OKI Semiconductor

MSM64162-001/002

Dual Thermometer with Clock Function

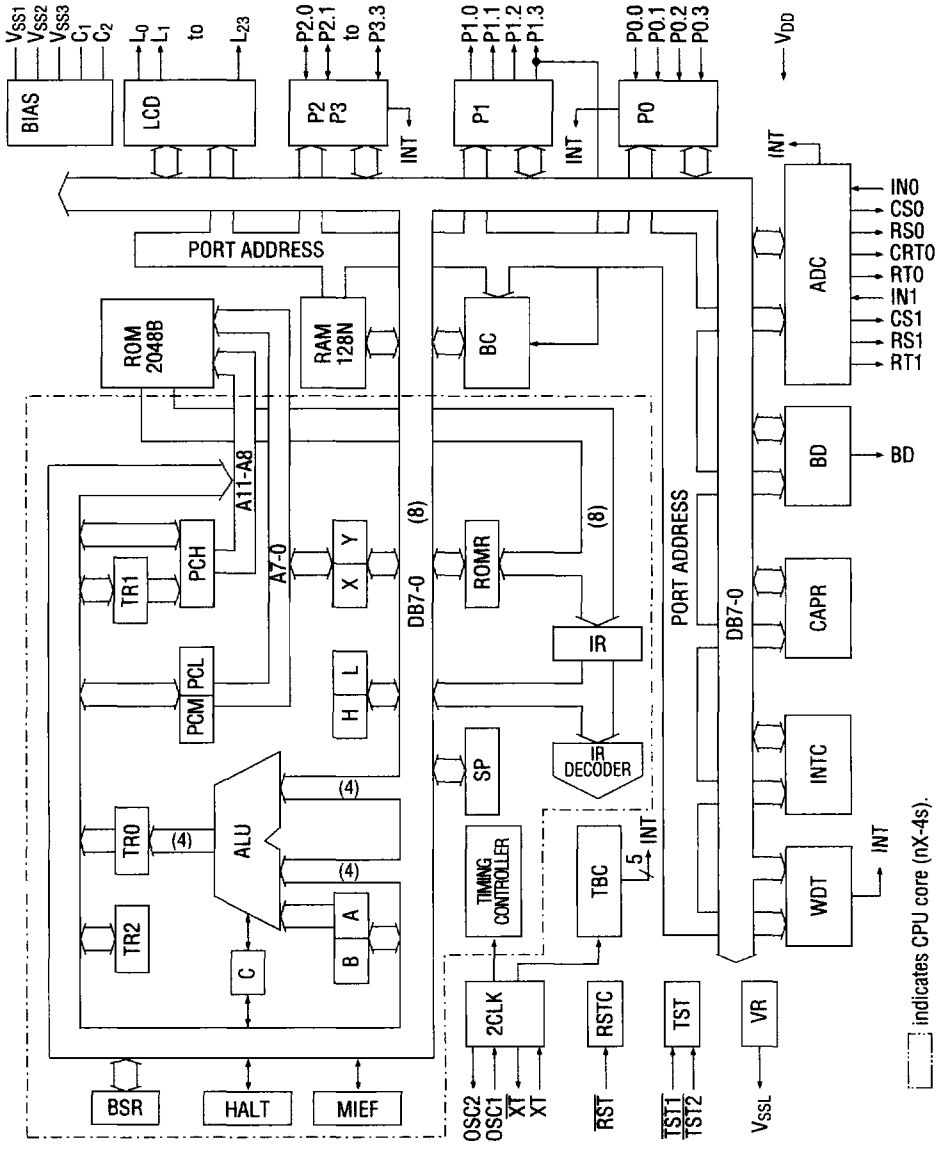
GENERAL DESCRIPTION

The MSM64162-001/002 is a clock IC with a temperature measuring function.

FEATURES

- The IC measures two different temperatures simultaneously using external thermistors.
  Temperature measuring ranges : -20.0°C to 70.0°C (0.0°F to 160°F)
  Resolution : 0.1°C (°F)
  Precision : ±1°C (when temperature around the IC is 20°C)
  A temperature measurement cycle of 1 minute or 2 seconds can be selected.
- 8 digits + 10 indicators, 1/4 duty LCD
- Upper limit/lower limit temperature alarm function (preset temperature can be changed)
- Centigrade or Fahrenheit can be selected.
- The IC clock function displays hours, minutes and AM/PM.
- Serial interface output for temperatures
- Operating voltage : 1.5V (MSM64162-001) or 3V (MSM64162-002)
- Few external parts
- Simple adjustment
- Applicable thermistor : 103AT (made by Ishizuka Electronics Co., Ltd.)
- Package options
  64-pin plastic QFP (QFP64-P-1420-K) (Product name: MSM64162-001GS-K/MSM64162-002GS-K)
  64-pin plastic QFP (QFP64-P-1420-BK) (Product name: MSM64162-001GS-BK/MSM64162-002GS-BK)
  Chip

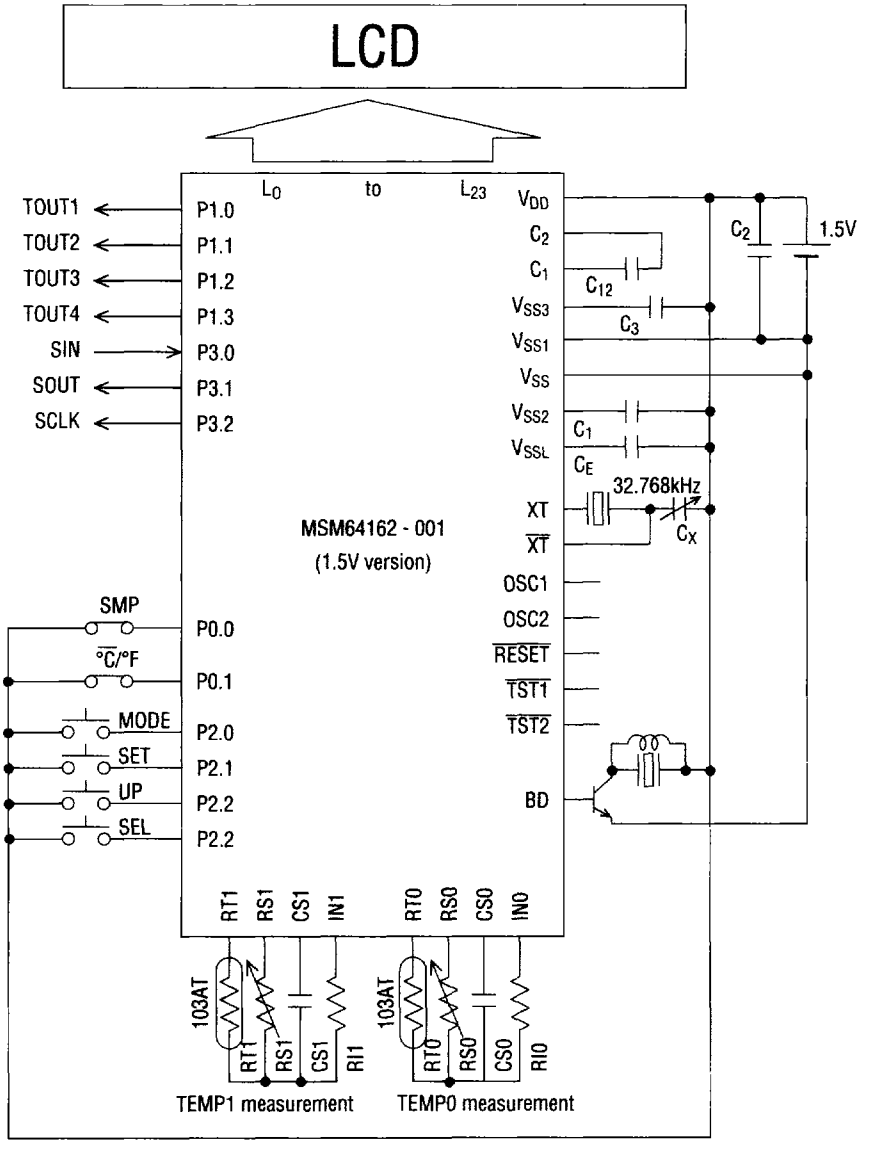
BLOCK DIAGRAM



APPLICATION CIRCUITS

Example of MSM64162-001 circuit

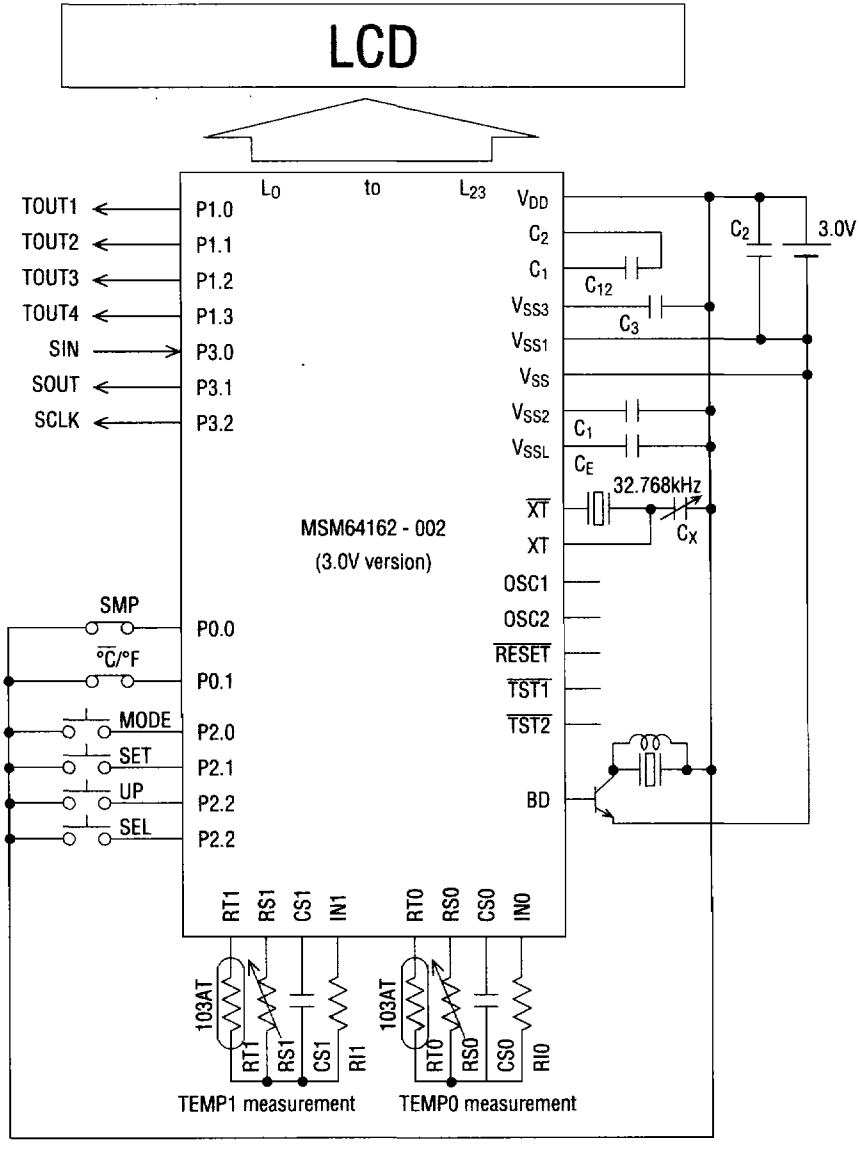
The temperature is shown in °F. The temperature measurement cycle is 1 minute.



