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LC87F2W48A

CMOS IC
50K-byte FROM and 1536-byte RAM integrated
8-bit 1-chip Microcontroller

ON Semiconductor®
http://onsemi.com

Overview

The LC87F2W48A is an 8-bit microcomputer that, centered around a CPU running at a minimum bus cycle time of 83.3ns, integrates on a single chip a number of hardware features such as 50K-byte flash ROM (On-board-programmable), 1536-byte RAM, an On-chip-debugger, sophisticated 16-bit timers/counters (may be divided into 8-bit timers), a 16-bit timer/counter (may be divided into 8-bit timers/counters or 8-bit PWMs), four 8-bit timers with a prescaler, a base timer serving as a time-of-day clock, a high-speed clock counter, a synchronous SIO interface, an asynchronous/synchronous SIO interface, a UART interface (full duplex), two 12-bit PWM channels, a 14-channel AD converter with 12-/8-bit resolution selector, a system clock frequency divider, an infrared remote controller receiver circuit, and a 24-source 10-vector interrupt feature.

Features

■Flash ROM
- Capable of on-board-programming with wide range, 2.7 to 5.5V, of voltage source.
- Block-erasable in 128 byte units
- Writable in 2-byte units
- 51200 × 8 bits

■RAM
- 1536 × 9 bits

■Minimum Bus Cycle
- 83.3ns (12MHz) V_{DD}=2.7V to 5.5V

Note: The bus cycle time here refers to the ROM read speed.

* This product is licensed from Silicon Storage Technology, Inc. (USA).

■Minimum instruction cycle time
- 250ns (12MHz) V_{DD}=2.7 to 5.5V

■Ports
- Normal withstand voltage I/O ports
  Ports I/O direction can be designated in 1-bit units — 38 (P0n, P1n, P2n, P31 to P36, P70 to P73, PWM0, PWM1, XT2, CF2)
- Dedicated oscillator ports/input ports — 2 (XT1, CF1)
- Reset pin — 1 (RES)
- On-chip Debugger pin — 1 (OWP0)
- Power pins — 6 (V_{SS}1 to 3, V_{DD}1 to 3)

■Timers
- Timer 0: 16 bit timer / counter with 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 output)
- Timer 7: 8-bit timer with a 6-bit prescaler (with toggle output)
- Base Timer
  (1) The clock is selectable from the subclock (32.768kHz crystal oscillation), system clock, and timer 0 prescaler output.
  (2) Interrupts are programmable in 5 different time schemes

■High-speed Clock Counter
1) Can count clocks with a maximum clock rate of 20MHz (at a main clock of 10MHz).
2) Can generate output real-time.

■Serial Interface
- SIO 0: 8-bit synchronous serial interface
  (1) LSB first/MSB first mode selectable
  (2) Built-in 8-bit baudrate generator (maximum transfer clock cycle=4/3 tCYC)
  (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)

- SIO 1: 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)

■UART
- Full duplex
- 7/8/9 bit data bits selectable
- 1 stop bit (2-bit in continuous data transmission)
- Built-in baudrate generator

■AD Converter: 12 bits/8 bits × 14 channels
- 12 bits/8 bits AD converter resolution selectable

■PWM: Multifrequency 12-bit PWM × 2 channels

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

■Clock Output Function
- Can generate clock outputs with a frequency of 1/1, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64 of the source clock selected as the system clock.
- Can generate the source clock for the subclock.

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

■Interrupts
- 24 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/REMOREC2
4	0001BH	H or L	INT3/INT5/BT0/BT1
5	00023H	H or L	T0H
6	0002BH	H or L	T1L/T1H
7	00033H	H or L	SIO0/UART1 receive
8	0003BH	H or L	SIO1/UART transmit
9	00043H	H or L	ADC/T6/T7
10	0004BH	H or L	Port 0/T4/T5/PWM0,1

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

- IFLG (List of interrupt source flag function)

(1) Shows a list of interrupt source flags that caused a branching to a particular vector address (shown in the table above.)

■Subroutine Stack Levels: 768 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

- Internal oscillation circuits
  1) Low-speed RC oscillation circuit: For system clock (100kHz)
  2) Medium-speed RC oscillation circuit: For system clock (1MHz)
  3) Frequency variable RC oscillation circuit: For system clock (6 to 10MHz)
    (1) Adjustable in ±0.5% (typ) step from a selected center frequency.
    (2) Measures oscillation clock using a input signal from XT1 as a reference.
- External oscillation circuits
  1) Low speed crystal oscillation circuit: For low-speed system clock, with internal Rf
  2) Hi-speed CF oscillation circuit: For system clock, with internal Rf
    (1) Both the CF and crystal oscillator circuits stop operation on a system reset.

■System Clock Divider function

- Can run on low current.
- The minimum instruction cycle selectable from 300ns, 600ns, 1.2μs, 2.4μs, 4.8μs, 9.6μs, 19.2μs, 38.4μs, and 76.8μs (at a main clock rate of 10MHz).

■Standby Function

- HALT mode: Halts instruction execution while allowing the peripheral circuits to continue operation.
  1) Oscillation is not halted automatically.
  2) There are three ways of resetting the HALT mode.
    (1) Setting the reset pin to the low level
    (2) System resetting by watchdog timer
    (3) 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 four ways of resetting the HOLD mode.
    (1) Setting the reset pin to the low level.
    (2) System resetting by watchdog timer
    (3) Having an interrupt source established at either INT0, INT1, INT2, INT4, or INT5
      * INT0 and INT1 HOLD mode reset is available only when level detection is set.
    (4) Having an interrupt source established at port 0
- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except 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 six ways of resetting the X'tal HOLD mode.
    (1) Setting the reset pin to the low level
    (2) System resetting by watchdog timer
    (3) Having an interrupt source established at either INT0, INT1, INT2, INT4, or INT5
      * INT0 and INT1 X'tal HOLD mode reset is available only when level detection is set.
    (4) Having an interrupt source established at port 0
    (5) Having an interrupt source established in the base timer circuit
    (6) Having an interrupt source established in the infrared remote controller receiver circuit

■Onchip Debugger

- Supports software debugging with the IC mounted on the target board.

■Data Security Function (Flash versions only)

- Protects the program data stored in flash memory from unauthorized read or copy.
  Note: This data security function does not necessarily provide absolute data security.

■Package Form
- SQFP48 (7×7) (Lead-/Halogen-free type)

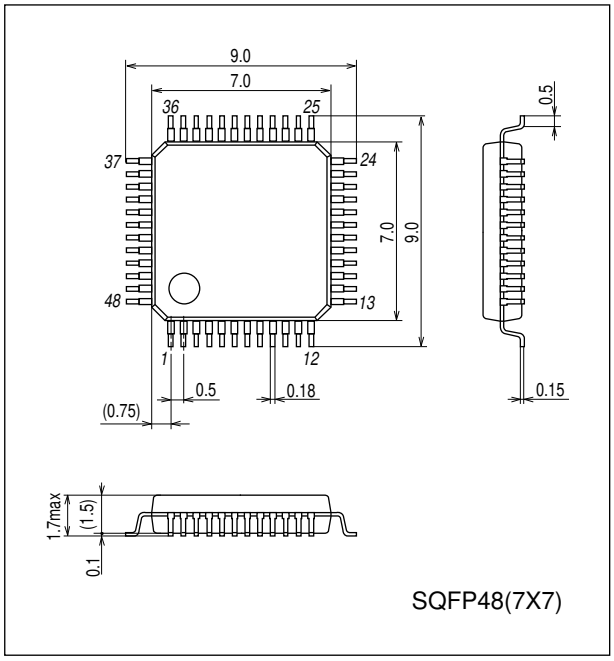
■Development Tools
- On-chip-debugger: TCB87-TypeC (1 wire version) + LC87F2W48A

