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LC87F2J32A

CMOS IC
FROM 32K byte, RAM 1024 byte on-chip
8-bit 1-chip Microcontroller

ON Semiconductor®
http://onsemi.com

Overview

The LC87F2J32A is an 8-bit microcomputer that, integrates on a single chip a number of hardware features such as 32K-byte flash ROM, 1024-byte RAM, an On-chip-debugger, a 16-bit timer/counter, four 8-bit timers, 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, two 12-bit PWM channels, a 12/8-bit 14-channel AD converter, a system clock frequency divider, remote control receive, an internal reset and an interrupt feature.

Features

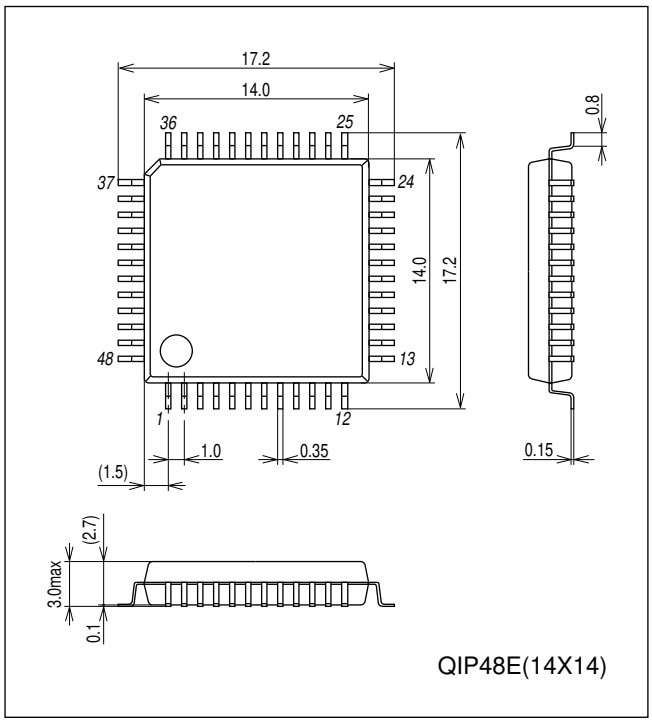
■Flash ROM
- 32768 × 8 bits
- Capable of on-board-programming with wide range (2.2 to 5.5V) of voltage source.
- Block-erasable in 128-byte units
- Writable in 2-byte units

■RAM
- 1024 × 9 bits

■Package Form
- QIP48E (14×14): Lead-free type
- SQFP48 (7×7): Lead-/Halogen-free type

Package Dimensions

unit : mm (typ)
3156A

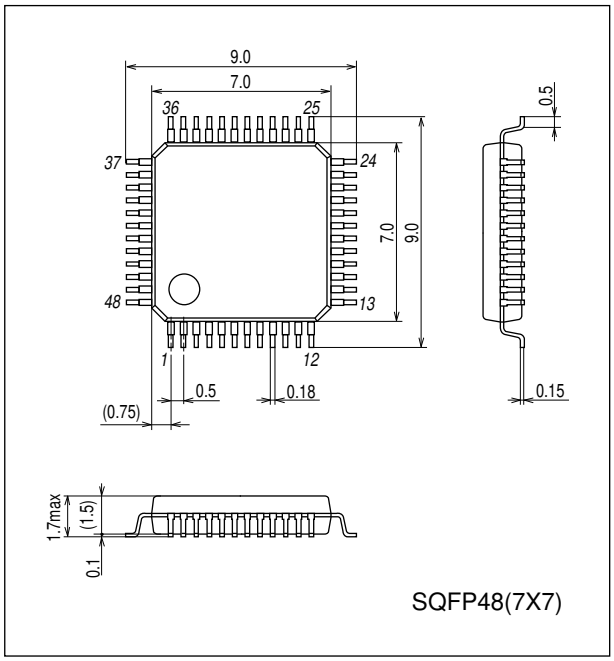


QIP48E(14X14)

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

Package Dimensions

unit : mm (typ)
3163B



■Minimum Bus Cycle

- 83.3ns (12MHz) V_{DD}=2.7 to 5.5V
- 100ns (10MHz) V_{DD}=2.2 to 5.5V
- 250ns (4MHz) V_{DD}=1.8 to 5.5V

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

■Minimum Instruction Cycle Time

- 250ns (12MHz) V_{DD}=2.7 to 5.5V
- 300ns (10MHz) V_{DD}=2.2 to 5.5V
- 750ns (4MHz) V_{DD}=1.8 to 5.5V

■Ports

• Normal withstand voltage I/O ports Ports I/O direction can be designated in 1-bit units	39 (P0n, P1n, P2n, P30 to P36, P70 to P73, PWM0, PWM1, XT2, CF2)
• Dedicated oscillator ports/input ports	2 (CF1, XT1)
• Reset pin	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 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

■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=4/3 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)
- 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)

■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
- 12/8 bits AD converter resolution selectable

■PWM: Multifrequency 12-bit PWM × 2 channels

■Remote Control Receiver Circuit (sharing pins with P73, INT3, and T0IN)
1) Noise rejection function
   (Units of noise rejection filter : about 120µs, when selecting a 32.768kHz crystal oscillator as a clock.)
2) Supporting reception formats with a guide-pulse of halt-clock/clock/none.
3) Determines a end of reception by detecting a no-signal periods (No carrier).
   (Supports same reception format with a different bit length.)
4) 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/UART1 transmit
9	00043H	H or L	ADC/T6/T7
10	0004BH	H or L	Port 0/T4/T5/PWM0, PWM1

- 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: 512 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(8MHz)
    (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).

