Ordering number : ENA2175

LC87F2608A

CMOS IC
8K-byte FROM and 512-byte RAM integrated

8-bit 1-chip microcontroller

ON Semiconductor®
http://onsemi.com

Overview

The LC87F2608A is an 8-bit microcontroller that, centered around a CPU running at a minimum bus cycle time of 100ns, integrates on a single chip a number of hardware features such as 8K-byte flash ROM, 512-byte RAM, an on-chip debugger, two sophisticated 16-bit timers/counters (may be divided into 8-bit timers), a synchronous SIO interface, a high-speed 12-bit PWM, two high-speed pulse width/period counters, a 3-channel AD converter with 12-/8-bit resolution selector, an analog comparator, a watchdog timer, an internal reset circuit, a system clock frequency divider, and a 16-source 10-vector interrupt feature.

Features

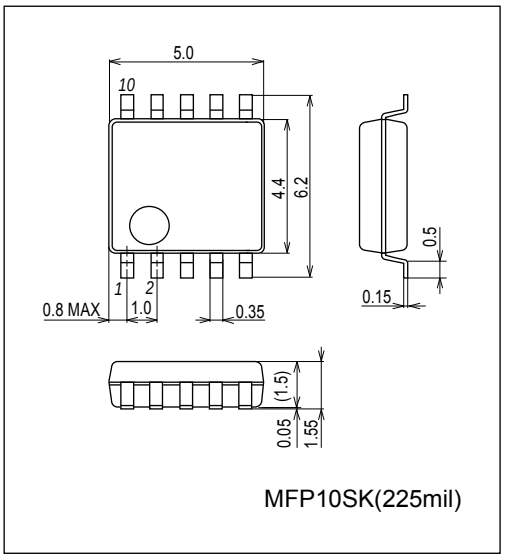
■ Flash ROM
- 8192 × 8 bits (LC87F2608A)
- Capable of on-board-programming with wide range of voltage source (3.0 to 5.5V).
- Block-erasable in 128-byte units

■ RAM
- 512 × 9 bits (LC87F2608A)

■ Package Form
- MFP10SK: Lead-/Halogen-free type
- MFP14S (for debugging only): Lead-free type
- MFP10S: Lead-/Halogen-free type (discontinued)

Package Dimensions

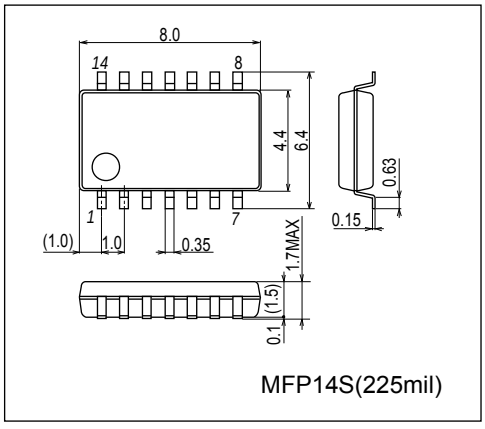
unit : mm (typ)
3420



MFP10SK(225mil)

Package Dimensions

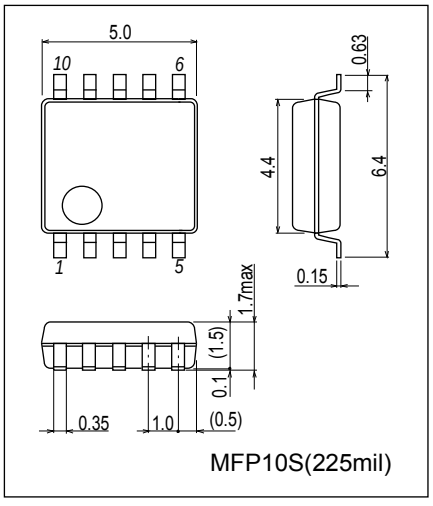
unit : mm (typ)
3111A (for debugging only)



MFP14S(225mil)

Package Dimensions

unit : mm (typ)
3086B (discontinued)



MFP10S(225mil)

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

April, 2013

■ Minimum Bus Cycle Time (Note1)
- 100ns (10MHz) V_{DD}=2.7 to 5.5V (Note2)

■ Minimum Instruction Cycle Time
- 300ns (10MHz) V_{DD}=2.7 to 5.5V (Note2)

Note1: The bus cycle time here refers to the ROM read speed.
Note2: Use this product in a voltage range of 3.0 to 5.5V because the minimum release voltage (PORRL) of the power-on reset (POR) circuit is 2.87V±0.12V.

■ Ports
- I/O ports
  Ports whose I/O direction can be designated in 1 bit units: 7 (P10 to P12, P30 to P33)
- Reset pins: 1 ($\overline{RES}$)
- Power pins: 2 ($V_{SS}1$, $V_{DD}1$)

■ 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
  Mode 0: 8-bit timer with an 8-bit prescaler + 8-bit timer/counter with an 8-bit prescaler
  Mode 2: 16-bit timer/counter with an 8-bit prescaler

■ Serial Interface
- SIO7: 8-bit synchronous serial interface
  1) LSB first/MSB first mode selectable
  2) Built-in 8-bit baudrate generator (maximum transfer clock cycle = 4/3 tCYC)

■ High-speed 12-bit PWM
- System clock/high-speed RC oscillation clock (20MHz or 40MHz) operation selectable
- Duty/period programmable
- Continuous PWM output/specific count PWM output (automatic stop) selectable

■ High-speed Pulse Width/Period Counter
- HCT1: High-speed pulse width/period counter 1
  1) System clock/high-speed RC oscillation clock (20MHz or 40MHz) operation selectable
  2) H-level width/L-level width/period measurement modes selectable
  3) Input triggering noise filter

- HCT2: High-speed pulse width/period counter 2
  1) System clock/high-speed RC oscillation clock (20MHz or 40MHz) operation selectable
  2) Can measure both L-level width and period simultaneously.
  3) Input triggering noise filter
  4) Input trigger selectable (from 3 signals, i.e., P11/HCT2IN, P31/HCT2IN, and analog comparator output)

■ AD Converter: 12 bits × 3 channels
- 12-/8-bit AD converter resolution selectable

■ Analog Comparator
- Sends output to the P32/CMPO port (polarity selectable).
- Edge detection function (shared with INTC and also allows the selection of the noise filter function)

■ Watchdog Timer
- Can generate the internal reset signal on a timer overflow monitored by the WDT-dedicated low-speed RC oscillation clock (30kHz).
- Allows selection of continue, stop, or hold mode operation of the counter on entry into the HALT/ HOLD mode.

■ Interrupt Source Flags
- 16 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	INTA
2	0000BH	X or L	INTB
3	00013H	H or L	INTC/T0L/INTE
4	0001BH	H or L	INTD/INTF
5	00023H	H or L	T0H/SIO7
6	0002BH	H or L	T1L/T1H
7	00033H	H or L	HCT1
8	0003BH	H or L	HCT2
9	00043H	H or L	ADC/HPWM automatic stop/HPWM cycle
10	0004BH	H or L	None

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

■ Subroutine Stack Levels: 256 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 Circuits
- Medium speed RC oscillation circuit (internal): For system clock (1MHz)
- Low speed RC oscillation circuit (internal): For watchdog timer (30kHz)
- High speed RC oscillation circuit (internal): For system clock (20MHz or 40MHz)

1) 2 source oscillation frequencies (20MHz or 40MHz) selectable for the high-speed RC oscillation circuit by optional configuration.

