

<b>SANYO</b>	No.4958	<b>LC651104N/F/L, 651102N/F/L</b>
		<b>Single-Chip 4-Bit Microcomputer For Small-Scale Control-Oriented Applications</b>

The LC651104N/F/L, LC651102N/F/L belong to our single-chip 4-bit microcomputer LC6500 series fabricated using CMOS process technology and are suited for use in small-scale control-oriented applications. Their basic architecture and instruction set are the same. The LC651104 and LC651102 comprise an eight-channel, 8-bit A/D converter. Application areas include audio equipment (tape deck, player, etc.), office equipment, communications equipment, car equipment, home appliances as well as circuits so far formed with the standard logic circuits and applications where the number of controls is small.

#### Features

- 1) CMOS technology for a low-power operation (with instruction-controlled standby function)
- 2) ROM/RAM
  - LC651104N/F/L ROM : 4K x 8bits, RAM : 256x 4bits
  - LC651102N/F/L ROM : 2K x 8bits, RAM : 256x 4bits
- 3) Instruction set : 80 instructions common to the LC6500 series
- 4) Wide operating voltage range from 2.5V to 6.0V (L version)
- 5) Instruction cycle time of 0.92 $\mu$ s (F version)
- 6) On-chip serial I/O port
- 7) Flexible I/O port
  - Number of ports : 6 ports/22 pins
  - All ports : Input/output common
    - Input/output voltage 15V max. (C,D,E,F at open drain)
    - Output current 20mA max. (sink current) (LED direct drivable)
  - Option selectable for your intended system
    - A. Open drain output, pull-up resistor : Single-bit select for all ports
    - B. Output level at the reset mode : 4-bit select of H/L level for port C/D
- 8) Interrupt function
  - Vectored interrupt by timer overflow (instruction-testable)
  - Vectored interrupt by  $\overline{\text{INT}}$  pin or completion of transmit/receive at serial I/O port (instruction-testable)
- 9) Stack level : 8 levels (common with interrupt)
- 10) Timer : 4-bit prescaler + 8-bit programmable timer
- 11) Clock oscillation option selectable for your intended system
  - Oscillator option : 2-pin RC oscillation (N, L version)
    - 2-pin ceramic resonator oscillation (N,F,L version)
  - Predivider option : No predivider, 1/3 predivider, 1/4 predivider (N, L version)
- 12) Burst pulse (64 x cycle time) output function

- 13) A/D converter (sequential comparison type)
  - 8-bit Accuracy x 8 channels
- 14) Watchdog timer
  - External RC type
  - The external pin can be assigned the watchdog reset function by option.

Function Table

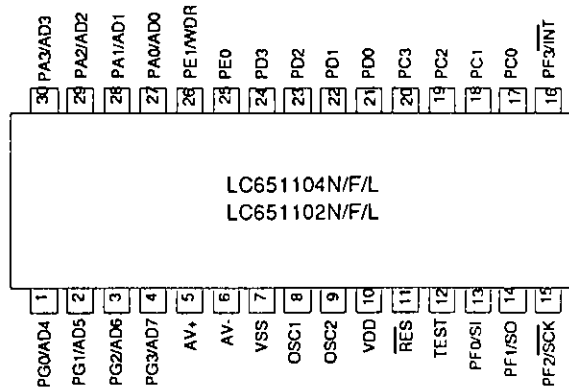
Item		LC651104N/1102N	LC651104F/1102F	LC651104L/1102L
Memory	ROM	4096 x 8 bits (1104N) 2048 x 8 bits (1102N)	4096 x 8 bits (1104F) 2048 x 8 bits (1102F)	4096 x 8 bits (1104L) 2048 x 8 bits (1102L)
	RAM	256 x 4 bits (1104N) 256 x 4 bits (1102N)	256 x 4 bits (1104F) 256 x 4 bits (1102F)	256 x 4 bits (1104L) 256 x 4 bits (1102L)
Instruction	Instruction set	80	80	80
	Table read	With	With	With
On-chip function	Interrupt	External 1, Internal 1	External 1, Internal 1	External 1, Internal 1
	Timer	4bit-prescaler + 8-bit timer	4bit-prescaler + 8-bit timer	4bit-prescaler + 8-bit timer
	Stack level	8	8	8
	Standby function	Standby available by HALT instruction	Standby available by HALT instruction	Standby available by HALT instruction
Input/output port	Number of ports	I/O 22	I/O 22	I/O 22
	Serial port	4/8-bit I/O	4/8-bit I/O	4/8-bit I/O
	I/O voltage	15V max.	15V max.	15V max.
	Output current	10mA typ. 20mA max.	10mA typ. 20mA max.	10mA typ. 20mA max.
	I/O circuit configuration	Open drain (N channel) or pull-up resistor-provided output selectable bit by bit.		
	Output level at reset mode	"H" or "L" level selectable port by port (port C, D only)		
	Burst pulse output	Available	Available	Available
Characteristic	Minimum cycle time	2.77μs (VDD≥3V)	0.92μs (VDD≥4V)	3.84μs (VDD≥2.5V)
	Supply voltage	3 to 6V	4 to 6V	2.5 to 6V
	Current dissipation	1.5mA typ.	2mA typ.	1.5mA typ.
Oscillation	Resonator	RC (900kHz typ.) ceramic (400k, 800k, 1MHz, 4MHz)	ceramic 4MHz	RC (400kHz typ.) ceramic (400k, 800k, 1MHz, 4MHz)
	predivider option	1/1, 1/3, 1/4	1/1	1/1, 1/3, 1/4
Other	Package	DIP30S-D, MFP30S	DIP30S-D, MFP30S	DIP30S-D, MFP30S

(Note) Information on the resonator and oscillation circuit constants will be presented as soon as the recommended circuit is determined.

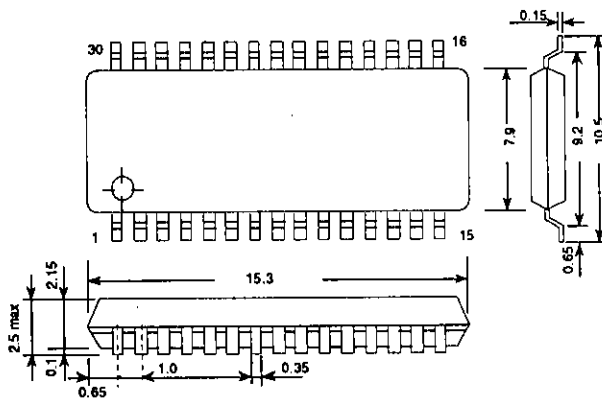
LC651104N/F/L, 651102N/F/L

Pin Assignment

Common to DIP • MFP

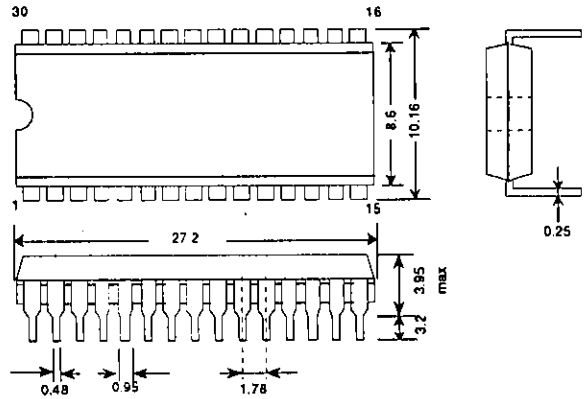


Case Outline 3073A (unit : mm)



SANYO : MFP30S

3061 (unit : mm)



SANYO : DIP30S-D

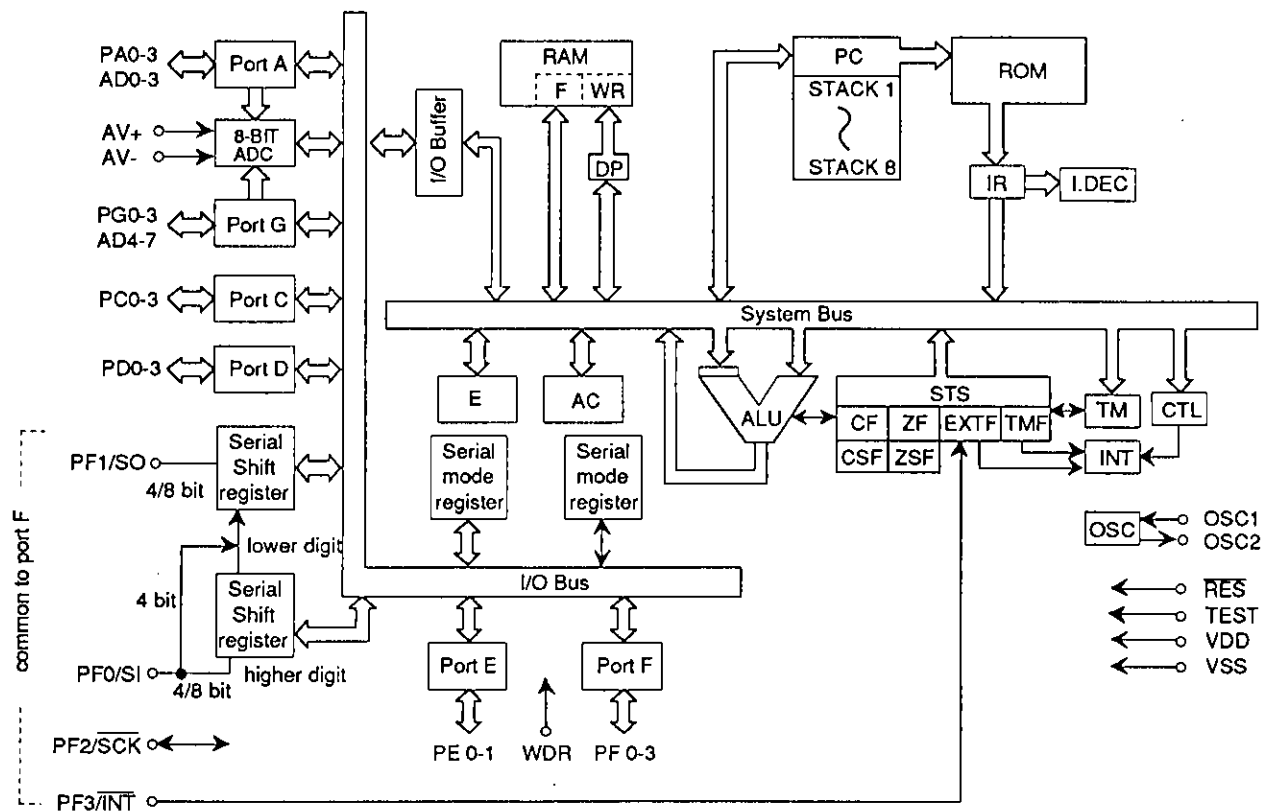
(Note) The package is the reference figure without the description of the rank. Please inquire us for the formal package.

**Pin Name**

OSC1, OSC2	: C, R or ceramic resonator for OSC	TEST	: Test
RES	: Reset	INT	: Interrupt request pin
PA 0-3	: Input/output common port A 0-3	SI	: Serial input pin
PC 0-3	: Input/output common port C 0-3	SO	: Serial output pin
PD 0-3	: Input/output common port D 0-3	SCK	: Serial clock input/output pin
PE 0-1	: Input/output common port E 0-1	AD 0-7	: AD converter input pin
PF 0-3	: Input/output common port F 0-3	AV+,AV-	: AD converter reference voltage input
PG 0-3	: Input/output common port G 0-3	WDR	: Watchdog reset pin
(Note)	• The SI, SO, SCK, and INT pins are common to the PF0 to PF3 pins respectively.		

**System Block Diagram**

LC651104N/F/L, LC651102N/F/L



RAM	: Data memory	ROM	: Program memory
F	: Flag	PC	: Program counter
WR	: Working register	INT	: Interrupt control
AC	: Accumulator	IR	: Instruction register
ALU	: Arithmetic and logic unit	I.DEC	: Instruction decoder
DP	: Data pointer	CF,CSF	: Carry flag, carry save flag
E	: E register	ZF, ZSF	: Zero flag, zero save flag
CTL	: Control register	EXT F	: External interrupt request flag
OSC	: Oscillator	TMF	: Internal interrupt request flag
TM	: Timer		
STS	: Status register		

**Development Support Tools**

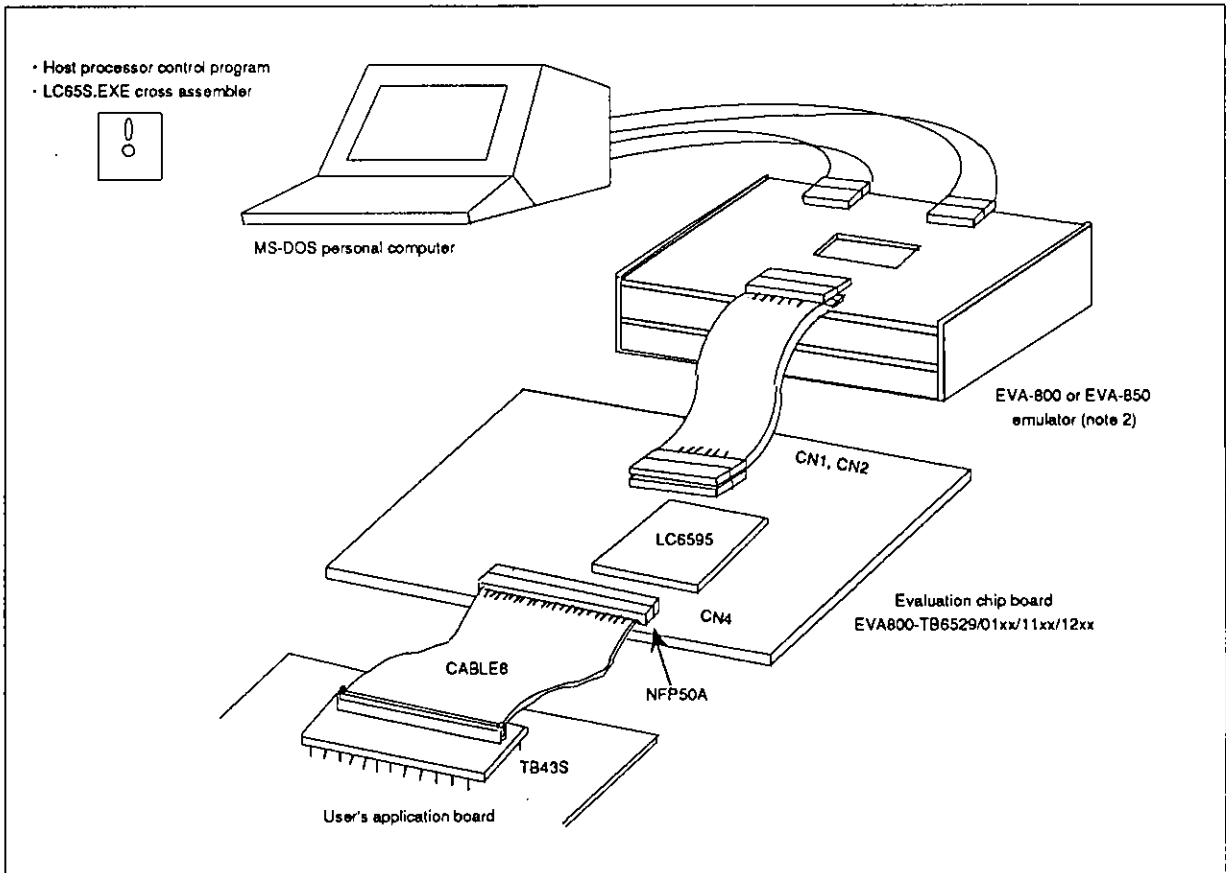
The following are available to support the program development for the LC651104, LC651102.