■Internal Reset Function

- Power-on reset (POR) function
  1) POR reset is generated only at power-on time.
  2) The POR release level can be selected from 8 levels (1.67V, 1.97V, 2.07V, 2.37V, 2.57V, 2.87V, 3.86V, and 4.35V) through option configuration.
- Low-voltage detection reset (LVD) function
  1) LVD and POR functions are combined to generate resets when power is turned on and when power voltage falls below a certain level.
  2) The use/disuse of the LVD function and the low voltage threshold level (7 levels: 1.91V, 2.01V, 2.31V, 2.51V, 2.81V, 3.79V, 4.28V).

■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 or low-voltage detection
     (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 or low-voltage detection
     (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 the base timer.
  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 or low-voltage detection
     (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
     (5) Having an interrupt source established in the base timer circuit
     (6) Having an interrupt source established in the infrared remote controller receiver circuit

■On-chip Debugger

- Supports software debugging with the IC mounted on the target board (LC87D2J32A).
  LC87F2J32A has an On-chip debugger but its function is limited.

■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.

■Development Tools

- On-chip debugger: TCB87- TypeB + LC87D2J32A

■Programming Board

Package	Programming boards
SQFP48 (7×7)	W87F55256SQ
QIP48E (14×14)	W87F55256Q

■Flash ROM Programmer

Maker		Model	Supported version	Device
Flash Support Group, Inc. (FSG)	Single programmer	AF9708 AF9709/AF9709B/AF9709C (Including Ando Electric Co., Ltd. models)	Rev 03.07 or later	LC87F2J32A
	Gang programmer	AF9723/AF9723B(Main body) (Including Ando Electric Co., Ltd. models)	-	-
		AF9833(Unit) (Including Ando Electric Co., Ltd. models)	-	
Flash Support Group, Inc. (FSG) + Our company (Note 1)	In-circuit programmer	AF9101/AF9103(Main body) (FSG models)	(Note 2)	LC87F2J32A
		SIB87(Inter Face Driver) (Our company model)		
Our company	Single/Gang programmer	SKK/SKK Type B (SANYO FWS)	Application Version 1.04 or later Chip Data Version 2.16 or later	LC87F2J32A
	In-circuit/ Gang programmer	SKK-DBG Type B (SANYO FWS)		

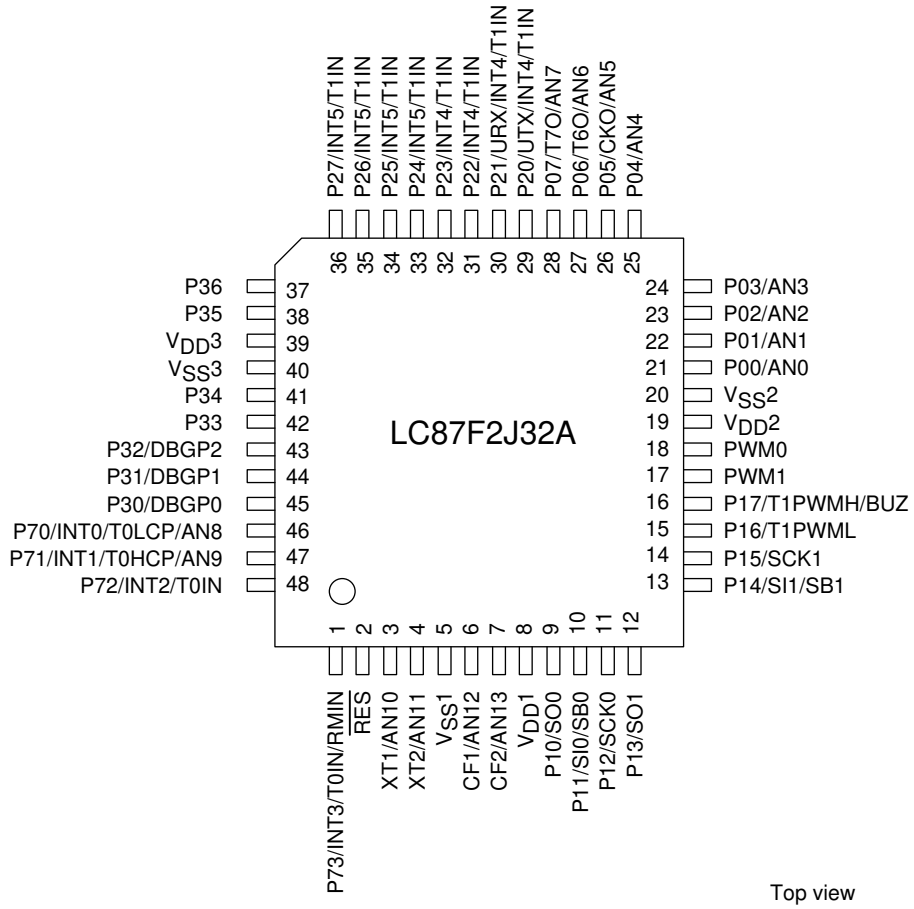
Note1: On-board-programmer from FSG (AF9101/AF9103) and serial interface driver from Our company (SIB87) together

can give a PC-less, standalone on-board-programming capabilities.

Note2: It needs a special programming devices and applications depending on the use of programming environment.

Please ask FSG or Our company for the information.