■ System Clock Divider Function
- Can run on low current.
- The minimum instruction cycle selectable from 300ns, 600ns, 1.2µs, 2.4µs, 4.8µs, 9.6µs, 19.2µs, 38.4µs, and 76.8µs (when high speed RC oscillation is selected for system clock.).

■ 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 3 levels (2.87V, 3.86V, and 4.35V) by optional 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 or disuse of the LVD function and the low voltage threshold level (3 levels: 2.81V, 3.79V, and 4.28V) can be selected by optional 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 the following three ways of resetting the HALT mode.
     (1) Setting the Reset pin to the low level
     (2) Generating a reset signal via the watchdog timer or brown-out detector
     (3) Having an interrupt generated

- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.
  1) The medium- and high-speed RC oscillation circuits automatically stop operation.
  2) There are the following four ways of resetting the HOLD mode.
     (1) Setting the Reset pin to the low level
     (2) Generating a reset signal via the watchdog timer or brown-out detector
     (3) Setting at least one of the INTA, INTB, INTC, INTD, INTE, and INTF pins to the specified level
     (INTA and INTB HOLD mode reset is available only when level detection is set.)
     (4) Applying input signals to the IN+ and IN- pins so that the analog comparator output is set to the specified level
     (when the analog comparator output is assigned to the INTC input)

■ On-chip Debugger Function

- Supports software debugging with the IC mounted on the target board (selectable from 3 series).
  1) LC87D2708A : All terminal function of LC87F2608A can be used.
  2) LC87F2708A : All terminal function of LC87F2608A can be used. The debug feature is limited.
  3) LC87F2608A : The debugger terminal function when an On-chip debugger is used cannot be used. The debug feature is limited.
- Two channels of on-chip debugger pins are available (LC87F2608A).

■ Data Security Function (Note3)

- Protects the program data stored in flash memory from unauthorized read or copy.

Note3: This data security function does not necessarily provide absolute data security.

■ Development Tools

- On-chip debugger: 1) TCB87-Type B + LC87D2708A or LC87F2708A
  2) TCB87-Type B + LC87F2608A
  3) TCB87-Type C (3 wire version) + LC87D2708A or LC87F2708A
  4) TCB87-Type C (3 wire version) + LC87F2608A

■ Programming Board

Package	Programming Board
MFP10S	W87F27M-DBG
MFP10SK	
MFP14S	

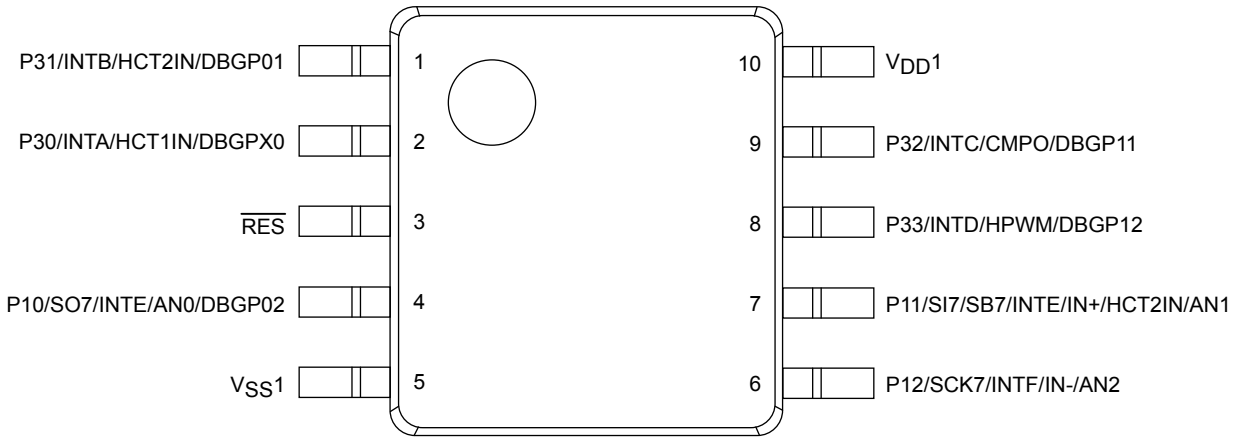
■ Flash ROM Programming Board

Maker		Model	Version	Device
Flash Support Group, Inc. (FSG) + Our company (Note 4)	In-circuit Programmer	AF9101/AF9103 (Main body) (FSG models)	Rev.01.01 or later	LC87F2608A
		SIB87 (Inter Face Driver) (Our company model)		
Our company	Single/Gang Programmer	SKK-DBG Type B (Sanyo FWS)	Application Version 1.04 or later Chip Data Version 2.10 or later	LC87F2608A
	In-circuit/ Gang Programmer			

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

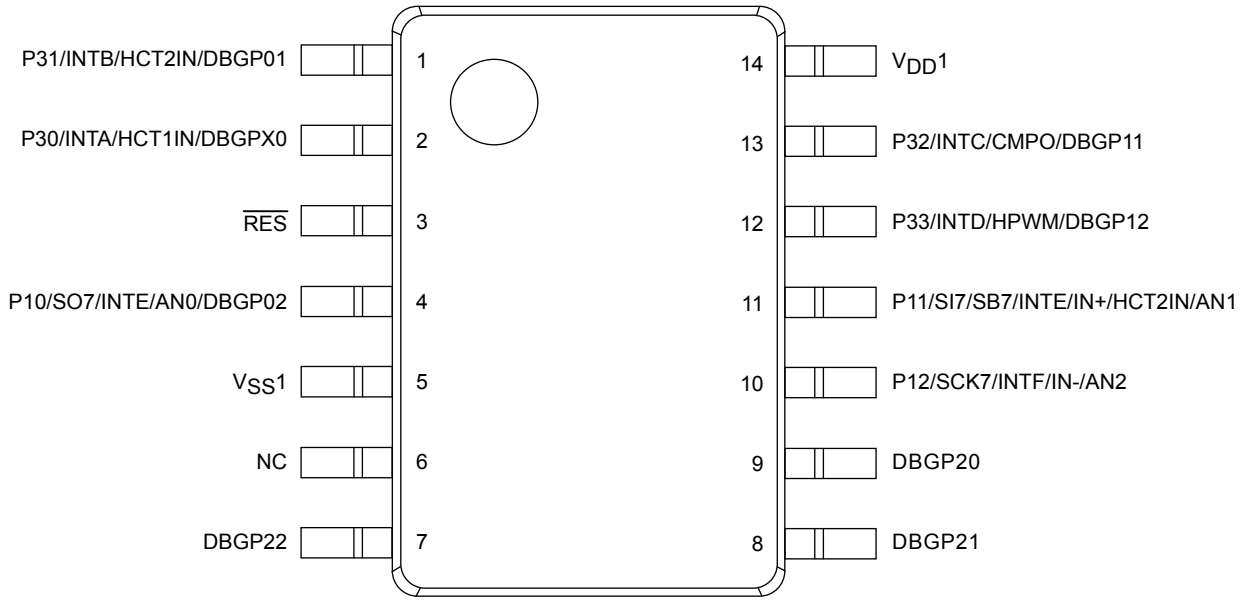
Note4: On-board-programmer from FSG (AF9101/AF9103) and serial interface driver from Our company (SIB87) together can give a PC-less, standalone on-board-programming capabilities.

