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LC87F1M16A

CMOS IC
16K-byte FROM and 1024-byte RAM integrated

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

ON Semiconductor®
http://onsemi.com

Overview

The LC87F1M16A is an 8-bit microcomputer that, integrates on a single chip a number of hardware features such as 16K-byte flash ROM, 1024-byte RAM, an on-chip debugger, a16-bit timer/counter, a 16-bit timer, four 8-bit timers, a base timer serving as a time-of-day clock, two channels of synchronous SIO interface (with automatic block transmission/reception capabilities), an asynchronous/synchronous SIO interface, a UART interface, a UART interface with Smartcard interface function, a full-speed USB interface (function), a 20-channel AD converter (12- or 8-bit resolution selectable), 2 channels of 12-bit PWM, a system clock frequency divider, an internal reset and an interrupt feature.

Features

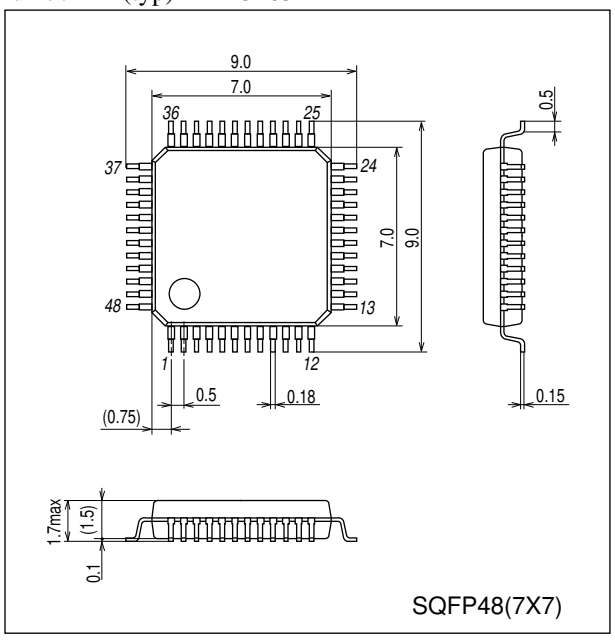
■Flash ROM
- 16384 × 8 bits
- Capable of on-board programming with a wide range of supply voltages: 3.0 to 5.5V
- Block-erasable in 128 byte units
- Writes data in 2-byte units

■RAM
- 1024 × 9 bits

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

Package Dimensions

unit : mm (typ) 3163B



SQFP48(7X7)

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

■Bus Cycle Time
- 83.3ns (When CF=12MHz)
  Note: The bus cycle time here refers to the ROM read speed.

■Minimum Instruction Cycle Time (tCYC)
- 250ns (When CF=12MHz)

■Ports
- I/O ports
  Ports whose I/O direction can be designated in 1-bit units 35 (P00 to P07, P10 to P17, P20 to P27, P31 to P34, P70 to P73, PWM0, PWM1, XT2)
- USB ports 2 (D+, D-)
- Dedicated oscillator ports 2 (CF1, CF2)
- Input-only port (also used for oscillation) 1 (XT1)
- Reset pins 1 ($\overline{\text{RES}}$)
- Dedicated debugger port 1 (OWP0)
- Power supply pins 6 (V_{SS}1 to 3, V_{DD}1 to 3)

■Timers
- Timer 0: 16-bit timer/counter with 2 capture registers.
  Mode 0: 8-bit timer with an 8-bit programmable prescaler (with two 8-bit capture registers) × 2 channels
  Mode 1: 8-bit timer with an 8-bit programmable prescaler (with two 8-bit capture registers) + 8-bit counter (with two 8-bit capture registers)
  Mode 2: 16-bit timer with an 8-bit programmable prescaler (with two 16-bit capture registers)
  Mode 3: 16-bit counter (with two 16-bit capture registers)
- 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 lower-order 8 bits)
  Mode 3: 16-bit timer with an 8-bit prescaler (with toggle outputs) (lower-order 8 bits may be used as a PWM output)
- Timer 4: 8-bit timer with a 6-bit prescaler
- Timer 5: 8-bit timer with a 6-bit prescaler
- Timer 6: 8-bit timer with a 6-bit prescaler (with toggle outputs)
- Timer 7: 8-bit timer with a 6-bit prescaler (with toggle outputs)
- 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 1024 bytes, specifiable in 1 byte units, suspension and resumption of data transmission possible in 1 byte or 2 bytes units)
  (4) Clock polarity selectable
  (5) 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
- SCUART
  (1) Data length : 7/8 bits selectable
  (2) Stop bits : 1/2 bits selectable
  (3) Parity bits : None/even parity/odd parity
  (4) Baud rate : 8/3 to 8192/3 tCYC
  (5) LSB first/MSB first mode delectable
  (6) Smartcard interface function

■AD Converter: 12 bits × 20 channels
- 12-/8-bit resolution selectable AD converter

■PWM: Multifrequency 12-bit PWM × 2 channels

■USB Interface (function controller)
(1) Compliant with USB 2.0 Full-Speed
(2) Supports a maximum of 6 user-defined endpoints.

