

# MSM64162A

## 4-Bit Microcontroller with Built-in RC Oscillation Type A/D Converter and LCD Driver

### GENERAL DESCRIPTION

The MSM64162A is a low power 4-bit microcontroller that employs Oki's original CPU core nX-4/20.

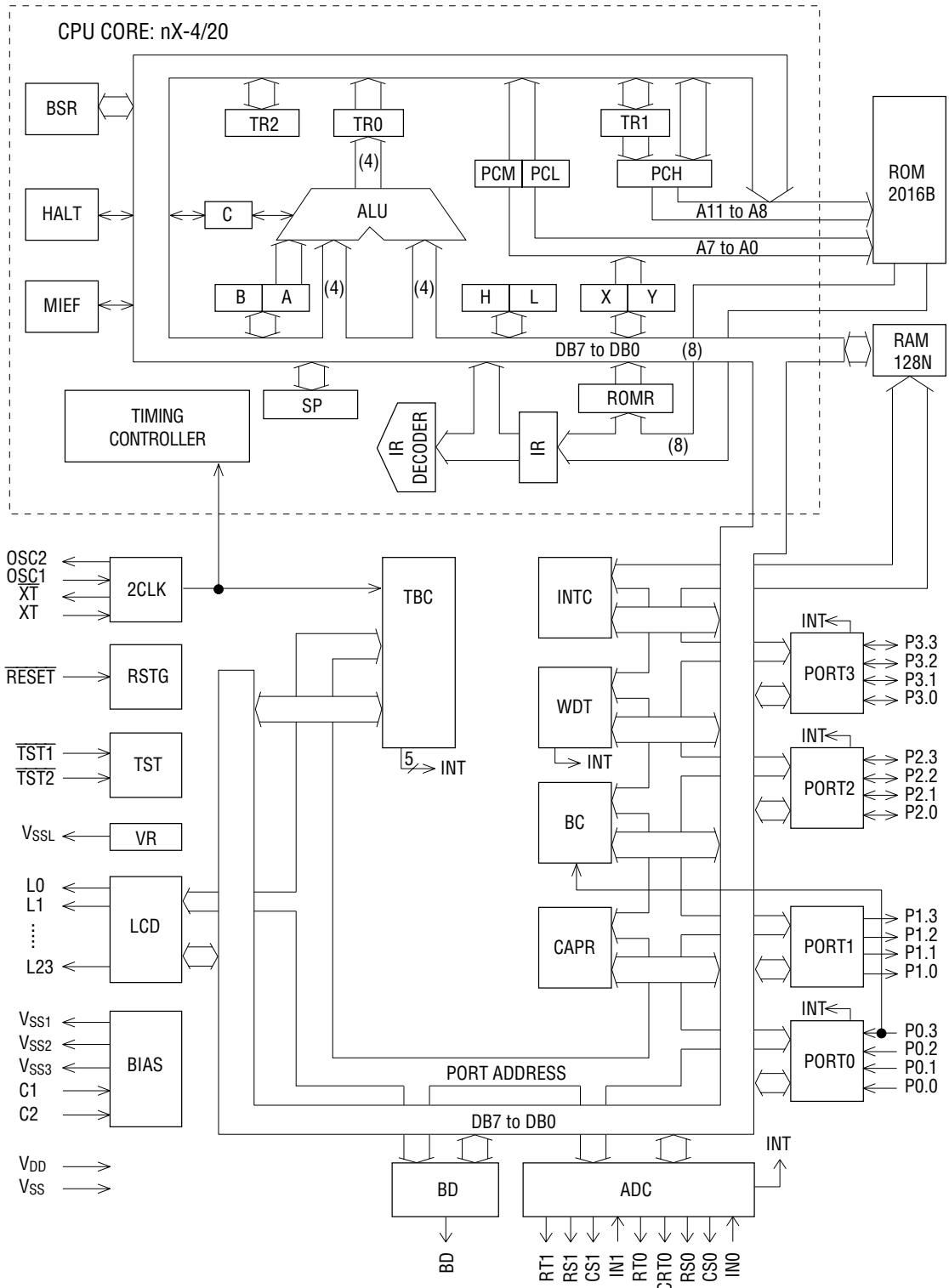
The MSM64162A has 2-channel RC oscillation type A/D converter, LCD driver for up to 80 segments, and buzzer output port. It is best suited for applications such as low power, high precision thermometers and hygrometers.

### FEATURES

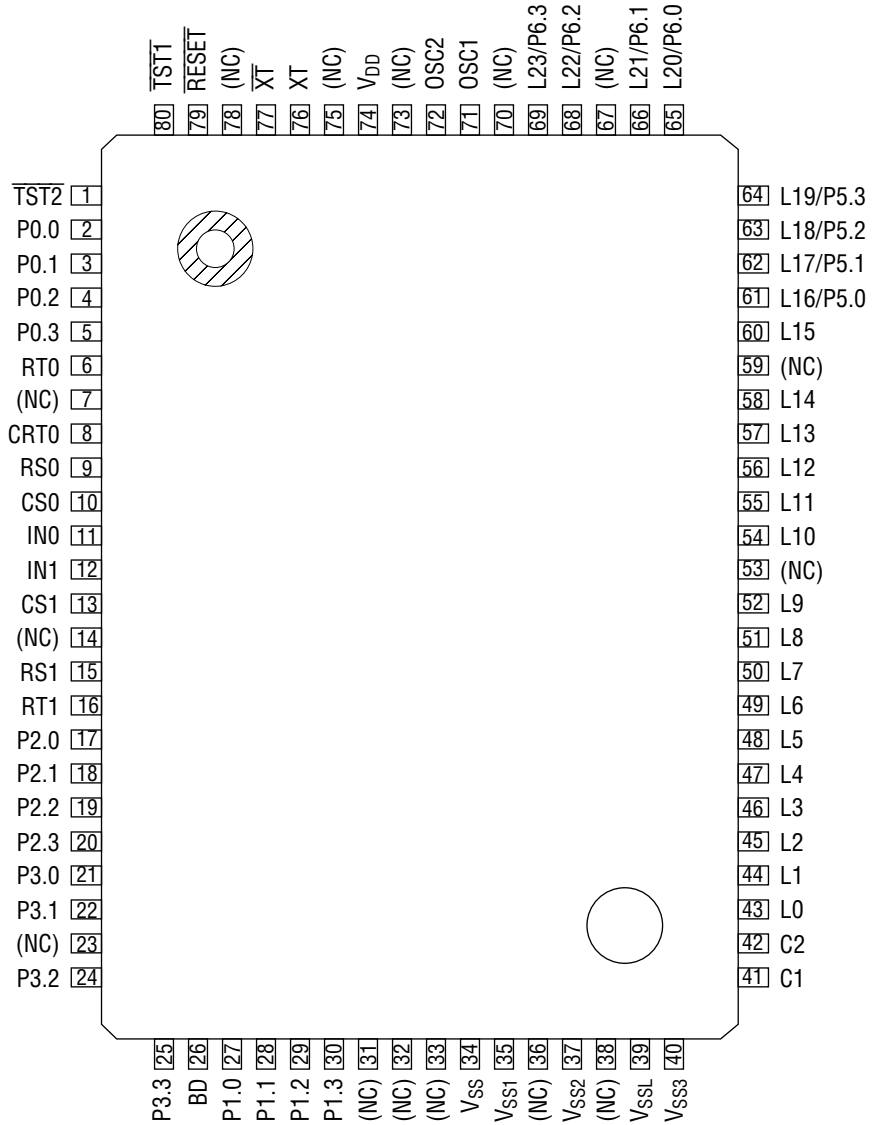
- Operating range
    - Operating frequencies : 32.768 kHz, 400 kHz
    - Operating voltage : 1.25 to 1.7 V (1.5 V spec.)  
2.0 to 3.5 V (3 V spec.)  
2.2 to 3.5 V (3 V spec., 1/2 duty)
    - Operating temperature : -40 to +85°C
  - Memory space
    - Internal program memory : 2016 bytes
    - Internal data memory : 128 nibbles
  - Minimum instruction execution time : 7.5 μs @ 400 kHz  
91.6 μs @ 32.768 kHz
  - RC oscillation type A/D converter : 2 channels  
Time division 2-channel method
  - LCD driver : 24 outputs
    - (1) At 1/4 duty and 1/3 bias : 80 segments (max)
    - (2) At 1/3 duty and 1/3 bias : 63 segments (max)
    - (3) At 1/2 duty and 1/2 bias : 44 segments (max)
- Voltage Regulator for LCD Driver (selectable by mask option)  
The LCD panel display is stable regardless of temporary supply voltage drop, because the voltage generated by the voltage regulator for LCD driver is supplied to the bias voltage generator as a reference voltage.
- LCD Operating Voltage
- When the voltage regulator for LCD driver is used
- : 3.6 V (Duty cycle = 1/4 or 1/3)
  - 2.4 V (Duty cycle = 1/2)
- When the voltage regulator for LCD driver is not used
- : 4.5 V (Duty cycle = 1/4 or 1/3)
  - 3.0 V (Duty cycle = 1/2)
- Buzzer driver : 1 output (4 output modes selectable)
  - Capture circuit : 2 channels
  - Watchdog timer
  - Clock : 32.768 kHz crystal oscillator and 400 kHz RC oscillator (with an external resistor)
  - CPU clock : 32.768 kHz/400 kHz (switchable by software)
  - Time base clock : 32.768 kHz
  - Power supply voltage : 1.5 V/3 V (selectable by mask option)

- I/O port
  - Input-output port : 2 ports × 4 bits
  - Input port : 1 port × 4 bits
  - Output port : 1 port × 4 bits  
(8 out of the 24 LCD driver outputs can be used as output-only ports by mask option.)
- Interrupt sources
  - External interrupt : 2 sources
  - Internal interrupt : 7 sources
- Battery check circuit : 1 (incorporated into the input-only port)
- Package:
  - 80-pin plastic QFP (QFP80-P-1420-0.80-BK) : (Product name : MSM64162A-xxxGS-BK)
  - Chip : (Product name : MSM64162A-xxx)  
xxx indicates a code number.

**BLOCK DIAGRAM**



**PIN CONFIGURATION (TOP VIEW)**

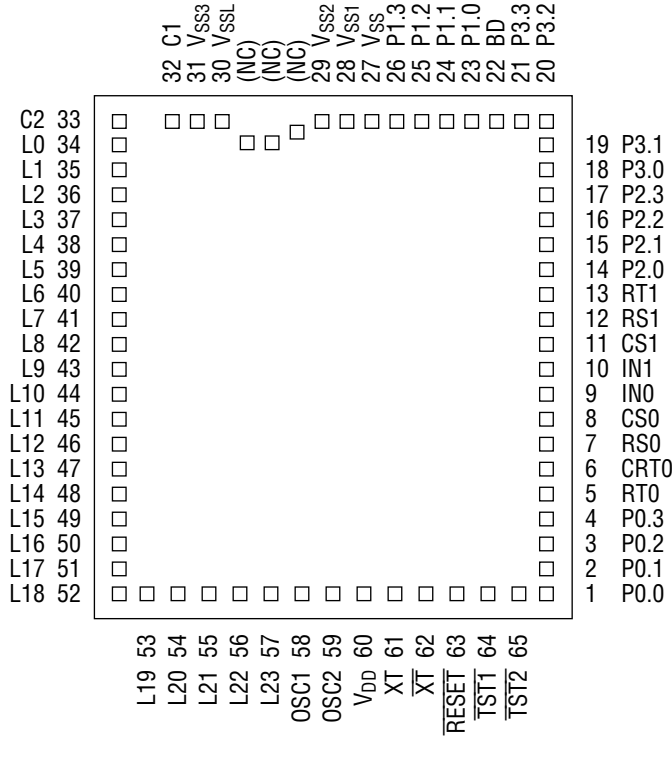


**80-Pin Plastic QFP**

Note: Pins marked as (NC) are no-connection pins which are left open.

## PAD CONFIGURATION

### Pad Layout



Chip Size : 3.96 mm × 4.32 mm  
 Chip Thickness : 350 μm (typ.)  
 Coordinate Origin : Chip center  
 Pad Hole Size : 110 μm × 110 μm  
 Pad Size : 120 μm × 120 μm  
 Minimum Pad Pitch : 180 μm

Note: The chip substrate voltage is V<sub>DD</sub>.