Pin Assignment



MFP10S "Lead-/Halogen-free type"
MFP10SK "Lead-/Halogen-free type"

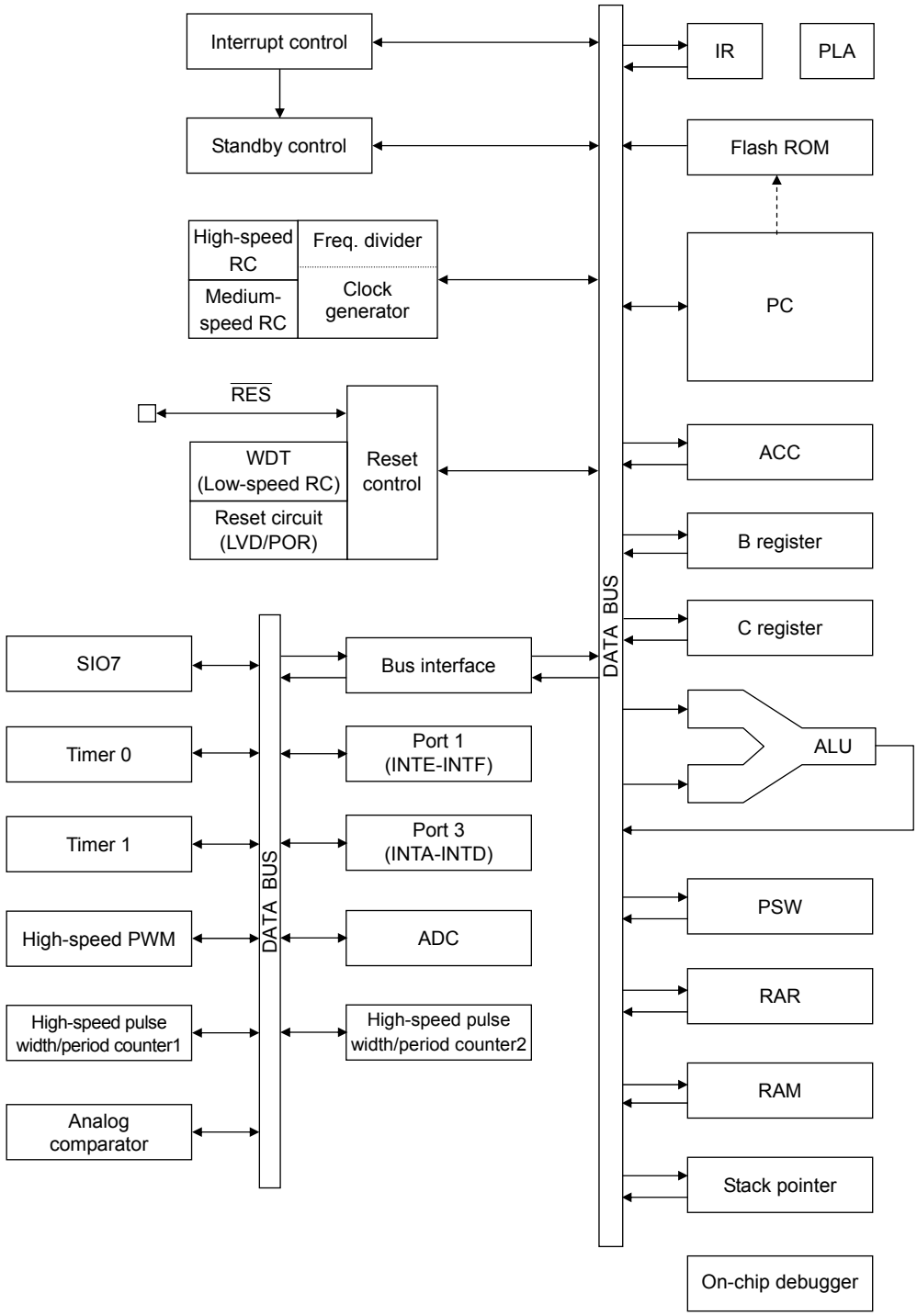
MFP10S MFP10SK	NAME
1	P31/INTB/HCT2IN/DBGP01
2	P30/INTA/HCT1IN/DBGPX0
3	$\overline{\text{RES}}$
4	P10/SO7/INTE/AN0/DBGP02
5	$V_{SS}1$
6	P12/SCK7/INTF/IN-/AN2
7	P11/SI7/SB7/INTE/IN+/HCT2IN/AN1
8	P33/INTD/HPWM/DBGP12
9	P32/INTC/CMPO/DBGP11
10	$V_{DD}1$



MFP14S (for debugging only) “Lead-free type”

MFP14S	NAME
1	P31/INTB/HCT2IN/DBGP01
2	P30/INTA/HCT1IN/DBGPX0
3	$\overline{\text{RES}}$
4	P10/SO7/INTE/AN0/DBGP02
5	$V_{SS}1$
6	NC
7	DBGP22
8	DBGP21
9	DBGP20
10	P12/SCK7/INTF/IN-/AN2
11	P11/SI7/SB7/INTE/IN+/HCT2IN/AN1
12	P33/INTD/HPWM/DBGP12
13	P32/INTC/CMPO/DBGP11
14	$V_{DD}1$

System Block Diagram



Pin Description

<table>
<tr><th>Pin Name</th><th>I/O</th><th>Description</th><th>Option</th></tr>
<tr><td>$V_{SS}1$</td><td>-</td><td>- power supply pin</td><td>No</td></tr>
<tr><td>$V_{DD}1$</td><td>-</td><td>+ power supply pin</td><td>No</td></tr>
<tr><td>PORT1
P10 to P12</td><td>I/O</td><td>• 3-bit I/O port
• I/O specifiable in 1-bit units
• Pull-up resistors can be turned on and off in 1-bit units
• Multiplexed pins
P10: SIO7 data output/
INTE input/HOLD release input/timer 1 event input/
timer 0L capture input/timer 0H capture input
P11: SIO7 data input/bus I/O/
high-speed pulse width/period counter 2 inpu/t
INTE input/HOLD release input/timer 1 event input/
timer 0L capture input/timer 0H capture input
P12: SIO7 clock I/O/
INTF input/HOLD release input/timer 1 event input/
timer 0L capture input/timer 0H capture input
AD converter input ports: AN0 to AN2 (P10 to P12)
Analog comparator input ports: IN+, IN- (P11, P12)
On-chip debugger pin 1: DBGP02 (P10)
• 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>INTE</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
<tr><td>INTF</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>PORT3
P30 to P33</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
• Multiplexed pins
P30: INTA input/HOLD release input/timer 0L capture input/
high-speed pulse width/period counter 1 input
P31: INTB input/HOLD release input/timer 0H capture input/
high-speed pulse width/period counter 2 input
P32: INTC input/HOLD release input/timer 0 event input/
timer 0L capture input/analog comparator output
P33: INTD input/HOLD release input/timer 0 event input/
timer 0H capture input/high-speed PWM output
On-chip debugger pin 1: DBGPX0 to DBGP01 (P30 to P31)
On-chip debugger pin 2: DBGPX0 to DBGP12 (P30, P32 to P33)
• 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>INTA</td><td>enable</td><td>enable</td><td>disable</td><td>enable</td><td>enable</td></tr>
<tr><td>INTB</td><td>enable</td><td>enable</td><td>disable</td><td>enable</td><td>enable</td></tr>
<tr><td>INTC</td><td>enable</td><td>enable</td><td>enable</td><td>disable</td><td>disable</td></tr>
<tr><td>INTD</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>$\overline{RES}$</td><td>I/O</td><td>External reset input/internal reset output</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
P10 to P12	1 bit	1	CMOS	Programmable
		2	N-channel open drain	Programmable
P30 to P33	1 bit	1	CMOS	Programmable
		2	N-channel open drain	Programmable

On-chip Debugger Pin Processing

For the processing of the on-chip debugger pins, refer to the separately available documents entitled "RD87 On-chip Debugger Installation" and "LC872000 Series On-chip Debugger Pin Processing."

