Ordering number : ENA1220A

LC87F1D64A

CMOS IC
FROM 64K byte, RAM 4K byte on-chip

8-bit 1-chip Microcontroller with Full-Speed USB

ON Semiconductor®

http://onsemi.com

Overview

The LC87F1D64A is an 8-bit microcomputer that, centered around a CPU running at a minimum bus cycle time of 62.5ns, integrates on a single chip a number of hardware features such as 64K-byte flash ROM (onboard programmable), 4096-byte RAM, an on-chip debugger, a sophisticated 16-bit timers/counters (may be divided into 8-bit timers), 16-bit timers/counter (may be divided into 8-bit timers/counters or 8-bit PWMs), two 8-bit timers with a prescaler, a base timer serving as a time-of-day clock, a high-speed clock counter, two synchronous SIO interface (with automatic block transmit/ receive function), an asynchronous/synchronous SIO interface, a UART interface (full duplex), a Full-Speed USB interface (function controller), 12-channel 12-bit A/D converter with 12-/8-bit resolution selector, two 12-bit PWM channels, a system clock frequency divider, an infrared remote control receiver circuit, and a 30-source 10-vector address interrupt feature.

Features

■Flash ROM
- Capable of on-board-programming with wide range, 3.0 to 5.5V, of voltage source.
- Block-erasable in 128 byte units
- Writes data in 2-byte units
- 65536 × 8 bits

■RAM
- 4096 × 9 bits

■Minimum Bus Cycle
- 62.5ns (CF=16MHz)
  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
- 188ns (CF=16MHz)

■Ports
- I/O ports
  Ports whose I/O direction can be designated in 1 bit units 28 (P10 to P17, P20 to P27, P30 to P34, P70 to P73, PWM0, PWM1, XT2)
  Ports whose I/O direction can be designated in 4 bit units 8 (P00 to P07)
- USB ports 2 (D+, D-)
- Dedicated oscillator ports 2 (CF1, CF2)
- Input-only port (also used for oscillation) 1 (XT1)
- Reset pins 1 ($\overline{\text{RES}}$)
- 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 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 programmable in 5 different time schemes

■SIO
- SIO0: Synchronous serial interface
  1) LSB first/MSB first mode selectable
  2) Transfer clock cycle: 4/3 to 512/3 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)
- SIO4: Synchronous serial interface
  1) LSB first/MSB first mode selectable
  2) Transfer clock cycle: 4/3 to 1020/3 tCYC
  3) Automatic continuous data transmission (1 to 4096 bytes, specifiable in 1 byte units, suspension and resumption of data transmission possible in 1 byte or 2 bytes units)
  4) Auto-start-on-falling-edge function
  5) Clock polarity selectable
  6) CRC16 calculator circuit built in

■Full Duplex UART
- UART1
  1) Data length: 7/8/9 bits selectable
  2) Stop bits: 1 bit (2 bits in continuous transmission mode)
  3) Baud rate: 16/3 to 8192/3 tCYC
- UART2
  1) Data length: 7/8/9 bits selectable
  2) Stop bits: 1 bit (2 bits in continuous transmission mode)
  3) Baud rate: 16/3 to 8192/3 tCYC

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

■PWM: Multifrequency 12-bit PWM × 2 channels

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

■USB Interface (function controller)
- Compliant with USB 2.0 Full-Speed
- Supports a maximum of 4 user-defined endpoints.

Endpoint		EP0	EP1	EP2	EP3	EP4
Transfer Type	Control	○	-	-	-	-
	Bulk	-	○	○	○	○
	Interrupt	-	○	○	○	○
	Isochronous	-	○	○	○	○
Max. payload		64	64	64	64	64

■Watchdog Timer
- External RC watchdog timer
  1) Interrupt and reset signals selectable
- Internal counter watchdog timer
  1) Generates an internal reset signal on overflow occurring in a timer that runs on a dedicated low-speed RC oscillator clock (30kHz).
  2) Three operating modes are selectable: continues counting, stops counting, or retains count when the CPU

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

■Interrupts

- 30 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/USB bus active/remote control receiver
4	0001BH	H or L	INT3/INT5/base timer
5	00023H	H or L	T0H
6	0002BH	H or L	T1L/T1H
7	00033H	H or L	SIO0/USB bus reset/USB suspend/UART1 receive/UART2 receive
8	0003BH	H or L	SIO1/USB endpoint/USB-SOF/SIO4/UART1 transmit/UART2 transmit
9	00043H	H or L	ADC/T6/T7
10	0004BH	H or L	Port 0/PWM0/PWM1

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

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

■High-speed Multiplication/Division Instructions

- 16 bits × 8 bits (5 tCYC execution time)
- 24 bits × 16 bits (12 tCYC execution time)
- 16 bits ÷ 8 bits (8 tCYC execution time)
- 24 bits ÷ 16 bits (12 tCYC execution time)

■Oscillation Circuits

- RC oscillation circuit (internal): For system clock (1MHz)
- Low-speed RC oscillation circuit (internal): For watchdog timer (30kHz)
- CF oscillation circuit: For system clock
- Crystal oscillation circuit: For system clock, time-of-day clock
- PLL circuit (internal): For USB interface (see Fig.5)

■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) Reset generated by watchdog timer

(3) Interrupt generation

- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.

1) The PLL base clock generator, CF, RC and crystal oscillators automatically stop operation.

2) There are five ways of resetting the HOLD mode.

(1) Setting the reset pin to the lower level.

(2) Reset generated by watchdog timer

(3) Having an interrupt source established at one of the INT0, INT1, INT2, INT4, and INT5 pins

* The INT0 and INT1 pins must be configured only for level detection.

(4) Having an interrupt source established at port 0

(5) Having an bus active interrupt source established in the USB interface circuit

Continued on next page.

Continued from preceding page.

- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer and the infrared remote control receiver circuit.
  1) The PLL base clock generator, CF and RC oscillator automatically stop operation.
  2) The state of crystal oscillation established when the X'tal HOLD mode is entered is retained.
  3) There are seven ways of resetting the X'tal HOLD mode.
     (1) Setting the reset pin to the low level
     (2) Reset generated by watchdog timer
     (3) Having an interrupt source established at one of the INT0, INT1, INT2, INT4, and INT5 pins
         * The INT0 and INT1 pins must be configured only for level detection.
     (4) Having an interrupt source established at port 0
     (5) Having an interrupt source established in the base timer circuit
     (6) Having an bus active interrupt source established in the USB interface circuit
     (7) Having an interrupt source established in the infrared remote control receiver circuit

■Package Form

- SQFP48(7×7): Lead-/Halogen-free type

■Development Tools

- On-chip debugger: TCB87 type B + LC87F1D64A

■Flash ROM Programming Boards

Package	Programming boards
SQFP48(7×7)	W87F55256SQ

■Flash ROM Programmer

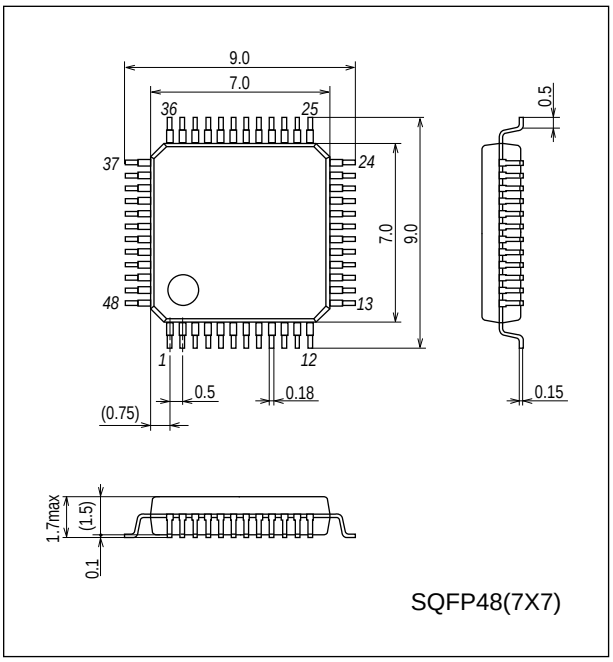
Maker		Model	Supported version	Device
Flash Support Group, Inc. (FSG)	Single Programmer	AF9708 AF9709/AF9709B/AF9709C (Including Ando Electric Co., Ltd. models)	Rev.03.06 or later	LC87F1D64A
Flash Support Group, Inc. (FSG) + Our company (Note 1)	In-circuit Programmer	AF9101/AF9103 (main body) (FSG models)	(Note 2)	
		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 2.15 or later	LC87F1D64
	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.