$C_1=C_2=C_{12}=C_3=0.1\mu F$, C_X = 30pF. Unconnected pins are OPEN

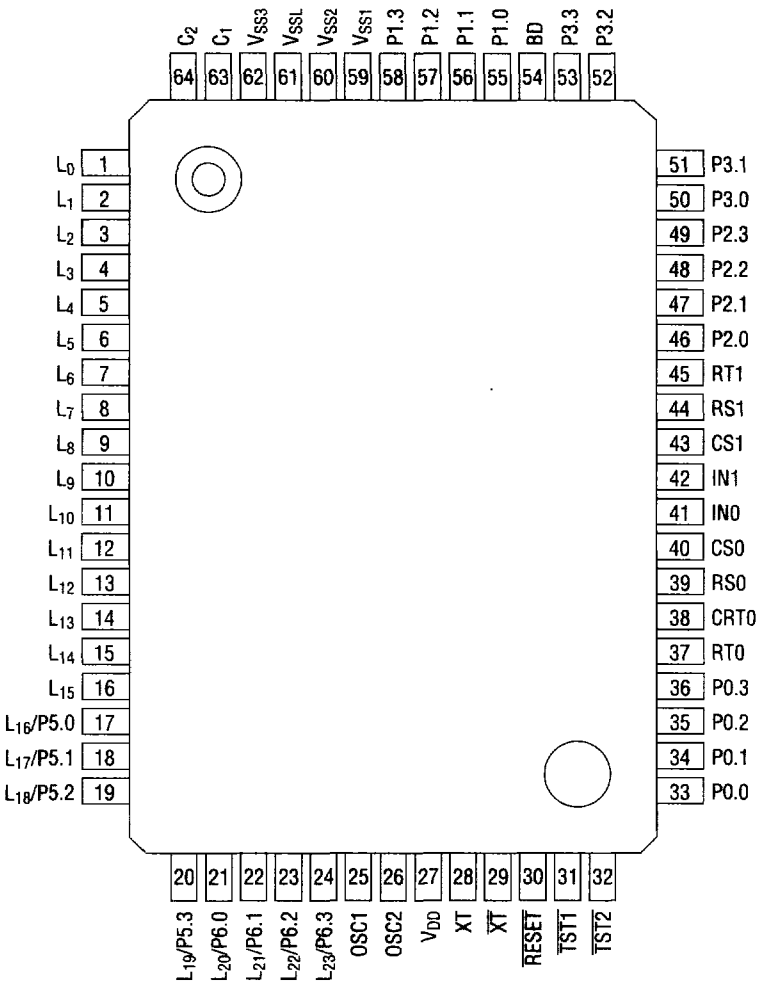
Example of MSM64162-002 circuit

The temperature is shown in °C. The temperature measurement cycle is 2 minutes.



$C_1=C_2=C_{12}=C_3=0.1\mu F$, C_X = 30pF. Unconnected pins are OPEN

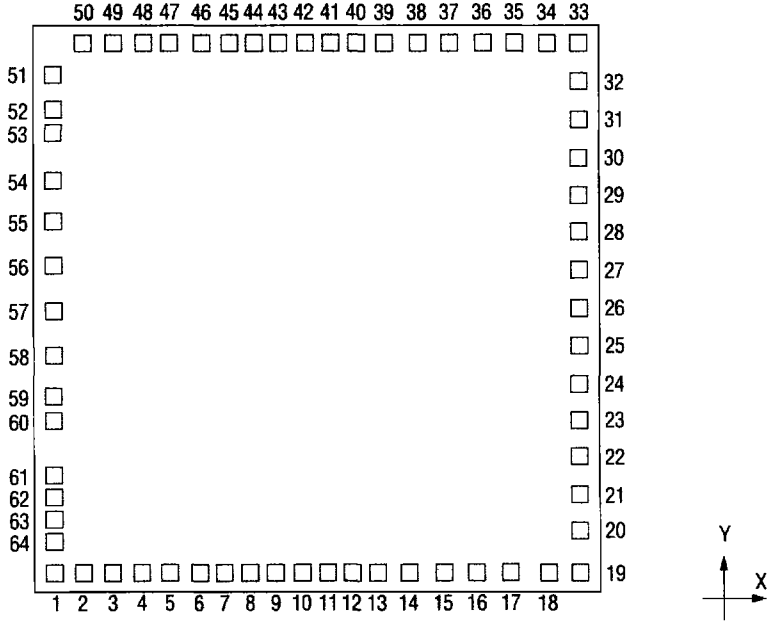
PIN CONFIGURATION (TOP VIEW)



64-Pin Plastic QFP

PAD CONFIGURATION

Pad Layout



Pad Coordinates

Chip size : 4.69 mm x 4.41 mm
Chip thickness : 350 µm

Center of chip: x=0, y=0

Pad No	Pad Name	x (µm)	y (µm)	Pad No	Pad Name	x (µm)	y (µm)
1	L_0	-2168	-2042	33	P0.0	2168	2042
2	L_1	-1918	-2042	34	P0.1	1899	2042
3	L_2	-1669	-2042	35	P0.2	1628	2042
4	L_3	-1426	-2042	36	P0.3	1364	2042
5	L_4	-1170	-2042	37	RT0	1100	2042
6	L_5	-934	-2042	38	CRT0	829	2042
7	L_6	-727	-2042	39	RS0	565	2042
8	L_7	-519	-2042	40	CS0	349	2042
9	L_8	-312	-2042	41	IN0	141	2042
10	L_9	-104	-2042	42	IN1	-67	2042
11	L_{10}	104	-2042	43	CS1	-274	2042
12	L_{11}	311	-2042	44	RS1	-482	2042
13	L_{12}	527	-2042	45	RT1	-689	2042
14	L_{13}	791	-2042	46	P2.0	-911	2042
15	L_{14}	1062	-2042	47	P2.1	-1160	2042
16	L_{15}	1340	-2042	48	P2.2	-1416	2042
17	L_{16}	1618	-2042	49	P2.3	-1666	2042
18	L_{17}	1897	-2042	50	P3.0	-1916	2042
19	L_{18}	2168	-2042	51	P3.1	-2168	1829
20	L_{19}	2168	-1714	52	P3.2	-2168	1563
21	L_{20}	2168	-1424	53	P3.3	-2168	1382
22	L_{21}	2168	-1134	54	BD	-2168	1017
23	L_{22}	2168	-844	55	P1.0	-2168	688
24	L_{23}	2168	-554	56	P1.1	-2168	328
25	OSC1	2168	-264	57	P1.2	-2168	6
26	OSC2	2168	26	58	P1.3	-2168	-353
27	V_{DD}	2168	316	59	V_{SS1}	-2168	-645
28	XT	2168	606	60	V_{SS2}	-2168	-826
29	$\overline{XT}$	2168	896	61	V_{SSL}	-2168	-1254
30	$\overline{RESET}$	2168	1186	62	V_{SS3}	-2168	-1435
31	$\overline{TST1}$	2168	1476	63	C1	-2168	-1616
32	$\overline{TST2}$	2168	1766	64	C2	-2168	-1796

