SANYO

SANYO Semiconductors
DATA SHEET

LC875932A
LC875924A
LC875916A

CMOS IC
Internal 32K/24K/16K-byte ROM and 1024-byte RAM
8-bit 1-chip Microcontroller

Overview

The SANYO LC875932A/24A/16A are 8-bit microcomputer that, centered around a CPU running at a minimum bus cycle time of 83.3ns, integrates on a single chip a number of hardware features such as 32K/24K/16K-byte ROM, 1024-byte RAM, sophisticated 16-bit timers/counters (may be divided into 8-bit timers), a 16-bit timer/counter (may be divided into 8-bit timers/counters or 8-bit PWMs), four 8-bit timers with a prescaler, a base timer serving as a time-of-day clock, a high-speed clock counter, a synchronous SIO interface (with automatic block transmission/reception capabilities), an asynchronous/synchronous SIO interface, a UART interface (full duplex), an 8-bit 11-channel AD converter, two 12-bit PWM channels, a system clock frequency divider, ROM correction function, and a 23-source 10-vector interrupt feature.

Features

■ROM
- 32768 × 8 bits (LC875932A)
- 24576 × 8 bits (LC875924A)
- 16384 × 8 bits (LC875916A)

■RAM
- 1024 × 9 bits (LC875932A/24A/16A)

■Minimum Bus Cycle
- 83.3ns (12MHz) V_{DD}=3.0 to 5.5V
- 125ns (8MHz) V_{DD}=2.5 to 5.5V
- 500ns (2MHz) V_{DD}=2.2 to 5.5V

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

■Minimum Instruction Cycle Time
- 250ns (12MHz)　　　V_{DD}=3.0 to 5.5V
- 375ns (8MHz)　　　V_{DD}=2.5 to 5.5V
- 1.5μs (2MHz)　　　V_{DD}=2.2 to 5.5V

■Ports
- Normal withstand voltage I/O ports
  Ports whose I/O direction can be designated in 1-bit units　46 (P1n, P2n, P70 to P73, P80 to P86, PBn, PCn, PWM2, PWM3, XT2)

  Ports whose I/O direction can be designated in 4-bit units　8 (P0n)
- Normal withstand voltage input ports　1 (XT1)
- Dedicated oscillator ports　2 (CF1, CF2)
- Reset pins　1 ($\overline{RES}$)
- Power pins　6 (V_{SS}1 to 3, V_{DD}1 to 3)

■Timers
- Timer 0: 16-bit timer/counter with a capture register
  Mode 0: 8-bit timer with an 8-bit programmable prescaler (with an 8-bit capture register) × 2 channels
  Mode 1: 8-bit timer with an 8-bit programmable prescaler (with an 8-bit capture register) + 8-bit counter (with an 8-bit capture register)
  Mode 2: 16-bit timer with an 8-bit programmable prescaler (with a 16-bit capture register)
  Mode 3: 16-bit counter (with a 16-bit capture register)
- Timer 1: 16-bit timer/counter that supports PWM/toggle outputs
  Mode 0: 8-bit timer with an 8-bit prescaler (with toggle outputs)
  　　　　+ 8-bit timer/counter with an 8-bit prescaler (with toggle outputs)
  Mode 1: 8-bit PWM with an 8-bit prescaler × 2 channels
  Mode 2: 16-bit timer/counter with an 8-bit prescaler (with toggle outputs)
  　　　　(toggle outputs also possible from the lower-order 8 bits)
  Mode 3: 16-bit timer with an 8-bit prescaler (with toggle outputs)
  　　　　(the lower-order 8 bits can be used as PWM)
- Timer 4: 8-bit timer with a 6-bit prescaler
- Timer 5: 8-bit timer with a 6-bit prescaler
- Timer 6: 8-bit timer with a 6-bit prescaler (with toggle 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

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

■SIO
- SIO0: 8-bit synchronous serial interface
  1) LSB first/MSB first mode selectable
  2) Built-in 8-bit baudrate generator (maximum transfer clock cycle =4/3 tCYC)
  3) Automatic continuous data transmission (1 to 256 bits, specifiable in 1 bit units, suspension and resumption of data transmission possible in 1 byte units)
- SIO1: 8-bit asynchronous/synchronous serial interface
  Mode 0: Synchronous 8-bit serial I/O (2- or 3-wire configuration, 2 to 512 tCYC transfer clocks)
  Mode 1: Asynchronous serial I/O (half-duplex, 8 data bits, 1 stop bit, 8 to 2048 tCYC baudrates)
  Mode 2: Bus mode 1 (start bit, 8 data bits, 2 to 512 tCYC transfer clocks)
  Mode 3: Bus mode 2 (start detect, 8 data bits, stop detect)

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

■AD Converter: 8 bits × 11 channels

■PWM: Multifrequency 12-bit PWM × 2 channels

■Remote Control Receiver Circuit (sharing pins with P73, INT3, and T0IN)
- Noise rejection function (noise filter time constant selectable from 1 tCYC, 32 tCYC, and 128 tCYC)

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

■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
- 23 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
4	0001BH	H or L	INT3/INT5/base timer0/base timer1
5	00023H	H or L	T0H
6	0002BH	H or L	T1L/T1H
7	00033H	H or L	SIO0/UART1 receive
8	0003BH	H or L	SIO1/UART1 transmit
9	00043H	H or L	ADC/T6/T7
10	0004BH	H or L	Port 0/T4/T5/PWM2, PWM3

- 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 (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
- CF oscillation circuit: For system clock, with internal Rf
- Crystal oscillation circuit: For low-speed system clock, with internal Rf

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

■Standby Function
- HALT mode: Halts instruction execution while allowing the peripheral circuits to continue operation.
    1) Oscillation is not halted automatically.
    2) There are three ways of resetting the HALT mode.
        (1) Setting the reset pin to the low level
        (2) System resetting by watchdog timer
        (3) Occurrence of an interrupt
- HOLD mode: Suspends instruction execution and the operation of the peripheral circuits.
    1) The CF, RC, and crystal oscillators automatically stop operation.
    2) There are four ways of resetting the HOLD mode.
        (1) Setting the reset pin to the low level
        (2) System resetting by watchdog timer
        (3) Having an interrupt source established at either INT0, INT1, INT2, INT4, or INT5
        * INT0 and INT1 HOLD mode reset is available only when level detection is set.
        (4) Having an interrupt source established at port 0
- X'tal HOLD mode: Suspends instruction execution and the operation of the peripheral circuits except the base timer.
    1) The CF and RC oscillators automatically stop operation.
    2) The state of crystal oscillation established when the X'tal HOLD mode is entered is retained.
    3) There are five ways of resetting the X'tal HOLD mode.
        (1) Setting the reset pin to the low level
        (2) System resetting by watchdog timer
        (3) Having an interrupt source established at either INT0, INT1, INT2, INT4, or INT5
        * INT0 and INT1 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

■ROM Correction Function
- Executes the correction program on detection of a match with the program counter value.
- Correction program area size: 128 bytes