- (1) User's Manual  
"LC651104/1102 User's Manual"
- (2) Development Tool Manual  
For the EVA-800 system, refer to "EVA-800, LC651104/1102 Development Tool Manual".
- (3) Development Tools

- a. For program development (EVA-800 system)
  - 1. MS-DOS for host system (Note 1)
  - 2. Cross assembler.....MS-DOS base cross assembler : <LC65S. EXE>
  - 3. Evaluation chip : LC6595
  - 4. Emulator : EVA-800 emulator and evaluation boards
- b. For program development (EVA-86000 system) under development
- c. For program evaluation During development EPROM built-in microcomputer (LC65E1104)

**Appearance of Development Support System**

**EVA-800 System**



(Note 1) MS-DOS : Trademark of Microsoft Corporation

(Note 2) The EVA-800 is a general term for emulator. A suffix (A, B,...) is added at the end of EVA-800 as the EVA-800 is improved to be a newer version. Do not use the EVA-800 with no suffix added.

## Pin Description

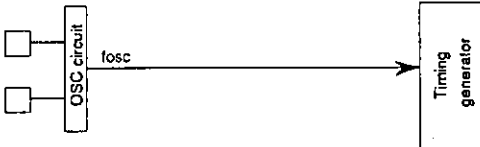
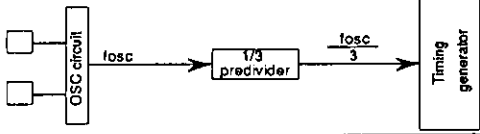
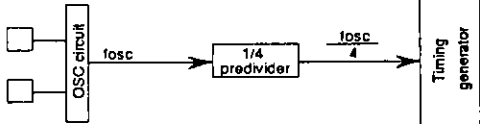
Pin Name	Pins	I/O	Function	Option	Reset Mode	Unused Pin Handling
VDD VSS	1 1	— —	Power supply	—	—	—
OSC1 OSC2	1 1	Input Output	<ul style="list-style-type: none"> <li>Pin for externally connecting RC, ceramic resonator for system clock generation.</li> <li>If external clock input is used, leave the OSC2 pin open.</li> </ul>	1) 2-pin RC OSC 2) 2-pin ceramic resonator OSC 3) Predivider option 1. No predivider 2. 1/3 predivider 3. 1/4 predivider	—	—
PA 0 to PA 3 /AD0 to AD3	4	Input/ output	<ul style="list-style-type: none"> <li>I/O port A0 to 3</li> <li>4-bit input (IP instruction)</li> <li>4-bit output (OP instruction)</li> <li>Single-bit decision (BP, BNP instruction)</li> <li>Single-bit set/reset (SPB, RPB instruction)</li> <li>Standby is controlled by PA3</li> <li>The PA3 pin must be free from chattering during the HALT instruction execution cycle.</li> <li>All these four port pins can be used for two purposes</li> </ul> <div style="border: 1px solid black; padding: 2px; margin-top: 5px;">           PA0/AD0 : AD converter input pin AD0            PA1/AD1 : AD converter input pin AD1            PA2/AD2 : AD converter input pin AD2            PA3/AD3 : AD converter input pin AD3         </div>	1) Open drain type output 2) With pull-up resistor 1), 2) : Specified bit by bit	<ul style="list-style-type: none"> <li>"H" output (Out-put Nch transistor : OFF)</li> </ul>	Should be set to the open drain output type and then connected to the VSS pin.
PC 0 to PC 3	4	Input/ output	<ul style="list-style-type: none"> <li>I/O port C0 to 3</li> <li>Same as for PA0 to 3 (Note)</li> <li>Option permits output at the reset mode to be "H" or "L".</li> <li>(Note) No standby control function is provided.</li> </ul>	1) Open drain type output 2) With pull-up resistor 3) Output at reset mode:"H" 4) Output at reset mode:"L" • 1), 2): Specified bit by bit • 3), 4): Specified in a group of 4 bits	<ul style="list-style-type: none"> <li>"H" output</li> <li>"L" output (Option - selectable)</li> </ul>	Same as for PA0 to 3
PD 0 to PD 3	4	Input/ output	<ul style="list-style-type: none"> <li>I/O port D0 to 3</li> <li>Same as for PC0 to 3</li> </ul>	Same as for PC0 to 3	Same as for PC0 to 3	Same as for PA0 to 3
PE 0 to PE 1/WDR	2	Input/ output	<ul style="list-style-type: none"> <li>I/O port E0 to 1</li> <li>4-bit input (IP instruction)</li> <li>4-bit output (OP instruction)</li> <li>Single-bit set/reset (SPB, RPB instruction)</li> <li>Single-bit decision (BP, BNP instruction)</li> <li>PE0 : With burst pulse (64Tcyc) output function</li> <li>PE1 pin can be switched WDR.</li> </ul>	1) Open drain type output 2) With pull-up resistor 1), 2) : Specified bit by bit 3) Normal port PE1 4) Watchdog reset :WDR 3), 4) : can be specified	<ul style="list-style-type: none"> <li>"H" output (Out- put Nch transistor : OFF)</li> </ul>	Same as for PA0 to 3

Pin Name	Pins	I/O	Function	Option	Reset Mode	Unused Pin Handling
PF 0 / SI PF 1 / SO PF 2 / $\overline{\text{SCK}}$ PF 3 / $\overline{\text{INT}}$	4	Input/output	<ul style="list-style-type: none"> <li>I/O port F0 to 3</li> <li>Same as for PE0 to 1 (Note)</li> <li>PF0 to 3 : Common with serial interface, <math>\overline{\text{INT}}</math> input.</li> </ul> Program-selectable SI •••• Serial input port SO ••• Serial output port $\overline{\text{SCK}}$ •• Serial clock input/output $\overline{\text{INT}}$ ••• Interrupt request input 4-bit/8-bit serial input/output is program-selectable. (Note) No burst pulse output function is provided.	Same as for PA0 to 3	Same as for PA0 to 3 Serial port : Disable Interrupt source: $\overline{\text{INT}}$	Same as for PA0 to 3
PG 0 to PG 3 / AD4 to AD7	4	Input/output	<ul style="list-style-type: none"> <li>I/O port G0 to 3</li> <li>Same as for PE0 to 1 (Note)</li> <li>(Note) No burst pulse output function is provided.</li> <li>All these four pins can be used for two purposes</li> </ul> <div style="border: 1px solid black; padding: 2px; width: fit-content;">                     PG0/AD4 : AD converter input pin AD4                      PG1/AD5 : AD converter input pin AD5                      PG2/AD6 : AD converter input pin AD6                      PG3/AD7 : AD converter input pin AD7                 </div>	Same as for PA0 to 3	Same as for PA0 to 3	Same as for PA0 to 3
AV+	1	—	<ul style="list-style-type: none"> <li>Reference voltage input pin for A/D conversion.</li> </ul>	—	—	Always connected to the VSS pin.
AV-	1	—				
RES	1	Input	<ul style="list-style-type: none"> <li>System reset input</li> <li>For power-up reset, C is connected externally.</li> <li>For reset restart, "L" level is applied for 4 clock cycles or more.</li> </ul>	—	—	—
TEST	1	Input	<ul style="list-style-type: none"> <li>LSI test pin</li> <li>Normally connected to VSS</li> </ul>	—	—	Always connected to the VSS pin.

Oscillator circuit option

Option Name	Circuit	Conditions, etc.
1. External clock		Leave the OSC2 pin open.
2. 2-pin RC OSC		
3. Ceramic resonator OSC		

**Predivider Option**

Option Name	Circuit	Conditions, etc.
1. No predivider (1/1)		<ul style="list-style-type: none"> <li>• Applicable to all of 3 OSC options.</li> <li>• The OSC frequency, external clock do not exceed 1444kHz. (LC651104N, 651102N)</li> <li>• The OSC frequency, external clock do not exceed 4330kHz. (LC651104F, 651102F)</li> <li>• The OSC frequency, external clock do not exceed 1040kHz. (LC651104L, 651102L)</li> </ul>
2. 1/3 predivider		<ul style="list-style-type: none"> <li>• Applicable to only 2 OSC options of external clock, ceramic resonator OSC.</li> <li>• The OSC frequency, external clock do not exceed 4330kHz.</li> </ul>
3. 1/4 predivider		<ul style="list-style-type: none"> <li>• Applicable to only 2 OSC options of external clock, ceramic resonator OSC.</li> <li>• The OSC frequency, external clock do not exceed 4330kHz.</li> </ul>

Note : The OSC option and predivider option are summarized below. Full care must be exercised.

Table of OSC, predivider Option of LC651104N/1102N, 1104F/1102F and 1104L/1102L

**LC651104N, LC651102N**

Circuit Configuration	Frequency	Predivider Option (Cycle Time)	VDD Range	Remarks
Ceramic resonator OSC	400kHz	1/1 (10 μs)	3 to 6V	Unusable with 1/3, 1/4 predivider
	800kHz	1/1 (5 μs)	3 to 6V	
		1/3 (15 μs)	3 to 6V	
		1/4 (20 μs)	3 to 6V	
1MHz	1/1 (4 μs)	3 to 6V		
	1/3 (12 μs)	3 to 6V		
	1/4 (16 μs)	3 to 6V		
4MHz	1/3 (3 μs)	3 to 6V		Unusable with 1/1 predivider
	1/4 (4 μs)	3 to 6V		
External clock by 2-pin RC OSC circuit	200k to 1444kHz	1/1 (20 to 2.77μs)	3 to 6V	
	600k to 4330kHz	1/3 (20 to 2.77μs)	3 to 6V	
	800k to 4330kHz	1/4 (20 to 3.70μs)	3 to 6V	
2-pin RC	Used with 1/1predivider, recommended constants. If used with other than recommended constants, the frequency, VDD range must be the same as for external clock.		3 to 6V	
External clock input to the ceramic oscillation circuit	The ceramic oscillation circuit cannot be driven by external clock. To drive the circuit with external clock, select the 2-pin RC option.			

**LC651104F, LC651102F**

Circuit Configuration	Frequency	Predivider Option (Cycle Time)	VDD Range	Remarks
Ceramic resonator OSC	4MHz	1/1 (1μs)	4 to 6V	
External clock by 2-pin RC OSC circuit	200k to 4330kHz	1/1 (20 to 0.92μs)	4 to 6V	
External clock input to the ceramic oscillation circuit	The ceramic oscillation circuit cannot be driven by external clock. To drive the circuit with external clock, select the 2-pin RC option.			



LC651104L, LC651102L

Circuit Configuration	Frequency	Predivider Option (Cycle Time)	VDD Range	Remarks
Ceramic resonator OSC	400kHz	1/1 (10 $\mu$ s)	2.5 to 6V	Unusable with 1/3, 1/4 predivider
	800kHz	1/1 (5 $\mu$ s)	2.5 to 6V	
		1/3 (15 $\mu$ s)	2.5 to 6V	
		1/4 (20 $\mu$ s)	2.5 to 6V	
1MHz	1/1 (4 $\mu$ s)	2.5 to 6V		
	1/3 (12 $\mu$ s)	2.5 to 6V		
	1/4 (16 $\mu$ s)	2.5 to 6V		
4MHz	1/4 (4 $\mu$ s)	2.5 to 6V	Unusable with 1/1, 1/3 predivider	
External clock by 2-pin RC OSC circuit	200k to 1040kHz	1/1 (20 to 3.84 $\mu$ s)	2.5 to 6V	
	600k to 3120kHz	1/3 (20 to 3.84 $\mu$ s)	2.5 to 6V	
	800k to 4160kHz	1/4 (20 to 3.84 $\mu$ s)	2.5 to 6V	
2-pin RC	Used with 1/1 predivider, recommended constants. If used with other than recommended constants, the frequency, VDD range must be the same as for external clock.		2.5 to 6V	
External clock input to the ceramic oscillation circuit	The ceramic oscillation circuit cannot be driven by external clock. To drive the circuit with external clock, select the 2-pin RC option.			

Option of ports C, D Output Level at the Reset Mode

For input/output common ports C, D either of the following two output levels may be selected in a group of 4 bits during reset by option.

Option Name	Conditions, etc.
1. Output at the reset mode : "H" level	All of 4 bits of ports C, D
2. Output at the reset mode : "L" level	All of 4 bits of ports C, D

Option of Port Output Configuration

For each input/output common port, either of the following two output configurations may be selected by option .

Option Name	Circuit	Applied ports
1. Open drain output		• Ports A, C, D, E, F and G
2. Output with pull-up resistor		

Watchdog reset option

This option can select the uses of PE1/WDR terminal. One is the normal port PE1, the other is the watchdog reset terminal WDR.

