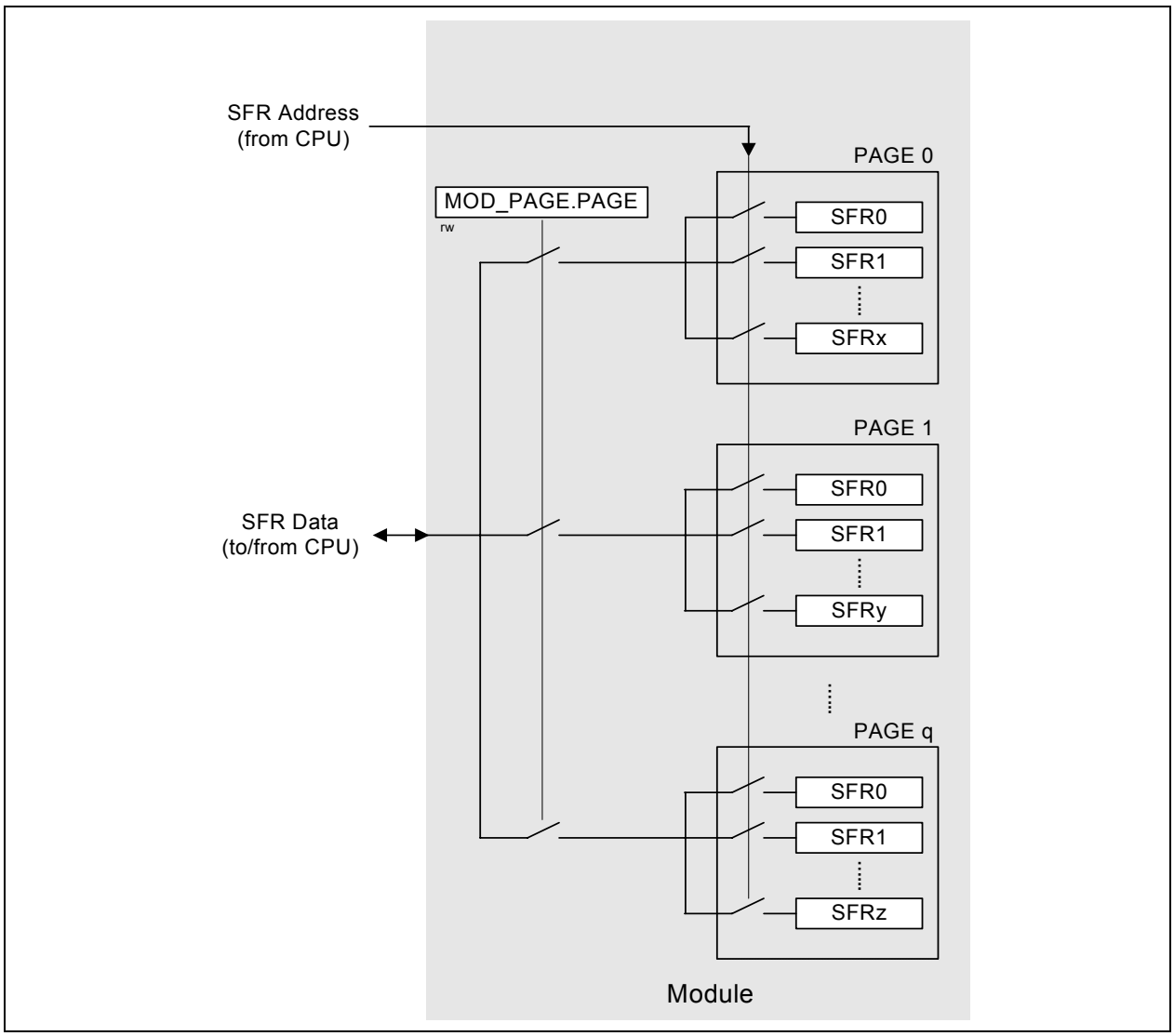



**Figure 10 Address Extension by Paging**

In order to access a register located in a page different from the actual one, the current page must be exited. This is done by reprogramming the bit field PAGE in the page register. Only then can the desired access be performed.

If an interrupt routine is initiated between the page register access and the module register access, and the interrupt needs to access a register located in another page, the current page setting can be saved, the new one programmed and the old page setting restored. This is possible with the storage fields STx (x = 0 - 3) for the save and restore action of the current page setting. By indicating which storage bit field should be used in parallel with the new page value, a single write operation can:

- Save the contents of PAGE in STx before overwriting with the new value
  (this is done in the beginning of the interrupt routine to save the current page setting and program the new page number); or

- Overwrite the contents of PAGE with the contents of STx, ignoring the value written to the bit positions of PAGE
  (this is done at the end of the interrupt routine to restore the previous page setting before the interrupt occurred)

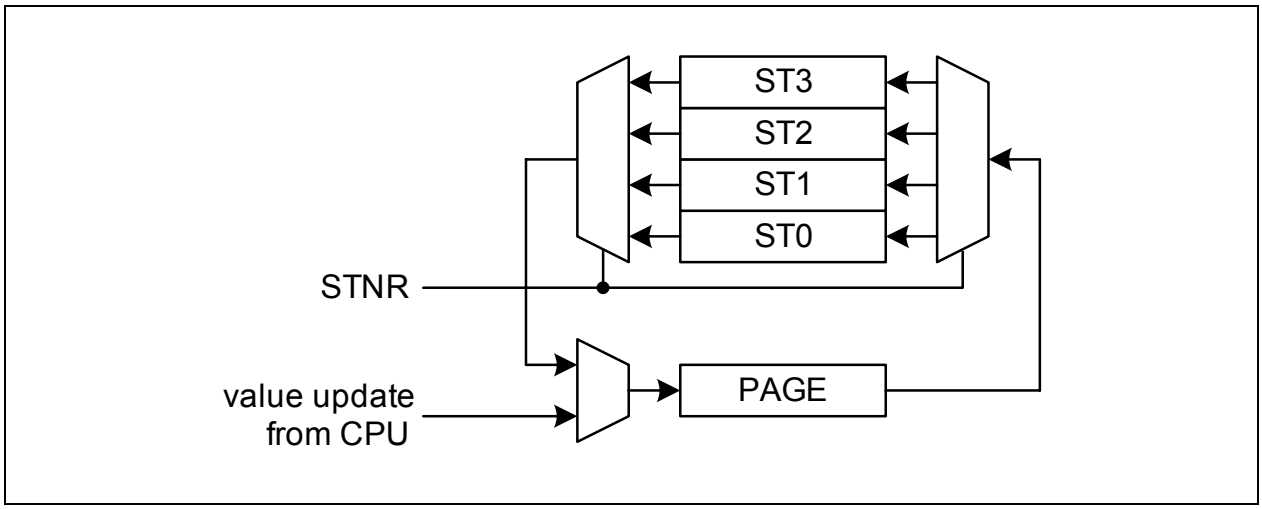



**Figure 11 Storage Elements for Paging**

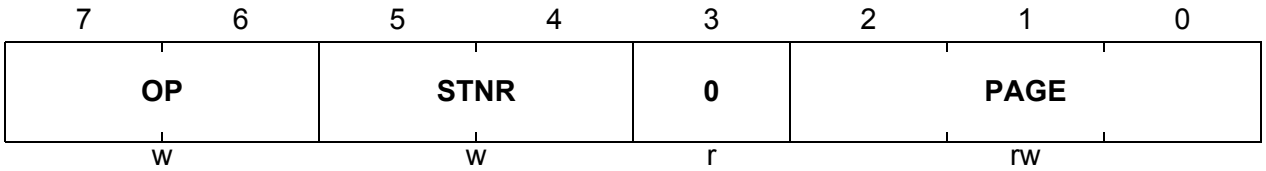
With this mechanism, a certain number of interrupt routines (or other routines) can perform page changes without reading and storing the previously used page information. The use of only write operations makes the system simpler and faster. Consequently, this mechanism significantly improves the performance of short interrupt routines.

The XC87x supports local address extension for:

- Parallel Ports
- Analog-to-Digital Converter (ADC)
- Capture/Compare Unit 6 (CCU6)
- System Control Registers

The page register has the following definition:

**MOD_PAGE**
**Page Register for module MOD** **Reset Value: $00_H$**




| Field | Bits | Type | Description |
|---|---|---|---|
| **PAGE** | [2:0] | rw | **Page Bits**<br>When written, the value indicates the new page.<br>When read, the value indicates the currently active page. |
| **STNR** | [5:4] | w | **Storage Number**<br>This number indicates which storage bit field is the target of the operation defined by bit field OP.<br>If OP = $10_B$,<br>the contents of PAGE are saved in STx before being overwritten with the new value.<br>If OP = $11_B$,<br>the contents of PAGE are overwritten by the contents of STx. The value written to the bit positions of PAGE is ignored.<br><br>00 ST0 is selected.<br>01 ST1 is selected.<br>10 ST2 is selected.<br>11 ST3 is selected. |

| Field | Bits | Type | Description |
|---|---|---|---|
| **OP** | [7:6] | w | **Operation**<br>0X Manual page mode. The value of STNR is ignored and PAGE is directly written.<br>10 New page programming with automatic page saving. The value written to the bit positions of PAGE is stored. In parallel, the previous contents of PAGE are saved in the storage bit field STx indicated by STNR.<br>11 Automatic restore page action. The value written to the bit positions PAGE is ignored and instead, PAGE is overwritten by the contents of the storage bit field STx indicated by STNR. |
| **0** | 3 | r | **Reserved**<br>Returns 0 if read; should be written with 0. |

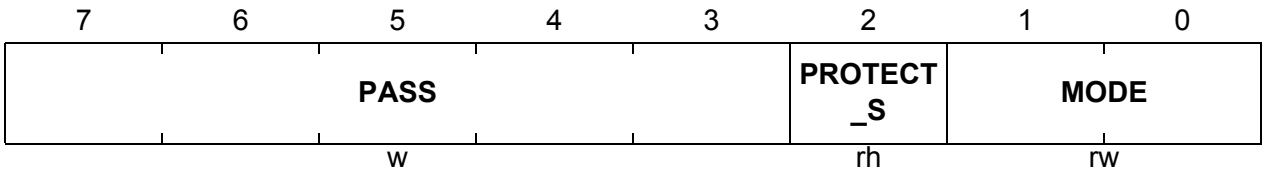
### 3.2.3 Bit Protection Scheme

The bit protection scheme prevents direct software writing of selected bits (i.e., protected bits) using the PASSWD register. When the bit field MODE is $11_B$, writing $10011_B$ to the bit field PASS opens access to writing of all protected bits, and writing $10101_B$ to the bit field PASS closes access to writing of all protected bits. In both cases, the value of the bit field MODE is not changed even if PASSWD register is written with $98_H$ or $A8_H$. It can only be changed when bit field PASS is written with $11000_B$, for example, writing $D0_H$ to PASSWD register disables the bit protection scheme.

Note that access is opened for maximum 32 CCLKs if the “close access” password is not written. If “open access” password is written again before the end of 32 CCLK cycles, there will be a recount of 32 CCLK cycles. The protected bits include the N- and K-Divider bits, NDIV and KDIV; the Watchdog Timer enable bit, WDTEN; and the power-down and slow-down enable bits, PD and SD.

### 3.2.3.1 Password Register

**PASSWD**
**Password Register** **Reset Value: $07_H$**




| Field | Bits | Type | Description |
|---|---|---|---|
| **MODE** | [1:0] | rw | **Bit Protection Scheme Control Bits**<br>00 Scheme disabled - direct access to the protected bits is allowed.<br>11 Scheme enabled - the bit field PASS has to be written with the passwords to open and close the access to protected bits. (default)<br>Others:Scheme Enabled.<br>These two bits cannot be written directly. To change the value between $11_B$ and $00_B$, the bit field PASS must be written with $11000_B$; only then, will the MODE[1:0] be registered. |
| **PROTECT_S** | 2 | rh | **Bit Protection Signal Status Bit**<br>This bit shows the status of the protection.<br>0 Software is able to write to all protected bits.<br>1 Software is unable to write to any protected bits. |
| **PASS** | [7:3] | w | **Password Bits**<br>The Bit Protection Scheme only recognizes three patterns.<br>$11000_B$ Enables writing of the bit field MODE.<br>$10011_B$ Opens access to writing of all protected bits.<br>$10101_B$ Closes access to writing of all protected bits |

### 3.2.4 XC87x Register Overview

The SFRs of the XC87x are organized into groups according to their functional units. The contents (bits) of the SFRs are summarized in **Chapter 3.2.4.1** to **Chapter 3.2.4.15**.

*Note: The addresses of the bitaddressable SFRs appear in bold typeface.*

#### 3.2.4.1 CPU Registers

The CPU SFRs can be accessed in both the standard and mapped memory areas (RMAP = 0 or 1).

**Table 5 CPU Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 or 1 | | | | | | | | | | |
| $81_H$ | **SP** **Reset: $07_H$**<br>Stack Pointer Register | Bit Field | SP | | | | | | | |
| | | Type | rw | | | | | | | |
| $82_H$ | **DPL** **Reset: $00_H$**<br>Data Pointer Register Low | Bit Field | DPL7 | DPL6 | DPL5 | DPL4 | DPL3 | DPL2 | DPL1 | DPL0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $83_H$ | **DPH** **Reset: $00_H$**<br>Data Pointer Register High | Bit Field | DPH7 | DPH6 | DPH5 | DPH4 | DPH3 | DPH2 | DPH1 | DPH0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $87_H$ | **PCON** **Reset: $00_H$**<br>Power Control Register | Bit Field | SMOD | 0 | | | GF1 | GF0 | 0 | IDLE |
| | | Type | rw | r | | | rw | rw | r | rw |
| **$88_H$** | **TCON** **Reset: $00_H$**<br>Timer Control Register | Bit Field | TF1 | TR1 | TF0 | TR0 | IE1 | IT1 | IE0 | IT0 |
| | | Type | rwh | rw | rwh | rw | rwh | rw | rwh | rw |
| $89_H$ | **TMOD** **Reset: $00_H$**<br>Timer Mode Register | Bit Field | GATE 1 | T1S | T1M | | GATE 0 | T0S | T0M | |
| | | Type | rw | rw | rw | | rw | rw | rw | |
| $8A_H$ | **TL0** **Reset: $00_H$**<br>Timer 0 Register Low | Bit Field | VAL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $8B_H$ | **TL1** **Reset: $00_H$**<br>Timer 1 Register Low | Bit Field | VAL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $8C_H$ | **TH0** **Reset: $00_H$**<br>Timer 0 Register High | Bit Field | VAL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $8D_H$ | **TH1** **Reset: $00_H$**<br>Timer 1 Register High | Bit Field | VAL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $94_H$ | **MEX1** **Reset: $00_H$**<br>Memory Extension Register 1 | Bit Field | CB | | | | NB | | | |
| | | Type | r | | | | rw | | | |
| $95_H$ | **MEX2** **Reset: $00_H$**<br>Memory Extension Register 2 | Bit Field | MCM | MCB | | | IB | | | |
| | | Type | rw | rw | | | rw | | | |
| $96_H$ | **MEX3** **Reset: $00_H$**<br>Memory Extension Register 3 | Bit Field | MCB19 | 0 | | MXB19 | MXM | MXB | | |
| | | Type | rw | r | | rw | rw | rw | | |

**Table 5 CPU Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $97_H$ | **MEXSP** **Reset: $7F_H$** Memory Extension Stack Pointer Register | Bit Field | 0 | MXSP | | | | | | |
| | | Type | r | rwh | | | | | | |
| **$98_H$** | **SCON** **Reset: $00_H$** Serial Channel Control Register | Bit Field | SM0 | SM1 | SM2 | REN | TB8 | RB8 | TI | RI |
| | | Type | rw | rw | rw | rw | rw | rwh | rwh | rwh |
| $99_H$ | **SBUF** **Reset: $00_H$** Serial Data Buffer Register | Bit Field | VAL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $A2_H$ | **EO** **Reset: $00_H$** Extended Operation Register | Bit Field | 0 | | | TRAP_EN | 0 | | | DPSEL0 |
| | | Type | r | | | rw | r | | | rw |
| **$A8_H$** | **IEN0** **Reset: $00_H$** Interrupt Enable Register 0 | Bit Field | EA | 0 | ET2 | ES | ET1 | EX1 | ET0 | EX0 |
| | | Type | rw | r | rw | rw | rw | rw | rw | rw |
| **$B8_H$** | **IP** **Reset: $00_H$** Interrupt Priority Register | Bit Field | 0 | | PT2 | PS | PT1 | PX1 | PT0 | PX0 |
| | | Type | r | | rw | rw | rw | rw | rw | rw |
| $B9_H$ | **IPH** **Reset: $00_H$** Interrupt Priority High Register | Bit Field | 0 | | PT2H | PSH | PT1H | PX1H | PT0H | PX0H |
| | | Type | r | | rw | rw | rw | rw | rw | rw |
| **$D0_H$** | **PSW** **Reset: $00_H$** Program Status Word Register | Bit Field | CY | AC | F0 | RS1 | RS0 | OV | F1 | P |
| | | Type | rwh | rwh | rw | rw | rw | rwh | rw | rh |
| **$E0_H$** | **ACC** **Reset: $00_H$** Accumulator Register | Bit Field | ACC7 | ACC6 | ACC5 | ACC4 | ACC3 | ACC2 | ACC1 | ACC0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$E8_H$** | **IEN1** **Reset: $00_H$** Interrupt Enable Register 1 | Bit Field | ECCIP3 | ECCIP2 | ECCIP1 | ECCIP0 | EXM | EX2 | ESSC | EADC |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$F0_H$** | **B** **Reset: $00_H$** B Register | Bit Field | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$F8_H$** | **IP1** **Reset: $00_H$** Interrupt Priority 1 Register | Bit Field | PCCIP3 | PCCIP2 | PCCIP1 | PCCIP0 | PXM | PX2 | PSSC | PADC |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $F9_H$ | **IPH1** **Reset: $00_H$** Interrupt Priority 1 High Register | Bit Field | PCCIP3H | PCCIP2H | PCCIP1H | PCCIP0H | PXMH | PX2H | PSSCH | PADCH |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |

### 3.2.4.2 MDU Registers

The MDU SFRs can be accessed in the mapped memory area (RMAP = 1).

**Table 6 MDU Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| **$B0_H$** | **MDUSTAT** **Reset: $00_H$** MDU Status Register | Bit Field | 0 | | | | | BSY | IERR | IRDY |
| | | Type | r | | | | | rh | rwh | rwh |

**Table 6 MDU Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $B1_H$ | **MDUCON** **Reset: $00_H$** MDU Control Register | Bit Field | IE | IR | RSEL | START | OPCODE | | | |
| | | Type | rw | rw | rw | rwh | rw | | | |
| $B2_H$ | **MD0** **Reset: $00_H$** MDU Operand Register 0 | Bit Field | DATA | | | | | | | |
| | | Type | rw | | | | | | | |
| $B2_H$ | **MR0** **Reset: $00_H$** MDU Result Register 0 | Bit Field | DATA | | | | | | | |
| | | Type | rh | | | | | | | |
| $B3_H$ | **MD1** **Reset: $00_H$** MDU Operand Register 1 | Bit Field | DATA | | | | | | | |
| | | Type | rw | | | | | | | |
| $B3_H$ | **MR1** **Reset: $00_H$** MDU Result Register 1 | Bit Field | DATA | | | | | | | |
| | | Type | rh | | | | | | | |
| $B4_H$ | **MD2** **Reset: $00_H$** MDU Operand Register 2 | Bit Field | DATA | | | | | | | |
| | | Type | rw | | | | | | | |
| $B4_H$ | **MR2** **Reset: $00_H$** MDU Result Register 2 | Bit Field | DATA | | | | | | | |
| | | Type | rh | | | | | | | |
| $B5_H$ | **MD3** **Reset: $00_H$** MDU Operand Register 3 | Bit Field | DATA | | | | | | | |
| | | Type | rw | | | | | | | |
| $B5_H$ | **MR3** **Reset: $00_H$** MDU Result Register 3 | Bit Field | DATA | | | | | | | |
| | | Type | rh | | | | | | | |
| $B6_H$ | **MD4** **Reset: $00_H$** MDU Operand Register 4 | Bit Field | DATA | | | | | | | |
| | | Type | rw | | | | | | | |
| $B6_H$ | **MR4** **Reset: $00_H$** MDU Result Register 4 | Bit Field | DATA | | | | | | | |
| | | Type | rh | | | | | | | |
| $B7_H$ | **MD5** **Reset: $00_H$** MDU Operand Register 5 | Bit Field | DATA | | | | | | | |
| | | Type | rw | | | | | | | |
| $B7_H$ | **MR5** **Reset: $00_H$** MDU Result Register 5 | Bit Field | DATA | | | | | | | |
| | | Type | rh | | | | | | | |

### 3.2.4.3 CORDIC Registers

The CORDIC SFRs can be accessed in the mapped memory area (RMAP = 1).

**Table 7 CORDIC Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| $9A_H$ | **CD_CORDXL** **Reset: $00_H$** CORDIC X Data Low Byte | Bit Field | DATAL | | | | | | | |
| | | Type | rw | | | | | | | |
| $9B_H$ | **CD_CORDXH** **Reset: $00_H$** CORDIC X Data High Byte | Bit Field | DATAH | | | | | | | |
| | | Type | rw | | | | | | | |

**Table 7 CORDIC Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $9C_H$ | **CD_CORDYL Reset: $00_H$** CORDIC Y Data Low Byte | Bit Field | DATAL | | | | | | | |
| | | Type | rw | | | | | | | |
| $9D_H$ | **CD_CORDYH Reset: $00_H$** CORDIC Y Data High Byte | Bit Field | DATAH | | | | | | | |
| | | Type | rw | | | | | | | |
| $9E_H$ | **CD_CORDZL Reset: $00_H$** CORDIC Z Data Low Byte | Bit Field | DATAL | | | | | | | |
| | | Type | rw | | | | | | | |
| $9F_H$ | **CD_CORDZH Reset: $00_H$** CORDIC Z Data High Byte | Bit Field | DATAH | | | | | | | |
| | | Type | rw | | | | | | | |
| **$A0_H$** | **CD_STATC Reset: $00_H$** CORDIC Status and Data Control Register | Bit Field | KEEPZ | KEEPY | KEEPX | DMAP | INT_EN | EOC | ERROR | BSY |
| | | Type | rw | rw | rw | rw | rw | rwh | rh | rh |
| $A1_H$ | **CD_CON Reset: $00_H$** CORDIC Control Register | Bit Field | MPS | | X_USIGN | ST_MODE | ROTVEC | MODE | | ST |
| | | Type | rw | | rw | rw | rw | rw | | rwh |

### 3.2.4.4 System Control Registers

The system control SFRs can be accessed in the mapped memory area (RMAP = 0).

**Table 8 SCU Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 or 1 | | | | | | | | | | |
| $8F_H$ | **SYSCON0 Reset: $04_H$** System Control Register 0 | Bit Field | 0 | | | IMODE | 0 | 1 | 0 | RMAP |
| | | Type | r | | | rw | r | r | r | rw |
| RMAP = 0 | | | | | | | | | | |
| $BF_H$ | **SCU_PAGE Reset: $00_H$** Page Register | Bit Field | OP | | STNR | | 0 | PAGE | | |
| | | Type | w | | w | | r | rwh | | |
| RMAP = 0, PAGE 0 | | | | | | | | | | |
| $B3_H$ | **MODPISEL Reset: $00_H$** Peripheral Input Select Register | Bit Field | 0 | URRISH | JTAGTDIS | JTAGTCKS | EXINT2IS | EXINT1IS | EXINT0IS | URRIS |
| | | Type | r | rw | rw | rw | rw | rw | rw | rw |
| $B4_H$ | **IRCON0 Reset: $00_H$** Interrupt Request Register 0 | Bit Field | 0 | EXINT6 | EXINT5 | EXINT4 | EXINT3 | EXINT2 | EXINT1 | EXINT0 |
| | | Type | r | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $B5_H$ | **IRCON1 Reset: $00_H$** Interrupt Request Register 1 | Bit Field | 0 | CANSRC2 | CANSRC1 | ADCSR1 | ADCSR0 | RIR | TIR | EIR |
| | | Type | r | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $B6_H$ | **IRCON2 Reset: $00_H$** Interrupt Request Register 2 | Bit Field | 0 | | | CANSRC3 | 0 | | | CANSRC0 |
| | | Type | r | | | rwh | r | | | rwh |

**Table 8 SCU Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $B7_H$ | **EXICON0** **Reset: $F0_H$** External Interrupt Control Register 0 | Bit Field | EXINT3 | | EXINT2 | | EXINT1 | | EXINT0 | |
| | | Type | rw | | rw | | rw | | rw | |
| $BA_H$ | **EXICON1** **Reset: $3F_H$** External Interrupt Control Register 1 | Bit Field | 0 | | EXINT6 | | EXINT5 | | EXINT4 | |
| | | Type | r | | rw | | rw | | rw | |
| $BB_H$ | **NMICON** **Reset: $00_H$** NMI Control Register | Bit Field | 0 | NMI ECC | NMI VDDP | 0 | NMI OCDS | NMI FLASH | NMI PLL | NMI WDT |
| | | Type | r | rw | rw | r | rw | rw | rw | rw |
| $BC_H$ | **NMISR** **Reset: $00_H$** NMI Status Register | Bit Field | 0 | FNMI ECC | FNMI VDDP | 0 | FNMI OCDS | FNMI FLASH | FNMI PLL | FNMI WDT |
| | | Type | r | rwh | rwh | r | rwh | rwh | rwh | rwh |
| $BD_H$ | **BCON** **Reset: $20_H$** Baud Rate Control Register | Bit Field | BGSEL | | NDOV EN | BRDIS | BRPRE | | | R |
| | | Type | rw | | rw | rw | rw | | | rw |
| $BE_H$ | **BG** **Reset: $00_H$** Baud Rate Timer/Reload Register | Bit Field | BR_VALUE | | | | | | | |
| | | Type | rwh | | | | | | | |
| $E9_H$ | **FDCON** **Reset: $00_H$** Fractional Divider Control Register | Bit Field | BGS | SYNE N | ERRS YN | EOFS YN | BRK | NDOV | FDM | FDEN |
| | | Type | rw | rw | rwh | rwh | rwh | rwh | rw | rw |
| $EA_H$ | **FDSTEP** **Reset: $00_H$** Fractional Divider Reload Register | Bit Field | STEP | | | | | | | |
| | | Type | rw | | | | | | | |
| $EB_H$ | **FDRES** **Reset: $00_H$** Fractional Divider Result Register | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| RMAP = 0, PAGE 1 | | | | | | | | | | |
| $B3_H$ | **ID** **Reset: $49_H$** Identity Register | Bit Field | PRODID | | | | | VERID | | |
| | | Type | r | | | | | r | | |
| $B4_H$ | **PMCON0** **Reset: $80_H$** Power Mode Control Register 0 | Bit Field | VDDP WARN | WDT RST | WKRS | WK SEL | SD | PD | WS | |
| | | Type | rh | rwh | rwh | rw | rw | rwh | rw | |
| $B5_H$ | **PMCON1** **Reset: $00_H$** Power Mode Control Register 1 | Bit Field | 0 | CDC_ DIS | CAN_ DIS | MDU_ DIS | T2CC U_DIS | CCU_ DIS | SSC_ DIS | ADC_ DIS |
| | | Type | r | rw | rw | rw | rw | rw | rw | rw |
| $B6_H$ | **OSC_CON** **Reset: $XX_H$** OSC Control Register | Bit Field | PLLRD RES | PLLBY P | PLLPD | 0 | XPD | OSC SS | EORD RES | EXTO SCR |
| | | Type | rwh | rwh | rw | r | rw | rwh | rwh | rh |
| $B7_H$ | **PLL_CON** **Reset: $18_H$** PLL Control Register | Bit Field | NDIV | | | | | | PLLR | PLL_L OCK |
| | | Type | rw | | | | | | rh | rh |
| $BA_H$ | **CMCON** **Reset: $10_H$** Clock Control Register | Bit Field | KDIV | | 0 | FCCF G | CLKREL | | | |
| | | Type | rw | | r | rw | rw | | | |

**Table 8 SCU Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $BB_H$ | **PASSWD** **Reset: $07_H$**<br>Password Register | Bit Field | PASS | | | | | PROTECT_S | MODE | |
| | | Type | w | | | | | rh | rw | |
| $BE_H$ | **COCON** **Reset: $00_H$**<br>Clock Output Control Register | Bit Field | COUTS | | TLEN | 0 | COREL | | | |
| | | Type | rw | | rw | r | rw | | | |
| $E9_H$ | **MISC_CON** **Reset: $00_H$**<br>Miscellaneous Control Register | Bit Field | ADCETR0_MUX | ADCETR1_MUX | 0 | | | | | DFLASHEN |
| | | Type | rw | rw | r | | | | | rwh |
| $EA_H$ | **PLL_CON1** **Reset: $20_H$**<br>PLL Control Register 1 | Bit Field | NDIV | | | PDIV | | | | |
| | | Type | rw | | | rw | | | | |
| $EB_H$ | **CR_MISC** **Reset: $00_H$ or $01_H$**<br>Reset Status Register | Bit Field | CCCFG | MDUCCFG | CCUCCFG | T2CCFG | 0 | | | HDRST |
| | | Type | rw | rw | rw | rw | r | | | rwh |
| RMAP = 0, PAGE 3 | | | | | | | | | | |
| $B3_H$ | **XADDRH** **Reset: $F0_H$**<br>On-chip XRAM Address Higher Order | Bit Field | ADDRH | | | | | | | |
| | | Type | rw | | | | | | | |
| $B4_H$ | **IRCON3** **Reset: $00_H$**<br>Interrupt Request Register 3 | Bit Field | 0 | | CANSRC5 | CCU6SR1 | 0 | | CANSRC4 | CCU6SR0 |
| | | Type | r | | rwh | rwh | r | | rwh | rwh |
| $B5_H$ | **IRCON4** **Reset: $00_H$**<br>Interrupt Request Register 4 | Bit Field | 0 | | CANSRC7 | CCU6SR3 | 0 | | CANSRC6 | CCU6SR2 |
| | | Type | r | | rwh | rwh | r | | rwh | rwh |
| $B6_H$ | **MODIEN** **Reset: $07_H$**<br>Peripheral Interrupt Enable Register | Bit Field | 0 | | | CM5EN | CM4EN | RIREN | TIREN | EIREN |
| | | Type | r | | | rw | rw | rw | rw | rw |
| $B7_H$ | **MODPISEL1** **Reset: $00_H$**<br>Peripheral Input Select Register 1 | Bit Field | EXINT6IS | | | UR1RIS | | T21EXIS | 0 | |
| | | Type | rw | | | rw | | rw | r | |
| $BA_H$ | **MODPISEL2** **Reset: $00_H$**<br>Peripheral Input Select Register 2 | Bit Field | 0 | | | T2EXIS | T21IS | T2IS | T1IS | T0IS |
| | | Type | r | | | rw | rw | rw | rw | rw |
| $BB_H$ | **PMCON2** **Reset: $00_H$**<br>Power Mode Control Register 2 | Bit Field | 0 | | | | | | UART1_DIS | T21_DIS |
| | | Type | r | | | | | | rw | rw |
| $BD_H$ | **MODSUSP** **Reset: $01_H$**<br>Module Suspend Control Register | Bit Field | 0 | | CCTSUSP | T21SUSP | T2SUSP | T13SUSP | T12SUSP | WDTSUSP |
| | | Type | r | | rw | rw | rw | rw | rw | rw |
| $BE_H$ | **MODPISEL3** **Reset: $00_H$**<br>Peripheral Input Select Register 3 | Bit Field | 0 | | CIS | | SIS | | MIS | |
| | | Type | r | | rw | | rw | | rw | |
| $EA_H$ | **MODPISEL4** **Reset: $00_H$**<br>Peripheral Input Select Register 4 | Bit Field | 0 | | EXINT5IS | | EXINT4IS | | EXINT3IS | |
| | | Type | r | | rw | | rw | | rw | |

### 3.2.4.5 WDT Registers

The WDT SFRs can be accessed in the mapped memory area (RMAP = 1).

**Table 9 WDT Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| $BB_H$ | **WDTCON** **Reset: $00_H$** Watchdog Timer Control Register | Bit Field | 0 | | WINBEN | WDTPR | 0 | WDTEN | WDTRS | WDTIN |
| | | Type | r | | rw | rh | r | rw | rwh | rw |
| $BC_H$ | **WDTREL** **Reset: $00_H$** Watchdog Timer Reload Register | Bit Field | WDTREL | | | | | | | |
| | | Type | rw | | | | | | | |
| $BD_H$ | **WDTWINB** **Reset: $00_H$** Watchdog Window-Boundary Count Register | Bit Field | WDTWINB | | | | | | | |
| | | Type | rw | | | | | | | |
| $BE_H$ | **WDTL** **Reset: $00_H$** Watchdog Timer Register Low | Bit Field | WDT | | | | | | | |
| | | Type | rh | | | | | | | |
| $BF_H$ | **WDTH** **Reset: $00_H$** Watchdog Timer Register High | Bit Field | WDT | | | | | | | |
| | | Type | rh | | | | | | | |

### 3.2.4.6 Port Registers

The Port SFRs can be accessed in the standard memory area (RMAP = 0).

