

# MSM64164C

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

### GENERAL DESCRIPTION

The MSM64164C is a low power 4-bit microcontroller that employs Oki's original CPU core nX-4/20.

The MSM64164C is best suitable for applications such as low power, high precision thermometers and hygrometers.

The MSM64P164 is a one-time-programmable ROM-version product having one-time PROM (OTP) as internal program memory.

The MSM64P164 is used to evaluate the software development.

The MSM64P164 differs from the MSM64164C in the polarity of the power supply.

### 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 : 4064 bytes
  - Internal data memory : 256 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 dividing 2-channel method
- Serial port : Synchronous 8-bit transfer
- LCD driver : 34 outputs; duty ratio switchable by software
  - (1) At 1/4 duty and 1/3 bias : 120 segments (max)
  - (2) At 1/3 duty and 1/3 bias : 93 segments (max)
  - (3) At 1/2 duty and 1/2 bias : 64 segments (max)
- 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 : 3 ports × 4 bits
  - Input port : 1 port × 4 bits
  - Output port : 1 port × 4 bits

(8 out of the 34 LCD driver outputs can be used as output-only ports by mask option.)



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- Interrupt sources
  - External interrupt : 2 sources
  - Internal interrupt : 8 sources
- Package options:
  - 80-pin plastic QFP (QFP80-P-1420-0.80-BK) : (Product name : MSM64164C-xxxGS-BK)
  - 80-pin plastic QFP (QFP80-P-1414-0.65-K) : (Product name : MSM64164C-xxxGS-K)
  - 80-pin plastic TQFP (TQFP80-P-1212-0.50-K) : (Product name : MSM64164C-xxxTS-K)
  - Chip : (Product name : MSM64164C-xxx)

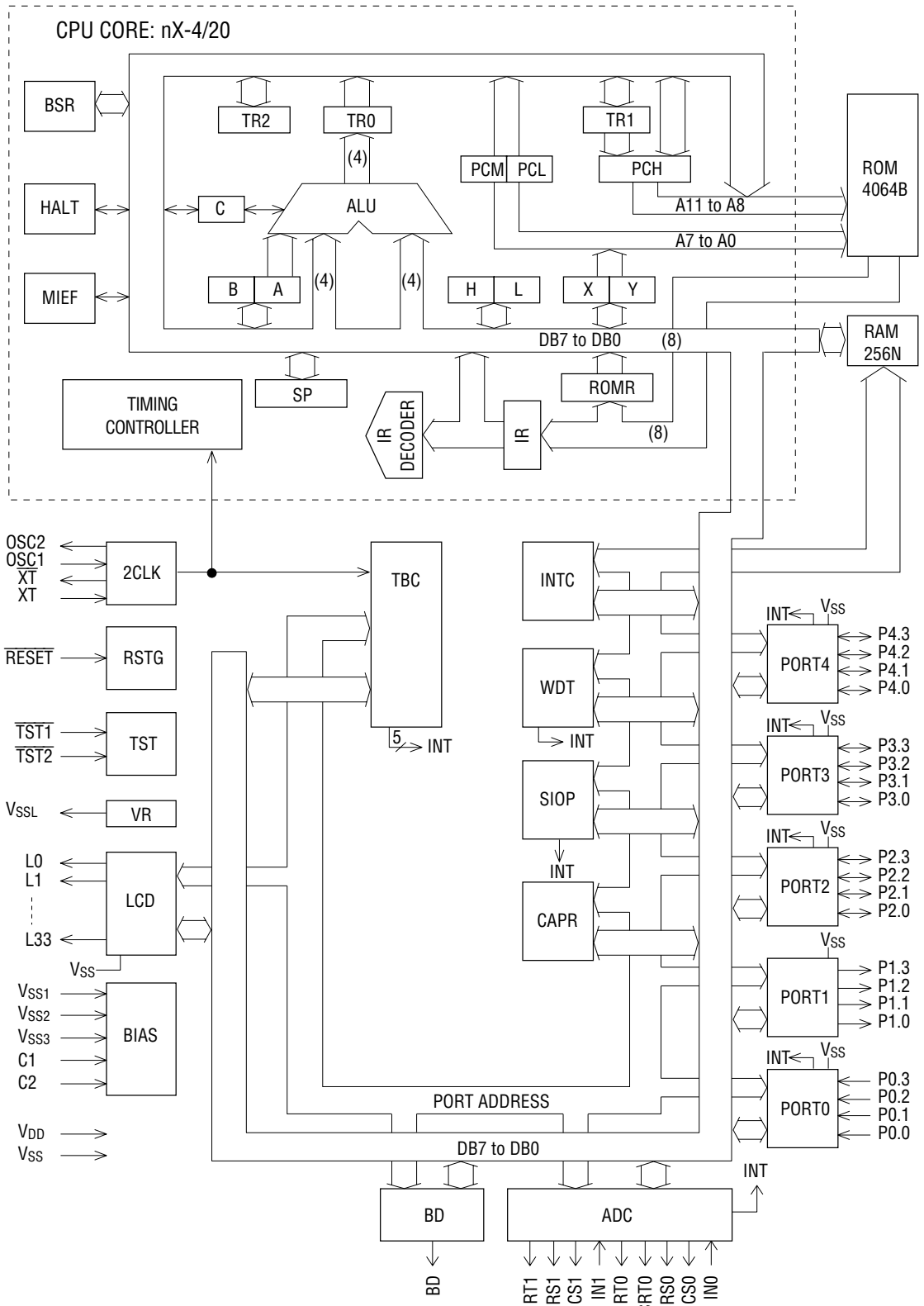
xxx indicates a code number.
- OTP version

The MSM64P164 has one-time PROM (OTP) as internal program memory and is used to evaluate the software development.

The MSM64P164 differs from the MSM64164C in the polarity of the power supply and operating voltage.

Refer to the "MSM64P164 User's Manual" for details.

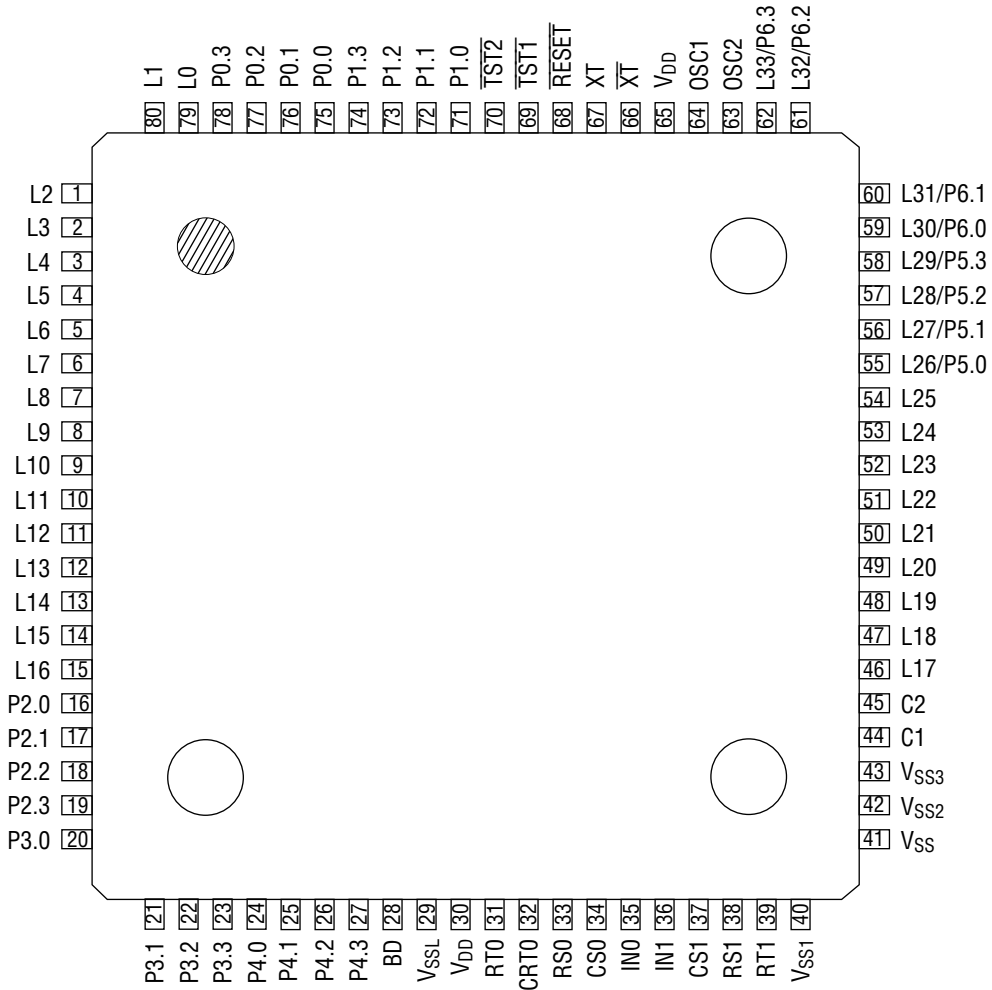
**BLOCK DIAGRAM**







PIN CONFIGURATION (TOP VIEW) (continued)

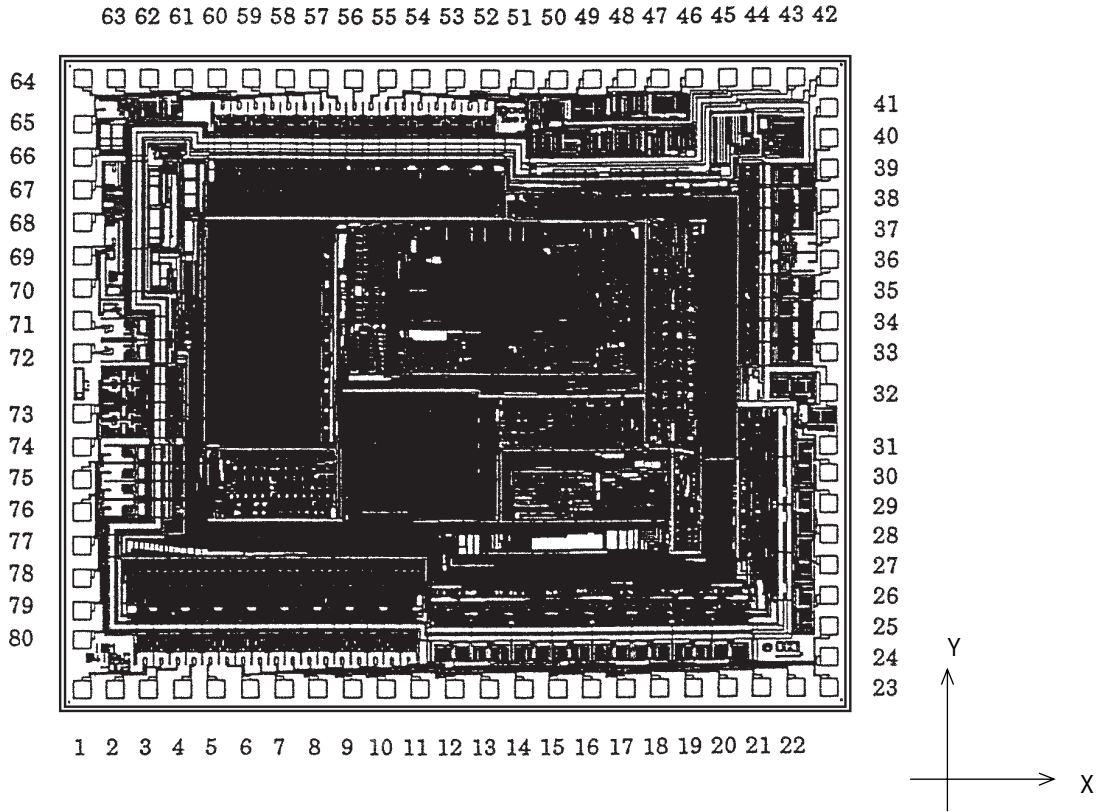


(TQFP80-P-1212-0.50-K)