**LC651104N, 651102N**

**1. Absolute Maximum Ratings at Ta=25°C, VSS=0V**

Parameter	Symbol	Conditions	Pins	Limits	unit
Maximum supply voltage	VDD max		VDD	-0.3 to +7.0	V
Output voltage	VO		OSC2	Allowable up to voltage generated	V
Input voltage	VI(1)		OSC1 (*1)	-0.3 to VDD+0.3	V
	VI(2)		TEST, RES, AV+, AV-	-0.3 to VDD+0.3	V
Input/output voltage	VIO(1)	Port of OD type	PC0 - 3, PD0 - 3	-0.3 to +15	V
	VIO(2)	Port of PU type	PE0,1, PF0 - 3	-0.3 to VDD+0.3	V
	VIO(3)		PA0 - 3, PG0 - 3	-0.3 to VDD+0.3	V
Peak output current	IOP		I/O port	-2 to +20	mA
Average output current	IOA	Per pin over the period of 100 ms	I/O Port	-2 to +20	mA
	ΣIOA(1)	Total current of PC0 to 3, PD0 to 3, PE0 to 1 (*2)	PC0 to 3 PD0 to 3 PE0 to 1	-15 to +100	mA
	ΣIOA(2)	Total current of PF0 to 3, PG0 to 3, PA0 to 3 (*2)	PF0 to 3 PG0 to 3 PA0 to 3	-15 to +100	mA
Allowable power dissipation	Pd max(1)	Ta=-40 to +85°C (DIP package)		250	mW
	Pd max(2)	Ta=-40 to +85°C (MFP package)		150	mW
Operating temperature	Topg			-40 to +85	°C
Storage temperature	Tstg			-55 to +125	°C

**2. Allowable Operating Conditions at Ta=-40 to +85°C, VSS=0V, VDD=3.0 to 6.0V**

Parameter	Symbol	Conditions	VDD [V]	Pins	Limits			unit
					min.	typ.	max.	
Operating supply voltage	VDD			VDD	3.0		6.0	V
Standby supply voltage	VST	RAM, register hold (*3)		VDD	1.8		6.0	V
"H"-level input voltage	VIH(1)	Output Nch Tr.OFF		Port C, D, E, F of OD type	0.7VDD		+13.5	V
	VIH(2)	Output Nch Tr.OFF		Port C, D, E, F of PU type	0.7VDD		VDD	V
	VIH(3)	Output Nch Tr.OFF		Port A, G	0.7VDD		VDD	V
	VIH(4)	Output Nch Tr.OFF		INT, SCK, SI of OD type	0.8VDD		+13.5	V
	VIH(5)	Output Nch Tr.OFF		INT, SCK, SI of PU type	0.8VDD		VDD	V
	VIH(6)		VDD=1.8 to 6	RES	0.8VDD		VDD	V
	VIH(7)	External clock mode		OSC1	0.8VDD		VDD	V
"L"-level input voltage	VIL(1)	Output Nch Tr.OFF	VDD=4 to 6	Port	VSS		0.3VDD	V
	VIL(2)	Output Nch Tr.OFF	3 to 6	Port	VSS		0.25VDD	V

Parameter	Symbol	Conditions	VDD [V]	Pins	Limits			
					min.	typ.	max.	unit
"L"-level input voltage	VIL(3)	Output Nch Tr.OFF	VDD=4 to 6	$\overline{INT}$ , $\overline{SCK}$ , SI	VSS		0.25VDD	V
	VIL(4)	Output Nch Tr.OFF	3 to 6	$\overline{INT}$ , $\overline{SCK}$ , SI	VSS		0.2VDD	V
	VIL(5)	External clock mode	VDD=4 to 6	OSC1	VSS		0.25VDD	V
	VIL(6)	External clock mode	3 to 6	OSC1	VSS		0.2VDD	V
	VIL(7)		VDD=4 to 6	TEST	VSS		0.3VDD	V
	VIL(8)		3 to 6	TEST	VSS		0.25VDD	V
	VIL(9)		VDD=4 to 6	$\overline{RES}$	VSS		0.25VDD	V
	VIL(10)		3 to 6	$\overline{RES}$	VSS		0.2VDD	V
Operating frequency (cycle time)	fop (Tcyc)	When the 1/3 or 1/4 predivider option is selected, clock must not exceed 4.33MHz.	VDD=3 to 6		200 (20)		1444 (2.77)	kHz ( $\mu$ s)
External clock conditions	text	Fig.1. When clock exceeds 1.444	VDD=3 to 6	OSC1	200		4330	kHz
Pulse width	textH, textL	MHz, the 1/3 or 1/4 predivider	VDD=3 to 6	OSC1	69			ns
Rise/Fall time	textR, textF	option is selected.	VDD=3 to 6	OSC1			50	ns
Oscillation guaranty constants 2-pin RC oscillation	Cext	Fig.2	VDD=3 to 6	OSC1, OSC2		270 $\pm$ 5%		pF
	Cext	Fig.2	VDD=4 to 6	OSC1, OSC2		270 $\pm$ 5%		pF
	Rext	Fig.2	VDD=3 to 6	OSC1, OSC2		12 $\pm$ 1%		k $\Omega$
	Rext	Fig.2	VDD=4 to 6	OSC1, OSC2		4.7 $\pm$ 1%		k $\Omega$
Ceramic		Fig.3				Table 1		

3. Electrical Characteristics at Ta=-40 to +85°C, VSS=0V, VDD=3.0V to 6.0V

Parameter	Symbol	Conditions	Pins	Limits			
				min.	typ.	max.	unit
"H"-level input current	I <sub>IH</sub> (1)	Output Nch Tr. OFF (including OFF leak current of Nch Tr.) VIN=+13.5V	Port C, D, E, F of OD type			+5.0	$\mu$ A
	I <sub>IH</sub> (2)	Output Nch Tr. OFF (including OFF leak current of Nch Tr.) VIN=VDD	Port A, G of OD type			+1.0	$\mu$ A
	I <sub>IH</sub> (3)	External clock mode, VIN=VDD	OSC1			+1.0	$\mu$ A
"L"-level input current	I <sub>IL</sub> (1)	Output Nch Tr. OFF VIN=VSS	Port of OD type	-1.0			$\mu$ A
	I <sub>IL</sub> (2)	Output Nch Tr. OFF VIN=VSS	Port of PU type	-1.3	-0.35		mA
	I <sub>IL</sub> (3)	VIN=VSS	$\overline{RES}$	-45	-10		$\mu$ A
	I <sub>IL</sub> (4)	External clock mode, VIN=VSS	OSC1	-1.0			$\mu$ A

Parameter		Symbol	Conditions	Pins	Limits			
					min.	typ.	max.	unit
"H"-level output voltage	VOH(1)		IOH=-50 $\mu$ A VDD=4.0 to 6.0V	Port of PU type	VDD-1.2			V
	VOH(2)		IOH=-10 $\mu$ A VDD=3.0 to 6.0V	Port of PU type	VDD-0.5			V
"L"-level output voltage	VOL(1)		IOL=10mA, VDD=4.0 to 6.0V	Port			1.5	V
	VOL(2)		IOL=1mA, IOL of each port: 1mA or less VDD=3.0 to 6.0V	Port			0.5	V
Schmitt characteristics	Hysteresis voltage	VHIS		$\overline{\text{RES}}, \overline{\text{INT}}, \overline{\text{SCK}},$ $\text{SI}, \text{OSC1}$ of schmitt type(*4)		0.1VDD		V
	'H' level threshold voltage	VtH			0.4VDD		0.8VDD	V
	'L' level threshold voltage	VtL			0.2VDD		0.6VDD	V
Current dissipation 2-pin RC oscillation	IDDOP(1)		Output Nch Tr. OFF at operating, Port=VDD Fig.2 fosc=900kHz (TYP)	VDD		1.5	4	mA
Ceramic resonator oscillation	IDDOP(2)		Fig.3 4MHz, 1/3 predivider	VDD		1.5	5	mA
	IDDOP(3)		Fig.3 4MHz, 1/4 predivider	VDD		1.5	4	mA
External clock	IDDOP(4)		Fig.3 400kHz	VDD		1.0	2.5	mA
	IDDOP(5)		Fig.3 800kHz	VDD		1.5	4	mA
	IDDOP(6)		200kHz to 1444kHz, 1/1 predivider 600kHz to 4330kHz, 1/3 predivider 800kHz to 4330kHz, 1/4 predivider	VDD		1.5	5	mA
Standby mode	IDDst		Output Nch Tr.OFF VDD=6V Port=VDD VDD=3V	VDD VDD	0.05 0.025	10 5	$\mu$ A $\mu$ A	
Oscillation characteristics Ceramic OSC Frequency	fCFOSC (*5)		Fig.3 fo=400kHz Fig.3 fo=800kHz Fig.3 fo=1MHz Fig.3 fo=4MHz,1/3 predivider 1/4 predivider	OSC1, OSC2 OSC1, OSC2 OSC1, OSC2 OSC1, OSC2	384 768 960 3840	400 800 1000 4000	416 832 1040 4160	kHz kHz kHz kHz
Stable time	tCFS		Fig.4 fo=400kHz Fig.4 fo=800kHz,1MHz,4MHz, 1/3 predivider,1/4 predivider				10 10	ms ms

Parameter	Symbol	Conditions	Pins	Limits				
				min.	typ.	max.	unit	
Oscillation characteristics 2-pin RC oscillation Frequency	fMOSC	Fig.2 Cext=270PF±5% Fig.2 Rext=4.7kΩ±1% VDD=4 to 6V	OSC1, OSC2	634	900	1278	kHz	
		Fig.2 Cext=270PF±5% Fig.2 Rext=12kΩ±1% VDD=3 to 6V	OSC1, OSC2	276	400	742		
Pull-up resistance I/O port	RPP	Output N-ch Tr. OFF VIN=VSS VDD=5V	Port of PU	8 type	14	30	kΩ	
	RES	VIN=VSS VDD=5V	RES	300	500	700		
External reset characteristics Reset time	tRST				See Fig.5.			
Pin capacitance	Cp	f=1MHz Other than pins to be tested, VIN=VSS			10		pF	
Serial Clock Input clock cycle time Output clock cycle time Input clock "L" level pulse width Onput clock "L" level pulse width Input clock "H" level pulse width Onput clock "H" level pulse width	tCKCY(1)	Fig.6	SCK	3.0			μs	
	tCKCY(2)	Fig.6	SCK		64 x tCYC (*6)		μs	
	tCKL(1)	Fig.6	SCK	1.0			μs	
	tCKL(2)	Fig.6	SCK		32 x tCYC		μs	
	tCKH(1)	Fig.6	SCK	1.0			μs	
	tCKH(2)	Fig.6	SCK		32 x tCYC		μs	
	Serial input Data setup time Data hold time	tICK	Specified for ↑ of SCK Fig.6	SI	0.4			μs
		tCKI		SI	0.4			μs
Serial output Output delay time	tCKO	Specified for ↓ of SCK Nch OD only, External 1kΩ, External 50pF, Fig.6	SO			0.6	μs	
Pulse output Period "H"-level pulse width "L"-level pulse width	tPCY	Fig.7 tCYC=4 x System clock Period, Nch OD only, External 1kΩ, External 50pF	PE0		64 x tCYC		μs	
	tPH		PE0		32 x tCYC ±10%		μs	
	tPL		PE0		32 x tCYC ±10		μs	

Parameter	Symbol	Conditions	Pins	Limits			
				min.	typ.	max.	unit
AD conversion characteristics							
Resolution		VDD=4 to 6			8		Bit
Absolute accuracy		AV+=VDD AV-=VSS VDD=4 to 6			±1	±2	LSB
Conversion time	TCAD	AD speed 1/1 At 26 x tCYC VDD=4 to 6		72 (tCYC= 2.77µs)		312 (tCYC= 12µs)	µs
		AD speed 1/2 At 51 x tCYC VDD=4 to 6		141 (tCYC= 2.77µs)		612 (tCYC= 12µs)	
Reference input voltage	AV+	VDD=4 to 6	AV+	AV-		VDD	V
	AV-		AV-	VSS		AV+	
Reference input current range	IRIF	AV+=VDD VDD=4 to 6 AV-=VSS	AV+, AV-	75	150	300	µA
Analog input voltage range	VAIN	VDD=4 to 6	AD0 to AD7	AV-		AV+	V
Analog port input current	IAIN	Including output OFF leakage current. VAIN=VDD VDD=4 to 6	Port pins AD0 to AD7 (with the output circuit of the input/output multi-functional port pins set to OD type)			1	µA
		VAIN=VSS VDD=4 to 6		-1			
Watchdog Timer	Guaranteed constant (*7)	Cw	PE1 at open drain output VDD=3 to 6V	WDR		0.1±5%	µF
		Rw	PE1 at open drain output VDD=3 to 6V	WDR		680±1%	kΩ
		Rl	PE1 at open drain output VDD=3 to 6V	WDR		100±1%	Ω
	Clear time (discharge)	tWCT	Fig. 8 VDD=3 to 6V	WDR	100		µs
	Clear time (charge)	tWCCY	Fig. 8 VDD=3 to 6V	WDR	36		ms
	Guaranteed constant (*7)	Cw	PE1 at open drain output VDD=4 to 6V	WDR		0.047±5%	µF
		Rw	PE1 at open drain output VDD=4 to 6V	WDR		680±1%	kΩ
		Rl	PE1 at open drain output VDD=4 to 6V	WDR		100±1%	Ω
	Clear time (discharge)	tWCT	Fig. 8 VDD=4 to 6V	WDR	40		µs
	Clear time (charge)	tWCCY	Fig. 8 VDD=4 to 6V	WDR	18		ms

- (\*1) When oscillated internally under the oscillating conditions in Fig.4, up to the oscillation amplitude generated is allowable.
- (\*2) Average over the period of 100ms.
- (\*3) Operating supply voltage VDD must be held until the standby mode is entered after the execution of the HALT instruction. The PA3 pin must be free from chattering during the HALT instruction execution cycle.
- (\*4) The OSC1 pin can be schmitt-triggered when the 2-pin RC oscillation option or external clock oscillation option has been selected.
- (\*5) fCFOSC: oscillation frequency. There is a tolerance of approximately 1% between the center frequency at the ceramic resonator mode and the nominal value presented by the ceramic resonator supplier. For details, refer to the specification for the ceramic resonator.
- (\*6) TCYC=4 x system clock period
- (\*7) If using under the wet environment, give care to the leak of the pin adjoined PE1, and the leak of the external RC constant.