■Flash ROM Programming Boards

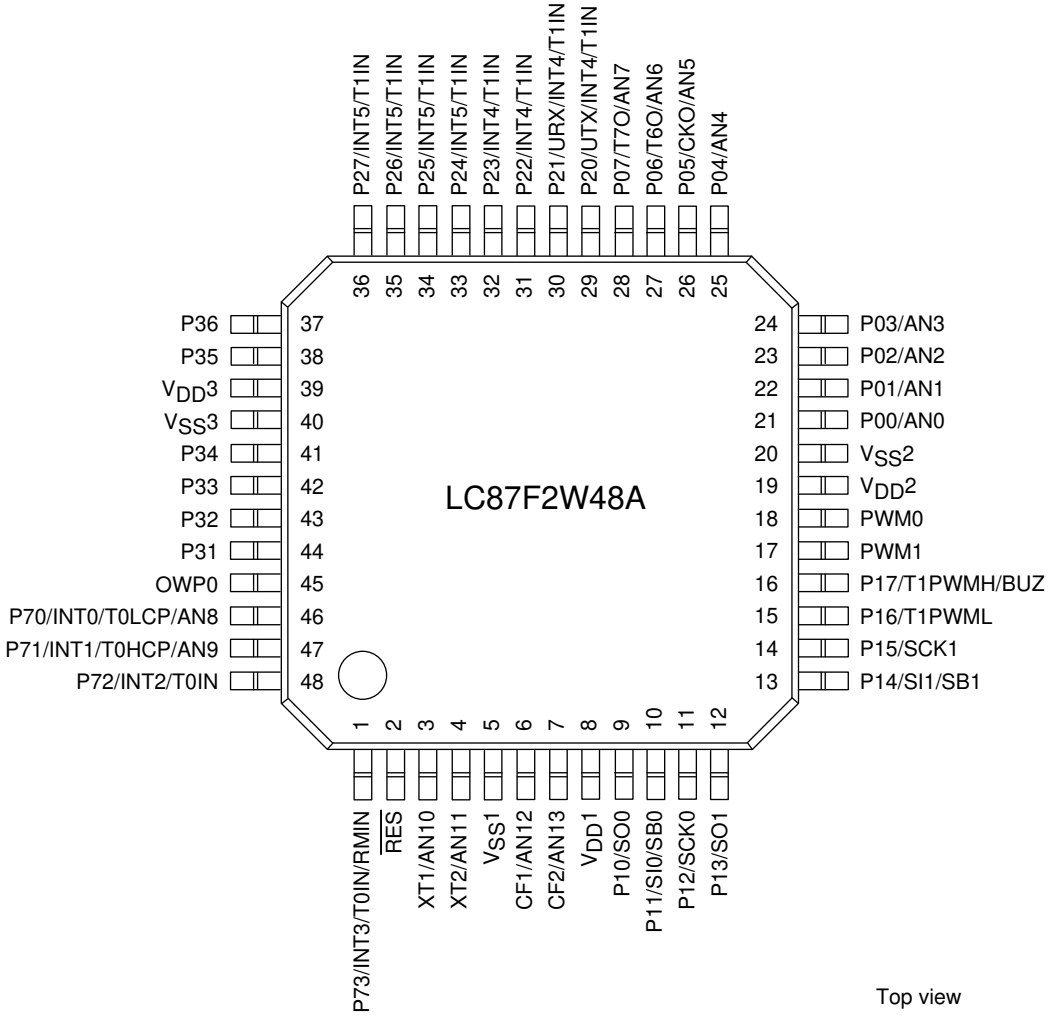
Package	Programming boards
SQFP48 (7×7)	W87F55256SQ

Package Dimensions

unit : mm (typ)
3163B



Pin Assignment



Top view

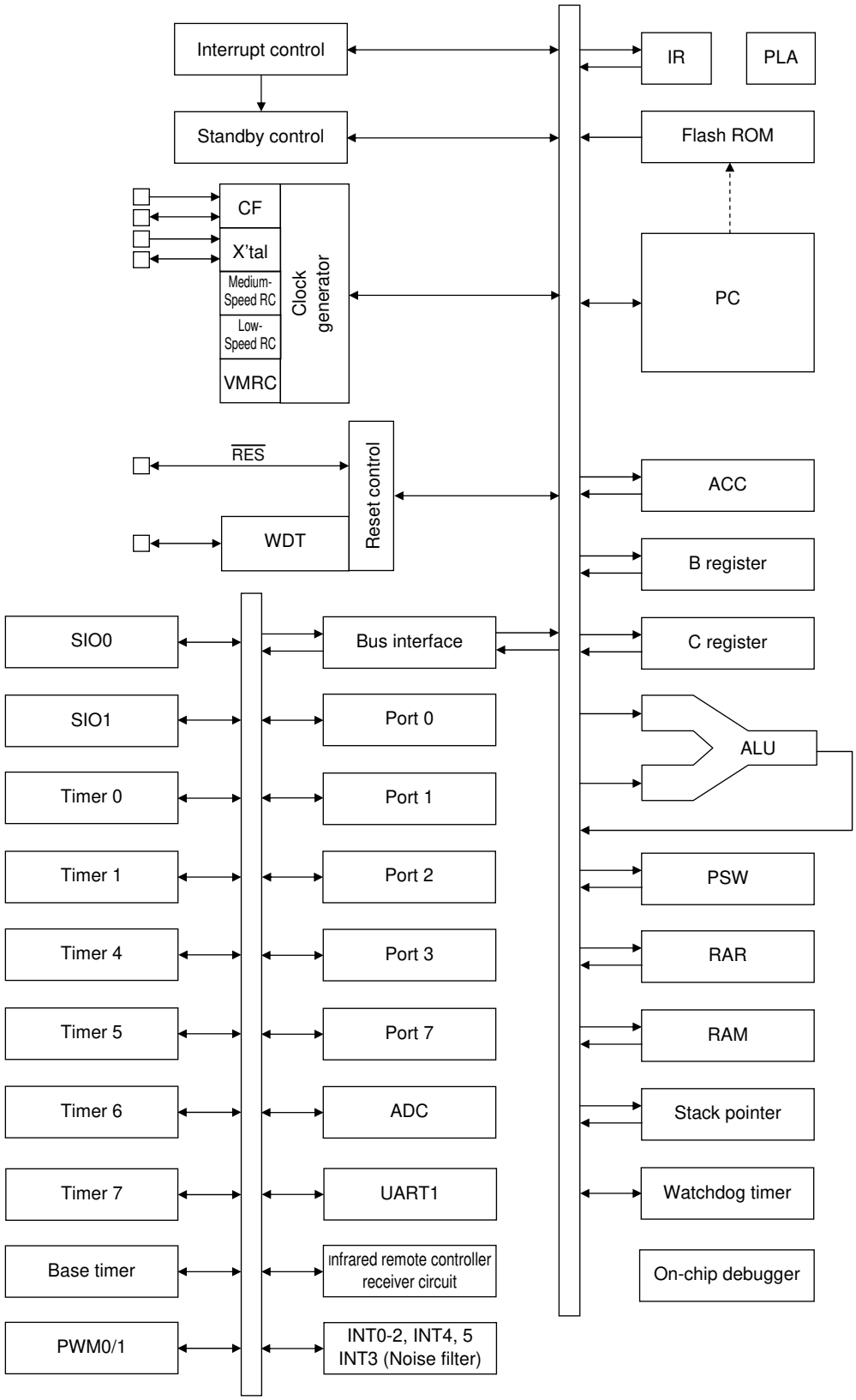
SQIP48 (7×7) “Lead-/Halogen-free type”

SQFP	NAME
1	P73/INT3/T0IN/RMIN
2	$\overline{\text{RES}}$
3	XT1/AN10
4	XT2/AN11
5	$V_{SS}1$
6	CF1/AN12
7	CF2/AN13
8	$V_{DD}1$
9	P10/SO0
10	P11/SI0/SB0
11	P12/SCK0
12	P13/SO1
13	P14/SI1/SB1
14	P15/SCK1
15	P16/T1PWML
16	P17/T1PWMH/BUZ