**Table 10 Port Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 | | | | | | | | | | |
| $B2_H$ | **PORT_PAGE** **Reset: $00_H$** Page Register | Bit Field | OP | | STNR | | 0 | PAGE | | |
| | | Type | w | | w | | r | rwh | | |
| RMAP = 0, PAGE 0 | | | | | | | | | | |
| **$80_H$** | **P0_DATA** **Reset: $00_H$** P0 Data Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $86_H$ | **P0_DIR** **Reset: $00_H$** P0 Direction Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$90_H$** | **P1_DATA** **Reset: $00_H$** P1 Data Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $91_H$ | **P1_DIR** **Reset: $00_H$** P1 Direction Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $92_H$ | **P5_DATA** **Reset: $00_H$** P5 Data Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $93_H$ | **P5_DIR** **Reset: $00_H$** P5 Direction Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |

**Table 10 Port Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $B0_H$ | **P3_DATA** **Reset: $00_H$** P3 Data Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $B1_H$ | **P3_DIR** **Reset: $00_H$** P3 Direction Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $C8_H$ | **P4_DATA** **Reset: $00_H$** P4 Data Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $C9_H$ | **P4_DIR** **Reset: $00_H$** P4 Direction Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| RMAP = 0, PAGE 1 | | | | | | | | | | |
| $80_H$ | **P0_PUDSEL** **Reset: $FF_H$** P0 Pull-Up/Pull-Down Select Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $86_H$ | **P0_PUDEN** **Reset: $C4_H$** P0 Pull-Up/Pull-Down Enable Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $90_H$ | **P1_PUDSEL** **Reset: $FF_H$** P1 Pull-Up/Pull-Down Select Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $91_H$ | **P1_PUDEN** **Reset: $FF_H$** P1 Pull-Up/Pull-Down Enable Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $92_H$ | **P5_PUDSEL** **Reset: $FF_H$** P5 Pull-Up/Pull-Down Select Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $93_H$ | **P5_PUDEN** **Reset: $FF_H$** P5 Pull-Up/Pull-Down Enable Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $B0_H$ | **P3_PUDSEL** **Reset: $BF_H$** P3 Pull-Up/Pull-Down Select Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $B1_H$ | **P3_PUDEN** **Reset: $40_H$** P3 Pull-Up/Pull-Down Enable Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $C8_H$ | **P4_PUDSEL** **Reset: $FF_H$** P4 Pull-Up/Pull-Down Select Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $C9_H$ | **P4_PUDEN** **Reset: $04_H$** P4 Pull-Up/Pull-Down Enable Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| RMAP = 0, PAGE 2 | | | | | | | | | | |
| $80_H$ | **P0_ALTSEL0** **Reset: $00_H$** P0 Alternate Select 0 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $86_H$ | **P0_ALTSEL1** **Reset: $00_H$** P0 Alternate Select 1 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $90_H$ | **P1_ALTSEL0** **Reset: $00_H$** P1 Alternate Select 0 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |

**Table 10 Port Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $91_H$ | **P1_ALTSEL1 Reset: $00_H$**<br>P1 Alternate Select 1 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $92_H$ | **P5_ALTSEL0 Reset: $00_H$**<br>P5 Alternate Select 0 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $93_H$ | **P5_ALTSEL1 Reset: $00_H$**<br>P5 Alternate Select 1 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$B0_H$** | **P3_ALTSEL0 Reset: $00_H$**<br>P3 Alternate Select 0 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $B1_H$ | **P3_ALTSEL1 Reset: $00_H$**<br>P3 Alternate Select 1 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$C8_H$** | **P4_ALTSEL0 Reset: $00_H$**<br>P4 Alternate Select 0 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $C9_H$ | **P4_ALTSEL1 Reset: $00_H$**<br>P4 Alternate Select 1 Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| RMAP = 0, PAGE 3 | | | | | | | | | | |
| **$80_H$** | **P0_OD Reset: $00_H$**<br>P0 Open Drain Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $86_H$ | **P0_DS Reset: $FF_H$**<br>P0 Drive Strength Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$90_H$** | **P1_OD Reset: $00_H$**<br>P1 Open Drain Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $91_H$ | **P1_DS Reset: $FF_H$**<br>P1 Drive Strength Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $92_H$ | **P5_OD Reset: $00_H$**<br>P5 Open Drain Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $93_H$ | **P5_DS Reset: $FF_H$**<br>P5 Drive Strength Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$B0_H$** | **P3_OD Reset: $00_H$**<br>P3 Open Drain Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $B1_H$ | **P3_DS Reset: $FF_H$**<br>P3 Drive Strength Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| **$C8_H$** | **P4_OD Reset: $00_H$**<br>P4 Open Drain Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $C9_H$ | **P4_DS Reset: $FF_H$**<br>P4 Drive Strength Control Register | Bit Field | P7 | P6 | P5 | P4 | P3 | P2 | P1 | P0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |

### 3.2.4.7 ADC Registers

The ADC SFRs can be accessed in the standard memory area (RMAP = 0).

**Table 11 ADC Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 | | | | | | | | | | |
| $D1_H$ | **ADC_PAGE Reset: $00_H$**<br>Page Register | Bit Field | OP | | STNR | | 0 | PAGE | | |
| | | Type | w | | w | | r | rw | | |
| RMAP = 0, PAGE 0 | | | | | | | | | | |
| $CA_H$ | **ADC_GLOBCTR Reset: $30_H$**<br>Global Control Register | Bit Field | ANON | DW | CTC | | 0 | | | |
| | | Type | rw | rw | rw | | r | | | |
| $CB_H$ | **ADC_GLOBSTR Reset: $00_H$**<br>Global Status Register | Bit Field | 0 | | CHNR | | | 0 | SAMPLE | BUSY |
| | | Type | r | | rh | | | r | rh | rh |
| $CC_H$ | **ADC_PRAR Reset: $00_H$**<br>Priority and Arbitration Register | Bit Field | ASEN1 | ASEN0 | 0 | ARBM | CSM1 | PRIO1 | CSM0 | PRIO0 |
| | | Type | rw | rw | r | rw | rw | rw | rw | rw |
| $CD_H$ | **ADC_LCBR Reset: $B7_H$**<br>Limit Check Boundary Register | Bit Field | BOUND1 | | | | BOUND0 | | | |
| | | Type | rw | | | | rw | | | |
| $CE_H$ | **ADC_INPCR0 Reset: $00_H$**<br>Input Class 0 Register | Bit Field | STC | | | | | | | |
| | | Type | rw | | | | | | | |
| $CF_H$ | **ADC_ETRCR Reset: $00_H$**<br>External Trigger Control Register | Bit Field | SYNEN1 | SYNEN0 | ETRSEL1 | | | ETRSEL0 | | |
| | | Type | rw | rw | rw | | | rw | | |
| RMAP = 0, PAGE 1 | | | | | | | | | | |
| $CA_H$ | **ADC_CHCTR0 Reset: $00_H$**<br>Channel Control Register 0 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $CB_H$ | **ADC_CHCTR1 Reset: $00_H$**<br>Channel Control Register 1 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $CC_H$ | **ADC_CHCTR2 Reset: $00_H$**<br>Channel Control Register 2 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $CD_H$ | **ADC_CHCTR3 Reset: $00_H$**<br>Channel Control Register 3 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $CE_H$ | **ADC_CHCTR4 Reset: $00_H$**<br>Channel Control Register 4 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $CF_H$ | **ADC_CHCTR5 Reset: $00_H$**<br>Channel Control Register 5 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $D2_H$ | **ADC_CHCTR6 Reset: $00_H$**<br>Channel Control Register 6 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |
| $D3_H$ | **ADC_CHCTR7 Reset: $00_H$**<br>Channel Control Register 7 | Bit Field | 0 | LCC | | | 0 | RESRSEL | | |
| | | Type | r | rw | | | r | rw | | |

**Table 11 ADC Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0, PAGE 2 | | | | | | | | | | |
| $CA_H$ | **ADC_RESR0L Reset: $00_H$** Result Register 0 Low | Bit Field | RESULT | | 0 | VF | DRC | CHNR | | |
| | | Type | rh | | r | rh | rh | rh | | |
| $CB_H$ | **ADC_RESR0H Reset: $00_H$** Result Register 0 High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $CC_H$ | **ADC_RESR1L Reset: $00_H$** Result Register 1 Low | Bit Field | RESULT | | 0 | VF | DRC | CHNR | | |
| | | Type | rh | | r | rh | rh | rh | | |
| $CD_H$ | **ADC_RESR1H Reset: $00_H$** Result Register 1 High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $CE_H$ | **ADC_RESR2L Reset: $00_H$** Result Register 2 Low | Bit Field | RESULT | | 0 | VF | DRC | CHNR | | |
| | | Type | rh | | r | rh | rh | rh | | |
| $CF_H$ | **ADC_RESR2H Reset: $00_H$** Result Register 2 High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $D2_H$ | **ADC_RESR3L Reset: $00_H$** Result Register 3 Low | Bit Field | RESULT | | 0 | VF | DRC | CHNR | | |
| | | Type | rh | | r | rh | rh | rh | | |
| $D3_H$ | **ADC_RESR3H Reset: $00_H$** Result Register 3 High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| RMAP = 0, PAGE 3 | | | | | | | | | | |
| $CA_H$ | **ADC_RESRA0L Reset: $00_H$** Result Register 0, View A Low | Bit Field | RESULT | | | VF | DRC | CHNR | | |
| | | Type | rh | | | rh | rh | rh | | |
| $CB_H$ | **ADC_RESRA0H Reset: $00_H$** Result Register 0, View A High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $CC_H$ | **ADC_RESRA1L Reset: $00_H$** Result Register 1, View A Low | Bit Field | RESULT | | | VF | DRC | CHNR | | |
| | | Type | rh | | | rh | rh | rh | | |
| $CD_H$ | **ADC_RESRA1H Reset: $00_H$** Result Register 1, View A High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $CE_H$ | **ADC_RESRA2L Reset: $00_H$** Result Register 2, View A Low | Bit Field | RESULT | | | VF | DRC | CHNR | | |
| | | Type | rh | | | rh | rh | rh | | |
| $CF_H$ | **ADC_RESRA2H Reset: $00_H$** Result Register 2, View A High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $D2_H$ | **ADC_RESRA3L Reset: $00_H$** Result Register 3, View A Low | Bit Field | RESULT | | | VF | DRC | CHNR | | |
| | | Type | rh | | | rh | rh | rh | | |
| $D3_H$ | **ADC_RESRA3H Reset: $00_H$** Result Register 3, View A High | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| RMAP = 0, PAGE 4 | | | | | | | | | | |
| $CA_H$ | **ADC_RCR0 Reset: $00_H$** Result Control Register 0 | Bit Field | VFCTR | WFR | 0 | IEN | 0 | | | DRCTR |
| | | Type | rw | rw | r | rw | r | | | rw |

**Table 11 ADC Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CB_H$ | **ADC_RCR1 Reset: $00_H$** Result Control Register 1 | Bit Field | VFCTR | WFR | 0 | IEN | 0 | | | DRCTR |
| | | Type | rw | rw | r | rw | r | | | rw |
| $CC_H$ | **ADC_RCR2 Reset: $00_H$** Result Control Register 2 | Bit Field | VFCTR | WFR | 0 | IEN | 0 | | | DRCTR |
| | | Type | rw | rw | r | rw | r | | | rw |
| $CD_H$ | **ADC_RCR3 Reset: $00_H$** Result Control Register 3 | Bit Field | VFCTR | WFR | 0 | IEN | 0 | | | DRCTR |
| | | Type | rw | rw | r | rw | r | | | rw |
| $CE_H$ | **ADC_VFCR Reset: $00_H$** Valid Flag Clear Register | Bit Field | 0 | | | | VFC3 | VFC2 | VFC1 | VFC0 |
| | | Type | r | | | | w | w | w | w |
| RMAP = 0, PAGE 5 | | | | | | | | | | |
| $CA_H$ | **ADC_CHINFR Reset: $00_H$** Channel Interrupt Flag Register | Bit Field | CHINF7 | CHINF6 | CHINF5 | CHINF4 | CHINF3 | CHINF2 | CHINF1 | CHINF0 |
| | | Type | rh | rh | rh | rh | rh | rh | rh | rh |
| $CB_H$ | **ADC_CHINCR Reset: $00_H$** Channel Interrupt Clear Register | Bit Field | CHINC7 | CHINC6 | CHINC5 | CHINC4 | CHINC3 | CHINC2 | CHINC1 | CHINC0 |
| | | Type | w | w | w | w | w | w | w | w |
| $CC_H$ | **ADC_CHINSR Reset: $00_H$** Channel Interrupt Set Register | Bit Field | CHINS7 | CHINS6 | CHINS5 | CHINS4 | CHINS3 | CHINS2 | CHINS1 | CHINS0 |
| | | Type | w | w | w | w | w | w | w | w |
| $CD_H$ | **ADC_CHINPR Reset: $00_H$** Channel Interrupt Node Pointer Register | Bit Field | CHINP7 | CHINP6 | CHINP5 | CHINP4 | CHINP3 | CHINP2 | CHINP1 | CHINP0 |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $CE_H$ | **ADC_EVINFR Reset: $00_H$** Event Interrupt Flag Register | Bit Field | EVINF7 | EVINF6 | EVINF5 | EVINF4 | 0 | | EVINF1 | EVINF0 |
| | | Type | rh | rh | rh | rh | r | | rh | rh |
| $CF_H$ | **ADC_EVINCR Reset: $00_H$** Event Interrupt Clear Flag Register | Bit Field | EVINC7 | EVINC6 | EVINC5 | EVINC4 | 0 | | EVINC1 | EVINC0 |
| | | Type | w | w | w | w | r | | w | w |
| $D2_H$ | **ADC_EVINSR Reset: $00_H$** Event Interrupt Set Flag Register | Bit Field | EVINS7 | EVINS6 | EVINS5 | EVINS4 | 0 | | EVINS1 | EVINS0 |
| | | Type | w | w | w | w | r | | w | w |
| $D3_H$ | **ADC_EVINPR Reset: $00_H$** Event Interrupt Node Pointer Register | Bit Field | EVINP7 | EVINP6 | EVINP5 | EVINP4 | 0 | | EVINP1 | EVINP0 |
| | | Type | rw | rw | rw | rw | r | | rw | rw |
| RMAP = 0, PAGE 6 | | | | | | | | | | |
| $CA_H$ | **ADC_CRCR1 Reset: $00_H$** Conversion Request Control Register 1 | Bit Field | CH7 | CH6 | CH5 | CH4 | 0 | | | |
| | | Type | rwh | rwh | rwh | rwh | r | | | |
| $CB_H$ | **ADC_CRPR1 Reset: $00_H$** Conversion Request Pending Register 1 | Bit Field | CHP7 | CHP6 | CHP5 | CHP4 | 0 | | | |
| | | Type | rwh | rwh | rwh | rwh | r | | | |

**Table 11 ADC Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $CC_H$ | **ADC_CRMR1 Reset: $00_H$** Conversion Request Mode Register 1 | Bit Field | Rsv | LDEV | CLRPND | SCAN | ENSI | ENTR | 0 | ENGT |
| | | Type | r | w | w | rw | rw | rw | r | rw |
| $CD_H$ | **ADC_QMR0 Reset: $00_H$** Queue Mode Register 0 | Bit Field | CEV | TREV | FLUSH | CLRV | 0 | ENTR | 0 | ENGT |
| | | Type | w | w | w | w | r | rw | r | rw |
| $CE_H$ | **ADC_QSR0 Reset: $20_H$** Queue Status Register 0 | Bit Field | Rsv | 0 | EMPTY | EV | 0 | | FILL | |
| | | Type | r | r | rh | rh | r | | rh | |
| $CF_H$ | **ADC_Q0R0 Reset: $00_H$** Queue 0 Register 0 | Bit Field | EXTR | ENSI | RF | V | 0 | REQCHNR | | |
| | | Type | rh | rh | rh | rh | r | rh | | |
| $D2_H$ | **ADC_QBUR0 Reset: $00_H$** Queue Backup Register 0 | Bit Field | EXTR | ENSI | RF | V | 0 | REQCHNR | | |
| | | Type | rh | rh | rh | rh | r | rh | | |
| $D2_H$ | **ADC_QINR0 Reset: $00_H$** Queue Input Register 0 | Bit Field | EXTR | ENSI | RF | 0 | | REQCHNR | | |
| | | Type | w | w | w | r | | w | | |

### 3.2.4.8 Timer 2 Compare/Capture Unit Registers

The Timer 2 Compare/Capture Unit SFRs can be accessed in the standard memory area (RMAP = 0).

**Table 12 T2CCU Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 | | | | | | | | | | |
| $C7_H$ | **T2_PAGE** **Reset: $00_H$** Page Register | Bit Field | OP | | STNR | | 0 | PAGE | | |
| | | Type | w | | w | | r | rwh | | |
| RMAP = 0, PAGE 0 | | | | | | | | | | |
| **$C0_H$** | **T2_T2CON** **Reset: $00_H$** Timer 2 Control Register | Bit Field | TF2 | EXF2 | 0 | | EXEN2 | TR2 | C/$\overline{T2}$ | $\underline{CP/RL2}$ |
| | | Type | rwh | rwh | r | | rw | rwh | rw | rw |
| $C1_H$ | **T2_T2MOD** **Reset: $00_H$** Timer 2 Mode Register | Bit Field | T2REGS | T2RHEN | EDGESEL | PREN | T2PRE | | | DCEN |
| | | Type | rw | rw | rw | rw | rw | | | rw |
| $C2_H$ | **T2_RC2L** **Reset: $00_H$** Timer 2 Reload/Capture Register Low | Bit Field | RC2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C3_H$ | **T2_RC2H** **Reset: $00_H$** Timer 2 Reload/Capture Register High | Bit Field | RC2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C4_H$ | **T2_T2L** **Reset: $00_H$** Timer 2 Register Low | Bit Field | THL2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C5_H$ | **T2_T2H** **Reset: $00_H$** Timer 2 Register High | Bit Field | THL2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C6_H$ | **T2_T2CON1** **Reset: $03_H$** Timer 2 Control Register 1 | Bit Field | 0 | | | | | | TF2EN | EXF2EN |
| | | Type | r | | | | | | rw | rw |
| RMAP = 0, PAGE 1 | | | | | | | | | | |
| $C0_H$ | **T2CCU_CCEN** **Reset: $00_H$** T2CCU Capture/Compare Enable Register | Bit Field | CCM3 | | CCM2 | | CCM1 | | CCM0 | |
| | | Type | rw | | rw | | rw | | rw | |
| $C1_H$ | **T2CCU_CCTBSELReset: $00_H$** T2CCU Capture/Compare Time Base Select Register | Bit Field | CASC | CCTTOV | CCTB5 | CCTB4 | CCTB3 | CCTB2 | CCTB1 | CCTB0 |
| | | Type | rw | rwh | rw | rw | rw | rw | rw | rw |
| $C2_H$ | **T2CCU_CCTRELLReset: $00_H$** T2CCU Capture/Compare Timer Reload Register Low | Bit Field | CCTREL | | | | | | | |
| | | Type | rw | | | | | | | |
| $C3_H$ | **T2CCU_CCTRELHReset: $00_H$** T2CCU Capture/Compare Timer Reload Register High | Bit Field | CCTREL | | | | | | | |
| | | Type | rw | | | | | | | |
| $C4_H$ | **T2CCU_CCTL** **Reset: $00_H$** T2CCU Capture/Compare Timer Register Low | Bit Field | CCT | | | | | | | |
| | | Type | rwh | | | | | | | |

**Table 12 T2CCU Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $C5_H$ | **T2CCU_CCTH Reset: $00_H$** T2CCU Capture/Compare Timer Register High | Bit Field | CCT | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C6_H$ | **T2CCU_CCTCON Reset: $00_H$** T2CCU CaptureCcompare Timer Control Register | Bit Field | CCTPRE | | | | CCTOVF | CCTOVEN | TIMSYN | CCTST |
| | | Type | rw | | | | rwh | rw | rw | rw |
| RMAP = 0, PAGE 2 | | | | | | | | | | |
| $C0_H$ | **T2CCU_COSHDW Reset: $00_H$** T2CCU Capture/compare Enable Register | Bit Field | ENSHDW | TXOV | COOUT5 | COOUT4 | COOUT3 | COOUT2 | COOUT1 | COOUT0 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $C1_H$ | **T2CCU_CC0L Reset: $00_H$** T2CCU Capture/Compare Register 0 Low | Bit Field | CCVALL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C2_H$ | **T2CCU_CC0H Reset: $00_H$** T2CCU Capture/compare Register 0 High | Bit Field | CCVALH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C3_H$ | **T2CCU_CC1L Reset: $00_H$** T2CCU Capture/compare Register 1 Low | Bit Field | CCVALL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C4_H$ | **T2CCU_CC1H Reset: $00_H$** T2CCU Capture/compare Register 1 High | Bit Field | CCVALH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C5_H$ | **T2CCU_CC2L Reset: $00_H$** T2CCU Capture/compare Register 2 Low | Bit Field | CCVALL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C6_H$ | **T2CCU_CC2H Reset: $00_H$** T2CCU Capture/compare Register 2 High | Bit Field | CCVALH | | | | | | | |
| | | Type | rwh | | | | | | | |
| RMAP = 0, PAGE 3 | | | | | | | | | | |
| $C0_H$ | **T2CCU_COCON Reset: $00_H$** T2CCU Compare Control Register | Bit Field | CCM5 | CCM4 | CM5F | CM4F | POLB | POLA | COMOD | |
| | | Type | rw | rw | rwh | rwh | rw | rw | rw | |
| $C1_H$ | **T2CCU_CC3L Reset: $00_H$** T2CCU Capture/compare Register 3 Low | Bit Field | CCVALL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C2_H$ | **T2CCU_CC3H Reset: $00_H$** T2CCU Capture/compare Register 3 High | Bit Field | CCVALH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C3_H$ | **T2CCU_CC4L Reset: $00_H$** T2CCU Capture/compare Register 4 Low | Bit Field | CCVALL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C4_H$ | **T2CCU_CC4H Reset: $00_H$** T2CCU Capture/compare Register 4 High | Bit Field | CCVALH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C5_H$ | **T2CCU_CC5L Reset: $00_H$** T2CCU Capture/compare Register 5 Low | Bit Field | CCVALL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C6_H$ | **T2CCU_CC5H Reset: $00_H$** T2CCU Capture/compare Register 5 High | Bit Field | CCVALH | | | | | | | |
| | | Type | rwh | | | | | | | |

**Table 12 T2CCU Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0, PAGE 4 | | | | | | | | | | |
| $C2_H$ | **T2CCU_CCTDTCLReset: $00_H$** T2CCU Capture/Compare Timer Dead-Time Control Register Low | Bit Field | DTM | | | | | | | |
| | | Type | rw | | | | | | | |
| $C3_H$ | **T2CCU_CCTDTCHReset: $00_H$** T2CCU Capture/Compare Timer Dead-Time Control Register High | Bit Field | DTRES | DTR2 | DTR1 | DTR0 | DTLEV | DTE2 | DTE1 | DTE0 |
| | | Type | rwh | rh | rh | rh | rw | rw | rw | rw |

### 3.2.4.9 Timer 21 Registers

The Timer 21 SFRs can be accessed in the mapped memory area (RMAP = 1).

**Table 13 T21 Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| **$C0_H$** | **T21_T2CON Reset: $00_H$** Timer 2 Control Register | Bit Field | TF2 | EXF2 | 0 | | EXEN2 | TR2 | C/$\overline{T2}$ | CP/$\overline{RL2}$ |
| | | Type | rwh | rwh | r | | rw | rwh | rw | rw |
| $C1_H$ | **T21_T2MOD Reset: $00_H$** Timer 2 Mode Register | Bit Field | T2REGS | T2RHEN | EDGESEL | PREN | T2PRE | | | DCEN |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $C2_H$ | **T21_RC2L Reset: $00_H$** Timer 2 Reload/Capture Register Low | Bit Field | RC2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C3_H$ | **T21_RC2H Reset: $00_H$** Timer 2 Reload/Capture Register High | Bit Field | RC2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C4_H$ | **T21_T2L Reset: $00_H$** Timer 2 Register Low | Bit Field | THL2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C5_H$ | **T21_T2H Reset: $00_H$** Timer 2 Register High | Bit Field | THL2 | | | | | | | |
| | | Type | rwh | | | | | | | |
| $C6_H$ | **T21_T2CON1 Reset: $03_H$** Timer 2 Control Register 1 | Bit Field | 0 | | | | | | TF2EN | EXF2EN |
| | | Type | r | | | | | | rw | rw |

### 3.2.4.10 CCU6 Registers

The CCU6 SFRs can be accessed in the standard memory area (RMAP = 0).

**Table 14 CCU6 Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 | | | | | | | | | | |
| $A3_H$ | **CCU6_PAGE** **Reset: $00_H$** Page Register | Bit Field | OP | | STNR | | 0 | PAGE | | |
| | | Type | w | | w | | r | rwh | | |
| RMAP = 0, PAGE 0 | | | | | | | | | | |
| $9A_H$ | **CCU6_CC63SRL** **Reset: $00_H$** Capture/Compare Shadow Register for Channel CC63 Low | Bit Field | CC63SL | | | | | | | |
| | | Type | rw | | | | | | | |
| $9B_H$ | **CCU6_CC63SRH** **Reset: $00_H$** Capture/Compare Shadow Register for Channel CC63 High | Bit Field | CC63SH | | | | | | | |
| | | Type | rw | | | | | | | |
| $9C_H$ | **CCU6_TCTR4L** **Reset: $00_H$** Timer Control Register 4 Low | Bit Field | T12 STD | T12 STR | 0 | | DT RES | T12 RES | T12R S | T12R R |
| | | Type | w | w | r | | w | w | w | w |
| $9D_H$ | **CCU6_TCTR4H** **Reset: $00_H$** Timer Control Register 4 High | Bit Field | T13 STD | T13 STR | 0 | | | T13 RES | T13R S | T13R R |
| | | Type | w | w | r | | | w | w | w |
| $9E_H$ | **CCU6_MCMOUTSL** **Reset: $00_H$** Multi-Channel Mode Output Shadow Register Low | Bit Field | STRM CM | 0 | MCMPS | | | | | |
| | | Type | w | r | rw | | | | | |
| $9F_H$ | **CCU6_MCMOUTSH** **Reset: $00_H$** Multi-Channel Mode Output Shadow Register High | Bit Field | STRH P | 0 | CURHS | | | EXPHS | | |
| | | Type | w | r | rw | | | rw | | |
| $A4_H$ | **CCU6_ISRL** **Reset: $00_H$** Capture/Compare Interrupt Status Reset Register Low | Bit Field | RT12 PM | RT12 OM | RCC6 2F | RCC6 2R | RCC6 1F | RCC6 1R | RCC6 0F | RCC6 0R |
| | | Type | w | w | w | w | w | w | w | w |
| $A5_H$ | **CCU6_ISRH** **Reset: $00_H$** Capture/Compare Interrupt Status Reset Register High | Bit Field | RSTR | RIDLE | RWH E | RCHE | 0 | RTRP F | RT13 PM | RT13 CM |
| | | Type | w | w | w | w | r | w | w | w |
| $A6_H$ | **CCU6_CMPMODIFL** **Reset: $00_H$** Compare State Modification Register Low | Bit Field | 0 | MCC6 3S | 0 | | | MCC6 2S | MCC6 1S | MCC6 0S |
| | | Type | r | w | r | | | w | w | w |
| $A7_H$ | **CCU6_CMPMODIFH** **Reset: $00_H$** Compare State Modification Register High | Bit Field | 0 | MCC6 3R | 0 | | | MCC6 2R | MCC6 1R | MCC6 0R |
| | | Type | r | w | r | | | w | w | w |
| $FA_H$ | **CCU6_CC60SRL** **Reset: $00_H$** Capture/Compare Shadow Register for Channel CC60 Low | Bit Field | CC60SL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FB_H$ | **CCU6_CC60SRH** **Reset: $00_H$** Capture/Compare Shadow Register for Channel CC60 High | Bit Field | CC60SH | | | | | | | |
| | | Type | rwh | | | | | | | |

**Table 14 CCU6 Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $FC_H$ | **CCU6_CC61SRL Reset: $00_H$** Capture/Compare Shadow Register for Channel CC61 Low | Bit Field | CC61SL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FD_H$ | **CCU6_CC61SRH Reset: $00_H$** Capture/Compare Shadow Register for Channel CC61 High | Bit Field | CC61SH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FE_H$ | **CCU6_CC62SRL Reset: $00_H$** Capture/Compare Shadow Register for Channel CC62 Low | Bit Field | CC62SL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FF_H$ | **CCU6_CC62SRH Reset: $00_H$** Capture/Compare Shadow Register for Channel CC62 High | Bit Field | CC62SH | | | | | | | |
| | | Type | rwh | | | | | | | |
| RMAP = 0, PAGE 1 | | | | | | | | | | |
| $9A_H$ | **CCU6_CC63RL Reset: $00_H$** Capture/Compare Register for Channel CC63 Low | Bit Field | CC63VL | | | | | | | |
| | | Type | rh | | | | | | | |
| $9B_H$ | **CCU6_CC63RH Reset: $00_H$** Capture/Compare Register for Channel CC63 High | Bit Field | CC63VH | | | | | | | |
| | | Type | rh | | | | | | | |
| $9C_H$ | **CCU6_T12PRL Reset: $00_H$** Timer T12 Period Register Low | Bit Field | T12PVL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $9D_H$ | **CCU6_T12PRH Reset: $00_H$** Timer T12 Period Register High | Bit Field | T12PVH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $9E_H$ | **CCU6_T13PRL Reset: $00_H$** Timer T13 Period Register Low | Bit Field | T13PVL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $9F_H$ | **CCU6_T13PRH Reset: $00_H$** Timer T13 Period Register High | Bit Field | T13PVH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $A4_H$ | **CCU6_T12DTCL Reset: $00_H$** Dead-Time Control Register for Timer T12 Low | Bit Field | DTM | | | | | | | |
| | | Type | rw | | | | | | | |
| $A5_H$ | **CCU6_T12DTCH Reset: $00_H$** Dead-Time Control Register for Timer T12 High | Bit Field | 0 | DTR2 | DTR1 | DTR0 | 0 | DTE2 | DTE1 | DTE0 |
| | | Type | r | rh | rh | rh | r | rw | rw | rw |
| $A6_H$ | **CCU6_TCTR0L Reset: $00_H$** Timer Control Register 0 Low | Bit Field | CTM | CDIR | STE12 | T12R | T12PRE | T12CLK | | |
| | | Type | rw | rh | rh | rh | rw | rw | | |
| $A7_H$ | **CCU6_TCTR0H Reset: $00_H$** Timer Control Register 0 High | Bit Field | 0 | | STE13 | T13R | T13PRE | T13CLK | | |
| | | Type | r | | rh | rh | rw | rw | | |
| $FA_H$ | **CCU6_CC60RL Reset: $00_H$** Capture/Compare Register for Channel CC60 Low | Bit Field | CC60VL | | | | | | | |
| | | Type | rh | | | | | | | |
| $FB_H$ | **CCU6_CC60RH Reset: $00_H$** Capture/Compare Register for Channel CC60 High | Bit Field | CC60VH | | | | | | | |
| | | Type | rh | | | | | | | |
| $FC_H$ | **CCU6_CC61RL Reset: $00_H$** Capture/Compare Register for Channel CC61 Low | Bit Field | CC61VL | | | | | | | |
| | | Type | rh | | | | | | | |

**Table 14 CCU6 Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $FD_H$ | **CCU6_CC61RH Reset: $00_H$**<br>Capture/Compare Register for Channel CC61 High | Bit Field | CC61VH | | | | | | | |
| | | Type | rh | | | | | | | |
| $FE_H$ | **CCU6_CC62RL Reset: $00_H$**<br>Capture/Compare Register for Channel CC62 Low | Bit Field | CC62VL | | | | | | | |
| | | Type | rh | | | | | | | |
| $FF_H$ | **CCU6_CC62RH Reset: $00_H$**<br>Capture/Compare Register for Channel CC62 High | Bit Field | CC62VH | | | | | | | |
| | | Type | rh | | | | | | | |
| RMAP = 0, PAGE 2 | | | | | | | | | | |
| $9A_H$ | **CCU6_T12MSELL Reset: $00_H$**<br>T12 Capture/Compare Mode Select Register Low | Bit Field | MSEL61 | | | | MSEL60 | | | |
| | | Type | rw | | | | rw | | | |
| $9B_H$ | **CCU6_T12MSELH Reset: $00_H$**<br>T12 Capture/Compare Mode Select Register High | Bit Field | DBYP | HSYNC | | | MSEL62 | | | |
| | | Type | rw | rw | | | rw | | | |
| $9C_H$ | **CCU6_IENL Reset: $00_H$**<br>Capture/Compare Interrupt Enable Register Low | Bit Field | ENT12PM | ENT12OM | ENCC62F | ENCC62R | ENCC61F | ENCC61R | ENCC60F | ENCC60R |
| | | Type | rw | rw | rw | rw | rw | rw | rw | rw |
| $9D_H$ | **CCU6_IENH Reset: $00_H$**<br>Capture/Compare Interrupt Enable Register High | Bit Field | ENSTR | ENIDLE | ENWHE | ENCHE | 0 | ENTRPF | ENT13PM | ENT13CM |
| | | Type | rw | rw | rw | rw | r | rw | rw | rw |
| $9E_H$ | **CCU6_INPL Reset: $40_H$**<br>Capture/Compare Interrupt Node Pointer Register Low | Bit Field | INPCHE | | INPCC62 | | INPCC61 | | INPCC60 | |
| | | Type | rw | | rw | | rw | | rw | |
| $9F_H$ | **CCU6_INPH Reset: $39_H$**<br>Capture/Compare Interrupt Node Pointer Register High | Bit Field | 0 | | INPT13 | | INPT12 | | INPERR | |
| | | Type | r | | rw | | rw | | rw | |
| $A4_H$ | **CCU6_ISSL Reset: $00_H$**<br>Capture/Compare Interrupt Status Set Register Low | Bit Field | ST12PM | ST12OM | SCC62F | SCC62R | SCC61F | SCC61R | SCC60F | SCC60R |
| | | Type | w | w | w | w | w | w | w | w |
| $A5_H$ | **CCU6_ISSH Reset: $00_H$**<br>Capture/Compare Interrupt Status Set Register High | Bit Field | SSTR | SIDLE | SWHE | SCHE | SWHC | STRPF | ST13PM | ST13CM |
| | | Type | w | w | w | w | w | w | w | w |
| $A6_H$ | **CCU6_PSLR Reset: $00_H$**<br>Passive State Level Register | Bit Field | PSL63 | 0 | PSL | | | | | |
| | | Type | rwh | r | rwh | | | | | |
| $A7_H$ | **CCU6_MCMCTR Reset: $00_H$**<br>Multi-Channel Mode Control Register | Bit Field | 0 | | SWSYN | | 0 | SWSEL | | |
| | | Type | r | | rw | | r | rw | | |
| $FA_H$ | **CCU6_TCTR2L Reset: $00_H$**<br>Timer Control Register 2 Low | Bit Field | 0 | T13TED | | T13TEC | | | T13SSC | T12SSC |
| | | Type | r | rw | | rw | | | rw | rw |
| $FB_H$ | **CCU6_TCTR2H Reset: $00_H$**<br>Timer Control Register 2 High | Bit Field | 0 | | | | T13RSEL | | T12RSEL | |
| | | Type | r | | | | rw | | rw | |
| $FC_H$ | **CCU6_MODCTRL Reset: $00_H$**<br>Modulation Control Register Low | Bit Field | MCMEN | 0 | T12MODEN | | | | | |
| | | Type | rw | r | rw | | | | | |

**Table 14 CCU6 Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $FD_H$ | **CCU6_MODCTRH Reset: $00_H$** Modulation Control Register High | Bit Field | ECT13O | 0 | T13MODEN | | | | | |
| | | Type | rw | r | rw | | | | | |
| $FE_H$ | **CCU6_TRPCTRL Reset: $00_H$** Trap Control Register Low | Bit Field | 0 | | | | | TRPM2 | TRPM1 | TRPM0 |
| | | Type | r | | | | | rw | rw | rw |
| $FF_H$ | **CCU6_TRPCTRH Reset: $00_H$** Trap Control Register High | Bit Field | TRPPEN | TRPEN13 | TRPEN | | | | | |
| | | Type | rw | rw | rw | | | | | |
| RMAP = 0, PAGE 3 | | | | | | | | | | |
| $9A_H$ | **CCU6_MCMOUTL Reset: $00_H$** Multi-Channel Mode Output Register Low | Bit Field | 0 | R | MCMP | | | | | |
| | | Type | r | rh | rh | | | | | |
| $9B_H$ | **CCU6_MCMOUTH Reset: $00_H$** Multi-Channel Mode Output Register High | Bit Field | 0 | | CURH | | | EXPH | | |
| | | Type | r | | rh | | | rh | | |
| $9C_H$ | **CCU6_ISL Reset: $00_H$** Capture/Compare Interrupt Status Register Low | Bit Field | T12PM | T12OM | ICC62F | ICC62R | ICC61F | ICC61R | ICC60F | ICC60R |
| | | Type | rh | rh | rh | rh | rh | rh | rh | rh |
| $9D_H$ | **CCU6_ISH Reset: $00_H$** Capture/Compare Interrupt Status Register High | Bit Field | STR | IDLE | WHE | CHE | TRPS | TRPF | T13PM | T13CM |
| | | Type | rh | rh | rh | rh | rh | rh | rh | rh |
| $9E_H$ | **CCU6_PISEL0L Reset: $00_H$** Port Input Select Register 0 Low | Bit Field | ISTRP | | ISCC62 | | ISCC61 | | ISCC60 | |
| | | Type | rw | | rw | | rw | | rw | |
| $9F_H$ | **CCU6_PISEL0H Reset: $00_H$** Port Input Select Register 0 High | Bit Field | IST12HR | | ISPOS2 | | ISPOS1 | | ISPOS0 | |
| | | Type | rw | | rw | | rw | | rw | |
| $A4_H$ | **CCU6_PISEL2 Reset: $00_H$** Port Input Select Register 2 | Bit Field | 0 | | | | | | IST13HR | |
| | | Type | r | | | | | | rw | |
| $FA_H$ | **CCU6_T12L Reset: $00_H$** Timer T12 Counter Register Low | Bit Field | T12CVL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FB_H$ | **CCU6_T12H Reset: $00_H$** Timer T12 Counter Register High | Bit Field | T12CVH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FC_H$ | **CCU6_T13L Reset: $00_H$** Timer T13 Counter Register Low | Bit Field | T13CVL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FD_H$ | **CCU6_T13H Reset: $00_H$** Timer T13 Counter Register High | Bit Field | T13CVH | | | | | | | |
| | | Type | rwh | | | | | | | |
| $FE_H$ | **CCU6_CMPSTATL Reset: $00_H$** Compare State Register Low | Bit Field | 0 | CC63ST | CCPOS2 | CCPOS1 | CCPOS0 | CC62ST | CC61ST | CC60ST |
| | | Type | r | rh | rh | rh | rh | rh | rh | rh |
| $FF_H$ | **CCU6_CMPSTATH Reset: $00_H$** Compare State Register High | Bit Field | T13IM | COUT63PS | COUT62PS | CC62PS | COUT61PS | CC61PS | COUT60PS | CC60PS |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |

### 3.2.4.11 UART1 Registers

The UART1 SFRs can be accessed in the mapped memory area (RMAP = 1).

