# LC87FC096A

**CMOS IC**
**FROM 98K byte, RAM 4096 byte on-chip**

# 8-bit 1-chip Microcontroller

**ON Semiconductor®**

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## Overview

The LC87FC096A is an 8-bit microcomputer, integrates a number of hardware features such as 98K-byte flash ROM, 4096-byte RAM, On-chip debugging function, 16-bit timers/counter, four 8-bit timers, a 16-bit timer, a base timer serving as a time-of-day clock, a high-speed clock counter, a synchronous SIO interface (with automatic block transmission/reception capabilities), an asynchronous/synchronous SIO port, two UART ports, a single master $I^2C$/synchronous SIO interface, an 11-channel AD converter, four PWM channels, a system clock frequency divider, a infrared remote controller receiver function, and interrupt feature.

## Features

■Flash ROM
- $100352 \times 8$ bits
  (Address: 00000H to 17FFFH, 1F800H to 1FFFFH)
- Capable of on-board-programing with 2.7 to 3.6V, of voltage source.
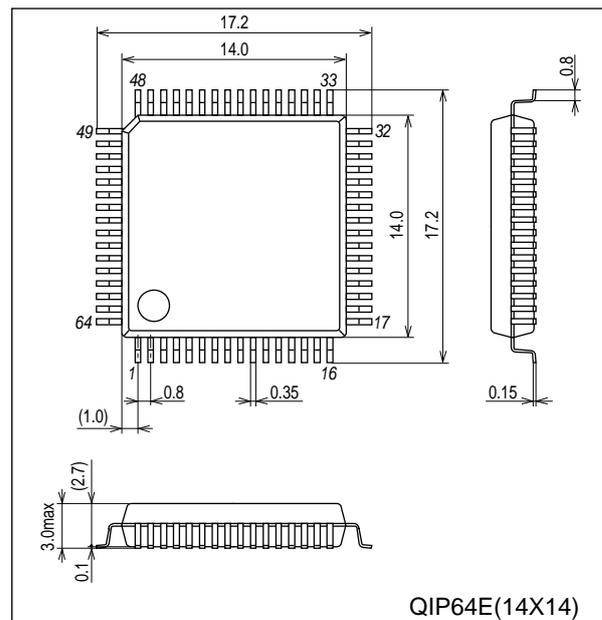- Block-erasable in 2K byte units

■RAM
- $4096 \times 9$ bits (LC87FC096A)

■Package Form
- QIP64E (14×14):
  Lead-free and halogen-free type

## Package Dimensions

unit : mm (typ)
3159A



QIP64E(14X14)

■Minimum Bus Cycle
- 83.3ns (12MHz)  $V_{DD}$=2.7 to 3.6V
- 125ns (8MHz)  $V_{DD}$=2.5 to 3.6V
    Note: The bus cycle time here refers to the ROM read speed.

■Minimum Instruction Cycle Time
- 250ns (12MHz)  $V_{DD}$=2.7V to 3.6V
- 375ns (8MHz)  $V_{DD}$=2.5V to 3.6V

■Ports
- Normal withstand voltage I/O ports
    Ports whose I/O direction can be designated in 1-bit units   46 (P1n, P2n, P3n, P70 to P73, P80 to P86, PCn,
                                                                        PWM2, PWM3, XT2)
    Ports whose I/O direction can be designated in 4-bit units   8 (P0n)
- Normal withstand voltage input port   1 (XT1)
- Dedicated oscillator ports   2 (CF1, CF2)
- Reset pins   1 ($\overline{RES}$)
- Power pins   6($V_{SS}$1 to 3, $V_{DD}$1 to 3)

■Timers
- Timer 0:16-bit timer/counter with a capture register
        Mode 0:8-bit timer with an 8-bit programmable prescaler (with an 8-bit capture register) × 2 channels
        Mode 1:8-bit timer with an 8-bit programmable prescaler (with an 8-bit capture register)
                + 8-bit counter (with an 8-bit capture register)
        Mode 2:16-bit timer with an 8-bit programmable prescaler (with a 16-bit capture register)
        Mode 3:16-bit counter (with a 16-bit capture register)
- Timer 1:16-bit timer/counter that supports PWM/toggle outputs
        Mode 0:8-bit timer with an 8-bit prescaler (with toggle outputs) + 8-bit timer/
                counter with an 8-bit prescaler (with toggle outputs)
        Mode 1:8-bit PWM with an 8-bit prescaler × 2 channels
        Mode 2:16-bit timer/counter with an 8-bit prescaler (with toggle outputs)
                (toggle outputs also possible from the lower-order 8 bits)
        Mode 3:16-bit timer with an 8-bit prescaler (with toggle outputs)
                (The lower-order 8 bits can be used as PWM)
- Timer 4:8-bit timer with a 6-bit prescaler
- Timer 5:8-bit timer with a 6-bit prescaler
- Timer 6:8-bit timer with a 6-bit prescaler (with toggle outputs)
- Timer 7:8-bit timer with a 6-bit prescaler (with toggle outputs)
- Timer A:16-bit timer
        Mode 0:8-bit timer with an 8-bit programmable prescaler × 2-channels
        Mode 1:16-bit timer with an 8-bit programmable prescaler
- Base timer
    1) The clock is selectable from the subclock (32.768kHz crystal oscillation), system clock, and timer 0 prescaler
       output.
    2) Interrupts programmable in 5 different time schemes

■High-Speed Clock Counter
- Can count clocks with a maximum clock rate of 24MHz (at a main clock of 12MHz)
- Can generate output real-time

■SIO
- SIO0:8-bit Synchronous serial interface
  1) LSB first/MSB first mode selectable
  2) Built-in 8-bit baudrate generator (maximum transfer clock cycle=4/3tCYC)
  3) Automatic continuous data transmission (1 to 256 bits, specifiable in 1 bit units, suspension and resumption of data transmission possible in 1 byte units)
- SIO1:8-bit asynchronous/synchronous serial interface
  Mode 0:Synchronous 8-bit serial I/O (2- or 3-wire configuration, 2 to 512 tCYC transfer clocks)
  Mode 1:Asynchronous serial I/O (half-duplex, 8 data bits, 1 stop bit, 8 to 2048 tCYC baudrates)
  Mode 2:Bus mode 1 (start bit, 8 data bits, 2 to 512 tCYC transfer clocks)
  Mode 3:Bus mode 2 (start detect, 8 data bits, stop detect)
- SMIIC0:Single master $I^2C$/8-bit synchronous SIO
  Mode 0:Single-master mode communication
  Mode 1:Synchronous 8-bit serial I/O (MSB first)

■UART: 2 channels
- Full duplex
- 7/8/9 bit data bits selectable
- 1 stop bit (2-bit in continuous data transmission)
- Built-in baudrate generator (with baudrates of 16/3 to 8192/3 tCYC)

■AD Converter: 12 bits × 11 channels

■PWM: Multifrequency 12-bit PWM × 4-channels

■Remote Control Receiver Circuit (sharing pins with P73, INT3, and T0IN)
- Noise filtering function (noise filter time constant selectable from 1 tCYC, 32 tCYC, and 128 tCYC)
- The noise filtering function is available for the INT3, T0IN, or T0HCP signal at P73. When P73 is read with an instruction, the signal level at that pin is read regardless of the availability of the noise filtering function.

■Infrared Remote Controller Receiver Circuit
- Noise rejection function (noise filter time constant: Approx. 120μs when the 32.768kHz crystal oscillator is selected as the reference clock source)
- Supports data encording systems such as PPM (Pulse Position Modulation) and Manchester encording
- X'tal HOLD mode release function

■Watchdog Timer
- External RC watchdog timer
- Interrupt and reset signals selectable

■Clock Output Function
- Able to output selected oscillation clock 1/1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64 as system clock.
- Able to output oscillation clock of sub clock.

■Interrupts
- 31 sources, 10 vector addresses
  1) Provides three levels (low (L), high (H), and highest (X)) of multiplex interrupt control. Any interrupt requests of the level equal to or lower than the current interrupt are not accepted.
  2) When interrupt requests to two or more vector addresses occur at the same time, the interrupt of the highest level takes precedence over the other interrupts. For interrupts of the same level, the interrupt into the smallest vector address takes precedence.

| No. | Vector Address | Level | Interrupt Source |
|-----|----------------|-------|------------------|
| 1 | 00003H | X or L | INT0 |
| 2 | 0000BH | X or L | INT1 |
| 3 | 00013H | H or L | INT2/T0L/INT4/TAL/Infrared remote control receiver |
| 4 | 0001BH | H or L | INT3/INT5/base timer0/base timer1 |
| 5 | 00023H | H or L | T0H/INT6/TAH |
| 6 | 0002BH | H or L | T1L/T1H/INT7/SMIIC0 |
| 7 | 00033H | H or L | SIO0/UART1 receive/ UART2 receive |
| 8 | 0003BH | H or L | SIO1/UART1 transmit/ UART2 transmit |
| 9 | 00043H | H or L | ADC/T6/T7 |
| 10 | 0004BH | H or L | Port 0/T4/T5/PWM2, PWM3/RMPWM |

- Priority levels X > H > L
- Of interrupts of the same level, the one with the smallest vector address takes precedence.

■Subroutine Stack Levels: 2048 levels (the stack is allocated in RAM)

■High-speed Multiplication/Division Instructions
- 16 bits × 8 bits        (5 tCYC execution time)
- 24 bits × 16 bits       (12 tCYC execution time)
- 16 bits ÷ 8 bits        (8 tCYC execution time)
- 24 bits ÷ 16 bits       (12 tCYC execution time)

■Oscillation Circuits
- RC oscillation circuit (internal):        For system clock
- CF oscillation circuit:                   For system clock, with internal Rf
- Crystal oscillation circuit:              For low-speed system clock

■System Clock Divider Function
- Can run on low current.
- The minimum instruction cycle selectable from 250ns, 500ns, 1.0μs, 2.0μs, 4.0μs, 8.0μs, 16.0μs, 32.0μs, and 64.0μs (at a main clock rate of 12MHz).

■Standby Function
- HALT mode: Halts instruction execution while allowing the peripheral circuits to continue operation.
  1) Oscillation is not halted automatically.
  2) Canceled by a system reset or occurrence of an interrupt.
- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.
  1) The CF, RC, and crystal oscillators automatically stop operation.
  2) There are three ways of resetting the HOLD mode.
     (1) Setting the reset pin to the low level
     (2) Setting at least one of the INT0, INT1, INT2, INT4, and INT5 pins to the specified level
     (3) Having an interrupt source established at port 0

Continued from preceding page.

- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer and infrared remote controller receiver circuit.
  1) The CF and RC oscillators automatically stop operation.
  2) The state of crystal oscillation established when the X'tal HOLD mode is entered is retained.
  3) There are four ways of resetting the X'tal HOLD mode.
     (1) Setting the reset pin to the low level
     (2) Setting at least one of the INT0, INT1, INT2, INT4, and INT5 pins to the specified level
     (3) Having an interrupt source established at port 0
     (4) Having an interrupt source established in the base timer circuit
     (5) Having an interrupt source established in the infrared remote controller receiver circuit

■On-chip Debugger Function
- Permits software debugging with the test device installed on the target board.

■Development Tools
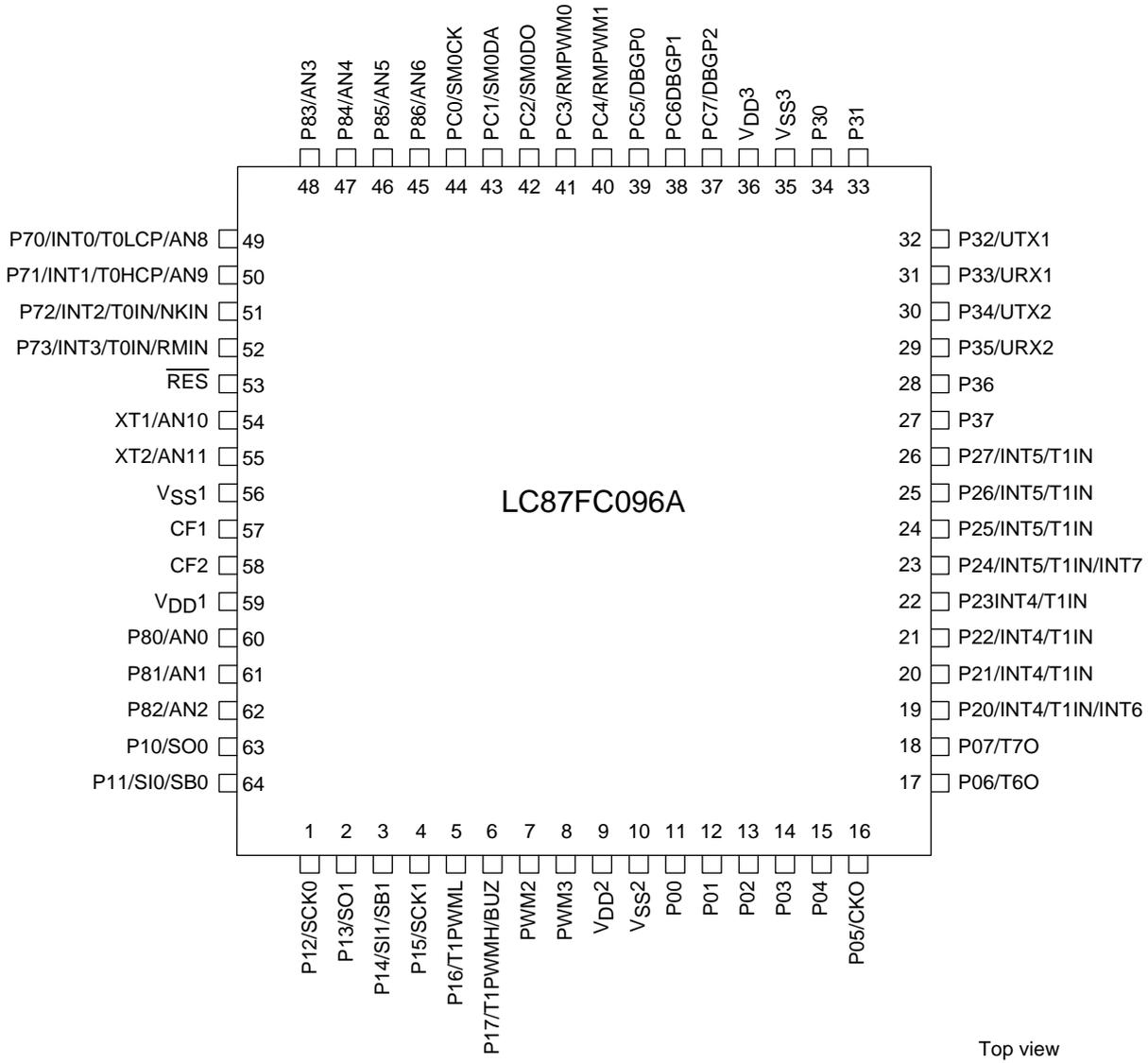- On-chip debugger:  TCB87-TypeC (3wire version) + LC87FC096A

■Programming Boards

| Package | Programming boards |
|---------|--------------------|
| QIP64E  | W87F50256Q         |

■Flash ROM Programmer

| Maker | Model | Supported version | Device |
|-------|-------|-------------------|--------|
| Our company | SKK/SKK Type-B/SKK DBG Type-B (SANYO FWS) | Application Version: After 1.08 Chip Data Version: After 2.42 | LC87FC096 |

## Pin Assignment
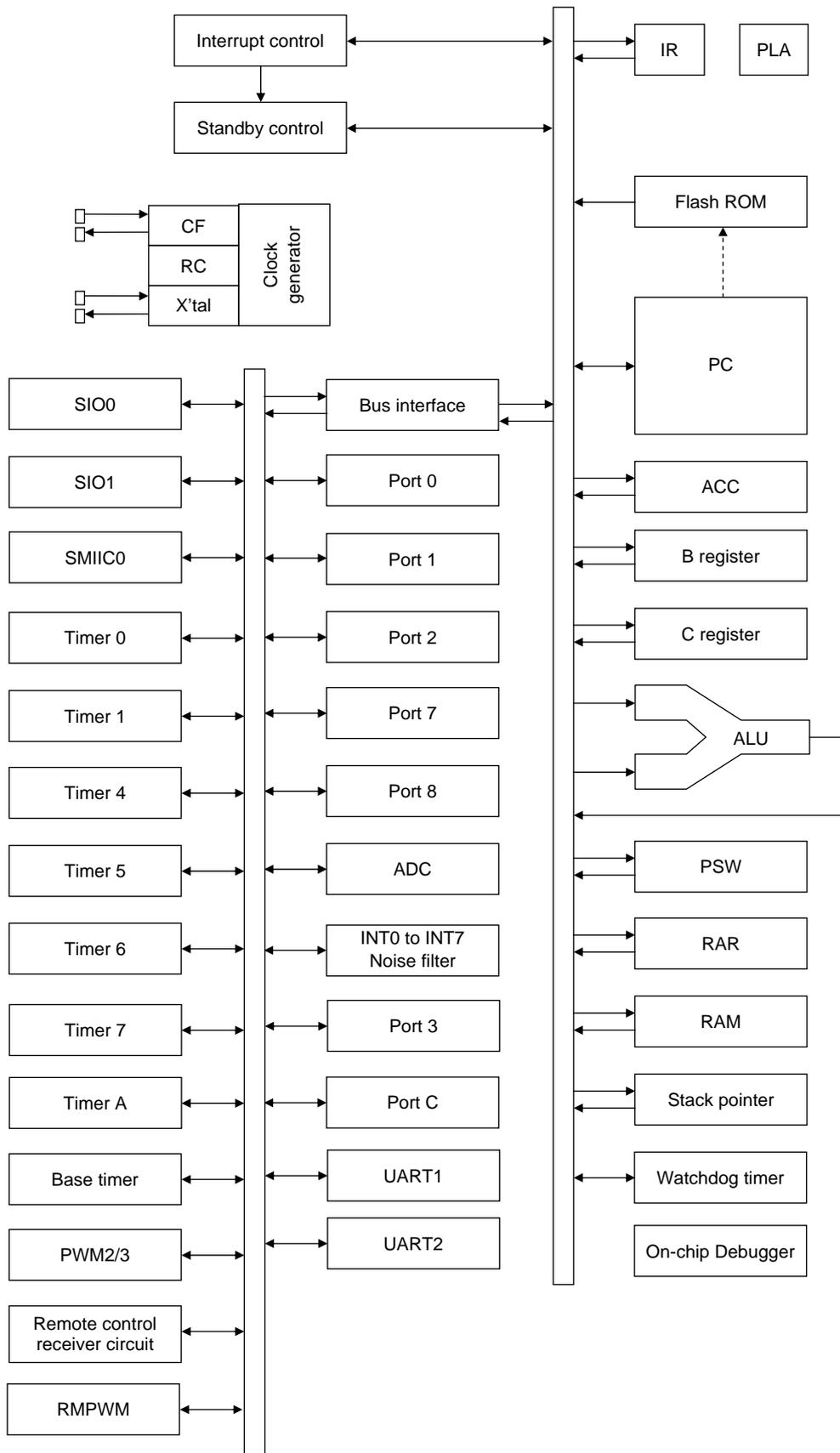
| Pin | Left side | | Pin | Right side |
|---|---|---|---|---|
| 49 | P70/INT0/T0LCP/AN8 | | 32 | P32/UTX1 |
| 50 | P71/INT1/T0HCP/AN9 | | 31 | P33/URX1 |
| 51 | P72/INT2/T0IN/NKIN | | 30 | P34/UTX2 |
| 52 | P73/INT3/T0IN/RMIN | | 29 | P35/URX2 |
| 53 | $\overline{\text{RES}}$ | | 28 | P36 |
| 54 | XT1/AN10 | | 27 | P37 |
| 55 | XT2/AN11 | | 26 | P27/INT5/T1IN |
| 56 | $V_{SS}1$ | | 25 | P26/INT5/T1IN |
| 57 | CF1 | | 24 | P25/INT5/T1IN |
| 58 | CF2 | | 23 | P24/INT5/T1IN/INT7 |
| 59 | $V_{DD}1$ | | 22 | P23INT4/T1IN |
| 60 | P80/AN0 | | 21 | P22/INT4/T1IN |
| 61 | P81/AN1 | | 20 | P21/INT4/T1IN |
| 62 | P82/AN2 | | 19 | P20/INT4/T1IN/INT6 |
| 63 | P10/SO0 | | 18 | P07/T7O |
| 64 | P11/SI0/SB0 | | 17 | P06/T6O |

Top pins (48–33): P83/AN3, P84/AN4, P85/AN5, P86/AN6, PC0/SM0CK, PC1/SM0DA, PC2/SM0DO, PC3/RMPWM0, PC4/RMPWM1, PC5/DBGP0, PC6DBGP1, PC7/DBGP2, $V_{DD}3$, $V_{SS}3$, P30, P31