## Pad Coordinates

Pad No.	Pad Name	X (μm)	Y (μm)	Pad No.	Pad Name	X (μm)	Y (μm)
1	P0.0	1828.80	-1940.40	41	L7	-1829.40	379.50
2	P0.1	1828.80	-1719.30	42	L8	-1829.40	199.50
3	P0.2	1828.80	-1539.30	43	L9	-1829.40	10.20
4	P0.3	1828.80	-1310.10	44	L10	-1829.40	-232.20
5	RT0	1828.80	-1048.50	45	L11	-1829.40	-412.20
6	CRT0	1828.80	-831.30	46	L12	-1829.40	-592.20
7	RS0	1828.80	-651.30	47	L13	-1829.40	-772.20
8	CS0	1828.80	-396.00	48	L14	-1829.40	-1008.00
9	IN0	1828.80	-208.20	49	L15	-1829.40	-1290.00
10	IN1	1828.80	-12.90	50	L16	-1829.40	-1470.00
11	CS1	1828.80	175.50	51	L17	-1829.40	-1710.00
12	RS1	1828.80	390.30	52	L18	-1829.40	-1928.10
13	RT1	1828.80	580.50	53	L19	-1495.20	-1957.50
14	P2.0	1828.80	794.10	54	L20	-1226.70	-1957.50
15	P2.1	1828.80	1001.70	55	L21	-958.80	-1957.50
16	P2.2	1828.80	1194.00	56	L22	-694.80	-1957.50
17	P2.3	1828.80	1374.00	57	L23	-448.80	-1957.50
18	P3.0	1828.80	1555.20	58	OSC1	-243.00	-1957.50
19	P3.1	1828.80	1735.20	59	OSC2	24.90	-1957.50
20	P3.2	1769.70	1957.80	60	V <sub>DD</sub>	300.60	-1957.50
21	P3.3	1589.70	1957.80	61	XT	480.60	-1957.50
22	BD	1317.60	1957.80	62	$\overline{XT}$	660.60	-1957.50
23	P1.0	999.30	1957.80	63	$\overline{RESET}$	979.50	-1957.50
24	P1.1	674.70	1957.80	64	$\overline{TST1}$	1247.70	-1957.50
25	P1.2	354.90	1957.80	65	$\overline{TST2}$	1599.90	-1957.50
26	P1.3	30.30	1957.80				
27	V <sub>SS</sub>	-231.00	1957.80				
28	V <sub>SS1</sub>	-411.00	1957.80				
29	V <sub>SS2</sub>	-647.10	1957.80				
30	V <sub>SSL</sub>	-1289.40	1957.80				
31	V <sub>SS3</sub>	-1469.40	1957.80				
32	C1	-1649.40	1957.80				
33	C2	-1829.40	1957.80				
34	L0	-1829.40	1704.00				
35	L1	-1829.40	1524.00				
36	L2	-1829.40	1344.00				
37	L3	-1829.40	1111.20				
38	L4	-1829.40	919.50				
39	L5	-1829.40	739.50				
40	L6	-1829.40	559.50				

## PIN DESCRIPTIONS

## Basic Functions

Function	Symbol	Pin	Pad	Type	Description
Power Supply	V <sub>DD</sub>	74	60	—	0 V power supply
	V <sub>SS</sub>	34	27	—	Negative power supply: Ground V <sub>SS1</sub> . (for 1.5 V spec.) Ground V <sub>SS2</sub> . (for 3.0 V spec.)
	V <sub>SS1</sub>	35	28	—	Negative power supply (for 1.5 V spec.) Bias output for driving LCD (–1.5 V) (for 3.0 V spec.) Bias output for driving LCD (–1.2 V) (when the voltage regulator for LCD driver is used)
	V <sub>SS2</sub>	37	29	—	Negative power supply (for 3.0 V spec.) Bias output for driving LCD (–3.0 V) (for 1.5 V spec.)
	V <sub>SS3</sub>	40	31	—	Bias output for driving LCD (–4.5 V).
	C1	41	32	—	Pins for connecting a capacitor for generating LCD driving bias
	C2	42	33	—	
Oscillation	V <sub>SSL</sub>	39	30	—	Negative power supply for internal logic (An internally generated constant voltage is present at this pin.)
	XT	76	61	I	Low-speed clock oscillation input and output pins: Connect to a crystal (32.768 kHz).
	$\overline{XT}$	77	62	O	
	OSC1	71	58	I	High-speed clock oscillation input and output pins: Connect to an external resistor for oscillation (R <sub>OS</sub> ).
OSC2	72	59	O		
Test	$\overline{TST1}$	80	64	I	Input pins for testing.
	$\overline{TST2}$	1	65	I	A pull-up resistor is internally connected to these pins.
Reset	$\overline{RESET}$	79	63	I	System reset input pin. Setting this pin to "L" level puts this device into a reset state. Then, setting this pin to "H" level starts executing an instruction from address 000H. A pull-up resistor is internally connected to this pin.

## Basic Functions (continued)

Function	Symbol	Pin	Pad	Type	Description
Ports	P0.0	2	1	I	4-bit input port (P0): Selectable as pull-up resistor input, pull-down resistor input, or high impedance input by the port 01 control register (P01CON). As secondary functions, P0.0 to P0.3 are assigned external interrupt functions, P0.0 and P0.1 are assigned a capture trigger function, and P0.3 is assigned an analog comparator input for battery check.
	P0.1	3	2	I	
	P0.2	4	3	I	
	P0.3	5	4	I	
	P1.0	27	23	O	4-bit output port (P1): Selectable as NMOS open drain output or CMOS output by the port 01 control register (P01CON). P1.0 is a high current drive output port.
	P1.1	28	24	O	
	P1.2	29	25	O	
	P1.3	30	26	O	
	P2.0	17	14	I/O	4-bit input-output port (P2): Following can be specified for each bit by the port 2 control registers 0 to 3 (P20CON to P23CON): (1) input or output, (2) pull-up/pull-down resistor input or high impedance input, and (3) NMOS open drain output or CMOS output. As secondary functions, P2.0 to P2.3 are assigned external interrupt functions.
	P2.1	18	15	I/O	
	P2.2	19	16	I/O	
	P2.3	20	17	I/O	
	P3.0	21	18	I/O	4-bit input-output port (P3): Following can be specified for each bit by the port 3 control registers 0 to 3 (P30CON to P33CON): (1) input or output, (2) pull-up/pull-down resistor input or high impedance input, and (3) NMOS open drain output or CMOS output. As secondary functions, P3.0 to P3.3 are assigned external interrupt functions, P3.3 is assigned a function that monitors the RC oscillation clock for A/D converter.
	P3.1	22	19	I/O	
P3.2	24	20	I/O		
P3.3/MON	25	21	I/O		
Buzzer	BD	26	22	O	Output pin for the buzzer driver
A/D Converter	RT0	6	5	O	Resistance temperature sensor connection pin (for channel 0)
	CRT0	8	6	O	Resistance/capacitance temperature sensor connection pin (for channel 0)
	RS0	9	7	O	Reference resistor connection pin (for channel 0)
	CS0	10	8	O	Reference capacitor connection pin (for channel 0)
	IN0	11	9	I	Input pin for RC oscillator circuit (for channel 0)
	RT1	16	13	O	Resistance temperature sensor connection pin (for channel 1)
	RS1	15	12	O	Reference resistor connection pin (for channel 1)
	CS1	13	11	O	Reference capacitor connection pin (for channel 1)
	IN1	12	10	I	Input pin for RC oscillator circuit (for channel 1)



**Basic Functions (continued)**

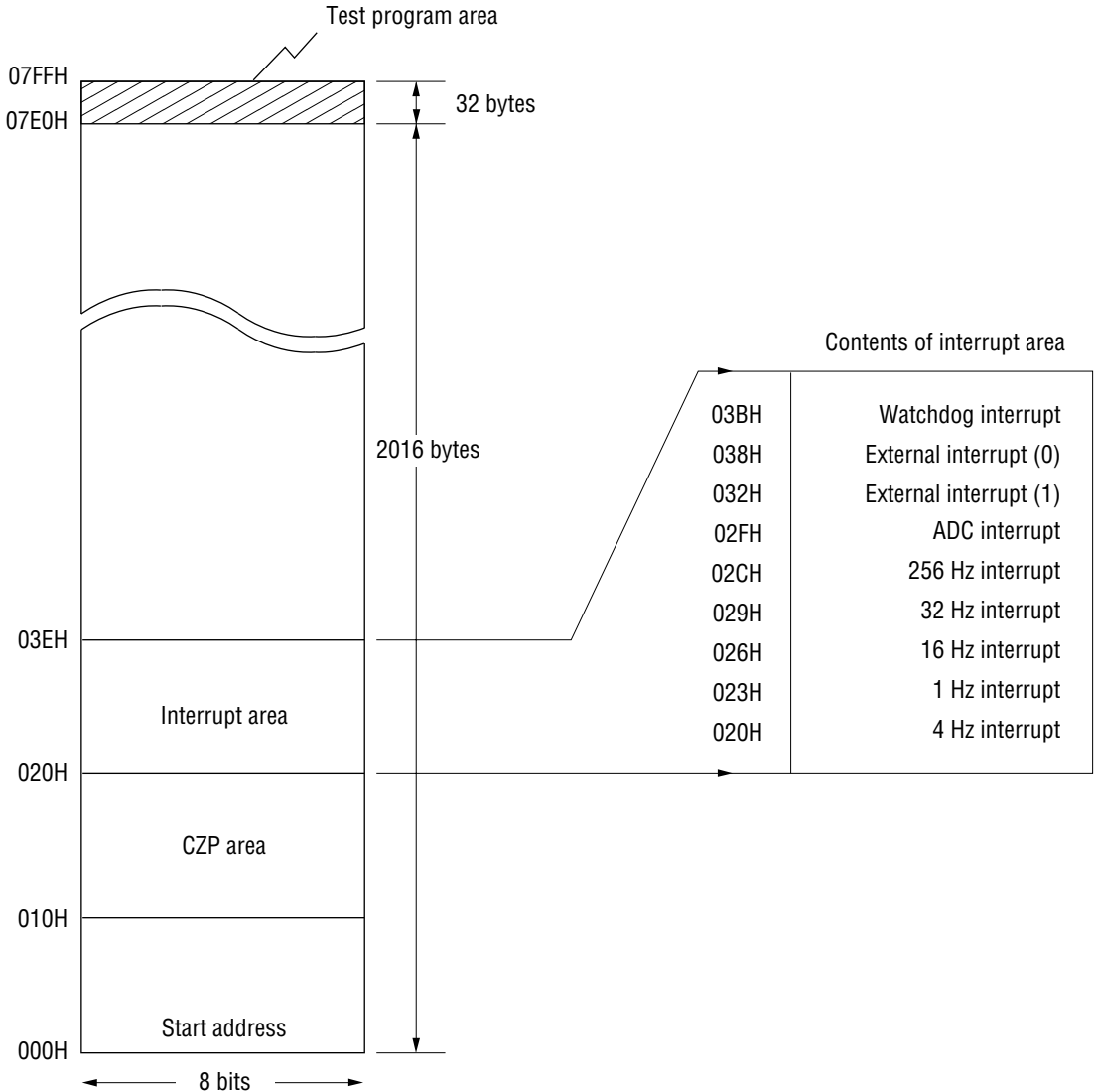
Function	Symbol	Pin	Pad	Type	Description
LCD Driver	L0	43	34	0	LCD segment and common signals output pins.
	L1	44	35	0	
	L2	45	36	0	
	L3	46	37	0	
	L4	47	38	0	
	L5	48	39	0	
	L6	49	40	0	
	L7	50	41	0	
	L8	51	42	0	
	L9	52	43	0	
	L10	54	44	0	
	L11	55	45	0	
	L12	56	46	0	
	L13	57	47	0	
	L14	58	48	0	
L15	60	49	0		
L16/P5.0	61	50	0	LCD segment and common signals output pins. Functions as output ports by mask option.	
L17/P5.1	62	51	0		
L18/P5.2	63	52	0		
L19/P5.3	64	53	0		
L20/P6.0	65	54	0		
L21/P6.1	66	55	0		
L22/P6.2	68	56	0		
L23/P6.3	69	57	0		

## Secondary Functions

Function	Symbol	Pin	Pad	Type	Description
External Interrupt	P0.0	2	1	I	Secondary functions of P0.0 to P0.3: Level-triggered external interrupt input pins. The change of input signal level causes an interrupt to occur.
	P0.1	3	2		
	P0.2	4	3		
	P0.3	5	4		
	P2.0	17	14	I	Secondary functions of P2.0 to P2.3 and P3.0 to P3.3: Level-triggered external interrupt input pins. The change of input signal level causes an interrupt to occur.
	P2.1	18	15		
	P2.2	19	16		
	P2.3	20	17		
	P3.0	21	18		
	P3.1	22	19		
Capture Trigger	P0.0	2	1	I	Secondary functions of P0.0 and P0.1: Capture circuit trigger input pins.
	P0.1	3	2		
RC Oscillation Monitor	P3.3	25	21	0	Secondary function of P3.3: Monitor output pin for an RC oscillation clock for A/D converter and a 400 kHz RC oscillation clock for the system clock.
Battery Check	P0.3	5	4	I	Secondary function of P0.3: Analog comparator input pin for battery check.