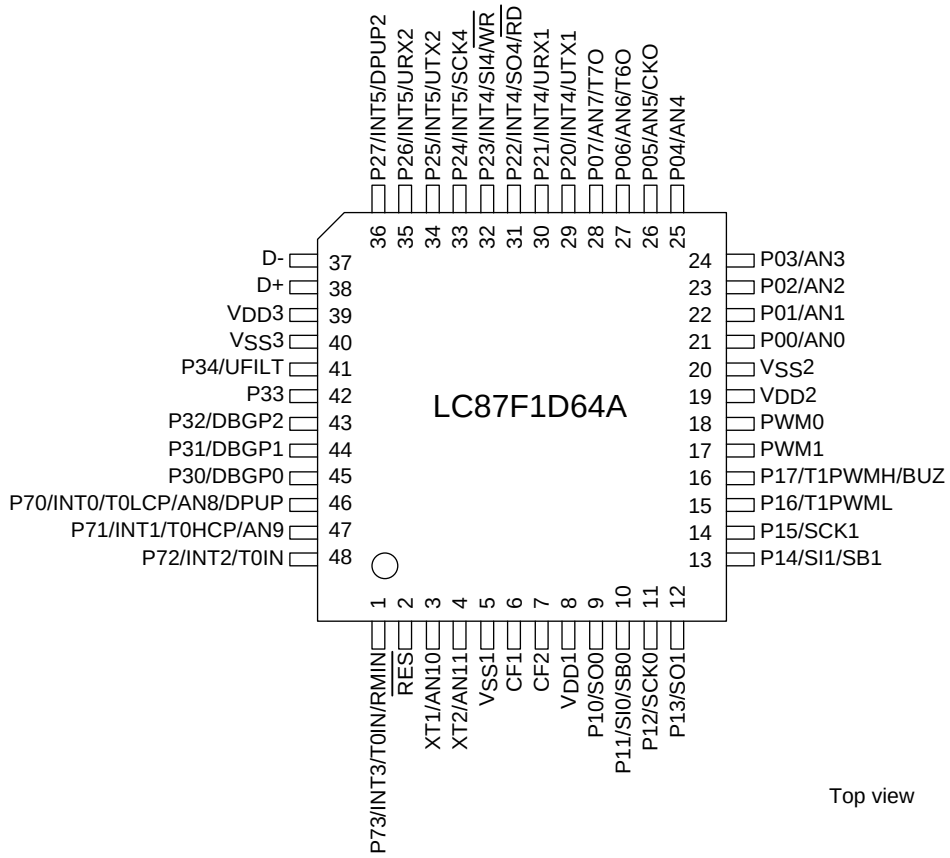
Note2: It needs a special programming devices and applications depending on the use of programming environment. Please ask FSG or Our company for the information.

Package Dimensions

unit : mm (typ)
3163B



Pin Assignment

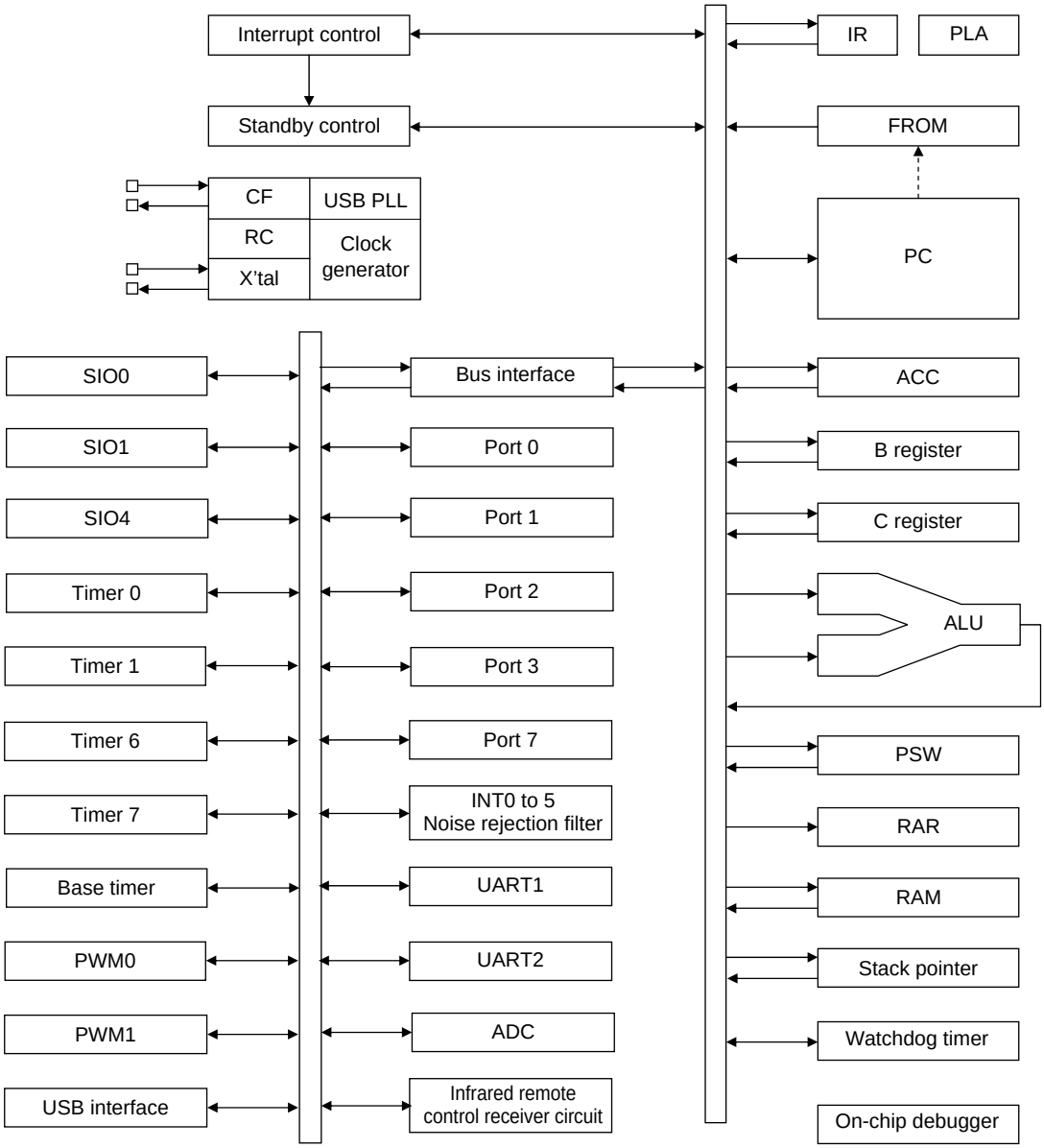


SQFP48(7×7) “Lead-/ Halogen-free Type”

SQFP48	NAME
1	P73/INT3/T0IN/RMIN
2	$\overline{RES}$
3	XT1/AN10
4	XT2/AN11
5	$V_{SS}1$
6	CF1
7	CF2
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
17	PWM1
18	PWM0
19	$V_{DD}2$
20	$V_{SS}2$
21	P00/AN0
22	P01/AN1
23	P02/AN2
24	P03/AN3