80-Pin Plastic TQFP

**PAD CONFIGURATION**

**Pad Layout**



Chip Size	: 5.39 mm × 4.48 mm
Chip Thickness	: 350 μm (typ.)
Coordinate Origin	: Chip center
Pad Hole Size	: 100 μm × 100 μm
Pad Size	: 120 μm × 120 μm
Minimum Pad Pitch	: 180 μm

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

## Pad Coordinates

Pad No.	Pad Name	X ( $\mu\text{m}$ )	Y ( $\mu\text{m}$ )	Pad No.	Pad Name	X ( $\mu\text{m}$ )	Y ( $\mu\text{m}$ )
1	L0	-2545	-2090	41	RT1	2545	1880
2	L1	-2314	-2090	42	V <sub>SS1</sub>	2545	2090
3	L2	-2083	-2090	43	V <sub>SS</sub>	2314	2090
4	L3	-1852	-2090	44	V <sub>SS2</sub>	2083	2090
5	L4	-1621	-2090	45	V <sub>SS3</sub>	1852	2090
6	L5	-1390	-2090	46	C1	1621	2090
7	L6	-1159	-2090	47	C2	1390	2090
8	L7	-928	-2090	48	L17	1159	2090
9	L8	-697	-2090	49	L18	928	2090
10	L9	-466	-2090	50	L19	697	2090
11	L10	-235	-2090	51	L20	466	2090
12	L11	0	-2090	52	L21	235	2090
13	L12	235	-2090	53	L22	0	2090
14	L13	466	-2090	54	L23	-235	2090
15	L14	697	-2090	55	L24	-466	2090
16	L15	928	-2090	56	L25	-697	2090
17	L16	1159	-2090	57	L26	-928	2090
18	P2.0	1390	-2090	58	L27	-1159	2090
19	P2.1	1621	-2090	59	L28	-1390	2090
20	P2.2	1852	-2090	60	L29	-1621	2090
21	P2.3	2083	-2090	61	L30	-1852	2090
22	P3.0	2314	-2090	62	L31	-2083	2090
23	P3.1	2545	-2090	63	L32	-2314	2090
24	P3.2	2545	-1880	64	L33	-2545	2090
25	P3.3	2545	-1670	65	OSC2	-2545	1775
26	P4.0	2545	-1460	66	OSC1	-2545	1551
27	P4.1	2545	-1250	67	V <sub>DD</sub>	-2545	1327
28	P4.2	2545	-1040	68	$\overline{\text{XT}}$	-2545	1103
29	P4.3	2545	-830	69	XT	-2545	879
30	BD	2545	-620	70	$\overline{\text{RESET}}$	-2545	655
31	V <sub>SSL</sub>	2545	-431	71	$\overline{\text{TST1}}$	-2545	431
32	V <sub>DD</sub>	2545	-74	72	$\overline{\text{TST2}}$	-2545	207
33	RT0	2545	200	73	P1.0	-2545	-207
34	CRT0	2545	410	74	P1.1	-2545	-431
35	RS0	2545	620	75	P1.2	-2545	-655
36	CS0	2545	830	76	P1.3	-2545	-879
37	IN0	2545	1040	77	P0.0	-2545	-1103
38	IN1	2545	1250	78	P0.1	-2545	-1327
39	CS1	2545	1460	79	P0.2	-2545	-1551
40	RS1	2545	1670	80	P0.3	-2545	-1747



**PIN DESCRIPTIONS**

**Basic Functions**

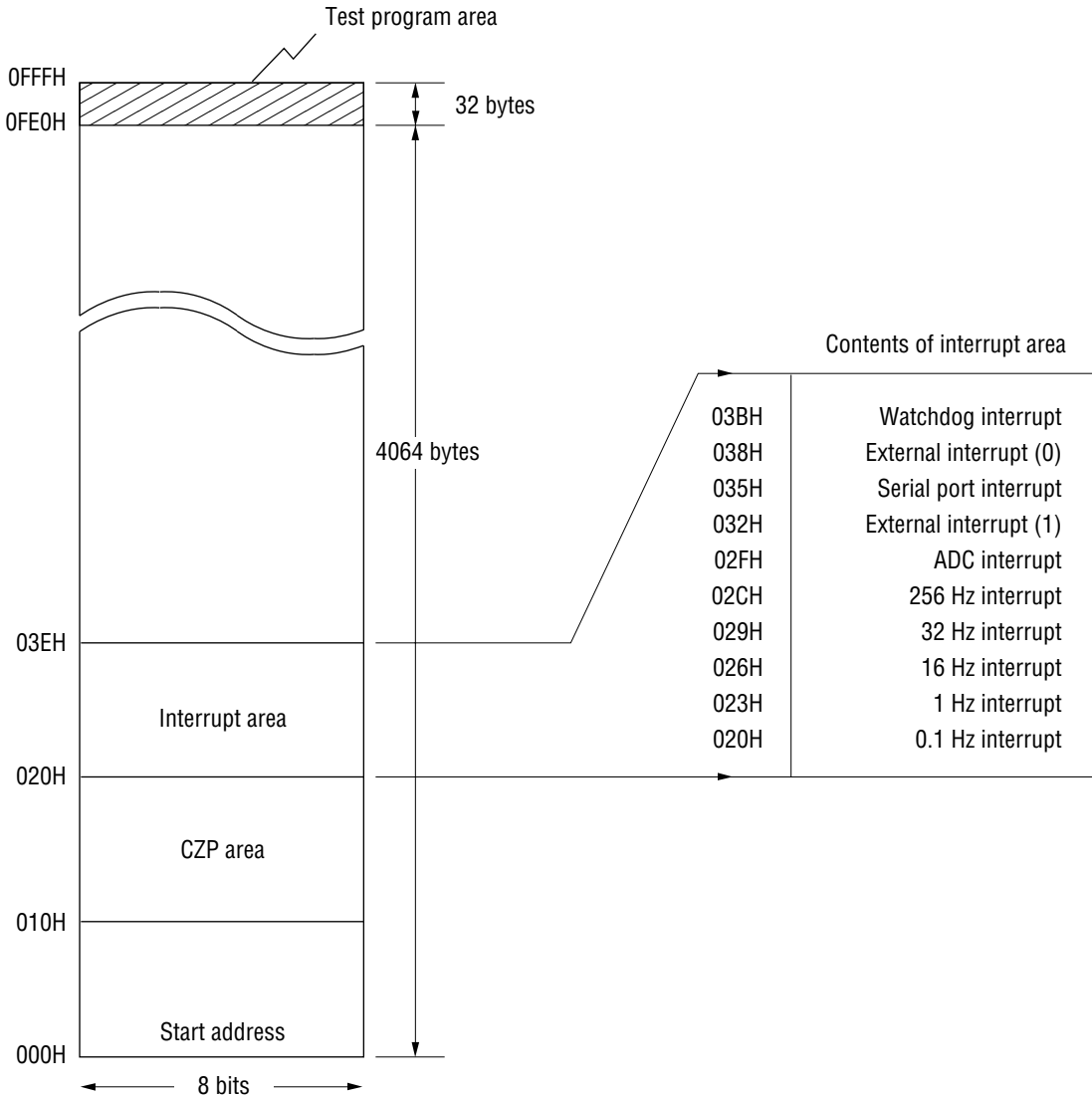
Function	Symbol	Type	Description	
Power Supply	V <sub>DD</sub>	—	0 V power supply	
	V <sub>SS1</sub>	—	Bias output for driving LCD (–1.5 V), or negative power supply at 1.5 V spec.	
	V <sub>SS2</sub>	—	Bias output for driving LCD (–3.0 V), or negative power supply at 3.0 V spec.	
	V <sub>SS3</sub>	—	Bias output for driving LCD (–4.5 V).	
	V <sub>SS</sub>	—	Negative power supply for I/O port interface	
	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	
	$\overline{\text{XT}}$	0		
	OSC1	I	External 400 kHz oscillation resistor (R <sub>OS</sub> ) connection pins	
	OSC2	0		
Ports	P1.0 to P1.3	0	Output port (P1.0 : high current output)	
	P0.0 to P0.3	I	Input port	
	P2.0 to P4.3	I/O	Input-output ports	
	BD	0	Output pin for the buzzer driver	
	L0 to L25	0	LCD driver pins	
	L26/P5.0 to L33/P6.3	0	LCD driver pins, or output ports by mask option	
A/D Converter	RT0	0	Resistance temperature sensor connection pin	RC oscillation pins for A/D converter (channel 0) (CROSC0)
	CRT0	0	Resistance/capacitance temperature sensor connection pin	
	RS0	0	Reference resistor connection pin	
	CS0	0	Reference capacitor connection pin	
	IN0	I	Input pin for RC oscillator circuit	RC oscillation pins for A/D converter (channel 1) (CROSC1)
	RT1	0	Resistance temperature sensor connection pin	
	RS1	0	Reference resistor connection pin	
	CS1	0	Reference capacitor connection pin	
IN1	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	
External Interrupt	P0.0	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			
	P0.2			
	P0.3			
		P2.0	I	Secondary functions of P2.0 to P2.3, P3.0 to P3.3, and P4.0 to P4.3: Level-triggered external interrupt input pins. The change of input signal level causes an interrupt to occur.
		P2.1		
		P2.2		
		P2.3		
		P3.0		
		P3.1		
		P3.2		
		P3.3		
		P4.0		
		P4.1		
Capture Trigger	P0.0	I	Secondary functions of P0.0 and P0.1: Capture circuit trigger input pins.	
	P0.1			
Serial Port	P3.3	I	Secondary functions of P3.3: This pin is assigned the data input of a serial port (SIN).	
	P4.0	O	Secondary functions of P4.0: This pin is assigned the data output of a serial port (SOUT).	
	P4.1	O	Secondary functions of P4.1: This pin is assigned the ready output of a serial port (SPR).	
	P4.2	I/O	Secondary functions of P4.2: This pin is assigned the clock I/O of a serial port (SCLK).	
RC Oscillation Monitor	P4.3	O	Secondary functions of P4.3: This pin is a monitor output (MON) of an RC oscillation clock (OSCCLK) for an A/D converter and a 400 kHz RC oscillation clock for a system clock.	

