

**OKI Semiconductor**This version: Sep. 1998  
Previous version: Mar. 1996

# MSM64162D

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

## GENERAL DESCRIPTION

The MSM64162D is a low power 4-bit microcontroller that employs Oki's original CPU core nX-4/20.

The MSM64162D has 1-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 thermometers and clinical thermometers.

## FEATURES

- Operating range
  - Operating frequencies : 32.768 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 : 91.6  $\mu$ s @ 32.768 kHz
- RC oscillation type A/D converter : 1 channel (2 sensors can be connected)
- LCD driver : 24 outputs; duty ratio switchable by software
  - (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)
- Buzzer driver : 1 output (4 output modes selectable)
- Capture circuit : 2 channels
- Watchdog timer
- Clock : 32.768 kHz crystal oscillator
  - CPU clock : 32.768 kHz
  - 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  $\times$  4 bits
  - Input port : 1 port  $\times$  4 bits
  - Output port : 1 port  $\times$  4 bits

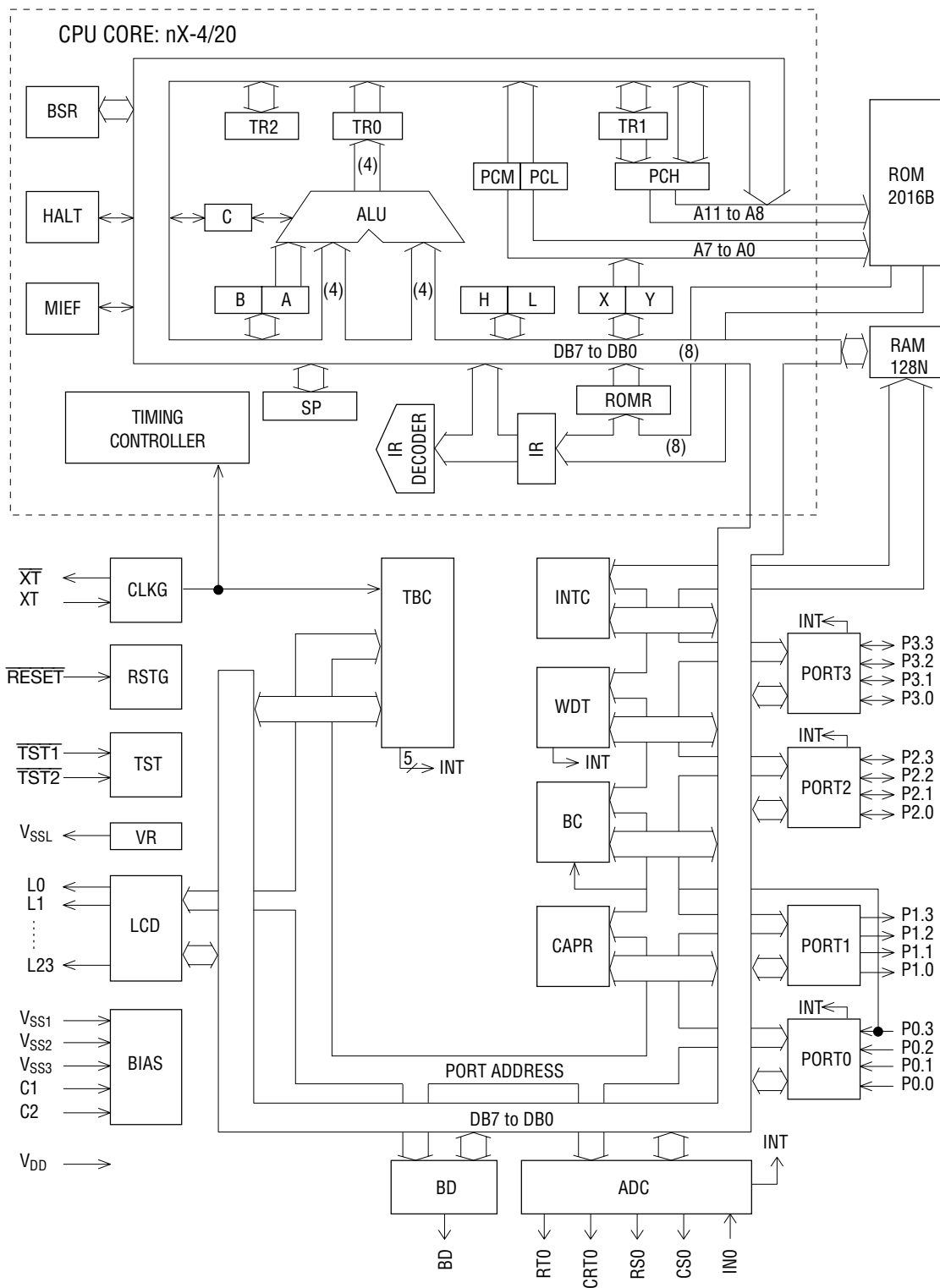
(8 out of the 24 LCD driver outputs can be used as output-only ports by mask option.)
- Interrupt sources
  - External interrupt : 2 sources
  - Internal interrupt : 7 sources
  - Battery check circuit : 1 (incorporated into the input-only port)



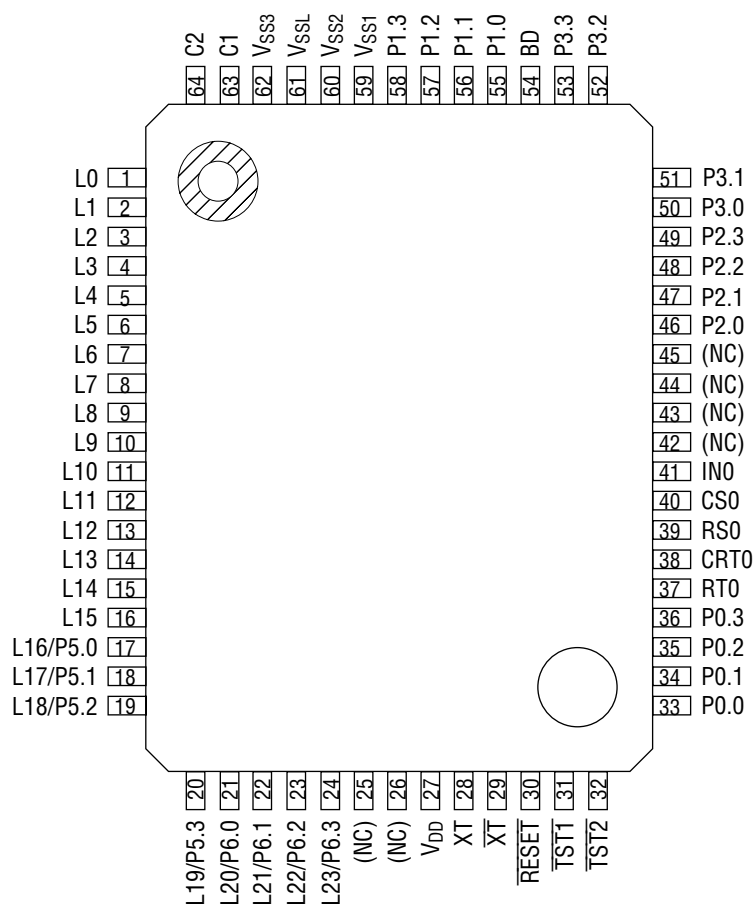
- Package options:

64-pin plastic QFP (QFP64-P-1420-1.00-BK) : (Product name : MSM64162D-××GS-BK)  
80-pin plastic QFP (QFP80-P-1420-0.80-BK) : (Product name : MSM64162D-××GS-BK-F)  
Chip : (Product name : MSM64162D-××)  
×× indicates a code number.

# BLOCK DIAGRAM



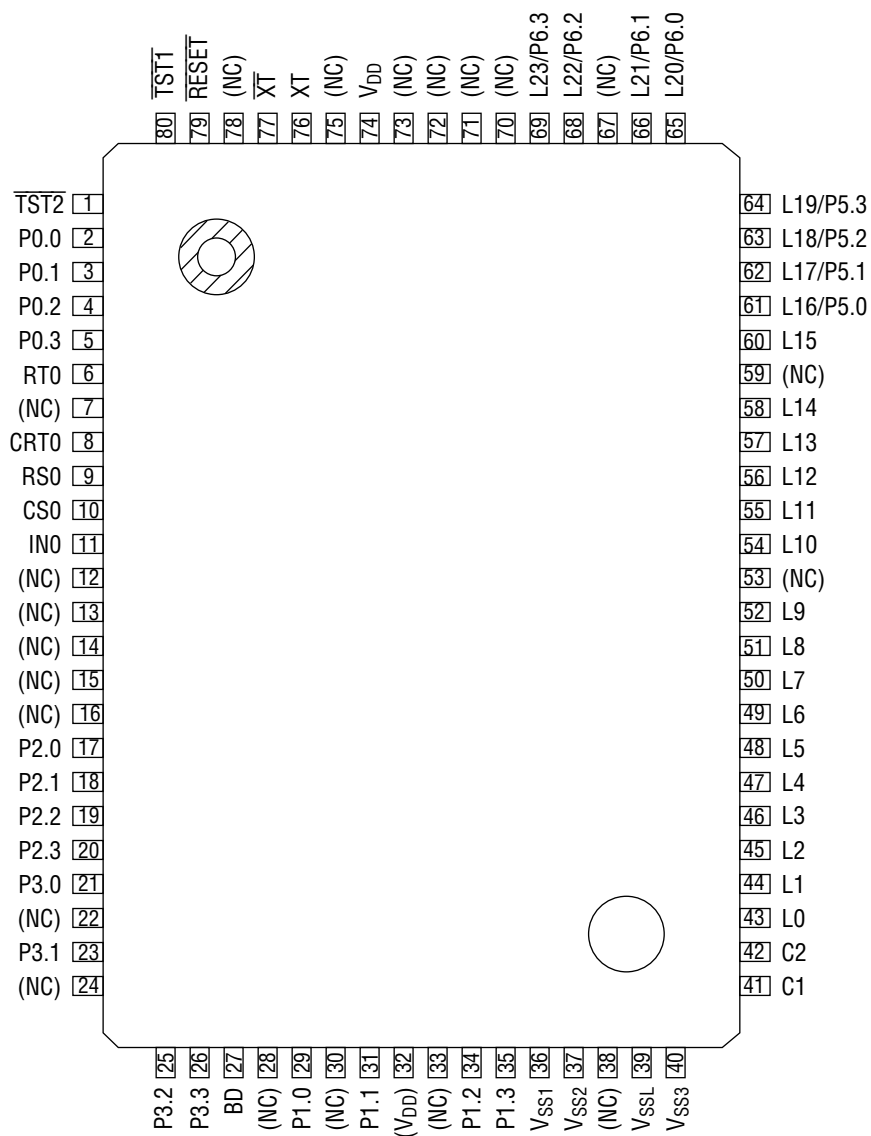
## PIN CONFIGURATION (TOP VIEW)