■Package Form
- QIP64E (14 × 14):   Lead-free type
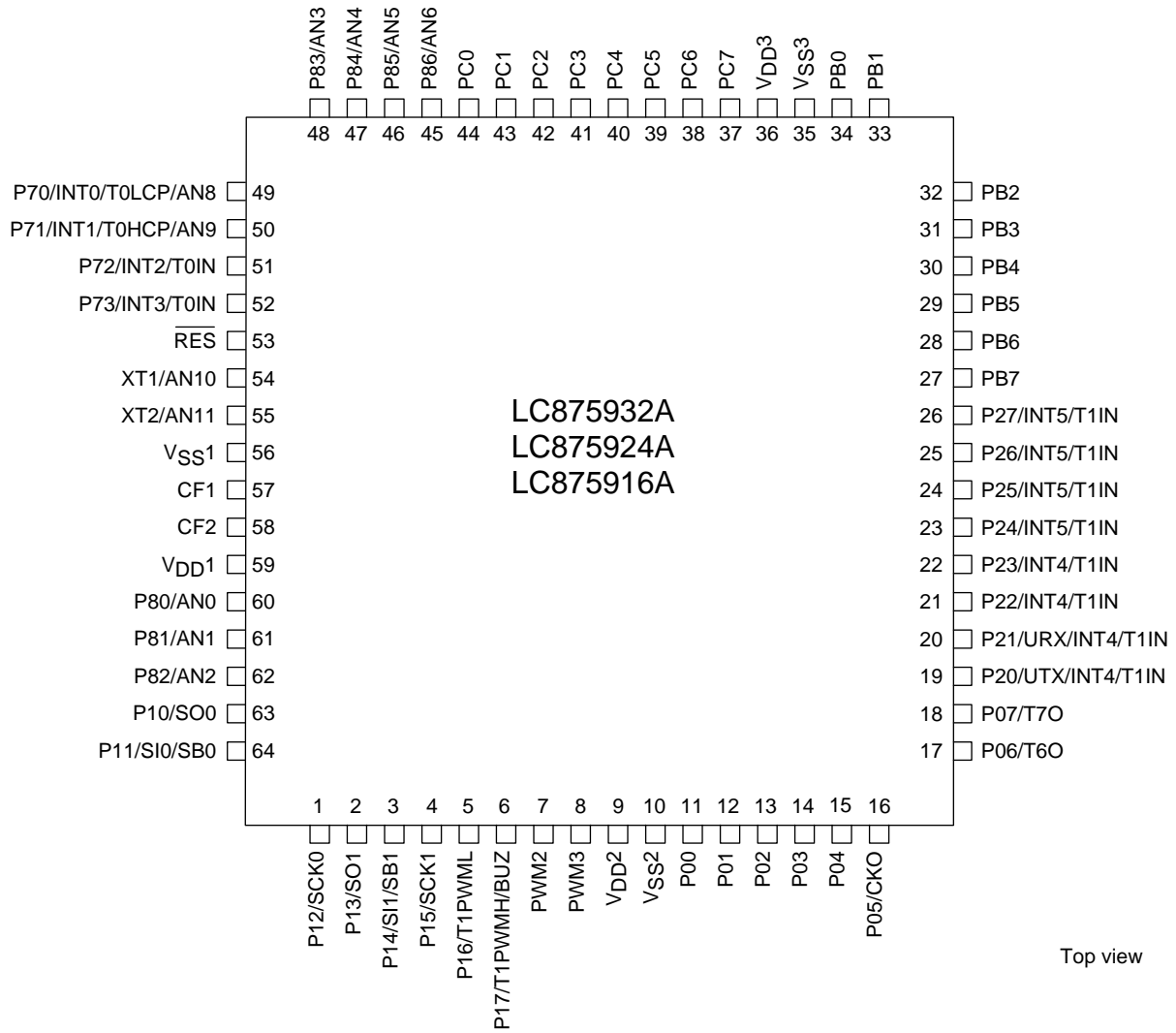- TQFP64J (7 × 7):   Lead-free type
- FLGA68K (6.0 × 6.0):   Lead-free type

■Development Tools
- Onchip debugger: LC87F5932A+TCB87 TypeA/TypeB

Package Dimensions

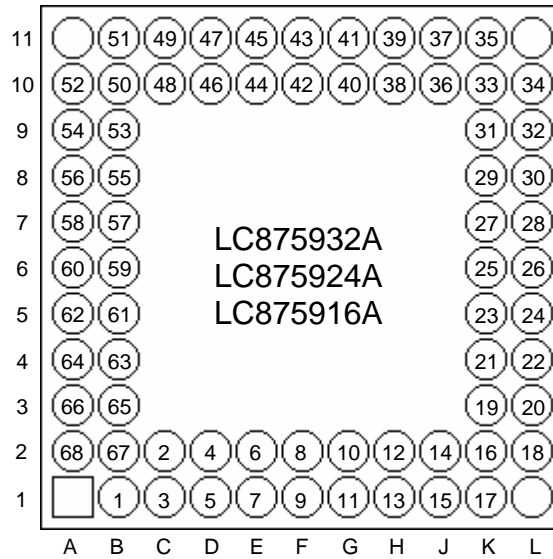unit : mm (typ)
3159A

SANYO : QIP64E(14X14)

Package Dimensions

unit : mm (typ)
3289

SANYO : TQFP64J(7X7)

Package Dimensions

unit : mm (typ)
3326

TOP VIEW

BOTTOM VIEW

SIDE VIEW

SANYO : FLGA68K(6.0X6.0)

Pin Assignments

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                         P83/AN3 ─┐ ┌─ P84/AN4
                         P85/AN5    P86/AN6
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Top pins (left to right): P83/AN3 (48), P84/AN4 (47), P85/AN5 (46), P86/AN6 (45), PC0 (44), PC1 (43), PC2 (42), PC3 (41), PC4 (40), PC5 (39), PC6 (38), PC7 (37), $V_{DD}3$ (36), $V_{SS}3$ (35), PB0 (34), PB1 (33)

Left pins (top to bottom):
Pin	Number
P70/INT0/T0LCP/AN8	49
P71/INT1/T0HCP/AN9	50
P72/INT2/T0IN	51
P73/INT3/T0IN	52
$\overline{RES}$	53
XT1/AN10	54
XT2/AN11	55
$V_{SS}1$	56
CF1	57
CF2	58
$V_{DD}1$	59
P80/AN0	60
P81/AN1	61
P82/AN2	62
P10/SO0	63
P11/SI0/SB0	64

LC875932A
LC875924A
LC875916A

Right pins (top to bottom):
Number	Pin
32	PB2
31	PB3
30	PB4
29	PB5
28	PB6
27	PB7
26	P27/INT5/T1IN
25	P26/INT5/T1IN
24	P25/INT5/T1IN
23	P24/INT5/T1IN
22	P23/INT4/T1IN
21	P22/INT4/T1IN
20	P21/URX/INT4/T1IN
19	P20/UTX/INT4/T1IN
18	P07/T7O
17	P06/T6O

Bottom pins (left to right): 1 P12/SCK0, 2 P13/SO1, 3 P14/SI1/SB1, 4 P15/SCK1, 5 P16/T1PWML, 6 P17/T1PWMH/BUZ, 7 PWM2, 8 PWM3, 9 $V_{DD}2$, 10 $V_{SS}2$, 11 P00, 12 P01, 13 P02, 14 P03, 15 P04, 16 P05/CKO

Top view

SANYO: QIP64E (14 × 14)   "Lead-free Type"
SANYO: TQFP64J (7 × 7)   "Lead-free Type"