**Table 15 UART1 Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| $C8_H$ | **SCON** **Reset: $00_H$** Serial Channel Control Register | Bit Field | SM0 | SM1 | SM2 | REN | TB8 | RB8 | TI | RI |
| | | Type | rw | rw | rw | rw | rw | rwh | rwh | rwh |
| $C9_H$ | **SBUF** **Reset: $00_H$** Serial Data Buffer Register | Bit Field | VAL | | | | | | | |
| | | Type | rwh | | | | | | | |
| $CA_H$ | **BCON** **Reset: $00_H$** Baud Rate Control Register | Bit Field | 0 | | | | BRPRE | | | R |
| | | Type | r | | | | rw | | | rw |
| $CB_H$ | **BG** **Reset: $00_H$** Baud Rate Timer/Reload Register | Bit Field | BR_VALUE | | | | | | | |
| | | Type | rwh | | | | | | | |
| $CC_H$ | **FDCON** **Reset: $00_H$** Fractional Divider Control Register | Bit Field | 0 | | | | | NDOV | FDM | FDEN |
| | | Type | r | | | | | rwh | rw | rw |
| $CD_H$ | **FDSTEP** **Reset: $00_H$** Fractional Divider Reload Register | Bit Field | STEP | | | | | | | |
| | | Type | rw | | | | | | | |
| $CE_H$ | **FDRES** **Reset: $00_H$** Fractional Divider Result Register | Bit Field | RESULT | | | | | | | |
| | | Type | rh | | | | | | | |
| $CF_H$ | **SCON1** **Reset: $07_H$** Serial Channel Control Register 1 | Bit Field | 0 | | | | | NDOV EN | TIEN | RIEN |
| | | Type | r | | | | | rw | rw | rw |

### 3.2.4.12 SSC Registers

The SSC SFRs can be accessed in the standard memory area (RMAP = 0).

**Table 16 SSC Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 | | | | | | | | | | |
| $A9_H$ | **SSC_PISEL** **Reset: $00_H$** Port Input Select Register | Bit Field | 0 | | | | | CIS | SIS | MIS |
| | | Type | r | | | | | rw | rw | rw |
| $AA_H$ | **SSC_CONL** **Reset: $00_H$** Control Register Low Programming Mode | Bit Field | LB | PO | PH | HB | BM | | | |
| | | Type | rw | rw | rw | rw | rw | | | |
| $AA_H$ | **SSC_CONL** **Reset: $00_H$** Control Register Low Operating Mode | Bit Field | 0 | | | | BC | | | |
| | | Type | r | | | | rh | | | |
| $AB_H$ | **SSC_CONH** **Reset: $00_H$** Control Register High Programming Mode | Bit Field | EN | MS | 0 | AREN | BEN | PEN | REN | TEN |
| | | Type | rw | rw | r | rw | rw | rw | rw | rw |

**Table 16 SSC Register Overview** (cont'd)

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| $AB_H$ | **SSC_CONH** **Reset: $00_H$** Control Register High Operating Mode | Bit Field | EN | MS | 0 | BSY | BE | PE | RE | TE |
| | | Type | rw | rw | r | rh | rwh | rwh | rwh | rwh |
| $AC_H$ | **SSC_TBL** **Reset: $00_H$** Transmitter Buffer Register Low | Bit Field | TB_VALUE | | | | | | | |
| | | Type | rw | | | | | | | |
| $AD_H$ | **SSC_RBL** **Reset: $00_H$** Receiver Buffer Register Low | Bit Field | RB_VALUE | | | | | | | |
| | | Type | rh | | | | | | | |
| $AE_H$ | **SSC_BRL** **Reset: $00_H$** Baud Rate Timer Reload Register Low | Bit Field | BR_VALUE | | | | | | | |
| | | Type | rw | | | | | | | |
| $AF_H$ | **SSC_BRH** **Reset: $00_H$** Baud Rate Timer Reload Register High | Bit Field | BR_VALUE | | | | | | | |
| | | Type | rw | | | | | | | |

### 3.2.4.13 MultiCAN Registers

The MultiCAN SFRs can be accessed in the standard memory area (RMAP = 0).

**Table 17 CAN Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 0 | | | | | | | | | | |
| **$D8_H$** | **ADCON** **Reset: $00_H$** CAN Address/Data Control Register | Bit Field | V3 | V2 | V1 | V0 | AUAD | | BSY | RWEN |
| | | Type | rw | rw | rw | rw | rw | | rh | rw |
| $D9_H$ | **ADL** **Reset: $00_H$** CAN Address Register Low | Bit Field | CA9 | CA8 | CA7 | CA6 | CA5 | CA4 | CA3 | CA2 |
| | | Type | rwh | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $DA_H$ | **ADH** **Reset: $00_H$** CAN Address Register High | Bit Field | 0 | | | | CA13 | CA12 | CA11 | CA10 |
| | | Type | r | | | | rwh | rwh | rwh | rwh |
| $DB_H$ | **DATA0** **Reset: $00_H$** CAN Data Register 0 | Bit Field | CD | | | | | | | |
| | | Type | rwh | | | | | | | |
| $DC_H$ | **DATA1** **Reset: $00_H$** CAN Data Register 1 | Bit Field | CD | | | | | | | |
| | | Type | rwh | | | | | | | |
| $DD_H$ | **DATA2** **Reset: $00_H$** CAN Data Register 2 | Bit Field | CD | | | | | | | |
| | | Type | rwh | | | | | | | |
| $DE_H$ | **DATA3** **Reset: $00_H$** CAN Data Register 3 | Bit Field | CD | | | | | | | |
| | | Type | rwh | | | | | | | |

### 3.2.4.14 OCDS Registers

The OCDS SFRs can be accessed in the mapped memory area (RMAP = 1).

## Table 18 OCDS Register Overview

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| $E9_H$ | **MMCR2** **Reset: $8U_H$** Monitor Mode Control 2 Register | Bit Field | STMODE | EXBC | DSUSP | MBCON | ALTDI | MMEP | MMODE | JENA |
| | | Type | rw | rw | rw | rwh | rw | rwh | rh | rh |
| $EA_H$ | **MEXTCR** **Reset: $0U_H$** Memory Extension Control Register | Bit Field | 0 | | | | BANKBPx | | | |
| | | Type | r | | | | rw | | | |
| $EB_H$ | **MMWR1** **Reset: $00_H$** Monitor Work Register 1 | Bit Field | MMWR1 | | | | | | | |
| | | Type | rw | | | | | | | |
| $EC_H$ | **MMWR2** **Reset: $00_H$** Monitor Work Register 2 | Bit Field | MMWR2 | | | | | | | |
| | | Type | rw | | | | | | | |
| $F1_H$ | **MMCR** **Reset: $00_H$** Monitor Mode Control Register | Bit Field | MEXIT_P | MEXIT | 0 | MSTEP | MRAMS_P | MRAMS | TRF | RRF |
| | | Type | w | rwh | r | rw | w | rwh | rh | rh |
| $F2_H$ | **MMSR** **Reset: $00_H$** Monitor Mode Status Register | Bit Field | MBCAM | MBCIN | EXBF | SWBF | HWB3F | HWB2F | HWB1F | HWB0F |
| | | Type | rw | rwh | rwh | rwh | rwh | rwh | rwh | rwh |
| $F3_H$ | **MMBPCR** **Reset: $00_H$** Breakpoints Control Register | Bit Field | SWBC | HWB3C | | HWB2C | | HWB1C | HWB0C | |
| | | Type | rw | rw | | rw | | rw | rw | |
| $F4_H$ | **MMICR** **Reset: $00_H$** Monitor Mode Interrupt Control Register | Bit Field | DVECT | DRETR | COMRST | MSTSEL | MMUIE_P | MMUIE | RRIE_P | RRIE |
| | | Type | rwh | rwh | rwh | rh | w | rw | w | rw |
| $F5_H$ | **MMDR** **Reset: $00_H$** Monitor Mode Data Transfer Register Receive | Bit Field | MMRR | | | | | | | |
| | | Type | rh | | | | | | | |
| $F6_H$ | **HWBPSR** **Reset: $00_H$** Hardware Breakpoints Select Register | Bit Field | 0 | | | BPSEL_P | BPSEL | | | |
| | | Type | r | | | w | rw | | | |
| $F7_H$ | **HWBPDR** **Reset: $00_H$** Hardware Breakpoints Data Register | Bit Field | HWBPxx | | | | | | | |
| | | Type | rw | | | | | | | |

### 3.2.4.15 Flash Registers

The Flash SFRs can be accessed in the mapped memory area (RMAP = 1).

**Table 19 Flash Register Overview**

| Addr | Register Name | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| RMAP = 1 | | | | | | | | | | |
| $D1_H$ | **FCON** **Reset: $10_H$**<br>P-Flash Control Register | Bit Field | 0 | FBSY | YE | 1 | NVSTR | MAS1 | ERASE | PROG |
| | | Type | r | rh | rwh | r | rw | rw | rw | rw |
| $D2_H$ | **EECON** **Reset: $10_H$**<br>D-Flash Control Register | Bit Field | 0 | EEBSY | YE | 1 | NVSTR | MAS1 | ERASE | PROG |
| | | Type | r | rh | rwh | r | rw | rw | rw | rw |
| $D3_H$ | **FCS** **Reset: $80_H$**<br>Flash Control and Status Register | Bit Field | 1 | SBEIE | FTEN | 0 | EEDERR | EESERR | FDERR | FSERR |
| | | Type | r | rw | rwh | r | rwh | rwh | rwh | rwh |
| $D4_H$ | **FEAL** **Reset: $00_H$**<br>Flash Error Address Register, Low Byte | Bit Field | ECCEADDR | | | | | | | |
| | | Type | rh | | | | | | | |
| $D5_H$ | **FEAH** **Reset: $00_H$**<br>Flash Error Address Register, High Byte | Bit Field | ECCEADDR | | | | | | | |
| | | Type | rh | | | | | | | |
| $D6_H$ | **FTVAL** **Reset: $78_H$**<br>Flash Timer Value Register | Bit Field | MODE | OFVAL | | | | | | |
| | | Type | rw | rw | | | | | | |
| $DD_H$ | **FCS1** **Reset: $00_H$**<br>Flash Control and Status Register 1 | Bit Field | 0 | | | | | | | EEABORT |
| | | Type | r | | | | | | | rwh |

## 3.3 Flash Memory

The Flash memory provides an embedded user-programmable non-volatile memory, allowing fast and reliable storage of user code and data. It is operated from a single 2.5 V supply from the Embedded Voltage Regulator (EVR) and does not require additional programming or erasing voltage. The pagination of the Flash memory allows each page to be erased independently.

### Features

- In-System Programming (ISP) via UART
- In-Application Programming (IAP)
- Error Correction Code (ECC) for dynamic correction of single-bit errors
- Background program and erase operations for CPU load minimization
- Support for aborting erase operation
- Minimum program width
- of 1-byte for D-Flash and 2-bytes for P-Flash
- 1-page minimum erase width
- 1-byte read access
- Flash is delivered in erased state (read all ones)
- Operating supply voltage: 2.5 V ± 7.5 %
- Read access time: 1 × $t_{CCLK}$ = 38 ns[1)]
- Program time for 1 wordline: 1.6 ms[2)]
- Page erase time: 20 ms
- Mass erase time: 200 ms

1) Values shown here are typical values. $f_{sys}$ = 144 MHz ± 7.5% ($f_{CCLK}$ = 24 MHz ± 7.5 %) is the maximum frequency range for Flash read access.

2) Values shown here are typical values. $f_{sys}$ = 144 MHz ± 7.5% ($f_{CCLK}$ = 24 MHz ± 7.5 %) is the typical frequency range for Flash programming and erasing. $f_{sysmin}$ is used for obtaining the worst case timing.

Table 20 and Table 21 shows the Flash data retention and endurance targets for Industrial profile and Automotive profile respectively.

**Table 20 Flash Data Retention and Endurance for Industrial Profile (Operating Conditions apply)**

| Retention | Endurance[1)2)] | Size | Remarks |
|---|---|---|---|
| **Program Flash** | | | |
| 15 years | 1000 cycles | up to 60 Kbytes | |
| **Data Flash** | | | |
| 15 years | 1000 cycles | 4 Kbytes | |
| 10 years | 10,000 cycles | 4 Kbytes | |
| 5 years | 30,000 cycles | 4 Kbytes | |
| 1 year | 100,000 cycles | 4 Kbytes | SAF and SAX variant |
| | 80,000 cycles | | SAK variant |

1) In Program Flash, one cycle refers to the programming of all pages in the flash bank and a mass erase.

2) In Data Flash, one cycle refers to the programming of all wordlines in a page and a page erase.

**Table 21 Flash Data Retention and Endurance for Automotive Profile (Operating Conditions apply)**

| Retention | Endurance[1)2)] | Size | Remarks |
|---|---|---|---|
| **Program Flash** | | | |
| 15 years | 1000 cycles | up to 60 Kbytes | |
| **Data Flash** | | | |
| 15 years | 1000 cycles | 4 Kbytes | |
| 5 years | 10,000 cycles | 1 Kbytes | |
| 2 years | 15,000 cycles | 512 Bytes | |
| 2 years | 30,000 cycles | 256 Bytes | |
| 1 year | 100,000 cycles | 128 Bytes | |

1) In Program Flash, one cycle refers to the programming of all pages in the flash bank and a mass erase.

2) In Data Flash, one cycle refers to the programming of all wordlines in a page and a page erase.

### 3.3.1 Flash Bank Pagination

The XC87x product family offers Flash devices with either 64 Kbytes or 52 Kbytes of embedded Flash memory. Each Flash device consists of a Program Flash (P-Flash) and a single Data Flash (D-Flash) bank. P-Flash has 120 pages of 8 wordlines per page with 64 bytes per wordline. D-Flash has 64 pages of 2 wordlines per page with 32 bytes per wordline.  Both types can be used for code and data storage.. The label “Data” neither implies that the D-Flash is mapped to the data memory region, nor that it can only be used for data storage. It is used to distinguish the different page width and wordline of each Flash bank.

The internal structure of each Flash bank represents a page architecture for flexible erase capability. The minimum erase width is always a complete page. The D-Flash bank is divided into smaller size for extended erasing and reprogramming capability; even numbers for each page size are provided to allow greater flexibility and the ability to adapt to a wide range of application requirements.

## 3.4 Interrupt System

The XC800 Core supports one non-maskable interrupt (NMI) and 14 maskable interrupt requests. In addition to the standard interrupt functions supported by the core, e.g., configurable interrupt priority and interrupt masking, the XC87x interrupt system provides extended interrupt support capabilities such as the mapping of each interrupt vector to several interrupt sources to increase the number of interrupt sources supported, and additional status registers for detecting and determining the interrupt source.

### 3.4.1 Interrupt Source

**Figure 12** to **Figure 16** give a general overview of the interrupt sources and nodes, and their corresponding control and status flags.

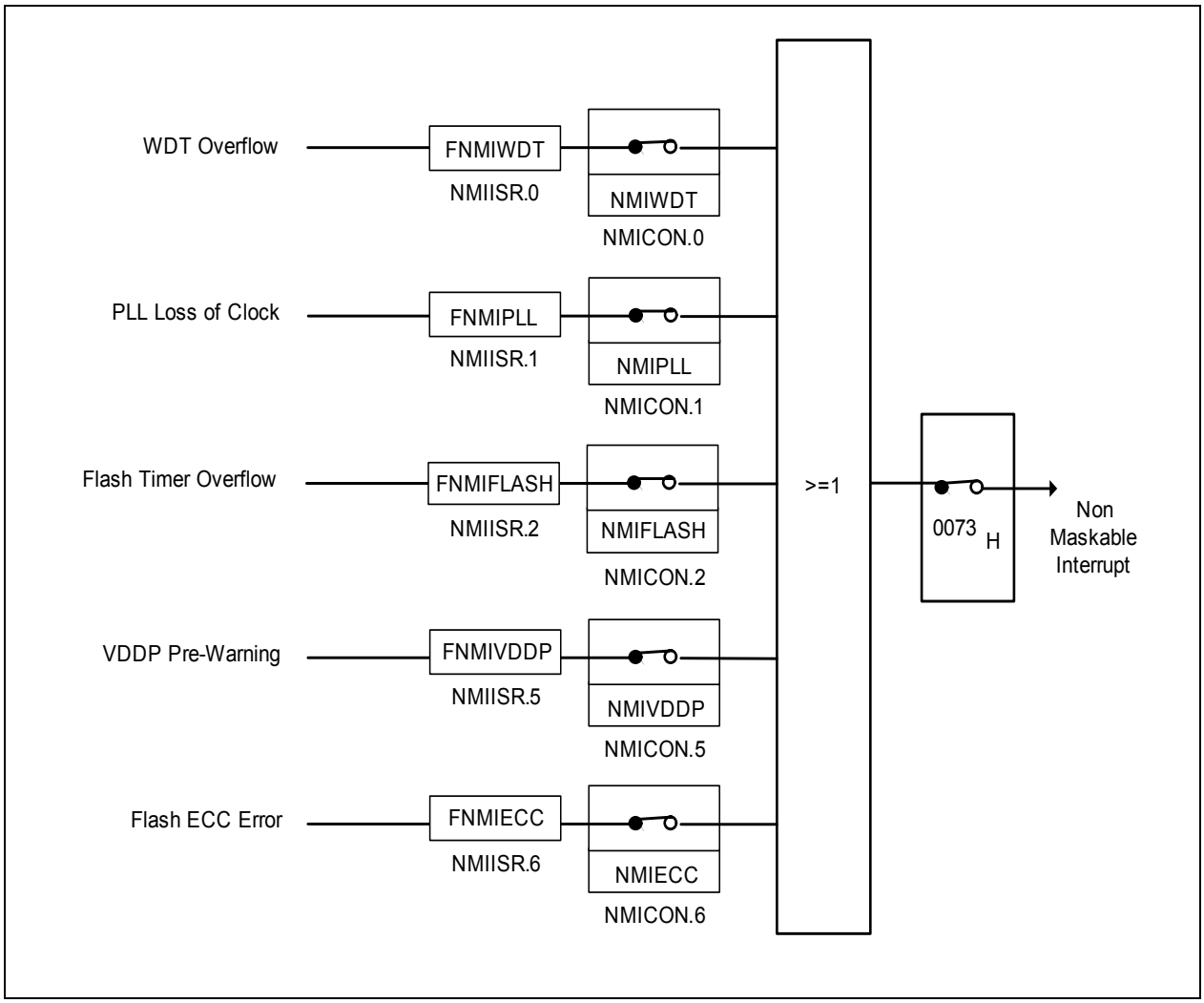



**Figure 12 Non-Maskable Interrupt Request Sources**

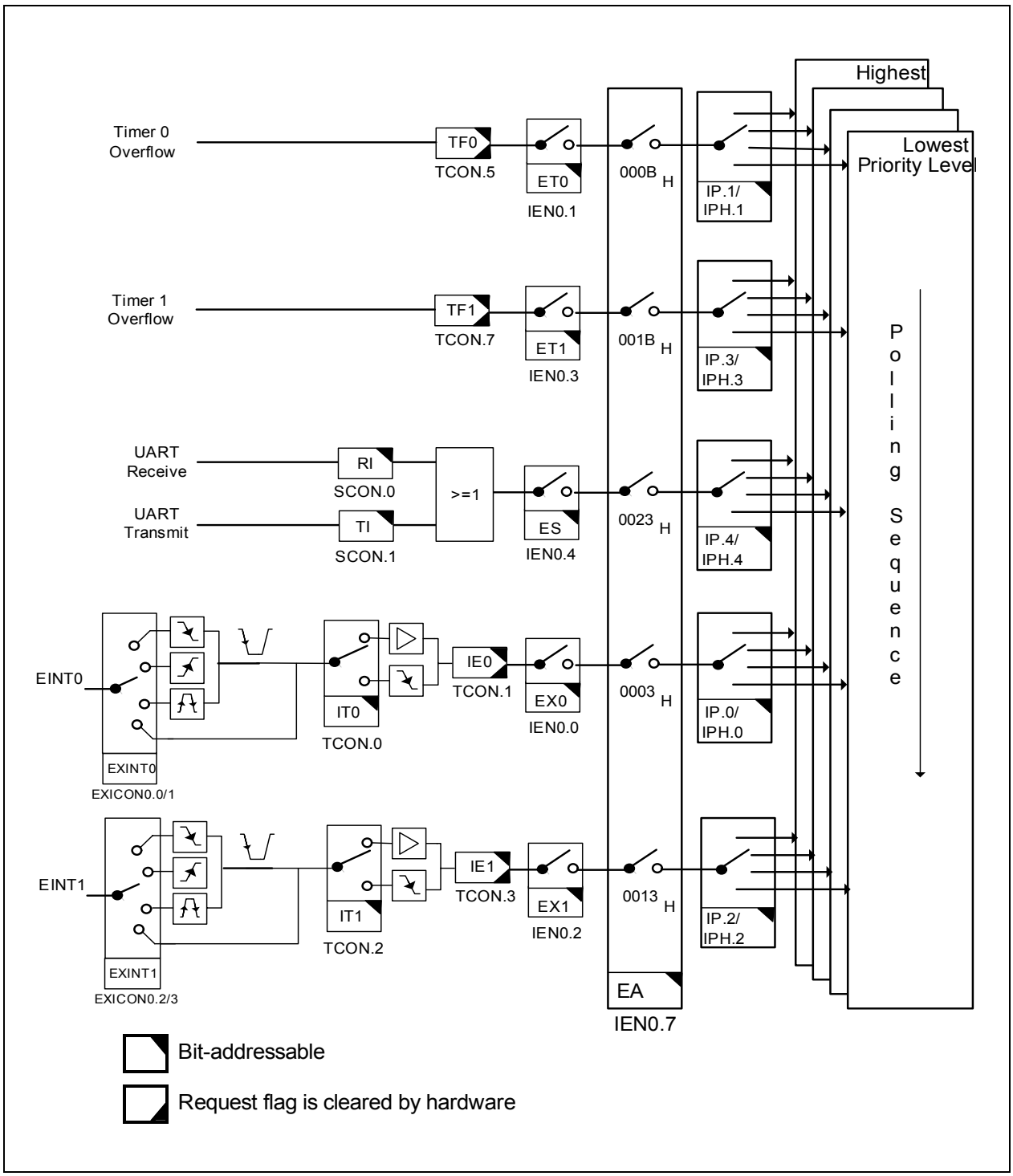



**Figure 13 Interrupt Request Sources (Part 1)**

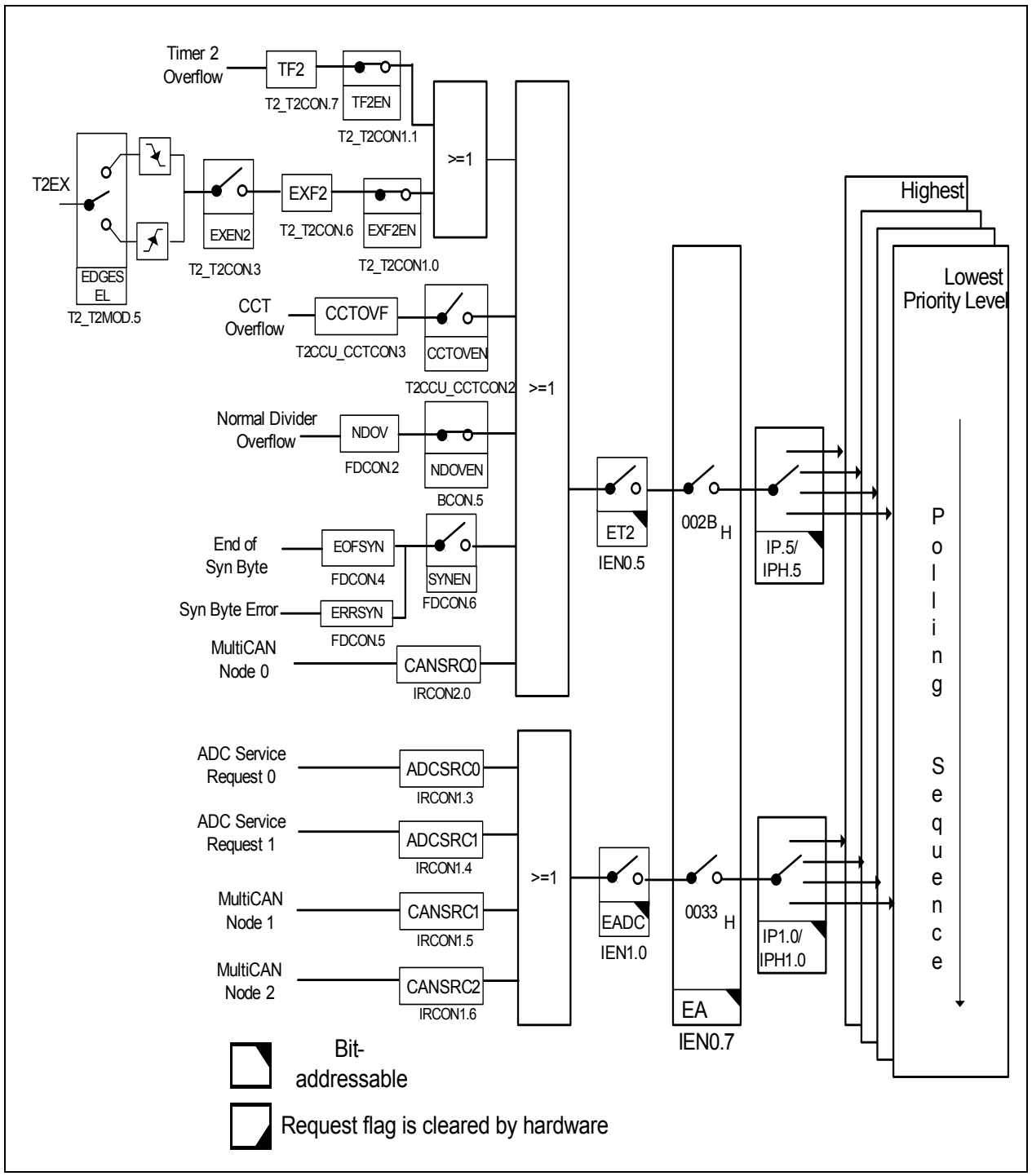



**Figure 14 Interrupt Request Sources (Part 2)**

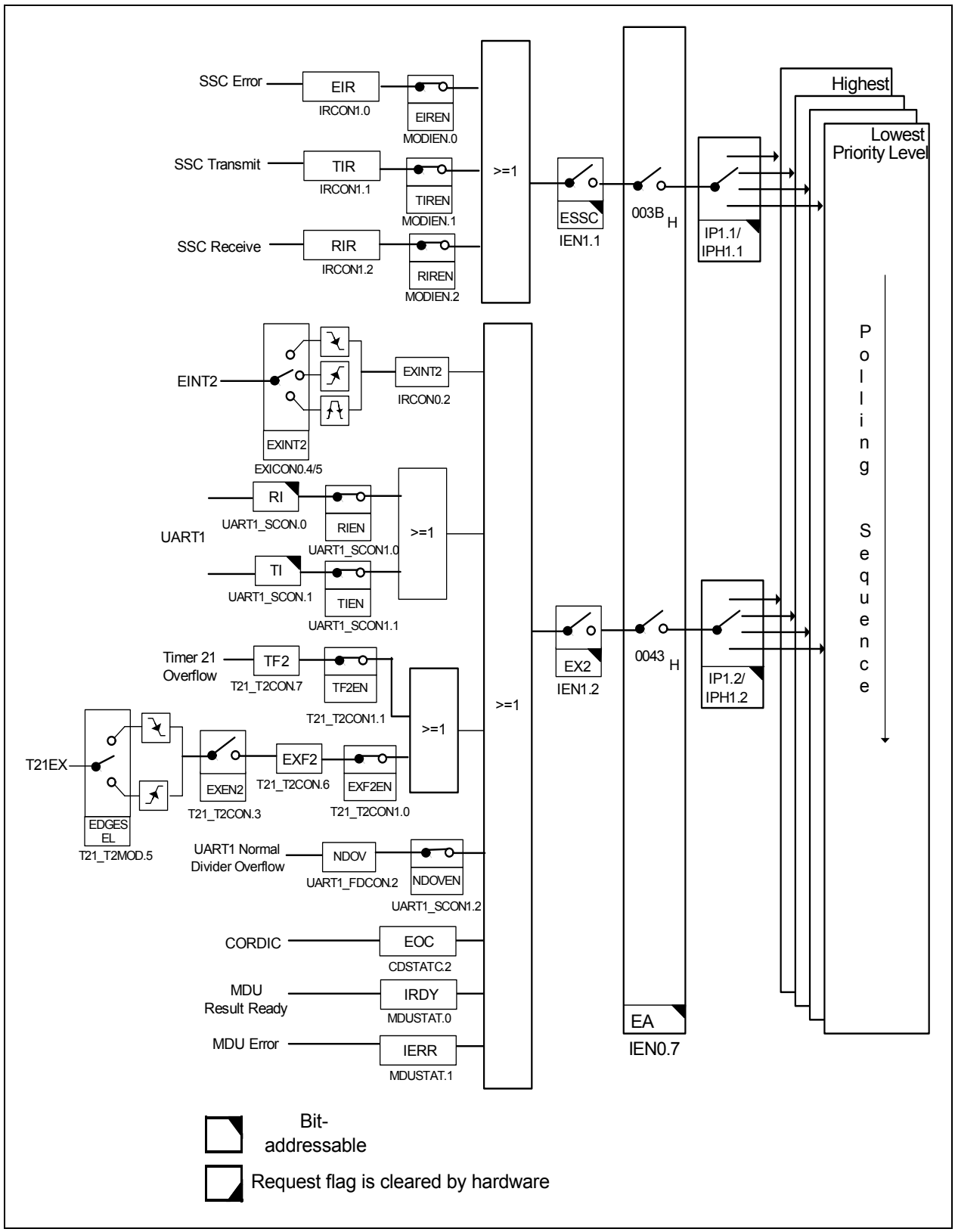



**Figure 15 Interrupt Request Sources (Part 3)**

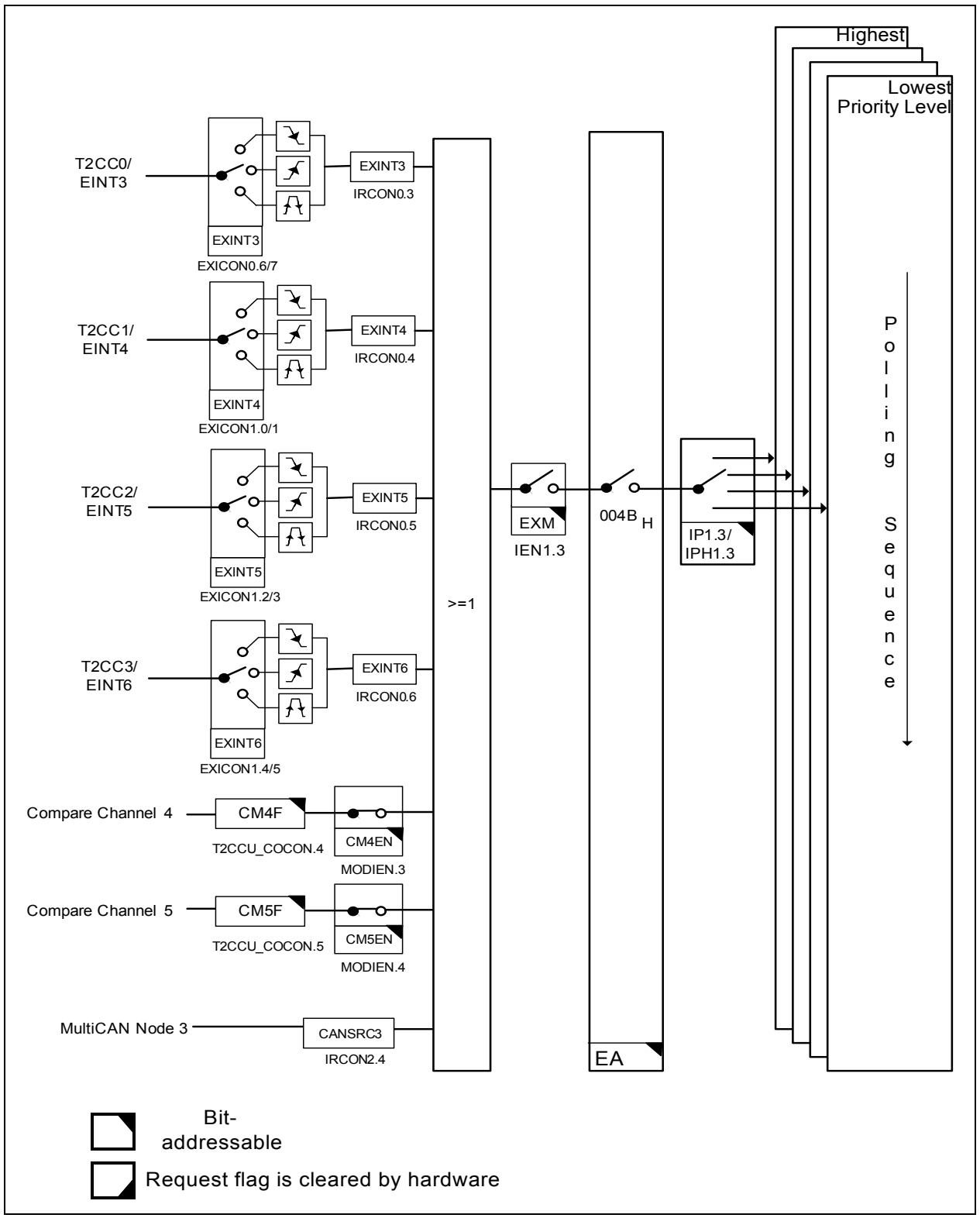



**Figure 16 Interrupt Request Sources (Part 4)**

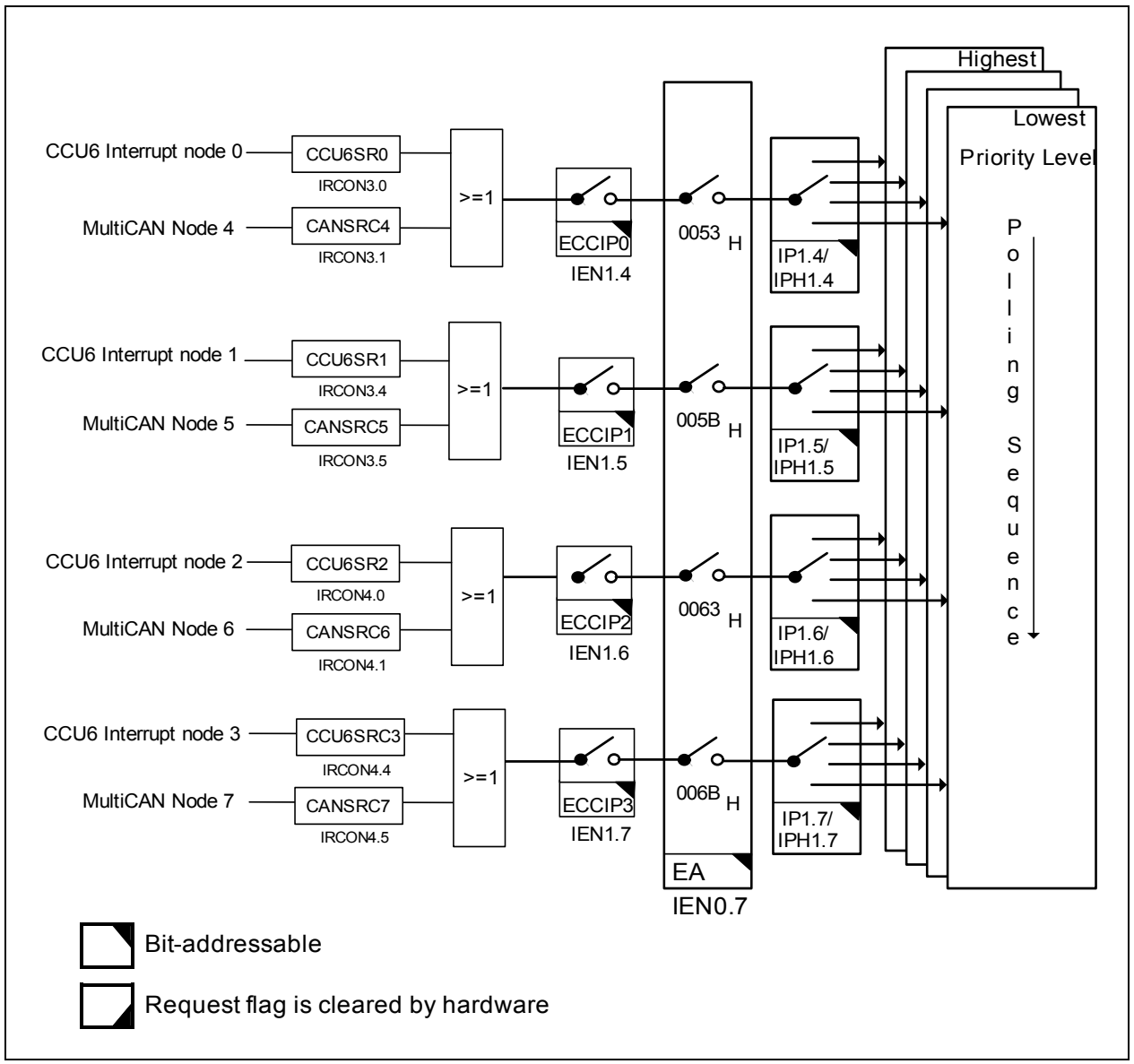



**Figure 17 Interrupt Request Sources (Part 5)**

### 3.4.2 Interrupt Source and Vector

Each interrupt event source has an associated interrupt vector address for the interrupt node it belongs to. This vector is accessed to service the corresponding interrupt node request. The interrupt service of each interrupt source can be individually enabled or disabled via an enable bit. The assignment of the XC87x interrupt sources to the interrupt vector address and the corresponding interrupt node enable bits are summarized in **Table 22**.