SQFP48	NAME
25	P04/AN4
26	P05/AN5/CKO
27	P06/AN6/T6O
28	P07/AN7/T7O
29	P20/INT4/UTX1
30	P21/INT4/URX1
31	P22/INT4/SO4/$\overline{RD}$
32	P23/INT4/SI4/$\overline{WR}$
33	P24/INT5/SCK4
34	P25/INT5/UTX2
35	P26/INT5/URX2
36	P27/INT5/DPUP2
37	D-
38	D+
39	$V_{DD}3$
40	$V_{SS}3$
41	P34/UFILT
42	P33
43	P32/DBGP2
44	P31/DBGP1
45	P30/DBGP0
46	P70/INT0/T0LCP/AN8/DPUP
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>$V_{SS}1$,
$V_{SS}2$,
$V_{SS}3$</td><td>-</td><td>-power supply pin</td><td>No</td></tr>
<tr><td>$V_{DD}1$,
$V_{DD}2$</td><td>-</td><td>+power supply pin</td><td>No</td></tr>
<tr><td>$V_{DD}3$</td><td>-</td><td>USB reference voltage pin</td><td>Yes</td></tr>
<tr><td>Port 0
P00 to P07</td><td>I/O</td><td>• 8-bit I/O port
• I/O specifiable in 4-bit units
• Pull-up resistors can be turned on and off in 4-bit units.
• HOLD reset input
• Port 0 interrupt input
• Pins functions
AD converter input port: AN0 to AN7 (P00 to P07)
P05: System Clock Output
P06: Timer 6 toggle outputs
P07: Timer 7 toggle outputs</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 1 PWML output
P17: Timer 1 PWMH 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 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
P20: UART1 transmit
P21: UART1 receive
P22: SIO4 date I/O/parallel interface $\overline{RD}$ output
P23: SIO4 date I/O/parallel interface $\overline{WR}$ output
P24: SIO4 clock I/O
P25: UART2 transmit
P26: UART2 receive
P27: D+ 1.5kΩ pull-up resistor connect pin
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>
</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 3
P30 to P34</td><td>I/O</td><td>• 5-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
P34: USB interface PLL filter pin (see Fig.5)
On-chip debugger pins: DBGP0 to DBGP2 (P30 to P32)</td><td>Yes</td></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/
D+ 1.5kΩ pull-up resistor connect pin
P71: INT1 input/HOLD reset input/timer 0H capture input
P72: INT2 input/HOLD reset input/timer 0 event input/timer 0L capture input/
high speed clock counter input
P73: INT3 input (with noise filter)/timer 0 event input/timer 0H capture input/
infrared remote control receiver input
AD converter input port: AN8(P70), AN9(P71)
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 port
• General-purpose input port</td><td>No</td></tr>
<tr><td>D-</td><td>I/O</td><td>• USB data I/O pin D-
• General-purpose I/O port</td><td>No</td></tr>
<tr><td>D+</td><td>I/O</td><td>• USB data I/O pin D+
• General-purpose I/O port</td><td>No</td></tr>
<tr><td>$\overline{\text{RES}}$</td><td>Input</td><td>Reset pin</td><td>No</td></tr>
<tr><td>XT1</td><td>Input</td><td>• 32.768kHz crystal oscillator input pin
• Pin functions
General-purpose input port
AD converter input port: AN10
Must be connected to $V_{DD}1$ if not to be used.</td><td>No</td></tr>
<tr><td>XT2</td><td>I/O</td><td>32.768kHz crystal oscillator output pin
• Pin functions
General-purpose I/O port
AD converter input port: AN11
Must be set for oscillation and kept open if not to be used.</td><td>No</td></tr>
<tr><td>CF1</td><td>Input</td><td>Ceramic resonator input pin</td><td>No</td></tr>
<tr><td>CF2</td><td>Output</td><td>Ceramic resonator output pin</td><td>No</td></tr>
</table>

Port Output Types

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

Port Name	Option Selected in Units of	Option Type	Output Type	Pull-up Resistor
P00 to P07	1 bit	1	CMOS	Programmable (Note 1)
		2	Nch-open drain	No
P10 to P17 P20 to P27 P30 to P34	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
D+, D-	-	No	CMOS	No
XT1	-	No	Input only	No
XT2	-	No	32.768kHz crystal oscillator output (N channel open drain when in general-purpose output mode)	No

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

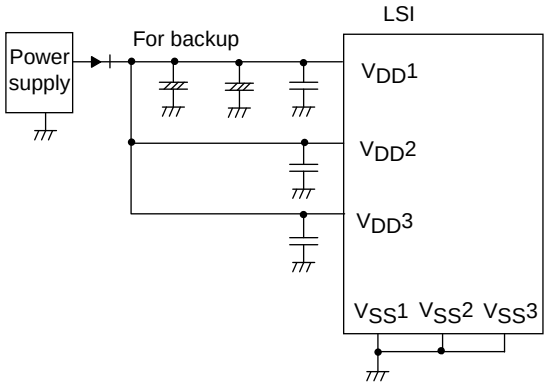
User Option Table

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 P34	○	1 bit	CMOS
				Nch-open drain
Program start address	-	○	-	00000h
				0FE00h
USB Regulator	USB Regulator	○	-	USE
				NONUSE
	USB Regulator (at HOLD mode)	○	-	USE
				NONUSE
	USB Regulator (at HALT mode)	○	-	USE
				NONUSE

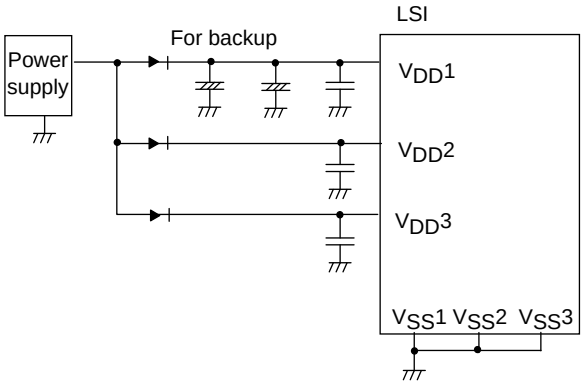
Power Pin Treatment

Connect the IC as shown below to minimize the noise input to the $V_{DD}1$ pin.
Be sure to electrically short the $V_{SS}1$, $V_{SS}2$, and $V_{SS}3$ pins.

Example 1: When the microcontroller is in the backup state in the HOLD mode, the power to sustain the high level of output ports is supplied by their backup capacitors.



Example 2: The high level output at ports is not sustained and unstable in the HOLD backup mode.



USB Reference Power Option

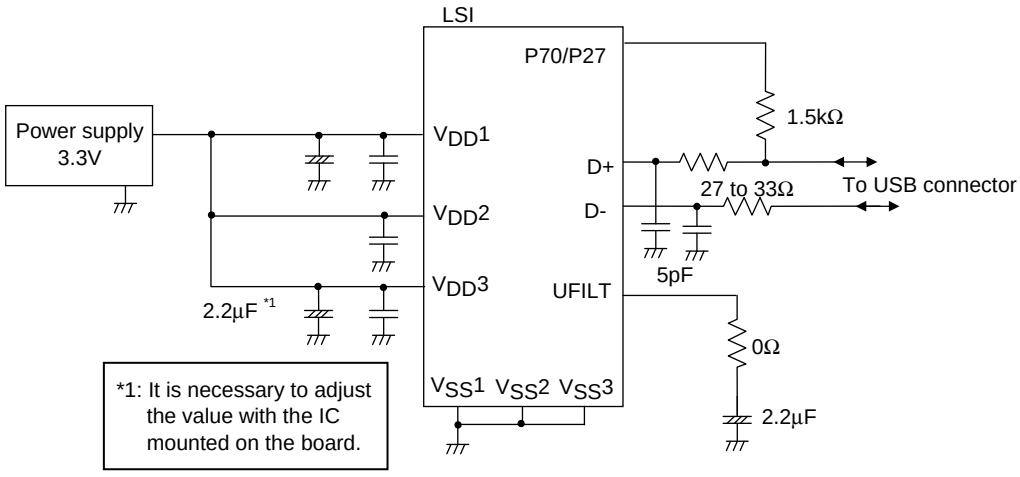
When a voltage 4.5 to 5.5V is supplied to $V_{DD}1$ and the internal USB reference voltage circuit is activated, the reference voltage for USB port output is generated. The active/inactive state of reference voltage circuit can be switched by the option select. The procedure for marking the option selection is described below.

		(1)	(2)	(3)	(4)
Option select	USB Regulator	USE	USE	USE	NONUSE
	USB Regulator at HOLD mode	USE	NONUSE	NONUSE	NONUSE
	USB Regulator at HALT mode	USE	NONUSE	USE	NONUSE
Reference voltage circuit state	Normal state	active	active	active	inactive
	HOLD mode	active	inactive	inactive	inactive
	HALT mode	active	inactive	active	inactive

- When the USB reference voltage circuit is made inactive, the level of the reference voltage for USB port output is equal to $V_{DD}1$.
- Selection (2) or (3) can be used to set the reference voltage circuit inactive in HOLD or HALT mode.
- When the reference voltage circuit is activated, the current drain increase by approximately 100µA compared with when the reference voltage circuit is inactive.