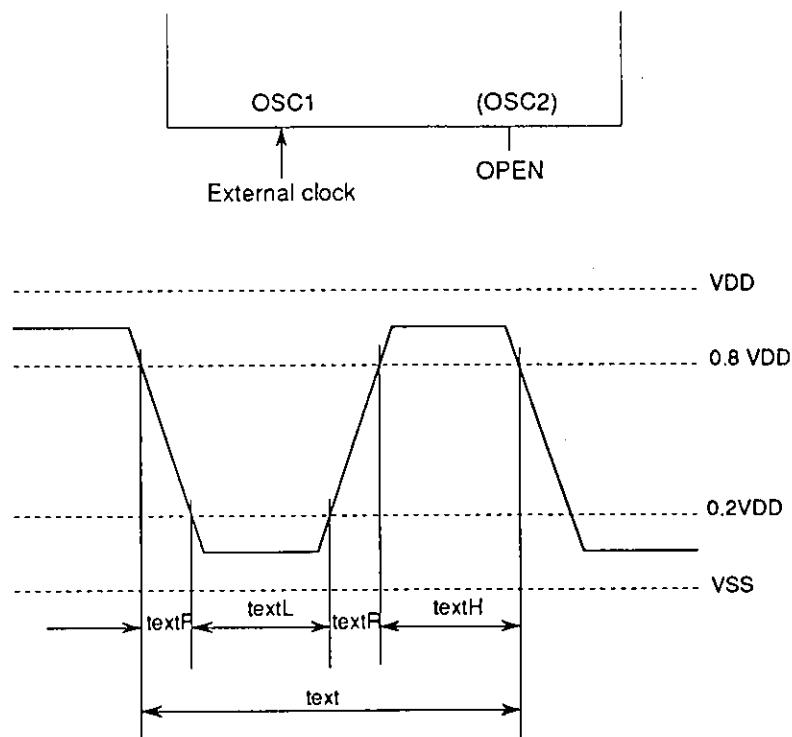


Fig. 1 External Clock Input Waveform

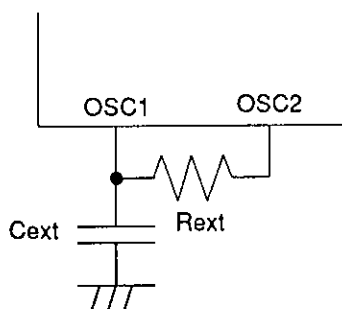


Fig. 2 2-pin RC Oscillation Circuit

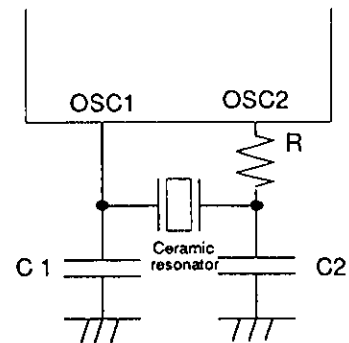


Fig. 3 Ceramic Resonator Oscillation Circuit

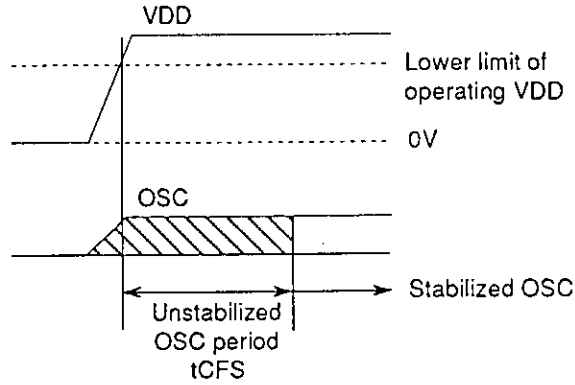


Fig. 4 Oscillation Stabilizing Period

Table 1 Constants Guaranteed for Ceramic Resonator OSC

4MHz (Murata)	C1	33pF±10%
CSA4.00MG	C2	33pF±10%
CST4.00MGW (built-in C)	R	0Ω
4MHz (Kyocera)	C1	33pF±10%
KBR4.0MSA	C2	33pF±10%
KBR4.0MKS (built-in C)	R	0Ω
1MHz (Murata)	C1	100pF±10%
CSB1000J	C2	100pF±10%
	R	2.2kΩ
1MHz (Kyocera)	C1	100pF±10%
KBR1000F	C2	100pF±10%
	R	0Ω
800kHz (Murata)	C1	100pF±10%
CSB800J	C2	100pF±10%
	R	2.2kΩ
800kHz (Kyocera)	C1	220pF±10%
KBR800F	C2	220pF±10%
	R	0Ω
400kHz (Murata)	C1	220pF±10%
CSB400P	C2	220pF±10%
	R	2.2kΩ
400kHz (Kyocera)	C1	330pF±10%
KBR400BK	C2	330pF±10%
	R	0Ω

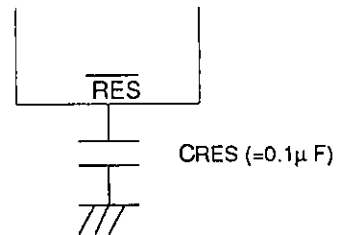


Fig. 5 Reset Circuit

(Note) When the rise time of the power supply is 0, the reset time becomes 10ms to 100ms at  $C_{RES}=0.1\mu F$ . If the rise time of the power supply is long, the value of  $C_{RES}$  must be increased so that the reset time becomes 10ms or more.



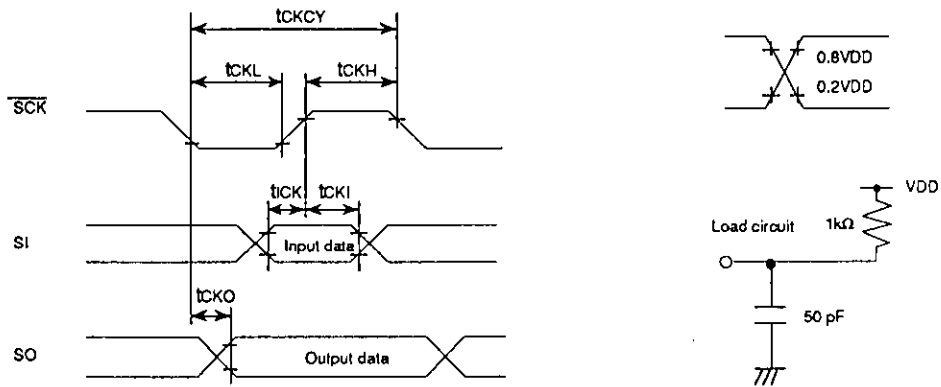
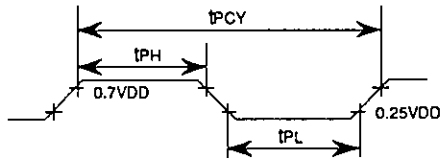
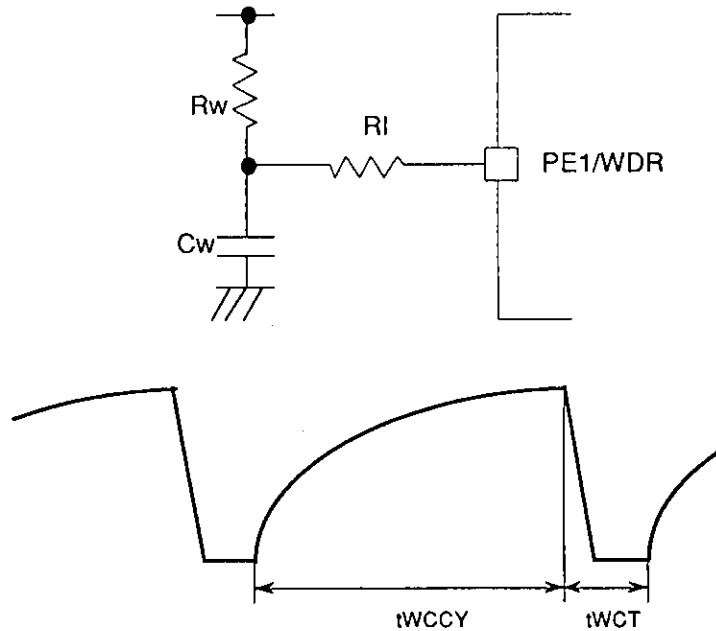


Fig. 6 Serial Input/Output Timing



The load conditions are the same as in Fig. 6.

Fig. 7 Pulse Output Timing at Port PE0



$t_{WCCY}$  : The charge time by the time constant of the external  $C_w$ ,  $R_w$ ,  $R_i$   
 $t_{WCT}$  : The discharge time by program operation

Fig. 8 Wave form of the watchdog timer

RC Oscillation Characteristics of the LC651104N, LC651102N  
To be determined.

## LC651104F, LC651102F

## 1. Absolute Maximum Ratings at Ta=25°C, VSS=0V

Parameter	Symbol	Conditions	Pin	Limits	unit
Maximum supply voltage	VDD max		VDD	-0.3 to +7.0	V
Output voltage	VO		OSC2	Allowable up to voltage generated	V
Input voltage	VI(1)		OSC1 (*1)	-0.3 to VDD+0.3	V
	VI(2)		TEST, RES, AV+, AV-	-0.3 to VDD+0.3	V
Input/output voltage	VIO(1)	Port of OD type	PC0-3, PD0-3,	-0.3 to +15	V
	VIO(2)	Port of PU type	PE0, 1, PF0-3	-0.3 to VDD+0.3	V
	VIO(3)		PA0-3, PG0-3	-0.3 to VDD+0.3	V
Peak output current	IOP		I/O Port	-2 to +20	mA
Average output current	IOA	Per pin over the period of 100ms	I/O Port	-2 to +20	mA
	ΣIOA(1)	Total current of PC0 to 3, PD0 to 3, PE0 to 1 (*2)	PC0 to 3 PD0 to 3 PE0 to 1	-15 to +100	mA
	ΣIOA(2)	Total current of PF0 to 3, PG0 to 3, PA0 to 3 (*2)	PF0 to 3 PG0 to 3 PA0 to 3	-15 to +100	mA
Allowable power dissipation	Pd max(1)	Ta=-40 to +85°C (DIP package)		250	mW
	Pd max(2)	Ta=-40 to +85°C (MFP package)		150	mW
Operating temperature	Topg			-40 to +85	°C
Storage temperature	Tstg			-55 to +125	°C

## 2. Allowable Operating Conditions at Ta=-40 to +85°C, VSS=0V, VDD=4.0 to 6.0V

Parameter	Symbol	Conditions	Pin	Limits				
				min.	typ.	max.	unit	
Operating supply voltage	VDD		VDD	4.0		6.0	V	
Standby supply voltage	VST	RAM, register hold (*3)	VDD	1.8		6.0	V	
"H"-level input voltage	VIH(1)	Output Nch Tr. OFF	Port C, D, E, F of OD type	0.7VDD		+13.5	V	
	VIH(2)	Output Nch Tr. OFF	Port C, D, E, F of PU type	0.7VDD		VDD	V	
	VIH(3)	Output Nch Tr. OFF	Port A, G	0.7VDD		VDD	V	
	VIH(4)	Output Nch Tr. OFF	INT, SCK, SI of OD type	0.8VDD		+13.5	V	
	VIH(5)	Output Nch Tr. OFF	INT, SCK, SI of PU type	0.8VDD		VDD	V	
	VIH(6)		VDD=1.8 to 6.0V	RES	0.8VDD		VDD	V
	VIH(7)		External clock mode	OSC1	0.8VDD		VDD	V

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
"L"-level input voltage	VIL(1)	Output Nch Tr. OFF	Port	VSS		0.3VDD	V
	VIL(2)	Output Nch Tr. OFF	INT, SCK, SI	VSS		0.25VDD	V
	VIL(3)	External clock mode	OSC1	VSS		0.25VDD	V
	VIL(4)		TEST	VSS		0.3VDD	V
	VIL(5)		RES	VSS		0.25VDD	V
Operating frequency (Cycle time)	fOP (Tcyc)			200 (20)		4330 (0.92)	kHz (μs)
External clock conditions							
Frequency	text	} Fig. 1	OSC1	200		4330	kHz
Pulse width	textH, textL		OSC1	69			ns
Rise/fall time	textR, textF		OSC1			50	ns
Oscillation guaranteed constants ceramic resonator OSC		Fig. 2		See Table 1.			

3. Electrical Characteristics at Ta=-40 to +85°C, VSS=0V, VDD=4.0 to 6.0V

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
"H"-level input current	IIH(1)	Output Nch Tr. OFF (including OFF leak current of Nch Tr.) VIN=+13.5V	Port C, D, E, F of OD type			+5.0	μA
	IIH(2)	Output Nch Tr. OFF (including OFF leak current of Nch Tr.) VIN=VDD	Port A, G, of OD type			+1.0	μA
	IIH(3)	External clock mode, VIN=VDD	OSC1			+1.0	μA
"L"-level input current	IIL(1)	Output Nch Tr. OFF VIN=VSS	Port of OD type	-1.0			μA
	IIL(2)	Output Nch Tr. OFF VIN=VSS	Port of PU type	-1.3	-0.35		mA
	IIL(3)	VIN=VSS	RES	-45	-10		μA
	IIL(4)	External clock mode, VIN=VSS	OSC1	-1.0			μA
"H"-level output voltage	VOH(1)	IOH=-50μA	Port of PU type	VDD-1.2			V
	VOH(2)	IOH=-10μA	Port of PU type	VDD-0.5			V
"L"-level output voltage	VOL(1)	IOL=10mA	Port			1.5	V
	VOL(2)	IOL=1mA, IOL of each port : 1mA or less	Port			0.5	V
Schmitt characteristics	Hysteresis voltage	VHIS	RES, INT, SCK, SI, OSC1 of schmitt type(*4)		0.1VDD		V
	'H' level threshold voltage	VtH		0.4VDD		0.8VDD	V
	'L' level threshold voltage	VtL		0.25VDD		0.6VDD	V