**MEMORY MAPS**

**Program Memory**



**Program Memory Map**

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

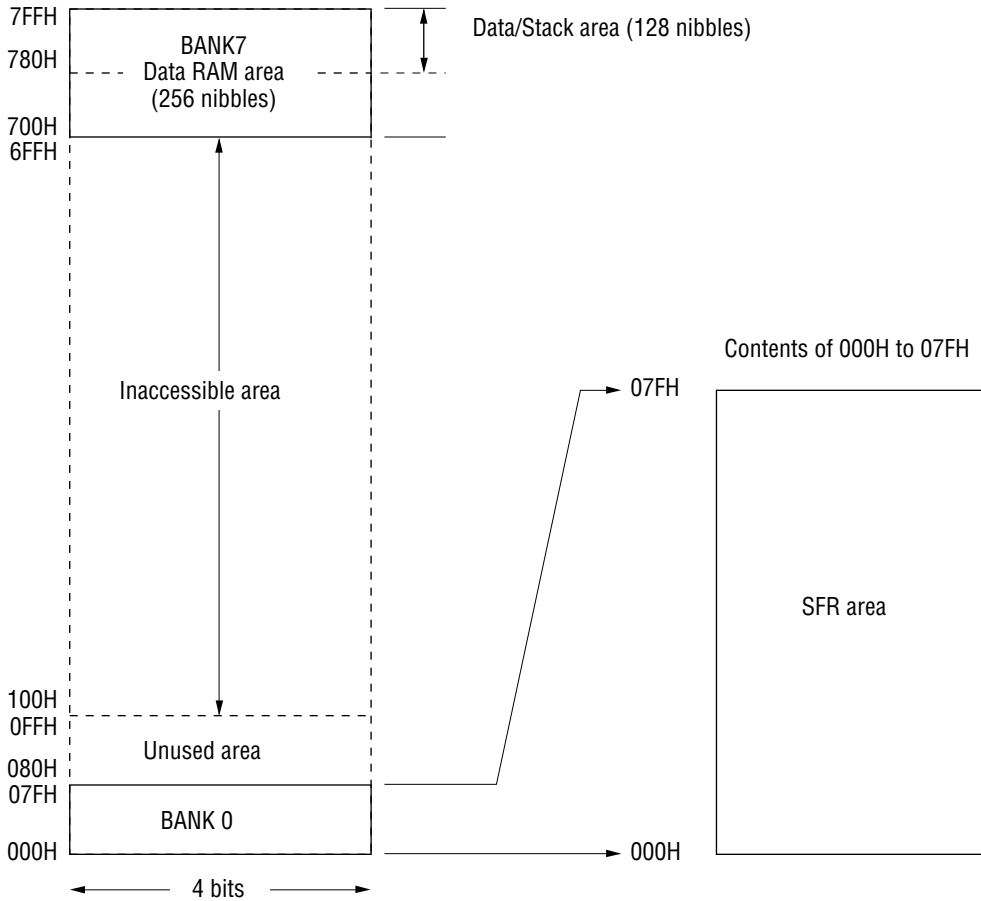
The CZP area from address 010H to address 01FH is the start address for the CZP subroutine of 1-byte call instruction.

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

The user area has 4064 bytes of address 000H to address 0FDF. 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 × 4 bits). The data RAM is assigned to BANK 7 and peripheral ports are assigned to BANK 0.



**Data Memory Map**

Half 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 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>	T <sub>a</sub> = 25°C	-2.0 to +0.3	V
Power Supply Voltage 2	V <sub>SS2</sub>	T <sub>a</sub> = 25°C	-4.0 to +0.3	V
Power Supply Voltage 3	V <sub>SS3</sub>	T <sub>a</sub> = 25°C	-5.5 to +0.3	V
Power Supply Voltage 4	V <sub>SSL</sub>	T <sub>a</sub> = 25°C	-2.0 to +0.3	V
Power Supply Voltage 5	V <sub>SS</sub>	T <sub>a</sub> = 25°C	-5.5 to +0.3	V
Input Voltage 1	V <sub>IN1</sub>	V <sub>SS1</sub> Input, T <sub>a</sub> = 25°C	V <sub>SS1</sub> - 0.3 to +0.3	V
Input Voltage 2	V <sub>IN2</sub>	V <sub>SS</sub> Input, T <sub>a</sub> = 25°C	V <sub>SS</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>SS1</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS1</sub> - 0.3 to +0.3	V
Output Voltage 2	V <sub>OUT2</sub>	V <sub>SS2</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS2</sub> - 0.3 to +0.3	V
Output Voltage 3	V <sub>OUT3</sub>	V <sub>SS3</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS3</sub> - 0.3 to +0.3	V
Output Voltage 4	V <sub>OUT4</sub>	V <sub>SS</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS</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>SS1</sub>	—	-1.7 to -1.25	V
	V <sub>SS</sub>	—	-5.25 to V <sub>SS1</sub>	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**

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

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
$V_{SS2}$ Voltage	$V_{SS2}$	$C_a, C_b, C_{12} = 0.1\ \mu\text{F}$ +100% -50%	-3.2	-3.0	-2.8	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	$V_{SSL}$	—	-1.5	-1.3	-0.6	V	
Crystal Oscillation Start Voltage	$V_{STA}$	Oscillation start time: within 5 seconds	—	—	-1.45	V	
Crystal Oscillation Hold Voltage	$V_{HOLD}$	—	—	—	-1.25	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	12	16	pF	
400k RC Oscillation Frequency	$f_{OSC}$	External resistor $R_{OS} = 300\ \text{k}\Omega$ $V_{SS1} = -1.25\text{ to }-1.7\ \text{V}$	80	220	350	kHz	
POR Generation Voltage	$V_{POR1}$	When $V_{SS1}$ is between $V_{POR1}$ and $-1.5\ \text{V}$	-0.4	—	0	V	
POR Non-generation Voltage	$V_{POR2}$	No POR when $V_{SS1}$ is between $V_{POR2}$ and $-1.5\ \text{V}$	-1.5	—	-1.2	V	

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)

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

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Supply Current 1	$I_{DD1}$	CPU in halt state (400k RC oscillation halt)	$T_a = -40\text{ to }+40^\circ\text{C}$	—	2	5	$\mu\text{A}$
			$T_a = +40\text{ to }+85^\circ\text{C}$	—	2	30	$\mu\text{A}$
Supply Current 2	$I_{DD2}$	CPU in operating state (400k RC oscillation halt)	$T_a = -40\text{ to }+40^\circ\text{C}$	—	5	15	$\mu\text{A}$
			$T_a = +40\text{ to }+85^\circ\text{C}$	—	5	40	$\mu\text{A}$
Supply Current 3	$I_{DD3}$	CPU in operating state (400k RC oscillation in operation) $R_{OS} = 300\text{ k}\Omega$		—	40	80	$\mu\text{A}$
Supply Current 4	$I_{DD4}$	Serial transfer, $f_{SCK} = 300\text{ kHz}$ , CPU in operating state (400k RC oscillation halt)	$T_a = -40\text{ to }+40^\circ\text{C}$	—	7	25	$\mu\text{A}$
			$T_a = +40\text{ to }+85^\circ\text{C}$	—	7	50	$\mu\text{A}$
Supply Current 5	$I_{DD5}$	CPU in halt state (400k RC oscillation halt), RC oscillator for A/D converter is in operating state	$RT0 = 10\text{ k}\Omega$	—	150	230	$\mu\text{A}$
			$RT0 = 2\text{ k}\Omega$	—	600	900	$\mu\text{A}$

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DC Characteristics (continued)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = V_{SS} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  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	-0.7	-0.2	mA	2
	$I_{OL1}$	$V_{OL1} = V_{SS} + 0.5\text{ V}$	1.0	3.0	9.0	mA	
	$I_{OH1S}$	$V_{SS} = -5\text{ V}$ , $V_{OH1S} = -0.5\text{ V}$	-36	-12	-4.0	mA	
	$I_{OL1S}$	$V_{SS} = -5\text{ V}$ , $V_{OL1} = V_{SS} + 0.5\text{ V}$	4.0	12	36	mA	
Output Current 2 (P1.1 to P1.3) (P2.0 to P2.3) (P3.0 to P3.3) (P4.0 to P4.3)	$I_{OH2}$	$V_{OH2} = -0.5\text{ V}$	-2.1	-0.7	-0.2	mA	
	$I_{OL2}$	$V_{OL2} = V_{SS} + 0.5\text{ V}$	0.2	0.7	2.1	mA	
	$I_{OH2S}$	$V_{SS} = -5\text{ V}$ , $V_{OH2S} = -0.5\text{ V}$	-9.0	-3.0	-1.0	mA	
	$I_{OL2S}$	$V_{SS} = -5\text{ V}$ , $V_{OL2} = V_{SS} + 0.5\text{ V}$	1.0	3.0	9.0	mA	
Output Current 3 (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 (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OH4}$	$V_{OH4} = -0.1\text{ V}$	-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 (When L26 to L33 are configured as output ports)	$I_{OH5}$	$V_{OH5} = -0.5\text{ V}$	-1.5	-0.5	-0.1	mA	
	$I_{OL5}$	$V_{OL5} = V_{SS} + 0.5\text{ V}$	0.1	0.5	1.5	mA	
	$I_{OH5S}$	$V_{SS} = -5\text{ V}$ , $V_{OH5S} = -0.5\text{ V}$	-2.0	-0.7	-0.2	mA	
	$I_{OL5S}$	$V_{SS} = -5\text{ V}$ , $V_{OL5S} = V_{SS} + 0.5\text{ V}$	0.2	0.7	2.0	mA	
Output Current 6 (OSC2)	$I_{OH6}$	$V_{OH6} = -0.5\text{ V}$	-2.1	-0.7	-0.2	mA	
	$I_{OL6}$	$V_{OL6} = V_{SS1} + 0.5\text{ V}$	0.2	0.7	2.1	mA	
Output Current 7 (L0 to L33)	$I_{OH7}$	$V_{OH7} = -0.2\text{ V}$ ( $V_{DD}$ 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) (P4.0 to P4.3) (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OOH}$	$V_{OH} = V_{DD}$	—	—	0.3	$\mu\text{A}$	
	$I_{OOL}$	$V_{OL} = V_{SS1}$	-0.3	—	—	$\mu\text{A}$	



DC Characteristics (continued)