## MEMORY MAPS

### Program Memory



**Program Memory Map**

Address 000H is the instruction execution start address by the system reset.

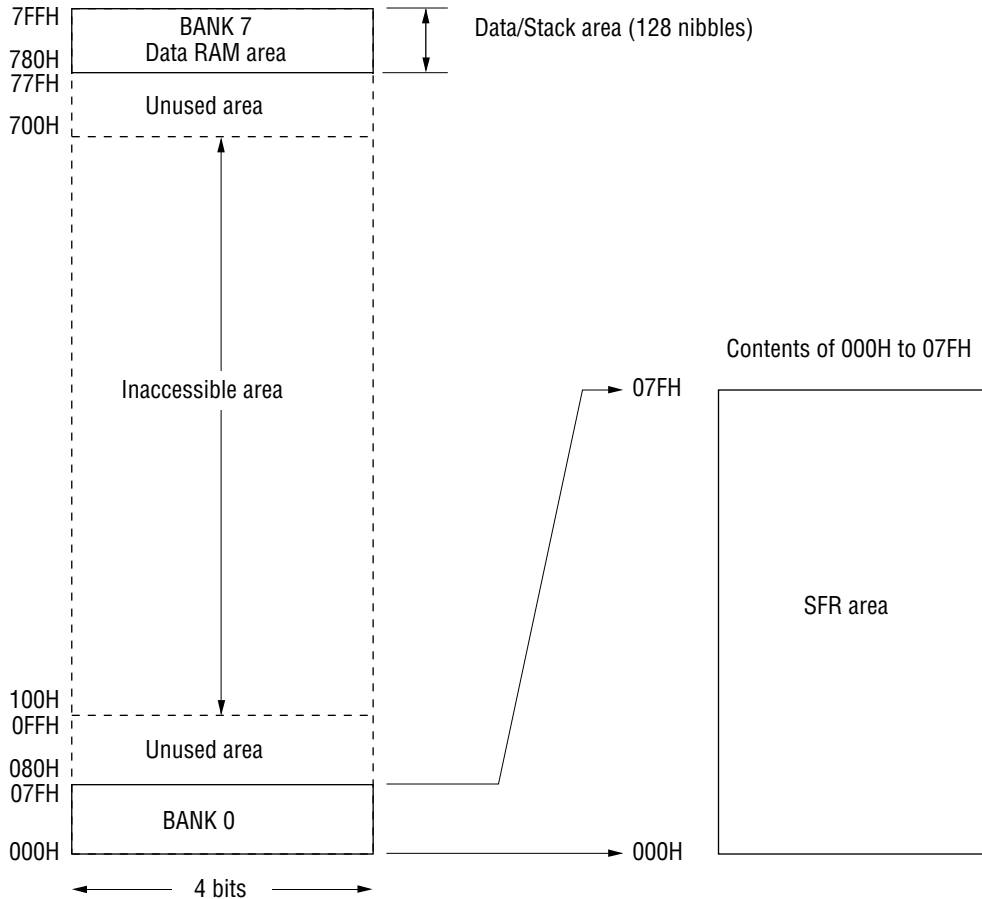
The CZP area from address 010H to address 01FH is the start address for the CZP subroutine of 1-byte call instruction.

The start address of interrupt subroutine is assigned to the interrupt address from address 020H to 03DH.

The user area has 2016 bytes of address 000H to address 07DFH. No program can be stored in the test program area.

## Data Memory

The data memory area consists of 8 banks and each bank has 256 nibbles ( $256 \times 4$  bits). The data RAM is assigned to BANK 7 and peripheral ports are assigned to BANK 0.



**Data Memory Map**

The data RAM area (128 nibbles) is shared by the stack area. The stack is a memory starting from address 7FFH toward the low-order addresses where 4 nibbles are used by Subroutine Call Instruction and 8 nibbles are used by an interrupt.

The addresses 080H to 0FFH of BANK 0 and the addresses 700H to 77FH of BANK 7 are not assigned as the data memory, so access to these addresses has no effect. Moreover, it is impossible to access BANK 1 to BANK 6.

**ABSOLUTE MAXIMUM RATINGS (1.5 V Spec.)**(V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage 1	V <sub>SS</sub>	T <sub>a</sub> = 25°C	-2.0 to +0.3	V
Power Supply Voltage 2	V <sub>SS1</sub>	T <sub>a</sub> = 25°C	-2.0 to +0.3	V
Power Supply Voltage 3	V <sub>SS2</sub>	T <sub>a</sub> = 25°C	-4.0 to +0.3	V
Power Supply Voltage 4	V <sub>SS3</sub>	T <sub>a</sub> = 25°C	-5.5 to +0.3	V
Power Supply Voltage 5	V <sub>SSL</sub>	T <sub>a</sub> = 25°C	-2.0 to +0.3	V
Input Voltage 1	V <sub>IN1</sub>	V <sub>SS</sub> Input, T <sub>a</sub> = 25°C	V <sub>SS</sub> - 0.3 to +0.3	V
Input Voltage 2	V <sub>IN2</sub>	V <sub>SS1</sub> Input, T <sub>a</sub> = 25°C	V <sub>SS1</sub> - 0.3 to +0.3	V
Input Voltage 3	V <sub>IN3</sub>	V <sub>SSL</sub> Input, T <sub>a</sub> = 25°C	V <sub>SSL</sub> - 0.3 to +0.3	V
Output Voltage 1	V <sub>OUT1</sub>	V <sub>SS</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS</sub> - 0.3 to +0.3	V
Output Voltage 2	V <sub>OUT2</sub>	V <sub>SS1</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS1</sub> - 0.3 to +0.3	V
Output Voltage 3	V <sub>OUT3</sub>	V <sub>SS2</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS2</sub> - 0.3 to +0.3	V
Output Voltage 4	V <sub>OUT4</sub>	V <sub>SS3</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS3</sub> - 0.3 to +0.3	V
Output Voltage 5	V <sub>OUT5</sub>	V <sub>SSL</sub> Output, T <sub>a</sub> = 25°C	V <sub>SSL</sub> - 0.3 to +0.3	V
Storage Temperature	T <sub>STG</sub>	—	-55 to +150	°C

**RECOMMENDED OPERATING CONDITIONS (1.5 V Spec.)**(V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Range	Unit
Operating Temperature	T <sub>op</sub>	—	-40 to +85	°C
Operating Voltage	V <sub>SS</sub> , V <sub>SS1</sub>	V <sub>SS1</sub> is grounded	-1.7 to -1.25	V
External 400 kHz RC Oscillator Resistance	R <sub>OS</sub>	—	250 to 500	kΩ
Crystal Oscillation Frequency	f <sub>XT</sub>	—	30 to 35	kHz

**ELECTRICAL CHARACTERISTICS (1.5 V Spec.)****DC Characteristics** $(V_{DD} = 0\text{ V}, V_{SS} = V_{SS1} = -1.5\text{ V}, T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
V <sub>SS2</sub> Voltage	V <sub>SS2</sub>	C <sub>a</sub> , C <sub>b</sub> , C <sub>12</sub> = 0.1 μF +100% -50%	-3.2	-3.0	-2.8	V	1
V <sub>SS3</sub> Voltage	V <sub>SS3</sub>	C <sub>a</sub> , C <sub>b</sub> , C <sub>12</sub> = 0.1 μF +100% -50%	-4.7	-4.5	-4.3	V	
V <sub>SSL</sub> Voltage	V <sub>SSL</sub>	—	-1.5	-1.3	-0.6	V	
Crystal Oscillation Start Voltage	V <sub>STA</sub>	Oscillation start time: within 5 seconds	—	—	-1.45	V	
Crystal Oscillation Hold Voltage	V <sub>HOLD</sub>	—	—	—	-1.25	V	
Crystal Oscillation Stop Detection Time	T <sub>STOP</sub>	—	0.1	—	1000	ms	
Internal Crystal Oscillator Capacitance	C <sub>G</sub>	—	10	15	20	pF	
External Crystal Oscillator Capacitance	C <sub>GEX</sub>	When external C <sub>G</sub> used	10	—	30	pF	
Internal Crystal Oscillator Capacitance	C <sub>D</sub>	—	10	15	20	pF	
Internal 400k RC Oscillator Capacitance	C <sub>OS</sub>	—	8.0	12	16	pF	
400k RC Oscillation Frequency	f <sub>OSC</sub>	External resistor R <sub>OS</sub> = 300 kΩ V <sub>SS</sub> = -1.25 to -1.7 V	80	220	350	kHz	
POR Generation Voltage	V <sub>POR1</sub>	When V <sub>SS</sub> is between V <sub>POR1</sub> and -1.5 V	-0.4	—	0	V	
POR Non-generation Voltage	V <sub>POR2</sub>	No POR when V <sub>SS</sub> is between V <sub>POR2</sub> and -1.5 V	-1.5	—	-1.2	V	
Battery Check Reference Voltage	V <sub>RB</sub>	T <sub>a</sub> = 25°C	-0.73	-0.63	-0.53	V	2
V <sub>RB</sub> Temperature Variation	ΔV <sub>RB</sub>	—	—	-2.0	—	mV/°C	

Notes: 1. "POR" denotes Power On Reset.

2. "T<sub>STOP</sub>" indicates that if the crystal oscillator stops over the value of T<sub>STOP</sub>, the system reset occurs.

## DC Characteristics (continued)

(V<sub>DD</sub> = 0 V, V<sub>SS</sub> = V<sub>SS1</sub> = -1.5 V, T<sub>a</sub> = -40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit	
Supply Current 1	I <sub>DD1</sub>	CPU in halt state (400k RC oscillation halt)	T <sub>a</sub> = -40 to +40°C	—	2.0	5.0	μA	1
			T <sub>a</sub> = +40 to +85°C	—	2.0	30	μA	
Supply Current 2	I <sub>DD2</sub>	CPU in operating state (400k RC oscillation halt)	T <sub>a</sub> = -40 to +40°C	—	5.0	15	μA	
			T <sub>a</sub> = +40 to +85°C	—	5.0	40	μA	
Supply Current 3	I <sub>DD3</sub>	CPU in operating state (400k RC oscillation in operation) R <sub>OS</sub> = 300 kΩ	—	40	80	μA		
Supply Current 4	I <sub>DD4</sub>	CPU in halt state (400k RC oscillation halt), RC oscillator for A/D converter is in operating state	RT0 = 10 kΩ	—	150	230	μA	
			RT0 = 2 kΩ	—	600	900	μA	
Supply Current 5	I <sub>DD5</sub>	Battery check circuit in operating state, CPU in operating state (400k RC oscillation halt)	—	25	125	μA		

## DC Characteristics (continued)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS} = V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Output Current 1 (P1.0)	$I_{OH1}$	$V_{OH1} = -0.5\text{ V}$	-2.1	-0.5	-0.1	mA	2
	$I_{OL1}$	$V_{OL1} = V_{SS} + 0.5\text{ V}$	1.0	3.0	9.0	mA	
Output Current 2 (P1.1 to P1.3) (P2.0 to P2.3) (P3.0 to P3.3)	$I_{OH2}$	$V_{OH2} = -0.5\text{ V}$	-2.1	-0.5	-0.1	mA	
	$I_{OL2}$	$V_{OL2} = V_{SS} + 0.5\text{ V}$	0.1	0.5	2.1	mA	
Output Current 3 (BD)	$I_{OH3}$	$V_{OH3} = -0.7\text{ V}$	-1.8	-0.4	-0.1	mA	
	$I_{OL3}$	$V_{OL3} = V_{SS} + 0.7\text{ V}$	0.1	0.4	1.8	mA	
Output Current 4 (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OH4}$	$V_{OH4} = -0.1\text{ V}$	-1.1	-0.4	-0.2	mA	
	$I_{OL4}$	$V_{OL4} = V_{SS} + 0.1\text{ V}$	0.2	0.4	1.1	mA	
Output Current 5 (When L16 to L23 are configured as output ports)	$I_{OH5}$	$V_{OH5} = -0.5\text{ V}$	-1.5	-0.4	-0.08	mA	
	$I_{OL5}$	$V_{OL5} = V_{SS} + 0.5\text{ V}$	0.08	0.4	1.5	mA	
Output Current 6 (OSC2)	$I_{OH6}$	$V_{OH6} = -0.5\text{ V}$	-2.1	-0.5	-0.1	mA	
	$I_{OL6}$	$V_{OL6} = V_{SS} + 0.5\text{ V}$	0.1	0.5	2.1	mA	
Output Current 7 (LO to L23)	$I_{OH7}$	$V_{OH7} = -0.2\text{ V}$ ( $V_{DD}$ level)	—	—	-4.0	$\mu\text{A}$	
	$I_{OMH7}$	$V_{OMH7} = V_{SS1} + 0.2\text{ V}$ ( $V_{SS1}$ level)	4.0	—	—	$\mu\text{A}$	
	$I_{OMH7S}$	$V_{OMH7S} = V_{SS1} - 0.2\text{ V}$ ( $V_{SS1}$ level)	—	—	-4.0	$\mu\text{A}$	
	$I_{OML7}$	$V_{OML7} = V_{SS2} + 0.2\text{ V}$ ( $V_{SS2}$ level)	4.0	—	—	$\mu\text{A}$	
	$I_{OML7S}$	$V_{OML7S} = V_{SS2} - 0.2\text{ V}$ ( $V_{SS2}$ level)	—	—	-4.0	$\mu\text{A}$	
	$I_{OL7}$	$V_{OL7} = V_{SS3} + 0.2\text{ V}$ ( $V_{SS3}$ level)	4.0	—	—	$\mu\text{A}$	
Output Leakage Current (P1.0 to P1.3) (P2.0 to P2.3) (P3.0 to P3.3) (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OOH}$	$V_{OH} = V_{DD}$	—	—	0.3	$\mu\text{A}$	
	$I_{OOL}$	$V_{OL} = V_{SS}$	-0.3	—	—	$\mu\text{A}$	