Bottom pins (1–16): P12/SCK0, P13/SO1, P14/SI1/SB1, P15/SCK1, P16/T1PWML, P17/T1PWMH/BUZ, PWM2, PWM3, $V_{DD}2$, $V_{SS}2$, P00, P01, P02, P03, P04, P05/CKO

LC87FC096A

Top view

QIP64E (14×14) "Lead-free and halogen-free type"

## System Block Diagram

## Pin Description

| Pin Name | I/O | Description | Option |
|---|---|---|---|
| $V_{SS}1$, $V_{SS}2$, $V_{SS}3$ | - | - Power supply pin | No |
| $V_{DD}1$, $V_{DD}2$, $V_{DD}3$ | - | + Power supply pin | No |
| Port 0<br><br>P00 to P07 | I/O | • 8-bit I/O port<br>• I/O specifiable in 4-bit units<br>• Pull-up resistor can be turned on and off in 4-bit units<br>• HOLD release input<br>• Port 0 interrupt input<br>• Shared Pins<br>  P05 : Clock output (system clock / can selected from sub clock)<br>  P06 : Timer 6 toggle output<br>  P07 : Timer 7 toggle output | Yes |
| Port 1<br><br>P10 to P17 | I/O | • 8-bit I/O port<br>• I/O specifiable in 1-bit units<br>• Pull-up resistor can be turned on and off in 1-bit units<br>• Pin functions<br>  P10 : SIO0 data output<br>  P11 : SIO0 data input/bus I/O<br>  P12 : SIO0 clock I/O<br>  P13 : SIO1 data output<br>  P14 : SIO1 data input/bus I/O<br>  P15 : SIO1 clock I/O<br>  P16 : Timer 1 PWML output<br>  P17 : Timer 1 PWMH output/beeper output | Yes |
| Port 2<br><br>P20 to P27 | I/O | • 8-bit I/O port<br>• I/O specifiable in 1-bit units<br>• Pull-up resistor can be turned on and off in 1-bit units<br>• Other functions<br>  P20: INT4 input/HOLD reset input/timer 1 event input/timer 0L capture input/<br>      timer 0H capture input/INT6 input/timer 0L capture 1 input<br>  P21 to P23: INT4 input/HOLD reset input/timer 1 event input/timer 0L capture input/<br>          timer 0H capture input<br>  P24: INT5 input/HOLD reset input/timer 1 event input/timer 0L capture input/<br>      timer 0H capture input/INT7 input/timer 0H capture 1 input<br>  P25 to P27: INT5 input/HOLD reset input/timer 1 event input/timer 0L capture input/<br>          timer 0H capture input<br>• Interrupt acknowledge type | Yes |

|  | Rising | Falling | Rising/Falling | H level | L level |
|---|---|---|---|---|---|
| INT4 | enable | enable | enable | disable | disable |
| INT5 | enable | enable | enable | disable | disable |
| INT6 | enable | enable | enable | disable | disable |
| INT7 | enable | enable | enable | disable | disable |

Continued from preceding page.

| Pin Name | I/O | Description | Option |
|---|---|---|---|
| Port 7<br><br>P70 to P73 | I/O | • 4-bit I/O port<br>• I/O specifiable in 1-bit units<br>• Pull-up resistor can be turned on and off in 1-bit units<br>• Shared pins<br>  P70 : INT0 input/HOLD reset input/timer 0L capture input/watchdog timer output<br>  P71 : INT1 input/HOLD reset input/timer 0H capture input<br>  P72 : INT2 input/HOLD reset input/timer 0 event input/timer 0L capture input/<br>      high speed clock counter input<br>  P73 : INT3 input (with noise filter)/timer 0 event input/timer 0H capture input/<br>      remote control receiver input<br>  AD converter input port: AN8 (P70), AN9 (P71)<br>• Interrupt acknowledge type<br><br>| No |

Interrupt acknowledge type:

| | Rising | Falling | Rising/Falling | H level | L level |
|---|---|---|---|---|---|
| INT0 | enable | enable | disable | enable | enable |
| INT1 | enable | enable | disable | enable | enable |
| INT2 | enable | enable | enable | disable | disable |
| INT3 | enable | enable | enable | disable | disable |

| Pin Name | I/O | Description | Option |
|---|---|---|---|
| Port 8<br><br>P80 to P86 | I/O | • 7-bit I/O port<br>• I/O specifiable in 1-bit units<br>• Shared pins<br>  AD converter input port : AN0 (P80) to AN6 (P86) | No |
| PWM2<br>PWM3 | I/O | • PWM2 and PWM3 output ports<br>• General-purpose I/O available | No |
| Port 3<br><br>P30 to P37 | I/O | • 8-bit I/O port<br>• I/O specifiable in 1-bit units<br>• Pull-up resistor can be turned on and off in 1-bit units<br>• Pin functions<br>  P32: UART1 transmit<br>  P33: UART1 receive<br>  P34: UART2 transmit<br>  P35: UART2 receive | Yes |
| Port C<br><br>PC0 to PC7 | I/O | • 8-bit I/O port<br>• I/O specifiable in 1-bit units<br>• Pull-up resistor can be turned on and off in 1-bit units<br>• Pin functions<br>  PC0: SMIIC0 clock input/output<br>  PC1: SMIIC0 bus input/output/data input<br>  PC2: SMIIC0 data output (used in 3-wire SIO mode)<br>  PC3: RMPWM0 output<br>  PC4: RMPWM1 output<br>  PC5: DBGP0<br>  PC6: DBGP1<br>  PC7: DBGP2<br>  DBGP0 to DBGP2: On-chip Debugger | Yes |
| $\overline{\text{RES}}$ | Input | Reset pin | No |
| XT1 | Input | • 32.768kHz crystal oscillator input pin<br>• Shared pins<br>  General-purpose input port<br>  AD converter input port : AN10<br>Must be connected to VDD1 if not to be used. | No |
| XT2 | I/O | • 32.768kHz crystal oscillator output pin<br>• Shared pins<br>  General-purpose I/O port<br>  AD converter input port : AN11<br>Must be set for oscillation and kept open if not to be used. | No |
| CF1 | Input | Ceramic resonator input pin | No |
| CF2 | Output | Ceramic resonator output pin | No |

## Port Output Types

The table below lists the types of port outputs and the presence/absence of a pull-up resistor.
Data can be read into any input port even if it is in the output mode.

| Port Name | Option Selected in Units of | Option Type | Output Type | Pull-up Resistor |
|---|---|---|---|---|
| P00 to P07 | 1 bit | 1 | CMOS | Programmable (Note 1) |
| | | 2 | Nch-open drain | No |
| P10 to P17 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| P20 to P27 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| P70 | - | No | Nch-open drain | Programmable |
| P71 to P73 | - | No | CMOS | Programmable |
| P80 to P86 | - | No | Nch-open drain | No |
| PWM2, PWM3 | - | No | CMOS | No |
| P30 to P37 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| PC0 to PC7 | 1 bit | 1 | CMOS | Programmable |
| | | 2 | Nch-open drain | Programmable |
| XT1 | - | No | Input for 32.768kHz crystal oscillator (Input only) | No |
| XT2 | - | No | Output for 32.768kHz crystal oscillator (Nch-open drain when in general-purpose output mode) | No |

Note 1:Programmable pull-up resistors for port 0 are controlled in 4-bit units (P00 to 03, P04 to 07).

*1: Make the following connection to minimize the noise input to the $V_{DD}1$ pin and prolong the backup time.
Be sure to electrically short the $V_{SS}1$, $V_{SS}2$ and $V_{SS}3$ pins.

(Example 1) When backup is active in the HOLD mode, the high level of the port outputs is supplied by the backup capacitors.
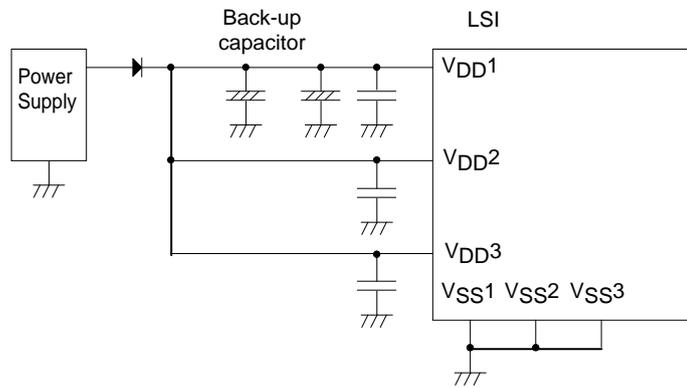


(Example 2) The high-level output at the ports is unstable when the HOLD mode backup is in effect.
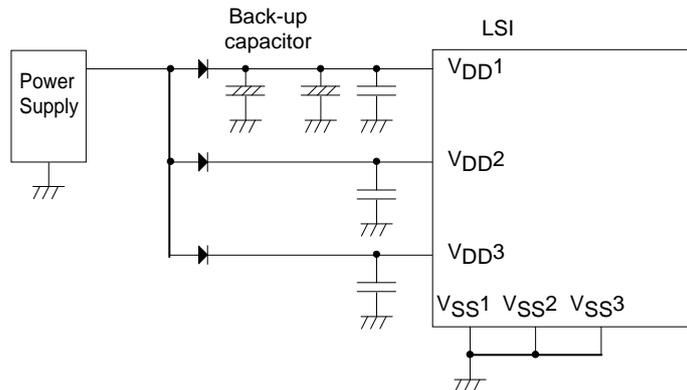
## Absolute Maximum Ratings at Ta = 25°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