SQFP	NAME
17	PWM1
18	PWM0
19	$V_{DD}2$
20	$V_{SS}2$
21	P00/AN0
22	P01/AN1
23	P02/AN2
24	P03/AN3
25	P04/AN4
26	P05/CKO/AN5
27	P06/T6O/AN6
28	P07/T7O/AN7
29	P20/UTX/INT4/T1IN
30	P21/URX/INT4/T1IN
31	P22/INT4/T1IN
32	P23/INT4/T1IN

SQFP	NAME
33	P24/INT5/T1IN
34	P25/INT5/T1IN
35	P26/INT5/T1IN
36	P27/INT5/T1IN
37	P36
38	P35
39	$V_{DD}3$
40	$V_{SS}3$
41	P34
42	P33
43	P32
44	P31
45	OWP0
46	P70/INT0/T0LCP/AN8
47	P71/INT1/T0HCP/AN9
48	P72/INT2/T0IN

System Block Diagram



Pin Description

<table>
<tr><th>Pin Name</th><th>I/O</th><th>Description</th><th>Option</th></tr>
<tr><td>$V_{SS}1$ to $V_{SS}3$</td><td>-</td><td>- power supply pins</td><td>No</td></tr>
<tr><td>$V_{DD}1$ to $V_{DD}3$</td><td>-</td><td>+ power supply pin</td><td>No</td></tr>
<tr><td>Port 0
P00 to P07</td><td>I/O</td><td>• 8-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units.
• HOLD reset input
• Port 0 interrupt input
• Pin functions
P05: System clock output
P06: Timer 6 toggle output
P07: Timer 7 toggle output
P00(AN0) to P07(AN7): AD converter input</td><td>Yes</td></tr>
<tr><td>Port 1
P10 to P17</td><td>I/O</td><td>• 8-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units.
• Pin functions
P10: SIO0 data output
P11: SIO0 data input/bus I/O
P12: SIO0 clock I/O
P13: SIO1 data output
P14: SIO1 data input/bus I/O
P15: SIO1 clock I/O
P16: Timer 1PWML output
P17: Timer 1PWMH output/beeper output</td><td>Yes</td></tr>
<tr><td>Port 2
P20 to P27</td><td>I/O</td><td>• 8-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units.
• Pin functions
P20: UART transmit
P21: UART receive
P20 to P23: INT4 input/HOLD reset input/timer 1 event input/timer 0L capture input/ timer 0H capture input
P24 to P27: INT5 input/HOLD reset input/timer 1 event input/timer 0L capture input/ timer 0H capture input
• Interrupt acknowledge type
<table>
<tr><th></th><th>Rising</th><th>Falling</th><th>Rising & Falling</th><th>H level</th><th>L level</th></tr>
<tr><td>INT4</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
<tr><td>INT5</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
</table>
</td><td>Yes</td></tr>
<tr><td>Port 3
P31 to P36</td><td>I/O</td><td>• 6-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units.</td><td>Yes</td></tr>
</table>

Continued on next page.

Continued from preceding page.

<table>
<tr><th>Pin Name</th><th>I/O</th><th>Description</th><th>Option</th></tr>
<tr><td>Port 7
P70 to P73</td><td>I/O</td><td>• 4-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units.
• Pin functions
P70: INT0 input/HOLD reset input/timer 0L capture input/watchdog timer output
P71: INT1 input/HOLD reset input/timer 0H capture input
P72: INT2 input HOLD reset input/timer 0 event input/timer 0L capture input
P73: INT3 input (with noise filter)/timer 0 event input/timer 0H capture input/
Infrared remote controller receiver input
P70(AN8), P71(AN9): AD converter input
• Interrupt acknowledge type
<table>
<tr><th></th><th>Rising</th><th>Falling</th><th>Rising & Falling</th><th>H level</th><th>L level</th></tr>
<tr><td>INT0</td><td>enable</td><td>enable</td><td>disable</td><td>enable</td><td>enable</td></tr>
<tr><td>INT1</td><td>enable</td><td>enable</td><td>disable</td><td>enable</td><td>enable</td></tr>
<tr><td>INT2</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
<tr><td>INT3</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
</table></td><td>No</td></tr>
<tr><td>PWM0</td><td>I/O</td><td>• PWM0 output port
• General-purpose I/O available</td><td>No</td></tr>
<tr><td>PWM1</td><td>I/O</td><td>• PWM1 output port
• General-purpose I/O available</td><td>No</td></tr>
<tr><td>$\overline{\text{RES}}$</td><td>I/O</td><td>External reset Input/internal reset output</td><td>No</td></tr>
<tr><td>XT1</td><td>Input</td><td>• 32.768kHz crystal oscillator input pin
• Shared pins
General-purpose input port
AD converter input port: AN10</td><td>No</td></tr>
<tr><td>XT2</td><td>I/O</td><td>• 32.768kHz crystal oscillator output pin
• Shared pins
General-purpose I/O port
AD converter input port: AN11</td><td>No</td></tr>
<tr><td>CF1</td><td>Input</td><td>• Ceramic resonator input pin
• Shared pins
General-purpose input port
AD converter input port: AN12</td><td>No</td></tr>
<tr><td>CF2</td><td>I/O</td><td>• Ceramic resonator output pin
• Shared pins
General-purpose I/O port
AD converter input port: AN13</td><td>No</td></tr>
<tr><td>OWP0</td><td>I/O</td><td>On-chip Debugger pin</td><td>No</td></tr>
</table>

On-chip Debugger Pin Connection Requirements

For the treatment of the on-chip debugger pins, refer to the separately available documents entitled “RD87 On-chip Debugger Installation Manual”

Recommended Unused Pin Connections

Port Name	Recommended Unused Pin Connections	
	Board	Software
P00 to P07	Open	Output low
P10 to P17	Open	Output low
P20 to P27	Open	Output low
P31 to P36	Open	Output low
P70 to P73	Open	Output low
PWM0, PWM1	Open	Output low
XT1	Pulled low with a 100kΩ resistor or less	General-purpose input port
XT2	Open	Output low
CF1	Pulled low with a 100kΩ resistor or less	General-purpose input port
CF2	Open	Output low

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	Programmable (Note 1)
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
P31 to P36	1 bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
P70	-	No	Nch-open drain	Programmable
P71 to P73	-	No	CMOS	Programmable
PWM0, PWM1	-	No	CMOS	No
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
CF1	-	No	Input for ceramic resonator oscillator (Input only)	No
CF2	-	No	Output for ceramic resonator oscillator (Nch-open drain when in general-purpose output mode)	No

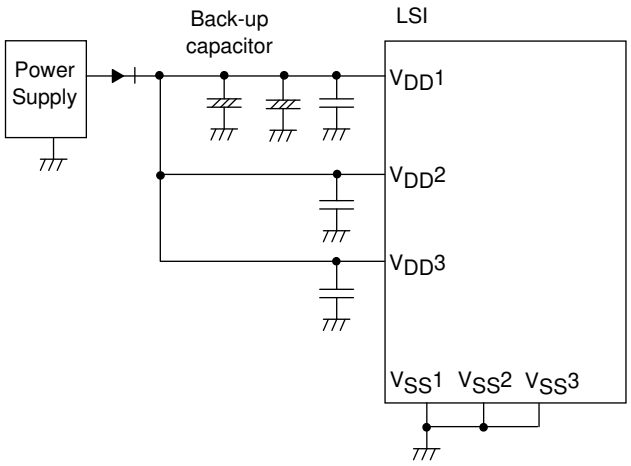
Note 1: The control of the presence or absence of the programmable pull-up resistors for port 0 and the switching between low- and high-impedance pull-up connection is exercised in 1-bit units.