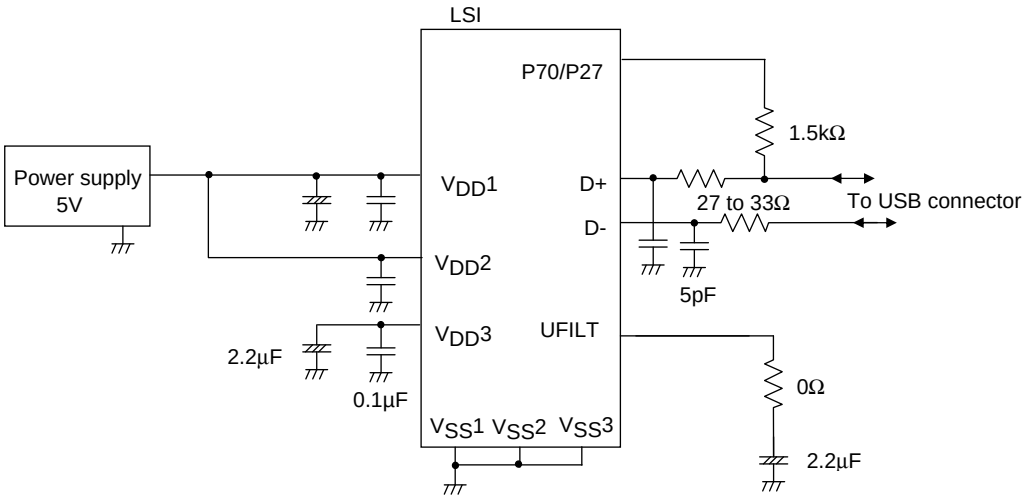
Example 1: $V_{DD}1=V_{DD}2=3.3V$

- Inactivating the reference voltage circuit (selection (4)).
- Connecting $V_{DD}3$ to $V_{DD}1$ and $V_{DD}2$.



Example 2: $V_{DD}1=V_{DD}2=5.0V$

- Activating the reference voltage circuit (selection (1)).
- Isolating $V_{DD}3$ from $V_{DD}1$ and $V_{DD}2$, and connecting capacitor between $V_{DD}3$ and V_{SS}.



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(1)	XT1, CF1			-0.3		V_{DD}+0.3	
Input/output voltage		V_{IO}(1)	Ports 0, 1, 2, 3, 7 PWM0, PWM1, XT2			-0.3		V_{DD}+0.3	
High level output current	Peak output current	IOPH(1)	Ports 0, 1, 2	• When CMOS output type is selected • Per 1 applicable pin		-10			mA
		IOPH(2)	PWM0, PWM1	Per 1 applicable pin		-20			
		IOPH(3)	Port 3 P71 to P73	• When CMOS output type is selected • Per 1 applicable pin		-5			
	Average output current (Note 1-1)	IOMH(1)	Ports 0, 1, 2	• When CMOS output type is selected • Per 1 applicable pin		-7.5			
		IOMH(2)	PWM0, PWM1	Per 1 applicable pin		-15			
		IOMH(3)	Port 3 P71 to P73	• When CMOS output type is selected • Per 1 applicable pin		-3			
	Total output current	ΣIOAH(1)	Ports 0, 2	Total of all applicable pins		-25			
		ΣIOAH(2)	Port 1 PWM0, PWM1	Total of all applicable pins		-25			
		ΣIOAH(3)	Ports 0, 1, 2 PWM0, PWM1	Total of all applicable pins		-45			
		ΣIOAH(4)	Port 3 P71 to P73	Total of all applicable pins		-10			
		ΣIOAH(5)	D+, D-	Total of all applicable pins		-25			
Low level output current	Peak output current	IOPL(1)	P02 to P07 Ports 1, 2 PWM0, PWM1	Per 1 applicable pin				20	
		IOPL(2)	P00, P01	Per 1 applicable pin				30	
		IOPL(3)	Ports 3, 7, XT2	Per 1 applicable pin				10	
	Average output current (Note 1-1)	IOML(1)	P02 to P07 Ports 1, 2 PWM0, PWM1	Per 1 applicable pin				15	
		IOML(2)	P00, P01	Per 1 applicable pin				20	
		IOML(3)	Ports 3, 7, XT2	Per 1 applicable pin				7.5	
	Total output current	ΣIOAL(1)	Ports 0, 2	Total of all applicable pins				45	
		ΣIOAL(2)	Port 1 PWM0, PWM1	Total of all applicable pins				45	
		ΣIOAL(3)	Ports 0, 1, 2 PWM0, PWM1	Total of all applicable pins				80	
		ΣIOAL(4)	Ports 3, 7, XT2	Total of all applicable pins				15	
		ΣIOAL(5)	D+, D-	Total of all applicable pins				25	
Allowable power Dissipation		Pd max	SQFP48(7×7)	Ta=-30 to +70°C				190	mW
Operating ambient Temperature		Topr				-30		+70	°C
Storage ambient temperature		Tstg				-55		+125	

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

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 = -30°C to +70°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)	$V_{DD}(1)$	$V_{DD}1=V_{DD}2=V_{DD}3$	0.183µs≤tCYC≤200µs		3.0		5.5	V
			0.183µs≤tCYC≤0.383µs USB circuit active		3.0		5.5	
			0.367µs≤tCYC≤200µs Except for onboard programming		2.7		5.5	
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 0, 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 70 watchdog timer side		2.7 to 5.5	$0.9V_{DD}$		V_{DD}	
	$V_{IH}(3)$	XT1, XT2, CF1, $\overline{RES}$		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		4.0 to 5.5	V_{SS}		$0.1V_{DD}$ +0.4	
	$V_{IL}(2)$			2.7 to 4.0	V_{SS}		$0.2V_{DD}$	
	$V_{IL}(3)$	Port 0 PWM0, PWM1		4.0 to 5.5	V_{SS}		$0.15V_{DD}$ +0.4	
	$V_{IL}(4)$			2.7 to 4.0	V_{SS}		$0.2V_{DD}$	
	$V_{IL}(5)$	Port 70 watchdog timer side		2.7 to 5.5	V_{SS}		$0.8V_{DD}$ -1.0	
	$V_{IL}(6)$	XT1, XT2, CF1, $\overline{RES}$		2.7 to 5.5	V_{SS}		$0.25V_{DD}$	
Instruction cycle time (Note 2-2)	tCYC			3.0 to 5.5	0.183		200	µs
			USB circuit active	3.0 to 5.5	0.183		0.383	
			Except for onboard programming	2.7 to 5.5	0.367		200	
External system clock frequency	FEXCF(1)	CF1	• CF2 pin open • System clock frequency division ratio=1/1 • External system clock duty =50±5%	3.0 to 5.5	0.1		16	MHz
			• CF2 pin open • System clock frequency division ratio=1/1 • External system clock duty =50±5%	2.7 to 5.5	0.1		8	
Oscillation frequency range (Note 2-3)	FmCF(1)	CF1, CF2	16MHz ceramic oscillation See Fig. 1.	3.0 to 5.5		16		MHz
	FmCF(2)	CF1, CF2	8MHz ceramic oscillation See Fig. 1.	2.7 to 5.5		8		
	FmRC		Internal RC oscillation	2.7 to 5.5	0.3	1.0	2.0	
	FmSLRC		Internal low-speed RC oscillation	2.7 to 5.5	15	30	60	kHz
	FsX'tal	XT1, XT2	32.768kHz crystal oscillation See Fig. 2.	2.7 to 5.5		32.768		

Note 2-1: V_{DD} must be held greater than or equal to 3.0V in the flash ROM onboard programming mode.