Top view

Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name
1	P12/SCK0	18	P06/T6O	35	PB1	52	P70/INT0/T0LCP/AN8
2	P13/SO1	19	P07/T7O	36	PB0	53	P71/INT1/T0HCP/AN9
3	P14/SI1/SB1	20	P20/UTX/INT4/T1IN	37	$V_{SS}3$	54	P72/INT2/T0IN
4	P15/SCK1	21	P21/URX/INT4/T1IN	38	$V_{DD}3$	55	P73/INT3/T0IN
5	P16/T1PWML	22	P22/INT4/T1IN	39	PC7	56	$\overline{RES}$
6	P17/T1PWMH/BUZ	23	P23/INT4/T1IN	40	PC6	57	XT1/AN10
7	PWM2	24	P24/INT5/T1IN	41	PC5	58	XT2/AN11
8	PWM3	25	P25/INT5/T1IN	42	PC4	59	$V_{SS}1$
9	$V_{DD}2$	26	P26/INT5/T1IN	43	PC3	60	CF1
10	$V_{SS}2$	27	P27/INT5/T1IN	44	PC2	61	CF2
11	P00	28	PB7	45	PC1	62	$V_{DD}1$
12	P01	29	PB6	46	PC0	63	P80/AN0
13	P02	30	PB5	47	P86/AN6	64	P81/AN1
14	P03	31	PB4	48	P85/AN5	65	P82/AN2
15	P04	32	PB3	49	P84/AN4	66	P10/SO0
16	P05/CKO	33	PB2	50	P83/AN3	67	P11/SI0/SB0
17	No Connect	34	No Connect	51	No Connect	68	No Connect

Note: Pin number 17, 34, 51, 68 of NC terminals are not connected electrically. Also, A1, A11, L1, L11 are dummy terminals for the package. These terminals need to be bonded with foot pattern for the secure bonding of the package.

SANYO: FLGA68K (6.0 × 6.0)   "Lead-free Type"

System Block Diagram

Interrupt control		IR	PLA

Standby control — ROM correct

CF / RC / X'tal — Clock generator

ROM

PC

SIO0 — Bus interface

SIO1 — Port 0 — ACC

Timer 0 — Port 1 — B register

Timer 1 — Port 2 — C register

Timer 4 — Port 7 — ALU

Timer 5 — Port 8

Timer 6 — ADC — PSW

Timer 7 — INT0 to INT5 Noise filter — RAR

Base timer — Port B — RAM

PWM2/3 — Port C — Stack pointer

UART1 — Watchdog timer
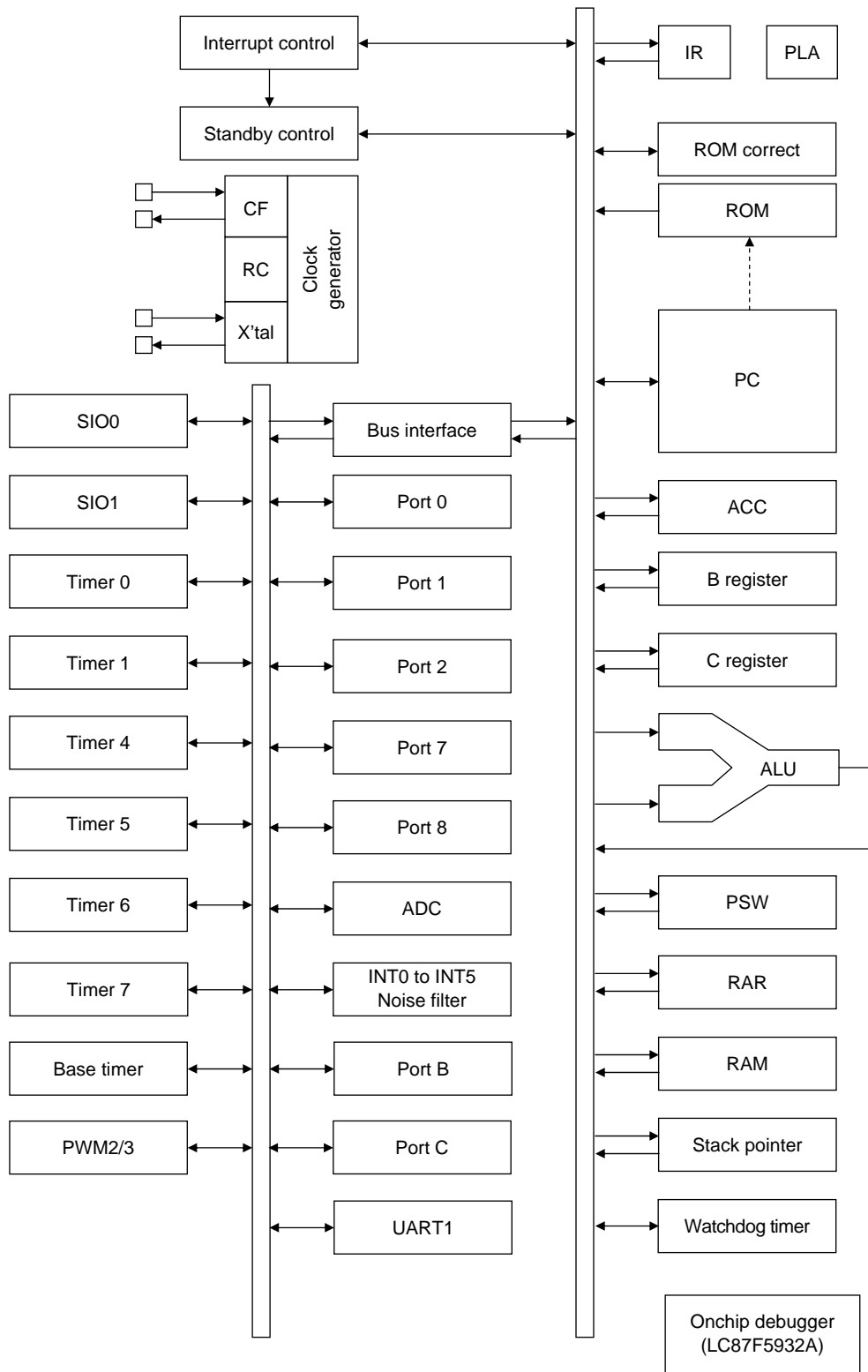
Onchip debugger
(LC87F5932A)

Pin Description

Pin Name	I/O	Description	Option
V_{SS}1 V_{SS}2 V_{SS}3	-	-Power supply pin	No
V_{DD}1 V_{DD}2 V_{DD}3	-	+Power supply pin	No
Port 0 P00 to P07	I/O	• 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 • Shared pins 　P05: Clock output (system clock/can selected from sub clock) 　P06: Timer 6 toggle output 　P07: Timer 7 toggle output	Yes
Port 1 P10 to P17	I/O	• 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. • Shared pins 　P10: SIO0 data output 　P11: SIO0 data input/bus I/O 　P12: SIO0 clock I/O 　P13: SIO1 data output 　P14: SIO1 data input/bus I/O 　P15: SIO1 clock I/O 　P16: Timer 1PWML output 　P17: Timer 1PWMH output/beeper output	Yes
Port 2 P20 to P27	I/O	• 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. • Shared pins 　P20: UART transmit 　P21: UART receive 　P20 to P23: INT4 input/HOLD reset input/timer 1 event input/timer 0L capture input/ timer 0H capture input 　P24 to P27: INT5 input/HOLD reset input/timer 1 event input/timer 0L capture input/ timer 0H capture input • Interrupt acknowledge type	Yes

	Rising	Falling	Rising & Falling	H level	L level
INT4	enable	enable	enable	disable	disable
INT5	enable	enable	enable	disable	disable

Continued from preceding page.

| Pin Name	I/O	Description	Option

Port 7
 	
P70 to P73
	I/O	• 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.
		• Shared pins
		  P70: INT0 input/HOLD reset input/timer 0L capture input/watchdog timer output
		  P71: INT1 input/HOLD reset input/timer 0H capture input
		  P72: INT2 input/HOLD reset input/timer 0 event input/timer 0L capture input/
		      High speed clock counter input
		  P73: INT3 input (with noise filter)/timer 0 event input/timer 0H capture input
		  AD converter input port: AN8 (P70), AN9 (P71)
		• Interrupt acknowledge type<table><tr><td></td><td>Rising</td><td>Falling</td><td>Rising & Falling</td><td>H level</td><td>L level</td></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>
			No