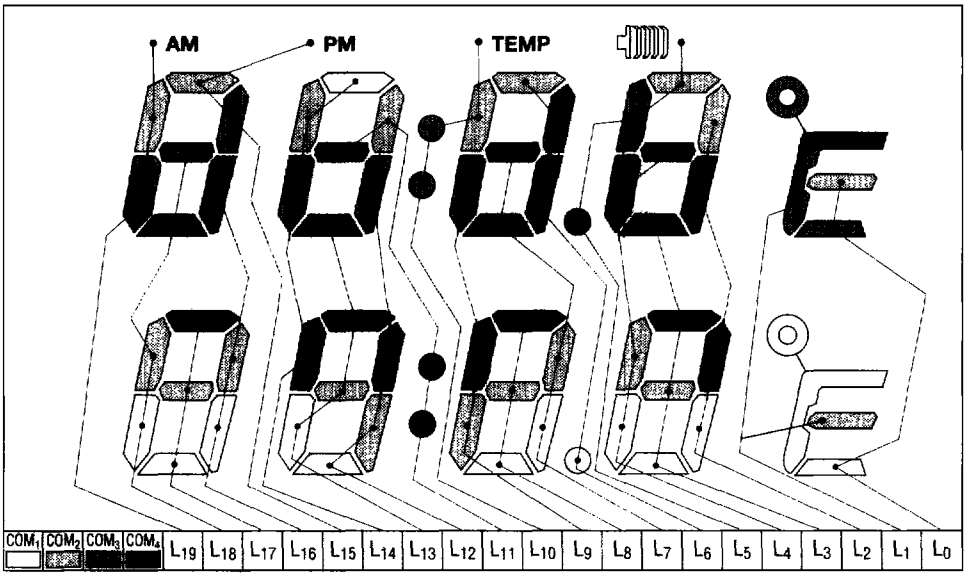
Level of substrate is V_{DD}

PIN DESCRIPTIONS

Symbol in Microcontroller	Symbol Used in this Manual	Input/Output Type	Description
P0.0	SMP	HiZ input	Temperature measurement cycle selection (H: 1-minute cycle, L: 2-second cycle)
P0.1	$\overline{°C}$/°F	HiZ input	°C or °F display temperature selection (H: °F, L: °C)
P2.0	MODE	Input with pull-down resistor	Mode selection, Correction items selection
P2.1	SET	Input with pull-down resistor	Normal state ↔ Correction state switch
P2.2	UP	Input with pull-down resistor	Addition of corrected values
P2.3	SEL	Input with pull-down resistor	Display temperature TEMP0/TEMP1 selection, ON/OFF of temperature alarm
P3.0	SIN	HiZ input	Serial communication input
P3.1	SOUT	CMOS output	Serial data output
P3.2	SCLK	CMOS output	Serial communication synchronous signal
P1.0	TOUT1	CMOS output	Temperature alarm output on H-side of TEMP0
P1.1	TOUT2	CMOS output	Temperature alarm output on L-side of TEMP0
P1.2	TOUT3	CMOS output	Temperature alarm output on H-side of TEMP1
P1.3	TOUT4	CMOS output	Temperature alarm output on L-side of TEMP1
RS0, CS0, RT0, IN0	RS0, CS0, RT0, IN0	—	Oscillation circuit for measuring TEMP0 (connecting thermistor, resistor and capacitor)
RS1, CS1, RT1, IN1	RS1, CS1, RT1, IN1	—	Oscillation circuit for measuring TEMP1 (connecting thermistor, resistor and capacitor)
BD	BD	CMOS output	Buzzer driver pin
$\overline{RESET}$	$\overline{RESET}$	Input with pull-up resistor	Initialization of microcontroller and instruction start from address 0 at L → H
L_0 to L_{33}	L_0 to L_{33}	—	LCD driver pins

LCD FORMAT

LCD Layout



LCD Segment Assignment

Pin	COM_1 Group	COM_2 Group	COM_3 Group	COM_4 Group
L_0	10d	5g	5d	—
L_1	10aef	10g	5aef	—
L_2	9c	4b	4c	9b
L_3	9d	9g	4d	9a
L_4	9e	9f	4g	4e
L_5	ALARM	4a	4f	DOT1
L_6	DOT2	3a	3b	3c
L_7	8c	8b	3g	3d
L_8	8d	8g	—	8a
L_9	—	8e	3e	8f
L_{10}	TEMP	3f	COL1	—
L_{11}	—	2b	2g	COL2
L_{12}	7d	7c	2c	7b
L_{13}	7e	7g	2d	7a
L_{14}	2a	2f	2e	7f
L_{15}	PM	1a	1b	—
L_{16}	6c	6b	—	1c
L_{17}	6d	6g	—	6a
L_{18}	6e	6f	1g	1d
L_{19}	AM	1f	1e	—
L_{20}	—	—	—	COM_4
L_{21}	—	—	COM_3	—
L_{22}	—	COM_2	—	—
L_{23}	COM_1	—	—	—

MSM64162-001 (1.5V Specifications)

ABSOLUTE MAXIMUM RATINGS

(V_{DD}=0V)

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage 1	V_{SS1}	Ta=25°C	−2.0 to +0.3	V
Power Supply Voltage 2	V_{SS2}	Ta=25°C	−4.0 to +0.3	V
Power Supply Voltage 3	V_{SS3}	Ta=25°C	−5.5 to +0.3	V
Power Supply Voltage 4	V_{SSL}	Ta=25°C	−2.0 to +0.3	V
Input Voltage 1	V_{IN1}	V_{SS1} input,Ta=25°C	V_{SS1}−0.3 to +0.3	V
Input Voltage 2	V_{IN2}	V_{SS} input,Ta=25°C	V_{SSL}−0.3 to +0.3	V
Output Voltage 1	V_{OUT1}	V_{SS1} output,Ta=25°C	V_{SS1}−0.3 to +0.3	V
Output Voltage 2	V_{OUT2}	V_{SS2} output,Ta=25°C	V_{SS2}−0.3 to +0.3	V
Output Voltage 3	V_{OUT3}	V_{SS3} output,Ta=25°C	V_{SS3}−0.3 to +0.3	V
Output Voltage 4	V_{OUT4}	V_{SSL} output,Ta=25°C	V_{SSL}−0.3 to +0.3	V
Storage Temperature	T_{STG}	—	−55 to +125	°C

RECOMMENDED OPERATING CONDITIONS

(V_{DD}=0V)

Parameter	Symbol	Condition	Range	Unit
Operating Temperature	T_{OP}	—	−40 to +85	°C
Operating Voltage	V_{SS1}	—	−1.7 to −1.25	V
400kHz OSC External Resistor	R_{OS}	—	250 to 500	kΩ
Crystal Oscillator Frequency	f_{XT}	—	30 to 35	kHz

ELECTRICAL CHACTERISTICS

DC Characteristics (1/3)

(V_{DD}=0V, V_{SS1}=–1.5V, Ta=–40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition		Min.	Typ.	Max.	Unit	Measuring Circuit
V_{SS2} Voltage	V_{SS2}	C_a, C_b, C_{12}=0.1µF, +100% –50%		–3.2	–3.0	–2.8	V	
V_{SS3} Voltage	V_{SS3}	C_a, C_b, C_{12}=0.1µF, +100% –50%		–4.7	–4.5	–4.3	V	
V_{SSL} Voltage	V_{SSL}	—		–1.5	–1.3	–0.6	V	
Power Consumption 1	I_{DD1}	CPU in halt state (400kOSC halt)	Ta=–40 to +40°C	—	2	5	µA	
			Ta=40 to 85°C	—	2	30		
Power Consumption 2	I_{DD2}	CPU in operation state (400kOSC halt)	Ta=–40 to +40°C	—	5	15	µA	
			Ta=40 to 85°C	—	5	40		
Power Consumption 3	I_{DD3}	CPU in operation state (400kOSC in operation)		—	90	180	µA	
Power Consumption 4	I_{DD4}	CPU in halt state (400kOSC halt), A/D converter in oscillation state	R_{TO}=10kΩ	—	150	230	µA	
			R_{TO}=2kΩ	—	600	900		
XTOSC Oscillation Start Voltage	V_{STA}	Oscillation must be started within 5 seconds.		—	—	–1.45	V	1
XTOSC Oscillation Maintaining Voltage	V_{HOLD}	—		—	—	–1.25	V	
XTOSC Stop Detection Time	T_{STOP}	—		0.1	—	1000	ms	
XTOSC Internal Capacitance	C_G	—		10	15	20	pF	
XTOSC External Capacitance	C_{GEX}	C_G external option		10	—	30	pF	
XTOSC Internal Capacitance	C_D	—		10	15	20	pF	
400kOSC Internal Capacitance	C_{OS}	—		8	12	16	pF	
400kOSC Oscillation Frequency	f_{OSC}	External resistor R_{OS}=300kΩ, V_{SS2}=–1.25 to –1.7V		80	220	350	kHz	
POR Generation Voltage	V_{POR1}	V_{SS1} is within V_{POR1} to –1.5V and POR is generated		–0.4	—	0	V	
POR Non-Generation Voltage	V_{POR2}	V_{SS1} is within V_{POR2} to –1.5V and no POR		–1.5	—	–1.2	V	

Notes:
- "XTOSC" refers to the 32.768kHz crystal oscillation circuit.
- "400kOSC" refers to the 400kHz CR oscillation circuit
- "POR" refers to Power-On-Reset
- "T_{STOP}" indicates that a system reset occurs if XTOSC stops oscillation for more than this duration.

DC Characteristics (2/3)

(V_{DD}=0V, V_{SS1}=V_{SSL}=–1.5V, V_{SS2}=–3.0V, V_{SS3}=–4.5V, Ta=–40 to +85°C unless otherwise specified)