## DC Characteristics (continued)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS} = V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

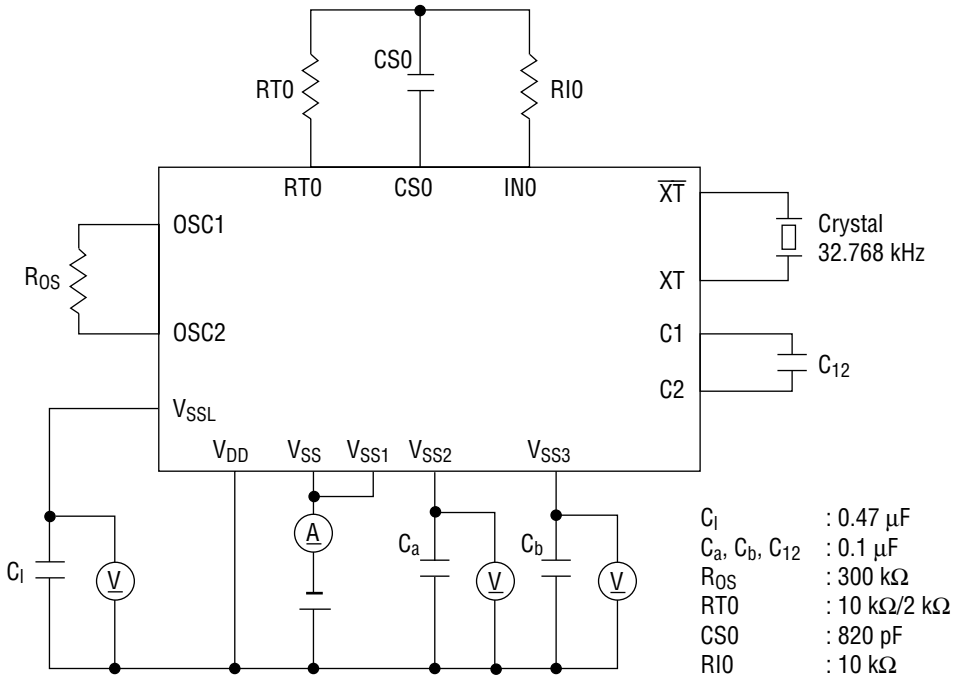
Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Input Current 1 (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3) (P4.0 to P4.3)	$I_{IH1}$	$V_{IH1} = V_{DD}$ (when pulled down)	2.0	10	60	$\mu\text{A}$	3
	$I_{IL1}$	$V_{IL1} = V_{SS}$ (when pulled up)	-60	-10	-2.0	$\mu\text{A}$	
	$I_{IH1Z}$	$V_{IH1} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL1Z}$	$V_{IL1} = V_{SS}$ (in a high impedance state)	-1.0	—	0	$\mu\text{A}$	
Input Current 2 (IN0, IN1)	$I_{IH2}$	$V_{IH2} = V_{DD}$ (when pulled down)	2.0	10	60	$\mu\text{A}$	
	$I_{IH2Z}$	$V_{IH2} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL2Z}$	$V_{IL2} = V_{SS}$ (in a high impedance state)	-1.0	—	0	$\mu\text{A}$	
Input Current 3 (OSC1)	$I_{IL3}$	$V_{IL3} = V_{SS}$ (when pulled up)	-60	-18	-4.0	$\mu\text{A}$	
	$I_{IH3Z}$	$V_{IH3} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL3Z}$	$V_{IL3} = V_{SS}$ (in a high impedance state)	-1.0	—	0	$\mu\text{A}$	
Input Current 4 (RESET, TST1, TST2)	$I_{IH4}$	$V_{IH4} = V_{DD}$	0	—	1.0	$\mu\text{A}$	
	$I_{IL4}$	$V_{IL4} = V_{SS}$	-1.5	-0.75	-0.3	$\text{mA}$	
Input Voltage 1 (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$V_{IH1}$	—	-0.3	—	0	V	4
	$V_{IL1}$	—	-1.5	—	-1.2	V	
Input Voltage 2 (IN0, IN1, OSC1)	$V_{IH2}$	—	-0.3	—	0	V	
	$V_{IL2}$	—	-1.5	—	-1.2	V	
Input Voltage 3 (RESET, TST1, TST2)	$V_{IH3}$	—	-0.3	—	0	V	
	$V_{IL3}$	—	-1.5	—	-1.2	V	

## DC Characteristics (continued)

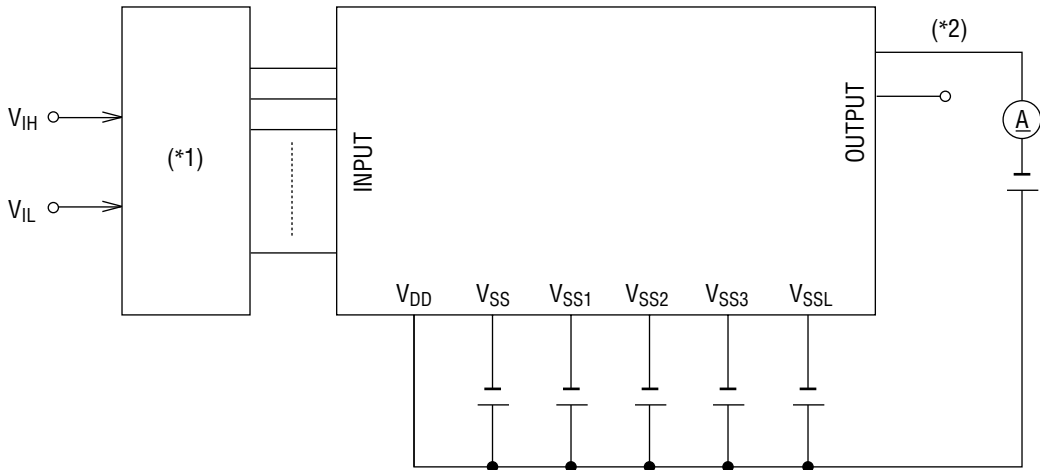
( $V_{DD} = 0\text{ V}$ ,  $V_{SS} = V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Hysteresis Width (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$\Delta V_{T1}$	—	0.05	0.1	0.3	V	4
Hysteresis Width (RESET, TST1, TST2)	$\Delta V_{T2}$	—	0.05	0.1	0.3	V	
Input Pin Capacitance (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$C_{IN}$	—	—	—	5.0	pF	1

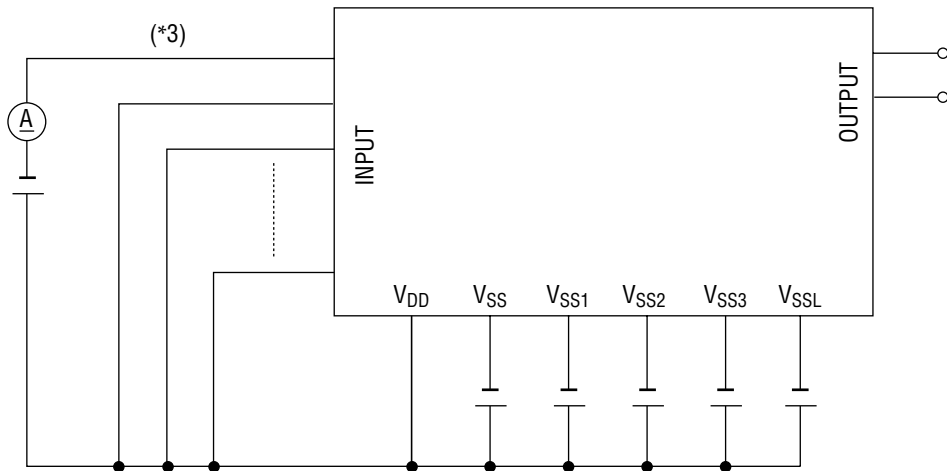
**Measuring circuit 1**



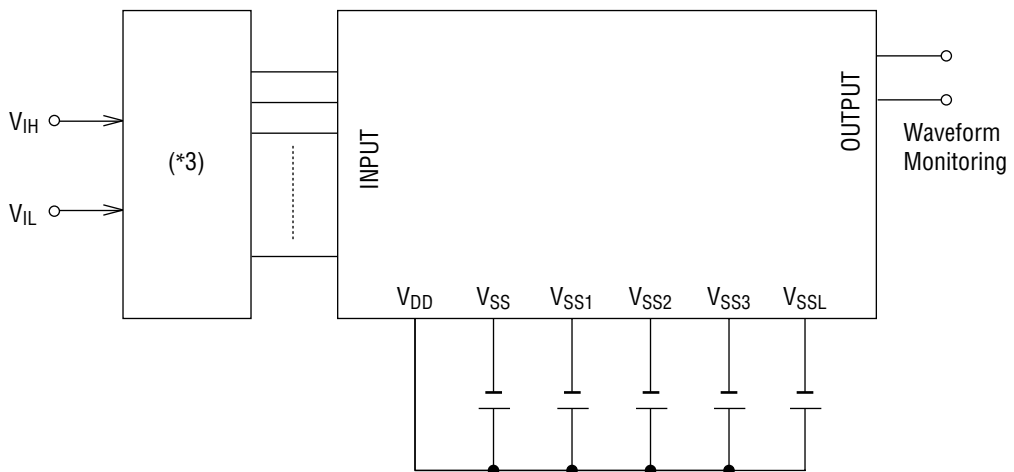
**Measuring circuit 2**



**Measuring circuit 3**



**Measuring circuit 4**



- \*1 Input logic circuit to determine the specified measuring conditions.
- \*2 Measured at the specified output pins.
- \*3 Measured at the specified input pins.

## A/D Converter Characteristics

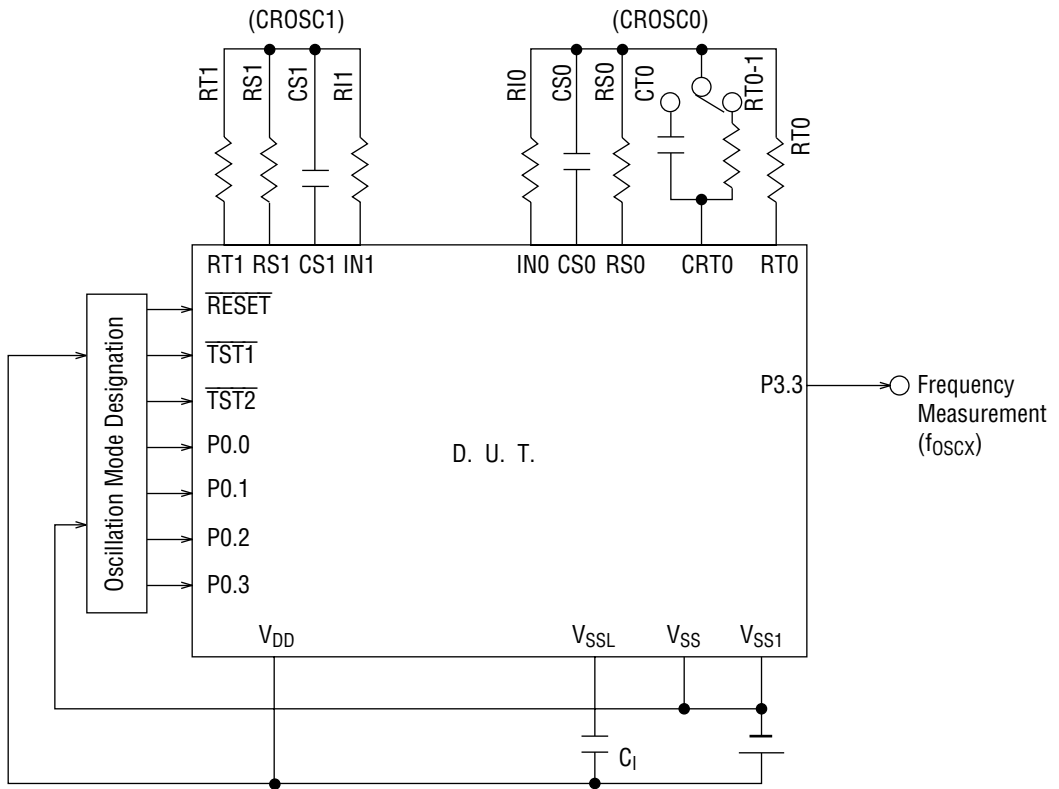
(V<sub>DD</sub> = 0 V, V<sub>SS</sub> = V<sub>SS1</sub> = -1.5 V, T<sub>a</sub> = -40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor for Oscillation	RS0, RS1, RT0, RT0-1, RT1	CS0, CT0, CS1 ≥ 740 pF	2.0	—	—	kΩ	5
Input Current Limiting Resistor	RI0, RI1	—	1.0	10	—	kΩ	
Oscillation Frequency	f <sub>OSC1</sub>	Resistor for oscillation = 2 kΩ	165	221	256	kHz	
	f <sub>OSC2</sub>	Resistor for oscillation = 10 kΩ	41.8	52.2	60.6	kHz	
	f <sub>OSC3</sub>	Resistor for oscillation = 200 kΩ	2.55	3.04	3.53	kHz	
RS•RT Oscillation Frequency Ratio (*)	Kf1	RT0, RT0-1, RT1 = 2 kΩ	3.89	4.18	4.35	—	
	Kf2	RT0, RT0-1, RT1 = 10 kΩ	0.990	1.0	1.010	—	
	Kf3	RT0, RT0-1, RT1 = 200 kΩ	0.0561	0.0584	0.0637	—	

