OKI Semiconductor

MSM64164C-011/012

Clock with Temperature Measuring Function

GENERAL DESCRIPTION

The MSM64164C-011/012 is a clock IC with a temperature measuring function.

FEATURES

- The clock function displays hour, minute, and AM/PM; it can be switched between 12/24 hour display.
- The temperature measuring function measures two different temperatures simultaneously (two channels).
  Two types of temperature measuring ranges for each channel can be selected:

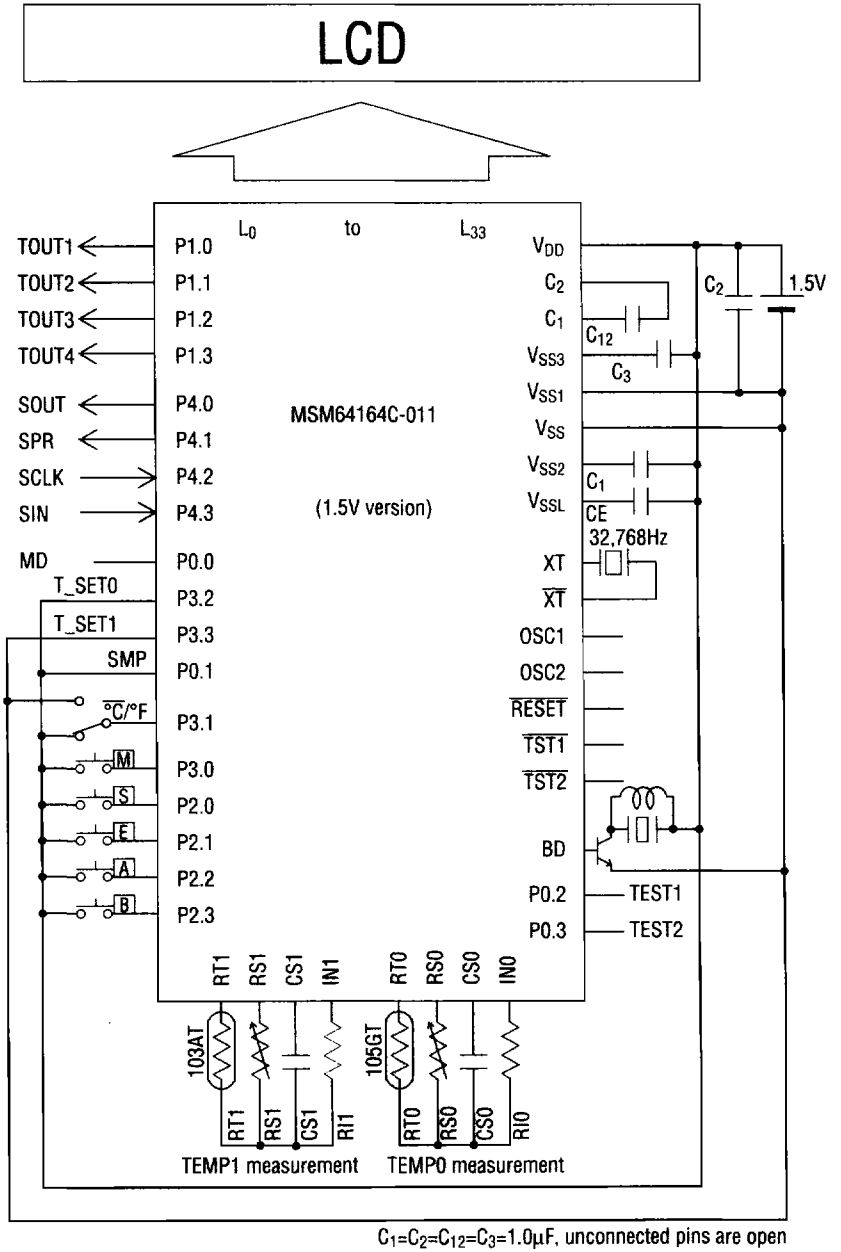
	TYPE 1	: –40.0°C to +70.0°C (–40.0°F to +160°F)
	TYPE 2	: +60°C to +200°C (+140°F to +400°F)
Resolution	Type 1	: 0.1°C, 0.2°F
	Type 2	: 1°C, 2°F
Precision	Type 1	: ±2°C (MSM64164C-011, at V_{DD} = 1.5V, –40 to +70°C) or ±1°C (MSM64164C-012, at V_{DD}=3.0V, –40 to +70°C)
	Type 2	: Under measurement

  Selection of a temperature measurement period : 1 minute or 2 seconds
- 8 digits + 20 indicators, 1/3 duty LCD drive
- Alarm function
- Countdown timer function: Up to a maximum of 23 hours 59 minutes can be set in 1 minute decrements.
- Upper limit/lower limit temperature alarm function, set with 1°C (°F) intervals.
- Maximum/minimum temperature memory functions.
- The second-time function displays hour, minute, and AM/PM; it can be switched between 12 and 24 hours.
- Low power consumption
- Serial interface output
- Power voltage : 1.5V (MSM64164C-011) or 3V (MSM64164C-012)
- Package options:
  80-pin plastic QFP (QFP80-P-1420-K)
  (Product name : MSM64164C-011GS-K/MSM64164C-012GS-K)
  80-pin plastic QFP (QFP80-P-1420-BK)
  (Product name : MSM64164C-011GS-BK/MSM64164C-012GS-BK)
  Chip

APPLICATION CIRCUITS

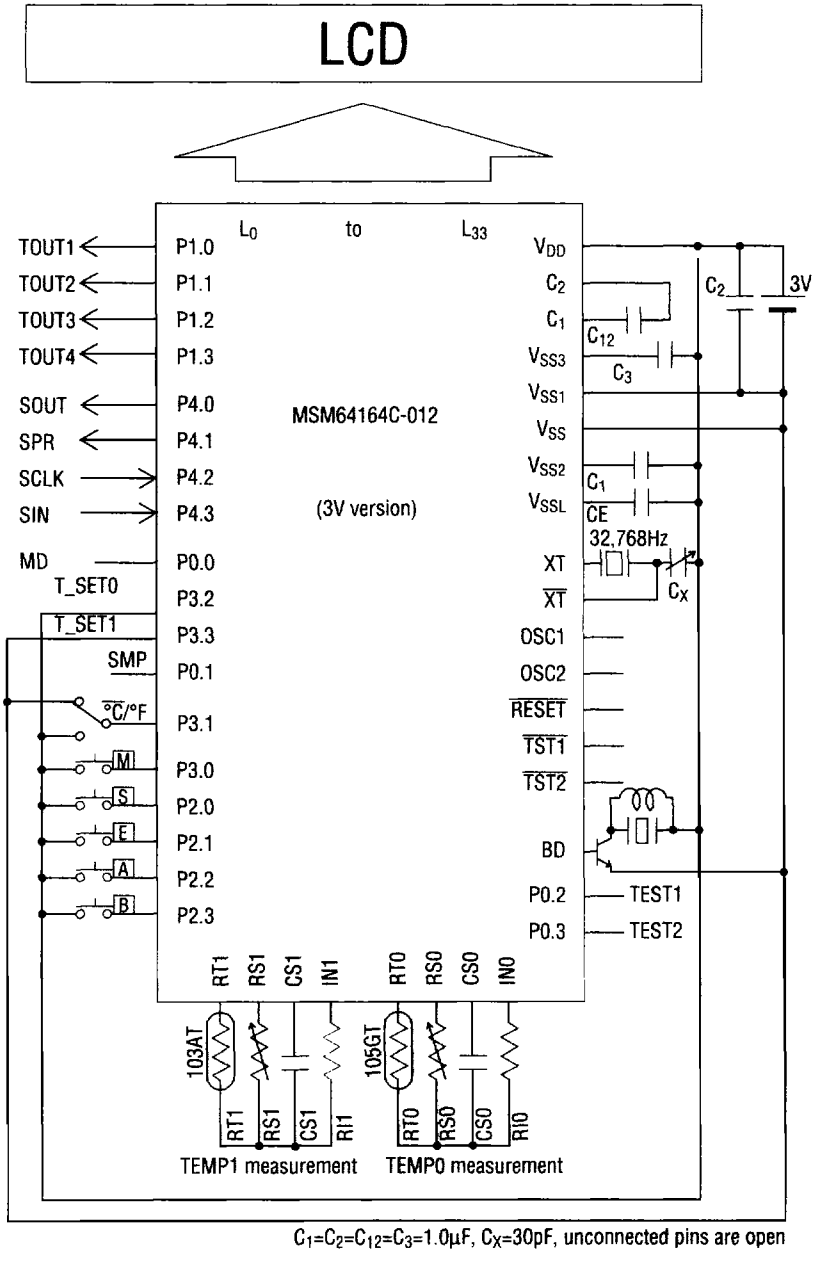
Example of MSM64164C-011 circuit

In the figure below, the temperature measurement range is set to type 1 for TEMP0 and type 2 for TEMP1. The temperature is shown in °F. The temperature measuring period is 1 minute.



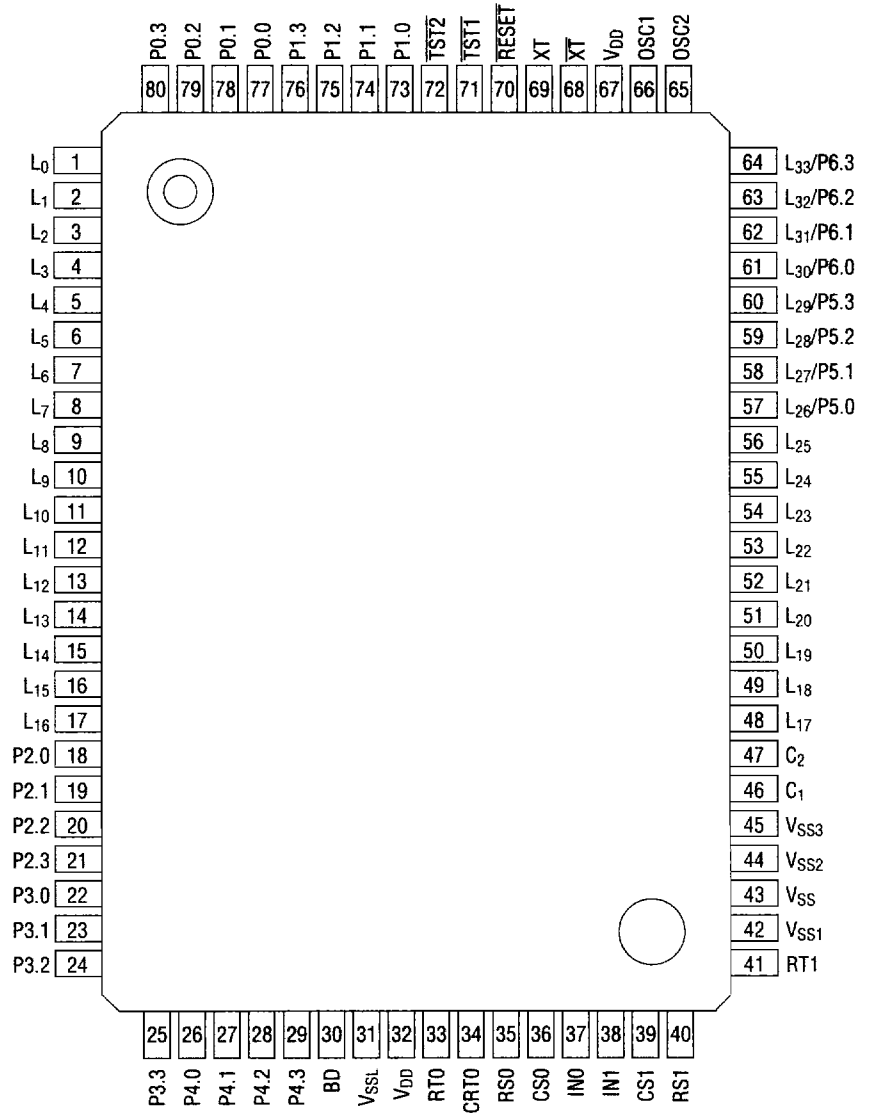
Example of MSM64164C-012 circuit

In the figure below, the temperature measurement range is set to type 2 for TEMP0 and type 1 for TEMP1. The temperatuere is shown in °C and the temperature measuring period is 2 seconds.