Pin Assignment



Top view

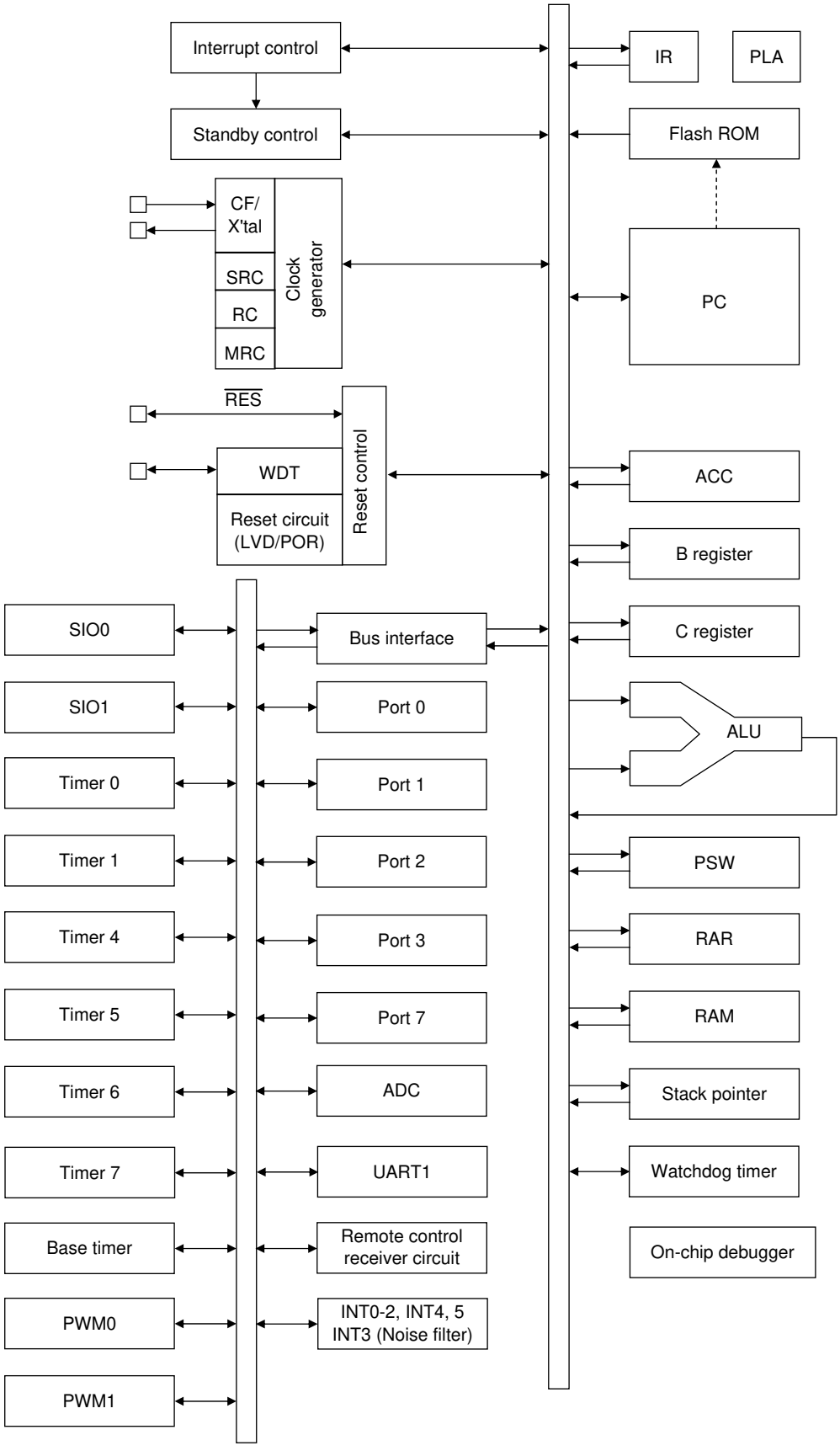
SQFP48 (7×7) "Lead- / Halogen-free Type"
QIP48E (14×14) "Lead-free Type"

SQFP/QIP	NAME
1	P73/INT3/T0IN/RMIN
2	$\overline{RES}$
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/QIP	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/QIP	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/DBGP2
44	P31/DBGP1
45	P30/DBGP0
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
P30 to P36</td><td>I/O</td><td>• 7-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units.
• Shared pins
On-chip debugger pins: DBGP0 to DBGP2 (P30 to P32)</td><td>Yes</td></tr>
</table>

Continued on next page.

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<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
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, PWM1</td><td>I/O</td><td>• PWM0 and PWM1 output ports
• 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>Output</td><td>Ceramic resonator output pin
• Shared pins
General-purpose I/O port
AD converter input port: AN13</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 P21	Open	Output low
P30 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
P30 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

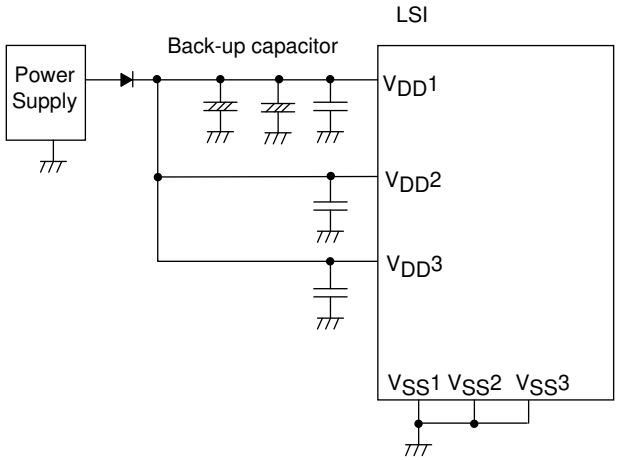
Note 1: The control of the presence or absence of the programmable pull-up resistors for port 0 and the switching between low- and high-impedance pull-up connection is exercised in 1-bit units.