\* K<sub>fx</sub> is the ratio of the oscillation frequency by a sensor resistor to the oscillation frequency by a reference resistor in the same condition.

$$K_{fx} = \frac{f_{oscx} \text{ (RT0-CS0 Oscillation)}}{f_{oscx} \text{ (RS0-CS0 Oscillation)}}, \frac{f_{oscx} \text{ (RT0-1-CS0 Oscillation)}}{f_{oscx} \text{ (RS0-CS0 Oscillation)}}, \frac{f_{oscx} \text{ (RT1-CS1 Oscillation)}}{f_{oscx} \text{ (RS1-CS1 Oscillation)}} \\ (x = 1, 2, 3)$$

**Measuring circuit 5**



RT0, RT0-1, RT1 = 2 kΩ/10 kΩ/200 kΩ  
 RS0, RS1 = 10 kΩ  
 RIO, RI1 = 10 kΩ  
 CS0, CTO, CS1 = 820 pF  
 C1 = 0.1 μF

**ABSOLUTE MAXIMUM RATINGS (3.0 V Spec.)**(V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage 1	V <sub>SS</sub>	Ta = 25°C	-4.0 to +0.3	V
Power Supply Voltage 2	V <sub>SS1</sub>	Ta = 25°C	-2.0 to +0.3	V
Power Supply Voltage 3	V <sub>SS2</sub>	Ta = 25°C	-4.0 to +0.3	V
Power Supply Voltage 4	V <sub>SS3</sub>	Ta = 25°C	-5.5 to +0.3	V
Power Supply Voltage 5	V <sub>SSL</sub>	Ta = 25°C	-4.0 to +0.3	V
Input Voltage 1	V <sub>IN1</sub>	V <sub>SS</sub> Input, Ta = 25°C	V <sub>SS</sub> - 0.3 to +0.3	V
Input Voltage 2	V <sub>IN2</sub>	V <sub>SS2</sub> Input, Ta = 25°C	V <sub>SS2</sub> - 0.3 to +0.3	V
Input Voltage 3	V <sub>IN3</sub>	V <sub>SSL</sub> Input, Ta = 25°C	V <sub>SSL</sub> - 0.3 to +0.3	V
Output Voltage 1	V <sub>OUT1</sub>	V <sub>SS</sub> Output, Ta = 25°C	V <sub>SS</sub> - 0.3 to +0.3	V
Output Voltage 2	V <sub>OUT2</sub>	V <sub>SS1</sub> Output, Ta = 25°C	V <sub>SS1</sub> - 0.3 to +0.3	V
Output Voltage 3	V <sub>OUT3</sub>	V <sub>SS2</sub> Output, Ta = 25°C	V <sub>SS2</sub> - 0.3 to +0.3	V
Output Voltage 4	V <sub>OUT4</sub>	V <sub>SS3</sub> Output, Ta = 25°C	V <sub>SSL</sub> - 0.3 to +0.3	V
Output Voltage 5	V <sub>OUT5</sub>	V <sub>SSL</sub> Output, Ta = 25°C	V <sub>SSL</sub> - 0.3 to +0.3	V
Storage Temperature	T <sub>STG</sub>	—	-55 to +150	°C

**RECOMMENDED OPERATING CONDITIONS (3.0 V Spec.)**(V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Range	Unit
Operating Temperature	T <sub>op</sub>	—	-40 to +85	°C
Operating Voltage	V <sub>SS</sub> , V <sub>SS2</sub>	Using LCD driver with "duty 1/2"	-3.5 to -2.2	V
		Except using LCD driver with "duty 1/2"	-3.5 to -2.0	
External 400 kHz RC Oscillator Resistance	R <sub>OS</sub>	—	90 to 500	kΩ
Crystal Oscillation Frequency	f <sub>XT</sub>	—	30 to 66	kHz

**ELECTRICAL CHARACTERISTICS (3.0 V Spec.)****DC Characteristics** $(V_{DD} = 0\text{ V}, V_{SS} = V_{SS2} = -3.0\text{ V}, T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
$V_{SS1}$ Voltage	$V_{SS1}$	$C_a, C_b, C_{12} = 0.1\ \mu\text{F}$ +100% -50%	-1.7	-1.5	-1.3	V	1
$V_{SS3}$ Voltage	$V_{SS3}$	$C_a, C_b, C_{12} = 0.1\ \mu\text{F}$ +100% -50%	-4.7	-4.5	-4.3	V	
$V_{SSL}$ Voltage	$V_{SSL}$	—	-1.9	-1.3	-0.6	V	
Crystal Oscillation Start Voltage	$V_{STA}$	Oscillation start time: within 5 seconds	—	—	-2.0	V	
Crystal Oscillation Hold Voltage	$V_{HOLD}$	—	—	—	-2.0	V	
Crystal Oscillation Stop Detection Time	$T_{STOP}$	—	0.1	—	1000	ms	
Internal Crystal Oscillator Capacitance	$C_G$	—	10	15	20	pF	
External Crystal Oscillator Capacitance	$C_{GEX}$	When external $C_G$ used	10	—	30	pF	
Internal Crystal Oscillator Capacitance	$C_D$	—	10	15	20	pF	
Internal 400k RC Oscillator Capacitance	$C_{OS}$	—	8.0	12	16	pF	
400k RC Oscillation Frequency	$f_{OSC}$	External resistor $R_{OS} = 100\ \text{k}\Omega$ $V_{SS} = -2.0\text{ to }-3.5\ \text{V}$	300	400	620	kHz	
POR Generation Voltage	$V_{POR1}$	When $V_{SS}$ is between $V_{POR1}$ and $-3.0\ \text{V}$	-0.7	—	0	V	
POR Non-generation Voltage	$V_{POR2}$	No POR when $V_{SS}$ is between $V_{POR2}$ and $-3.0\ \text{V}$	-3.0	—	-2.0	V	
Battery Check Reference Voltage	$V_{RB}$	$T_a = 25^\circ\text{C}$	-0.73	-0.63	-0.53	V	2
$V_{RB}$ Temperature Variation	$\Delta V_{RB}$	—	—	-2.0	—	mV/ $^\circ\text{C}$	

Notes: 1. "POR" denotes Power On Reset.

2. " $T_{STOP}$ " indicates that if the crystal oscillator stops over the value of  $T_{STOP}$ , the system reset occurs.



## DC Characteristics (continued)

(V<sub>DD</sub> = 0 V, V<sub>SS</sub> = V<sub>SS2</sub> = -3.0 V, T<sub>a</sub> = -40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit	
Supply Current 1	I <sub>DD1</sub>	CPU in halt state	T <sub>a</sub> = -40 to +40°C	—	1.5	4.5	μA	1
		(400k RC oscillation halt)	T <sub>a</sub> = +40 to +85°C	—	1.5	30	μA	
Supply Current 2	I <sub>DD2</sub>	CPU in operating state	T <sub>a</sub> = -40 to +40°C	—	5.0	15	μA	
		(400k RC oscillation halt)	T <sub>a</sub> = +40 to +85°C	—	5.0	40	μA	
Supply Current 3	I <sub>DD3</sub>	CPU in operating state (400k RC oscillation in operation) R <sub>OS</sub> = 100kΩ	—	220	450	μA		
Supply Current 4	I <sub>DD4</sub>	CPU in halt state (400k RC oscillation halt), RC oscillator for	RT0 = 10 kΩ	—	300	450	μA	
		A/D converter is in operating state	RT0 = 2 kΩ	—	1300	2000	μA	
Supply Current 5	I <sub>DD5</sub>	Battery check circuit in operating state, CPU in operating state (400k RC oscillation halt)	—	55	150	μA		

## DC Characteristics (continued)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS} = V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Output Current 1 (P1.0)	$I_{OH1}$	$V_{OH1} = -0.5\text{ V}$	-6.0	-1.5	-0.4	mA	2
	$I_{OL1}$	$V_{OL1} = V_{SS} + 0.5\text{ V}$	3.0	8.0	25	mA	
Output Current 2 (P1.1 to P1.3) (P2.0 to P2.3) (P3.0 to P3.3)	$I_{OH2}$	$V_{OH2} = -0.5\text{ V}$	-6.0	-1.5	-0.4	mA	
	$I_{OL2}$	$V_{OL2} = V_{SS} + 0.5\text{ V}$	0.4	1.5	6.0	mA	
Output Current 3 (BD)	$I_{OH3}$	$V_{OH3} = -0.7\text{ V}$	-6.0	-2.0	-0.4	mA	
	$I_{OL3}$	$V_{OL3} = V_{SS} + 0.7\text{ V}$	0.4	2.0	6.0	mA	
Output Current 4 (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OH4}$	$V_{OH4} = -0.1\text{ V}$	-2.5	-0.8	-0.3	mA	
	$I_{OL4}$	$V_{OL4} = V_{SS} + 0.1\text{ V}$	0.3	0.8	2.5	mA	
Output Current 5 (When L16 to L23 are configured as output ports)	$I_{OH5}$	$V_{OH5} = -0.5\text{ V}$	-1.5	-0.6	-0.15	mA	
	$I_{OL5}$	$V_{OL5} = V_{SS} + 0.5\text{ V}$	0.15	0.6	1.5	mA	
Output Current 6 (OSC2)	$I_{OH6}$	$V_{OH6} = -0.5\text{ V}$	-6.0	-2.0	-0.4	mA	
	$I_{OL6}$	$V_{OL6} = V_{SS} + 0.5\text{ V}$	0.4	2.0	6.0	mA	
Output Current 7 (L0 to L23)	$I_{OH7}$	$V_{OH7} = -0.2\text{ V}$ ( $V_{DD}$ level)	—	—	-4.0	$\mu\text{A}$	
	$I_{OMH7}$	$V_{OMH7} = V_{SS1} + 0.2\text{ V}$ ( $V_{SS1}$ level)	4.0	—	—	$\mu\text{A}$	
	$I_{OMH7S}$	$V_{OMH7S} = V_{SS1} - 0.2\text{ V}$ ( $V_{SS1}$ level)	—	—	-4.0	$\mu\text{A}$	
	$I_{OML7}$	$V_{OML7} = V_{SS2} + 0.2\text{ V}$ ( $V_{SS2}$ level)	4.0	—	—	$\mu\text{A}$	
	$I_{OML7S}$	$V_{OML7S} = V_{SS2} - 0.2\text{ V}$ ( $V_{SS2}$ level)	—	—	-4.0	$\mu\text{A}$	
	$I_{OL7}$	$V_{OL7} = V_{SS3} + 0.2\text{ V}$ ( $V_{SS3}$ level)	4.0	—	—	$\mu\text{A}$	
Output Leakage Current (P1.0 to P1.3) (P2.0 to P2.3) (P3.0 to P3.3) (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OOH}$	$V_{OH} = V_{DD}$	—	—	0.3	$\mu\text{A}$	
	$I_{OOL}$	$V_{OL} = V_{SS}$	-0.3	—	—	$\mu\text{A}$	

## DC Characteristics (continued)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS} = V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