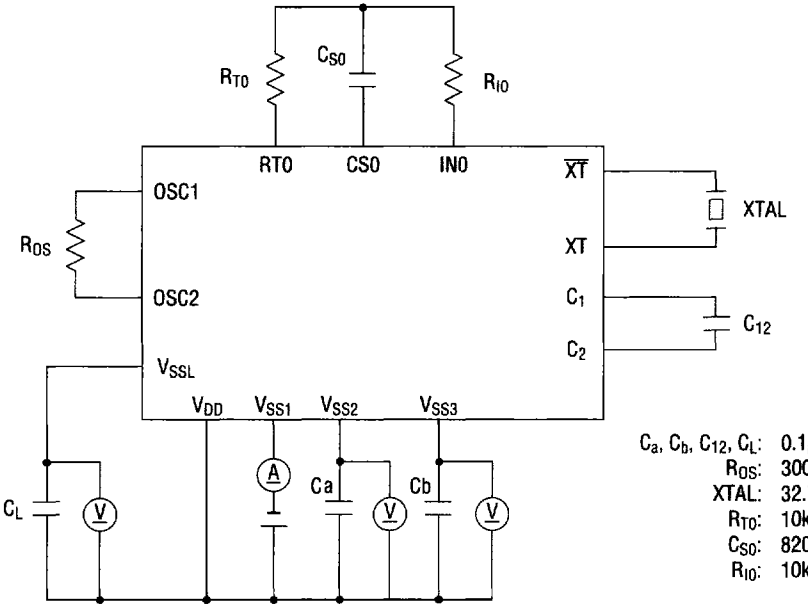
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Output Current 1(P1.0)	I_{OH1}	V_{OH1}=–0.5V	–2.1	–0.7	–0.2	mA	2
	I_{OL1}	V_{OL1}=V_{SS1}+0.5V	1	3	9	mA	
Output Current 2 (P1.1 to P1.3), (P2.0 to P2.3), (P3.0 to P3.3)	I_{OH2}	V_{OH2}=–0.5V	–2.1	–0.7	–0.2	mA	
	I_{OL2}	V_{OL2}=V_{SS1}+0.5V	0.2	0.7	2.1	mA	
Output Current 3 (BD)	I_{OH3}	V_{OH3}=–0.7V	–1.8	–0.6	–0.2	mA	
	I_{OL3}	V_{OL3}=V_{SS1}+0.7V	0.2	0.6	1.8	mA	
Output Current 4 (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	I_{OH4}	V_{OH4}=–0.1V	–1.1	–0.6	–0.3	mA	
	I_{OL4}	V_{OL4}=V_{SS1}+0.1V	0.3	0.6	1.1	mA	
Output Current 5 (When L_{16}-L_{23} are output ports)	I_{OH5}	V_{OH5}=–0.5V	–1.5	–0.5	–0.1	mA	
	I_{OL5}	V_{OL5}=V_{SS1}+0.5V	0.1	0.5	1.5	mA	
Output Current 6 (OSC2)	I_{OH6}	V_{OH6}=–0.5V	–2.1	–0.7	–0.2	mA	
	I_{OL6}	V_{OL6}=V_{SS1}+0.5V	0.2	0.7	2.1	mA	
Output Current 7 (L_0-L_{23})	I_{OH7}	V_{OH7}=–0.2V (V_{DD} level)	—	—	–4	µA	
	I_{OMH7}	V_{OMH7}=V_{SS1}+0.2V (V_{SS1} level)	4	—	—	µA	
	I_{OMH7S}	V_{OMH7S}=V_{SS1}–0.2V (V_{SS1} level)	—	—	–4	µA	
	I_{OML7}	V_{OML7}=V_{SS2}+0.2V (V_{SS2} level)	4	—	—	µA	
	I_{OML7S}	V_{OML7S}=V_{SS2}–0.2V (V_{SS2} level)	—	—	–4	µA	
	I_{OL7}	V_{OL7}=V_{SS3}+0.2V (V_{SS3} level)	4	—	—	µA	
Output Leakage (P1.1 to P1.3), (P2.0 to P2.3), (P3.0 to P3.3), (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	I_{OOH}	V_{OH}=V_{DD}	—	—	0.3	µA	
	I_{OOL}	V_{OL}=V_{SS1}	–0.3	—	—	µA	

DC Characteristics (3/3)

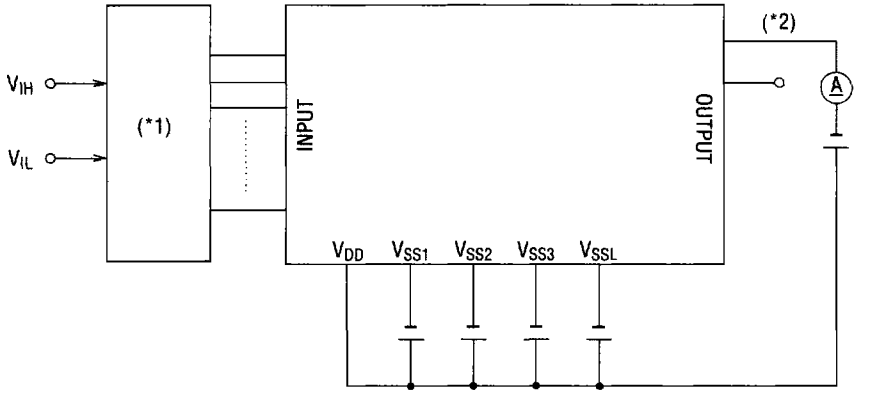
(V_{DD}=0V, V_{SS1}=V_{SSL}=−1.5V, V_{SS2}=−3.0V, V_{SS3}=−4.5V, Ta=−40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Input Current 1 (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	I_{IH1}	V_{IH1}=V_{DD} (pull-down)	5	18	60	µA	3
	I_{IL1}	V_{ILk1}=V_{SS1} (pull-up)	−60	−18	−5	µA	
	I_{IH1Z}	V_{IH1}=V_{DD} (high-impedance)	0	—	1	µA	
	I_{IL1Z}	V_{IL1}=V_{SS1} (high-impedance)	−1	—	0	µA	
Intput Current 2 (IN0, IN1)	I_{IH2}	V_{IH2}=V_{DD} (pull-down)	5	18	60	µA	
	I_{IH2Z}	V_{IH2}=V_{DD} (high-impedance)	0	—	1	µA	
	I_{IL2Z}	V_{IL2}=V_{SS1} (high-impedance)	−1	—	0	µA	
Intput Current 3 (OSC1)	I_{IL3}	V_{IL3}=V_{SS1} (pull-up)	−60	−22	−6	µA	
	I_{IH3Z}	V_{IH3}=V_{DD} (high-impedance)	0	—	1	µA	
	I_{IL3Z}	V_{IL3}=V_{SS1} (high-impedance)	−1	—	0	µA	
Intput Current 4 ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	I_{IH4}	V_{IH4}=V_{DD}	0	—	1	µA	
	I_{L4}	V_{IL4}=V_{SS1}	−1.5	−0.75	−0.3	mA	
Input Voltage1 (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	V_{IH1}	—	−0.3	—	0	V	4
	V_{IL1}	—	−1.5	—	−1.2	V	
Input Voltage 2 (IN0, IN1, OSC1)	V_{IH2}	—	−0.3	—	0	V	
	V_{IL2}	—	−1.5	—	−1.2	V	
Input Voltage 3 ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	V_{IH3}	—	−0.3	—	0	V	
	V_{IL3}	—	−1.5	—	−1.2	V	
Hysteresis Width (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	ΔVT1	—	0.05	0.1	0.3	V	
Hysteresis Width ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	ΔVT2	—	0.05	0.1	0.3	V	
Input Capacitance (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	C_{IN}	—	—	—	5	pF	1

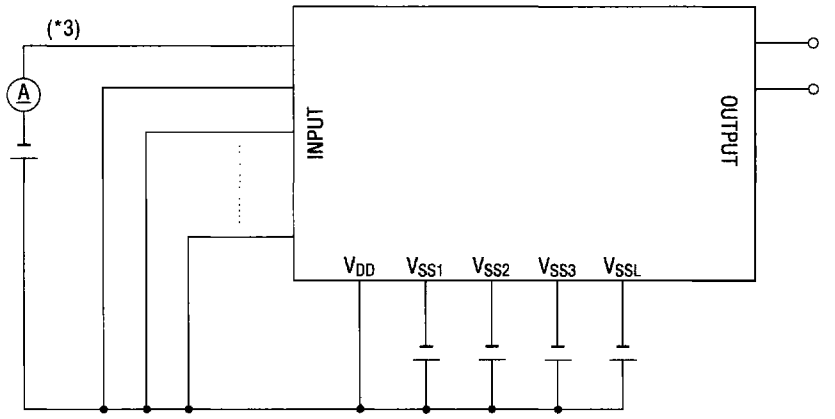
Measuring circuit 1



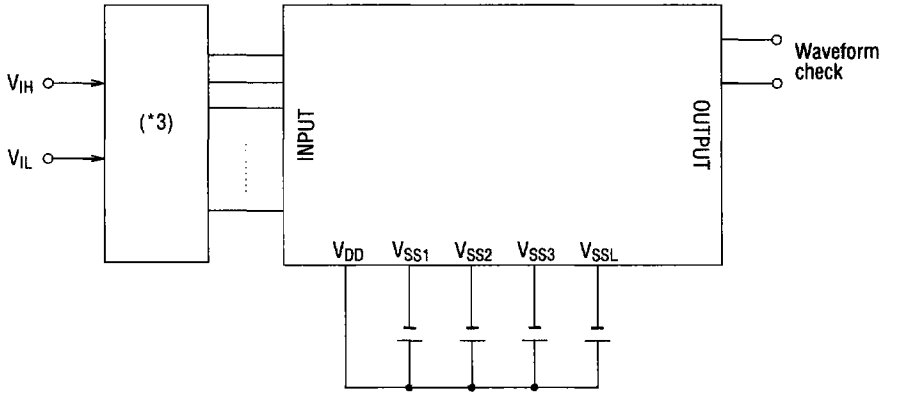
Measuring circuit 2



Measuring circuit 3



Measuring circuit 4



*1 Input logic to select a specified state.
*2 To be repeated for the specified output pin.
*3 To be repeated for the specified input pin.

A/D Converter Characteristics

(V_{DD}=0V, V_{SS1}=−1.5V, Ta=−40 to +85°C unless otherwise specified)

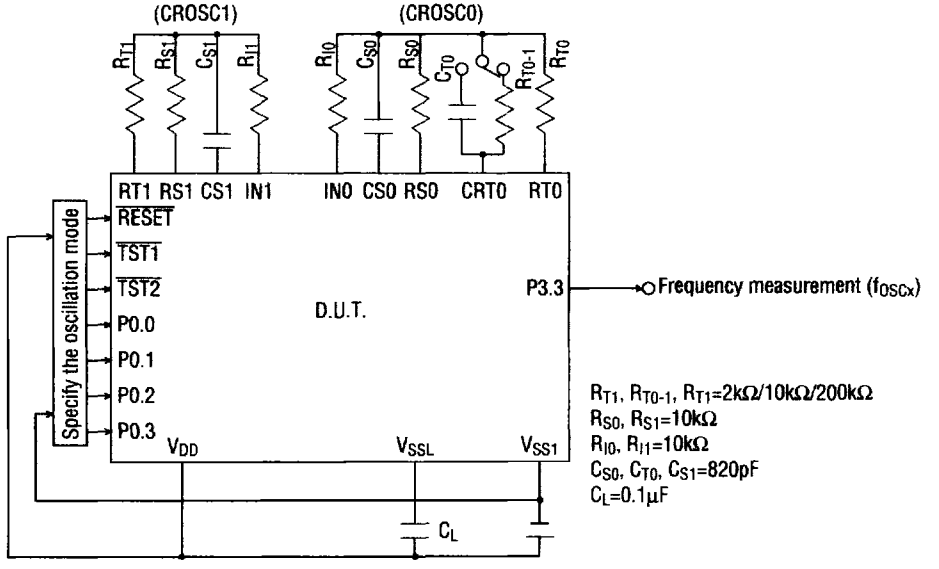
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor For Oscillator	R_{S0}, R_{S1}, R_{T0}, R_{T0-1}, R_{T1}	C_{S0}, C_{T0}, C_{S1} ≥740pF	2	—	—	kΩ	
Input Current Limiting Resistor	R_{I0}, R_{I1}	—	1	10	—	kΩ	5
Oscillation Frequency	f_{OSC1}	Resistor for oscillation=2kΩ	—	221	—	kHz	
	f_{OSC2}	Resistor for oscillation=10kΩ	—	52.2	—	kHz	
	f_{OSC3}	Resistor for oscillation=200kΩ	—	3.04	—	kHz	
RS • RT Oscillation Frequency Ratio (*)	Kf1	R_{T0}, R_{T0-1}, R_{T1}=2kΩ	—	—	—	—	
	Kf2	R_{T0}, R_{T0-1}, R_{T1}=10kΩ	—	1	—	—	
	Kf3	R_{T0}, R_{T0-1}, R_{T1}=200kΩ	—	—	—	—	