User Option Table

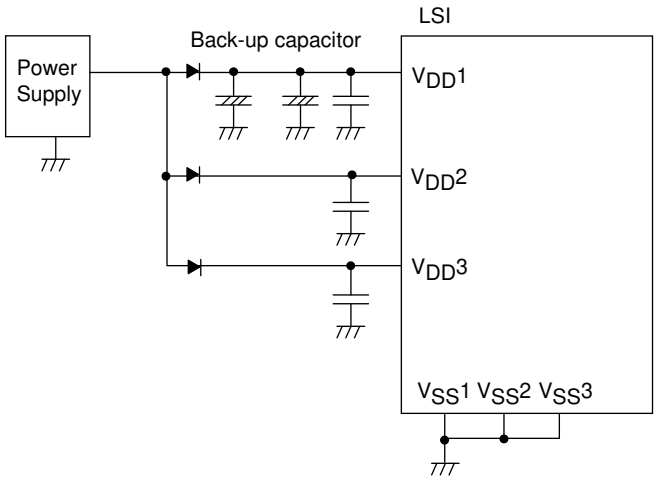
Option name	Option to be applied on	Flash-ROM version	Option selected in units of	Option selection
Port output type	P00 to P07	○	1 bit	CMOS
				Nch-open drain
	P10 to P17	○	1 bit	CMOS
				Nch-open drain
	P20 to P27	○	1 bit	CMOS
				Nch-open drain
	P30 to P36	○	1 bit	CMOS
				Nch-open drain
Program start address	-	○	-	00000h
				07E00h
Low-voltage detection reset function	Detect function	○	-	Enable: Use
				Disable: Not Used
	Detect level	○	-	7-level
Power-on reset function	Power-On reset level	○	-	8-level

Note: To reduce V_{DD} 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	Pin/Remarks	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			-0.3		V_{DD}+0.3	V
Input/output voltage		V_{IO}	Ports 0, 1, 2, 3, Port 7, PWM0, PWM1, XT2, CF2			-0.3		V_{DD}+0.3	V
High level output current	Peak output current	IOPH(1)	Ports 0, 1, 2, 3	CMOS output select Per 1 applicable pin		-10			mA
		IOPH(2)	PWM0, PWM1			-20			mA
		IOPH(3)	P71 to P73	Per 1 applicable pin		-5			mA
	Mean output current (Note 1-1)	IOMH(1)	Ports 0, 1, 2, 3	CMOS output select Per 1 applicable pin		-7.5			mA
		IOMH(2)	PWM0, PWM1			-15			mA
		IOMH(3)	P71 to P73	Per 1 applicable pin		-3			mA
	Total output current	ΣIOAH(1)	P71 to P73	Total of all applicable pins		-10			mA
		ΣIOAH(2)	Port 0	Total of all applicable pins		-25			mA
		ΣIOAH(3)	Port 1, PWM0, PWM1	Total of all applicable pins		-25			mA
		ΣIOAH(4)	Ports 0, 1,PWM0, PWM1	Total of all applicable pins		-45			mA
		ΣIOAH(5)	Ports 2, P35, P36	Total of all applicable pins		-25			mA
		ΣIOAH(6)	P30 to P34	Total of all applicable pins		-25			mA
		ΣIOAH(7)	Pots 2, 3	Total of all applicable pins		-45			mA
Low level output current	Peak output current	IOPL(1)	P02 to P07, Ports 1, 2, 3, PWM0, PWM1	Per 1 applicable pin				20	mA
		IOPL(2)	P00, P01	Per 1 applicable pin				30	mA
		IOPL(3)	Port 7, XT2, CF2	Per 1 applicable pin				10	mA
	Mean output current (Note 1-1)	IOML(1)	P02 to P07, Ports 1, 2, 3, PWM0, PWM1	Per 1 applicable pin				15	mA
		IOML(2)	P00, P01	Per 1 applicable pin				20	mA
		IOML(3)	Port 7, XT2, CF2	Per 1 applicable pin				7.5	mA
	Total output current	ΣIOAL(1)	Port 7, XT2, CF2	Total of all applicable pins				15	mA
		ΣIOAL(2)	Port 0	Total of all applicable pins				45	mA
		ΣIOAL(3)	Port 1, PWM0, PWM1	Total of all applicable pins				45	mA
		ΣIOAL(4)	Port 0, 1, PWM0, PWM1	Total of all applicable pins				80	mA
		ΣIOAL(5)	Ports 2, P35, P36	Total of all applicable pins				45	mA
		ΣIOAL(6)	P30 to P34	Total of all applicable pins				45	mA
		ΣIOAL(7)	Ports 2, 3	Total of all applicable pins				60	mA
Power dissipation		Pd max(1)	SQFP48 (7×7)	Ta=-40 to +85°C Package only				139	mW
		Pd max(2)		Ta=-40 to +85°C Package with thermal resistance board (Note 1-2)				356	mW
		Pd max(3)	QIP48E (14×14)	Ta=-40 to +85°C Package only				281	mW
		Pd max(4)		Ta=-40 to +85°C Package with thermal resistance board (Note 1-2)				489	mW
Operating ambient temperature		Topr				-40		+85	°C
Storage ambient temperature		Tstg				-55		+125	°C