Endpoint		EP0	EP1	EP2	EP3	EP4	EP5	EP6
Transfer Type	Control	○	-	-	-	-	-	-
	Bulk	-	○	○	○	○	○	○
	Interrupt	-	○	○	○	○	○	○
	Isochronous	-	○	○	○	○	○	○
Max. payload		64	64	64	64	64	64	64

■Watchdog Timer
- Internal counter watchdog timer
  (1) Generates an internal reset on an overflow occurring in the timer running on the low-speed RC oscillator clock (approx. 30kHz) or subclock.
  (2) Operating mode at HALT/HOLD mode is selectable from 3 modes (continue counting/suspend operation/suspend counting with the count value retained)

■Clock Output Function
(1) Can output a clock with a clock rate of 1/1, 1/2, 1/4, 1/8, 1/16, 1/32, or 1/64 of the source oscillator clock selected as the system clock.
(2) Can output the source oscillation clock for the subclock.

■Interrupts

- 35 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
4	0001BH	H or L	INT3/INT5/base timer
5	00023H	H or L	T0H/INT6
6	0002BH	H or L	T1L/T1H/INT7
7	00033H	H or L	SIO0/USB bus reset/USB suspend/UART1 receive complete/ SCUART receive complete
8	0003BH	H or L	SIO1/USB endpoint/USB-SOF/SIO4/ UART1 buffer empty/UART1 transmit complete/ SCUART buffer empty/SCUART transmit complete
9	00043H	H or L	ADC/T6/T7
10	0004BH	H or L	Port 0/PWM0/PWM1/T4/T5

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

■Subroutine Stack Levels: 512 levels maximum (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 and PLL Circuits

- RC oscillation circuit (internal) : For system clock (approx. 1MHz)
- Low-speed RC oscillation circuit (internal) : For watchdog timer (approx. 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)

■Internal Reset Circuit

•Power-on reset (POR) function

(1) POR reset is generated only at power-on time.

(2) The POR release level can be selected from 4 levels (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 voltage threshold level can be selected from 3 levels (2.81V, 3.79V and 4.28V) through option configuration.

■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 HOLD mode.
    1) Setting the reset pin to the lower level
    2) Having the watchdog timer or LVD function generate a reset
    3) Having an interrupt generated
- 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.
    Note: The low-speed RC oscillator is controlled directly by the watchdog timer; its oscillation in the standby mode is also controlled by the watchdog timer.
  (2) There are five ways of resetting the HOLD mode.
    1) Setting the reset pin to the lower level
    2) Having the watchdog timer or LVD function generate a reset
    3) Having an interrupt source established at one of the INT0, INT1, INT2, INT4 or INT5 pins
      * 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 bus active interrupt source established in the USB interface circuit
- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer.
  (1) The PLL base clock generator, CF and RC oscillator automatically stop operation.
    Note: The low-speed RC oscillator is controlled directly by the watchdog timer; its oscillation in the standby mode is also controlled by the watchdog timer.
  (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) Having the watchdog timer or LVD function generate a reset
    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 bus active interrupt source established in the USB interface circuit

