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# MB9B510T Series

# 32-bit ARM® Cortex®-M3 FM3 Microcontroller

The MB9B510T Series are highly integrated 32-bit microcontrollers dedicated for embedded controllers with high-performance and competitive cost.

These series are based on the ARM® Cortex®-M3 Processor with on-chip Flash memory and SRAM, and has peripheral functions such as Motor Control Timers, ADCs and Communication Interfaces (USB, CAN, UART, CSIO, $I^2C$, LIN).

The products which are described in this datasheet are placed into TYPE2 product categories in "FM3 Family Peripheral Manual".

## Features

### 32-bit ARM® Cortex®-M3 Core

- Processor version: r2p1
- Up to 144 MHz Frequency Operation
- Memory Protection Unit (MPU): improves the reliability of an embedded system
- Integrated Nested Vectored Interrupt Controller (NVIC): 1 NMI (non-maskable interrupt) and 48 peripheral interrupts and 16 priority levels
- 24-bit System timer (Sys Tick): System timer for OS task management

### On-chip Memories

#### [Flash memory]

- Up to 1 Mbyte
- Built-in Flash Accelerator System with 16 Kbyte trace buffer memory
- The read access to Flash memory can be achieved without wait cycle up to operation frequency of 72 MHz. Even at the operation frequency more than 72 MHz, an equivalent access to Flash memory can be obtained by Flash Accelerator System.
- Security function for code protection

#### [SRAM]

This Series contain a total of up to 128 Kbyte on-chip SRAM memories. This is composed of two independent SRAM (SRAM0, SRAM1). SRAM0 is connected to I-code bus and D-code bus of Cortex-M3 core. SRAM1 is connected to System bus.

- SRAM0: Up to 64 Kbyte.
- SRAM1: Up to 64 Kbyte.

### External Bus Interface

- Supports SRAM, NOR and NAND Flash device
- Up to 8 chip selects
- 8-/16-bit Data width
- Up to 25-bit Address bit
- Maximum area size: Up to 256 Mbytes
- Supports Address/Data multiplex
- Supports external RDY input

### USB Interface (Max 2 channels)

USB interface is composed of Device and Host.

#### [USB device]

- USB2.0 Full-Speed supported
- Max 6 EndPoint supported
  - EndPoint 0 is control transfer
  - EndPoint 1,2 can be selected Bulk-transfer, Interrupt-transfer or Isochronous-transfer
  - EndPoint 3 – 5 can be selected Bulk-transfer or Interrupt-transfer
  - EndPoint 1 to 5 is comprised Double Buffer
    - EndPoint 0, 2 to 5: 64 bytes
    - EndPoint 1: 256 bytes

#### [USB host]

- USB2.0 Full/Low speed supported
- Bulk-transfer, interrupt-transfer and Isochronous-transfer support
- USB Device connected/dis-connected automatically detect
- IN/OUT token handshake packet automatically
- Max 256-byte packet-length supported
- Wake-up function supported

### CAN Interface (Max. 2 channels)

- Compatible with CAN Specification 2.0A/B
- Maximum transfer rate: 1 Mbps
- Built-in 32 message buffer

### Multi-function Serial Interface (Max 8 channels)

- 4 channels with 16steps×9-bit FIFO (ch.4 to ch.7), 4 channels without FIFO (ch.0 to ch.3)
- Operation mode is selectable from the followings for each channel.
  - UART
  - CSIO
  - LIN
  - $I^2C$

**[UART]**

- Full-duplex double buffer
- Selection with or without parity supported
- Built-in dedicated baud rate generator
- External clock available as a serial clock
- Hardware Flow control: Automatically control the transmission by CTS/RTS (only ch.4)
- Various error detect functions available (parity errors, framing errors, and overrun errors)

**[CSIO]**

- Full-duplex double buffer
- Built-in dedicated baud rate generator
- Overrun error detect function available

**[LIN]**

- LIN protocol Rev.2.1 supported
- Full-duplex double buffer
- Master/Slave mode supported
- LIN break field generate (can be changed 13-16bit length)
- LIN break delimiter generate (can be changed 1-4bit length)
- Various error detect functions available (parity errors, framing errors, and overrun errors)

**[$I^2C$]**

- Standard-mode (Max 100 kbps) / Fast-mode (Max 400 kbps) supported

### DMA Controller (8 channels)

DMA Controller has an independent bus for CPU, so CPU and DMA Controller can process simultaneously.

- 8 independently configured and operated channels
- Transfer can be started by software or request from the built-in peripherals
- Transfer address area: 32 bit (4 Gbyte)
- Transfer mode: Block transfer/Burst transfer/Demand transfer
- Transfer data type: byte/half-word/word
- Transfer block count: 1 to 16
- Number of transfers: 1 to 65536

### A/D Converter (Max 32 channels)

**[12-bit A/D Converter]**

- Successive Approximation Register type
- Built-in 3unit
- Conversion time: 1.0 µs @ 5 V
- Priority conversion available (priority at 2 levels)
- Scanning conversion mode
- Built-in FIFO for conversion data storage (for SCAN conversion:16 steps, for Priority conversion:4 steps)

### Base Timer (Max 16 channels)

Operation mode is selectable from the followings for each channel.

- 16-bit PWM timer
- 16-bit PPG timer
- 16-/32-bit reload timer
- 16-/32-bit PWC timer

### General Purpose I/O Port

This series can use its pins as I/O ports when they are not used for external bus or peripherals. Moreover, the port relocate function is built in. It can set which I/O port the peripheral function can be allocated.

- Capable of pull-up control per pin
- Capable of reading pin level directly
- Built-in the port relocate function
- Up 154 fast I/O Ports @ 176 pin Package
- Some pin is 5 V tolerant I/O.
  See "Pin Description" to confirm the corresponding pins.

### Multi-function Timer (Max 3 units)

The Multi-function timer is composed of the following blocks.

- 16-bit free-run timer × 3 ch/unit
- Input capture × 4 ch/unit
- Output compare × 6 ch/unit
- A/D activation compare × 3 ch/unit
- Waveform generator × 3 ch/unit
- 16-bit PPG timer × 3 ch/unit

The following function can be used to achieve the motor control.

- PWM signal output function
- DC chopper waveform output function
- Dead time function
- Input capture function
- A/D convertor activate function
- DTIF (Motor emergency stop) interrupt function

### Quadrature Position/Revolution Counter (QPRC) (Max 3 channels)

The Quadrature Position/Revolution Counter (QPRC) is used to measure the position of the position encoder. Moreover, it is possible to use up/down counter.

- The detection edge of the three external event input pins AIN, BIN and ZIN is configurable.
- 16-bit position counter
- 16-bit revolution counter
- Two 16-bit compare registers

### Dual Timer (32-/16-bit Down Counter)

The Dual Timer consists of two programmable 32-/16-bit down counters.
Operation mode is selectable from the followings for each channel.

- Free-running
- Periodic (=Reload)
- One-shot

### Watch Counter

The Watch counter is used for wake up from power saving mode.

Interval timer: up to 64 s (Max) @ Sub Clock: 32.768 kHz

### External Interrupt Controller Unit

- Up to 32 external interrupt input pin
- Include one non-maskable interrupt(NMI)

### Watch dog Timer (2 channels)

A watchdog timer can generate interrupts or a reset when a time-out value is reached.

This series consists of two different watchdogs, a "Hardware" watchdog and a "Software" watchdog.

"Hardware" watchdog timer is clocked by low speed internal CR oscillator. Therefore, "Hardware" watchdog is active in any power saving mode except STOP mode.

### CRC (Cyclic Redundancy Check) Accelerator

The CRC accelerator helps a verify data transmission or storage integrity.

CCITT CRC16 and IEEE-802.3 CRC32 are supported.

- CCITT CRC16 Generator Polynomial: 0x1021
- IEEE-802.3 CRC32 Generator Polynomial: 0x04C11DB7

### Clock and Reset

#### [Clocks]

Five clock sources (2 external oscillators, 2 internal CR oscillator, and Main PLL) that are dynamically selectable.

- Main Clock: 4 MHz to 48 MHz
- Sub Clock: 32.768 kHz
- High-speed internal CR Clock: 4 MHz
- Low-speed internal CR Clock: 100 kHz
- Main PLL Clock

#### [Resets]

- Reset requests from INITX pin
- Power on reset
- Software reset
- Watchdog timers reset
- Low voltage detector reset
- Clock supervisor reset

### Clock Super Visor (CSV)

Clocks generated by internal CR oscillators are used to supervise abnormality of the external clocks.

- External OSC clock failure (clock stop) is detected, reset is asserted.
- External OSC frequency anomaly is detected, interrupt or reset is asserted.

### Low Voltage Detector (LVD)

This Series include 2-stage monitoring of voltage on the VCC pins. When the voltage falls below the voltage has been set, Low Voltage Detector generates an interrupt or reset.

- LVD1: error reporting via interrupt
- LVD2: auto-reset operation

### Low Power Mode

Three power saving modes supported.

- SLEEP
- TIMER
- STOP

### Debug

- Serial Wire JTAG Debug Port (SWJ-DP)
- Embedded Trace Macrocells (ETM) provide comprehensive debug and trace facilities.

### Power Supply

- Three Power Supplies
- Wide range voltage VCC = 2.7 V to 5.5 V
- USBVCC0 = 3.0 V to 3.6 V: for USB ch.0 I/O voltage, when USB ch.0 is used.
  = 2.7 V to 5.5 V: when GPIO is used.
- USBVCC1 = 3.0 V to 3.6 V: for USB ch.1 I/O voltage, when USB ch.1 is used.
  = 2.7 V to 5.5 V: when GPIO is used.

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# 1. Product Lineup

### Memory Size

| Product name | MB9BF516S/T | MB9BF517S/T | MB9BF518S/T |
|---|---|---|---|
| On-chip Flash memory | 512 Kbyte | 768 Kbyte | 1 Mbyte |
| On-chip RAM | 64 Kbyte | 96 Kbyte | 128 Kbyte |

### Function

| Product name | | | MB9BF516S<br>MB9BF517S<br>MB9BF518S | MB9BF516T<br>MB9BF517T<br>MB9BF518T |
|---|---|---|---|---|
| Pin count | | | 144 | 176/192 |
| CPU | | | Cortex-M3 | |
| | Freq. | | 144 MHz | |
| Power supply voltage range | | | VCC: 2.7 V to 5.5 V<br>( USBVCC0:3.0 V to 3.6 V )<br>( USBVCC1:3.0 V to 3.6 V ) | |
| USB2.0 (Device/Host) | | | 2 ch. (Max) | |
| CAN Interface | | | 2 ch. (Max) | |
| DMAC | | | 8ch. | |
| External Bus Interface | | | Addr:19-bit (Max)<br>R/Wdata:8-/16-bit (Max)<br>CS: 8 (Max)<br>Support: SRAM, NOR & NAND Flash | Addr:25-bit (Max)<br>R/Wdata:8-/16-bit (Max)<br>CS: 8 (Max)<br>Support: SRAM, NOR & NAND Flash |
| Multi-function Serial Interface<br>(UART/CSIO/LIN/I$^2$C) | | | 8 ch. (Max)<br>ch.4 to ch.7: FIFO (16steps × 9-bit)<br>ch.0 to ch.3: No FIFO | |
| Base Timer<br>(PWC/ Reload timer/PWM/PPG) | | | 16 ch. (Max) | |
| MF-Timer | A/D activation compare | 3 ch. | 3 units (Max) | |
| | Input capture | 4 ch. | | |
| | Free-run timer | 3 ch. | | |
| | Output compare | 6 ch. | | |
| | Waveform generator | 3 ch. | | |
| | PPG | 3 ch. | | |
| QPRC | | | 3 ch. (Max) | |
| Dual Timer | | | 1 unit | |
| Watch Counter | | | 1 unit | |
| CRC Accelerator | | | Yes | |
| Watchdog timer | | | 1 ch. (SW) + 1 ch. (HW) | |
| External Interrupts | | | 32 pins (Max)+ NMI × 1 | |
| I/O ports | | | 122 pins (Max) | 154 pins (Max) |
| 12-bit A/D converter | | | 24 ch. (3 units) | 32 ch. (3 units) |
| CSV (Clock Super Visor) | | | Yes | |
| LVD (Low Voltage Detector) | | | 2 ch. | |
| Built-in CR | High-speed | | 4 MHz | |
| | Low-speed | | 100 kHz | |
| Debug Function | | | SWJ-DP/ETM | |

***Note:***

- *All signals of the peripheral function in each product cannot be allocated by limiting the pins of package. It is necessary to use the port relocate function of the General I/O port according to your function use.*
  *See "12. Electrical Characteristics 12.4. AC Characteristics 12.4.3. Internal CR Oscillation Characteristics" for accuracy of built-in CR.*

## 2. Packages

| Package \ Product name | MB9BF516S<br>MB9BF517S<br>MB9BF518S | MB9BF516T<br>MB9BF517T<br>MB9BF518T |
|---|---|---|
| LQFP: LQS144 (0.5 mm pitch) | ○ | - |
| LQFP: LQP176 (0.5 mm pitch) | - | ○ |
| BGA: LBE192 (0.8 mm pitch) | - | ○ |

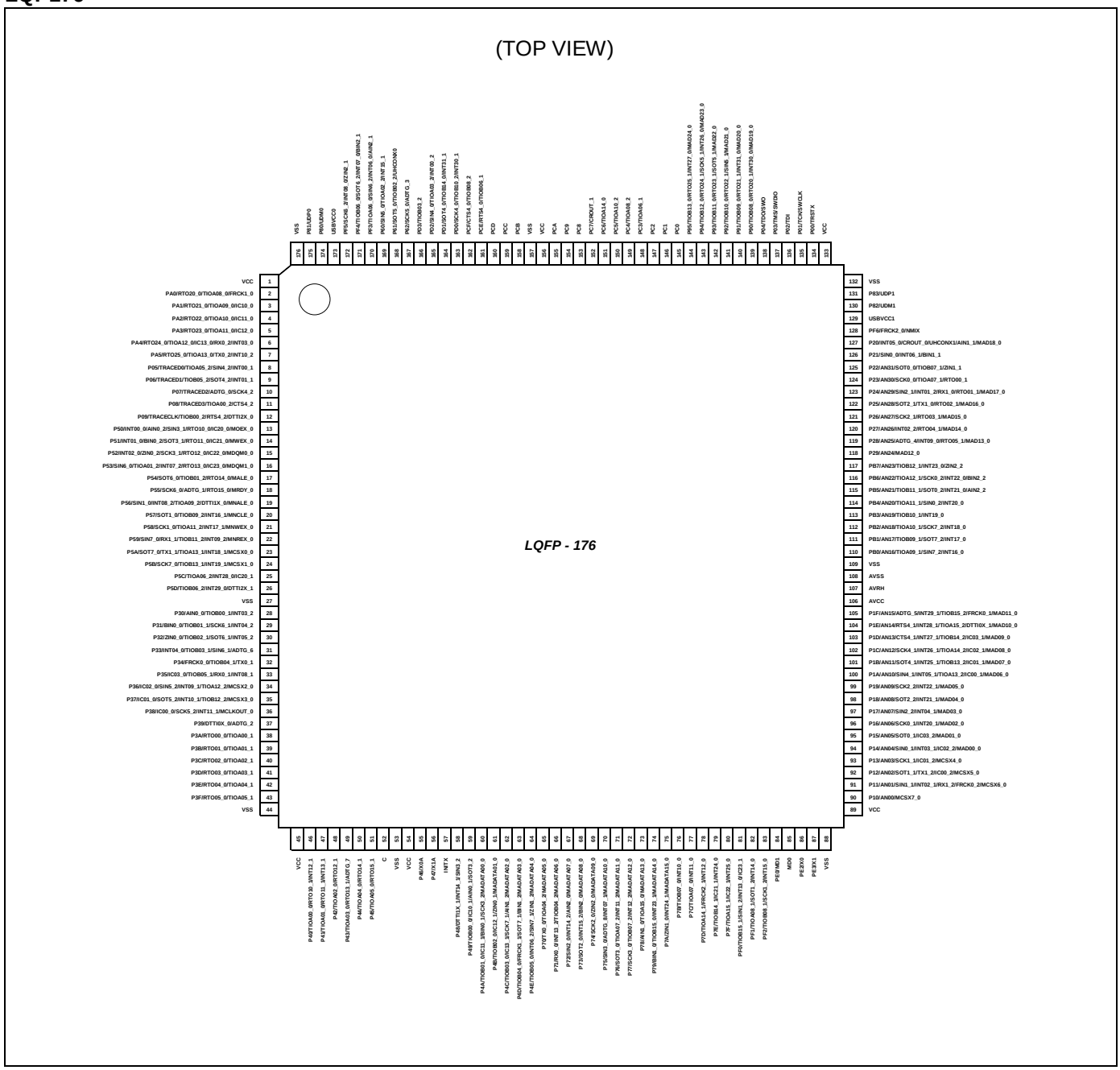
○: Supported

***Note:***

- *See "14. Package Dimensions" for detailed information on each package.*

# 3. Pin Assignment

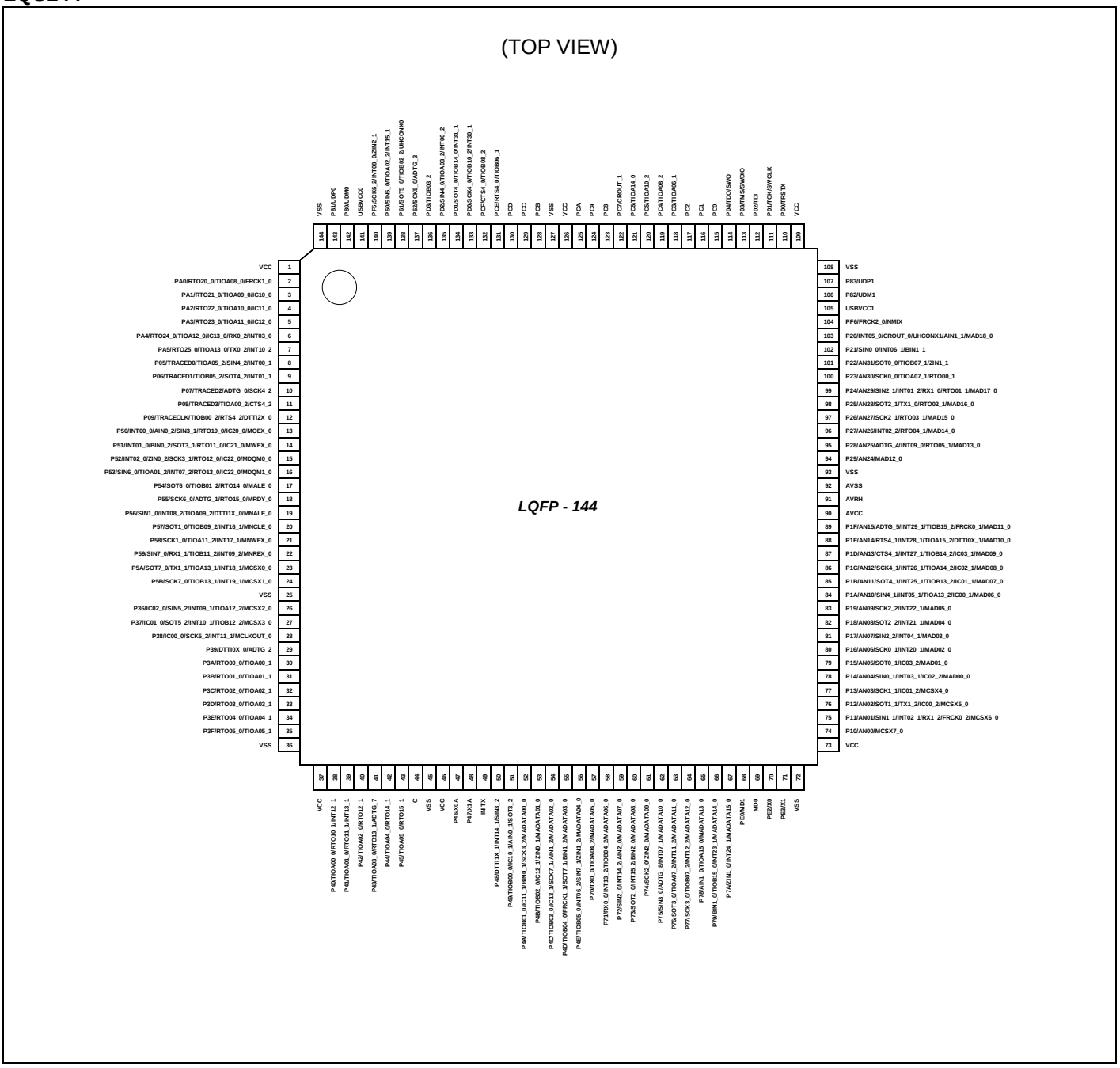
## LQP176




***Note:***

- *The number after the underscore ("_") in pin names such as XXX_1 and XXX_2 indicates the relocated port number. For these pins, there are multiple pins that provide the same function for the same channel. Use the extended port function register (EPFR) to select the pin. TIOA09_0, TIOA09_1, and TIOA09_2 cannot be used as the external startup trigger input (TGIN signal) at I/O mode 1 (timer full mode) of the Base Timer. See "Base Timer" in "7. Handling Devices" for details.*

## LQS144




***Note:***

- *The number after the underscore ("_") in pin names such as XXX_1 and XXX_2 indicates the relocated port number. For these pins, there are multiple pins that provide the same function for the same channel. Use the extended port function register (EPFR) to select the pin. TIOA09_0 and TIOA09_2 cannot be used as the external startup trigger input (TGIN signal) at I/O mode 1 (timer full mode) of the Base Timer. See "Base Timer" in "7. Handling Devices" for details.*

**LBE192**

(TOP VIEW)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | UDP0 | UDM0 | USB VCC0 | VSS | PCD | PCB | VSS | VCC | PC8 | VSS | TCK | VCC | |
| B | VSS | PA0 | PF5 | PF3 | P61 | PD1 | PCA | PC1 | P95 | P92 | TDO | TMS | TRSTX | VSS |
| C | VCC | PA1 | PA2 | PF4 | P60 | PD2 | PCC | PC5 | PC0 | P93 | P90 | TDI | PF6 | UDP1 |
| D | PA5 | PA4 | P05 | P06 | PA3 | PD3 | PCE | PC6 | PC2 | P94 | P91 | P21 | P20 | UDM1 |
| E | VSS | P07 | P08 | P09 | P50 | P62 | PCF | PC7 | PC3 | P25 | P24 | P23 | P22 | USB VCC1 |
| F | P51 | P52 | P53 | P54 | P55 | P56 | PD0 | PC9 | PC4 | P29 | P28 | P27 | P26 | VSS |
| G | VSS | P57 | P58 | P59 | P5A | P5B | VSS | VSS | PB7 | PB6 | PB5 | PB4 | PB3 | AVSS |
| H | P5C | P5D | P30 | P31 | P32 | P33 | VSS | VSS | P1F | P1E | PB2 | PB1 | PB0 | AVRH |
| J | VSS | P37 | P36 | P35 | P34 | P70 | VSS | P76 | P1D | P1C | P1B | P1A | P19 | AVCC |
| K | P38 | P39 | P3A | P3B | P4A | P4E | VSS | P74 | P7B | P7F | P18 | P16 | P15 | P17 |
| L | P3C | P3D | P3E | P43 | P49 | P4D | VSS | P73 | P7A | P7E | P14 | P13 | P12 | VSS |
| M | VSS | P3F | P42 | P44 | P48 | P4C | VSS | P72 | P79 | PF0 | PF2 | P11 | P10 | VCC |
| N | VCC | P40 | P41 | P45 | INITX | P4B | VSS | P71 | P78 | P7D | PF1 | MD0 | MD1 | VSS |
| P | | C | VSS | VCC | X0A | X1A | VSS | P75 | P77 | P7C | VSS | X0 | X1 | |

***Note:***

- *The number after the underscore ("_") in pin names such as XXX_1 and XXX_2 indicates the relocated port number. For these pins, there are multiple pins that provide the same function for the same channel. Use the extended port function register (EPFR) to select the pin. TIOA09_0, TIOA09_1, and TIOA09_2 cannot be used as the external startup trigger input (TGIN signal) at I/O mode 1 (timer full mode) of the Base Timer. See "Base Timer" in "7. Handling Devices" for details.*

# 4. List of Pin Functions

### List of pin numbers

The number after the underscore ("_") in pin names such as XXX_1 and XXX_2 indicates the relocated port number. For these pins, there are multiple pins that provide the same function for the same channel. Use the extended port function register (EPFR) to select the pin.

| Pin No | | | Pin Name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 1 | 1 | C1 | VCC | - | |
| 2 | 2 | B2 | PA0<br>RTO20_0<br>TIOA08_0<br>FRCK1_0 | G | I |
| 3 | 3 | C2 | PA1<br>RTO21_0<br>TIOA09_0<br>IC10_0 | G | I |
| 4 | 4 | C3 | PA2<br>RTO22_0<br>TIOA10_0<br>IC11_0 | G | I |
| 5 | 5 | D5 | PA3<br>RTO23_0<br>TIOA11_0<br>IC12_0 | G | I |
| 6 | 6 | D2 | PA4<br>RTO24_0<br>TIOA12_0<br>RX0_2<br>IC13_0<br>INT03_0 | G | H |
| 7 | 7 | D1 | PA5<br>RTO25_0<br>TX0_2<br>TIOA13_0<br>INT10_2 | G | H |
| 8 | 8 | D3 | P05<br>TRACED0<br>TIOA05_2<br>SIN4_2<br>INT00_1 | E | F |
| 9 | 9 | D4 | P06<br>TRACED1<br>TIOB05_2<br>SOT4_2<br>INT01_1 | E | F |
| 10 | 10 | E2 | P07<br>TRACED2<br>ADTG_0<br>SCK4_2 | E | G |

| Pin No | | | Pin Name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 11 | 11 | E3 | P08<br>TRACED3<br>TIOA00_2<br>CTS4_2 | E | G |
| 12 | 12 | E4 | P09<br>TRACECLK<br>TIOB00_2<br>RTS4_2<br>DTTI2X_0 | E | G |
| 13 | 13 | E5 | P50<br>INT00_0<br>AIN0_2<br>SIN3_1<br>RTO10_0<br>IC20_0<br>MOEX_0 | E | H |
| 14 | 14 | F1 | P51<br>INT01_0<br>BIN0_2<br>SOT3_1<br>RTO11_0<br>IC21_0<br>MWEX_0 | E | H |
| 15 | 15 | F2 | P52<br>INT02_0<br>ZIN0_2<br>SCK3_1<br>RTO12_0<br>IC22_0<br>MDQM0_0 | E | H |
| 16 | 16 | F3 | P53<br>SIN6_0<br>TIOA01_2<br>INT07_2<br>RTO13_0<br>IC23_0<br>MDQM1_0 | E | H |
| 17 | 17 | F4 | P54<br>SOT6_0<br>TIOB01_2<br>RTO14_0<br>MALE_0 | E | I |
| 18 | 18 | F5 | P55<br>SCK6_0<br>ADTG_1<br>RTO15_0<br>MRDY_0 | E | I |
| 19 | 19 | F6 | P56<br>SIN1_0<br>INT08_2<br>TIOA09_2<br>DTTI1X_0<br>MNALE_0 | E | H |

| Pin No | | | Pin Name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 20 | 20 | G2 | P57<br>SOT1_0<br>TIOB09_2<br>INT16_1<br>MNCLE_0 | E | H |
| 21 | 21 | G3 | P58<br>SCK1_0<br>TIOA11_2<br>INT17_1<br>MNWEX_0 | E | H |
| 22 | 22 | G4 | P59<br>SIN7_0<br>RX1_1<br>TIOB11_2<br>INT09_2<br>MNREX_0 | E | H |
| 23 | 23 | G5 | P5A<br>SOT7_0<br>TX1_1<br>TIOA13_1<br>INT18_1<br>MCSX0_0 | E | H |
| 24 | 24 | G6 | P5B<br>SCK7_0<br>TIOB13_1<br>INT19_1<br>MCSX1_0 | E | H |
| 25 | - | H1 | P5C<br>TIOA06_2<br>INT28_0<br>IC20_1 | E | H |
| 26 | - | H2 | P5D<br>TIOB06_2<br>INT29_0<br>DTTI2X_1 | E | H |
| 27 | 25 | J1 | VSS | - | |
| 28 | - | H3 | P30<br>AIN0_0<br>TIOB00_1<br>INT03_2 | E | H |
| 29 | - | H4 | P31<br>BIN0_0<br>TIOB01_1<br>SCK6_1<br>INT04_2 | E | H |
| 30 | - | H5 | P32<br>ZIN0_0<br>TIOB02_1<br>SOT6_1<br>INT05_2 | E | H |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 31 | - | H6 | P33<br>INT04_0<br>TIOB03_1<br>SIN6_1<br>ADTG_6 | E | H |
| 32 | - | J4 | P34<br>FRCK0_0<br>TX0_1<br>TIOB04_1 | E | I |
| 33 | - | J4 | P35<br>IC03_0<br>RX0_1<br>TIOB05_1<br>INT08_1 | E | H |
| 34 | 26 | J3 | P36<br>IC02_0<br>SIN5_2<br>INT09_1<br>TIOA12_2<br>MCSX2_0 | E | H |
| 35 | 27 | J2 | P37<br>IC01_0<br>SOT5_2<br>INT10_1<br>TIOB12_2<br>MCSX3_0 | E | H |
| 36 | 28 | K1 | P38<br>IC00_0<br>SCK5_2<br>INT11_1<br>MCLKOUT_0 | E | H |
| 37 | 29 | K2 | P39<br>DTTI0X_0<br>ADTG_2 | E | I |
| 38 | 30 | K3 | P3A<br>RTO00_0<br>TIOA00_1 | G | I |
| 39 | 31 | K4 | P3B<br>RTO01_0<br>TIOA01_1 | G | I |
| 40 | 32 | L1 | P3C<br>RTO02_0<br>TIOA02_1 | G | I |
| 41 | 33 | L2 | P3D<br>RTO03_0<br>TIOA03_1 | G | I |
| 42 | 34 | L3 | P3E<br>RTO04_0<br>TIOA04_1 | G | I |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 43 | 35 | M2 | P3F<br>RTO05_0<br>TIOA05_1 | G | I |
| 44 | 36 | M1 | VSS | - | |
| 45 | 37 | N1 | VCC | - | |
| 46 | 38 | N2 | P40<br>TIOA00_0<br>RTO10_1<br>INT12_1 | G | H |
| 47 | 39 | N3 | P41<br>TIOA01_0<br>RTO11_1<br>INT13_1 | G | H |
| 48 | 40 | M3 | P42<br>TIOA02_0<br>RTO12_1 | G | I |
| 49 | 41 | L4 | P43<br>TIOA03_0<br>RTO13_1<br>ADTG_7 | G | I |
| 50 | 42 | M4 | P44<br>TIOA04_0<br>RTO14_1 | G | I |
| 51 | 43 | N4 | P45<br>TIOA05_0<br>RTO15_1 | G | I |
| 52 | 44 | P2 | C | - | |
| 53 | 45 | P3 | VSS | - | |
| 54 | 46 | P4 | VCC | - | |
| 55 | 47 | P5 | P46<br>X0A | D | M |
| 56 | 48 | P6 | P47<br>X1A | D | N |
| 57 | 49 | N5 | INITX | B | C |
| 58 | 50 | M5 | P48<br>DTTI1X_1<br>INT14_1<br>SIN3_2 | E | H |
| 59 | 51 | L5 | P49<br>TIOB00_0<br>IC10_1<br>AIN0_1<br>SOT3_2 | E | I |
| 60 | 52 | K5 | P4A<br>TIOB01_0<br>IC11_1<br>BIN0_1<br>SCK3_2<br>MADATA00_0 | E | I |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 61 | 53 | N6 | P4B<br>TIOB02_0<br>IC12_1<br>ZIN0_1<br>MADATA01_0 | E | I |
| 62 | 54 | M6 | P4C<br>TIOB03_0<br>IC13_1<br>SCK7_1<br>AIN1_2<br>MADATA02_0 | E | I |
| 63 | 55 | L6 | P4D<br>TIOB04_0<br>FRCK1_1<br>SOT7_1<br>BIN1_2<br>MADATA03_0 | E | I |
| 64 | 56 | K6 | P4E<br>TIOB05_0<br>INT06_2<br>SIN7_1<br>ZIN1_2<br>MADATA04_0 | E | H |
| 65 | 57 | J6 | P70<br>TIOA04_2<br>TX0_0<br>MADATA05_0 | E | I |
| 66 | 58 | N8 | P71<br>INT13_2<br>TIOB04_2<br>RX0_0<br>MADATA06_0 | E | H |
| 67 | 59 | M8 | P72<br>SIN2_0<br>INT14_2<br>AIN2_0<br>MADATA07_0 | E | H |
| 68 | 60 | L8 | P73<br>SOT2_0<br>INT15_2<br>BIN2_0<br>MADATA08_0 | E | H |
| 69 | 61 | K8 | P74<br>SCK2_0<br>ZIN2_0<br>MADATA09_0 | E | I |
| 70 | 62 | P8 | P75<br>SIN3_0<br>ADTG_8<br>INT07_1<br>MADATA10_0 | E | H |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 71 | 63 | J8 | P76<br>SOT3_0<br>TIOA07_2<br>INT11_2<br>MADATA11_0 | E | H |
| 72 | 64 | P9 | P77<br>SCK3_0<br>TIOB07_2<br>INT12_2<br>MADATA12_0 | E | H |
| 73 | 65 | N9 | P78<br>AIN1_0<br>TIOA15_0<br>MADATA13_0 | E | I |
| 74 | 66 | M9 | P79<br>BIN1_0<br>TIOB15_0<br>INT23_1<br>MADATA14_0 | E | H |
| - | - | E1 | VSS | - | |
| - | - | G1 | VSS | - | |
| 75 | 67 | L9 | P7A<br>ZIN1_0<br>INT24_1<br>MADATA15_0 | E | H |
| 76 | - | K9 | P7B<br>TIOB07_0<br>INT10_0 | E | H |
| 77 | - | P10 | P7C<br>TIOA07_0<br>INT11_0 | E | H |
| 78 | - | N10 | P7D<br>TIOA14_1<br>FRCK2_1<br>INT12_0 | E | H |
| 79 | - | L10 | P7E<br>TIOB14_1<br>IC21_1<br>INT24_0 | E | H |
| 80 | - | K10 | P7F<br>TIOA15_1<br>IC22_1<br>INT25_0 | E | H |
| 81 | - | M10 | PF0<br>TIOB15_1<br>SIN1_2<br>INT13_0<br>IC23_1 | I* | H |
| 82 | - | N11 | PF1<br>TIOA08_1<br>SOT1_2<br>INT14_0 | I* | H |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 83 | - | M11 | PF2<br>TIOB08_1<br>SCK1_2<br>INT15_0 | I* | H |
| 84 | 68 | N13 | PE0<br>MD1 | C | P |
| 85 | 69 | N12 | MD0 | J | D |
| 86 | 70 | P12 | PE2<br>X0 | A | A |
| 87 | 71 | P13 | PE3<br>X1 | A | B |
| 88 | 72 | N14 | VSS | - | |
| 89 | 73 | M14 | VCC | - | |
| - | - | L7 | VSS | - | |
| - | - | K7 | VSS | - | |
| 90 | 74 | M13 | P10<br>AN00<br>MCSX7_0 | F | K |
| 91 | 75 | M12 | P11<br>AN01<br>SIN1_1<br>RX1_2<br>INT02_1<br>FRCK0_2<br>MCSX6_0 | F | L |
| 92 | 76 | L13 | P12<br>AN02<br>SOT1_1<br>TX1_2<br>IC00_2<br>MCSX5_0 | F | K |
| 93 | 77 | L12 | P13<br>AN03<br>SCK1_1<br>IC01_2<br>MCSX4_0 | F | K |
| 94 | 78 | L11 | P14<br>AN04<br>SIN0_1<br>INT03_1<br>IC02_2<br>MAD00_0 | F | L |
| 95 | 79 | K13 | P15<br>AN05<br>SOT0_1<br>IC03_2<br>MAD01_0 | F | K |
| 96 | 80 | K12 | P16<br>AN06<br>SCK0_1<br>INT20_1<br>MAD02_0 | F | L |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 97 | 81 | K14 | P17<br>AN07<br>SIN2_2<br>INT04_1<br>MAD03_0 | F | L |
| - | - | P7 | VSS | - | |
| - | - | P11 | VSS | - | |
| - | - | L14 | VSS | - | |
| 98 | 82 | K11 | P18<br>AN08<br>SOT2_2<br>INT21_1<br>MAD04_0 | F | L |
| 99 | 83 | J13 | P19<br>AN09<br>SCK2_2<br>INT22_1<br>MAD05_0 | F | L |
| 100 | 84 | J12 | P1A<br>AN10<br>SIN4_1<br>INT05_1<br>TIOA13_2<br>IC00_1<br>MAD06_0 | F | L |
| 101 | 85 | J11 | P1B<br>AN11<br>SOT4_1<br>INT25_1<br>TIOB13_2<br>IC01_1<br>MAD07_0 | F | L |
| 102 | 86 | J10 | P1C<br>AN12<br>SCK4_1<br>INT26_1<br>TIOA14_2<br>IC02_1<br>MAD08_0 | F | L |
| 103 | 87 | J9 | P1D<br>AN13<br>CTS4_1<br>INT27_1<br>TIOB14_2<br>IC03_1<br>MAD09_0 | F | L |
| 104 | 88 | H10 | P1E<br>AN14<br>RTS4_1<br>INT28_1<br>TIOA15_2<br>DTTI0X_1<br>MAD10_0 | F | L |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 105 | 89 | H9 | P1F<br>AN15<br>ADTG_5<br>INT29_1<br>TIOB15_2<br>FRCK0_1<br>MAD11_0 | F | L |
| 106 | 90 | J14 | AVCC | - | |
| 107 | 91 | H14 | AVRH | - | |
| 108 | 92 | G14 | AVSS | - | |
| 109 | 93 | F14 | VSS | - | |
| 110 | - | H13 | PB0<br>AN16<br>TIOA09_1<br>SIN7_2<br>INT16_0 | F | L |
| 111 | - | H12 | PB1<br>AN17<br>TIOB09_1<br>SOT7_2<br>INT17_0 | F | L |
| 112 | - | H11 | PB2<br>AN18<br>TIOA10_1<br>SCK7_2<br>INT18_0 | F | L |
| 113 | - | G13 | PB3<br>AN19<br>TIOB10_1<br>INT19_0 | F | L |
| 114 | - | G12 | PB4<br>AN20<br>TIOA11_1<br>SIN0_2<br>INT20_0 | F | L |
| 115 | - | G11 | PB5<br>AN21<br>TIOB11_1<br>SOT0_2<br>INT21_0<br>AIN2_2 | F | L |
| - | - | G7 | VSS | - | |
| - | - | J7 | VSS | - | |
| 116 | - | G10 | PB6<br>AN22<br>TIOA12_1<br>SCK0_2<br>INT22_0<br>BIN2_2 | F | L |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 117 | - | G9 | PB7<br>AN23<br>TIOB12_1<br>INT23_0<br>ZIN2_2 | F | L |
| 118 | 94 | F10 | P29<br>AN24<br>MAD12_0 | F | K |
| 119 | 95 | F11 | P28<br>AN25<br>ADTG_4<br>INT09_0<br>RTO05_1<br>MAD13_0 | F | L |
| 120 | 96 | F12 | P27<br>AN26<br>INT02_2<br>RTO04_1<br>MAD14_0 | F | L |
| 121 | 97 | F13 | P26<br>AN27<br>SCK2_1<br>RTO03_1<br>MAD15_0 | F | K |
| 122 | 98 | E10 | P25<br>AN28<br>SOT2_1<br>TX1_0<br>RTO02_1<br>MAD16_0 | F | K |
| 123 | 99 | E11 | P24<br>AN29<br>SIN2_1<br>RX1_0<br>INT01_2<br>RTO01_1<br>MAD17_0 | F | L |
| 124 | 100 | E12 | P23<br>AN30<br>SCK0_0<br>TIOA07_1<br>RTO00_1 | F | K |
| 125 | 101 | E13 | P22<br>AN31<br>SOT0_0<br>TIOB07_1<br>ZIN1_1 | F | K |
| 126 | 102 | D12 | P21<br>SIN0_0<br>INT06_1<br>BIN1_1 | E | H |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 127 | 103 | D13 | P20<br>INT05_0<br>CROUT_0<br>UHCONX1<br>AIN1_1<br>MAD18_0 | E | H |
| 128 | 104 | C13 | PF6<br>FRCK2_0<br>NMIX | I* | J |
| 129 | 105 | E14 | USBVCC1 | - | |
| 130 | 106 | D14 | P82<br>UDM1 | H | O |
| 131 | 107 | C14 | P83<br>UDP1 | H | O |
| 132 | 108 | B14 | VSS | - | |
| 133 | 109 | A13 | VCC | - | |
| 134 | 110 | B13 | P00<br>TRSTX | E | E |
| 135 | 111 | A12 | P01<br>TCK<br>SWCLK | E | E |
| 136 | 112 | C12 | P02<br>TDI | E | E |
| 137 | 113 | B12 | P03<br>TMS<br>SWDIO | E | E |
| 138 | 114 | B11 | P04<br>TDO<br>SWO | E | E |
| 139 | - | C11 | P90<br>TIOB08_0<br>RTO20_1<br>INT30_0<br>MAD19_0 | E | H |
| - | - | A8 | VSS | - | |
| 140 | - | D11 | P91<br>TIOB09_0<br>RTO21_1<br>INT31_0<br>MAD20_0 | E | H |
| 141 | - | B10 | P92<br>TIOB10_0<br>RTO22_1<br>SIN5_1<br>MAD21_0 | E | I |
| 142 | - | C10 | P93<br>TIOB11_0<br>RTO23_1<br>SOT5_1<br>MAD22_0 | E | I |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 143 | - | D10 | P94<br>TIOB12_0<br>RTO24_1<br>SCK5_1<br>INT26_0<br>MAD23_0 | E | H |
| 144 | - | B9 | P95<br>TIOB13_0<br>RTO25_1<br>INT27_0<br>MAD24_0 | E | H |
| 145 | 115 | C9 | PC0 | K | Q |
| 146 | 116 | B8 | PC1 | K | Q |
| 147 | 117 | D9 | PC2 | K | Q |
| 148 | 118 | E9 | PC3<br>TIOA06_1 | K | Q |
| 149 | 119 | F9 | PC4<br>TIOA08_2 | K | Q |
| 150 | 120 | C8 | PC5<br>TIOA10_2 | K | Q |
| - | - | A5 | VSS | - | |
| 151 | 121 | D8 | PC6<br>TIOA14_0 | K | Q |
| 152 | 122 | E8 | PC7<br>CROUT_1 | L | Q |
| 153 | 123 | A10 | PC8 | K | Q |
| 154 | 124 | F8 | PC9 | K | Q |
| 155 | 125 | B7 | PCA | K | Q |
| 156 | 126 | A9 | VCC | - | |
| 157 | 127 | A11 | VSS | - | |
| 158 | 128 | A7 | PCB | L | Q |
| 159 | 129 | C7 | PCC | K | Q |
| 160 | 130 | A6 | PCD | K | Q |
| 161 | 131 | D7 | PCE<br>RTS4_0<br>TIOB06_1 | L | Q |
| 162 | 132 | E7 | PCF<br>CTS4_0<br>TIOB08_2 | L | Q |
| 163 | 133 | F7 | PD0<br>SCK4_0<br>TIOB10_2<br>INT30_1 | L | R |
| 164 | 134 | B6 | PD1<br>SOT4_0<br>TIOB14_0<br>INT31_1 | L | R |
| - | - | N7 | VSS | - | |
| - | - | G8 | VSS | - | |
| - | - | H7 | VSS | - | |
| - | - | H8 | VSS | - | |

| Pin No | | | Pin name | I/O circuit type | Pin state type |
|---|---|---|---|---|---|
| LQFP-176 | LQFP-144 | BGA-192 | | | |
| 165 | 135 | C6 | PD2<br>SIN4_0<br>TIOA03_2<br>INT00_2 | L | R |
| 166 | 136 | D6 | PD3<br>TIOB03_2 | L | Q |
| 167 | 137 | E6 | P62<br>SCK5_0<br>ADTG_3 | E | Q |
| 168 | 138 | B5 | P61<br>SOT5_0<br>TIOB02_2<br>UHCONX0 | E | I |
| 169 | 139 | C5 | P60<br>SIN5_0<br>TIOA02_2<br>INT15_1 | E | H |
| 170 | - | B4 | PF3<br>TIOA06_0<br>SIN6_2<br>INT06_0<br>AIN2_1 | I* | H |
| 171 | - | C4 | PF4<br>TIOB06_0<br>SOT6_2<br>INT07_0<br>BIN2_1 | I* | H |
| 172 | 140 | B3 | PF5<br>SCK6_2<br>INT08_0<br>ZIN2_1 | I* | H |
| 173 | 141 | A4 | USBVCC0 | - | |
| 174 | 142 | A3 | P80<br>UDM0 | H | O |
| 175 | 143 | A2 | P81<br>UDP0 | H | O |
| 176 | 144 | B1 | VSS | - | |
| - | - | M7 | VSS | - | |

*: 5 V tolerant I/O

## List of functions

The number after the underscore ("_") in pin names such as XXX_1 and XXX_2 indicates the relocated port number. For these pins, there are multiple pins that provide the same function for the same channel. Use the extended port function register (EPFR) to select the pin.

