

THERMOSTAT IC

FEATURES

- Internal Temperature Sensor, Voltage Reference and Two Comparators with
- Temperature Threshold and Hysteresis Set by Only Two External Resistors
- Output Logic:
Low to High with Increasing Temp. by OUTPUT1
High to Low with Increasing Temp. by OUTPUT2
- Very Wide Operating Supply Range
($V_{CC} = 2.7$ to 6.0 V)
- Miniature Package (SOT23L-8)
- Minimum External Parts Count
- Low Power Consumption
- Very Wide Temperature Range

DESCRIPTION

The TK11052 is an accurate temperature controller IC for use over the -30 to $+105$ °C temperature range. The TK11052 monolithic bipolar integrated circuit contains a temperature sensor, stable voltage reference and two comparators, making the device very useful as an on/off thermostat. Two external resistors easily set the sensing temperature threshold and hysteresis of each thermostat. Its wide operating voltage range of 2.7 to 6.0 V makes this IC suitable for a number of applications requiring an accurate thermostat.

The TK11052 is available in a miniature SOT23L-8 surface mount package.

APPLICATIONS

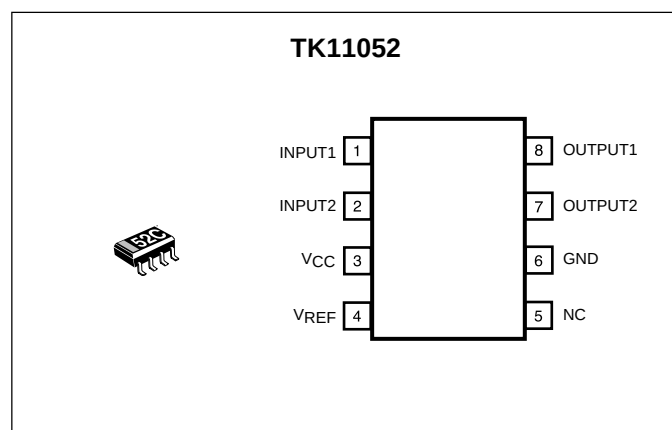
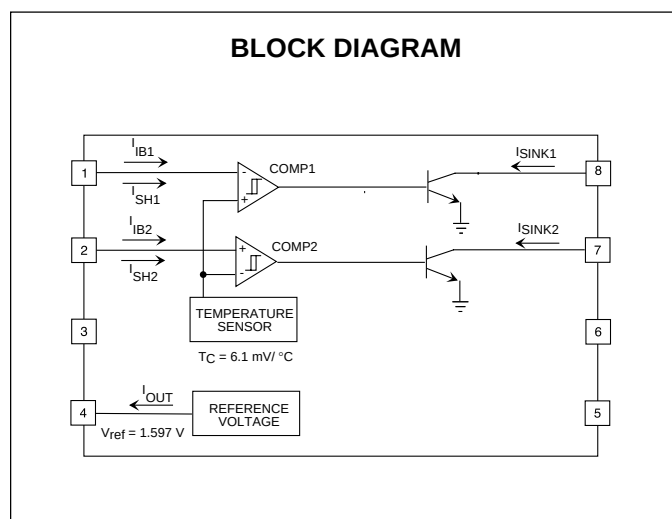
- Home and Industrial Thermostats
- Home Appliance Temperature Control
- Notebook Computer Temperature Monitor
- Pentium Processor Temperature Monitor
- Power Supply Overtemperature Protection
- Copy Machine Overtemperature Protection
- System Overtemperature Protection

ORDERING INFORMATION

TK11052MTL

 Tape/Reel Code

TAPE/REEL CODE
 TL: Tape Left



ABSOLUTE MAXIMUM RATINGS

Supply Voltage	10 V	Operating Voltage Range	2.7 to 6.0 V
Power Dissipation	200 mW	Junction Temperature	150 °C
Storage Temperature Range	-55 to +150 °C	Lead Soldering Temperature (10 s)	235 °C
Operating Temperature Range	-30 to +105 °C		

TK11052 ELECTRICAL CHARACTERISTICS

Test conditions: $T_A = 25\text{ °C}$, $V_{CC} = 3.0\text{ V}$, $I_{OUT} = 80\text{ }\mu\text{A}$, $R_{OUT1} = 300\text{ k}\Omega$, $R_{OUT2} = 300\text{ k}\Omega$, unless otherwise specified.