| Parameter | | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $V_{DD}$ [V] | min | typ | max | unit |
| Maximum supply voltage | | $V_{DD}$ max | $V_{DD}1$, $V_{DD}2$, $V_{DD}3$ | $V_{DD}1=V_{DD}2=V_{DD}3$ | | -0.3 | | +4.6 | V |
| Input voltage | | VI(1) | XT1, CF1 | | | -0.3 | | $V_{DD}$+0.3 | |
| Input/output voltage | | VIO(1) | Ports 0, 1, 2 / Ports 7, 8 / Ports 3, C / PWM2, PWM3, XT2 | | | -0.3 | | $V_{DD}$+0.3 | |
| High level output current | Peak output current | IOPH(1) | Ports 0, 1, 2 / Ports 3, C | CMOS output select / Per 1 applicable pin | | -7.5 | | | |
| | | IOPH(2) | PWM2, PWM3 | Per 1 applicable pin | | -12.5 | | | |
| | | IOPH(3) | P71 to P73 | Per 1 applicable pin | | -4.5 | | | |
| | Mean output current (Note 1-1) | IOMH(1) | Ports 0, 1, 2 / Ports 3, C | CMOS output select / Per 1 applicable pin | | -5 | | | |
| | | IOMH(2) | PWM2, PWM3 | Per 1 applicable pin | | -10 | | | |
| | | IOMH(3) | P71 to P73 | Per 1 applicable pin | | -3 | | | |
| | Total output current | ΣIOAH(1) | P71 to P73 | Total of all applicable pins | | -10 | | | |
| | | ΣIOAH(2) | Port 1 / PWM2, PWM3 | Total of all applicable pins | | -15 | | | |
| | | ΣIOAH(3) | Ports 0, 2 | Total of all applicable pins | | -15 | | | |
| | | ΣIOAH(4) | Ports 0, 1, 2 / PWM2, PWM3 | Total of all applicable pins | | -30 | | | |
| | | ΣIOAH(5) | Port 3 | Total of all applicable pins | | -15 | | | |
| | | ΣIOAH(6) | Port C | Total of all applicable pins | | -15 | | | |
| | | ΣIOAH(7) | Ports 3, C | Total of all applicable pins | | -30 | | | |
| Low level output current | Peak output current | IOPL(1) | P02 to P07 / Ports 1, 2 / Ports 3, C / PWM2, PWM3 | Per 1 applicable pin | | | | 10 | mA |
| | | IOPL(2) | P00, P01 | Per 1 applicable pin | | | | 15 | |
| | | IOPL(3) | Ports 7, 8, XT2 | Per 1 applicable pin | | | | 7.5 | |
| | Mean output current (Note 1-1) | IOML(1) | P02 to P07 / Ports 1, 2 / Ports 3, C / PWM2, PWM3 | Per 1 applicable pin | | | | 7.5 | |
| | | IOML(2) | P00, P01 | Per 1 applicable pin | | | | 10 | |
| | | IOML(3) | Ports 7, 8, XT2 | Per 1 applicable pin | | | | 5 | |
| | Total output current | ΣIOAL(1) | Port 7 / P83 to P86, XT2 | Total of all applicable pins | | | | 15 | |
| | | ΣIOAL(2) | P80 to P82 | Total of all applicable pins | | | | 10 | |
| | | ΣIOAL(3) | Ports 7, 8, XT2 | Total of all applicable pins | | | | 25 | |
| | | ΣIOAL(4) | Port 1 / PWM2, PWM3 | Total of all applicable pins | | | | 25 | |
| | | ΣIOAL(5) | Ports 0, 2 | Total of all applicable pins | | | | 25 | |
| | | ΣIOAL(6) | Ports 0, 1, 2 / PWM2, PWM3 | Total of all applicable pins | | | | 50 | |
| | | ΣIOAL(7) | Port 3 | Total of all applicable pins | | | | 25 | |
| | | ΣIOAL(8) | Port C | Total of all applicable pins | | | | 25 | |
| | | ΣIOAL(9) | Ports 3, C | Total of all applicable pins | | | | 50 | |
| Maximum power dissipation | | Pdmax | QIP64E(14×14) | Ta=-40 to +85°C | | | | 300 | mW |
| Operating ambient temperature | | Topr | | | | -40 | | 85 | °C |
| Storage ambient temperature | | Tstg | | | | -55 | | 125 | |

Note 1-1: The mean output current is a mean value measured over 100ms.

## Allowable Operating Conditions at Ta = -40°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | VDD[V] | min | typ | max | unit |
| Operating supply voltage (Note 2-1) | $V_{DD}$ (1) | $V_{DD}1=V_{DD}2=V_{DD}3$ | $0.245\mu s \leq tCYC \leq 200\mu s$ | | 2.7 | | 3.6 | V |
| | | | $0.367\mu s \leq tCYC \leq 200\mu s$ | | 2.5 | | 3.6 | |
| Memory sustaining supply voltage | $V_{HD}$ | $V_{DD}1=V_{DD}2=V_{DD}3$ | RAM and register contents sustained in HOLD mode. | | 2.0 | | 3.6 | |
| High level input voltage | $V_{IH}(1)$ | Ports 1, 2 P71 to P73 P70 port input /interrupt side | | 2.5 to 3.6 | $0.3V_{DD}$ +0.7 | | $V_{DD}$ | |
| | $V_{IH}(2)$ | Ports 0, 8, 3, C PWM2, PWM3 | | 2.5 to 3.6 | $0.3V_{DD}$ +0.7 | | $V_{DD}$ | |
| | $V_{IH}(3)$ | Port 70 watchdog timer side | | 2.5 to 3.6 | $0.9V_{DD}$ | | $V_{DD}$ | |
| | $V_{IH}(4)$ | XT1, XT2, CF1, $\overline{RES}$ | | 2.5 to 3.6 | $0.75V_{DD}$ | | $V_{DD}$ | |
| Low level input voltage | $V_{IL}(1)$ | Ports 1, 2 P71 to P73 P70 port input/ interrupt side | | 2.5 to 3.6 | $V_{SS}$ | | $0.25V_{DD}$ | |
| | $V_{IL}(2)$ | Ports 0, 8, 3, C PWM2, PWM3 | | 2.5 to 3.6 | $V_{SS}$ | | $0.2V_{DD}$ | |
| | $V_{IL}(3)$ | Port 70 watchdog timer side | | 2.5 to 3.6 | $V_{SS}$ | | $0.8V_{DD}$ -1.0 | |
| | $V_{IL}(4)$ | XT1, XT2, CF1, $\overline{RES}$ | | 2.5 to 3.6 | $V_{SS}$ | | $0.25V_{DD}$ | |
| Instruction cycle time (Note 2-2) | tCYC | | | 2.7 to 3.6 | 0.245 | | 200 | μs |
| | | | | 2.5 to 3.6 | 0.367 | | 200 | |
| External system clock frequency | FEXCF(1) | CF1 | • CF2 pin open • System clock frequency division rate=1/1 • External system clock duty=50±5% | 2.7 to 3.6 | 0.1 | | 12 | MHz |
| | | | | 2.5 to 3.6 | 0.1 | | 8 | |
| | | | • CF2 pin open • System clock frequency division rate=1/2 | 2.7 to 3.6 | 0.2 | | 24 | |
| | | | | 2.5 to 3.6 | 0.2 | | 16 | |
| Oscillation frequency range (Note 2-3) | FmCF(1) | CF1, CF2 | 12MHz ceramic oscillation See Fig. 1. | 2.7 to 3.6 | | 12 | | MHz |
| | FmCF(2) | CF1, CF2 | 8MHz ceramic oscillation See Fig. 1. | 2.5 to 3.6 | | 8 | | |
| | FmRC | | Internal RC oscillation | 2.5 to 3.6 | 0.3 | 1.0 | 2.0 | |
| | FsX'tal | XT1, XT2 | 32.768kHz crystal oscillation See Fig. 2. | 2.5 to 2.6 | | 32.768 | | kHz |

Note 2-1: $V_{DD}$ must be held greater than or equal to 2.7V in the flash ROM onboard programming mode.

Note 2-2: Relationship between tCYC and oscillation frequency is 3/FmCF at a division ratio of 1/1 and 6/FmCF at a division ratio of 1/2.

Note 2-3: See Tables 1 and 2 for the oscillation constants.

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**Electrical Characteristics** at Ta = -40°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

| Parameter | Symbol | Pins | Conditions | $V_{DD}$[V] | min | typ | max | unit |
|---|---|---|---|---|---|---|---|---|
| High level input current | $I_{IH}(1)$ | Ports 0, 1, 2<br>Ports 7, 8<br>Ports 3, C<br>$\overline{RES}$<br>PWM2, PWM3 | Output disabled<br>Pull-up resistor off<br>$V_{IN}=V_{DD}$<br>(Including output Tr's off leakage current) | 2.5 to 3.6 | | | 1 | μA |
| | $I_{IH}(2)$ | XT1, XT2 | For input port specification<br>$V_{IN}=V_{DD}$ | 2.5 to 3.6 | | | 1 | |
| | $I_{IH}(3)$ | CF1 | $V_{IN}=V_{DD}$ | 2.5 to 3.6 | | | 15 | |
| Low level input current | $I_{IL}(1)$ | Ports 0, 1, 2<br>Ports 7, 8<br>Ports 3, C<br>$\overline{RES}$<br>PWM2, PWM3 | Output disabled<br>Pull-up resistor off<br>$V_{IN}=V_{SS}$<br>(Including output Tr's off leakage current) | 2.5 to 3.6 | -1 | | | |
| | $I_{IL}(2)$ | XT1, XT2 | For input port specification<br>$V_{IN}=V_{SS}$ | 2.5 to 3.6 | -1 | | | |
| | $I_{IL}(3)$ | CF1 | $V_{IN}=V_{SS}$ | 2.5 to 3.6 | -15 | | | |
| High level output voltage | $V_{OH}(1)$ | Ports 0, 1, 2 | $I_{OH}=-0.4mA$ | 3.0 to 3.6 | $V_{DD}$-0.4 | | | V |
| | $V_{OH}(2)$ | Ports 3, C | $I_{OH}=-0.2mA$ | 2.5 to 3.6 | $V_{DD}$-0.4 | | | |
| | $V_{OH}(3)$ | P71 to P73 | $I_{OH}=-0.4mA$ | 3.0 to 3.6 | $V_{DD}$-0.4 | | | |
| | $V_{OH}(4)$ | | $I_{OH}=-0.2mA$ | 2.5 to 3.6 | $V_{DD}$-0.4 | | | |
| | $V_{OH}(5)$ | PWM2, PWM3 | $I_{OH}=-1.6mA$ | 3.0 to 3.6 | $V_{DD}$-0.4 | | | |
| | $V_{OH}(6)$ | | $I_{OH}=-1mA$ | 2.5 to 3.6 | $V_{DD}$-0.4 | | | |
| Low level output voltage | $V_{OL}(1)$ | Ports 0, 1, 2<br>Ports 3, C<br>PWM2, PWM3 | $I_{OL}=1.6mA$ | 3.0 to 3.6 | | | 0.4 | V |
| | $V_{OL}(2)$ | | $I_{OL}=1mA$ | 2.5 to 3.6 | | | 0.4 | |
| | $V_{OL}(3)$ | Ports 7, 8<br>XT2 | $I_{OL}=1.6mA$ | 3.0 to 3.6 | | | 0.4 | |
| | $V_{OL}(4)$ | | $I_{OL}=1mA$ | 2.5 to 3.6 | | | 0.4 | |
| | $V_{OL}(5)$ | P00, P01 | $I_{OL}=5mA$ | 3.0 to 5.5 | | | 0.4 | |
| | $V_{OL}(6)$ | | $I_{OL}=2.5mA$ | 2.2 to 5.5 | | | 0.4 | |
| Pull-up resistance | Rpu(1) | Ports 0, 1, 2, 7<br>Ports 3, C | $V_{OH}=0.9V_{DD}$ | 3.0 to 3.6 | 15 | 35 | 80 | kΩ |
| | Rpu(2) | | | 2.5 to 3.6 | 15 | 35 | 100 | |
| Hysteresis voltage | VHYS | $\overline{RES}$<br>Ports 1, 2, 7 | | 2.5 to 3.6 | | 0.1 $V_{DD}$ | | V |
| Pin capacitance | CP | All pins | For pins other than that under test:<br>$V_{IN}=V_{SS}$<br>f=1MHz<br>Ta=25°C | 2.5 to 3.6 | | 10 | | pF |