## 64-Pin Plastic QFP

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

## PIN CONFIGURATION (TOP VIEW) (continued)

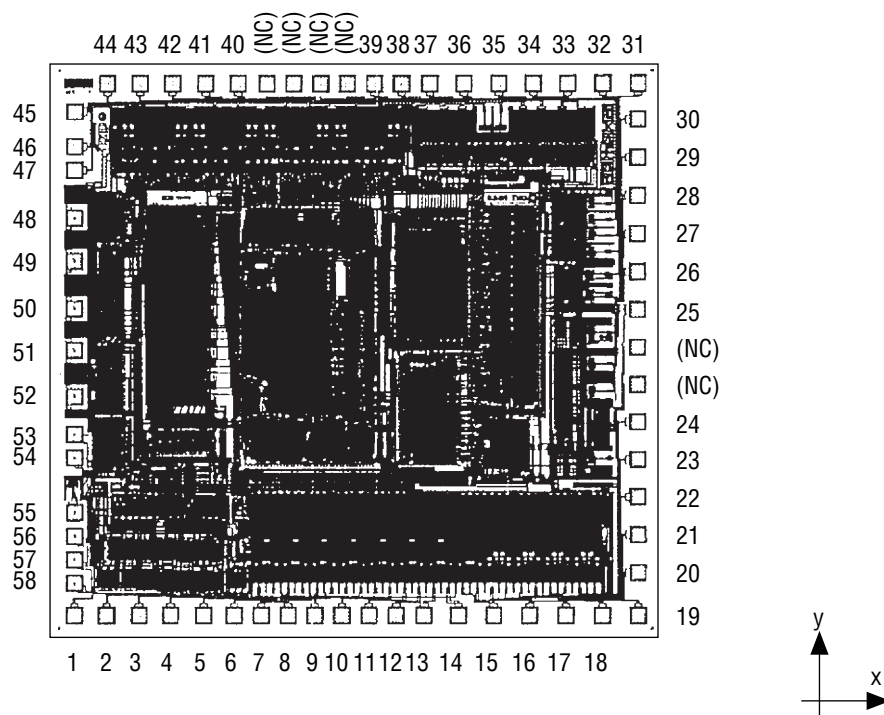


## 80-Pin Plastic QFP

- Notes:
1. Pins marked as (NC) are no-connection pins which are left open.
  2. V<sub>DD</sub> should be supplied from pin 74. Pin 32 is internally connected to V<sub>DD</sub>.

## PAD CONFIGURATION

### Pad Layout



|                   |                     |
|-------------------|---------------------|
| Chip Size         | : 4.69 mm × 4.41 mm |
| Chip Thickness    | : 350 μm (typ.)     |
| Coordinate Origin | : Chip center       |
| Pad Hole Size     | : 110 μm × 110 μm   |
| Pad Size          | : 130 μm × 130 μm   |
| Minimum Pad Pitch | : 180 μm            |

Note: The chip substrate voltage is  $V_{DD}$ .

## Pad Coordinates

| Pad No. | Pad Name        | X (μm) | Y (μm) | Pad No. | Pad Name         | X (μm) | Y (μm) |
|---------|-----------------|--------|--------|---------|------------------|--------|--------|
| 1       | L0              | -2168  | -2042  | 30      | TST2             | 2168   | 1766   |
| 2       | L1              | -1918  | -2042  | 31      | P0.0             | 2168   | 2042   |
| 3       | L2              | -1669  | -2042  | 32      | P0.1             | 1899   | 2042   |
| 4       | L3              | -1426  | -2042  | 33      | P0.2             | 1628   | 2042   |
| 5       | L4              | -1170  | -2042  | 34      | P0.3             | 1364   | 2042   |
| 6       | L5              | -934   | -2042  | 35      | RT0              | 1100   | 2042   |
| 7       | L6              | -727   | -2042  | 36      | CRT0             | 829    | 2042   |
| 8       | L7              | -519   | -2042  | 37      | RS0              | 565    | 2042   |
| 9       | L8              | -312   | -2042  | 38      | CS0              | 349    | 2042   |
| 10      | L9              | -104   | -2042  | 39      | IN0              | 141    | 2042   |
| 11      | L10             | 104    | -2042  | 40      | P2.0             | -911   | 2042   |
| 12      | L11             | 311    | -2042  | 41      | P2.1             | -1160  | 2042   |
| 13      | L12             | 527    | -2042  | 42      | P2.2             | -1416  | 2042   |
| 14      | L13             | 791    | -2042  | 43      | P2.3             | -1666  | 2042   |
| 15      | L14             | 1062   | -2042  | 44      | P3.0             | -1916  | 2042   |
| 16      | L15             | 1340   | -2042  | 45      | P3.1             | -2168  | 1829   |
| 17      | L16/P5.0        | 1618   | -2042  | 46      | P3.2             | -2168  | 1563   |
| 18      | L17/P5.1        | 1897   | -2042  | 47      | P3.3             | -2168  | 1382   |
| 19      | L18/P5.2        | 2168   | -2042  | 48      | BD               | -2168  | 1017   |
| 20      | L19/P5.3        | 2168   | -1714  | 49      | P1.0             | -2168  | 688    |
| 21      | L20/P6.0        | 2168   | -1424  | 50      | P1.1             | -2168  | 328    |
| 22      | L21/P6.1        | 2168   | -1134  | 51      | P1.2             | -2168  | 6      |
| 23      | L22/P6.2        | 2168   | -844   | 52      | P1.3             | -2168  | -353   |
| 24      | L23/P6.3        | 2168   | -554   | 53      | V <sub>SS1</sub> | -2168  | -645   |
| 25      | V <sub>DD</sub> | 2168   | 316    | 54      | V <sub>SS2</sub> | -2168  | -826   |
| 26      | XT              | 2168   | 606    | 55      | V <sub>SSL</sub> | -2168  | -1254  |
| 27      | X <sub>T</sub>  | 2168   | 896    | 56      | V <sub>SS3</sub> | -2168  | -1435  |
| 28      | RESET           | 2168   | 1186   | 57      | C1               | -2168  | -1616  |
| 29      | TST1            | 2168   | 1476   | 58      | C2               | -2168  | -1796  |

## PIN DESCRIPTIONS

### Basic Functions

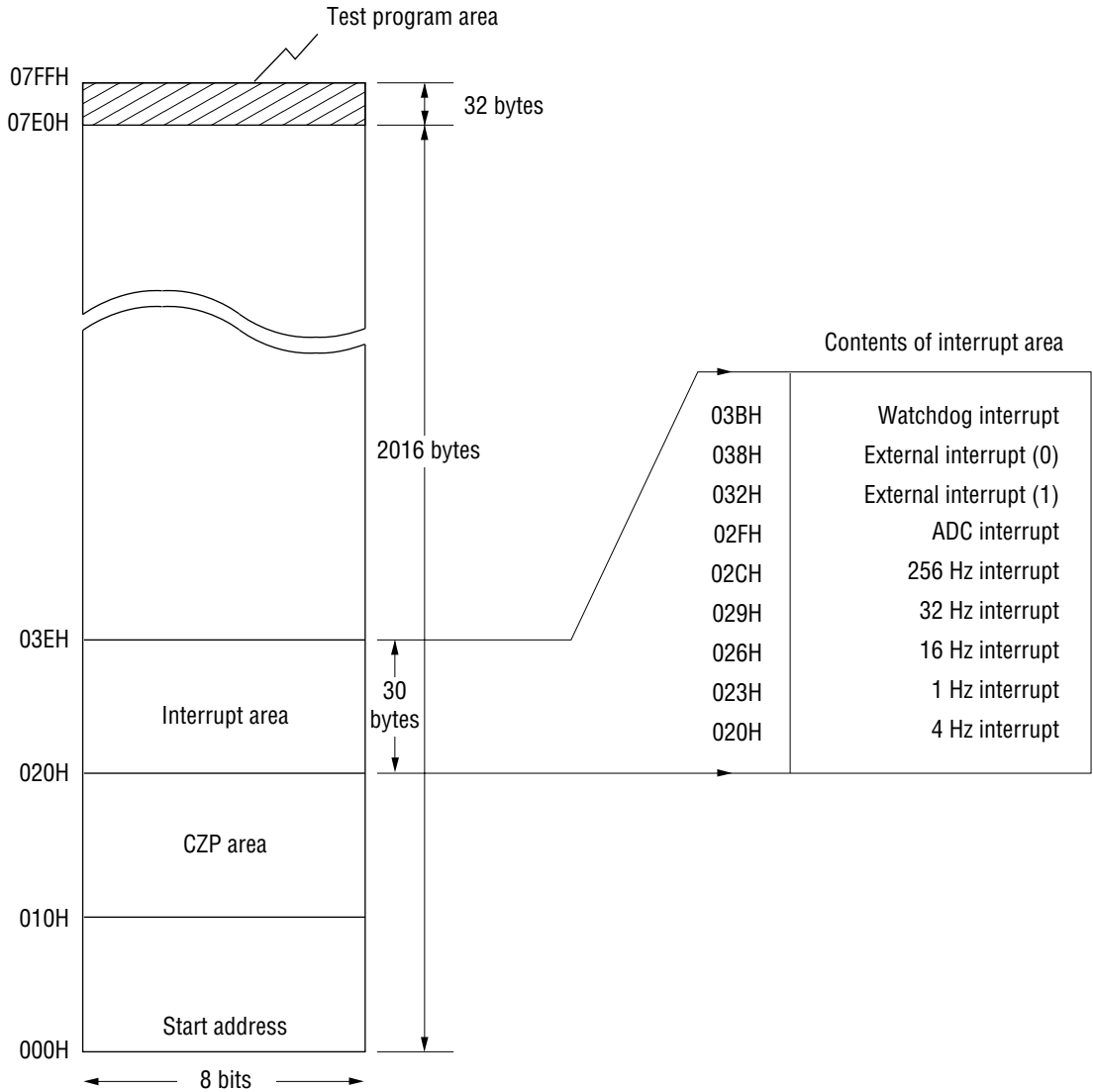
| Function      | Symbol                    | Type | Description                                                                                                 |
|---------------|---------------------------|------|-------------------------------------------------------------------------------------------------------------|
| Power Supply  | V <sub>DD</sub>           | —    | 0 V power supply                                                                                            |
|               | V <sub>SS1</sub>          | —    | Bias output for driving LCD (–1.5 V), or negative power supply at 1.5 V spec.                               |
|               | V <sub>SS2</sub>          | —    | Bias output for driving LCD (–3.0 V), or negative power supply at 3.0 V spec.                               |
|               | V <sub>SS3</sub>          | —    | Bias output for driving LCD (–4.5 V).                                                                       |
|               | V <sub>SSL</sub>          | —    | Negative power supply pin for internal logic (internally generated constant voltage)                        |
|               | C1, C2                    | —    | Pins for connecting a capacitor for generating V <sub>SS1</sub> , V <sub>SS2</sub> , and V <sub>SS3</sub> . |
| Oscillation   | XT                        | I    | 32.768 kHz crystal connection pins                                                                          |
|               | $\overline{\text{XT}}$    | O    |                                                                                                             |
| Ports         | P1.0 to P1.3              | O    | Output port (P1.0 : high current output)                                                                    |
|               | P0.0 to P0.3              | I    | Input port                                                                                                  |
|               | P2.0 to P3.3              | I/O  | Input-output ports                                                                                          |
|               | BD                        | O    | Output pin for the buzzer driver                                                                            |
|               | L0 to L15                 | O    | LCD driver pins                                                                                             |
|               | L16/P5.0 to L23/P6.3      | O    | LCD driver pins, or output ports by mask option                                                             |
| A/D Converter | RT0                       | O    | Resistance temperature sensor connection pin                                                                |
|               | CRT0                      | O    | Resistance/capacitance temperature sensor connection pin                                                    |
|               | RS0                       | O    | Reference resistor connection pin                                                                           |
|               | CS0                       | O    | Reference capacitor connection pin                                                                          |
|               | IN0                       | I    | Input pin for RC oscillator circuit                                                                         |
| Reset         | $\overline{\text{RESET}}$ | I    | Reset pin                                                                                                   |
| Test          | $\overline{\text{TST1}}$  | I    | Input pins for testing                                                                                      |
|               | $\overline{\text{TST2}}$  | I    |                                                                                                             |