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

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

Electrical Characteristics at Ta = -30°C to +70°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 D+, D-	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	For input port specification $V_{IN}=V_{DD}$	2.7 to 5.5			1	
	$I_{IH}(3)$	CF1	$V_{IN}=V_{DD}$	2.7 to 5.5			15	
Low level input current	IIL(1)	Ports 0, 1, 2, 3 Port 7 $\overline{RES}$ PWM0, PWM1 D+, D-	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	For input port specification $V_{IN}=V_{SS}$	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}=-0.4mA	3.0 to 5.5	V_{DD}-0.4			
	$V_{OH}(3)$		I_{OH}=-0.2mA	2.7 to 5.5	V_{DD}-0.4			
	$V_{OH}(4)$	PWM0, PWM1 P05 (CK0 when using system clock output function)	I_{OH}=-10mA	4.5 to 5.5	V_{DD}-1.5			
	$V_{OH}(5)$		I_{OH}=-1.6mA	3.0 to 5.5	V_{DD}-0.4			
	$V_{OH}(6)$		I_{OH}=-1mA	2.7 to 5.5	V_{DD}-0.4			
Low level output voltage	$V_{OL}(1)$	P00, P01	I_{OL}=30mA	4.5 to 5.5			1.5	
	$V_{OL}(2)$		I_{OL}=5mA	3.0 to 5.5			0.4	
	$V_{OL}(3)$		I_{OL}=2.5mA	2.7 to 5.5			0.4	
	$V_{OL}(4)$	Ports 0, 1, 2 PWM0, PWM1 XT2	I_{OL}=10mA	4.5 to 5.5			1.5	
	$V_{OL}(5)$		I_{OL}=1.6mA	3.0 to 5.5			0.4	
	$V_{OL}(6)$		I_{OL}=1mA	2.7 to 5.5			0.4	
	$V_{OL}(7)$	Ports 3, 7	I_{OL}=1.6mA	3.0 to 5.5			0.4	
	$V_{OL}(8)$		I_{OL}=1mA	2.7 to 5.5			0.4	
Pull-up resistance	Rpu(1)	Ports 0, 1, 2, 3 Port 7	$V_{OH}=0.9V_{DD}$	4.5 to 5.5	15	35	80	kΩ
	Rpu(2)			2.7 to 5.5	18	50	150	
Hysteresis voltage	VHYS	$\overline{RES}$ Ports 1, 2, 3, 7		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 = -30°C to +70°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		Specification			
						V_{DD}[V]	min	typ	max	unit
Serial clock	Input clock	Frequency	tSCK(1)	SCK0(P12)	See Fig.8.	2.7 to 5.5	2			tCYC
		Low level pulse width	tSCKL(1)				1			
		High level pulse width	tSCKH(1)				1			
			tSCKHA(1a)		• Continuous data transmission/ reception mode • USB nor SIO4 are not in use simultaneous. • See Fig.8. • (Note 4-1-2)		4			
			tSCKHA(1b)		• Continuous data transmission/reception mode • USB is in use simultaneous. • SIO4 is not in use simultaneous. • See Fig.8. • (Note 4-1-2)		7			
			tSCKHA(1c)		• Continuous data transmission/ reception mode • USB and SIO4 are in use simultaneous. • See Fig.8. • (Note 4-1-2)		9			
	Output clock	Frequency	tSCK(2)	SCK0(P12)	• CMOS output selected • See Fig.8.	2.7 to 5.5	4/3			tSCK
		Low level pulse width	tSCKL(2)				1/2			
		High level pulse width	tSCKH(2)				1/2			
			tSCKHA(2a)		• Continuous data transmission/ reception mode • USB nor SIO4 are not in use simultaneous. • CMOS output selected • See Fig.8.		tSCKH(2) +2tCYC		tSCKH(2) +(10/3) tCYC	tCYC
			tSCKHA(2b)		• Continuous data transmission/ reception mode • USB is in use simultaneous. • SIO4 is not in use simultaneous. • CMOS output selected • See Fig.8.		tSCKH(2) +2tCYC		tSCKH(2) +(19/3) tCYC	
			tSCKHA(2c)		• Continuous data transmission/ reception mode • USB and SIO4 are in use simultaneous. • CMOS output selected • See Fig.8.		tSCKH(2) +2tCYC		tSCKH(2) +(25/3) tCYC	

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

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

Continued on next page.

Continued from preceding page.

Parameter			Symbol	Pin/Remarks	Conditions	Specification				
						V_{DD}[V]	min	typ	max	unit
Serial input	Data setup time		tsDI(1)	SB0(P11), SI0(P11)	• Must be specified with respect to rising edge of SIOCLK. • See Fig.8.	2.7 to 5.5	0.03			µs
	Data hold time		thDI(1)			2.7 to 5.5	0.03			
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 +0.05	
			tdD0(2)		• Synchronous 8-bit mode • (Note 4-1-3)	2.7 to 5.5			1tCYC +0.05	
	Output clock		tdD0(3)		(Note 4-1-3)	2.7 to 5.5			(1/3)tCYC +0.05	

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.8.

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

Parameter			Symbol	Pin/Remarks	Conditions	Specification				
						V_{DD}[V]	min	typ	max	unit
Serial clock	Input clock	Frequency	tSCK(3)	SCK1(P15)	See Fig.8.	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.8.		2			
		Low level pulse width	tSCKL(4)			2.7 to 5.5	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.8.	2.7 to 5.5	0.03			µs
	Data hold time		thDI(2)			2.7 to 5.5	0.03			
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.8.	2.7 to 5.5			(1/3)tCYC +0.05	

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

3. SIO4 Serial I/O Characteristics (Note 4-3-1)

Parameter			Symbol	Pin/ Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Serial clock	Input clock	Frequency	tSCK(5)	SCK4(P24)	See Fig.8.	2.7 to 5.5	2			tCYC
		Low level pulse width	tSCKL(5)				1			
		High level pulse width	tSCKH(5)				1			
			tSCKHA(5a)		• USB nor continuous data transmission/reception mode Of SIO0 are not in use simultaneous. • See Fig.8. • (Note 4-3-2)		4			
			tSCKHA(5b)		• USB is in use simultaneous. • Continuous data transmission/ reception mode of SIO0 is not in use simultaneous. • See Fig.8. • (Note 4-3-2)		7			
			tSCKHA(5c)		• USB and continuous data transmission/ reception mode of SIO0 are in use simultaneous. • See Fig.8. • (Note 4-3-2)		10			
	Output clock	Frequency	tSCK(6)	SCK4(P24)	• CMOS output selected • See Fig.8.	2.7 to 5.5	4/3			tSCK
		Low level pulse width	tSCKL(6)				1/2			
		High level pulse width (Note 4-3-3)	tSCKH(6)				1/2			
			tSCKHA(6a)		• USB nor continuous data transmission/reception mode of SIO0 are not in use simultaneous. • CMOS output selected • See Fig.8.		tSCKH(6) +(5/3) tCYC		tSCKH(6) +(10/3) tCYC	tCYC
			tSCKHA(6b)		• USB is in use simultaneous. • Continuous data transmission/ reception mode of SIO0 is not in use simultaneous. • CMOS output selected • See Fig.8.		tSCKH(6) +(5/3) tCYC		tSCKH(6) +(19/3) tCYC	
			tSCKHA(6c)		• USB and continuous data transmission/reception mode of SIO0 are in use simultaneous. • CMOS output selected • See Fig.8.		tSCKH(6) +(5/3) tCYC		tSCKH(6) +(28/3) tCYC	
Serial input	Data setup time		tsDI(3)	SO4(P22), SI4(P23)	• Must be specified with respect to rising edge of SIOCLK. • See Fig.8.	2.7 to 5.5	0.03			µs
	Data hold time		thDI(3)			2.7 to 5.5	0.03			
Serial output	Output delay time		tdD0(5)	SO4(P22), SI4(P23)	• Must be specified with respect to rising edge of SIOCLK. • Must be specified as the time to the beginning of output state change in open drain output mode. • See Fig.8.	2.7 to 5.5			(1/3)tCYC +0.05	µs

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

Note 4-3-2: To use serial-clock-input in continuous trans/rec mode, a time from SI4RUN being set when serial clock is "H" to the first negative edge of the serial clock must be longer than tSCKHA.

Note 4-3-3: When using the serial clock output, make sure that the load at the SCK4 (P24) pin meets the following conditions:
Clock rise time tSCKR < 0.037µs (see Figure 11.) at Ta=+25°C, V_{DD}=3.3V

Pulse Input Conditions at Ta = -30°C to +70°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/low level pulse width	tP1H(1) tP1L(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			
	tPIL(5)	RMIN(P73)	Recognized by the infrared remote control 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 tCYC to 128 tCYC or the source frequency of the subclock) for the infrared remote control receiver circuit.