Port 8 P80 to P86	I/O	• 7-bit I/O port • I/O specifiable in 1-bit units • Shared pins AD converter input port: AN0 (P80) to AN6 (P86)	No
PWM2, PWM3	I/O	• PWM2 and PWM3 output ports • General-purpose I/O available	No
Port B PB0 to PB7	I/O	• 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.	Yes
Port C PC0 to PC7	I/O	• 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. • Shared pins (for LC87F5932A) On-chip debugger pins: DBGP0 to DBGP2 (PC5 to PC7)	Yes
$\overline{\text{RES}}$	Input	Reset pin	No

XT1	Input	• 32.768kHz crystal oscillator input pin
		• Shared pins
		  General-purpose input port
		  AD converter input port : AN10
		Must be connected to $V_{DD}1$ if not to be used.
			No

XT2	I/O	• 32.768kHz crystal oscillator output pin
		• Shared pins
		  General-purpose I/O port
		  AD converter input port: AN11
		Must be set for oscillation and kept open if not to be used.
			No

CF1	Input	Ceramic resonator input pin	No
CF2	Output	Ceramic resonator output pin	No

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	1 bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
P20 to P27	1 bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
P70	-	No	Nch-open drain	Programmable
P71 to P73	-	No	CMOS	Programmable
P80 to P86	-	No	Nch-open drain	No
PWM2, PWM3	-	No	CMOS	No
PB0 to PB7	1 bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
PC0 to PC7	1 bit	1	CMOS	Programmable
		2	Nch-open drain	Programmable
XT1	-	No	Input for 32.768 kHz crystal oscillator (Input only)	No
XT2	-	No	Output for 32.768kHz crystal oscillator (Nch-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).

*1: 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.
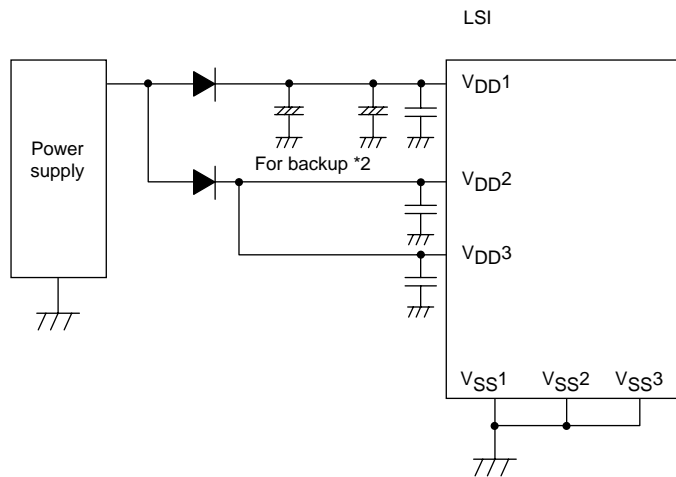
*2: The internal memory is sustained by $V_{DD}1$. If none of $V_{DD}2$ and $V_{DD}3$ are backed up, the high level output at the ports are unstable in the HOLD backup mode, allowing through current to flow into the input buffer and thus shortening the backup time.
   Make sure that the port outputs are held at the low level in the HOLD backup mode.

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			-0.3		V_{DD}+0.3	
Input/output voltage		$V_{IO}(1)$	Ports 0, 1, 2 Ports 7, 8 Ports B, C PWM2, PWM3 XT2			-0.3		V_{DD}+0.3	
High level output current	Peak output current	IOPH(1)	Ports 0, 1, 2 Ports B, C	CMOS output select Per 1 applicable pin		-10			
		IOPH(2)	PWM2, PWM3	Per 1 applicable pin		-20			
		IOPH(3)	P71 to P73	Per 1 applicable pin		-5			
	Mean output current (Note 1-1)	IOMH(1)	Ports 0, 1, 2 Ports B, C	CMOS output select Per 1 applicable pin		-7.5			
		IOMH(2)	PWM2, PWM3	Per 1 applicable pin		-15			
		IOMH(3)	P71 to P73	Per 1 applicable pin		-3			
	Total output current	ΣIOAH(1)	P71 to P73	Total of all applicable pins		-10			
		ΣIOAH(2)	Port 1 PWM2, PWM3	Total of all applicable pins		-25			
		ΣIOAH(3)	Ports 0, 2	Total of all applicable pins		-25			
		ΣIOAH(4)	Ports 0, 1, 2 PWM2, PWM3	Total of all applicable pins		-45			
		ΣIOAH(5)	Port B	Total of all applicable pins		-25			
		ΣIOAH(6)	Port C	Total of all applicable pins		-25			
		ΣIOAH(7)	Ports B, C	Total of all applicable pins		-45			
Low level output current	Peak output current	IOPL(1)	P02 to P07 Ports 1, 2 Ports B, C PWM2, PWM3	Per 1 applicable pin				20	mA
		IOPL(2)	P00, P01	Per 1 applicable pin				30	
		IOPL(3)	Ports 7, 8, XT2	Per 1 applicable pin				10	
	Mean output current (Note 1-1)	IOML(1)	P02 to P07 Ports 1, 2 Ports B, C PWM2, PWM3	Per 1 applicable pin				15	
		IOML(2)	P00, P01	Per 1 applicable pin				20	
		IOML(3)	Ports 7, 8, XT2	Per 1 applicable pin				7.5	
	Total output current	ΣIOAL(1)	Port 7 P83 to P86, XT2	Total of all applicable pins				15	
		ΣIOAL(2)	P80 to P82	Total of all applicable pins				15	
		ΣIOAL(3)	Ports 7, 8, XT2	Total of all applicable pins				20	
		ΣIOAL(4)	Port 1 PWM2, PWM3	Total of all applicable pins				45	
		ΣIOAL(5)	Ports 0, 2	Total of all applicable pins				45	
		ΣIOAL(6)	Ports 0, 1, 2 PWM2, PWM3	Total of all applicable pins				80	
		ΣIOAL(7)	Port B	Total of all applicable pins				45	
		ΣIOAL(8)	Port C	Total of all applicable pins				45	
		ΣIOAL(9)	Ports B, C	Total of all applicable pins				80	
Power dissipation		Pd max	QIP64E(14 × 14)	Ta=-30 to +70°C				375	mW
			TQFP64J(7 × 7)					170	
			FLGA68K(6.0 × 6.0)					121	
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.