$C_1=C_2=C_{12}=C_3=1.0\mu F$, $C_X=30pF$, unconnected pins are open

PIN CONFIGURATION (TOP VIEW)



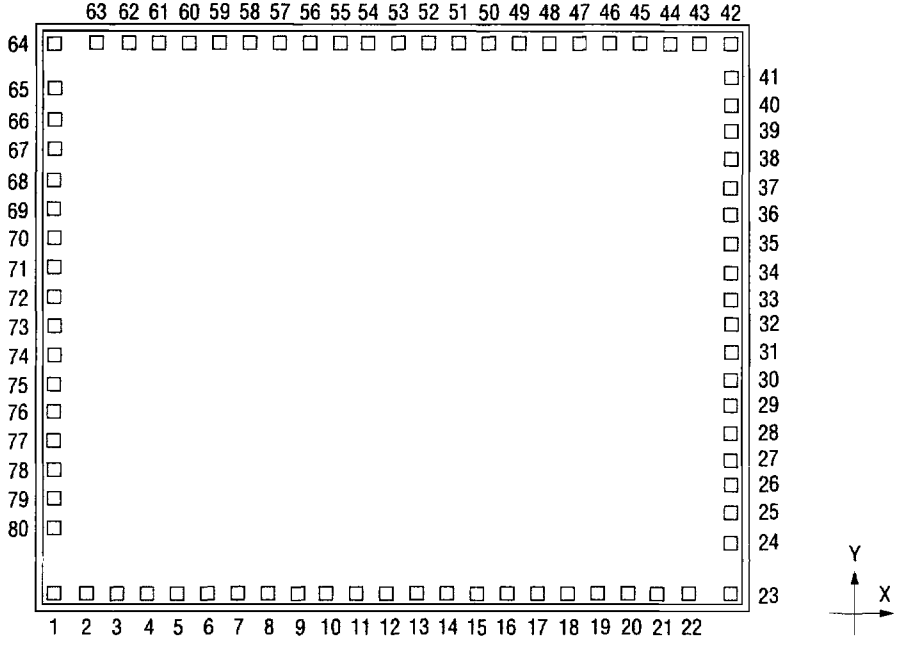
80-Pin Plastic QFP

Note: Supply V_{DD} from pin 32.

PAD CONFIGURATION

Pad Layout

Chip size: 5.57mm x 4.52mm



Pad Coordinates

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	−2678	−2153	33	RT0	2678	177
2	L_1	−2430	−2153	34	CRT0	2678	391
3	L_2	−2188	−2153	35	RS0	2678	604
4	L_3	−1947	−2153	36	CS0	2678	818
5	L_4	−1705	−2153	37	IN0	2678	1031
6	L_5	−1464	−2153	38	IN1	2678	1245
7	L_6	−1222	−2153	39	CS1	2678	1459
8	L_7	−980	−2153	40	RS1	2678	1673
9	L_8	−739	−2153	41	RT1	2678	1886
10	L_9	−497	−2153	42	V_{SS1}	2678	2153
11	L_{10}	−255	−2153	43	V_{SS}	2424	2153
12	L_{11}	−14	−2153	44	V_{SS2}	2181	2153
13	L_{12}	228	−2153	45	V_{SS3}	1939	2153
14	L_{13}	470	−2153	46	C_1	1697	2153
15	L_{14}	712	−2153	47	C_2	1455	2153
16	L_{15}	954	−2153	48	L_{17}	1213	2153
17	L_{16}	1196	−2153	49	L_{18}	971	2153
18	P2.0	1437	−2153	50	L_{19}	729	2153
19	P2.1	1679	−2153	51	L_{20}	487	2153
20	P2.2	1921	−2153	52	L_{21}	245	2153
21	P2.3	2163	−2153	53	L_{22}	2	2153
22	P3.0	2405	−2153	54	L_{23}	−240	2153
23	P3.1	2678	−2153	55	L_{24}	−482	2153
24	P3.2	2678	−1745	56	L_{25}	−724	2153
25	P3.3	2678	−1531	57	L_{26}	−966	2153
26	P4.0	2678	−1318	58	L_{27}	−1208	2153
27	P4.1	2678	−1104	59	L_{28}	−1450	2153
28	P4.2	2678	−891	60	L_{29}	−1693	2153
29	P4.3	2678	−678	61	L_{30}	−1934	2153
30	BD	2678	−464	62	L_{31}	−2177	2153
31	V_{SSL}	2678	−251	63	L_{32}	−2418	2153
32	V_{DD}	2678	−37	64	L_{33}	−2678	2153

Pad Coordinates (continued)

Center of chip: x=0, y=0

Pad No.	Pad Name	x (μm)	y (μm)	Pad No.	Pad Name	x (μm)	y (μm)
65	OSC2	−2678	1782	73	P1.0	−2678	−79
66	OSC1	−2678	1549	74	P1.1	−2678	−305
67	V_{DD}	−2678	1315	75	P1.2	−2678	−532
68	$\overline{XT}$	−2678	1081	76	P1.3	−2678	−758
69	XT	−2678	848	77	P0.0	−2678	−984
70	$\overline{RESET}$	−2678	615	78	P0.1	−2678	−1203
71	$\overline{TST1}$	−2678	381	79	P0.2	−2678	−1429
72	$\overline{TST2}$	−2678	148	80	P0.3	−2678	−1656

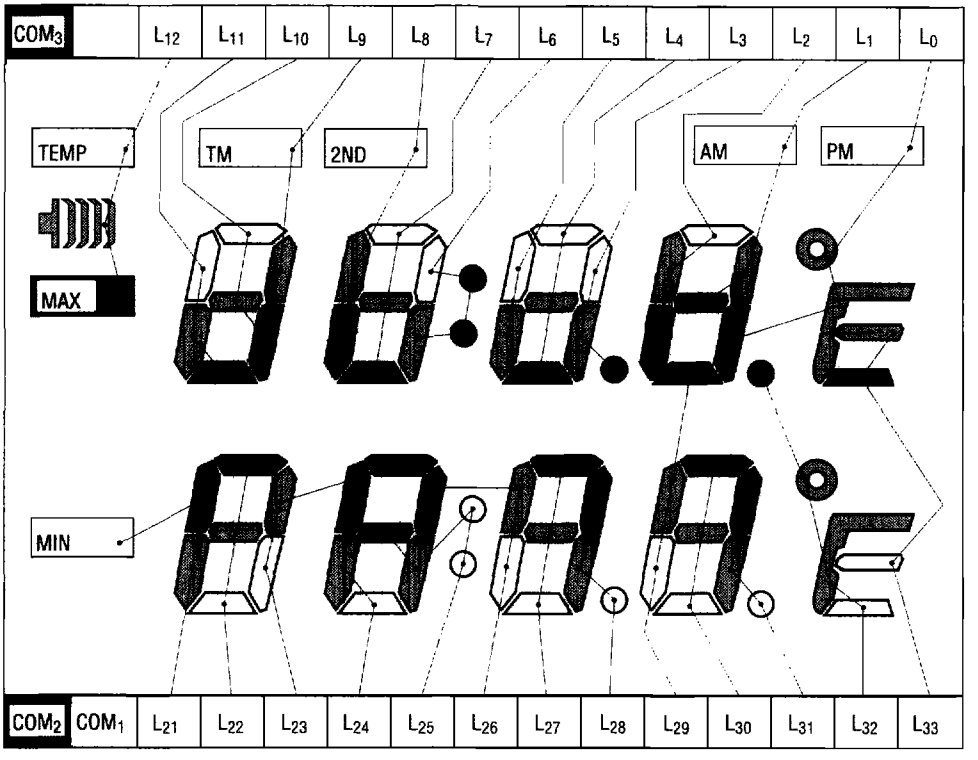
PIN DESCRIPTIONS

Symbol in Microcontrollers	Symbol Used in This Manual	Input/Output Type	Description
P0.0	MD	Input with pull-down resistor	Mode layout setting (H: temperature mode only, L: all modes available)
P0.1	SMP	Input with pull-down resistor	Temperature measuring cycle (H: 1-minute cycle, L: 2-second cycle)
P0.2	TEST1	Input with pull-down resistor	Test mode selection switch (H: test mode. L: normal mode)
P0.3	TEST2	Input with pull-down resistor	Test mode selection switch (H: oscillation test, L: Idd test)
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
P2.0	[S] *	Input with pull-down resistor	Switching between normal state and correction state
P2.1	[E] *	Input with pull-down resistor	Display time switching, timer start/stop and alarm ON/OFF
P2.2	[A] *	Input with pull-down resistor	Display temperature switching and setting of conversion values
P2.3	[B] *	Input with pull-down resistor	Display temperature switching and setting of conversion values
P3.0	[M] *	Input with pull-down resistor	Mode selection
P3.1	°C/°F	CMOS input	Switching between °C and °F of display temperature (H: °F, L: °C)
P3.2	T_SET0	CMOS input	Thermistor setting of TEMP0 (H: Type 2, L: type 1)
P3.3	T_SET1	CMOS input	Thermistor setting of TEMP1 (H: type 2, L: type 1)
P4.0	SOUT	NMOS open drain output	Serial data output
P4.1	SPR	NMOS open drain output	Serial communication synchronous signal
P4.2	SCLK	Input with pull-down resistor	Serial communication clock
P4.3	SIN	Input with pull-down resistor	Serial communication start
$\overline{\text{RESET}}$	$\overline{\text{RESET}}$	Input with pull-up resistor	When the level is changed from L to H, microcontroller is initialized and execution of instruction starts from address 0.
RS0, CS0, RT0, IN0	RS0, CS0, RT0, IN0	—	TEMP0 measuring oscillation circuit (thermistor, resistor and capacitor are connected)
RS1, CS1, RT1, IN1	RS1, CS1, RT1, IN1	—	TEMP1 measuring oscillation circuit (thermistor, resistor and capacitor are connected)
BD	BD	CMOS output	Buzzer driver pin
L_0 to L_{33}	L_0 to L_{33}	—	LCD driver pins

* [S], [E], [A], [B], and [M] also indicate the names of the switches connected to corresponding pins.