**Table 22 Interrupt Vector Addresses**

| Interrupt Source | Vector Address | Assignment for XC87x | Enable Bit | SFR |
|---|---|---|---|---|
| NMI | $0073_H$ | Watchdog Timer NMI | NMIWDT | NMICON |
| | | PLL NMI | NMIPLL | |
| | | Flash Timer NMI | NMIFLASH | |
| | | $V_{DDP}$ Prewarning NMI | NMIVDDP | |
| | | Flash ECC NMI | NMIECC | |
| XINTR0 | $0003_H$ | External Interrupt 0 | EX0 | IEN0 |
| XINTR1 | $000B_H$ | Timer 0 | ET0 | |
| XINTR2 | $0013_H$ | External Interrupt 1 | EX1 | |
| XINTR3 | $001B_H$ | Timer 1 | ET1 | |
| XINTR4 | $0023_H$ | UART | ES | |
| XINTR5 | $002B_H$ | T2CCU | ET2 | |
| | | UART Fractional Divider (Normal Divider Overflow) | | |
| | | MultiCAN Node 0 | | |
| | | LIN | | |

**Table 22 Interrupt Vector Addresses** (cont'd)

| Interrupt Source | Vector Address | Assignment for XC87x | Enable Bit | SFR |
|---|---|---|---|---|
| XINTR6 | $0033_H$ | MultiCAN Nodes 1 and 2 | EADC | IEN1 |
| | | ADC[1:0] | | |
| XINTR7 | $003B_H$ | SSC | ESSC | |
| XINTR8 | $0043_H$ | External Interrupt 2 | EX2 | |
| | | T21 | | |
| | | CORDIC | | |
| | | UART1 | | |
| | | UART1 Fractional Divider (Normal Divider Overflow) | | |
| | | MDU[1:0] | | |
| XINTR9 | $004B_H$ | External Interrupt 3 | EXM | |
| | | External Interrupt 4 | | |
| | | External Interrupt 5 | | |
| | | External Interrupt 6 | | |
| | | T2CCU | | |
| | | MultiCAN Node 3 | | |
| XINTR10 | $0053_H$ | CCU6 INP0 | ECCIP0 | |
| | | MultiCAN Node 4 | | |
| XINTR11 | $005B_H$ | CCU6 INP1 | ECCIP1 | |
| | | MultiCAN Node 5 | | |
| XINTR12 | $0063_H$ | CCU6 INP2 | ECCIP2 | |
| | | MultiCAN Node 6 | | |
| XINTR13 | $006B_H$ | CCU6 INP3 | ECCIP3 | |
| | | MultiCAN Node 7 | | |

### 3.4.3 Interrupt Priority

An interrupt that is currently being serviced can only be interrupted by a higher-priority interrupt, but not by another interrupt of the same or lower priority. Hence, an interrupt of the highest priority cannot be interrupted by any other interrupt request.

If two or more requests of different priority levels are received simultaneously, the request of the highest priority is serviced first. If requests of the same priority are received simultaneously, then an internal polling sequence determines which request is serviced first. Thus, within each priority level, there is a second priority structure determined by the polling sequence shown in **Table 23**.

**Table 23 Priority Structure within Interrupt Level**

| Source | Level |
|---|---|
| Non-Maskable Interrupt (NMI) | (highest) |
| External Interrupt 0 | 1 |
| Timer 0 Interrupt | 2 |
| External Interrupt 1 | 3 |
| Timer 1 Interrupt | 4 |
| UART Interrupt | 5 |
| T2CCU,UART Normal Divider Overflow, MultiCAN, LIN Interrupt | 6 |
| ADC, MultiCAN Interrupt | 7 |
| SSC Interrupt | 8 |
| External Interrupt 2, Timer 21, UART1, UART1 Normal Divider Overflow, MDU, CORDIC Interrupt | 9 |
| External Interrupt [6:3], MultiCAN Interrupt | 10 |
| CCU6 Interrupt Node Pointer 0, MultiCAN interrupt | 11 |
| CCU6 Interrupt Node Pointer 1, MultiCAN Interrupt | 12 |
| CCU6 Interrupt Node Pointer 2, MultiCAN Interrupt | 13 |
| CCU6 Interrupt Node Pointer 3, MultiCAN Interrupt | 14 |

## 3.5 Parallel Ports

The XC87x has 40 port pins organized into five parallel ports: Port 0 (P0), Port 1 (P1), Port 3 (P3), Port 4 (P4) and Port 5 (P5). Each pin has a pair of internal pull-up and pull-down devices that can be individually enabled or disabled. These ports are bidirectional and can be used as general purpose input/output (GPIO) or to perform alternate input/output functions for the on-chip peripherals. When configured as an output, the open drain mode can be selected.

**Bidirectional Port Features**

- Configurable pin direction
- Configurable pull-up/pull-down devices
- Configurable open drain mode
- Configurable drive strength
- Transfer of data through digital inputs and outputs (general purpose I/O)
- Alternate input/output for on-chip peripherals

**Figure 18** shows the structure of a bidirectional port pin.

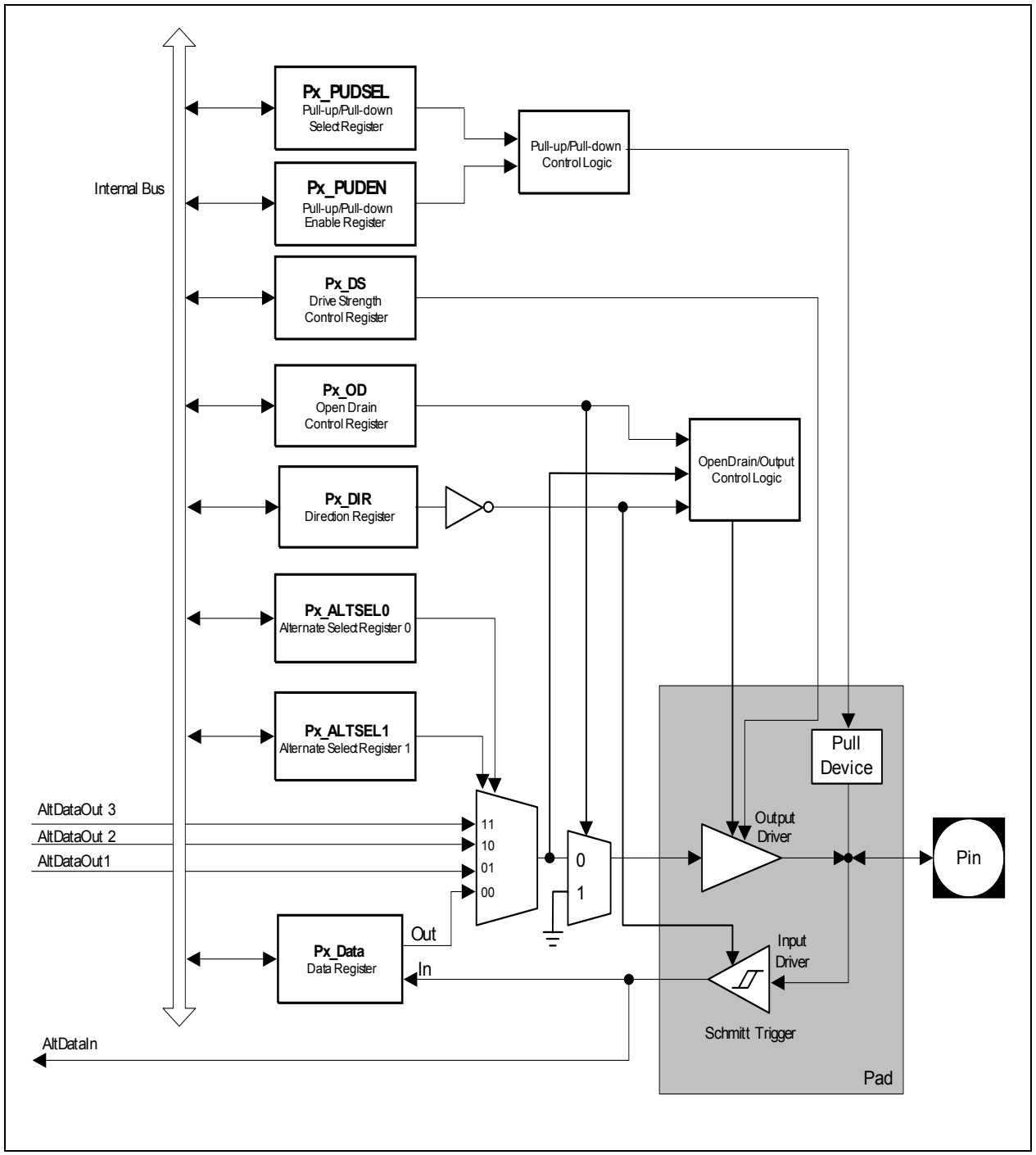



**Figure 18 General Structure of Bidirectional Port**

## 3.6 Power Supply System with Embedded Voltage Regulator

The XC87x microcontroller requires two different levels of power supply:

- 3.3 V or 5.0 V for the Embedded Voltage Regulator (EVR) and Ports
- 2.5 V for the core, memory, on-chip oscillator, and peripherals

**Figure 19** shows the XC87x power supply system. A power supply of 3.3 V or 5.0 V must be provided from the external power supply pin. The 2.5 V power supply for the logic is generated by the EVR. The EVR helps to reduce the power consumption of the whole chip and the complexity of the application board design.

The EVR consists of a main voltage regulator and a low power voltage regulator. In active mode, both voltage regulators are enabled. In power-down mode[1)], the main voltage regulator is switched off, while the low power voltage regulator continues to function and provide power supply to the system with low power consumption.

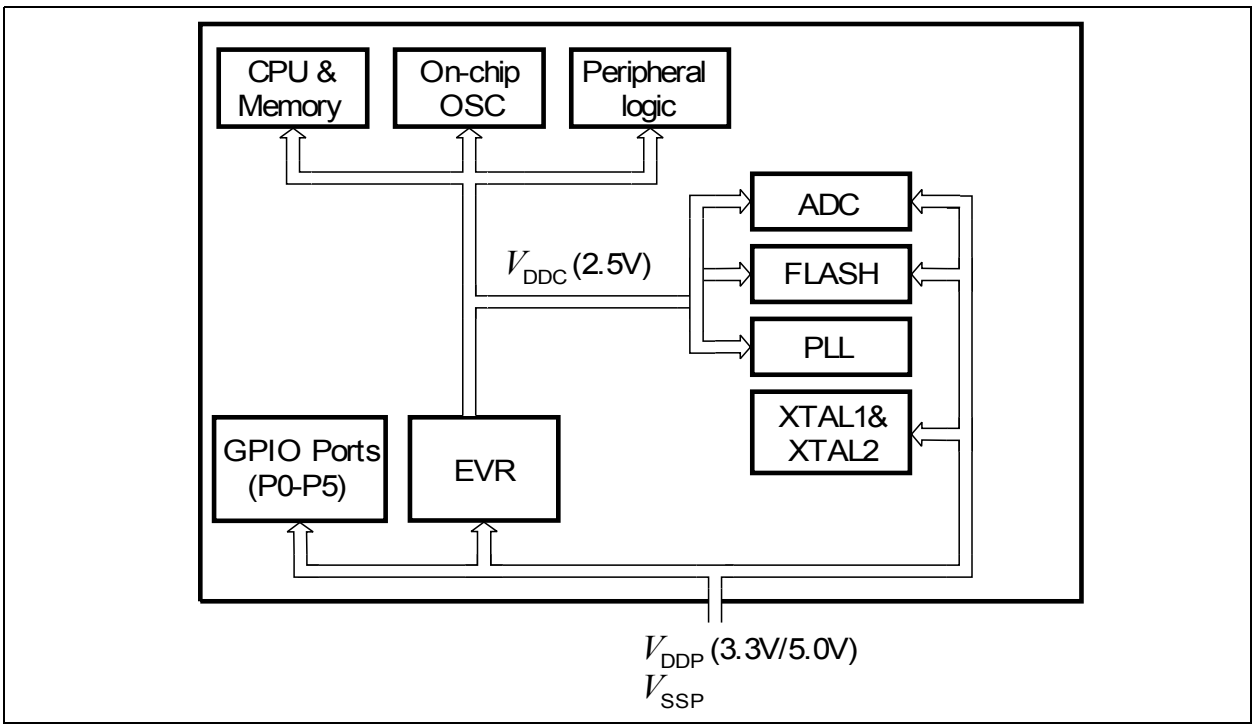



**Figure 19 XC87x Power Supply System**

### EVR Features

- Input voltage ($V_{DDP}$): 3.3 V/5.0 V
- Output voltage ($V_{DDC}$): 2.5 V ± 7.5%
- Low power voltage regulator provided in power-down mode[1)]
- $V_{DDP}$ prewarning detection
- $V_{DDC}$ brownout detection

1) SAK product variant does not support power-down mode.

## 3.7 Reset Control

The XC87x has five types of reset: power-on reset, hardware reset, watchdog timer reset, power-down wake-up reset, and brownout reset.

When the XC87x is first powered up, the status of certain pins (see **Table 25**) must be defined to ensure proper start operation of the device. At the end of a reset sequence, the sampled values are latched to select the desired boot option, which cannot be modified until the next power-on reset or hardware reset. This guarantees stable conditions during the normal operation of the device.

The second type of reset in XC87x is the hardware reset. This reset function can be used during normal operation or when the chip is in power-down mode. A reset input pin $\overline{\text{RESET}}$ is provided for the hardware reset.

The Watchdog Timer (WDT) module is also capable of resetting the device if it detects a malfunction in the system.

Another type of reset that needs to be detected is a reset while the device is in power-down mode (wake-up reset). While the contents of the static RAM are undefined after a power-on reset, they are well defined after a wake-up reset from power-down mode.

### 3.7.1 Module Reset Behavior

**Table 24** lists the functions of the XC87x and the various reset types that affect these functions. The symbol "■" signifies that the particular function is reset to its default state.

**Table 24 Effect of Reset on Device Functions**

| Module/ Function | Wake-Up Reset | Watchdog Reset | Hardware Reset | Power-On Reset | Brownout Reset |
|---|---|---|---|---|---|
| **CPU Core** | ■ | ■ | ■ | ■ | ■ |
| **Peripherals** | ■ | ■ | ■ | ■ | ■ |
| **On-Chip Static RAM** | Not affected, Reliable | Not affected, Reliable | Not affected, Reliable | Affected, un-reliable | Affected, un-reliable |
| **Oscillator, PLL** | ■ | Not affected | ■ | ■ | ■ |
| **Port Pins** | ■ | ■ | ■ | ■ | ■ |
| **EVR** | The voltage regulator is switched on | Not affected | Not affected | ■ | ■ |
| **FLASH** | ■ | ■ | ■ | ■ | ■ |
| **NMI** | Disabled | Disabled | ■ | ■ | ■ |

### 3.7.2 Booting Scheme

When the XC87x is reset, it must identify the type of configuration with which to start the different modes once the reset sequence is complete. Thus, boot configuration information that is required for activation of special modes and conditions needs to be applied by the external world through input pins. After power-on reset or hardware reset, the pins MBC, TMS and P0.0 collectively select the different boot options. **Table 25** shows the available boot options in the XC87x.

**Table 25 XC87x Boot Selection [1)]**

| MBC | TMS | P0.0 | Type of Mode | PC Start Value |
|---|---|---|---|---|
| 1 | 0 | X | User Mode[2)]; on-chip OSC/PLL non-bypassed | $0000_H$ |
| 0 | 0 | X | BSL Mode; (LIN Mode[3)], UART/ MultiCAN Mode[4)5)] and Alternate BSL Mode[6)]); on-chip OSC/PLL non-bypassed | $0000_H$ |
| 0 | 1 | 0 | OCDS Mode; on-chip OSC/PLL non-bypassed | $0000_H$ |
| 1 | 1 | 0 | User (JTAG) Mode[7)]; on-chip OSC/PLL non-bypassed (normal) | $0000_H$ |

1) In addition to the pins MBC, TMS and P0.0, TM pin also requires an external pull down for all the boot options.

2) BSL mode is automatically entered if no valid password is installed and data at memory address 0000H equals zero.

3) If a device is programmed as LIN, LIN BSL is always used instead of UART/MultiCAN.

4) UART or MultiCAN BSL is decoded by firmware based on the protocol for product variant with MultiCAN. If no MultiCAN and LIN variant, UART BSL is used.

5) In MultiCAN BSL mode, the clock source is switched to XTAL by firmware, bypassing the on-chip oscillator. This avoids any frequency invariance with the on-chip oscillator and allows other frequency clock input, thus ensuring accurate baud rate detection (especially at high bit rates).

6) Alternate BSL Mode is a user defined BSL code programmed in Flash. It is entered if the AltBSLPassword is valid.

7) Normal user mode with standard JTAG (TCK,TDI,TDO) pins for hot-attach purpose.

*Note: The boot options are valid only with the default set of UART and JTAG pins.*

## 3.8 Clock Generation Unit

The Clock Generation Unit (CGU) allows great flexibility in the clock generation for the XC87x. The power consumption is indirectly proportional to the frequency, whereas the performance of the microcontroller is directly proportional to the frequency. During user program execution, the frequency can be programmed for an optimal ratio between performance and power consumption. Therefore the power consumption can be adapted to the actual application state.

### Features

- Phase-Locked Loop (PLL) for multiplying clock source by different factors
- PLL Base Mode
- Prescaler Mode
- PLL Mode
- Power-down mode support[1)]

The CGU consists of an oscillator circuit and a PLL. In the XC87x, the oscillator can be from either of these two sources: the on-chip oscillator (4 MHz) or the external oscillator (2 MHz to 20 MHz). The term “oscillator” is used to refer to both on-chip oscillator and external oscillator, unless otherwise stated. After the reset, the on-chip oscillator will be used by default.The external oscillator can be selected via software. In addition, the PLL provides a fail-safe logic to perform oscillator run and loss-of-lock detection. This allows emergency routines to be executed for system recovery or to perform system shut down.

1) SAK product variant does not support power-down mode.

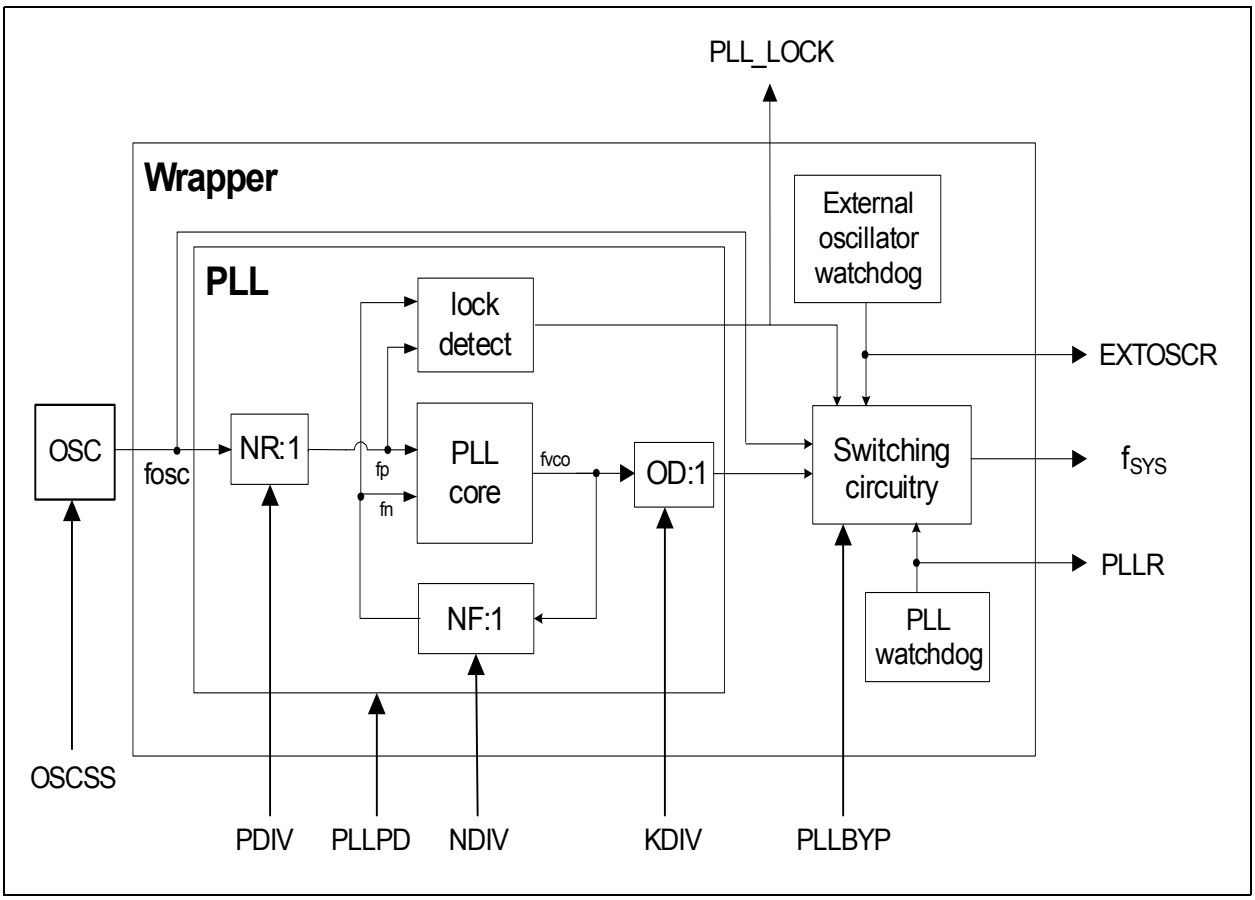



**Figure 20 CGU Block Diagram**

### Direct Drive (PLL Bypass Operation)

During PLL bypass operation, the system clock has the same frequency as the external clock source.

(3.1)

$$f_{SYS} = f_{OSC}$$

### PLL Mode

The CPU clock is derived from the oscillator clock, divided by the NR factor (PDIV), multiplied by the NF factor (NDIV), and divided by the OD factor (KDIV). PLL output must

not be bypassed for this PLL mode. The PLL mode is used during normal system operation.

(3.2)

$$f_{SYS} = f_{OSC} \times \frac{NF}{NR \times OD}$$

**System Frequency Selection**

For the XC87x, the value of NF, NR and OD can be selected by bits NDIV, PDIV and KDIV respectively for different oscillator inputs inorder to obtain the required fsys. But the combination of these factors must fulfill the following condition:

- 100 MHz < $f_{VCO}$ < 175 MHz
- 800 KHz < $f_{OSC}$ / (2 * NR) < 8 MHz

**Table 26** provides examples on how the typical system frequency of fsys = 144 MHz and maximum frequency of 160 MHz (CPU clock = 26.67 MHz)can be obtained for the different oscillator sources.

**Table 26 System frequency ($f_{sys}$ = 144 MHz)**

| Oscillator | fosc | N | P | K | fsys |
|---|---|---|---|---|---|
| On-chip | 4 MHz | 72 | 2 | 1 | 144 MHz |
| | 4 MHz | 80 | 2 | 1 | 160 MHz |
| External | 8 MHz | 72 | 4 | 1 | 144 MHz |
| | 6 MHz | 72 | 3 | 1 | 144 MHz |
| | 4 MHz | 72 | 2 | 1 | 144 MHz |

### 3.8.1 Recommended External Oscillator Circuits

The oscillator circuit, a Pierce oscillator, is designed to work with both, an external crystal oscillator or an external stable clock source. It basically consists of an inverting amplifier and a feedback element with XTAL1 as input, and XTAL2 as output.

When using a crystal, a proper external oscillator circuitry must be connected to both pins, XTAL1 and XTAL2. The crystal frequency can be within the range of 2 MHz to 20 MHz. Additionally, it is necessary to have two load capacitances $C_{X1}$ and $C_{X2}$, and depending on the crystal type, a series resistor $R_{X2}$, to limit the current. A test resistor $R_Q$ may be temporarily inserted to measure the oscillation allowance (negative resistance) of the oscillator circuitry. $R_Q$ values are typically specified by the crystal vendor. An external feedback resistor $R_f$ is also required in the external oscillator circuitry. The exact values and related operating range are dependent on the crystal frequency and have to be determined and optimized together with the crystal vendor using the negative

resistance method. Oscillation measurement with the final target system is strongly recommended to verify the input amplitude at XTAL1 and to determine the actual oscillation allowance (margin negative resistance) for the oscillator-crystal system.

When using an external clock signal, the signal must be connected to XTAL1. XTAL2 is left open (unconnected).

The oscillator can also be used in combination with a ceramic resonator. The final circuitry must also be verified by the resonator vendor. **Figure 21** shows the recommended external oscillator circuitries for both operating modes, external crystal mode and external input clock mode.

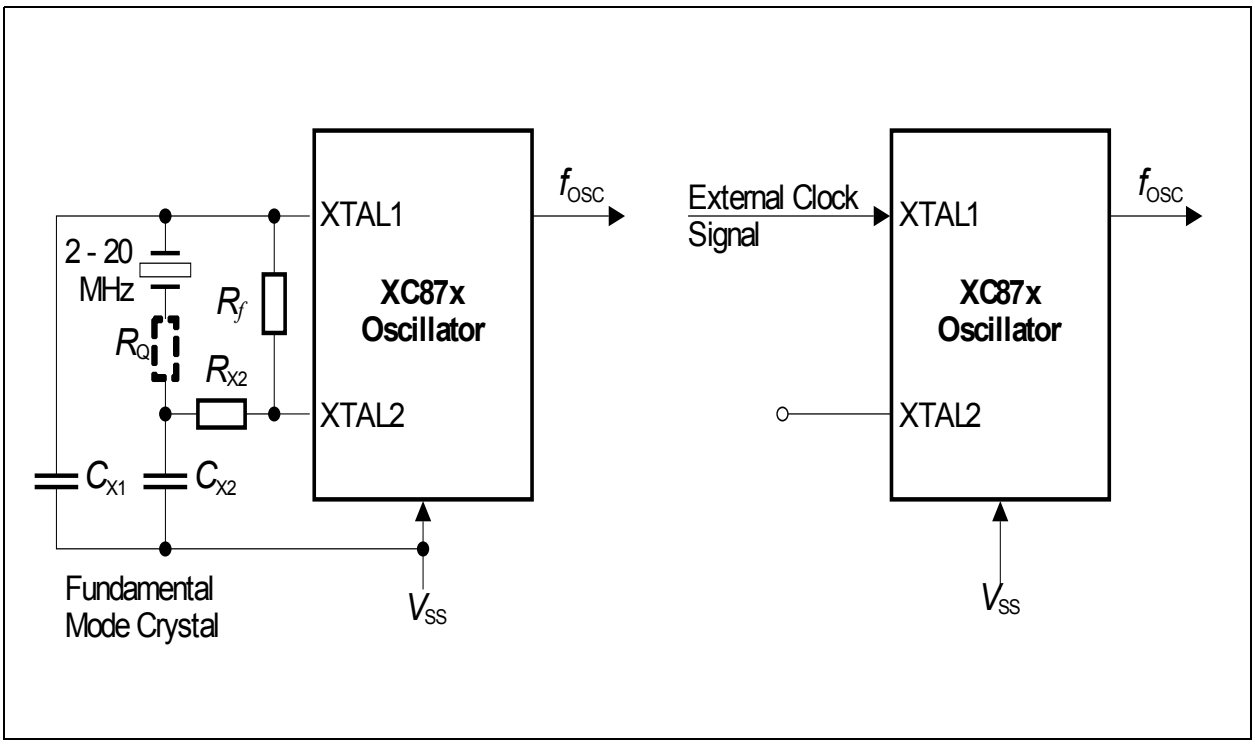



**Figure 21 External Oscillator Circuitry**

*Note: For crystal operation, it is strongly recommended to measure the negative resistance in the final target system (layout) to determine the optimum parameters for the oscillator operation. Please refer to the minimum and maximum values of the negative resistance specified by the crystal supplier.*

### 3.8.2 Clock Management

The CGU generates all clock signals required within the microcontroller from a single clock, $f_{sys}$. During normal system operation, the typical frequencies of the different modules are as follow:

- CPU clock: CCLK, SCLK = 24 MHz
- MultiCAN clock : MCANCLK = 24 or 48 MHz
- MDU clock : MDUCLK = 24 or 48 MHz
- CORDIC clock : CORDICCLK = 24 or 48 MHz
- CCU6 clock : CCU6CLK = 24 or 48 MHz
- T2CCU clock : T2CCUCLK = 24 or 48 MHz
- Peripheral clock: PCLK = 24 MHz

In addition, different clock frequencies can be output to pin CLKOUT (P0.0 or P0.7). The clock output frequency, which is derived from the clock output divider (bit COREL), can further be divided by 2 using toggle latch (bit TLEN is set to 1). The resulting output frequency has a 50% duty cycle. **Figure 22** shows the clock distribution of the XC87x.

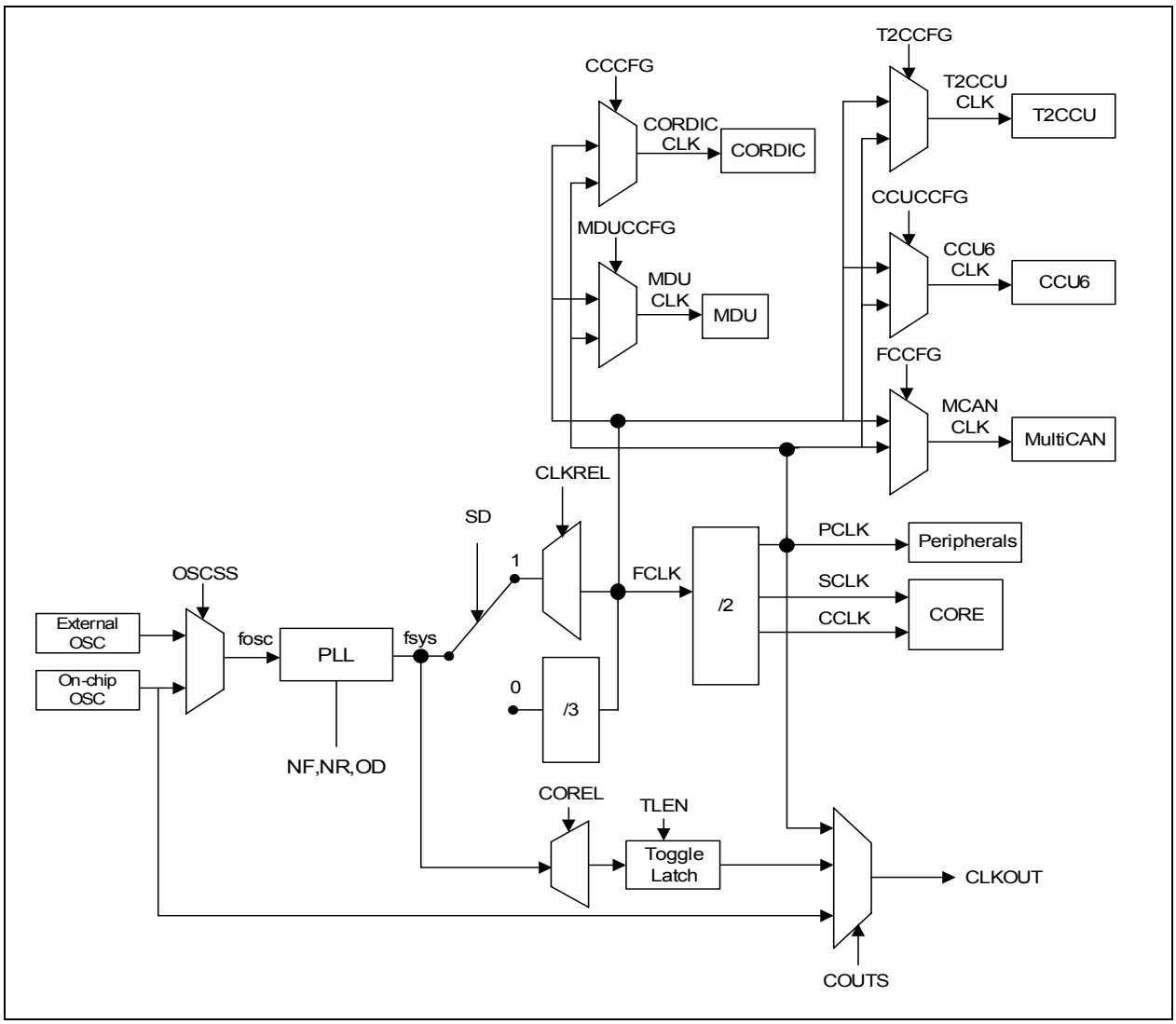



**Figure 22 Clock Generation from $f_{sys}$**

For power saving purposes, the clocks may be disabled or slowed down according to Table 27.