AD Converter Characteristics at Ta= -30°C to +70°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

<12-bits AD Converter Mode>

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)		3.0 to 5.5		12		bit
Absolute accuracy	ET		(Note 6-1)	3.0 to 5.5			±16	LSB
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	
			AD division ratio=1/16	3.0 to 5.5	50		115	
Analog input voltage range	VAIN			3.0 to 5.5	V_{SS}		V_{DD}	V
Analog port input current	IAINH		VAIN=V_{DD}	3.0 to 5.5			1	µA
	IAINL		VAIN=V_{SS}	3.0 to 5.5	-1			

<8-bits AD Converter Mode>

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)		3.0 to 5.5		8		bit
Absolute accuracy	ET		(Note 6-1)	3.0 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	
			AD division ratio=1/16	3.0 to 5.5	31		90	
Analog input voltage range	VAIN			3.0 to 5.5	V_{SS}		V_{DD}	V
Analog port input current	IAINH		VAIN=V_{DD}	3.0 to 5.5			1	µA
	IAINL		VAIN=V_{SS}	3.0 to 5.5	-1			

<Conversion time calculation formulas>

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

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

<Recommended Operating Conditions>

External oscillator FmCF[MHz]	Supply Voltage Range V_{DD}[V]	System Clock Division (SYSDIV)	Cycle Time tCYC [ns]	AD Frequency Division Ratio (ADDIV)	Conversion Time (TCAD)[µs]	
					12-bit AD	8-bit AD
16	3.0 to 5.5	1/1	187.5	1/16	52.125	32.125
12	4.0 to 5.5	1/1	250	1/8	34.8	21.5
	3.0 to 5.5	1/1	250	1/16	69.5	42.8
8	4.0 to 5.5	1/1	375	1/8	52.25	32.25
	3.0 to 5.5	1/1	375	1/16	104.25	64.25

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 = -30°C to +70°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

Parameter	Symbol	Pin/ Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
Normal mode consumption current (Note 7-1)	IDDOP(1)	$V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$	• FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal PLL oscillation stopped • Internal RC oscillation stopped • USB circuit stopped • 1/1 frequency division ration	4.5 to 5.5		9.9	25	mA
	IDDOP(2)			3.0 to 3.6		5.7	14	
	IDDOP(3)		• FmCF=16MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 16MHz side • Internal PLL oscillation stopped • Internal RC oscillation stopped • USB circuit stopped • 1/1 frequency division ration	4.5 to 5.5		12	30	
	IDDOP(4)			3.0 to 3.6		6.8	17	
	IDDOP(5)		• FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal PLL oscillation mode • Internal RC oscillation stopped • USB circuit active • 1/1 frequency division ration	4.5 to 5.5		14	35	
	IDDOP(6)			3.0 to 3.6		7.7	19	
	IDDOP(7)		• FmCF=16MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 16MHz side • Internal PLL oscillation mode • Internal RC oscillation stopped • USB circuit active • 1/1 frequency division ration	4.5 to 5.5		16	40	
	IDDOP(8)			3.0 to 3.6		8.8	22	
	IDDOP(9)		• FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 6MHz side • Internal RC oscillation stopped • 1/2 frequency division ration	4.5 to 5.5		6.8	16	
	IDDOP(10)			3.0 to 3.6		4.1	9.7	
	IDDOP(11)			2.7 to 3.0		3.5	7.9	
	IDDOP(12)		• FmCF=16MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 8MHz side • Internal RC oscillation stopped • 1/2 frequency division ration	4.5 to 5.5		8.2	20	
	IDDOP(13)			3.0 to 3.6		4.7	12	
	IDDOP(14)			2.7 to 3.0		4.0	9.2	
	IDDOP(15)		• FmCF=0MHz (oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to internal RC oscillation • 1/2 frequency division ration	4.5 to 5.5		0.73	3.5	
	IDDOP(16)			3.0 to 3.6		0.43	1.9	
	IDDOP(17)			2.7 to 3.0		0.37	1.5	
	IDDOP(18)		• FmCF=0MHz (oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal RC oscillation stopped • 1/2 frequency division ration	4.5 to 5.5		45	174	µA
	IDDOP(19)			3.0 to 3.6		18	86	
	IDDOP(20)			2.7 to 3.0		14	63	
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 PLL oscillation stopped • Internal RC oscillation stopped • USB circuit stopped • 1/1 frequency division ration	4.5 to 5.5		4.9	12	mA
	IDDHALT(2)			3.0 to 3.6		2.6	6.3	

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

Continued on next page.

Continued from preceding page.

Parameter	Symbol	Pin/ Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
HALT mode consumption current (Note 7-1)	IDDHALT(3)	$V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$	• HALT mode • FmCF=16MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 16MHz side • Internal PLL oscillation stopped • Internal RC oscillation stopped • USB circuit stopped • 1/1 frequency division ration	4.5 to 5.5		5.7	14	mA
	IDDHALT(4)			3.0 to 3.6		3.1	7.6	
	IDDHALT(5)		• HALT mode • FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal PLL oscillation mode • Internal RC oscillation stopped • USB circuit active • 1/1 frequency division ration	4.5 to 5.5		8.9	23	
	IDDHALT(6)			3.0 to 3.6		4.6	12	
	IDDHALT(7)		• HALT mode • FmCF=16MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 16MHz side • Internal PLL oscillation mode • Internal RC oscillation stopped • USB circuit active • 1/1 frequency division ration	4.5 to 5.5		9.7	24	
	IDDHALT(8)			3.0 to 3.6		5.0	13	
	IDDHALT(9)		• HALT mode • FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 6MHz side • Internal RC oscillation stopped • 1/2 frequency division ration	4.5 to 5.5		3.0	7.2	
	IDDHALT(10)			3.0 to 3.6		1.6	3.8	
	IDDHALT(11)			2.7 to 3.0		1.3	2.9	
	IDDHALT(12)		• HALT mode • FmCF=16MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 8MHz side • Internal RC oscillation stopped • 1/2 frequency division ration	4.5 to 5.5		3.5	8.6	
	IDDHALT(13)			3.0 to 3.6		1.9	4.6	
	IDDHALT(14)			2.7 to 3.0		1.5	3.5	
	IDDHALT(15)		• HALT mode • FmCF=0MHz (oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to internal RC oscillation • 1/2 frequency division ration	4.5 to 5.5		0.41	2.0	
	IDDHALT(16)			3.0 to 3.6		0.20	0.93	
	IDDHALT(17)			2.7 to 3.0		0.16	0.69	
	IDDHALT(18)		• HALT mode • FmCF=0MHz (oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal RC oscillation stopped • 1/2 frequency division ration	4.5 to 5.5		32	134	μA
	IDDHALT(19)			3.0 to 3.6		8.8	60	
	IDDHALT(20)			2.7 to 3.0		6.0	40	
HOLD mode consumption current	IDDHOLD(1)	$V_{DD}1$	HOLD mode • CF1=V_{DD} or open (External clock mode)	4.5 to 5.5		0.08	30	
	IDDHOLD(2)			3.0 to 3.6		0.03	18	
	IDDHOLD(3)			2.7 to 3.0		0.02	15	
	IDDHOLD(4)		HOLD mode • Internal counter watchdog timer operation mode (internal low-speed RC oscillation circuit operation) • CF1=V_{DD} or open (External clock mode)	4.5 to 5.5		2.9	38	
	IDDHOLD(5)			3.0 to 3.6		1.4	23	
	IDDHOLD(6)			2.7 to 3.0		1.2	20	
Timer HOLD mode consumption current	IDDHOLD(7)	$V_{DD}1$	Timer HOLD mode • CF1=V_{DD} or open (External clock mode) • FsX'tal=32.768kHz crystal oscillation mode	4.5 to 5.5		27	118	
	IDDHOLD(8)			3.0 to 3.6		6.1	51	
	IDDHOLD(9)			2.7 to 3.0		3.8	34	

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

USB Characteristics and Timing at Ta = 0°C to +70°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

Parameter	Symbol	Conditions	Specification			
			min	typ	max	unit
High level output	$V_{OH(USB)}$	• 15kΩ±5% to GND	2.8		3.6	V
Low level output	$V_{OL(USB)}$	• 1.5kΩ±5% to 3.6 V	0.0		0.3	V
Output signal crossover voltage	V_{CRS}		1.3		2.0	V
Differential input sensitivity	V_{DI}	• |(D+)-(D-)|	0.2			V
Differential input common mode range	V_{CM}		0.8		2.5	V
High level input	$V_{IH(USB)}$		2.0			V
Low level input	$V_{IL(USB)}$				0.8	V
USB data rise time	t_R	• R_S=27 to 33Ω, CL=50pF • $V_{DD}3$=3.0 to 3.6V	4		20	ns
USB data fall time	t_F	• R_S=27 to 33Ω, CL=50pF • $V_{DD}3$=3.0 to 3.6V	4		20	ns

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

Parameter	Symbol	Pin	Conditions		Specification			
				V_{DD}[V]	min	typ	max	unit
Onboard programming current	IDDFW(1)	$V_{DD}1$	• Excluding power dissipation in the microcontroller block	3.0 to 5.5		5	10	mA
Programming time	tFW(1)		• Erase operation	3.0 to 5.5		20	30	ms
	tFW(2)		• Write operation			40	60	µs