■Development Tools

- On-chip debugger: TCB87 type-C (one wire communication cable) + LC87F1M16A

■Flash ROM Programming Boards

Package	Programming boards
SQFP48(7×7)	W87F55256SQ

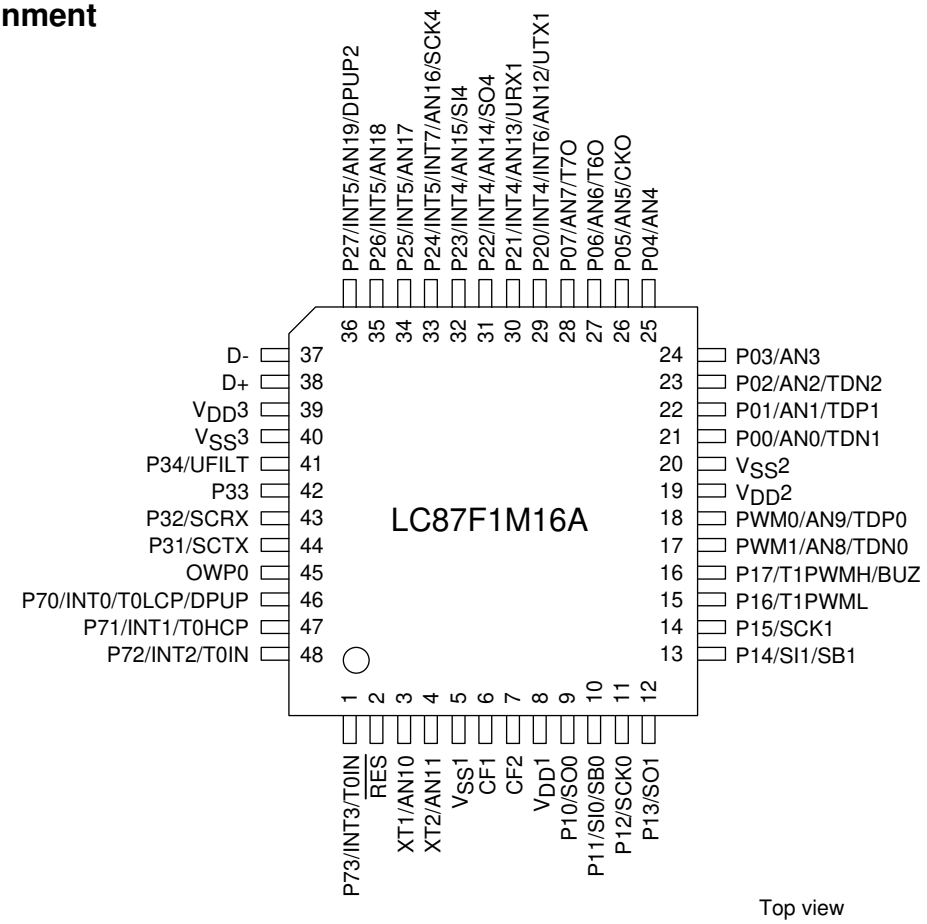
■Flash Programmer

Maker		Model	Supported version	Device
Flash Support Group, Inc. (FSG)	Single Programmer	AF9709/AF9709B/AF9709C (Including Ando Electric Co., Ltd. models)	Rev 03.32 or later	87F016JU
Flash Support Group, Inc. (FSG) + Our company (Note 1)	Onboard Single/Gang Programmer	AF9101/AF9103(Main unit) (FSG models)	(Note 2)	LC87F1M16A
		SIB87(Inter Face Driver) (Our company model)		
Our company	Single/Gang Programmer	SKK/SKK Type B (SanyoFWS)	Application Version 1.06 or later Chip Data Version 2.31 or later	LC87F1M16
	Onboard Single/Gang Programmer	SKK-DBG Type C (SanyoFWS)		

For information about AF-Series:
Flash Support Group, Inc.
TEL: +81-53-459-1050
E-mail: sales@j-fsg.co.jp