LCD FORMAT

LCD Layout



Segment Assignment

Symbol	COM_1 Group	COM_2 Group	COM_3 Group
L_0	PM	9a	1c
L_1	AM	1b	1g
L_2	1a	1f	1e
L_3	2b	2c	DOT1
L_4	2a	2g	2d
L_5	2f	3e	—
L_6	3b	3c	COL1
L_7	3a	3g	3d
L_8	2ND	3f	3e
L_9	TM	4d	—
L_{10}	4a	4g	4c
L_{11}	4f	4e	4d
L_{12}	TEMP	ALARM	MAX
L_{13}	—	—	COM_3
L_{19}	—	COM_2	—
L_{20}	COM_1	—	—
L_{21}	MIN	8e	8f
L_{22}	8d	8g	8a
L_{23}	8c	8b	7a
L_{24}	7d	7e	7f
L_{25}	COL2	7c	7g
L_{26}	6e	6f	7b
L_{27}	6d	6g	6a
L_{28}	DOT3	6c	6b
L_{29}	5e	5f	1d
L_{30}	5d	5g	5a
L_{31}	DOT4	5c	5b
L_{32}	10d	10a	DOT2
L_{33}	10f	9f	9d

MSM64164C-011 (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
Power Supply Voltage 5	V_{SS}	Ta=25°C	−5.5 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_{SS}−0.3 to +0.3	V
Input Voltage 3	V_{IN3}	V_{SSL} 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_{SS} output,Ta=25°C	V_{SS}−0.3 to +0.3	V
Output Voltage 5	V_{OUT5}	V_{SSL} output,Ta=25°C	V_{SSL}−0.3 to +0.3	V
Storage Temparature	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
	V_{SS}	—	−5.25 to V_{SS1}	
400kHz OSC External Resistance	R_{OS}	—	250 to 500	kΩ
Crystal Oscillation Frequency	f_{XT}	—	30 to 35	kHz

ELECTRICAL CHARACTERISTICS

DC Characteristics

(V_{DD}=0V, V_{SS1}=V_{SS}=−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	
XTOSC Oscillation Start Voltage	V_{STA}	Within 5 seconds after oscillation starts		—	—	−1.45	V	
XTOSC Oscillation Hold Voltage	V_{HOLD}	—		—	—	−1.25	V	
XTOSC Stop Detection Time	T_{STOP}	—		0.1	—	1000	ms	
XTOSC Internal Capacitance	CG	—		10	15	20	pF	
XTOSC External Capacitance	CGEX	When CG is connected externally		10	—	30	pF	
XTOSC Internal Capacitance	CD	—		10	15	20	pF	
400kOSC Internal Capacitance	COS	—		8	12	16	pF	
400kOSC Oscillation Frequency	f_{OSC}	External resistance R_{OS}=300kΩ V_{SS2}=−1.25 to −1.7V		80	220	350	kHz	
POR Generation Voltage	V_{POR1}	POR is generated when V_{SS1} is between V_{PROR1} and −1.5V		−0.4	—	0	V	1
POR Non-Generation Voltage	V_{POR2}	POR is not generated when V_{SS1} is between V_{PROR2} and −1.5V		−1.5	—	−1.2	V	
Current 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		
Current 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		
Current Consumption 3	I_{DD3}	CPU in operation state (400kOSC in operation)		—	90	180	µA	
Current Consumption 4	I_{DD4}	Serial transfer, f_{SCK}=300kHz, CPU in operation state (400kOSC in halt)	Ta=−40 to +40°C	—	7	25	µA	
			Ta=+40 to +85°C	—	7	50		
Current Consumption 5	I_{DD5}	CPU in halt state (400kOSC halt), RC oscillator for A/D converter in operation	RT0=10kΩ	—	150	230	µA	
			RT0=2kΩ	—	600	900		

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

DC Characteristics (continued)

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

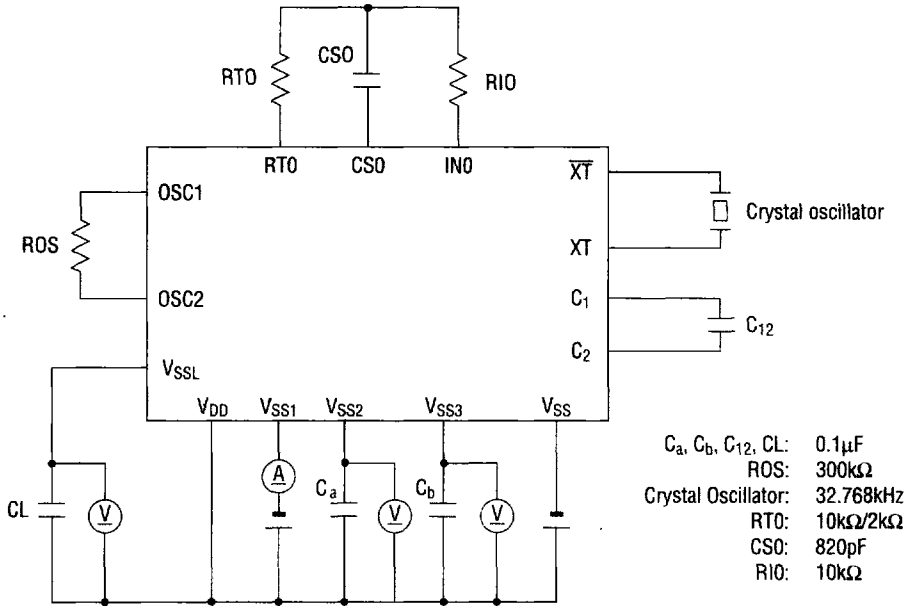
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Output Current 1 (P1.0)	I_{OH1}	V_{OH1}=–0.5V	–2.1	–0.7	–0.2	mA	
	I_{OL1}	V_{OL1}=V_{SS1}+0.5V	1	3	9	mA	
	I_{OL1S}	V_{SS}=–5V, V_{OL1}=V_{SS}+0.5V	4	12	36	mA	
Output Current 2 (P1.1 to P1.3), (P2.0 to P2.3) (P3.0 to P3.3), (P4.0 to P4.3)	I_{OH2}	V_{OH2}=–0.5V	–2.1	–0.7	–0.2	mA	
	I_{OL2}	V_{OL2}=V_{SS1}+0.5V	0.2	0.7	2.1	mA	
	I_{OL2S}	V_{SS}=–5V, V_{OL2}=V_{SS}+0.5V	1	3	9	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 Current4 (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_{26}-L_{33} are output ports)	I_{OH5}	V_{OH5}=–0.5V	–1.5	–0.5	–0.1	mA	
	I_{OL5}	V_{OL5}=V_{SS}+0.5V	0.1	0.5	1.5	mA	
	I_{OL5S}	V_{SS}=–5V, V_{OL5S}=V_{SS}+0.5V	0.2	0.7	2.0	mA	2
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_{33})	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 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	µA	
	I_{OOL}	V_{OL}=V_{SS1}	–0.3	—	—	µA	

DC Characteristics (continued)

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

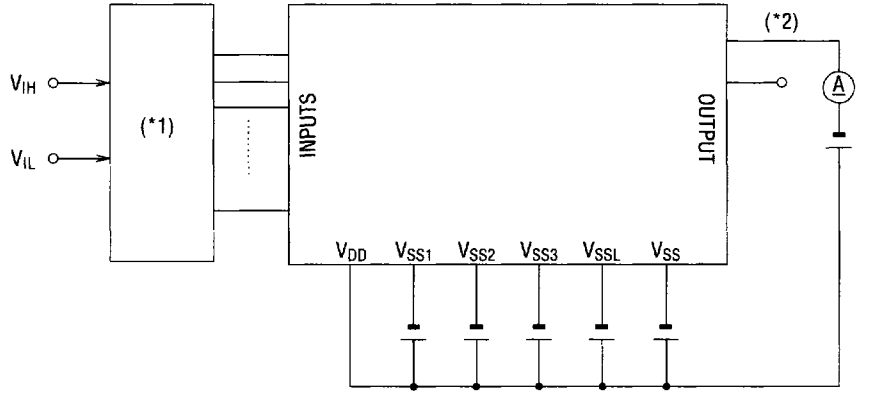
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Input Current 1 (P0.0 to P0.3), (P2.0 to P2.3) (P3.0 to P3.3), (P4.0 to P4.3)	I_{IH1}	V_{IH1}=V_{DD} (when pulled down)	5	18	60	µA	3
	I_{IL1}	V_{IL1}=V_{SS} (when pulled up)	–60	–18	–5	µA	
	I_{IH1S}	V_{IH1}=V_{DD}, V_{SS}=–5V (when pulled down)	70	250	660	µA	
	I_{IL1S}	V_{IL1}=V_{SS}=–5V (when pulled up)	–660	–250	–70	µA	
	I_{IH1Z}	V_{IH1}=V_{DD} (at high impedance)	0	—	1	µA	
	I_{IL1Z}	V_{IL1}=V_{SS} (at high impedance)	–1	—	0	µA	
Intput Current 2 (IN0, IN1)	I_{IH2}	V_{IH2}=V_{DD} (when pulled down)	5	18	60	µA	
	I_{IH2Z}	V_{IH2}=V_{DD} (at high impedance)	0	—	1	µA	
	I_{IL2Z}	V_{IL2}=V_{SS1} (at high impedance)	–1	—	0	µA	
Intput Current3 (OSC1)	I_{IL3}	V_{IL3}=V_{SS1} (when pulled up)	–60	–22	–6	µA	
	I_{IH3Z}	V_{IH3}=V_{DD} (at high impedance)	0	—	–1	µA	
	I_{IL3Z}	V_{IL3}=V_{SS1} (at high impedance)	–1	—	0	µA	
Intput Current4 ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	I_{IH4}	V_{IH4}=V_{DD}	0	—	1	µA	
	I_{IL4}	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), (P4.0 to P4.3)	V_{IH1}	—	–0.3	—	0	V	4
	V_{IL1}	—	–1.5	—	–1.2	V	
	V_{IL1S}	V_{SS}=–5V	–1	—	0	V	
	V_{IL1S}	V_{SS}=–5V	–5	—	–4	V	
Input Voltage2 (IN0, IN1, OSC1)	V_{IH2}	—	–0.3	—	0	V	
	V_{IL2}	—	–1.5	—	–1.2	V	
Input Voltage3 ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	V_{IH3}	—	–0.3	—	0	V	
	V_{IL3}	—	–1.5	—	–1.2	V	
Hysteresis Width (P0.0 to P0.3)	$\triangle V_{T1}$	—	0.05	0.1	0.3	V	
(P3.0 to P3.3), (P4.0 to P4.3)	$\triangle V_{T1S}$	V_{SS}=–5V	0.25	1.0	1.5	V	
Hysteresis Width ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	$\triangle V_{T2}$	—	0.05	0.1	0.3	V	
Input Capacitance (P0.0 to P0.3), (P2.0 to P2.3) (P3.0 to P3.3), (P4.0 to P4.3)	C_{IN}	—	—	—	5	pF	1

Measuring circuit 1

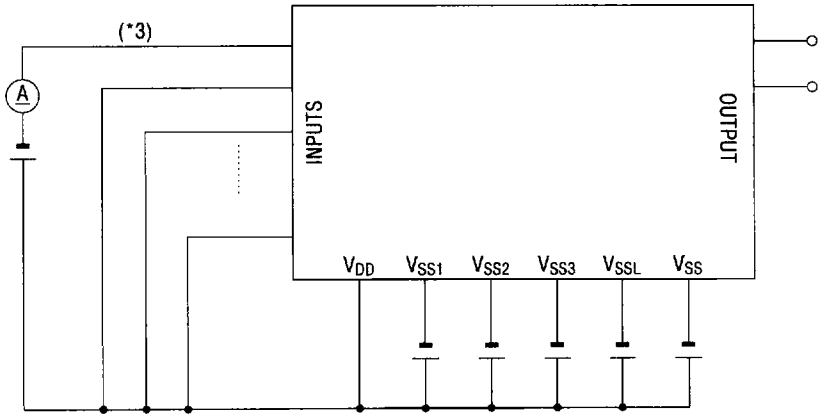


C_a, C_b, C_{12}, CL: 0.1μF
ROS: 300kΩ
Crystal Oscillator: 32.768kHz
RTO: 10kΩ/2kΩ
CSO: 820pF
RIO: 10kΩ

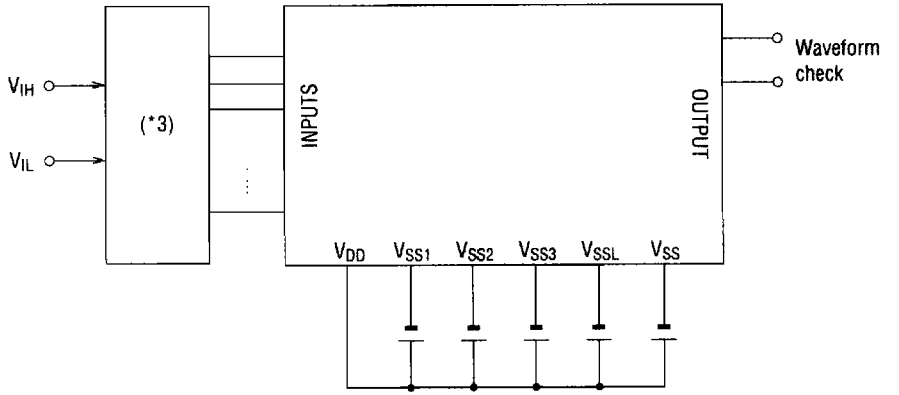
Measuring circuit 2



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}=V_{SS}=−1.5V, Ta=−40 to +85°C unless otherwise specified)