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## Serial I/O Characteristics at Ta = -40°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

### 1. SIO0 Serial I/O Characteristics (Note 4-1-1)

| Parameter | | | Symbol | Pin/ Remarks | Conditions | $V_{DD}$ [V] | min | typ | max | unit |
|---|---|---|---|---|---|---|---|---|---|---|
| Serial clock | Input clock | Frequency | tSCK(1) | SCK0(P12) | See Fig. 6. | 2.5 to 3.6 | 2 | | | tCYC |
| | | Low level pulse width | tSCKL(1) | | | | 1 | | | |
| | | High level pulse width | tSCKH(1) | | | | 1 | | | |
| | | | tSCKHA(1) | | • Continuous data transmission/reception mode<br>• See Fig. 6.<br>• (Note 4-1-2) | | 4 | | | |
| | Output clock | Frequency | tSCK(2) | SCK0(P12) | • CMOS output selected<br>• See Fig. 6. | 2.5 to 3.6 | 4/3 | | | tCYC |
| | | Low level pulse width | tSCKL(2) | | | | | 1/2 | | tSCK |
| | | High level pulse width | tSCKH(2) | | | | | 1/2 | | tSCK |
| | | | tSCKHA(2) | | • Continuous data transmission/reception mode<br>• CMOS output selected<br>• See Fig. 6. | | tSCKH(2) +2tCYC | | tSCKH(2) +(10/3) tCYC | tCYC |
| Serial input | | Data setup time | tsDI(1) | SB0(P11), SI0(P11) | • Must be specified with respect to rising edge of SIOCLK.<br>• See Fig. 6. | 2.5 to 3.6 | 0.03 | | | |
| | | Data hold time | thDI(1) | | | 2.5 to 3.6 | 0.03 | | | |
| Serial output | Input clock | Output delay time | tdD0(1) | SO0(P10), SB0(P11) | • Continuous data transmission/reception mode<br>• (Note 4-1-3) | 2.5 to 3.6 | | | (1/3)tCYC +0.05 | μs |
| | | | tdD0(2) | | • Synchronous 8-bit mode<br>• (Note 4-1-3) | 2.5 to 3.6 | | | 1tCYC +0.05 | |
| | Output clock | | tdD0(3) | | (Note 4-1-3) | 2.5 to 3.6 | | | (1/3)tCYC +0.15 | |

Note 4-1-1: These specifications are theoretical values. Add margin depending on its use.

Note 4-1-2: To use serial-clock-input in continuous trans / rec mode, a time from SI0RUN being set when serial clock is "H" to the first negative edge of the serial clock must be longer than tSCKHA.

Note 4-1-3: Must be specified with respect to falling edge of SIOCLK. Must be specified as the time to the beginning of output state change in open drain output mode. See Fig. 6.

## 2. SIO1 Serial I/O Characteristics (Note 4-2-1)

| Parameter | | | Symbol | Pin/Remarks | Conditions | V$_{DD}$ [V] | Specification | | | unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | min | typ | max | |
| Serial clock | Input clock | Frequency | tSCK(3) | SCK1(P15) | See Fig. 6. | 2.5 to 3.6 | 2 | | | tCYC |
| | | Low level pulse width | tSCKL(3) | | | | 1 | | | |
| | | High level pulse width | tSCKH(3) | | | | 1 | | | |
| | Output clock | Frequency | tSCK(4) | SCK1(P15) | • CMOS output selected<br>• See Fig. 6. | 2.5 to 3.6 | 2 | | | tSCK |
| | | Low level pulse width | tSCKL(4) | | | | | 1/2 | | |
| | | High level pulse width | tSCKH(4) | | | | | 1/2 | | |
| Serial input | | Data setup time | tsDI(2) | SB1(P14),<br>SI1(P14) | • Must be specified with respect to rising edge of SIOCLK.<br>• See Fig. 6. | 2.5 to 3.6 | 0.03 | | | µs |
| | | Data hold time | thDI(2) | | | 2.5 to 3.6 | 0.03 | | | |
| Serial output | | Output delay time | tdD0(4) | SO1(P13),<br>SB1(P14) | • Must be specified with respect to falling edge of SIOCLK.<br>• Must be specified as the time to the beginning of output state change in open drain output mode.<br>• See Fig. 6. | 2.5 to 3.6 | | | (1/3)tCYC<br>+0.05 | |

Note 4-2-1: These specifications are theoretical values. Add margin depending on its use.

### 3-1. SMIIC0 Simple SIO Mode Input/Output Characteristics

| Parameter | | | Symbol | Applicable Pin/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $V_{DD}$[V] | min | typ | max | unit |
| Serial clock | Input clock | Period | tSCK (4) | SM0CK (PC0) | See Fig. 6. | 2.5 to 3.6 | 4/3 | | | tCYC |
| | | Low level pulse width | tSCKL (4) | | | | 2/3 | | | |
| | | High level pulse width | tSCKH (4) | | | | 2/3 | | | |
| | Output clock | Period | tSCK (5) | SM0CK (PC0) | • CMOS output selected <br> • See Fig. 6. | 2.5 to 3.6 | 4/3 | | | tSCK |
| | | Low level pulse width | tSCKL (5) | | | | | 1/2 | | |
| | | High level pulse width | tSCKH (5) | | | | | 1/2 | | |
| Serial input | | Data setup time | tsDI (3) | SM0DA (PC1) | • Specified with respect to rising edge of SIOCLK <br> • See Fig. 6. | 2.5 to 3.6 | 0.03 | | | µs |
| | | Data hold time | thDI (3) | | | | 0.03 | | | |
| Serial output | | Output delay time | tdD0 (5) | SM0DO (PC2), SM0DA (PC1) | • Specified with respect to falling edge of SIOCLK <br> • Specified as interval up to time when output state starts changing. <br> • See Fig. 6. | 2.5 to 3.6 | | | 1/3tCYC +0.05 | µs |

Note 4-3-1: These specifications are theoretical values. Add margin depending on its use.

## 3-2. SMIIC0 I2C Mode Input/Output Characteristics

| Parameter | | | Symbol | Applicable Pin/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | V$_{DD}$[V] | Min | typ | max | Unit |
| Clock | Input clock | Period | tSCL | SM0CK (PC0) | • See Fig. 8. | 2.5 to 3.6 | 5 | | | Tfilt |
| | | Low level pulse width | tSCLL | | | | 2.5 | | | |
| | | High level pulse width | tSCLH | | | | 2 | | | |
| | Output clock | Period | tSCLx | SM0CK (PC0) | • Specified as interval up to time when output state starts changing. | 2.5 to 3.6 | 10 | | | tSCL |
| | | Low level pulse width | tSCLLx | | | | | 1/2 | | |
| | | High level pulse width | tSCLHx | | | | | 1/2 | | |
| SM0CK and SM0DA pins input spike suppression time | | | tsp | SM0CK (PC0) SM0DA (PC1) | • See Fig. 8. | 2.5 to 3.6 | | | 1 | Tfilt |
| Bus release time between start and stop | Input | | tBUF | SM0CK (PC0) SM0DA (PC1) | • See Fig. 8. | 2.5 to 3.6 | 2.5 | | | Tfilt |
| | Output | | tBUFx | SM0CK (PC0) SM0DA (PC1) | • Standard clock mode • Specified as interval up to time when output state starts changing. | | 5.5 | | | μs |
| | | | | | • High-speed clock mode • Specified as interval up to time when output state starts changing. | | 1.6 | | | |
| Start/restart condition hold time | Input | | tHD;STA | SM0CK (PC0) SM0DA (PC1) | • When SMIIC register control bit, SHDS=0 • See Fig. 8. | 2.5 to 3.6 | 2.0 | | | Tfilt |
| | | | | | • When SMIIC register control bit, SHDS=1 • See Fig. 8. | | 2.5 | | | |
| | Output | | tHD;STAx | SM0CK (PC0) SM0DA (PC1) | • Standard clock mode • Specified as interval up to time when output state starts changing. | | 4.1 | | | μs |
| | | | | | • High-speed clock mode • Specified as interval up to time when output state starts changing. | | 1.0 | | | |
| Restart condition setup time | Input | | tSU;STA | SM0CK (PC0) SM0DA (PC1) | • See Fig. 8. | 2.5 to 3.6 | 1.0 | | | Tfilt |
| | Output | | tSU;STAx | SM0CK (PC0) SM0DA (PC1) | • Standard clock mode • Specified as interval up to time when output state starts changing. | | 5.5 | | | μs |
| | | | | | • High-speed clock mode • Specified as interval up to time when output state starts changing. | | 1.6 | | | |

Continued from preceding page.

| Parameter | | Symbol | Applicable Pin/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | V$_{DD}$[V] | Min | typ | max | Unit |
| Stop condition setup time | Input | tSU;STO | SM0CK (PC0) SM0DA (PC1) | • See Fig. 8. | 2.5 to 3.6 | 1.0 | | | Tfilt |
| | Output | tSU;STOx | SM0CK (PC0) SM0DA (PC1) | • Standard clock mode • Specified as interval up to time when output state starts changing. | | 4.9 | | | μs |
| | | | | • High-speed clock mode • Specified as interval up to time when output state starts changing. | | 1.6 | | | |
| Data hold time | Input | tHD;DAT | SM0CK (PC0) SM0DA (PC1) | • See Fig. 8. | 2.5 to 3.6 | 0 | | | Tfilt |
| | Output | tHD;DATx | SM0CK (PC0) SM0DA (PC1) | • Specified as interval up to time when output state starts changing. | | 1 | | 1.5 | |
| Data setup time | Input | tSU;DAT | SM0CK (PC0) SM0DA (PC1) | • See Fig. 8. | 2.5 to 3.6 | 1 | | | Tfilt |
| | Output | tSU;DATx | SM0CK (PC0) SM0DA (PC1) | • Specified as interval up to time when output state starts changing. | | 1tSCL-1.5Tfilt | | | |

Note 4-3-2: These specifications are theoretical values. Add margin depending on its use.