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

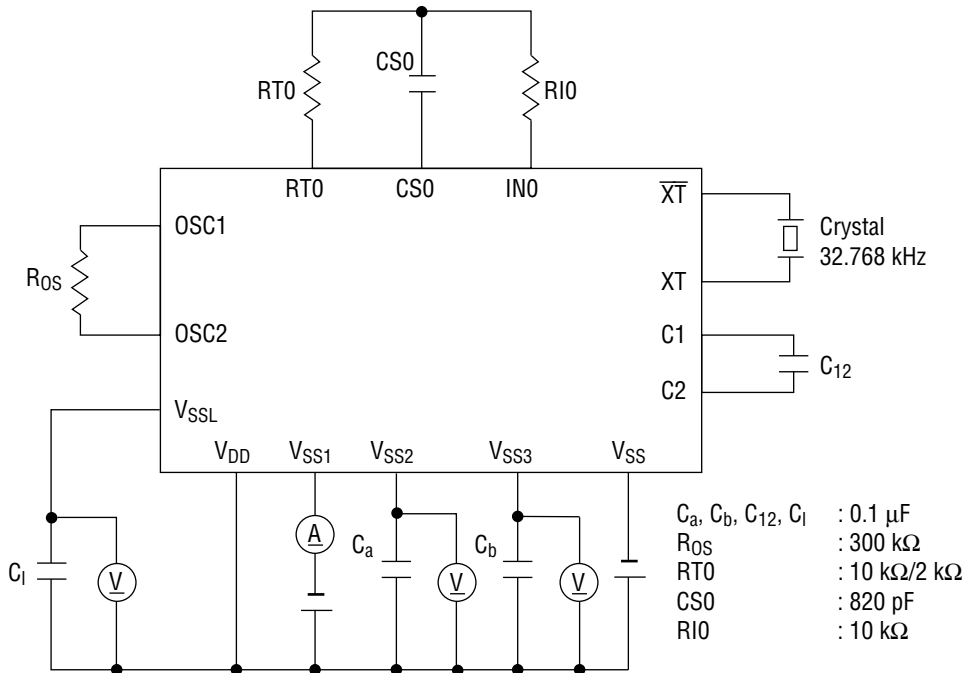
Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Input Current 1 (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3) (P4.0 to P4.3)	$I_{IH1}$	$V_{IH1} = V_{DD}$ (when pulled down)	5.0	18	60	$\mu\text{A}$	3
	$I_{IL1}$	$V_{IL1} = V_{SS}$ (when pulled up)	-60	-18	-5.0	$\mu\text{A}$	
	$I_{IH1S}$	$V_{IH1} = V_{DD}$ , $V_{SS} = -5\text{ V}$ (when pulled down)	70	250	660	$\mu\text{A}$	
	$I_{IL1S}$	$V_{IL1} = V_{SS} = -5\text{ V}$ (when pulled up)	-660	-250	-70	$\mu\text{A}$	
	$I_{IH1Z}$	$V_{IH1} = V_{DD}$ (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)	5.0	18	60	$\mu\text{A}$	3
	$I_{IH2Z}$	$V_{IH2} = V_{DD}$ (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 (OSC1)	$I_{IL3}$	$V_{IL3} = V_{SS1}$ (when pulled up)	-60	-22	-6.0	$\mu\text{A}$	3
	$I_{IH3Z}$	$V_{IH3} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL3Z}$	$V_{IL3} = V_{SS1}$ (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	$\mu\text{A}$	3
	$I_{IL4}$	$V_{IL4} = V_{SS1}$	-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) (P4.0 to P4.3)	$V_{IH1}$	—	-0.3	—	0	V	4
	$V_{IL1}$	—	-1.5	—	-1.2	V	
	$V_{IH1S}$	$V_{SS} = -5\text{ V}$	-1.0	—	0	V	
	$V_{IL1S}$	$V_{SS} = -5\text{ V}$	-5.0	—	-4.0	V	
Input Voltage 2 (IN0, IN1, OSC1)	$V_{IH2}$	—	-0.3	—	0	V	4
	$V_{IL2}$	—	-1.5	—	-1.2	V	
Input Voltage 3 (RESET, TST1, TST2)	$V_{IH3}$	—	-0.3	—	0	V	4
	$V_{IL3}$	—	-1.5	—	-1.2	V	

## DC Characteristics (continued)

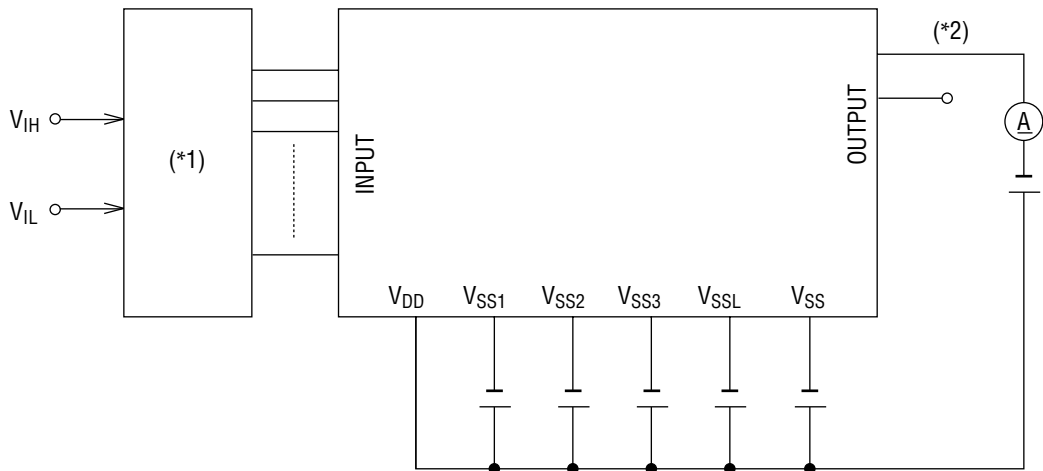
( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = V_{SS} = -1.5\text{ V}$ ,  $V_{SS2} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

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) (P4.0 to P4.3)	$\Delta V_{T1}$	—	0.05	0.1	0.3	V	4
	$\Delta V_{T1S}$	$V_{SS} = -5\text{ V}$	0.25	1.0	1.5	V	
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) (P4.0 to P4.3)	$C_{IN}$	—	—	—	5.0	pF	1

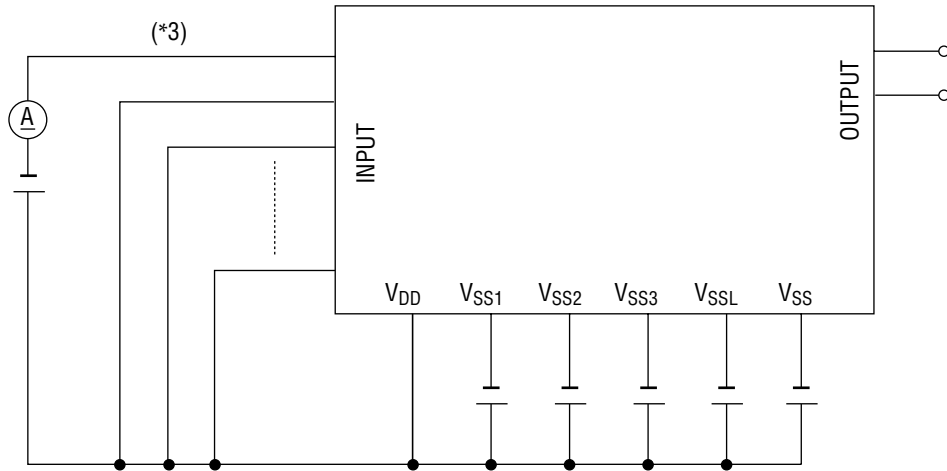
**Measuring circuit 1**



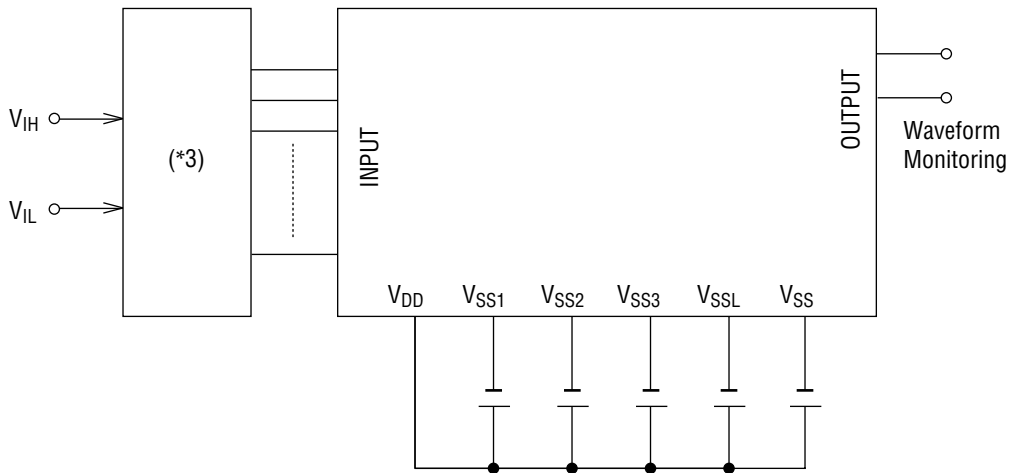
**Measuring circuit 2**



**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**

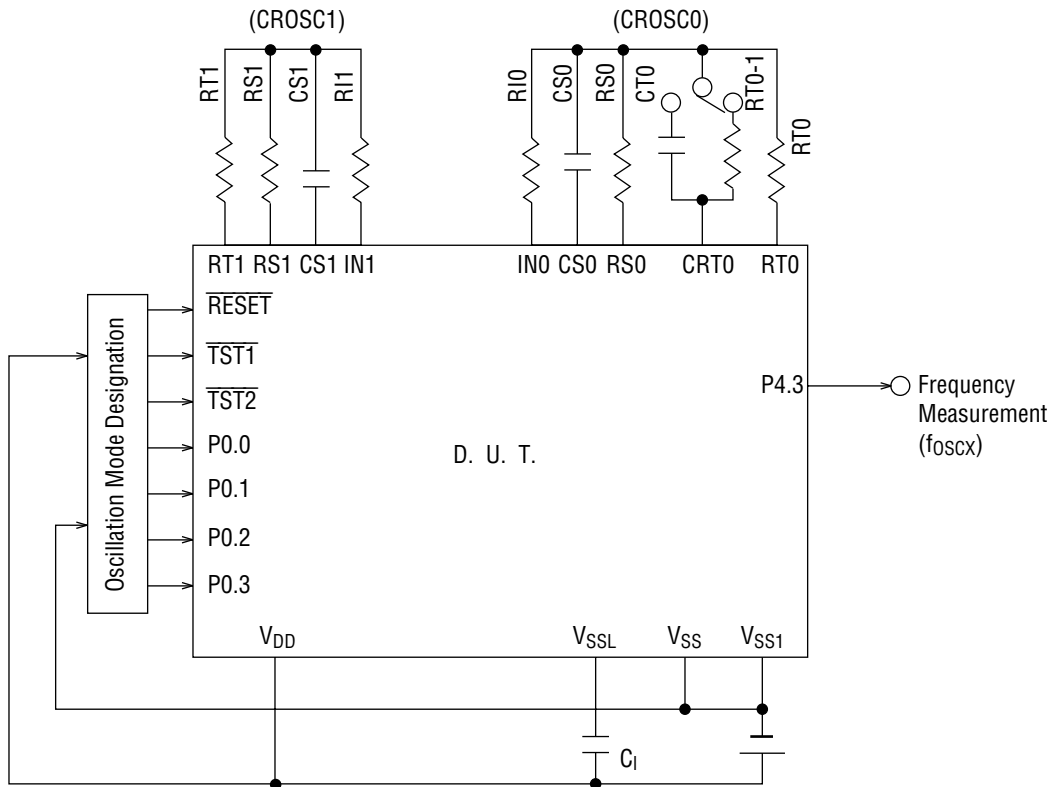
(V<sub>DD</sub> = 0 V, V<sub>SS1</sub> = V<sub>SS</sub> = -1.5 V, T<sub>a</sub> = -40 to +85°C unless otherwise specified)