* The RS • RT oscillation frequency ratio (Kfx) is the ratio of the oscillation frequency by a sensor resistor to the oscillation frequency by a reference resistor in the same condition.

$$Kfx = \frac{f_{OSCx}(R_{T0}\text{–}C_{S0}\ \text{Oscillation})}{f_{OSCx}(R_{S0}\text{–}C_{S0}\ \text{Oscillation})},\ \frac{f_{OSCx}(R_{T0-1}\text{–}C_{S0}\ \text{Oscillation})}{f_{OSCx}(R_{S0}\text{–}C_{S0}\ \text{Oscillation})},\ \frac{f_{OSCx}(R_{T1}\text{–}C_{S1}\ \text{Oscillation})}{f_{OSCx}(R_{S1}\text{–}C_{S1}\ \text{Oscillation})}$$

(x=1,2,3)

Measuring circuit 5



MSM64162-002 (3.0V Specifications)

ABSOLUTE MAXIMUM RATINGS

V_{DD}=0V

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage 1	V_{SS1}	Ta=25°C	−2.0 to +0.3	V
Power Supply Voltage 2	V_{SS2}	Ta=25°C	−4.0 to +0.3	V
Power Supply Voltage 3	V_{SS3}	Ta=25°C	−5.5 to +0.3	V
Power Supply Voltage 4	V_{SSL}	Ta=25°C	−4.0 to +0.3	V
Input Voltage 1	V_{IN1}	V_{SS2} input,Ta=25°C	V_{SS2}−0.3 to +0.3	V
Input Voltage 2	V_{IN2}	V_{SSL} input,Ta=25°C	V_{SSL}−0.3 to +0.3	V
Output Voltage 1	V_{OUT1}	V_{SS2} output,Ta=25°C	V_{SS2}−0.3 to +0.3	V
Output Voltage 2	V_{OUT2}	V_{SS3} output,Ta=25°C	V_{SS3}−0.3 to +0.3	V
Output Voltage 3	V_{OUT3}	V_{SSL} output,Ta=25°C	V_{SSL}−0.3 to +0.3	V
Storage Temperature	T_{STG}	—	−55 to +125	°C

RECOMMENDED OPERATING CONDITIONS

V_{DD}=0V

Parameter	Symbol	Condition	Range	Unit
Operating Temperature	T_{OP}	—	−40 to +85	°C
Operating Voltage	V_{SS2}	Using LCD with "1/2 duty"	−3.5 to −2.2	V
		Using LCD without "1/2 duty"	−3.5 to −2.0	
400kHz OSC External Resistor	R_{OS}	—	90 to 500	kΩ
Crystal Oscillator Frequency	f_{XT}	—	30 to 66	kHz

DC Characteristics (1/3)

(V_{DD}=0V, V_{SS2}=–3.0V, Ta=–40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition		Min.	Typ.	Max.	Unit	Measuring Circuit
V_{SS1} Voltage	V_{SS1}	C_a, C_b, C_{12}=0.1µF, +100% –50%		–1.7	–1.5	–1.3	V	
V_{SS3} Voltage	V_{SS3}	C_a, C_b, C_{12}=0.1µF, +100% –50%		–4.7	–4.5	–4.3	V	
V_{SSL} Voltage	V_{SSL}	—		–1.9	–1.3	–0.6	V	
Power Consumption 1	I_{DD1}	CPU in halt state (400kOSC halt)	Ta=–40 to 40°C	—	1.5	4.5	µA	
			Ta=40 to 85°C	—	1.5	30		
Power Consumption 2	I_{DD2}	CPU in operation state (400kOSC halt)	Ta=–40 to 40°C	—	5	15	µA	
			Ta=40 to 85°C	—	5	40		
Power Consumption 3	I_{DD3}	CPU in operation state (400kOSC in operation)		—	220	450	µA	
Power Consumption 4	I_{DD4}	CPU in halt state (400kOSC halt), A/D converter in oscillation state	R_{T0}=10kΩ	—	300	450	µA	
			R_{T0}=2kΩ	—	1300	2000		
XTOSC Oscillation Start Voltage	V_{STA}	Oscillation must be started within 5 seconds.		—	—	–2.0	V	1
XTOSC Oscillation Maintaining Voltage	V_{HOLD}	—		—	—	–2.0	V	
XTOSC Stop Detection Time	T_{STOP}	—		0.1	—	1000	ms	
XTOSC Internal Capacitance	C_G	—		10	15	20	pF	
XTOSC External Capacitance	C_{GEX}	C_G external option		10	—	30	pF	
XTOSC Internal Capacitance	C_D	—		10	15	20	pF	
400kOSC Internal Capacitance	C_{OS}	—		8	12	16	pF	
400kOSC Oscillation Frequency	f_{OSC}	External resistor R_{OS}=100kΩ, V_{SS2}=–2.0 to –3.5V		300	400	620	kHz	
POR Generation Voltage	V_{POR1}	V_{SS2} is within V_{POR1} to –3.0V and POR generated		–0.7	—	0	V	
POR Non-Generation Voltage	V_{POR2}	V_{SS2} is within V_{POR2} to –3.0V and no POR		–3	—	–2	V	

Notes:
- "XTOSC" refers to the 32.768kHz crystal oscillation circuit.
- "400kOSC" refers to the 400kHz RC oscillation circuit.
- "POR" refers to Power-On-Reset.
- "T_{STOP}" indicates that a system reset occurs if XTOSC stops oscillation for more than this duration.

DC Characteristics (2/3)

(V_{DD}=0V, V_{SS1}=V_{SSL}=–1.5V, V_{SS2}=–3.0V, V_{SS3}=–4.5V, Ta=–40 to +85°C unless otherwise specified)

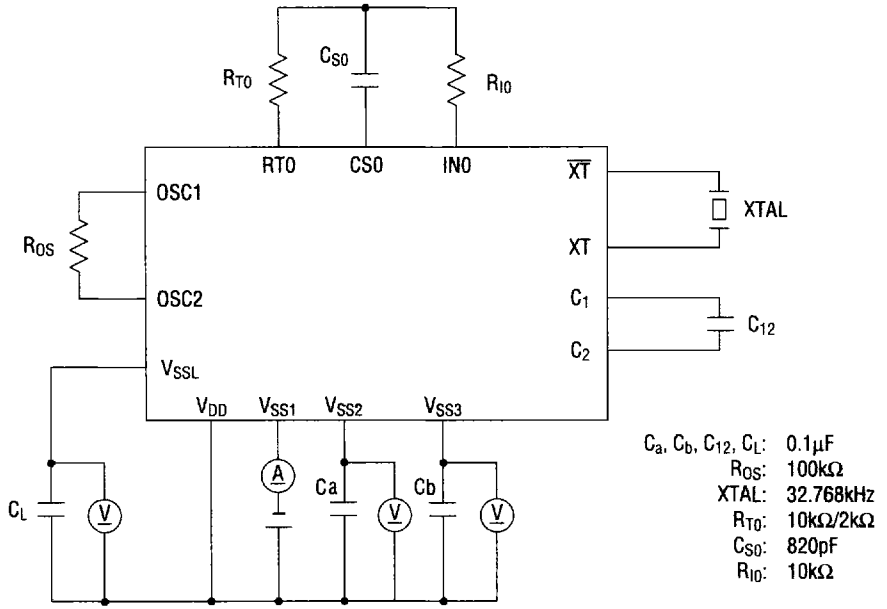
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Output Current 1(P1.0)	I_{OH1}	V_{OH1}=–0.5V	–6	–2	–0.7	mA	2
	I_{OL1}	V_{OL1}=V_{SS2}+0.5V	3	8	25	mA	
Output Current 2 (P1.1 to P1.3), (P2.0 to P2.3), (P3.0 to P3.3)	I_{OH2}	V_{OH2}=–0.5V	–6	–2	–0.7	mA	
	I_{OL2}	V_{OL2}=V_{SS2}+0.5V	0.7	2	6	mA	
Output Current 3 (BD)	I_{OH3}	V_{OH3}=–0.7V	–6	–2	–0.7	mA	
	I_{OL3}	V_{OL3}=V_{SS2}+0.7V	0.7	2	6	mA	
Output Current 4 (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	I_{OH4}	V_{OH4}=–0.1V	–2.5	–1.3	–0.7	mA	
	I_{OL4}	V_{OL4}=V_{SS2}+0.1V	0.7	1.3	2.5	mA	
Output Current 5 (When L_{16}-L_{23} are output ports)	I_{OH5}	V_{OH5}=–0.5V	–1.5	–0.6	–0.15	mA	
	I_{OL5}	V_{OL5}=V_{SS2}+0.5V	0.15	0.6	1.5	mA	
Output Current 6 (OSC2)	I_{OH6}	V_{OH6}=–0.5V	–6	–2	–0.7	mA	
	I_{OL6}	V_{OL6}=V_{SS2}+0.5V	0.7	2	6	mA	
Output Current 7 (L_0-L_{23})	I_{OH7}	V_{OH7}=–0.2V (V_{DD} level)	—	—	–4	µA	
	I_{OMH7}	V_{OMH7}=V_{SS1}+0.2V (V_{SS1} level)	4	—	—	µA	
	I_{OMH7S}	V_{OMH7S}=V_{SS1}–0.2V (V_{SS1} level)	—	—	–4	µA	
	I_{OML7}	V_{OML7}=V_{SS2}+0.2V (V_{SS2} level)	4	—	—	µA	
	I_{OML7S}	V_{OML7S}=V_{SS2}–0.2V (V_{SS2} level)	—	—	–4	µA	
	I_{OL7}	V_{OL7}=V_{SS3}+0.2V (V_{SS3} level)	4	—	—	µA	
Output Leakage (P1.1 to P1.3), (P2.0 to P2.3), (P3.0 to P3.3), (RT0, RT1, RS0, RS1, CRT0, CS0, CS1)	I_{OOH}	V_{OH}=V_{DD}	—	—	0.3	µA	
	I_{OOL}	V_{OL}=V_{SS2}	–0.3	—	—	µA	