Note 4-3-3: The value of Tfilt is determined by the values of the register SMIC0BRG, bits 7 and 6 (BRP1, BRP0) and the system clock frequency.

| BRP1 | BRP0 | Tfilt |
|---|---|---|
| 0 | 0 | (1/3)tCYC×1 |
| 0 | 1 | (1/3)tCYC×2 |
| 1 | 0 | (1/3)tCYC×3 |
| 1 | 1 | (1/3)tCYC×4 |

Set bits (BPR1, BPR0) so that the value of Tfilt falls between the following range:

250ns  Tfilt > 140ns

Note 4-3-4: The standard clock mode refers to a mode that is entered by configuring SMIC0BRG as follows:

250ns ≥ Tfilt > 140ns

BRDQ (bit5) = 1

SCL frequency setting ≤ 100kHz

The high-speed clock mode refers to a mode that is entered by configuring SMIC0BRG as follows:

250ns ≥ Tfilt > 140ns

BRDQ (bit5) = 0

SCL frequency setting ≤ 400kHz

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## Pulse Input Conditions at Ta = -40°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

| Parameter | Symbol | Pins/Remarks | Conditions | $V_{DD}$ [V] | Specification | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | min | typ | max | unit |
| High/low level pulse width | tPIH(1) tPIL(1) | INT0(P70), INT1(P71), INT2(P72), INT4(P20 to P23), INT5(P24 to P27) INT6(P20), INT7(P24) | • Interrupt source flag can be set. • Event inputs for timer 0 or 1 are enabled. | 2.5 to 3.6 | 1 | | | tCYC |
| | tPIH(2) tPIL(2) | INT3(P73) when noise filter time constant is 1/1 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 2.5 to 3.6 | 2 | | | |
| | tPIH(3) tPIL(3) | INT3(P73) when noise filter time constant is 1/32 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 2.5 to 3.6 | 64 | | | |
| | tPIH(4) tPIL(4) | INT3(P73) when noise filter time constant is 1/128 | • Interrupt source flag can be set. • Event inputs for timer 0 are enabled. | 2.5 to 3.6 | 256 | | | |
| | tPIL(5) | $\overline{RES}$ | Resetting is enabled. | 2.5 to 3.6 | 200 | | | μs |

## AD Converter Characteristics at $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

<12bits AD Converter Mode at Ta = -40°C to +85°C >

| Parameter | Symbol | Pin/Remarks | Conditions | $V_{DD}$[V] | Specification | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | min | typ | max | unit |
| Resolution | N | AN0(P80) to AN6(P86), AN8(P70), AN9(P71), AN10(XT1), AN11(XT2) | | 2.5 to 3.6 | | 12 | | bit |
| Absolute accuracy | ET | | (Note 6-1) | 2.5 to 3.6 | | | ±16 | LSB |
| Conversion time | TCAD | | See Conversion time calculation formulas. (Note 6-2) | 3.0 to 3.6 | 64 | | 115 | μs |
| | | | | 2.7 to 3.6 | 128 | | 230 | |
| | | | | 2.5 to 3.6 | 256 | | 460 | |
| Analog input voltage range | VAIN | | | 2.5 to 3.6 | $V_{SS}$ | | $V_{DD}$ | V |
| Analog port input current | IAINH(1) | analog channel | VAIN=$V_{DD}$ | 2.5 to 3.6 | | | 1 | μA |
| | IAINL(1) | | VAIN=$V_{SS}$ | 2.5 to 3.6 | -1 | | | |

<8bits AD Converter Mode at Ta = -40°C to +85°C >

| Parameter | Symbol | Pin/Remarks | Conditions | $V_{DD}$[V] | Specification | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | min | typ | max | unit |
| Resolution | N | AN0(P80) to AN6(P86), AN8(P70), AN9(P71), AN10(XT1), AN11(XT2) | | 2.5 to 3.6 | | 8 | | bit |
| Absolute accuracy | ET | | (Note 6-1) | 2.5 to 3.6 | | | ±1.5 | LSB |
| Conversion time | TCAD | | See Conversion time calculation formulas. (Note 6-2) | 3.0 to 3.6 | 39 | | 71 | μs |
| | | | | 2.7 to 3.6 | 79 | | 140 | |
| | | | | 2.5 to 3.6 | 157 | | 280 | |
| Analog input voltage range | VAIN | | | 2.5 to 3.6 | $V_{SS}$ | | $V_{DD}$ | V |
| Analog port input current | IAINH(1) | analog channel | VAIN=$V_{DD}$ | 2.5 to 3.6 | | | 1 | μA |
| | IAINL(1) | | VAIN=$V_{SS}$ | 2.5 to 3.6 | -1 | | | |

12bits AD Converter Mode: TCAD(Conversion time)= ((52/(AD division ratio))+2)×(1/3)×tCYC

8bits AD Converter Mode: TCAD(Conversion time)=((32/(AD division ratio))+2)×(1/3)×tCYC

Note 6-1: The quantization error (±1/2LSB) must be excluded from the absolute accuracy. The absolute accuracy must be measured in the microcontroller's state in which no I/O operations occur at the pins adjacent to the analog input channel.

Note 6-2: The conversion time refers to the period from the time an instruction for starting a conversion process till the time the conversion results register(s) are loaded with a complete digital conversion value corresponding to the analog input value.

The conversion time is 2 times the normal-time conversion time when:

• The first AD conversion is performed in the 12-bit AD conversion mode after a system reset.

• The first AD conversion is performed after the AD conversion mode is switched from 8-bit to 12-bit conversion mode.

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**Consumption Current Characteristics** at Ta = -40°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

| Parameter | Symbol | Pins/Remarks | Conditions | $V_{DD}$[V] | min | Typ | Max | unit |
|---|---|---|---|---|---|---|---|---|
| Normal mode consumption current (Note 7-1) | IDDOP(1) | $V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$ | • FmCF=12MHz ceramic oscillation mode<br>• FmX'tal=32.768kHz by crystal oscillation mode<br>• System clock set to 12MHz side<br>• Internal RC oscillation stopped<br>• frequency variable RC oscillation stopped<br>• 1/1 frequency division ratio. | 2.7 to 3.6 | | 3.6 | 9.5 | mA |
| | IDDOP(2) | | • FmCF=8MHz ceramic oscillation mode<br>• FmX'tal=32.768kHz by crystal oscillation mode<br>• System clock set to 8MHz side<br>• Internal RC oscillation stopped<br>• frequency variable RC oscillation stopped<br>• 1/1 frequency division ratio. | 2.5 to 3.6 | | 2.9 | 7.1 | |
| | IDDOP(3) | | • FmCF=0Hz (oscillation stopped)<br>• FmX'tal=32.768kHz by crystal oscillation mode<br>• System clock set to internal RC oscillation<br>• frequency variable RC oscillation stopped<br>• 1/2 frequency division ratio. | 2.5 to 3.6 | | 0.186 | 0.96 | |
| | IDDOP(4) | | • FmCF=0Hz (oscillation stopped)<br>• FmX'al=32.768kHz by crystal oscillation mode.<br>• System clock set to 32.768kHz side.<br>• Internal RC oscillation stopped<br>• frequency variable RC oscillation stopped<br>• 1/2 frequency division ratio. | 2.5 to 3.6 | | 11.5 | 58 | µA |
| HALT mode consumption current (Note 7-1) | IDDHALT(1) | $V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$ | • HALT mode<br>• FmCF=12MHz ceramic oscillation mode<br>• FmX'tal=32.768kHz by crystal oscillation mode<br>• System clock set to 12MHz side<br>• Internal RC oscillation stopped<br>• frequency variable RC oscillation stopped<br>• 1/1 frequency division ratio. | 2.7 to 3.6 | | 1.5 | 2.9 | |
| | IDDHALT(2) | | • HALT mode<br>• FmCF=8MHz ceramic oscillation mode<br>• FmX'tal=32.768kHz by crystal oscillation mode<br>• System clock set to 8MHz side<br>• Internal RC oscillation stopped<br>• frequency variable RC oscillation stopped<br>• 1/1 frequency division ratio. | 2.5 to 3.6 | | 1 | 1.8 | mA |
| | IDDHALT(3) | | • HALT mode<br>• FmCF=0Hz (oscillation stopped)<br>• FmX'tal=32.768kHz by crystal oscillation mode<br>• System clock set to internal RC oscillation<br>• frequency variable RC oscillation stopped<br>• 1/2 frequency division ratio. | 2.5 to 3.6 | | 0.067 | 0.28 | |

Note 7-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors

Continued from preceding page.

| Parameter | Symbol | Pins/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | V$_{DD}$[V] | min | typ | Max | unit |
| HALT mode consumption current (Note 7-1) | IDDHALT(4) | V$_{DD}$1 =V$_{DD}$2 =V$_{DD}$3 | • HALT mode<br>• FmCF=0Hz (oscillation stopped)<br>• FmX'al=32.768kHz by crystal oscillation mode.<br>• System clock set to 32.768kHz side.<br>• Internal RC oscillation stopped<br>• frequency variable RC oscillation stopped<br>• 1/2 frequency division ratio. | 2.5 to 3.6 | | 7.4 | 49 | µA |
| HOLD mode consumption current | IDDHOLD(1) | V$_{DD}$1 | • HOLD mode<br>• CF1=V$_{DD}$ or open (External clock mode) | 2.5 to 3.6 | | 0.04 | 20 | µA |
| Timer HOLD mode consumption current | IDDHOLD(2) | | • Timer HOLD mode<br>• CF1=V$_{DD}$ or open (External clock mode)<br>• FmX'tal=32.768kHz by crystal oscillation mode | 2.5 to 3.6 | | 5.9 | 35 | |