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| ADC | ADTG_0 | A/D converter external trigger input pin | 10 | 10 | E2 |
| | ADTG_1 | | 18 | 18 | F5 |
| | ADTG_2 | | 37 | 29 | K2 |
| | ADTG_3 | | 167 | 137 | E6 |
| | ADTG_4 | | 119 | 95 | F11 |
| | ADTG_5 | | 105 | 89 | H9 |
| | ADTG_6 | | 31 | - | H6 |
| | ADTG_7 | | 49 | 41 | L4 |
| | ADTG_8 | | 70 | 62 | P8 |
| | AN00 | A/D converter analog input pin<br>ANxx describes ADC ch.xx | 90 | 74 | M13 |
| | AN01 | | 91 | 75 | M12 |
| | AN02 | | 92 | 76 | L13 |
| | AN03 | | 93 | 77 | L12 |
| | AN04 | | 94 | 78 | L11 |
| | AN05 | | 95 | 79 | K13 |
| | AN06 | | 96 | 80 | K12 |
| | AN07 | | 97 | 81 | K14 |
| | AN08 | | 98 | 82 | K11 |
| | AN09 | | 99 | 83 | J13 |
| | AN10 | | 100 | 84 | J12 |
| | AN11 | | 101 | 85 | J11 |
| | AN12 | | 102 | 86 | J10 |
| | AN13 | | 103 | 87 | J9 |
| | AN14 | | 104 | 88 | H10 |
| | AN15 | | 105 | 89 | H9 |
| | AN16 | | 110 | - | H13 |
| | AN17 | | 111 | - | H12 |
| | AN18 | | 112 | - | H11 |
| | AN19 | | 113 | - | G13 |
| | AN20 | | 114 | - | G12 |
| | AN21 | | 115 | - | G11 |
| | AN22 | | 116 | - | G10 |
| | AN23 | | 117 | - | G9 |
| | AN24 | | 118 | 94 | F10 |
| | AN25 | | 119 | 95 | F11 |
| | AN26 | | 120 | 96 | F12 |
| | AN27 | | 121 | 97 | F13 |
| | AN28 | | 122 | 98 | E10 |
| | AN29 | | 123 | 99 | E11 |
| | AN30 | | 124 | 100 | E12 |
| | AN31 | | 125 | 101 | E13 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Base Timer 0 | TIOA0_0 | Base timer ch.0 TIOA pin | 46 | 38 | N2 |
| | TIOA0_1 | | 38 | 30 | K3 |
| | TIOA0_2 | | 11 | 11 | E3 |
| | TIOB0_0 | Base timer ch.0 TIOB pin | 59 | 51 | L5 |
| | TIOB0_1 | | 28 | - | H3 |
| | TIOB0_2 | | 12 | 12 | E4 |
| Base Timer 1 | TIOA1_0 | Base timer ch.1 TIOA pin | 47 | 39 | N3 |
| | TIOA1_1 | | 39 | 31 | K4 |
| | TIOA1_2 | | 16 | 16 | F3 |
| | TIOB1_0 | Base timer ch.1 TIOB pin | 60 | 52 | K5 |
| | TIOB1_1 | | 29 | - | H4 |
| | TIOB1_2 | | 17 | 17 | F4 |
| Base Timer 2 | TIOA2_0 | Base timer ch.2 TIOA pin | 48 | 40 | M3 |
| | TIOA2_1 | | 40 | 32 | L1 |
| | TIOA2_2 | | 169 | 139 | C5 |
| | TIOB2_0 | Base timer ch.2 TIOB pin | 61 | 53 | N6 |
| | TIOB2_1 | | 30 | - | H5 |
| | TIOB2_2 | | 168 | 138 | B5 |
| Base Timer 3 | TIOA3_0 | Base timer ch.3 TIOA pin | 49 | 41 | L4 |
| | TIOA3_1 | | 41 | 33 | L2 |
| | TIOA3_2 | | 165 | 135 | C6 |
| | TIOB3_0 | Base timer ch.3 TIOB pin | 62 | 54 | M6 |
| | TIOB3_1 | | 31 | - | H6 |
| | TIOB3_2 | | 166 | 136 | D6 |
| Base Timer 4 | TIOA4_0 | Base timer ch.4 TIOA pin | 50 | 42 | M4 |
| | TIOA4_1 | | 42 | 34 | L3 |
| | TIOA4_2 | | 65 | 57 | J6 |
| | TIOB4_0 | Base timer ch.4 TIOB pin | 63 | 55 | L6 |
| | TIOB4_1 | | 32 | - | J5 |
| | TIOB4_2 | | 66 | 58 | N8 |
| Base Timer 5 | TIOA5_0 | Base timer ch.5 TIOA pin | 51 | 43 | N4 |
| | TIOA5_1 | | 43 | 35 | M2 |
| | TIOA5_2 | | 8 | 8 | D3 |
| | TIOB5_0 | Base timer ch.5 TIOB pin | 64 | 56 | K6 |
| | TIOB5_1 | | 33 | - | J4 |
| | TIOB5_2 | | 9 | 9 | D4 |
| Base Timer 6 | TIOA6_0 | Base timer ch.6 TIOA pin | 170 | - | B4 |
| | TIOA6_1 | | 148 | 118 | E9 |
| | TIOA6_2 | | 25 | - | H1 |
| | TIOB6_0 | Base timer ch.6 TIOB pin | 171 | - | C4 |
| | TIOB6_1 | | 161 | 131 | D7 |
| | TIOB6_2 | | 26 | - | H2 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Base Timer 7 | TIOA07_0 | Base timer ch.7 TIOA pin | 77 | - | P10 |
| | TIOA07_1 | | 124 | 100 | E12 |
| | TIOA07_2 | | 71 | 63 | J8 |
| | TIOB07_0 | Base timer ch.7 TIOB pin | 76 | - | K9 |
| | TIOB07_1 | | 125 | 101 | E13 |
| | TIOB07_2 | | 72 | 64 | P9 |
| Base Timer 8 | TIOA08_0 | Base timer ch.8 TIOA pin | 2 | 2 | B2 |
| | TIOA08_1 | | 82 | - | N11 |
| | TIOA08_2 | | 149 | 119 | F9 |
| | TIOB08_0 | Base timer ch.8 TIOB pin | 139 | - | C11 |
| | TIOB08_1 | | 83 | - | M11 |
| | TIOB08_2 | | 162 | 132 | E7 |
| Base Timer 9 | TIOA09_0 | Base timer ch.9 TIOA pin | 3 | 3 | C2 |
| | TIOA09_1 | | 110 | - | H13 |
| | TIOA09_2 | | 19 | 19 | F6 |
| | TIOB09_0 | Base timer ch.9 TIOB pin | 140 | - | D11 |
| | TIOB09_1 | | 111 | - | H12 |
| | TIOB09_2 | | 20 | 20 | G2 |
| Base Timer 10 | TIOA10_0 | Base timer ch.10 TIOA pin | 4 | 4 | C3 |
| | TIOA10_1 | | 112 | - | H11 |
| | TIOA10_2 | | 150 | 120 | C8 |
| | TIOB10_0 | Base timer ch.10 TIOB pin | 141 | - | B10 |
| | TIOB10_1 | | 113 | - | G13 |
| | TIOB10_2 | | 163 | 133 | F7 |
| Base Timer 11 | TIOA11_0 | Base timer ch.11 TIOA pin | 5 | 5 | D5 |
| | TIOA11_1 | | 114 | - | G12 |
| | TIOA11_2 | | 21 | 21 | G3 |
| | TIOB11_0 | Base timer ch.11 TIOB pin | 142 | - | C10 |
| | TIOB11_1 | | 115 | - | G11 |
| | TIOB11_2 | | 22 | 22 | G4 |
| Base Timer 12 | TIOA12_0 | Base timer ch.12 TIOA pin | 6 | 6 | D2 |
| | TIOA12_1 | | 116 | - | G10 |
| | TIOA12_2 | | 34 | 26 | J3 |
| | TIOB12_0 | Base timer ch.12 TIOB pin | 143 | - | D10 |
| | TIOB12_1 | | 117 | - | G9 |
| | TIOB12_2 | | 35 | 27 | J2 |
| Base Timer 13 | TIOA13_0 | Base timer ch.13 TIOA pin | 7 | 7 | D1 |
| | TIOA13_1 | | 23 | 23 | G5 |
| | TIOA13_2 | | 100 | 84 | J12 |
| | TIOB13_0 | Base timer ch.13 TIOB pin | 144 | - | B9 |
| | TIOB13_1 | | 24 | 24 | G6 |
| | TIOB13_2 | | 101 | 85 | J11 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Base Timer 14 | TIOA14_0 | Base timer ch.14 TIOA pin | 151 | 121 | D8 |
| | TIOA14_1 | | 78 | - | N10 |
| | TIOA14_2 | | 102 | 86 | J10 |
| | TIOB14_0 | Base timer ch.14 TIOB pin | 164 | 134 | B6 |
| | TIOB14_1 | | 79 | - | L10 |
| | TIOB14_2 | | 103 | 87 | J9 |
| Base Timer 15 | TIOA15_0 | Base timer ch.15 TIOA pin | 73 | 65 | N9 |
| | TIOA15_1 | | 80 | - | K10 |
| | TIOA15_2 | | 104 | 88 | H10 |
| | TIOB15_0 | Base timer ch.15 TIOB pin | 74 | 66 | M9 |
| | TIOB15_1 | | 81 | - | M10 |
| | TIOB15_2 | | 105 | 89 | H9 |
| CAN 0 | TX0_0 | CAN interface ch.0 TX output | 65 | 57 | J6 |
| | TX0_1 | | 32 | - | J5 |
| | TX0_2 | | 7 | 7 | D1 |
| | RX0_0 | CAN interface ch.0 RX output | 66 | 58 | N8 |
| | RX0_1 | | 33 | - | J4 |
| | RX0_2 | | 6 | 6 | D2 |
| CAN 1 | TX1_0 | CAN interface ch.1 TX output | 122 | 98 | E10 |
| | TX1_1 | | 23 | 23 | G5 |
| | TX1_2 | | 92 | 76 | L13 |
| | RX1_0 | CAN interface ch.1 RX output | 123 | 99 | E11 |
| | RX1_1 | | 22 | 22 | G4 |
| | RX1_2 | | 91 | 75 | M12 |
| Debugger | SWCLK | Serial wire debug interface clock input | 135 | 111 | A12 |
| | SWDIO | Serial wire debug interface data input / output | 137 | 113 | B12 |
| | SWO | Serial wire viewer output | 138 | 114 | B11 |
| | TCK | JTAG test clock input | 135 | 111 | A12 |
| | TDI | JTAG test data input | 136 | 112 | C12 |
| | TDO | JTAG debug data output | 138 | 114 | B11 |
| | TMS | JTAG test mode state input/output | 137 | 113 | B12 |
| | TRACECLK | Trace CLK output of ETM | 12 | 12 | E4 |
| | TRACED0 | Trace data output of ETM | 8 | 8 | D3 |
| | TRACED1 | | 9 | 9 | D4 |
| | TRACED2 | | 10 | 10 | E2 |
| | TRACED3 | | 11 | 11 | E3 |
| | TRSTX | JTAG test reset Input | 134 | 110 | B13 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| External Bus | MAD00_0 | External bus interface address bus | 94 | 78 | L11 |
| | MAD01_0 | | 95 | 79 | K13 |
| | MAD02_0 | | 96 | 80 | K12 |
| | MAD03_0 | | 97 | 81 | K14 |
| | MAD04_0 | | 98 | 82 | K11 |
| | MAD05_0 | | 99 | 83 | J13 |
| | MAD06_0 | | 100 | 84 | J12 |
| | MAD07_0 | | 101 | 85 | J11 |
| | MAD08_0 | | 102 | 86 | J10 |
| | MAD09_0 | | 103 | 87 | J9 |
| | MAD10_0 | | 104 | 88 | H10 |
| | MAD11_0 | | 105 | 89 | H9 |
| | MAD12_0 | | 118 | 94 | F10 |
| | MAD13_0 | | 119 | 95 | F11 |
| | MAD14_0 | | 120 | 96 | F12 |
| | MAD15_0 | | 121 | 97 | F13 |
| | MAD16_0 | | 122 | 98 | E10 |
| | MAD17_0 | | 123 | 99 | E11 |
| | MAD18_0 | | 127 | 103 | D13 |
| | MAD19_0 | | 139 | - | C11 |
| | MAD20_0 | | 140 | - | D11 |
| | MAD21_0 | | 141 | - | B10 |
| | MAD22_0 | | 142 | - | C10 |
| | MAD23_0 | | 143 | - | D10 |
| | MAD24_0 | | 144 | - | B9 |
| | MCSX0_0 | External bus interface chip select output pin | 23 | 23 | G5 |
| | MCSX1_0 | | 24 | 24 | G6 |
| | MCSX2_0 | | 34 | 26 | J3 |
| | MCSX3_0 | | 35 | 27 | J2 |
| | MCSX4_0 | | 93 | 77 | L12 |
| | MCSX5_0 | | 92 | 76 | L13 |
| | MCSX6_0 | | 91 | 75 | M12 |
| | MCSX7_0 | | 90 | 74 | M13 |
| | MDQM0_0 | External bus interface byte mask signal output | 15 | 15 | F2 |
| | MDQM1_0 | | 16 | 16 | F3 |
| | MOEX_0 | External bus interface read enable signal for SRAM | 13 | 13 | E5 |
| | MWEX_0 | External bus interface write enable signal for SRAM | 14 | 14 | F1 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| External Bus | MNALE_0 | External bus interface ALE signal to control NAND Flash output pin | 19 | 19 | F6 |
| | MNCLE_0 | External bus interface CLE signal to control NAND Flash output pin | 20 | 20 | G2 |
| | MNREX_0 | External bus interface read enable signal to control NAND Flash | 22 | 22 | G4 |
| | MNWEX_0 | External bus interface write enable signal to control NAND Flash | 21 | 21 | G3 |
| | MADATA00_0 | External bus interface data bus (Address / data multiplex bus) | 60 | 52 | K5 |
| | MADATA01_0 | | 61 | 53 | N6 |
| | MADATA02_0 | | 62 | 54 | M6 |
| | MADATA03_0 | | 63 | 55 | L6 |
| | MADATA04_0 | | 64 | 56 | K6 |
| | MADATA05_0 | | 65 | 57 | J6 |
| | MADATA06_0 | | 66 | 58 | N8 |
| | MADATA07_0 | | 67 | 59 | M8 |
| | MADATA08_0 | | 68 | 60 | L8 |
| | MADATA09_0 | | 69 | 61 | K8 |
| | MADATA10_0 | | 70 | 62 | P8 |
| | MADATA11_0 | | 71 | 63 | J8 |
| | MADATA12_0 | | 72 | 64 | P9 |
| | MADATA13_0 | | 73 | 65 | N9 |
| | MADATA14_0 | | 74 | 66 | M9 |
| | MADATA15_0 | | 75 | 67 | L9 |
| | MALE_0 | External bus interface Address Latch enable output signal for multiplex | 17 | 17 | F4 |
| | MRDY_0 | External bus interface external RDY input signal | 18 | 18 | F5 |
| | MCLKOUT_0 | External bus interface external clock output | 36 | 28 | K1 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| External Interrupt | INT00_0 | External interrupt request 00 input pin | 13 | 13 | E5 |
| | INT00_1 | | 8 | 8 | D3 |
| | INT00_2 | | 165 | 135 | C6 |
| | INT01_0 | External interrupt request 01 input pin | 14 | 14 | F1 |
| | INT01_1 | | 9 | 9 | D4 |
| | INT01_2 | | 123 | 99 | E11 |
| | INT02_0 | External interrupt request 02 input pin | 15 | 15 | F2 |
| | INT02_1 | | 91 | 75 | M12 |
| | INT02_2 | | 120 | 96 | F12 |
| | INT03_0 | External interrupt request 03 input pin | 6 | 6 | D2 |
| | INT03_1 | | 94 | 78 | L11 |
| | INT03_2 | | 28 | - | H3 |
| | INT04_0 | External interrupt request 04 input pin | 31 | - | H6 |
| | INT04_1 | | 97 | 81 | K14 |
| | INT04_2 | | 29 | - | H4 |
| | INT05_0 | External interrupt request 05 input pin | 127 | 103 | D13 |
| | INT05_1 | | 100 | 84 | J12 |
| | INT05_2 | | 30 | - | H5 |
| | INT06_0 | External interrupt request 06 input pin | 170 | - | B4 |
| | INT06_1 | | 126 | 102 | D12 |
| | INT06_2 | | 64 | 56 | K6 |
| | INT07_0 | External interrupt request 07 input pin | 171 | - | C4 |
| | INT07_1 | | 70 | 62 | P8 |
| | INT07_2 | | 16 | 16 | F3 |
| | INT08_0 | External interrupt request 08 input pin | 172 | 140 | B3 |
| | INT08_1 | | 33 | - | J4 |
| | INT08_2 | | 19 | 19 | F6 |
| | INT09_0 | External interrupt request 09 input pin | 119 | 95 | F11 |
| | INT09_1 | | 34 | 26 | J3 |
| | INT09_2 | | 22 | 22 | G4 |
| | INT10_0 | External interrupt request 10 input pin | 76 | - | K9 |
| | INT10_1 | | 35 | 27 | J2 |
| | INT10_2 | | 7 | 7 | D1 |
| | INT11_0 | External interrupt request 11 input pin | 77 | - | P10 |
| | INT11_1 | | 36 | 28 | K1 |
| | INT11_2 | | 71 | 63 | J8 |
| | INT12_0 | External interrupt request 12 input pin | 78 | - | N10 |
| | INT12_1 | | 46 | 38 | N2 |
| | INT12_2 | | 72 | 64 | P9 |
| | INT13_0 | External interrupt request 13 input pin | 81 | - | M10 |
| | INT13_1 | | 47 | 39 | N3 |
| | INT13_2 | | 66 | 58 | N8 |
| | INT14_0 | External interrupt request 14 input pin | 82 | - | N11 |
| | INT14_1 | | 58 | 50 | M5 |
| | INT14_2 | | 67 | 59 | M8 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| External Interrupt | INT15_0 | External interrupt request 15 input pin | 83 | - | M11 |
| | INT15_1 | | 169 | 139 | C5 |
| | INT15_2 | | 68 | 60 | L8 |
| | INT16_0 | External interrupt request 16 input pin | 110 | - | H13 |
| | INT16_1 | | 20 | 20 | G2 |
| | INT17_0 | External interrupt request 17 input pin | 111 | - | H12 |
| | INT17_1 | | 21 | 21 | G3 |
| | INT18_0 | External interrupt request 18 input pin | 112 | - | H11 |
| | INT18_1 | | 23 | 23 | G5 |
| | INT19_0 | External interrupt request 19 input pin | 113 | - | G13 |
| | INT19_1 | | 24 | 24 | G6 |
| | INT20_0 | External interrupt request 20 input pin | 114 | - | G12 |
| | INT20_1 | | 96 | 80 | K12 |
| | INT21_0 | External interrupt request 21 input pin | 115 | - | G11 |
| | INT21_1 | | 98 | 82 | K11 |
| | INT22_0 | External interrupt request 22 input pin | 116 | - | G10 |
| | INT22_1 | | 99 | 83 | J13 |
| | INT23_0 | External interrupt request 23 input pin | 117 | - | G9 |
| | INT23_1 | | 74 | 66 | M9 |
| | INT24_0 | External interrupt request 24 input pin | 79 | - | L10 |
| | INT24_1 | | 75 | 67 | L9 |
| | INT25_0 | External interrupt request 25 input pin | 80 | - | K10 |
| | INT25_1 | | 101 | 85 | J11 |
| | INT26_0 | External interrupt request 26 input pin | 143 | - | D10 |
| | INT26_1 | | 102 | 86 | J10 |
| | INT27_0 | External interrupt request 27 input pin | 144 | - | B9 |
| | INT27_1 | | 103 | 87 | J9 |
| | INT28_0 | External interrupt request 28 input pin | 25 | - | H1 |
| | INT28_1 | | 104 | 88 | H10 |
| | INT29_0 | External interrupt request 29 input pin | 26 | - | H2 |
| | INT29_1 | | 105 | 89 | H9 |
| | INT30_0 | External interrupt request 30 input pin | 139 | - | C11 |
| | INT30_1 | | 163 | 133 | F7 |
| | INT31_0 | External interrupt request 31 input pin | 140 | - | D11 |
| | INT31_1 | | 164 | 134 | B6 |
| | NMIX | Non-Maskable Interrupt input | 128 | 104 | C13 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| GPIO | P00 | General-purpose I/O port 0 | 134 | 110 | B13 |
| | P01 | | 135 | 111 | A12 |
| | P02 | | 136 | 112 | C12 |
| | P03 | | 137 | 113 | B12 |
| | P04 | | 138 | 114 | B11 |
| | P05 | | 8 | 8 | D3 |
| | P06 | | 9 | 9 | D4 |
| | P07 | | 10 | 10 | E2 |
| | P08 | | 11 | 11 | E3 |
| | P09 | | 12 | 12 | E4 |
| | P10 | General-purpose I/O port 1 | 90 | 74 | M13 |
| | P11 | | 91 | 75 | M12 |
| | P12 | | 92 | 76 | L13 |
| | P13 | | 93 | 77 | L12 |
| | P14 | | 94 | 78 | L11 |
| | P15 | | 95 | 79 | K13 |
| | P16 | | 96 | 80 | K12 |
| | P17 | | 97 | 81 | K14 |
| | P18 | | 98 | 82 | K11 |
| | P19 | | 99 | 83 | J13 |
| | P1A | | 100 | 84 | J12 |
| | P1B | | 101 | 85 | J11 |
| | P1C | | 102 | 86 | J10 |
| | P1D | | 103 | 87 | J9 |
| | P1E | | 104 | 88 | H10 |
| | P1F | | 105 | 89 | H9 |
| | P20 | General-purpose I/O port 2 | 127 | 103 | D13 |
| | P21 | | 126 | 102 | D12 |
| | P22 | | 125 | 101 | E13 |
| | P23 | | 124 | 100 | E12 |
| | P24 | | 123 | 99 | E11 |
| | P25 | | 122 | 98 | E10 |
| | P26 | | 121 | 97 | F13 |
| | P27 | | 120 | 96 | F12 |
| | P28 | | 119 | 95 | F11 |
| | P29 | | 118 | 94 | F10 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| GPIO | P30 | General-purpose I/O port 3 | 28 | - | H3 |
| | P31 | | 29 | - | H4 |
| | P32 | | 30 | - | H5 |
| | P33 | | 31 | - | H6 |
| | P34 | | 32 | - | J5 |
| | P35 | | 33 | - | J4 |
| | P36 | | 34 | 26 | J3 |
| | P37 | | 35 | 27 | J2 |
| | P38 | | 36 | 28 | K1 |
| | P39 | | 37 | 29 | K2 |
| | P3A | | 38 | 30 | K3 |
| | P3B | | 39 | 31 | K4 |
| | P3C | | 40 | 32 | L1 |
| | P3D | | 41 | 33 | L2 |
| | P3E | | 42 | 34 | L3 |
| | P3F | | 43 | 35 | M2 |
| | P40 | General-purpose I/O port 4 | 46 | 38 | N2 |
| | P41 | | 47 | 39 | N3 |
| | P42 | | 48 | 40 | M3 |
| | P43 | | 49 | 41 | L4 |
| | P44 | | 50 | 42 | M4 |
| | P45 | | 51 | 43 | N4 |
| | P46 | | 55 | 47 | P5 |
| | P47 | | 56 | 48 | P6 |
| | P48 | | 58 | 50 | M5 |
| | P49 | | 59 | 51 | L5 |
| | P4A | | 60 | 52 | K5 |
| | P4B | | 61 | 53 | N6 |
| | P4C | | 62 | 54 | M6 |
| | P4D | | 63 | 55 | L6 |
| | P4E | | 64 | 56 | K6 |
| | P50 | General-purpose I/O port 5 | 13 | 13 | E5 |
| | P51 | | 14 | 14 | F1 |
| | P52 | | 15 | 15 | F2 |
| | P53 | | 16 | 16 | F3 |
| | P54 | | 17 | 17 | F4 |
| | P55 | | 18 | 18 | F5 |
| | P56 | | 19 | 19 | F6 |
| | P57 | | 20 | 20 | G2 |
| | P58 | | 21 | 21 | G3 |
| | P59 | | 22 | 22 | G4 |
| | P5A | | 23 | 23 | G5 |
| | P5B | | 24 | 24 | G6 |
| | P5C | | 25 | - | H1 |
| | P5D | | 26 | - | H2 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| GPIO | P60 | General-purpose I/O port 6 | 169 | 139 | C5 |
| | P61 | | 168 | 138 | B5 |
| | P62 | | 167 | 137 | E6 |
| | P70 | General-purpose I/O port 7 | 65 | 57 | J6 |
| | P71 | | 66 | 58 | N8 |
| | P72 | | 67 | 59 | M8 |
| | P73 | | 68 | 60 | L8 |
| | P74 | | 69 | 61 | K8 |
| | P75 | | 70 | 62 | P8 |
| | P76 | | 71 | 63 | J8 |
| | P77 | | 72 | 64 | P9 |
| | P78 | | 73 | 65 | N9 |
| | P79 | | 74 | 66 | M9 |
| | P7A | | 75 | 67 | L9 |
| | P7B | | 76 | - | K9 |
| | P7C | | 77 | - | P10 |
| | P7D | | 78 | - | N10 |
| | P7E | | 79 | - | L10 |
| | P7F | | 80 | - | K10 |
| | P80 | General-purpose I/O port 8 | 174 | 142 | A3 |
| | P81 | | 175 | 143 | A2 |
| | P82 | | 130 | 106 | D14 |
| | P83 | | 131 | 107 | C14 |
| | P90 | General-purpose I/O port 9 | 139 | - | C11 |
| | P91 | | 140 | - | D11 |
| | P92 | | 141 | - | B10 |
| | P93 | | 142 | - | C10 |
| | P94 | | 143 | - | D10 |
| | P95 | | 144 | - | B9 |
| | PA0 | General-purpose I/O port A | 2 | 2 | B2 |
| | PA1 | | 3 | 3 | C2 |
| | PA2 | | 4 | 4 | C3 |
| | PA3 | | 5 | 5 | D5 |
| | PA4 | | 6 | 6 | D2 |
| | PA5 | | 7 | 7 | D1 |
| | PB0 | General-purpose I/O port B | 110 | - | H13 |
| | PB1 | | 111 | - | H12 |
| | PB2 | | 112 | - | H11 |
| | PB3 | | 113 | - | G13 |
| | PB4 | | 114 | - | G12 |
| | PB5 | | 115 | - | G11 |
| | PB6 | | 116 | - | G10 |
| | PB7 | | 117 | - | G9 |

| Module | Pin name | Function | Pin no | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| GPIO | PC0 | General-purpose I/O port C | 145 | 115 | C9 |
| | PC1 | | 146 | 116 | B8 |
| | PC2 | | 147 | 117 | D9 |
| | PC3 | | 148 | 118 | E9 |
| | PC4 | | 149 | 119 | F9 |
| | PC5 | | 150 | 120 | C8 |
| | PC6 | | 151 | 121 | D8 |
| | PC7 | | 152 | 122 | E8 |
| | PC8 | | 153 | 123 | A10 |
| | PC9 | | 154 | 124 | F8 |
| | PCA | | 155 | 125 | B7 |
| | PCB | | 158 | 128 | A7 |
| | PCC | | 159 | 129 | C7 |
| | PCD | | 160 | 130 | A6 |
| | PCE | | 161 | 131 | D7 |
| | PCF | | 162 | 132 | E7 |
| | PD0 | General-purpose I/O port D | 163 | 133 | F7 |
| | PD1 | | 164 | 134 | B6 |
| | PD2 | | 165 | 135 | C6 |
| | PD3 | | 166 | 136 | D6 |
| | PE0 | General-purpose I/O port E | 84 | 68 | N13 |
| | PE2 | | 86 | 70 | P12 |
| | PE3 | | 87 | 71 | P13 |
| | PF0 | General-purpose I/O port F* | 81 | - | M10 |
| | PF1 | | 82 | - | N11 |
| | PF2 | | 83 | - | M11 |
| | PF3 | | 170 | - | B4 |
| | PF4 | | 171 | - | C4 |
| | PF5 | | 172 | 140 | B3 |
| | PF6 | | 128 | 104 | C13 |

| Module | Pin name | Function | Pin No. | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Serial 0 | SIN0_0 | Multifunction serial interface ch.0 input pin | 126 | 102 | D12 |
| | SIN0_1 | | 94 | 78 | L11 |
| | SIN0_2 | | 114 | - | G12 |
| | SOT0_0 (SDA0_0) | Multifunction serial interface ch.0 output pin. This pin operates as SOT0 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA0 when it is used in an $I^2C$ (operation mode 4). | 125 | 101 | E13 |
| | SOT0_1 (SDA0_1) | | 95 | 79 | K13 |
| | SOT0_2 (SDA0_2) | | 115 | - | G11 |
| | SCK0_0 (SCL0_0) | Multifunction serial interface ch.0 clock I/O pin. This pin operates as SCK0 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL0 when it is used in an $I^2C$ (operation mode 4). | 124 | 100 | E12 |
| | SCK0_1 (SCL0_1) | | 96 | 80 | K12 |
| | SCK0_2 (SCL0_2) | | 116 | - | G10 |
| Multi Function Serial 1 | SIN1_0 | Multifunction serial interface ch.1 input pin | 19 | 19 | F6 |
| | SIN1_1 | | 91 | 75 | M12 |
| | SIN1_2 | | 81 | - | M10 |
| | SOT1_0 (SDA1_0) | Multifunction serial interface ch.1 output pin. This pin operates as SOT1 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA1 when it is used in an $I^2C$ (operation mode 4). | 20 | 20 | G2 |
| | SOT1_1 (SDA1_1) | | 92 | 76 | L13 |
| | SOT1_2 (SDA1_2) | | 82 | - | N11 |
| | SCK1_0 (SCL1_0) | Multifunction serial interface ch.1 clock I/O pin. This pin operates as SCK1 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL1 when it is used in an $I^2C$ (operation mode 4). | 21 | 21 | G3 |
| | SCK1_1 (SCL1_1) | | 93 | 77 | L12 |
| | SCK1_2 (SCL1_2) | | 83 | - | M11 |

| Module | Pin name | Function | Pin No. | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Serial 2 | SIN2_0 | Multifunction serial interface ch.2 input pin | 67 | 59 | M8 |
| | SIN2_1 | | 123 | 99 | E11 |
| | SIN2_2 | | 97 | 81 | K14 |
| | SOT2_0 (SDA2_0) | Multifunction serial interface ch.2 output pin. This pin operates as SOT2 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA2 when it is used in an $I^2C$ (operation mode 4). | 68 | 60 | L8 |
| | SOT2_1 (SDA2_1) | | 122 | 98 | E10 |
| | SOT2_2 (SDA2_2) | | 98 | 82 | K11 |
| | SCK2_0 (SCL2_0) | Multifunction serial interface ch.2 clock I/O pin. This pin operates as SCK2 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL2 when it is used in an $I^2C$ (operation mode 4). | 69 | 61 | K8 |
| | SCK2_1 (SCL2_1) | | 121 | 97 | F13 |
| | SCK2_2 (SCL2_2) | | 99 | 83 | J13 |
| Multi Function Serial 3 | SIN3_0 | Multifunction serial interface ch.3 input pin | 70 | 62 | P8 |
| | SIN3_1 | | 13 | 13 | E5 |
| | SIN3_2 | | 58 | 50 | M5 |
| | SOT3_0 (SDA3_0) | Multifunction serial interface ch.3 output pin. This pin operates as SOT3 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA3 when it is used in an $I^2C$ (operation mode 4). | 71 | 63 | J8 |
| | SOT3_1 (SDA3_1) | | 14 | 14 | F1 |
| | SOT3_2 (SDA3_2) | | 59 | 51 | L5 |
| | SCK3_0 (SCL3_0) | Multifunction serial interface ch.3 clock I/O pin. This pin operates as SCK3 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL3 when it is used in an $I^2C$ (operation mode 4). | 72 | 64 | P9 |
| | SCK3_1 (SCL3_1) | | 15 | 15 | F2 |
| | SCK3_2 (SCL3_2) | | 60 | 52 | K5 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Serial 4 | SIN4_0 | Multifunction serial interface ch.4 input pin | 165 | 135 | C6 |
| | SIN4_1 | | 100 | 84 | J12 |
| | SIN4_2 | | 8 | 8 | D3 |
| | SOT4_0 (SDA4_0) | Multifunction serial interface ch.4 output pin. This pin operates as SOT4 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA4 when it is used in an $I^2C$ (operation mode 4). | 164 | 134 | B6 |
| | SOT4_1 (SDA4_1) | | 101 | 85 | J11 |
| | SOT4_2 (SDA4_2) | | 9 | 9 | D4 |
| | SCK4_0 (SCL4_0) | Multifunction serial interface ch.4 clock I/O pin. This pin operates as SCK4 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL4 when it is used in an $I^2C$ (operation mode 4). | 163 | 133 | F7 |
| | SCK4_1 (SCL4_1) | | 102 | 86 | J10 |
| | SCK4_2 (SCL4_2) | | 10 | 10 | E2 |
| | RTS4_0 | Multifunction serial interface ch.4 RTS output pin | 161 | 131 | D7 |
| | RTS4_1 | | 104 | 88 | H10 |
| | RTS4_2 | | 12 | 12 | E4 |
| | CTS4_0 | Multifunction serial interface ch.4 CTS input pin | 162 | 132 | E7 |
| | CTS4_1 | | 103 | 87 | J9 |
| | CTS4_2 | | 11 | 11 | E3 |
| Multi Function Serial 5 | SIN5_0 | Multifunction serial interface ch.5 input pin | 169 | 139 | C5 |
| | SIN5_1 | | 141 | - | B10 |
| | SIN5_2 | | 34 | 26 | J3 |
| | SOT5_0 (SDA5_0) | Multifunction serial interface ch.5 output pin. This pin operates as SOT5 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA5 when it is used in an $I^2C$ (operation mode 4). | 168 | 138 | B5 |
| | SOT5_1 (SDA5_1) | | 142 | - | C10 |
| | SOT5_2 (SDA5_2) | | 35 | 27 | J2 |
| | SCK5_0 (SCL5_0) | Multifunction serial interface ch.5 clock I/O pin. This pin operates as SCK5 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL5 when it is used in an $I^2C$ (operation mode 4). | 167 | 137 | E6 |
| | SCK5_1 (SCL5_1) | | 143 | - | D10 |
| | SCK5_2 (SCL5_2) | | 36 | 28 | K1 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Serial 6 | SIN6_0 | Multifunction serial interface ch.6 input pin | 16 | 16 | F3 |
| | SIN6_1 | | 31 | - | H6 |
| | SIN6_2 | | 170 | - | B4 |
| | SOT6_0 (SDA6_0) | Multifunction serial interface ch.6 output pin. This pin operates as SOT6 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA6 when it is used in an $I^2C$ (operation mode 4). | 17 | 17 | F4 |
| | SOT6_1 (SDA6_1) | | 30 | - | H5 |
| | SOT6_2 (SDA6_2) | | 171 | - | C4 |
| | SCK6_0 (SCL6_0) | Multifunction serial interface ch.6 clock I/O pin. This pin operates as SCK6 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL6 when it is used in an $I^2C$ (operation mode 4). | 18 | 18 | F5 |
| | SCK6_1 (SCL6_1) | | 29 | - | H4 |
| | SCK6_2 (SCL6_2) | | 172 | 140 | B3 |
| Multi Function Serial 7 | SIN7_0 | Multifunction serial interface ch.7 input pin | 22 | 22 | G4 |
| | SIN7_1 | | 64 | 56 | K6 |
| | SIN7_2 | | 110 | - | H13 |
| | SOT7_0 (SDA7_0) | Multifunction serial interface ch.7 output pin. This pin operates as SOT7 when it is used in a UART/CSIO (operation modes 0 to 2) and as SDA7 when it is used in an $I^2C$ (operation mode 4). | 23 | 23 | G5 |
| | SOT7_1 (SDA7_1) | | 63 | 55 | L6 |
| | SOT7_2 (SDA7_2) | | 111 | - | H12 |
| | SCK7_0 (SCL7_0) | Multifunction serial interface ch.7 clock I/O pin. This pin operates as SCK7 when it is used in a UART/CSIO (operation modes 0 to 2) and as SCL7 when it is used in an $I^2C$ (operation mode 4). | 24 | 24 | G6 |
| | SCK7_1 (SCL7_1) | | 62 | 54 | M6 |
| | SCK7_2 (SCL7_2) | | 112 | - | H11 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Timer 0 | DTTI0X_0 | Input signal controlling wave form generator outputs RTO00 to RTO05 of multi-function timer 0. | 37 | 29 | K2 |
| | DTTI0X_1 | | 104 | 88 | H10 |
| | FRCK0_0 | 16-bit free-run timer ch.0 external clock input pin | 32 | - | J5 |
| | FRCK0_1 | | 105 | 89 | H9 |
| | FRCK0_2 | | 91 | 75 | M12 |
| | IC00_0 | 16-bit input capture ch.0 input pin of multi-function timer 0<br>ICxx describes channel number. | 36 | 28 | K1 |
| | IC00_1 | | 100 | 84 | J12 |
| | IC00_2 | | 92 | 76 | L13 |
| | IC01_0 | | 35 | 27 | J2 |
| | IC01_1 | | 101 | 85 | J11 |
| | IC01_2 | | 93 | 77 | L12 |
| | IC02_0 | | 34 | 26 | J3 |
| | IC02_1 | | 102 | 86 | J10 |
| | IC02_2 | | 94 | 78 | L11 |
| | IC03_0 | | 33 | - | J4 |
| | IC03_1 | | 103 | 87 | J9 |
| | IC03_2 | | 95 | 79 | K13 |
| | RTO00_0 (PPG00_0) | Wave form generator output of multi-function timer 0<br>This pin operates as PPG00 when it is used in PPG0 output modes. | 38 | 30 | K3 |
| | RTO00_1 (PPG00_1) | | 124 | 100 | E12 |
| | RTO01_0 (PPG00_0) | Wave form generator output of multi-function timer 0<br>This pin operates as PPG00 when it is used in PPG0 output modes. | 39 | 31 | K4 |
| | RTO01_1 (PPG00_1) | | 123 | 99 | E11 |
| | RTO02_0 (PPG02_0) | Wave form generator output of multi-function timer 0<br>This pin operates as PPG02 when it is used in PPG0 output modes. | 40 | 32 | L1 |
| | RTO02_1 (PPG02_1) | | 122 | 98 | E10 |
| | RTO03_0 (PPG02_0) | Wave form generator output of multi-function timer 0<br>This pin operates as PPG02 when it is used in PPG0 output modes. | 41 | 33 | L2 |
| | RTO03_1 (PPG02_1) | | 121 | 97 | F13 |
| | RTO04_0 (PPG04_0) | Wave form generator output of multi-function timer 0<br>This pin operates as PPG04 when it is used in PPG0 output modes. | 42 | 34 | L3 |
| | RTO04_1 (PPG04_1) | | 120 | 96 | F12 |
| | RTO05_0 (PPG04_0) | Wave form generator output of multi-function timer 0<br>This pin operates as PPG04 when it is used in PPG0 output modes. | 43 | 35 | M2 |
| | RTO05_1 (PPG04_1) | | 119 | 95 | F11 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Timer 1 | DTTI1X_0 | Input signal controlling wave form generator outputs RTO10 to RTO15 of multi-function timer 1. | 19 | 19 | F6 |
| | DTTI1X_1 | | 58 | 50 | M5 |
| | FRCK1_0 | 16-bit free-run timer ch.1 external clock input pin | 2 | 2 | B2 |
| | FRCK1_1 | | 63 | 55 | L6 |
| | IC10_0 | 16-bit input capture ch.1 input pin of multi-function timer 1. ICxx describes channel number | 3 | 3 | C2 |
| | IC10_1 | | 59 | 51 | L5 |
| | IC11_0 | | 4 | 4 | C3 |
| | IC11_1 | | 60 | 52 | K5 |
| | IC12_0 | | 5 | 5 | D5 |
| | IC12_1 | | 61 | 53 | N6 |
| | IC13_0 | | 6 | 6 | D2 |
| | IC13_1 | | 62 | 54 | M6 |
| | RTO10_0 (PPG10_0) | Wave form generator output of multi-function timer 1. This pin operates as PPG10 when it is used in PPG1 output modes. | 13 | 13 | E5 |
| | RTO10_1 (PPG10_1) | | 46 | 38 | N2 |
| | RTO11_0 (PPG10_0) | Wave form generator output of multi-function timer 1. This pin operates as PPG10 when it is used in PPG1 output modes. | 14 | 14 | F1 |
| | RTO11_1 (PPG10_1) | | 47 | 39 | N3 |
| | RTO12_0 (PPG12_0) | Wave form generator output of multi-function timer 1. This pin operates as PPG12 when it is used in PPG1 output modes. | 15 | 15 | F2 |
| | RTO12_1 (PPG12_1) | | 48 | 40 | M3 |
| | RTO13_0 (PPG12_0) | Wave form generator output of multi-function timer 1. This pin operates as PPG12 when it is used in PPG1 output modes. | 16 | 16 | F3 |
| | RTO13_1 (PPG12_1) | | 49 | 41 | L4 |
| | RTO14_0 (PPG14_0) | Wave form generator output of multi-function timer 1. This pin operates as PPG14 when it is used in PPG1 output modes. | 17 | 17 | F4 |
| | RTO14_1 (PPG14_1) | | 50 | 42 | M4 |
| | RTO15_0 (PPG14_0) | Wave form generator output of multi-function timer 1. This pin operates as PPG14 when it is used in PPG1 output modes. | 18 | 18 | F5 |
| | RTO15_1 (PPG14_1) | | 51 | 43 | N4 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Multi Function Timer 2 | DTTI2X_0 | Input signal controlling wave form generator outputs RTO20 to RTO25 of multi-function timer 2. | 12 | 12 | E4 |
| | DTTI2X_1 | | 26 | - | H2 |
| | FRCK2_0 | 16-bit free-run timer ch.2 external clock input pin | 128 | 104 | C13 |
| | FRCK2_1 | | 78 | - | N10 |
| | IC20_0 | 16-bit input capture ch.2 input pin of multi-function timer 2. ICxx describes channel number. | 13 | 13 | E5 |
| | IC20_1 | | 25 | - | H1 |
| | IC21_0 | | 14 | 14 | F1 |
| | IC21_1 | | 79 | - | L10 |
| | IC22_0 | | 15 | 15 | F2 |
| | IC22_1 | | 80 | - | K10 |
| | IC23_0 | | 16 | 16 | F3 |
| | IC23_1 | | 81 | - | M10 |
| | RTO20_0 (PPG20_0) | Wave form generator output of multi-function timer 2. This pin operates as PPG20 when it is used in PPG2 output modes. | 2 | 2 | B2 |
| | RTO20_1 (PPG20_1) | | 139 | - | C11 |
| | RTO21_0 (PPG20_0) | Wave form generator output of multi-function timer 2. This pin operates as PPG20 when it is used in PPG2 output modes. | 3 | 3 | C2 |
| | RTO21_1 (PPG20_1) | | 140 | - | D11 |
| | RTO22_0 (PPG22_0) | Wave form generator output of multi-function timer 2. This pin operates as PPG22 when it is used in PPG2 output modes. | 4 | 4 | C3 |
| | RTO22_1 (PPG22_1) | | 141 | - | B10 |
| | RTO23_0 (PPG22_0) | Wave form generator output of multi-function timer 2. This pin operates as PPG22 when it is used in PPG2 output modes. | 5 | 5 | D5 |
| | RTO23_1 (PPG22_1) | | 142 | - | C10 |
| | RTO24_0 (PPG24_0) | Wave form generator output of multi-function timer 2. This pin operates as PPG24 when it is used in PPG2 output modes. | 6 | 6 | D2 |
| | RTO24_1 (PPG24_1) | | 143 | - | D10 |
| | RTO25_0 (PPG24_0) | Wave form generator output of multi-function timer 2. This pin operates as PPG24 when it is used in PPG2 output modes. | 7 | 7 | D1 |
| | RTO25_1 (PPG24_1) | | 144 | - | B9 |

| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Quadrature Position/ Revolution Counter 0 | AIN0_0 | QPRC ch.0 AIN input pin | 28 | - | H3 |
| | AIN0_1 | | 59 | 51 | L5 |
| | AIN0_2 | | 13 | 13 | E5 |
| | BIN0_0 | QPRC ch.0 BIN input pin | 29 | - | H4 |
| | BIN0_1 | | 60 | 52 | K5 |
| | BIN0_2 | | 14 | 14 | F1 |
| | ZIN0_0 | QPRC ch.0 ZIN input pin | 30 | - | H5 |
| | ZIN0_1 | | 61 | 53 | N6 |
| | ZIN0_2 | | 15 | 15 | F2 |
| Quadrature Position/ Revolution Counter 1 | AIN1_0 | QPRC ch.1 AIN input pin | 73 | 65 | N9 |
| | AIN1_1 | | 127 | 103 | D13 |
| | AIN1_2 | | 62 | 54 | M6 |
| | BIN1_0 | QPRC ch.1 BIN input pin | 74 | 66 | M9 |
| | BIN1_1 | | 126 | 102 | D12 |
| | BIN1_2 | | 63 | 55 | L6 |
| | ZIN1_0 | QPRC ch.1 ZIN input pin | 75 | 67 | L9 |
| | ZIN1_1 | | 125 | 101 | E13 |
| | ZIN1_2 | | 64 | 56 | K6 |
| Quadrature Position/ Revolution Counter 2 | AIN2_0 | QPRC ch.2 AIN input pin | 67 | 59 | M8 |
| | AIN2_1 | | 170 | - | B4 |
| | AIN2_2 | | 115 | - | G11 |
| | BIN2_0 | QPRC ch.2 BIN input pin | 68 | 60 | L8 |
| | BIN2_1 | | 171 | - | C4 |
| | BIN2_2 | | 116 | - | G10 |
| | ZIN2_0 | QPRC ch.2 ZIN input pin | 69 | 61 | K8 |
| | ZIN2_1 | | 172 | 140 | B3 |
| | ZIN2_2 | | 117 | - | G9 |
| USB0 | UDM0 | USB ch.0 device/host D – pin | 174 | 142 | A3 |
| | UDP0 | USB ch.0 device/host D + pin | 175 | 143 | A2 |
| | UHCONX0 | USB ch.0 USB external pull-up control pin | 168 | 138 | B5 |
| USB1 | UDM1 | USB ch.1 device/host D – pin | 130 | 106 | D14 |
| | UDP1 | USB ch.1 device/host D + pin | 131 | 107 | C14 |
| | UHCONX1 | USB ch.1 USB external pull-up control pin | 127 | 103 | D13 |

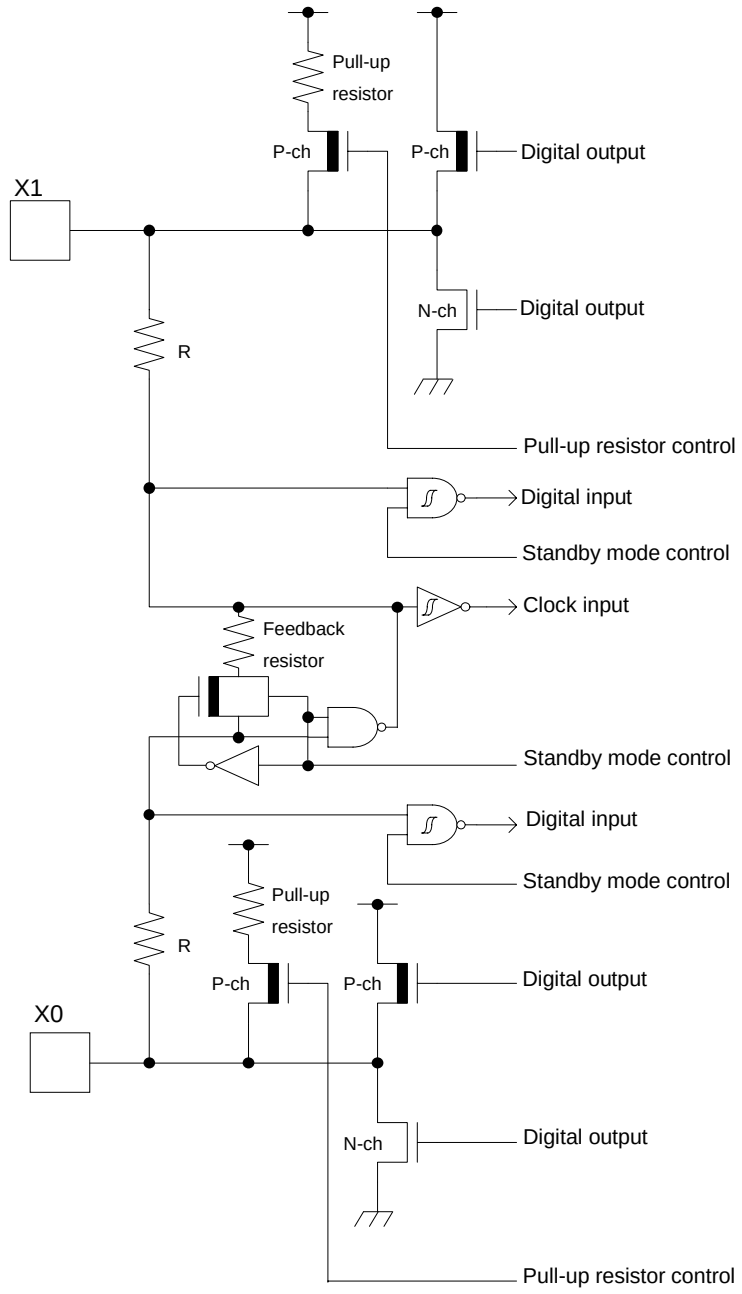
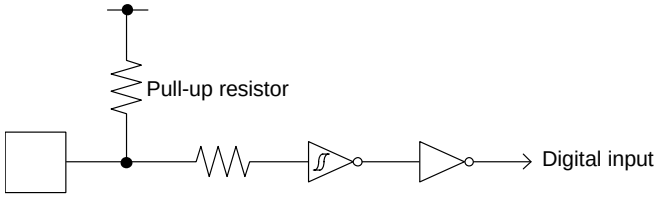
| Module | Pin name | Function | Pin No | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Reset | INITX | External Reset Input. A reset is valid when INITX="L". | 57 | 49 | N5 |
| Mode | MD0 | Mode 0 Pin.<br>During normal operation, MD0="L" must be input.<br>During serial programming to Flash memory, MD0="H" must be input. | 85 | 69 | N12 |
| | MD1 | Mode 1 Pin.<br>During serial programming to Flash memory, MD1="L" must be input. | 84 | 68 | N13 |
| Power | VCC | Power supply Pin | 1 | 1 | C1 |
| | VCC | Power supply Pin | 45 | 37 | N1 |
| | VCC | Power supply Pin | 54 | 46 | P4 |
| | VCC | Power supply Pin | 89 | 73 | M14 |
| | VCC | Power supply Pin | 133 | 109 | A13 |
| | USBVCC0 | 3.3V Power supply port for USB I/O | 173 | 141 | A4 |
| | USBVCC1 | | 129 | 105 | E14 |
| | VCC | Power supply Pin | 156 | 126 | A9 |
| GND | VSS | GND Pin | 27 | 25 | J1 |
| | VSS | GND Pin | 44 | 36 | M1 |
| | VSS | GND Pin | 53 | 45 | P3 |
| | VSS | GND Pin | 88 | 72 | N14 |
| | VSS | GND Pin | 109 | 93 | F14 |
| | VSS | GND Pin | 132 | 108 | B14 |
| | VSS | GND Pin | 157 | 127 | A11 |
| | VSS | GND Pin | 176 | 144 | B1 |
| | VSS | GND Pin | - | - | E1 |
| | VSS | GND Pin | - | - | G1 |
| | VSS | GND Pin | - | - | P7 |
| | VSS | GND Pin | - | - | P11 |
| | VSS | GND Pin | - | - | L14 |
| | VSS | GND Pin | - | - | A8 |
| | VSS | GND Pin | - | - | A5 |
| | VSS | GND Pin | - | - | N7 |
| | VSS | GND Pin | - | - | M7 |
| | VSS | GND Pin | - | - | L7 |
| | VSS | GND Pin | - | - | K7 |
| | VSS | GND Pin | - | - | J7 |
| | VSS | GND Pin | - | - | G7 |
| | VSS | GND Pin | - | - | H7 |
| | VSS | GND Pin | - | - | H8 |
| | VSS | GND Pin | - | - | G8 |

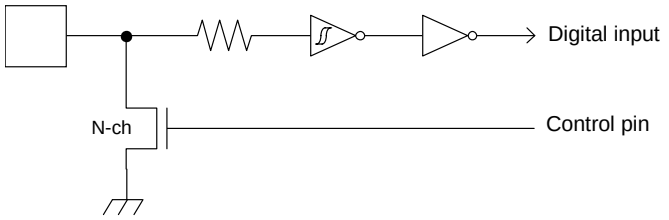
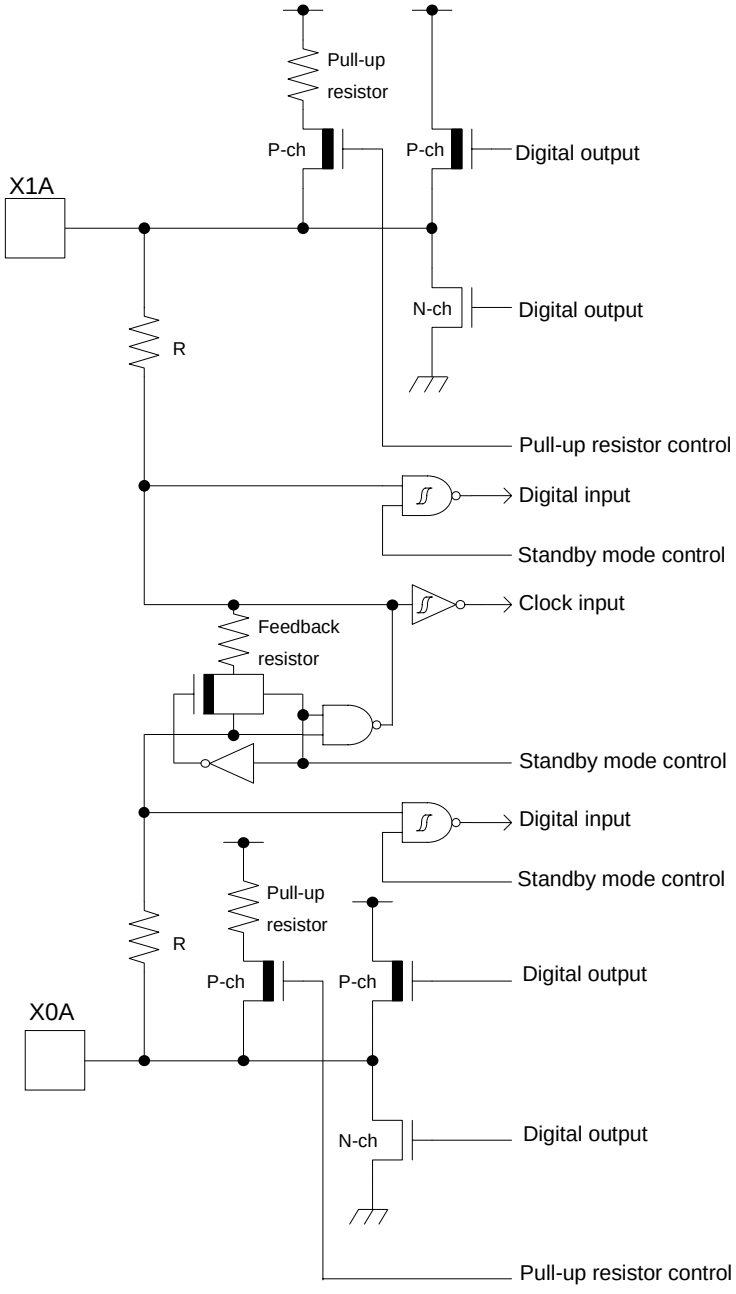
| Module | Pin name | Function | Pin No. | | |
|---|---|---|---|---|---|
| | | | LQFP-176 | LQFP-144 | BGA-192 |
| Clock | X0 | Main clock (oscillation) input pin | 86 | 70 | P12 |
| | X0A | Sub clock (oscillation) input pin | 55 | 47 | P5 |
| | X1 | Main clock (oscillation) I/O pin | 87 | 71 | P13 |
| | X1A | Sub clock (oscillation) I/O pin | 56 | 48 | P6 |
| | CROUT_0 | Built-in high-speed CR-osc clock output port | 127 | 103 | D13 |
| | CROUT_1 | | 152 | 122 | E8 |
| Analog Power | AVCC | A/D converter analog power pin | 106 | 90 | J14 |
| | AVRH | A/D converter analog reference voltage input pin | 107 | 91 | H14 |
| Analog GND | AVSS | A/D converter GND pin | 108 | 92 | G14 |
| C pin | C | Power stabilization capacity pin | 52 | 44 | P2 |

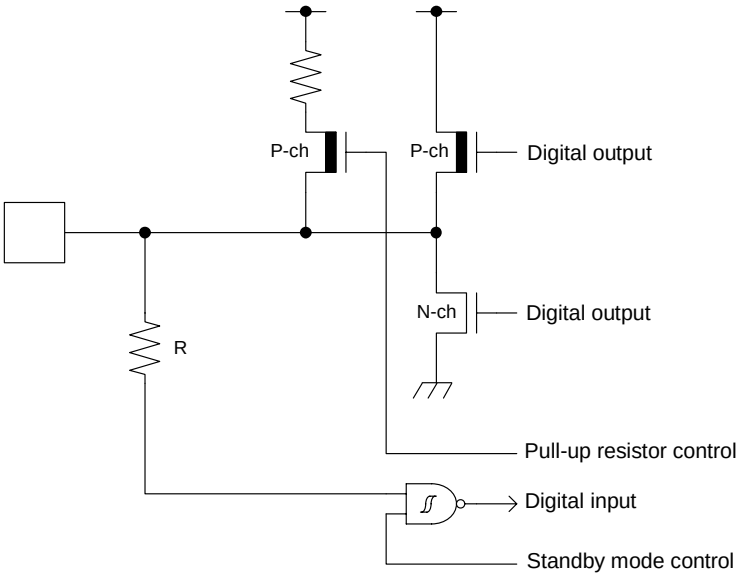
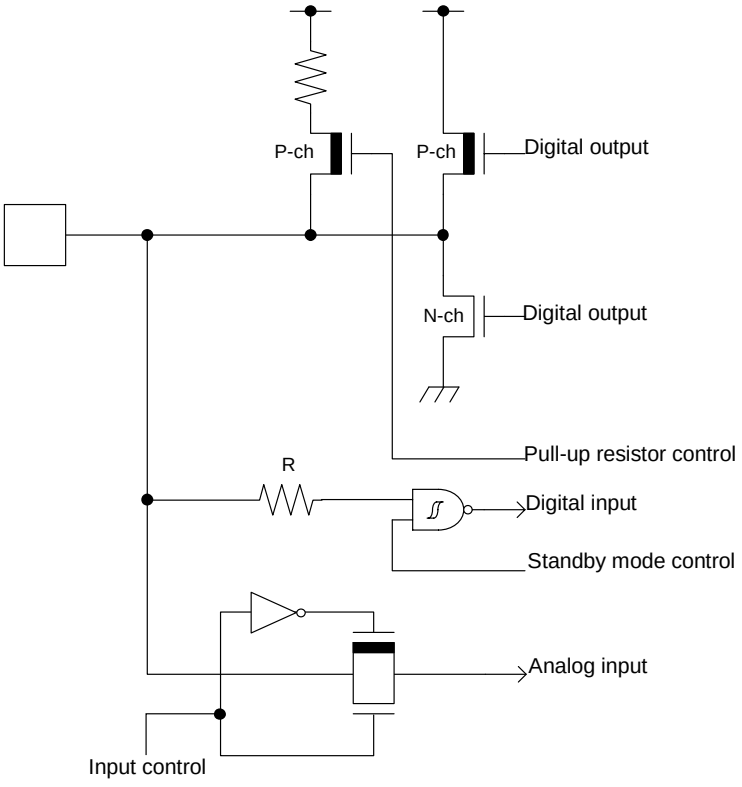
***Note:***

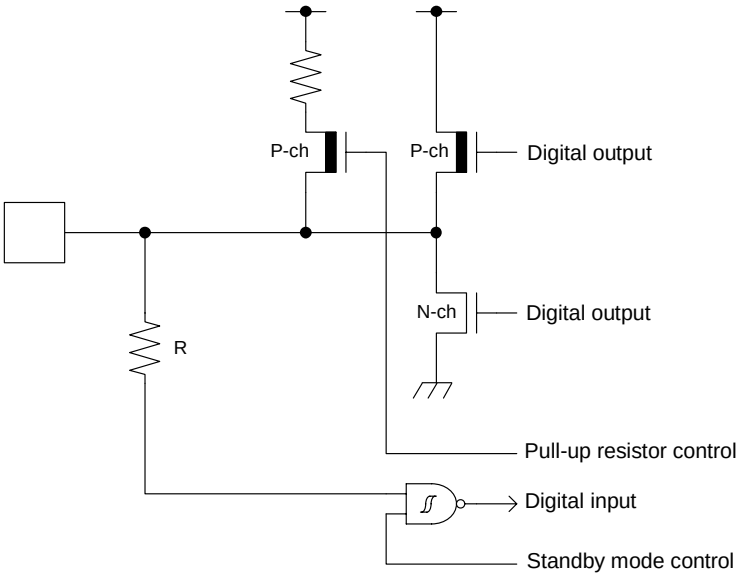
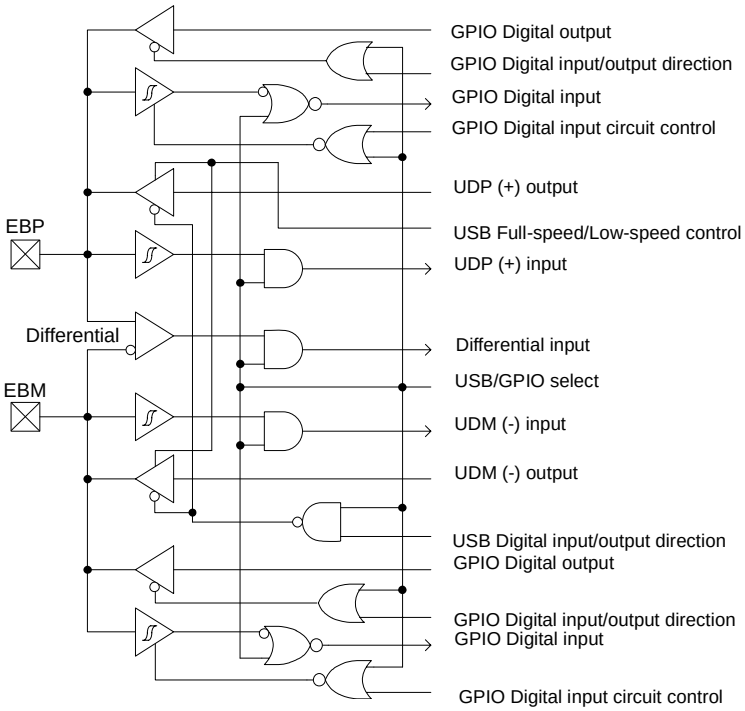
- *While this device contains a Test Access Port (TAP) based on the IEEE 1149.1-2001 JTAG standard, it is not fully compliant to all requirements of that standard. This device may contain a 32-bit device ID that is the same as the 32-bit device ID in other devices with different functionality. The TAP pins may also be configurable for purposes other than access to the TAP controller.*

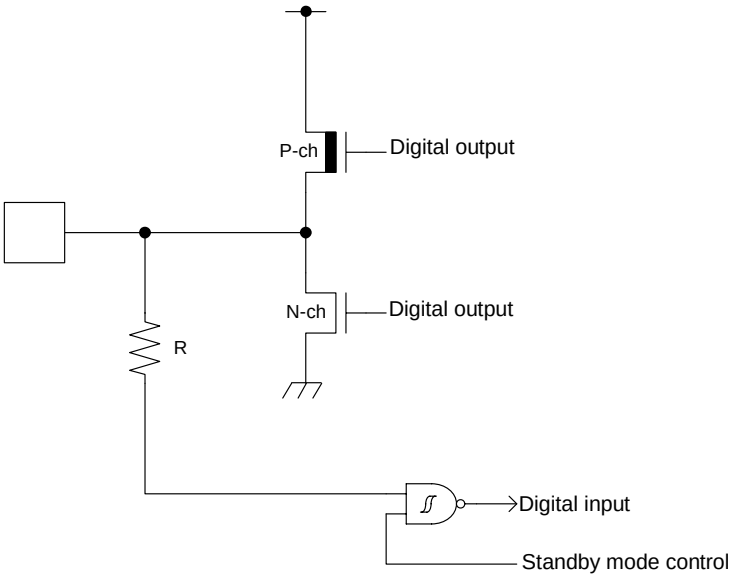
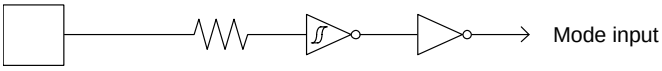
## 5. I/O Circuit Type

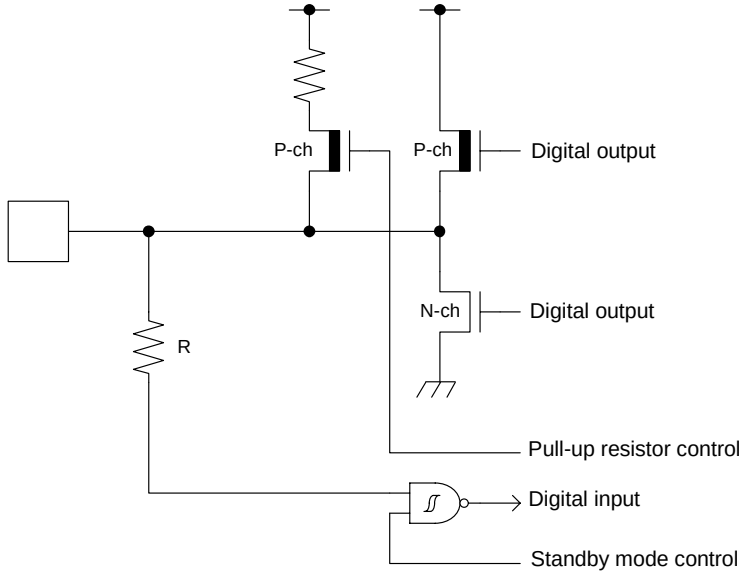
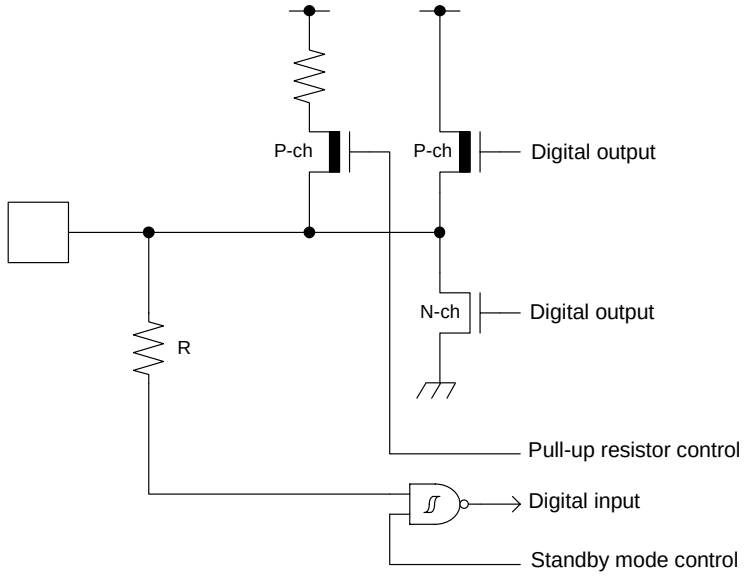
| Type | Circuit | Remarks |
|---|---|---|
| A |  | It is possible to select the main oscillation / GPIO function<br><br>When the main oscillation is selected.<br>– Oscillation feedback resistor : Approximately 1 MΩ<br>– With Standby mode control<br><br>When the GPIO is selected.<br>– CMOS level output.<br>– CMOS level hysteresis input<br>– With pull-up resistor control<br>– With standby mode control<br>– Pull-up resistor : Approximately 50 kΩ<br>– $I_{OH}$ = -4 mA, $I_{OL}$ = 4 mA |
| B |  | – CMOS level hysteresis input<br>– Pull-up resistor : Approximately 50 kΩ |

| Type | Circuit | Remarks |
|---|---|---|
| C |  | – Open drain output<br>– CMOS level hysteresis input |
| D |  | It is possible to select the sub oscillation / GPIO function<br><br>When the sub oscillation is selected.<br>– Oscillation feedback resistor : Approximately 5 MΩ<br>– With Standby mode control<br><br>When the GPIO is selected.<br>– CMOS level output.<br>– CMOS level hysteresis input<br>– With pull-up resistor control<br>– With standby mode control<br>– Pull-up resistor : Approximately 50 kΩ<br>– $I_{OH}$ = -4 mA, $I_{OL}$ = 4 mA |

| Type | Circuit | Remarks |
|---|---|---|
| E |  | – CMOS level output<br>– CMOS level hysteresis input<br>– With pull-up resistor control<br>– With standby mode control<br>– Pull-up resistor<br>: Approximately 50 kΩ<br>– $I_{OH}$ = -4 mA, $I_{OL}$ = 4 mA<br>– When this pin is used as an $I^2C$ pin, the digital output P-ch transistor is always off<br>– +B input is available |
| F |  | – CMOS level output<br>– CMOS level hysteresis input<br>– With input control<br>– Analog input<br>– With pull-up resistor control<br>– With standby mode control<br>– Pull-up resistor<br>: Approximately 50 kΩ<br>– $I_{OH}$ = -4 mA, $I_{OL}$ = 4 mA<br>– When this pin is used as an $I^2C$ pin, the digital output P-ch transistor is always off<br>– +B input is available |

| Type | Circuit | Remarks |
|---|---|---|
| G |  | − CMOS level output<br>− CMOS level hysteresis input<br>− With pull-up resistor control<br>− With standby mode control<br>− Pull-up resistor<br>: Approximately 50 kΩ<br>− $I_{OH}$ = -12 mA, $I_{OL}$ = 12 mA<br>− +B input is available |
| H |  | It is possible to select the USB I/O / GPIO function.<br><br>When the USB I/O is selected.<br>− Full-speed, Low-speed control<br><br>When the GPIO is selected.<br>− CMOS level output<br>− CMOS level hysteresis input<br>− With standby mode control<br>− $I_{OH}$ = -20.5 mA, $I_{OL}$ = 18.5 mA |

| Type | Circuit | Remarks |
|---|---|---|
| I |  | – CMOS level output<br>– CMOS level hysteresis input<br>– 5 V tolerant<br>– With standby mode control<br>– $I_{OH}$ = -4 mA, $I_{OL}$ = 4 mA<br>– Available to control of PZR registers.<br>– When this pin is used as an $I^2C$ pin, the digital output P-ch transistor is always off |
| J |  | CMOS level hysteresis input |

| Type | Circuit | Remarks |
|---|---|---|
| K |  | – CMOS level output<br>– TTL level hysteresis input<br>– With pull-up resistor control<br>– With standby mode control<br>– Pull-up resistor<br>: Approximately 50 kΩ<br>– $I_{OH}$ = -4 mA, $I_{OL}$ = 4 mA |
| L |  | – CMOS level output<br>– CMOS level hysteresis input<br>– With pull-up resistor control<br>– With standby mode control<br>– Pull-up resistor<br>: Approximately 50 kΩ<br>– $I_{OH}$ = -8 mA, $I_{OL}$ = 8 mA<br>– When this pin is used as an $I^2C$ pin, the digital output P-ch transistor is always off<br>– +B input is available |

# 6. Handling Precautions

Any semiconductor devices have inherently a certain rate of failure. The possibility of failure is greatly affected by the conditions in which they are used (circuit conditions, environmental conditions, etc.). This page describes precautions that must be observed to minimize the chance of failure and to obtain higher reliability from your Cypress semiconductor devices.

## 6.1 Precautions for Product Design

This section describes precautions when designing electronic equipment using semiconductor devices.

### Absolute Maximum Ratings

Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of certain established limits, called absolute maximum ratings. Do not exceed these ratings.

### Recommended Operating Conditions

Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges.

Always use semiconductor devices within the recommended operating conditions. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the datasheet. Users considering application outside the listed conditions are advised to contact their sales representative beforehand.

### Processing and Protection of Pins

These precautions must be followed when handling the pins which connect semiconductor devices to power supply and input/output functions.

1. Preventing Over-Voltage and Over-Current Conditions

   Exposure to voltage or current levels in excess of maximum ratings at any pin is likely to cause deterioration within the device, and in extreme cases leads to permanent damage of the device. Try to prevent such overvoltage or over-current conditions at the design stage.
2. Protection of Output Pins

   Shorting of output pins to supply pins or other output pins, or connection to large capacitance can cause large current flows. Such conditions if present for extended periods of time can damage the device.
   Therefore, avoid this type of connection.
3. Handling of Unused Input Pins

   Unconnected input pins with very high impedance levels can adversely affect stability of operation. Such pins should be connected through an appropriate resistance to a power supply pin or ground pin.

### Latch-up

Semiconductor devices are constructed by the formation of P-type and N-type areas on a substrate. When subjected to abnormally high voltages, internal parasitic PNPN junctions (called thyristor structures) may be formed, causing large current levels in excess of several hundred mA to flow continuously at the power supply pin. This condition is called latch-up.

CAUTION: The occurrence of latch-up not only causes loss of reliability in the semiconductor device, but can cause injury or damage from high heat, smoke or flame. To prevent this from happening, do the following:

1. Be sure that voltages applied to pins do not exceed the absolute maximum ratings. This should include attention to abnormal noise, surge levels, etc.
2. Be sure that abnormal current flows do not occur during the power-on sequence.

### Observance of Safety Regulations and Standards

Most countries in the world have established standards and regulations regarding safety, protection from electromagnetic interference, etc. Customers are requested to observe applicable regulations and standards in the design of products.

### Fail-Safe Design

Any semiconductor devices have inherently a certain rate of failure. You must protect against injury, damage or loss from such failures by incorporating safety design measures into your facility and equipment such as redundancy, fire protection, and prevention of over-current levels and other abnormal operating conditions.

**Precautions Related to Usage of Devices**

Cypress semiconductor devices are intended for use in standard applications (computers, office automation and other office equipment, industrial, communications, and measurement equipment, personal or household devices, etc.).

CAUTION: Customers considering the use of our products in special applications where failure or abnormal operation may directly affect human lives or cause physical injury or property damage, or where extremely high levels of reliability are demanded (such as aerospace systems, atomic energy controls, sea floor repeaters, vehicle operating controls, medical devices for life support, etc.) are requested to consult with sales representatives before such use. The company will not be responsible for damages arising from such use without prior approval.

## 6.2 Precautions for Package Mounting

Package mounting may be either lead insertion type or surface mount type. In either case, for heat resistance during soldering, you should only mount under Cypress recommended conditions. For detailed information about mount conditions, contact your sales representative.

**Lead Insertion Type**

Mounting of lead insertion type packages onto printed circuit boards may be done by two methods: direct soldering on the board, or mounting by using a socket.

Direct mounting onto boards normally involves processes for inserting leads into through-holes on the board and using the flow soldering (wave soldering) method of applying liquid solder. In this case, the soldering process usually causes leads to be subjected to thermal stress in excess of the absolute ratings for storage temperature. Mounting processes should conform to Cypress recommended mounting conditions.

If socket mounting is used, differences in surface treatment of the socket contacts and IC lead surfaces can lead to contact deterioration after long periods. For this reason it is recommended that the surface treatment of socket contacts and IC leads be verified before mounting.

**Surface Mount Type**

Surface mount packaging has longer and thinner leads than lead-insertion packaging, and therefore leads are more easily deformed or bent. The use of packages with higher pin counts and narrower pin pitch results in increased susceptibility to open connections caused by deformed pins, or shorting due to solder bridges.

You must use appropriate mounting techniques. Cypress recommends the solder reflow method, and has established a ranking of mounting conditions for each product. Users are advised to mount packages in accordance with Cypress ranking of recommended conditions.

**Lead-Free Packaging**

CAUTION: When ball grid array (BGA) packages with Sn-Ag-Cu balls are mounted using Sn-Pb eutectic soldering, junction strength may be reduced under some conditions of use.

**Storage of Semiconductor Devices**

Because plastic chip packages are formed from plastic resins, exposure to natural environmental conditions will cause absorption of moisture. During mounting, the application of heat to a package that has absorbed moisture can cause surfaces to peel, reducing moisture resistance and causing packages to crack. To prevent, do the following:

1. Avoid exposure to rapid temperature changes, which cause moisture to condense inside the product. Store products in locations where temperature changes are slight.
2. Use dry boxes for product storage. Products should be stored below 70% relative humidity, and at temperatures between 5°C and 30°C. When you open Dry Package that recommends humidity 40% to 70% relative humidity.
3. When necessary, Cypress packages semiconductor devices in highly moisture-resistant aluminum laminate bags, with a silica gel desiccant. Devices should be sealed in their aluminum laminate bags for storage.
4. Avoid storing packages where they are exposed to corrosive gases or high levels of dust.

**Baking**

Packages that have absorbed moisture may be de-moisturized by baking (heat drying). Follow the Cypress recommended conditions for baking.

Condition: 125°C/24 h

**Static Electricity**

Because semiconductor devices are particularly susceptible to damage by static electricity, you must take the following precautions:

1. Maintain relative humidity in the working environment between 40% and 70%. Use of an apparatus for ion generation may be needed to remove electricity.
2. Electrically ground all conveyors, solder vessels, soldering irons and peripheral equipment.
3. Eliminate static body electricity by the use of rings or bracelets connected to ground through high resistance (on the level of 1 MΩ).
   Wearing of conductive clothing and shoes, use of conductive floor mats and other measures to minimize shock loads is recommended.
4. Ground all fixtures and instruments, or protect with anti-static measures.
5. Avoid the use of Styrofoam or other highly static-prone materials for storage of completed board assemblies.

## 6.3 Precautions for Use Environment

Reliability of semiconductor devices depends on ambient temperature and other conditions as described above.

For reliable performance, do the following:

1. Humidity

   Prolonged use in high humidity can lead to leakage in devices as well as printed circuit boards. If high humidity levels are anticipated, consider anti-humidity processing.
2. Discharge of Static Electricity

   When high-voltage charges exist close to semiconductor devices, discharges can cause abnormal operation. In such cases, use anti-static measures or processing to prevent discharges.
3. Corrosive Gases, Dust, or Oil

   Exposure to corrosive gases or contact with dust or oil may lead to chemical reactions that will adversely affect the device. If you use devices in such conditions, consider ways to prevent such exposure or to protect the devices.
4. Radiation, Including Cosmic Radiation

   Most devices are not designed for environments involving exposure to radiation or cosmic radiation. Users should provide shielding as appropriate.
5. Smoke, Flame

   CAUTION: Plastic molded devices are flammable, and therefore should not be used near combustible substances. If devices begin to smoke or burn, there is danger of the release of toxic gases.

Customers considering the use of Cypress products in other special environmental conditions should consult with sales representatives.

# 7. Handling Devices

### Power supply pins

In products with multiple VCC and VSS pins, respective pins at the same potential are interconnected within the device in order to prevent malfunctions such as latch-up. However, all of these pins should be connected externally to the power supply or ground lines in order to reduce electromagnetic emission levels, to prevent abnormal operation of strobe signals caused by the rise in the ground level, and to conform to the total output current rating.

Moreover, connect the current supply source with each Power supply pin and GND pin of this device at low impedance. It is also advisable that a ceramic capacitor of approximately 0.1 µF be connected as a bypass capacitor between each Power supply pin and GND pin, between AVCC pin and AVSS pin near this device.

### Stabilizing power supply voltage

A malfunction may occur when the power supply voltage fluctuates rapidly even though the fluctuation is within the recommended operating conditions of the VCC power supply voltage. As a rule, with voltage stabilization, suppress the voltage fluctuation so that the fluctuation in VCC ripple (peak-to-peak value) at the commercial frequency (50 Hz/60 Hz) does not exceed 10% of the VCC value in the recommended operating conditions, and the transient fluctuation rate does not exceed 0.1 V/µs when there is a momentary fluctuation on switching the power supply.

### Crystal oscillator circuit

Noise near the X0/X1 and X0A/X1A pins may cause the device to malfunction. Design the printed circuit board so that X0/X1, X0A/X1A pins, the crystal oscillator (or ceramic oscillator), and the bypass capacitor to ground are located as close to the device as possible.

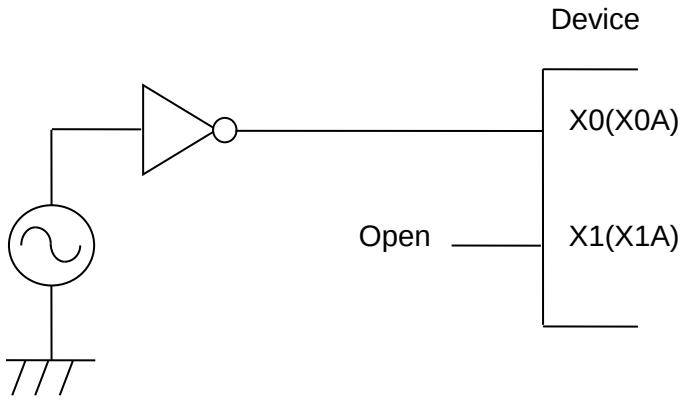
It is strongly recommended that the PC board artwork be designed such that the X0/X1 and X0A/X1A pins are surrounded by ground plane as this is expected to produce stable operation.

Evaluate oscillation of your using crystal oscillator by your mount board.

### Using an external clock

When using an external clock, the clock signal should be input to the X0, X0A pin only and the X1,X1A pin should be kept open.