Recommended Unused Pin Connections

Pin Name	Recommended Unused Pin Connections	
	Board	Software
P10 to P12	OPEN	Set output low
P30 to P33	OPEN	Set output low

User Options

Option Name	Option Type	Flash Version	Option Switched in Unit of	Description
Port output type	P10 to P12	enable	1bit	CMOS
				N-channel open drain
	P30 to P33	enable	1bit	CMOS
				N-channel open drain
Program start address	-	enable	-	00000H
				01E00H
Brown-out detector reset function	Brown-out detector function	enable	-	Enable: Used
				Disable: Not used
	Brown-out trip level	enable	-	3 levels
Power-on-reset function	Power-on-reset level	enable	-	3 levels
High-speed RC oscillator circuit	Oscillation frequency	enable	-	20 MHz
				40 MHz
Package type	-	enable	-	MFP10S: LC87F2608A
				MFP14S: Debugged by using LC87D2708A or LC87F2708A

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

Parameter		Symbol	Pin/Remarks	Conditions	V_{DD}[V]	Specification min	typ	max	unit
Maximum supply voltage		V_{DD} max	$V_{DD}1$			-0.3	to	+6.5	V
Input voltage		V_I	$\overline{RES}$			-0.3	to	V_{DD}+0.3	
Input/output voltage		V_{IO}	• Port 1 • Port 3			-0.3	to	V_{DD}+0.3	
High level output current	Peak output current	I_{OPH}(1)	Port 1	• CMOS output selected • Per applicable pin		-7.5			mA
		I_{OPH}(2)	Port 3	• CMOS output selected • Per applicable pin		-10			
	Mean output current (Note 1-1)	I_{OMH}(1)	Port 1	• CMOS output selected • Per applicable pin		-5			
		I_{OMH}(2)	Port 3	• CMOS output selected • Per applicable pin		-7.5			
	Total output current	ΣI_{OAH}(1)	• Port 10 • Ports 30, 31	Total of currents at all applicable pins		-20			
		ΣI_{OAH}(2)	• Ports 11, 12 • Ports 32, 33	Total of currents at all applicable pins		-20			
		ΣI_{OAH}(3)	• Port 1 • Port 3	Total of currents at all applicable pins		-35			
Low level output current	Peak output current	I_{OPL}(1)	Port 1	Per applicable pin				15	
		I_{OPL}(2)	Port 3	Per applicable pin				10	
	Mean output current (Note 1-1)	I_{OML}(1)	Port 1	Per applicable pin				10	
		I_{OML}(2)	Port 3	Per applicable pin				7.5	
	Total output current	ΣI_{OAL}(1)	• Port 10 • Ports 30, 31	Total of currents at all applicable pins				25	
		ΣI_{OAL}(2)	• Ports 11, 12 • Ports 32, 33	Total of currents at all applicable pins				35	
		Σ_{IOAL}(3)	• Port 1 • Port 3	Total of currents at all applicable pins				55	
Power dissipation		Pd max(1)	MFP10S	• Ta=-40 to +85°C • Independent package				100	mW
		Pd max(2)		• Ta=-40 to +85°C • Mounted on thermal test board (Note 1-2)				237	
		Pd max(3)	MFP10SK	• Ta=-40 to +85°C • Independent package				100	
		Pd max(4)		• Ta=-40 to +85°C • Mounted on thermal test board (Note 1-2)				237	
Operating ambient temperature		Topr				-40	to	+85	°C
Storage ambient temperature		Tstg				-55	to	+125	

Note 1-1: Mean output current refers to the average of output currents measured for a period of 100ms.
Note 1-2: Thermal test board used conforms to SEMI (size: 76.1×114.3×1.6tmm, glass epoxy board).

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

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

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD}[V]	Specification			
					min	typ	max	unit
Operating supply voltage (Note 2-1)	V_{DD}	$V_{DD}1$	0.272µs ≤ tCYC ≤ 100µs		2.7		5.5	V
Memory sustaining supply voltage	V_{HD}	$V_{DD}1$	RAM and register contents sustained in HOLD mode		2.0		5.5	
High level input voltage	V_{IH}(1)	• Port 1 • Port 3	Output disabled	2.7 to 5.5	$0.3V_{DD}$ +0.7		V_{DD}	
	V_{IH}(2)	$\overline{RES}$		2.7 to 5.5	$0.75V_{DD}$		V_{DD}	
Low level input voltage	V_{IL}(1)	• Port 1 • Port 3	Output disabled	4.0 to 5.5	V_{SS}		$0.1V_{DD}$+0.4	
				2.7 to 4.0	V_{SS}		$0.2V_{DD}$	
	V_{IL}(2)	$\overline{RES}$		2.7 to 5.5	V_{SS}		$0.25V_{DD}$	
Instruction cycle time (Note 2-2)	tCYC			2.7 to 5.5	0.272		100	µs
Oscillation frequency range	FmHRC(1)		• High-speed RC oscillation • 40MHz selected as option • Ta=-20 to +85°C	4.5 to 5.5	38	40	42	MHz
	FmHRC(2)		• High-speed RC oscillation • 40MHz selected as option • Ta=-40 to +85°C	4.5 to 5.5	37.6	40	42.4	
	FmHRC(3)			3.5 to 5.5	36.8	40	43.2	
	FmHRC(4)			2.7 to 5.5	32	40	43.2	
	FmHRC(5)		• High-speed RC oscillation • 20MHz selected as option • Ta=-20 to +85°C	3.0 to 5.5	19	20	21	
	FmHRC(6)		• High-speed RC oscillation • 20MHz selected as option • Ta=-40 to +85°C	2.7 to 5.5	18.7	20	21.3	
	FmRC		Medium-speed RC oscillation	2.7 to 5.5	0.5	1.0	2.0	
	FmSLRC		Low-speed RC oscillation	2.7 to 5.5	15	30	60	kHz
Oscillation stabilization time	tmsHRC		• When high-speed RC oscillation state is switched from stopped to enabled. • See Fig. 2.	2.7 to 5.5			100	µs

Note 2-1: Use this product in a voltage range of 3.0 to 5.5V because the minimum release voltage (PORRL) of the power-on reset (POR) circuit is 2.87V±0.12V.