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

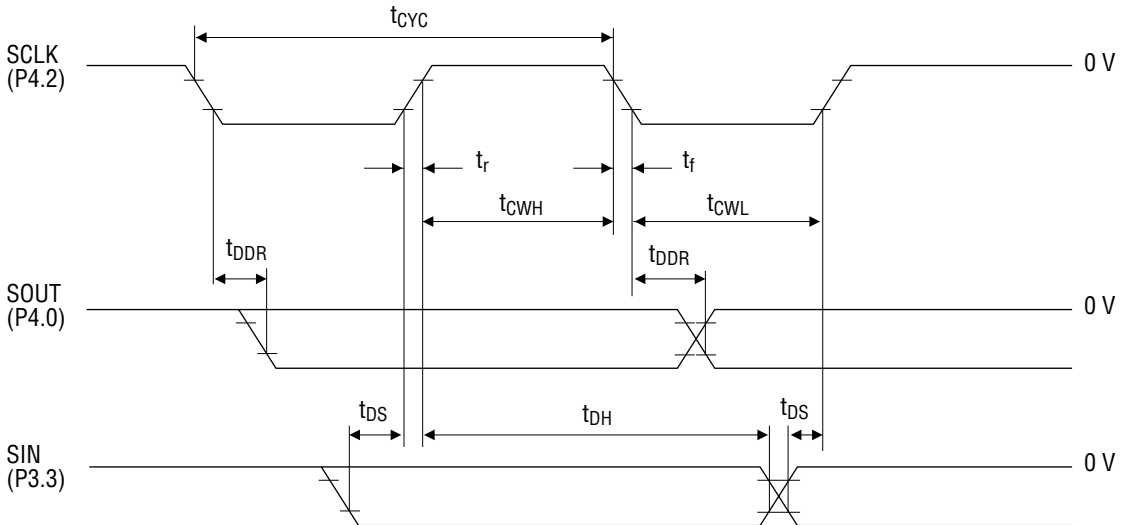


- RT0, RT0-1, RT1 = 2 kΩ/10 kΩ/200 kΩ
- RS0, RS1 = 10 kΩ
- RI0, RI1 = 10 kΩ
- CS0, CTO, CS1 = 820 pF
- C<sub>i</sub> = 0.1 μF

AC Characteristics (Serial Interface)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = -1.5\text{ V}$ ,  $V_{SS} = -5\text{ V}$ ,  $T_a = -40\text{ to }+85^\circ\text{C}$ )

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SCLK Input Fall Time	$t_f$	—	—	—	1.0	$\mu\text{s}$
SCLK Input Rise Time	$t_r$	—	—	—	1.0	$\mu\text{s}$
SCLK Input "L" Level Pulse Width	$t_{CWL}$	—	0.8	—	—	$\mu\text{s}$
SCLK Input "H" Level Pulse Width	$t_{CWH}$	—	0.8	—	—	$\mu\text{s}$
SCLK Input Cycle Time	$t_{CYC}$	$V_{SS} = -5.25\text{ V to }V_{SS1}$	2.0	—	—	$\mu\text{s}$
SCLK Output Cycle Time	$t_{CYC1(0)}$	CPU is operating at 32.768 kHz.	—	30.5	—	$\mu\text{s}$
SCLK Output Cycle Time	$t_{CYC2(0)}$	CPU is operating at 400 kHz.	—	2.5	—	$\mu\text{s}$
SOUT Output Delay Time	$t_{DDR}$	$C_i = 10\text{ pF}$	—	—	0.4	$\mu\text{s}$
SIN Input Setup Time	$t_{DS}$	—	0.5	—	—	$\mu\text{s}$
SIN Input Hold Time	$t_{DH}$	—	0.8	—	—	$\mu\text{s}$



("H" level = -1 V, "L" level = -4 V)

**ABSOLUTE MAXIMUM RATINGS (3.0 V Spec.)**

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage 1	V <sub>SS1</sub>	T <sub>a</sub> = 25°C	-2.0 to +0.3	V
Power Supply Voltage 2	V <sub>SS2</sub>	T <sub>a</sub> = 25°C	-4.0 to +0.3	V
Power Supply Voltage 3	V <sub>SS3</sub>	T <sub>a</sub> = 25°C	-5.5 to +0.3	V
Power Supply Voltage 4	V <sub>SSL</sub>	T <sub>a</sub> = 25°C	-4.0 to +0.3	V
Power Supply Voltage 5	V <sub>SS</sub>	T <sub>a</sub> = 25°C	-5.5 to +0.3	V
Input Voltage 1	V <sub>IN1</sub>	V <sub>SS2</sub> Input, T <sub>a</sub> = 25°C	V <sub>SS2</sub> - 0.3 to +0.3	V
Input Voltage 2	V <sub>IN2</sub>	V <sub>SS</sub> Input, T <sub>a</sub> = 25°C	V <sub>SS</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>SS2</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS2</sub> - 0.3 to +0.3	V
Output Voltage 2	V <sub>OUT2</sub>	V <sub>SS3</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS3</sub> - 0.3 to +0.3	V
Output Voltage 3	V <sub>OUT3</sub>	V <sub>SS</sub> Output, T <sub>a</sub> = 25°C	V <sub>SS</sub> - 0.3 to +0.3	V
Output Voltage 4	V <sub>OUT4</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 (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	
	V <sub>SS</sub>	—	-5.25 to (0.8•V <sub>SS2</sub> , -2.0 max.)*	
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

\* Indicates that the value of V<sub>SS</sub> is 80% of V<sub>SS2</sub> and should not exceed -2.0 V.



**ELECTRICAL CHARACTERISTICS (3.0 V Spec.)**

**DC Characteristics**

( $V_{DD} = 0\text{ V}$ ,  $V_{SS2} = V_{SS} = -3.0\text{ V}$ ,  $T_a = -40\text{ to }+85^\circ\text{C}$  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 $R_{OS} = 100\ \text{k}\Omega$ $V_{SS2} = -2.0\text{ to }-3.5\text{ V}$	300	400	620	kHz	
POR Generation Voltage	$V_{POR1}$	When $V_{SS2}$ is between $V_{POR1}$ and $-3.0\text{ V}$	-0.7	—	0	V	
POR Non-generation Voltage	$V_{POR2}$	No POR when $V_{SS2}$ is between $V_{POR2}$ and $-3.0\text{ V}$	-3.0	—	-2.0	V	

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)

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

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Supply Current 1	$I_{DD1}$	CPU in halt state (400k RC oscillation halt)	$T_a = -40\text{ to }+40^\circ\text{C}$	—	1.5	4.5	$\mu\text{A}$
			$T_a = +40\text{ to }+85^\circ\text{C}$	—	1.5	30	$\mu\text{A}$
Supply Current 2	$I_{DD2}$	CPU in operating state (400k RC oscillation halt)	$T_a = -40\text{ to }+40^\circ\text{C}$	—	5.0	15	$\mu\text{A}$
			$T_a = +40\text{ to }+85^\circ\text{C}$	—	5.0	40	$\mu\text{A}$
Supply Current 3	$I_{DD3}$	CPU in operating state (400k RC oscillation in operation)		—	220	450	$\mu\text{A}$
Supply Current 4	$I_{DD4}$	Serial transfer, $f_{SCK} = 300\text{ kHz}$ ,	$T_a = -40\text{ to }+40^\circ\text{C}$	—	7.0	25	$\mu\text{A}$
		CPU in operating state (400k RC oscillation halt)	$T_a = +40\text{ to }+85^\circ\text{C}$	—	7.0	50	$\mu\text{A}$
Supply Current 5	$I_{DD5}$	CPU in halt state (400k RC oscillation halt), RC oscillator for A/D converter is in operating state	$RT0 = 10\text{ k}\Omega$	—	300	450	$\mu\text{A}$
			$RT0 = 2\text{ k}\Omega$	—	1300	2000	$\mu\text{A}$

1

DC Characteristics (continued)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = V_{SS} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  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	-2	-0.7	mA	2
	$I_{OL1}$	$V_{OL1} = V_{SS} + 0.5\text{ V}$	3.0	8.0	25	mA	
	$I_{OH1S}$	$V_{SS} = -5\text{ V}$ , $V_{OH1S} = -0.5\text{ V}$	-36	-12	-4	mA	
	$I_{OL1S}$	$V_{SS} = -5\text{ V}$ , $V_{OL1} = V_{SS} + 0.5\text{ V}$	4.0	12	36	mA	
Output Current 2 (P1.1 to P1.3) (P2.0 to P2.3) (P3.0 to P3.3) (P4.0 to P4.3)	$I_{OH2}$	$V_{OH2} = -0.5\text{ V}$	-6.0	-2.0	-0.7	mA	
	$I_{OL2}$	$V_{OL2} = V_{SS} + 0.5\text{ V}$	0.7	2.0	6.0	mA	
	$I_{OH2S}$	$V_{SS} = -5\text{ V}$ , $V_{OH2S} = -0.5\text{ V}$	-9.0	-3.0	-1.0	mA	
	$I_{OL2S}$	$V_{SS} = -5\text{ V}$ , $V_{OL2} = V_{SS} + 0.5\text{ V}$	1.0	3.0	9.0	mA	
Output Current 3 (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 (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OH4}$	$V_{OH4} = -0.1\text{ V}$	-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 (When L26 to L33 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	
	$I_{OH5S}$	$V_{SS} = -5\text{ V}$ , $V_{OH5S} = -0.5\text{ V}$	-2.0	-0.7	-0.2	mA	
	$I_{OL5S}$	$V_{SS} = -5\text{ V}$ , $V_{OL5S} = V_{SS} + 0.5\text{ V}$	0.2	0.7	2.0	mA	
Output Current 6 (OSC2)	$I_{OH6}$	$V_{OH6} = -0.5\text{ V}$	-6.0	-2.0	-0.7	mA	
	$I_{OL6}$	$V_{OL6} = V_{SS2} + 0.5\text{ V}$	0.7	2.0	6.0	mA	
Output Current 7 (L0 to L33)	$I_{OH7}$	$V_{OH7} = -0.2\text{ V}$ ( $V_{DD}$ 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) (P4.0 to P4.3) (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	$I_{OOH}$	$V_{OH} = V_{DD}$	—	—	0.3	$\mu\text{A}$	
	$I_{OOL}$	$V_{OL} = V_{SS2}$	-0.3	—	—	$\mu\text{A}$	

DC Characteristics (continued)