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



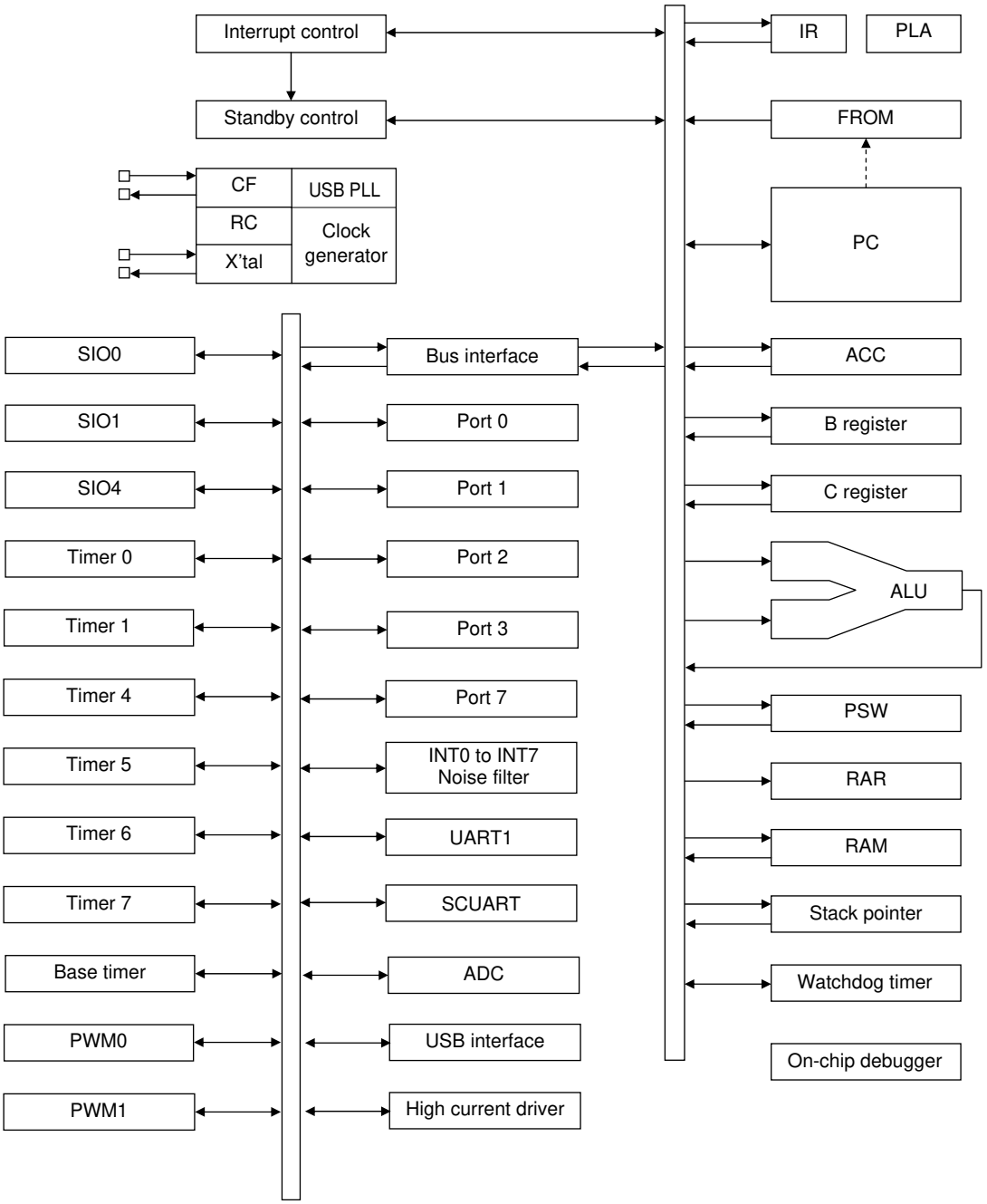
Top view

SQFP48(7×7) "Lead-/Halogen-free Type"

SQFP48	NAME
1	P73/INT3/T0IN
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/AN8/TDN0
18	PWM0/AN9/TDP0
19	$V_{DD}2$
20	$V_{SS}2$
21	P00/AN0/TDN1
22	P01/AN1/TDP1
23	P02/AN2/TDN2
24	P03/AN3

SQFP48	NAME
25	P04/AN4
26	P05/AN5/CKO
27	P06/AN6/T6O
28	P07/AN7/T7O
29	P20/INT4/INT6/AN12/UTX1
30	P21/INT4/AN13/URX1
31	P22/INT4/AN14/SO4
32	P23/INT4/AN15/SI4
33	P24/INT5/INT7/AN16/SCK4
34	P25/INT5/AN17
35	P26/INT5/AN18
36	P27/INT5/AN19/DPUP2
37	D-
38	D+
39	$V_{DD}3$
40	$V_{SS}3$
41	P34/UFILT
42	P33
43	P32/SCRX
44	P31/SCTX
45	OWP0
46	P70/INT0/T0LCP/DPUP
47	P71/INT1/T0HCP
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</td><td>No</td></tr>
<tr><td>$V_{DD}1$, $V_{DD}2$</td><td>-</td><td>+ Power supply</td><td>No</td></tr>
<tr><td>$V_{DD}3$</td><td>-</td><td>USB reference voltage</td><td>Yes</td></tr>
<tr><td>Port 0
P00 to P07</td><td>I/O</td><td>• 8-bit I/O ports
• 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
AD converter input ports: AN0 to AN7(P00 to P07)
P00: High current Nch driver(TDN1)
P01: High current Pch driver(TDP1)
P02: High current Nch driver(TDN2)
P05: System clock output
P06: Timer 6 toggle output
P07: Timer 7 toggle output</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 ports
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units
• Pin functions
AD converter input ports: AN12 to AN19(P20 to P27)
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: INT6 input/timer 0L capture 1 input/UART1 transmit
P21: UART1 receive
P22: SIO4 date I/O
P23: SIO4 date I/O
P24: INT7 input/timer 0H capture 1 input/SIO4 clock I/O
P27: D+ 1.5kΩ pull-up resistor connect pin
Interrupt acknowledge types
<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>
<tr><td>INT6</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
<tr><td>INT7</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
</table></td><td>Yes</td></tr>
<tr><td>Port 3
P31 to P34</td><td>I/O</td><td>• 4-bit I/O ports
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units
• Pin functions
P31: SCUART transmit
P32: SCUART receive
P34: USB interface PLL filter pin (see Fig. 5.)</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/ 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 (input with noise filter)/timer 0 event input/timer 0H capture input
Interrupt acknowledge types
<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, PWM1 output port
• Pin functions
General-purpose input ports
AD converter input ports: AN8(PWM1), AN9(PWM0)
PWM0: High current Pch driver(TDP0)
PWM1: High current Nch driver(TDN0)</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>External reset input/internal reset output pin</td><td>No</td></tr>
<tr><td>XT1</td><td>Input</td><td>• 32.768kHz crystal oscillator input
• Pin functions
General-purpose input port
AD converter input ports: AN10</td><td>No</td></tr>
<tr><td>XT2</td><td>I/O</td><td>• 32.768kHz crystal oscillator output
• Pin functions
General-purpose I/O
AD converter input port: AN11</td><td>No</td></tr>
<tr><td>CF1</td><td>Input</td><td>Ceramic resonator input</td><td>No</td></tr>
<tr><td>CF2</td><td>Output</td><td>Ceramic resonator output</td><td>No</td></tr>
<tr><td>OWP0</td><td>I/O</td><td>Dedicated debugger port</td><td>No</td></tr>
</table>

On-chip Debugger Pin Connection Requirements

For the treatment of the on-chip debugger pins, refer to the separately available documents entitled “Rd87 On-chip Debugger Installation Manual”

Recommended Unused Pin Connections

Port Name	Recommended Unused Pin Connections	
	Board	Software
P00 to P07	Open	Output low
P10 to P17	Open	Output low
P20 to P27	Open	Output low
P31 to P34	Open	Output low
P70 to P73	Open	Output low
PWM0, PWM1	Open	Output low
D+, D-	Open	Output low
XT1	Pulled low with a 100kΩ resistor or less	-
XT2	Open	Output low
OWP0	Pulled low with a 100kΩ resistor	-

Note: P34 and UFILT share the same pin, so if USB function is used, the pin must be set to input mode.