Note 2-2: Relationship between tCYC and oscillation frequency is as follows:

- When system clock source is set to medium-speed RC oscillation
  3/FmRC at a division ratio of 1/1, 6/FmRC at a division ratio of 1/2, 12/FmRC a division ratio of 1/4, and so forth
- When system clock source is set to high-speed RC oscillation (40MHz selected by optional configuration)
  12/FmHRC at a division ratio of 1/1, 24/FmHRC at a division ratio of 1/2, 48/FmHRC a division ratio of 1/4, and so forth
- When system clock source is set to high-speed RC oscillation (20MHz selected by optional configuration)
  6/FmHRC at a division ratio of 1/1, 12/FmHRC at a division ratio of 1/2, 24/FmHRC a division ratio of 1/4, and so forth

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

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
High level input current	$I_{IH}(1)$	• Port 1 • Port 3	• Output disabled • Pull-up resistor off • $V_{IN}=V_{DD}$ (including output Tr. off leakage current)	2.7 to 5.5			1	μA
	$I_{IH}(2)$	$\overline{RES}$	$V_{IN}=V_{DD}$	2.7 to 5.5			1	
Low level input current	I_{IL}	• Port 1 • Port 3	• Output disabled • Pull-up resistor off • $V_{IN}=V_{SS}$ (including output Tr. off leakage current)	2.7 to 5.5	-1			
High level output voltage	$V_{OH}(1)$	CMOS output type port 1	I_{OH}=-1mA	4.5 to 5.5	V_{DD}-1			V
	$V_{OH}(2)$		I_{OH}=-0.35mA	2.7 to 5.5	V_{DD}-0.4			
	$V_{OH}(3)$	CMOS output type port 3	I_{OH}=-5mA	4.5 to 5.5	V_{DD}-1.5			
	$V_{OH}(4)$		I_{OH}=-0.7mA	2.7 to 5.5	V_{DD}-0.4			
Low level output voltage	$V_{OL}(1)$	Port 1	I_{OL}=10mA	4.5 to 5.5			1.5	
	$V_{OL}(2)$		I_{OL}=1.4mA	2.7 to 5.5			0.4	
	$V_{OL}(3)$	Port 3	I_{OL}=5mA	4.5 to 5.5			1.5	
	$V_{OL}(4)$		I_{OL}=0.7mA	2.7 to 5.5			0.4	
Pull-up resistance	Rpu(1)	• Port 1 • Port 3	$V_{OH}=0.9V_{DD}$	4.5 to 5.5	15	35	80	kΩ
	Rpu(2)			2.7 to 4.5	18	50	150	
	Rpu(3)	$\overline{RES}$		2.7 to 5.5	216	360	504	
Hysteresis voltage	VHYS	• Port 1 • Port 3 • $\overline{RES}$		2.7 to 5.5		$0.1V_{DD}$		V
Pin capacitance	CP	All pins	• VIN=VSS for pins other than that under test • f=1 MHz • Ta=25°C	2.7 to 5.5		10		pF

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

SIO7 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)	SCK7(P12)	• See Fig. 4. (Note 4-1-2)	2.7 to 5.5	2			tCYC
		Low level pulse width	tSCKL(1)				1			
		High level pulse width	tSCKH(1)				1			
	Output clock	Frequency	tSCK(2)	SCK7(P12)	• CMOS output selected • See Fig. 4.	2.7 to 5.5	4/3			
		Low level pulse width	tSCKL(2)				1/2			tSCK
		High level pulse width	tSCKH(2)				1/2			
Serial input	Data setup time		tsDI(1)	SB7(P11), SI7(P11)	• Must be specified with respect to Rising edge of SIOCLK. • See Fig. 4.	2.7 to 5.5	0.03			µs
	Data hold time		thDI(1)				0.03			
Serial output	Input clock	Output delay time	tdDO(1)	SO7(P10), SB7(P11)	• 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. 4.	2.7 to 5.5			1tCYC +0.05	
	Output clock		tdDO(2)						(1/3)tCYC +0.05	

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 transmission/reception mode, the time from SI7RUN being set when serial clock is "H" to the first falling edge of the serial clock must be longer than 1tCYC.

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

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD}[V]	min	typ	max	unit
High/low level pulse width	tPIH(1) tPIL(1)	INTA(P30), INTB(P31), INTD(P33), INTE(P10, P11), INTF(P12)	• Interrupt source flag can be set. • Event inputs for timers 0 and 1 are enabled.	2.7 to 5.5	1			tCYC
	tPIH(2) tPIL(2)	INTC(P32) when noise filter time constant is "none"	• Interrupt source flag can be set. • Event inputs for timer 0 are enabled.	2.7 to 5.5	1			
	tPIH(3) tPIL(3)	INTC(P32) when noise filter time constant is "1/16"	• Interrupt source flag can be set. • Event inputs for timer 0 are enabled.	2.7 to 5.5	64			
	tPIH(4) tPIL(4)	INTC(P32) 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	128			
	tPIH(5) tPIL(5)	INTC(P32) when noise filter time constant is "1/64"	• Interrupt source flag can be set. • Event inputs for timer 0 are enabled.	2.7 to 5.5	256			
	tPIH(6) tPIL(6)	HCT1IN(P30)	Pulses can be recognized as signals by the high-speed pulse width/period counter 1.	2.7 to 5.5	3			H1CK (Note 5-1)
	tPIH(7) tPIL(7)	HCT2IN(P11, P31)	Pulses can be recognized as signals by the high-speed pulse width/period counter 2.	2.7 to 5.5	6			H2CK (Note 5-2)
	tPIL(8)	$\overline{RES}$	Resetting is enabled.	2.7 to 5.5	200			μs

Note 5-1: H1CK denotes the period of the base clock (1 to 8 × high-speed RC oscillation clock or system clock) for the high-speed pulse width/period counter 1.

Note 5-2: H2CK denotes the period of the base clock (2 to 16 × high-speed RC oscillation clock or system clock) for the high-speed pulse width/period counter 2.

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

Parameter	Symbol	Pin/Remarks	Conditions	Specification				
				V_{DD} [V]	min	typ	max	unit
Common mode input voltage range	VCMIN	IN+(P11), IN-(P12)		2.7 to 5.5	V_{SS}		V_{DD}-1.5	V
Offset voltage	VOFF		Within common mode input voltage range	2.7 to 5.5		±10	±30	mV
Response time	tRT		• Within common mode input voltage range • Input amplitude=100mV • Overdrive=50mV	2.7 to 5.5		200	600	ns
Operation stabilization time (Note 6-1)	tCMW			2.7 to 5.5			1.0	μs

Note 6-1: The interval after CMPON is set till the operation gets stabilized.