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

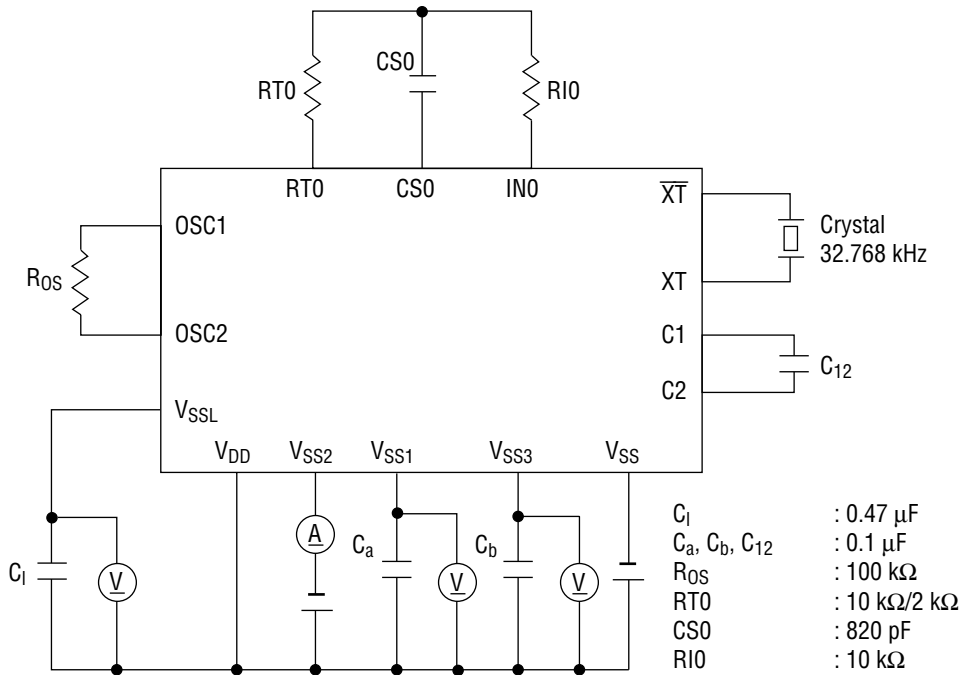
Parameter (Pin Name)	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Input Current 1 (P0.0 to P0.3) (P2.0 to P2.3) (P3.0 to P3.3) (P4.0 to P4.3)	$I_{IH1}$	$V_{IH1} = V_{DD}$ (when pulled down)	30	90	300	$\mu\text{A}$	3
	$I_{IL1}$	$V_{IL1} = V_{SS}$ (when pulled up)	-300	-90	-30	$\mu\text{A}$	
	$I_{IH1S}$	$V_{IH1} = V_{DD}$ , $V_{SS} = -5\text{ V}$ (when pulled down)	80	250	800	$\mu\text{A}$	
	$I_{IL1S}$	$V_{IL1} = V_{SS} = -5\text{ V}$ (when pulled up)	-800	-250	-80	$\mu\text{A}$	
	$I_{IH1Z}$	$V_{IH1} = V_{DD}$ (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)	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 (OSC1)	$I_{IL3}$	$V_{IL3} = V_{SS2}$ (when pulled up)	-300	-110	-10	$\mu\text{A}$	
	$I_{IH3Z}$	$V_{IH3} = V_{DD}$ (in a high impedance state)	0	—	1.0	$\mu\text{A}$	
	$I_{IL3Z}$	$V_{IL3} = V_{SS2}$ (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	$\mu\text{A}$	
	$I_{IL4}$	$V_{IL4} = V_{SS2}$	-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) (P4.0 to P4.3)	$V_{IH1}$	—	-0.6	—	0	$\text{V}$	4
	$V_{IL1}$	—	-3.0	—	-2.4	$\text{V}$	
	$V_{IH1S}$	$V_{SS} = -5\text{ V}$	-1.0	—	0	$\text{V}$	
	$V_{IL1S}$	$V_{SS} = -5\text{ V}$	-5.0	—	-4.0	$\text{V}$	
Input Voltage 2 (IN0, IN1, OSC1)	$V_{IH2}$	—	-0.6	—	0	$\text{V}$	
	$V_{IL2}$	—	-3.0	—	-2.4	$\text{V}$	
Input Voltage 3 (RESET, TST1, TST2)	$V_{IH3}$	—	-0.6	—	0	$\text{V}$	
	$V_{IL3}$	—	-3.0	—	-2.4	$\text{V}$	

DC Characteristics (continued)

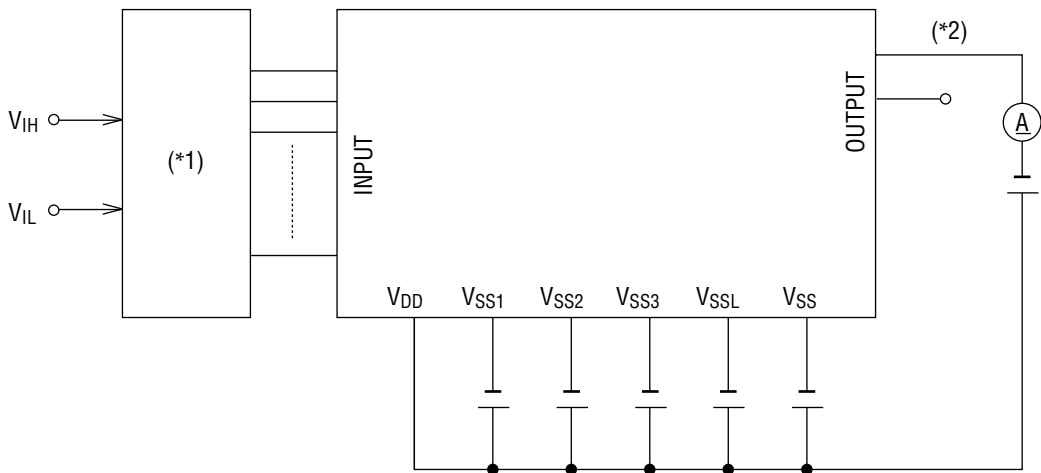
( $V_{DD} = 0\text{ V}$ ,  $V_{SS1} = V_{SSL} = -1.5\text{ V}$ ,  $V_{SS2} = V_{SS} = -3.0\text{ V}$ ,  $V_{SS3} = -4.5\text{ V}$ ,  
 $T_a = -40\text{ to }+85^\circ\text{C}$  unless otherwise specified)

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) (P4.0 to P4.3)	$\Delta V_{T1}$	—	0.2	0.5	1.0	V	4
	$\Delta V_{T1S}$	$V_{SS} = -5\text{ V}$	0.25	1.0	1.5	V	
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) (P4.0 to P4.3)	$C_{IN}$	—	—	—	5.0	pF	1

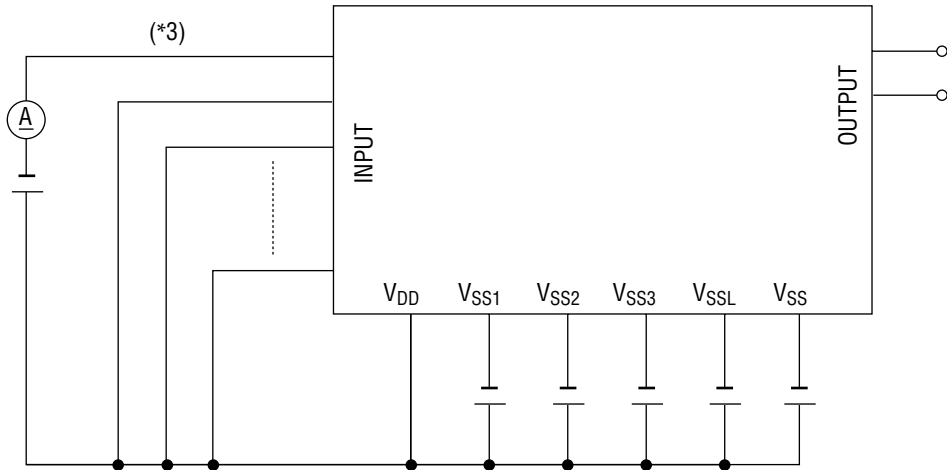
Measuring circuit 1



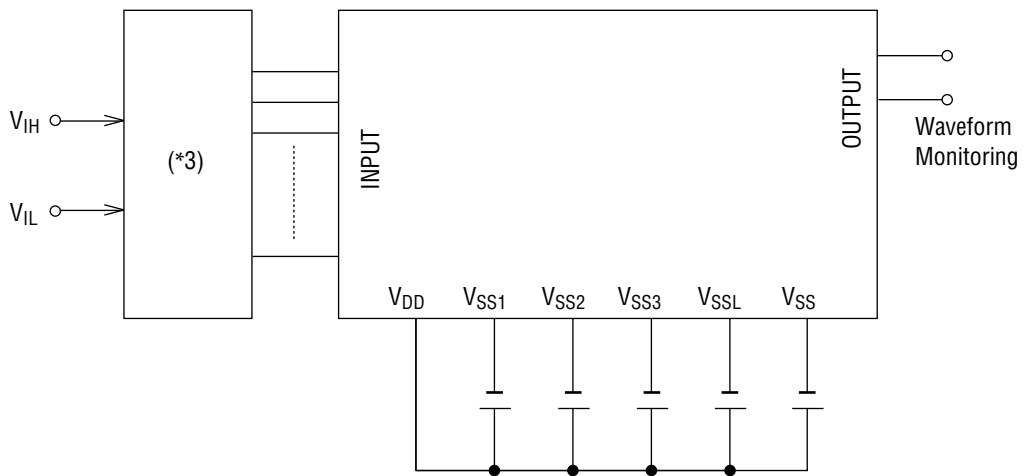
Measuring circuit 2



**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> = V<sub>SS</sub> = -3.0 V, Ta = -40 to +85°C unless otherwise specified)

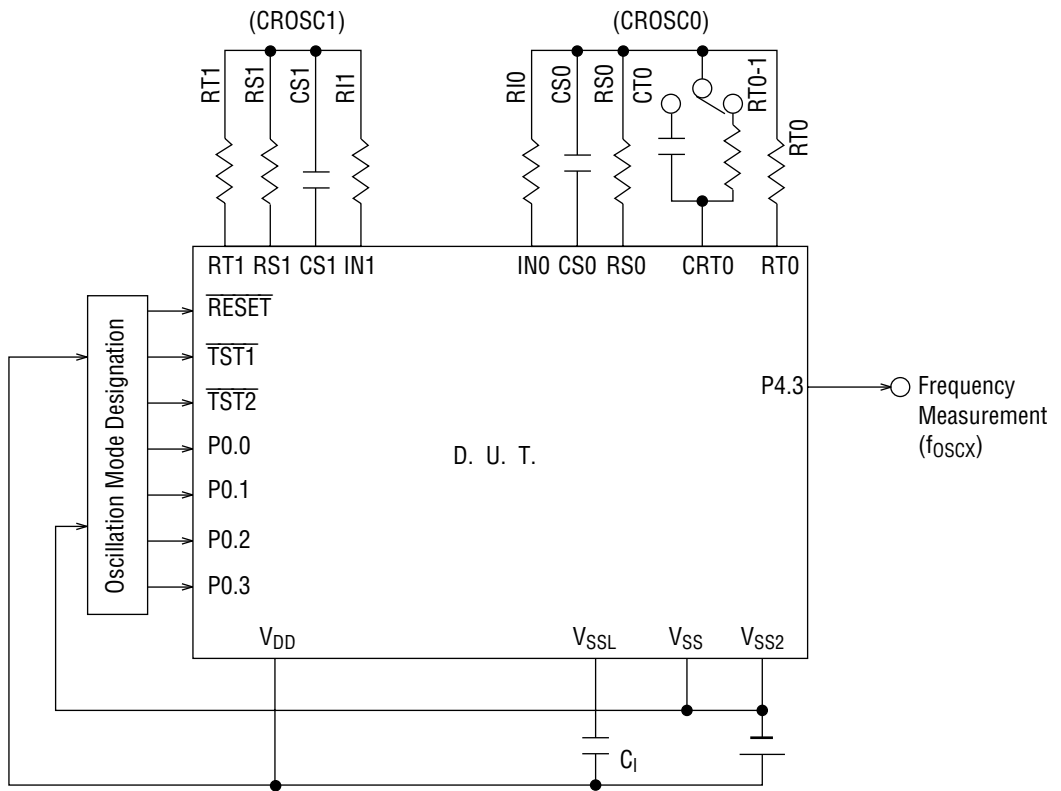
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor for Oscillation	RS0, RS1, RT0, RT0-1, RT1	CS0, CT0, CS1 ≥ 740 pF	1.0	—	—	kΩ	5
Input Current Limiting Resistor	RI0, RI1	—	1.0	10	—	kΩ	
Oscillation Frequency	f <sub>osc1</sub>	Resistor for oscillation = 2 kΩ	200	239	277	kHz	
	f <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