User Option Table

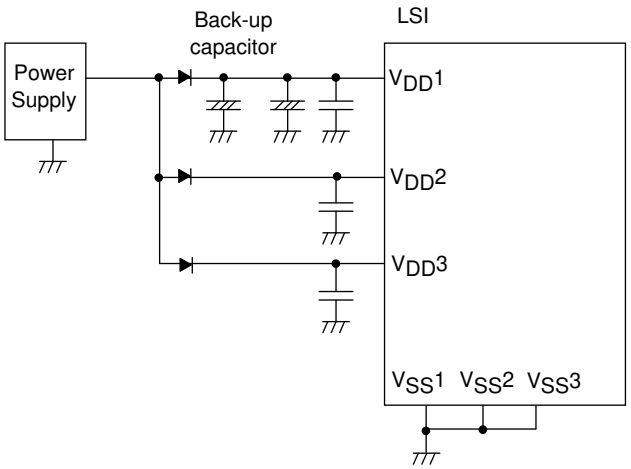
Option name	Option to be Applied on	Flash-ROM Version	Option Selected in Units of	Option selection
Port output type	P00 to P07	○	1 bit	CMOS
				Nch-open drain
	P10 to P17	○	1 bit	CMOS
				Nch-open drain
	P20 to P27	○	1 bit	CMOS
				Nch-open drain
	P31 to P36	○	1 bit	CMOS
				Nch-open drain
Program start address	-	○	-	00000h
				0FE00h

Note: To reduce $V_{DD}1$ signal noise and to increase the duration of the backup battery supply, $V_{SS}1$, $V_{SS}2$, and $V_{SS}3$ should connect to each other and they should also be grounded.

Example 1: During backup in hold mode, port output 'H' level is supplied from the back-up capacitor.



Example 2: During backup in hold mode, output is not held high and its value in unsettled.



Absolute Maximum Ratings at Ta=25°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

Parameter		Symbol	Pins	Conditions	V_{DD}[V]	Specification 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		+6.5	V
Input voltage		V_I	XT1, CF1, $\overline{RES}$			-0.3		V_{DD}+0.3	
Input/Output voltage		V_{IO}	Ports 0, 1, 2, 3 Port 7 PWM0, PWM1 XT2, CF2			-0.3		V_{DD}+0.3	
High level output current	Peak output current	IOPH(1)	Ports 0, 1, 2, 3	CMOS output selected Per 1 applicable pin		-10			mA
		IOPH(2)	PWM0, PWM1	Per 1 applicable pin		-20			
		IOPH(3)	P71 to P73	Per 1 applicable pin		-5			
	Mean output current (Note 1-1)	IOMH(1)	Ports 0, 1, 2, 3	CMOS output select Per 1 applicable pin		-7.5			
		IOMH(2)	PWM0, PWM1	Per 1 applicable pin		-15			
		IOMH(3)	P71 to P73	Per 1 applicable pin		-3			
	Total output current	∑IOAH(1)	P71 to P73	Total of all applicable pins		-10			
		∑IOAH(2)	Port 0	Total of all applicable pins		-25			
		∑IOAH(3)	Port 1 PWM0, PWM1	Total of all applicable pins		-25			
		∑IOAH(4)	Ports 0, 1 PWM0, PWM1	Total of all applicable pins		-45			
		∑IOAH(5)	Port 2 P35, P36	Total of all applicable pins		-25			
		∑IOAH(6)	P31 to P34	Total of all applicable pins		-25			
		∑IOAH(7)	Ports 2, 3	Total of all applicable pins		-45			
Low level output current	Peak output current	IOPL(1)	P02 to P07 Ports 1, 2, 3 PWM0, PWM1	Per 1 applicable pin				20	
		IOPL(2)	P00, P01	Per 1 applicable pin				30	
		IOPL(3)	Port 7 XT2, CF2	Per 1 applicable pin				10	
	Mean output current (Note 1-1)	IOML(1)	P02 to P07 Ports 1, 2, 3 PWM0, PWM1	Per 1 applicable pin				15	
		IOML(2)	P00, P01	Per 1 applicable pin				20	
		IOML(3)	Port 7 XT2, CF2	Per 1 applicable pin				7.5	
	Total output current	∑IOAL(1)	Port 7 XT2, CF2	Total of all applicable pins				15	
		∑IOAL(2)	Port 0	Total of all applicable pins				45	
		∑IOAL(3)	Port 1 PWM0, PWM1	Total of all applicable pins				45	
		∑IOAL(4)	Ports 0, 1 PWM0, PWM1	Total of all applicable pins				80	
		∑IOAL(5)	Port 2 P35, P36	Total of all applicable pins				45	
		∑IOAL(6)	P31 to P34	Total of all applicable pins				45	
		∑IOAL(7)	Ports 2, 3	Total of all applicable pins				60	
Power dissipation		Pdmax(1)	SQFP48(7×7)	Ta=-40 to +85°C Package only				129	mW
		Pdmax(2)		Ta=-40 to +85°C Package with thermal resistance board (Note 1-2)				383	
Operating temperature range		Topr				-40		85	°C
Storage temperature range		Tstg				-55		125	

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

Note 1-2: SEMI standards thermal resistance board (size: 76.1×114.3×1.6 tmm, glass epoxy) is used.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

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

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Operating supply voltage	V_{DD}	$V_{DD}1=V_{DD}2=V_{DD}3$	0.245µs≤tCYC≤200µs		2.7		5.5	V
Memory sustaining supply voltage	VHD	$V_{DD}1=V_{DD}2=V_{DD}3$	RAM and register contents sustained in HOLD mode.		2.0		5.5	
High level input voltage	V_{IH}(1)	Ports 1, 2, 3 P71 to P73 P70 port input/ interrupt side PWM0, PWM1		2.7 to 5.5	$0.3V_{DD}$ +0.7		V_{DD}	
	V_{IH}(2)	Port 0		2.7 to 5.5	$0.3V_{DD}$ +0.7		V_{DD}	
	V_{IH}(3)	Port 70 watchdog timer side		2.7 to 5.5	$0.9V_{DD}$		V_{DD}	
	V_{IH}(4)	XT1, XT2, CF1, CF2 $\overline{RES}$		2.7 to 5.5	$0.75V_{DD}$		V_{DD}	
Low level input voltage	V_{IL}(1)	Ports 1, 2, 3 P71 to P73 P70 port input/ interrupt side PWM0, PWM1		4.0 to 5.5	V_{SS}		$0.1V_{DD}$ +0.4	
				2.7 to 4.0	V_{SS}		$0.2V_{DD}$	
	V_{IL}(2)	Port 0		4.0 to 5.5	V_{SS}		$0.15V_{DD}$ +0.4	
				2.7 to 4.0	V_{SS}		$0.2V_{DD}$	
	V_{IL}(3)	Port 70 watchdog timer side		2.7 to 5.5	V_{SS}		$0.8V_{DD}$ -1.0	
	V_{IL}(4)	XT1, XT2, CF1, CF2 $\overline{RES}$		2.7 to 5.5	V_{SS}		$0.25V_{DD}$	
Instruction cycle time	tCYC (Note 2-1)			2.7 to 5.5	0.245		200	µs
External system clock frequency	FEXCF	CF1	CF2 pin open System clock frequency division ratio=1/1 External system clock duty=50±5%	2.7 to 5.5	0.1		12	MHz
			CF2 pin open System clock frequency division ratio=1/2 External system clock duty=50±5%	3.0 to 5.5	0.2		24.4	
Oscillation frequency range (Note 2-2)	FmCF(1)	CF1, CF2	12MHz ceramic oscillation See Fig. 1.	2.7 to 5.5		12		
	FmCF(2)	CF1, CF2	10MHz ceramic oscillation See Fig. 1.	2.7 to 5.5		10		
	FmCF(3)	CF1, CF2	4MHz ceramic oscillation. CF oscillation normal amplifier size selected. (CFLAMP=0) See Fig. 1.	2.7 to 5.5		4		
			4MHz ceramic oscillation. CF oscillation low amplifier size selected. (CFLAMP=1) See Fig. 1.	2.7 to 5.5		4		

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

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Parameter	Symbol	Pin/Remarks	Conditions		Specification			
				V_{DD}[V]	min	typ	max	unit
Oscillation frequency range (Note 2-2)	FmVMRC		Frequency variable RC oscillation. (VM3FRQ1/0=0/1) (Note 2-3)	2.7 to 5.5		8.0		MHz
	FmRC		Internal Medium-speed RC oscillation	2.7 to 5.5	0.5	1.0	2.0	
	FmSRC		Internal Low-speed RC oscillation	2.7 to 5.5	50	100	200	kHz
	FsX'tal	XT1, XT2	32.768kHz crystal oscillation See Fig. 3.	2.7 to 5.5		32.768		
Frequency variable RC oscillation usable range	OpVMRC		Frequency variable RC oscillation. (VM3FRQ1/0=0/1)	2.7 to 5.5	6	8	10	MHz
Frequency variable RC oscillation adjustment range	VmADJ(1)		Each step of V3RCHBn	2.7 to 5.5	3.6	7.0	11	%
	VmADJ(2)		Each step of V3FCHBn	2.7 to 5.5	0.7	1.5	2.3	
	VmADJ(3)		Each step of V3DCHn	2.7 to 5.5	0.2	0.5	1.1	

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

Note 2-3: When switching the system clock, allow an oscillation stabilization time of 100µs or longer after the multifrequency RC oscillator circuit transmits from the "oscillation stopped" to "oscillation enabled" state.