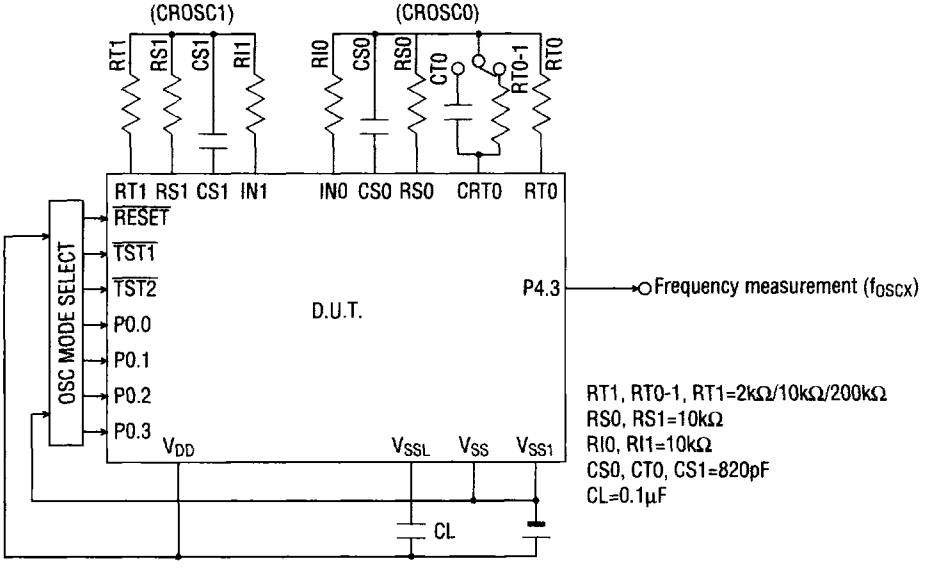
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor for Oscillator	RS0, RS1, RT0, RT0-1, RT1	CS0, CT0, CS1≥740pF	2	—	—	kΩ	5
Input Current Limiting Resistor	RI0, RI1	—	1	10	—	kΩ	
Oscillation Frequency	f_{OSC1}	Resistor for oscillation=2kΩ	165	221	256	kHz	
	f_{OSC2}	Resistor for oscillation=10kΩ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

* 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.

$$Kfx = \frac{f_{OSCX}(\text{RT0–CS0 oscillation})}{f_{OSCX}(\text{RS0–CS0 oscillation})}, \frac{f_{OSCX}(\text{RT0-1–CS0 oscillation})}{f_{OSCX}(\text{RS0–CS0 oscillation})}, \frac{f_{OSCX}(\text{RT1–CS1 oscillation})}{f_{OSCX}(\text{RS1–CS1 oscillation})}$$

(x=1, 2, 3)

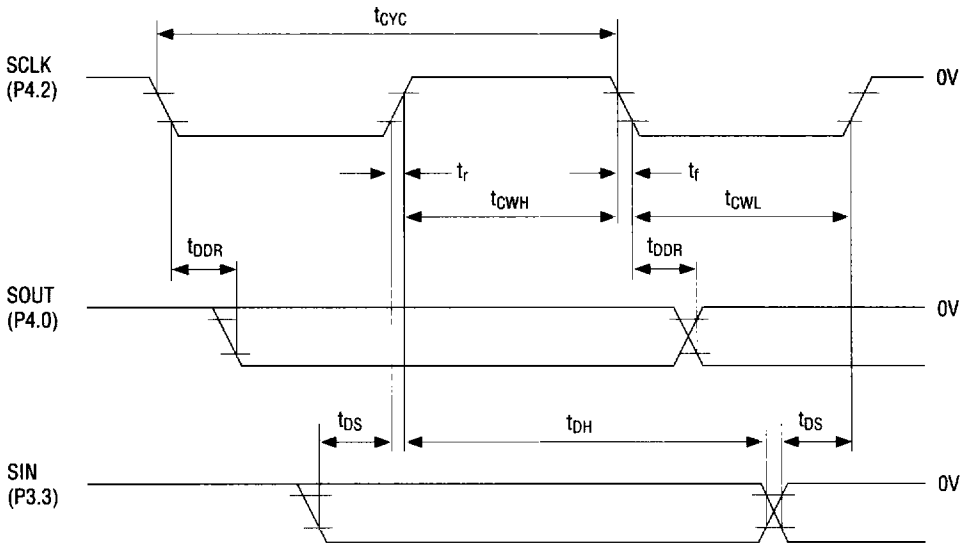
Measuring circuit 5



AC Characteristics

(Serial interface, V_{DD}=0V, V_{SS1}=–1.5V, V_{SS}=–5.0V, Ta=–40 to +85°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SCLK Input Fall Time	t_f	—	—	15	50	ns
SCLK Input Rise Time	t_r	—	—	15	50	ns
SCLK Input "L" Level Pulse Width	t_{CWL}	—	0.8	—	—	µs
SCLK Input "H" Level Pulse Width	t_{CWH}	—	0.8	—	—	µs
SCLK Input Cycle Time	t_{CYC}	—	2.0	—	—	µs
SCLK Output Cycle Time	$t_{CYC1(0)}$	CPU in operation at 32kHz	—	30.5	—	µs
SCLK Output Cycle Time	$t_{CYC2(0)}$	CPU in operation at 400kHz	—	2.5	—	µs
SOUT Output Delay Time	t_{DDR}	CL=10pF	—	—	0.4	µs
SIN Input Setup Time	t_{DS}	—	0.5	—	—	µs
SIN Input Hold Time	t_{DH}	—	0.8	—	—	µs



("H" level = –1V, "L" level = –4V)

MSM64164C-012 (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
Power Supply Voltage 5	V_{SS}	Ta=25°C	−5.5 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_{SS} input,Ta=25°C	V_{SS}−0.3 to +0.3	V
Input Voltage 3	V_{IN3}	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_{SS} output,Ta=25°C	V_{SS}−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_{SS2}	Using LCD driver with "duty 1/2"	−3.5 to −2.2	V
		Other than the above	−3.5 to −2.0	
	V_{SS}	—	−5.25 to (0.8•V_{SS2}, −2.0 max.) (*)	
400kHz OSC External Resistance	ROS	—	90 to 500	kΩ
Crystal Oscillator Frequency	f_{XT}	—	30 to 66	kHz

* Upper limit of V_{SS} is 80% of V_{SS2} level and is −2.0V of maximum.

ELECTRICAL CHARACTERISTICS

DC Characteristics

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

Parameter	Symbol	Condition		Min.	Typ.	Max.	Unit	Measuring Circuit
V_{SS1} Voltage	V_{SS1}	Ca, Cb, C_{12}=0.1µF, +100%, –50%		–1.7	–1.5	–1.3	V	
V_{SS3} Voltage	V_{SS3}	Ca, Cb, 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	
XTOSC Oscillation Start Voltage	V_{STA}	Within 5 seconds after oscillation starts		—	—	–2.0	V	
XTOSC Oscillation Hold Voltage	V_{HOLD}	—		—	—	–2.0	V	
XTOSC Stop Detection Time	T_{STOP}	—		0.1	—	1000	ms	
XTOSC Internal Capacitance	CG	—		10	15	20	pF	
XTOSC External Capacitance	CGEX	CG external option		10	—	30	pF	
XTOSC Internal Capacitance	CD	—		10	15	20	pF	
400kOSC Internal Capacitance	COS	—		8	12	16	pF	
400kOSC Oscillation Frequency	f_{OSC}	External resistance ROS=100kΩ V_{SS2}=–2.0 to –3.5V		300	400	620	kHz	
POR Generation Voltage	V_{POR1}	POR is generated when V_{SS2} is between V_{PROR1} and –3.0V		–0.7	—	0	V	1
POR Non-Generation Voltage	V_{POR2}	POR is not generated when V_{SS2} is between V_{PROR2} and –3.0V		–3	—	–2	V	
Current 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		
Current 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		
Current Consumption 3	I_{DD3}	CPU in operation state (400kOSC in operation)		—	220	450	µA	
Current Consumption 4	I_{DD4}	Serial transfer, f_{SCK}=300kHz, CPU in operation (400kOSC in halt)	Ta=–40 to +40°C	—	7	25	µA	
			Ta=+40 to +85°C	—	7	50		
Current Consumption 5	I_{DD5}	CPU in halt state (400kOSC halt), RC oscillator for A/D converter in operation	RT0=10kΩ	—	300	450	µA	
			RT0=2kΩ	—	1300	2000		

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

DC Characteristics (continued)

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

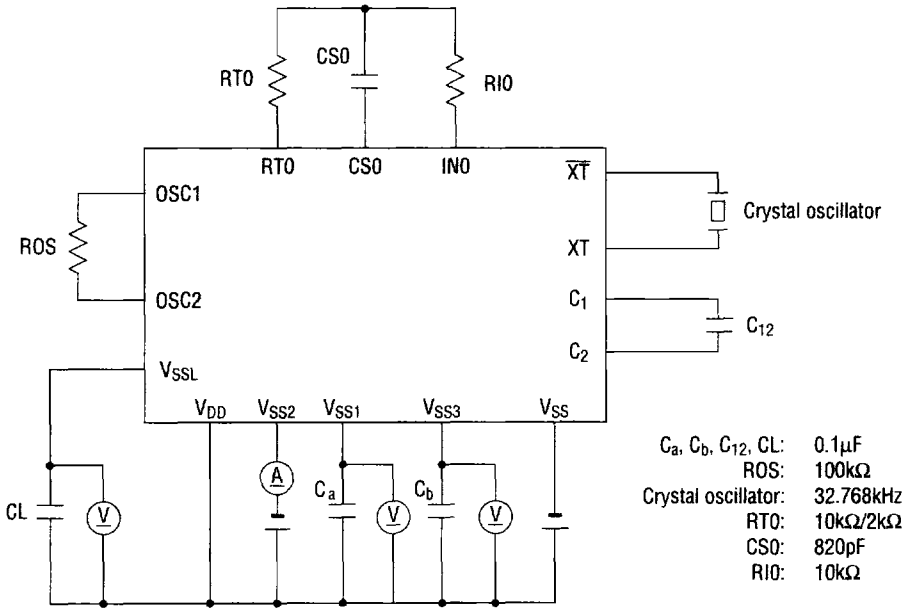
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Output Current 1 (P1.0)	I_{OH1}	V_{OH1}=−0.5V	−6	−2	−0.7	mA	
	I_{OL1}	V_{OL1}=V_{SS}+0.5V	3	8	25	mA	
	I_{OL1S}	V_{SS}=−5V, V_{OL1}=V_{SS}+0.5V	4	12	36	mA	
Output Current 2 (P1.1 to P1.3), (P2.0 to P2.3) (P3.0 to P3.3), (P4.0 to P4.3)	I_{OH2}	V_{OH2}=−0.5V	−6	−2	−0.7	mA	
	I_{OL2}	V_{OL2}=V_{SS}+0.5V	0.7	2	6	mA	
	I_{OL2S}	V_{SS}=−5V, V_{OL2}=V_{SS}+0.5V	1	3	9	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 Current4 (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_{26}-L_{33} are output ports)	I_{OH5}	V_{OH5}=−0.5V	−1.5	−0.6	−0.15	mA	
	I_{OL5}	V_{OL5}=V_{SS}+0.5V	0.15	0.6	1.5	mA	
	I_{OL5S}	V_{SS}=−5V, V_{OL5S}+V_{SS}+0.5V	0.2	0.7	2.0	mA	2
Output Current6 (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 Current7 (L_0-L_{33})	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 (P1.0 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	µA	
	I_{OOL}	V_{OL}=V_{SS2}	−0.3	—	—	µA	