LC875932A/24A/16A

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	Specification				
				V_{DD} [V]	min	typ	max	unit
Operating supply voltage	$V_{DD}(1)$	$V_{DD}1=V_{DD}2=VDD3$	$0.245\mu s \leq tCYC \leq 200\mu s$		3.0		5.5	
			$0.367\mu s \leq tCYC \leq 200\mu s$		2.5		5.5	
			$1.47\mu s \leq tCYC \leq 200\mu s$		2.2		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 1, 2 P71 to P73 P70 port input /interrupt side		2.2 to 5.5	$0.3V_{DD}$ +0.7		V_{DD}	V
	$V_{IH}(2)$	Ports 0, 8, B, C PWM2, PWM3		2.2 to 5.5	$0.3V_{DD}$ +0.7		V_{DD}	
	$V_{IH}(3)$	Port 70 watchdog timer side		2.2 to 5.5	$0.9V_{DD}$		V_{DD}	
	$V_{IH}(4)$	XT1, XT2, CF1 $\overline{RES}$		2.2 to 5.5	$0.75V_{DD}$		V_{DD}	
Low level input voltage	$V_{IL}(1)$	Ports 1, 2 P71 to P73 P70 port input /interrupt side		4.0 to 5.5	V_{SS}		$0.1V_{DD}$ +0.4	
				2.2 to 4.0	V_{SS}		$0.2V_{DD}$	
	$V_{IL}(2)$	Ports 0, 8, B, C PWM2, PWM3		4.0 to 5.5	V_{SS}		$0.15V_{DD}$ +0.4	
				2.2 to 4.0	V_{SS}		$0.2V_{DD}$	
	$V_{IL}(3)$	Port 70 watchdog timer side		2.2 to 5.5	V_{SS}		$0.8V_{DD}$ -1.0	
	$V_{IL}(4)$	XT1, XT2, CF1 $\overline{RES}$		2.2 to 5.5	V_{SS}		$0.25V_{DD}$	
Instruction cycle time (Note 2-1)	tCYC			3.0 to 5.5	0.245		200	μs
				2.5 to 5.5	0.367		200	
				2.2 to 5.5	1.47		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		12	MHz
				2.5 to 5.5	0.1		8	
				2.2 to 5.5	0.1		2	
			• CF2 pin open • System clock frequency division ratio=1/2	3.0 to 5.5	0.2		24.4	
				2.5 to 5.5	0.2		16	
				2.2 to 5.5	0.2		4	
Oscillation frequency range (Note2-2)	FmCF(1)	CF1, CF2	12MHz ceramic oscillation See Fig. 1.	3.0 to 5.5		12		
	FmCF(2)	CF1, CF2	8MHz ceramic oscillation See Fig. 1.	2.5 to 5.5		8		
	FmCF(3)	CF1, CF2	4MHz ceramic oscillation See Fig. 1.	2.2 to 5.5		4		
	FmRC		Internal RC oscillation	2.2 to 5.5	0.3	1.0	2.0	
	FsX'tal	XT1, XT2	32.768kHz crystal oscillation See Fig. 2.	2.2 to 5.5		32.768		kHz

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

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

LC875932A/24A/16A

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 Ports 7, 8 Ports B, C $\overline{RES}$ PWM2, PWM3	Output disabled Pull-up resistor off $V_{IN}=V_{DD}$ (Including output Tr's off leakage current)	2.2 to 5.5			1	μA
	$I_{IH}(2)$	XT1, XT2	For input port specification $V_{IN}=V_{DD}$	2.2 to 5.5			1	
	$I_{IH}(3)$	CF1	$V_{IN}=V_{DD}$	2.2 to 5.5			15	
Low level input current	$I_{IL}(1)$	Ports 0, 1, 2 Ports 7, 8 Ports B, C $\overline{RES}$ PWM2, PWM3	Output disabled Pull-up resistor off $V_{IN}=V_{SS}$ (Including output Tr's off leakage current)	2.2 to 5.5	-1			
	$I_{IL}(2)$	XT1, XT2	For input port specification $V_{IN}=V_{SS}$	2.2 to 5.5	-1			
	$I_{IL}(3)$	CF1	$V_{IN}=V_{SS}$	2.2 to 5.5	-15			
High level output voltage	$V_{OH}(1)$	Ports 0, 1, 2 Ports B, C	$I_{OH}=-1mA$	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			
	$V_{OH}(3)$		$I_{OH}=-0.2mA$	2.2 to 5.5	V_{DD}-0.4			
	$V_{OH}(4)$	P71 to P73	$I_{OH}=-0.4mA$	3.0 to 5.5	V_{DD}-0.4			
	$V_{OH}(5)$		$I_{OH}=-0.2mA$	2.2 to 5.5	V_{DD}-0.4			
	$V_{OH}(6)$	PWM2, PWM3	$I_{OH}=-10mA$	4.5 to 5.5	V_{DD}-1.5			
	$V_{OH}(7)$		$I_{OH}=-1.6mA$	3.0 to 5.5	V_{DD}-0.4			
	$V_{OH}(8)$		$I_{OH}=-1mA$	2.2 to 5.5	V_{DD}-0.4			
Low level output voltage	$V_{OL}(1)$	Ports 0, 1, 2 Ports B, C PWM2, PWM3	$I_{OL}=10mA$	4.5 to 5.5			1.5	
	$V_{OL}(2)$		$I_{OL}=1.6mA$	3.0 to 5.5			0.4	
	$V_{OL}(3)$		$I_{OL}=1mA$	2.2 to 5.5			0.4	
	$V_{OL}(4)$	Ports 7, 8 XT2	$I_{OL}=1.6mA$	3.0 to 5.5			0.4	
	$V_{OL}(5)$		$I_{OL}=1mA$	2.2 to 5.5			0.4	
	$V_{OL}(6)$	P00, P01	$I_{OL}=30mA$	4.5 to 5.5			1.5	
	$V_{OL}(7)$		$I_{OL}=5mA$	3.0 to 5.5			0.4	
	$V_{OL}(8)$		$I_{OL}=2.5mA$	2.2 to 5.5			0.4	
Pull-up resistance	$R_{pu}(1)$	Ports 0, 1, 2, 7 Ports B, C	$V_{OH}=0.9V_{DD}$	4.5 to 5.5	15	35	80	kΩ
	$R_{pu}(2)$			2.2 to 5.5	18	50	150	
Hysteresis voltage	VHYS	$\overline{RES}$ Ports 1, 2, 7		2.2 to 5.5		0.1 V_{DD}		V
Pin capacitance	CP	All pins	For pins other than that under test: $V_{IN}=V_{SS}$ f=1MHz Ta=25°C	2.2 to 5.5		10		pF

LC875932A/24A/16A

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. 6.	2.2 to 5.5	2			tCYC
		Low level pulse width	tSCKL(1)				1			
		High level pulse width	tSCKH(1)				1			
			tSCKHA(1)		• Continuous data transmission/reception mode • See Fig. 6. • (Note 4-1-2)		4			
	Output clock	Frequency	tSCK(2)	SCK0(P12)	• CMOS output selected • See Fig. 6.	2.2 to 5.5	4/3			tSCK
		Low level pulse width	tSCKL(2)					1/2		
		High level pulse width	tSCKH(2)					1/2		
			tSCKHA(2)		• Continuous data transmission/reception mode • CMOS output selected • See Fig. 6.		tSCKH(2) +2tCYC		tSCKH(2) +(10/3) tCYC	tCYC
Serial input		Data setup time	tsDI(1)	SI0(P11), SB0(P11)	• Must be specified with respect to rising edge of SIOCLK. • See Fig. 6.	2.2 to 5.5	0.03			μs
		Data hold time	thDI(1)			2.2 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)	2.2 to 5.5			(1/3)tCYC +0.05	
			tdD0(2)		• Synchronous 8-bit mode • (Note 4-1-3)	2.2 to 5.5			1tCYC +0.05	
	Output clock		tdD0(3)		(Note 4-1-3)	2.2 to 5.5			(1/3)tCYC +0.15	

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.

Note 4-1-3: Must be specified with respect to falling edge of SIOCLK. Must be specified as the time to the beginning of output state change in open drain output mode. See Fig. 6.