- **Example of Using an External Clock**

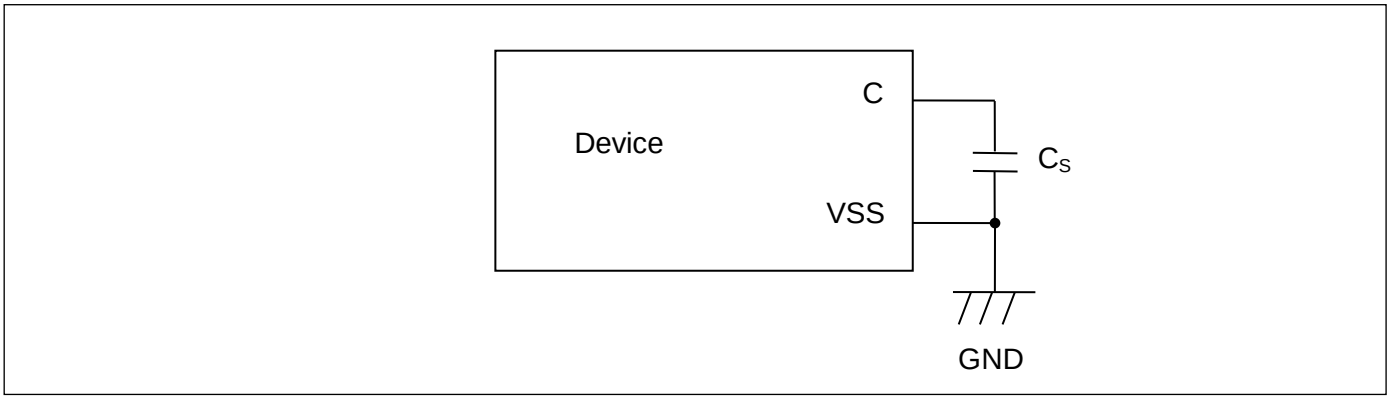


### Handling when using Multi-function serial pin as I²C pin

If it is using multi-function serial pin as I²C pins, P-ch transistor of digital output is always disable. However, I²C pins need to keep the electrical characteristic like other pins and not to connect to external I²C bus system with power OFF.

### C Pin

This series contains the regulator. Be sure to connect a smoothing capacitor ($C_S$) for the regulator between the C pin and the GND pin. Please use a ceramic capacitor or a capacitor of equivalent frequency characteristics as a smoothing capacitor.
However, some laminated ceramic capacitors have the characteristics of capacitance variation due to thermal fluctuation (F characteristics and Y5V characteristics). Please select the capacitor that meets the specifications in the operating conditions to use by evaluating the temperature characteristics of a capacitor.
A smoothing capacitor of about 4.7µF would be recommended for this series.




### Mode pins (MD0)

Connect the MD pin (MD0) directly to VCC or VSS pins. Design the printed circuit board such that the pull-up/down resistance stays low, as well as the distance between the mode pins and VCC pins or VSS pins is as short as possible and the connection impedance is low, when the pins are pulled-up/down such as for switching the pin level and rewriting the Flash memory data. It is because of preventing the device erroneously switching to test mode due to noise.

### Notes on power-on

Turn power on/off in the following order or at the same time.
If not using the A/D converter, connect AVCC = VCC and AVSS = VSS.

| | |
|---|---|
| Turning on: | VCC → USBVCC0 |
| | VCC → USBVCC1 |
| | VCC →AVCC → AVRH |
| Turning off: | AVRH → AVCC → VCC |
| | USBVCC1 → VCC |
| | USBVCC0 → VCC |

### Serial Communication

There is a possibility to receive wrong data due to the noise or other causes on the serial communication.
Therefore, design a printed circuit board so as to avoid noise.
Consider the case of receiving wrong data due to noise, perform error detection such as by applying a checksum of data at the end.
If an error is detected, retransmit the data.

### Differences in features among the products with different memory sizes and between Flash products and MASK products

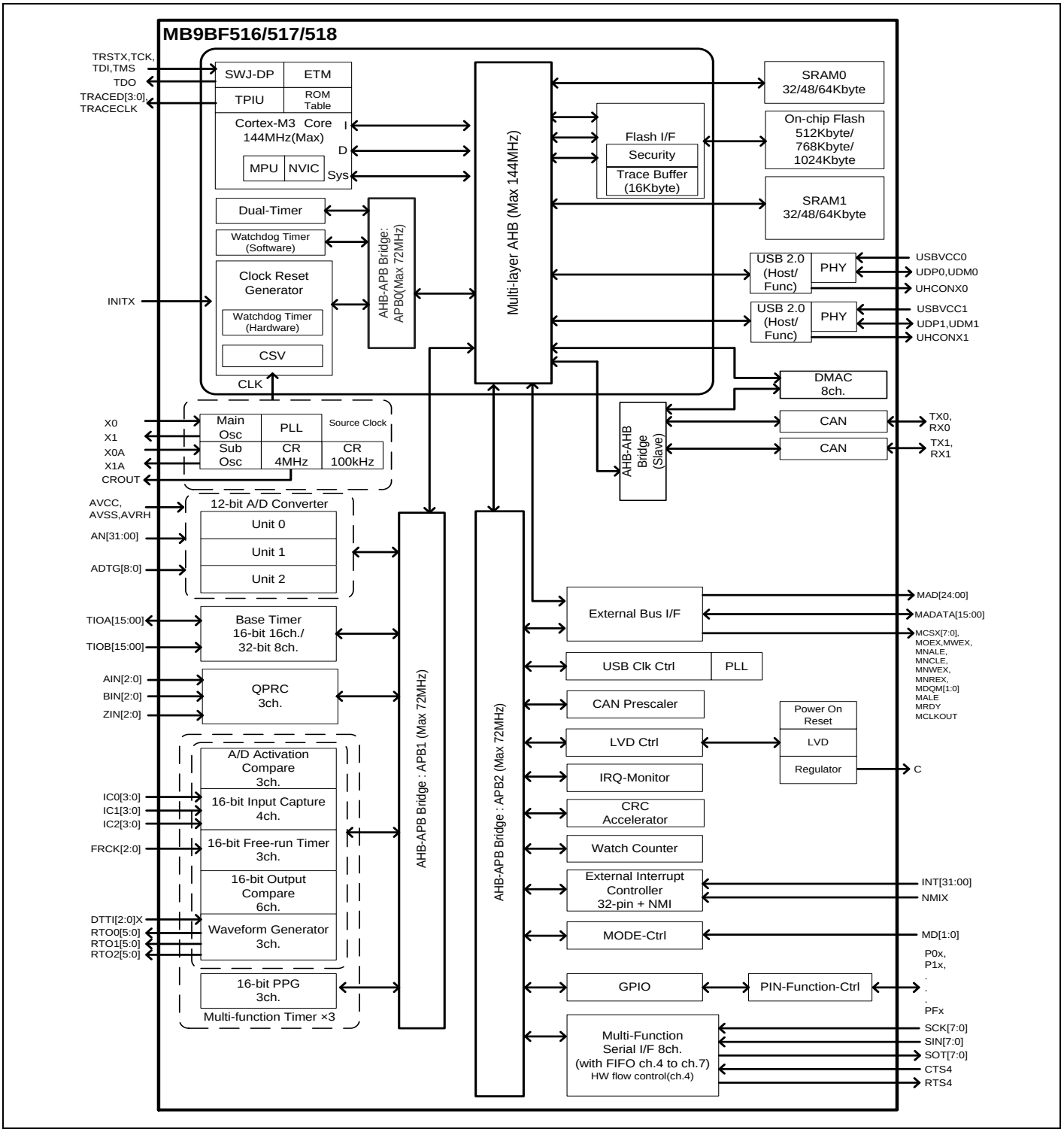
The electric characteristics including power consumption, ESD, latch-up, noise characteristics, and oscillation characteristics among the products with different memory sizes and between Flash products and MASK products are different because chip layout and memory structures are different.

If you are switching to use a different product of the same series, please make sure to evaluate the electric characteristics.

### Base Timer

In the case of using ch.8 and ch.9 at I/O mode 1 (timer full mode), the TIOA09 pin cannot be used for external startup trigger input (TGIN).
Be sure to use the pin with making ESG1 and ESG2 bits of the Timer Control Register (Ch.9-TMCR) in the Base Timer to be "0b00" in order to disable trigger input.

## 8. Block Diagram




***Note:***

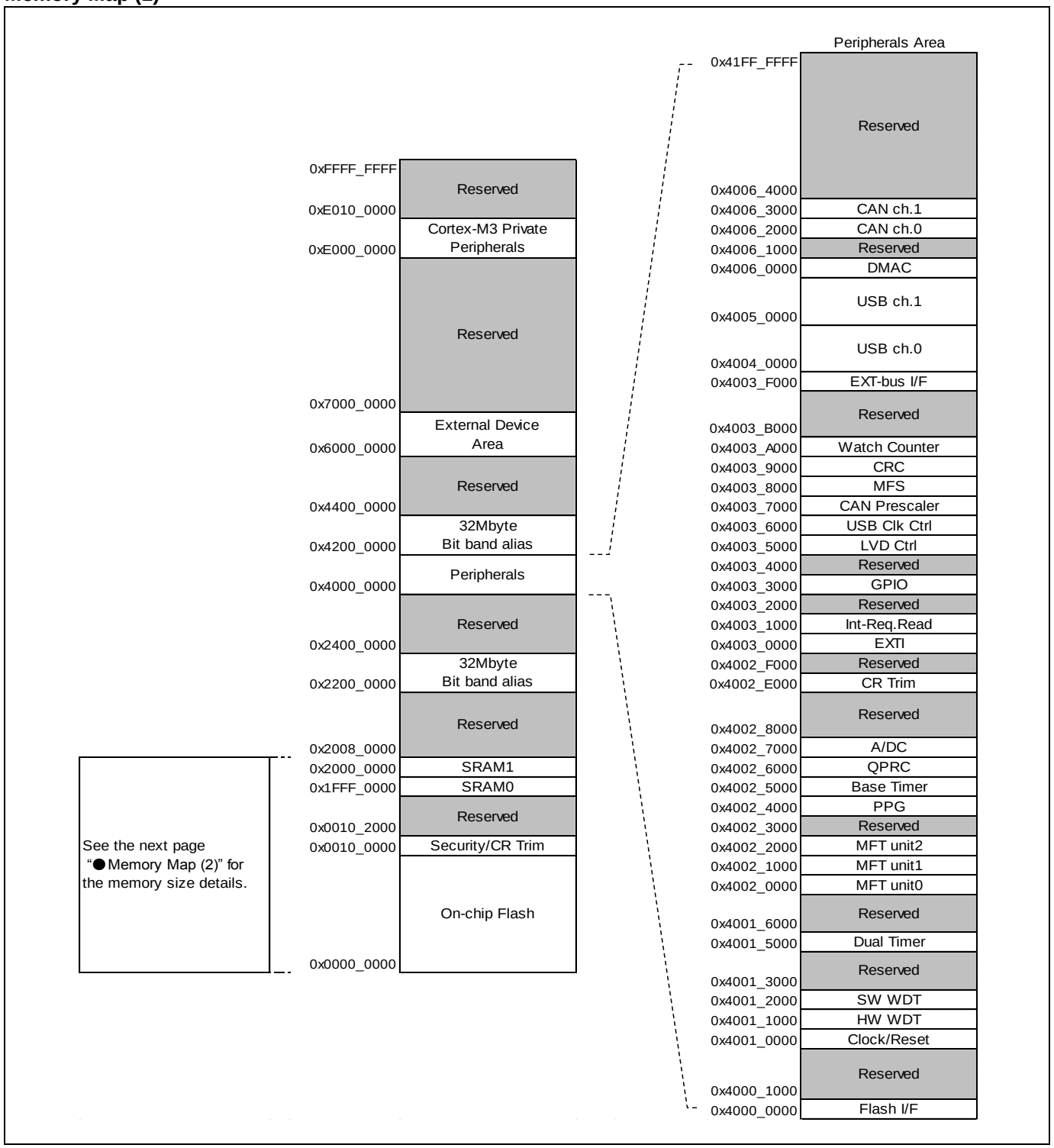
- *The following items vary depending on the package.*
  - *Number of external bus interface pin*
  - *Number of 12-bit A/D converter channel*

## 9. Memory Size

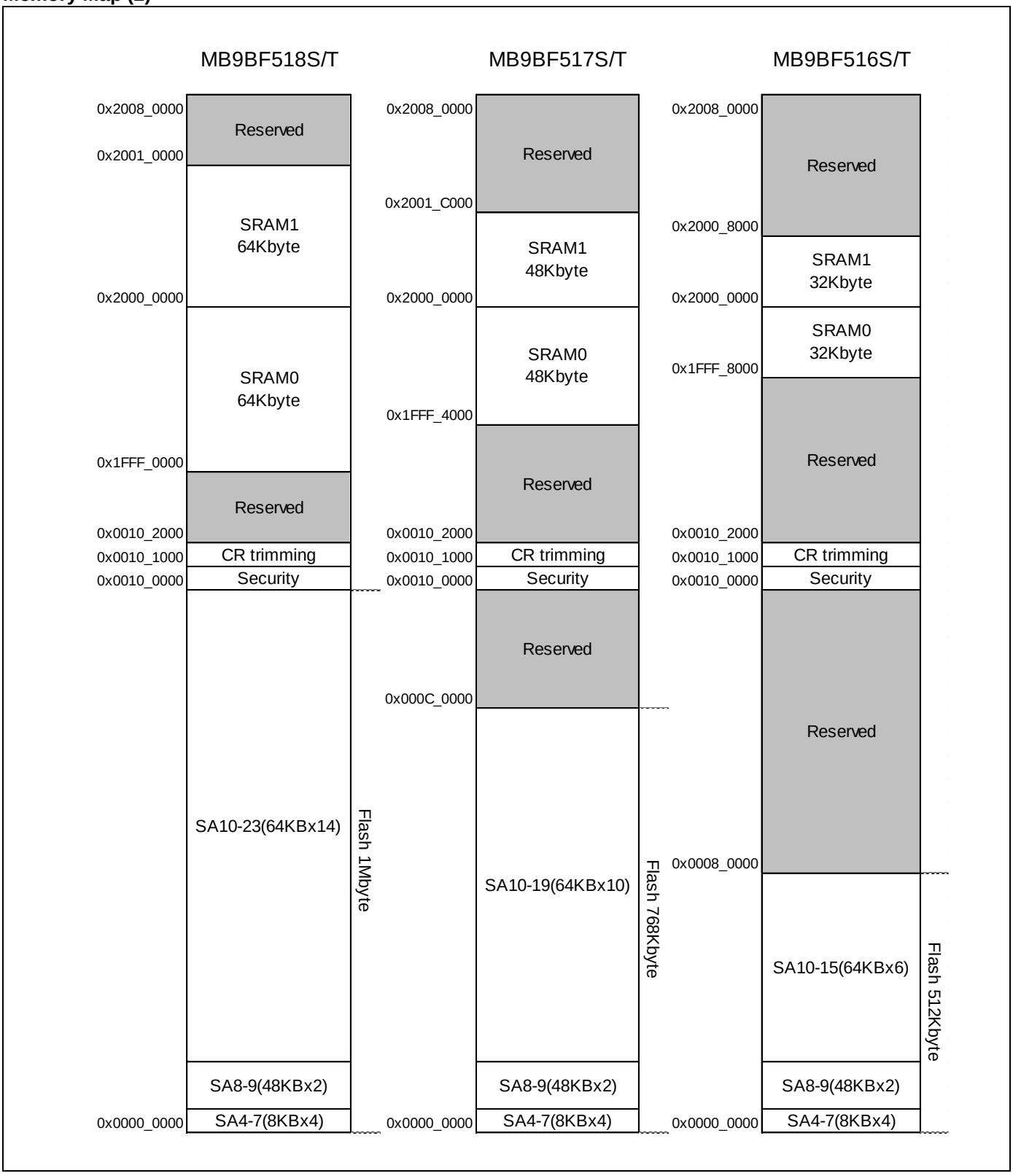
See "Memory Size" in "1. Product Lineup" to confirm the memory size.

## 10. Memory Map

### Memory Map (1)



**Memory Map (2)**


MB9BF518S/T
MB9BF517S/T
MB9BF516S/T
0x2008_0000
Reserved
0x2001_0000
SRAM1
64Kbyte
0x2000_0000
SRAM0
64Kbyte
0x1FFF_0000
Reserved
0x0010_2000
CR trimming
0x0010_1000
Security
0x0010_0000
SA10-23(64KBx14)
SA8-9(48KBx2)
SA4-7(8KBx4)
0x0000_0000
Flash 1Mbyte
0x2001_C000
SRAM1
48Kbyte
SRAM0
48Kbyte
0x1FFF_4000
0x000C_0000
SA10-19(64KBx10)
Flash 768Kbyte
0x2000_8000
SRAM1
32Kbyte
SRAM0
32Kbyte
0x1FFF_8000
0x0008_0000
SA10-15(64KBx6)
Flash 512Kbyte

## Peripheral Address Map

| Start address | End address | Bus | Peripherals |
|---|---|---|---|
| 0x4000_0000 | 0x4000_0FFF | AHB | Flash memory I/F register |
| 0x4000_1000 | 0x4000_FFFF | | Reserved |
| 0x4001_0000 | 0x4001_0FFF | APB0 | Clock/Reset Control |
| 0x4001_1000 | 0x4001_1FFF | | Hardware Watchdog timer |
| 0x4001_2000 | 0x4001_2FFF | | Software Watchdog timer |
| 0x4001_3000 | 0x4001_4FFF | | Reserved |
| 0x4001_5000 | 0x4001_5FFF | | Dual-Timer |
| 0x4001_6000 | 0x4001_FFFF | | Reserved |
| 0x4002_0000 | 0x4002_0FFF | APB1 | Multi-function timer unit0 |
| 0x4002_1000 | 0x4002_1FFF | | Multi-function timer unit1 |
| 0x4002_2000 | 0x4002_3FFF | | Multi-function timer unit2 |
| 0x4002_4000 | 0x4002_4FFF | | PPG |
| 0x4002_5000 | 0x4002_5FFF | | Base Timer |
| 0x4002_6000 | 0x4002_6FFF | | Quadrature Position/Revolution Counter |
| 0x4002_7000 | 0x4002_7FFF | | A/D Converter |
| 0x4002_8000 | 0x4002_DFFF | | Reserved |
| 0x4002_E000 | 0x4002_EFFF | | Internal CR trimming |
| 0x4002_F000 | 0x4002_FFFF | | Reserved |
| 0x4003_0000 | 0x4003_0FFF | APB2 | External Interrupt Controller |
| 0x4003_1000 | 0x4003_1FFF | | Interrupt Request Batch-Read Function |
| 0x4003_2000 | 0x4003_2FFF | | Reserved |
| 0x4003_3000 | 0x4003_3FFF | | GPIO |
| 0x4003_4000 | 0x4003_4FFF | | Reserved |
| 0x4003_5000 | 0x4003_5FFF | | Low Voltage Detector |
| 0x4003_6000 | 0x4003_6FFF | | USB clock generator |
| 0x4003_7000 | 0x4003_7FFF | | CAN Prescaler |
| 0x4003_8000 | 0x4003_8FFF | | Multi-function serial Interface |
| 0x4003_9000 | 0x4003_9FFF | | CRC |
| 0x4003_A000 | 0x4003_AFFF | | Watch Counter |
| 0x4003_B000 | 0x4003_EFFF | | Reserved |
| 0x4003_F000 | 0x4003_FFFF | | External Memory interface |
| 0x4004_0000 | 0x4004_FFFF | AHB | USB ch.0 |
| 0x4005_0000 | 0x4005_FFFF | | USB ch.1 |
| 0x4006_0000 | 0x4006_0FFF | | DMAC register |
| 0x4006_1000 | 0x4006_1FFF | | Reserved |
| 0x4006_2000 | 0x4006_2FFF | | CAN ch.0 |
| 0x4006_3000 | 0x4006_3FFF | | CAN ch.1 |
| 0x4006_4000 | 0x41FF_FFFF | | Reserved |

## 11. Pin Status in Each CPU State

The terms used for pin status have the following meanings.

- INITX=0

  This is the period when the INITX pin is the "L" level.

- INITX=1

  This is the period when the INITX pin is the "H" level.

- SPL=0

  This is the status that standby pin level setting bit (SPL) in standby mode control register (STB_CTL) is set to "0".

- SPL=1

  This is the status that standby pin level setting bit (SPL) in standby mode control register (STB_CTL) is set to "1".

- Input enabled

  Indicates that the input function can be used.

- Internal input fixed at "0"

  This is the status that the input function cannot be used. Internal input is fixed at "L".

- Hi-Z

  Indicates that the output drive transistor is disabled and the pin is put in the Hi-Z state.

- Setting disabled

  Indicates that the setting is disabled.

- Maintain previous state

  Maintains the state that was immediately prior to entering the current mode.
  If a built-in peripheral function is operating, the output follows the peripheral function.
  If the pin is being used as a port, that output is maintained.

- Analog input is enabled

  Indicates that the analog input is enabled.

- Trace output

  Indicates that the trace function can be used.

## List of Pin Status

| Pin status type | Function group | Power-on reset or low voltage detection state | INITX input state | Device internal reset state | Run mode or sleep mode state | Timer mode or sleep mode state | |
|---|---|---|---|---|---|---|---|
| | | Power supply unstable | Power supply stable | | Power supply stable | Power supply stable | |
| | | - | INITX=0 | INITX=1 | INITX=1 | INITX=1 | |
| | | - | - | - | - | SPL=0 | SPL=1 |
| A | GPIO selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| | Main crystal oscillator input pin | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled |
| B | GPIO selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| | Main crystal oscillator output pin | Hi-Z/ Internal input fixed at "0"/ or Input enable | Hi-Z/ Internal input fixed at "0" | Hi-Z/ Internal input fixed at "0" | Maintain previous state | Maintain previous state/ Hi-Z at oscillation stop*[1] Internal input fixed at "0" | Maintain previous state/ Hi-Z at oscillation stop*[1] Internal input fixed at "0" |
| C | INITX input pin | Pull-up/ Input enabled | Pull-up/ Input enabled | Pull-up/ Input enabled | Pull-up/ Input enabled | Pull-up/ Input enabled | Pull-up/ Input enabled |
| D | Mode input pin | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled |
| E | JTAG selected | Hi-Z | Pull-up/ Input enabled | Pull-up/ Input enabled | Maintain previous state | Maintain previous state | Maintain previous state |
| | GPIO selected | Setting disabled | Setting disabled | Setting disabled | | | Hi-Z/ Internal input fixed at "0" |
| F | Trace selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Trace output |
| | External interrupt enabled selected | | | | | | Maintain previous state |
| | GPIO selected, or other than above resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | | | Hi-Z/ Internal input fixed at "0" |
| G | Trace selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Trace output |
| | GPIO selected, or other than above resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | | | Hi-Z/ Internal input fixed at "0" |

| Pin status type | Function group | Power-on reset or low voltage detection state | INITX input state | Device internal reset state | Run mode or sleep mode state | Timer mode or sleep mode state | |
|---|---|---|---|---|---|---|---|
| | | Power supply unstable | Power supply stable | | Power supply stable | Power supply stable | |
| | | - | INITX=0 | INITX=1 | INITX=1 | INITX=1 | |
| | | - | - | - | - | SPL=0 | SPL=1 |
| H | External interrupt enabled selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Maintain previous state |
| | GPIO selected, or other than above resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | | | Hi-Z/ Internal input fixed at "0" |
| I | GPIO selected, resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| J | NMIX selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Maintain previous state |
| | GPIO selected, or other than above resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | | | Hi-Z/ Internal input fixed at "0" |
| K | Analog input selected | Hi-Z | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled |
| | GPIO selected, or other than above resource selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| L | External interrupt enabled selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Maintain previous state |
| | Analog input selected | Hi-Z | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled | Hi-Z/ Internal input fixed at "0"/ Analog input enabled |
| | GPIO selected, or other than above resource selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| M | GPIO selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| | Sub crystal oscillator input pin | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled |

| Pin status type | Function group | Power-on reset or low voltage detection state | INITX input state | Device internal reset state | Run mode or sleep mode state | Timer mode or sleep mode state | |
|---|---|---|---|---|---|---|---|
| | | Power supply unstable | Power supply stable | | Power supply stable | Power supply stable | |
| | | - | INITX=0 | INITX=1 | INITX=1 | INITX=1 | |
| | | - | - | - | - | SPL=0 | SPL=1 |
| N | GPIO selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| | Sub crystal oscillator output pin | Hi-Z/ Internal input fixed at "0"/ or Input enable | Hi-Z/ Internal input fixed at "0" | Hi-Z/ Internal input fixed at "0" | Maintain previous state | Maintain previous state/ Hi-Z at oscillation stop*2/ Internal input fixed at "0" | Maintain previous state/ Hi-Z at oscillation stop*2/ Internal input fixed at "0" |
| O | GPIO selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| | USB I/O pin | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Hi-Z at transmission/ Input enabled/ Internal input fixed at "0" at reception | Hi-Z at transmission/ Input enabled/ Internal input fixed at "0" at reception |
| P | Mode input pin | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled | Input enabled |
| | GPIO selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Hi-Z/ Input enabled |
| Q | GPIO selected, resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | Maintain previous state | Maintain previous state | Hi-Z/ Internal input fixed at "0" |
| R | External interrupt enabled selected | Setting disabled | Setting disabled | Setting disabled | Maintain previous state | Maintain previous state | Maintain previous state |
| | GPIO selected, or other than above resource selected | Hi-Z | Hi-Z/ Input enabled | Hi-Z/ Input enabled | | | Hi-Z/ Internal input fixed at "0" |

*1: Oscillation is stopped at Sub timer mode, Low speed CR timer mode, and STOP mode.

*2: Oscillation is stopped at STOP mode.

# 12. Electrical Characteristics

## 12.1 Absolute Maximum Ratings

| Parameter | Symbol | Rating | | Unit | Remarks |
|---|---|---|---|---|---|
| | | Min | Max | | |
| Power supply voltage*1,*2 | Vcc | Vss - 0.5 | Vss + 6.5 | V | |
| Power supply voltage (for USB ch.0)*1,*3 | USBVcc0 | Vss - 0.5 | Vss + 6.5 | V | |
| Power supply voltage (for USB ch.1)*1,*3 | USBVcc1 | Vss - 0.5 | Vss + 6.5 | V | |
| Analog power supply voltage*1,*4 | AVcc | Vss - 0.5 | Vss + 6.5 | V | |
| Analog reference voltage*1,*4 | AVRH | Vss - 0.5 | Vss + 6.5 | V | |
| Input voltage*1 | $V_I$ | Vss - 0.5 | Vcc + 0.5 (≤ 6.5 V) | V | Except for USB pin |
| | | Vss - 0.5 | USBVcc0 + 0.5 (≤ 6.5 V) | V | USB ch.0 pin |
| | | Vss - 0.5 | USBVcc1 + 0.5 (≤ 6.5 V) | V | USB ch.1 pin |
| | | Vss - 0.5 | Vss + 6.5 | V | 5V tolerant |
| Analog pin input voltage*1 | $V_{IA}$ | Vss - 0.5 | AVcc + 0.5 (≤ 6.5 V) | V | |
| Output voltage*1 | $V_O$ | Vss - 0.5 | Vcc + 0.5 (≤ 6.5 V) | V | |
| Clamp maximum current | $I_{CLAMP}$ | -2 | +2 | mA | *8 |
| Clamp total maximum current | $\Sigma [I_{CLAMP}]$ | | +20 | mA | *8 |
| "L" level maximum output current*5 | $I_{OL}$ | - | 10 | mA | 4 mA type |
| | | | 20 | mA | 8 mA type |
| | | | 20 | mA | 12 mA type |
| | | | 39 | mA | P80,P81,P82,P83 |
| "L" level average output current*6 | $I_{OLAV}$ | - | 4 | mA | 4 mA type |
| | | | 8 | mA | 8 mA type |
| | | | 12 | mA | 12 mA type |
| | | | 18.5 | mA | P80,P81,P82,P83 |
| "L" level total maximum output current | $\sum I_{OL}$ | - | 100 | mA | |
| "L" level total average output current*7 | $\sum I_{OLAV}$ | - | 50 | mA | |
| "H" level maximum output current*5 | $I_{OH}$ | - | - 10 | mA | 4 mA type |
| | | | - 20 | mA | 8 mA type |
| | | | - 20 | mA | 12 mA type |
| | | | - 39 | mA | P80,P81,P82,P83 |
| "H" level average output current*6 | $I_{OHAV}$ | - | - 4 | mA | 4 mA type |
| | | | - 8 | mA | 8 mA type |
| | | | - 12 | mA | 12 mA type |
| | | | - 20.5 | mA | P80,P81,P82,P83 |
| "H" level total maximum output current | $\sum I_{OH}$ | - | - 100 | mA | |
| "H" level total average output current*7 | $\sum I_{OHAV}$ | - | - 50 | mA | |
| Power consumption | $P_D$ | - | 1000 | mW | |
| Storage temperature | $T_{STG}$ | - 55 | + 150 | °C | |

*1: These parameters are based on the condition that Vss = AVss = 0.0 V.

*2: Vcc must not drop below Vss - 0.5 V.

*3: USBVcc0 and USBVcc1 must not drop below Vss - 0.5 V.

*4: Ensure that the voltage does not to exceed Vcc + 0.5 V, for example, when the power is turned on.

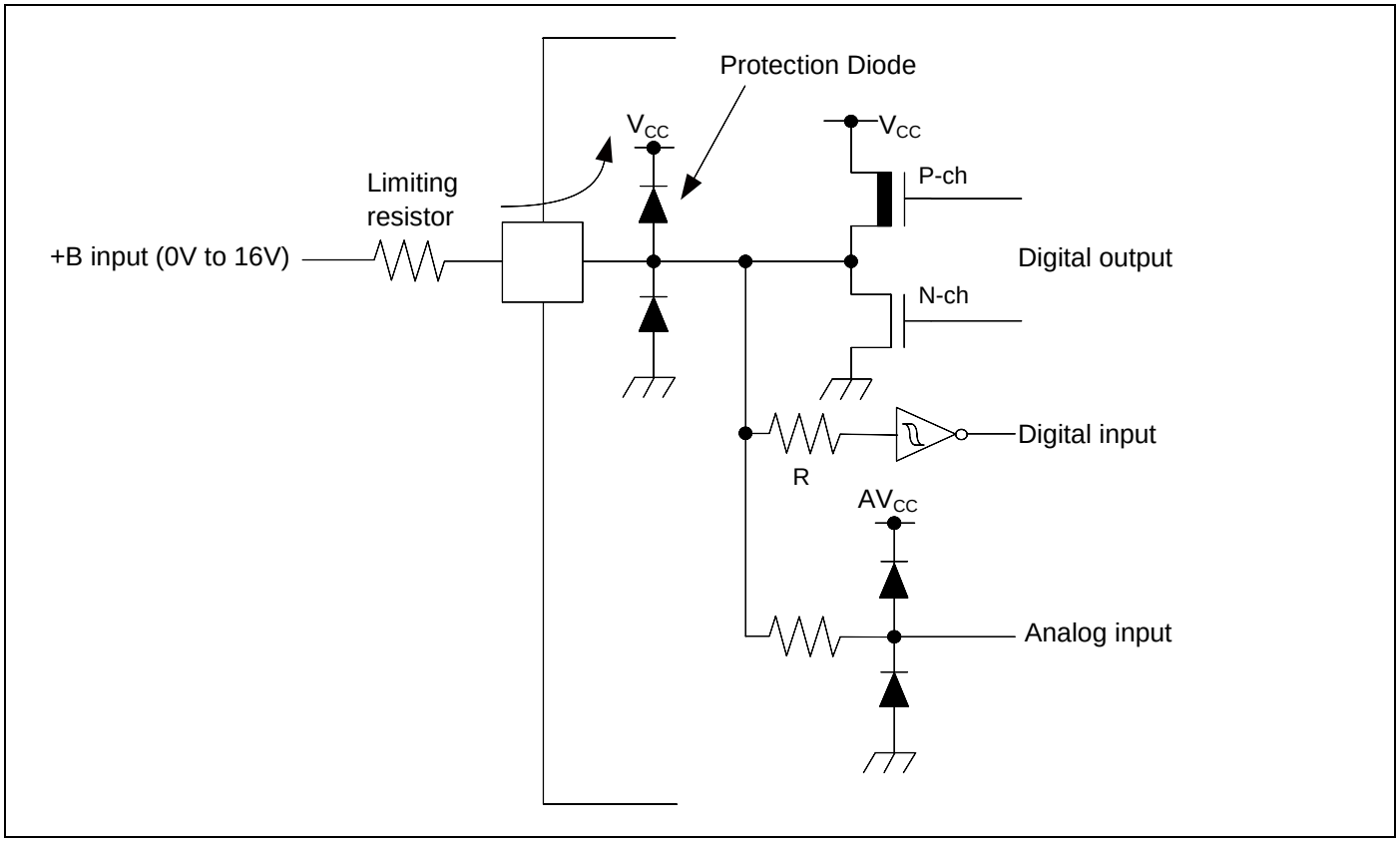
*5: The maximum output current is the peak value for a single pin.

*6: The average output is the average current for a single pin over a period of 100 ms.

*7: The total average output current is the average current for all pins over a period of 100 ms.

*8:

- See "4. List of Pin Functions" and "5. I/O Circuit Type" about +B input available pin.
- Use within recommended operating conditions.
- Use at DC voltage (current) the +B input.
- The +B signal should always be applied a limiting resistance placed between the +B signal and the device.
- The value of the limiting resistance should be set so that when the +B signal is applied the input current to the device pin does not exceed rated values, either instantaneously or for prolonged periods.
- Note that when the device drive current is low, such as in the low-power consumption modes, the +B input potential may pass through the protective diode and increase the potential at the VCC and AVCC pin, and this may affect other devices.
- Note that if a +B signal is input when the device power supply is off (not fixed at 0 V), the power supply is provided from the pins, so that incomplete operation may result.
- The following is a recommended circuit example (I/O equivalent circuit).




***WARNING:***

- *Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.*

## 12.2 Recommended Operating Conditions

(Vss = AVss = 0.0V)

| Parameter | | Symbol | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Power supply voltage | | Vcc | - | 2.7*6 | 5.5 | V | |
| Power supply voltage (3V power supply) for USB ch.0 | | USBVcc0 | - | 3.0 | 3.6 (≤ Vcc) | V | *1 |
| | | | | 2.7 | 5.5 (≤ Vcc) | | *2 |
| Power supply voltage (3V power supply) for USB ch.1 | | USBVcc1 | - | 3.0 | 3.6 (≤ Vcc) | V | *3 |
| | | | | 2.7 | 5.5 (≤ Vcc) | | *4 |
| Analog power supply voltage | | AVcc | - | 2.7 | 5.5 | V | AVcc = Vcc |
| Analog reference voltage | | AVRH | - | 2.7 | AVcc | V | |
| Smoothing capacitor | | $C_S$ | - | 1 | 10 | µF | for built-in regulator *5 |
| Operating temperature | LQS144, LQP176, LBE192 | $T_A$ | When mounted on four-layer PCB | - 40 | + 85 | °C | |

*1: When P81/UDP0 and P80/UDM0 pin are used as USB (UDP0, UDM0).

*2: When P81/UDP0 and P80/UDM0 pin are used as GPIO (P81, P80).

*3: When P83/UDP1 and P82/UDM1 pin are used as USB (UDP1, UDM1).

*4: When P83/UDP1 and P82/UDM1 pin are used as GPIO (P83, P82).

*5: See "C pin" in "7. Handling Devices" for the connection of the smoothing capacitor.

*6: In between less than the minimum power supply voltage and low voltage reset/interrupt detection voltage or more, instruction execution and low voltage detection function by built-in High-speed CR (including Main PLL is used) or built-in Low-speed CR is possible to operate only.

***WARNING:***

- *The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.*
  *Always use semiconductor devices within their recommended operating condition ranges. Operation outside these ranges may adversely affect reliability and could result in device failure. No warranty is made with respect to uses, operating conditions, or combinations not represented on the datasheet. Users considering application outside the listed conditions are advised to contact their representatives beforehand.*

## 12.3 DC Characteristics

### *12.3.1 Current Rating*

(Vcc = AVcc = USBVcc0 = USBVcc1 = 2.7V to 5.5V, Vss = AVss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | Typ*3 | Max*4 | | |
| RUN mode current | Icc | VCC | PLL RUN mode | CPU: 144MHz, Peripheral: 72MHz, Flash 2Wait, TraceBuffer: ON, FRWTR.RWT = 10, FSYNDN.SD = 000, FBFCR.BE = 1 | 100 | 180 | mA | *1, *5 |
| | | | | CPU: 72MHz, Peripheral: 72MHz, Flash 0Wait, TraceBuffer: OFF, FRWTR.RWT = 00, FSYNDN.SD = 000, FBFCR.BE = 0 | 65 | 135 | mA | *1, *5 |
| | | | High-speed CR RUN mode | CPU/ Peripheral: 4MHz*2, Flash 0Wait, FRWTR.RWT = 00, FSYNDN.SD = 000 | 6 | 57.8 | mA | *1 |
| | | | Sub RUN mode | CPU/ Peripheral: 32kHz, Flash 0Wait, FRWTR.RWT = 00, FSYNDN.SD = 000 | 1.3 | 51.7 | mA | *1, *6 |
| | | | Low-speed CR RUN mode | CPU/ Peripheral: 100kHz, Flash 0Wait, FRWTR.RWT = 00, FSYNDN.SD = 000 | 1.3 | 51.7 | mA | *1 |
| SLEEP mode current | Iccs | | PLL SLEEP mode | Peripheral: 72MHz | 30 | 89 | mA | *1, *5 |
| | | | High-speed CR SLEEP mode | Peripheral: 4MHz*2 | 4.5 | 55.9 | mA | *1 |
| | | | Sub SLEEP mode | Peripheral: 32kHz | 1.2 | 51.6 | mA | *1, *6 |
| | | | Low-speed CR SLEEP mode | Peripheral: 100kHz | 1.2 | 51.6 | mA | *1 |

*1: When all ports are fixed.

*2: When setting it to 4 MHz by trimming.

*3: $T_A$=+25°C, $V_{CC}$=5.5 V

*4: $T_A$=+85°C, $V_{CC}$=5.5 V

*5: When using the crystal oscillator of 4 MHz (Including the current consumption of the oscillation circuit)

*6: When using the crystal oscillator of 32 kHz (Including the current consumption of the oscillation circuit)

(Vcc = AVcc = USBVcc0 = USBVcc1 = 2.7V to 5.5V, Vss = AVss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | | Value Typ*2 | Value Max*2 | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| TIMER mode current | $I_{CCT}$ | VCC | Main TIMER mode | $T_A$ = + 25°C, When LVD is off | 4 | 10 | mA | *1, *3 |
| | | | | $T_A$ = + 85°C, When LVD is off | - | 55 | mA | *1, *3 |
| | | | Sub TIMER mode | $T_A$ = + 25°C, When LVD is off | 1.1 | 5 | mA | *1, *4 |
| | | | | $T_A$ = + 85°C, When LVD is off | - | 50 | mA | *1, *4 |
| STOP mode current | $I_{CCH}$ | | STOP mode | $T_A$ = + 25°C, When LVD is off | 1 | 5 | mA | *1 |
| | | | | $T_A$ = + 85°C, When LVD is off | - | 50 | mA | *1 |

*1: When all ports are fixed.

*2: $V_{CC}$=5.5 V

*3: When using the crystal oscillator of 4 MHz (Including the current consumption of the oscillation circuit)

*4: When using the crystal oscillator of 32 kHz (Including the current consumption of the oscillation circuit)

### Low-Voltage Detection Current

($V_{CC}$ = 2.7V to 5.5V, $V_{SS}$ = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value Typ | Value Max | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Low-voltage detection circuit (LVD) power supply current | $I_{CCLVD}$ | VCC | At operation for interrupt | 4 | 7 | µA | At not detect |

### Flash Memory Current

($V_{CC}$ = 2.7V to 5.5V, $V_{SS}$ = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value Typ | Value Max | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Flash memory write/erase current | $I_{CCFLASH}$ | VCC | At Write/Erase | 12 | 14 | mA | |

### A/D Converter Current

($V_{CC}$ = $AV_{CC}$ = 2.7V to 5.5V, $V_{SS}$ = $AV_{SS}$ = AVRL = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value Typ | Value Max | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Power supply current | $I_{CCAD}$ | AVCC | At 1unit operation | 0.57 | 0.72 | mA | |
| | | | At stop | 0.06 | 35 | µA | |
| Reference power supply current | $I_{CCAVRH}$ | AVRH | At 1unit operation AVRH=5.5 V | 1.1 | 1.96 | mA | |
| | | | At stop | 0.06 | 4 | µA | |

### 12.3.2 Pin Characteristics

(Vcc = USBVcc0 = USBVcc1 = AVcc = 2.7V to 5.5V, Vss = AVss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| "H" level input voltage (hysteresis input) | $V_{IHS}$ | CMOS hysteresis input pin, MD0, MD1 | - | Vcc × 0.8 | - | Vcc + 0.3 | V | *1 |
| | | 5 V tolerant input pin | - | Vcc × 0.8 | - | Vss + 5.5 | V | |
| | | TTL Schmitt input pin | - | 2.0 | - | Vcc + 0.3 | V | |
| "L" level input voltage (hysteresis input) | $V_{ILS}$ | CMOS hysteresis input pin, MD0, MD1 | - | Vss - 0.3 | - | Vcc × 0.2 | V | *1 |
| | | 5V tolerant input pin | - | Vss - 0.3 | - | Vcc × 0.2 | V | |
| | | TTL Schmitt input pin | - | Vss - 0.3 | - | 0.8 | V | |
| "H" level output voltage | $V_{OH}$ | 4mA type | Vcc ≥ 4.5 V, $I_{OH}$ = - 4 mA | Vcc - 0.5 | - | Vcc | V | *1 |
| | | | Vcc < 4.5 V, $I_{OH}$ = - 2 mA | | | | | |
| | | 8mA type | Vcc ≥ 4.5 V, $I_{OH}$ = - 8 mA | Vcc - 0.5 | - | Vcc | V | *1 |
| | | | Vcc < 4.5 V, $I_{OH}$ = - 4 mA | | | | | |
| | | 12mA type | Vcc ≥ 4.5 V, $I_{OH}$ = - 12 mA | Vcc - 0.5 | - | Vcc | V | |
| | | | Vcc < 4.5 V, $I_{OH}$ = - 8 mA | | | | | |
| | | P80, P81, P82, P83 | USBVcc ≥ 4.5 V, $I_{OH}$ = - 20.5 mA | USBVcc - 0.4 | - | USBVcc | V | *2 |
| | | | USBVcc < 4.5 V, $I_{OH}$ = - 13.0 mA | | | | | |

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| "L" level output voltage | $V_{OL}$ | 4 mA type | Vcc ≥ 4.5 V, $I_{OL}$ = 4 mA | Vss | - | 0.4 | V | |
| | | | Vcc < 4.5 V, $I_{OL}$ = 2 mA | | | | | |
| | | 8 mA type | Vcc ≥ 4.5 V, $I_{OL}$ = 8 mA | Vss | - | 0.4 | V | |
| | | | Vcc < 4.5 V, $I_{OL}$ = 4 mA | | | | | |
| | | 12 mA type | Vcc ≥ 4.5 V, $I_{OL}$ = 12 mA | Vss | - | 0.4 | V | |
| | | | Vcc < 4.5 V, $I_{OL}$ = 8 mA | | | | | |
| | | P80, P81, P82, P83 | USBVcc ≥ 4.5 V, $I_{OL}$ = 18.5 mA | Vss | - | 0.4 | V | * |
| | | | USBVcc < 4.5 V, $I_{OL}$ = 10.5 mA | | | | | |
| Input leak current | $I_{IL}$ | - | - | - 5 | - | + 5 | µA | |
| Pull-up resistance value | $R_{PU}$ | Pull-up pin | Vcc ≥ 4.5 V | 25 | 50 | 100 | kΩ | |
| | | | Vcc < 4.5 V | 30 | 80 | 200 | | |
| Input capacitance | $C_{IN}$ | Other than VCC, USBVCC0, USBVCC1, VSS, AVCC, AVSS, AVRH | - | - | 5 | 15 | pF | |

*: USBVcc0 and USBVcc1 are described as USBVcc.