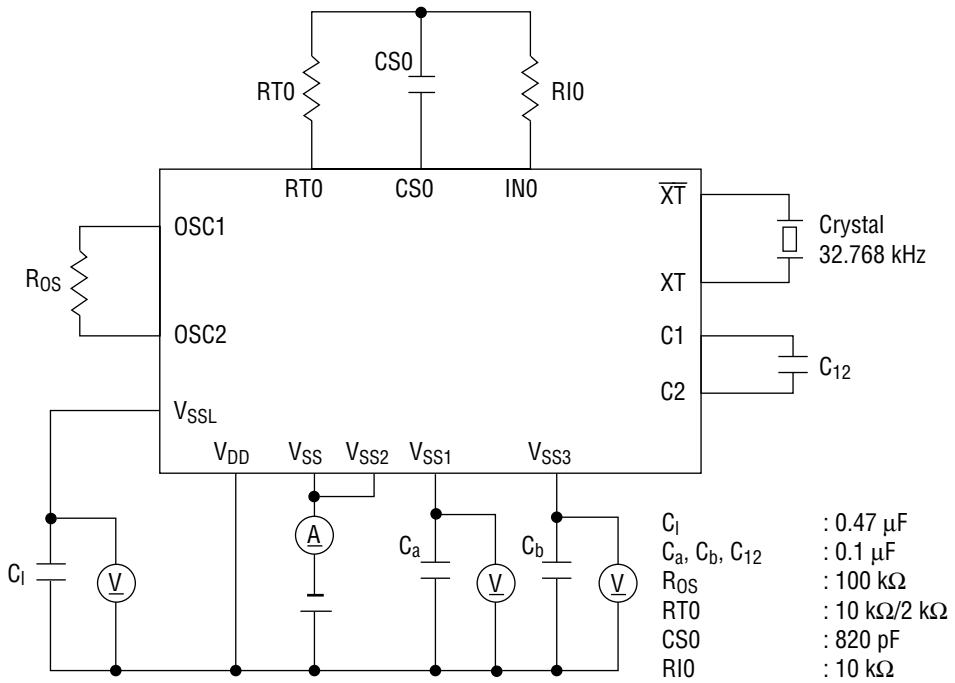
Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Input Current 1 (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$I_{IH1}$	$V_{IH1} = V_{DD}$ (when pulled down)	20	60	300	$\mu\text{A}$	3
	$I_{IL1}$	$V_{IL1} = V_{SS}$ (when pulled up)	-300	-60	-20	$\mu\text{A}$	
	$I_{IH1Z}$	$V_{IH1} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL1Z}$	$V_{IL1} = V_{SS}$ (in a high impedance state)	-1.0	—	0	$\mu\text{A}$	
Input Current 2 (IN0, IN1)	$I_{IH2}$	$V_{IH2} = V_{DD}$ (when pulled down)	20	60	300	$\mu\text{A}$	
	$I_{IH2Z}$	$V_{IH2} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL2Z}$	$V_{IL2} = V_{SS}$ (in a high impedance state)	-1.0	—	0	$\mu\text{A}$	
Input Current 3 (OSC1)	$I_{IL3}$	$V_{IL3} = V_{SS}$ (when pulled up)	-300	-110	-30	$\mu\text{A}$	
	$I_{IH3Z}$	$V_{IH3} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL3Z}$	$V_{IL3} = V_{SS}$ (in a high impedance state)	-1.0	—	0	$\mu\text{A}$	
Input Current 4 (RESET, TST1, TST2)	$I_{IH4}$	$V_{IH4} = V_{DD}$	0	—	1.0	$\mu\text{A}$	
	$I_{IL4}$	$V_{IL4} = V_{SS}$	-3.0	-1.5	-0.75	$\text{mA}$	
Input Voltage 1 (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$V_{IH1}$	—	-0.6	—	0	V	4
	$V_{IL1}$	—	-3.0	—	-2.4	V	
Input Voltage 2 (IN0, IN1, OSC1)	$V_{IH2}$	—	-0.6	—	0	V	
	$V_{IL2}$	—	-3.0	—	-2.4	V	
Input Voltage 3 (RESET, TST1, TST2)	$V_{IH3}$	—	-0.6	—	0	V	
	$V_{IL3}$	—	-3.0	—	-2.4	V	

## DC Characteristics (continued)

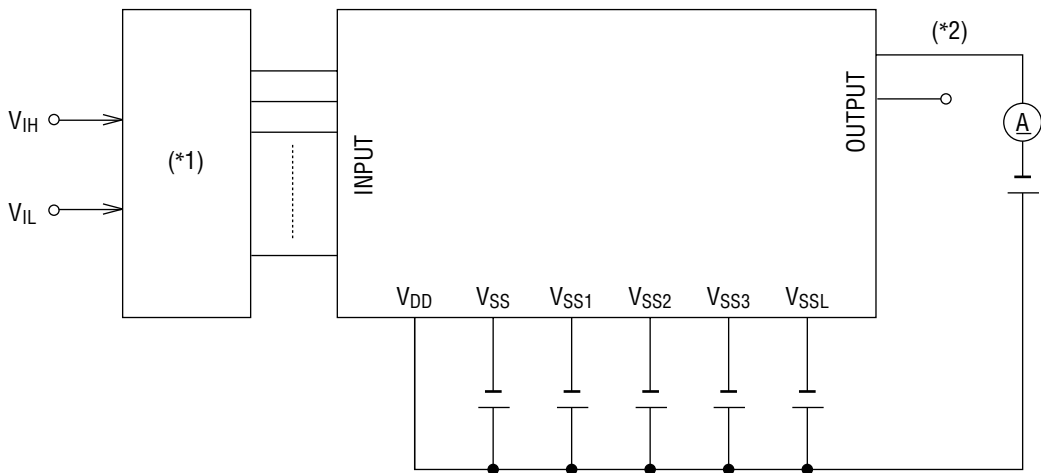
( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS} = V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Hysteresis Width (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$\Delta V_{T1}$	—	0.2	0.5	1.0	V	4
Hysteresis Width (RESET, TST1, TST2)	$\Delta V_{T2}$	—	0.2	0.5	1.0	V	
Input Pin Capacitance (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3)	$C_{IN}$	—	—	—	5.0	pF	1

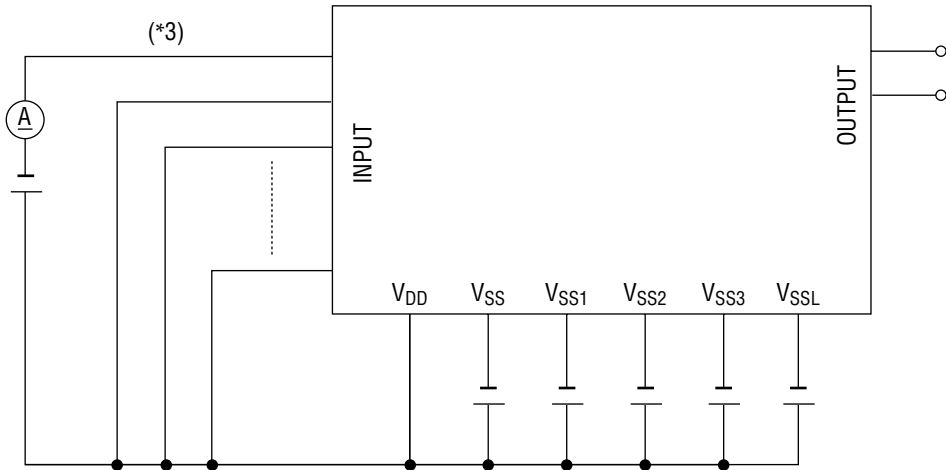
**Measuring circuit 1**



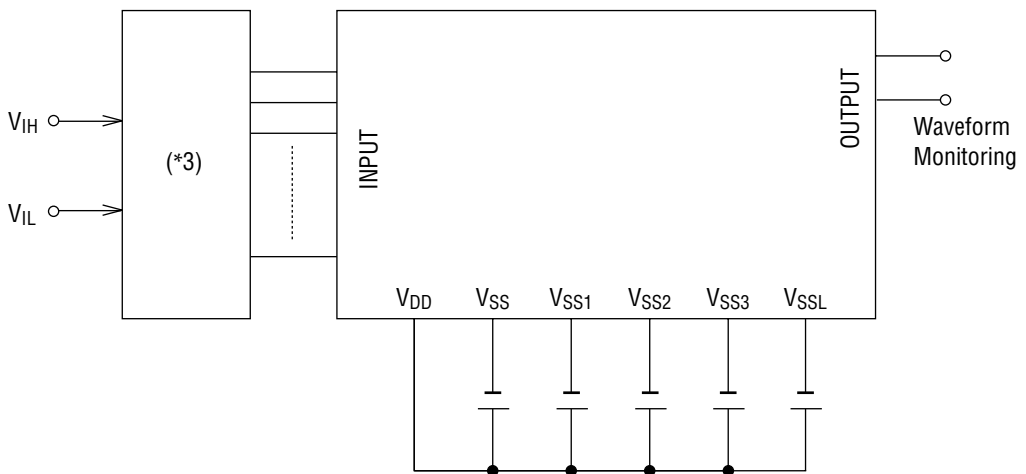
**Measuring circuit 2**



**Measuring circuit 3**



**Measuring circuit 4**



- \*1 Input logic circuit to determine the specified measuring conditions.
- \*2 Measured at the specified output pins.
- \*3 Measured at the specified input pins.

## A/D Converter Characteristics

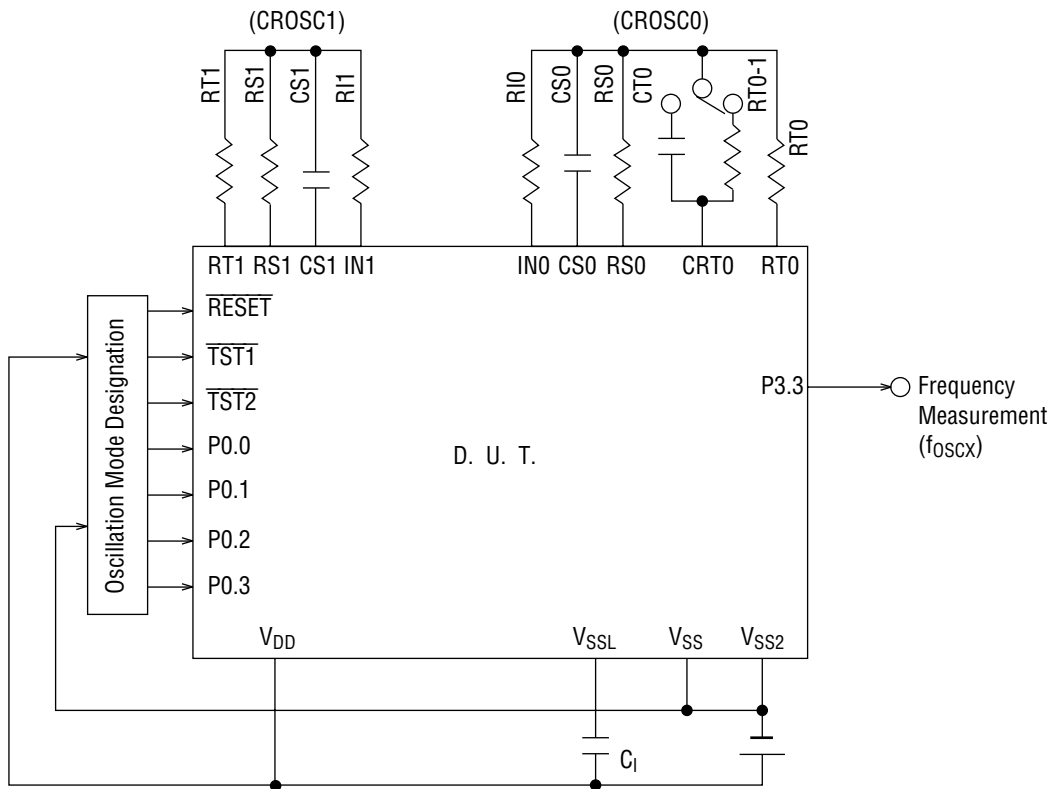
(V<sub>DD</sub> = 0 V, V<sub>SS</sub> = V<sub>SS2</sub> = -3.0 V, T<sub>a</sub> = -40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor for Oscillation	RS0, RS1, RT0, RT0-1, RT1	CS0, CT0, CS1 ≥ 740 pF	1.0	—	—	kΩ	5
Input Current Limiting Resistor	RI0, RI1	—	1.0	10	—	kΩ	
Oscillation Frequency	f <sub>OSC1</sub>	Resistor for oscillation = 2 kΩ	200	239	277	kHz	
	f <sub>OSC2</sub>	Resistor for oscillation = 10 kΩ	46.5	55.4	64.3	kHz	
	f <sub>OSC3</sub>	Resistor for oscillation = 200 kΩ	2.79	3.32	3.85	kHz	
RS*RT Oscillation Frequency Ratio(*)	Kf1	RT0, RT0-1, RT1 = 2 kΩ	4.115	4.22	4.326	—	
	Kf2	RT0, RT0-1, RT1 = 10 kΩ	0.990	1.0	1.010	—	
	Kf3	RT0, RT0-1, RT1 = 200 kΩ	0.0573	0.0616	0.0659	—	