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
Current dissipation Ceramic resonator OSC External clock	IDDOP(1)	Fig. 2 4MHz	VDD		2	6	mA
	IDDOP(2)	200kHz to 4330kHz *1 Output Nch Tr. OFF at Operating mode Port=VDD	VDD		2	6	mA
Standby mode	IDDst	Output Nch Tr. OFF VDD=6V Port=VDD VDD=3V	VDD		0.05	10	$\mu$ A
			VDD		0.025	5	$\mu$ A
Oscillation characteristics Ceramic resonator OSC Frequency Stable time	fCFOSC	Fig.2 fo=4MHz (*5)	OSC1, OSC2	3840	4000	4160	kHz
	tCFS	Fig.3 fo=4MHz				10	ms
Pull-up resistance I/O port $\overline{\text{RES}}$	RPP	Output Nch Tr. OFF VIN=VSS VDD=5V	Port of PU type	8	14	30	k $\Omega$
	RU	VIN=VSS VDD=5V	$\overline{\text{RES}}$	300	500	700	k $\Omega$
External reset characteristics Reset time	tRST				See Fig. 4		
Pin capacitance	Cp	f=1MHz, other than pins to be tested, VIN=VSS			10		pF
Serial clock Input clock Cycle time Output clock Cycle time Input clock "L"-level pulse width Output clock "L"-level pulse width Input clock "H"-level pulse width Output clock "H"-level pulse width	tCKCY(1)	Fig. 5	$\overline{\text{SCK}}$	2.0			$\mu$ s
	tCKCY(2)	Fig. 5	$\overline{\text{SCK}}$		64 x tCYC (*6)		$\mu$ s
	tCKL(1)	Fig. 5	SCK	0.6			$\mu$ s
	tCKL(2)	Fig. 5	$\overline{\text{SCK}}$			32 x tCYC	$\mu$ s
	tCKH(1)	Fig. 5	$\overline{\text{SCK}}$		0.6		$\mu$ s
	tCKH(2)	Fig. 5	SCK			32 x tCYC	$\mu$ s
Serial input Data setup time Data hold time	tICK	Specified for $\uparrow$ of $\overline{\text{SCK}}$	SI	0.2			$\mu$ s
	tCKI	Fig. 5	SI	0.2			$\mu$ s

LC651104N/F/L, 651102N/F/L

Parameter	Symbol	Conditions	Pin	Limits				
				min.	typ.	max.	unit	
Serial output Output delay time	tCKO	Specified for ↓ of $\overline{SCK}$ Nch OD only, External 1kΩ External 50pF, Fig.5	SO			0.4	μs	
Pulse output Period "H"-level Pulse width "L"-level Pulse width	tPCY	Fig. 6 TCYC=4 x System clock Period Nch OD only, External 1kΩ External 50pF	PE0		64 x tCYC		μs	
	tPH		PE0		32 x tCYC ±10%		μs	
	tPL		PE0		32 x tCYC ±10%		μs	
AD conversion characteristics Resolution Absolute accuracy		VDD=4 to 6			8		Bit	
		AV+=VDD AV-=VSS	VDD=4.5 to 6 AD speed 1/1		±1	±2	LSB	
			VDD=4 to 6 AD speed 1/2		±1	±2	LSB	
Conversion time	TCAD	AD speed 1/1 At 26 x tCYC VDD=4.5 to 6		24 (tCYC= 0.92μs)		312 (tCYC= 12μs)	μs	
		AD speed 1/2 At 51 x tCYC VDD=4 to 6		47 (tCYC= 0.92μs)		612 (tCYC= 12μs)	μs	
Reference input voltage	AV+	VDD=4 to 6	AV+	AV-		VDD	V	
	AV-		AV-	VSS		AV+		
Reference input current range	IRIF	AV+=VDD AV-=VSS	VDD=4 to 6	AV+, AV-	75	150	300	μA
Analog input voltage range	VAIN	VDD=4 to 6	AD0 to AD7	AV-		AV+	V	
Analog port input current	IAIN	Including output OFF leakage current. VAIN=VDD	VDD=4 to 6	Port pins AD0 to AD7 (with the output circuit of the input/output multi-functional port pins set to OD type)			1	μA
		VAIN=VSS	VDD=4 to 6		-1			
Watchdog Timer	Guaranteed constant (*7)	Cw	PE1 at open drain output	WDR		0.01 ±5%		μF
		Rw	PE1 at open drain output	WDR		680 ±1%		kΩ
		Rl	PE1 at open drain output	WDR		100 ±1%		Ω
	Clear time (discharge)	tWCT	Fig. 7	WDR	10			μs
	Clear time (charge)	tWCCY	Fig. 7	WDR	4.2			ms

(\*1) When oscillated internally under the oscillating conditions in Fig.2, up to the oscillation amplitude generated is allowable.

(\*2) Average over the period of 100ms.

(\*3) Operating supply voltage VDD must be held until the standby mode is entered after the execution of the HALT instruction. The PA3 pin must be free from chattering during the HALT instruction execution cycle.

- (\*4) The OSC1 pin can be schmitt-triggered when the external clock oscillation option has been selected.
- (\*5)  $f_{CFOSC}$  : Oscillatable frequency.
- (\*6)  $TCYC=4 \times$  System clock period
- (\*7) If using under the wet environment, give care to the leak of the pin adjoined PE1, and the leak of the external RC constant.

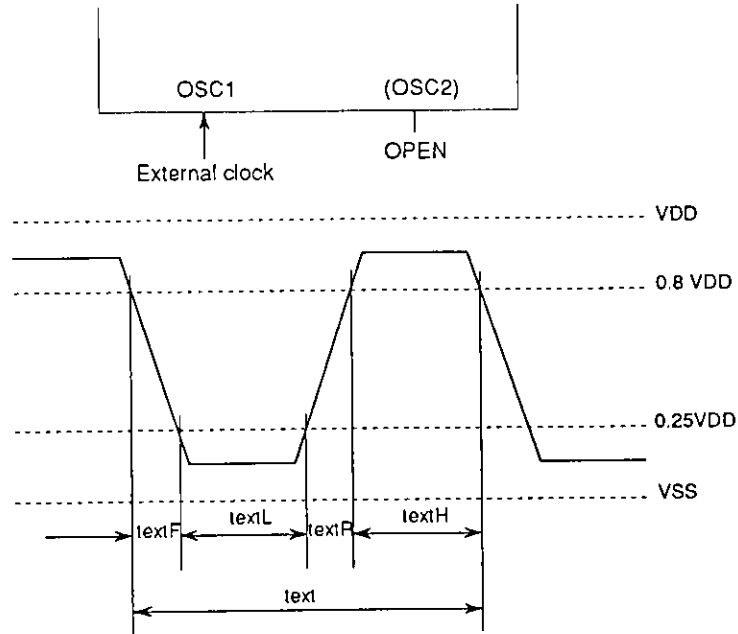


Fig. 1 External Clock Input Waveform

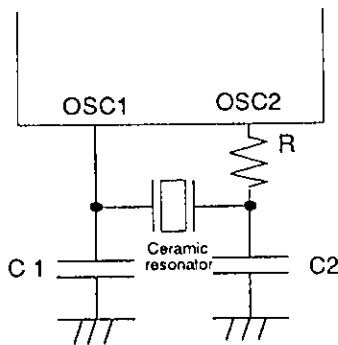


Fig. 2 Ceramic resonator OSC circuit

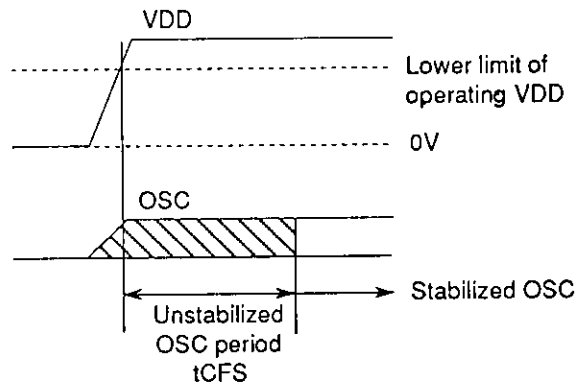


Fig. 3 OSC Stabilizing Period

Table 1. Constants Guaranteed for Ceramic Resonator OSC

4MHz (Murata)	C1	33pF $\pm$ 10%
CSA4.00MG	C2	33pF $\pm$ 10%
CST4.00MGW (built-in C)	R	0 $\Omega$
4MHz (Kyocera)	C1	33pF $\pm$ 10%
KBR4.0MSA	C2	33pF $\pm$ 10%
KBR4.0MKS (built-in C)	R	0 $\Omega$

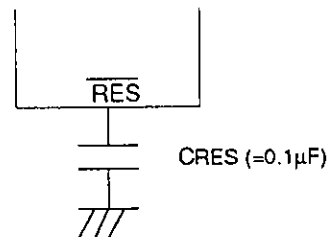


Fig. 4 Reset Circuit

(Note) When the rise time of the power supply is 0, the reset time becomes 10ms to 100ms at  $CRES=0.1\mu F$ . If the rise time of the power supply is long, the value of  $CRES$  must be increased so that the reset time becomes 10ms or more.

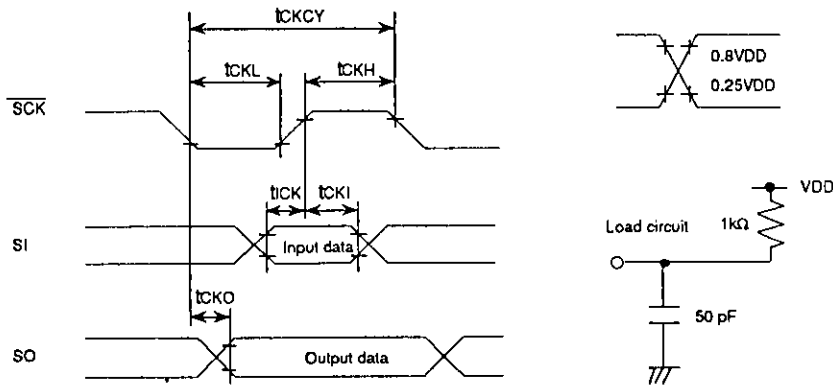
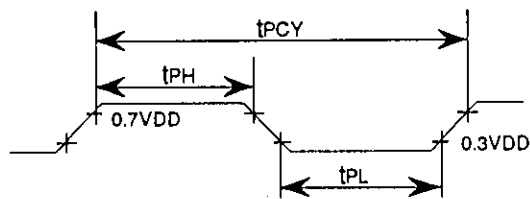
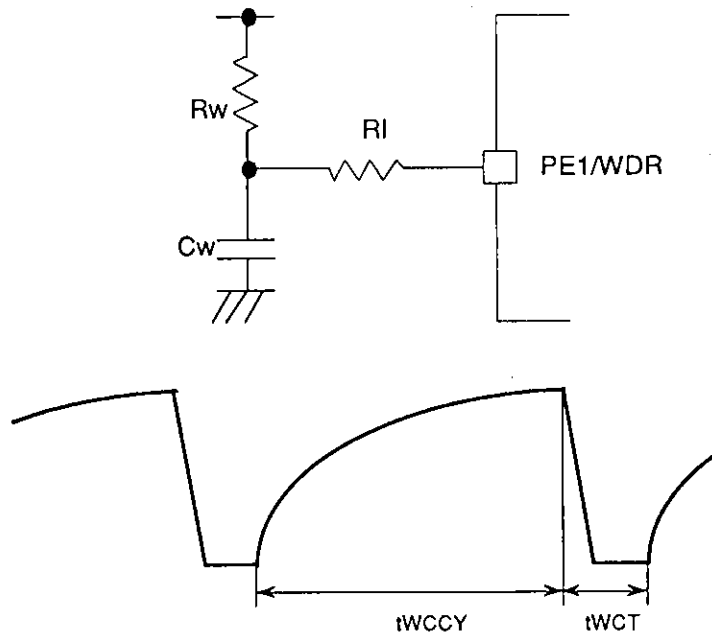


Fig. 5 Serial Input/Output Timing



The load conditions are the same as in Fig. 5.

Fig. 6 Pulse Output Timing at Port PE0



$t_{WCCY}$  : The charge time by the time constant of the external  $C_w$ ,  $R_w$ ,  $R_l$   
 $t_{WCT}$  : The discharge time by program operation

Fig. 7 Wave form of the watchdog timer



## LC651104L, LC651102L

## 1. Absolute Maximum Ratings at Ta=25°C, VSS=0V

Parameter	Symbol	Conditions	Pin	Limits	unit
Maximum supply voltage	VDD max		VDD	-0.3 to 7.0	V
Output voltage	VO		OSC2	Allowable up to voltage generated	V
Input voltage	VI(1)		OSC1 (*1)	-0.3 to VDD+0.3	V
	VI(2)		TEST, RES, AV+, AV-	-0.3 to VDD+0.3	V
Input/output voltage	VIO(1)	Port of OD type	PC0-3, PD0-3	-0.3 to +15	V
	VIO(2)	Port of PU type	PE0, 1, PF0-3	-0.3 to VDD+0.3	V
	VIO(3)		PA0-3, PG0-3	-0.3 to VDD+0.3	V
Peak output current	IOP		I/O Port	-2 to +20	mA
Average output current	IOA	Per pin over the period of 100ms	I/O Port	-2 to +20	mA
	ΣIOA(1)	Total curren of PC0 to 3, PD0 to 3, PE0 to 1 (*2)	PC0 to 3 PD0 to 3 PE0 to 1	-15 to +100	mA
	ΣIOA(2)	Total curren of PF0 to 3, PG0 to 3, PA0 to 3 (*2)	PF0 to 3 PG0 to 3 PA0 to 3	-15 to +100	mA
Allowable power dissipation	Pd max(1)	Ta=-40 to +85°C (DIP package)		250	mW
	Pd max(2)	Ta=-40 to +85°C (MFP package)		150	mW
Operating temperature	Topg			-40 to +85	°C
Storage temperature	Tstg			-55 to +125	°C

## 2. Allowable Operating Conditions at Ta=-40°C to 85°C, VSS=0V, VDD=2.5 to 6.0V

Parameter	Symbol	Conditions	Pin	Limits			unit
				min.	typ.	max.	
Operating supply voltage	VDD		VDD	2.5		6.0	V
Standby supply voltage	VST	RAM, register hold (*3)	VDD	1.8		6.0	V
"H"-level input voltage	VIH(1)	Output Nch Tr. OFF	Port C, D, E, F of OD type	0.7VDD		+13.5	V
	VIH(2)	Output Nch Tr. OFF	Port C, D, E, F of PU type	0.7VDD		VDD	V
	VIH(3)	Output Nch Tr. OFF	Port A, G	0.7VDD		VDD	V
	VIH(4)	Output Nch Tr. OFF	INT, SCK, SI of OD type	0.8VDD		+13.5	V
	VIH(5)	Output Nch Tr. OFF	INT, SCK, SI of PU type	0.8VDD		VDD	V
	VIH(6)	VDD=1.8 to 6.0V	RES	0.8VDD		VDD	V
	VIH(7)	External clock	OSC1	0.8VDD		VDD	V

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
"L"-level input voltage	VIL(1)	Output Nch Tr. OFF	Port	VSS		0.2VDD	V
	VIL(2)	Output Nch Tr. OFF	INT, SCK, SI	VSS		0.15VDD	V
	VIL(3)	External clock	OSC1	VSS		0.15VDD	V
	VIL(4)		TEST	VSS		0.2VDD	V
	VIL(5)		RES	VSS		0.15VDD	V
Operating frequency (cycle time)	fOP (Tcyc)	When the 1/4 predivider option is selected, clock must not exceed 4.16MHz.		200 (20)		1040kHz (3.84)	(μs)
External Clock conditions	Frequency	Fig.1 When clock exceeds 1.040MHz, the 1/3 or 1/4 predivider option is selected.	OSC1	200		4160	kHz
	Pulse width		OSC1	100			ns
	Rise/fall time		OSC1			100	ns
Oscillation guaranteed constants	2-pin RC oscillation	Fig.2	OSC1, OSC2			270±5%	pF
	Ceramic oscillation	Fig.3				12±1%	kΩ
						See Table 1.	