## 12.4 AC Characteristics

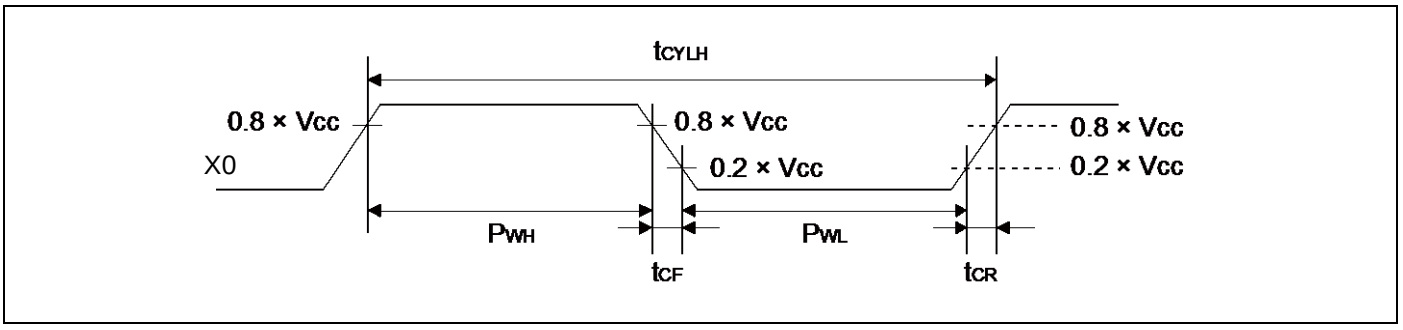
### *12.4.1 Main Clock Input Characteristics*

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Input frequency | $F_{CH}$ | X0, X1 | Vcc ≥ 4.5 V | 4 | 50 | MHz | When crystal oscillator is connected |
| | | | Vcc < 4.5 V | 4 | 20 | | |
| | | | Vcc ≥ 4.5 V | 4 | 50 | MHz | When using external clock |
| | | | Vcc < 4.5 V | 4 | 20 | | |
| Input clock cycle | $t_{CYLH}$ | | Vcc ≥ 4.5 V | 20 | 250 | ns | When using external clock |
| | | | Vcc < 4.5 V | 50 | 250 | | |
| Input clock pulse width | - | | PWH/tCYLH, PWL/tCYLH | 45 | 55 | % | When using external clock |
| Input clock rise time and fall time | $t_{CF}$, $t_{CR}$ | | - | - | 5 | ns | When using external clock |
| Internal operating clock*1 frequency | $F_{CM}$ | - | - | - | 144 | MHz | Master clock |
| | $F_{CC}$ | - | - | - | 144 | MHz | Base clock (HCLK/FCLK) |
| | $F_{CP0}$ | - | - | - | 72 | MHz | APB0 bus clock*2 |
| | $F_{CP1}$ | - | - | - | 72 | MHz | APB1 bus clock*2 |
| | $F_{CP2}$ | - | - | - | 72 | MHz | APB2 bus clock*2 |
| Internal operating clock*1 cycle time | $t_{CYCC}$ | - | - | 6.94 | - | ns | Base clock (HCLK/FCLK) |
| | $t_{CYCP0}$ | - | - | 13.8 | - | ns | APB0 bus clock*2 |
| | $t_{CYCP1}$ | - | - | 13.8 | - | ns | APB1 bus clock*2 |
| | $t_{CYCP2}$ | - | - | 13.8 | - | ns | APB2 bus clock*2 |

*1: For more information about each internal operating clock, see "Chapter 2-1: Clock" in "FM3 Family Peripheral Manual".

*2: For about each APB bus which each peripheral is connected to, see "8. Block Diagram" in this datasheet.

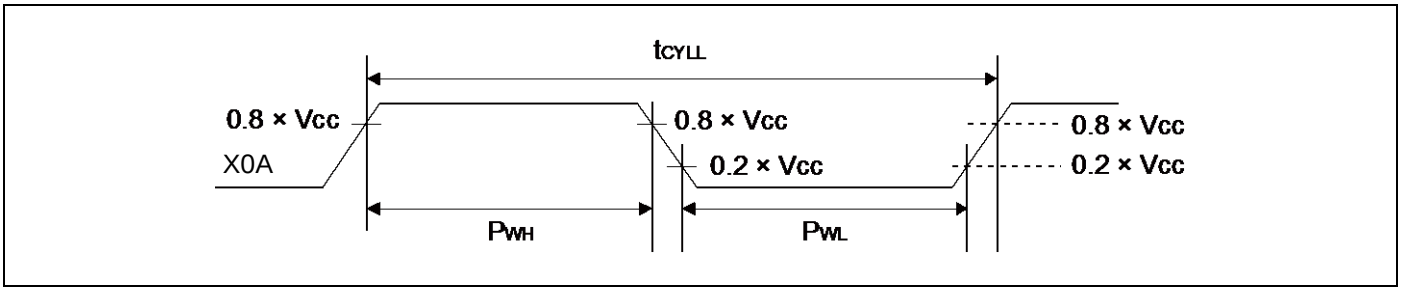


### 12.4.2 Sub Clock Input Characteristics

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| Input frequency | $1/t_{CYLL}$ | X0A, X1A | - | - | 32.768 | - | kHz | When crystal oscillator is connected |
| | | | - | 32 | - | 100 | kHz | When using external clock |
| Input clock cycle | $t_{CYLL}$ | | - | 10 | - | 31.25 | µs | When using external clock |
| Input clock pulse width | - | | PWH/tCYLL, PWL/tCYLL | 45 | - | 55 | % | When using external clock |

*: See "Sub crystal oscillator" in "7. Handling Devices" for the crystal oscillator used.




### 12.4.3 Internal CR Oscillation Characteristics

**High-speed Internal CR**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Clock frequency | $F_{CRH}$ | $T_A$ = + 25°C | 3.96 | 4 | 4.04 | MHz | When trimming* |
| | | $T_A$ = 0°C to + 70°C | 3.84 | 4 | 4.16 | | |
| | | $T_A$ = - 40°C to + 85°C | 3.8 | 4 | 4.2 | | |
| | | $T_A$ = - 40°C to + 85°C | 3 | 4 | 5 | | When not trimming |
| Frequency stability time | $t_{CRWT}$ | - | - | - | 90 | µs | *2 |

*1: In the case of using the values in CR trimming area of Flash memory at shipment for frequency trimming.

*2: Frequency stable time is time to stable of the frequency of the High-speed CR clock after the trim value is set. After setting the trim value, the period when the frequency stability time passes can use the High-speed CR clock as a source clock.

**Low-speed Internal CR**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Clock frequency | $F_{CRL}$ | - | 50 | 100 | 150 | kHz | |

### *12.4.4 Operating Conditions of Main PLL and USB PLL (In the case of using main clock for input of PLL)*

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|
| | | Min | Typ | Max | | |
| PLL oscillation stabilization wait time*1 (LOCK UP time) | $t_{LOCK}$ | 100 | - | - | µs | |
| PLL input clock frequency | $F_{PLLI}$ | 4 | - | 16 | MHz | |
| PLL multiple rate | - | 13 | - | 75 | multiple | |
| PLL macro oscillation clock frequency | $F_{PLLO}$ | 200 | - | 300 | MHz | |
| Main PLL clock frequency*2 | $F_{CLKPLL}$ | - | - | 144 | MHz | |
| USB clock frequency*3 | $F_{CLKSPLL}$ | - | - | 48 | MHz | After the M frequency division |

*1: Time from when the PLL starts operating until the oscillation stabilizes.

*2: For more information about Main PLL clock (CLKPLL), see "Chapter 2-1: Clock" in "FM3 Family Peripheral Manual".

*3: For more information about USB clock, see "Chapter 2-2: USB clock Generation" in "FM3 Family Peripheral Manual Communication Macro Part".

### *12.4.5 Operating Conditions of Main PLL (In the case of using high-speed internal CR)*

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

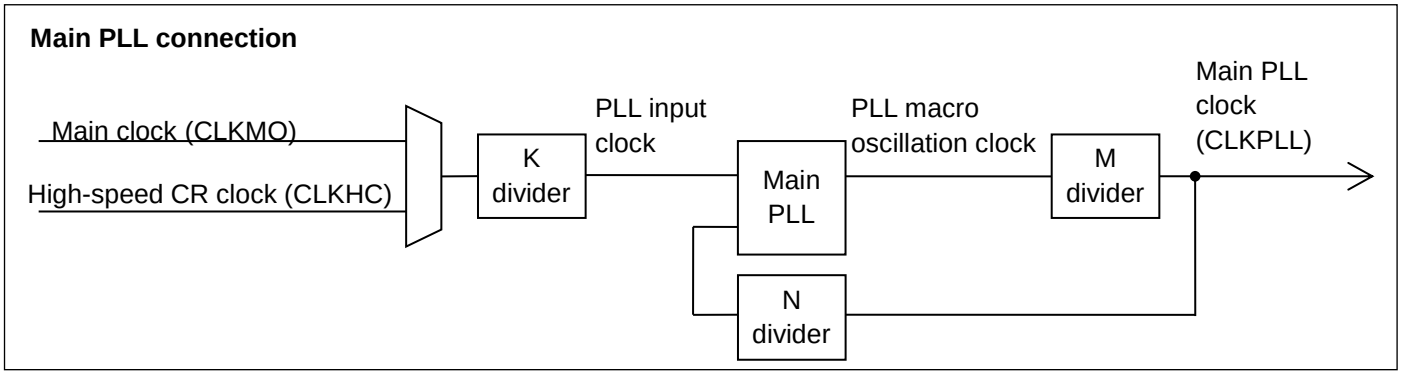
| Parameter | Symbol | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|
| | | Min | Typ | Max | | |
| PLL oscillation stabilization wait time*1 (LOCK UP time) | $t_{LOCK}$ | 100 | - | - | µs | |
| PLL input clock frequency | $F_{PLLI}$ | 3.8 | 4 | 4.2 | MHz | |
| PLL multiple rate | - | 50 | - | 71 | multiple | |
| PLL macro oscillation clock frequency | $F_{PLLO}$ | 190 | - | 300 | MHz | |
| Main PLL clock frequency*2 | $F_{CLKPLL}$ | - | - | 144 | MHz | |

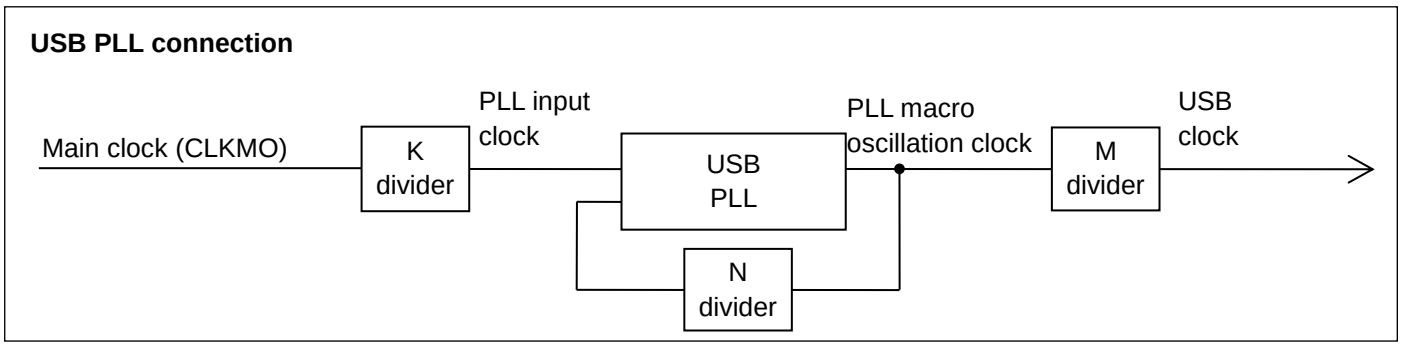
*1: Time from when the PLL starts operating until the oscillation stabilizes.

*2: For more information about Main PLL clock (CLKPLL), see "Chapter 2-1: Clock" in "FM3 Family Peripheral Manual".

***Note:***

- *Make sure to input to the main PLL source clock, the high-speed CR clock (CLKHC) that the frequency has been trimmed.*




### *12.4.6 Reset Input Characteristics*

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Reset input time | $t_{INITX}$ | INITX | - | 500 | - | ns | |

### 12.4.7 Power-on Reset Timing

(Vss = 0V, $T_A$ = - 40°C to + 85°C)

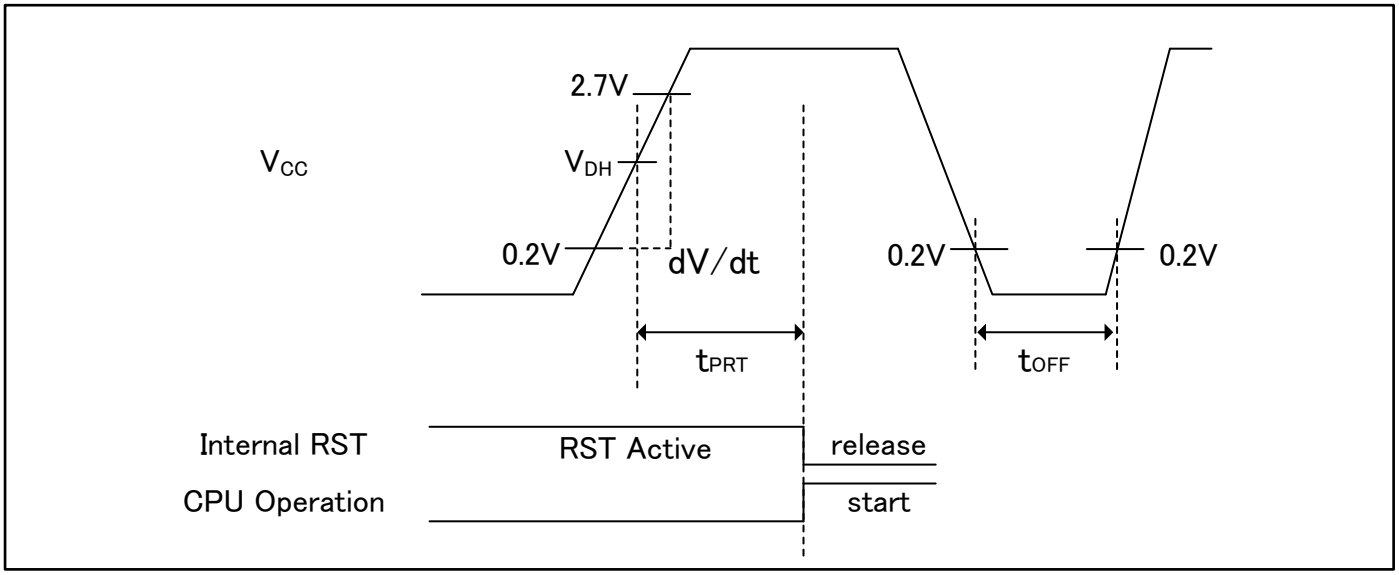
| Parameter | Symbol | Pin name | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| Power supply shut down time | $t_{OFF}$ | VCC | - | 50 | - | - | ms | *1 |
| Power ramp rate | dV/dt | | Vcc:0.2 V to 2.70 V | 0.9 | - | 1000 | mV/µs | *2 |
| Time until releasing Power-on reset | $t_{PRT}$ | | - | 0.46 | - | 0.76 | ms | |

*1: $V_{CC}$ must be held below 0.2 V for minimum period of $t_{OFF}$. Improper initialization may occur if this condition is not met.

*2: This dV/dt characteristic is applied at the power-on of cold start ($t_{OFF}$>50 ms).

***Note:***

- *If $t_{OFF}$ cannot be satisfied designs must assert external reset(INITX) at power-up and at any brownout event per 12. 4. 6.*




***Glossary***

VDH: detection voltage of Low Voltage detection reset. See ““12.7 Low-Voltage Detection Characteristics”

### 12.4.8 External Bus Timing

**External bus clock output characteristics**

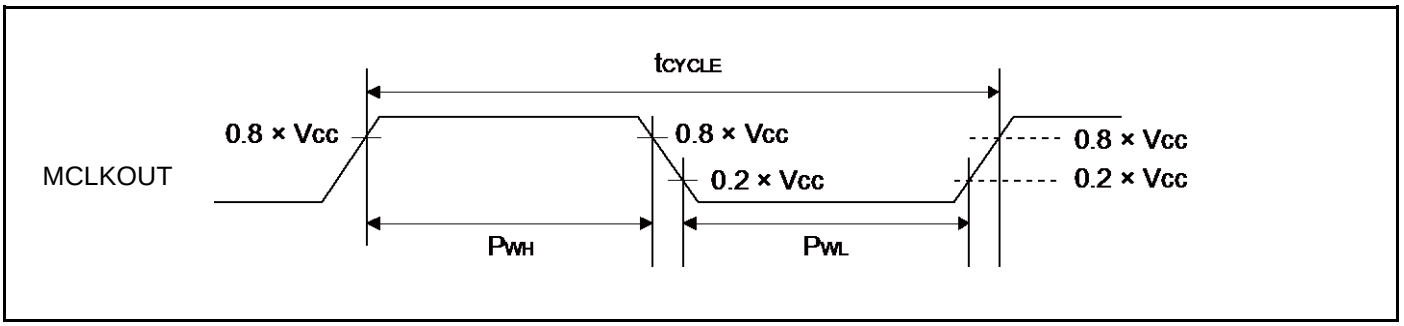
(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| Output frequency | $t_{CYCLE}$ | MCLKOUT*1 | Vcc ≥ 4.5 V | - | 50*2 | MHz |
| | | | Vcc < 4.5 V | - | 32*3 | MHz |

*1: External bus clock (MCLKOUT) is divided clock of HCLK.
For more information about setting of clock divider, see "CHAPTER 12: External Bus Interface" in "FM3 Family PERIPHERAL MANUAL".
When external bus clock is not output, this characteristic does not give any effect on external bus operation.

*2: When AHB bus clock frequency is more than 100MHz, the divider setting for MCLKOUT must be more than 4.

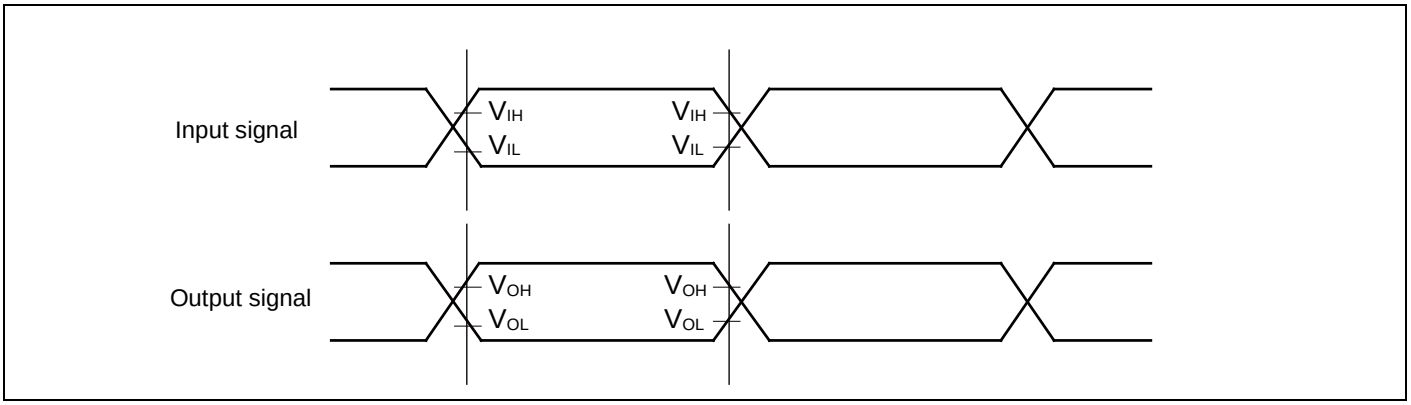
*3: When AHB bus clock frequency is more than 64MHz, the divider setting for MCLKOUT must be more than 4.




**External bus signal input/output characteristics**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Value | Unit | Remarks |
|---|---|---|---|---|---|
| Signal input characteristics | $V_{IH}$ | - | 0.8 × $V_{CC}$ | V | |
| | $V_{IL}$ | | 0.2 × $V_{CC}$ | V | |
| Signal output characteristics | $V_{OH}$ | | 0.8 × $V_{CC}$ | V | |
| | $V_{OL}$ | | 0.2 × $V_{CC}$ | V | |



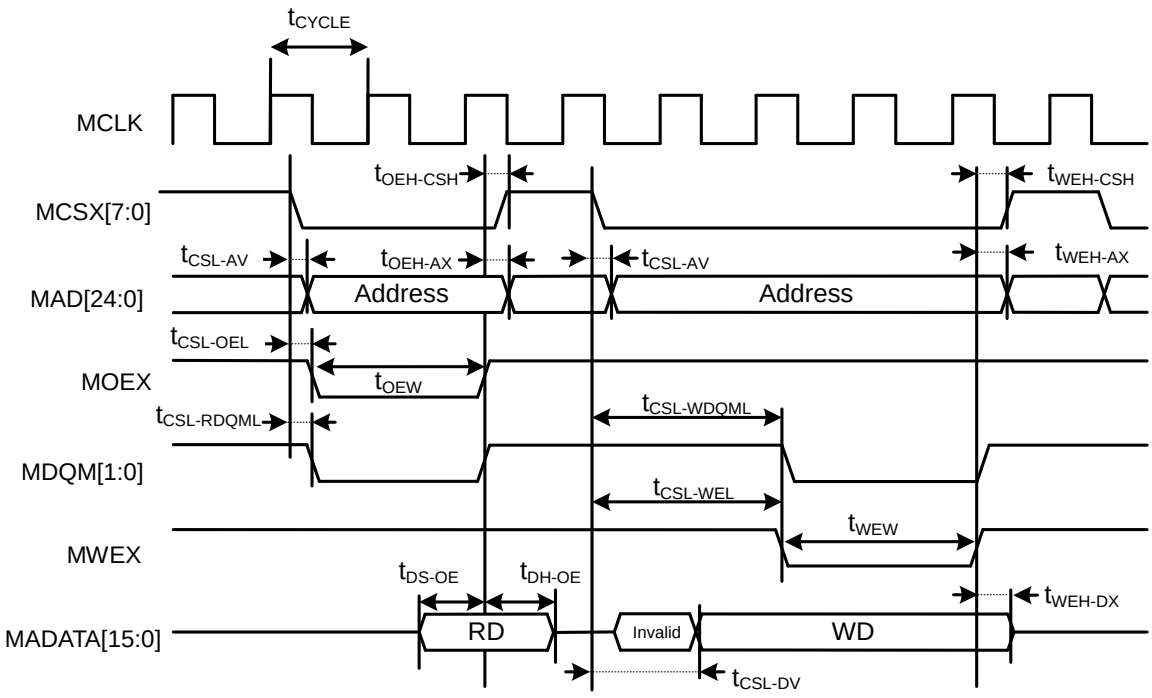
### Separate Bus Access Asynchronous SRAM Mode

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| MOEX<br>Min pulse width | $t_{OEW}$ | MOEX | Vcc ≥ 4.5 V | MCLK×n-3 | - | ns |
| | | | Vcc < 4.5 V | | | |
| MCSX ↓ → Address output delay time | $t_{CSL-AV}$ | MCSX[7:0],<br>MAD[24:0] | Vcc ≥ 4.5 V | -9 | +9 | ns |
| | | | Vcc < 4.5 V | -12 | +12 | |
| MOEX ↑ →<br>Address hold time | $t_{OEH-AX}$ | MOEX,<br>MAD[24:0] | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |
| MCSX ↓ →<br>MOEX ↓ delay time | $t_{CSL-OEL}$ | MOEX,<br>MCSX[7:0] | Vcc ≥ 4.5 V | MCLK×m-9 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | MCLK×m-12 | MCLK×m+12 | |
| MOEX ↑ →<br>MCSX ↑ time | $t_{OEH-CSH}$ | | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |
| MCSX ↓ →<br>MDQM ↓ delay time | $t_{CSL-RDQML}$ | MCSX,<br>MDQM[1:0] | Vcc ≥ 4.5 V | MCLK×m-9 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | MCLK×m-12 | MCLK×m+12 | |
| Data set up →<br>MOEX ↑ time | $t_{DS-OE}$ | MOEX,<br>MADATA[15:0] | Vcc ≥ 4.5 V | 20 | - | ns |
| | | | Vcc < 4.5 V | 38 | - | |
| MOEX ↑ →<br>Data hold time | $t_{DH-OE}$ | MOEX,<br>MADATA[15:0] | Vcc ≥ 4.5 V | 0 | - | ns |
| | | | Vcc < 4.5 V | | | |
| MWEX<br>Min pulse width | $t_{WEW}$ | MWEX | Vcc ≥ 4.5 V | MCLK×n-3 | - | ns |
| | | | Vcc < 4.5 V | | | |
| MWEX ↑ → Address output delay time | $t_{WEH-AX}$ | MWEX,<br>MAD[24:0] | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |
| MCSX ↓ →<br>MWEX ↓ delay time | $t_{CSL-WEL}$ | MWEX,<br>MCSX[7:0] | Vcc ≥ 4.5 V | MCLK×n-9 | MCLK×n+9 | ns |
| | | | Vcc < 4.5 V | MCLK×n-12 | MCLK×n+12 | |
| MWEX ↑ →<br>MCSX ↑ delay time | $t_{WEH-CSH}$ | | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |
| MCSX ↓ →<br>MDQM ↓ delay time | $t_{CSL-WDQML}$ | MCSX,<br>MDQM[1:0] | Vcc ≥ 4.5 V | MCLK×n-9 | MCLK×n+9 | ns |
| | | | Vcc < 4.5 V | MCLK×n-12 | MCLK×n+12 | |
| MCSX ↓ →<br>Data output time | $t_{CSL-DV}$ | MCSX,<br>MADATA[15:0] | Vcc ≥ 4.5 V | MCLK-9 | MCLK+9 | ns |
| | | | Vcc < 4.5 V | MCLK-12 | MCLK+12 | |
| MWEX ↑ →<br>Data hold time | $t_{WEH-DX}$ | MWEX,<br>MADATA[15:0] | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |

***Note:***

- *When the external load capacitance = 30 pF. (m = 0 to 15, n = 1 to 16)*


tCYCLE
MCLK
MCSX[7:0]
MAD[24:0]
MOEX
MDQM[1:0]
MWEX
MADATA[15:0]
tOEH-CSH
tWEH-CSH
tCSL-AV
tOEH-AX
tCSL-AV
tWEH-AX
Address
Address
tCSL-OEL
tOEW
tCSL-RDQML
tCSL-WDQML
tCSL-WEL
tWEW
tDS-OE
tDH-OE
tWEH-DX
RD
Invalid
WD
tCSL-DV

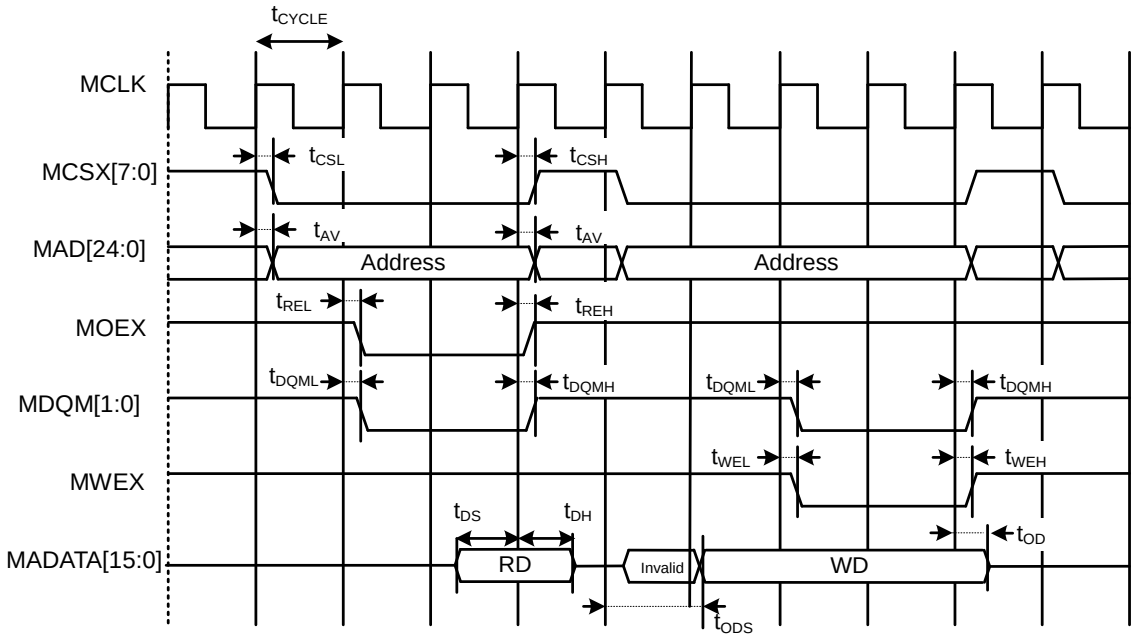
**Separate Bus Access Synchronous SRAM Mode**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| Address delay time | $t_{AV}$ | MCLK, MAD[24:0] | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| MCSX delay time | $t_{CSL}$ | MCLK, MCSX[7:0] | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| | $t_{CSH}$ | | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| MOEX delay time | $t_{REL}$ | MCLK, MOEX | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| | $t_{REH}$ | | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| Data set up → MCLK ↑ time | $t_{DS}$ | MCLK, MADATA[15:0] | Vcc ≥ 4.5 V | 19 | - | ns |
| | | | Vcc < 4.5 V | 37 | | |
| MCLK ↑ → Data hold time | $t_{DH}$ | MCLK, MADATA[15:0] | Vcc ≥ 4.5 V | 0 | - | ns |
| | | | Vcc < 4.5 V | | | |
| MWEX delay time | $t_{WEL}$ | MCLK, MWEX | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| | $t_{WEH}$ | | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| MDQM[1:0] delay time | $t_{DQML}$ | MCLK, MDQM[1:0] | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| | $t_{DQMH}$ | | Vcc ≥ 4.5 V | 1 | 9 | ns |
| | | | Vcc < 4.5 V | | 12 | |
| MCLK ↑ → Data output time | $t_{OD}$ | MCLK, MADATA[15:0] | Vcc ≥ 4.5 V | MCLK+1 | MCLK+18 | ns |
| | | | Vcc < 4.5 V | | MCLK+24 | |
| MCLK ↑ → Data hold time | $t_{OD}$ | MCLK, MADATA[15:0] | Vcc ≥ 4.5 V | 1 | 18 | ns |
| | | | Vcc < 4.5 V | | 24 | |

***Note:***

- *When the external load capacitance = 30 pF.*



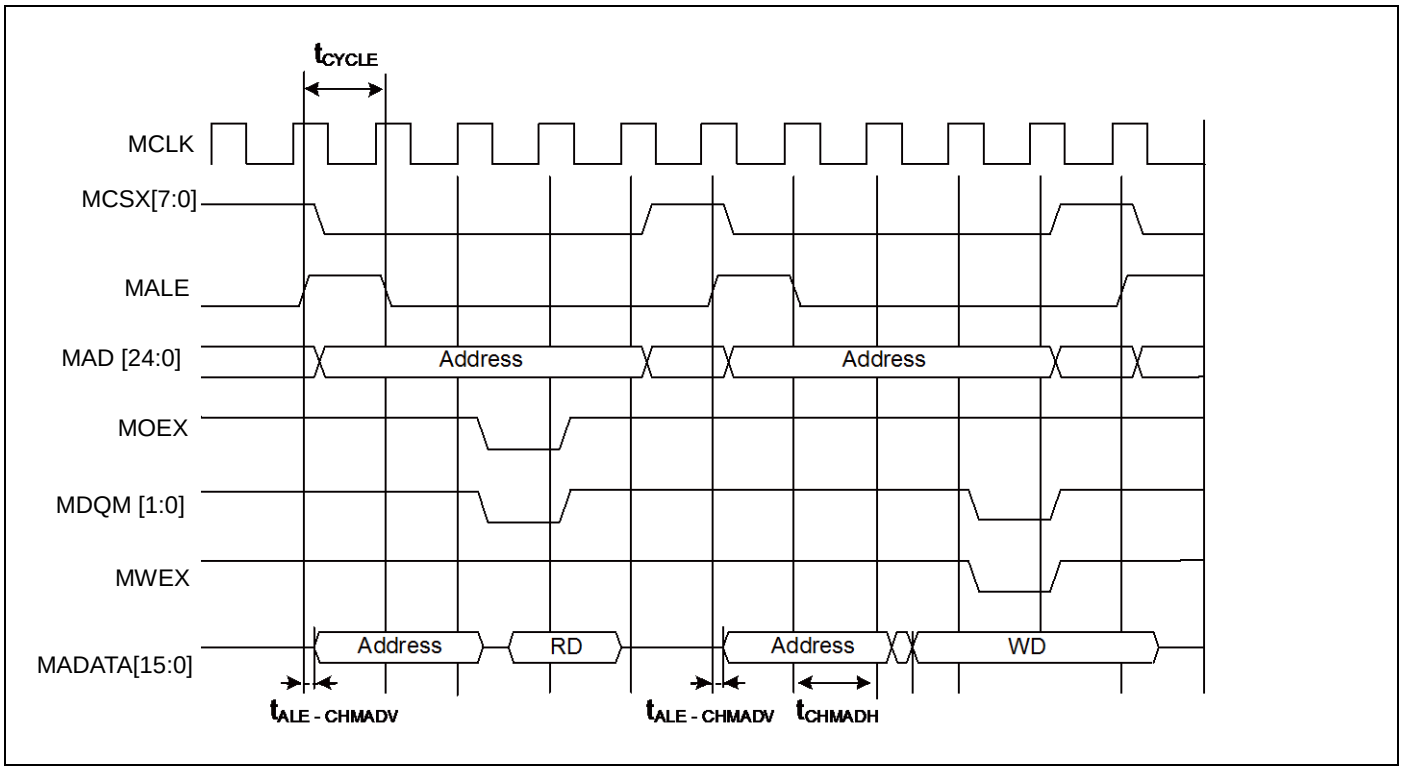

**Multiplexed Bus Access Asynchronous SRAM Mode**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| Multiplexed address delay time | $t_{ALE-CHMADV}$ | MALE, MADATA[15:0] | Vcc ≥ 4.5 V | 0 | 10 | ns |
| | | | Vcc < 4.5 V | | 20 | |
| Multiplexed address hold time | $t_{CHMADH}$ | | Vcc ≥ 4.5 V | MCLK×n+0 | MCLK×n+10 | ns |
| | | | Vcc < 4.5 V | MCLK×n+0 | MCLK×n+20 | |

***Note:***

- *When the external load capacitance = 30 pF. (m = 0 to 15, n = 1 to 16)*



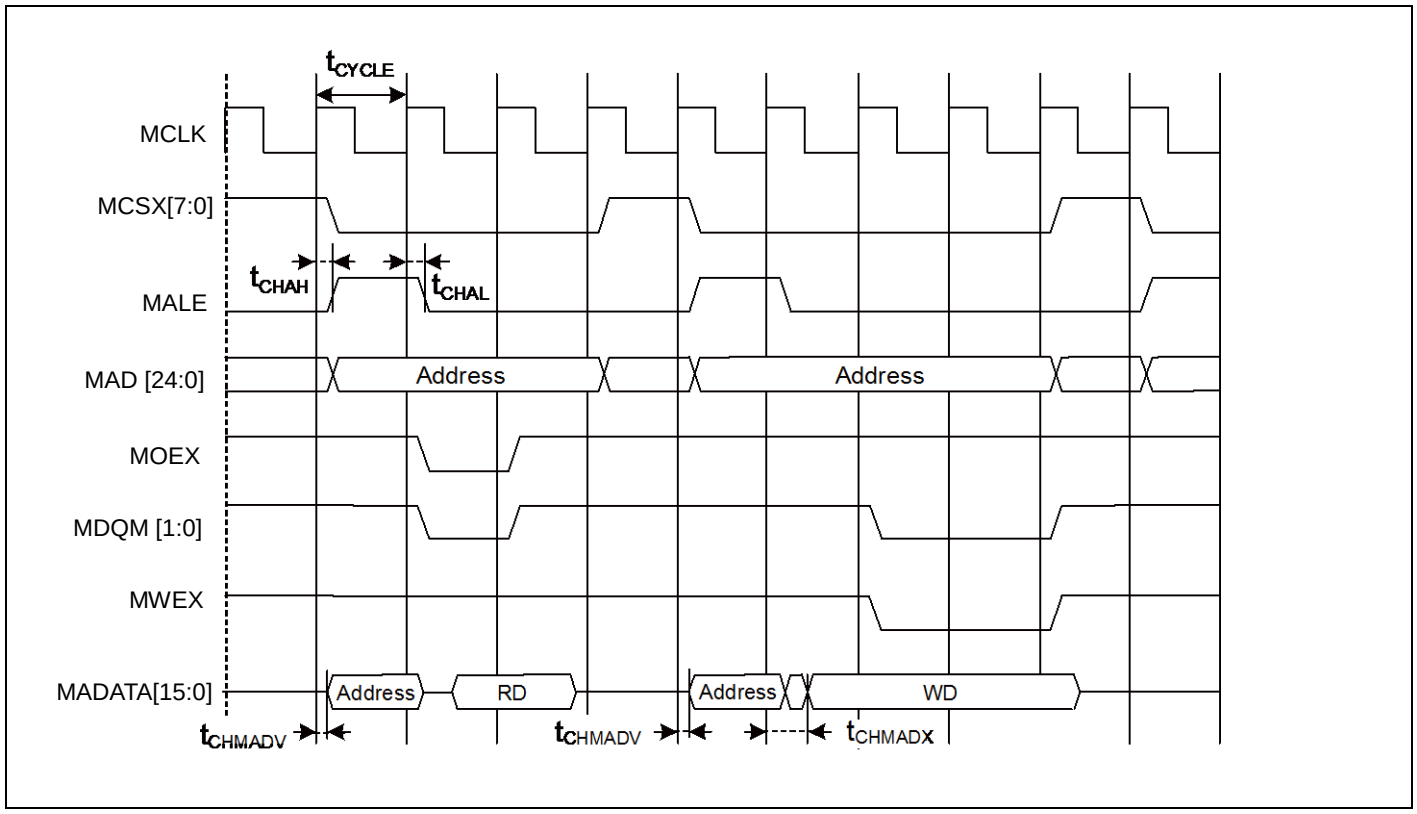

**Multiplexed Bus Access Synchronous SRAM Mode**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| MALE delay time | $t_{CHAL}$ | MCLK, ALE | Vcc ≥ 4.5 V | 1 | 9 | ns | |
| | | | Vcc < 4.5 V | | 12 | ns | |
| | $t_{CHAH}$ | | Vcc ≥ 4.5 V | 1 | 9 | ns | |
| | | | Vcc < 4.5 V | | 12 | ns | |
| MCLK ↑ → Multiplexed Address delay time | $t_{CHMADV}$ | MCLK, MADATA[15:0] | Vcc ≥ 4.5 V | 1 | $t_{OD}$ | ns | |
| | | | Vcc < 4.5 V | | | | |
| MCLK ↑ → Multiplexed Data output time | $t_{CHMADX}$ | | Vcc ≥ 4.5 V | 1 | $t_{OD}$ | ns | |
| | | | Vcc < 4.5 V | | | | |

***Note:***

- *When the external load capacitance = 30 pF.*




**NAND Flash Mode**

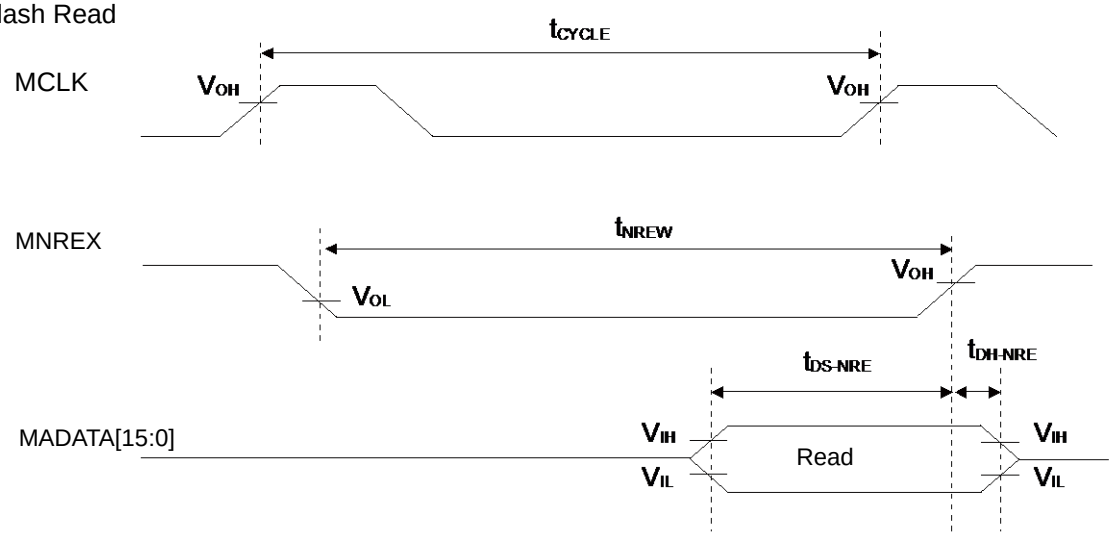
(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| MNREX Min pulse width | $t_{NREW}$ | MNREX | Vcc ≥ 4.5 V | MCLK×n-3 | - | ns |
| | | | Vcc < 4.5 V | | | |
| Data setup → MNREX↑time | $t_{DS-NRE}$ | MNREX, MADATA[15:0] | Vcc ≥ 4.5 V | 20 | - | ns |
| | | | Vcc < 4.5 V | 38 | - | |
| MNREX↑→ Data hold time | $t_{DH-NRE}$ | MNREX, MADATA[15:0] | Vcc ≥ 4.5 V | 0 | - | ns |
| | | | Vcc < 4.5 V | | | |
| MNALE↑→ MNWEX delay time | $t_{ALEH-NWEL}$ | MNALE, MNWEX | Vcc ≥ 4.5 V | MCLK×m-9 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | MCLK×m-12 | MCLK×m+12 | |
| MNALE↓→ MNWEX delay time | $t_{ALEL-NWEL}$ | MNALE, MNWEX | Vcc ≥ 4.5 V | MCLK×m-9 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | MCLK×m-12 | MCLK×m+12 | |
| MNCLE↑→ MNWEX delay time | $t_{CLEH-NWEL}$ | MNCLE, MNWEX | Vcc ≥ 4.5 V | MCLK×m-9 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | MCLK×m-12 | MCLK×m+12 | |
| MNWEX↑→ MNCLE delay time | $t_{NWEH-CLEL}$ | MNCLE, MNWEX | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |
| MNWEX Min pulse width | $t_{NWEW}$ | MNWEX | Vcc ≥ 4.5 V | MCLK×n-3 | - | ns |
| | | | Vcc < 4.5 V | | | |
| MNWEX↓→ Data output time | $t_{NWEL-DV}$ | MNWEX, MADATA[15:0] | Vcc ≥ 4.5 V | -9 | +9 | ns |
| | | | Vcc < 4.5 V | -12 | +12 | |
| MNWEX↑→ Data hold time | $t_{NWEH-DX}$ | MNWEX, MADATA[15:0] | Vcc ≥ 4.5 V | 0 | MCLK×m+9 | ns |
| | | | Vcc < 4.5 V | | MCLK×m+12 | |