## Secondary Functions

| Function               | Symbol | Type | Description                                                    |
|------------------------|--------|------|----------------------------------------------------------------|
| RC Oscillation Monitor | P3.3   | 0    | Monitor output pin (MON) for an RC oscillation clock.          |
| Battery Check          | P0.3   | I    | Analog comparator input pin for battery check.                 |
| External Interrupt     | P3.0   | I    | Level-triggered external 0 interrupt input pins.               |
|                        | P3.1   | I    | The change of input signal level causes an interrupt to occur. |
|                        | P3.2   | I    |                                                                |
|                        | P3.3   | I    |                                                                |
|                        | P2.0   | I    |                                                                |
|                        | P2.1   | I    |                                                                |
|                        | P2.2   | I    |                                                                |
|                        | P2.3   | I    |                                                                |
|                        | P0.0   | I    | Level-triggered external 1 interrupt input pins.               |
|                        | P0.1   | I    | The change of input signal level causes an interrupt to occur. |
|                        | P0.2   | I    |                                                                |
|                        | P0.3   | I    |                                                                |
| Capture                | P0.0   | I    | Capture circuit trigger input pins.                            |
|                        | P0.1   | I    |                                                                |

MEMORY MAPS

Program Memory

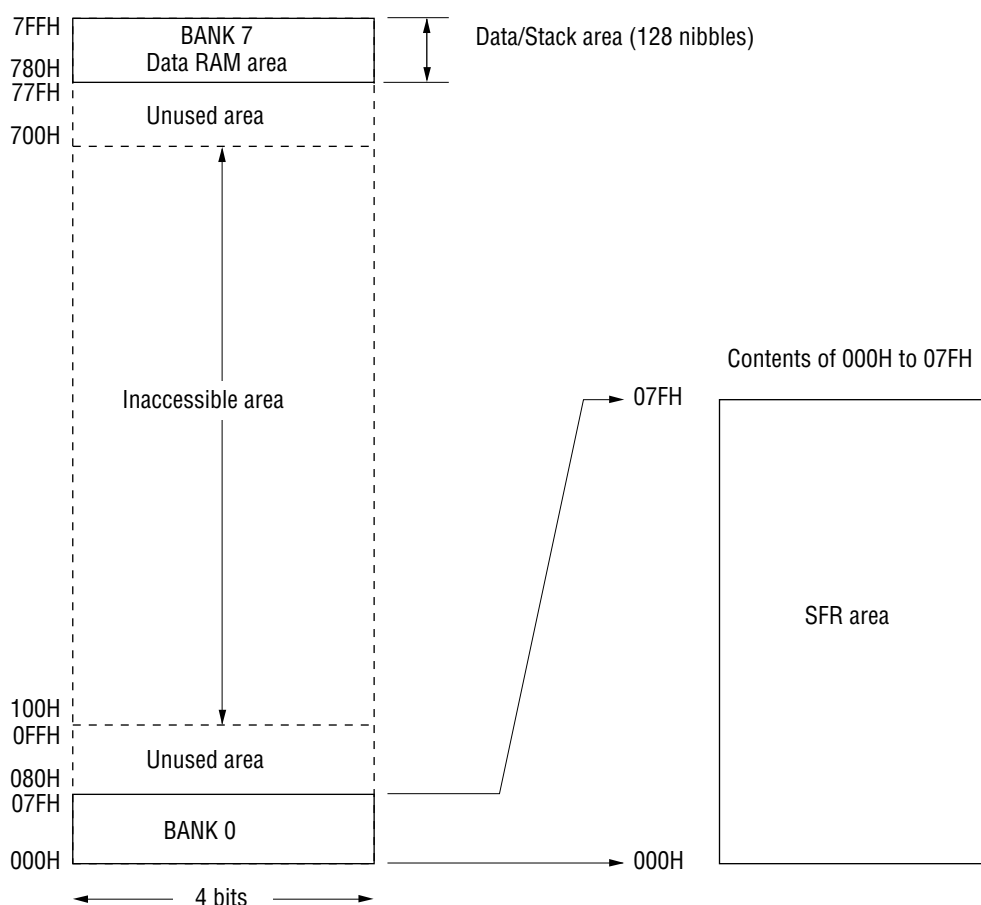


Program Memory Map

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>SS1</sub>  | Ta = 25°C                          | −2.0 to +0.3                   | V    |
| Power Supply Voltage 2 | V <sub>SS2</sub>  | Ta = 25°C                          | −4.0 to +0.3                   | V    |
| Power Supply Voltage 3 | V <sub>SS3</sub>  | Ta = 25°C                          | −5.5 to +0.3                   | V    |
| Power Supply Voltage 4 | V <sub>SSL</sub>  | Ta = 25°C                          | −2.0 to +0.3                   | V    |
| Input Voltage 1        | V <sub>IN1</sub>  | V <sub>SS1</sub> Input, Ta = 25°C  | V <sub>SS1</sub> − 0.3 to +0.3 | V    |
| Input Voltage 2        | V <sub>IN2</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>SS1</sub> Output, Ta = 25°C | V <sub>SS1</sub> − 0.3 to +0.3 | V    |
| Output Voltage 2       | V <sub>OUT2</sub> | V <sub>SS2</sub> Output, Ta = 25°C | V <sub>SS2</sub> − 0.3 to +0.3 | V    |
| Output Voltage 3       | V <sub>OUT3</sub> | V <sub>SS3</sub> Output, Ta = 25°C | V <sub>SS3</sub> − 0.3 to +0.3 | V    |
| Output Voltage 4       | V <sub>OUT4</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 (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>SS1</sub> | —         | −1.7 to −1.25 | V    |
| Crystal Oscillation Frequency | f <sub>XT</sub>  | —         | 30 to 35      | kHz  |

**ELECTRICAL CHARACTERISTICS (1.5 V Spec.)****DC Characteristics**(V<sub>DD</sub> = 0 V, V<sub>SS1</sub> = -1.5 V, Ta = -40 to +85°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<br>+100%<br>-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<br>+100%<br>-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:<br>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    |                   |
| POR Generation Voltage                  | V <sub>POR1</sub> | When V <sub>SS1</sub> is between V <sub>POR1</sub><br>and -1.5 V            | -0.4  | —     | 0     | V     |                   |
| POR Non-generation Voltage              | V <sub>POR2</sub> | No POR when V <sub>SS1</sub> is between<br>V <sub>POR2</sub> and -1.5 V     | -1.5  | —     | -1.2  | V     |                   |
| Battery Check Reference Voltage         | V <sub>RB</sub>   | Ta = 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>SS1</sub> = -1.5 V, Ta = -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                                                        | Ta = -40 to +40°C | —    | 2.0  | 5.0  | μA                |
|                  |                  |                                                                          | Ta = +40 to +85°C | —    | 2.0  | 30   | μA                |
| Supply Current 2 | I <sub>DD2</sub> | CPU in operating state                                                   | Ta = -40 to +40°C | —    | 5.0  | 15   | μA                |
|                  |                  |                                                                          | Ta = +40 to +85°C | —    | 5.0  | 40   | μA                |
| Supply Current 3 | I <sub>DD3</sub> | CPU in halt state, RC oscillator for A/D converter is in operating state | RT0 = 10 kΩ       | —    | 150  | 230  | μA                |
|                  |                  |                                                                          | RT0 = 2 kΩ        | —    | 600  | 900  | μA                |
| Supply Current 4 | I <sub>DD4</sub> | Battery check circuit in operating state, CPU in operating state         | —                 | 25   | 125  | μA   | 1                 |