3. Electrical Characteristics at Ta=-40 to +85°C, VSS=0V, VDD=2.5 to 6.0V

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
"H"-level input current	IIH(1)	Output Nch Tr. OFF (including OFF leak current of Nch Tr.) VIN=+13.5V	Port C, D, E, F of OD type			+5.0	μA
	IIH(2)	Output Nch Tr. OFF (including OFF leak current of Nch Tr.) VIN=VDD	Port A, G of OD type			+1.0	μA
	IIH(3)	External clock mode, VIN=VDD	OSC1			+1.0	μA
"L"-level input current	IIL(1)	Output Nch Tr. OFF VIN=VSS	Port of OD type	-1.0			μA
	IIL(2)	Output Nch Tr. OFF VIN=VSS	Port of PU type	-1.3	-0.35		mA
	IIL(3)	VIN=VSS	RES	-45	-10		μA
	IIL(4)	External clock mode, VIN=VSS	OSC1	-1.0			μA
"H"-level output voltage	VOH	IOH=-10μA	Port of PU type	VDD-0.5			V
"L"-level output voltage	VOL(1)	IOL=3mA	Port			1.5	V
	VOL(2)	IOL=1mA, IOL of each port: 1mA or less	Port			0.4	V

Parameter		Symbol	Conditions	Pin	Limits			
					min.	typ.	max.	unit
Schmitt Characteristics	Hysteresis voltage	VHIS		$\overline{RES}$ , $\overline{INT}$ , $\overline{SCR}$ , SI, OSC1 of schmitt type(*4)		0.1VDD		V
	'H' level threshold voltage	VtH			0.4VDD		0.8VDD	V
	'L' level threshold voltage	VtL			0.2VDD		0.6VDD	V
Current dissipation 2-pin RC OSC Ceramic OSC		IDDOP(1)	Output Nch Tr. OFF at operating, Port=VDD Fig.2 fOSC=400kHz (TYP)	VDD		1.0	4	mA
		IDDOP(2)	Fig.3 4MHz, 1/4predivider	VDD		1.5	4	mA
		IDDOP(3)	Fig.3 4MHz, 1/4predivider VDD=2.5V	VDD		0.5	1	mA
		IDDOP(4)	Fig.3 400kHz	VDD		1.0	2.5	mA
		IDDOP(5)	Fig.3 800kHz	VDD		1.5	4.0	mA
	External clock	IDDOP(6)	200kHz to 1024kHz, 1/1 predivider 600kHz to 3120kHz, 1/3 predivider 800kHz to 4160kHz, 1/4 predivider	VDD		1.5	4	mA
Standby mode	IDDst	Output Nch Tr. OFF VDD=6V	VDD		0.05	10	$\mu$ A	
		Port=VDD VDD=2.5V	VDD		0.020	4	$\mu$ A	
Oscillation characteristics Ceramic OSC								
Frequency	fCFOSC (*5)	Fig.3 fo=400kHz	OSC1, OSC2	384	400	416	kHz	
		Fig.3 fo=800kHz	OSC1, OSC2	768	800	832	kHz	
		Fig.3 fo=1MHz	OSC1, OSC2	960	1000	1040	kHz	
		Fig.3 fo=4MHz, 1/4 predivider	OSC1, OSC2	3840	4000	4160	kHz	
Stable time	tCFS	Fig.4 fo=400kHz				10	ms	
		Fig.4 fo=800kHz, 1MHz, 4MHz, 1/4 predivider				10	ms	
2-pin RC OSC Frequency	fMOSC	Fig.2 Cext=270PF $\pm$ 5% Fig.2 Rext=12k $\Omega$ $\pm$ 1%	OSC1, OSC2	276	400	742	kHz	
Pull-up resistance I/O port	RPP	Output Nch Tr. OFF VIN=VSS VDD=5V	Port of PU type	8	14	30	k $\Omega$	
	RES	VIN=VSS VDD=5V	$\overline{RES}$	300	500	700	k $\Omega$	
External reset characteristics								
Reset time	tRST				See Fig.5			
Pin capacitance	Cp	f=1MHz, Other than pins to be tested, VIN=VSS			10		pF	

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
Serial clock Input clock Cycle time	tCKCY(1)	Fig.6	$\overline{SCK}$	6.0			$\mu s$
Output clock Cycle time	tCKCY(2)	Fig.6	$\overline{SCK}$		64 x tCYC (*6)		$\mu s$
Input clock "L"-level pulse width	tCKL(1)	Fig.6	$\overline{SCK}$	2.0			$\mu s$
Output clock "L"-level pulse width	tCKL(2)	Fig.6	$\overline{SCK}$		32 x tCYC		$\mu s$
Input clock "H"-level pulse width	tCKH(1)	Fig.6	$\overline{SCK}$	2.0			$\mu s$
Output clock "H"-level pulse width	tCKH(2)	Fig.6	$\overline{SCK}$		32 x tCYC		$\mu s$
Serial Input Data setup time	tICK	Specified for $\uparrow$ of $\overline{SCK}$	SI	0.5			$\mu s$
Data hold time	tCKI	Fig.6	SI	0.5			$\mu s$
Serial Output Output delay time	tCKO	Specified for $\downarrow$ of $\overline{SCK}$ Nch OD only, External 1k $\Omega$ Fig.6 External 50pF	SO			1.0	$\mu s$
Pulse output Period	tPCY	Fig.7	PE0		64 x tCYC		$\mu s$
"H"-level pulse width	tPH	TCYC=4 x System clock Period	PE0		32 x tCYC $\pm 10\%$		$\mu s$
"L"-level pulse width	tPL	Nch OD only, External 1k $\Omega$ External 50pF	PE0		32 x tCYC $\pm 10\%$		$\mu s$
AD conversion characteristics							
Resolution		VDD=4 to 6			8		Bit
Absolute accuracy		AV+=VDD AV-=VSS VDD=4 to 6			$\pm 1$	$\pm 2$	LSB
Conversion time	TCAD	AD speed 1/1 At 26 x tCYC VDD=4 to 6		99 (tCYC= 3.84 $\mu s$ )		312 (tCYC= 12 $\mu s$ )	$\mu s$
		AD speed 1/2 At 51 x tCYC VDD=4 to 6		195 (tCYC= 3.84 $\mu s$ )		612 (tCYC= 12 $\mu s$ )	$\mu s$
Reference input voltage	AV+	VDD=4 to 6	AV+	AV-		VDD	V
	AV-		AV-	VSS		AV+	
Reference input current range	IRIF	AV+=VDD VDD=4 to 6 AV-=VSS	AV+, AV-	75	150	300	$\mu A$
Analog input voltage range	VAIN	VDD=4 to 6	AD0 to AD7	AV-		AV+	V

Parameter	Symbol	Conditions	Pin	Limits			
				min.	typ.	max.	unit
AD conversion characteristics							
Analog port input current	IAIN	Including output OFF leakage current. VAIN=VDD VDD=4 to 6	Port pins AD0 to AD7 (with the output circuit of the input/output multi-functional port pins set to OD type)			1	$\mu\text{A}$
		VAIN=VSS VDD=4 to 6		-1			
Watchdog Timer	Guaranteed constant (*7)	Cw	PE1 at open drain output VDD=2.5V to 6V	WDR		$0.1 \pm 5\%$	$\mu\text{F}$
		Rw	PE1 at open drain output VDD=2.5V to 6V	WDR		$680 \pm 1\%$	$\text{k}\Omega$
		RI	PE1 at open drain output VDD=2.5V to 6V	WDR		$100 \pm 1\%$	$\Omega$
	Clear time (discharge)	tWCT	Fig. 8 VDD=2.5V to 6V	WDR	100		$\mu\text{s}$
	Clear time (charge)	tWCCY	Fig. 8 VDD=2.5V to 6V	WDR	31		ms
	Guaranteed constant (*7)	Cw	PE1 at open drain output VDD=2.5V to 6V	WDR		$0.047 \pm 5\%$	$\mu\text{F}$
		Rw	PE1 at open drain output VDD=2.5V to 6V	WDR		$680 \pm 1\%$	$\text{k}\Omega$
		RI	PE1 at open drain output VDD=2.5V to 6V	WDR		$100 \pm 1\%$	$\Omega$
	Clear time (discharge)	tWCT	Fig. 8 VDD=2.5V to 6V	WDR	40		$\mu\text{s}$
	Clear time (charge)	tWCCY	Fig. 8 VDD=2.5V to 6V	WDR	14		ms

(\*1) When oscillated internally under the oscillating conditions in Fig.3, up to the oscillation amplitude generated is allowable.

(\*2) Average over the period of 100ms.

(\*3) Operating supply voltage VDD must be held until the standby mode is entered after the execution of the HALT instruction.

The PA3 pin must be free from chattering during the HALT instruction execution cycle.

(\*4) The OSC1 pin can be schmitt-triggered when the 2-pin RC oscillation option, or external clock oscillation option has been selected.

(\*5) fCFOSC : Oscillatable frequency.

(\*6) TCYC=4 x System clock period

(\*7) If using under the wet environment, give care to the leak of the pin adjoined PE1, and the leak of the external RC constant.

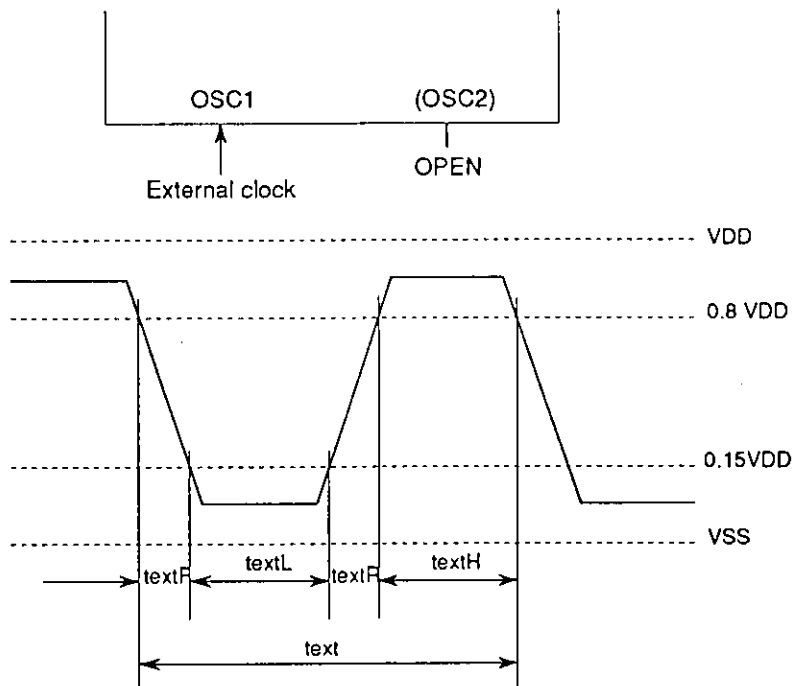


Fig. 1 External Clock Input Waveform

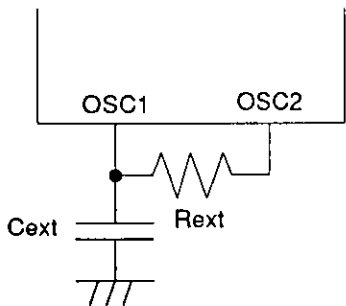


Fig. 2 2-pin RC Oscillation Circuit

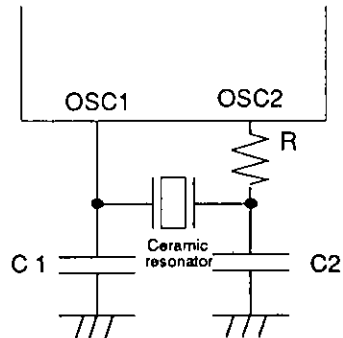


Fig. 3 Ceramic Resonator Oscillation Circuit

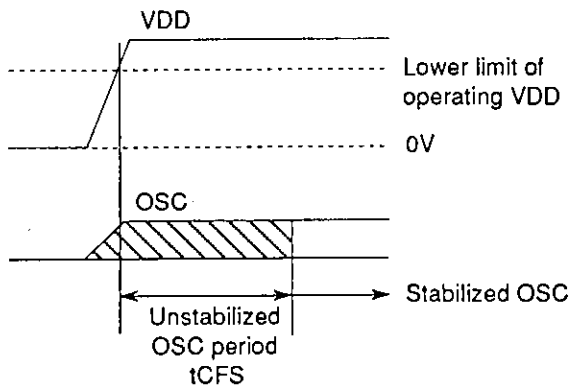


Fig. 4 Oscillation Stabilizing Period

Table 1 Constants Guaranteed for Ceramic Resonator OSC

4MHz (Murata) CSA4.00MGU CST4.00MGWU (built-in C)	C1	33pF±10%
	C2	33pF±10%
	R	0Ω
1MHz (Murata) CSB1000J	C1	100pF±10%
	C2	100pF±10%
	R	2.2kΩ
1MHz (Kyocera) KBR1000F	C1	100pF±10%
	C2	100pF±10%
	R	0Ω
800kHz (Murata) CSB800J	C1	100pF±10%
	C2	100pF±10%
	R	2.2kΩ
800kHz (Kyocera) KBR800F	C1	220pF±10%
	C2	220pF±10%
	R	0Ω
400kHz (Murata) CSB400P	C1	220pF±10%
	C2	220pF±10%
	R	2.2kΩ
400kHz (Kyocera) KBR400BK	C1	330pF±10%
	C2	330pF±10%
	R	0Ω

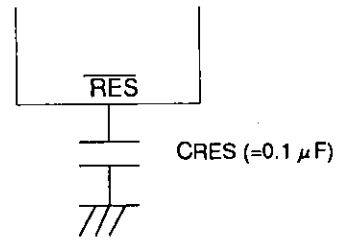


Fig. 5 Reset Circuit

(Note) When the rise time of the power supply is 0, the reset time becomes 10ms to 100ms at CRES=0.1μF. If the rise time of the power supply is long, the value of CRES must be increased so that the reset time becomes 10ms or more.