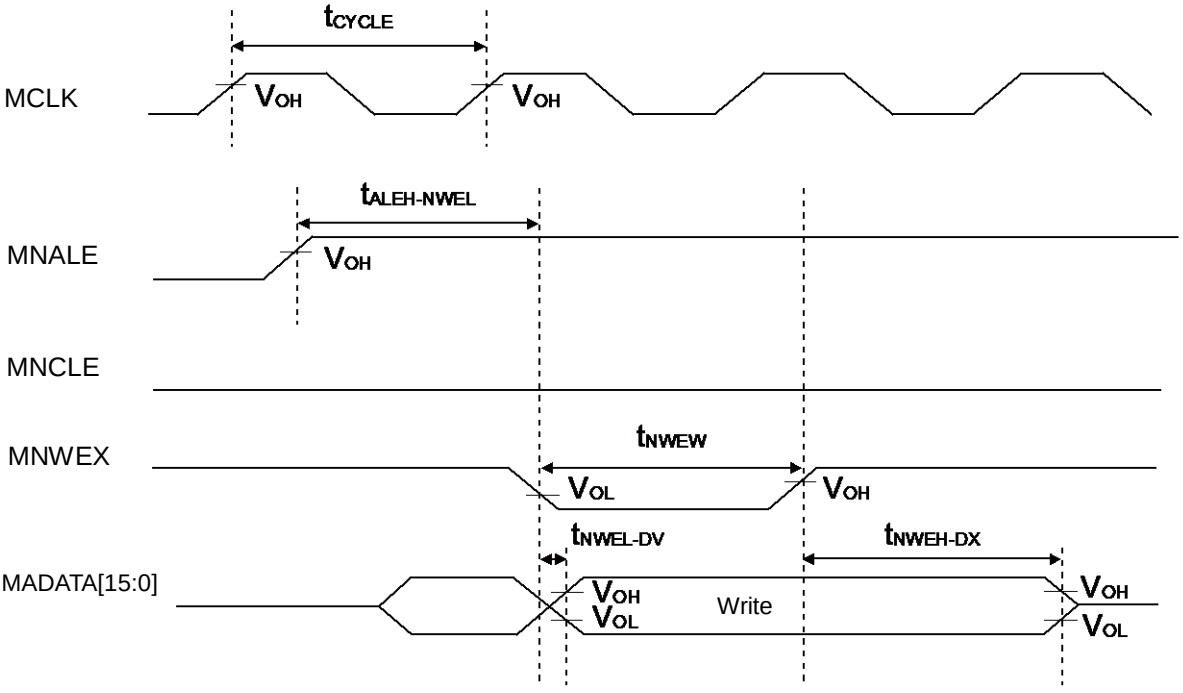
***Note:***

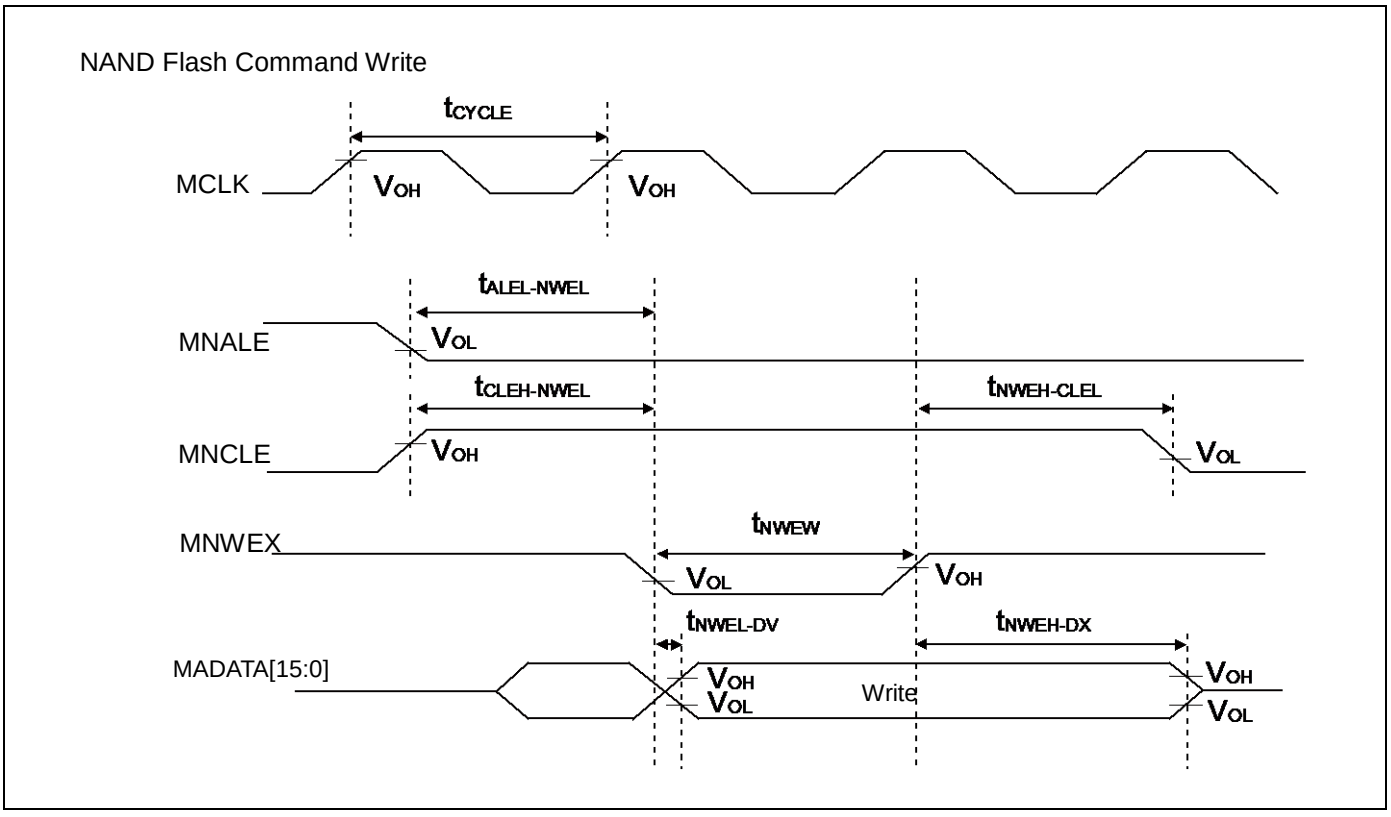
- *When the external load capacitance = 30 pF. (m=0 to 15, n=1 to 16)*

NAND Flash Read




NAND Flash Address Write



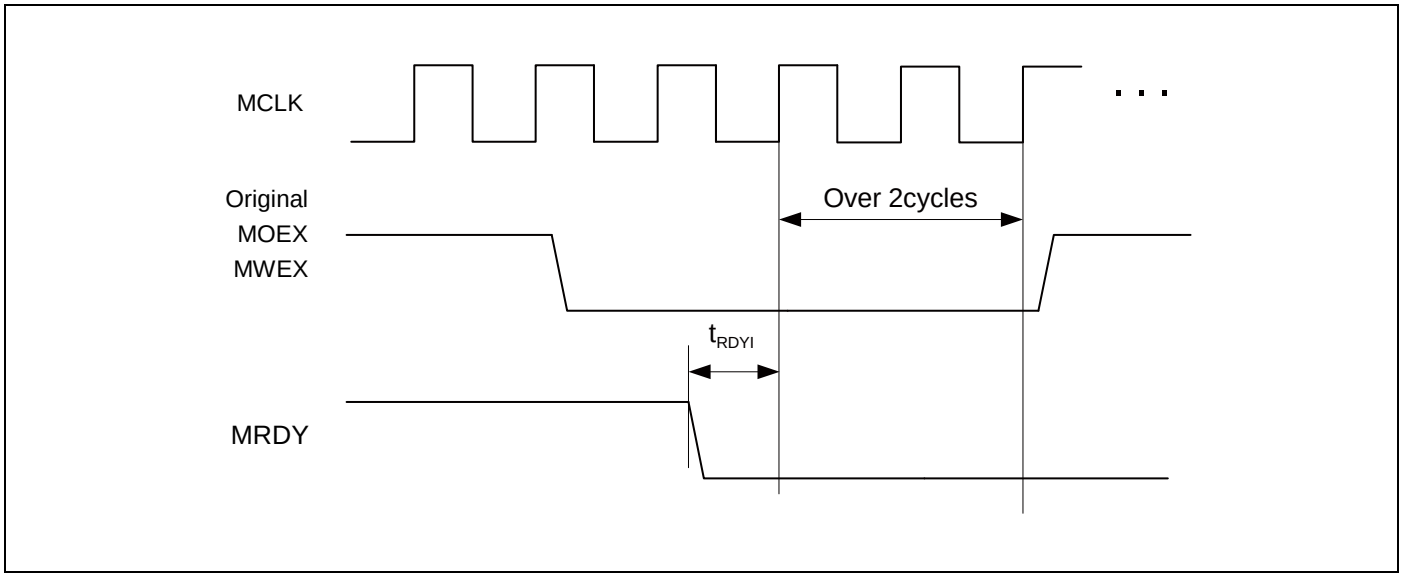



**External Ready Input Timing**

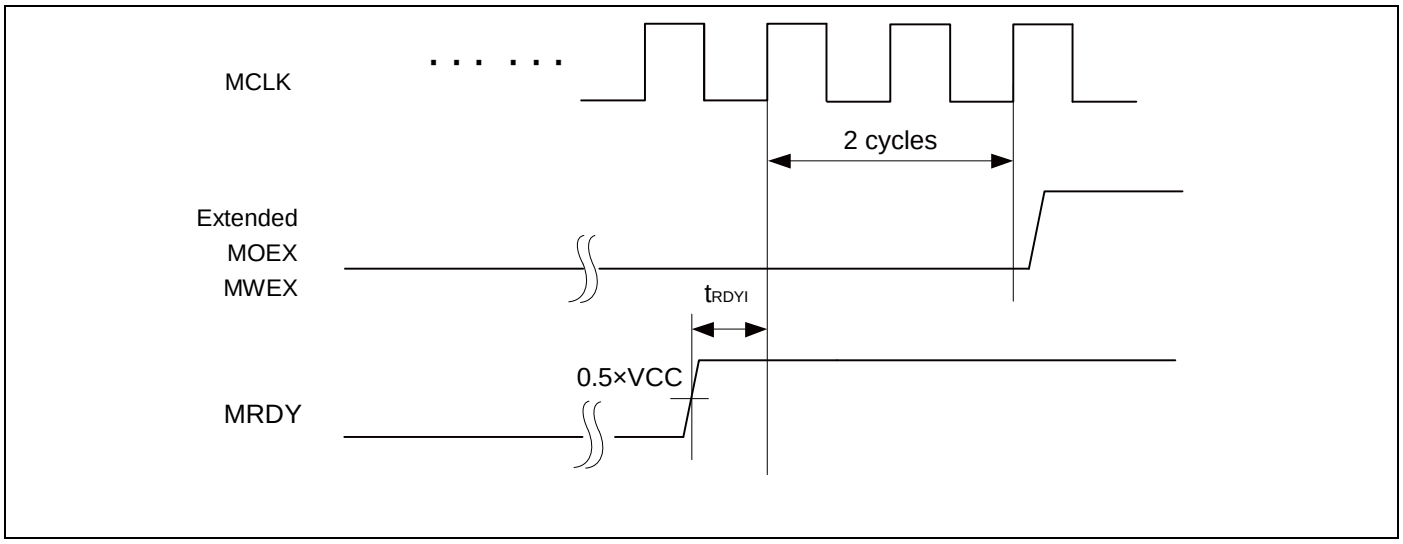
(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| MCLK ↑ MRDY input setup time | $t_{RDYI}$ | MCLK, MRDY | Vcc ≥ 4.5 V | 19 | - | ns | |
| | | | Vcc < 4.5 V | 37 | | | |

**When RDY is input**




**When RDY is released**

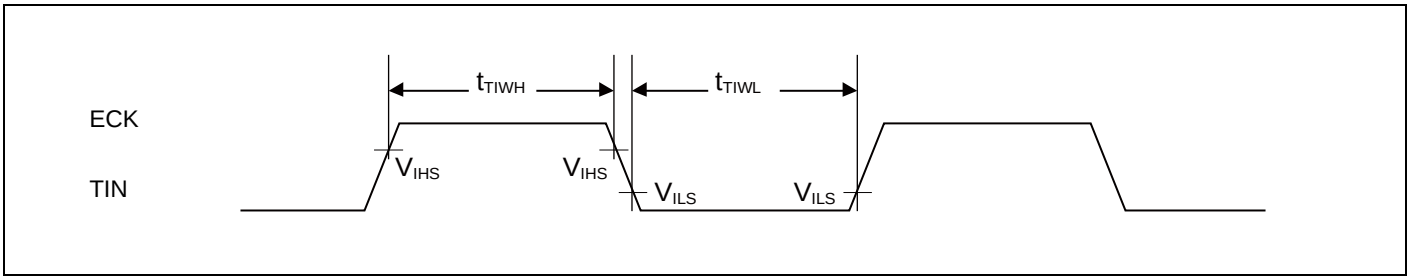


### 12.4.9 Base Timer Input Timing

**Timer input timing**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

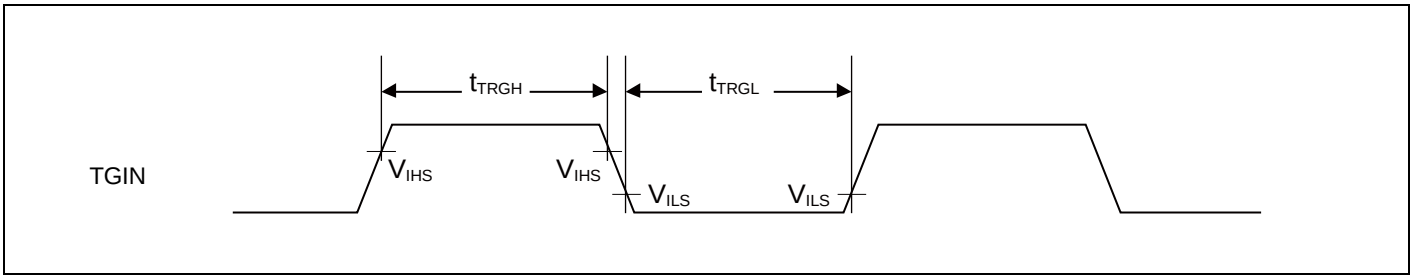
| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Input pulse width | $t_{TIWH}$, $t_{TIWL}$ | TIOAn/TIOBn (when using as ECK, TIN) | - | $2t_{CYCP}$ | - | ns | |




**Trigger input timing**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Input pulse width | $t_{TRGH}$, $t_{TRGL}$ | TIOAn/TIOBn (when using as TGIN) | - | $2t_{CYCP}$ | - | ns | |




***Note:***

- *$t_{CYCP}$ indicates the APB bus clock cycle time.*
  *About the APB bus number which Base Timer is connected to, see "8. Block Diagram" in this datasheet.*

### *12.4.10 CSIO/UART Timing*

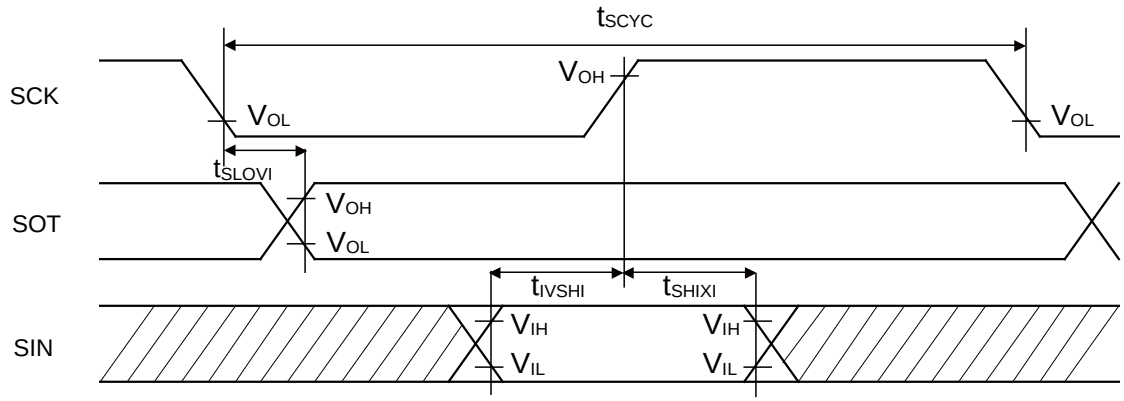
**CSIO (SPI = 0, SCINV = 0)**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

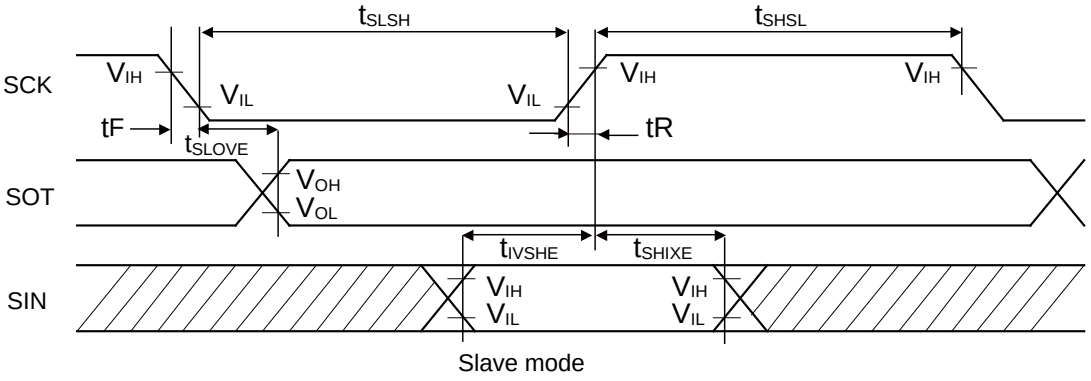
| Parameter | Symbol | Pin name | Conditions | Vcc < 4.5 V | | Vcc ≥ 4.5 V | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Min | Max | |
| Baud rate | - | - | - | - | 8 | - | 8 | Mbps |
| Serial clock cycle time | $t_{SCYC}$ | SCKx | Master mode | $4t_{CYCP}$ | - | $4t_{CYCP}$ | - | ns |
| SCK ↓ → SOT delay time | $t_{SLOVI}$ | SCKx, SOTx | | - 30 | + 30 | - 20 | + 20 | ns |
| SIN → SCK ↑ setup time | $t_{IVSHI}$ | SCKx, SINx | | 50 | - | 30 | - | ns |
| SCK ↑ → SIN hold time | $t_{SHIXI}$ | SCKx, SINx | | 0 | - | 0 | - | ns |
| Serial clock "L" pulse width | $t_{SLSH}$ | SCKx | Slave mode | $2t_{CYCP}$ - 10 | - | $2t_{CYCP}$ - 10 | - | ns |
| Serial clock "H" pulse width | $t_{SHSL}$ | SCKx | | $t_{CYCP}$ + 10 | - | $t_{CYCP}$ + 10 | - | ns |
| SCK ↓ → SOT delay time | $t_{SLOVE}$ | SCKx, SOTx | | - | 50 | - | 30 | ns |
| SIN → SCK ↑ setup time | $t_{IVSHE}$ | SCKx, SINx | | 10 | - | 10 | - | ns |
| SCK ↑ → SIN hold time | $t_{SHIXE}$ | SCKx, SINx | | 20 | - | 20 | - | ns |
| SCK fall time | tF | SCKx | | - | 5 | - | 5 | ns |
| SCK rise time | tR | SCKx | | - | 5 | - | 5 | ns |

***Notes:***

- *The above characteristics apply to CLK synchronous mode.*
- *$t_{CYCP}$ indicates the APB bus clock cycle time.*
  *About the APB bus number which Multi-function Serial is connected to, see "8. Block Diagram" in this datasheet.*
- *These characteristics only guarantee the same relocate port number.*
  *For example, the combination of SCKx_0 and SOTx_1 is not guaranteed.*
- *When the external load capacitance = 30 pF.*




Master mode




Slave mode

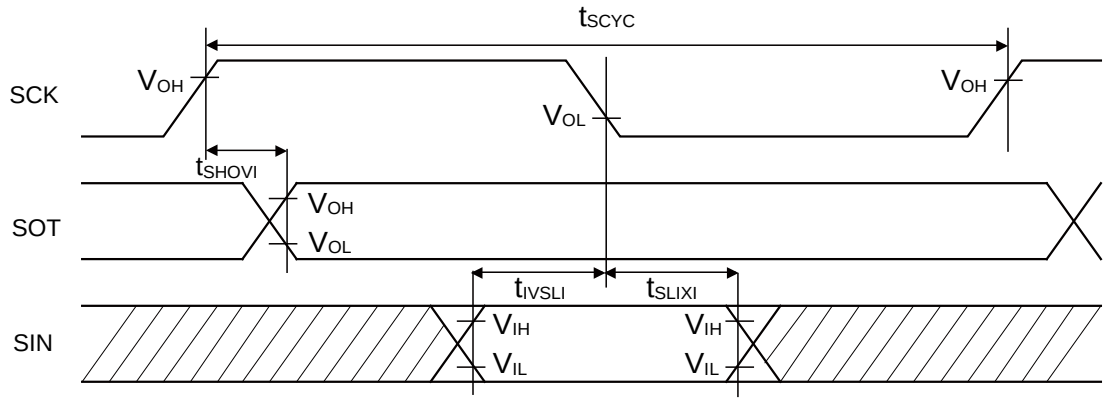
**CSIO (SPI = 0, SCINV = 1)**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

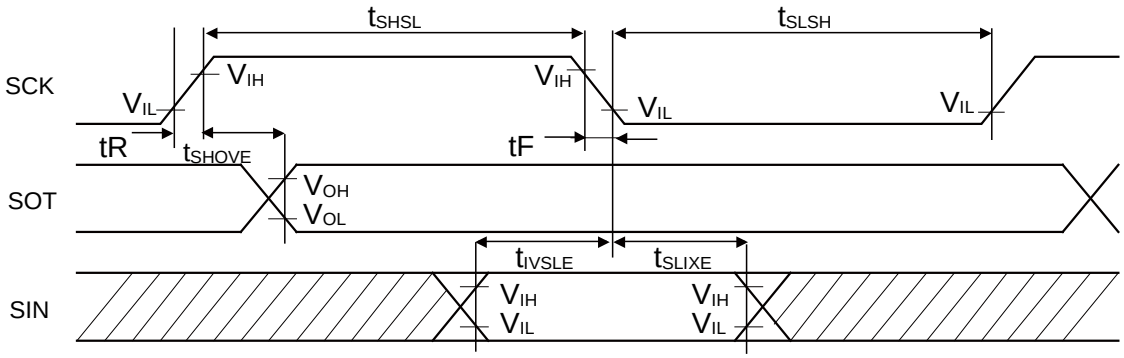
| Parameter | Symbol | Pin name | Conditions | Vcc < 4.5 V | | Vcc ≥ 4.5 V | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Min | Max | |
| Baud rate | - | - | - | - | 8 | - | 8 | Mbps |
| Serial clock cycle time | $t_{SCYC}$ | SCKx | Master mode | $4t_{CYCP}$ | - | $4t_{CYCP}$ | - | ns |
| SCK ↑ → SOT delay time | $t_{SHOVI}$ | SCKx, SOTx | | - 30 | + 30 | - 20 | + 20 | ns |
| SIN → SCK ↓ setup time | $t_{IVSLI}$ | SCKx, SINx | | 50 | - | 30 | - | ns |
| SCK ↓ → SIN hold time | $t_{SLIXI}$ | SCKx, SINx | | 0 | - | 0 | - | ns |
| Serial clock "L" pulse width | $t_{SLSH}$ | SCKx | Slave mode | $2t_{CYCP}$ - 10 | - | $2t_{CYCP}$ - 10 | - | ns |
| Serial clock "H" pulse width | $t_{SHSL}$ | SCKx | | $t_{CYCP}$ + 10 | - | $t_{CYCP}$ + 10 | - | ns |
| SCK ↑ → SOT delay time | $t_{SHOVE}$ | SCKx, SOTx | | - | 50 | - | 30 | ns |
| SIN → SCK ↓ setup time | $t_{IVSLE}$ | SCKx, SINx | | 10 | - | 10 | - | ns |
| SCK ↓ → SIN hold time | $t_{SLIXE}$ | SCKx, SINx | | 20 | - | 20 | - | ns |
| SCK fall time | tF | SCKx | | - | 5 | - | 5 | ns |
| SCK rise time | tR | SCKx | | - | 5 | - | 5 | ns |

***Notes:***

- *The above characteristics apply to CLK synchronous mode.*
- *$t_{CYCP}$ indicates the APB bus clock cycle time.*
  *About the APB bus number which Multi-function serial is connected to, see "8. Block Diagram" in this datasheet.*
- *These characteristics only guarantee the same relocate port number.*
  *For example, the combination of SCKx_0 and SOTx_1 is not guaranteed.*
- *When the external load capacitance = 30 pF.*




Master mode




Slave mode

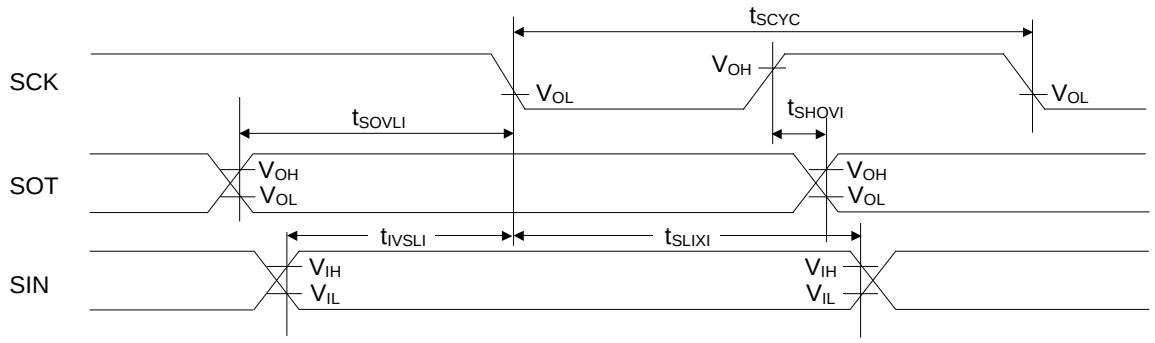
**CSIO (SPI = 1, SCINV = 0)**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

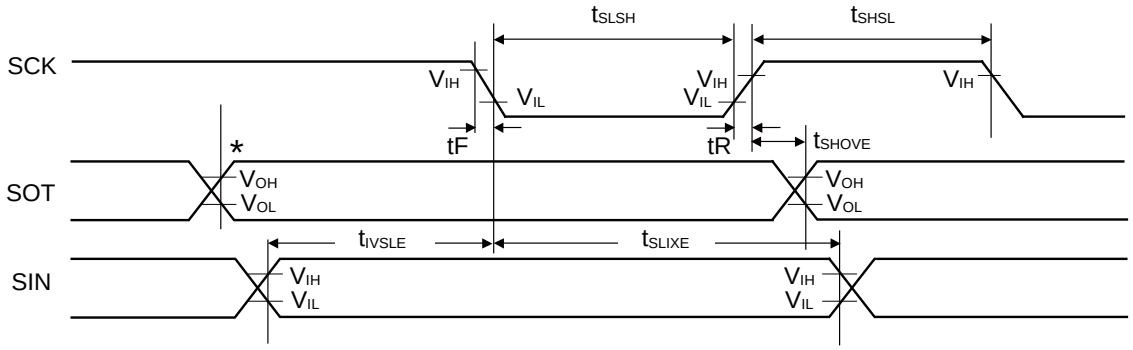
| Parameter | Symbol | Pin name | Conditions | Vcc < 4.5 V | | Vcc ≥ 4.5 V | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Min | Max | |
| Baud rate | - | - | - | - | 8 | - | 8 | Mbps |
| Serial clock cycle time | $t_{SCYC}$ | SCKx | Master mode | $4t_{CYCP}$ | - | $4t_{CYCP}$ | - | ns |
| SCK ↑ → SOT delay time | $t_{SHOVI}$ | SCKx, SOTx | | - 30 | + 30 | - 20 | + 20 | ns |
| SIN → SCK ↓ setup time | $t_{IVSLI}$ | SCKx, SINx | | 50 | - | 30 | - | ns |
| SCK ↓ → SIN hold time | $t_{SLIXI}$ | SCKx, SINx | | 0 | - | 0 | - | ns |
| SOT → SCK ↓ delay time | $t_{SOVLI}$ | SCKx, SOTx | | $2t_{CYCP}$ - 30 | - | $2t_{CYCP}$ - 30 | - | ns |
| Serial clock "L" pulse width | $t_{SLSH}$ | SCKx | Slave mode | $2t_{CYCP}$ - 10 | - | $2t_{CYCP}$ - 10 | - | ns |
| Serial clock "H" pulse width | $t_{SHSL}$ | SCKx | | $t_{CYCP}$ + 10 | - | $t_{CYCP}$ + 10 | - | ns |
| SCK ↑ → SOT delay time | $t_{SHOVE}$ | SCKx, SOTx | | - | 50 | - | 30 | ns |
| SIN → SCK ↓ setup time | $t_{IVSLE}$ | SCKx, SINx | | 10 | - | 10 | - | ns |
| SCK ↓ → SIN hold time | $t_{SLIXE}$ | SCKx, SINx | | 20 | - | 20 | - | ns |
| SCK fall time | tF | SCKx | | - | 5 | - | 5 | ns |
| SCK rise time | tR | SCKx | | - | 5 | - | 5 | ns |

***Notes:***

- *The above characteristics apply to CLK synchronous mode.*
- *$t_{CYCP}$ indicates the APB bus clock cycle time.*
  *About the APB bus number which Multi-function serial is connected to, see "8. Block Diagram" in this datasheet.*
- *These characteristics only guarantee the same relocate port number.*
  *For example, the combination of SCKx_0 and SOTx_1 is not guaranteed.*
- *When the external load capacitance = 30 pF.*




Master mode




Slave mode

*: Changes when writing to TDR register

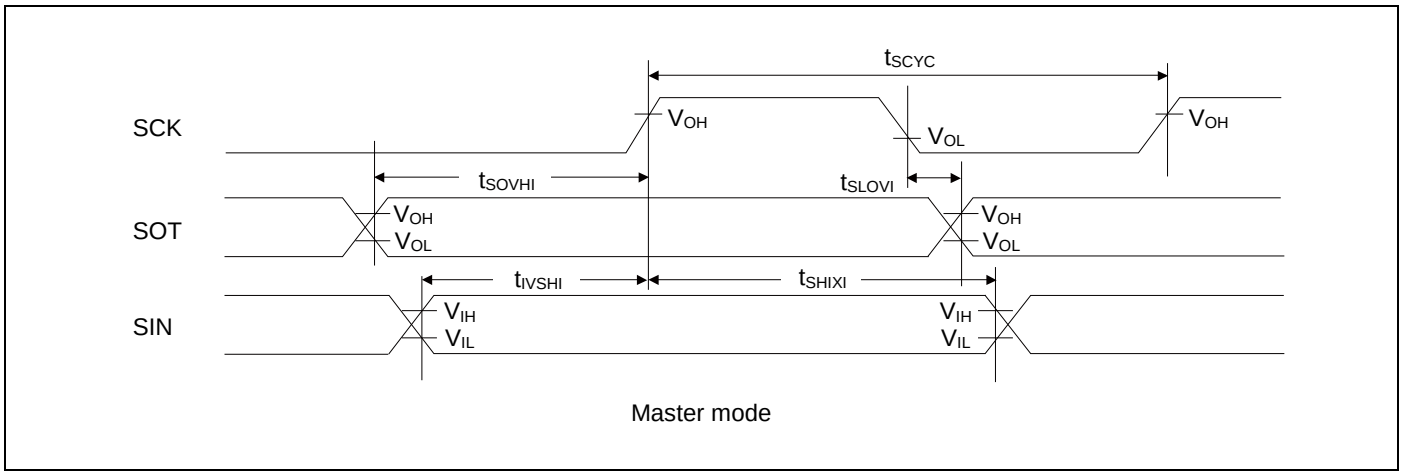
**CSIO (SPI = 1, SCINV = 1)**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 105°C)

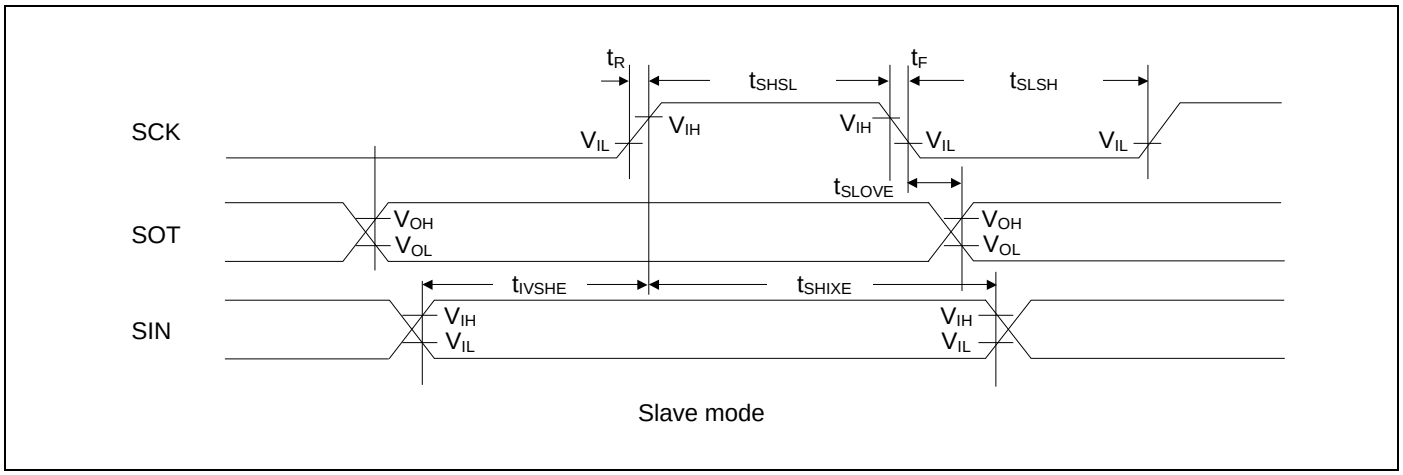
| Parameter | Symbol | Pin name | Conditions | $V_{CC}$ < 4.5 V | | $V_{CC}$ ≥ 4.5 V | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Min | Max | |
| Baud rate | - | - | - | - | 8 | - | 8 | Mbps |
| Serial clock cycle time | $t_{SCYC}$ | SCKx | Master mode | $4t_{CYCP}$ | - | $4t_{CYCP}$ | - | ns |
| SCK ↓ → SOT delay time | $t_{SLOVI}$ | SCKx, SOTx | | - 30 | + 30 | - 20 | + 20 | ns |
| SIN → SCK ↑ setup time | $t_{IVSHI}$ | SCKx, SINx | | 50 | - | 30 | - | ns |
| SCK ↑ → SIN hold time | $t_{SHIXI}$ | SCKx, SINx | | 0 | - | 0 | - | ns |
| SOT → SCK ↑ delay time | $t_{SOVHI}$ | SCKx, SOTx | | $2t_{CYCP}$ - 30 | - | $2t_{CYCP}$ - 30 | - | ns |
| Serial clock L pulse width | $t_{SLSH}$ | SCKx | Slave mode | $2t_{CYCP}$ - 10 | - | $2t_{CYCP}$ - 10 | - | ns |
| Serial clock H pulse width | $t_{SHSL}$ | SCKx | | $t_{CYCP}$ + 10 | - | $t_{CYCP}$ + 10 | - | ns |
| SCK ↓ → SOT delay time | $t_{SLOVE}$ | SCKx, SOTx | | - | 50 | - | 30 | ns |
| SIN → SCK ↑ setup time | $t_{IVSHE}$ | SCKx, SINx | | 10 | - | 10 | - | ns |
| SCK ↑ → SIN hold time | $t_{SHIXE}$ | SCKx, SINx | | 20 | - | 20 | - | ns |
| SCK falling time | $t_F$ | SCKx | | - | 5 | - | 5 | ns |
| SCK rising time | $t_R$ | SCKx | | - | 5 | - | 5 | ns |

***Notes:***

- *The above characteristics apply to CLK synchronous mode.*
- *$t_{CYCP}$ indicates the APB bus clock cycle time.*
  *About the APB bus number which Multi-function serial is connected to, see "8. Block Diagram" in this datasheet.*
- *These characteristics only guarantee the same relocate port number.*
  *For example, the combination of SCKx_0 and SOTx_1 is not guaranteed.*
- *When the external load capacitance = 30 pF.*




Master mode

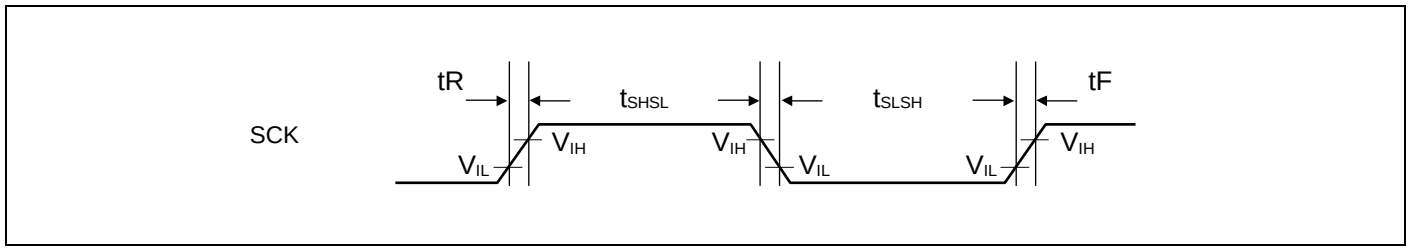



Slave mode

**UART external clock input (EXT = 1)**

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|
| | | | Min | Max | | |
| Serial clock "L" pulse width | $t_{SLSH}$ | $C_L$ = 30 pF | $t_{CYCP}$ + 10 | - | ns | |
| Serial clock "H" pulse width | $t_{SHSL}$ | | $t_{CYCP}$ + 10 | - | ns | |
| SCK fall time | tF | | - | 5 | ns | |
| SCK rise time | tR | | - | 5 | ns | |

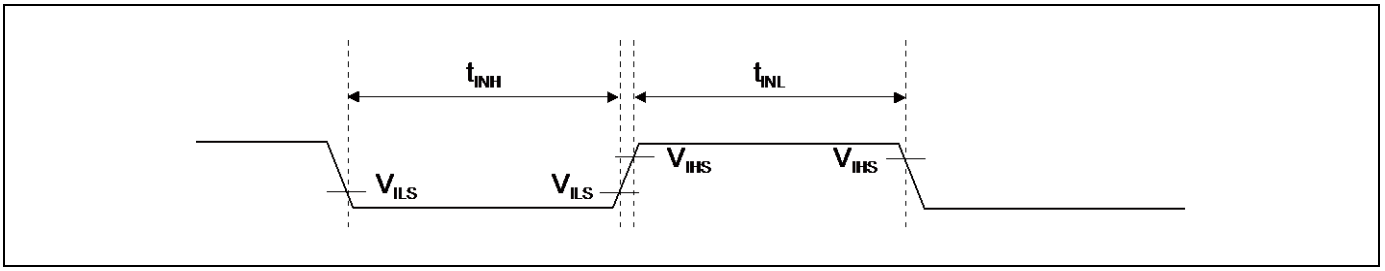


### 12.4.11 External Input Timing

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Input pulse width | $t_{INH}$, $t_{INL}$ | ADTG | - | $2t_{CYCP}$* | - | ns | A/D converter trigger input |
| | | FRCKx | | | | | Free-run timer input clock |
| | | ICxx | | | | | Input capture |
| | | DTTIxX | - | $2t_{CYCP}$* | - | ns | Wave form generator |
| | | INTxx, NMIX | Except Timer mode, Stop mode | $2t_{CYCP}$ + 100* | - | ns | External interrupt NMI |
| | | | Timer mode, Stop mode | 500 | - | ns | |

*: $t_{CYCP}$ indicates the APB bus clock cycle time.
About the APB bus number which the A/D converter, Multi-function Timer, External interrupt are connected to, see "8. Block Diagram" in this datasheet.