DC Characteristics (continued)

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

| Parameter<br>(Pin Name)                                                                                  | Symbol      | Condition                                               | Min. | Typ. | Max. | Unit          | Measuring<br>Circuit |
|----------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------|------|------|------|---------------|----------------------|
| Output Current 1<br>(P1.0)                                                                               | $I_{OH1}$   | $V_{OH1} = -0.5\text{ V}$                               | -2.1 | -0.7 | -0.2 | mA            | 2                    |
|                                                                                                          | $I_{OL1}$   | $V_{OL1} = V_{SS1} + 0.5\text{ V}$                      | 1.0  | 3.0  | 9.0  | mA            |                      |
| Output Current 2<br>(P1.1 to P1.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3)                                   | $I_{OH2}$   | $V_{OH2} = -0.5\text{ V}$                               | -2.1 | -0.7 | -0.2 | mA            |                      |
|                                                                                                          | $I_{OL2}$   | $V_{OL2} = V_{SS1} + 0.5\text{ V}$                      | 0.2  | 0.7  | 2.1  | mA            |                      |
| Output Current 3<br>(BD)                                                                                 | $I_{OH3}$   | $V_{OH3} = -0.7\text{ V}$                               | -1.8 | -0.6 | -0.2 | mA            |                      |
|                                                                                                          | $I_{OL3}$   | $V_{OL3} = V_{SS1} + 0.7\text{ V}$                      | 0.2  | 0.6  | 1.8  | mA            |                      |
| Output Current 4<br>(RT0, RS0, CRT0,<br>CS0)                                                             | $I_{OH4}$   | $V_{OH4} = -0.1\text{ V}$                               | -1.1 | -0.6 | -0.3 | mA            |                      |
|                                                                                                          | $I_{OL4}$   | $V_{OL4} = V_{SS1} + 0.1\text{ V}$                      | 0.3  | 0.6  | 1.1  | mA            |                      |
| Output Current 5<br>(When L16 to L23 are<br>configured as output<br>ports)                               | $I_{OH5}$   | $V_{OH5} = -0.5\text{ V}$                               | -1.5 | -0.5 | -0.1 | mA            |                      |
|                                                                                                          | $I_{OL5}$   | $V_{OL5} = V_{SS1} + 0.5\text{ V}$                      | 0.1  | 0.5  | 1.5  | mA            |                      |
| Output Current 6<br>(L0 to L23)                                                                          | $I_{OH6}$   | $V_{OH6} = -0.2\text{ V}$ ( $V_{DD}$ level)             | —    | —    | -4.0 | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OMH6}$  | $V_{OMH6} = V_{SS1} + 0.2\text{ V}$ ( $V_{SS1}$ level)  | 4.0  | —    | —    | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OMH6S}$ | $V_{OMH6S} = V_{SS1} - 0.2\text{ V}$ ( $V_{SS1}$ level) | —    | —    | -4.0 | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OML6}$  | $V_{OML6} = V_{SS2} + 0.2\text{ V}$ ( $V_{SS2}$ level)  | 4.0  | —    | —    | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OML6S}$ | $V_{OML6S} = V_{SS2} - 0.2\text{ V}$ ( $V_{SS2}$ level) | —    | —    | -4.0 | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OL6}$   | $V_{OL6} = V_{SS3} + 0.2\text{ V}$ ( $V_{SS3}$ level)   | 4.0  | —    | —    | $\mu\text{A}$ |                      |
| Output Leakage Current<br>(P1.0 to P1.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3)<br>(RT0, RS0, CRT0,<br>CS0) | $I_{OOH}$   | $V_{OH} = V_{DD}$                                       | —    | —    | 0.3  | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OOL}$   | $V_{OL} = V_{SS1}$                                      | -0.3 | —    | —    | $\mu\text{A}$ |                      |

DC Characteristics (continued)

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

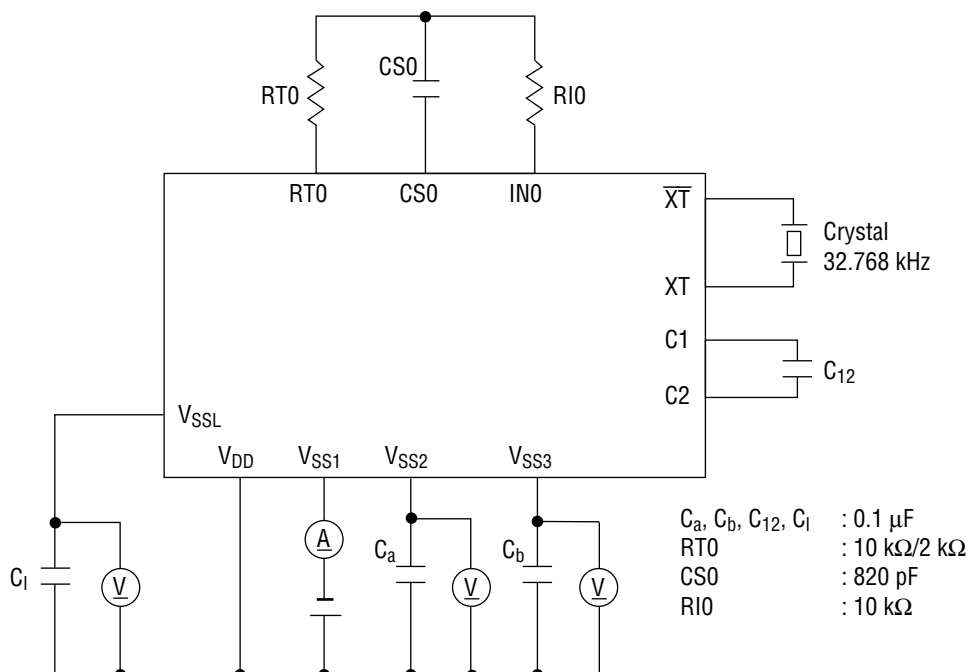
| Parameter<br>(Pin Name)                                                                 | Symbol     | Condition                                       | Min. | Typ.  | Max. | Unit          | Measuring<br>Circuit |
|-----------------------------------------------------------------------------------------|------------|-------------------------------------------------|------|-------|------|---------------|----------------------|
| Input Current 1<br>(P0.0 to P0.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3)<br>(P4.0 to P4.3) | $I_{IH1}$  | $V_{IH1} = V_{DD}$ (when pulled down)           | 5    | 18    | 60   | $\mu\text{A}$ | 3                    |
|                                                                                         | $I_{IL1}$  | $V_{IL1} = V_{SS1}$ (when pulled up)            | -60  | -18   | -5.0 | $\mu\text{A}$ |                      |
|                                                                                         | $I_{IH1Z}$ | $V_{IH1} = V_{DD}$ (in a high impedance state)  | 0    | —     | 1.0  | $\mu\text{A}$ |                      |
|                                                                                         | $I_{IL1Z}$ | $V_{IL1} = V_{SS1}$ (in a high impedance state) | -1.0 | —     | 0    | $\mu\text{A}$ |                      |
| Input Current 2<br>(IN0)                                                                | $I_{IH2}$  | $V_{IH2} = V_{DD}$ (when pulled down)           | 5    | 18    | 60   | $\mu\text{A}$ |                      |
|                                                                                         | $I_{IH2Z}$ | $V_{IH2} = V_{DD}$ (in a high impedance state)  | 0    | —     | 1.0  | $\mu\text{A}$ |                      |
|                                                                                         | $I_{IL2Z}$ | $V_{IL2} = V_{SS1}$ (in a high impedance state) | -1.0 | —     | 0    | $\mu\text{A}$ |                      |
| Input Current 3<br>(RESET, TST1, TST2)                                                  | $I_{IH3}$  | $V_{IH3} = V_{DD}$                              | 0    | —     | 1.0  | $\mu\text{A}$ | 4                    |
|                                                                                         | $I_{IL3}$  | $V_{IL3} = V_{SS1}$                             | -1.5 | -0.75 | -0.3 | $\text{mA}$   |                      |
| Input Voltage 1<br>(P0.0 to P0.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3)                   | $V_{IH1}$  | —                                               | -0.3 | —     | 0    | V             |                      |
|                                                                                         | $V_{IL1}$  | —                                               | -1.5 | —     | -1.2 | V             |                      |
| Input Voltage 2<br>(IN0)                                                                | $V_{IH2}$  | —                                               | -0.3 | —     | 0    | V             |                      |
|                                                                                         | $V_{IL2}$  | —                                               | -1.5 | —     | -1.2 | V             |                      |
| Input Voltage 3<br>(RESET, TST1, TST2)                                                  | $V_{IH3}$  | —                                               | -0.3 | —     | 0    | V             |                      |
|                                                                                         | $V_{IL3}$  | —                                               | -1.5 | —     | -1.2 | V             |                      |

DC Characteristics (continued)

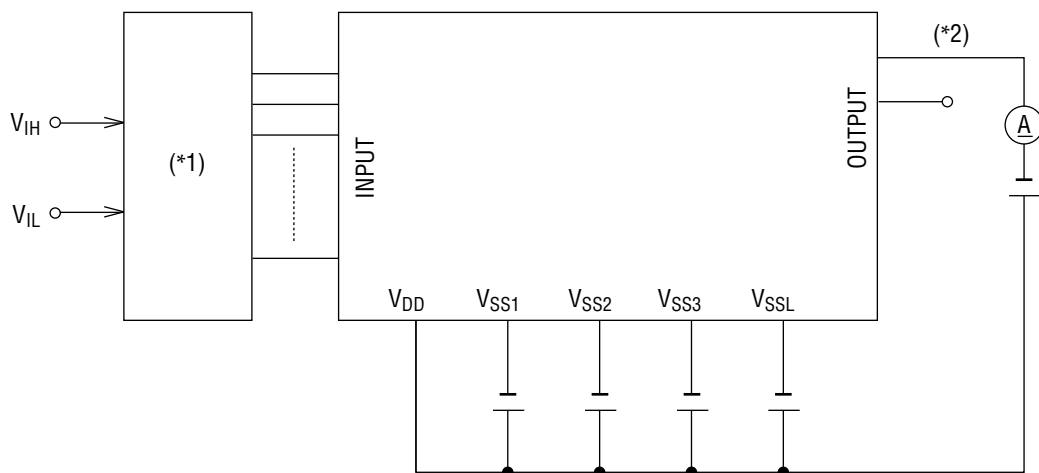
( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