Electrical Characteristics at Ta=-40 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
High level input current	$I_{IH}(1)$	Ports 0, 1, 2, 3 Port 7 $\overline{RES}$ PWM0, PWM1	Output disabled Pull-up resistor off $V_{IN}=V_{DD}$ (Including output Tr's off leakage current)	2.7 to 5.5			1	μA
	$I_{IH}(2)$	XT1, XT2, CF2	Input port selected $V_{IN}=V_{DD}$	2.7 to 5.5			1	
	$I_{IH}(3)$	CF1	$V_{IN}=V_{DD}$	2.7 to 5.5			15	
Low level input current	$I_{IL}(1)$	Ports 0, 1, 2, 3 Port 7 $\overline{RES}$ PWM0, PWM1	Output disabled Pull-up resistor off $V_{IN}=V_{SS}$ (Including output Tr's off leakage current)	2.7 to 5.5	-1			
	$I_{IL}(2)$	XT1, XT2, CF2	Input port selected $V_{IN}=V_{SS}$	2.7 to 5.5	-1			
	$I_{IL}(3)$	CF1	$V_{IN}=V_{SS}$	2.7 to 5.5	-15			
High level output voltage	$V_{OH}(1)$	Ports 0, 1, 2, 3 P71 to P73	I_{OH}=-1mA	4.5 to 5.5	V_{DD}-1			V
	$V_{OH}(2)$		I_{OH}=-0.35mA	2.7 to 5.5	V_{DD} -0.4			
	$V_{OH}(3)$	PWM0, PWM1 P05(System clock output function used)	I_{OH}=-6mA	4.5 to 5.5	V_{DD}-1			
	$V_{OH}(4)$		I_{OH}=-1.4mA	2.7 to 5.5	V_{DD} -0.4			
Low level output voltage	$V_{OL}(1)$	Ports 0, 1, 2, 3 PWM0, PWM1	I_{OL}=10mA	4.5 to 5.5			1.5	
	$V_{OL}(2)$		I_{OL}=1.4mA	2.7 to 5.5			0.4	
	$V_{OL}(3)$	P00, P01	I_{OL}=25mA	4.5 to 5.5			1.5	
	$V_{OL}(4)$		I_{OL}=4mA	2.7 to 5.5			0.4	
	$V_{OL}(5)$	Port 7, XT2, CF2	I_{OL}=1.4mA	2.7 to 5.5			0.4	
Pull-up resistance	Rpu(1)	Ports 0, 1, 2, 3 Port 7	$V_{OH}=0.9V_{DD}$ When Port 0 selected low-impedance pull-up.	4.5 to 5.5	15	35	80	kΩ
	Rpu(2)			2.7 to 5.5	18	50	230	
	Rpu(3)	Port 0	$V_{OH}=0.9V_{DD}$ When Port 0 selected high-impedance pull-up.	2.7 to 5.5	100	210	400	
Hysteresis voltage	VHYS	Ports 1, 2, 3, 7 $\overline{RES}$, XT2		2.7 to 5.5		$0.1V_{DD}$		V
Pin capacitance	CP	All pins	For pins other than that under test: $V_{IN}=V_{SS}$, f=1MHz, Ta=25°C	2.7 to 5.5		10		pF

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]	Specification min	typ	max	unit
Serial clock	Input clock	Frequency	tSCK(1)	SCK0(P12)	See Fig. 6.	2.7 to 5.5	2			tCYC
		Low level pulse width	tSCKL(1)				1			
		High level pulse width	tSCKH(1)				1			
			tSCKHA(1)		Continuous data transmission/ reception mode See Fig. 6. (Note 4-1-2)		4			
	Output clock	Frequency	tSCK(2)	SCK0(P12)	CMOS output selected See Fig 6	2.7 to 5.5	4/3			
		Low level pulse width	tSCKL(2)				1/2			tSCK
		High level pulse width	tSCKH(2)				1/2			
			tSCKHA(2)		Continuous data transmission/ reception mode CMOS output selected. 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. See Fig. 6.	2.7 to 5.5	0.05			µs
	Data hold time		thDI(1)				0.05			
Serial output	Input clock	Output delay time	tdD0(1)	SO0(P10), SB0(P11)	Continuous data transmission/reception mode (Note 4-1-3)	2.7 to 5.5			(1/3)tCYC +0.08	
			tdD0(2)		Synchronous 8-bit mode (Note 4-1-3)				1tCYC +0.08	
	Output clock		tdD0(3)		(Note 4-1-3)				(1/3)tCYC +0.08	

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

Note 4-1-2: When using the serial clock input in the continuous data transmission/reception mode, make sure, at the beginning of continuous data transmission/reception, that the interval from the time SI0RUN is set while the serial clock is high till the first falling edge of the serial clock is 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 min	typ	max	unit
Serial clock	Input clock	Frequency	tSCK(3)	SCK1(P15)	See Fig. 6.	2.7 to 5.5	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 See Fig. 6.	2.7 to 5.5	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), SI1(P14)	Must be specified with respect to rising edge of SIOCLK. See Fig. 6.	2.7 to 5.5	0.05			µs
	Data hold time		thDI(2)				0.05			
Serial output	Output delay time		tdD0(4)	SO1(P13), SB1(P14)	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.	2.7 to 5.5			(1/3)tCYC +0.08	

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

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

Parameter	Symbol	Pin/Remarks	Conditions	VDD[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)	Interrupt source flag can be set. Event inputs for timer 0 or 1 are enabled.	2.7 to 5.5	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.	2.7 to 5.5	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.	2.7 to 5.5	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.	2.7 to 5.5	256			
	tPIH(5) tPIL(5)	RMIN(P73)	Recognized by the infrared remote controller receiver circuit as a signal.	2.7 to 5.5	4			RMCK (Note 5-1)
	tPIL(6)	$\overline{RES}$	Resetting is enabled.	2.7 to 5.5	200			µs

Note 5-1: Represents the period of the reference clock (1 to 128 tCYC or the source frequency of the subclock) for the infrared remote controller receiver circuit.