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 at Ta = 0°C to +70°C

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant			Operating Voltage Range [V]	Oscillation Stabilization Time		Remarks
			C1 [pF]	C2 [pF]	Rd1 [Ω]		typ [ms]	max [ms]	
8MHz	MURATA	CSTCE8M00G15L**-R0	(33)	(33)	680	2.7 to 5.5	0.1	0.5	C1 and C2 integrated SMD type
12MHz	MURATA	CSTCE12M0G15L**-R0	(33)	(33)	470	3.0 to 5.5	0.1	0.5	
16MHz	MURATA	CSTCE16M0V13L**-R0	(15)	(15)	330	3.0 to 5.5	0.05	0.25	

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized in the following cases (see Figure 4):

- Till the oscillation gets stabilized after V_{DD} goes above the operating voltage lower limit.
- Till the oscillation gets stabilized after the instruction for starting the main clock oscillation circuit is executed
- Till the oscillation gets stabilized after the HOLD mode is reset.
- Till the oscillation gets stabilized after the X'tal HOLD mode is reset with CFSTOP (OCR register, bit 0) set to 0

Characteristics of a Sample Subsystem Clock Oscillator Circuit

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

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

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant				Operating Voltage Range [V]	Oscillation Stabilization Time		Remarks
			C3 [pF]	C4 [pF]	Rf [Ω]	Rd2 [Ω]		typ [s]	max [s]	
32.768kHz	EPSON TOYOCOM	MC-306	18	18	OPEN	560k	2.7 to 5.0	1.1	3.0	Applicable CL value=12.5pF SMD type

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized in the following cases (see Figure 4):

- Till the oscillation gets stabilized after the instruction for starting the subclock oscillation circuit is executed
- Till the oscillation gets stabilized after the HOLD mode is reset with EXTOSC (OCR register, bit 6) set to 1

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

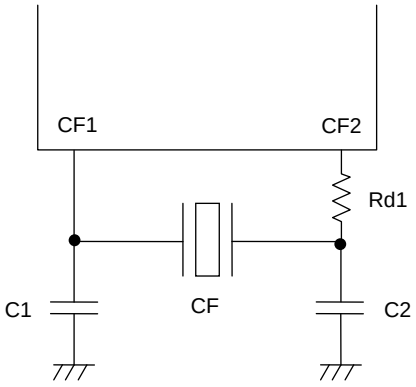


Figure 1 CF Oscillator Circuit

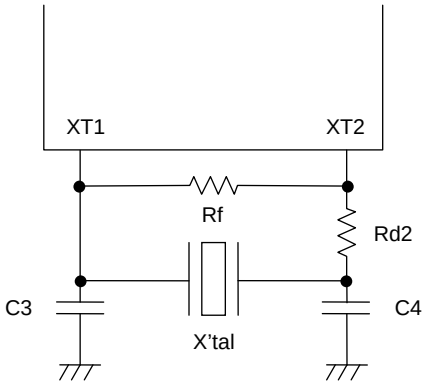


Figure 2 XT Oscillator Circuit

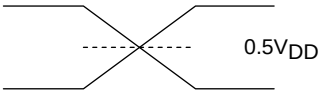
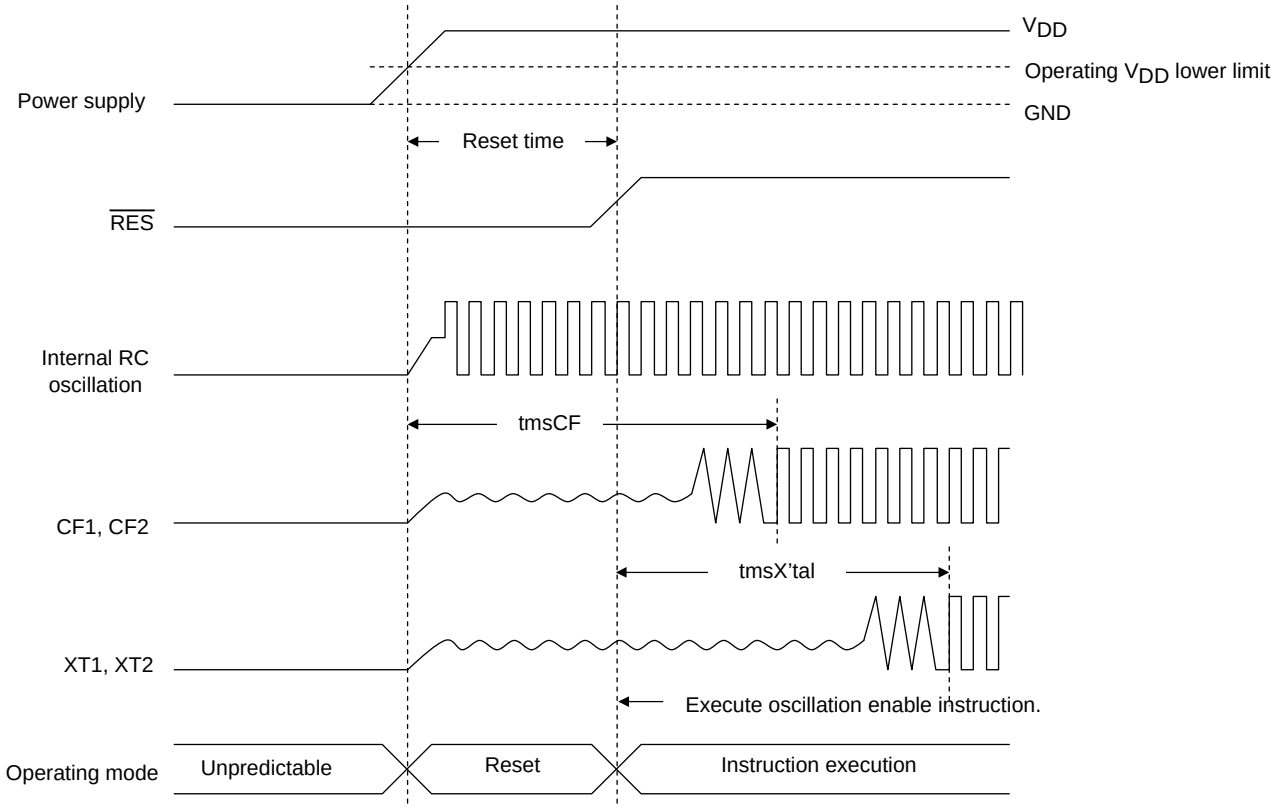
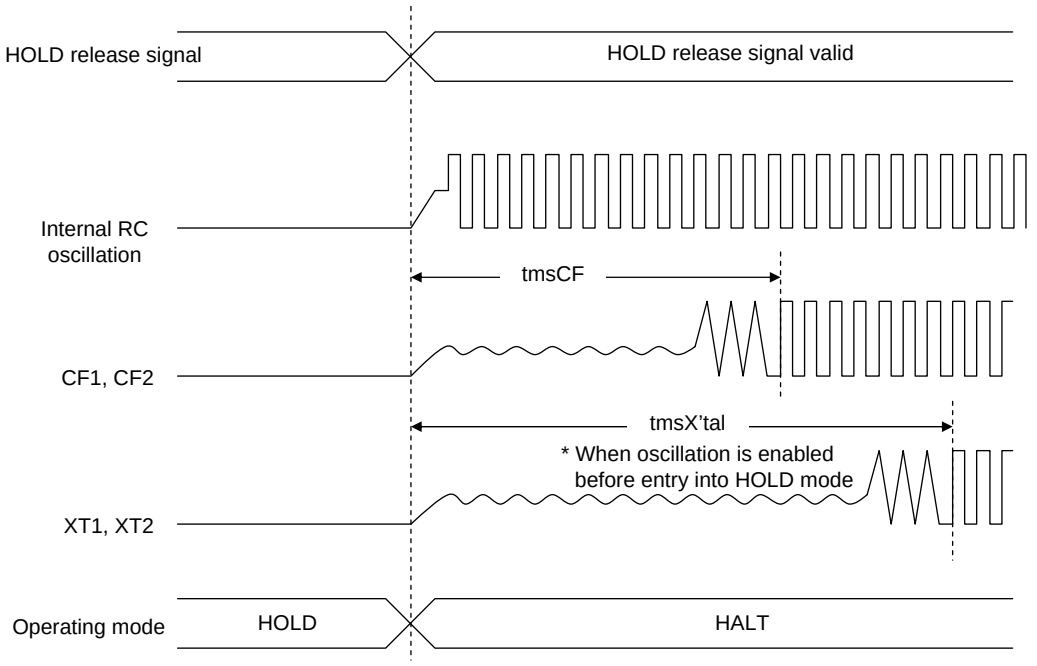