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 P10 to P17	1 bit	1	CMOS	Programmable
P20 to P27 P31 to P34		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 resonator output (N channel open drain when in general-purpose output mode)	No

User Option Table

Option Name	Option Type	Flash Version	Option Selected in Units of	Option Selection
Port output form	P00 to P07	enable	1 bit	CMOS
				Nch-open drain
	P10 to P17	enable	1 bit	CMOS
				Nch-open drain
	P20 to P27	enable	1 bit	CMOS
				Nch-open drain
	P31 to P34	enable	1 bit	CMOS
				Nch-open drain
Program start address	-	enable	-	00000h
				03E00h
USB Regulator	USB Regulator	enable	-	USE
				NONUSE
	USB Regulator (at HOLD mode)	enable	-	USE
				NONUSE
	USB Regulator (at HALT mode)	enable	-	USE
				NONUSE
Main clock 8MHz selection	-	enable	-	ENABLE
				DISABLE
Low-voltage detection reset function	Detect function	enable	-	Enable: Use
				Disable: Not Used
	Detect level	enable	-	3-level
Power-on reset function	Power-On reset level	enable	-	4-level

USB Reference Power Option

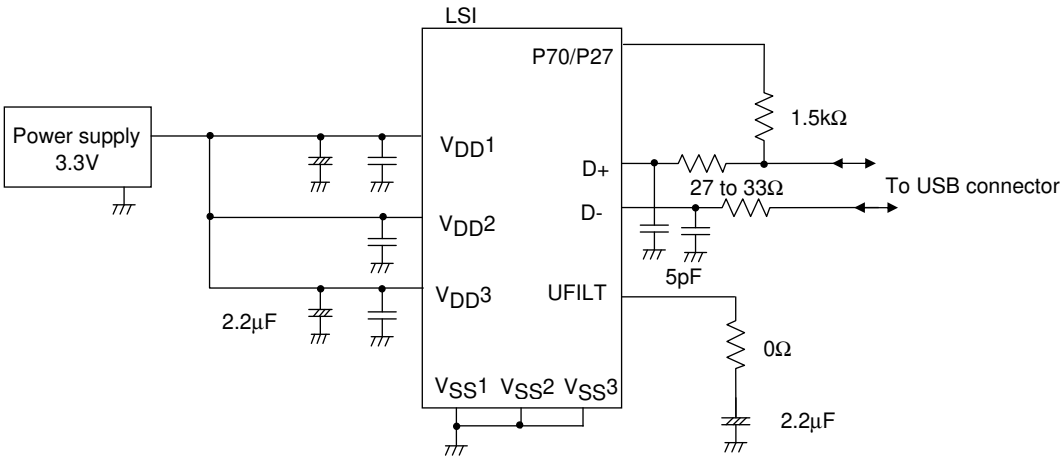
When a voltage 4.5 to 5.5V is supplied to $V_{DD}1$ and the internal USB reference voltage circuit is activated, the reference voltage for USB port output is generated. The active/inactive state of the reference voltage circuit can be switched by option select. The procedure for marking the option selection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

		(1)	(2)	(3)	(4)
Option settings	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 mode	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 increases by approximately 100µA compared with when the reference voltage circuit is inactive.