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

<12-bit AD conversion mode at Ta=-40 to +85°C >

Parameter	Symbol	Pin/Remarks	Conditions		Specification			
				V_{DD} [V]	min	typ	max	unit
Resolution	N	AN0(P10) to AN2(P12)		3.0 to 5.5		12		bit
Absolute accuracy	ET		(Note 7-1)	3.0 to 5.5			±16	LSB
Conversion time	tCAD		• See "Conversion time calculation method." (Note 7-2)	4.0 to 5.5	38		104.3	µs
				3.0 to 5.5	75.8		104.3	
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-bit AD Converter Mode at Ta=-40 to +85°C >

Parameter	Symbol	Pin/Remarks	Conditions		Specification			
				V_{DD} [V]	min	typ	max	unit
Resolution	N	AN0(P10) to AN2(P12)		3.0 to 5.5		8		bit
Absolute accuracy	ET		(Note 7-1)	3.0 to 5.5			±1.5	LSB
Conversion time	tCAD		• See "Conversion time calculation method." (Note 7-2)	4.0 to 5.5	23.4		64.3	µs
				3.0 to 5.5	46.7		64.3	
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 method>

12-bit AD conversion mode: tCAD (conversion time) = ((52/(division ratio)) + 2) × (1/3) × tCYC

8-bit AD conversion mode: tCAD (conversion time) = ((32/(division ratio)) + 2) × (1/3) × tCYC

<Recommended Operating Conditions>

High-speed RC Oscillation (FmHRC)	Supply Voltage Range (V_{DD})	System Clock Division Ratio (SYSDIV)	Cycle Time (tCYC)	AD Division Ratio (ADDIV)	Conversion Time (tCAD)	
					12-bit AD	8-bit AD
40MHz/20MHz	4.0V to 5.5V	1/1	300ns	1/8	41.8µs	25.8µs
	3.0V to 5.5V	1/1	300ns	1/16	83.4µs	51.4µs

Note 7-1: The quantization error (±1/2LSB) is excluded from the absolute accuracy. The absolute accuracy is measured when no change occurs in the I/O state of the pins that are adjacent to the analog input channel during AD conversion processing.

Note 7-2: The conversion time refers to the interval from the time a conversion starting instruction is issued till the time the complete digital conversion value against the analog input value is loaded in the result register.

*The conversion time is twice the normal value when one of the following conditions occurs:

- The first AD conversion executed in the 12-bit AD conversion mode after a system reset.
- The first AD conversion executed after the AD conversion mode is switched from 8-bit to 12-bit AD conversion mode.

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

Parameter	Symbol	Pin/Remarks	Conditions	Option Selecting Voltage	Specification min	typ	max	unit
POR release voltage	PORRL		• Option selected • See Fig. 6. (Note 8-1)	2.87V	2.75	2.87	2.99	V
				3.86V	3.73	3.86	3.99	
				4.35V	4.21	4.35	4.49	
Unknown voltage area	POUKS		• See Fig. 6. (Note 8-2)			0.7	0.95	
Power startup time	PORIS		Power startup time from V_{DD}=0V to 2.8V				100	ms

Note 8-1: The POR release voltage can be selected from three levels when the low-voltage detection feature is deselected.
Note 8-2: There is an unpredictable period before the power-on reset transistor starts to turn on.

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

Parameter	Symbol	Pin/Remarks	Conditions	Option Selecting Voltage	Specification min	typ	max	unit
LVD reset voltage (Note 9-2)	LVDET		• Option selected • See Fig. 7. (Note 9-1) (Note 9-3)	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 voltage hysteresis	LVHYS			2.81V		60		mV
				3.79V		65		
				4.28V		65		
Unknown voltage area	LVUKS		• See Fig. 7. (Note 9-4)			0.7	0.95	V
Minimum low voltage detection width (response sensitivity)	tLVDW		• LVDET-0.5V • See Fig. 8.		0.2			ms

Note 9-1: The LVD reset voltage can be selected from three levels when the low-voltage detection feature is selected.
Note 9-2: The hysteresis voltage is not included in the LVD reset voltage value.
Note 9-3: There are cases when the LVD reset voltage value is exceeded when a greater change in the output level or large current is applied to the port.
Note 9-4: There is an unpredictable period before the low-voltage detection resetting transistor starts to run.

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

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD} [V]	Specification min	typ	max	unit
Normal mode consumption current (Note 10-1)	IDDOP(1)	V_{DD}1	• FmHRC=40MHz oscillation mode • System clock set to high-speed RC, 10MHz (1/4 of 40MHz)	4.5 to 5.5		7.8	14	mA
	IDDOP(2)		• Medium-speed RC oscillation stopped • System clock frequency division ratio set to 1/1	2.7 to 3.6		4.9	9.4	
	IDDOP(3)		• FmHRC=20MHz oscillation mode • System clock set to high-speed RC, 10MHz (1/2 of 20MHz)	4.5 to 5.5		7.1	12.8	
	IDDOP(4)		• Medium-speed RC oscillation stopped • System clock frequency division ratio set to 1/1	2.7 to 3.6		4.5	8.6	
	IDDOP(5)		• High-speed RC oscillation stopped • System clock set to medium-speed RC oscillation mode	4.5 to 5.5		0.60	1.9	
	IDDOP(6)		• System clock frequency division ratio set to 1/2	2.7 to 3.6		0.38	1.3	
HALT mode consumption current (Note 10-1)	IDDHALT(1)		HALT mode • FmHRC=40MHz oscillation mode • System clock set to high-speed RC, 10MHz(1/4 of 40MHz)	4.5 to 5.5		3.2	5.0	
	IDDHALT(2)		• Medium-speed RC oscillation stopped • System clock frequency division ratio set to 1/1	2.7 to 3.6		2.0	3.1	
	IDDHALT(3)		HALT mode • FmHRC=20MHz oscillation mode • System clock set to high-speed RC, 10MHz (1/2 of 20MHz)	4.5 to 5.5		2.5	3.9	
	IDDHALT(4)		• Medium-speed RC oscillation stopped • System clock frequency division ratio set to 1/1	2.7 to 3.6		1.6	2.5	
	IDDHALT(5)		HALT mode • High-speed RC oscillation stopped • System clock set to medium-speed RC oscillation mode	4.5 to 5.5		0.32	1.0	
	IDDHALT(6)		• System clock frequency division ratio set to 1/2	2.7 to 3.6		0.16	0.55	
HOLD mode consumption current (Note 10-1)	IDDHOLD(1)		HOLD mode • Ta=-10 to +50°C	4.5 to 5.5		0.04	3.0	µA
	IDDHOLD(2)			2.7 to 3.6		0.02	1.8	
	IDDHOLD(3)		HOLD mode • Ta=-40 to +85°C	4.5 to 5.5		0.04	34	
	IDDHOLD(4)			2.7 to 3.6		0.02	22	
	IDDHOLD(5)		HOLD mode • LVD option selected • Ta=-10 to +50°C	4.5 to 5.5		3.1	6.8	
	IDDHOLD(6)			2.7 to 3.6		2.4	4.2	
	IDDHOLD(7)		HOLD mode • LVD option selected • Ta=-40 to +85°C	4.5 to 5.5		3.1	39	
	IDDHOLD(8)			2.7 to 3.6		2.4	25	
	IDDHOLD(9)		HOLD mode • Watchdog timer active • Ta=-10 to +50°C	4.5 to 5.5		3.4	10	
	IDDHOLD(10)			2.7 to 3.6		1.7	6.0	
	IDDHOLD(11)		HOLD mode • Watchdog timer active • Ta=-40 to +85°C	4.5 to 5.5		3.4	42	
	IDDHOLD(12)			2.7 to 3.6		1.7	27	
	IDDHOLD(13)		HOLD mode • Comparator active (IN+= V_{DD}, IN-= V_{SS})	4.5 to 5.5		110	160	
	IDDHOLD(14)			2.7 to 3.6		65	100	

Note 10-1: The consumption current value includes none of the currents that flow into the output Tr and internal pull-up resistors.