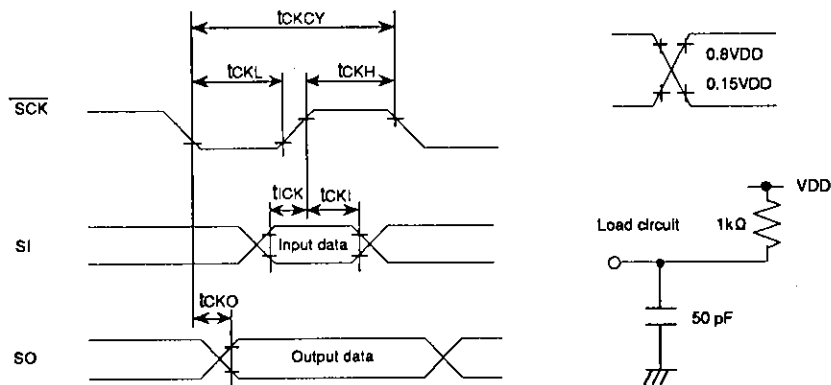


Fig. 6 Serial Input/Output Timing

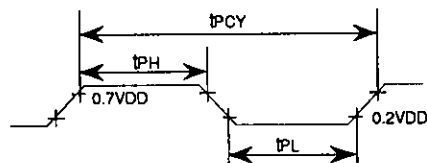
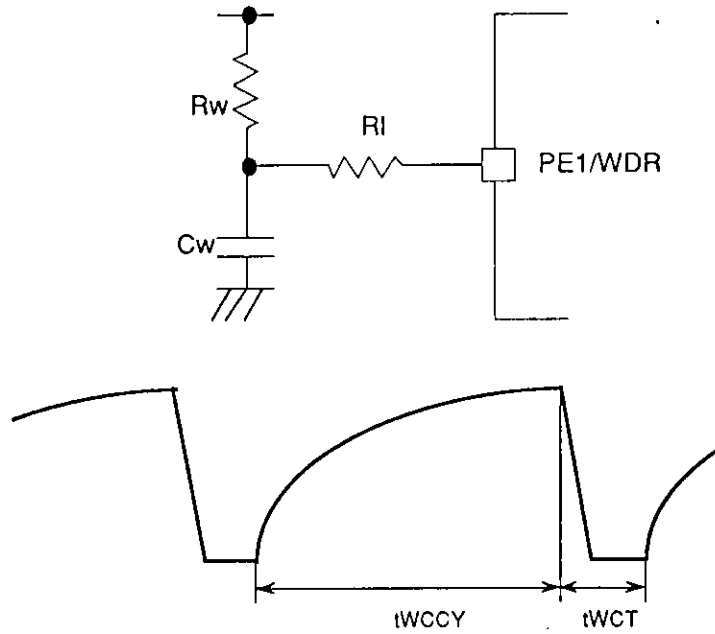


Fig.7 Pulse Output Timing at Port PE0

The load conditions are the same as in Fig. 6.



$t_{WCCY}$  : The charge time by the time constant of the external  $C_w$ ,  $R_w$ ,  $R_i$   
 $t_{WCT}$  : The discharge time by program operation

Fig. 8 Wave form of the watchdog timer

RC Oscillation Characteristic of the LC651104L, 651102L  
 To be determined.



LC651104, LC651102 SERIES INSTRUCTION SET (BY FUNCTIONS)

Symbol	Description	M(DP)	: Memory addressed by DP	( )	: Contents
AC	: Accumulator	P(DP <sub>L</sub> )	: Input/output port addressed by DP <sub>L</sub>	-	: Transfer and direction
ACt	: Accumulator bit t	PC	: Program counter	+	: Addition
CF	: Carry flag	STACK	: Stack register	-	: Subtraction
CTL	: Control register	TM	: Timer	∧	: AND
DP	: Data pointer	TMF	: Timer (internal) interrupt request flag	∨	: OR
E	: E register	At, Ha, La	: Working register	⊕	: Exclusive OR
EXTF	: External interrupt request flag	ZF	: Zero flag		
F <sub>n</sub>	: Flag bit n				
M	: Memory				

Instruction group	Mnemonic		Instruction code		Bytes	Cycles	Function	Description	Status flag affected	Remarks											
			D <sub>7</sub> D <sub>6</sub> D <sub>5</sub> D <sub>4</sub>	D <sub>3</sub> D <sub>2</sub> D <sub>1</sub> D <sub>0</sub>																	
Accumulator manipulation instructions	CLA	Clear AC	1 1 0 0	0 0 0 0	1	1	AC ← 0	The AC contents are cleared.	ZF	* 1											
	CLC	Clear CF	1 1 1 0	0 0 0 1	1	1	CF ← 0	The CF contents are cleared.	CF												
	STC	Set CF	1 1 1 1	0 0 0 1	1	1	CF ← 1	The CF is set.	CF												
	CMA	Complement AC	1 1 1 0	1 0 1 1	1	1	AC ← $\overline{AC}$	The AC contents are complemented.	ZF												
	INC	Increment AC	0 0 0 0	1 1 1 0	1	1	AC ← (AC) + 1	The AC contents are incremented +1.	ZF CF												
	DEC	Decrement AC	0 0 0 0	1 1 1 1	1	1	AC ← (AC) - 1	The AC contents are decremented -1.	ZF CF												
	RAL	Rotate AC left through CF	0 0 0 0	0 0 0 1	1	1	AC <sub>0</sub> ← (CF), AC <sub>n+1</sub> ← (AC) <sub>n</sub> , CF ← (AC) <sub>3</sub>	The AC contents are shifted left through the CF.	ZF CF												
	TAE	Transfer AC to E	0 0 0 0	0 0 1 1	1	1	E ← (AC)	The AC contents are transferred to the E.													
XAE	Exchange AC with E	0 0 0 0	1 1 0 1	1	1	(AC) ↔ (E)	The AC contents and the E contents are exchanged.														
Memory manipulation instructions	INM	Increment M	0 0 1 0	1 1 1 0	1	1	M(DP) ← (M(DP)) + 1	The M(DP) contents are incremented +1.	ZF CF												
	DEM	Decrement M	0 0 1 0	1 1 1 1	1	1	M(DP) ← (M(DP)) - 1	The M(DP) contents are decremented -1.	ZF CF												
	SMB bit	Set M data bit	0 0 0 0	1 0 B <sub>1</sub> B <sub>0</sub>	1	1	M(DP, B <sub>1</sub> B <sub>0</sub> ) ← 1	A single bit of the M(DP) specified with B <sub>1</sub> B <sub>0</sub> is set.													
	RMB bit	Reset M data bit	0 0 1 0	1 0 B <sub>1</sub> B <sub>0</sub>	1	1	M(DP, B <sub>1</sub> B <sub>0</sub> ) ← 0	A single bit of the M(DP) specified with B <sub>1</sub> B <sub>0</sub> is reset.	ZF												
Arithmetic operation/comparison instructions	AD	Add M to AC	0 1 1 0	0 0 0 0	1	1	AC ← (AC) + (M(DP))	Binary addition of the AC contents and the M(DP) contents is performed and the result is stored in the AC.	ZF CF												
	ADC	Add M to AC with CF	0 0 1 0	0 0 0 0	1	1	AC ← (AC) + (M(DP)) + (CF)	Binary addition of the AC, CF contents and the M(DP) contents is performed and the result is stored in the AC.	ZF CF												
	DAA	Decimal adjust AC in addition	1 1 1 0	0 1 1 0	1	1	AC ← (AC) + 6	6 is added to the AC contents.	ZF												
	DAS	Decimal adjust AC in subtraction	1 1 1 0	1 0 1 0	1	1	AC ← (AC) + 10	10 is added to the AC contents.	ZF												
	EXL	Exclusive or M to AC	1 1 1 1	0 1 0 1	1	1	AC ← (AC) ∨ (M(DP))	The AC contents and the M(DP) contents are exclusive-ORed and the result is stored in the AC.	ZF												
	AND	And M to AC	1 1 1 0	0 1 1 1	1	1	AC ← (AC) ∧ (M(DP))	The AC contents and the M(DP) contents are ANDed and the result is stored in the AC.	ZF												
	OR	Or M to AC	1 1 1 0	0 1 0 1	1	1	AC ← (AC) ∨ (M(DP))	The AC contents and the M(DP) contents are ORed and the result is stored in the AC.	ZF												
	CM	Compare AC with M	1 1 1 1	1 0 1 1	1	1	(M(DP)) + (AC) + 1	The AC contents and the M(DP) contents are compared and the CF and ZF are set/reset. <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Comparison result</td> <td>CF</td> <td>ZF</td> </tr> <tr> <td>(M(DP)) &gt; (AC)</td> <td>0</td> <td>0</td> </tr> <tr> <td>(M(DP)) = (AC)</td> <td>1</td> <td>1</td> </tr> <tr> <td>(M(DP)) &lt; (AC)</td> <td>1</td> <td>0</td> </tr> </table>	Comparison result	CF	ZF	(M(DP)) > (AC)	0	0	(M(DP)) = (AC)	1	1	(M(DP)) < (AC)	1	0	ZF CF
Comparison result	CF	ZF																			
(M(DP)) > (AC)	0	0																			
(M(DP)) = (AC)	1	1																			
(M(DP)) < (AC)	1	0																			
CI data	Compare AC with immediate data	0 0 1 0 0 1 0 0	1 1 0 0 1 3 1 2 1 1 0	2	2	( $1_3 1_2 1_1 1_0$ ) + (AC) + 1	The AC contents and the immediate data $1_3 1_2 1_1 1_0$ are compared and the ZF and CF are set/reset. <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>Comparison result</td> <td>CF</td> <td>ZF</td> </tr> <tr> <td><math>1_3 1_2 1_1 1_0 &gt; (AC)</math></td> <td>0</td> <td>0</td> </tr> <tr> <td><math>1_3 1_2 1_1 1_0 = (AC)</math></td> <td>1</td> <td>1</td> </tr> <tr> <td><math>1_3 1_2 1_1 1_0 &lt; (AC)</math></td> <td>1</td> <td>0</td> </tr> </table>	Comparison result	CF	ZF	$1_3 1_2 1_1 1_0 > (AC)$	0	0	$1_3 1_2 1_1 1_0 = (AC)$	1	1	$1_3 1_2 1_1 1_0 < (AC)$	1	0	ZF CF	
Comparison result	CF	ZF																			
$1_3 1_2 1_1 1_0 > (AC)$	0	0																			
$1_3 1_2 1_1 1_0 = (AC)$	1	1																			
$1_3 1_2 1_1 1_0 < (AC)$	1	0																			
CLI data	Compare DP <sub>L</sub> with immediate data	0 0 1 0 0 1 0 1	1 1 0 0 1 3 1 2 1 1 0	2	2	(DP <sub>L</sub> ) ∨ ( $1_3 1_2 1_1 1_0$ )	The DP <sub>L</sub> contents and the immediate data $1_3 1_2 1_1 1_0$ are compared.	ZF													
Load/store instructions	LI data	Load AC with immediate data	1 1 0 0	1 3 1 2 1 1 0	1	1	AC ← $1_3 1_2 1_1 1_0$	The immediate data $1_3 1_2 1_1 1_0$ is loaded in the AC.	ZF	* 1											
	S	Store AC to M	0 0 0 0	0 0 1 0	1	1	M(DP) ← (AC)	The AC contents are stored in the M(DP).													
	L	Load AC from M	0 0 1 0	0 0 0 1	1	1	AC ← (M(DP))	The M(DP) contents are loaded in the AC.	ZF												
	XM data	Exchange AC with M, then modify DP <sub>H</sub> with immediate data	1 0 1 0	0 M <sub>2</sub> M <sub>1</sub> M <sub>0</sub>	1	2	(AC) ↔ (M(DP)) DP <sub>H</sub> ← (DP <sub>H</sub> ) ∨ (M <sub>2</sub> M <sub>1</sub> M <sub>0</sub> )	The AC contents and the M(DP) contents are exchanged and then the DP <sub>H</sub> contents are modified with the contents of (DP <sub>H</sub> ) ∨ (M <sub>2</sub> M <sub>1</sub> M <sub>0</sub> ).	ZF	The ZF is set/reset according to the result of (DP <sub>H</sub> ) ∨ (M <sub>2</sub> M <sub>1</sub> M <sub>0</sub> ).											
	X	Exchange AC with M	1 0 1 0	0 0 0 0	1	2	(AC) ↔ (M(DP))	The AC contents and the M(DP) contents are exchanged.	ZF	The ZF is set/reset according to the DP <sub>H</sub> contents at the time of instruction execution.											
	XI	Exchange AC with M, then increment DP <sub>L</sub>	1 1 1 1	1 1 1 0	1	2	(AC) ↔ (M(DP)) DP <sub>L</sub> ← (DP <sub>L</sub> ) + 1	The AC contents and the M(DP) contents are exchanged and then the DP <sub>L</sub> contents are incremented +1.	ZF	The ZF is set/reset according to the result of (DP <sub>L</sub> ) + 1.											
	XD	Exchange AC with M, then decrement DP <sub>L</sub>	1 1 1 1	1 1 1 1	1	2	(AC) ↔ (M(DP)) DP <sub>L</sub> ← (DP <sub>L</sub> ) - 1	The AC contents and the M(DP) contents are exchanged and then the DP <sub>L</sub> contents are decremented -1.	ZF	The ZF is set/reset according to the result of (DP <sub>L</sub> ) - 1.											
RTBL	Read table data from program ROM	0 1 1 0	0 0 1 1	1	2	AC, E ← ROM (PC, E, AC)	The contents of ROM addressed by the PC whose low-order 8 bits are replaced with the E and AC contents are loaded in the AC and E.														