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

Note 1-2: SEMI standards thermal resistance board (size: 76.1×114.3×1.6tmm, 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°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
Operating supply voltage (Note 2-1)	$V_{DD}(1)$	$V_{DD}1=V_{DD}2=V_{DD}3$	0.245µs≤tCYC≤200µs	2.7 to 5.5				V
	$V_{DD}(2)$		0.294µs≤tCYC≤200µs	2.2 to 5.5				
	$V_{DD}(3)$		0.735µs≤tCYC≤200µs	1.8 to 5.5				
Memory sustaining supply voltage	VHD	$V_{DD}1=V_{DD}2=V_{DD}3$	RAM and register contents sustained in HOLD mode.	1.6 to 5.5				
High level input voltage	$V_{IH}(1)$	Ports 1, 2, 3, P71 to P73 P70 port input/ interrupt side PWM0, PWM1		1.8 to 5.5	$0.3V_{DD}+0.7$		V_{DD}	
	$V_{IH}(2)$	Port 0		1.8 to 5.5	$0.3V_{DD}+0.7$		V_{DD}	
	$V_{IH}(3)$	Port 70 watchdog timer side		1.8 to 5.5	$0.9V_{DD}$		V_{DD}	
	$V_{IH}(4)$	XT1, XT2, CF1, CF2, $\overline{RES}$		1.8 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}		$0.1V_{DD}+0.4$	
				1.8 to 4.0	V_{SS}		$0.2V_{DD}$	
	$V_{IL}(2)$	Port 0		4.0 to 5.5	V_{SS}		$0.15V_{DD}+0.4$	
				1.8 to 4.0	V_{SS}		$0.2V_{DD}$	
	$V_{IL}(3)$	Port 70 watchdog timer side		1.8 to 5.5	V_{SS}		$0.8V_{DD}-1.0$	
	$V_{IL}(4)$	XT1, XT2, CF1, CF2, $\overline{RES}$		1.8 to 5.5	V_{SS}		$0.25V_{DD}$	
Instruction cycle time (Note 2-1)	tCYC (Note 2-2)			2.7 to 5.5	0.245		200	µs
				2.2 to 5.5	0.294		200	
				1.8 to 5.5	0.735		200	
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
				1.8 to 5.5	0.1		4	
			• 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	
				2.0 to 5.5	0.2		8	
Oscillation frequency range (Note 2-3)	FmCF(1)	CF1, CF2	12MHz ceramic oscillation See Fig. 1.	2.7 to 5.5		12		MHz
	FmCF(2)	CF1, CF2	10MHz ceramic oscillation See Fig. 1.	2.2 to 5.5		10		
	FmCF(3)	CF1, CF2	4MHz ceramic oscillation. CF oscillation normal amplifier size selected. See Fig. 1. CFLAMP=0)	1.8 to 5.5		4		
			4MHz ceramic oscillation. CF oscillation low amplifier size selected. (CFLAMP=1) See Fig. 1.	2.2 to 5.5		4		

Note 2-1: V_{DD} must be held greater than or equal to 2.2V 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.

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Parameter	Symbol	Pin/Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Oscillation frequency range (Note 2-3)	FmMRC(1)		Frequency variable RC oscillation. 1/2 frequency division ratio. (RCCTD=0) (Note 2-4)	2.4 to 5.5	7.44	8.0	8.56	MHz
	FmMRC(2)		Frequency variable RC oscillation. 1/2 frequency division ratio. (RCCTD=0) Ta=-10 to +50°C (Note 2-4)	2.4 to 5.5	7.6	8.0	8.4	
	FmRC		Internal Medium-speed RC oscillation	1.8 to 5.5	0.5	1.0	2.0	
	FmSRC		Internal Low-speed RC oscillation	1.8 to 5.5	50	100	200	kHz
	FsX'tal	XT1, XT2	32.768kHz crystal oscillation See Fig. 3.	1.8 to 5.5		32.768		
Frequency variable RC oscillation usable range	OpVMRC		Frequency variable RC oscillation. 1/2 frequency division ratio. (RCCTD=0)	2.4 to 5.5	6	8	10	MHz
Frequency variable RC oscillation adjustment range	VmADJ(1)		Each step of VMRCHBn	2.4 to 5.5	3.6	7.0	11	%
	VmADJ(2)		Each step of VMFCHBn	2.4 to 5.5	0.7	1.5	2.3	
	VmADJ(3)		Each step of VMDCHn	2.4 to 5.5	0.2	0.5	1.1	

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

Note 2-4: 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°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
High level input current	$I_{IH}(1)$	Ports 0, 1, 2, 3 Ports 7 $\overline{RES}$ PWM0, PWM1	Output disabled Pull-up resistor off $V_{IN}=V_{DD}$ (Including output Tr's off leakage current)	1.8 to 5.5			1	μA
	$I_{IH}(2)$	XT1, XT2, CF2	Input port selected $V_{IN}=V_{DD}$	1.8 to 5.5			1	
	$I_{IH}(3)$	CF1	$V_{IN}=V_{DD}$	1.8 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)	1.8 to 5.5	-1			
	$I_{IL}(2)$	XT1, XT2, CF2	Input port selected $V_{IN}=V_{SS}$	1.8 to 5.5	-1			
	$I_{IL}(3)$	CF1	$V_{IN}=V_{SS}$	1.8 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			
	$V_{OH}(3)$		I_{OH}=-0.15mA	1.8 to 5.5	V_{DD} -0.4			
	$V_{OH}(4)$	PWM0, PWM1, P05(System clock output function used)	I_{OH}=-6mA	4.5 to 5.5	V_{DD}-1			
	$V_{OH}(5)$		I_{OH}=-1.4mA	2.7 to 5.5	V_{DD} -0.4			
	$V_{OH}(6)$		I_{OH}=-0.8mA	1.8 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	
	$V_{OL}(3)$		I_{OL}=0.8mA	1.8 to 5.5			0.4	
	$V_{OL}(4)$	P00, P01	I_{OL}=25mA	4.5 to 5.5			1.5	
	$V_{OL}(5)$		I_{OL}=4mA	2.7 to 5.5			0.4	
	$V_{OL}(6)$		I_{OL}=2mA	1.8 to 5.5			0.4	
	$V_{OL}(7)$	Port 7, XT2, CF2	I_{OL}=1.4mA	2.7 to 5.5			0.4	
	$V_{OL}(8)$		I_{OL}=0.8mA	1.8 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)			1.8 to 4.5	18	50	230	
	Rpu(3)	Port 0	$V_{OH}=0.9V_{DD}$ When Port 0 selected High-impedance pull-up.	1.8 to 5.5	100	210	400	
Hysteresis voltage	VHYS(1)	Ports 1, 2, 3, 7, $\overline{RES}$, XT2		2.7 to 5.5		0.1 V_{DD}		V
	VHYS(2)			1.8 to 2.7		0.07 V_{DD}		
Pin capacitance	CP	All pins	For pins other than that under test: $V_{IN}=V_{SS}$, f=1MHz, Ta=25°C	1.8 to 5.5		10		pF