**Table 27 System frequency ($f_{sys}$ = 144 MHz)**

| Power Saving Mode | Action |
|---|---|
| Idle | Clock to the CPU is disabled. |
| Slow-down | Clocks to the CPU and all the peripherals are divided by a common programmable factor defined by bit field CMCON.CLKREL. |
| Power-down[1)] | Oscillator and PLL are switched off. |

1) SAK product variant does not support power-down mode.

## 3.9 Power Saving Modes

The power saving modes of the XC87x provide flexible power consumption through a combination of techniques, including:

- Stopping the CPU clock
- Stopping the clocks of individual system components
- Reducing clock speed of some peripheral components
- Power-down of the entire system with fast restart capability

After a reset, the active mode (normal operating mode) is selected by default (see **Figure 23**) and the system runs in the main system clock frequency. From active mode, different power saving modes can be selected by software. They are:

- Idle mode
- Slow-down mode
- Power-down mode

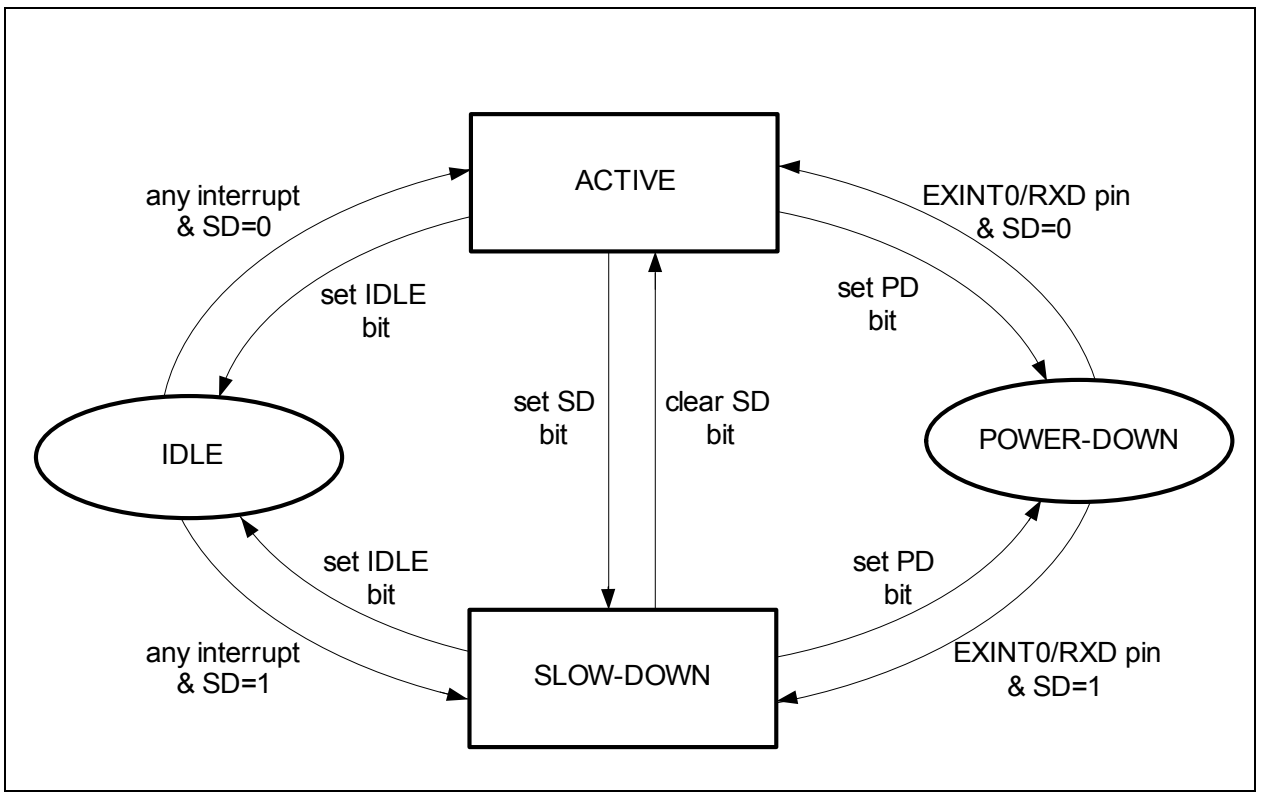



**Figure 23 Transition between Power Saving Modes**

*Note: SAK product variant does not support power-down mode.*

## 3.10 Watchdog Timer

The Watchdog Timer (WDT) provides a highly reliable and secure way to detect and recover from software or hardware failures. The WDT is reset at a regular interval that is predefined by the user. The CPU must service the WDT within this interval to prevent the WDT from causing an XC87x system reset. Hence, routine service of the WDT confirms that the system is functioning properly. This ensures that an accidental malfunction of the XC87x will be aborted in a user-specified time period.

In debug mode, the WDT is default suspended and stops counting. Therefore, there is no need to refresh the WDT during debugging.

### Features

- 16-bit Watchdog Timer
- Programmable reload value for upper 8 bits of timer
- Programmable window boundary
- Selectable input frequency of $f_{PCLK}/2$ or $f_{PCLK}/128$
- Time-out detection with NMI generation and reset prewarning activation (after which a system reset will be performed)

The WDT is a 16-bit timer incremented by a count rate of $f_{PCLK}/2$ or $f_{PCLK}/128$. This 16-bit timer is realized as two concatenated 8-bit timers. The upper 8 bits of the WDT can be preset to a user-programmable value via a watchdog service access in order to modify the watchdog expire time period. The lower 8 bits are reset on each service access. **Figure 24** shows the block diagram of the WDT unit.

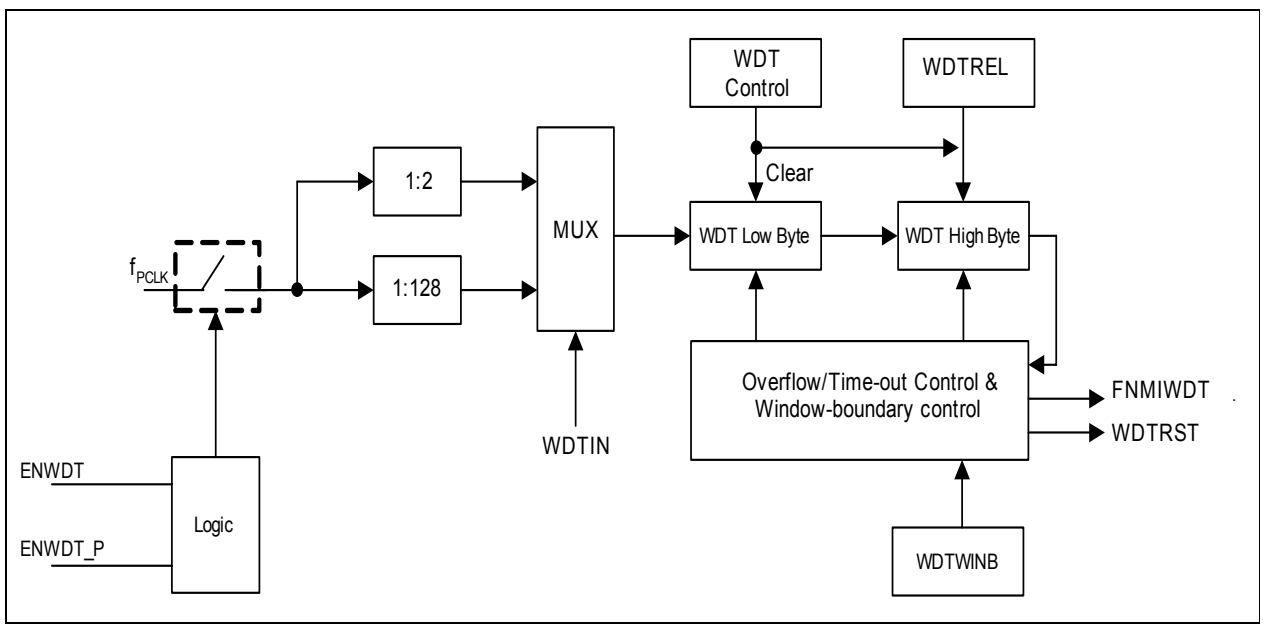



**Figure 24 WDT Block Diagram**

If the WDT is not serviced before the timer overflow, a system malfunction is assumed. As a result, the WDT NMI is triggered (assert FNMIWDT) and the reset prewarning is entered. The prewarning period lasts for $30_H$ count, after which the system is reset (assert WDTRST).

The WDT has a “programmable window boundary” which disallows any refresh during the WDT’s count-up. A refresh during this window boundary constitutes an invalid access to the WDT, causing the reset prewarning to be entered but without triggering the WDT NMI. The system will still be reset after the prewarning period is over. The window boundary is from $0000_H$ to the value obtained from the concatenation of WDTWINB and $00_H$.

After being serviced, the WDT continues counting up from the value (<WDTREL> * $2^8$). The time period for an overflow of the WDT is programmable in two ways:

- The input frequency to the WDT can be selected to be either $f_{PCLK}/2$ or $f_{PCLK}/128$
- The reload value WDTREL for the high byte of WDT can be programmed in register WDTREL

The period, $P_{WDT}$, between servicing the WDT and the next overflow can be determined by the following formula:

$$P_{WDT} = \frac{2^{(1 + WDTIN \times 6)} \times (2^{16} - WDTREL \times 2^8)}{f_{PCLK}} \quad (3.3)$$

If the Window-Boundary Refresh feature of the WDT is enabled, the period $P_{WDT}$ between servicing the WDT and the next overflow is shortened if WDTWINB is greater than WDTREL, see **Figure 25**. This period can be calculated using the same formula by replacing WDTREL with WDTWINB. For this feature to be useful, WDTWINB cannot be smaller than WDTREL.

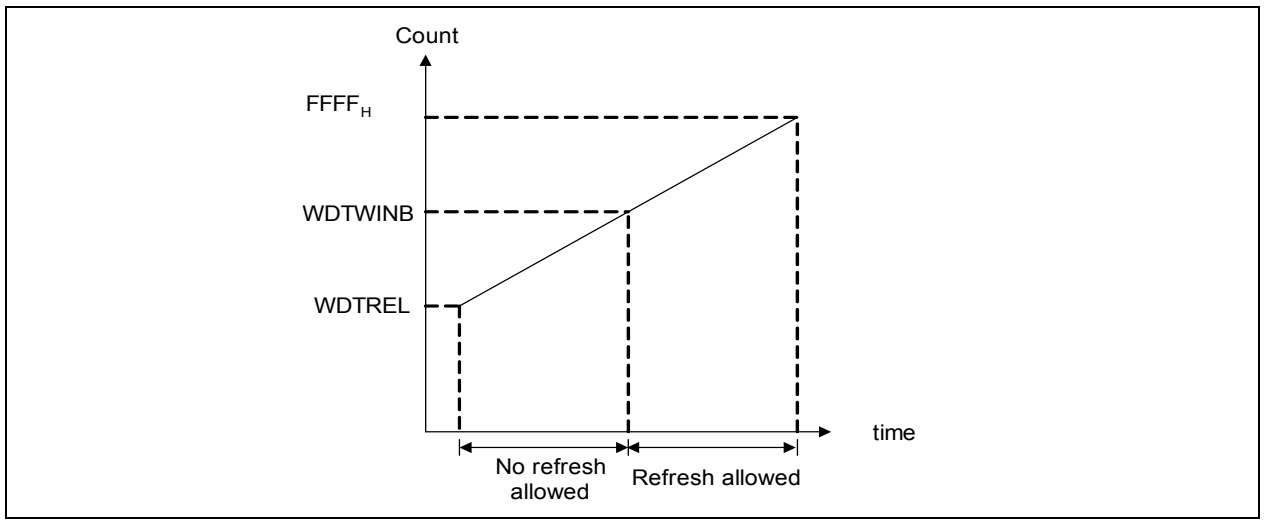



**Figure 25 WDT Timing Diagram**

Table 28 lists the possible watchdog time ranges that can be achieved using a certain module clock. Some numbers are rounded to 3 significant digits.

**Table 28 Watchdog Time Ranges**

| Reload value In WDTREL | Prescaler for $f_{PCLK}$ | |
|---|---|---|
| | **2 (WDTIN = 0)** | **128 (WDTIN = 1)** |
| | **24 MHz** | **24 MHz** |
| $FF_H$ | 21.3 µs | 1.37 ms |
| $7F_H$ | 2.75 ms | 176 ms |
| $00_H$ | 5.46 ms | 350 ms |

## 3.11 Multiplication/Division Unit

The Multiplication/Division Unit (MDU) provides fast 16-bit multiplication, 16-bit and 32-bit division as well as shift and normalize features. It has been integrated to support the XC87x Core in real-time control applications, which require fast mathematical computations.

### Features

- Fast signed/unsigned 16-bit multiplication
- Fast signed/unsigned 32-bit divide by 16-bit and 16-bit divide by 16-bit operations
- 32-bit unsigned normalize operation
- 32-bit arithmetic/logical shift operations

**Table 29** specifies the number of clock cycles used for calculation in various operations.

**Table 29 MDU Operation Characteristics**

| Operation | Result | Remainder | No. of Clock Cycles used for calculation |
|---|---|---|---|
| Signed 32-bit/16-bit | 32-bit | 16-bit | 33 |
| Signed 16-bit/16bit | 16-bit | 16-bit | 17 |
| Signed 16-bit x 16-bit | 32-bit | - | 16 |
| Unsigned 32-bit/16-bit | 32-bit | 16-bit | 32 |
| Unsigned 16-bit/16-bit | 16-bit | 16-bit | 16 |
| Unsigned 16-bit x 16-bit | 32-bit | - | 16 |
| 32-bit normalize | - | - | No. of shifts + 1 (Max. 32) |
| 32-bit shift L/R | - | - | No. of shifts + 1 (Max. 32) |

## 3.12 CORDIC Coprocessor

The CORDIC Coprocessor provides CPU with hardware support for the solving of circular (trigonometric), linear (multiply-add, divide-add) and hyperbolic functions.

**Features**

- Modes of operation
  - Supports all CORDIC operating modes for solving circular (trigonometric), linear (multiply-add, divide-add) and hyperbolic functions
  - Integrated look-up tables (LUTs) for all operating modes
- Circular vectoring mode: Extended support for values of initial X and Y data up to full range of $[-2^{15},(2^{15}-1)]$ for solving angle and magnitude
- Circular rotation mode: Extended support for values of initial Z data up to full range of $[-2^{15},(2^{15}-1)]$, representing angles in the range $[-\pi,((2^{15}-1)/2^{15})\pi]$ for solving trigonometry
- Implementation-dependent operational frequency of up to 80 MHz
- Gated clock input to support disabling of module
- 16-bit accessible data width
  - 24-bit kernel data width plus 2 overflow bits for X and Y each
  - 20-bit kernel data width plus 1 overflow bit for Z
  - With KEEP bit to retain the last value in the kernel register for a new calculation
- 16 iterations per calculation: Approximately 41 clock-cycles or less, from set of start (ST) bit to set of end-of-calculation flag, excluding time taken for write and read access of data bytes.
- Twos complement data processing
  - Only exception: X result data with user selectable option for unsigned result
- X and Y data generally accepted as integer or rational number; X and Y must be of the same data form
- Entries of LUTs are 20-bit signed integers
  - Entries of atan and atanh LUTs are integer representations (S19) of angles with the scaling such that $[-2^{15},(2^{15}-1)]$ represents the range $[-\pi,((2^{15}-1)/2^{15})\pi]$
  - Accessible Z result data for circular and hyperbolic functions is integer in data form of S15
- Emulated LUT for linear function
  - Data form is 1 integer bit and 15-bit fractional part (1.15)
  - Accessible Z result data for linear function is rational number with fixed data form of S4.11 (signed 4Q16)
- Truncation Error
  - The result of a CORDIC calculation may return an approximation due to truncation of LSBs
  - Good accuracy of the CORDIC calculated result data, especially in circular mode
- Interrupt
  - On completion of a calculation

– Interrupt enabling and corresponding flag

## 3.13 UART and UART1

The XC87x provides two Universal Asynchronous Receiver/Transmitter (UART and UART1) modules for full-duplex asynchronous reception/transmission. Both are also receive-buffered, i.e., they can commence reception of a second byte before a previously received byte has been read from the receive register. However, if the first byte still has not been read by the time reception of the second byte is complete, one of the bytes will be lost.

### Features

- Full-duplex asynchronous modes
  – 8-bit or 9-bit data frames, LSB first
  – Fixed or variable baud rate
- Receive buffered
- Multiprocessor communication
- Interrupt generation on the completion of a data transmission or reception

The UART modules can operate in the four modes shown in **Table 30**.

**Table 30 UART Modes**

| Operating Mode | Baud Rate |
|---|---|
| Mode 0: 8-bit shift register | $f_{PCLK}/2$ |
| Mode 1: 8-bit shift UART | Variable |
| Mode 2: 9-bit shift UART | $f_{PCLK}/32$ or $f_{PCLK}/64$[1)] |
| Mode 3: 9-bit shift UART | Variable |

1) For UART1 module, the baud rate is fixed at $f_{PCLK}/64$.

There are several ways to generate the baud rate clock for the serial port, depending on the mode in which it is operating. In mode 0, the baud rate for the transfer is fixed at $f_{PCLK}/2$. In mode 2, the baud rate is generated internally based on the UART input clock and can be configured to either $f_{PCLK}/32$ or $f_{PCLK}/64$. For UART1 module, only $f_{PCLK}/64$ is available. The variable baud rate is set by the underflow rate on the dedicated baud-rate generator. For UART module, the variable baud rate alternatively can be set by the overflow rate on Timer 1.

### 3.13.1 Baud-Rate Generator

Both UART modules have their own dedicated baud-rate generator, which is based on a programmable 8-bit reload value, and includes divider stages (i.e., prescaler and

fractional divider) for generating a wide range of baud rates based on its input clock $f_{PCLK}$, see **Figure 26**.

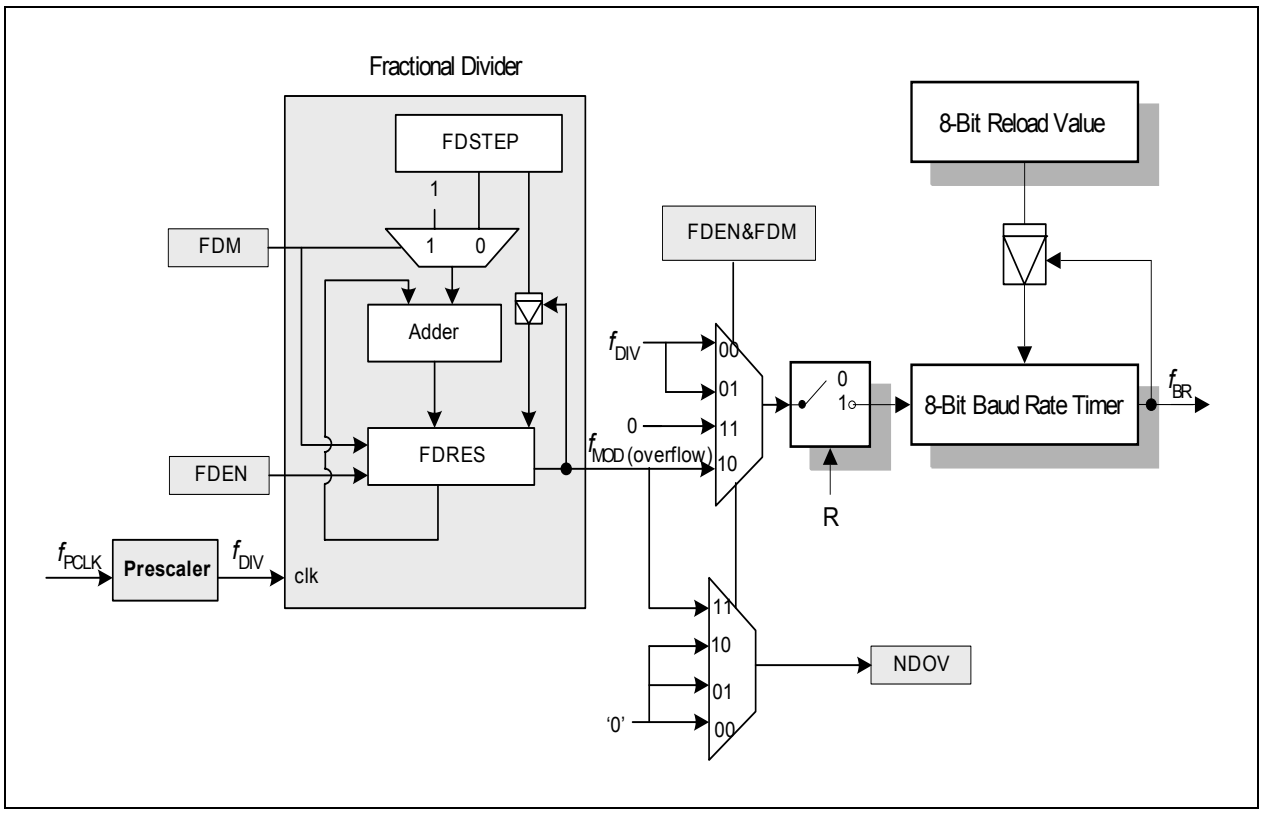



**Figure 26 Baud-rate Generator Circuitry**

The baud rate timer is a count-down timer and is clocked by either the output of the fractional divider ($f_{MOD}$) if the fractional divider is enabled (FDCON.FDEN = 1), or the output of the prescaler ($f_{DIV}$) if the fractional divider is disabled (FDEN = 0). For baud rate generation, the fractional divider must be configured to fractional divider mode (FDCON.FDM = 0). This allows the baud rate control run bit BCON.R to be used to start or stop the baud rate timer. At each timer underflow, the timer is reloaded with the 8-bit reload value in register BG and one clock pulse is generated for the serial channel.

Enabling the fractional divider in normal divider mode (FDEN = 1 and FDM = 1) stops the baud rate timer and nullifies the effect of bit BCON.R. See **Section 3.14**.

The baud rate ($f_{BR}$) value is dependent on the following parameters:

- Input clock $f_{PCLK}$
- Prescaling factor ($2^{BRPRE}$) defined by bit field BRPRE in register BCON
- Fractional divider (STEP/256) defined by register FDSTEP
  (to be considered only if fractional divider is enabled and operating in fractional divider mode)
- 8-bit reload value (BR_VALUE) for the baud rate timer defined by register BG

The following formulas calculate the final baud rate without and with the fractional divider respectively:

$$\text{baud rate} = \frac{f_{PCLK}}{16 \times 2^{BRPRE} \times (BR_VALUE + 1)} \quad \text{where} \quad 2^{BRPRE} \times (BR_VALUE + 1) > 1 \tag{3.4}$$

$$\text{baud rate} = \frac{f_{PCLK}}{16 \times 2^{BRPRE} \times (BR_VALUE + 1)} \times \frac{STEP}{256} \tag{3.5}$$

The maximum baud rate that can be generated is limited to $f_{PCLK}/32$. Hence, for a module clock of 24 MHz, the maximum achievable baud rate is 0.75 MBaud.

Standard LIN protocol can support a maximum baud rate of 20 kHz, the baud rate accuracy is not critical and the fractional divider can be disabled. Only the prescaler is used for auto baud rate calculation. For LIN fast mode, which supports the baud rate of 20 kHz to 57.6 kHz, the higher baud rates require the use of the fractional divider for greater accuracy.

**Table 31** lists the various commonly used baud rates with their corresponding parameter settings and deviation errors. The fractional divider is disabled and a module clock of 24 MHz is used.

**Table 31 Typical Baud rates for UART with Fractional Divider disabled**

| Baud rate | Prescaling Factor (2BRPRE) | Reload Value (BR_VALUE + 1) | Deviation Error |
|---|---|---|---|
| 19.2 kBaud | 1 (BRPRE=$000_B$) | 78 ($4E_H$) | 0.17 % |
| 9600 Baud | 1 (BRPRE=$000_B$) | 156 ($9C_H$) | 0.17 % |
| 4800 Baud | 2 (BRPRE=$001_B$) | 156 ($9C_H$) | 0.17 % |
| 2400 Baud | 4 (BRPRE=$010_B$) | 156 ($9C_H$) | 0.17 % |

The fractional divider allows baud rates of higher accuracy (lower deviation error) to be generated. **Table 32** lists the resulting deviation errors from generating a baud rate of 57.6 kHz, using different module clock frequencies. The fractional divider is enabled (fractional divider mode) and the corresponding parameter settings are shown.

**Table 32 Deviation Error for UART with Fractional Divider enabled**

| $f_{PCLK}$ | Prescaling Factor (2BRPRE) | Reload Value (BR_VALUE + 1) | STEP | Deviation Error |
|---|---|---|---|---|
| 24 MHz | 1 | 6 ($6_H$) | 59 ($3B_H$) | +0.03 % |
| 12 MHz | 1 | 3 ($3_H$) | 59 ($3B_H$) | +0.03 % |
| 8 MHz | 1 | 2 ($2_H$) | 59 ($3B_H$) | +0.03 % |
| 6 MHz | 1 | 6 ($6_H$) | 236 ($EC_H$) | +0.03 % |

### 3.13.2 Baud Rate Generation using Timer 1

In UART modes 1 and 3 of UART module, Timer 1 can be used for generating the variable baud rates. In theory, this timer could be used in any of its modes. But in practice, it should be set into auto-reload mode (Timer 1 mode 2), with its high byte set to the appropriate value for the required baud rate. The baud rate is determined by the Timer 1 overflow rate and the value of SMOD as follows:

$$\text{Mode 1, 3 baud rate} = \frac{2^{SMOD} \times f_{PCLK}}{32 \times 2 \times (256 - TH1)} \tag{3.6}$$

## 3.14 Normal Divider Mode (8-bit Auto-reload Timer)

Setting bit FDM in register FDCON to 1 configures the fractional divider to normal divider mode, while at the same time disables baud rate generation (see **Figure 26**). Once the fractional divider is enabled (FDEN = 1), it functions as an 8-bit auto-reload timer (with no relation to baud rate generation) and counts up from the reload value with each input clock pulse. Bit field RESULT in register FDRES represents the timer value, while bit field STEP in register FDSTEP defines the reload value. At each timer overflow, an overflow flag (FDCON.NDOV) will be set and an interrupt request generated. This gives an output clock $f_{MOD}$ that is 1/n of the input clock $f_{DIV}$, where n is defined by 256 - STEP.

The output frequency in normal divider mode is derived as follows:

$$f_{MOD} = f_{DIV} \times \frac{1}{256 - STEP} \tag{3.7}$$

## 3.15 LIN Protocol

The UART module can be used to support the Local Interconnect Network (LIN) protocol for both master and slave operations. The LIN baud rate detection feature, which consists of the hardware logic for Break and Synch Byte detection, provides the capability to detect the baud rate within LIN protocol using Timer 2. This allows the UART to be synchronized to the LIN baud rate for data transmission and reception.

*Note: The LIN baud rate detection feature is available for use only with UART. To use UART1 for LIN communication, software has to be implemented to detect the Break and Synch Byte.*

LIN is a holistic communication concept for local interconnected networks in vehicles. The communication is based on the SCI (UART) data format, a single-master/multiple-slave concept, a clock synchronization for nodes without stabilized time base. An attractive feature of LIN is self-synchronization of the slave nodes without a crystal or ceramic resonator, which significantly reduces the cost of hardware platform. Hence, the baud rate must be calculated and returned with every message frame.

The structure of a LIN frame is shown in **Figure 27**. The frame consists of the:

- Header, which comprises a Break (13-bit time low), Synch Byte ($55_H$), and ID field
- Response time
- Data bytes (according to UART protocol)
- Checksum

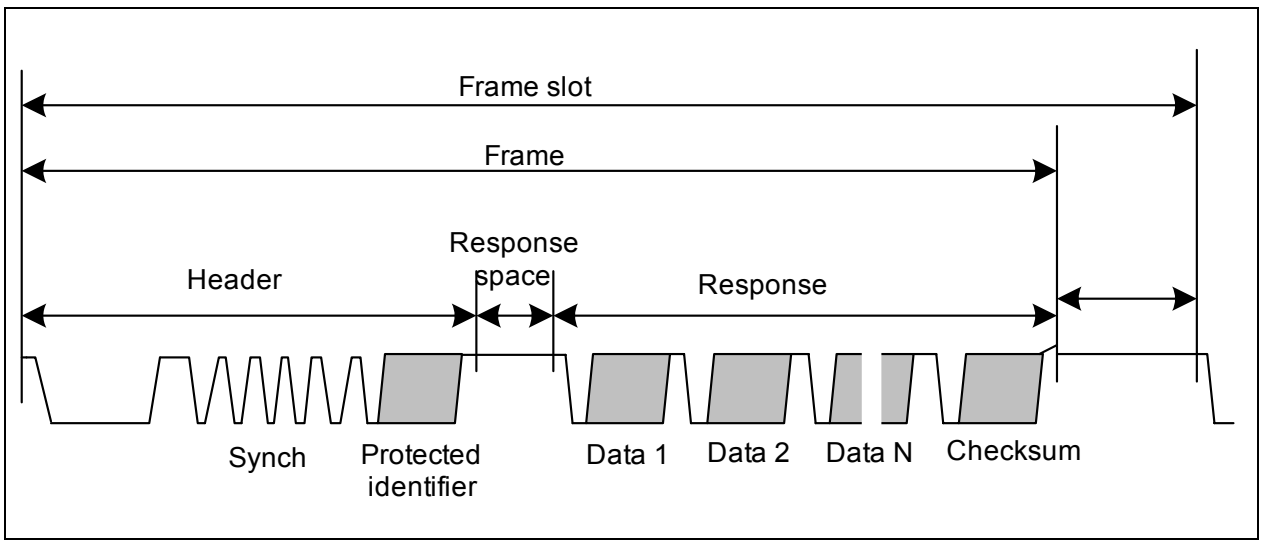



**Figure 27 Structure of LIN Frame**

### 3.15.1 LIN Header Transmission

LIN header transmission is only applicable in master mode. In the LIN communication, a master task decides when and which frame is to be transferred on the bus. It also identifies a slave task to provide the data transported by each frame. The information

needed for the handshaking between the master and slave tasks is provided by the master task through the header portion of the frame.

The header consists of a break and synch pattern followed by an identifier. Among these three fields, only the break pattern cannot be transmitted as a normal 8-bit UART data. The break must contain a dominant value of 13 bits or more to ensure proper synchronization of slave nodes.

In the LIN communication, a slave task is required to be synchronized at the beginning of the protected identifier field of frame. For this purpose, every frame starts with a sequence consisting of a break field followed by a synch byte field. This sequence is unique and provides enough information for any slave task to detect the beginning of a new frame and be synchronized at the start of the identifier field.

Upon entering LIN communication, a connection is established and the transfer speed (baud rate) of the serial communication partner (host) is automatically synchronized in the following steps:

STEP 1: Initialize interface for reception and timer for baud rate measurement

STEP 2: Wait for an incoming LIN frame from host

STEP 3: Synchronize the baud rate to the host

STEP 4: Enter for Master Request Frame or for Slave Response Frame

*Note: Re-synchronization and setup of baud rate are always done for **every** Master Request Header or Slave Response Header LIN frame.*

## 3.16 High-Speed Synchronous Serial Interface

The High-Speed Synchronous Serial Interface (SSC) supports full-duplex and half-duplex synchronous communication. The serial clock signal can be generated by the SSC internally (master mode), using its own 16-bit baud-rate generator, or can be received from an external master (slave mode). Data width, shift direction, clock polarity and phase are programmable. This allows communication with SPI-compatible devices or devices using other synchronous serial interfaces.

### Features

- Master and slave mode operation
  - Full-duplex or half-duplex operation
- Transmit and receive buffered
- Flexible data format
  - Programmable number of data bits: 2 to 8 bits
  - Programmable shift direction: LSB or MSB shift first
  - Programmable clock polarity: idle low or high state for the shift clock
  - Programmable clock/data phase: data shift with leading or trailing edge of the shift clock
- Variable baud rate
- Compatible with Serial Peripheral Interface (SPI)
- Interrupt generation
  - On a transmitter empty condition
  - On a receiver full condition
  - On an error condition (receive, phase, baud rate, transmit error)

Data is transmitted or received on lines TXD and RXD, which are normally connected to the pins MTSR (Master Transmit/Slave Receive) and MRST (Master Receive/Slave Transmit). The clock signal is output via line MS_CLK (Master Serial Shift Clock) or input via line SS_CLK (Slave Serial Shift Clock). Both lines are normally connected to the pin SCLK. Transmission and reception of data are double-buffered.