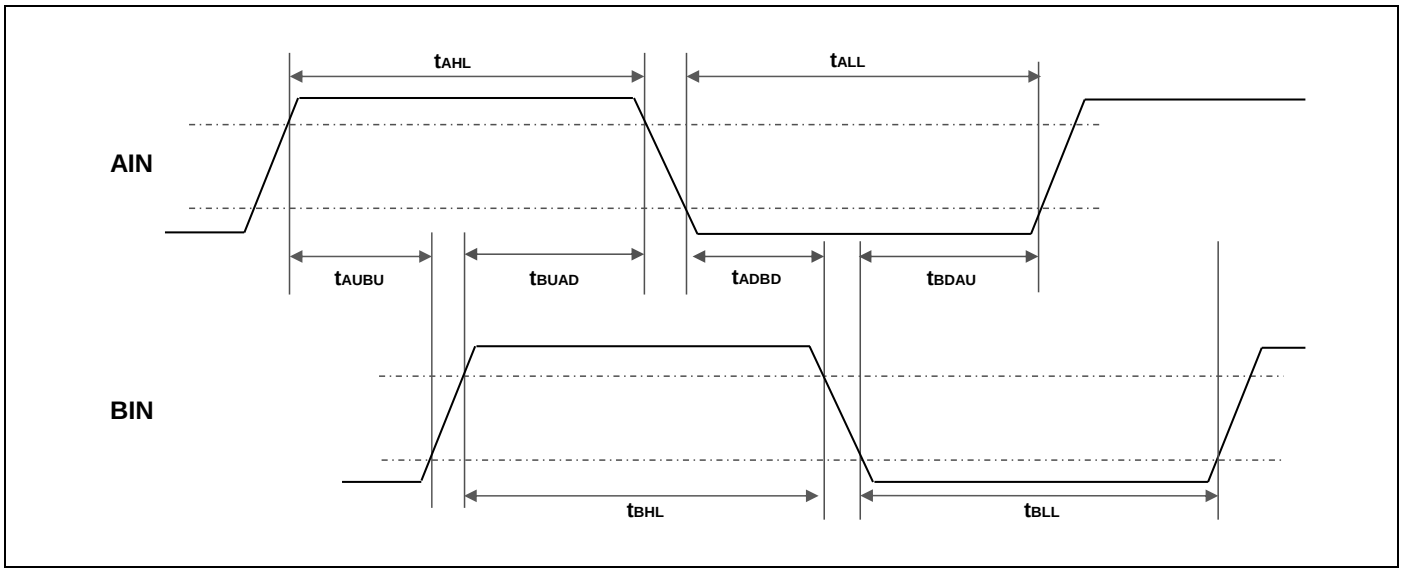


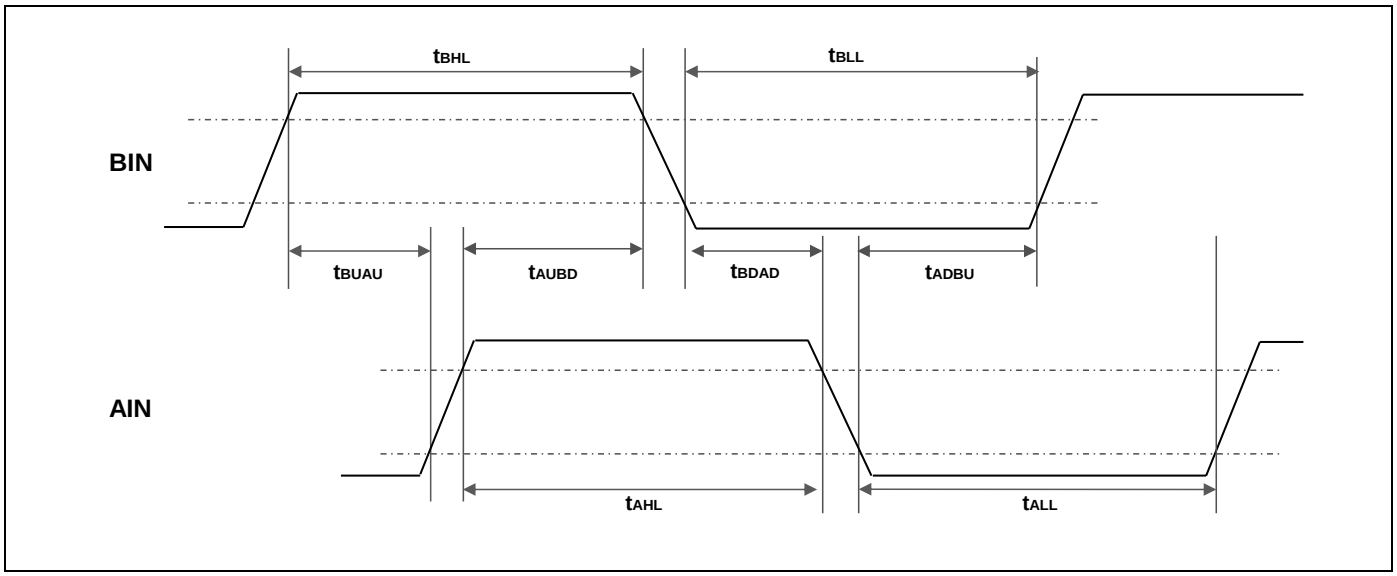
### 12.4.12 Quadrature Position/Revolution Counter timing

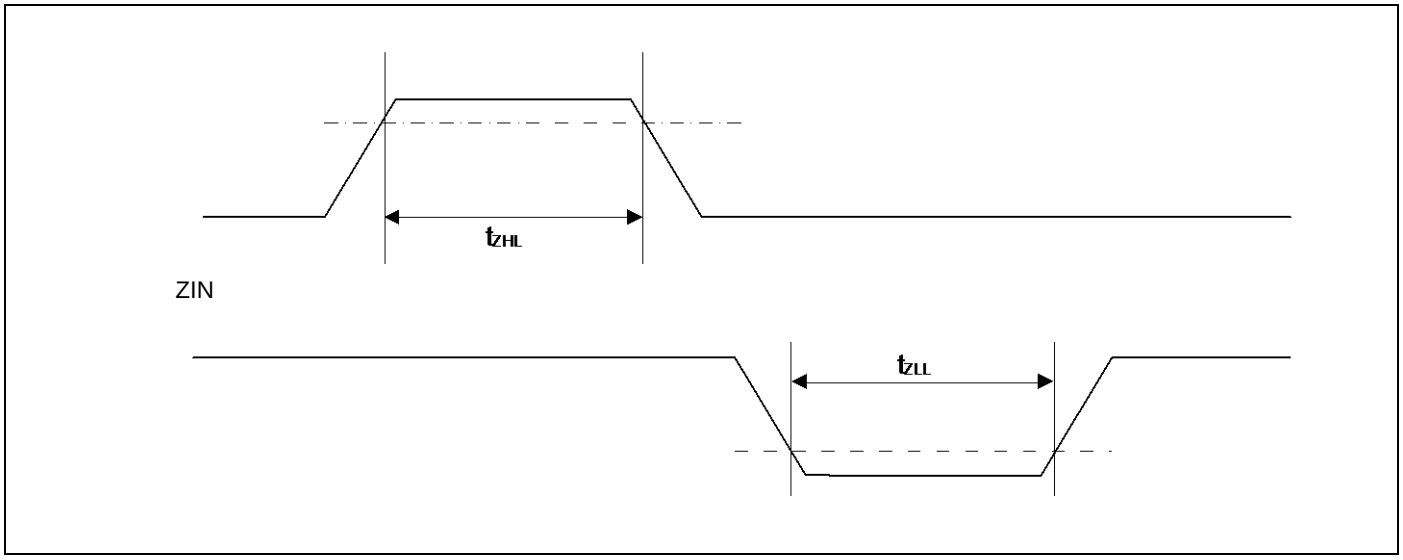
(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

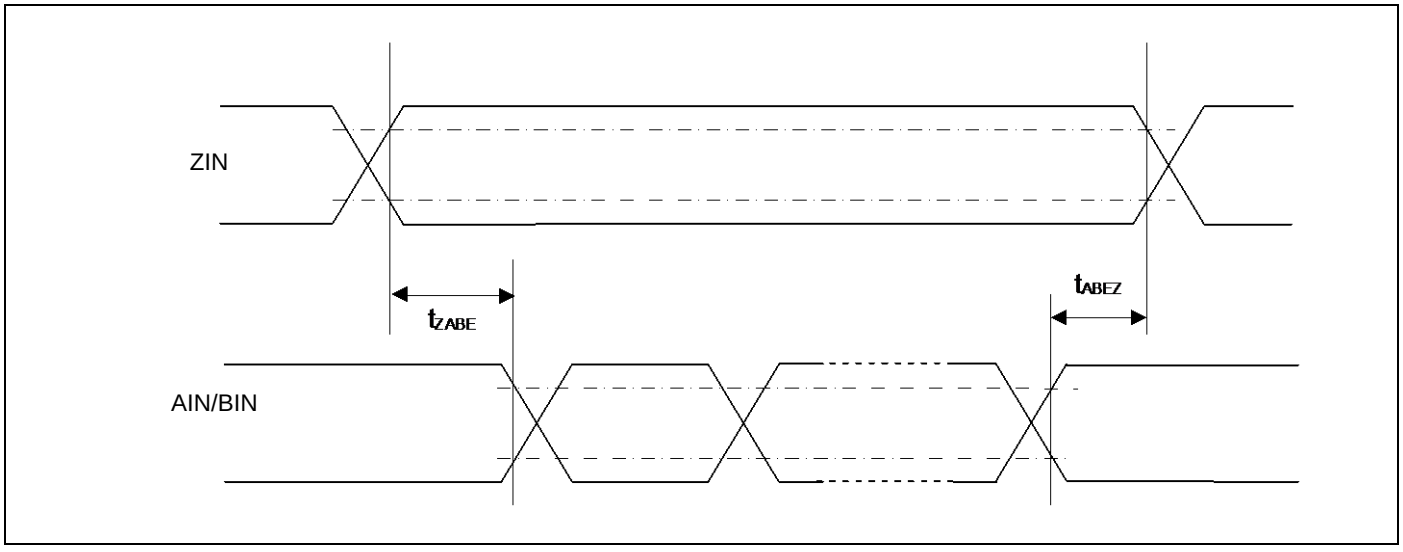
| Parameter | Symbol | Conditions | Value | | Unit |
|---|---|---|---|---|---|
| | | | Min | Max | |
| AIN pin "H" width | $t_{AHL}$ | - | $2t_{CYCP}$* | - | ns |
| AIN pin "L" width | $t_{ALL}$ | - | | | |
| BIN pin "H" width | $t_{BHL}$ | - | | | |
| BIN pin "L" width | $t_{BLL}$ | - | | | |
| BIN rise time from AIN pin "H" level | $t_{AUBU}$ | PC_Mode2 or PC_Mode3 | | | |
| AIN fall time from BIN pin "H" level | $t_{BUAD}$ | PC_Mode2 or PC_Mode3 | | | |
| BIN fall time from AIN pin "L" level | $t_{ADBD}$ | PC_Mode2 or PC_Mode3 | | | |
| AIN rise time from BIN pin "L" level | $t_{BDAU}$ | PC_Mode2 or PC_Mode3 | | | |
| AIN rise time from BIN pin "H" level | $t_{BUAU}$ | PC_Mode2 or PC_Mode3 | | | |
| BIN fall time from AIN pin "H" level | $t_{AUBD}$ | PC_Mode2 or PC_Mode3 | | | |
| AIN fall time from BIN pin "L" level | $t_{BDAD}$ | PC_Mode2 or PC_Mode3 | | | |
| BIN rise time from AIN pin "L" level | $t_{ADBU}$ | PC_Mode2 or PC_Mode3 | | | |
| ZIN pin "H" width | $t_{ZHL}$ | QCR:CGSC="0" | | | |
| ZIN pin "L" width | $t_{ZLL}$ | QCR:CGSC="0" | | | |
| AIN/BIN rise and fall time from determined ZIN level | $t_{ZABE}$ | QCR:CGSC="1" | | | |
| Determined ZIN level from AIN/BIN rise and fall time | $t_{ABEZ}$ | QCR:CGSC="1" | | | |

*: $t_{CYCP}$ indicates the APB bus clock cycle time.
About the APB bus number which the Quadrature Position/Revolution Counter is connected to, see "8. Block Diagram" in this datasheet.




BIN
AIN
tBHL
tBLL
tBUAU
tAUBD
tBDAD
tADBU
tAHL
tALL


ZIN
tZHL
tZLL


ZIN
AIN/BIN
tZABE
tABEZ

### 12.4.13 $I^2C$ Timing

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Standard-mode | | Fast-mode | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max | | |
| SCL clock frequency | $F_{SCL}$ | $C_L$ = 30 pF, R = ($V_p/I_{OL}$)*1 | 0 | 100 | 0 | 400 | kHz | |
| (Repeated) START condition hold time SDA ↓ → SCL ↓ | $t_{HDSTA}$ | | 4.0 | - | 0.6 | - | µs | |
| SCLclock "L" width | $t_{LOW}$ | | 4.7 | - | 1.3 | - | µs | |
| SCLclock "H" width | $t_{HIGH}$ | | 4.0 | - | 0.6 | - | µs | |
| (Repeated) START setup time SCL ↑ → SDA ↓ | $t_{SUSTA}$ | | 4.7 | - | 0.6 | - | µs | |
| Data hold time SCL ↓ → SDA ↓ ↑ | $t_{HDDAT}$ | | 0 | 3.45*2 | 0 | 0.9*3 | µs | |
| Data setup time SDA ↓ ↑ → SCL ↑ | $t_{SUDAT}$ | | 250 | - | 100 | - | ns | |
| STOP condition setup time SCL ↑ → SDA ↑ | $t_{SUSTO}$ | | 4.0 | - | 0.6 | - | µs | |
| Bus free time between "STOP condition" and "START condition" | $t_{BUF}$ | | 4.7 | - | 1.3 | - | µs | |
| Noise filter | $t_{SP}$ | 8 MHz ≤ $t_{CYCP}$ ≤ 40 MHz | 2 $t_{CYCP}$*4 | - | 2 $t_{CYCP}$*4 | - | ns | *5 |
| | | 40 MHz < $t_{CYCP}$ ≤ 60 MHz | 3 $t_{CYCP}$*4 | - | 3 $t_{CYCP}$*4 | - | ns | *5 |
| | | 60 MHz < $t_{CYCP}$ ≤ 72 MHz | 4 $t_{CYCP}$*4 | - | 4 $t_{CYCP}$*4 | - | ns | *5 |

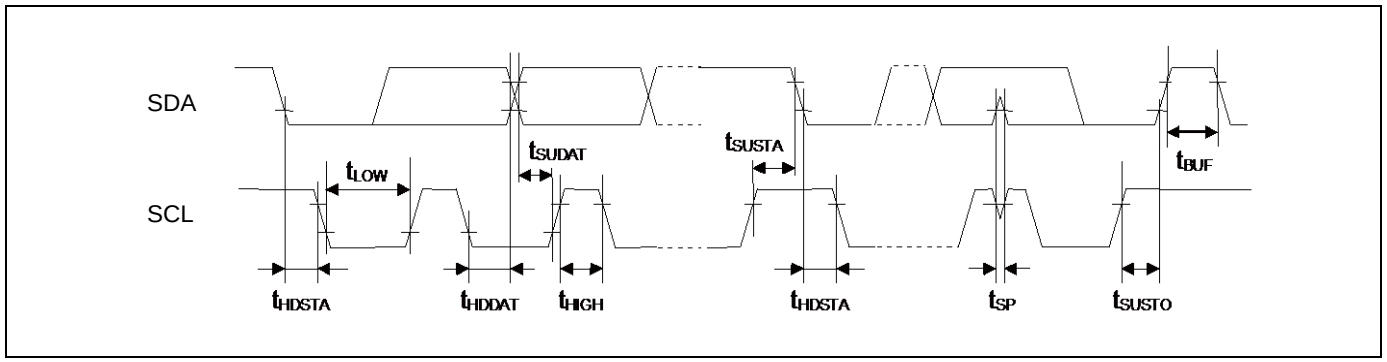
*1: R and C represent the pull-up resistance and load capacitance of the SCL and SDA lines, respectively.
Vp indicates the power supply voltage of the pull-up resistance and $I_{OL}$ indicates $V_{OL}$ guaranteed current.

*2: The maximum $t_{HDDAT}$ must satisfy that it does not extend at least "L" period ($t_{LOW}$) of device's SCL signal.

*3: A Fast-mode $I^2C$ bus device can be used on a Standard-mode $I^2C$ bus system as long as the device satisfies the requirement of "$t_{SUDAT}$ ≥ 250 ns".

*4: $t_{CYCP}$ is the APB bus clock cycle time.
About the APB bus number that $I^2C$ is connected to, see "8. Block Diagram" in this datasheet.
To use Standard-mode, set the APB bus clock at 2 MHz or more
To use Fast-mode, set the APB bus clock at 8 MHz or more.

*5: The number of steps of the noise filter can be changed with register settings.
Change the number of the noise filter steps according to APB2 bus clock frequency.



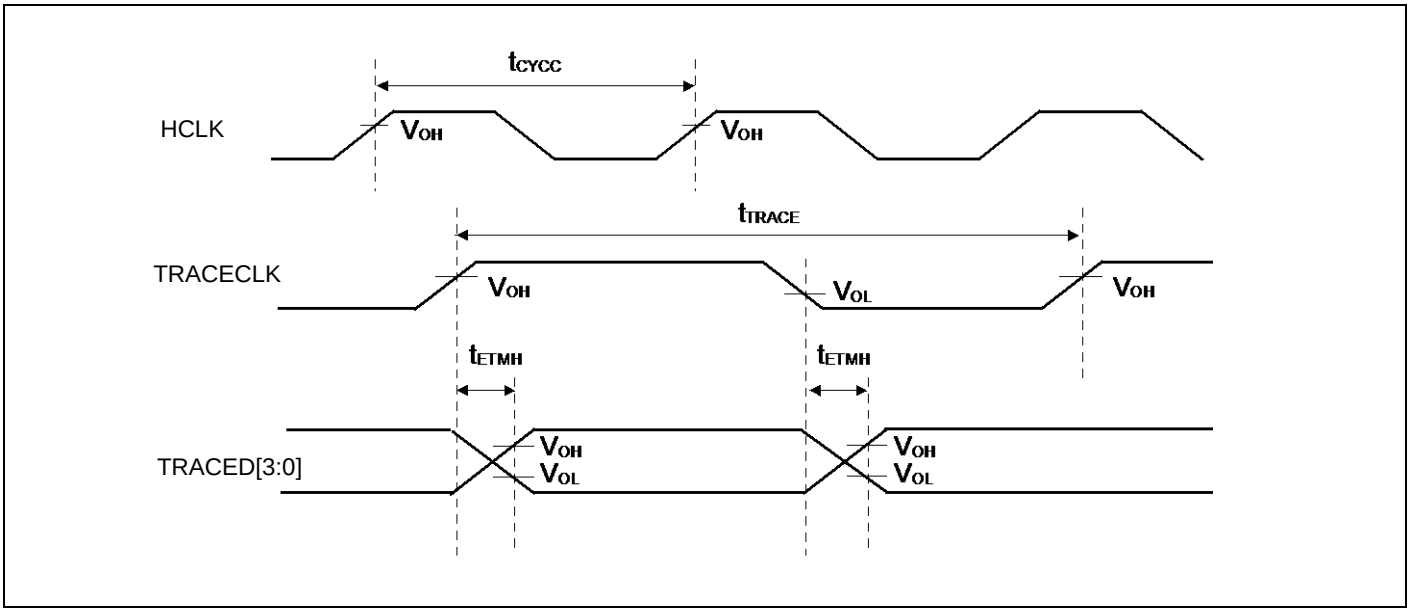
### 12.4.14 ETM Timing

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| Data hold | $t_{ETMH}$ | TRACECLK, TRACED[3:0] | Vcc ≥ 4.5 V | 2 | 9 | ns | |
| | | | Vcc < 4.5 V | 2 | 15 | | |
| TRACECLK frequency | 1/ $t_{TRACE}$ | TRACECLK | Vcc ≥ 4.5 V | - | 50 | MHz | |
| | | | Vcc < 4.5 V | - | 32 | MHz | |
| TRACECLK cycle time | $t_{TRACE}$ | | Vcc ≥ 4.5 V | 20 | - | ns | |
| | | | Vcc < 4.5 V | 31.25 | - | ns | |

***Note:***

- *When the external load capacitance = 30 pF.*



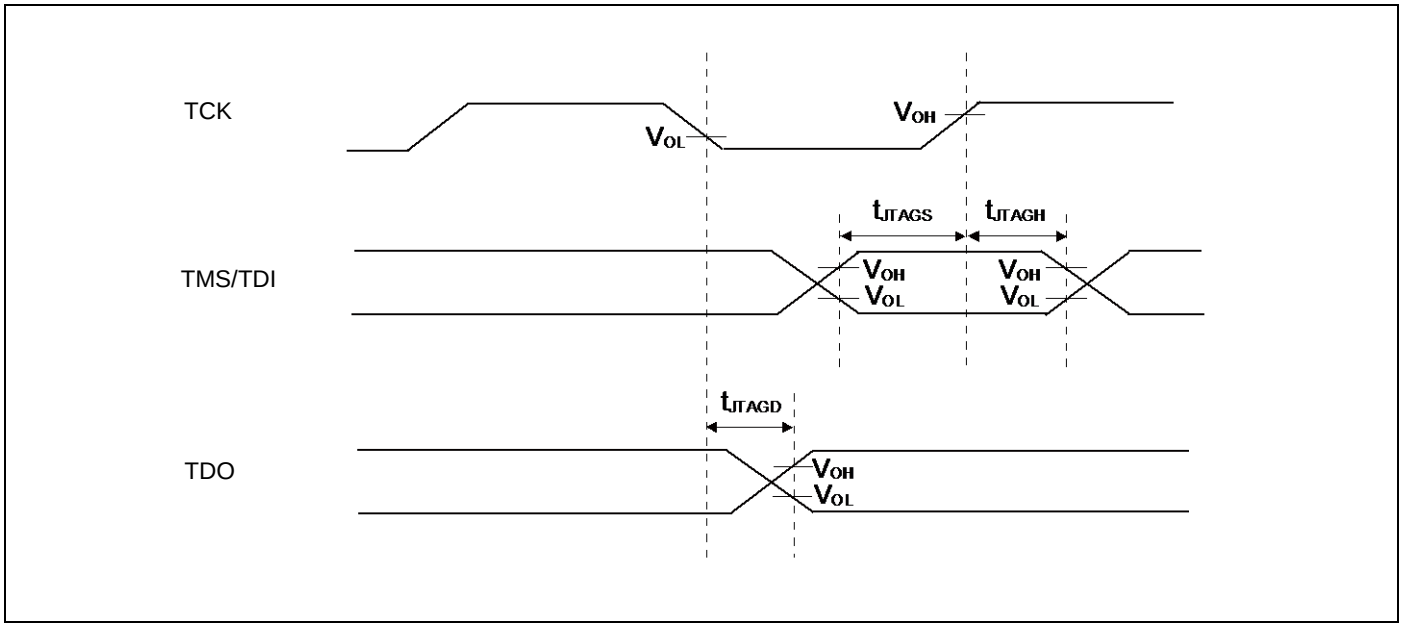
### 12.4.15 JTAG Timing

(Vcc = 2.7V to 5.5V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | |
| TMS, TDI setup time | $t_{JTAGS}$ | TCK, TMS, TDI | Vcc ≥ 4.5 V | 15 | - | ns | |
| | | | Vcc < 4.5 V | | | | |
| TMS, TDI hold time | $t_{JTAGH}$ | TCK, TMS, TDI | Vcc ≥ 4.5 V | 15 | - | ns | |
| | | | Vcc < 4.5 V | | | | |
| TDO delay time | $t_{JTAGD}$ | TCK, TDO | Vcc ≥ 4.5 V | - | 25 | ns | |
| | | | Vcc < 4.5 V | - | 45 | | |

***Note:***

- *When the external load capacitance = 30 pF.*



## 12.5 12-bit A/D Converter

### Electrical Characteristics for the A/D Converter

(Vcc = AVcc = 2.7V to 5.5V, Vss = AVss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Pin name | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Resolution | - | - | - | - | 12 | bit | |
| Integral Nonlinearity | - | - | - | | ± 4.5 | LSB | AVRH = 2.7 V to 5.5 V |
| Differential Nonlinearity | - | - | - | | ± 2.5 | LSB | |
| Zero transition voltage | $V_{ZT}$ | ANxx | - | | ± 15 | mV | |
| Full-scale transition voltage | $V_{FST}$ | ANxx | - | | AVRH ± 15 | mV | |
| Conversion time | - | - | 1.0*1 | - | - | µs | AVcc ≥ 4.5 V |
| | | | 1.2*1 | - | - | | AVcc < 4.5 V |
| Sampling time | Ts | - | *2 | - | - | ns | AVcc ≥ 4.5 V |
| | | | *2 | - | - | | AVcc < 4.5 V |
| Compare clock cycle*3 | Tcck | - | 50 | - | 2000 | ns | |
| State transition time to operation permission | Tstt | - | - | - | 1.0 | µs | |
| Analog input capacity | $C_{AIN}$ | - | - | - | 12.9 | pF | |
| Analog input resistance | $R_{AIN}$ | - | - | - | 2 | kΩ | AVcc ≥ 4.5 V |
| | | | | | 3.8 | | AVcc < 4.5 V |
| Interchannel disparity | - | - | - | - | 4 | LSB | |
| Analog port input leak current | - | ANxx | - | - | 5 | µA | |
| Analog input voltage | - | ANxx | $AV_{SS}$ | - | AVRH | V | |
| Reference voltage | - | AVRH | 2.7 | - | $AV_{CC}$ | V | |

*1: The Conversion time is the value of sampling time (Ts) + compare time (Tc).

The condition of the minimum conversion time is the following.

AVcc ≥ 4.5 V, HCLK=120 MHz sampling time: 300 ns compare time: 700 ns
AVcc < 4.5 V, HCLK=120 MHz sampling time: 500 ns compare time: 700 ns
Ensure that it satisfies the value of the sampling time (Ts) and compare clock cycle (Tcck).
For setting of the sampling time and compare clock cycle, see "Chapter 1-1: A/D Converter" in "FM3 Family Peripheral Manual Analog Macro Part".

The registers setting of the A/D Converter are reflected in the operation according to the APB bus clock timing.

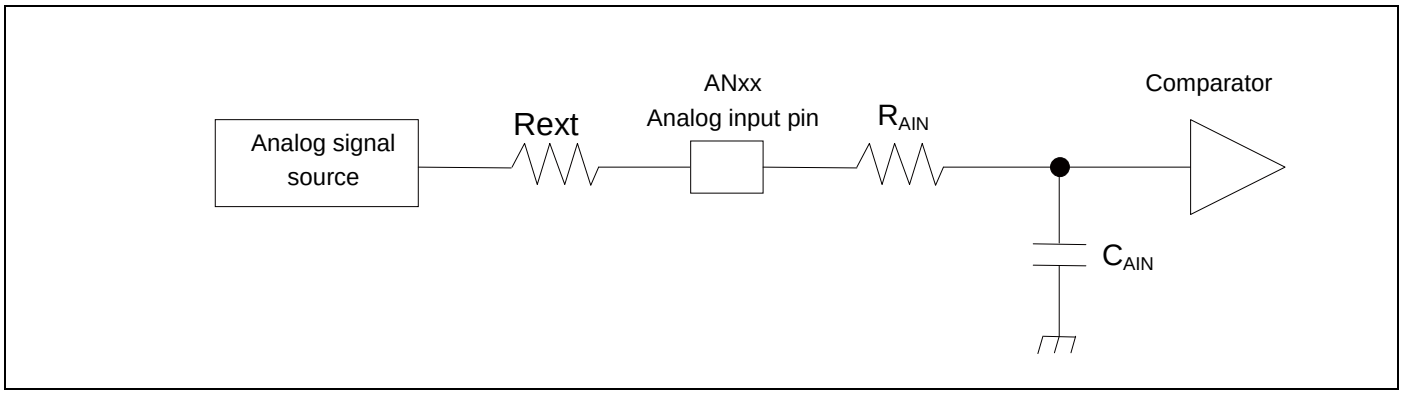
The sampling clock and compare clock is generated from the Base clock (HCLK).

About the APB bus number which the A/D Converter is connected to, see "8. Block Diagram" in this datasheet.

*2: A necessary sampling time changes by external impedance.

Ensure that it set the sampling time to satisfy (Equation 1).

*3: Compare time (Tc) is the value of (Equation 2).




(Equation 1) $T_S \geq ( R_{AIN} + Rext ) \times C_{AIN} \times 9$

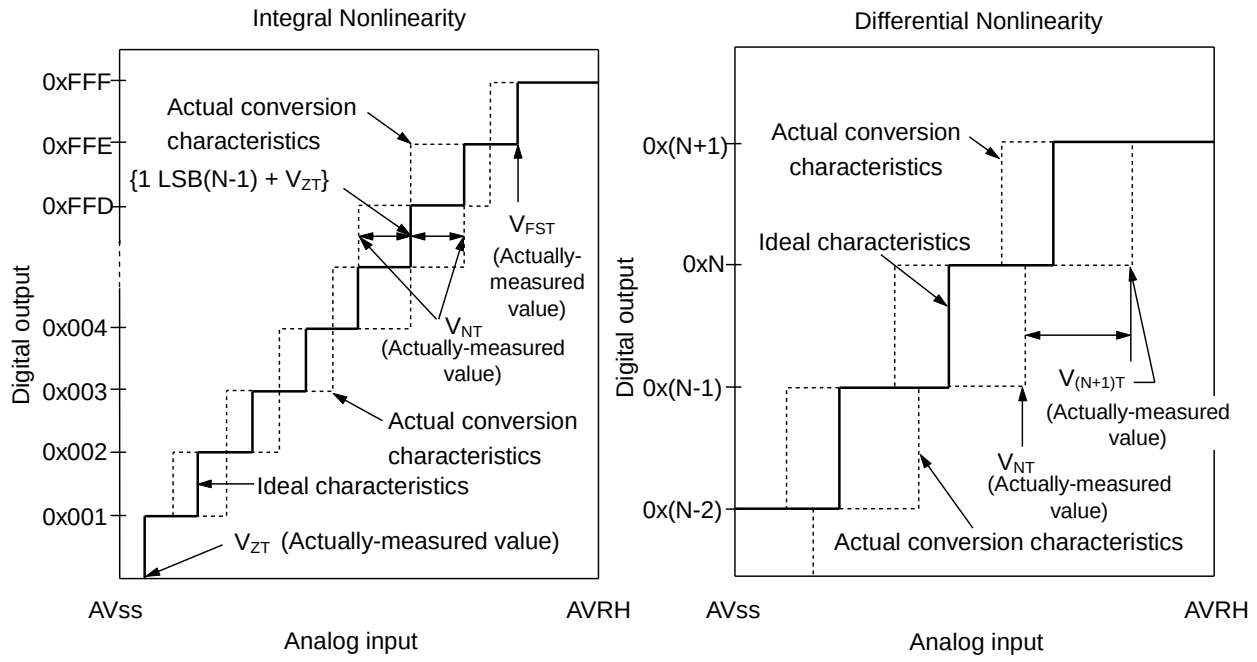
| | |
|---|---|
| $T_S$: | Sampling time |
| $R_{AIN}$: | Input resistance of A/ D = 2 kΩ at 4.5 V ≤ $AV_{CC}$ ≤ 5.5 V |
| | Input resistance of A/D = 3.8 kΩ at 2.7 V ≤ $AV_{CC}$ < 4.5 V |
| $C_{AIN}$: | Input capacity of A/D = 12.9 pF at 2.7 V ≤ $AV_{CC}$ ≤ 5.5 V |
| Rext: | Output impedance of external circuit |

(Equation 2) Tc = Tcck × 14

| | |
|---|---|
| Tc: | Compare time |
| Tcck: | Compare clock cycle |

### Definition of 12-bit A/D Converter Terms

- Resolution: Analog variation that is recognized by an A/D converter.
- Integral Nonlinearity: Deviation of the line between the zero-transition point (0b000000000000←→0b000000000001) and the full-scale transition point (0b111111111110←→0b111111111111) from the actual conversion characteristics.
- Differential Nonlinearity: Deviation from the ideal value of the input voltage that is required to change the output code by 1 LSB.




$$\text{Integral Nonlinearity of digital output N} = \frac{V_{NT} - \{1LSB \times (N - 1) + V_{ZT}\}}{1LSB} \text{ [LSB]}$$

$$\text{Differential Nonlinearity of digital output N} = \frac{V_{(N+1)T} - V_{NT}}{1LSB} - 1 \text{ [LSB]}$$

$$1LSB = \frac{V_{FST} - V_{ZT}}{4094}$$

N: A/D converter digital output value.
$V_{ZT}$: Voltage at which the digital output changes from 0x000 to 0x001.
$V_{FST}$: Voltage at which the digital output changes from 0xFFE to 0xFFF.
$V_{NT}$: Voltage at which the digital output changes from 0x(N − 1) to 0xN.

## 12.6 USB characteristics

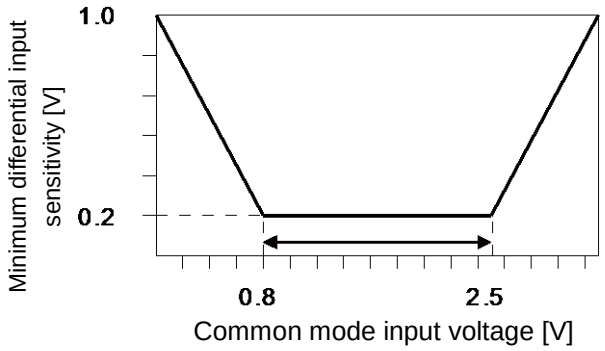
The USB characteristics of ch.0 and those of ch.1 are the same.
USBVcc0 and USBVcc1 are described as USBVcc below.

(Vcc = 2.7V to 5.5V, USBVcc = 3.0V to 3.6V, Vss = 0V, $T_A$ = - 40°C to + 85°C)

| Parameter | | Symbol | Pin name | Conditions | Value | | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Max | | |
| Input characteristics | Input "H" level voltage | $V_{IH}$ | UDP0, UDM0 | - | 2.0 | USBVcc + 0.3 | V | *1 |
| | Input "L" level voltage | $V_{IL}$ | | - | Vss - 0.3 | 0.8 | V | *1 |
| | Differential input sensitivity | $V_{DI}$ | | - | 0.2 | - | V | *2 |
| | Different common mode range | $V_{CM}$ | | - | 0.8 | 2.5 | V | *2 |
| Output characteristics | Output "H" level voltage | $V_{OH}$ | | External pull-down resistance= 15 kΩ | 2.8 | 3.6 | V | *3 |
| | Output "L" level voltage | $V_{OL}$ | | External pull-up resistance= 1.5 kΩ | 0.0 | 0.3 | V | *3 |
| | Crossover voltage | $V_{CRS}$ | | - | 1.3 | 2.0 | V | *4 |
| | Rise time | $t_{FR}$ | | Full-Speed | 4 | 20 | ns | *5 |
| | Fall time | $t_{FF}$ | | Full-Speed | 4 | 20 | ns | *5 |
| | Rise/ fall time matching | $t_{FRFM}$ | | Full-Speed | 90 | 111.11 | % | *5 |
| | Output impedance | $Z_{DRV}$ | | Full-Speed | 28 | 44 | Ω | *6 |
| | Rise time | $t_{LR}$ | | Low-Speed | 75 | 300 | ns | *7 |
| | Fall time | $t_{LF}$ | | Low-Speed | 75 | 300 | ns | *7 |
| | Rise/ fall time matching | $t_{LRFM}$ | | Low-Speed | 80 | 125 | % | *7 |

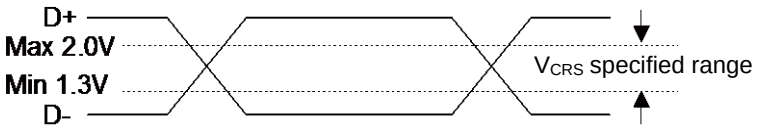
*1: The switching threshold voltage of Single-End-Receiver of USB I/O buffer is set as within $V_{IL}$ (Max) = 0.8 V, $V_{IH}$ (Min) = 2.0 V (TTL input standard).
There are some hysteresis to lower noise sensitivity.

*2: Use differential-Receiver to receive USB differential data signal.
Differential-Receiver has 200 mV of differential input sensitivity when the differential data input is within 0.8 V to 2.5 V to the local ground reference level.
Above voltage range is the common mode input voltage range.

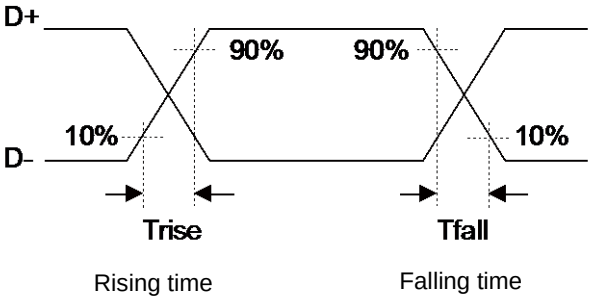


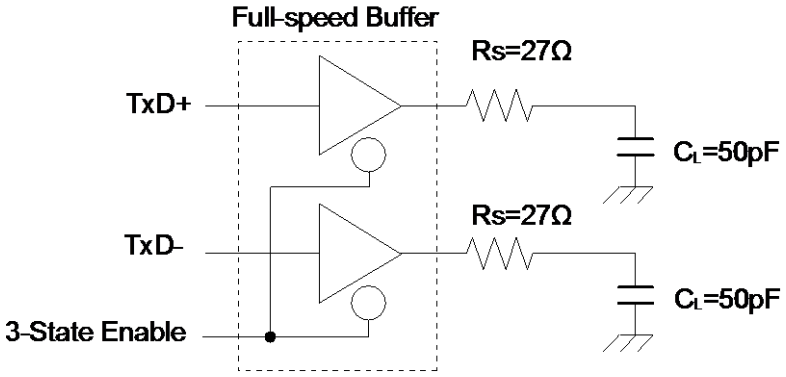
*3: The output drive capability of the driver is below 0.3 V at Low-State ($V_{OL}$) (to 3.6 V and 1.5 kΩ load), and 2.8 V or above (to ground and 1.5 kΩ load) at High-State ($V_{OH}$).

*4: The cross voltage of the external differential output signal (D + /D −) of USB I/O buffer is within 1.3 V to 2.0 V.

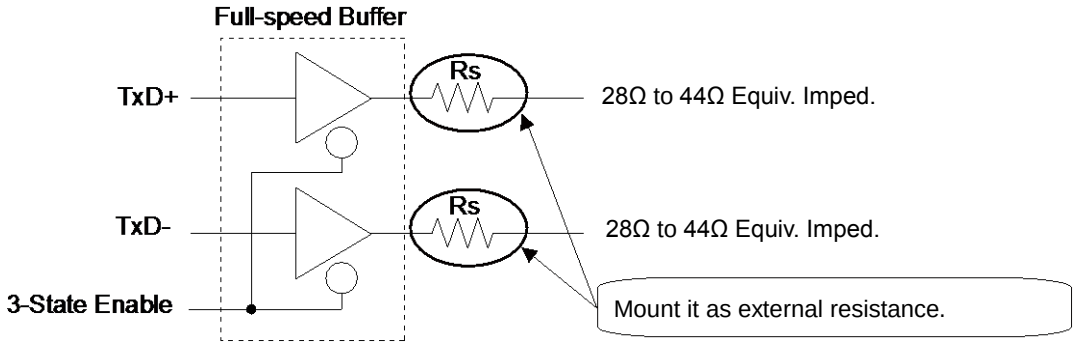



*5: They indicate rise time (Trise) and fall time (Tfall) of the full-speed differential data signal.
They are defined by the time between 10% and 90% of the output signal voltage.
For full-speed buffer, Tr/Tf ratio is regulated as within ± 10% to minimize RFI emission.



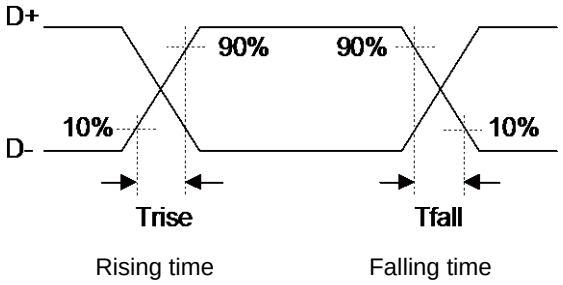



*6: USB Full-speed connection is performed via twist pair cable shield with 90Ω ± 15% characteristic impedance (Differential Mode). USB standard defines that output impedance of USB driver must be in range from 28 Ω to 44 Ω. So, discrete series resistor (Rs) addition is defined in order to satisfy the above definition and keep balance.
When using this USB I/O, use it with 25 Ω to 30 Ω (recommendation value 27 Ω) series resistor Rs.



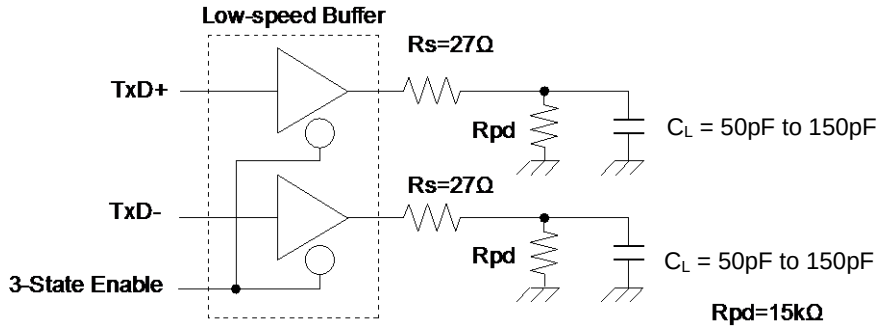

Rs series resistor 25Ω to 30Ω
Series resistor of 27Ω (recommendation value) must be added.
And, use "resistance with an uncertainty of 5% by E24 sequence".

*7: They indicate rise time (Trise) and fall time (Tfall) of the low-speed differential data signal.
They are defined by the time between 10% and 90% of the output signal voltage.

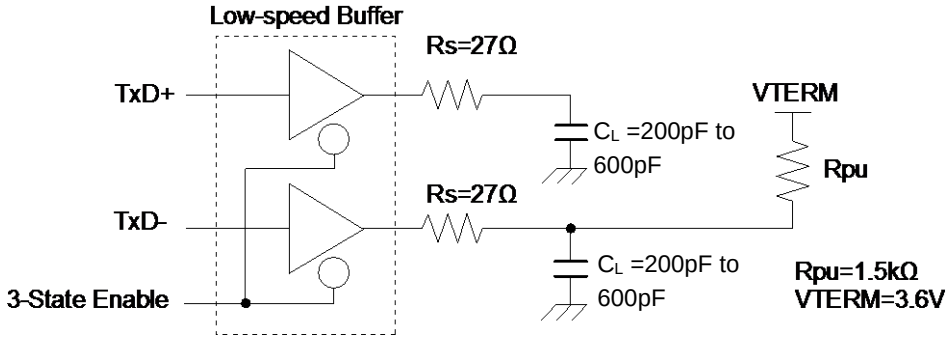



See Figure "Low-Speed Load (Compliance Load)" for conditions of external load.