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

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

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
Resolution	N	AN0(P00) to AN7(P07), AN8(P70), AN9(P71), AN10(XT1), AN11(XT2), AN12(CF1), AN13(CF2)		2.7 to 5.5		12		bit
Absolute accuracy	ET		(Note 6-1)	3.0 to 5.5			±16	LSB
			(Note 6-1)	2.7 to 3.6			±20	
Conversion time	TCAD		See Conversion time calculation formulas. (Note 6-2)	4.5 to 5.5	32		115	µs
				3.0 to 5.5	64		115	
			See Conversion time calculation formulas. (Note 6-2)	2.7 to 3.6	410		425	
Analog input voltage range	VAIN			2.7 to 5.5	V_{SS}		V_{DD}	V
Analog port input current	IAINH(1)	analog channel except AN12	VAIN=V_{DD}	2.7 to 5.5			1	µA
	IAINL(1)		VAIN=V_{SS}	2.7 to 5.5	-1			
	IAINH(2)	AN12	VAIN=V_{DD}	2.7 to 5.5			15	
	IAINL(2)		VAIN=V_{SS}	2.7 to 5.5	-15			

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

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
Resolution	N	AN0(P00) to AN7(P07), AN8(P70), AN9(P71), AN10(XT1), AN11(XT2), AN12(CF1), AN13(CF2)		2.7 to 5.5		8		bit
Absolute accuracy	ET		(Note 6-1)	2.7 to 5.5			±1.5	LSB
Conversion time	TCAD		See Conversion time calculation formulas. (Note 6-2)	4.5 to 5.5	20		70	µs
				3.0 to 5.5	40		70	
			See Conversion time calculation formulas. (Note 6-2)	2.7 to 3.6	250		265	
Analog input voltage range	VAIN			2.7 to 5.5	V_{SS}		V_{DD}	V
Analog port input current	IAINH(1)	analog channel except AN12	VAIN=V_{DD}	2.7 to 5.5			1	µA
	IAINL(1)		VAIN=V_{SS}	2.7 to 5.5	-1			
	IAINH(2)	AN12	VAIN=V_{DD}	2.7 to 5.5			15	
	IAINL(2)		VAIN=V_{SS}	2.7 to 5.5	-15			

Conversion time calculation formulas:

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

<Recommended Operating Conditions>

External oscillation (FmCF)	Operating supply voltage range (V_{DD})	System division ratio (SYSDIV)	Cycle time (tCYC)	AD division ratio (ADDIV)	AD conversion time (TCAD)	
					12bit AD	8bit AD
CF-12MHz	4.5V to 5.5V	1/1	250ns	1/8	34.8µs	21.5µs
	3.0V to 5.5V	1/1	250ns	1/16	69.5µs	42.8µs
CF-10MHz	4.5V to 5.5V	1/1	300ns	1/8	41.8µs	25.8µs
	3.0V to 5.5V	1/1	300ns	1/16	83.4µs	51.4µs
CF-4MHz	3.0V to 5.5V	1/1	750ns	1/8	104.5µs	64.5µs
	2.7V to 3.6V	1/1	750ns	1/32	416.5µs	256.5µs

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.

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

Parameter	Symbol	Pin/ Remarks	Conditions	V_{DD}[V]	Specification 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 • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		4.5	9.5	mA
				2.7 to 3.6		2.7	6.5	
	IDDOP(2)		• CF1=24MHz external clock • FsX'tal=32.768kHz crystal oscillation mode • System clock set to CF1 side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	3.0 to 5.5		5	10.5	
				3.0 to 3.6		3	7.2	
	IDDOP(3)		• FmCF=10MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 10MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		4	8.2	
				2.7 to 3.6		2.4	5.8	
	IDDOP(4)		• FmCF=4MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 4MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		2	4.3	
				2.7 to 3.6		1.3	3	
	IDDOP(5)		• CF oscillation low amplifier size selected. (CFLAMP=1) • FmCF=4MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 4MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/4 frequency division ratio	2.7 to 5.5		0.8	2.1	
				2.7 to 3.6		0.5	1.2	
	IDDOP(6)		• External FmCF oscillation stopped. • FsX'tal=32.768kHz Crystal oscillation mode • System clock set to internal Medium speed RC oscillation. • Internal Low speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	2.7 to 5.5		0.5	1.8	
				2.7 to 3.6		0.3	0.95	
	IDDOP(7)		• External FmCF oscillation stopped. • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 8MHz with Frequency variable RC oscillation • Internal Low speed and Medium speed RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		3.5	6.8	
				2.7 to 3.6		2.3	5.2	
	IDDOP(8)		• External FsX'tal and FmCF oscillation stopped. • System clock set to internal Low speed RC oscillation. • Internal Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		58	200	μA
				2.7 to 3.6		37	135	

Note 7-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

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Parameter	Symbol	Pin/ Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Normal mode consumption current (Note 7-1)	IDDOP(9)	$V_{DD}1$ = $V_{DD}2$ = $V_{DD}3$	• External FmCF oscillation stopped. • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	2.7 to 5.5		38	130	μA
				2.7 to 3.6		12	65	
HALT mode consumption current (Note 7-1)	IDDHALT(1)	$V_{DD}1$ = $V_{DD}2$ = $V_{DD}3$	HALT mode • FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		2	3.1	mA
				2.7 to 3.6		0.9	1.7	
	IDDHALT(2)		HALT mode • CF1=24MHz external clock • FsX'tal=32.768kHz crystal oscillation mode • System clock set to CF1 side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	3.0 to 5.5		2.2	3.5	
				3.0 to 3.6		1	2	
	IDDHALT(3)		HALT mode • FmCF=10MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 10MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		1.8	2.8	
				2.7 to 3.6		0.8	1.5	
	IDDHALT(4)		HALT mode • FmCF=4MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 4MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		1	1.6	
				2.7 to 3.6		0.4	0.8	
	IDDHALT(5)		HALT mode • CF oscillation low amplifier size selected. (CFLAMP=1) • FmCF=4MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 4MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/4 frequency division ratio	2.7 to 5.5		0.5	1	
				2.7 to 3.6		0.2	0.5	
	IDDHALT(6)		HALT mode • External FmCF oscillation stopped. • FsX'tal=32.768kHz crystal oscillation mode • System clock set to internal Medium speed RC oscillation • Internal Low speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	2.7 to 5.5		0.35	0.8	
				2.7 to 3.6		0.15	0.4	

Note 7-1: Values of the consumption current do not include current that flows into the output transistors and internal pull-up resistors.

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Parameter	Symbol	Pin/ remarks	Conditions	Specification				
				V_{DD}[V]	min.	typ.	max.	unit
HALT mode consumption current (Note 7-1)	IDDHALT(7)	$V_{DD}1$ = $V_{DD}2$ = $V_{DD}3$	HALT mode • External FmCF oscillation stopped. • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 8MHz with Frequency variable RC oscillation • Internal Low speed and Medium speed RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		1.5	2.4	mA
				2.7 to 3.6		1	1.6	
	IDDHALT(8)		HALT mode • External FsX'tal and FmCF oscillation stopped. • System clock set to internal Low speed RC oscillation. • Internal Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/1 frequency division ratio	2.7 to 5.5		18	74	µA
				2.7 to 3.6		9	40	
	IDDHALT(9)		HALT mode • External FmCF oscillation stopped. • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768 kHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	2.7 to 5.5		27	95	
				2.7 to 3.6		5.5	42	
HOLD mode consumption current (Note 7-1)	IDDHOLD(1)	$V_{DD}1$ = $V_{DD}2$ = $V_{DD}3$	HOLD mode • CF1=V_{DD} or open (External clock mode)	2.7 to 5.5		0.04	20	µA
				2.7 to 3.6		0.03	10	
Timer HOLD mode consumption current (Note 7-1)	IDDHOLD(2)		Timer HOLD mode • CF1=VDD or open (External clock mode) • FsX'tal=32.768kHz crystal oscillation mode	2.7 to 5.5		25	88	
				2.7 to 3.6		4.5	38	

Note 7-1: Values of the consumption current do not include current that flows into the output transistors 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

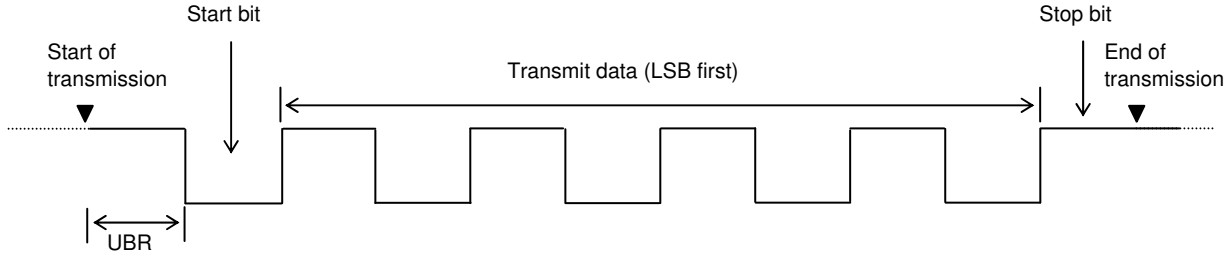
Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
Onboard programming current	IDDFW	$V_{DD}1$ = $V_{DD}2$ = $V_{DD}3$	Only current of the Flash block.	2.7 to 5.5		5	10	mA
Programming time	tFW(1)		Erasing time	2.7 to 5.5		20	30	ms
	tFW(2)		Programming time			40	60	µs