DC Characteristics (continued)

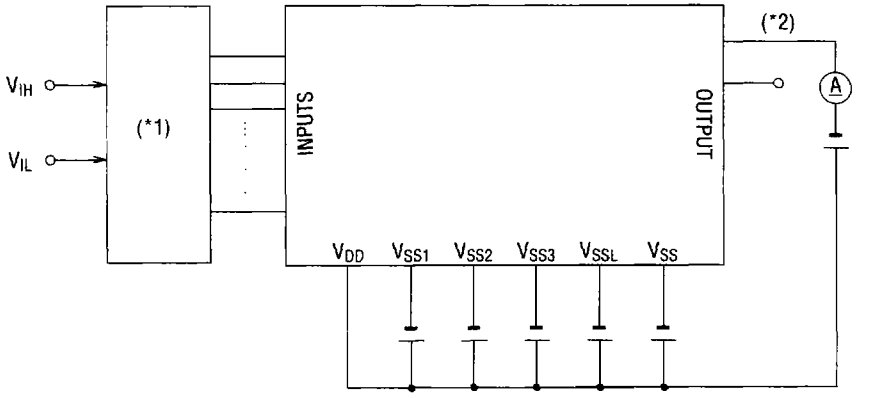
(V_{DD}=0V, V_{SS1}=V_{SSL}=−1.5V, V_{SS2}=V_{SS}=−3.0V, V_{SS3}=−4.5V, Ta=−40 to +85°C unless otherwise specified)

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), (P4.0 to P4.3)	I_{IH1}	V_{IH1}=V_{DD} (when pulled down)	30	90	300	µA	
	I_{IL1}	V_{IL1}=V_{SS} (when pulled up)	−300	−90	−30	µA	
	I_{IH1S}	V_{IH1}=V_{DD}, V_{SS}=−5V (when pulled down)	80	250	800	µA	
	I_{IL1S}	V_{IL1}=V_{SS}=−5V (when pulled up)	−800	−250	−80	µA	
	I_{IH1Z}	V_{IH1}=V_{DD} (at high impedance)	0	—	1	µA	
	I_{IL1Z}	V_{IL1}=V_{SS} (at high impedance)	−1	—	0	µA	
Intput Current 2 (IN0, IN1)	I_{IH2}	V_{IH2}=V_{DD} (when pulled down)	30	90	300	µA	3
	I_{IH2Z}	V_{IH2}=V_{DD} (at high impedance)	0	—	1	µA	
	I_{IL2Z}	V_{IL2}=V_{SS2} (at high impedance)	−1	—	0	µA	
Intput Current 3 (OSC1)	I_{IL3}	V_{IL3}=V_{SS2} (when pulled up)	−300	−110	−10	µA	
	I_{IH3Z}	V_{IH3}=V_{DD} (at high impedance)	0	—	1	µA	
	I_{IL3Z}	V_{IL3}=V_{SS2} (at 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 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	V	
	V_{IL1}	—	−3.0	—	−2.4	V	
	V_{IH1S}	V_{SS}=−5V	−1	—	0	V	
	V_{IL1S}	V_{SS}=−5V	−5	—	−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	4
	V_{IL3}	—	−3.0	—	−2.4	V	
Hysteresis Width (P0.0 to P0.3), (P2.0 to P2.3) (P3.0 to P3.3), (P4.0 to P4.3)	$\triangle V_{T1}$	—	0.2	0.5	1	V	
	$\triangle V_{T1S}$	V_{SS}=−5V	0.25	1.0	1.5	V	
Hysteresis Width ($\overline{RESET}$, $\overline{TST1}$, $\overline{TST2}$)	$\triangle V_{T2}$	—	0.2	0.5	1	V	
Input Capacitance (P0.0 to P0.3), (P2.0 to P2.3) (P3.0 to P3.3), (P4.0 to P4.3)	C_{IN}	—	—	—	5	pF	1

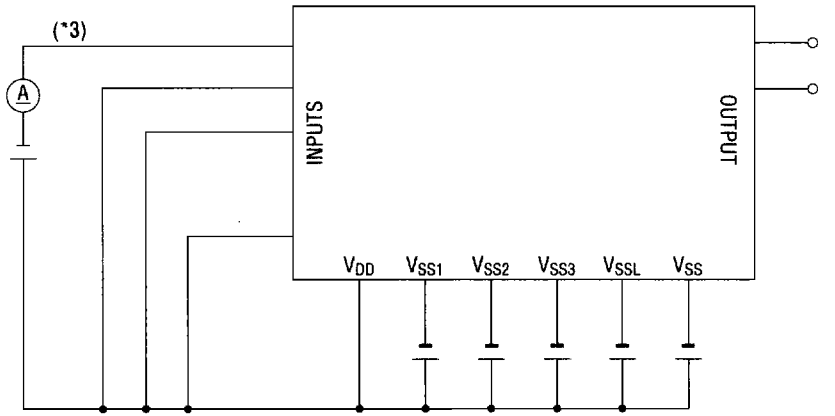
Measuring circuit 1



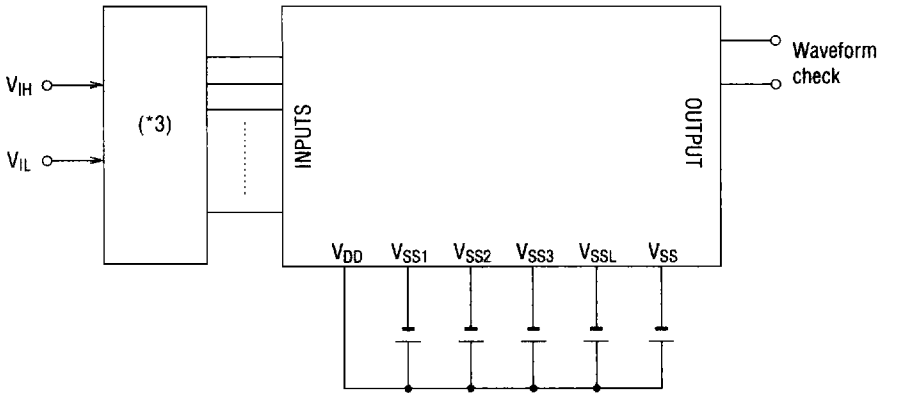
Measuring circuit 2



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}=V_{SS}=–3.0V, Ta=–40 to +85°C unless otherwise specified)

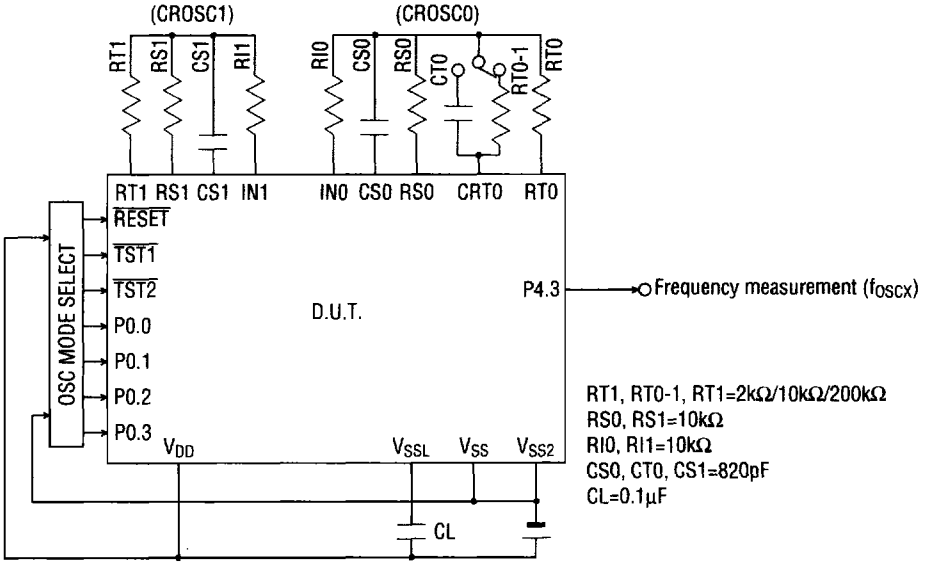
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Measuring Circuit
Resistor For Oscillator	RS0, RS1, RT0, RT0-1, RT1	CS0, CT0, CS1≥740pF	1	—	—	kΩ	5
Input Current Limiting Resistor	RI0, RI1	—	1	10	—	kΩ	
Oscillation Frequency	f_{OSC1}	Resistor for oscillation=2kΩ	200	239	277	kHz	
	f_{OSC2}	Resistor for oscillation=10kΩ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

$$Kfx = \frac{f_{OSCX}(\text{RT0–CS0 oscillation})}{f_{OSCX}(\text{RS0–CS0 oscillation})}, \frac{f_{OSCX}(\text{RT0-1–CS0 oscillation})}{f_{OSCX}(\text{RS0–CS0 oscillation})}, \frac{f_{OSCX}(\text{RT1–CS1 oscillation})}{f_{OSCX}(\text{RS1–CS1 oscillation})}$$

(x=1, 2, 3)

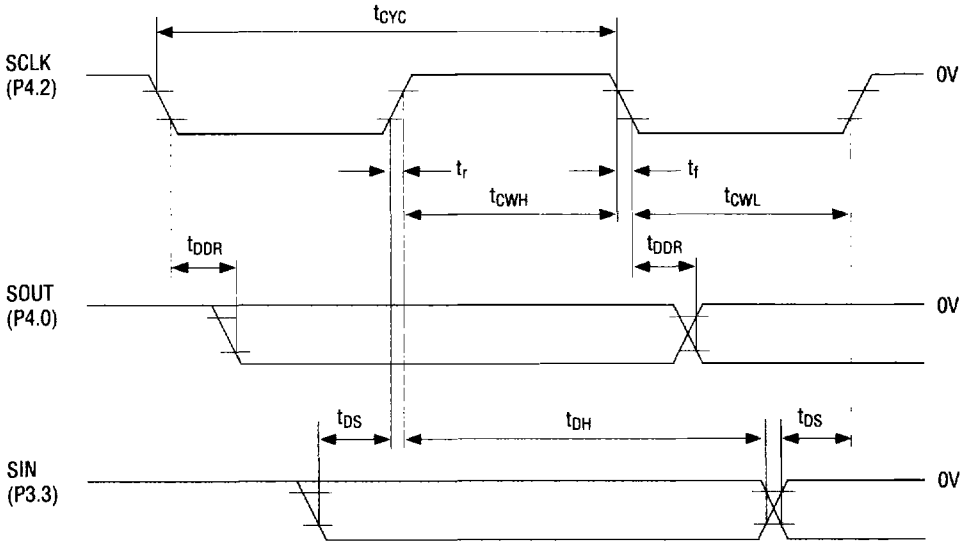
Measuring circuit 5



AC Characteristics

(Serial interface, V_{DD}=0V, V_{SS2}=–3V, V_{SS}=–5V, Ta=–40 to +85°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SCLK Input Fall Time	t_f	—	—	15	50	ns
SCLK Input Rise Time	t_r	—	—	15	50	ns
SCLK Input "L" Level Pulse Width	t_{CWL}	—	0.8	—	—	µs
SCLK Input "H" Level Pulse Width	t_{CWH}	—	0.8	—	—	µs
SCLK Input Cycle Time	t_{CYC}	—	2.0	—	—	µs
SCLK Output Cycle Time	$t_{CYC1(0)}$	CPU in operation at 32kHz	—	30.5	—	µs
SCLK Output Cycle Time	$t_{CYC2(0)}$	CPU in operation at 400kHz	—	2.5	—	µs
SOUT Output Delay Time	t_{DDR}	CL=10pF	—	—	0.4	µs
SIN Input Setup Time	t_{DS}	—	0.5	—	—	µs
SIN Input Hold Time	t_{DH}	—	0.8	—	—	µs