**Figure 28** shows the block diagram of the SSC.

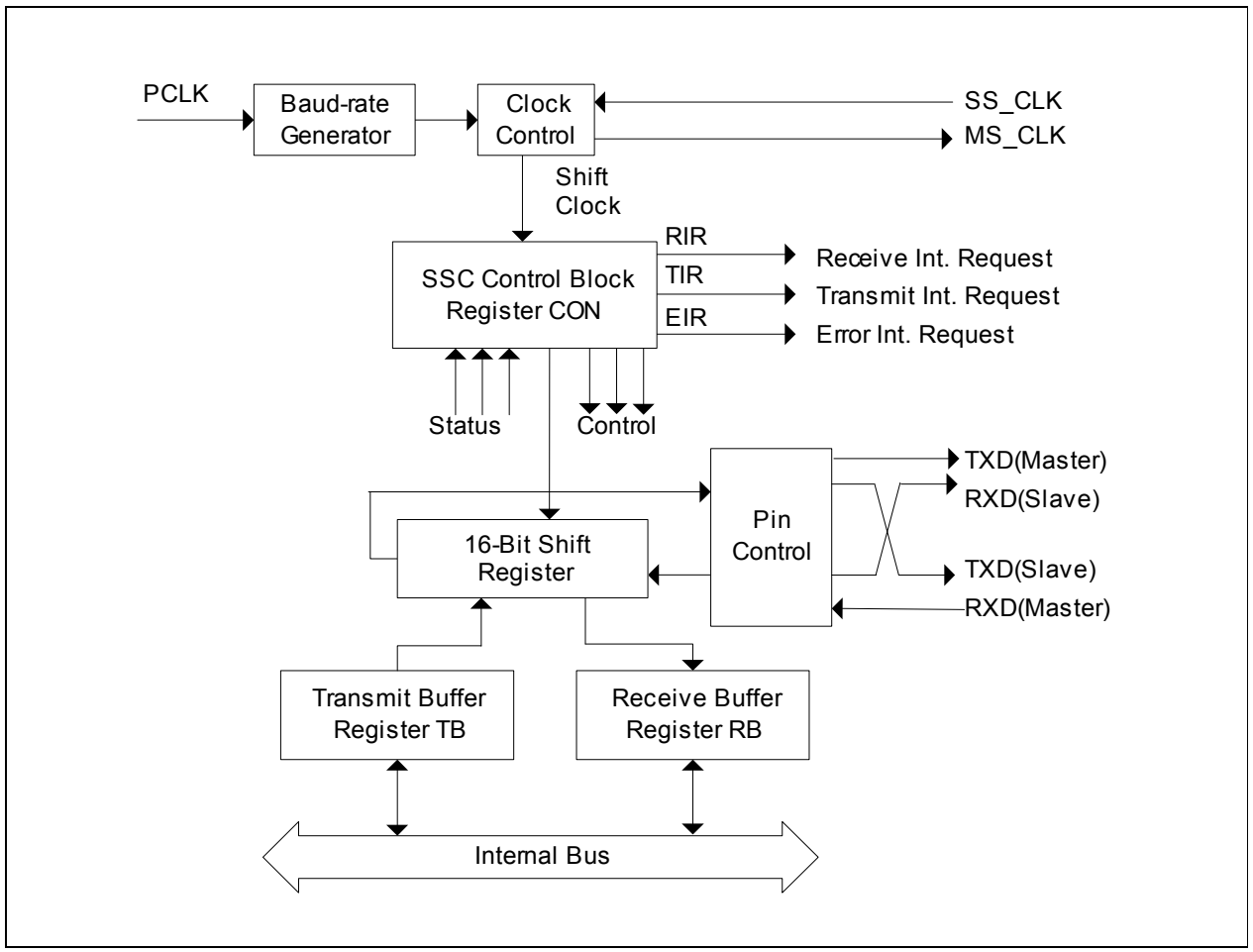



**Figure 28 SSC Block Diagram**

## 3.17 Timer 0 and Timer 1

Timer 0 and Timer 1 can function as both timers or counters. When functioning as a timer, Timer 0 and Timer 1 are incremented every machine cycle, i.e. every 2 input clocks (or 2 PCLKs). When functioning as a counter, Timer 0 and Timer 1 are incremented in response to a 1-to-0 transition (falling edge) at their respective external input pins, T0 or T1.

Timer 0 and 1 are fully compatible and can be configured in four different operating modes for use in a variety of applications, see **Table 33**. In modes 0, 1 and 2, the two timers operate independently, but in mode 3, their functions are specialized.

**Table 33 Timer 0 and Timer 1 Modes**

| Mode | Operation |
|---|---|
| **0** | **13-bit timer**<br>The timer is essentially an 8-bit counter with a divide-by-32 prescaler. This mode is included solely for compatibility with Intel 8048 devices. |
| **1** | **16-bit timer**<br>The timer registers, TLx and THx, are concatenated to form a 16-bit counter. |
| **2** | **8-bit timer with auto-reload**<br>The timer register TLx is reloaded with a user-defined 8-bit value in THx upon overflow. |
| **3** | **Timer 0 operates as two 8-bit timers**<br>The timer registers, TL0 and TH0, operate as two separate 8-bit counters. Timer 1 is halted and retains its count even if enabled. |

## 3.18 Timer 2 and Timer 21

Timer 2 and Timer 21 are 16-bit general purpose timers (THL2) that are fully compatible and have two modes of operation, a 16-bit auto-reload mode and a 16-bit one channel capture mode, see **Table 34**. As a timer, the timers count with an input clock of PCLK/12 (if prescaler is disabled). As a counter, they count 1-to-0 transitions on pin T2. In the counter mode, the maximum resolution for the count is PCLK/24 (if prescaler is disabled).

**Table 34 Timer 2 Modes**

| Mode | Description |
|---|---|
| **Auto-reload** | **Up/Down Count Disabled**<br>• Count up only<br>• Start counting from 16-bit reload value, overflow at $FFFF_H$<br>• Reload event configurable for trigger by overflow condition only, or by negative/positive edge at input pin T2EX as well<br>• Programmble reload value in register RC2<br>• Interrupt is generated with reload event |
| | **Up/Down Count Enabled**<br>• Count up or down, direction determined by level at input pin T2EX<br>• No interrupt is generated<br>• Count up<br>– Start counting from 16-bit reload value, overflow at $FFFF_H$<br>– Reload event triggered by overflow condition<br>– Programmble reload value in register RC2<br>• Count down<br>– Start counting from $FFFF_H$, underflow at value defined in register RC2<br>– Reload event triggered by underflow condition<br>– Reload value fixed at $FFFF_H$ |
| **Channel capture** | • Count up only<br>• Start counting from $0000_H$, overflow at $FFFF_H$<br>• Reload event triggered by overflow condition<br>• Reload value fixed at $0000_H$<br>• Capture event triggered by falling/rising edge at pin T2EX<br>• Captured timer value stored in register RC2<br>• Interrupt is generated with reload or capture event |

## 3.19 Timer 2 Capture/Compare Unit

The T2CCU (Timer 2 Capture/Compare Unit) consists of the standard Timer 2 unit and a Capture/compare unit (CCU). The Capture/Compare Timer (CCT) is part of the CCU. Control is available in the T2CCU to select individually for each of its 16-bit capture/compare channel, either the Timer 2 or the Capture/Compare Timer (CCT) as the time base. Both timers have a resolution of 16 bits.The clock frequency of T2CCU, $f_{T2CCU}$, could be set at PCLK frequency or 2 times the PCLK frequency.

The T2CCU can be used for various digital signal generation and event capturing like pulse generation, pulse width modulation, pulse width measuring etc. Target applications include various automotive control as well as industrial (frequency generation, digital-to-analog conversion, process control etc.).

### T2CCU Features

- Option to select individually for each channel, either Timer 2 or Capture/Compare Timer as time base
- Extremely flexible Capture/Compare Timer count rate by cascading with Timer 2
- Capture/Compare Timer may be ‘reset’ immediately by triggering overflow event
- 16-bit resolution
- Six compare channels in total
- Four capture channels multiplexed with the compare channels, in total
- Shadow register for each compare register
  – Transfer via software control or on timer overflow.
- Compare Mode 0: Compare output signal changes from the inactive level to active level on compare match. Returns to inactive level on timer overflow.
  – Active level can be defined by register bit for channel groups A and B.
  – Support of 0% to 100% duty cycle in compare mode 0.
- Compare Mode 1: Full control of the software on the compare output signal level, for the next compare match.
- Concurrent Compare Mode with channel 0
- Capture Mode 0: Capture on any external event (rising/falling/both edge) at the 4 pins T2CC0 to T2CC3.
- Capture Mode 1: Capture upon writing to the low byte of the corresponding channel capture register.
- Capture mode 0 or 1 can be established independently on the 4 capture channels.

## 3.20 Capture/Compare Unit 6

The Capture/Compare Unit 6 (CCU6) provides two independent timers (T12, T13), which can be used for Pulse Width Modulation (PWM) generation, especially for AC-motor control. The CCU6 also supports special control modes for block commutation and multi-phase machines.

The timer T12 can function in capture and/or compare mode for its three channels. The timer T13 can work in compare mode only.

The multi-channel control unit generates output patterns, which can be modulated by T12 and/or T13. The modulation sources can be selected and combined for the signal modulation.

### Timer T12 Features

- Three capture/compare channels, each channel can be used either as a capture or as a compare channel
- Supports generation of a three-phase PWM (six outputs, individual signals for highside and lowside switches)
- 16-bit resolution, maximum count frequency = peripheral clock frequency
- Dead-time control for each channel to avoid short-circuits in the power stage
- Concurrent update of the required T12/13 registers
- Generation of center-aligned and edge-aligned PWM
- Supports single-shot mode
- Supports many interrupt request sources
- Hysteresis-like control mode

### Timer T13 Features

- One independent compare channel with one output
- 16-bit resolution, maximum count frequency = peripheral clock frequency
- Can be synchronized to T12
- Interrupt generation at period-match and compare-match
- Supports single-shot mode

### Additional Features

- Implements block commutation for Brushless DC-drives
- Position detection via Hall-sensor pattern
- Automatic rotational speed measurement for block commutation
- Integrated error handling
- Fast emergency stop without CPU load via external signal ($\overline{\text{CTRAP}}$)
- Control modes for multi-channel AC-drives
- Output levels can be selected and adapted to the power stage

The block diagram of the CCU6 module is shown in **Figure 29**.

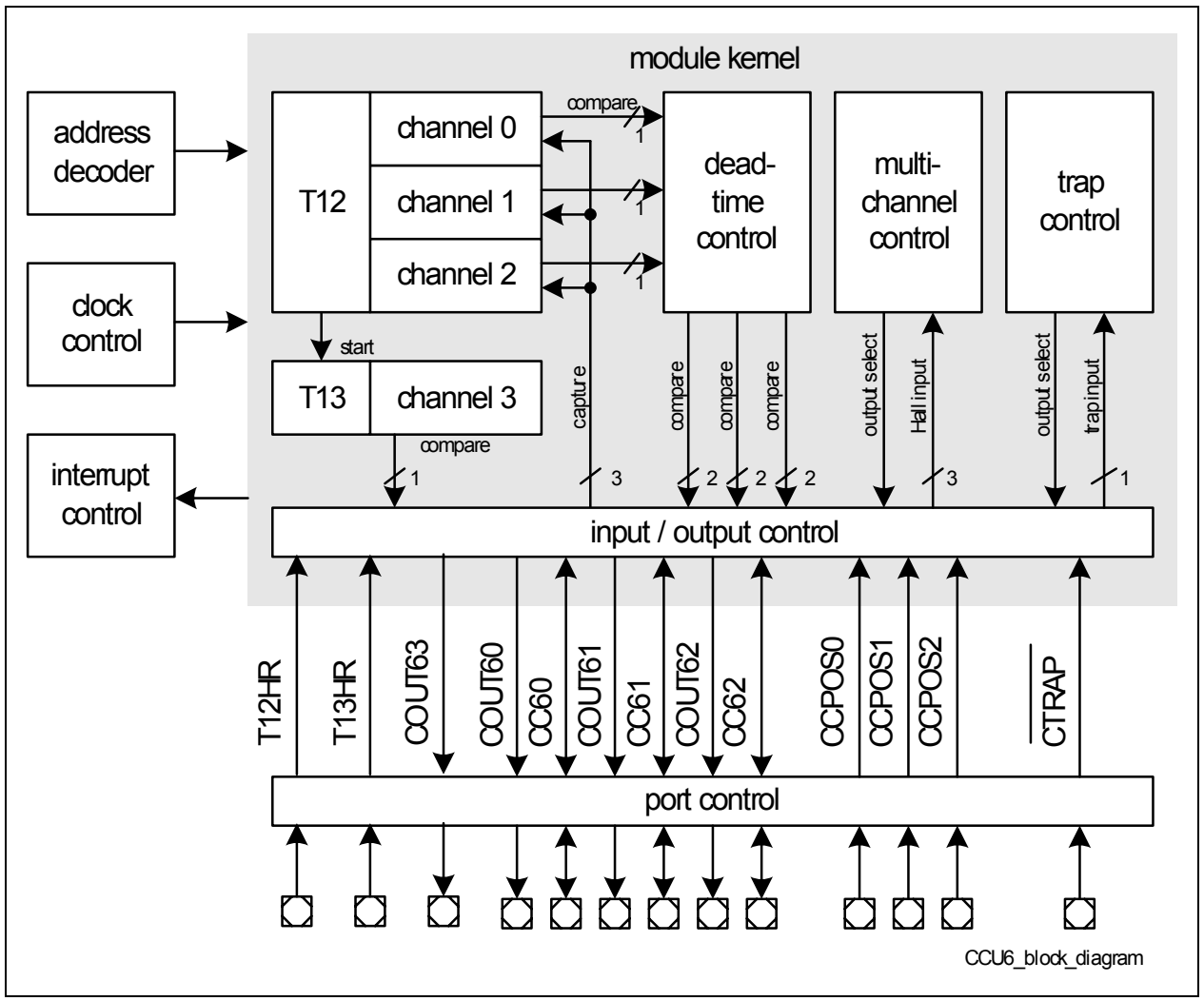



**Figure 29 CCU6 Block Diagram**

## 3.21 Controller Area Network (MultiCAN)

The MultiCAN module contains two Full-CAN nodes operating independently or exchanging data and remote frames via a gateway function. Transmission and reception of CAN frames is handled in accordance to CAN specification V2.0 B active. Each CAN node can receive and transmit standard frames with 11-bit identifiers as well as extended frames with 29-bit identifiers.

Both CAN nodes share a common set of message objects, where each message object may be individually allocated to one of the CAN nodes. Besides serving as a storage container for incoming and outgoing frames, message objects may be combined to build gateways between the CAN nodes or to setup a FIFO buffer.

The message objects are organized in double chained lists, where each CAN node has it's own list of message objects. A CAN node stores frames only into message objects that are allocated to the list of the CAN node. It only transmits messages from objects of this list. A powerful, command driven list controller performs all list operations.

The bit timings for the CAN nodes are derived from the peripheral clock ($f_{CAN}$) and are programmable up to a data rate of 1 MBaud. A pair of receive and transmit pins connects each CAN node to a bus transceiver.

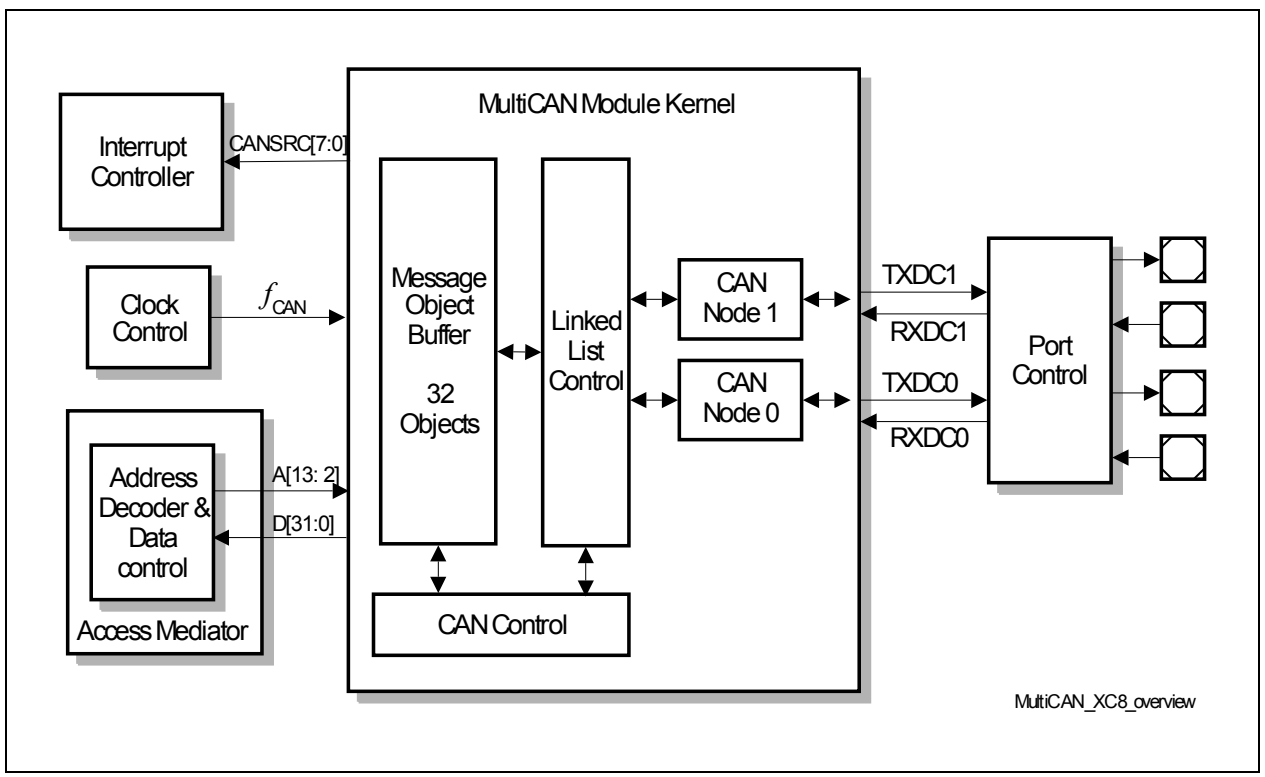



**Figure 30 Overview of the MultiCAN**

### Features

- Compliant to ISO 11898.

- CAN functionality according to CAN specification V2.0 B active.
- Dedicated control registers are provided for each CAN node.
- A data transfer rate up to 1 MBaud is supported.
- Flexible and powerful message transfer control and error handling capabilities are implemented.
- Advanced CAN bus bit timing analysis and baud rate detection can be performed for each CAN node via the frame counter.
- Full-CAN functionality: A set of 32 message objects can be individually
  - allocated (assigned) to any CAN node
  - configured as transmit or receive object
  - setup to handle frames with 11-bit or 29-bit identifier
  - counted or assigned a timestamp via a frame counter
  - configured to remote monitoring mode
- Advanced Acceptance Filtering:
  - Each message object provides an individual acceptance mask to filter incoming frames.
  - A message object can be configured to accept only standard or only extended frames or to accept both standard and extended frames.
  - Message objects can be grouped into 4 priority classes.
  - The selection of the message to be transmitted first can be performed on the basis of frame identifier, IDE bit and RTR bit according to CAN arbitration rules.
- Advanced Message Object Functionality:
  - Message Objects can be combined to build FIFO message buffers of arbitrary size, which is only limited by the total number of message objects.
  - Message objects can be linked to form a gateway to automatically transfer frames between 2 different CAN buses. A single gateway can link any two CAN nodes. An arbitrary number of gateways may be defined.
- Advanced Data Management:
  - The Message objects are organized in double chained lists.
  - List reorganizations may be performed any time, even during full operation of the CAN nodes.
  - A powerful, command driven list controller manages the organization of the list structure and ensures consistency of the list.
  - Message FIFOs are based on the list structure and can easily be scaled in size during CAN operation.
  - Static Allocation Commands offer compatibility with TwinCAN applications, which are not list based.
- Advanced Interrupt Handling:
  - Up to 8 interrupt output lines are available. Most interrupt requests can be individually routed to one of the 8 interrupt output lines.
  - Message postprocessing notifications can be flexibly aggregated into a dedicated register field of 64 notification bits.

## 3.22 Analog-to-Digital Converter

The XC87x includes a high-performance 10-bit Analog-to-Digital Converter (ADC) with eight multiplexed analog input channels. The ADC uses a successive approximation technique to convert the analog voltage levels from up to eight different sources. The analog input channels of the ADC are available at AN0 - AN7.

**Features**

- Successive approximation
- 8-bit or 10-bit resolution
- Eight analog channels
- Four independent result registers
- Result data protection for slow CPU access (wait-for-read mode)
- Single conversion mode
- Autoscan functionality
- Limit checking for conversion results
- Data reduction filter (accumulation of up to 2 conversion results)
- Two independent conversion request sources with programmable priority
- Selectable conversion request trigger
- Flexible interrupt generation with configurable service nodes
- Programmable sample time
- Programmable clock divider
- Cancel/restart feature for running conversions
- Integrated sample and hold circuitry
- Compensation of offset errors
- Low power modes

### 3.22.1 ADC Clocking Scheme

A common module clock $f_{ADC}$ generates the various clock signals used by the analog and digital parts of the ADC module:

- $f_{ADCA}$ is input clock for the analog part.
- $f_{ADCI}$ is internal clock for the analog part (defines the time base for conversion length and the sample time). This clock is generated internally in the analog part, based on the input clock $f_{ADCA}$ to generate a correct duty cycle for the analog components.
- $f_{ADCD}$ is input clock for the digital part.

**Figure 31** shows the clocking scheme of the ADC module. The prescaler ratio is selected by bit field CTC in register GLOBCTR. A prescaling ratio of 32 can be selected when the maximum performance of the ADC is not required.

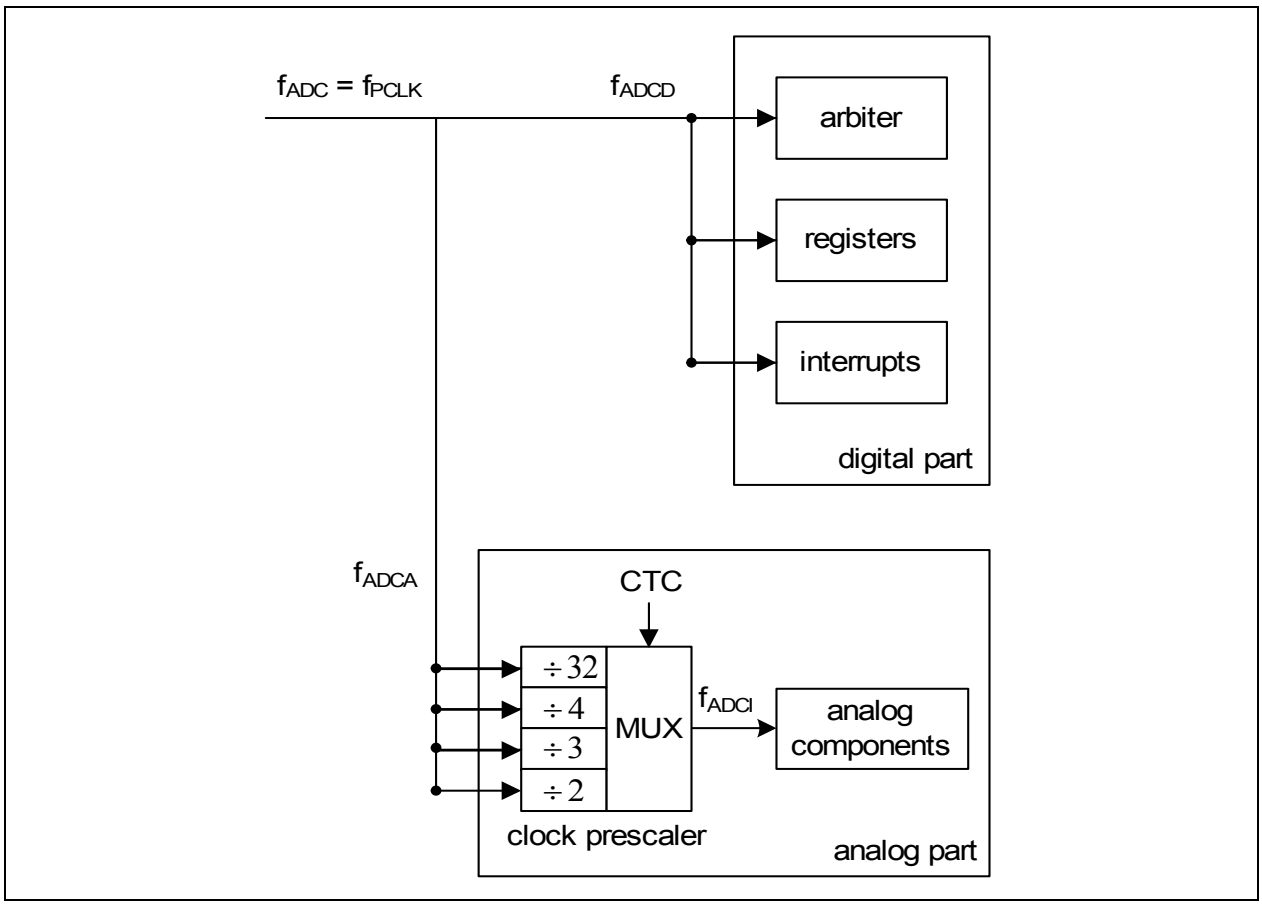



**Figure 31 ADC Clocking Scheme**

For module clock $f_{ADC}$ = 24 MHz, the analog clock $f_{ADCI}$ frequency can be selected as shown in **Table 35**.

**Table 35 $f_{ADCI}$ Frequency Selection**

| Module Clock $f_{ADC}$ | CTC | Prescaling Ratio | Analog Clock $f_{ADCI}$ |
|---|---|---|---|
| 24 MHz | $00_B$ | ÷ 2 | 12 MHz |
| | $01_B$ | ÷ 3 | 8 MHz |
| | $10_B$ | ÷ 4 | 6 MHz |
| | $11_B$ (default) | ÷ 32 | 750 kHz |

During slow-down mode, $f_{ADC}$ may be reduced further, for example, to 12 MHz or 6 MHz. However, it is important to note that the conversion error could increase due to loss of charges on the capacitors, if $f_{ADC}$ becomes too low during slow-down mode.

### 3.22.2 ADC Conversion Sequence

The analog-to-digital conversion procedure consists of the following phases:

- Synchronization phase ($t_{SYN}$)
- Sample phase ($t_S$)
- Conversion phase
- Write result phase ($t_{WR}$)

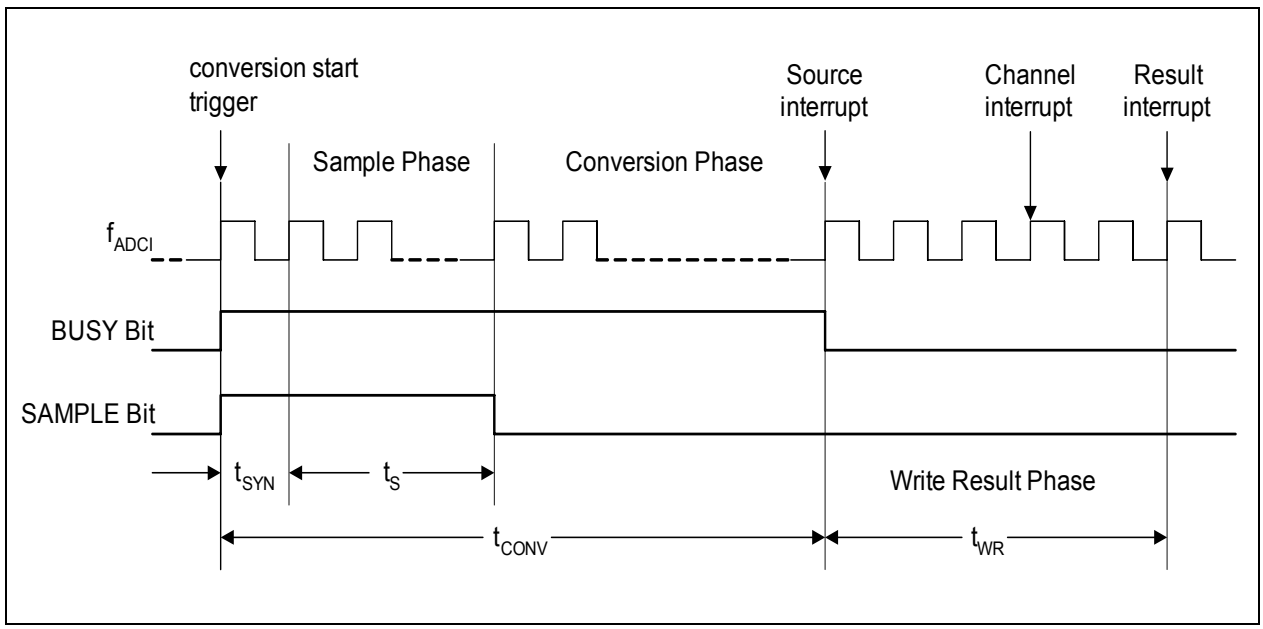



**Figure 32 ADC Conversion Timing**

## 3.23 On-Chip Debug Support

The On-Chip Debug Support (OCDS) provides the basic functionality required for the software development and debugging of XC800-based systems.

The OCDS design is based on these principles:

- Use the built-in debug functionality of the XC800 Core
- Add a minimum of hardware overhead
- Provide support for most of the operations by a Monitor Program
- Use standard interfaces to communicate with the Host (a Debugger)

### Features

- Set breakpoints on instruction address and on address range within the Program Memory
- Set breakpoints on internal RAM address range
- Support unlimited software breakpoints in Flash/RAM code region
- Process external breaks via JTAG and upon activating a dedicated pin
- Step through the program code

The OCDS functional blocks are shown in **Figure 33**. The Monitor Mode Control (MMC) block at the center of OCDS system brings together control signals and supports the overall functionality. The MMC communicates with the XC800 Core, primarily via the Debug Interface, and also receives reset and clock signals.

After processing memory address and control signals from the core, the MMC provides proper access to the dedicated extra-memories: a Monitor ROM (holding the code) and a Monitor RAM (for work-data and Monitor-stack).

The OCDS system is accessed through the JTAG[1)], which is an interface dedicated exclusively for testing and debugging activities and is not normally used in an application. The dedicated MBC pin is used for external configuration and debugging control.

*Note: All the debug functionality described here can normally be used only after XC87x has been started in OCDS mode.*

1) The pins of the JTAG port can be assigned to either the primary port (Port 0) or either of the secondary ports (Ports 1 and 2/Port 5).
User must set the JTAG pins (TCK and TDI) as input during connection with the OCDS system.

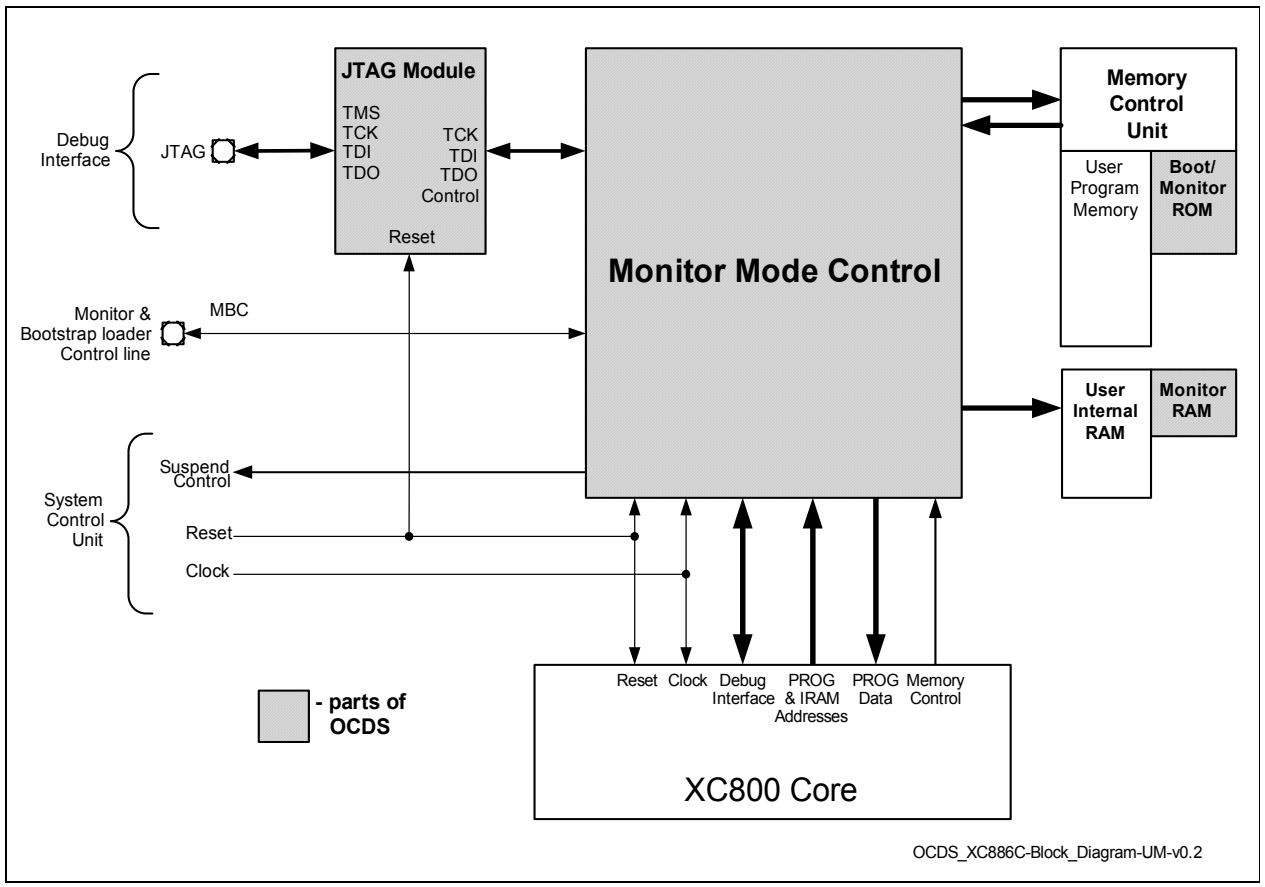



**Figure 33 OCDS Block Diagram**

### 3.23.1 JTAG ID Register

This is a read-only register located inside the JTAG module, and is used to recognize the device(s) connected to the JTAG interface. Its content is shifted out when INSTRUCTION register contains the IDCODE command (opcode $04_H$), and the same is also true immediately after reset.

The JTAG ID register contents for the XC87x Flash devices are given in **Table 36**.

**Table 36 JTAG ID Summary**

| Device Type | Device Name | JTAG ID |
|---|---|---|
| Flash | XC87x*-16FF | $1018\ 2083_H$ |
| | XC87x*-13FF | $1018\ 3083_H$ |

*Note: The asterisk (*) above denotes all possible device configurations.*

## 3.24 Chip Identification Number

The XC87x identity (ID) register is located at Page 1 of address $B3_H$. The value of ID register is $49_H$. However, for easy identification of product variants, the Chip Identification Number, which is an unique number assigned to each product variant, is available. The differentiation is based on the product, variant type and device step information.