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Instruction group	Mnemonic	Instruction code		Bytes	Cycles	Function	Description	Status flag affected	Remarks	
		D <sub>7</sub> D <sub>6</sub> D <sub>5</sub> D <sub>4</sub>	D <sub>3</sub> D <sub>2</sub> D <sub>1</sub> D <sub>0</sub>							
Data pointer manipulation instructions	LDZ data	Load DP <sub>H</sub> with Zero and DP <sub>L</sub> with immediate data respectively	1 0 0 0	1 3 1 2 1 1 1 0	1	1	DP <sub>H</sub> ← 0 DP <sub>L</sub> ← 1 3 1 2 1 1 1 0	The DP <sub>H</sub> and DP <sub>L</sub> are loaded with 0 and the immediate data 1 3 1 2 1 1 1 0 respectively.		
	LHI data	Load DP <sub>H</sub> with immediate data	0 1 0 0	1 3 1 2 1 1 1 0	1	1	DP <sub>H</sub> ← 1 3 1 2 1 1 1 0	The DP <sub>H</sub> is loaded with the immediate data 1 3 1 2 1 1 1 0.		
	IND	Increment DP <sub>L</sub>	1 1 1 0	1 1 1 1 0	1	1	DP <sub>L</sub> ← (DP <sub>L</sub> ) + 1	The DP <sub>L</sub> contents are incremented +1.	ZF	
	DED	Decrement DP <sub>L</sub>	1 1 1 0	1 1 1 1 1	1	1	DP <sub>L</sub> ← (DP <sub>L</sub> ) - 1	The DP <sub>L</sub> contents are decremented -1.	ZF	
	TAL	Transfer AC to DP <sub>L</sub>	1 1 1 1	0 1 1 1	1	1	DP <sub>L</sub> ← (AC)	The AC contents are transferred to the DP <sub>L</sub>		
	TLA	Transfer DP <sub>L</sub> to AC	1 1 1 0	1 0 0 1	1	1	AC ← (DP <sub>L</sub> )	The DP <sub>L</sub> contents are transferred to the AC	ZF	
	XAH	Exchange AC with DP <sub>H</sub>	0 0 1 0	0 0 1 1	1	1	(AC) ↔ (DP <sub>H</sub> )	The AC contents and the DP <sub>H</sub> contents are exchanged.		
Working register manipulation instructions	XA <sub>i</sub>	Exchange AC with working register A <sub>i</sub>	1 1 1 0	0 0 0 0	1	1	(AC) ↔ (A <sub>0</sub> )	The AC contents and the contents of working register A <sub>i</sub> are exchanged. A <sub>i</sub> is assigned one of A <sub>0</sub> , A <sub>1</sub> , A <sub>2</sub> , A <sub>3</sub> according to t <sub>1</sub> <sup>10</sup> .		
	XAO		1 1 1 0	0 0 1 0	1	1	(AC) ↔ (A <sub>0</sub> )			
	XA <sub>1</sub>		1 1 1 0	0 1 0 0	1	1	(AC) ↔ (A <sub>1</sub> )			
	XA <sub>2</sub>		1 1 1 0	1 0 0 0	1	1	(AC) ↔ (A <sub>2</sub> )			
	XA <sub>3</sub>		1 1 1 0	1 1 0 0	1	1	(AC) ↔ (A <sub>3</sub> )			
	XH <sub>a</sub>	Exchange DP <sub>H</sub> with working register H <sub>a</sub>	1 1 1 1	1 0 0 0	1	1	(DP <sub>H</sub> ) ↔ (H <sub>0</sub> )	The DP <sub>H</sub> contents and the contents of working register H <sub>a</sub> are exchanged. H <sub>a</sub> is assigned either of H <sub>0</sub> or H <sub>1</sub> according to a.		
XHO		1 1 1 1	1 1 0 0	1	1	(DP <sub>H</sub> ) ↔ (H <sub>1</sub> )				
XL <sub>a</sub>	Exchange DP <sub>L</sub> with working register L <sub>a</sub>	1 1 1 1	0 0 0 0	1	1	(DP <sub>L</sub> ) ↔ (L <sub>0</sub> )	The DP <sub>L</sub> contents and the contents of working register L <sub>a</sub> are exchanged. L <sub>a</sub> is assigned either of L <sub>0</sub> or L <sub>1</sub> according to a.			
	XLO		1 1 1 1	0 1 0 0	1	1	(DP <sub>L</sub> ) ↔ (L <sub>0</sub> )			
	XL <sub>1</sub>		1 1 1 1	0 1 1 0	1	1	(DP <sub>L</sub> ) ↔ (L <sub>1</sub> )			
Flag manipulation instructions	SFB flag	Set flag bit	0 1 0 1	B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub>	1	1	F <sub>n</sub> ← 1	The flag specified with B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub> is set.		
	RFB flag	Reset flag bit	0 0 0 1	B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub>	1	1	F <sub>n</sub> ← 0	The flag specified with B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub> is reset.	ZF	The flags are divided into 4 groups of F <sub>0</sub> to F <sub>3</sub> , F <sub>4</sub> to F <sub>7</sub> , F <sub>8</sub> to F <sub>11</sub> , F <sub>12</sub> to F <sub>15</sub> . The ZF is set/reset according to the 4 bits including a single bit specified with the immediate data B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub> .
Jump/subroutine instructions	JMP addr	Jump in the current bank	0 1 1 0	1 P <sub>10</sub> P <sub>9</sub> P <sub>8</sub> P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC ← P <sub>10</sub> P <sub>9</sub> P <sub>8</sub> P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	A jump to the address specified with immediate data P <sub>10</sub> P <sub>9</sub> P <sub>8</sub> P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> occurs.		
	JPEA	Jump in the current page modified by E and AC	1 1 1 1	1 0 1 0	1	1	PC <sub>7-0</sub> ← (E, AC)	A jump to the address specified with the contents of the PC whose low-order 8 bits are replaced by the E and AC contents occurs.		
	CZP addr	Call subroutine in the zero page	1 0 1 1	P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	1	1	STACK ← (PC) + 1 PC <sub>10-6</sub> , PC <sub>1-0</sub> ← 0 PC <sub>5-2</sub> ← P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	A subroutine in page 0 of bank 0 is called.		
	CAL addr	Call subroutine in the zero bank	1 0 1 0	1 P <sub>10</sub> P <sub>9</sub> P <sub>8</sub> P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	STACK ← (PC) + 2 PC <sub>10-0</sub> ← 0 P <sub>10</sub> P <sub>9</sub> P <sub>8</sub> P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	A subroutine in bank 0 is called.		
	RT	Return from subroutine	0 1 1 0	0 0 1 0	1	1	PC ← (STACK)	A return from a subroutine occurs.		
	RTI	Return from interrupt routine	0 0 1 0	0 0 1 0	1	1	PC ← (STACK) CF ZF ← CSF, ZSF	A return from an interrupt service routine occurs.	ZF CF	
	BANK	Change bank	1 1 1 1	1 1 0 1	1	1		The bank is changed. A pseudo I/O port is specified.		Effective only when used immediately before an I/O instruction or branch instruction.
Branch instructions	BA <sub>t</sub> addr	Branch on AC bit	0 1 1 1	0 0 1 1 1 0 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if AC <sub>t</sub> = 1	If a single bit of the AC specified with the immediate data t <sub>1</sub> t <sub>0</sub> is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BA0 to BA3 according to the value of t.
	BNA <sub>t</sub> addr	Branch on no AC bit	0 0 1 1	0 0 1 1 1 0 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if AC <sub>t</sub> = 0	If a single bit of the AC specified with the immediate data t <sub>1</sub> t <sub>0</sub> is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BNA0 to BNA3 according to the value of t.
	BM <sub>t</sub> addr	Branch on M bit	0 1 1 1	0 1 1 1 1 0 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if (M(DP <sub>L</sub> ), t <sub>1</sub> t <sub>0</sub> ) = 1	If a single bit of the M(DP <sub>L</sub> ) specified with the immediate data t <sub>1</sub> t <sub>0</sub> is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BM0 to BM3 according to the value of t.
	BNM <sub>t</sub> addr	Branch on no M bit	0 0 1 1	0 1 1 1 1 0 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if (M(DP <sub>L</sub> ), t <sub>1</sub> t <sub>0</sub> ) = 0	If a single bit of the M(DP <sub>L</sub> ) specified with the immediate data t <sub>1</sub> t <sub>0</sub> is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BNM0 to BNM3 according to the value of t.
	BP <sub>t</sub> addr	Branch on Port bit	0 1 1 1	1 0 1 1 1 0 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if (P(DP <sub>L</sub> ), t <sub>1</sub> t <sub>0</sub> ) = 1	If a single bit of port P(DP <sub>L</sub> ) specified with the immediate data t <sub>1</sub> t <sub>0</sub> is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BP0 to BP3 according to the value of t.
	BNP <sub>t</sub> addr	Branch on no Port bit	0 0 1 1	1 0 1 1 1 0 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if (P(DP <sub>L</sub> ), t <sub>1</sub> t <sub>0</sub> ) = 0	If a single bit of port P(DP <sub>L</sub> ) specified with the immediate data t <sub>1</sub> t <sub>0</sub> is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BNP0 to BNP3 according to the value of t.
	BTM addr	Branch on timer	0 1 1 1	1 1 0 0	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if TMF = 1 then TMF ← 0	If the TMF is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs. The TMF is reset.	TMF	

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Instruction group	Mnemonic	Instruction code		Bytes	Cycles	Function	Description	Status flag affected	Remarks	
		D <sub>7</sub> D <sub>6</sub> D <sub>5</sub> D <sub>4</sub>	D <sub>3</sub> D <sub>2</sub> D <sub>1</sub> D <sub>0</sub>							
Branch instructions	BNTM addr	Branch on no timer	0 0 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 0 0 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if TMF = 0 then TMF ← 0	If the TMF is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs. The TMF is reset.	TMF	
	BI addr	Branch on interrupt	0 1 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 0 1 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if EXTF = 1 then EXTF ← 0	If the EXTF is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs. The EXTF is reset.	EXTF	
	BNI addr	Branch on no interrupt	0 0 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 0 1 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if EXTF = 0 then EXTF ← 0	If the EXTF is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs. The EXTF is reset.	EXTF	
	BC addr	Branch on CF	0 1 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 1 1 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if CF = 1	If the CF is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		
	BNC addr	Branch on no CF	0 0 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 1 1 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if CF = 0	If the CF is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		
	BZ addr	Branch on ZF	0 1 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 1 0 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if ZF = 1	If the ZF is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		
	BNZ addr	Branch on no ZF	0 0 1 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	1 1 1 0 P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if ZF = 0	If the ZF is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		
	BFn addr	Branch on flag bit	1 1 0 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	n <sub>3</sub> n <sub>2</sub> n <sub>1</sub> n <sub>0</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if Fn = 1	If the flag bit of the 16 flags specified with the immediate data n <sub>3</sub> n <sub>2</sub> n <sub>1</sub> n <sub>0</sub> is 1, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BFO to #P 16 according to the value of n.
	BNFn addr	Branch on no flag bit	1 0 0 1 P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub>	n <sub>3</sub> n <sub>2</sub> n <sub>1</sub> n <sub>0</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub>	2	2	PC <sub>7-0</sub> ← P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> if Fn = 0	If the flag bit of the 16 flags specified with the immediate data n <sub>3</sub> n <sub>2</sub> n <sub>1</sub> n <sub>0</sub> is 0, a branch to the address specified with the immediate data P <sub>7</sub> P <sub>6</sub> P <sub>5</sub> P <sub>4</sub> P <sub>3</sub> P <sub>2</sub> P <sub>1</sub> P <sub>0</sub> within the same page occurs.		Mnemonic is BNFO to #P 16 according to the value of n.
Input/Output instructions	IP	Input port to AC	0 0 0 0	1 1 0 0	1	1	AC ← (P(DP <sub>L</sub> ))	Port P(DP <sub>L</sub> ) contents are loaded in the AC.	ZF	
	OP	Output AC to port	0 1 1 0	0 0 0 1	1	1	P(DP <sub>L</sub> ) ← (AC)	The AC contents are outputted to port P(DP <sub>L</sub> ).		
	SPB bit	Set port bit	0 0 0 0	0 1 B <sub>1</sub> B <sub>0</sub>	1	2	P(DP <sub>L</sub> , B <sub>1</sub> B <sub>0</sub> ) ← 1	A single bit in port P(DP <sub>L</sub> ) specified with the immediate data B <sub>1</sub> B <sub>0</sub> is set.		When this instruction is executed, the E contents are destroyed.
	RPB bit	Reset port bit	0 0 1 0	0 1 B <sub>1</sub> B <sub>0</sub>	1	2	P(DP <sub>L</sub> , B <sub>1</sub> B <sub>0</sub> ) ← 0	A single bit in port P(DP <sub>L</sub> ) specified with the immediate data B <sub>1</sub> B <sub>0</sub> is reset.	ZF	When this instruction is executed, the E contents are destroyed.
Other instructions	SCTL bit	Set control register bit(S)	0 0 1 0 1 0 0 0	1 1 0 0 B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub>	2	2	CTL ← (CTL) V B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub>	The bits of the control register specified with the immediate data B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub> are set.		
	RCTL bit	Reset control register bit(S)	0 0 1 0 1 0 0 1	1 1 0 0 B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub>	2	2	CTL ← (CTL) A B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub>	The bits of the control register specified with the immediate data B <sub>3</sub> B <sub>2</sub> B <sub>1</sub> B <sub>0</sub> are reset.	ZF	
	WTTM	Write timer	1 1 1 1	1 0 0 1	1	1	TM ← (E), (AC) TMF ← 0	The E and AC contents are loaded in the timer. The TMF is reset.	TMF	
	HALT	Halt	1 1 1 1	0 1 1 0	1	1	Halt	All operations stop.		Only when all pins of port PA are set at L, stop
	NOP	No operation	0 0 0 0	0 0 0 0	1	1	No operation	No operation is performed, but 1 machine cycle is consumed.		

\*1 If the CLA instruction is used continuously in such a manner as CLA, CLA, -----, the first CLA instruction only is effective and the following CLA instructions are changed to the NOP instructions. This is also true of the LI instruction.

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