Note 7-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors

## F-ROM Programming Characteristics at Ta = +10°C to +55°C, V$_{SS}$1 = V$_{SS}$2 = V$_{SS}$3 = 0V

| Parameter | Symbol | Pins/Remarks | Conditions | Specification | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | V$_{DD}$[V] | Min | Typ | Max | unit |
| Onboard programming current | IDDFW(1) | V$_{DD}$1 | • Without CPU curent | 2.7 to 3.6 | | 7 | 11 | mA |
| Programming time | tFW(1) | | • 2k byte Erasing | 2.7 to 3.6 | | 12 | 15 | ms |
| | tFW(2) | | • 2 byte Programming | 2.7 to 3.6 | | 35 | 45 | µs |

# LC87FC096A

**UART (Full Duplex) Operating Conditions** at Ta = -40°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

| Parameter | Symbol | Pin/Remarks | Conditions | Specification | | | | |
|-----------|--------|-------------|------------|---------------|---|---|---|---|
| | | | | $V_{DD}$ [V] | min | typ | max | unit |
| Transfer rate | UBR | P32(UTX1), P33(URX1), P34(UTX2), P35(URX2) | | 2.5 to 3.6 | 16/3 | | 8192/3 | tCYC |

Data length:     7, 8, and 9 bits (LSB first)
Stop bits:        1 bit (2-bit in continuous data transmission)
Parity bits:      None

Example of Continuous 8-bit Data Transmission Mode Processing (first transmit data=55H)
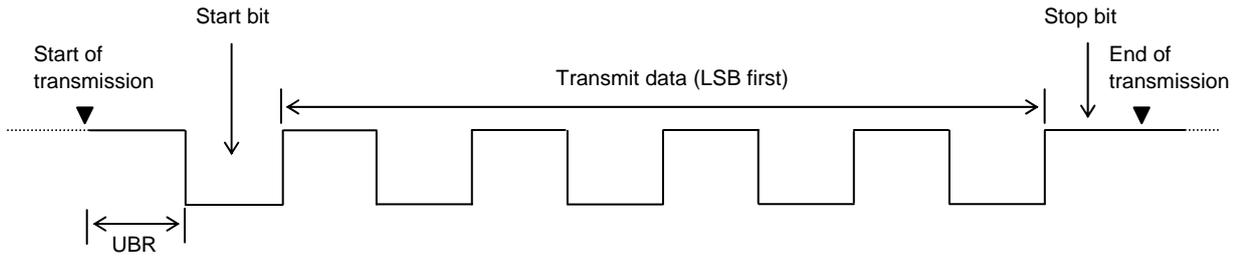


Example of Continuous 8-bit Data Reception Mode Processing (first receive data=55H)
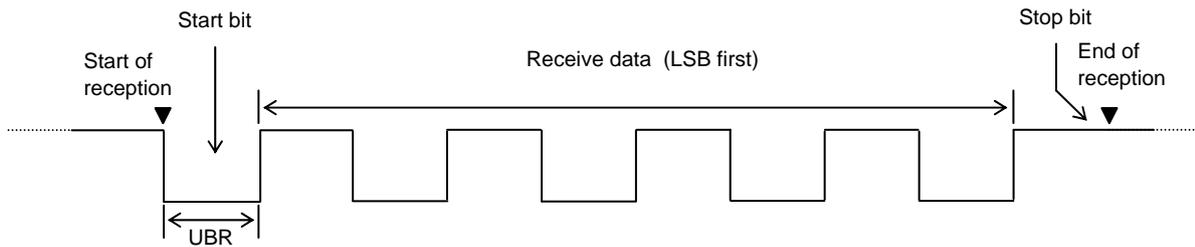


## $V_{DD}1, V_{SS}1$ Terminal Condition

It is necessary to place capacitors between $V_{DD}1$ and $V_{SS}1$ as describe below.

- Place capacitors as close to $V_{DD}1$ and $V_{SS}1$ as possible.
- Place capacitors so that the length of each terminal to the each leg of the capacitor be equal (L1 = L1', L2 = L2').
- Place high capacitance capacitor C1 and low capacitance capacitor C2 in parallel.
- Capacitance of C2 must be more than 0.1μF.
- Use thicker pattern for $V_{DD}1$ and $V_{SS}1$.
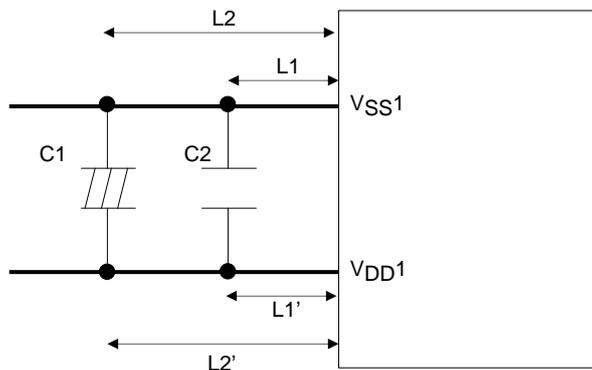
## Characteristics of a Sample Main System Clock Oscillation Circuit

Given below are the characteristics of a sample main system clock oscillation circuit that are measured using a Our designated oscillation characteristics evaluation board and external components with circuit constant values with which the oscillator vendor confirmed normal and stable oscillation.

Table 1 Characteristics of a Sample Main System Clock Oscillator Circuit with a Ceramic Oscillator

| Nominal Frequency | Vendor Name | Oscillator Name | Circuit Constant | | | | Operating Voltage Range [V] | Oscillation Stabilization Time | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C1 [pF] | C2 [pF] | Rf1 [Ω] | Rd1 [Ω] | | typ [ms] | max [ms] | |
| 12MHz | MURATA | CSTCE12M0G52-R0 | (10) | (10) | Open | 330 | 2.2 to 3.6 | 0.02 | 0.2 | C1, C2 integrated type |
| 8MHz | | CSTCE8M00G52-R0 | (10) | (10) | Open | 680 | 2.2 to 3.6 | 0.02 | 0.2 | C1, C2 integrated type |
| | | CSTLS8M00G53-B0 | (15) | (15) | Open | 680 | 2.2 to 3.6 | 0.02 | 0.2 | C1, C2 integrated type |
| 4MHz | | CSTCR4M00G53-R0 | (15) | (15) | Open | 1.5K | 2.2 to 3.6 | 0.02 | 0.2 | C1, C2 integrated type |
| | | CSTLS4M00G53-B0 | (15) | (15) | Open | 1.5K | 2.2 to 3.6 | 0.01 | 0.1 | C1, C2 integrated type |

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after VDD goes above the operating voltage lower limit (see Fig. 4).

## Characteristics of a Sample Subsystem Clock Oscillator Circuit

Given below are the characteristics of a sample subsystem clock oscillation circuit that are measured using a Our designated oscillation characteristics evaluation board and external components with circuit constant values with which the oscillator vendor confirmed normal and stable oscillation.

Table 2 Characteristics of a Sample Subsystem Clock Oscillator Circuit with a Crystal Oscillator

| Nominal Frequency | Vendor Name | Oscillator Name | Circuit Constant | | | | Operating Voltage Range [V] | Oscillation Stabilization Time | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C3 [pF] | C4 [pF] | Rf2 [Ω] | Rd2 [Ω] | | typ [s] | max [s] | |
| 32.768kHz | EPSON TOYOCOM | MC-306 | 9 | 9 | OPEN | 330K | 2.2 to 3.6 | 1.0 | 3.0 | CL=7pF |

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after the instruction for starting the subclock oscillation circuit is executed and to the time interval that is required for the oscillation to get stabilized after the HOLD mode is reset (see Figure 4).

Note: The components that are involved in oscillation should be placed as close to the IC and to one another as possible because they are vulnerable to the influences of the circuit pattern.
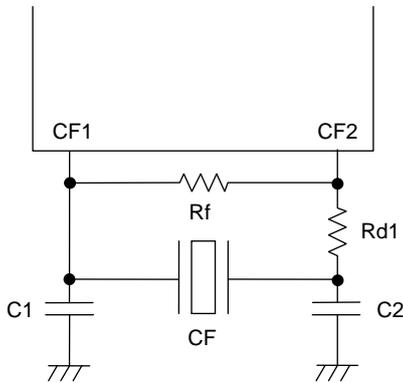