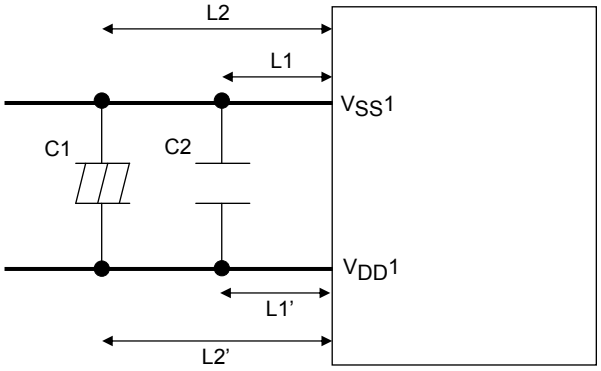
F-ROM Programming Characteristics at Ta=+10 to +55°C, $V_{SS}1$=0V

Parameter	Symbol	Pin/Remarks	Conditions		Specification			
				V_{DD} [V]	min	typ	max	unit
Onboard programming current	IDDFW	V_{DD} 1	• Microcontroller consumption current is excluded.	3.0 to 5.5		5	10	mA
Programming time	tFW(1)		• Erase operation	3.0 to 5.5		20	30	ms
	tFW(2)		• Programming operation			40	60	μs

Power Pin Treatment Recommendations ($V_{DD}1$, $V_{SS}1$)

Connect bypass capacitors that meet the following conditions between the $V_{DD}1$ and $V_{SS}1$ pins:

- Connect among the $V_{DD}1$ and $V_{SS}1$pins and bypass capacitors C1 and C2 with the shortest possible heavy lead wires, making sure that the impedances between the both pins and the bypass capacitors are as equal as possible (L1=L1', L2=L2').
- Connect a large-capacity capacitor C1 and a small-capacity capacitor C2 in parallel. The capacitance of C2 should be approximately 0.1μF.



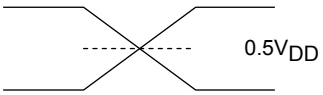
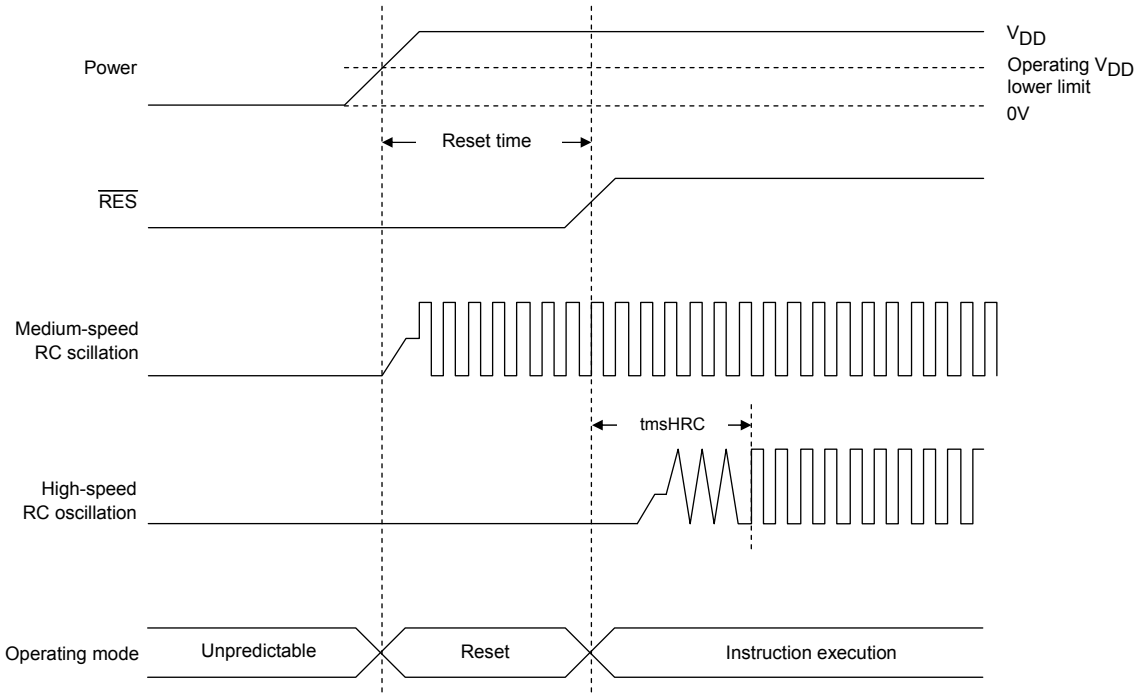
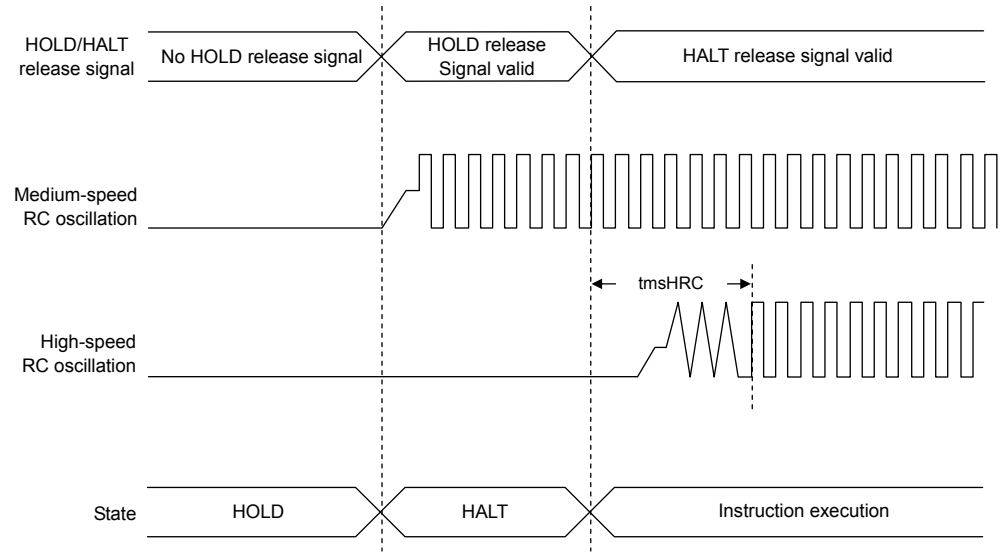


Figure 1 AC Timing Measurement Point

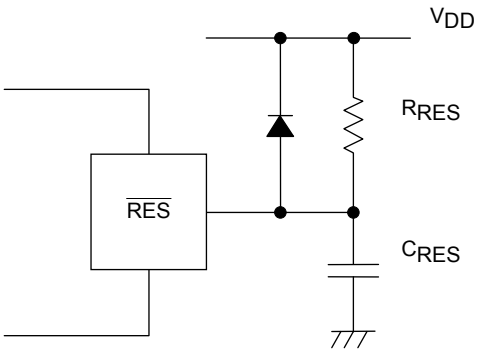


Reset Time and Oscillation Stabilization Time



HOLD Release Signal and Oscillation Stabilization Time

Figure 2 Oscillation Stabilization Times



Note:
The external peripheral circuit differs depending on the way in which the power-on reset and low-voltage detection reset functions are used. Refer to the Chapter, entitled "Reset Function," of the user's manual.