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

Parameter			Symbol	Pin/Remarks	Conditions	V_{DD} [V]	Specification			unit
							min	typ	max	
Serial clock	Input clock	Frequency	tSCK(3)	SCK1(P15)	See Fig. 6.	2.2 to 5.5	2			tCYC
		Low level pulse width	tSCKL(3)				1			
		High level pulse width	tSCKH(3)				1			
	Output clock	Frequency	tSCK(4)	SCK1(P15)	• CMOS output selected • See Fig. 6.	2.2 to 5.5	2			tSCK
		Low level pulse width	tSCKL(4)					1/2		
		High level pulse width	tSCKH(4)					1/2		
Serial input		Data setup time	tsDI(2)	SI1(P14), SB1(P14)	• Must be specified with respect to rising edge of SIOCLK. • See Fig. 6.	2.2 to 5.5	0.03			µs
		Data hold time	thDI(2)			2.2 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. 6.	2.2 to 5.5			(1/3)tCYC +0.05	

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

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	tPIH(1) tPIL(1)	INT0(P70), INT1(P71), INT2(P72), INT4(P20 to P23), INT5(P24 to P27)	• Interrupt source flag can be set. • Event inputs for timer 0 or 1 are enabled.	2.2 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.	2.2 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.	2.2 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.	2.2 to 5.5	256			
	tPIL(5)	$\overline{RES}$	Resetting is enabled.	2.2 to 5.5	200			µs

AD Converter 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
Resolution	N	AN0(P80) to AN6(P86), 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		AD conversion time=32 × tCYC (when ADCR2=0) (Note 6-2)	4.5 to 5.5	15.68 (tCYC= 0.49µs)		97.92 (tCYC= 3.06µs)	µs
				3.0 to 5.5	23.52 (tCYC= 0.735µs)		97.92 (tCYC= 3.06µs)	
			AD conversion time=64 × tCYC (when ADCR2=1) (Note 6-2)	4.5 to 5.5	18.82 (tCYC= 0.294µs)		97.92 (tCYC= 1.53µs)	
				3.0 to 5.5	47.04 (tCYC= 0.735µs)		97.92 (tCYC= 1.53µs)	
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			

Note 6-1: The quantization error (±1/2LSB) is excluded from the absolute accuracy value.

Note 6-2: The conversion time refers to the interval from the time the instruction for starting the converter is issued till the time the complete digital value corresponding to the analog input value is loaded in the required register.

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 • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal RC oscillation stopped. • 1/1 frequency division ratio	4.5 to 5.5		8	13.5	
	IDDOP(2)			3.0 to 3.6		4.5	8.5	
	IDDOP(3)		• FmCF=8MHz ceramic oscillation mode • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 8MHz side • Internal RC oscillation stopped. • 1/1 frequency division ratio	4.5 to 5.5		5.5	9	
	IDDOP(4)			3.0 to 3.6		2.9	6.8	
	IDDOP(5)			2.5 to 3.0		2.3	5.3	mA
	IDDOP(6)		• FmCF=4MHz ceramic oscillation mode • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 4MHz side • Internal RC oscillation stopped. • 1/2 frequency division ratio	4.5 to 5.5		2	3.2	
	IDDOP(7)			3.0 to 3.6		0.95	2.3	
	IDDOP(8)			2.2 to 3.0		0.66	1.8	
	IDDOP(9)		• FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • System clock set to internal RC oscillation • 1/2 frequency division ratio	4.5 to 5.5		0.55	2.1	
	IDDOP(10)			3.0 to 3.6		0.29	1.3	
	IDDOP(11)			2.2 to 3.0		0.2	0.96	
	IDDOP(12)		• FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal RC oscillation stopped. • 1/2 frequency division ratio	4.5 to 5.5		27	65	
	IDDOP(13)			3.0 to 3.6		11	38	µA
	IDDOP(14)			2.2 to 3.0		7.7	28	
HALT mode consumption current (Note 7-1)	IDDHALT(1)		HALT mode • FmCF=12MHz ceramic oscillation mode • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 12MHz side • Internal RC oscillation stopped. • 1/1 frequency division ratio	4.5 to 5.5		2.7	5.5	
	IDDHALT(2)			3.0 to 3.6		1.4	3	
	IDDHALT(3)		HALT mode • FmCF=8MHz ceramic oscillation mode • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 8MHz side • Internal RC oscillation stopped. • 1/1 frequency division ratio	4.5 to 5.5		2	4.2	
	IDDHALT(4)			3.0 to 3.6		1.0	2.5	mA
	IDDHALT(5)			2.5 to 3.0		0.77	1.9	
	IDDHALT(6)		HALT mode • FmCF=4MHz ceramic oscillation mode • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 4MHz side • Internal RC oscillation stopped. • 1/2 frequency division ratio	4.5 to 5.5		1	2.1	
	IDDHALT(7)			3.0 to 3.6		0.48	1.2	
	IDDHALT(8)			2.2 to 3.0		0.3	0.88	

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

Continued from preceding page.

Parameter	Symbol	Pin/ Remarks	Conditions	Specification				
				V_{DD} [V]	min	typ	max	unit
HALT mode consumption current (Note 7-1)	IDDHALT(9)	$V_{DD}1$ =$V_{DD}2$ =$V_{DD}3$	HALT mode • FmCF=0Hz (oscillation stopped) • FmX'tal=32.768 kHz crystal oscillation mode • System clock set to internal RC oscillation • 1/2 frequency division ratio	4.5 to 5.5		0.28	1	mA
	IDDHALT(10)			3.0 to 3.6		0.17	0.73	
	IDDHALT(11)			2.2 to 3.0		0.12	0.56	
	IDDHALT(12)		HALT mode • FmCF=0Hz (oscillation stopped) • FmX'tal=32.768kHz crystal oscillation mode • System clock set to 32.768kHz side • Internal RC oscillation stopped. • 1/2 frequency division ratio	4.5 to 5.5		19	50	
	IDDHALT(13)			3.0 to 3.6		7.6	26	
	IDDHALT(14)			2.2 to 3.0		4.7	18	
HOLD mode consumption current	IDDHOLD(1)	$V_{DD}1$	HOLD mode • CF1=V_{DD} or open (External clock mode)	4.5 to 5.5		0.07	10	µA
	IDDHOLD(2)			3.0 to 3.6		0.04	8	
	IDDHOLD(3)			2.2 to 3.0		0.03	6	
Timer HOLD mode consumption current	IDDHOLD(4)	$V_{DD}1$	Timer HOLD mode • CF1=V_{DD} or open (External clock mode) • FmX'tal=32.768 kHz crystal oscillation mode	4.5 to 5.5		16	45	
	IDDHOLD(5)			3.0 to 3.6		6.3	22	
	IDDHOLD(6)			2.2 to 3.0		3.8	15	

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

UART (Full Duplex) Operating 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
Transfer rate	UBR	P20, P21		2.2 to 5.5	16/3		8192/3	tCYC

Data length :   7, 8, and 9 bits (LSB first)
Stop bits :   1 bit (2-bit in continuous data transmission)
Parity bits :   None