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

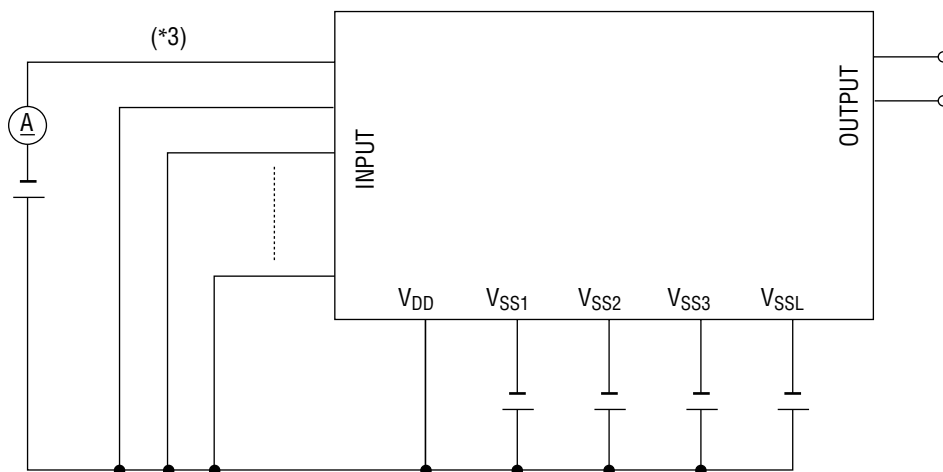
### Measuring circuit 1



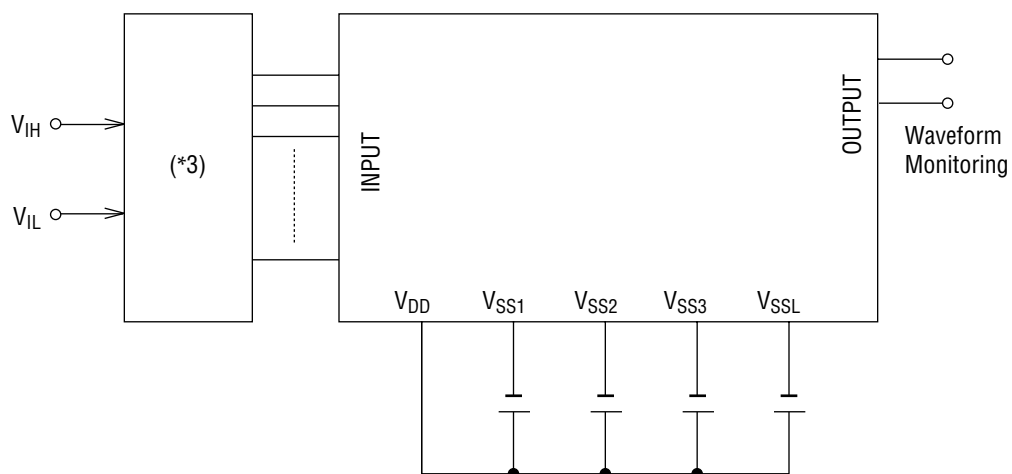
### Measuring circuit 2



### 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

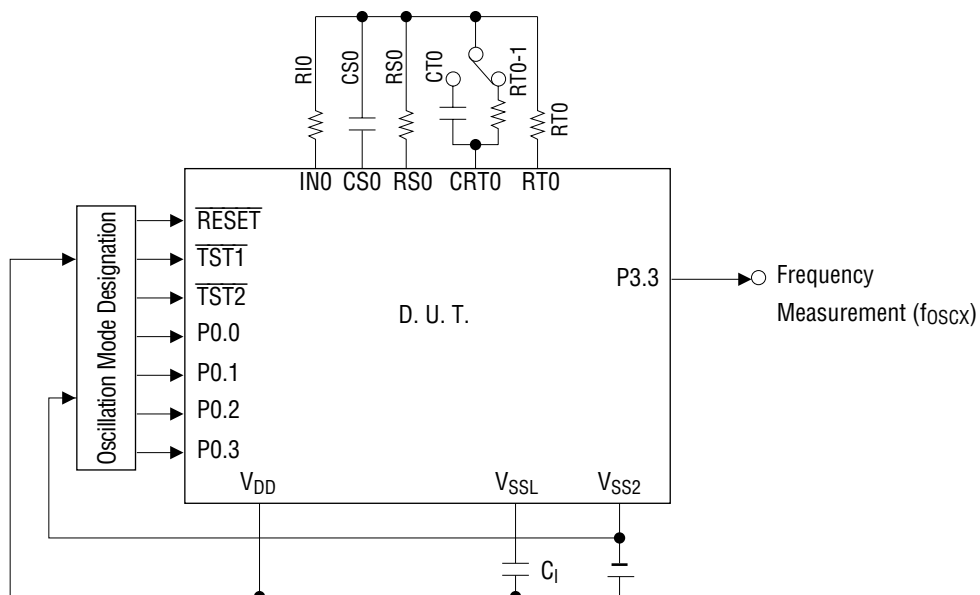
(V<sub>DD</sub> = 0 V, V<sub>SS1</sub> = -1.5 V, Ta = -40 to +85°C unless otherwise specified)

| Parameter                             | Symbol            | Condition                         | Min.   | Typ.   | Max.   | Unit | Measuring Circuit |
|---------------------------------------|-------------------|-----------------------------------|--------|--------|--------|------|-------------------|
| Resistor for Oscillation              | RS0, RT0, RT0-1   | CS0, CT0 ≥ 740 pF                 | 2.0    | —      | —      | kΩ   | 5                 |
| Input Current Limiting Resistor       | RI0               | —                                 | 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 = 2 kΩ                 | 3.89   | 4.18   | 4.35   | —    |                   |
|                                       | Kf2               | RT0, RT0-1 = 10 kΩ                | 0.990  | 1.0    | 1.010  | —    |                   |
|                                       | Kf3               | RT0, RT0-1 = 200 kΩ               | 0.0561 | 0.0584 | 0.0637 | —    |                   |

\* Kfx is the ratio of the oscillation frequency by a sensor resistor to the oscillation frequency by a reference resistor in the same condition.

$$Kfx = \frac{f_{oscx} \text{ (RT0-CS0 Oscillation)}}{f_{oscx} \text{ (RS0-CS0 Oscillation)}}, \frac{f_{oscx} \text{ (RT0-1-CS0 Oscillation)}}{f_{oscx} \text{ (RS0-CS0 Oscillation)}} \\ (x = 1, 2, 3)$$

## Measuring circuit 5



$R_{T0}, RT0-1 = 2\text{ k}\Omega/10\text{ k}\Omega/200\text{ k}\Omega$

$R_{S0} = 10\text{ k}\Omega$

$R_{I0} = 10\text{ k}\Omega$

$C_{S0}, C_{T0} = 820\text{ pF}$

$C_1 = 0.1\text{ }\mu\text{F}$

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

| Parameter              | Symbol            | Condition                          | Rating                         | Unit |
|------------------------|-------------------|------------------------------------|--------------------------------|------|
| Power Supply Voltage 1 | V <sub>SS1</sub>  | Ta = 25°C                          | −2.0 to +0.3                   | V    |
| Power Supply Voltage 2 | V <sub>SS2</sub>  | Ta = 25°C                          | −4.0 to +0.3                   | V    |
| Power Supply Voltage 3 | V <sub>SS3</sub>  | Ta = 25°C                          | −5.5 to +0.3                   | V    |
| Power Supply Voltage 4 | V <sub>SSL</sub>  | Ta = 25°C                          | −4.0 to +0.3                   | V    |
| Input Voltage 1        | V <sub>IN1</sub>  | V <sub>SS2</sub> Input, Ta = 25°C  | V <sub>SS2</sub> − 0.3 to +0.3 | V    |
| Input Voltage 2        | V <sub>IN2</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>SS2</sub> Output, Ta = 25°C | V <sub>SS2</sub> − 0.3 to +0.3 | V    |
| Output Voltage 2       | V <sub>OUT2</sub> | V <sub>SS3</sub> Output, Ta = 25°C | V <sub>SS3</sub> − 0.3 to +0.3 | V    |
| Output Voltage 3       | V <sub>OUT3</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>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 |      |
| Crystal Oscillation Frequency | f <sub>XT</sub>  | —                                       | 30 to 66     | kHz  |

**ELECTRICAL CHARACTERISTICS (3.0 V Spec.)****DC Characteristics**(V<sub>DD</sub> = 0 V, V<sub>SS2</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>  | C <sub>a</sub> , C <sub>b</sub> , C <sub>12</sub> = 0.1 μF<br>+100%<br>-50% | -1.7  | -1.5  | -1.3  | 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<br>+100%<br>-50% | -4.7  | -4.5  | -4.3  | V     |                   |
| V <sub>SSL</sub> Voltage                | V <sub>SSL</sub>  | —                                                                           | -1.9  | -1.3  | -0.6  | V     |                   |
| Crystal Oscillation Start Voltage       | V <sub>STA</sub>  | Oscillation start time:<br>within 5 seconds                                 | —     | —     | -2.0  | V     |                   |
| Crystal Oscillation Hold Voltage        | V <sub>HOLD</sub> | —                                                                           | —     | —     | -2.0  | 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    |                   |
| POR Generation Voltage                  | V <sub>POR1</sub> | When V <sub>SS2</sub> is between V <sub>POR1</sub><br>and -3.0 V            | -0.7  | —     | 0     | V     |                   |
| POR Non-generation Voltage              | V <sub>POR2</sub> | No POR when V <sub>SS2</sub> is between<br>V <sub>POR2</sub> and -3.0 V     | -3.0  | —     | -2.0  | V     |                   |
| Battery Check Reference Voltage         | V <sub>RB</sub>   | Ta = 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>SS2</sub> = -3.0 V, Ta = -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                                                        | Ta = -40 to +40°C | —    | 1.5  | 4.5  | μA                |
|                  |                  |                                                                          | Ta = +40 to +85°C | —    | 1.5  | 30   | μA                |
| Supply Current 2 | I <sub>DD2</sub> | CPU in operating state                                                   | Ta = -40 to +40°C | —    | 5.0  | 15   | μA                |
|                  |                  |                                                                          | Ta = +40 to +85°C | —    | 5.0  | 40   | μA                |
| Supply Current 3 | I <sub>DD3</sub> | CPU in halt state, RC oscillator for A/D converter is in operating state | RT0 = 10 kΩ       | —    | 300  | 450  | μA                |
|                  |                  |                                                                          | RT0 = 2 kΩ        | —    | 1300 | 2000 | μA                |
| Supply Current 4 | I <sub>DD4</sub> | Battery check circuit in operating state, CPU in operating state         | —                 | 55   | 150  | μA   |                   |