Serial Input/Output 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.	1.8 to 5.5	2			tCYC
		Low level pulse width	tSCKL(1)				1			
		High level pulse width	tSCKH(1)				1			
	Output clock	Frequency	tSCK(2)	SCK0(P12)	• CMOS output selected • See Fig. 6	1.8 to 5.5	4/3			
		Low level pulse width	tSCKL(2)				1/2			tSCK
		High level pulse width	tSCKH(2)				1/2			
Serial input	Data setup time		tsDI(1)	SB0(P11), SI0(P11)	• Must be specified with respect to rising edge of SIOCLK. • See Fig. 6.	1.8 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 4-1-2)	1.8 to 5.5			(1/3)tCYC +0.08	
			tdD0(2)		• Synchronous 8-bit mode (Note 4-1-2)				1tCYC +0.08	
	Output clock		tdD0(3)		(Note 4-1-2)				(1/3)tCYC +0.08	

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

Note 4-1-2: 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.	1.8 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.	1.8 to 5.5	2			
		Low level pulse width	tSCKL(4)				1/2			tSCK
		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.	1.8 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.	1.8 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	Specification				
				VDD[V]	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.	1.8 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.	1.8 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.	1.8 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.	1.8 to 5.5	256			
	tPIL(5)	$\overline{RES}$	• Resetting is enabled.	1.8 to 5.5	200			µs

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)		2.4 to 5.5		12		bit
Absolute accuracy	ET		(Note 6-1)	3.0 to 5.5			±16	LSB
			(Note 6-1)	2.4 to 3.6			±20	
Conversion time	TCAD		• See Conversion time calculation formulas. (Note 6-2)	4.0 to 5.5	32		115	µs
				3.0 to 5.5	64		115	
			• See Conversion time calculation formulas. (Note 6-2)	2.4 to 3.6	410		425	
Analog input voltage range	VAIN			2.4 to 5.5	V_{SS}		V_{DD}	V
Analog port input current	IAINH(1)	analog channel except AN12	VAIN=V_{DD}	2.4 to 5.5			1	µA
	IAINL(1)		VAIN=V_{SS}	2.4 to 5.5	-1			
	IAINH(2)	AN12	VAIN=V_{DD}	2.4 to 5.5			15	
	IAINL(2)		VAIN=V_{SS}	2.4 to 5.5	-15			

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.

<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)		2.4 to 5.5		8		bit
Absolute accuracy	ET		(Note 6-1)	2.4 to 5.5			±1.5	LSB
Conversion time	TCAD		• See Conversion time calculation formulas. (Note 6-2)	4.0 to 5.5	20		90	µs
				3.0 to 5.5	40		90	
			• See Conversion time calculation formulas. (Note 6-2)	2.4 to 3.6	250		265	
Analog input voltage range	VAIN			2.4 to 5.5	V_{SS}		V_{DD}	V
Analog port input current	IAINH(1)	analog channel except AN12	VAIN=V_{DD}	2.4 to 5.5			1	µA
	IAINL(1)		VAIN=V_{SS}	2.4 to 5.5	-1			
	IAINH(2)	AN12	VAIN=V_{DD}	2.4 to 5.5			15	
	IAINL(2)		VAIN=V_{SS}	2.4 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

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	4.0V 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	4.0V 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
	2.4V 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.

Power-on reset (POR) Characteristics at Ta = -40 to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				Option selected voltage	min	typ	max	unit
POR release voltage	PORRL		• Select from option. (Note 7-1)	1.67V	1.55	1.67	1.79	V
				1.97V	1.85	1.97	2.09	
				2.07V	1.95	2.07	2.19	
				2.37V	2.25	2.37	2.49	
				2.57V	2.45	2.57	2.69	
				2.87V	2.75	2.87	2.99	
				3.86V	3.73	3.86	3.99	
				4.35V	4.21	4.35	4.49	
Detection voltage unknown state	POUKS		• See Fig. 8. (Note 7-2)			0.7	0.95	
Power supply rise time	PORIS		• Power supply rise time from 0V to 1.6V.				100	ms

Note7-1: The POR release level can be selected out of 8 levels only when the LVD reset function is disabled.
Note7-2: POR is in an unknown state before transistors start operation.

Low voltage detection reset (LVD) Characteristics at Ta = -40 to +85°C, $V_{SS}1=V_{SS}2=V_{SS}3=0V$

Parameter	Symbol	Pin/Remarks	Conditions	Option selected voltage	Specification min	typ	max	unit
LVD reset Voltage (Note 8-2)	LVDET		• Select from option. (Note 8-1) (Note 8-3) • See Fig. 9.	1.91V	1.81	1.91	2.01	V
				2.01V	1.91	2.01	2.11	
				2.31V	2.21	2.31	2.41	
				2.51V	2.41	2.51	2.61	
				2.81V	2.71	2.81	2.91	
				3.79V	3.69	3.79	3.89	
				4.28V	4.18	4.28	4.38	
LVD hysteresis width	LVHYS			1.91V		55		mV
				2.01V		55		
				2.31V		55		
				2.51V		55		
				2.81V		60		
				3.79V		65		
				4.28V		65		
Detection voltage unknown state	LVUKS		• See Fig. 9. (Note 8-4)			0.7	0.95	V
Low voltage detection minimum width (Reply sensitivity)	TLVDW		• LVDET-0.5V • See Fig. 10.		0.2			ms

Note8-1: The LVD reset level can be selected out of 7 levels only when the LVD reset function is enabled.