Two methods are provided to read a device's chip identification number:

- In-application subroutine, GET_CHIP_INFO
- Bootstrap loader (BSL) mode A

**Table 37** lists the chip identification numbers of available XC87x Flash device variants.

**Table 37 Chip Identification Number**

| Product Variant | Chip Identification Number |
|---|---|
| | AC-step |
| **Flash Devices** | |
| XC878-16FF 5V | $4B580063_H$ |
| XC878M-16FF 5V | $4B580023_H$ |
| XC878CM-16FF 5V | $4B580003_H$ |
| XC878LM-16FF 5V | $4B500023_H$ |
| XC878CLM-16FF 5V | $4B500003_H$ |
| XC878-13FF 5V | $4B590463_H$ |
| XC878M-13FF 5V | $4B590423_H$ |
| XC878CM-13FF 5V | $4B590403_H$ |
| XC878LM-13FF 5V | $4B510423_H$ |
| XC878CLM-13FF 5V | $4B510403_H$ |
| XC878-16FF 3V3 | $4B180063_H$ |
| XC878M-16FF 3V3 | $4B180023_H$ |
| XC878CM-16FF 3V3 | $4B180003_H$ |
| XC878-13FF 3V3 | $4B190463_H$ |
| XC878M-13FF 3V3 | $4B190423_H$ |
| XC878CM-13FF 3V3 | $4B190403_H$ |
| XC874CM-16FV 5V | $4B580002_H$ |
| XC874LM-16FV 5V | $4B500022_H$ |
| XC874-16FV 5V | $4B580062_H$ |

**Table 37 Chip Identification Number** (cont'd)

| Product Variant | Chip Identification Number |
|---|---|
| | **AC-step** |
| XC874CM-13FV 5V | $4B590402_H$ |
| XC874LM-13FV 5V | $4B510422_H$ |
| XC874-13FV 5V | $4B590462_H$ |

# 4 Electrical Parameters

Chapter 4 provides the characteristics of the electrical parameters which are implementation-specific for the XC87x.

## 4.1 General Parameters

The general parameters are described here to aid the users in interpreting the parameters mainly in Section 4.2 and Section 4.3.

### 4.1.1 Parameter Interpretation

The parameters listed in this section represent partly the characteristics of the XC87x and partly its requirements on the system. To aid interpreting the parameters easily when evaluating them for a design, they are indicated by the abbreviations in the “Symbol” column:

- **CC**
  These parameters indicate **C**ontroller **C**haracteristics, which are distinctive features of the XC87x and must be regarded for a system design.
- **SR**
  These parameters indicate **S**ystem **R**equirements, which must be provided by the microcontroller system in which the XC87x is designed in.

### 4.1.2 Absolute Maximum Rating

Maximum ratings are the extreme limits to which the XC87x can be subjected to without permanent damage.

**Table 38 Absolute Maximum Rating Parameters**

| Parameter | Symbol | Limit Values | | Unit | Notes |
|---|---|---|---|---|---|
| | | min. | max. | | |
| Ambient temperature | $T_A$ | -40 | 125 | °C | under bias |
| Storage temperature | $T_{ST}$ | -65 | 150 | °C | |
| Junction temperature | $T_J$ | -40 | 140 | °C | under bias |
| Voltage on power supply pin with respect to $V_{SS}$ | $V_{DDP}$ | -0.5 | 6 | V | |
| Voltage on any pin with respect to $V_{SS}$ | $V_{IN}$ | -0.5 | $V_{DDP}$ + 0.5 or max. 6 | V | Whatever is lower |
| Input current on any pin during overload condition | $I_{IN}$ | -10 | 10 | mA | |
| Absolute sum of all input currents during overload condition | $\Sigma\|I_{IN}\|$ | – | 50 | mA | |

*Note: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. During absolute maximum rating overload conditions ($V_{IN} > V_{DDP}$ or $V_{IN} < V_{SS}$) the voltage on $V_{DDP}$ pin with respect to ground ($V_{SS}$) must not exceed the values defined by the absolute maximum ratings.*

### 4.1.3 Operating Conditions

The following operating conditions must not be exceeded in order to ensure correct operation of the XC87x. All parameters mentioned in the following table refer to these operating conditions, unless otherwise noted.

**Table 39 Operating Condition Parameters**

| Parameter | Symbol | Limit Values | | Unit | Notes/ Conditions |
|---|---|---|---|---|---|
| | | min. | max. | | |
| Digital power supply voltage | $V_{DDP}$ | 4.5 | 5.5 | V | 5V Device |
| Digital power supply voltage | $V_{DDP}$ | 3.0 | 3.6 | V | 3.3V Device |
| Digital ground voltage | $V_{SS}$ | 0 | | V | |
| CPU Clock Frequency[1)] | $f_{CCLK}$ | | 26.67[2)] | MHz | |
| Ambient temperature | $T_A$ | -40 | 85 | °C | SAF-XC878/874... |
| | | -40 | 105 | °C | SAX-XC878... |
| | | -40 | 125 | °C | SAK-XC878/874... |

1) $f_{CCLK}$ is the input frequency to the XC800 core. Please refer to **Figure 22** for detailed description.

2)Default setting of $f_{CCLK}$ upon reset is 24 MHz.

## 4.2 DC Parameters

The electrical characteristics of the DC Parameters are detailed in this section.

### 4.2.1 Input/Output Characteristics

**Table 40** provides the characteristics of the input/output pins of the XC87x.

**Table 40 Input/Output Characteristics (Operating Conditions apply)**

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min. | max. | | |
| **$V_{DDP}$ = 5 V Range** | | | | | | |
| Output low voltage | $V_{OL}$ | CC | – | 0.6 | V | $I_{OL}$ = 9 mA (DS = 0)[1)]<br>$I_{OL}$ = 12 mA (DS = 1)[2)] |
| Output high voltage | $V_{OH}$ | CC | 2.4 | – | V | $I_{OH}$ = -20 mA (DS = 0)[1)]<br>$I_{OH}$ = -25 mA (DS = 1)[2)] |
| Input low voltage | $V_{IL}$ | SR | -0.3 | 0.8 | V | CMOS Mode |
| Input high voltage | $V_{IH}$ | SR | 2.2 | $V_{DDP}$ | V | CMOS Mode |
| Input Hysteresis | $HYS$ | CC | 0.35 | – | V | CMOS Mode[3)7)] |
| Input low voltage at XTAL1 | $V_{ILX}$ | SR | -0.3 | 0.8 | V | |
| Input high voltage at XTAL1 | $V_{IHX}$ | SR | 3.4 | $V_{DDP}$ | V | |
| Pull-up current | $I_{PU}$ | SR | – | -20 | µA | $V_{IH,min}$ |
| | | | -88 | – | µA | $V_{IL,max}$ |
| Pull-down current | $I_{PD}$ | SR | – | 10 | µA | $V_{IL,max}$ |
| | | | 66 | – | µA | $V_{IH,min}$ |
| Input leakage current | $I_{OZ1}$ | CC | -1 | 1 | µA | $0 < V_{IN} < V_{DDP}$,<br>$T_A \leq 105°C$[4)] |
| Overload current on any pin | $I_{OV}$ | SR | -5 | 5 | mA | |
| Absolute sum of overload currents | $\Sigma\|I_{OV}\|$ | SR | – | 25 | mA | [5)] |
| Voltage on any pin during $V_{DDP}$ power off | $V_{PO}$ | SR | – | 0.3 | V | [6)] |

**Table 40 Input/Output Characteristics (Operating Conditions apply)** (cont'd)

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min. | max. | | |
| Maximum current per pin (excluding $V_{DDP}$ and $V_{SS}$) | $I_M$ | SR | – | 25 | mA | |
| Maximum current for all pins (excluding $V_{DDP}$ and $V_{SS}$) | $\Sigma\|I_M\|$ | SR | – | 150 | mA | |
| Maximum current into $V_{DDP}$ | $I_{MVDDP}$ | SR | – | 200 | mA | 5) |
| Maximum current out of $V_{SS}$ | $I_{MVSS}$ | SR | – | 200 | mA | 5) |
| **$V_{DDP}$ = 3.3 V Range** | | | | | | |
| Output low voltage | $V_{OL}$ | CC | – | 0.5 | V | $I_{OL}$ = 6 mA (DS = 0)[1)]<br>$I_{OL}$ = 8 mA (DS = 1)[2)] |
| Output high voltage | $V_{OH}$ | CC | 2.2 | – | V | $I_{OH}$ = -5 mA (DS = 0)[1)]<br>$I_{OH}$ = -7 mA (DS = 1)[2)] |
| Input low voltage | $V_{IL}$ | SR | -0.3 | 0.7 | V | CMOS Mode |
| Input high voltage | $V_{IH}$ | SR | 2 | $V_{DDP}$ | V | CMOS Mode |
| Input Hysteresis | $HYS$ | CC | 0.28 | – | V | CMOS Mode[3)7)] |
| Input low voltage at XTAL1 | $V_{ILX}$ | SR | -0.3 | 0.7 | V | |
| Input high voltage at XTAL1 | $V_{IHX}$ | SR | 2.3 | $V_{DDP}$ | V | |
| Pull-up current | $I_{PU}$ | SR | – | -7 | µA | $V_{IH,min}$ |
| | | | -35 | – | µA | $V_{IL,max}$ |
| Pull-down current | $I_{PD}$ | SR | – | 12 | µA | $V_{IL,max}$ |
| | | | 60 | – | µA | $V_{IH,min}$ |
| Input leakage current | $I_{OZ1}$ | CC | -1 | 1 | µA | $0 < V_{IN} < V_{DDP}$,<br>$T_A \leq 105°C$[4)] |
| Overload current on any pin | $I_{OV}$ | SR | -5 | 5 | mA | |
| Absolute sum of overload currents | $\Sigma\|I_{OV}\|$ | SR | – | 25 | mA | 5) |

**Table 40 Input/Output Characteristics (Operating Conditions apply)** (cont'd)

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min. | max. | | |
| Voltage on any pin during $V_{DDP}$ power off | $V_{PO}$ | SR | – | 0.3 | V | 6) |
| Maximum current per pin (excluding $V_{DDP}$ and $V_{SS}$) | $I_M$ SR | SR | – | 8 | mA | |
| Maximum current for all pins (excluding $V_{DDP}$ and $V_{SS}$) | $\Sigma\|I_M\|$ | SR | – | 150 | mA | |
| Maximum current into $V_{DDP}$ | $I_{MVDDP}$ | SR | – | 200 | mA | 5) |
| Maximum current out of $V_{SS}$ | $I_{MVSS}$ | SR | – | 200 | mA | 5) |

1) DS = 0 refers to the pin having a weak drive strength which is programmable via Px_DS register.

2) DS = 1 refers to the pin having a strong drive strength which is programmable via Px_DS register.

3) Not subjected to production test, verified by design/characterization. Hysteresis is implemented to avoid meta stable states and switching due to internal ground bounce. It cannot be guaranteed that it suppresses switching due to external system noise.

4) An additional error current ($I_{INJ}$) will flow if an overload current flows through an adjacent pin. TMS pin and $\overline{\text{RESET}}$ pin have internal pull devices and are not included in the input leakage current characteristic.

5) Not subjected to production test, verified by design/characterization.

6) Not subjected to production test, verified by design/characterization. However, for applications with strict low power-down current requirements, it is mandatory that no active voltage source is supplied at any GPIO pin when $V_{DDP}$ is powered off.

7) P0.1 has a minimum input hysteresis of 0.25V.

### 4.2.2 Supply Threshold Characteristics

**Table 41** provides the characteristics of the supply threshold in the XC87x.

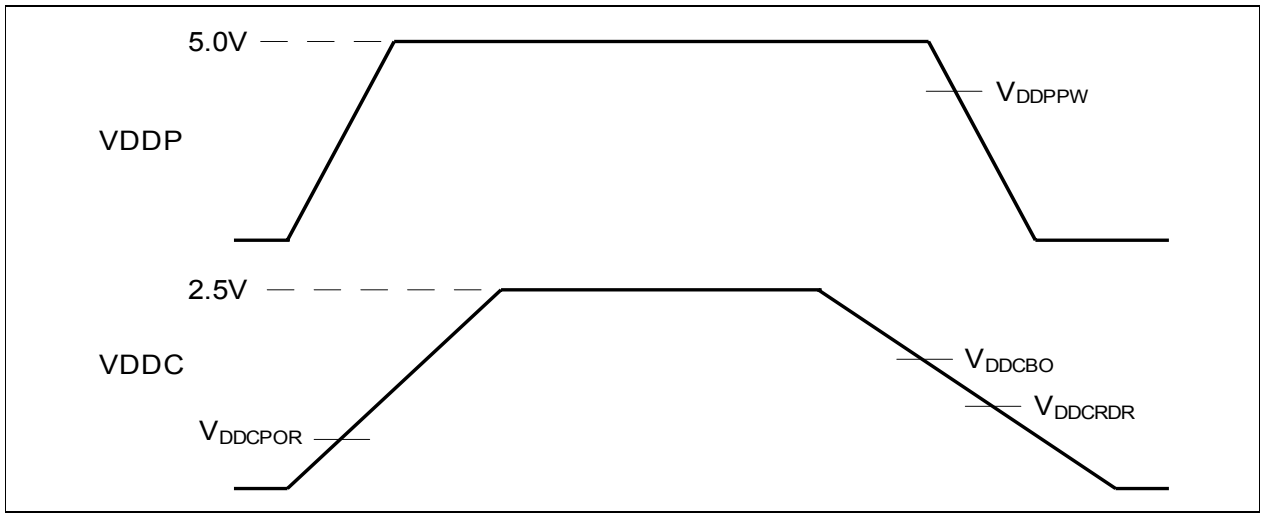



**Figure 34 Supply Threshold Parameters**

**Table 41 Supply Threshold Parameters (Operating Conditions apply)**

| Parameters | Symbol | | Limit Values | | | Unit |
|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | |
| $V_{DDC}$ brownout voltage[1)] | $V_{DDCBO}$ | CC | 1.7 | 1.9 | 2.2 | V |
| RAM data retention voltage | $V_{DDCRDR}$ | CC | 1.2 | – | – | V |
| $V_{DDP}$ prewarning voltage[2)] | $V_{DDPPW}$ | CC | 3.8 | 4.2 | 4.5 | V |
| Power-on reset voltage[1)3)] | $V_{DDCPOR}$ | CC | 1.7 | 1.9 | 2.2 | V |

1) Detection is enabled in both active and power-down mode.

2) Detection is enabled for 5.0V power supply variant.
Detection is disabled for 3.3V power supply variant.

3) The reset of EVR is extended by 300 µs typically after the VDDC reaches the power-on reset voltage.

### 4.2.3 ADC Characteristics

The values in the table below are given for an analog power supply between 4.5 V to 5.5 V. The ADC can be used with an analog power supply down to 3 V. But in this case, the analog parameters may show a reduced performance. All ground pins ($V_{SS}$) must be externally connected to one single star point in the system. The voltage difference between the ground pins must not exceed 200mV.

**Table 42 ADC Characteristics (Operating Conditions apply; $V_{DDP}$ = 5V Range)**

| Parameter | Symbol | | Limit Values | | | Unit | Test Conditions/ Remarks |
|---|---|---|---|---|---|---|---|
| | | | min. | typ . | max. | | |
| Analog reference voltage | $V_{AREF}$ | SR | $V_{AGND}$ + 1 | $V_{DDP}$ | $V_{DDP}$ + 0.05 | V | [1] |
| Analog reference ground | $V_{AGND}$ | SR | $V_{SS}$ - 0.05 | $V_{SS}$ | $V_{AREF}$ - 1 | V | [1] |
| Analog input voltage range | $V_{AIN}$ | SR | $V_{AGND}$ | – | $V_{AREF}$ | V | |
| ADC clocks | $f_{ADC}$ | | – | 24 | – | MHz | module clock[1] |
| | $f_{ADCI}$ | | – | – | 14[2] | MHz | internal analog clock[1] See **Figure 31** |
| Sample time | $t_S$ | CC | (2 + INPCR0.STC) × $t_{ADCI}$ | | | µs | [1] |
| Conversion time | $t_C$ | CC | See **Section 4.2.3.1** | | | µs | [1] |
| Differential Nonlinearity | $\|EA_{DNL}\|$ | CC | – | – | 1.5 | LSB | 10-bit conversion |
| Integral Nonlinearity | $\|EA_{INL}\|$ | CC | – | – | 2 | LSB | 10-bit conversion |
| Offset | $\|EA_{OFF}\|$ | CC | – | – | 3 | LSB | 10-bit conversion |
| Gain | $\|EA_{GAIN}\|$ | CC | – | – | 2.5 | LSB | 10-bit conversion |
| Switched capacitance at the reference voltage input | $C_{AREFSW}$ | CC | – | 10 | 14 | pF | [1][3] |
| Switched capacitance at the analog voltage inputs | $C_{AINSW}$ | CC | – | 4 | 5 | pF | [1][4] |

**Table 42 ADC Characteristics (Operating Conditions apply; $V_{DDP}$ = 5V Range)**

| Parameter | Symbol | | Limit Values | | | Unit | Test Conditions/ Remarks |
|---|---|---|---|---|---|---|---|
| | | | min. | typ . | max. | | |
| Input resistance of the reference input | $R_{AREF}$ | CC | – | 1 | 2 | kΩ | 1) |
| Input resistance of the selected analog channel | $R_{AIN}$ | CC | – | 1 | 3 | kΩ | 1) |

1) Not subjected to production test, verified by design/characterization.

2) This value includes the maximum oscillator deviation.

3) This represents an equivalent switched capacitance. This capacitance is not switched to the reference voltage at once. Instead of this, smaller capacitances are successively switched to the reference voltage.

4) The sampling capacity of the conversion C-Network is pre-charged to $V_{AREF}$/2 before connecting the input to the C-Network. Because of the parasitic elements, the voltage measured at ANx is lower than $V_{AREF}$/2.

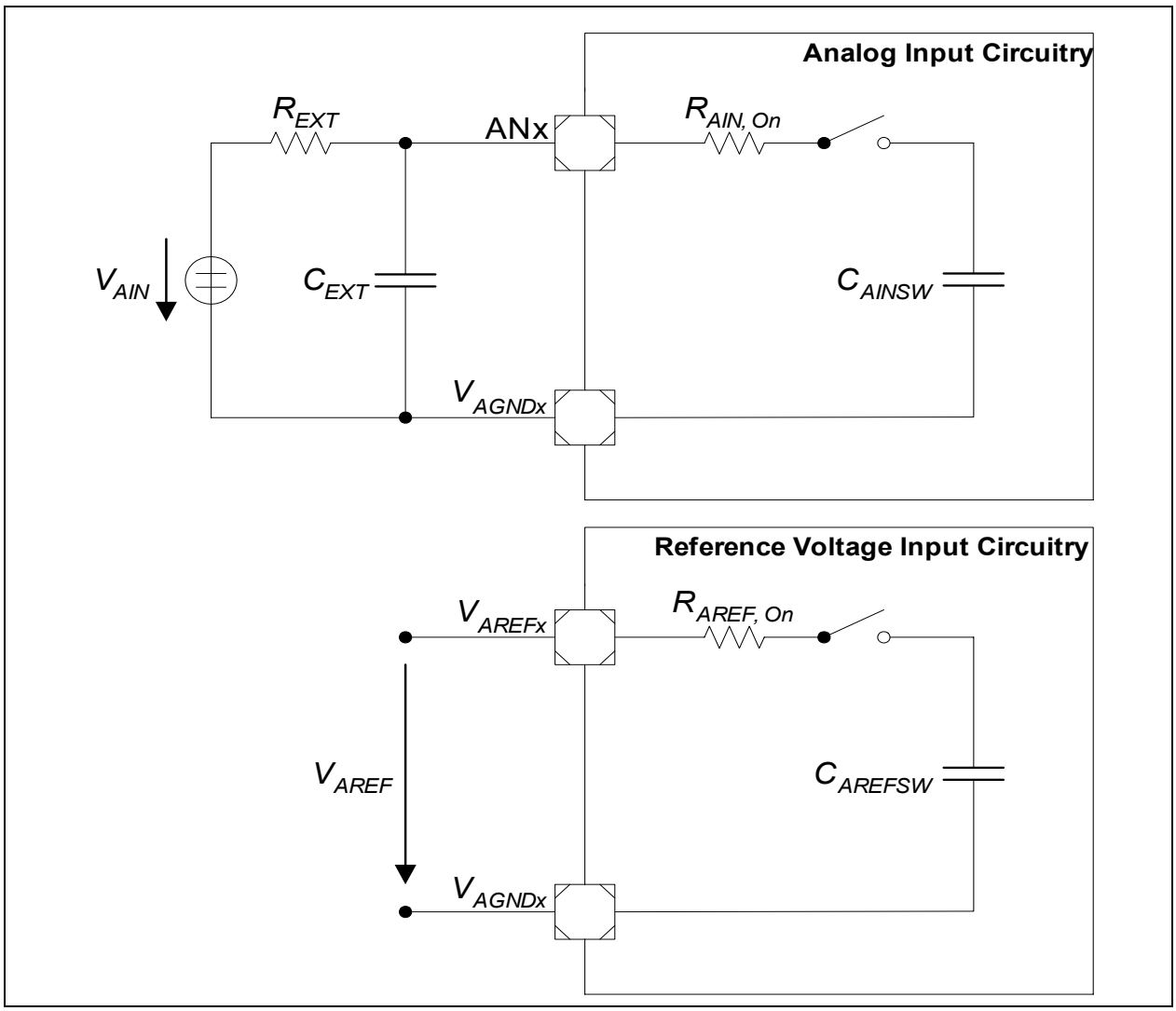



**Figure 35 ADC Input Circuits**

### 4.2.3.1 ADC Conversion Timing

Conversion time, $t_C = t_{ADC} \times ( 1 + r \times (3 + n + STC) )$ , where

r = CTC + 2 for CTC = $00_B$, $01_B$ or $10_B$,

r = 32 for CTC = $11_B$,

CTC = Conversion Time Control (GLOBCTR.CTC),

STC = Sample Time Control (INPCR0.STC),

n = 8 or 10 (for 8-bit and 10-bit conversion respectively),

$t_{ADC} = 1 / f_{ADC}$

### 4.2.4 Power Supply Current

**Table 43**, **Table 44**, **Table 45** and **Table 46** provide the characteristics of the power supply current in the XC87x.

**Table 43 Power Supply Current Parameters (Operating Conditions apply; $V_{DDP}$ = 5V range)**

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|
| | | typ.[1] | max.[2] | | |
| **$V_{DDP}$ = 5V Range** | | | | | |
| Active Mode | $I_{DDP}$ | 37.5 | 45 | mA | [3] SAF and SAX variants |
| | | 40.5 | 48 | mA | [3] SAK variant |
| Idle Mode | $I_{DDP}$ | 29.2 | 35 | mA | [4] SAF and SAX variants |
| | | 32.2 | 38 | mA | [4] SAK variant |
| Active Mode with slow-down enabled | $I_{DDP}$ | 10 | 15 | mA | [5] SAF and SAX variants |
| | | 13 | 18 | mA | [5] SAK variant |
| Idle Mode with slow-down enabled | $I_{DDP}$ | 9.2 | 14 | mA | [6] SAF and SAX variants |
| | | 12.2 | 17 | mA | [6] SAK variant |

1) The typical $I_{DDP}$ values are based on preliminary measurements and are to be used as reference only. These values are periodically measured at $T_A$ = + 25 °C and $V_{DDP}$ = 5.0 V.

2) The maximum $I_{DDP}$ values are measured under worst case conditions ($T_A$ = + 105 °C and $V_{DDP}$ = 5.5 V).

3) $I_{DDP}$ (active mode) is measured with: CPU clock and input clock to all peripherals running at 24 MHz with on-chip oscillator of 4 MHz, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

4) $I_{DDP}$ (idle mode) is measured with: CPU clock disabled, watchdog timer disabled, input clock to all peripherals enabled and running at 24 MHz, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

5) $I_{DDP}$ (active mode with slow-down mode) is measured with: CPU clock and input clock to all peripherals running at 1 MHz by setting CLKREL in CMCON to $1000_B$, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

6) $I_{DDP}$ (idle mode with slow-down mode) is measured with: CPU clock disabled, watchdog timer disabled, input clock to all peripherals enabled and running at 1 MHz by setting CLKREL in CMCON to $1000_B$, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

**Table 44 Power Down Current[1](Operating Conditions apply; $V_{DDP}$ = 5V range)**

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|
| | | typ.[2] | max.[3] | | |
| **$V_{DDP}$ = 5V Range** | | | | | |
| Power-Down Mode | $I_{PDP}$ | 20 | 80 | µA | $T_A$ = + 25 °C[4][5] |
| | | - | 250 | µA | $T_A$ = + 85 °C[5][6] |

1) The table is only applicable to SAF and SAX variants. SAK variant does not support power-down mode

2) The typical $I_{PDP}$ values are based on preliminary measurements and are to be used as reference only. These values are measured at $V_{DDP}$ = 5.0 V.

3) The maximum $I_{PDP}$ values are measured at $V_{DDP}$ = 5.5 V.

4) $I_{PDP}$ has a maximum value of 450 µA at $T_A$ = + 105 °C.

5) $I_{PDP}$ is measured with: $\overline{\text{RESET}}$ = $V_{DDP}$, $V_{AGND}$= $V_{SS}$, RXD/INT0 = $V_{DDP}$; rest of the ports are programmed to be input with either internal pull devices enabled or driven externally to ensure no floating inputs.

6) Not subjected to production test, verified by design/characterization.

**Table 45 Power Supply Current Parameters[1] (Operating Conditions apply; $V_{DDP}$ = 3.3V range)**

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|
| | | typ.[2] | max.[3] | | |
| **$V_{DDP}$ = 3.3V Range** | | | | | |
| Active Mode | $I_{DDP}$ | 35.4 | 43 | mA | [4] |
| Idle Mode | $I_{DDP}$ | 27.6 | 33 | mA | [5] |
| Active Mode with slow-down enabled | $I_{DDP}$ | 8.6 | 13 | mA | [6] |
| Idle Mode with slow-down enabled | $I_{DDP}$ | 8 | 12 | mA | [7] |

1) The table is only applicable to SAF and SAX variants.

2) The typical $I_{DDP}$ values are based on preliminary measurements and are to be used as reference only. These values are periodically measured at $T_A$ = + 25 °C and $V_{DDP}$ = 3.3 V.

3) The maximum $I_{DDP}$ values are measured under worst case conditions ($T_A$ = + 105 °C and $V_{DDP}$ = 3.6 V).

4) $I_{DDP}$ (active mode) is measured with: CPU clock and input clock to all peripherals running at 24 MHz with on-chip oscillator of 4 MHz, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

5) $I_{DDP}$ (idle mode) is measured with: CPU clock disabled, watchdog timer disabled, input clock to all peripherals enabled and running at 24 MHz, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

6) $I_{DDP}$ (active mode with slow-down mode) is measured with: CPU clock and input clock to all peripherals running at 1 MHz by setting CLKREL in CMCON to $1000_B$, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

7) $I_{DDP}$ (idle mode with slow-down mode) is measured with: CPU clock disabled, watchdog timer disabled, input clock to all peripherals enabled and running at 1 MHz by setting CLKREL in CMCON to $1000_B$, $\overline{\text{RESET}}$ = $V_{DDP}$; all other pins are disconnected, no load on ports.

**Table 46 Power Down Current[1](Operating Conditions apply; $V_{DDP}$ = 3.3V range)**

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|
| | | typ.[2] | max.[3] | | |
| **$V_{DDP}$ = 3.3V Range** | | | | | |
| Power-Down Mode | $I_{PDP}$ | 20 | 80 | µA | $T_A$ = + 25 °C[4][5] |
| | | - | 250 | µA | $T_A$ = + 85 °C[5][6] |

1) The table is only applicable to SAF and SAX variants.

2) The typical $I_{PDP}$ values are based on preliminary measurements and are to be used as reference only. These values are measured at $V_{DDP}$ = 3.3 V.

3) The maximum $I_{PDP}$ values are measured at $V_{DDP}$ = 3.6 V.

4) $I_{PDP}$ has a maximum value of 450 µA at $T_A$ = + 105 °C.

5) $I_{PDP}$ is measured with: $\overline{\text{RESET}}$ = $V_{DDP}$, $V_{AGND}$= $V_{SS}$, RXD/INT0 = $V_{DDP}$; rest of the ports are programmed to be input with either internal pull devices enabled or driven externally to ensure no floating inputs.

6) Not subjected to production test, verified by design/characterization.

## 4.3 AC Parameters

The electrical characteristics of the AC Parameters are detailed in this section.

### 4.3.1 Testing Waveforms

The testing waveforms for rise/fall time, output delay and output high impedance are shown in **Figure 36**, **Figure 37** and **Figure 38**.

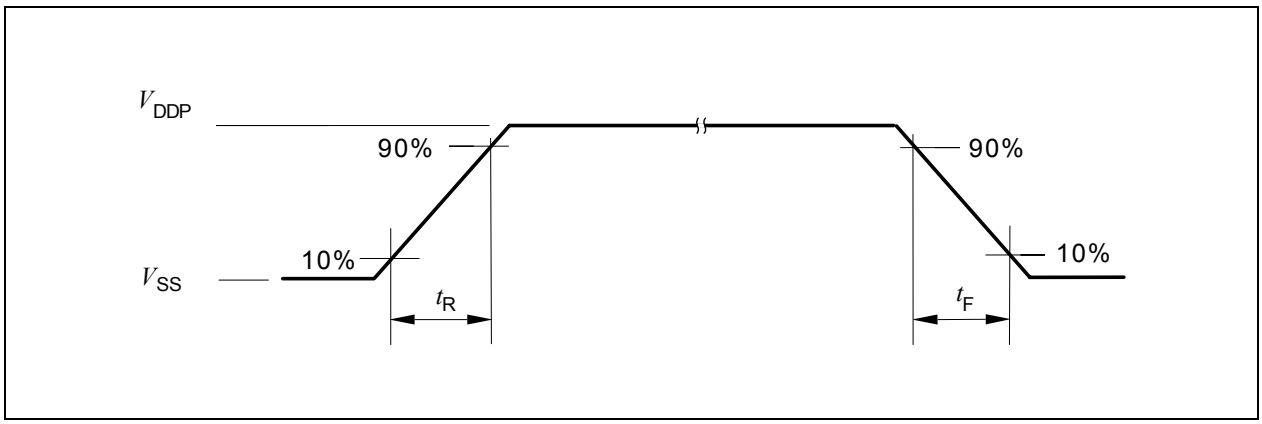



**Figure 36 Rise/Fall Time Parameters**

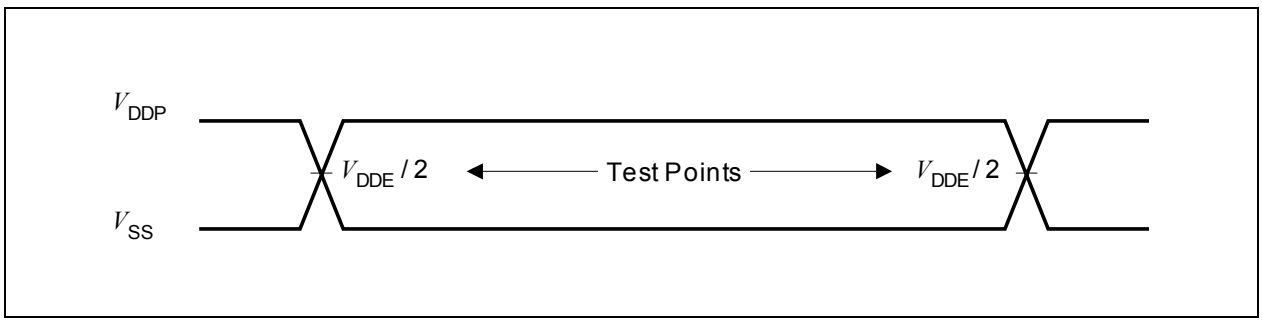



**Figure 37 Testing Waveform, Output Delay**

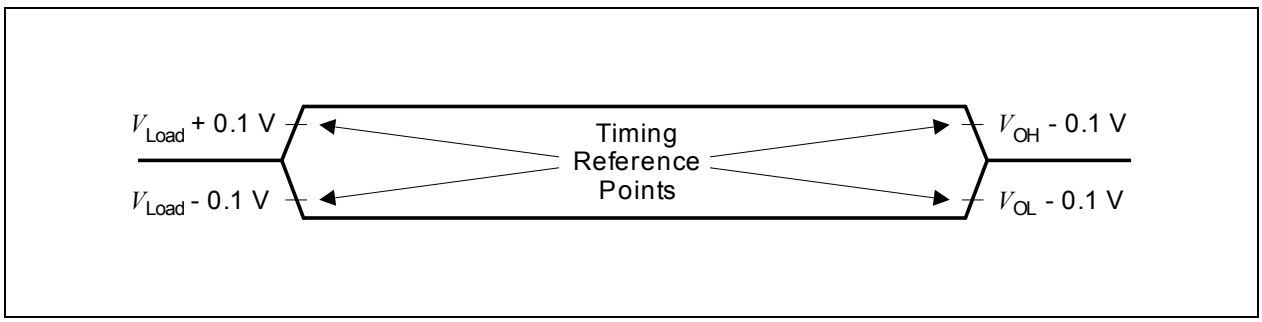



**Figure 38 Testing Waveform, Output High Impedance**

### 4.3.2 Output Rise/Fall Times

Table 47 provides the characteristics of the output rise/fall times in the XC87x.

**Table 47 Output Rise/Fall Times Parameters (Operating Conditions apply)**

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|
| | | min. | max. | | |
| **$V_{DDP}$ = 5V Range** | | | | | |
| Rise/fall times | $t_R$, $t_F$ | – | 10 | ns | 20 pF.[1) 2)3)] |
| **$V_{DDP}$ = 3.3V Range** | | | | | |
| Rise/fall times | $t_R$, $t_F$ | – | 10 | ns | 20 pF.[1) 2)4)] |

1) Rise/Fall time measurements are taken with 10% - 90% of pad supply.

2) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

3) Additional rise/fall time valid for $C_L$ = 20pF - 100pF @ 0.125 ns/pF.

4) Additional rise/fall time valid for $C_L$ = 20pF - 100pF @ 0.225 ns/pF.

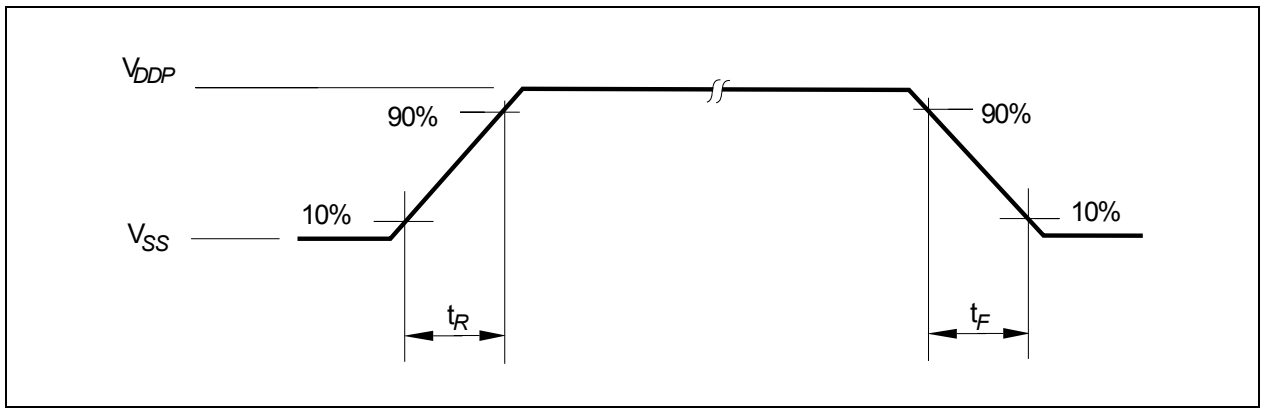



**Figure 39 Rise/Fall Times Parameters**

### 4.3.3 Power-on Reset and PLL Timing

**Table 48** provides the characteristics of the power-on reset and PLL timing in the XC87x.

**Table 48 Power-On Reset and PLL Timing (Operating Conditions apply)**

| Parameter | Symbol | | Limit Values | | | Unit | Test Conditions |
|---|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | | |
| On-Chip Oscillator start-up time | $t_{OSCST}$ | CC | – | – | 500 | ns | 1) |
| PLL lock-in in time | $t_{LOCK}$ | CC | – | – | 200 | µs | 1) |
| PLL accumulated jitter | $D_P$ | | – | – | 1.8 | ns | 1)2) |

1) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

2) PLL lock at 144 MHz using a 4 MHz external oscillator. The PLL Divider settings are K = 2, N = 72 and P = 1.