DC Characteristics (3/3)

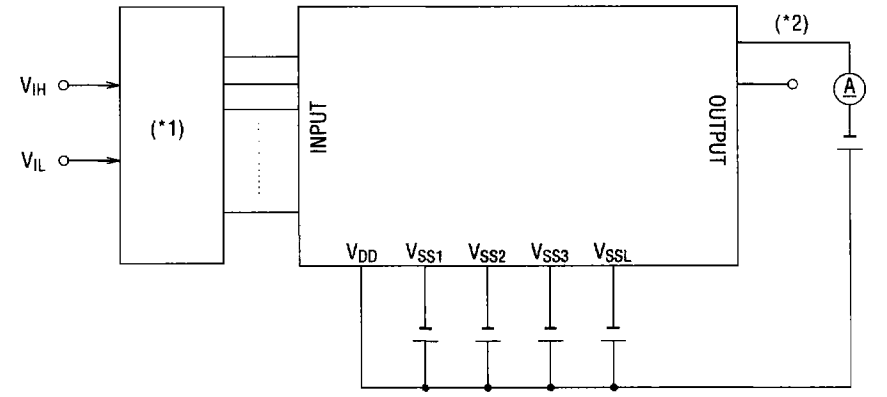
(V_{DD}=0V, V_{SS1}=V_{SSL}=–1.5V, V_{SS2}=–3.0V, V_{SS3}=–4.5V, Ta=–40 to +85°C unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Mesuring Circuit
Input Current 1 (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	I_{IH1}	V_{IH1}=V_{DD} (pull-down)	30	90	300	µA	3
	I_{IL1}	V_{IL1}=V_{SS2} (pull-up)	–300	–90	–30	µA	
	I_{IH1Z}	V_{IH1}=V_{DD} (high-impedance)	0	—	1	µA	
	I_{IL1Z}	V_{IL1}=V_{SS2} (high-impedance)	–1	—	0	µA	
Intput Current 2 (IN0, IN1)	I_{IH2}	V_{IH2}=V_{DD} (pull-down)	30	90	300	µA	
	I_{IH2Z}	V_{IH2}=V_{DD} (high-impedance)	0	—	1	µA	
	I_{IL2Z}	V_{IL2}=V_{SS2} (high-impedance)	–1	—	0	µA	
Intput Current 3 (OSC1)	I_{IL3}	V_{IL3}=V_{SS2} (pull-up)	–300	–110	–10	µA	
	I_{IH3Z}	V_{IH3}=V_{DD} (high-impedance)	0	—	1	µA	
	I_{IL3Z}	V_{IL3}=V_{SS2} (high-impedance)	–1	—	0	µA	
Intput Current 4 ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	I_{IH4}	V_{IH4}=V_{DD}	0	—	1	µA	
	I_{L4}	V_{IL4}=V_{SS2}	–3	–1.5	–0.75	mA	
Input Voltage1 (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	V_{IH1}	—	–0.6	—	0	V	4
	V_{IL1}	—	–3.0	—	–2.4	V	
Input Voltage 2 (IN0, IN1, OSC1)	V_{IH2}	—	–0.6	—	0	V	
	V_{IL2}	—	–3.0	—	–2.4	V	
Input Voltage 3 ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	V_{IH3}	—	–0.6	—	0	V	
	V_{IL3}	—	–3.0	—	–2.4	V	
Hysteresis Width (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	ΔVT1	—	0.2	0.5	1	V	
Hysteresis Width ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	ΔVT2	—	0.2	0.5	1	V	
Input Capacitance (P0.0 to P0.3), (P2.0 to P2.3), (P3.0 to P3.3)	C_{IN}	—	—	—	5	pF	1

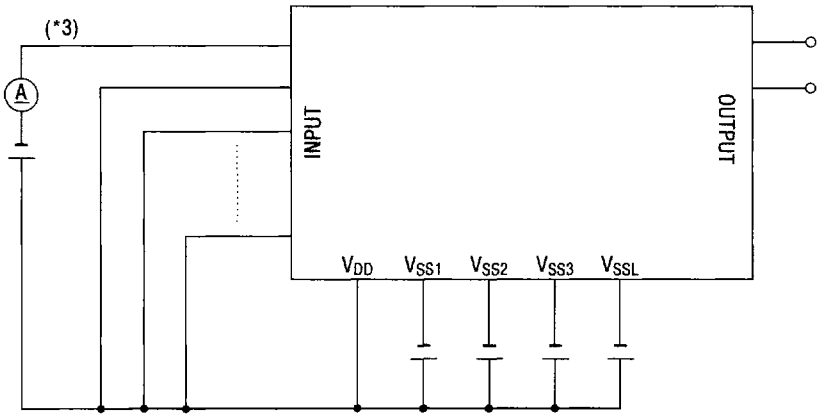
Measuring circuit 1



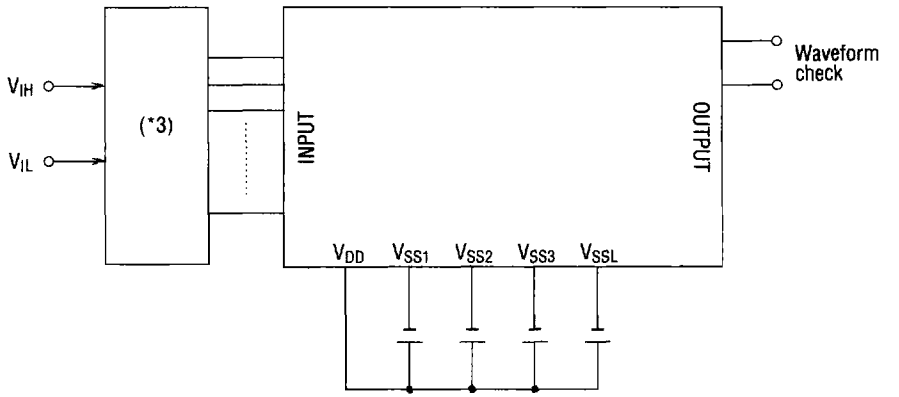
Measuring circuit 2



Measuring circuit 3



Measuring circuit 4



*1 Input logic to select a specified state.
*2 To be repeated for the specified output pin.
*3 To be repeated for the specified input pin.

A/D Converter Characteristics

(V_{DD}=0V, V_{SS2}=–3.0V, Ta=–40 to +85°C unless otherwise specified)

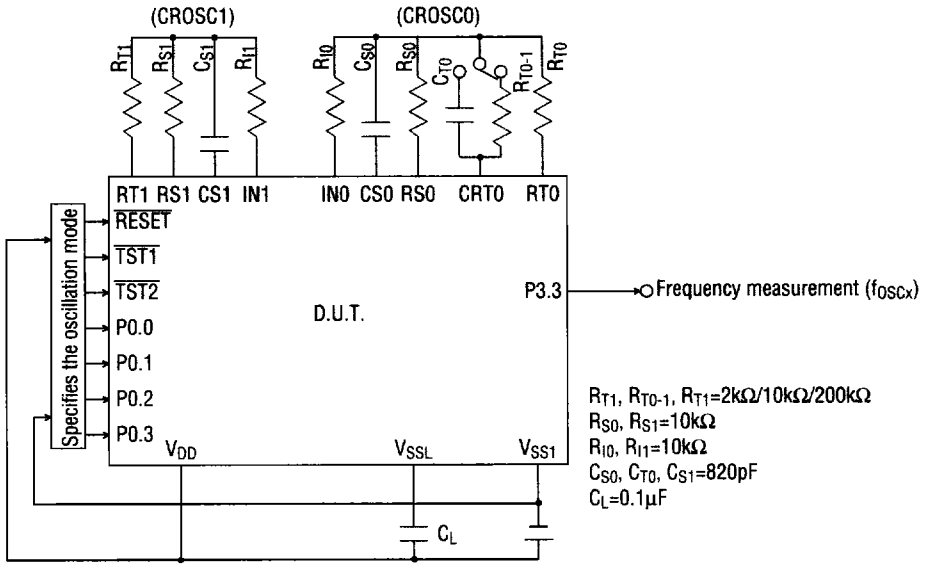
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor for Oscillator	R_{S0}, R_{S1}, R_{T0}, R_{T0-1}, R_{T1}	CS0, CT0, CS1≥740pF	1	—	—	kΩ	5
Input Current Limiting Resistor	R_{I0}, R_{I1}	—	1	10	—	kΩ	
Oscillation Frequency	f_{OSC1}	Resistor for oscillation=2kΩ	200	239	277	kHz	
	f_{OSC2}	Resistor for oscillation=10kΩ	465	55.4	64.3	kHz	
	f_{OSC3}	Resistor for oscillation=200kΩ	2.79	3.32	3.85	kHz	
RS • RT Oscillation Frequency Ratio (*)	Kf1	R_{T0}, R_{T0-1}, R_{T1}=2kΩ	4.115	4.22	4.326	—	
	Kf2	R_{T0}, R_{T0-1}, R_{T1}=10kΩ	0.990	1	1.010	—	
	Kf3	R_{T0}, R_{T0-1}, R_{T1}=200kΩ	0.0573	0.0616	0.0659	—	