Note8-2: LVD reset voltage specification values do not include hysteresis voltage.

Note8-3: LVD reset voltage may exceed its specification values when port output state changes and/or when a large current flows through port.

Note8-4: LVD is in an unknown state before transistors start operation.

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 9-1) (Note 9-2)	IDDOP(1)	$V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$	• FmCF=12MHz ceramic 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		6.6	11.3	
				2.7 to 3.6		4.0	7.3	
	IDDOP(2)		• CF1=24MHz external clock • 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		8.0	12.7	
				3.0 to 3.6		4.6	7.6	
	IDDOP(3)		• FmCF=10MHz ceramic 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	2.2 to 5.5		5.9	10.5	
				2.2 to 3.6		3.6	6.7	
	IDDOP(4)		• FmCF=4MHz ceramic 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	1.8 to 5.5		2.6	6.1	
				1.8 to 3.6		1.9	3.9	mA
	IDDOP(5)		• CF oscillation low amplifier size selected. (CFLAMP=1) • FmCF=4MHz ceramic 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	2.2 to 5.5		0.9	2.2	
				2.2 to 3.6		0.5	1.1	
	IDDOP(6)		• FsX'tal=32.768kHz Crystal oscillation mode • Internal Low speed RC oscillation stopped. • System clock set to internal Medium speed RC oscillation. • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	1.8 to 5.5		0.5	1.5	
				1.8 to 3.6		0.3	0.8	
	IDDOP(7)		• FsX'tal=32.768kHz crystal oscillation mode • Internal Low speed and Medium speed RC oscillation stopped. • System clock set to 8MHz with Frequency variable RC oscillation • 1/1 frequency division ratio	2.7 to 5.5		5.6	10.8	
				2.7 to 3.6		3.8	6.6	
	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	1.8 to 5.5		70	173	
				1.8 to 3.6		47	106	
	IDDOP(9)		• 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 • Ta=-10 to +50°C	5.0		70	145	µA
				3.3		47	86	
				2.5		35	65	

Note 9-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors.

Note9-2: The consumption current values do not include operational current of LVD function if not specified

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Parameter	Symbol	Pin/ Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Normal mode consumption current (Note 9-1) (Note 9-2)	IDDOP(10)	V_{DD}1	• 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	1.8 to 5.5		27	120	μA
				1.8 to 3.6		13	59	
	IDDOP(11)		• 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 • Ta=-10 to +50°C	5.0		27	84	
				3.3		13	33	
				2.5		8.1	22	
HALT mode consumption current (Note 9-1) (Note 9-2)	IDDHALT(1)	V_{DD}1	• HALT mode • FmCF=12MHz ceramic 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		2.6	4.7	mA
				2.7 to 3.6		1.4	2.5	
	IDDHALT(2)		• HALT mode • CF1=24MHz external clock • 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		4.0	6.9	
				3.0 to 3.6		2.0	3.4	
	IDDHALT(3)		• HALT mode • FmCF=10MHz ceramic 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	2.2 to 5.5		2.2	4.4	
				2.2 to 3.6		1.2	2.3	
	IDDHALT(4)		• HALT mode • FmCF=4MHz ceramic 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	1.8 to 5.5		1.2	3.0	
				1.8 to 3.6		0.6	1.4	
	IDDHALT(5)		• HALT mode • CF oscillation low amplifier size selected. (CFLAMP=1) • FmCF=4MHz ceramic oscillation mode • System clock set to 4 MHz side • Internal Low speed and Medium speed RC oscillation stopped. • Frequency variable RC oscillation stopped. • 1/4 frequency division ratio	2.2 to 5.5		0.6	1.5	
				2.2 to 3.6		0.3	0.7	
	IDDHALT(6)		• HALT mode • FsX'tal=32.768 kHz crystal oscillation mode • Internal Low speed RC oscillation stopped. • System clock set to internal Medium speed RC oscillation • Frequency variable RC oscillation stopped. • 1/2 frequency division ratio	1.8 to 5.5		0.3	0.9	
				1.8 to 3.6		0.2	0.5	

Note 9-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors.

Note9-2: The consumption current values do not include operational current of LVD function if not specified