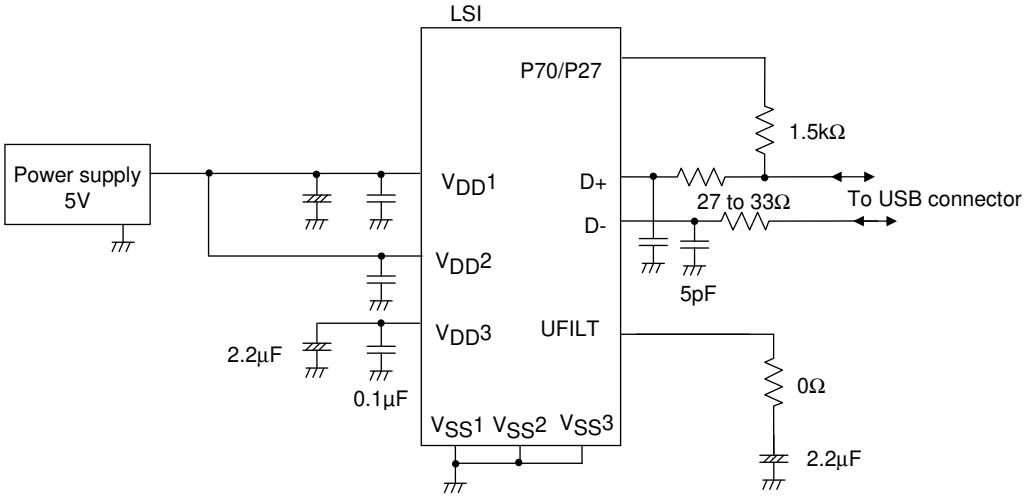
Example 1: $V_{DD}1=V_{DD}2=3.3V$

- 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		Specification			
					V_{DD}[V]	min	typ	max	unit
Maximum supply voltage		V_{DD} max	$V_{DD}1$, $V_{DD}2$, $V_{DD}3$	$V_{DD}1 = V_{DD}2 = V_{DD}3$		-0.3		+6.5	V
Input voltage		V_I(1)	XT1, CF1, $\overline{RES}$			-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)	P00, P02 to P07 Ports 1, 2	• When CMOS output type is selected • Per 1 applicable pin		-10			mA
		IOPH(2)	PWM1	Per 1 applicable pin		-20			
		IOPH(3)	PWM0(TDP0) P01(TDP1)	• When CMOS output type is selected • Per 1 applicable pin		-50			
		IOPH(4)	Port 3 P71 to P73	• When CMOS output type is selected • Per 1 applicable pin		-5			
	Average output current (Note 1-1)	IOMH(1)	P00, P02 to P07 Ports 1, 2	• When CMOS output type is selected • Per 1 applicable pin		-7.5			
		IOMH(2)	PWM1	Per 1 applicable pin		-15			
		IOMH(3)	PWM0(TDP0) P01(TDP1)	• When CMOS output type is selected • Per 1 applicable pin		-30			
		IOMH(4)	Port 3 P71 to P73	• When CMOS output type is selected • Per 1 applicable pin		-3			
	Total output current	ΣIOAH(1)	P00, P02 to P07 Ports 2	Total current of all applicable pins		-25			
		ΣIOAH(2)	Port 1 PWM1	Total current of all applicable pins		-25			
		ΣIOAH(3)	PWM0(TDP0) P01(TDP1)	Total current of all applicable pins		-50			
		ΣIOAH(4)	Ports 0, 1, 2 PWM0, PWM1	Total current of all applicable pins		-100			
		ΣIOAH(5)	Port 3 P71 to P73	Total current of all applicable pins		-10			
		ΣIOAH(6)	D+, D-	Total current of all applicable pins		-25			

Note 1-1: The average output current is an average of current values measured over 100ms intervals.

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Parameter		Symbol	Pin/Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Low level output current	Peak output current	IOPL(1)	P03 to P07 Ports 1, 2 PWM0	Per 1 applicable pin				20	mA
		IOPL(2)	P01	Per 1 applicable pin				30	
		IOPL(3)	PWM1(TDN0) P00(TDN1) P02(TDN2)	Per 1 applicable pin				50	
		IOPL(4)	Ports 3, 7 XT2	Per 1 applicable pin				10	
	Average output current (Note 1-1)	IOML(1)	P03 to P07 Ports 1, 2 PWM0	Per 1 applicable pin				15	
		IOML(2)	P01	Per 1 applicable pin				20	
		IOML(3)	PWM1(TDN0) P00(TDN1) P02(TDN2)	Per 1 applicable pin				30	
		IOML(4)	Ports 3, 7 XT2	Per 1 applicable pin				7.5	
	Total output current	ΣIOAL(1)	P01, P03 to P07 Ports 2	Total current of all applicable pins				45	
		ΣIOAL(2)	Port 1 PWM0	Total current of all applicable pins				45	
		ΣIOAL(3)	PWM1(TDN0) P00(TDN1) P02(TDN2)	Total current of all applicable pins				50	
		ΣIOAL(4)	Ports 0, 1, 2 PWM0, PWM1	Total current of all applicable pins				140	
		ΣIOAL(5)	Ports 3, 7 XT2	Total current of all applicable pins				15	
		ΣIOAL(6)	D+, D-	Total current of all applicable pins				25	
Allowable power Dissipation		Pd max	SQFP48(7×7)	Ta=-30 to +70°C				190	mW
				Ta=-40 to +85°C				140	
Operating ambient Temperature		Topr				-40		+85	°C
Storage ambient temperature		Tstg				-55		+125	

Note 1-1: The average output current is an average of current values measured over 100ms intervals.