\* K<sub>fx</sub> is the ratio of the oscillation frequency by a sensor resistor to the oscillation frequency by a reference resistor in the same condition.

$$K_{fx} = \frac{f_{oscx} \text{ (RT0-CS0 Oscillation)}}{f_{oscx} \text{ (RS0-CS0 Oscillation)}}, \frac{f_{oscx} \text{ (RT0-1-CS0 Oscillation)}}{f_{oscx} \text{ (RS0-CS0 Oscillation)}}, \frac{f_{oscx} \text{ (RT1-CS1 Oscillation)}}{f_{oscx} \text{ (RS1-CS1 Oscillation)}} \\ (x = 1, 2, 3)$$

**Measuring circuit 5**



RT0, RT0-1, RT1 = 2 kΩ/10 kΩ/200 kΩ  
 RS0, RS1 = 10 kΩ  
 RIO, RI1 = 10 kΩ  
 CS0, CTO, CS1 = 820 pF  
 Ci = 0.47 μF



**RECOMMENDED OPERATING CONDITIONS (When Voltage Regulator for LCD Driver Used)**(V<sub>DD</sub> = 0 V)

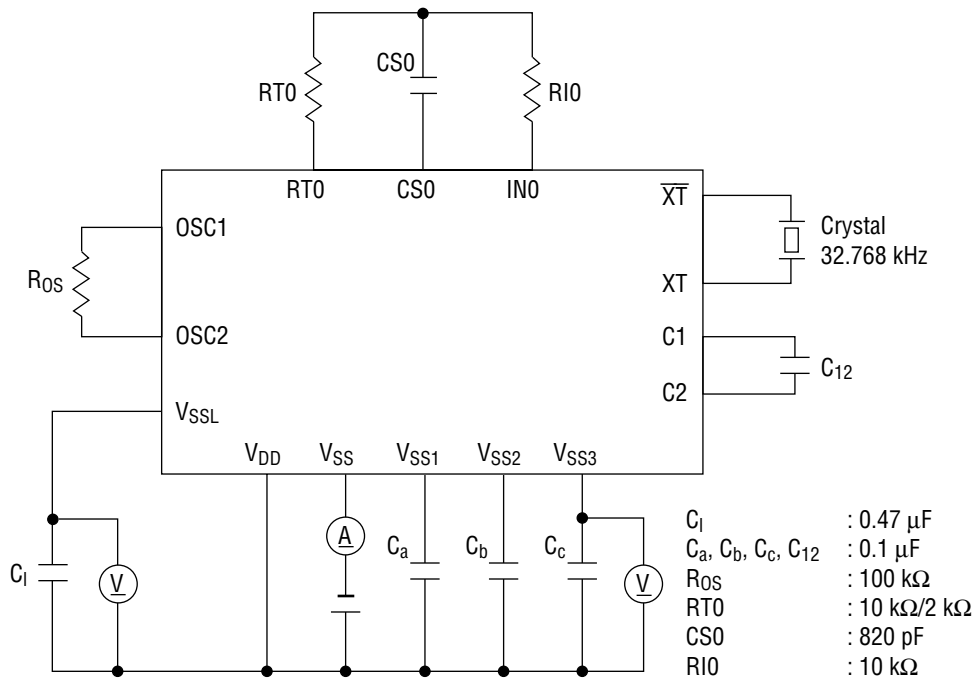
Parameter	Symbol	Condition	Range	Unit
Operating Temperature	T <sub>OP</sub>	—	-40 to +85	°C
Operating Voltage	V <sub>SS</sub>	—	-3.5 to -1.25	V
External 400 kHz RC Oscillator Resistance	R <sub>OS</sub>	V <sub>SS</sub> = -1.7 V to -1.25 V	250 to 500	kΩ
		V <sub>SS</sub> = -3.5 V to -2.0 V	90 to 500	
Crystal Oscillation Frequency	f <sub>XT</sub>	—	30 to 66	kHz

**ELECTRICAL CHARACTERISTICS (When Voltage Regulator for LCD Driver Used)****DC Characteristics**(V<sub>DD</sub> = 0 V, V<sub>SS</sub> = -3.0 V, Ta = -40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit	
V <sub>SS1</sub> Voltage	V <sub>SS1</sub>	V <sub>SS</sub> = -3.5 to -1.25, Ta = 25°C	-1.35	-1.2	-1.05	V		1
	ΔV <sub>SS1</sub>	—	—	-4	—	mV/°C		
V <sub>SS2</sub> Voltage	V <sub>SS2</sub>	V <sub>SS</sub> = -3.5 to -1.25	Typ. - 0.1	2 × V <sub>SS1</sub>	Typ. + 0.1	V		
V <sub>SS3</sub> Voltage	V <sub>SS3</sub>	V <sub>SS</sub> = -3.5 to -1.25	Typ. - 0.2	3 × V <sub>SS1</sub>	Typ. + 0.2	V		
Supply Current 1	I <sub>DD1</sub>	V <sub>SS</sub> = -1.5 V (CPU in halt state)	Ta = -40 to +40°C	—	2.5	7.5	mA	
			Ta = +40 to +85°C	—	2.5	35		
		V <sub>SS</sub> = -3.0 V (CPU in halt state)	Ta = -40 to +40°C	—	2.3	7.5		
			Ta = +40 to +85°C	—	2.3	35		
Supply Current 2	I <sub>DD2</sub>	V <sub>SS</sub> = -1.5 V (CPU in operating state)	Ta = -40 to +40°C	—	5	15	mA	
			Ta = +40 to +85°C	—	5	40		
		V <sub>SS</sub> = -3.0 V (CPU in operating state)	Ta = -40 to +40°C	—	5	15		
			Ta = +40 to +85°C	—	5	40		

\* The other electrical characteristics are the same as those for the 1.5 V and 3.0 V specifications.

**Measuring circuit 1**



## FUNCTIONAL DESCRIPTION

### • A/D converter (ADC)

The MSM64162A has a built-in 2-channel RC oscillation type A/D converter. The A/D converter is composed of a 2-channel oscillation circuit, Counter A (CNTA0-4, a 4.8-digit decade counter), Counter B (CNTB0-3, a 14-bit binary counter), and A/D Converter Control Registers 0 and 1 (ADCON0, ADCON1).

By counting oscillation frequencies that vary depending on a resistor or capacitor connected to the RC oscillation circuit, the A/D converter converts resistance values or capacitance values to corresponding digital values. By using a thermistor or humidity sensor as a resistance, a thermometer or a hygrometer can be constructed. By applying a separate sensor to each channel of the 2-channel RC oscillation circuit, it is also possible to extend measure ranges or measure at two places.

### • LCD driver (LCD)

The MSM64162A has a built-in LCD driver for 24 outputs.

The LCD driver consists of  $21 \times 4$ -bit display registers (DSPR0-20), the Display Control Register (DSPCON), a 24-output LCD driver circuit, and a bias generation circuit (BIAS).

The bias generation circuit for LCD driver (BIAS) generates bias voltages for the LCD driver by rising or dropping the power supply voltage by externally installing capacitors. Alternatively, it generates bias voltages by rising the constant voltage ( $V_{SS1} = -1.2$  V) generated by the voltage regulator for LCD driver. Which way is to be used is specified by mask option.

There are three types of driving methods: 1/4 duty, 1/3 duty and 1/2 duty. Software selects the duty mode.

A mask option can select either a common driver or a segment driver for each LCD driver pin. A mask option can also specify assignment of each bit of the display register to each segment. All the display registers must be selected by a mask option.

L16 to L23 of the LCD driver can be configured to be output ports by a mask option.

The relationship between the duty, the bias method, and the maximum segment number follows:

1/4 duty 1/3 bias method	-----	80 segments
1/3 duty 1/3 bias method	-----	63 segments
1/2 duty 1/2 bias method	-----	44 segments

### • Buzzer driver (BD)

The MSM64162A has a built-in buzzer driver with 2 buzzer output frequencies and 4 buzzer output modes. Each buzzer output is selected by the Buzzer Control Register (BDCON) and the Buzzer Frequency Control Register (BFCON).

### • Capture circuit (CAPR)

The MSM64162A captures 32 Hz to 256 Hz output of the time base counter at the falling of Port 0.0 or 0.1 (P0.0 or P0.1) to "L" level when the pull-up resistor input is chosen, or at the rising to "H" level when the pull-down resistor input is chosen. The capture circuit is composed of the Capture Control Register (CAPCON) and the Capture Registers (CAPR0, CAPR1) that fetch output from the time base counter.

### • Watchdog timer (WDT)

The MSM64162A has a built-in watchdog timer to detect CPU malfunction. The watchdog timer is composed of a 6-bit watchdog timer counter (WDTC) to count a 16 Hz output and a watchdog timer control register (WDTCON) to reset WDTC.

**• Clock generation circuit (2CLK)**

The clock generation circuit (2CLK) in the MSM64162A contains a 32.768 kHz crystal oscillation circuit, a 400 kHz RC oscillation circuit, and a clock control port. This circuit generates the system clock (CLK) and the time base clock (32.768 kHz).

The system clock drives the CPU while the time base clock drives the time base counter and the buzzer driver.

Via the contents of the frequency Control Register (FCON), the system clock can be switched between 32.768 kHz (the output of the crystal oscillation circuit) and 400 kHz (the output of the RC oscillation circuit).

Note: The oscillation frequency of the RC oscillation circuit varies depending on the value of an external resistor ( $R_{OS}$ ), operating power supply voltage ( $V_{DD}$ ), and ambient temperatures ( $T_a$ ).

**• Time base counter (TBC)**

The MSM64162A has a built-in time base counter (TBC) that generates clocks to be supplied to internal peripheral circuits. The time base counter is composed of 15 binary counters. The count clock of the time base is driven by the oscillation clock (32.768 kHz) of the crystal oscillation circuit. The output of the time base counter is used for the buzzer driver, the system reset circuit, the watchdog timer, the time base interrupt, the sampling clocks of each port, and the capture circuit.

**• I/O port**

Input-output ports (P2, P3) (8 bits)	: Pull-up (pull-down) resistor input or high-impedance input, CMOS output or NMOS open drain output: these can be specified for each bit; external 0 interrupt
Input port (P0) (4 bits)	: Pull-up (pull-down) resistor input or high-impedance input; external 1 interrupt
Output port (P1) (4 bits)	: CMOS output or NMOS open drain output

**• Interrupt (INTC)**

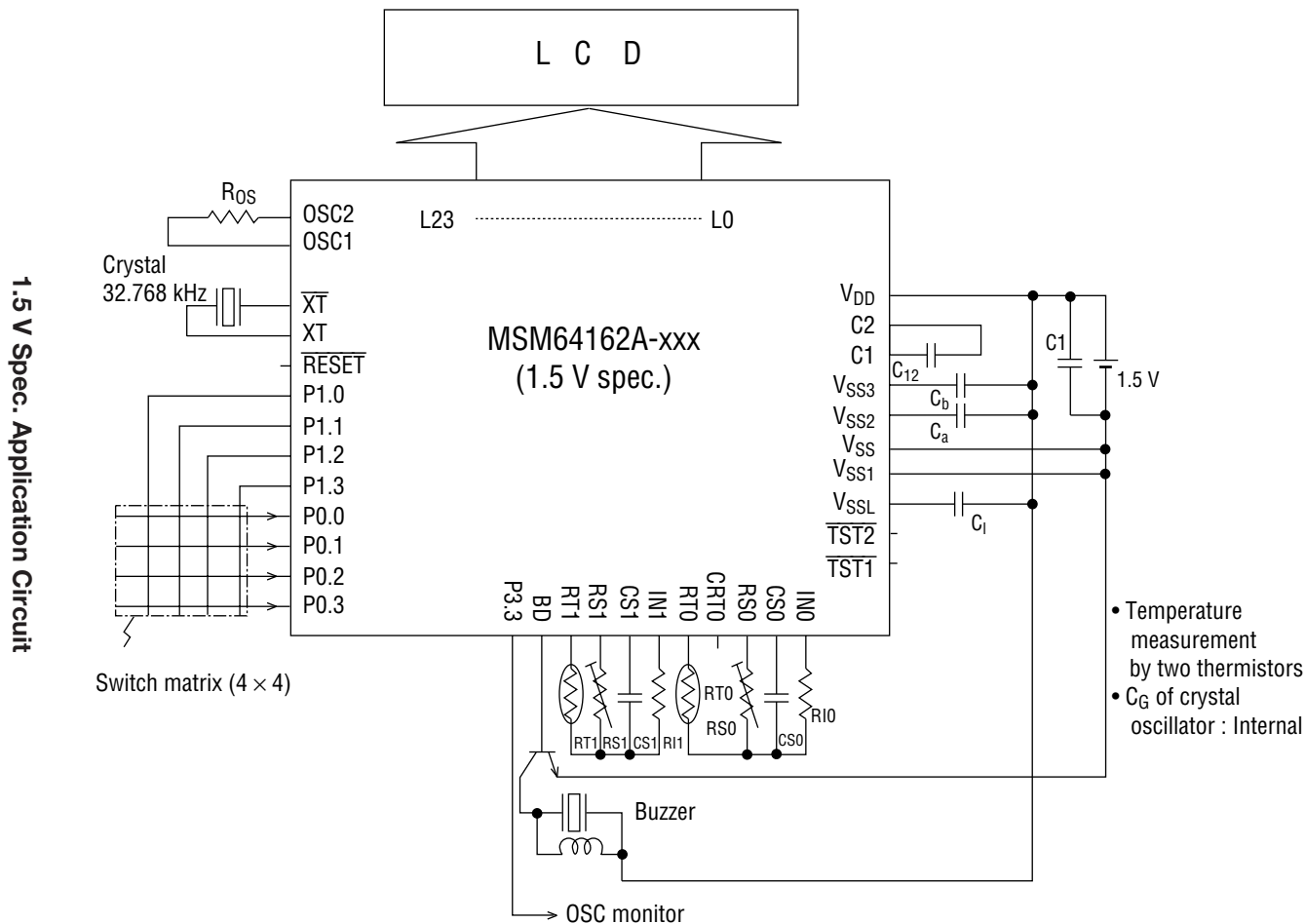
The MSM64162A has 9 interrupt sources (9 vector addresses), of which two are external interrupts from ports and seven are internal interrupts.