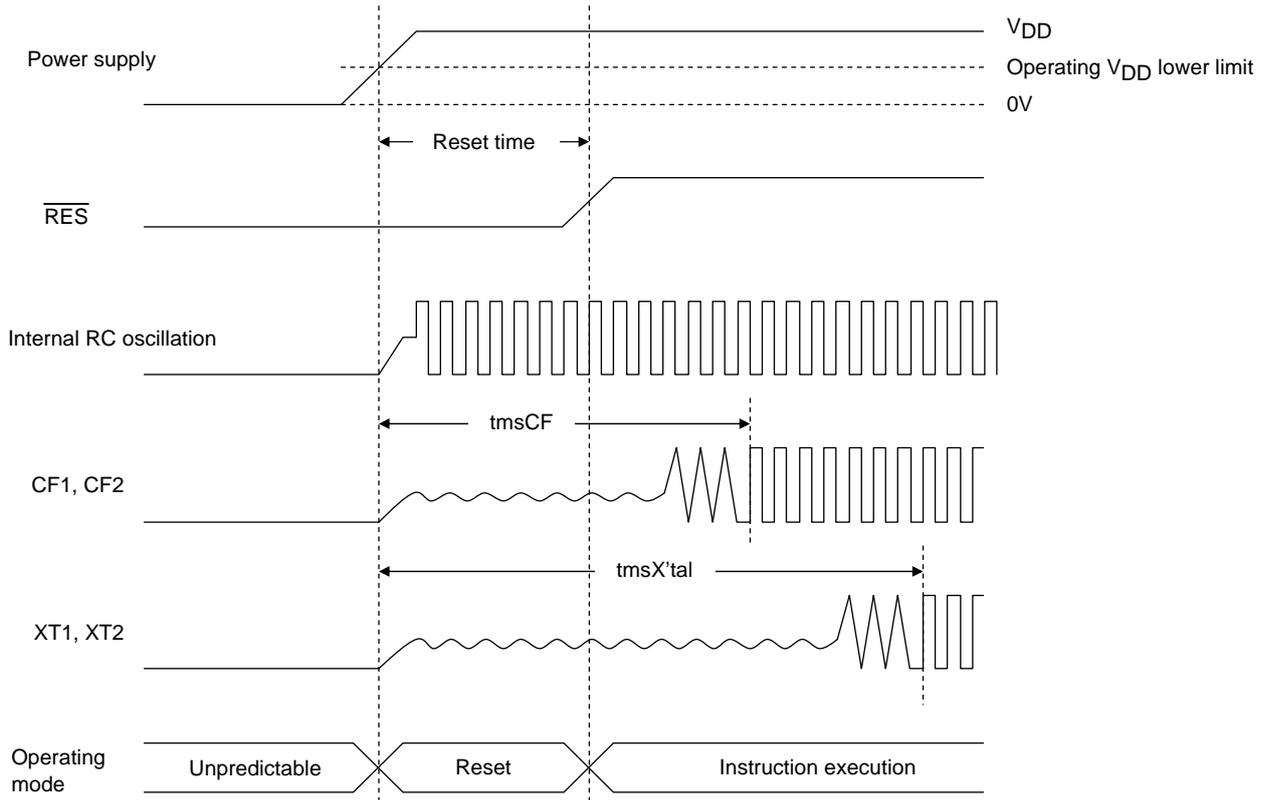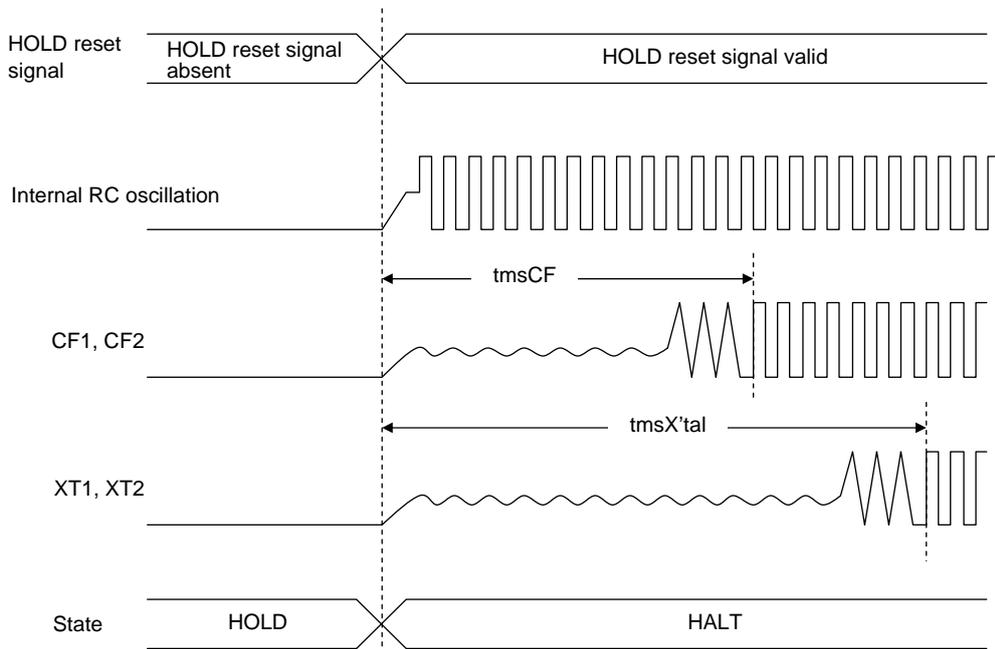Figure 1 CF Oscillator Circuit
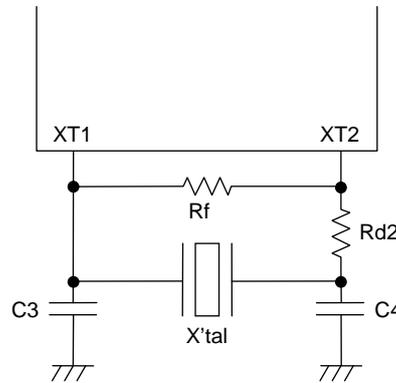
Figure 2 XT Oscillator Circuit
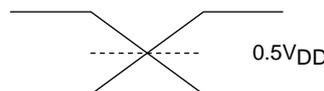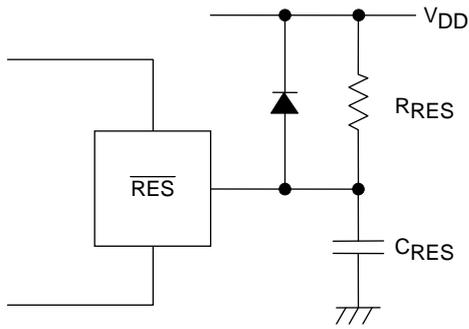


Figure 3 AC Timing Measurement Point

Reset Time and Oscillation Stabilization Time



HOLD Reset Signal and Oscillation Stabilization Time

Figure 4 Oscillation Stabilization Times

Note :
    Determine the value of $C_{RES}$ and $R_{RES}$ so that the reset signal is present for a period of 200μs after the supply voltage goes beyond the lower limit of the IC's operating voltage.
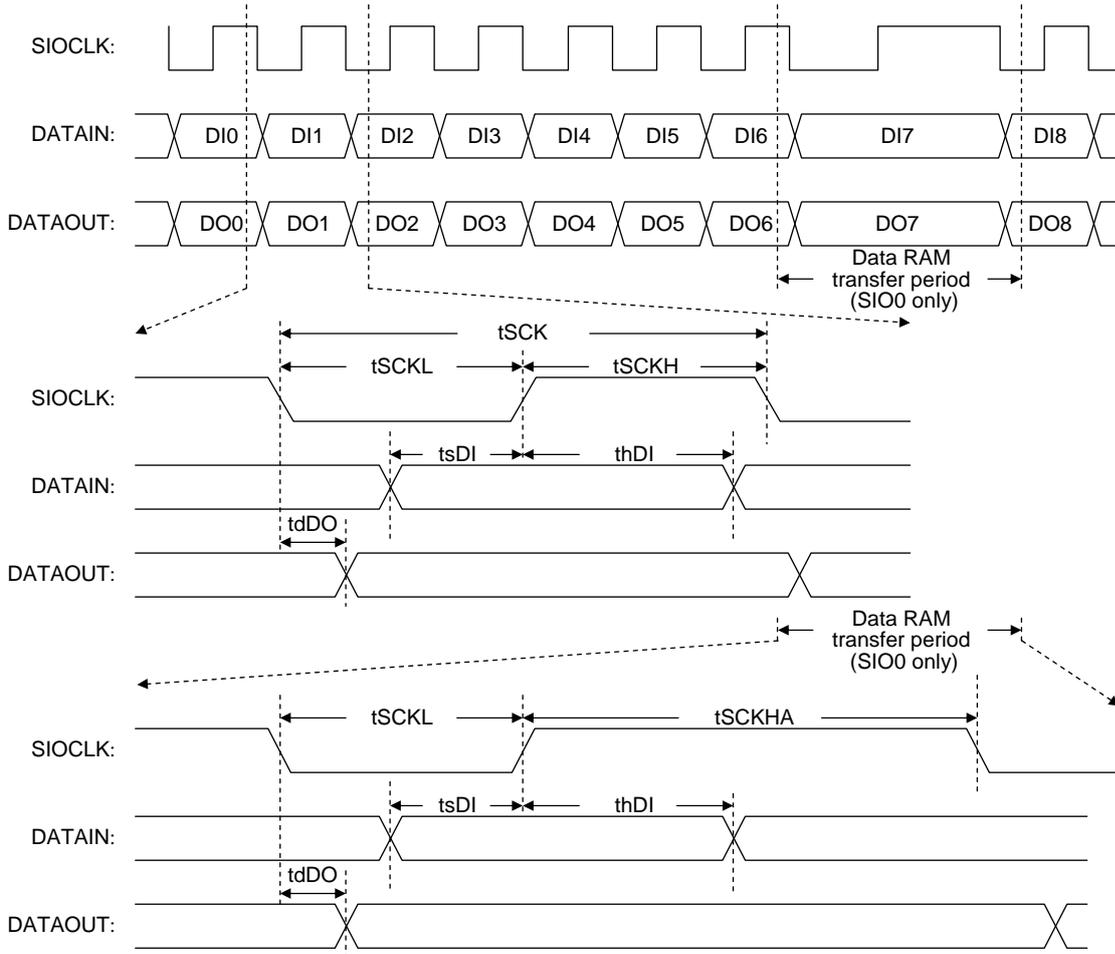
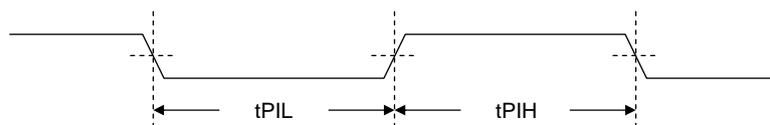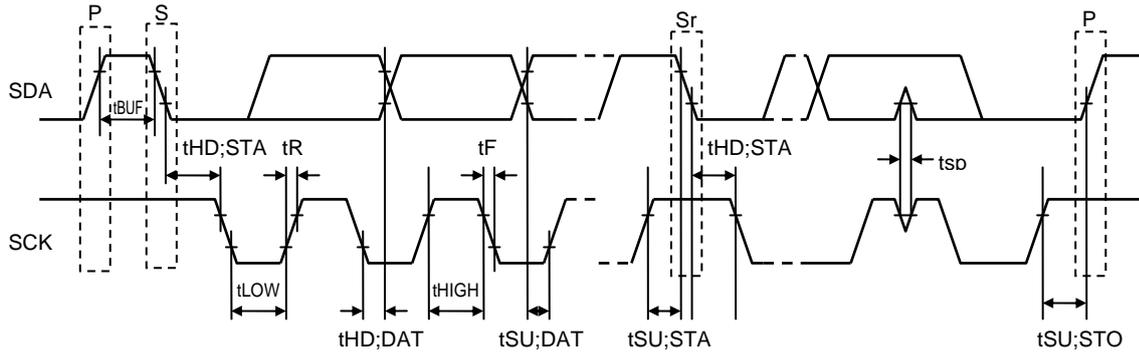Figure 5 Reset Circuit



Figure 6 Serial Input/Output Waveforms



Figure 7 Pulse Input Timing Signal Waveform

S: Start condition
P: Stop condition

Sir: Restart condition

Figure 8 I$^2$C Timing

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✉ info@moschip.ru

Общество с ограниченной ответственностью «МосЧип» ИНН 7719860671 / КПП 771901001
Адрес: 105318, г.Москва, ул.Щербаковская д.3, офис 1107

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### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: info@moschip.ru

Skype отдела продаж:
moschip.ru                                    moschip.ru_6
moschip.ru_4                                  moschip.ru_9