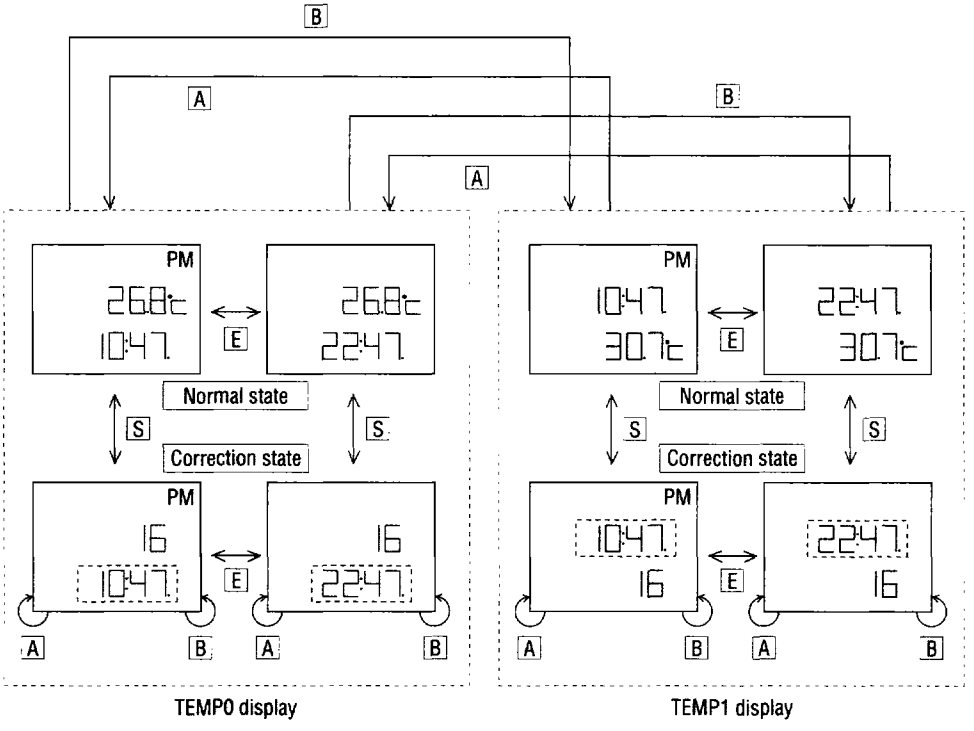


("H" level = –1V, "L" level = –4V)

OPERATIONAL DESCRIPTION

Clock/Temperature Mode

In clock/temperature mode, clocking/correction and temperature measuring/display are performed.
The following figure is the transition diagram of time and temperature mode.



TEMP0 display TEMP1 display

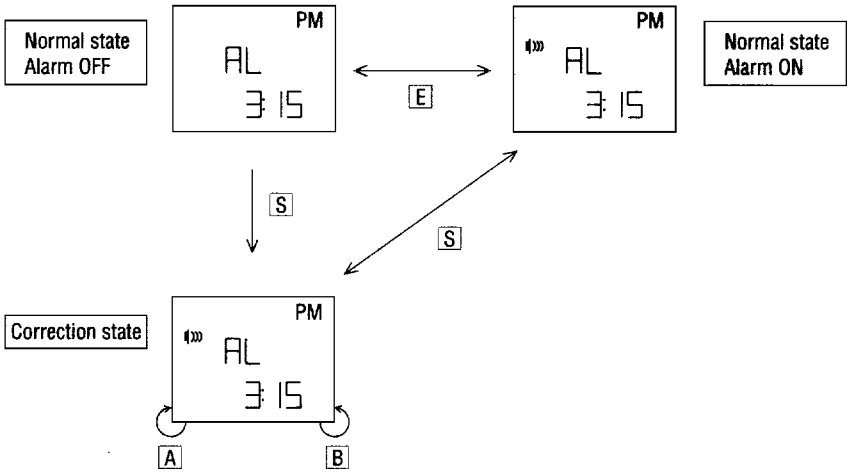
<12/24 hour display switching>
When [E] is pressed, 12/24 hour is toggled.

<Time correction>
In the normal state, pressing [S] selects the time correction state. In this state, the hour/minute display flashes at 2Hz. Seconds are also displayed.
In the correction state, pressing [A] advances the hour by 1. If [B] is pressed, the minute is advanced by 1 and the second is set to 0.
Continuously pressing [A] or [B] selects the 8Hz fast-forward correction state.
In the correction mode, pressing [S] restores the normal state.

<Temperature display switching>
In the normal state, pressing [A] selects TEMP0 and pressing [B] selects TEMP1.
TEMP0 is displayed in the upper part of the LCD and TEMP1 is displayed in the lower part of the LCD.

Alarm Mode

In alarm mode, alarm time setting and ON/OFF of alarm are performed. Alarm time is displayed in the same way as the clock (12/24 hour).
The following figure is the transition diagram of alarm mode.

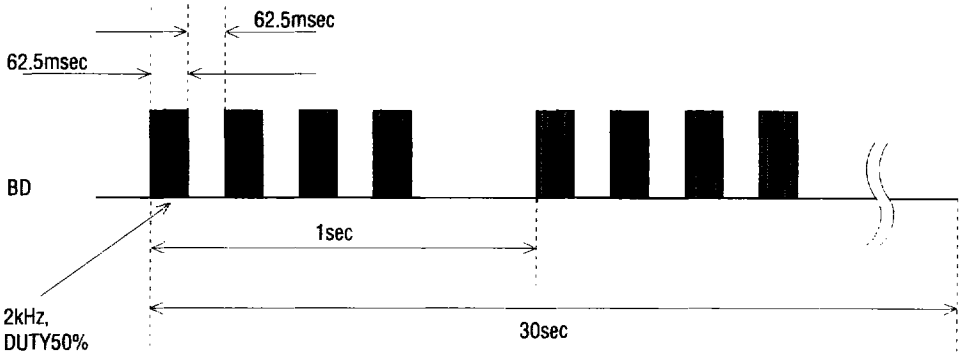


<Alarm ON/OFF>
In the normal state, pressing [E] toggles ON/OFF of the alarm. When the alarm is ON, the alarm mark appears.

<Alarm correction>
In the normal state, pressing [S] selects the alarm correction state and the alarm is automatically set to ON. During correction, hour/minute flashes at 2Hz.
In the correction state, pressing [A] advances the hour by 1 and pressing [B] advances the minute by 1. Continuously pressing [A] or [B] selects the 8Hz fast-forward correction state.
In the correction state, pressing [S] restores the normal state.

<Alarm output>
When the alarm time and the clock time coincide, the buzzer sounds for 30 seconds. The alarm output can be stopped by pressing any of the switches.

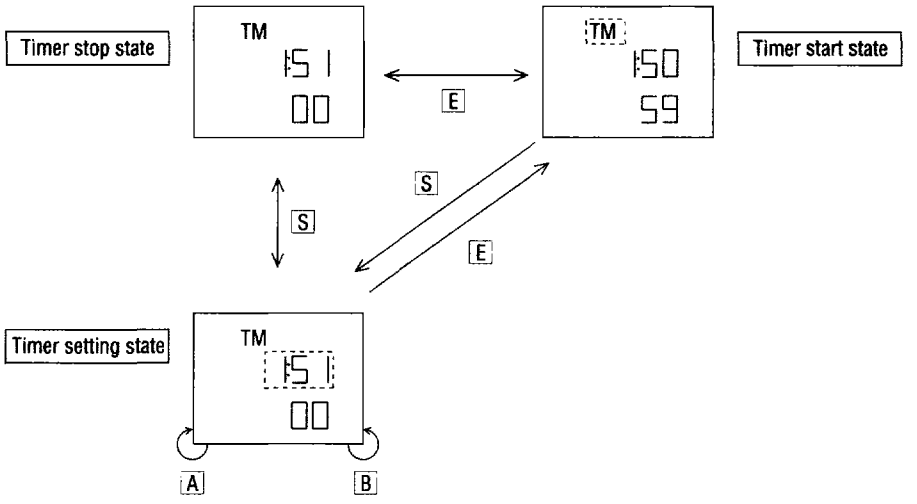
The figure below shows the alarm output waveforms.



Alarm output waveforms

Timer Mode

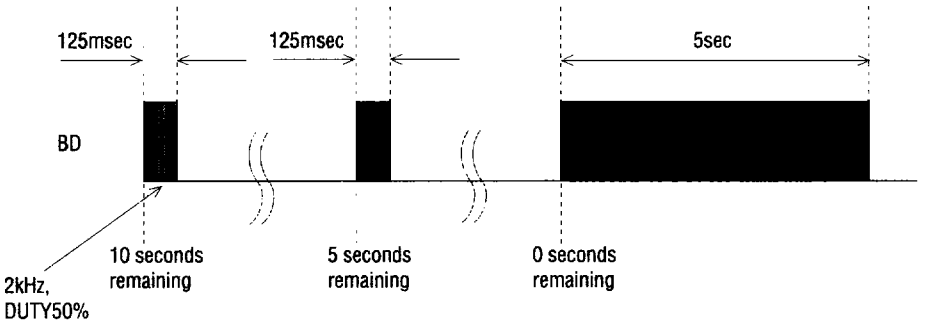
In timer mode, the setting of the countdown timer and start/stop of the countdown timer are performed. The following figure is the transition diagram of timer mode.



<Timer setting>
Pressing [S] while the timer is in stop or start state selects the timer setting state.
In the timer setting state, pressing [A] advances the hour by 1. When pressing [B], the minute is advanced by 1. Continuously pressing either [A] or [B] selects the 8Hz fast-forward setting state. The timer can be set up to a maximum of 23 hours 59 minutes.
Pressing [A] and [B] simultaneously sets the timer to 0 hours, 0 minutes.
Pressing [S] in the timer setting state selects the timer stop state. Pressing [E] starts the timer again.

<Timer start/stop>
In timer mode, pressing [E] toggles the timer start/stop.

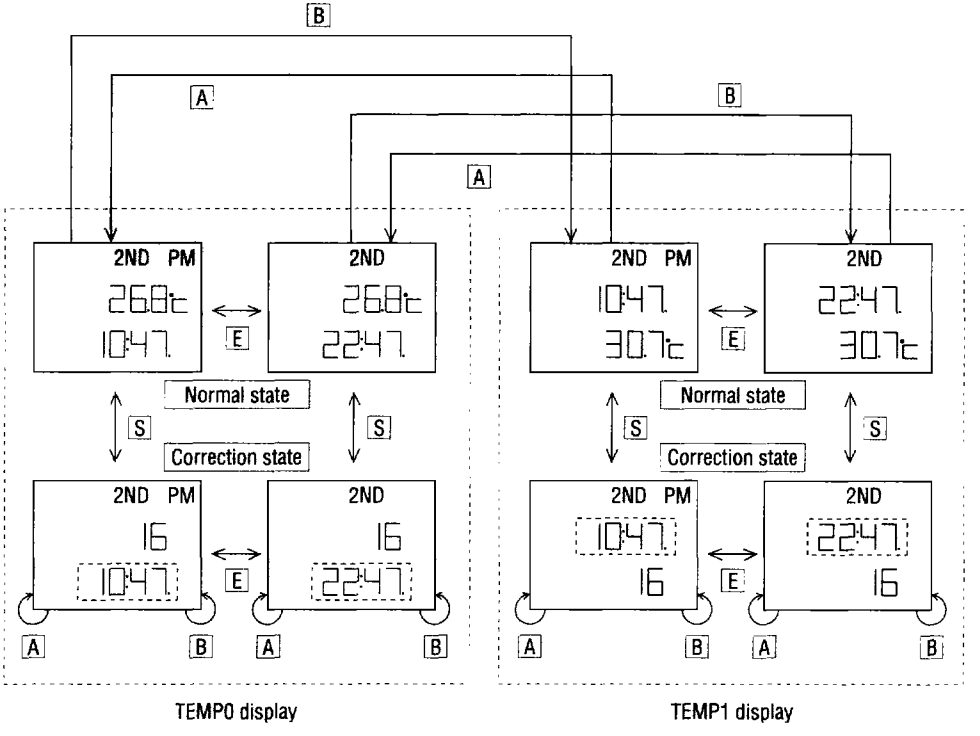
<Timer output>
When the remaining time is 10 seconds, 5 seconds, or 0 seconds in all modes, the buzzer sounds. The figure below shows the timer output waveforms.