Of the nine interrupt sources, only the watchdog interrupt cannot be disabled (non-maskable interrupt). The other eight interrupts are controlled by the master interrupt enable flag (MI) and the interrupt enable registers (IE0, IE1 and IE2). When an interrupt condition is met, the CPU branches to a vector address corresponding to the interrupt source.

**• Battery check circuit (BC)**

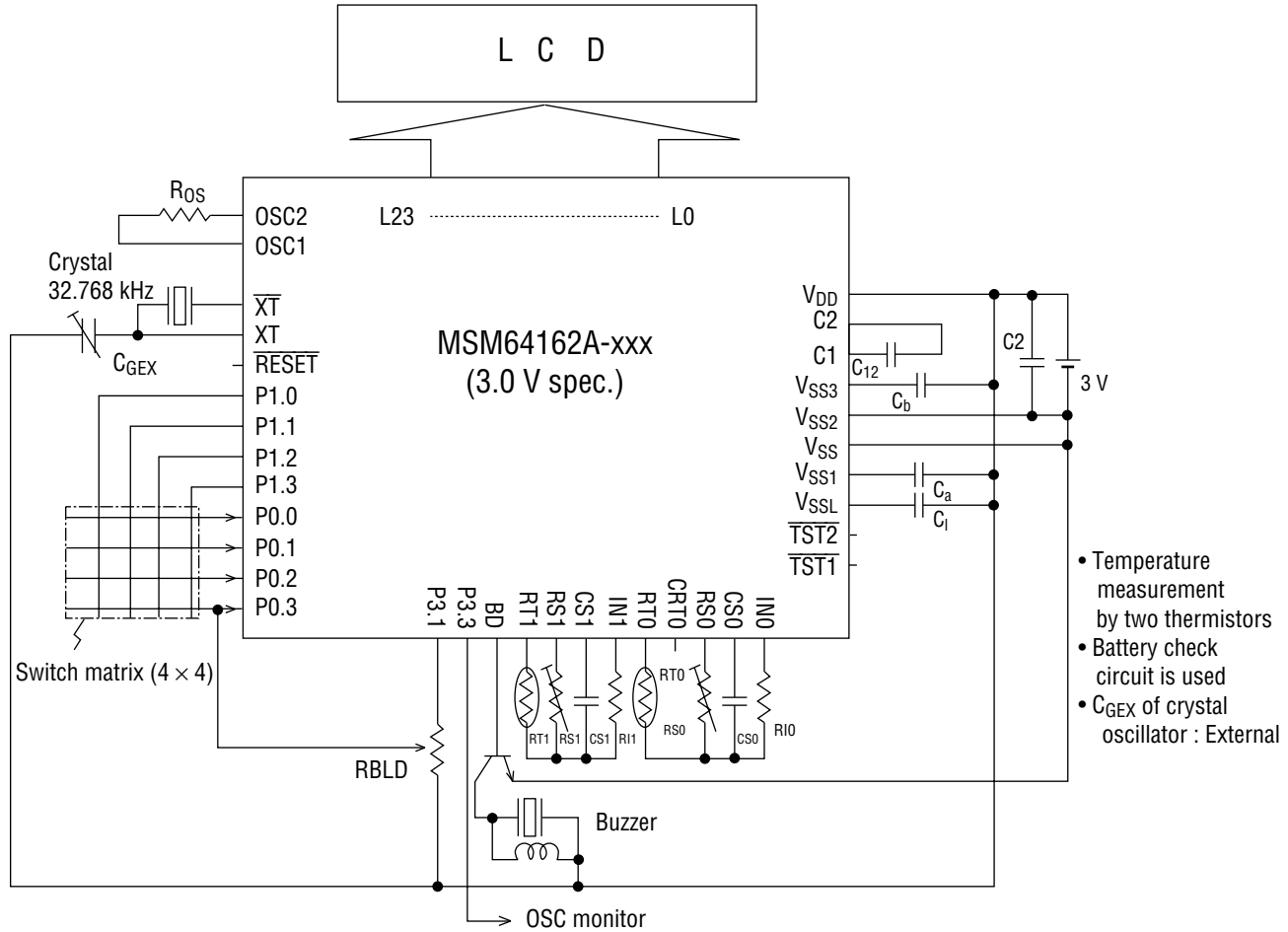
The battery check circuit (BC) detects the level of the supply voltage by comparing the voltage generated by an external supply-voltage dividing resistor (RBLD) with the internal reference voltage ( $V_{rb}$ ).

APPLICATION CIRCUITS



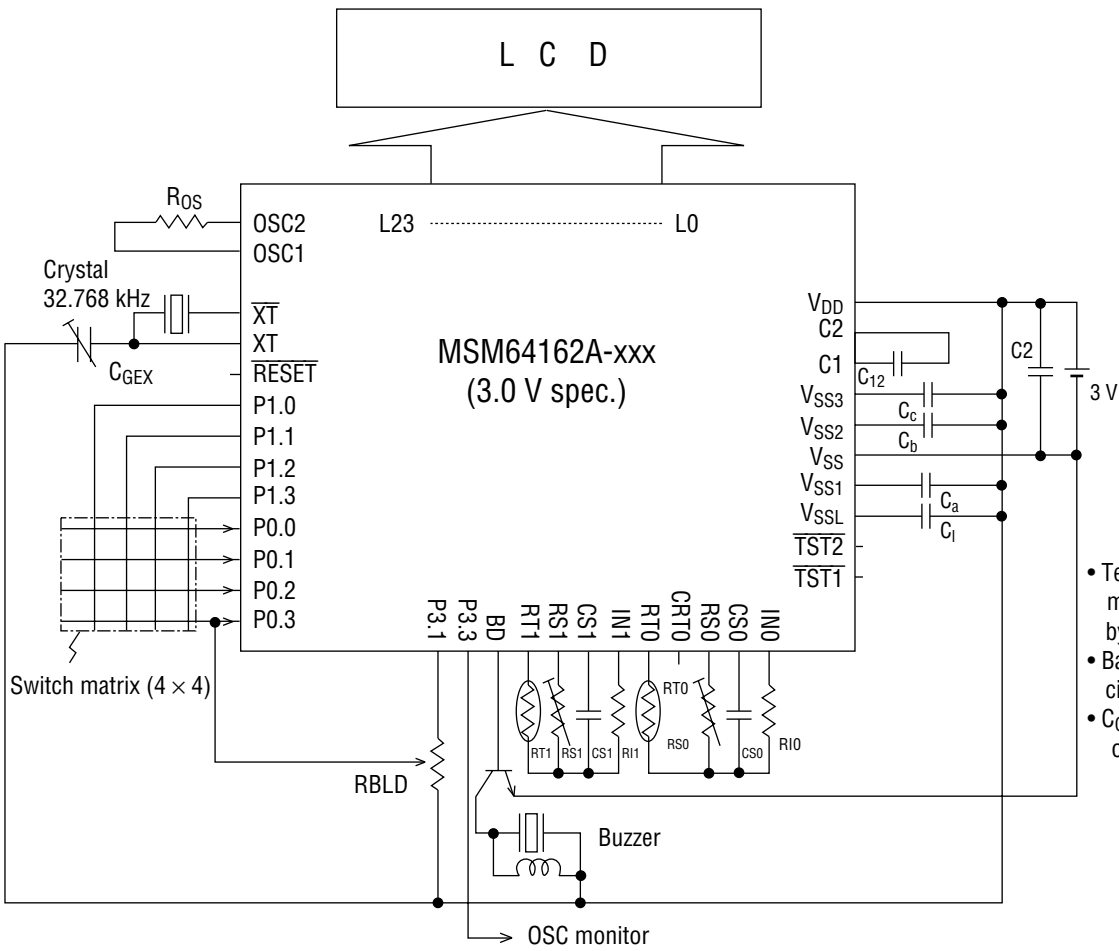
APPLICATION CIRCUITS (continued)

3.0 V Spec. Application Circuit



APPLICATION CIRCUITS (continued)

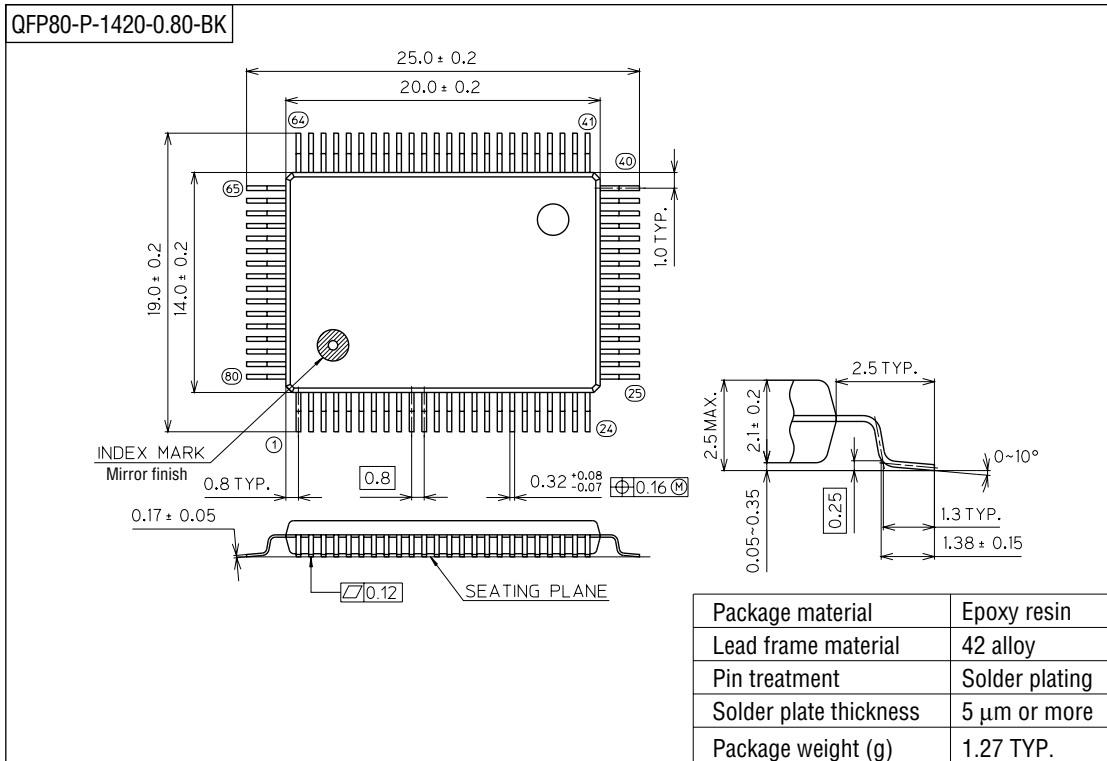
3.0 V Spec. Application Circuit  
(Voltage Regulator for LCD Driver Used)



- Temperature measurement by two thermistors
- Battery check circuit is used
- C<sub>GEX</sub> of crystal oscillator : External

**PACKAGE DIMENSIONS**

(Unit : mm)



Notes for Mounting the Surface Mount Type Package

The SOP, QFP, TSOP, SOJ, QFJ (PLCC), SHP and BGA are surface mount type packages, which are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact Oki's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).