## DC Characteristics (continued)

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

| Parameter<br>(Pin Name)                                                                                  | Symbol      | Condition                                               | Min. | Typ. | Max.  | Unit          | Measuring<br>Circuit |
|----------------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------|------|------|-------|---------------|----------------------|
| Output Current 1<br>(P1.0)                                                                               | $I_{OH1}$   | $V_{OH1} = -0.5\text{ V}$                               | -6.0 | -2.0 | -0.7  | mA            | 2                    |
|                                                                                                          | $I_{OL1}$   | $V_{OL1} = V_{SS2} + 0.5\text{ V}$                      | 3.0  | 8.0  | 25    | mA            |                      |
| Output Current 2<br>(P1.1 to P1.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3)                                   | $I_{OH2}$   | $V_{OH2} = -0.5\text{ V}$                               | -6.0 | -2.0 | -0.7  | mA            |                      |
|                                                                                                          | $I_{OL2}$   | $V_{OL2} = V_{SS2} + 0.5\text{ V}$                      | 0.7  | 2.0  | 6.0   | mA            |                      |
| Output Current 3<br>(BD)                                                                                 | $I_{OH3}$   | $V_{OH3} = -0.7\text{ V}$                               | -6.0 | -2.0 | -0.7  | mA            |                      |
|                                                                                                          | $I_{OL3}$   | $V_{OL3} = V_{SS2} + 0.7\text{ V}$                      | 0.7  | 2.0  | 6.0   | mA            |                      |
| Output Current 4<br>(RT0, RS0, CRT0,<br>CS0)                                                             | $I_{OH4}$   | $V_{OH4} = -0.1\text{ V}$                               | -2.5 | -1.3 | -0.7  | mA            |                      |
|                                                                                                          | $I_{OL4}$   | $V_{OL4} = V_{SS2} + 0.1\text{ V}$                      | 0.7  | 1.3  | 2.5   | mA            |                      |
| Output Current 5<br>(When L16 to L23 are<br>configured as output<br>ports)                               | $I_{OH5}$   | $V_{OH5} = -0.5\text{ V}$                               | -1.5 | -0.6 | -0.15 | mA            |                      |
|                                                                                                          | $I_{OL5}$   | $V_{OL5} = V_{SS2} + 0.5\text{ V}$                      | 0.15 | 0.6  | 1.5   | mA            |                      |
| Output Current 6<br>(L0 to L23)                                                                          | $I_{OH6}$   | $V_{OH6} = -0.2\text{ V}$ ( $V_{DD}$ level)             | —    | —    | -4.0  | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OMH6}$  | $V_{OMH6} = V_{SS1} + 0.2\text{ V}$ ( $V_{SS1}$ level)  | 4.0  | —    | —     | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OMH6S}$ | $V_{OMH6S} = V_{SS1} - 0.2\text{ V}$ ( $V_{SS1}$ level) | —    | —    | -4.0  | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OML6}$  | $V_{OML6} = V_{SS2} + 0.2\text{ V}$ ( $V_{SS2}$ level)  | 4.0  | —    | —     | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OML6S}$ | $V_{OML6S} = V_{SS2} - 0.2\text{ V}$ ( $V_{SS2}$ level) | —    | —    | -4.0  | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OL6}$   | $V_{OL6} = V_{SS3} + 0.2\text{ V}$ ( $V_{SS3}$ level)   | 4.0  | —    | —     | $\mu\text{A}$ |                      |
| Output Leakage Current<br>(P1.0 to P1.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3)<br>(RT0, RS0, CRT0,<br>CS0) | $I_{OOH}$   | $V_{OH} = V_{DD}$                                       | —    | —    | 0.3   | $\mu\text{A}$ |                      |
|                                                                                                          | $I_{OOL}$   | $V_{OL} = V_{SS2}$                                      | -0.3 | —    | —     | $\mu\text{A}$ |                      |

# DC Characteristics (continued)

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

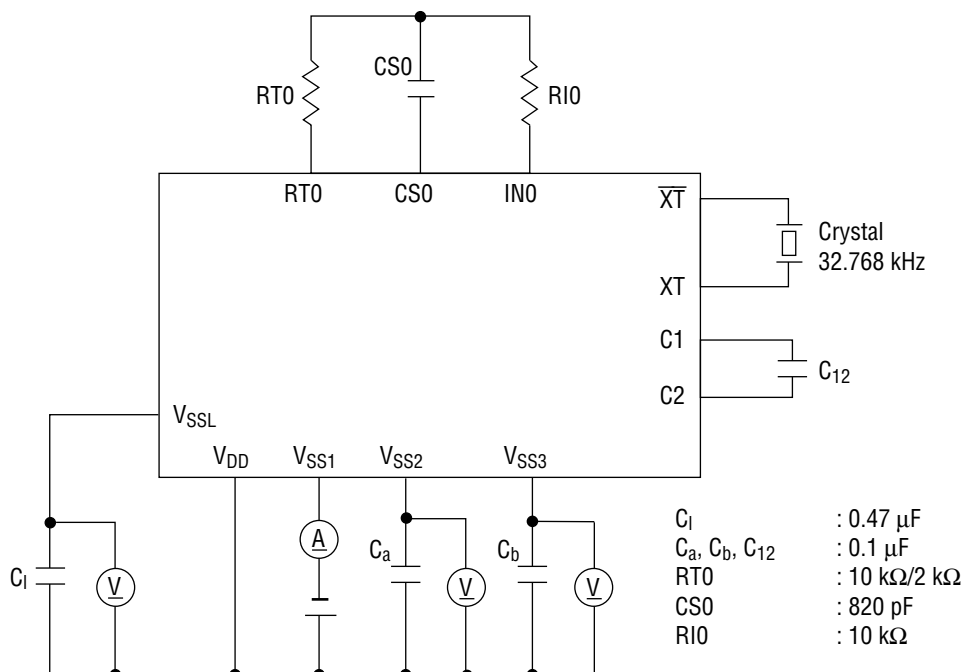
| Parameter<br>(Pin Name)                                               | Symbol     | Condition                                       | Min. | Typ. | Max.  | Unit          | Measuring<br>Circuit |
|-----------------------------------------------------------------------|------------|-------------------------------------------------|------|------|-------|---------------|----------------------|
| Input Current 1<br>(P0.0 to P0.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3) | $I_{IH1}$  | $V_{IH1} = V_{DD}$ (when pulled down)           | 30   | 90   | 300   | $\mu\text{A}$ | 3                    |
|                                                                       | $I_{IL1}$  | $V_{IL1} = V_{SS2}$ (when pulled up)            | -300 | -90  | -30   | $\mu\text{A}$ |                      |
|                                                                       | $I_{IH1Z}$ | $V_{IH1} = V_{DD}$ (in a high impedance state)  | 0    | —    | 1.0   | $\mu\text{A}$ |                      |
|                                                                       | $I_{IL1Z}$ | $V_{IL1} = V_{SS2}$ (in a high impedance state) | -1.0 | —    | 0     | $\mu\text{A}$ |                      |
| Input Current 2<br>(IN0)                                              | $I_{IH2}$  | $V_{IH2} = V_{DD}$ (when pulled down)           | 30   | 90   | 300   | $\mu\text{A}$ |                      |
|                                                                       | $I_{IH2Z}$ | $V_{IH2} = V_{DD}$ (in a high impedance state)  | 0    | —    | 1.0   | $\mu\text{A}$ |                      |
|                                                                       | $I_{IL2Z}$ | $V_{IL2} = V_{SS2}$ (in a high impedance state) | -1.0 | —    | 0     | $\mu\text{A}$ |                      |
| Input Current 3<br>(RESET, TST1, TST2)                                | $I_{IH3}$  | $V_{IH3} = V_{DD}$                              | 0    | —    | 1.0   | $\mu\text{A}$ | 4                    |
|                                                                       | $I_{IL3}$  | $V_{IL3} = V_{SS2}$                             | -3.0 | -1.5 | -0.75 | $\text{mA}$   |                      |
| Input Voltage 1<br>(P0.0 to P0.3)<br>(P2.0 to P2.3)<br>(P3.0 to P3.3) | $V_{IH1}$  | —                                               | -0.6 | —    | 0     | $\text{V}$    |                      |
|                                                                       | $V_{IL1}$  | —                                               | -3.0 | —    | -2.4  | $\text{V}$    |                      |
| Input Voltage 2<br>(IN0)                                              | $V_{IH2}$  | —                                               | -0.6 | —    | 0     | $\text{V}$    |                      |
|                                                                       | $V_{IL2}$  | —                                               | -3.0 | —    | -2.4  | $\text{V}$    |                      |
| Input Voltage 3<br>(RESET, TST1, TST2)                                | $V_{IH3}$  | —                                               | -0.6 | —    | 0     | $\text{V}$    |                      |
|                                                                       | $V_{IL3}$  | —                                               | -3.0 | —    | -2.4  | $\text{V}$    |                      |