* The RS • RT oscillation frequency ratio (Kfx) is the ratio of the oscillation frequency by a sensor resistor to the oscillation frequency by a reference resistor in the same condition.

$$Kfx = \frac{f_{OSCx}(R_{T0}\text{–}C_{S0}\ \text{Oscillation})}{f_{OSCx}(R_{S0}\text{–}C_{S0}\ \text{Oscillation})},\ \frac{f_{OSCx}(R_{T0\text{-}1}\text{–}C_{S0}\ \text{Oscillation})}{f_{OSCx}(R_{S0}\text{–}C_{S0}\ \text{Oscillation})},\ \frac{f_{OSCx}(R_{T1}\text{–}C_{S1}\ \text{Oscillation})}{f_{OSCx}(R_{S1}\text{–}C_{S1}\ \text{Oscillation})}$$

(x=1,2,3)

Measuring circuit 5



FUNCTIONAL DESCRIPTION

Temperature Measuring and Display

The (built-in) thermometer can measure the temperatures of two different points simultaneously. (Temperatures measured by IN0, RS0, CS0, and RT0 are called TEMP0, and those measured by IN1, RS1, CS1, and RT1 are called TEMP1.)
Either TEMP0 or TEMP1 is displayed in time and temperature mode, and both TEMP0 and TEMP1 are displayed in temperature mode.
Temperatures are detected with the thermistor and the frequency conversion method is used for A/D conversion. Since the frequency conversion method is suited to compensate the non-linearity of thermistor, higher precision can be obtained in a wide range of temperature (-20°C to +70°C).

- Temperature measuring range
  °C: C/F="L" (V_{SS})
  -20 to +70°C (displays "-20L" when temperature is under -20°C, and "70H" when temperature is over 70°C)
  °F: C/F="H" (V_{DD})
  0 to +160°F (displays "0L" when temperature is under 0°F, and "160H" when temperature is over 160°F)

- Applicable thermistor
  103AT (manufactured by Ishizuka Electronics Co., Ltd.)

- Resolution
  0.1°C (0.1°F) in the whole range of temperature

- Sampling cycle
  By the level of the SMP pin at reset time, temperature measurement of both TEMP0 and TEMP1 can be set as follows:
- When the input level of SMP is "L" (V_{SS}), TEMP0 and TEMP1 are measured once in two seconds.
- When the input level of SMP is "H" (V_{DD}), TEMP0 and TEMP1 are measured once per minute. However, sampling is not performed during time setting, temperature alarm setting, and buzzer output.

- C°/F° display setting
  By the input level of °C/°F pin at reset time, °C/°F display can be set as follows:
- When °C/°F pin is L (V_{SS}) level, the unit of temperature is Centigrade (°C).
- When °C/°F pin is H (V_{DD}) level, the unit of temperature is Fahrenheit (°F).
  The unit of temperature cannot be changed during operation.

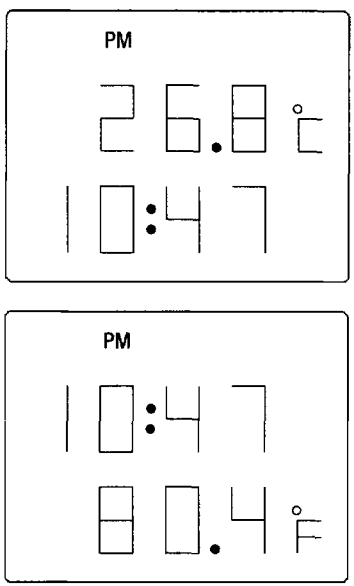
Clock and Temperature Display

Displays current time and measured temperature at the same time. Either TEMP0 or TEMP1 can be selected for display by using the SEL switch.

In the case of TEMP0, the measured temperature is displayed in the upper part of LCD, and the current time in the lower part.

In the case of TEMP1, the measured temperature is displayed in the lower part of LCD, and the current time in the upper part (see figure below). The current time is displayed in 12-hour system.

Display examples



Temperature (TEMP0) Centigrade display

Clock

Clock

Temperature (TEMP1) Fahrenheit display

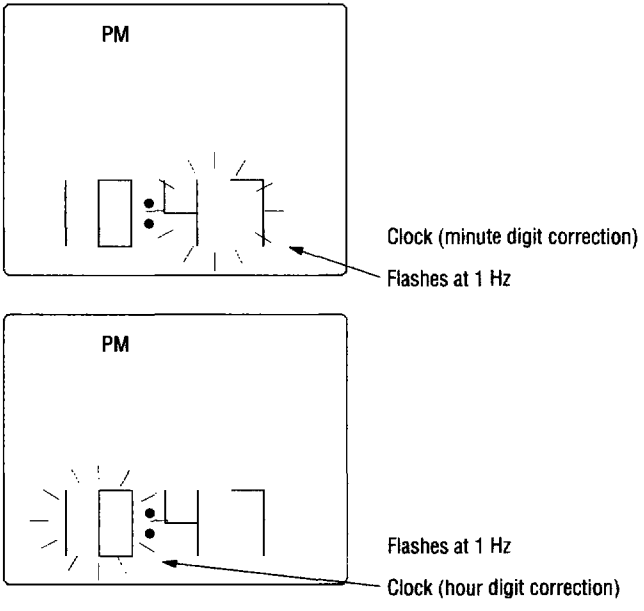
Time Correction State

When the SET switch is pressed continuously for two seconds or more in the time and temperature state, the minute correction state is selected.

During this state, the minute digit flashes at 1 Hz. If the UP switch is pressed in this state, the minute digit advances by 1, and the second digits become 00. When UP switch is pressed continuously for 1 to 2 seconds, the minute digit increments at a 8-Hz rate.

When the MODE switch is pressed in the minute correction state, the hour correction state is selected. In this state, the hour digit flashes at 1 Hz. If the UP switch is pressed in this state, the hour digit advances by 1. And when the UP switch is pressed continuously for 1 to 2 seconds, the hour digit is fast forwarded by 8 Hz.

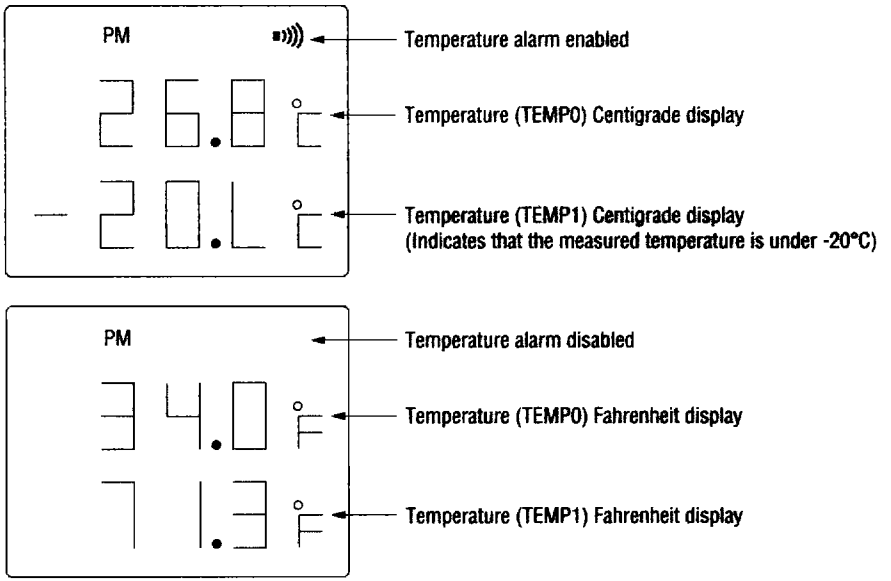
The clock and temperature display state is restored by pressing the SET switch. In this case, TEMP0 is selected.



Temperature Display State

Temperature display state is selected by pressing the MODE switch in time and temperature state. In this state, the measured temperatures TEMP0 and TEMP1 are displayed at the same time.

The temperature alarm is enabled or disabled with the SEL switch. An alarm mark ( ) appears during alarm enable state.



Temperature Alarm Setting

The temperature alarm function compares measured temperature with preset temperature. There are following two types of temperature alarm:

- Higher-temperature alarm: When the measured temperature is higher than the preset temperature, alarm sounds for ten seconds and "H" (V_{DD}) is output from corresponding port.

- Lower-temperature alarm: When the measured temperature is lower than the preset temperature, alarm sounds for ten seconds and "H" (V_{DD}) is output from corresponding port.

Both higher-temperature alarm and lower-temperature alarm can select TEMP0 and TEMP1 for a total of four available temperature alarm modes. Alarm enable/disable is performed independently.

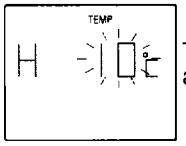
1) Temperature alarm setting
   Pressing SET in the temperature display state selects the temperature setting of temperature alarm. Each time MODE switch is pressed, the temperature alarm setting is changed in the following order:

   TEMP0 higher-temperature alarm
   ↓
   TEMP0 lower-temperature alarm
   ↓
   TEMP1 higher-temperature alarm
   ↓
   TEMP1 lower-temperature alarm
   ↓
   TEMP0 higher-temperature alarm

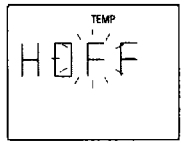
By pressing SEL in the setting state, setting mode can be toggled between enable and disable individually. In disable mode, "OFF" is displayed instead of temperatures. However, if all the temperature alarms are disabled in the temperature display state, the individual enable becomes invalid.
To increase the temperature in 1°C (°F) increments, press UP while in the enable mode.
The temperature display state is restored by pressing the SET switch.