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		Specification			
				V_{DD}[V]	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		3.0		5.5	V
			0.490µs ≤ tCYC ≤ 200µs Except in onboard programming mode		2.7		5.5	
			0.245µs ≤ CYC ≤ 0.383µs USB circuit active		3.0		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	$V_{IH}(1)$	Port 0, 1, 2, 3, 7 PWM0, PWM1		2.7 to 5.5	$0.3V_{DD}$ +0.7		V_{DD}	
	$V_{IH}(2)$	XT1, XT2, CF1, $\overline{RES}$		2.7 to 5.5	$0.75V_{DD}$		V_{DD}	
Low level input voltage	$V_{IL}(1)$	Port 1, 2, 3, 7		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}		$0.2V_{DD}$	
	$V_{IL}(5)$	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	0.245		200	µs
			Except for onboard programming mode	2.7 to 5.5	0.490		200	
			USB circuit active	3.0 to 5.5	0.245		0.383	
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		12	MHz
			• CF2 pin open • System clock frequency division ratio=1/1 • External system clock duty =50±5%	2.7 to 5.5	0.1		6	
Oscillation frequency range (Note 2-3)	FmCF	CF1, CF2	When 12MHz ceramic oscillation See Fig. 1.	3.0 to 5.5		12		MHz
	FmRC		Internal RC oscillation	2.7 to 5.5	0.5	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 = -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
High level input current	$I_{IH}(1)$	Ports 0, 1, 2, 3, 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	Input port configuration $V_{IN}=V_{DD}$	2.7 to 5.5			1	
	$I_{IH}(3)$	CF1	$V_{IN}=V_{DD}$	2.7 to 5.5			15	
Low level input current	$I_{IL}(1)$	Ports 0, 1, 2, 3, 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	Input port configuration $V_{IN}=V_{SS}$	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, WM1 P05(CKO 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			
	$V_{OH}(7)$	PWM0, P01 (when using high current driver)	I_{OH}=-30mA	4.5 to 5.5	V_{DD}-0.5	V_{DD}-0.15		
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	
	$V_{OL}(9)$	PWM1, P00, P02 (when using high current driver)	I_{OL}=30mA	4.5 to 5.5		0.15	0.5	
Pull-up resistance	Rpu(1)	Ports 0, 1, 2, 3, 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	$\overline{RES}$ Port 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 = -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. 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			tCYC
		Low level pulse width	tSCKL(2)				1/2			tSCK
		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.

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Parameter			Symbol	Pin/ Remarks	Conditions	V_{DD}[V]	Specification 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)				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)				1tCYC +0.05	
	Output clock		tdD0(3)		(Note 4-1-3)				(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	V_{DD}[V]	Specification 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)	• When CMOS output type is selected • See Fig. 8.	2.7 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. 8.	2.7 to 5.5	(1/3)tCYC +0.01			µs
	Data hold time		thDI(2)				0.01			
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			(1/2)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. • Do not use SIO0 continuous data transmission mode at the same time. • 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	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. • Do not use SIO0 continuous data transmission mode at the same time. • CMOS output selected • See Fig8.		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			

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.

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Parameter		Symbol	Pin/ Remarks	Conditions	Specification				
					V_{DD}[V]	min	typ	max	unit
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

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				
				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), INT6(P20), INT7(P24)	• 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 nabled.	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)	$\overline{RES}$	Resetting is enabled.	2.7 to 5.5	200			µs

AD Converter Characteristics at Ta = -40°C to +85°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(PWM1), AN9(PWM0), AN10(XT1), AN11(XT2), AN12(P20) to AN19(P27)		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)	4.5 to 5.5	32		115	µs
				3.0 to 5.5	64		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(PWM1), AN9(PWM0), AN10(XT1), AN11(XT2), AN12(P20) to AN19(P27)		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)	4.5 to 5.5	20		90	µs
				3.0 to 5.5	40		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
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

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°C to +85°C, $V_{SS}1 = V_{SS}2 = V_{SS}3 = 0V$

Parameter	Symbol	Conditions	Option selected voltage	Specification min	typ	max	unit
POR release voltage	PORRL	Select from option (Note 7-1)	2.57V	2.45	2.57	2.69	V
			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.11 (Note 7-2)			0.7	0.95	
Power supply rise time	PORIS	Power supply rise time from 0V to 1.6V				100	ms

Note 7-1: The POR release level can be selected out of 4 levels only when the LVD reset function is disabled.
Note 7-2: POR is in unknown state before transistor start operation.

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

Parameter	Symbol	Conditions	Option selected voltage	Specification min	typ	max	unit
LVD reset voltage (Note 8-2)	LVDET	Select from option See Fig.12 (Note 8-1) (Note 8-3)	2.81V	2.71	2.81	2.91	V
			3.79V	3.69	3.79	3.89	
			4.28V	4.18	4.28	4.38	
LVD hysteresis width	LVHYS		2.81V		55		mV
			3.79V		60		
			4.28V		60		
Detection voltage unknown state	LVUKS	See Fig.12 (Note 8-4)			0.7	0.95	V
Low voltage detection minimum width (Reply sensitivity).	TLVDW	LVDET-0.5V See Fig.13		0.2			ms