**DC Characteristics (continued)**

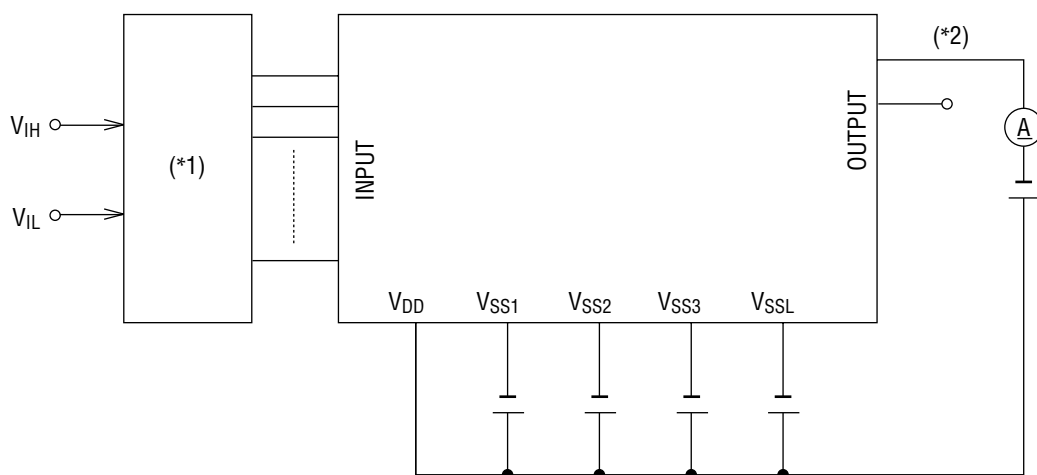
( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

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

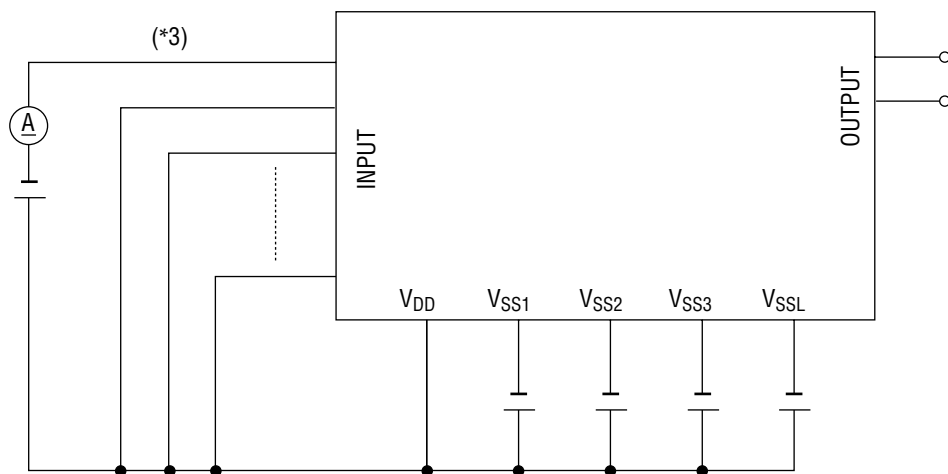
### Measuring circuit 1



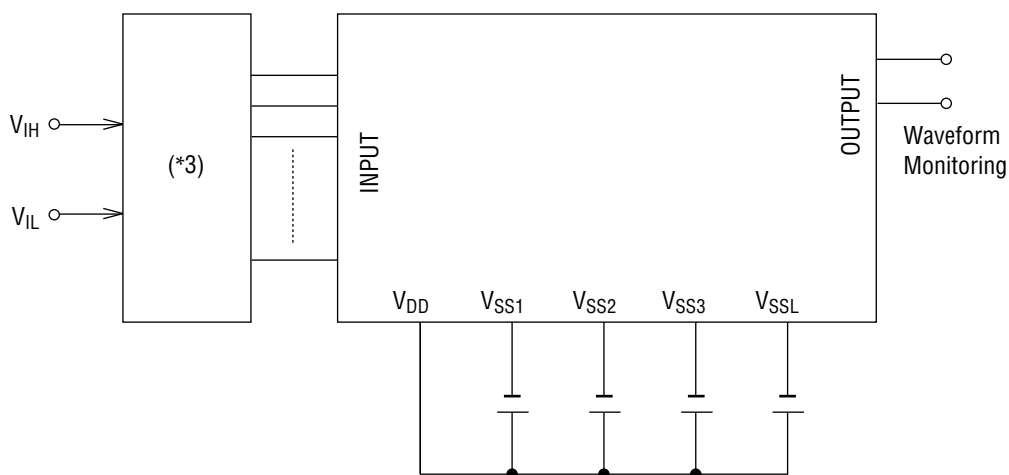
### Measuring circuit 2



### 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

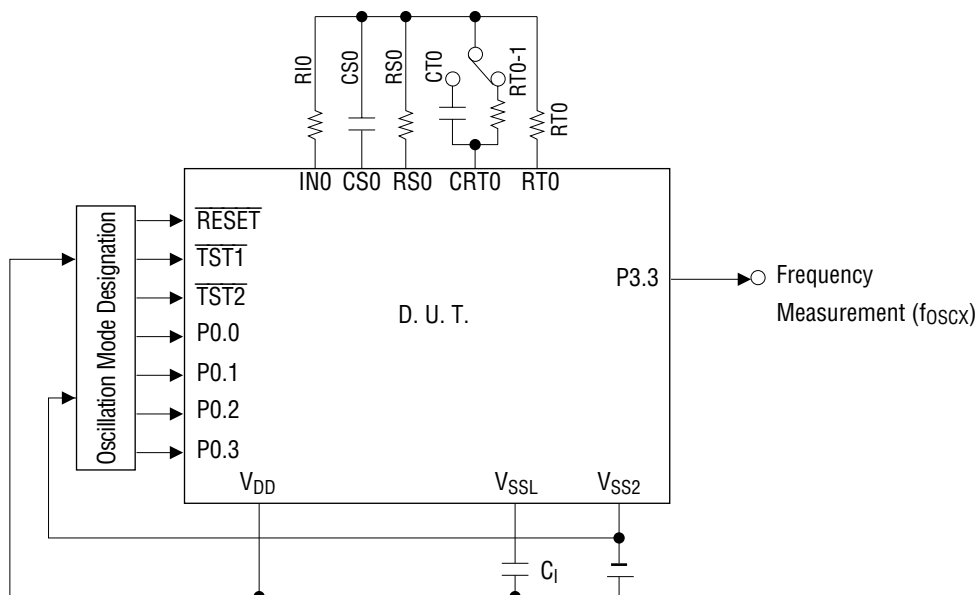
(V<sub>DD</sub> = 0 V, V<sub>SS2</sub> = -3.0 V, Ta = -40 to +85°C unless otherwise specified)

| Parameter                            | Symbol            | Condition                         | Min.   | Typ.   | Max.   | Unit | Measuring Circuit |
|--------------------------------------|-------------------|-----------------------------------|--------|--------|--------|------|-------------------|
| Resistor for Oscillation             | RS0, RT0, RT0-1   | CS0, CT0 ≥ 740 pF                 | 1.0    | —      | —      | kΩ   | 5                 |
| Input Current Limiting Resistor      | RI0               | —                                 | 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 = 2 kΩ                 | 4.115  | 4.22   | 4.326  | —    |                   |
|                                      | Kf2               | RT0, RT0-1 = 10 kΩ                | 0.990  | 1.0    | 1.010  | —    |                   |
|                                      | Kf3               | RT0, RT0-1 = 200 kΩ               | 0.0573 | 0.0616 | 0.0659 | —    |                   |

\* Kfx is the ratio of the oscillation frequency by a sensor resistor to the oscillation frequency by a reference resistor in the same condition.

$$Kfx = \frac{f_{OSCx} \text{ (RT0-CS0 Oscillation)}}{f_{OSCx} \text{ (RS0-CS0 Oscillation)}}, \frac{f_{OSCx} \text{ (RT0-1-CS0 Oscillation)}}{f_{OSCx} \text{ (RS0-CS0 Oscillation)}} \\ (x = 1, 2, 3)$$

## Measuring circuit 5



RT0, RT0-1 = 2 k $\Omega$ /10 k $\Omega$ /200 k $\Omega$

RS0 = 10 k $\Omega$

R10 = 10 k $\Omega$

CS0, CT0 = 820 pF

C1 = 0.47  $\mu$ F

## FUNCTIONAL DESCRIPTION

### • A/D converter (ADC)

The MSM64162D has a built-in 1-channel RC oscillation type A/D converter. The A/D converter is composed of a 1-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.

### • LCD driver (LCD)

The MSM64162D 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).

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 MSM64162D 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 MSM64162D 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 MSM64162D 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 (CLKG)**

The clock generation circuit (CLKG) in the MSM64162D contains a 32.768 kHz crystal oscillation circuit. 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.

The system clock frequency is 32.768 kHz, which is the output of the crystal oscillation circuit.