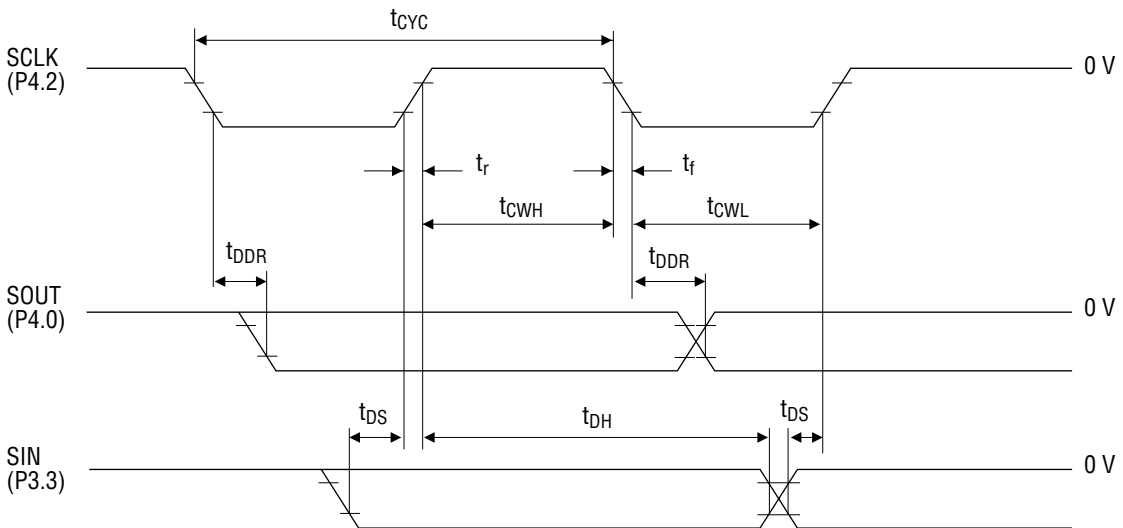


- RT0, RT0-1, RT1 = 2 kΩ/10 kΩ/200 kΩ
- RS0, RS1 = 10 kΩ
- RI0, RI1 = 10 kΩ
- CS0, CT0, CS1 = 820 pF
- C<sub>i</sub> = 0.47 μF

AC Characteristics (Serial Interface)

( $V_{DD} = 0\text{ V}$ ,  $V_{SS2} = -3\text{ V}$ ,  $V_{SS} = -5\text{ V}$ ,  $T_a = -40\text{ to }+85^\circ\text{C}$ )

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SCLK Input Fall Time	$t_f$	—	—	—	1.0	$\mu\text{s}$
SCLK Input Rise Time	$t_r$	—	—	—	1.0	$\mu\text{s}$
SCLK Input "L" Level Pulse Width	$t_{CWL}$	—	0.8	—	—	$\mu\text{s}$
SCLK Input "H" Level Pulse Width	$t_{CWH}$	—	0.8	—	—	$\mu\text{s}$
SCLK Input Cycle Time	$t_{CYC}$	—	2.0	—	—	$\mu\text{s}$
SCLK Output Cycle Time	$t_{CYC1(0)}$	CPU is operating at 32.768 kHz.	—	30.5	—	$\mu\text{s}$
SCLK Output Cycle Time	$t_{CYC2(0)}$	CPU is operating at 400 kHz.	—	2.5	—	$\mu\text{s}$
SOUT Output Delay Time	$t_{DDR}$	$C_1 = 10\text{ pF}$	—	—	0.4	$\mu\text{s}$
SIN Input Setup Time	$t_{DS}$	—	0.5	—	—	$\mu\text{s}$
SIN Input Hold Time	$t_{DH}$	—	0.8	—	—	$\mu\text{s}$



("H" level = -1 V, "L" level = -4 V)

## FUNCTIONAL DESCRIPTION

### • A/D converter (ADC)

The MSM64164C 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.

### • Serial port (SIOP)

The MSM64164C has an 8-bit synchronous serial port. Receive/transmit operation of the serial port is performed simultaneously and the serial transfer clock can select either internal or external mode. Direction of transfer data can be big endian or little endian. Each pin of the serial port is assigned as secondary functions of P3.3 and P4.0 to P4.2. Setting each bit of SIN, SOUT, SPR and SCLK of P33CON and P40CON to P42CON to "1" makes each pin valid.

### • LCD driver (LCD)

The MSM64164C has a built-in LCD driver for 34 outputs.

The LCD driver consists of  $31 \times 4$ -bit display registers (DSPR0-30), the Display Control Register (DSPCON), a 34-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.

L26 to L33 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	-----	120 segments
1/3 duty 1/3 bias method	-----	93 segments
1/2 duty 1/2 bias method	-----	64 segments

### • Buzzer driver (BD)

The MSM64164C has a built-in buzzer driver with 15 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 MSM64164C 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 MSM64164C 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 MSM64164C 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 MSM64164C 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 and a 1/10 frequency dividing circuit. 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

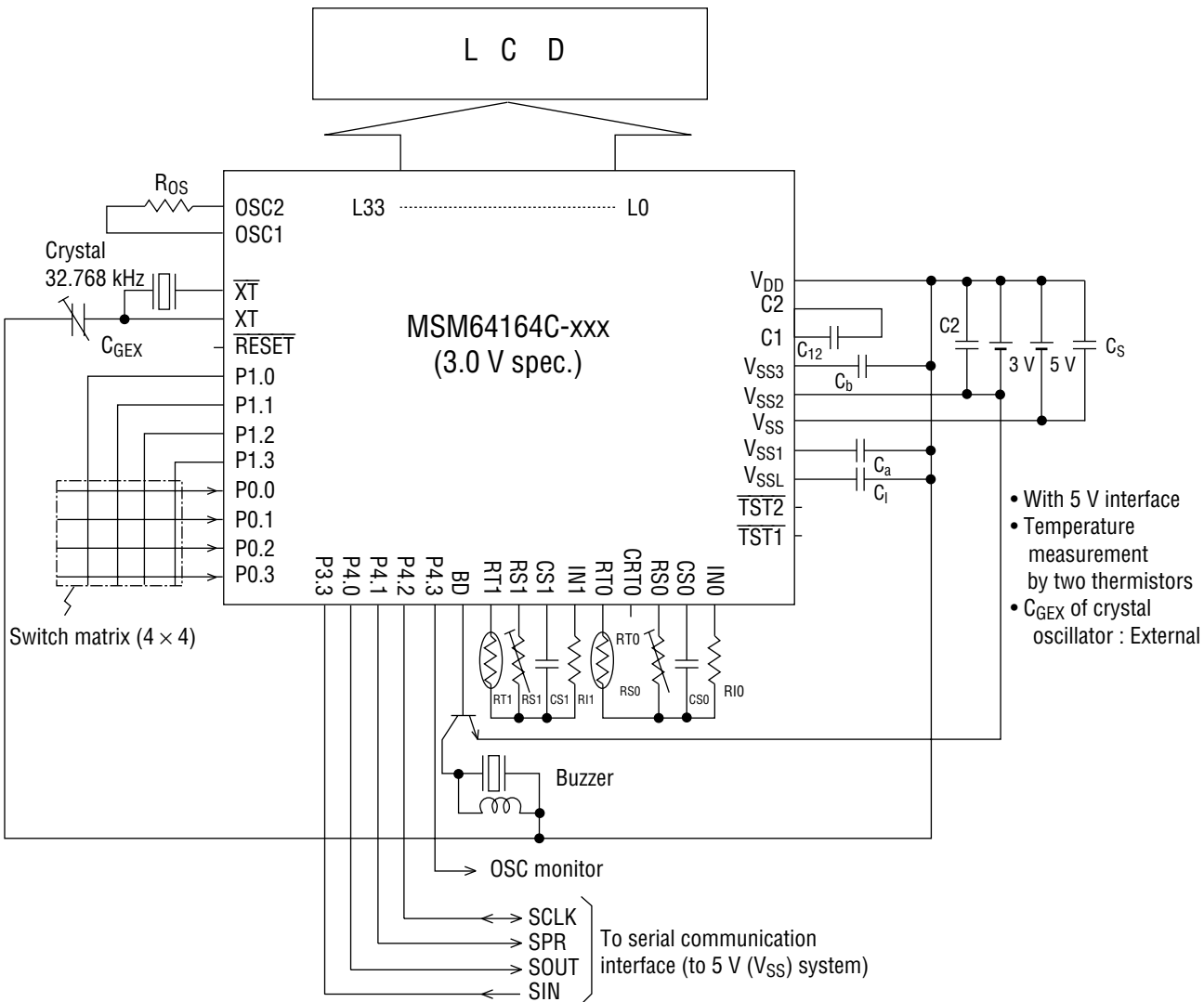
- |  |  |
|--|--|
| Input-output ports (P2, P3, P4) (12 bits): | Pull-up (pull-down) resistor input or high-impedance input, CMOS output or NMOS open drain output: these can be specified for each bit; external 0 interrupt |
| Input port (P0) (4 bits)                   | : Pull-up (pull-down) resistor input or high-impedance input; external 1 interrupt   |
| Output port (P1) (4 bits)                  | : CMOS output or NMOS open drain output  |

### • Interrupt (INTC)

The MSM64164C has ten interrupt sources (10 vector addresses), of which two are external interrupts from ports and eight are internal interrupts.

Of the ten interrupt sources, only the watchdog interrupt cannot be disabled (non-maskable interrupt). The other nine 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.