Figure 3 AC Timing Measurement Point

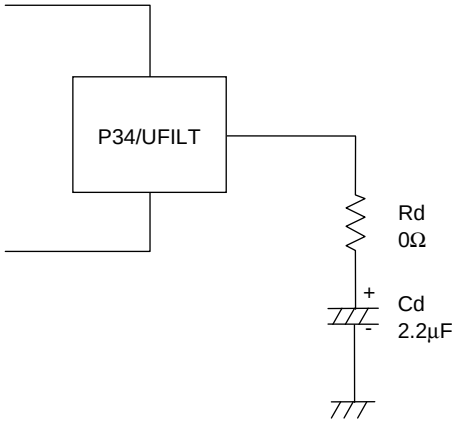


Reset Time and Oscillation Stabilization Time



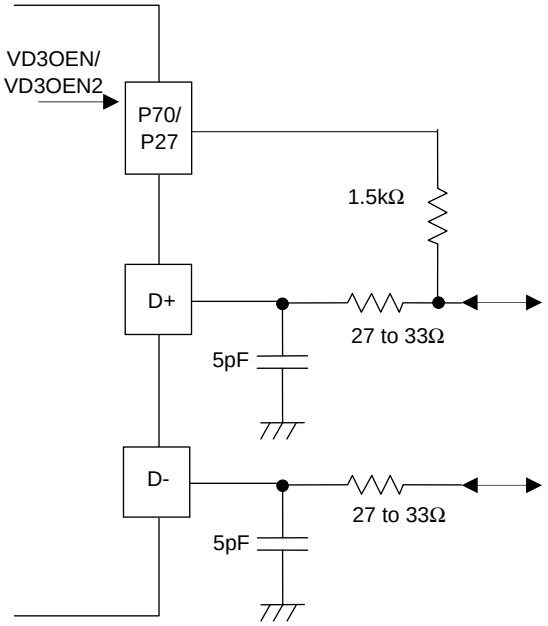
HOLD Reset Signal and Oscillation Stabilization Time

Figure 4 Oscillation Stabilization Time



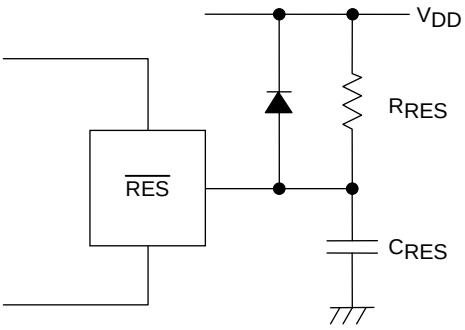
When using the internal PLL circuit to generate the 48MHz clock for USB , it is necessary to connect a filter circuit such as that shown to the left to the P34/UFILT pin.

Figure 5 External Filter Circuit for the Internal USB-dedicated PLL Circuit



Note:
It's necessary to adjust the Circuit Constant of the USB Port Peripheral Circuit each mounting board. Make the D+ Pull-up resistors available to control on/off according to the Vbus.

Figure 6 USB Port Peripheral Circuit



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 7 Reset Circuit

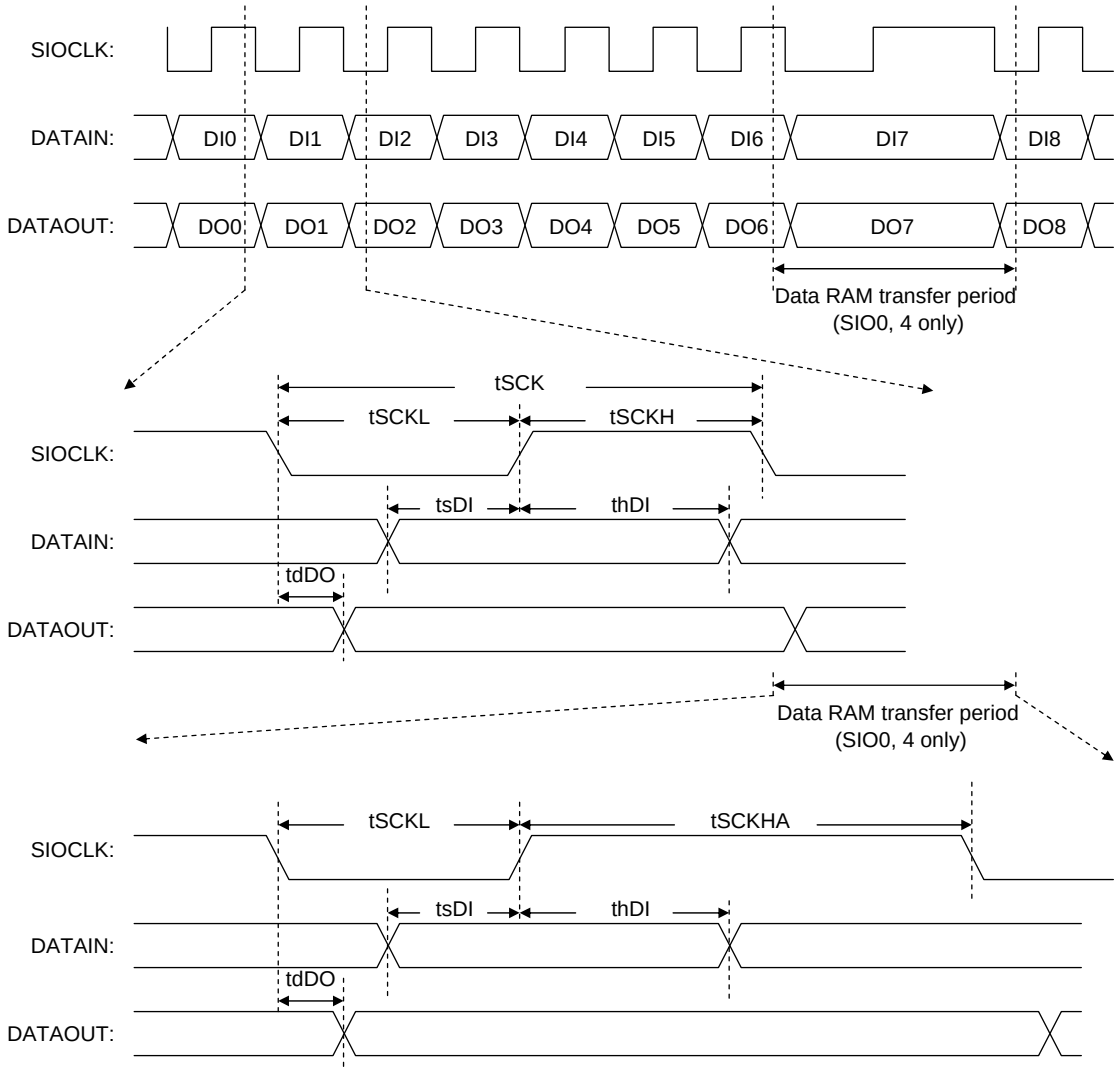


Figure 8 Serial I/O Waveforms

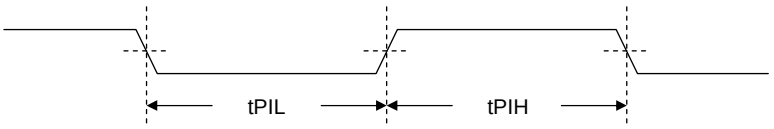


Figure 9 Pulse Input Timing Signal Waveform

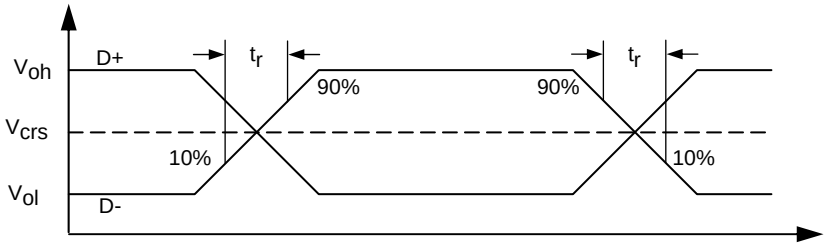
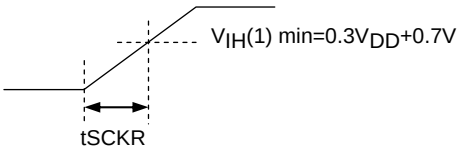


Figure 10 USB Data Signal Timing and Voltage Level



tSCKR:
Defined as the time period from the time the state of the output starts changing till the time it reaches the value of $V_{IH}(1)$.

Figure 11 Serial Clock Output Timing Signal Waveform