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

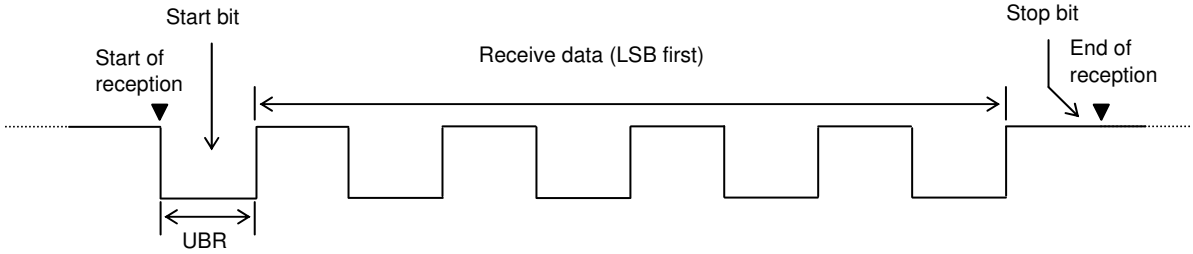
Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
Transfer rate	UBR	UTX(P20), URX(P21)		2.7 to 5.5	16/3		8192/3	tCYC

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)



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
• CF oscillation normal amplifier size selected (CFLAMP=0)

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant				Operating Voltage Range [V]	Oscillation Stabilization Time (Symbol: tmsCF)		Remarks
			C1 [pF]	C2 [pF]	Rf1 [Ω]	Rd1 [Ω]		typ [ms]	max [ms]	
12MHz	MURATA	CSTCE12M0G52-R0	(10)	(10)	Open	680	2.7 to 5.5	0.03		Internal C1,C2
10MHz		CSTCE10M0G52-R0	(10)	(10)	Open	680	2.7 to 5.5	0.03		
		CSTLS10M0G53-B0	(15)	(15)	Open	680	2.7 to 5.5	0.03		
8MHz		CSTCE8M00G52-R0	(10)	(10)	Open	1.0k	2.7 to 5.5	0.03		
		CSTLS8M00G53-B0	(15)	(15)	Open	1.0k	2.7 to 5.5	0.03		
6MHz		CSTCR6M00G53-R0	(15)	(15)	Open	1.5k	2.7 to 5.5	0.05		
		CSTLS6M00G53-B0	(15)	(15)	Open	1.5k	2.7 to 5.5	0.03		
4MHz		CSTCR4M00G53-R0	(15)	(15)	Open	1.5k	2.7 to 5.5	0.05		
		CSTLS4M00G53-B0	(15)	(15)	Open	1.5k	2.7 to 5.5	0.03		

• CF oscillation low amplifier size selected (CFLAMP=1)

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant				Operating Voltage Range [V]	Oscillation Stabilization Time (Symbol: tmsCF)		Remarks
			C1 [pF]	C2 [pF]	Rf1 [Ω]	Rd1 [Ω]		typ [ms]	max [ms]	
4MHz	MURATA	CSTCR4M00G53-R0	(15)	(15)	Open	1.0k	2.7 to 5.5	0.07		Internal C1,C2
		CSTLS4M00G53-B0	(15)	(15)	Open	1.0k	2.7 to 5.5	0.05		

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after an instruction for starting the main clock oscillation circuit or the time interval that is required for the oscillation to get stabilized (when oscillation is enabled before HOLD or X'tal HOLD mode is entered) after that mode is released (see Figure 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 (Symbol: tmsXtal)		Remarks
			C3 [pF]	C4 [pF]	Rf2 [Ω]	Rd2 [Ω]		typ [s]	max [s]	
32.768kHz	EPSON TOYOCOM	MC-306	18	18	Open	560k	2.7 to.5.5	1.5	3.0	Applicable CL value= 12.5pF

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 or the time interval that is required for the oscillation to get stabilized (when oscillation is enabled before HOLD mode is entered) after that mode is released (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.