APPLICATION CIRCUITS

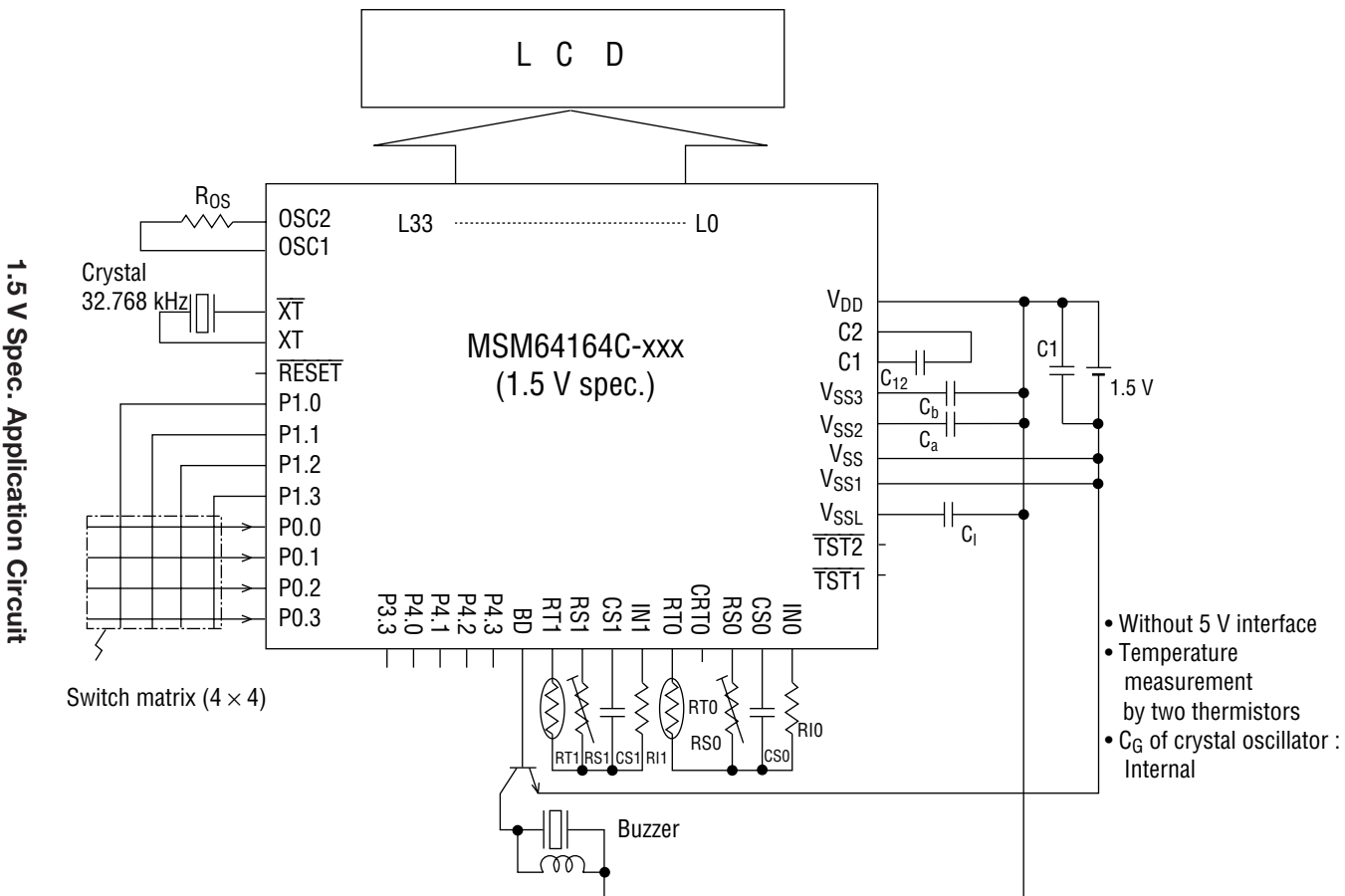


3.0 V Spec. Application Circuit

- With 5 V interface
- Temperature measurement by two thermistors
- C<sub>GEX</sub> of crystal oscillator : External

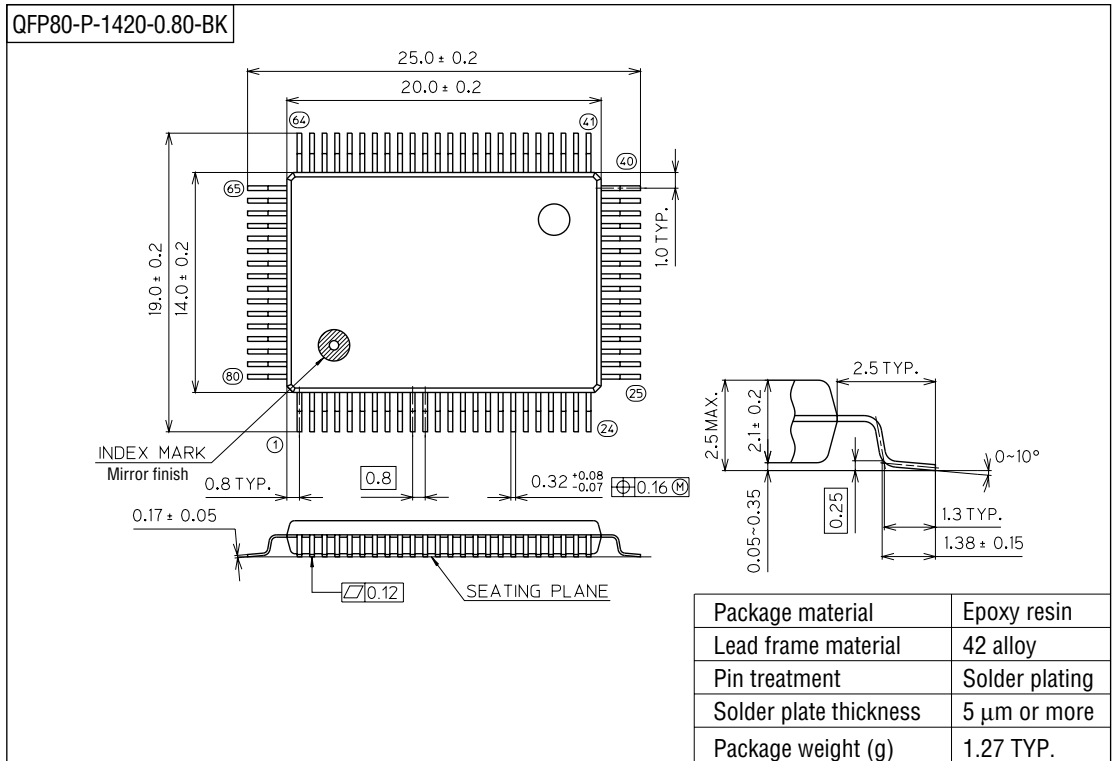
To serial communication interface (to 5 V (V<sub>SS</sub>) system)

APPLICATION CIRCUITS (continued)



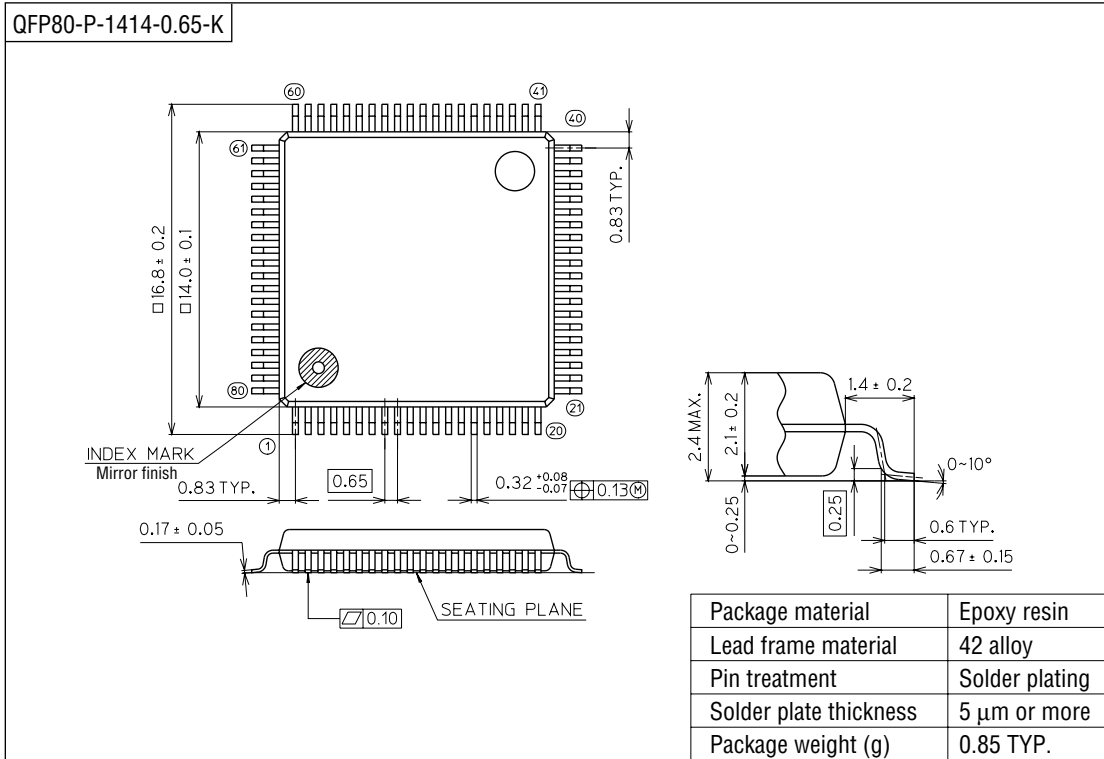
**PACKAGE DIMENSIONS**

(Unit : mm)



**Notes for Mounting the Surface Mount Type Package**

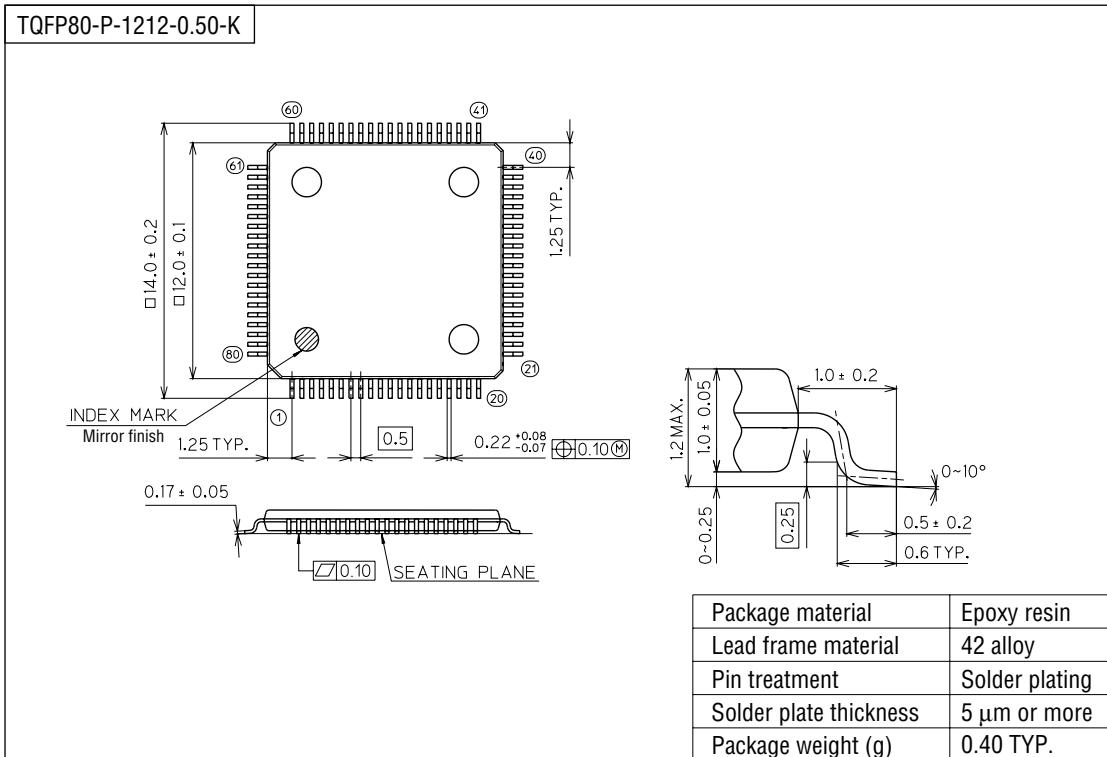
The SOP, QFP, TSOP, SOJ, QFJ (PLCC), SHP and BGA are surface mount type packages, which are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact Oki's responsible sales person for the product name, package name, pin number,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



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