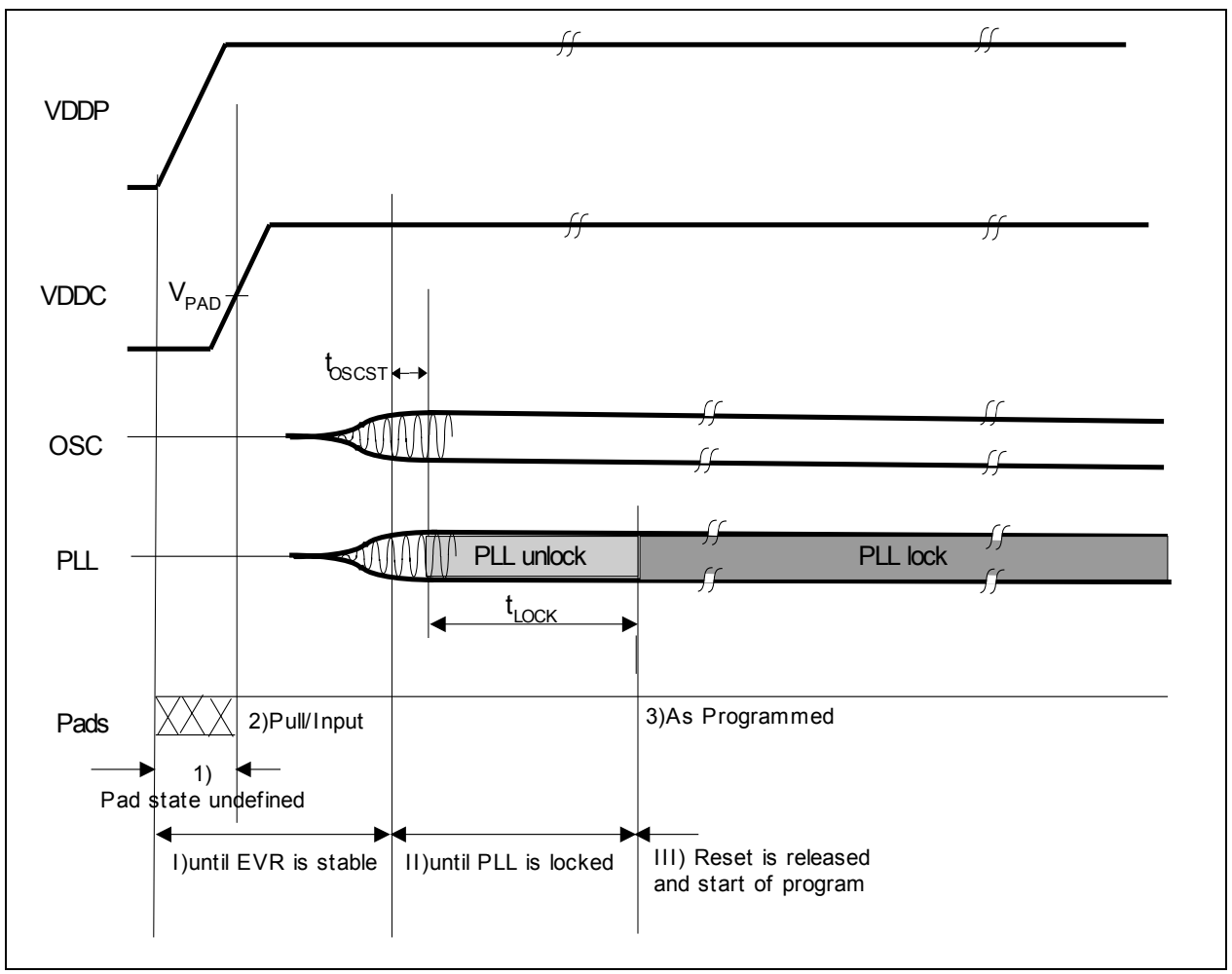



**Figure 40 Power-on Reset Timing**

### 4.3.4 On-Chip Oscillator Characteristics

Table 49 provides the characteristics of the on-chip oscillator in the XC87x.

**Table 49 On-chip Oscillator Characteristics (Operating Conditions apply)**

| Parameter | Symbol | | Limit Values | | | Unit | Test Conditions |
|---|---|---|---|---|---|---|---|
| | | | min. | typ. | max. | | |
| Nominal frequency | $f_{NOM}$ | CC | 3.88 | 4 | 4.12 | MHz | under nominal conditions[1] after IFX-backend trimming |
| Long term frequency deviation | $\Delta f_{LT}$ | CC | -5 | – | 5 | % | with respect to $f_{NOM}$, over lifetime and temperature (-40°C to 105°C), for one given device after trimming |
| Short term frequency deviation | $\Delta f_{ST}$ | CC | -1.0 | – | 1.0 | % | within one LIN message (<10 ms .... 100 ms) |

1) Nominal condition: $V_{DDC}$ = 2.5 V, $T_A$ = + 25°C.

### 4.3.5 External Data Memory Characteristics

**Table 50** shows the timing of the external data memory read cycle.

**Table 50 External Data Memory Read Timing[1] (Operating Conditions apply)**

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | Min. | Max. | | |
| $\overline{RD}$ pulse width | $t_1$ | CC | $2*f_{CCLK}$ - 17 | - | ns | 2) |
| Address valid to $\overline{RD}$ | $t_2$ | CC | $f_{CCLK}$ - 12 | - | ns | 2) |
| $\overline{RD}$ to valid data in | $t_3$ | SR | - | $1.5*f_{CCLK}$ - 27 | ns | 2) |
| Address to valid data in | $t_4$ | SR | - | $3*f_{CCLK}$ - 7 | ns | 2) |
| Data hold after $\overline{RD}$ | $t_5$ | SR | $0.5*f_{CCLK}$ -17 | - | ns | 2) |

1) External Bus Interface is not available in XC874.

2) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

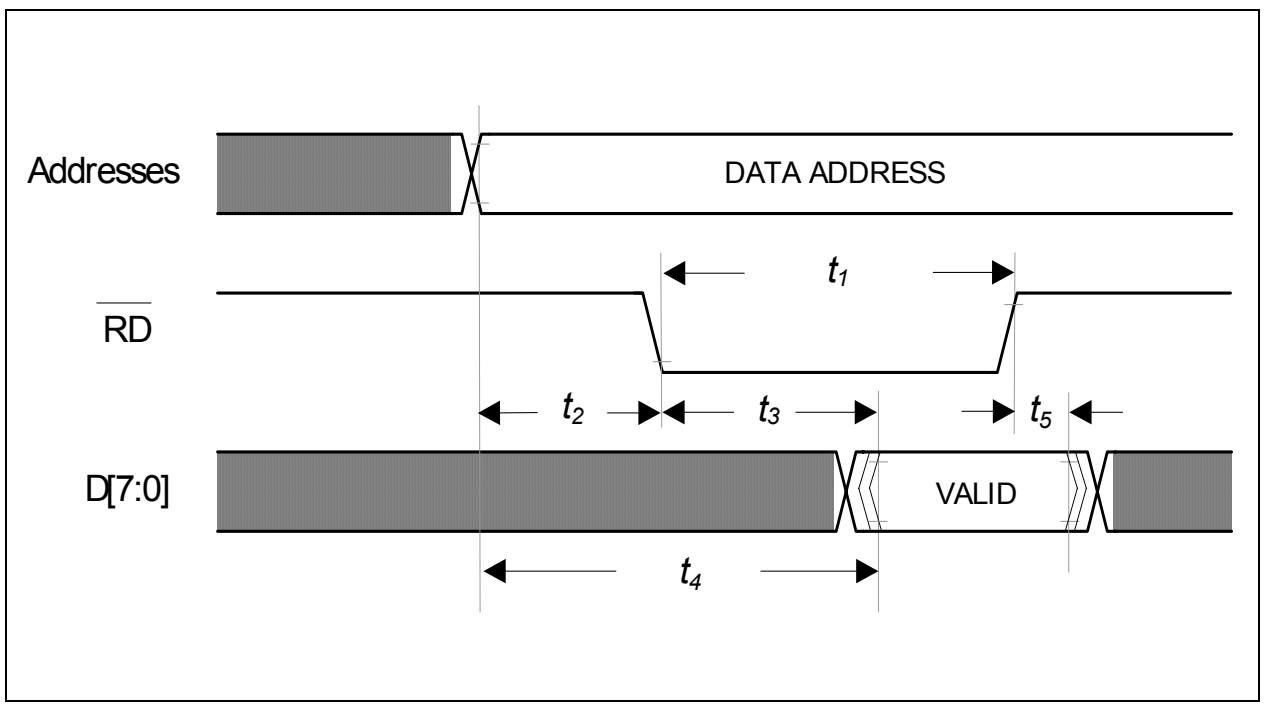



**Figure 41 External Data Memory Read Cycle**

**Table 51** shows the timing of the external data memory write cycle.

**Table 51 External Data Memory Write Timing[1] (Operating Conditions apply)**

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | Min. | Max. | | |
| $\overline{WR}$ pulse width | $t_1$ | CC | $f_{CCLK}$ - 10 | - | ns | [2] |
| Address valid to $\overline{WR}$ | $t_2$ | CC | 2*$f_{CCLK}$ - 7 | - | ns | [2] |
| Data valid to $\overline{WR}$ transition | $t_3$ | SR | $f_{CCLK}$ - 5 | - | ns | [2] |
| Data setup before $\overline{WR}$ | $t_4$ | SR | 9*$f_{CCLK}$ - 13 | - | ns | [2] |
| Data hold after $\overline{WR}$ | $t_5$ | SR | 6*$f_{CCLK}$ - 3 | - | ns | [2] |

1) External Bus Interface is not available in XC874.

2) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

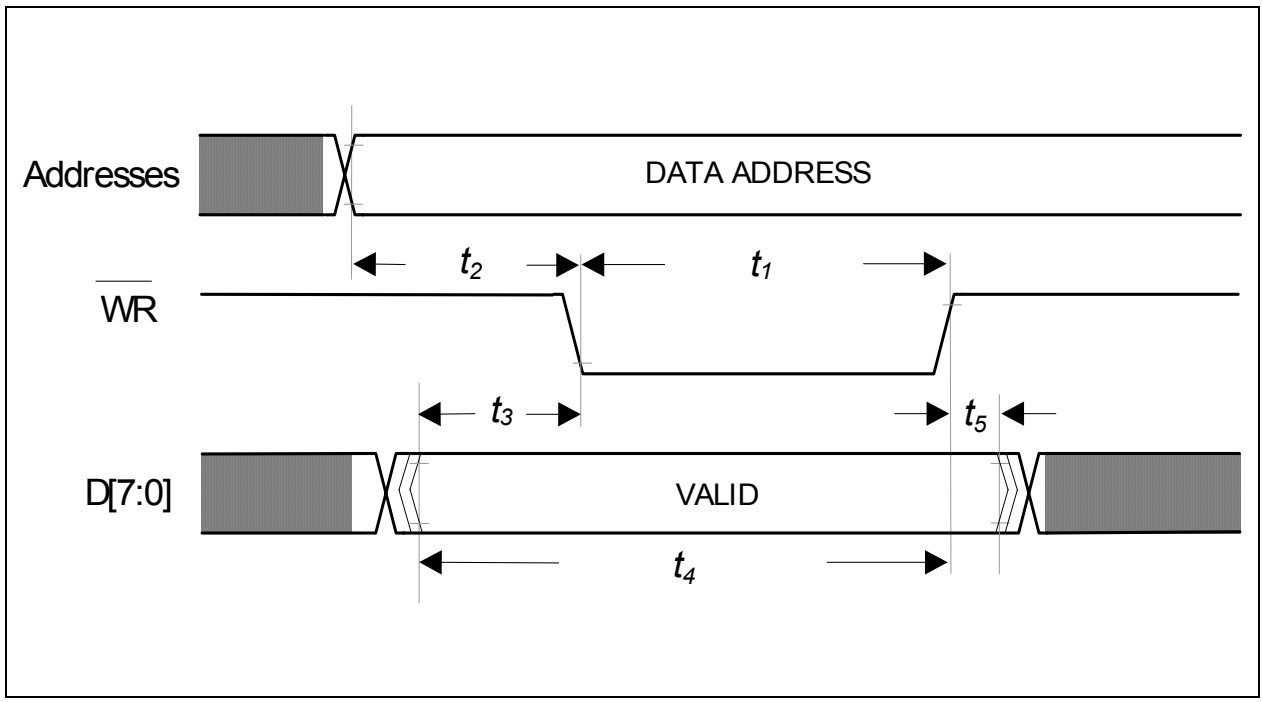



**Figure 42 External Data Memory Write Cycle**

### 4.3.6 External Clock Drive XTAL1

Table 52 shows the parameters that define the external clock supply for XC87x. These timing parameters are based on the direct XTAL1 drive of clock input signals. They are not applicable if an external crystal or ceramic resonator is considered.

**Table 52 External Clock Drive Characteristics (Operating Conditions apply)**

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | Min. | Max. | | |
| Oscillator period | $t_{osc}$ | SR | 50 | 500 | ns | 1)2) |
| High time | $t_1$ | SR | 15 | - | ns | 2)3) |
| Low time | $t_2$ | SR | 15 | - | ns | 2)3) |
| Rise time | $t_3$ | SR | - | 10 | ns | 2)3) |
| Fall time | $t_4$ | SR | - | 10 | ns | 2)3) |

1) The clock input signals with 45-55% duty cycle are used.

2) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

3) The clock input signal must reach the defined levels $V_{ILX}$ and $V_{IHX}$.

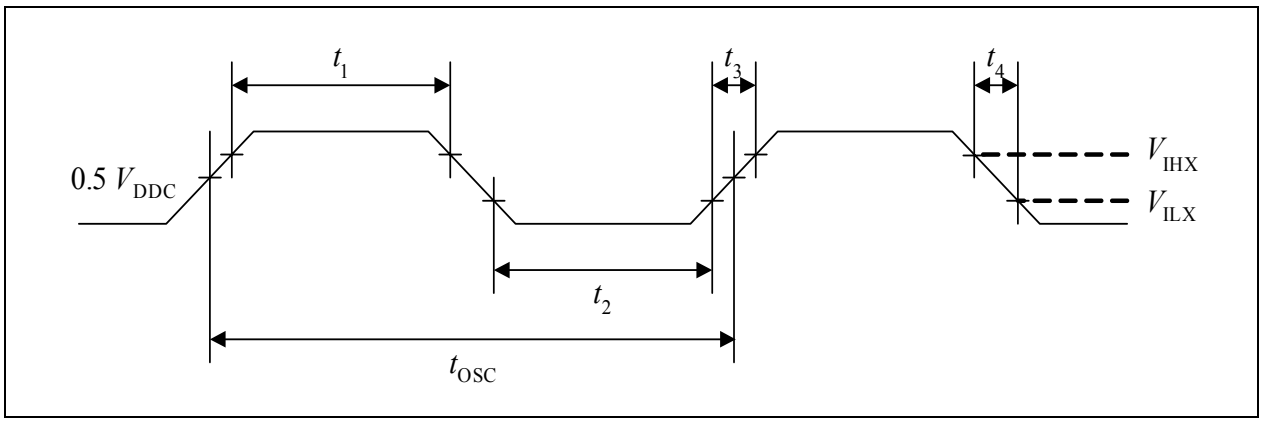



**Figure 43 External Clock Drive XTAL1**

### 4.3.7 JTAG Timing

**Table 53** provides the characteristics of the JTAG timing in the XC87x.

**Table 53 TCK Clock Timing (Operating Conditions apply; CL = 50 pF)**

| Parameter | Symbol | | Limits | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min | max | | |
| TCK clock period | $t_{TCK}$ | SR | 50 | - | ns | 1) |
| TCK high time | $t_1$ | SR | 20 | - | ns | 1) |
| TCK low time | $t_2$ | SR | 20 | - | ns | 1) |
| TCK clock rise time | $t_3$ | SR | - | 4 | ns | 1) |
| TCK clock fall time | $t_4$ | SR | - | 4 | ns | 1) |

1) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

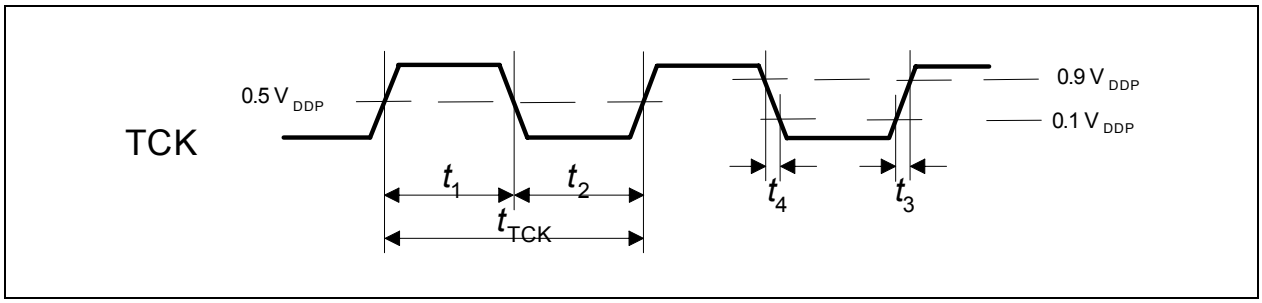



**Figure 44 TCK Clock Timing**

**Table 54 JTAG Timing (Operating Conditions apply; CL = 50 pF)**

| Parameter | Symbol | | Limits | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min | max | | |
| TMS setup to TCK | $t_1$ | SR | 8 | - | ns | 1) |
| TMS hold to TCK | $t_2$ | SR | 0 | - | ns | 1) |
| TDI setup to TCK | $t_1$ | SR | 8 | - | ns | 1) |
| TDI hold to TCK | $t_2$ | SR | 4 | - | ns | 1) |
| TDO valid output from TCK | $t_3$ | CC | - | 24 | ns | 5V Device[1)] |
| | | | - | 31 | ns | 3.3V Device[1)] |

**Table 54 JTAG Timing (Operating Conditions apply; CL = 50 pF)** (cont'd)

| Parameter | Symbol | | Limits | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min | max | | |
| TDO high impedance to valid output from TCK | $t_4$ | CC | - | 18 | ns | 5V Device[1)] |
| | | | - | 21 | ns | 3.3V Device[1)] |
| TDO valid output to high impedance from TCK | $t_5$ | CC | - | 21 | ns | 5V Device[1)] |
| | | | - | 20 | ns | 3.3V Device[1)] |

1) Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

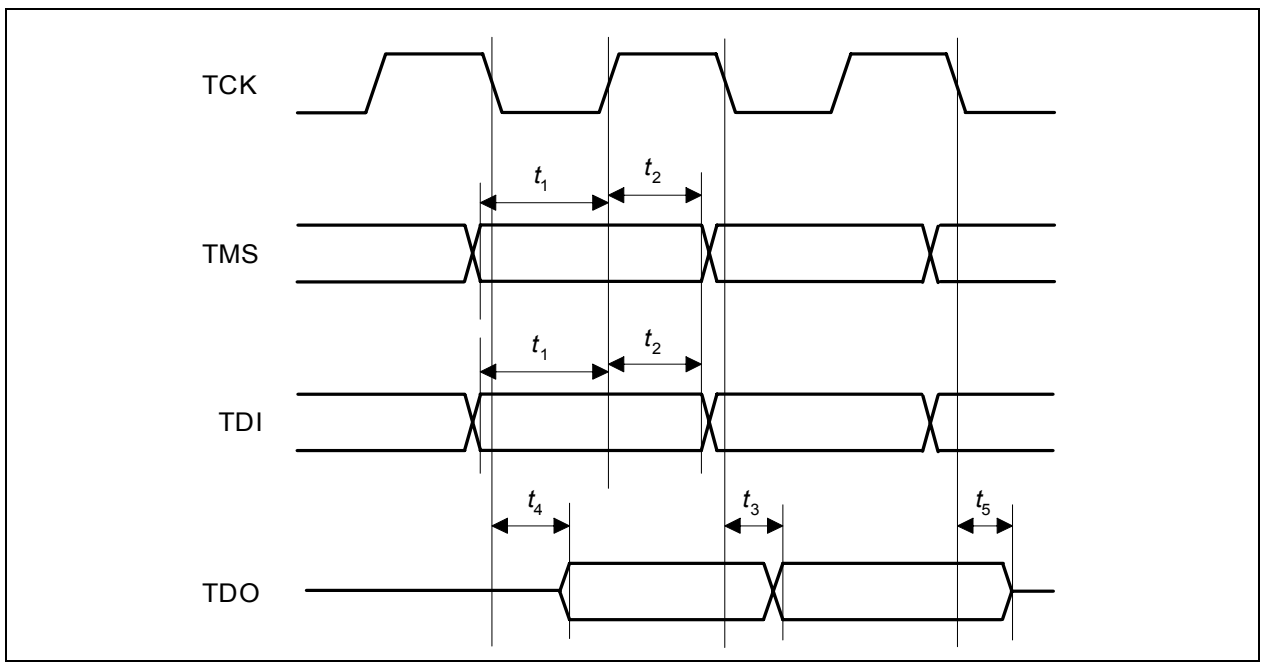



**Figure 45 JTAG Timing**

### 4.3.8 SSC Master Mode Timing

**Table 55** provides the characteristics of the SSC timing in the XC87x.

**Table 55 SSC Master Mode Timing (Operating Conditions apply; CL = 50 pF)**

| Parameter | Symbol | | Limit Values | | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| | | | min. | max. | | |
| SCLK clock period | $t_0$ | CC | $2*T_{SSC}$ | – | ns | 1)2) |
| MTSR delay from SCLK ↓ | $t_1$ | CC | 0 | 5 | ns | 2) |
| MRST setup to SCLK ↓ | $t_2$ | SR | 13 | – | ns | 2) |
| MRST hold from SCLK ↓ | $t_3$ | SR | 0 | – | ns | 2) |

1) $T_{SSCmin} = T_{CPU} = 1/f_{CPU}$. When $f_{CPU}$ = 24 MHz, $t_0$ = 83.3ns. $T_{CPU}$ is the CPU clock period.

2) 1Not all parameters are 100% tested, but are verified by design/characterization and test correlation.

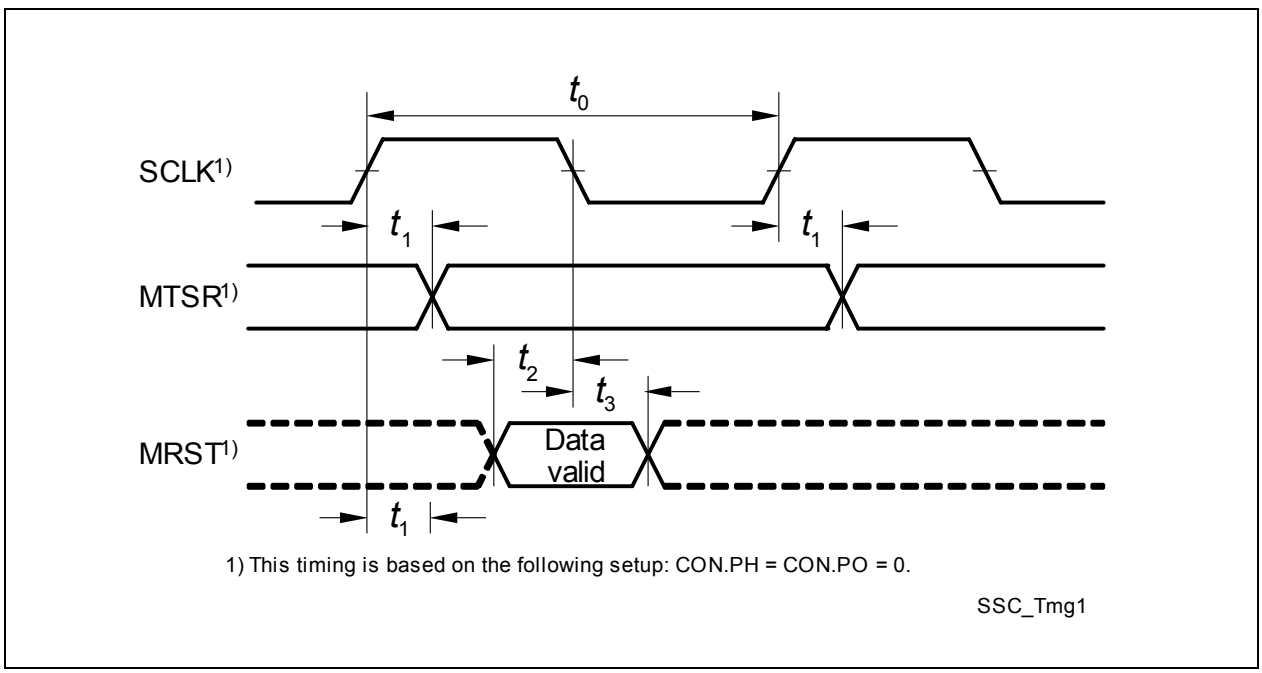



**Figure 46 SSC Master Mode Timing**

# 5 Package and Quality Declaration

**Chapter 5** provides the information of the XC87x package and reliability section.

## 5.1 Package Parameters

**Table 56** provides the thermal characteristics of the package used in XC878 and XC874.

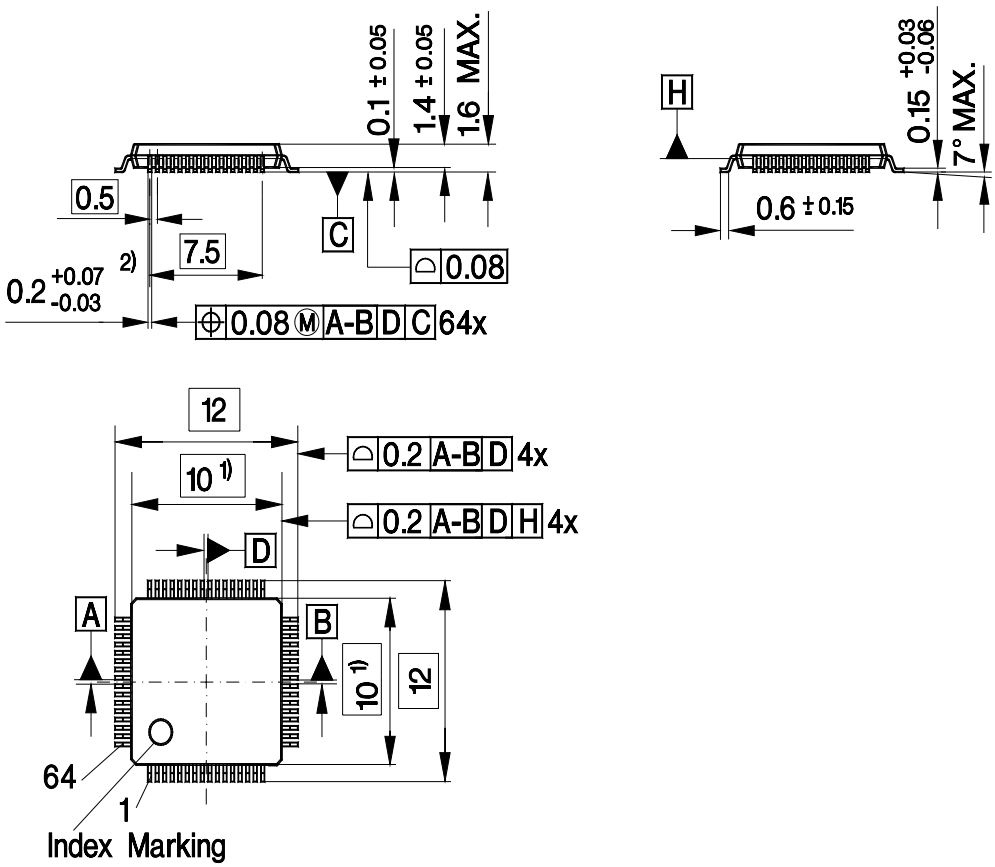
**Table 56 Thermal Characteristics of the Packages**

| Parameter | Symbol | | Limit Values | | Unit | Notes |
|---|---|---|---|---|---|---|
| | | | Min. | Max. | | |
| **PG-LQFP-64-4 (XC878)** | | | | | | |
| Thermal resistance junction case[1)] | $R_{TJC}$ | CC | - | 13.8 | K/W | - |
| Thermal resistance junction lead[1)] | $R_{TJL}$ | CC | - | 34.6 | K/W | - |
| **PG-VQFN-48-22 (XC874)** | | | | | | |
| Thermal resistance junction case[1)] | $R_{TJC}$ | CC | - | 16.6 | K/W | - |
| Thermal resistance junction lead[1)] | $R_{TJL}$ | CC | - | 30.7 | K/W | - |

1) The thermal resistances between the case and the ambient ($R_{TCA}$) , the lead and the ambient ($R_{TLA}$) are to be combined with the thermal resistances between the junction and the case ($R_{TJC}$), the junction and the lead ($R_{TJL}$) given above, in order to calculate the total thermal resistance between the junction and the ambient ($R_{TJA}$). The thermal resistances between the case and the ambient ($R_{TCA}$), the lead and the ambient ($R_{TLA}$) depend on the external system (PCB, case) characteristics, and are under user responsibility.
The junction temperature can be calculated using the following equation: $T_J=T_A+R_{TJA} \times P_D$, where the $R_{TJA}$ is the total thermal resistance between the junction and the ambient. This total junction ambient resistance $R_{TJA}$ can be obtained from the upper four partial thermal resistances, by
a) simply adding only the two thermal resistances (junction lead and lead ambient), or
b) by taking all four resistances into account, depending on the precision needed.

## 5.2 Package Outline

**Figure 47** shows the package outlines of the XC878.




1) Does not include plastic or metal protrusion of 0.25 max. per side
2) Does not include dambar protrusion of 0.08 max. per side

**Figure 47 PG-LQFP-64-4 Package Outline**

**Figure 48** shows the package outlines of the XC874.

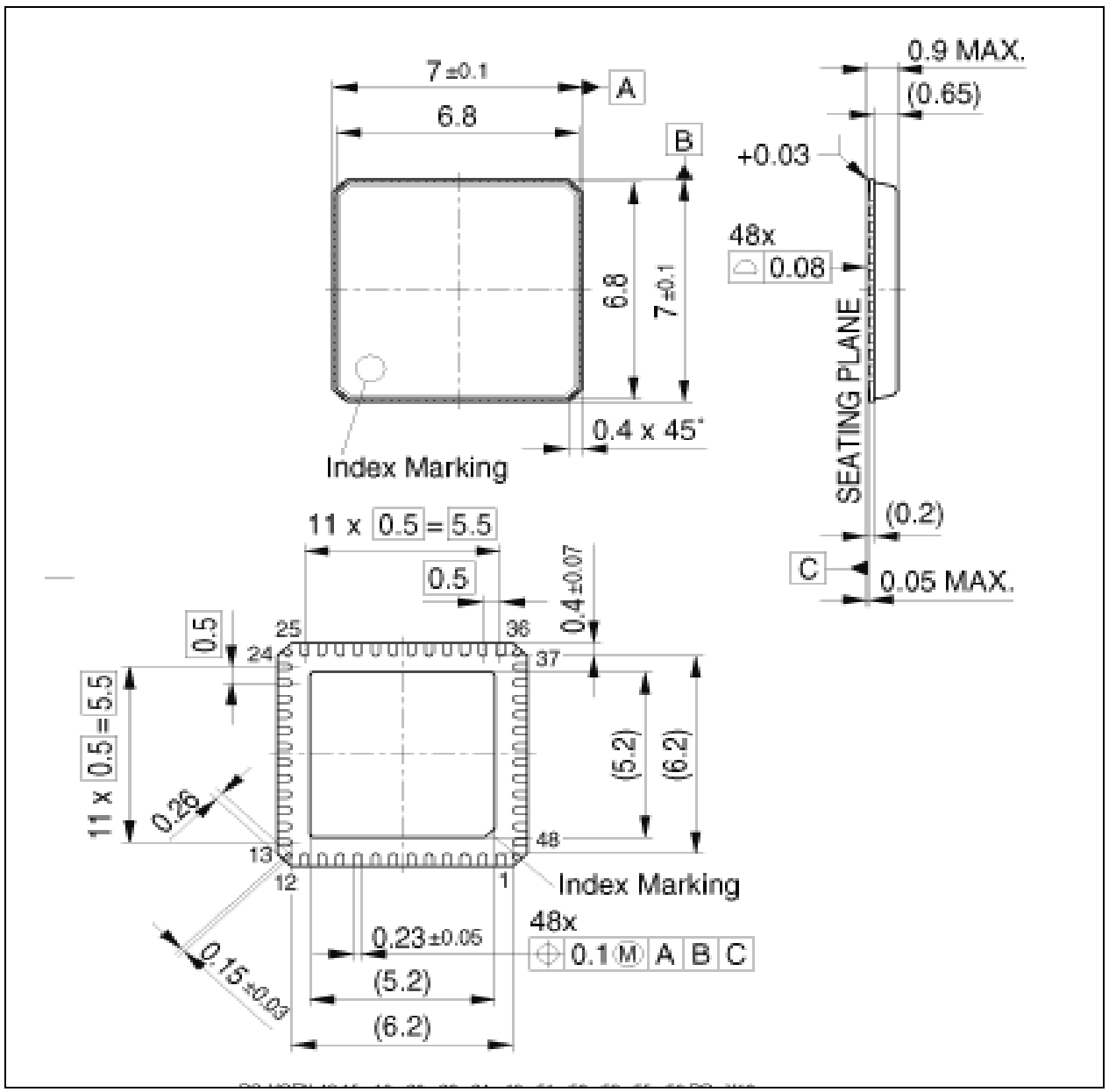



**Figure 48 PG-VQFN-48-22 Package Outline**

## 5.3 Quality Declaration

Table 57 shows the characteristics of the quality parameters in the XC87x.

**Table 57 Quality Parameters**

| Parameter | Symbol | Limit Values | | Unit | Notes |
|---|---|---|---|---|---|
| | | Min. | Max. | | |
| Operation Lifetime when the device is used at the two stated $T_J$ 1) | $t_{OP1}$ | - | 15000 | hours | $T_J$ = 110°C |
| | | - | 2000 | hours | $T_J$ = -40°C |
| Operation Lifetime when the device is used at the five stated $T_J$ 1) | $t_{OP2}$ | - | 120 | hours | $T_J$ = 140°C |
| | | - | 960 | hours | $T_J$ = 135°C |
| | | - | 7800 | hours | $T_J$ = 91°C |
| | | - | 2400 | hours | $T_J$ = 38°C |
| | | - | 720 | hours | $T_J$ = -25°C |
| ESD susceptibility according to Human Body Model (HBM) | $V_{HBM}$ | - | 2000 | V | Conforming to EIA/JESD22-A114-B |
| ESD susceptibility according to Charged Device Model (CDM) pins | $V_{CDM}$ | - | 750 | V | Conforming to JESD22-C101-C |

1) This lifetime refers only to the time when device is powered-on.

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