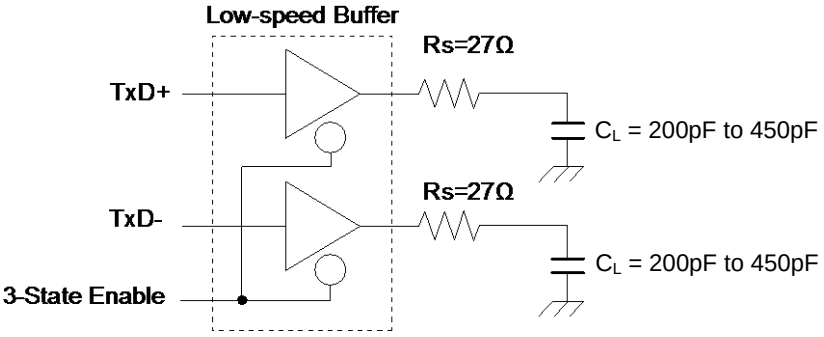
**Low-Speed Load (Upstream Port Load) - Reference 1**




**Low-Speed Load (Downstream Port Load) - Reference 2**




**Low-Speed Load (Compliance Load)**



## 12.7 Low-Voltage Detection Characteristics

### *12.7.1 Low-Voltage Detection Reset*

($T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Detected voltage | VDL | - | 2.25 | 2.45 | 2.65 | V | When voltage drops |
| Released voltage | VDH | - | 2.30 | 2.50 | 2.70 | V | When voltage rises |

### *12.7.2 Interrupt of Low-Voltage Detection*

($T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Conditions | Value | | | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| Detected voltage | VDL | SVHI = 0000 | 2.58 | 2.8 | 3.02 | V | When voltage drops |
| Released voltage | VDH | | 2.67 | 2.9 | 3.13 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 0001 | 2.76 | 3.0 | 3.24 | V | When voltage drops |
| Released voltage | VDH | | 2.85 | 3.1 | 3.34 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 0010 | 2.94 | 3.2 | 3.45 | V | When voltage drops |
| Released voltage | VDH | | 3.04 | 3.3 | 3.56 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 0011 | 3.31 | 3.6 | 3.88 | V | When voltage drops |
| Released voltage | VDH | | 3.40 | 3.7 | 3.99 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 0100 | 3.40 | 3.7 | 3.99 | V | When voltage drops |
| Released voltage | VDH | | 3.50 | 3.8 | 4.10 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 0111 | 3.68 | 4.0 | 4.32 | V | When voltage drops |
| Released voltage | VDH | | 3.77 | 4.1 | 4.42 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 1000 | 3.77 | 4.1 | 4.42 | V | When voltage drops |
| Released voltage | VDH | | 3.86 | 4.2 | 4.53 | V | When voltage rises |
| Detected voltage | VDL | SVHI = 1001 | 3.86 | 4.2 | 4.53 | V | When voltage drops |
| Released voltage | VDH | | 3.96 | 4.3 | 4.64 | V | When voltage rises |
| LVD stabilization wait time | $T_{LVDW}$ | - | - | - | 4032 × $t_{CYCP}$* | µs | |

*: $t_{CYCP}$ indicates the APB2 bus clock cycle time.

## 12.8 Flash Memory Write/Erase Characteristics

### *12.8.1 Write / Erase time*

(Vcc = 2.7V to 5.5V, $T_A$ = - 40°C to + 85°C)

| Parameter | | Value | | Unit | Remarks |
|---|---|---|---|---|---|
| | | Typ* | Max* | | |
| Sector erase time | Large Sector | 0.7 | 3.7 | s | Includes write time prior to internal erase |
| | Small Sector | 0.3 | 1.1 | | |
| Half word (16-bit) write time | | 12 | 384 | µs | Not including system-level overhead time. |
| Chip erase time | | 13.6 | 68 | s | Includes write time prior to internal erase |

*: The typical value is immediately after shipment, the maximum value is guarantee value under 100,000 cycle of erase/write.

### *12.8.2 Write cycles and data hold time*

| Erase/write cycles (cycle) | Data hold time (year) | Remarks |
|---|---|---|
| 1,000 | 20* | |
| 10,000 | 10* | |
| 100,000 | 5* | |

*: At average + 85°C

## 12.9 Return Time from Low-Power Consumption Mode

### *12.9.1 Return Factor: Interrupt*

The return time from Low-Power consumption mode is indicated as follows. It is from receiving the return factor to starting the program operation.

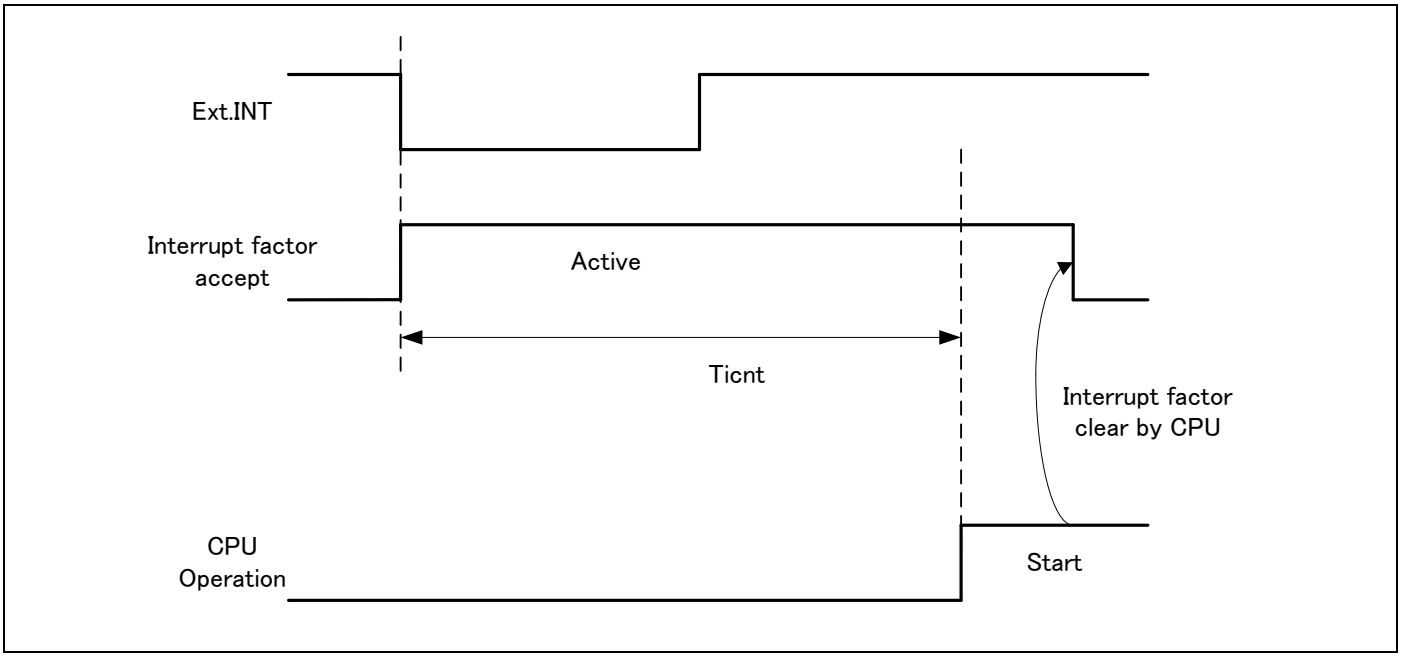
**Return Count Time**

($V_{CC}$ = 2.7V to 5.5V, $T_A$ = - 40°C to + 85°C)

| Parameter | Symbol | Value | | Unit | Remarks |
|---|---|---|---|---|---|
| | | Typ | Max* | | |
| SLEEP mode | Ticnt | $t_{CYCC}$ | | ns | |
| High-speed CR TIMER mode, Main TIMER mode, PLL TIMER mode | | 40 | 80 | µs | |
| Low-speed CR TIMER mode | | 453 | 737 | µs | |
| Sub TIMER mode | | 453 | 737 | µs | |
| STOP mode | | 453 | 737 | µs | |

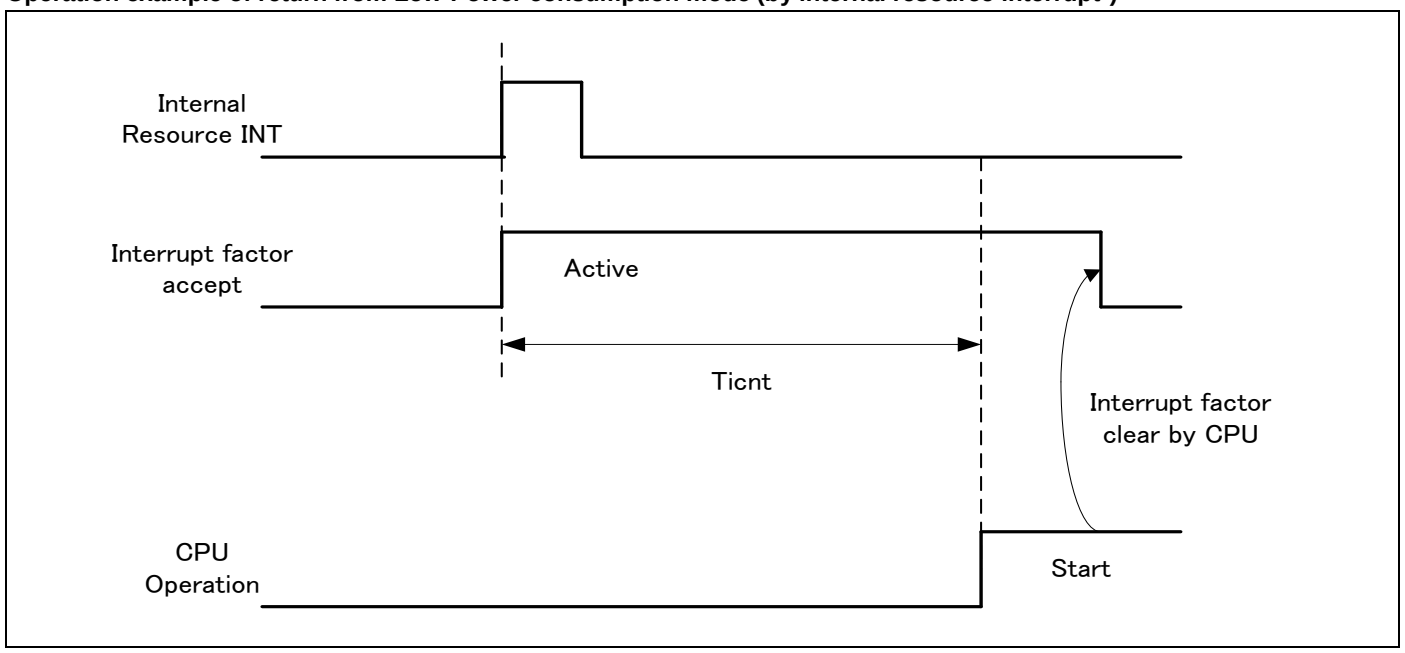
*: The maximum value depends on the accuracy of built-in CR.

**Operation example of return from Low-Power consumption mode (by external interrupt*)**




*: External interrupt is set to detecting fall edge.

**Operation example of return from Low-Power consumption mode (by internal resource interrupt*)**




*: Internal resource interrupt is not included in return factor by the kind of Low-Power consumption mode.

***Notes:***

- *The return factor is different in each Low-Power consumption modes.*
  *See "Chapter 6: Low Power Consumption Mode" and "Operations of Standby Modes" in FM3 Family Peripheral Manual about the return factor from Low-Power consumption mode.*
- *When interrupt recoveries, the operation mode that CPU recoveries depend on the state before the Low-Power consumption mode transition. See "Chapter 6: Low Power Consumption Mode" in "FM3 Family Peripheral Manual".*

### *12.9.2 Return Factor: Reset*

The return time from Low-Power consumption mode is indicated as follows. It is from releasing reset to starting the program operation.

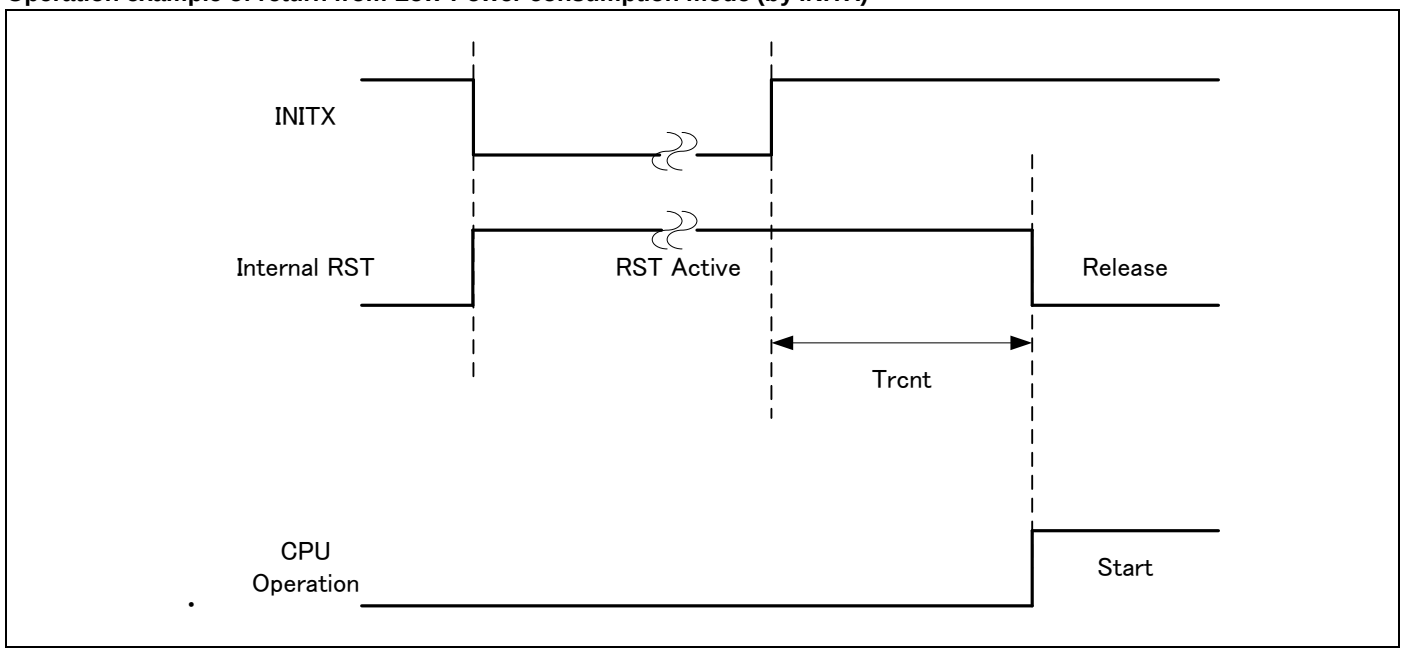
**Return Count Time**

($V_{CC}$ = 2.7V to 5.5V, $T_A$ = - 40°C to + 85°C)

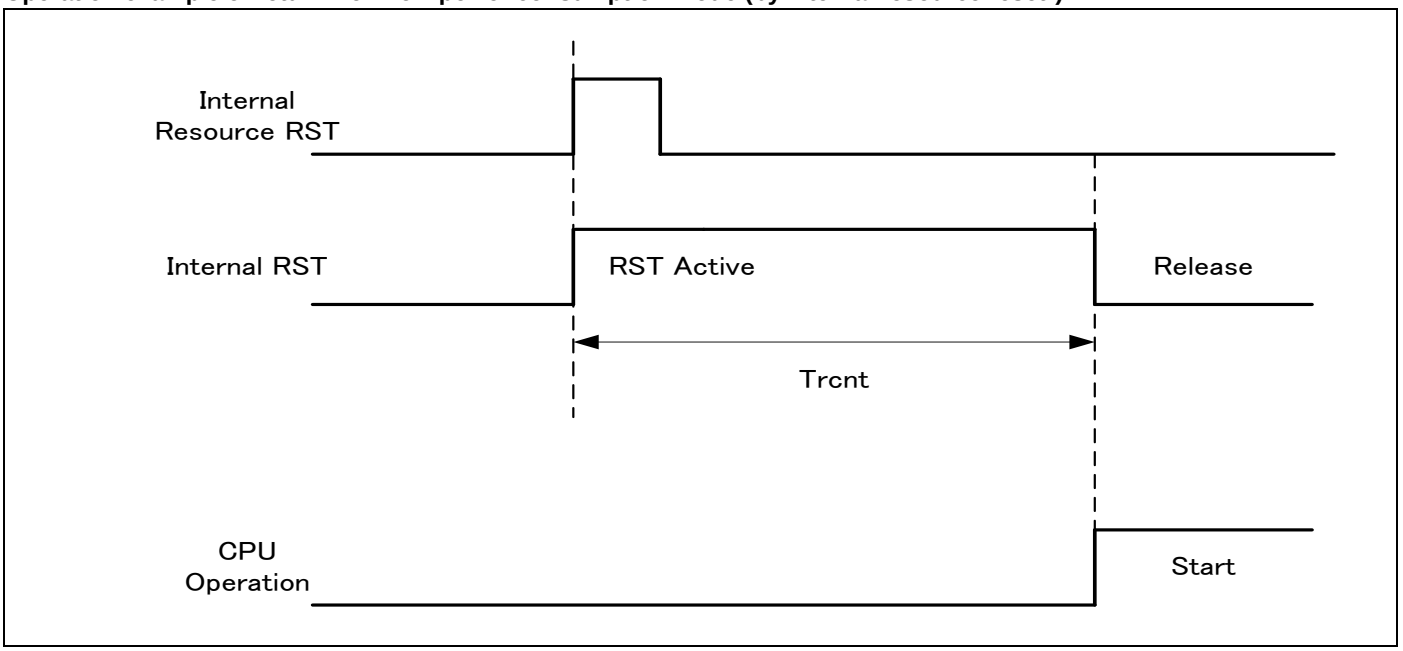
| Parameter | Symbol | Value | | Unit | Remarks |
|---|---|---|---|---|---|
| | | Typ | Max* | | |
| SLEEP mode | Trcnt | 321 | 461 | µs | |
| High-speed CR TIMER mode, Main TIMER mode, PLL TIMER mode | | 321 | 461 | µs | |
| Low-speed CR TIMER mode | | 441 | 701 | µs | |
| Sub TIMER mode | | 441 | 701 | µs | |
| STOP mode | | 441 | 701 | µs | |

*: The maximum value depends on the accuracy of built-in CR.

**Operation example of return from Low-Power consumption mode (by INITX)**



**Operation example of return from low power consumption mode (by internal resource reset*)**




*: Internal resource reset is not included in return factor by the kind of Low-Power consumption mode.

***Notes:***

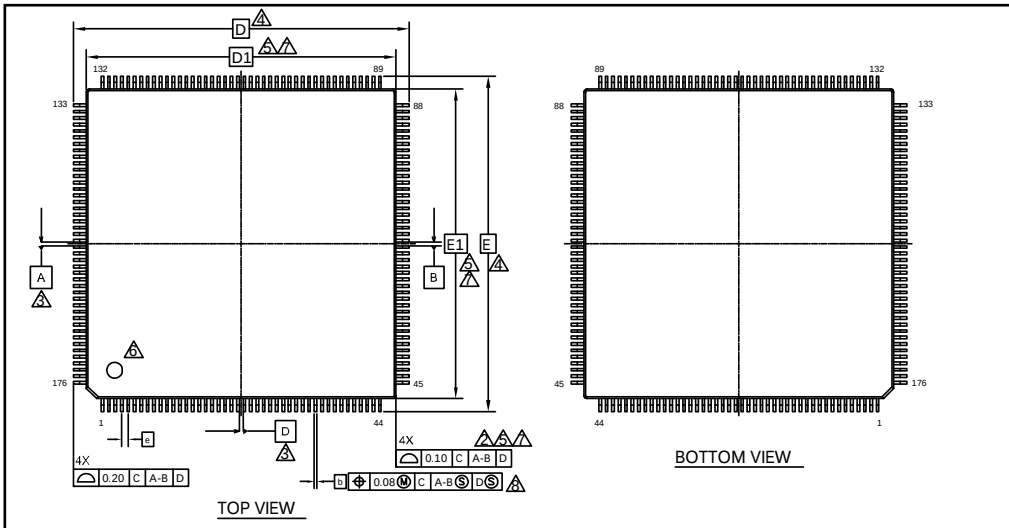
- *The return factor is different in each Low-Power consumption modes.*
  *See "Chapter 6: Low Power Consumption Mode" and "Operations of Standby Modes" in FM3 Family Peripheral Manual.*
- *When interrupt recoveries, the operation mode that CPU recoveries depend on the state before the Low-Power consumption mode transition. See "Chapter 6: Low Power Consumption Mode" in "FM3 Family Peripheral Manual".*
- *The time during the power-on reset/low-voltage detection reset is excluded. See "12.4.3. Internal CR Oscillation Characteristics in 12.4. AC Characteristics in 12. Electrical Characteristics" for the detail on the time during the power-on reset/low -voltage detection reset.*
- *When in recovery from reset, CPU changes to the high-speed CR run mode. When using the main clock or the PLL clock, it is necessary to add the main clock oscillation stabilization wait time or the Main PLL clock stabilization wait time.*
- *The internal resource reset means the watchdog reset and the CSV reset.*

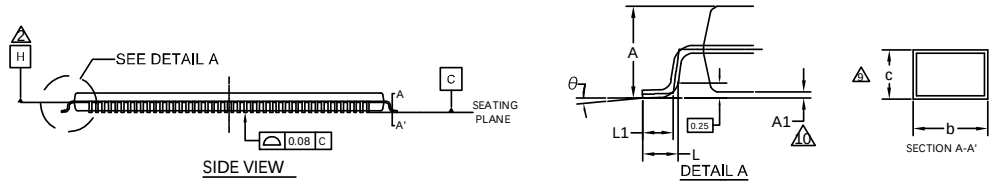
## 13. Ordering Information

| Part number | On-chip Flash memory | On-chip SRAM | Package | Packing |
|---|---|---|---|---|
| MB9BF516SPMC-GK7E1 | 512 Kbyte | 64 Kbyte | 144-pin plastic LQFP (0.5 mm pitch), (LQS144) | Tray |
| MB9BF517SPMC-GK7E1 | 768 Kbyte | 96 Kbyte | | |
| MB9BF518SPMC-GK7E1 | 1 Mbyte | 128 Kbyte | | |
| MB9BF516TPMC-GK7E1 | 512 Kbyte | 64 Kbyte | 176-pin plastic LQFP (0.5 mm pitch) , (LQP176) | |
| MB9BF517TPMC-GK7E1 | 768 Kbyte | 96 Kbyte | | |
| MB9BF518TPMC-GK7E1 | 1 Mbyte | 128 Kbyte | | |
| MB9BF516TBGL-GK7E1 | 512 Kbyte | 64 Kbyte | 192-ball plastic FBGA (0.8 mm pitch), (LBE192) | |
| MB9BF517TBGL-GK7E1 | 768 Kbyte | 96 Kbyte | | |
| MB9BF518TBGL-GK7E1 | 1 Mbyte | 128 Kbyte | | |

## 14. Package Dimensions

| Package Type | Package Code |
|---|---|
| LQFP 176 | LQP176 |




| SYMBOL | DIMENSIONS | | |
|---|---|---|---|
| | MIN. | NOM. | MAX. |
| A | — | — | 1.70 |
| A1 | 0.05 | — | 0.15 |
| b | 0.17 | 0.22 | 0.27 |
| c | 0.09 | — | 0.20 |
| D | 26.00 BSC | | |
| D1 | 24.00 BSC | | |
| e | 0.50 BSC | | |
| E | 26.00 BSC | | |
| E1 | 24.00 BSC | | |
| L | 0.45 | 0.60 | 0.75 |
| L1 | 0.30 | 0.50 | 0.70 |
| θ | 0° | — | 8° |

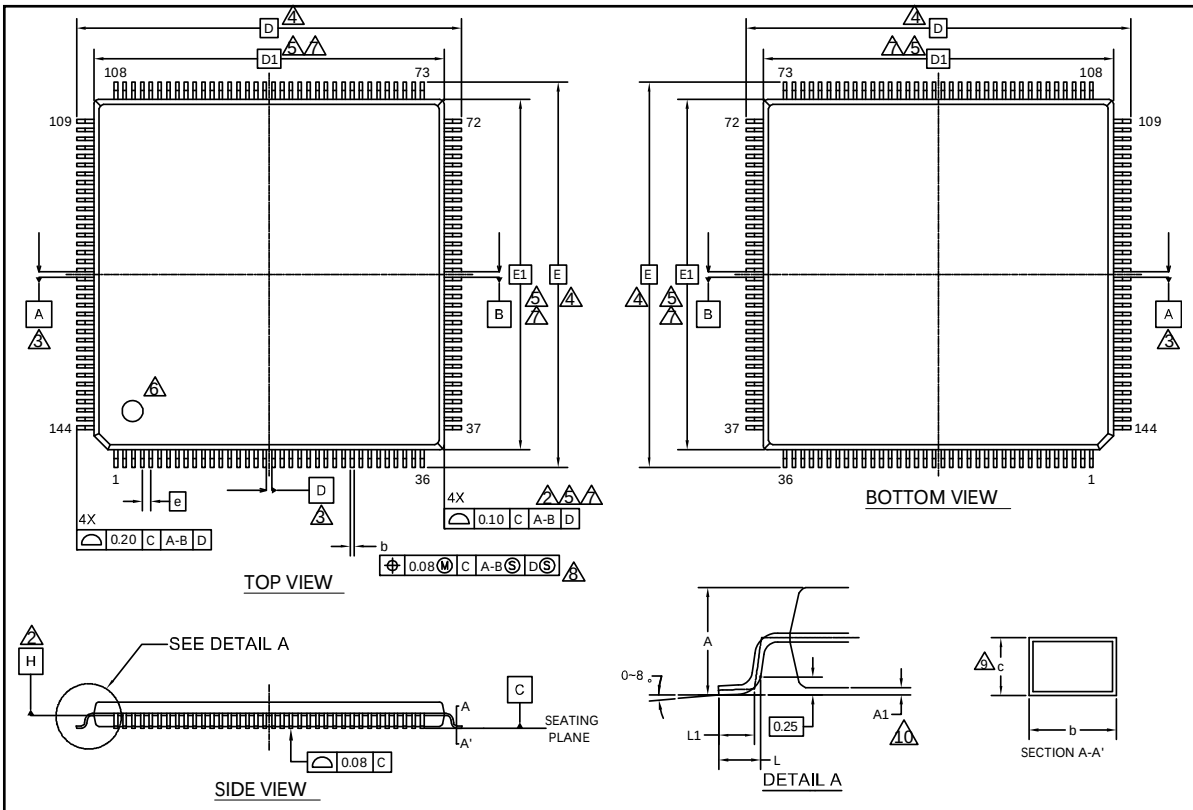
NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DATUM PLANE H IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.
3. DATUMS A-B AND D TO BE DETERMINED AT DATUM PLANE H.
4. TO BE DETERMINED AT SEATING PLANE C.
5. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25mm PRE SIDE. DIMENSIONS D1 AND E1 INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
6. DETAILS OF PIN 1 IDENTIFIER ARE OPTIONAL BUT MUST BE LOCATED WITHIN THE ZONE INDICATED.
7. REGARDLESS OF THE RELATIVE SIZE OF THE UPPER AND LOWER BODY SECTIONS. DIMENSIONS D1 AND E1 ARE DETERMINED AT THE LARGEST FEATURE OF THE BODY EXCLUSIVE OF MOLD FLASH AND GATE BURRS. BUT INCLUDING ANY MISMATCH BETWEEN THE UPPER AND LOWER SECTIONS OF THE MOLDER BODY.
8. DIMENSION b DOES NOT INCLUDE DAMBER PROTRUSION. THE DAMBAR PROTRUSION (S) SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED b MAXIMUM BY MORE THAN 0.08mm. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE LEAD FOOT.
9. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.10mm AND 0.25mm FROM THE LEAD TIP.
10. A1 IS DEFINED AS THE DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT OF THE PACKAGE BODY.

PACKAGE OUTLINE, 176 LEAD LQFP
24.0X24.0X1.7 MM LQP176 REV**

002-15150 **

| Package Type | Package Code |
|---|---|
| LQFP 144 | LQS144 |




| SYMBOL | DIMENSIONS | | |
|---|---|---|---|
| | MIN. | NOM. | MAX. |
| A | — | — | 1.70 |
| A1 | 0.05 | — | 0.15 |
| b | 0.17 | 0.22 | 0.27 |
| c | 0.09 | — | 0.20 |
| D | 22.00 BSC | | |
| D1 | 20.00 BSC | | |
| e | 0.50 BSC | | |
| E | 22.00 BSC | | |
| E1 | 20.00 BSC | | |
| L | 0.45 | 0.60 | 0.75 |
| L1 | 0.30 | 0.50 | 0.70 |

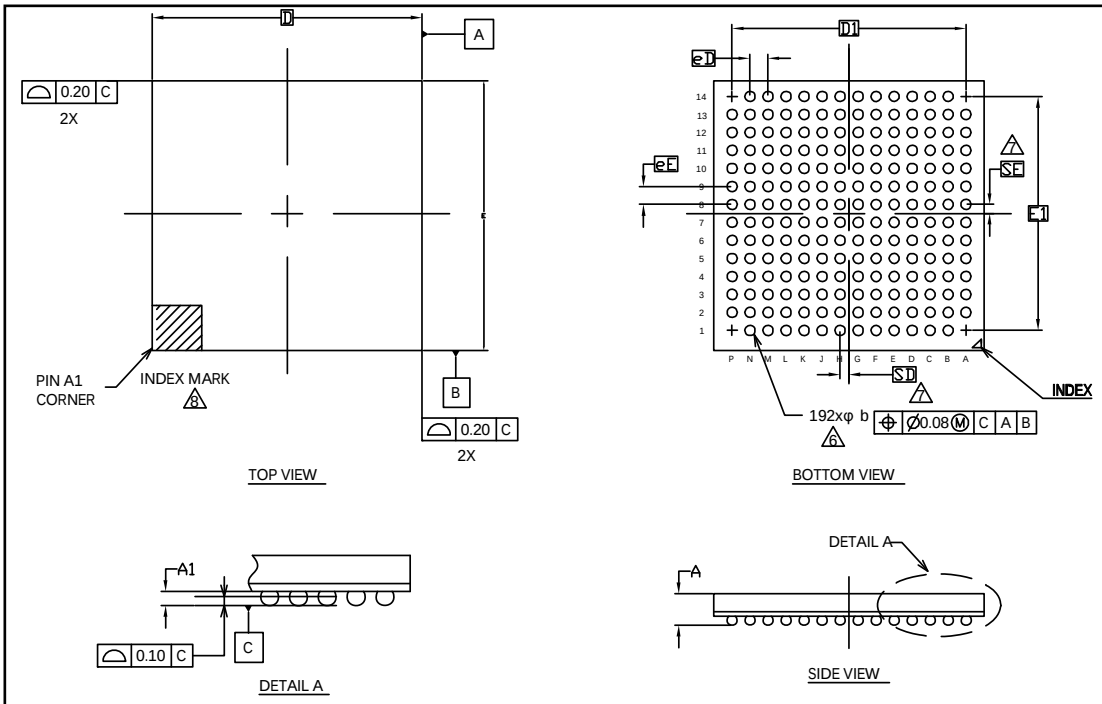
NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS
2. DATUM PLANE H IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.
3. DATUMS A-B AND D TO BE DETERMINED AT DATUM PLANE H.
4. TO BE DETERMINED AT SEATING PLANE C.
5. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25mm PRE SIDE. DIMENSIONS D1 AND E1 INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
6. DETAILS OF PIN 1 IDENTIFIER ARE OPTIONAL BUT MUST BE LOCATED WITHIN THE ZONE INDICATED.
7. REGARDLESS OF THE RELATIVE SIZE OF THE UPPER AND LOWER BODY SECTIONS. DIMENSIONS D1 AND E1 ARE DETERMINED AT THE LARGEST FEATURE OF THE BODY EXCLUSIVE OF MOLD FLASH AND GATE BURRS. BUT INCLUDING ANY MISMATCH BETWEEN THE UPPER AND LOWER SECTIONS OF THE MOLDER BODY.
8. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. THE DAMBAR PROTRUSION (S) SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED b MAXIMUM BY MORE THAN 0.08mm. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OR THE LEAD FOOT.
9. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.10mm AND 0.25mm FROM THE LEAD TIP.
10. A1 IS DEFINED AS THE DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT OF THE PACKAGE BODY.

PACKAGE OUTLINE, 144 LEAD LQFP
20.0X20.0X1.7 MM LQS144 REV*A

002-13015 *A

| Package Type | Package Code |
|---|---|
| FBGA 192 | LBE192 |




| SYMBOL | DIMENSIONS | | |
|---|---|---|---|
| | MIN. | NOM. | MAX. |
| A | —— | —— | 1.45 |
| A1 | 0.25 | 0.35 | 0.45 |
| D | 12.00 BSC | | |
| E | 12.00 BSC | | |
| D1 | 10.40 BSC | | |
| E 1 | 10.40 BSC | | |
| MD | 14 | | |
| ME | 14 | | |
| n | 192 | | |
| Φb | 0.35 | 0.45 | 0.55 |
| eD | 0.80 BSC | | |
| eE | 0.80 BSC | | |
| SD / SE | 0.40 BSC | | |

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS AND TOLERANCES METHODS PER ASME Y14.5-2009. THIS OUTLINE CONFORMS TO JEP95, SECTION 4.5.
3. BALL POSITION DESIGNATION PER JEP95, SECTION 3, SPP-010.
4. "e" REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL MATRIX SIZE IN THE "D" DIRECTION. SYMBOL "ME" IS THE BALL MATRIX SIZE IN THE "E" DIRECTION. n IS THE NUMBER OF POPULATED SOLDER BALL POSITIONS FOR MATRIX SIZE MD X ME.

6. DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.

7. "SD" AND "SE" ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW. WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW, "SD" OR "SE" =0. WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, "SD" = eD/2 AND "SE" = eE/2.

8. A1 CORNER TO BE IDENTIFIED BY CHAMFER, LASER OR INK MARK. METALLIZED MARK INDENTATION OR OTHER MEANS.

9. "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED BALLS.

PACKAGE OUTLINE, 192 BALL FBGA
12.00X12.00X1.45 MM LBE192 REV**

002-13493 **

## 15. Major Changes

**Spansion Publication Number: DS706-00019**

| Page | Section | Change Results |
|---|---|---|
| Revision 1.0 | | |
| - | - | Initial release |
| - | - | Preliminary → Datasheet |
| 3 | FEATURES<br>Multi-function Serial Interface<br>(Max 8channels) | Revised the following description.<br>"4 channels with 16-byte FIFO"<br>"4 channels with 16steps×9-bit FIFO" |
| 7 | PRODUCT LINEUP<br>Multi-function Serial Interface<br>(UART/CSIO/LIN/I$^2$C) | Added the following description.<br>"ch.4 to ch.7: FIFO (16steps × 9-bit)<br>ch.0 to ch.3: No FIFO" |
| 9 to 11 | PIN ASSIGNMENT | Added the description of "Note". |
| 54 | I/O CIRCUIT TYPE | Added the following description to "Type H".<br>$I_{OH}$ = -20.5mA, $I_{OL}$ = 18.5mA |
| 62, 63 | HANDLING DEVICES | Revised the description of "•C pin".<br>Added the description of "Base Timer". |
| 64 | BLOCK DIAGRAM | Corrected the figure.<br>TIOA: input → input/output<br>TIOB: output → input |
| 75 | ELECTRICAL CHARACTERISTICS<br>2. Recommended Operating Conditions | Corrected the value of "Analog reference voltage (AVRH)".<br>Min: $AV_{SS}$ → 2.7V<br>Added the "Smoothing capacitor ($C_S$)".<br>Added the footnote. |
| 77 | 3. DC Characteristics<br>(1) Current Rating | Revised the value of "TBD".<br>Revised the unit.<br>Deleted "and estimated values." |
| 78, 79 | (2) Pin Characteristics | Deleted the footnote "*1". |
| 80 | 4. AC Characteristics<br>(1) Main Clock Input Characteristics | Revised the value of Input frequency ($F_{CH}$) at "Vcc ≥ 4.5V".<br>Max: 50 → 48<br>Added "Internal operating clock frequency ($F_{CM}$): Master clock". |
| 82 | (4-1) Operating Conditions of Main and USB PLL (In the case of using main clock for input of PLL)<br>(4-2) Operating Conditions of Main PLL<br>(In the case of using high-speed internal CR) | Added "Main PLL clock frequency ($F_{CLKPLL}$)".<br>Added "USB/Ethernet clock frequency ($F_{CLKSPLL}$)". |
| 109 | 5. 12-bit A/D Converter<br>Electrical characteristics for the<br>A/D converter | Deleted "(Preliminary value)".<br>Added the Symbol.<br>Revised the value of "TBD".<br>Corrected the parameter and value as follows.<br>Full transition voltage<br>Full-scale transition voltage<br>Min : - 20 → AVRH - 20<br>Max : + 20 → AVRH + 20<br>Revised the maximum value of "Power supply current (analog + digital)":<br>A/D 1unit operation:<br>Typ: 0.47 → 0.57 / Max: 0.62 → 0.72<br>When A/D stops: Typ: 0.01 → 0.06<br>Revised the value of "Reference power supply current (between AVRH to AVSS)"<br>When A/D stops: Typ: 0.01 → 0.06 / Max: 1.6 → 4<br>Deleted the following Pin name.<br>- "Sampling time"<br>- "Compare clock cycle"<br>- "State transition time to operation permission"<br>- "Analog input capacity"<br>- "Analog input resistance"<br>Corrected the value of "Compare clock cycle (Tcck)".<br>Max: 10000 → 2000 |

| Page | Section | Change Results |
|---|---|---|
| 116 | 7. Low-voltage Detection Characteristics<br>(2) Interrupt of Low-voltage Detection | Corrected the value of "LVD stabilization wait time ($T_{LVDW}$)".<br>Max: 2240×tcyc → 4032×$t_{CYCP}$ |
| 117 | 8. Flash Memory Write/Erase Characteristics<br>Erase/write cycles and data hold time | Deleted "(targeted value)". |
| Revision 1.1 | | |
| - | - | Company name and layout design change |
| Revision 2.0 | | |
| 2 | Features<br>External Bus Interface | Added the description of Maximum area size |
| 2 | Features<br>USB Interface | Added the description of PLL for USB |
| 2 | Features<br>USB Interface | Added the size of each EndPoint |
| 9, 10 | Pin Assignment | Added SWCLK and SWDIO and SWO |
| 51 to 56 | I/O Circuit Type | Added the description of $I^2C$ to the type of E, F, I, L<br>Added about +B input |
| 61 | Handling Devices | Added "Stabilizing power supply voltage" |
| 61 | Handling Devices<br>Crystal oscillator circuit | Added the following description<br>"Evaluate oscillation of your using crystal oscillator by your mount board." |
| 62 | Handling Devices<br>C Pin | Changed the description |
| 64 | Block Diagram | Modified the block diagram |
| 66 | Memory Map<br>Memory map(1) | Modified the area of "External Device Area" |
| 67 | Memory Map<br>Memory map(2) | Added the summary of Flash memory sector and the note |
| 74, 75 | Electrical Characteristics<br>1. Absolute Maximum Ratings | Added the Clamp maximum current<br>Added the output current of P80, P81, P82, P83<br>Added about +B input |
| 76 | Electrical Characteristics<br>2. Recommended Operation Conditions | Modified the minimum value of Analog reference voltage<br>Added Smoothing capacitor<br>Added the note about less than the minimum power supply voltage |
| 77, 78 | Electrical Characteristics<br>3. DC Characteristics<br>(1) Current rating | Changed the table format<br>Added Main TIMER mode current<br>Added Flash Memory Current<br>Moved A/D Converter Current |
| 82 | Electrical Characteristics<br>4. AC Characteristics<br>(3) Built-in CR Oscillation Characteristics | Added Frequency stability time at Built-in high-speed CR |
| 84 | Electrical Characteristics<br>4. AC Characteristics<br>(6) Power-on Reset Timing | Added Time until releasing Power-on reset<br>Changed the figure of timing |
| 86 to 88 | Electrical Characteristics<br>4. AC Characteristics<br>(7) External Bus Timing | Modified Data output time |
| 95 to 102 | Electrical Characteristics<br>4. AC Characteristics<br>(9) CSIO/UART Timing | Modified from UART Timing to CSIO/UART Timing<br>Changed from Internal shift clock operation to Master mode<br>Changed from External shift clock operation to Slave mode |
| 109 | Electrical Characteristics<br>5. 12bit A/D Converter | Added the typical value of Integral Nonlinearity, Differential Nonlinearity, Zero transition voltage and Full-scale transition voltage<br>Added Conversion time at AVcc < 4.5 V<br>Modified Stage transition time to operation permission<br>Modified the minimum value of Reference voltage |
| 118 to 121 | Electrical Characteristics<br>9. Return Time from Low-Power Consumption Mode | Added Return Time from Low-Power Consumption Mode |
| 122 | Ordering Information | Change to full part number |

***Note:***

- *Please see "Document History" about later revised information.*

## Document History

**Document Title: MB9B510T Series 32-bit ARM® Cortex®-M3 FM3 Microcontroller**
**Document Number: 002-05602**

| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
|---|---|---|---|---|
| ** | - | TOYO | 03/18/2015 | Migrated to Cypress and assigned document number 002-05602.<br>No change to document contents or format. |
| *A | 5206259 | TOYO | 04/11/2016 | Updated to Cypress format. |
| *B | 5560212 | YSKA | 03/09/2017 | Updated “12.4.7 Power-On Reset Timing”. Changed parameter from “Power Supply rising time(Tr)[ms]” to “Power ramp rate(dV/dt)[mV/us]” and added some comments (Page 79)<br>Added Notes for JTAG (Page 47), Changed “J-TAG” to” JTAG” in “4 List of Pin Functions” (Page 29)<br>Updated Package code and dimensions as follows (Page 8-11, 70, 118-121)<br>FPT-144P-M08 -> LQS144, FPT-176P-M07 -> LQP176,<br>BGA-192P-M06 -> LBE192<br>Change the name from “USB Function” to “USB Device” (Page 1, 7, 45)<br>Corrected the following statement<br>Analog port input current → Analog port input leak current<br>in chapter 12.5. 12-bit A/D Converter (Page 105)<br>Added the Baud rate spec in “12.4.10 CSIO/UART Timing”.(Page 91, 93, 95, 97)<br>Deleted MPNs below from “13. Ordering Information” (Page 118)<br>MB9BF516SPMC-GE1, MB9BF516TBGL-GE1, MB9BF516TPMC-GE1,<br>MB9BF517SPMC-GE1, MB9BF517TBGL-GE1, MB9BF517TPMC-GE1,<br>MB9BF518SPMC-GE1, MB9BF518TBGL-GE1, MB9BF518TPMC-GE1<br>Added MPNs below to “13. Ordering Information” (Page 118)<br>MB9BF516SPMC-GK7E1, MB9BF516TBGL-GK7E1, MB9BF516TPMC-GK7E1,<br>MB9BF517SPMC-GK7E1, MB9BF517TBGL-GK7E1, MB9BF517TPMC-GK7E1,<br>MB9BF518SPMC-GK7E1, MB9BF518TBGL-GK7E1, MB9BF518TPMC-GK7E1 |
| *C | 5797514 | YSAT | 07/11/2017 | Adapted new Cypress logo |

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