Timer output waveforms

Second-Time Mode

In second-time mode, the clocking/correction and temperature measuring/display of the second time are performed.
The following figure is the transition of the second time mode.



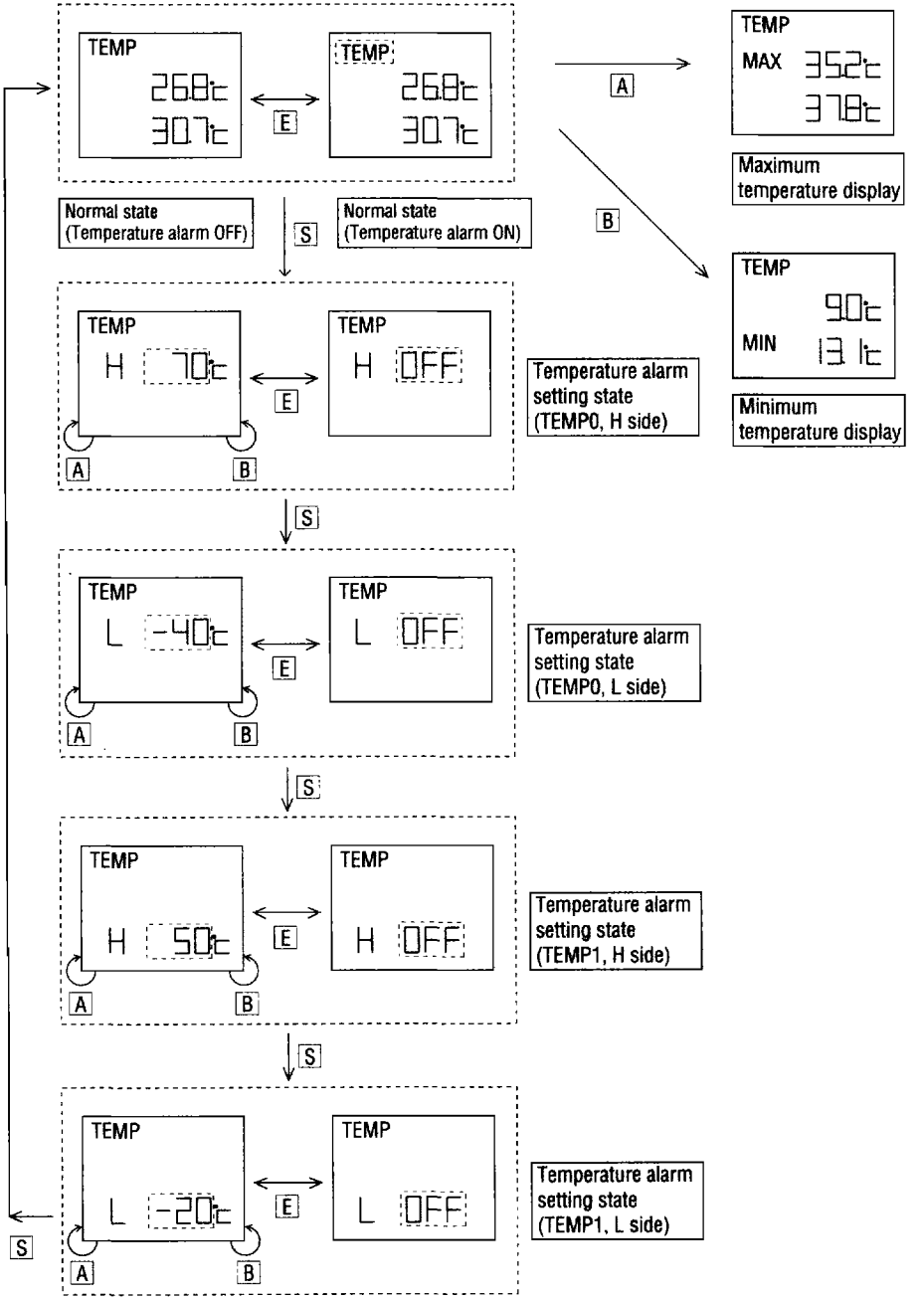
<12/24 hour display switching>
Pressing [E] in any state toggles the 12/24 hour.

<Time correction>
In the normal state, pressing [S] selects the time correction state. In this state, the hour/minute display flashes at 2Hz. Seconds are also displayed.
In the correction state, pressing [A] advances the hour by 1. Pressing [B] advances the minute by 1. Although seconds are displayed they cannot be set.
Continuously pressing [A] or [B] selects the 8Hz fast-forward correction state.
In the correction state, pressing [S] restores the normal state.

<Temperature display switching>
In the normal state, pressing [A] selects TEMP0 and [B] selects TEMP1.
TEMP0 is diaplayed in the upper part of the LCD and TEMP1 is displayed in the lower part of the LCD.

Temperature Mode

In the temperature mode, simultaneous display of TEMP0 and TEMP1, maximum/minimum temperature display, and setting of temperature alarm are performed.



<TEMP 0/1 simultaneous display>
In normal state, TEMP0 is displayed at the top of the LCD and TEMP1 is displayed at the bottom. In this mode, pressing [E] toggles enable or disable for the temperature alarm.

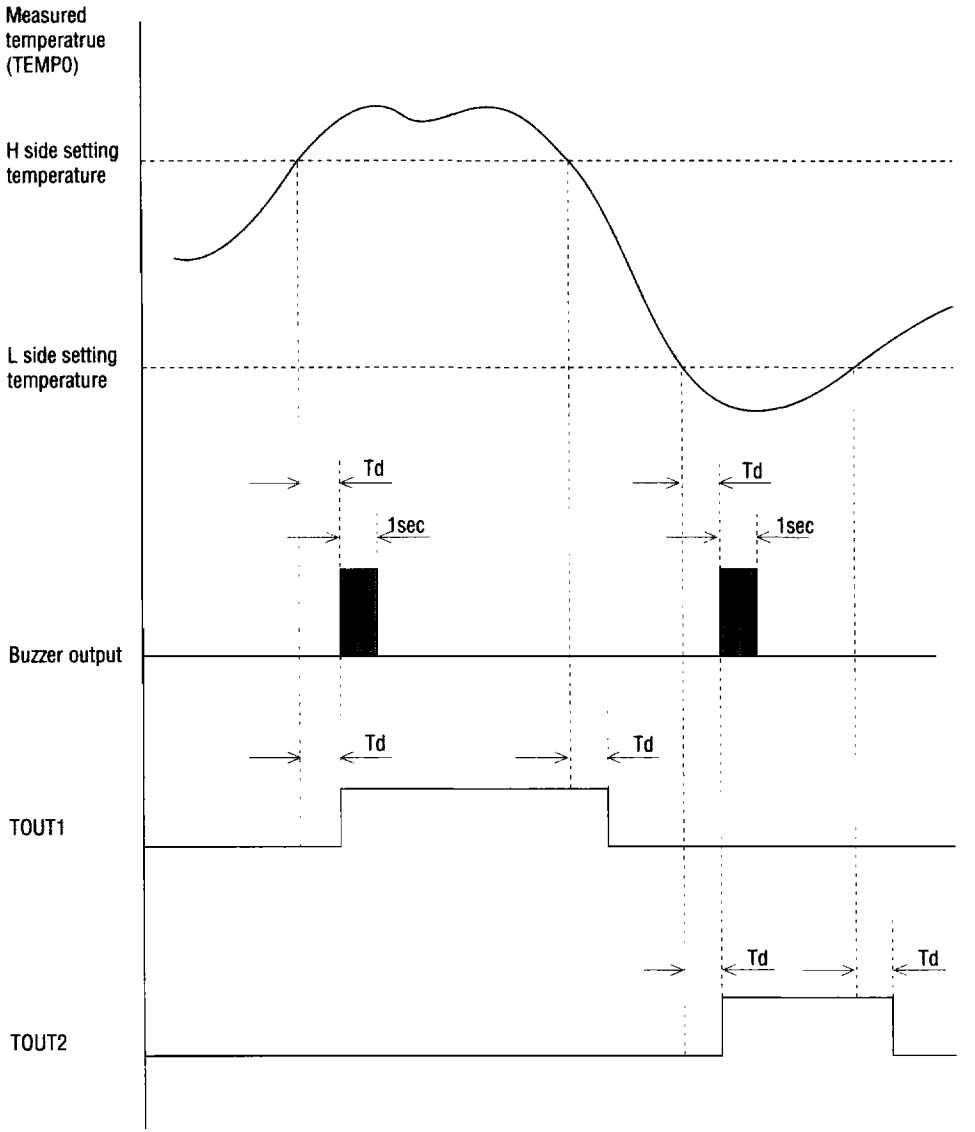
<Maximum/minimum temperature display>
In normal state, the maximum temperature is displayed while [A] is being pressed. The maximum temperature of TEMP0 is displayed at the top and the maximum temperature of TEMP1 is displayed at the bottom.
In normal mode, the minimum temperature is displayed while [B] is being pressed. The minimum temperature of TEMP0 is displayed in the upper part and the minimum temperature of TEMP1 is displayed in the lower part.
When [A] and [B] are pressed simultaneously, both the maximum and minimum temperatures are initialized. The current temperatures become the maximum and minimum temperatures.

<Temperature alarm setting>
In normal state, temperature alarm setting state is selected by pressing [S] . Each time [S] is pressed, the setting item is changed.
The temperate alarm has two types of setting items: H side setting and L side setting. Each item can select TEMP0 and TEMP1; thus, the total of four temperature alarm items are available.
By pressing [E] in setting state, each setting item can be switched between enable and disable.
In the enable mode, each time [A] is pressed, the temperature is increased by + 1°C (°F), and each time [B] is pressed, the temperature is decreased by 1°C (°F). If [A] or [B] is held down, 8Hz fast forwarding mode is selected.
In the disable mode, "OFF" is displayed instead of temperatures.
Below are the selectable temperature ranges:
Type 1 thermistor: –40°C to +70°C (–40°F to +160°F)
Type 2 thermistor: +60°C to +200°C (+170°F to +400°F)

Note
The temperature alarms can be in °C or in °F. To display temperatures in °C, select the temperature alarm to °C. Select the temperature alarm to °F if temperatures are to be displayed in °F.
Therefore, when changing °C/°F in temperature display, it is necessary to set the temperature alarm again.

<Temperature alarm output>
In H side setting, temperature alarm and buzzer sound when temperatures higher than the pre-set temperature are measured.
In L side setting, temperature alarm and buzzer are output from the port when temperatures lower than pre-set temperature are measured.
Temperature alarm output can be performed from any mode.
The buzzer rings for 1 second when the measured temperature exceeds the H side setting temperature or falls below the L side setting temperature. The buzzer frequency is 2 kHz with duty of 50%.
TOUT1 outputs L when the measured TEMP0 is higher than the H side TEMP0 setting temperature.
TOUT2 outputs L when the measured TEMP0 is lower than the L side TEMP0 setting temperature.
TOUT3 outputs L when the measured TEMP1 is higher than the H side TEMP1 setting temperature.
TOUT4 outputs L when the measured TEMP1 is lower than the L side TEMP1 setting temperature.