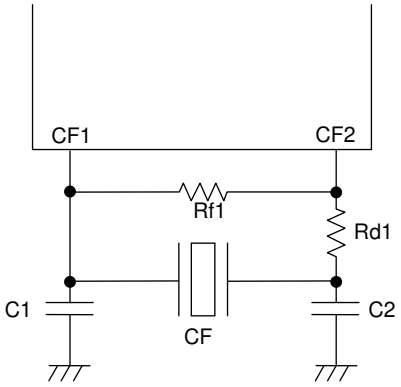


Figure 1 CF Oscillator Circuit

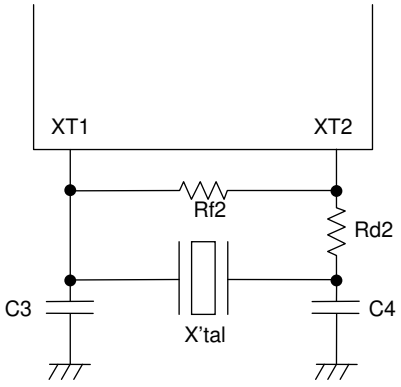


Figure 2 XT Oscillator Circuit

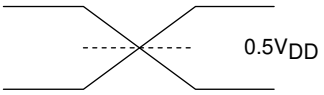
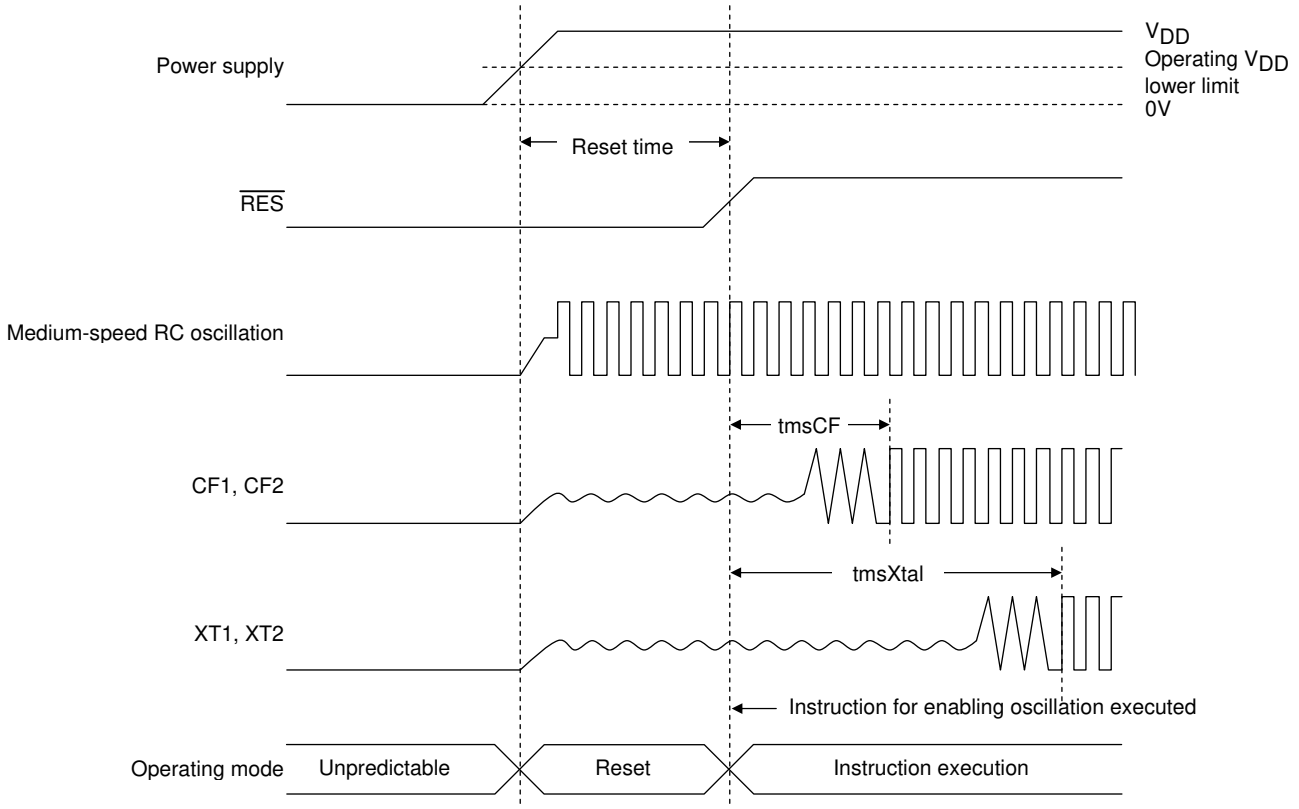
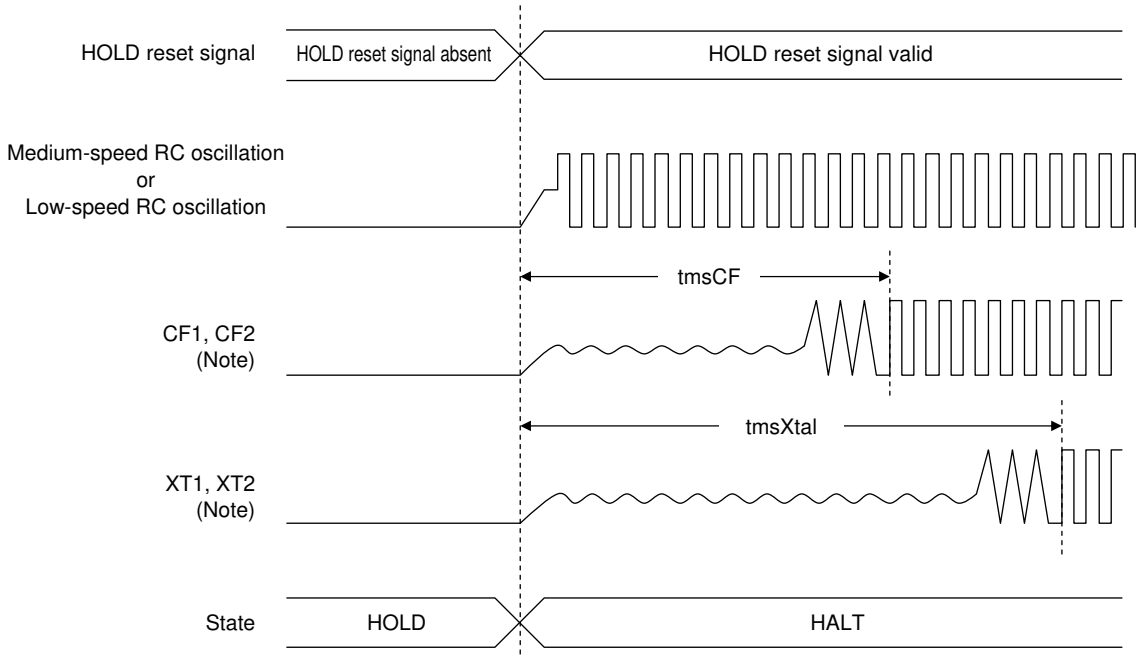


Figure 3 AC Timing Measurement Point

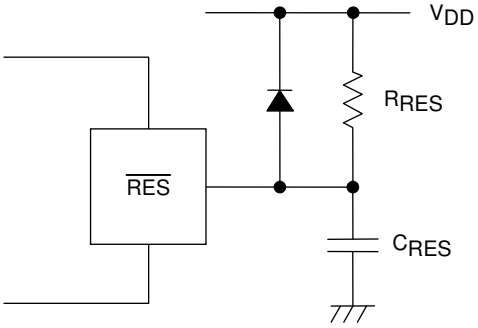


Reset Time and Oscillation Stabilizing Time



HOLD Release Signal and Oscillation Stabilization Time
(Note: When oscillation is enabled before HOLD mode is entered.)

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

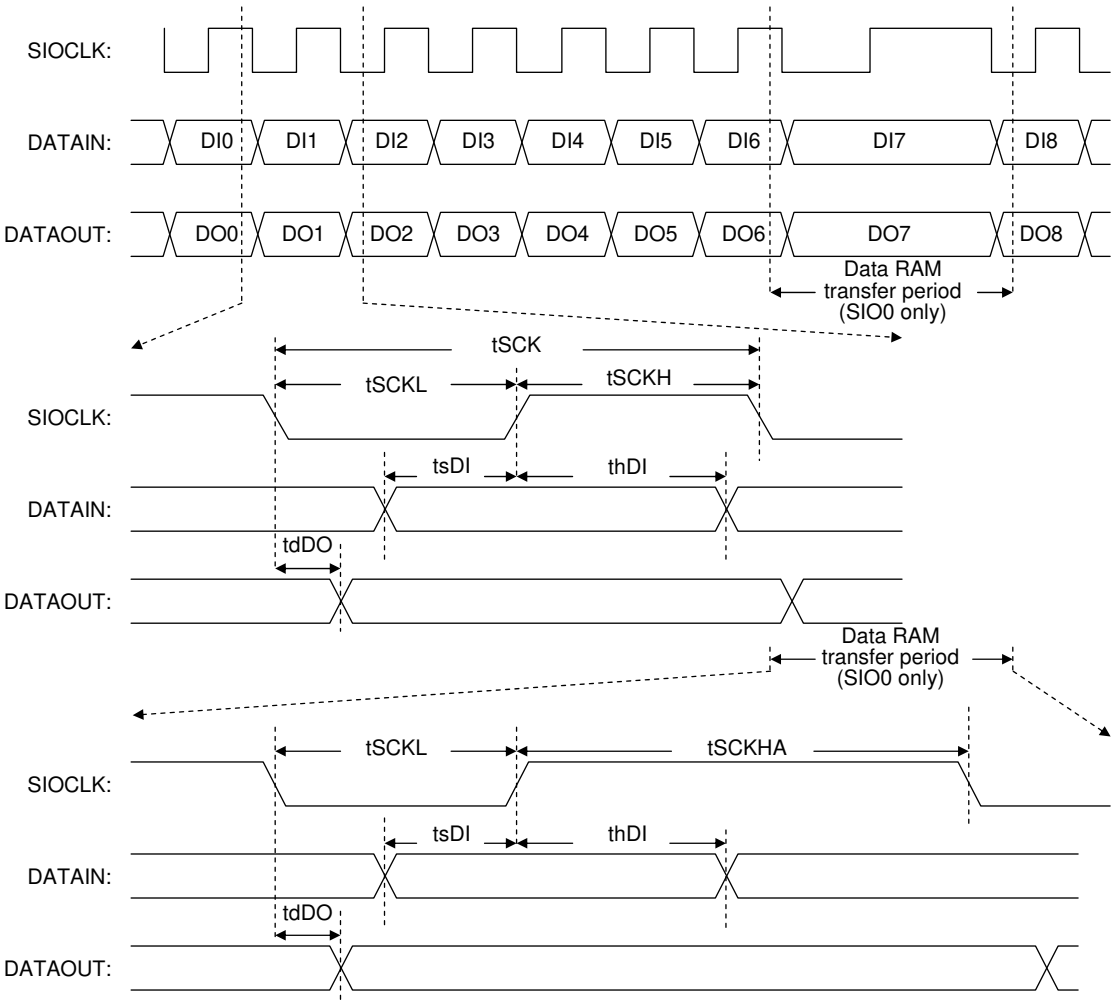


Figure 6 Serial Input/Output Wave Forms

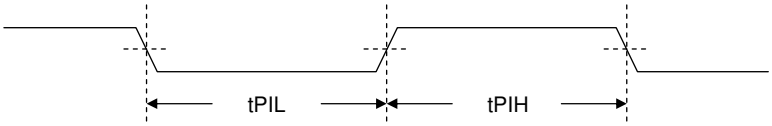


Figure 7 Pulse Input Timing Signal Waveform