Note 8-1: The LVD reset level can be selected out of 3 levels only when the LVD reset function is enabled.
Note 8-2: LVD reset voltage specification values do not include hysteresis voltage.
Note 8-3: LVD reset voltage may exceed its specification values when port output state changes and and/or when a large current flows through port.
Note 8-4: LVD is in unknown state before transistor 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	Specification				
				V_{DD}[V]	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 • 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 ratio	4.5 to 5.5		8.8	16	mA
	IDDOP(2)			3.0 to 3.6		5.1	9.2	
	IDDOP(3)		• FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal PLL oscillation mode active • Internal RC oscillation stopped • USB circuit active • 1/1 frequency division ratio	4.5 to 5.5		13	23	
	IDDOP(4)			3.0 to 3.6		7.0	13	
	IDDOP(5)		• 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 ratio	4.5 to 5.5		5.6	9.5	
	IDDOP(6)			3.0 to 3.6		3.6	6.0	
	IDDOP(7)			2.7 to 3.0		3.0	4.8	
	IDDOP(8)		• FmCF=0Hz(oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to internal RC oscillation • 1/2 frequency division ratio	4.5 to 5.5		0.76	2.8	
	IDDOP(9)			3.0 to 3.6		0.43	1.5	
	IDDOP(10)			2.7 to 3.0		0.36	1.2	
	IDDOP(11)		• FmCF=0Hz(oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to crystal oscillation. (32.768kHz) • Internal RC oscillation stopped • 1/2 frequency division ratio	4.5 to 5.5		48	140	µA
	IDDOP(12)			3.0 to 3.6		18	55	
	IDDOP(13)			2.7 to 3.0		14	40	
HALT mode consumption current (Note9-1) (Note9-2)	IDDHALT(1)		• 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 ratio	4.5 to 5.5		4.3	7.6	mA
	IDDHALT(2)			3.0 to 3.6		2.2	4.0	
	IDDHALT(3)		• HALT mode • FmCF=12MHz ceramic oscillation mode • FsX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal PLL oscillation mode active • Internal RC oscillation stopped • USB circuit active • 1/1 frequency division ratio	4.5 to 5.5		8.1	15	
	IDDHALT(4)			3.0 to 3.6		4.2	7.5	
	IDDHALT(5)		• 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 ratio	4.5 to 5.5		2.7	4.8	
	IDDHALT(6)			3.0 to 3.6		1.3	2.4	
	IDDHALT(7)			2.7 to 3.0		1.1	1.8	
	IDDHALT(8)		• HALT mode • FmCF=0Hz(oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to internal RC oscillation. • 1/2 frequency division ratio	4.5 to 5.5		0.48	1.9	
	IDDHALT(9)			3.0 to 3.6		0.22	0.81	
	IDDHALT(10)			2.7 to 3.0		0.17	0.57	

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

Note9-2: Unless otherwise specified, the consumption current for the LVD circuits is not included.

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Parameter	Symbol	Pin/ Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
HALT mode consumption current (Note 9-1) (Note 9-2)	IDDHALT(11)	$V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$	• HALT mode • FmCF=0MHz (oscillation stopped) • FsX'tal=32.768kHz crystal oscillation mode • System clock set to crystal oscillation. (32.768kHz) • Internal RC oscillation stopped • 1/2 frequency division ratio	4.5 to 5.5		35	120	μA
	IDDHALT(12)			3.0 to 3.6		9.5	39	
	IDDHALT(13)			2.7 to 3.0		6.4	27	
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)	4.5 to 5.5		0.08	24	
	IDDHOLD(2)			3.0 to 3.6		0.03	11	
	IDDHOLD(3)			2.7 to 3.0		0.02	9.6	
	IDDHOLD(4)		• HOLD mode • LVD option selected • CF1=V_{DD} or open (External clock mode)	4.5 to 5.5		2.9	29	
	IDDHOLD(5)			3.0 to 3.6		2.2	15	
	IDDHOLD(6)			2.7 to 3.0		2.1	12	
	IDDHOLD(7)		• HOLD mode • 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	32	
	IDDHOLD(8)			3.0 to 3.6		1.4	16	
	IDDHOLD(9)			2.7 to 3.0		1.2	14	
Timer HOLD mode consumption current (Note 9-1) (Note 9-2)	IDDHOLD(10)		• Timer HOLD mode • CF1=V_{DD} or open (External clock mode) • FsX'tal=32.768kHz crystal oscillation mode	4.5 to 5.5		31	110	
	IDDHOLD(11)			3.0 to 3.6		7.0	34	
	IDDHOLD(12)			2.7 to 3.0		4.3	22	

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

Note9-2: Unless otherwise specified, the consumption current for the LVD circuits is not included.

USB Characteristics and Timing at Ta = -40°C to +85°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 3.6V	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, C_L=50pF • $V_{DD}3$=3.0 to 3.6V	4		20	ns
USB data fall time	t_F	• R_S=27 to 33Ω, C_L=50pF • $V_{DD}3$=3.0 to 3.6V	4		20	ns

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

Parameter	Symbol	Pin/ Remarks	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