Example of Continuous 8-bit Data Transmission Mode Processing (first transmit data=55H)
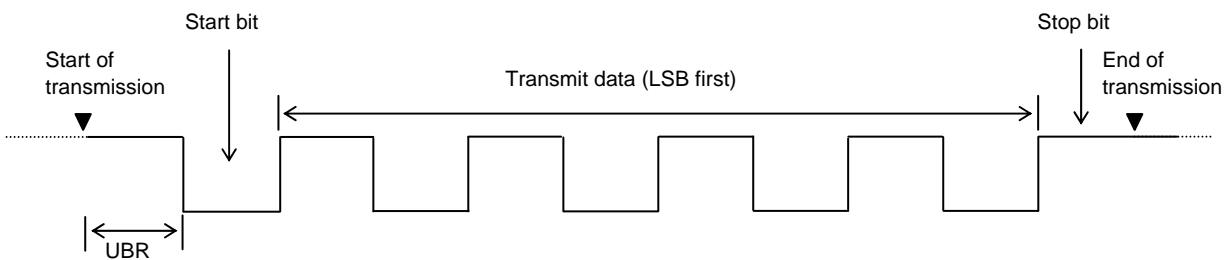
Example of Continuous 8-bit Data Reception Mode Processing (first receive data=55H)
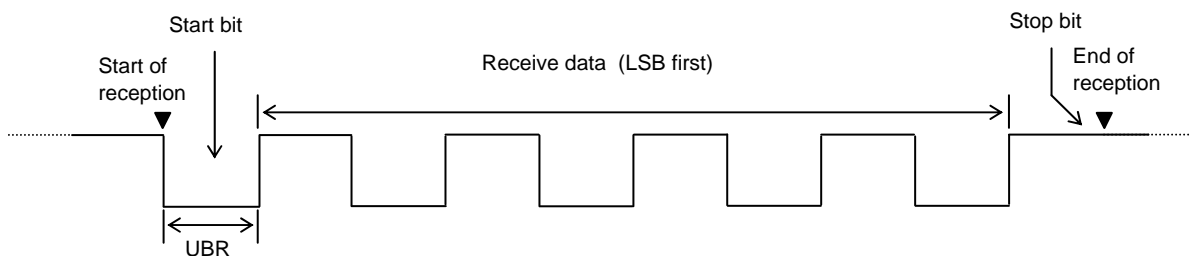
Characteristics of a Sample Main System Clock Oscillation Circuit

Given below are the characteristics of a sample main system clock oscillation circuit that are measured using a SANYO-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

Nominal Frequency	Vendor Name	Oscillator Name	Circuit Constant				Operating Voltage Range [V]	Oscillation Stabilization Time		Remarks
			C1 [pF]	C2 [pF]	Rf1 [Ω]	Rd1 [Ω]		typ [ms]	max [ms]	
12MHz	MURATA	CSTCE12M0G52-R0	(10)	(10)	Open	470	2.8 to 5.5	0.05	0.15	Internal C1, C2
8MHz	MURATA	CSTCE8M00G52-R0	(10)	(10)	Open	2.2k	2.7 to 5.5	0.05	0.15	Internal C1, C2
		CSTLS8M00G53-B0	(15)	(15)	Open	680	2.5 to 5.5	0.05	0.15	
4MHz	MURATA	CSTCR4M00G53-R0	(15)	(15)	Open	3.3k	2.2 to 5.5	0.05	0.15	Internal C1, C2
		CSTLS4M00G53-B0	(15)	(15)	Open	3.3k	2.2 to 5.5	0.05	0.15	

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

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 SANYO-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]	Rf2 [Ω]	Rd2 [Ω]		typ [s]	max [s]	
32.768kHz	SEIKO EPSON	MC-306	18	18	Open	560k	2.2 to 5.5	1.3	3.0	Applicable CL value =12.5pF

The oscillation stabilization time refers to the time interval that is required for the oscillation to get stabilized after the instruction for starting the subclock oscillation circuit is executed and to the time interval that is required for the oscillation to get stabilized after the HOLD mode is reset (see Figure 4).

Note : The components that are involved in oscillation should be placed as close to the IC and to one another as possible because they are vulnerable to the influences of the circuit pattern.
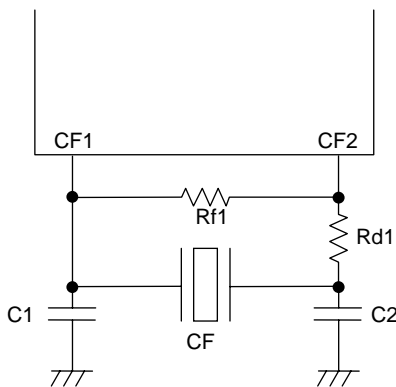
Figure 1 CF Oscillator Circuit
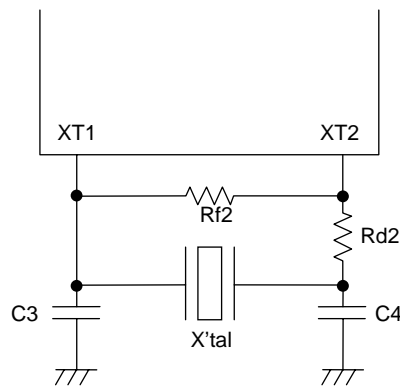
Figure 2 XT Oscillator Circuit
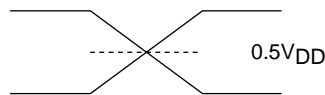
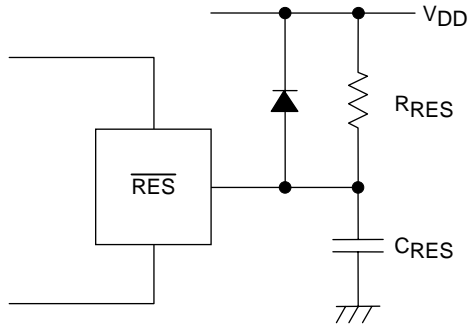Figure 3 AC Timing Measurement Point
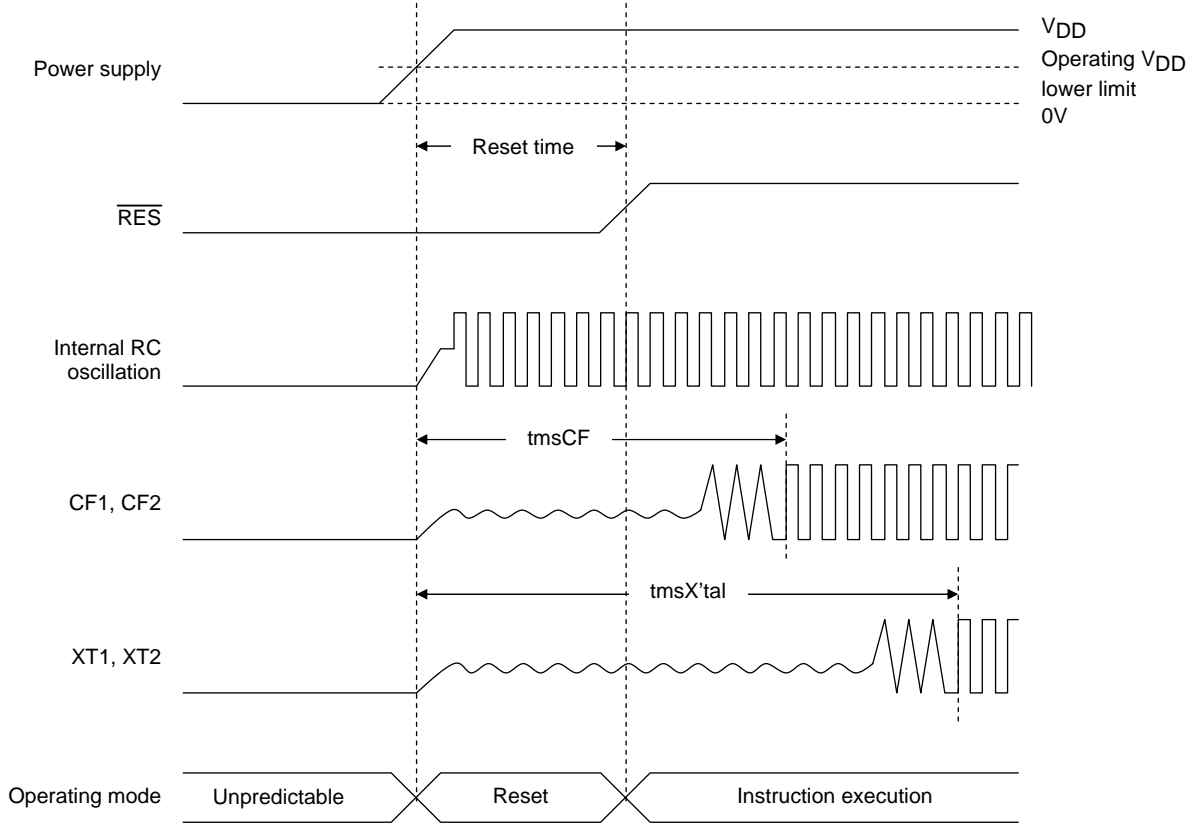
Reset Time and Oscillation Stabilization Time
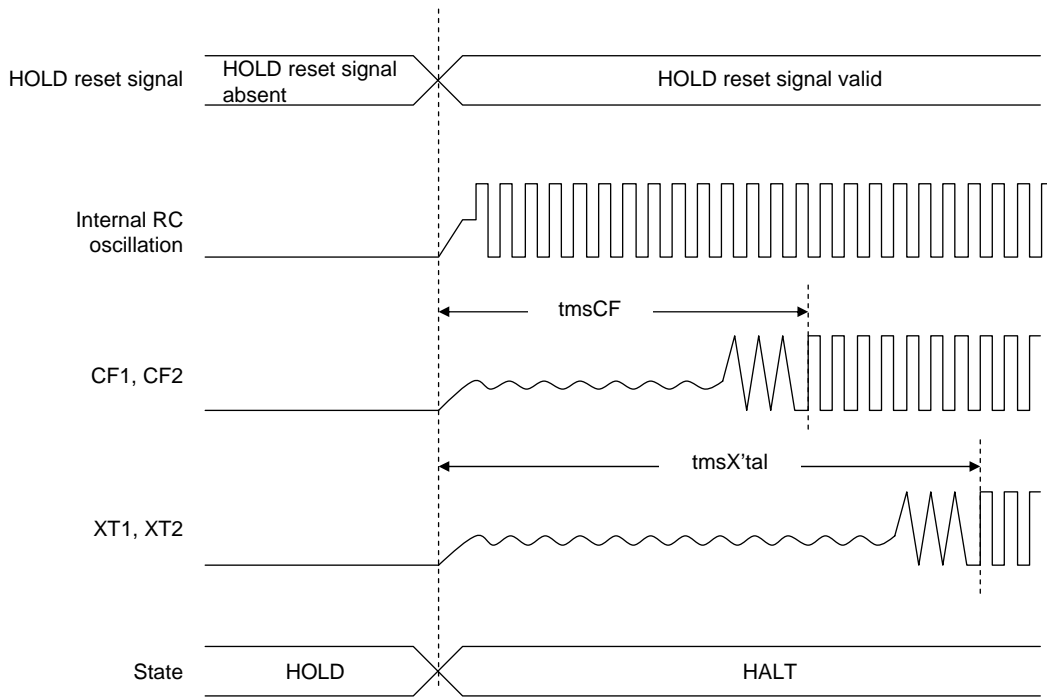
HOLD Reset Signal and Oscillation Stabilization Time