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Parameter	Symbol	Pin/ remarks	Conditions	V_{DD}[V]	Specification min.	typ.	max.	unit
HALT mode consumption current (Note 9-1) (Note 9-2)	IDDHALT(7)	V_{DD}1	• HALT mode • FsX'tal=32.768kHz crystal oscillation mode • Internal Low speed and Medium speed RC oscillation stopped. • System clock set to 8MHz with Frequency variable RC oscillation • 1/1 frequency division ratio	2.7 to 5.5		2.5	5.0	μA
				2.7 to 3.6		1.4	2.6	
	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	1.8 to 5.5		26	91	
				1.8 to 3.6		15	48	
	IDDHALT(9)		• 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 • Ta=-10 to +50°C	5.0		26	52	
				3.3		15	26	
				2.5		10	18	
	IDDHALT(10)		• HALT mode • FsX'tal=32.768 kHz 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	1.8 to 5.5		16	96	
				1.8 to 3.6		6.2	43	
	IDDHALT(11)		• HALT mode • 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 • Ta=-10 to +50°C	5.0		16	56	
				3.3		6.2	18	
				2.5		3.4	11	
HOLD mode consumption current (Note 9-1) (Note 9-2)	IDDHOLD(1)	V_{DD}1	HOLD mode • CF1=V_{DD} or open (External clock mode)	1.8 to 5.5		0.04	30	μA
				1.8 to 3.6		0.02	14	
	IDDHOLD(2)		HOLD mode • CF1=V_{DD} or open (External clock mode) • Ta=-10 to +50°C	5.0		0.04	2.8	
				3.3		0.02	1.2	
				2.5		0.015	0.9	
	IDDHOLD(3)		HOLD mode • CF1=V_{DD} or open (External clock mode) • LVD option selected	1.8 to 5.5		2.9	35	
				1.8 to 3.6		2.2	18	
	IDDHOLD(4)		HOLD mode • CF1=V_{DD} or open (External clock mode) • Ta=-10 to +50°C • LVD option selected	5.0		2.9	7.2	
				3.3		2.2	4.1	
				2.5		1.9	3.4	
Timer HOLD mode consumption current (Note 9-1) (Note 9-2)	IDDHOLD(5)	V_{DD}1	Timer HOLD mode • FsX'tal=32.768kHz crystal oscillation mode	1.8 to 5.5		14	89	
				1.8 to 3.6		4.8	38	
	IDDHOLD(6)		Timer HOLD mode • FsX'tal=32.768kHz crystal oscillation mode • Ta=-10 to +50°C	5.0		14	40	
				3.3		4.8	15	
				2.5		2.4	7.6	

Note 9-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors.

Note9-2: The consumption current values do not include operational current of LVD function if not specified

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

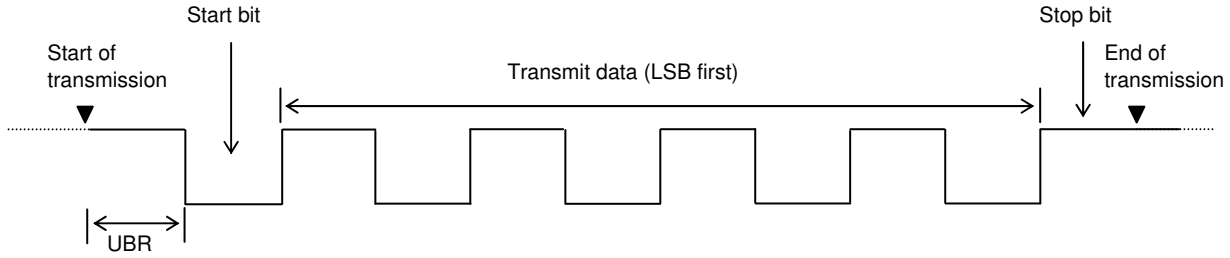
Parameter	Symbol	Pin/Remarks	Conditions		Specification			
				V_{DD}[V]	min	typ	max	unit
Onboard programming current	IDDFW(1)	$V_{DD}1$	• Only current of the Flash block.	2.2 to 5.5		5	10	mA
Programming time	tFW(1)		• Erasing time	2.2 to 5.5		20	30	ms
	tFW(2)		• Programming time			40	60	µs

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

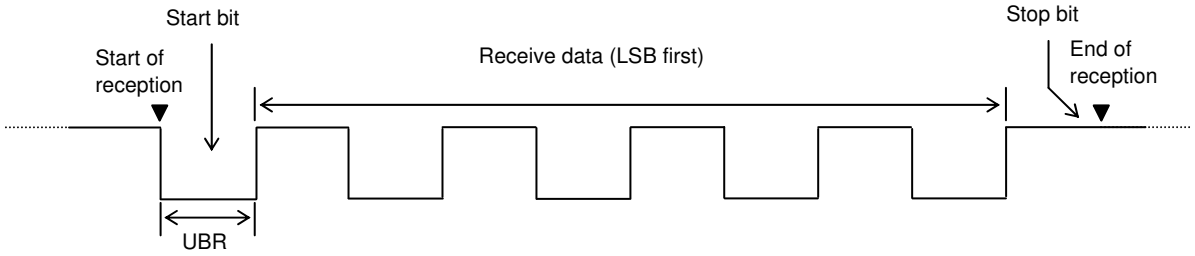
Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
Transfer rate	UBR	UTX(P20), URX(P21)		1.8 to 5.5	16/3		8192/3	tCYC

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		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	0.1	0.5	Internal C1,C2
10MHz		CSTCE10M0G52-R0	(10)	(10)	Open	680	2.2 to 5.5	0.1	0.5	
		CSTLS10M0G53-B0	(15)	(15)	Open	680	2.2 to 5.5	0.1	0.5	
8MHz		CSTCE8M00G52-R0	(10)	(10)	Open	1.0k	2.2 to 5.5	0.1	0.5	
		CSTLS8M00G53-B0	(15)	(15)	Open	1.0k	2.2 to 5.5	0.1	0.5	
6MHz		CSTCR6M00G53-R0	(15)	(15)	Open	1.5k	2.2 to 5.5	0.1	0.5	
		CSTLS6M00G53-B0	(15)	(15)	Open	1.5k	2.2 to 5.5	0.1	0.5	
4MHz		CSTCR4M00G53-R0	(15)	(15)	Open	1.5k	1.8 to 5.5	0.2	0.6	
		CSTLS4M00G53-B0	(15)	(15)	Open	1.5k	1.8 to 5.5	0.2	0.6	

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

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]	
4MHz	MURATA	CSTCR4M00G53-R0	(15)	(15)	Open	1.0k	1.9 to 5.5	0.2	0.6	Internal C1,C2
		CSTLS4M00G53-B0	(15)	(15)	Open	1.0k	1.9 to 5.5	0.2	0.6	

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after V_{DD} goes above the operating voltage lower limit (see Figure 4).