The figure below shows the output timing of the temperature alarm for TEMP0. A similar figure is also available for TEMP1.



Temperature Alarm Timing (for TEMP0)

The alarm output delay time, Td, varies depending on the temperature measuring period. When the temperature measuring period is 1 minute, Td has a maximum of 1 minute. Td has a maximum of 2 seconds when the temperature measuring period is 2 seconds.

Test Mode

After reset, when TEST1 is "H", the MSM64164C-011/012 goes into the test mode. There are two test modes, an oscillation test and Idd test. When TEST2 is "H" during reset, the IC enters the oscillation test mode. When TEST2 is "L" during reset, the device enters Idd test mode.

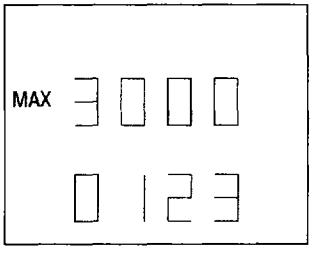
<Oscillation test>
The oscillation test is used to measure the oscillating frequency against the thermistor resistor of the thermal measuring circuit for the MSM641164C-011/012.
The oscillation test indicates the oscillating count N for the thermistor (or the reference resistor) during the reference time TB.
The reference oscillation count (decimal) is displayed on the upper part of the LCD and the oscillation count (hexadecimal) is displayed at the lower part.
The oscillating time TB is attained by the following formula:

Oscillation time (seconds) = Reference oscillation count divided by 32768

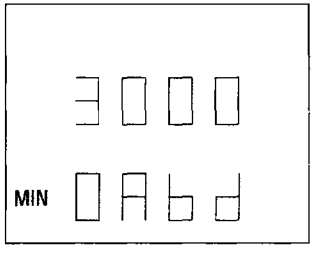
For example, when the reference oscillating count is 3000, the oscillating time becomes 91.5msec.

When [S] is pressed in the oscillation test, the thermistor to be oscillated is switched. When MAX is indicated, the oscillation is made by RT0 and CS0 and when MIN is indicated, it is made by RT1 and CS1. (See figures below.)
In addition, when [S] and [E] are pressed simultaneously the TEMP flag appears. At this time, the oscillation is performed by RS0 and CS0 (or RS1 and CS1). (See figures below.)
Press [A] or [B] to change the reference oscillating count.
When [A] is pressed, the reference oscillating count are reduced by 10 and when [B] is pressed, they are added by 10.

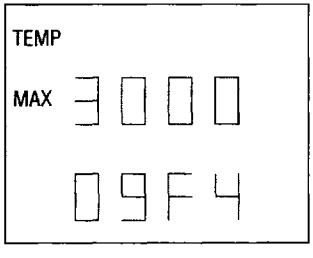
RT0-CS0 Oscillation



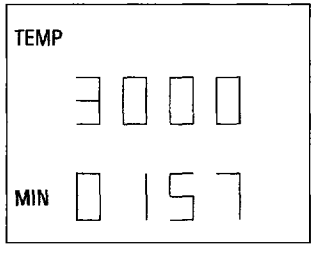
RT1-CS1 Oscillation



RT0-CS0 Oscillation



RT1-CS1 Oscillation



<Idd test>
In Idd testing, each time [A], [B], [S], [M] or [E] is pressed, the internal state is changed in the following order. If one of the switches is pressed in a state of e), MSM64164C-011/012 is reset internally.

State	Operating Clock	LCD Display State	Program Duty
a)	32kHz	Entire LCD ON	1% or less
b)	32kHz	Entire LCD OFF	1% or less
c)	32kHz	Entire LCD OFF	Approx. 1%
d)	32kHz	Entire LCD OFF	100%
e)	400kHz	Entire LCD OFF	100%

For the Idd test, connect the resistor for 400kHz oscillation.

FUNCTIONAL DESCRIPTION

Temperature Measuring Function

• Setting of temperature measuring function

The MSM64164C-011/012 has two-channel temperature measuring circuits.

Temperatures measured by RT0, RS0, CS0 and IN0 are called "TEMP0".
Temperatures measured by RT1, RS1, CS1 and IN1 are called "TEMP1".

The MSM64164C-011/012 can select the temperature measuring range.
There are two types of temperature ranges: Type 1 and Type 2. The following are their measurement ranges:

Type 1: –40.0°C to +70.0°C (–40.0°F to +160°F)
Type 2: 60°C to 200°C (140°F to 400°F)

The temperature measuring range is determined by the state of the T_SET0 and T_SET1 pins at the reset.

T_SET0 sets the temperature range of TEMP0 and T_SET1 sets the temperature range of TEMP1.

T_SETx = L level : Type 1 is selected for the temperature range.
T_SETx = H level : Type 2 is selected for the temperature range (x = 0 or 1).

Temperatures can be displayed by either °C or °F. The °C/°F switch can toggle the display mode. However, when the °C/°F switch is activated in correction mode, the display is not switched. When the correction mode is finished, the display is switched in obedience to °C/°F switch state.

°C/°F = L level : °C display
°C/°F = H level : °F display

For the temperature measurement cycle, either 1 minute or 2 seconds can be selected using the SMP switch.

SMP = L level : 2-second cycle
SMP = H level : 1-minute cycle

However, temperature measuring is suspended when buzzer output, serial communication, or switch input takes place.

• Recommended values for temperature measuring circuit

Recommended values of resistors, capacitors, and thermistors that are connected to the oscillation circuit of the MSM64164C-011/012 for measuring temperatures follow.

Type 1: $R_{Sx} = R_{1x} = 10k\Omega \pm 5\%$
$C_{Sx} = 820pF \pm 10\%$
Type 2: $R_{Sx} = R_{1x} = 10k\Omega \pm 5\%$
$C_{Sx} = 2200pF \pm 10\%$ (x = 0 or 1)

Recommended thermistor characteristics of MSM64164C-011/012

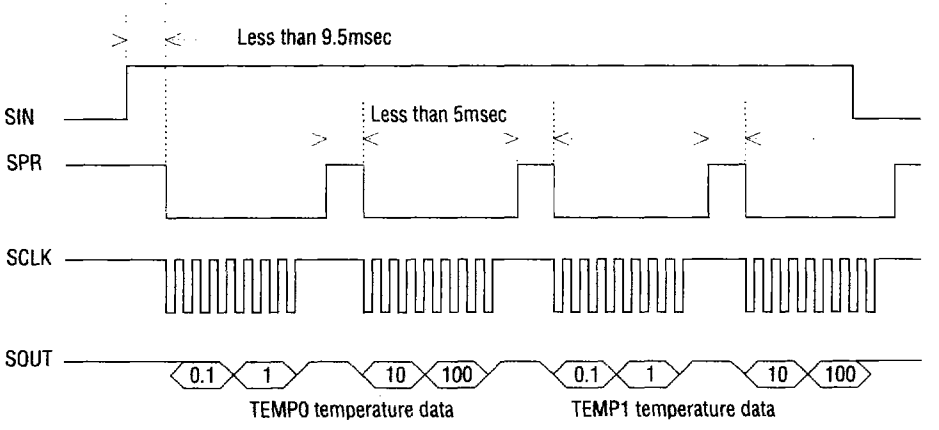
Temperature Measuring Range: Type 1		Temperature Measuring Range: Type 2	
Temperature(°C)	Thermistor Resistance Value(kΩ)	Temperature(°C)	Thermistor Resistance Value(kΩ)
–40	188.4	60	201.2
–30	111.3	70	133.6
–20	67.74	80	90.53
–10	42.45	90	62.49
0	27.28	100	43.90
10	17.96	110	31.34
20	12.09	120	22.69
30	8.313	130	16.65
40	5.828	140	12.39
50	4.161	150	9.330
60	3.021	160	7.107
70	2.229	170	5.427
		180	4.255
		190	3.339
		200	2.644

• **Serial communication functions**

When an "H" level is asserted on the SIN pin, the device transmits the measured temperature onto a serial port. The figure below shows a timing chart for a serial transfer.

During a serial data transmission of the temperature for both TEMP0 and TEMP1, the LSB of the temperature (0.1°C) is transmitted first, and the MSB (100°C) is transmitted last.

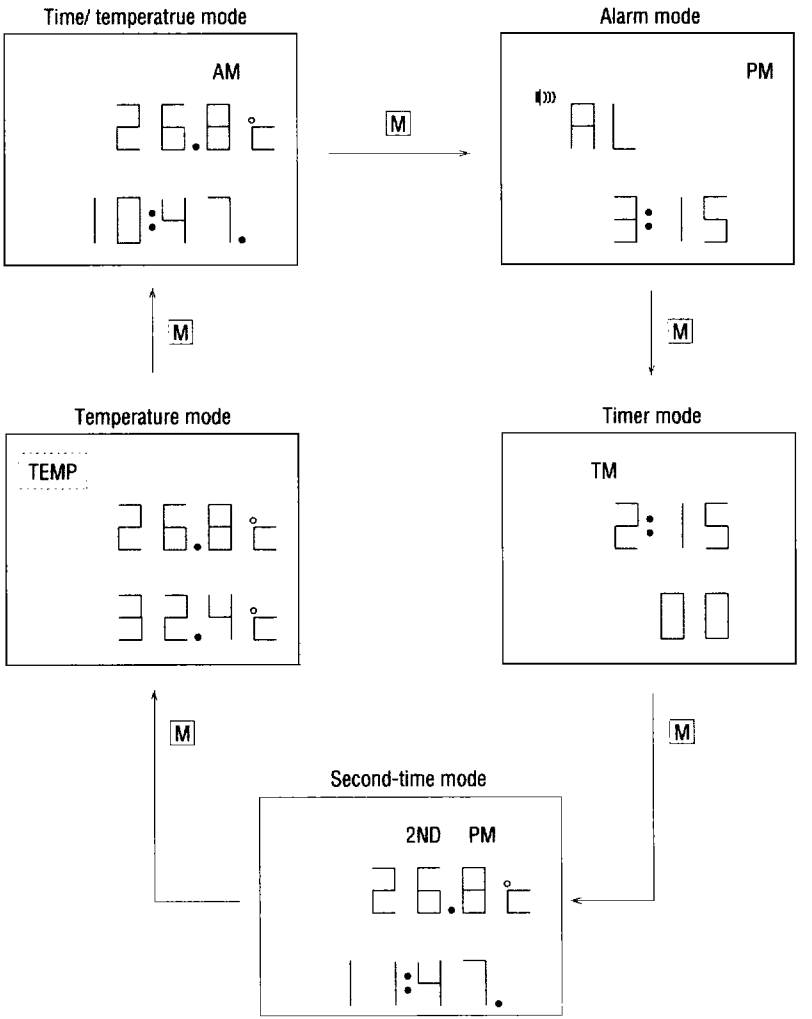
Data is output by synchronizing with an external clock supplied to SCLK. If the data transfer is not finished within 2 to 3 seconds after SPR changes to a "L" level, the communication is terminated.



Serial communication timing

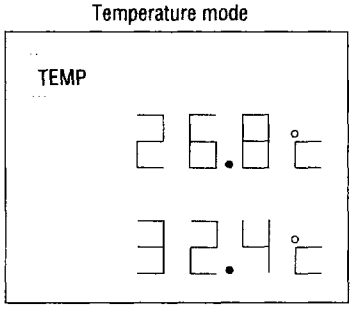
Detailed Description of Functions

Mode transition diagram



Mode transition diagram for MSM64164C-011/012 (MD = OPEN)

The figure below shows the mode transition for the MSM64164C-011/012 when MD is at "H" level. The temperature mode is the only mode available.



Mode transition diagram for MSM64164C-011/012 (MD = "H" level)