Figure 4 Oscillation Stabilization Times

Note :
Determine the value of C_{RES} and R_{RES} so that the reset signal is present for a period of 200μs after the supply voltage goes beyond the lower limit of the IC's operating voltage.
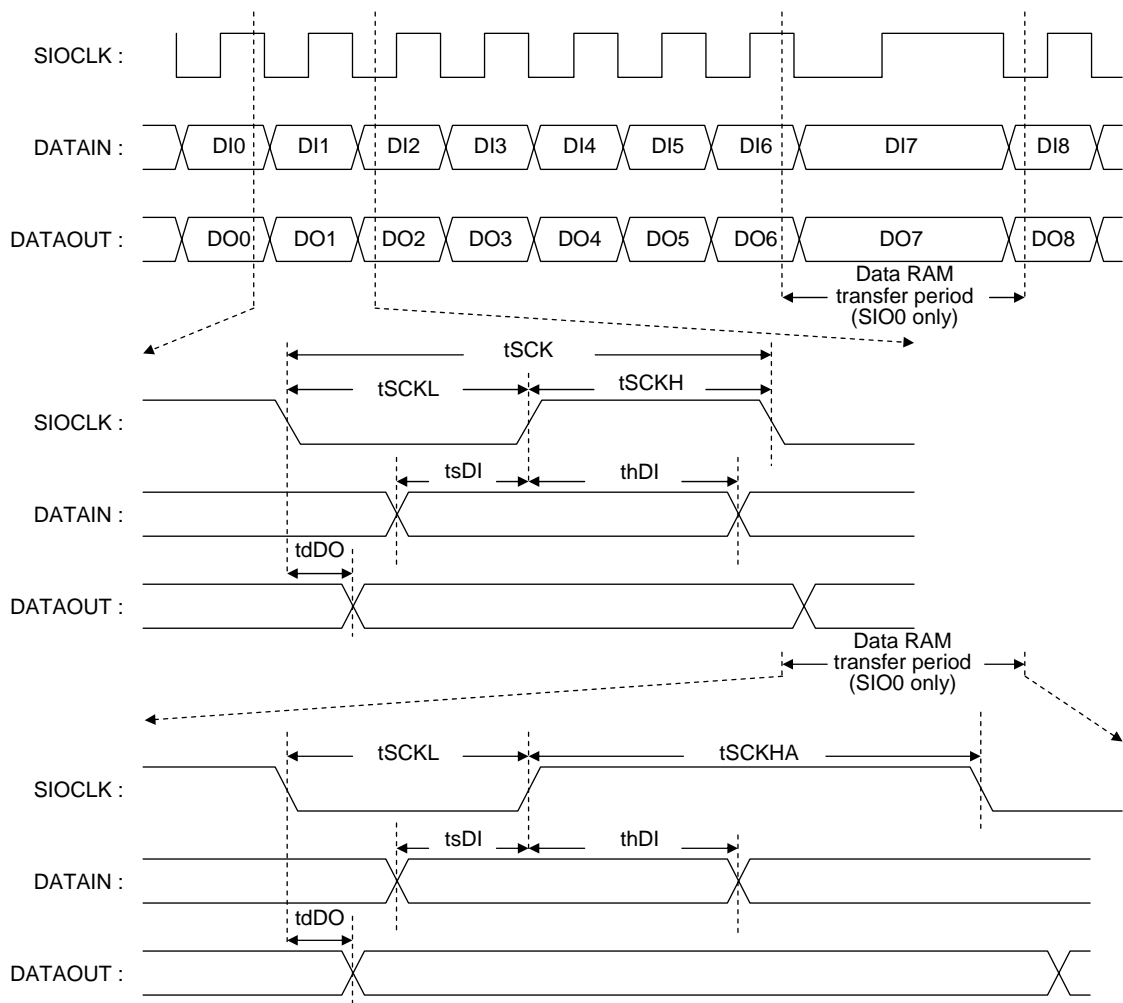
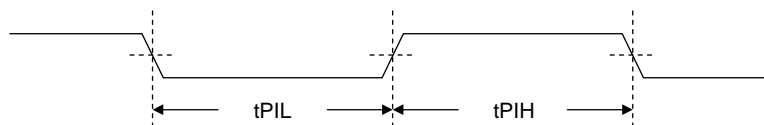Figure 5 Reset Circuit

Figure 6 Serial I/O Output Waveforms

Figure 7 Pulse Input Timing Signal Waveform