2) Temperature alarm output
   The temperature alarm has two outputs: buzzer output and port output.
   The buzzer sounds for 10 seconds after the start of temperature alarm operation. The buzzer frequency is 2 kHz with a 50% duty cycle.
   There are four output ports corresponding to each temperature alarm.
   If temperature alarm starts operation, then H (V_{DD}) is output from corresponding port. (See "Pin Description" for the correspondence between temperature alarm and ports.) H (V_{DD}) is output from that port until the temperature alarm ends.

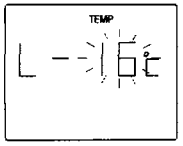
Display examples



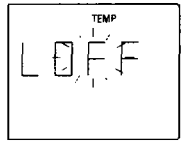
TEMP0 higher-temperature alarm



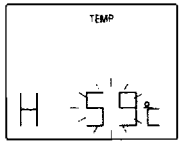
TEMP0 higher-temperature alarm disabled



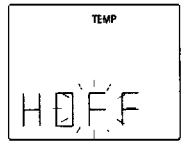
TEMP0 lower-temperature alarm



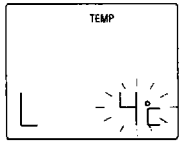
TEMP0 lower-temperature alarm disabled



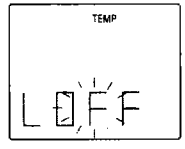
TEMP1 higher-temperature alarm



TEMP1 higher-temperature alarm disabled



TEMP1 lower-temperature alarm



TEMP1 lower-temperature alarm disabled

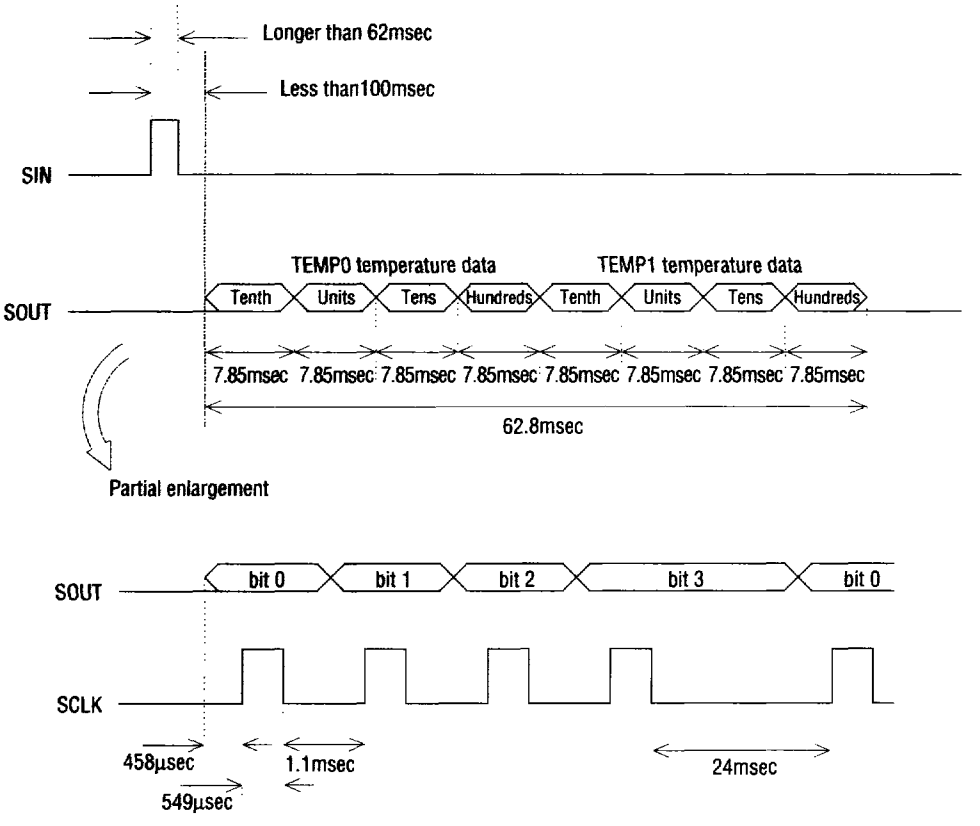
Serial Communication Functions

When an "H" level is input to the SIN pin, the latest measured temperature is output in serial mode through the SOUT pin.

The length of data is 8 nibbles in unsigned BCD code format. When the measured temperature is negative, "A" ("1010" in binary) is transferred instead of the hundreds data.

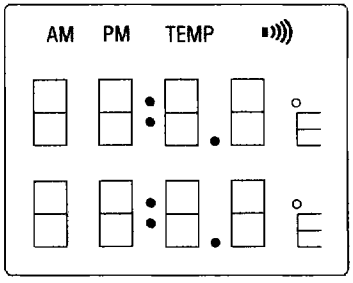
Serial data is output from LSB in synchronization with the pulse output from SCLK pin.

Serial communication waveform



Entire LCD ON

The entire LCD is turned on when any switch (MODE, SET, SEL or UP) is pressed at the time of reset of the MSM64162-001/002. To end this mode, reset the MSM64162-001/002 again.



Adjustment and Initialization

- Temperature adjustment
  To adjust the temperature measurement circuit, take the following procedure.

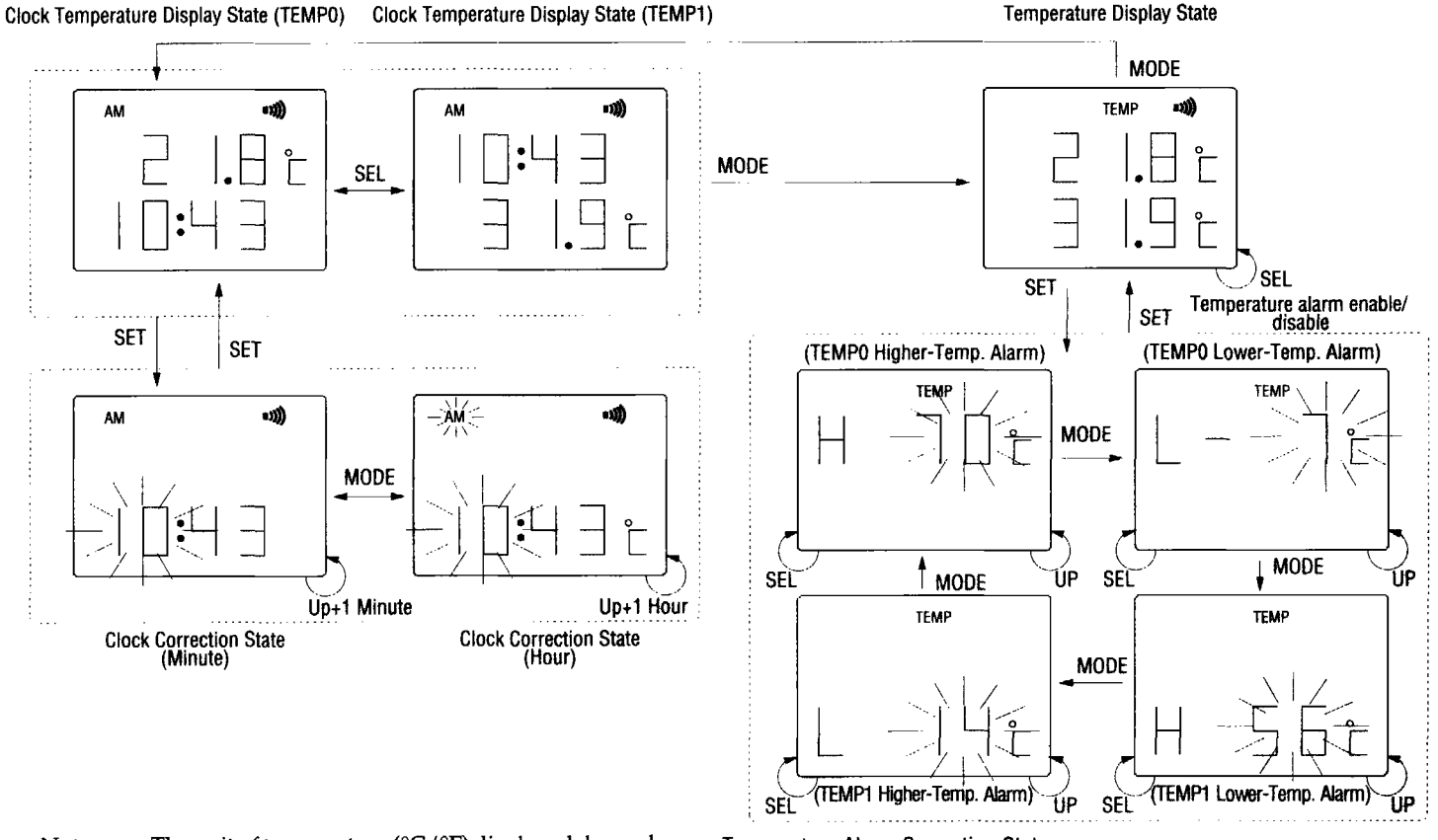
  1) Set the temperature around the thermistor to 25.0°C.

  2) Set the temperature display TEMP0 to 25.0°C by changing the resistor RS0 of the temperature measurement circuit.

  3) Set the temperature display TEMP1 to 25.0°C by changing the resistor RS1 of temperature measuremant circuit. The external resistor of the temperature measurement circuit influences the measurement accuracy. It is therefore recommended to use a resistor with little variance in temperature and aging characteristics.
     Use the type 103AT thermistor manufactured by Ishizuka Electronics Co., Ltd.

- Initialization
  The MSM64162-001/002 is initialized at POWER ON.
  It can also be initialized by applying L level (V_{SS}) to the RESET pin.
  The initialized state is as follows:
  Clock time: 12:00 AM.
  Temperature Alarm: Disabled
  Lower-temperature alarm setting temperature : -20°C or 0°F
  Higher-temperature alarm setting temperature : 70°C or 160°F

Mode Transition Diagram



Note: The unit of temperature (°C/°F) displayed depends on the input level of the C/F pin at reset. Once displayed, the unit cannot be changed during operation.

Temperature Alarm Correction State
(Pressing the UP switch increases the preset temperature by 1 in temperature alarm state. Pressing the SEL switch enables/disables each temperature alarm.)