Figure 3 Sample Reset Circuit

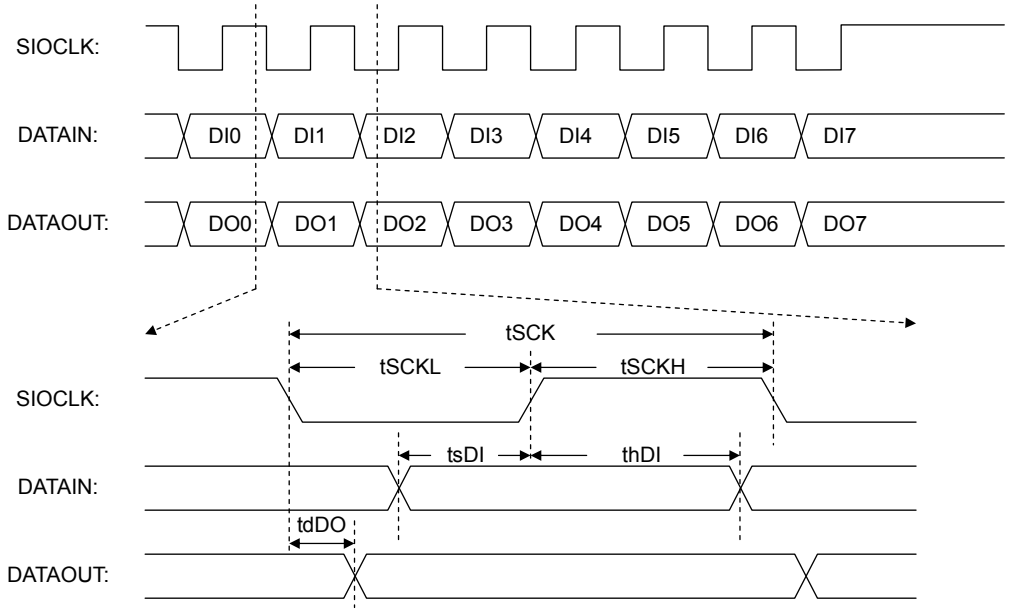


Figure 4 Serial I/O Waveforms

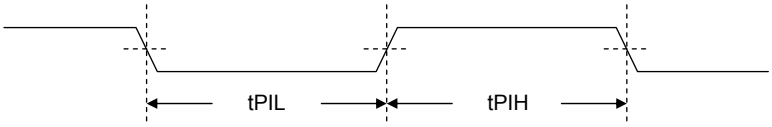


Figure 5 Pulse Input Timing Signal Waveform

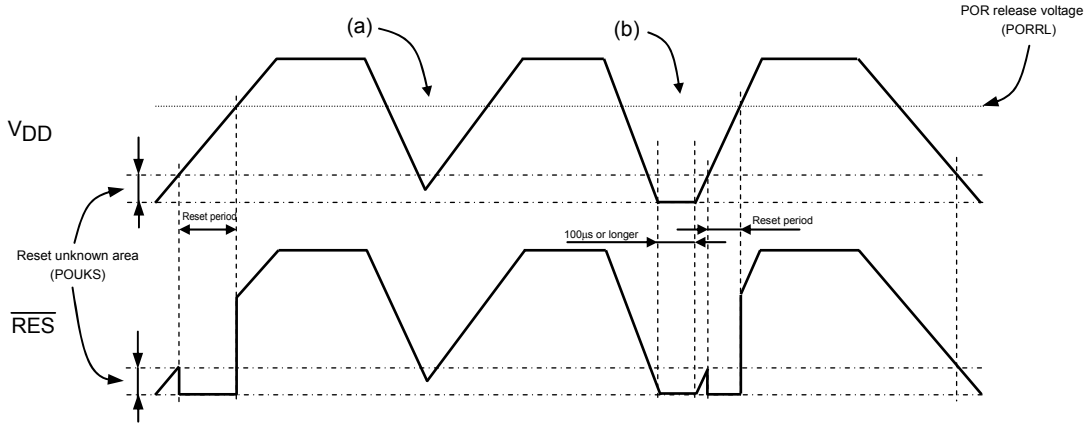


Figure 6 Example of POR Only (LVD Deselected) Mode Waveforms (at Reset Pin with RRES Pull-up Resistor Only)

- The POR circuit generates a reset signal only when the power voltage is raised from the V_{SS} level.
- No stable reset signal is generated if power is turned on again when the power voltage does not go down to the V_{SS} level as shown in (a). If this case is anticipated, use the LVD function as explained below or configure an external reset circuit.
- A reset is effected only when power is turned on again after the power voltage goes down to and remains at the V_{SS} level for 100µs or longer as shown in (b).

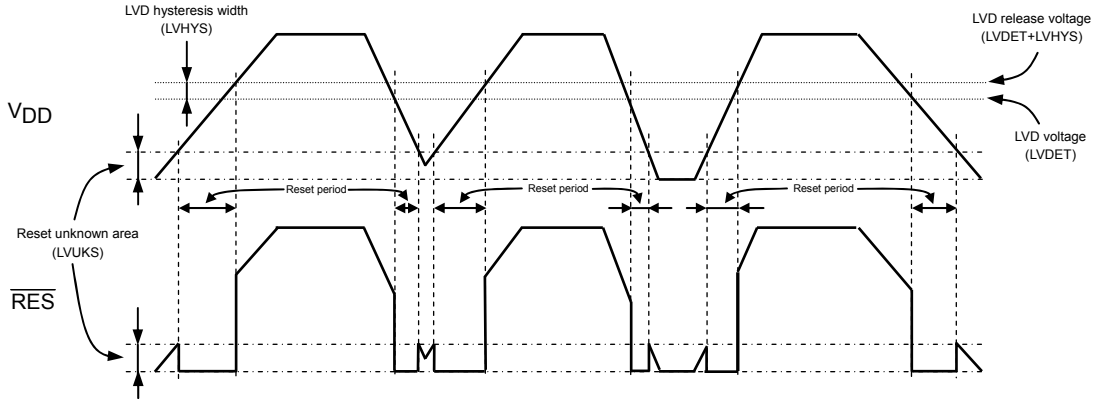


Figure 7 Example of POR + LVD Mode Waveforms (at Reset Pin with R_{RES} Pull-up Resistor Only)

- A reset is effected both when power is turned on and when it goes down.
- The hysteresis width (LVHYS) is introduced in the LVD circuit to prevent the iterations of the IC entering and exiting the reset state near the detection threshold level.

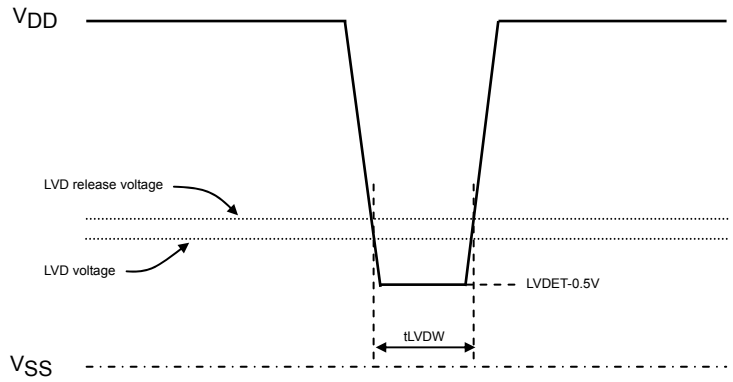


Figure 8 Minimum Low Voltage Detection Width
(Example of Short Interruption of Power/ Power Fluctuation Waveform)

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