**• Time base counter (TBC)**

The MSM64162D 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)**

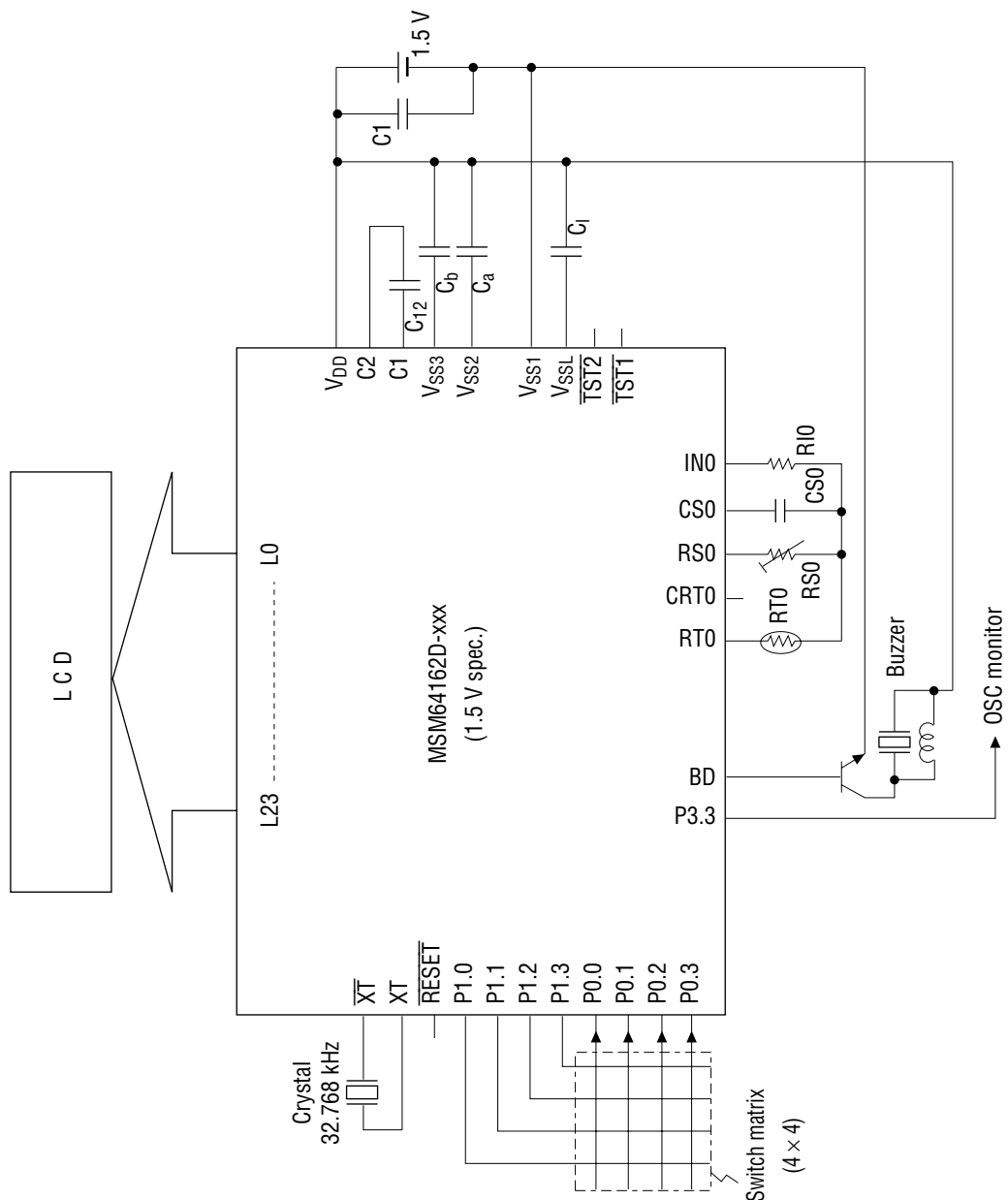
The MSM64162D has 9 interrupt sources (9 vector addresses), of which two are external interrupts from ports and seven are internal interrupts.

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)**

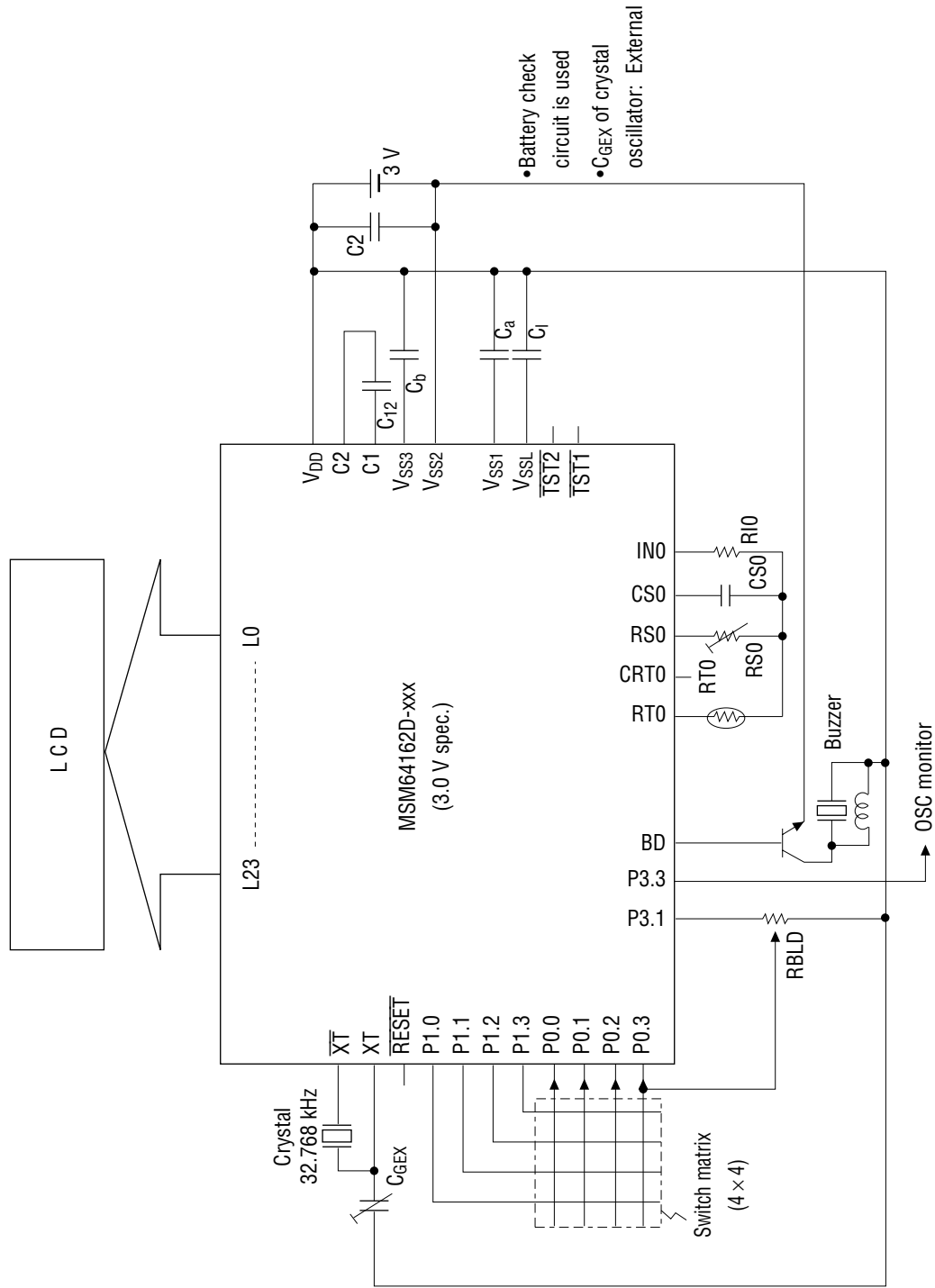
The battery check circuit (BC) detects the level of the supply voltage by comparing the voltage generated by an external supply-voltage dividing resistor (RBLD) with the internal reference voltage (Vrb).

# APPLICATION CIRCUITS



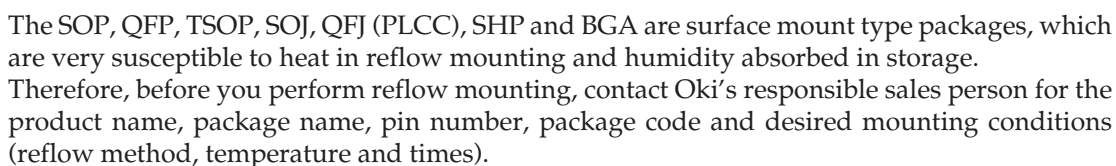
1.5 V Spec. Application Circuit

APPLICATION CIRCUITS (continued)

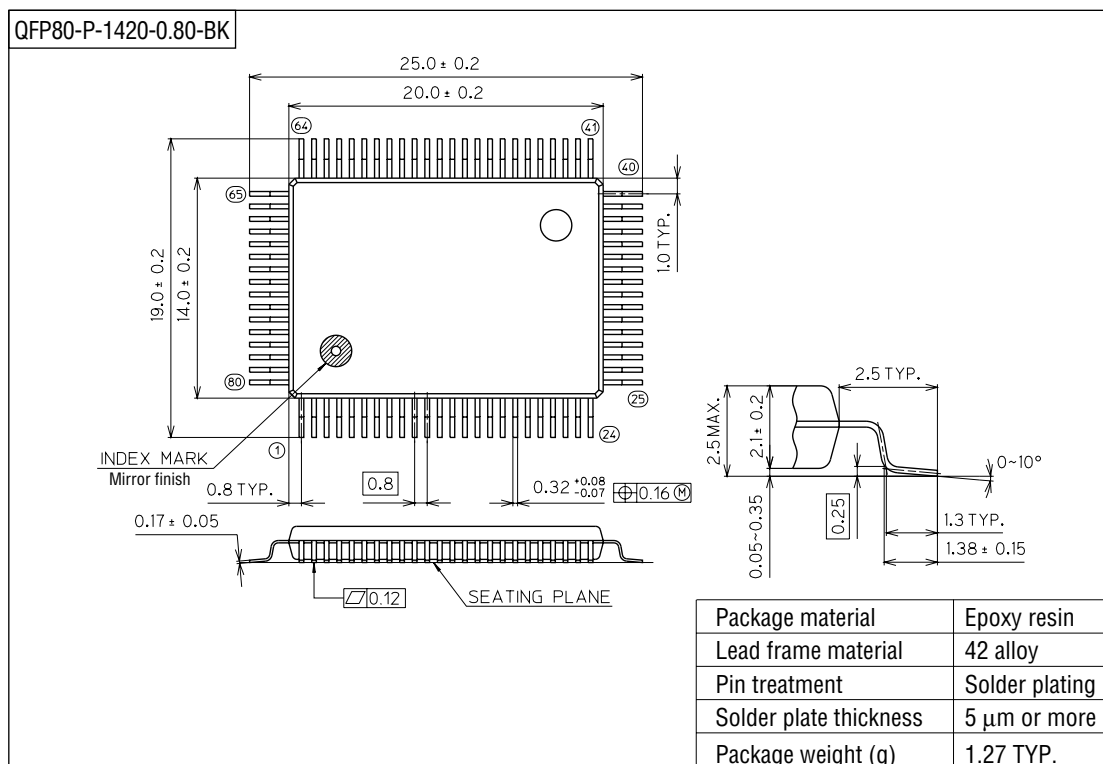


3.0 V Spec. Application Circuit

(Unit : mm)



(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).