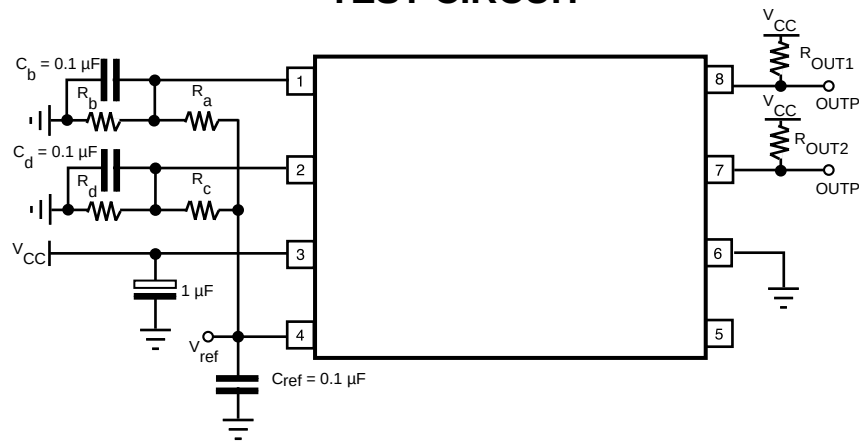
SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
I_{CC}	Supply Current	OUT1: C_{LH} , OUT2: C_{LL}		280	350	μA
V_{ref}	Reference Voltage	(Pin 4)		1.597		V
I_{OUT}	Output Current (V_{ref})	Load Reg < 12 mV (Pin 4)		80	500	μA
Line Reg	Line Regulation (V_{ref})	$V_{CC} = 3\text{ V to }6\text{ V}$ (Pin 4)	-9	0	+9	mV
Load Reg	Load Regulation (V_{ref})	$I_{OUT} = 0\text{ }\mu\text{A to }500\text{ }\mu\text{A}$ (Pin 4)		3	12	mV
V_{TEMP}	Temperature Sensor (internal)	$T_A = 25\text{ °C}$		645		mV
		$T_A = 85\text{ °C}$		1011		mV
		$T_A = 0\text{ °C}$		492.5		mV
T_C	Temperature Coefficient (internal)	$T_A = 0\text{ °C to }85\text{ °C}$		6.1		mV/°C
T_{ERR}	Total Temperature Error	$T_A = 0\text{ °C to }85\text{ °C}$ (Note 1)	-4.0	0	4.0	°C
C_{LH}	Comparator Output High Level	(Note 2)	2.8			V
C_{LL}	Comparator Output Low Level	$I_{SINK} \leq 500\text{ }\mu\text{A}$ (Note 2)			0.3	V
I_{IB1}	Input Bias Current 1	OUT1: C_{LH}	-50	0	50	nA
I_{SH1}	Hysteresis Set Current 1	OUT1: C_{LL}	0.9	1.35	1.8	μA
I_{IB2}	Input Bias Current 2	OUT2: C_{LL}	-50	0	50	μA
I_{SH2}	Hysteresis Set Current 2	OUT2: C_{LH}	0.9	1.35	1.8	μA
I_{SINK}	Output Sink Current	$C_{LL} \leq 0.3\text{ V}$, (Pin 7, Pin 8)		10	500	μA

Note 1: This spec. is an error between a temp. to which the comparator reverses and a set temp. The resistance values of R_a , R_b , R_c , R_d can be calculated as follows:

$$R_a \text{ or } R_c = \frac{V_{REF} \times T_{SM} \times T_C}{(0.4925 + T_{SET} \times T_C) \times I_{SH}}$$

$$R_b \text{ or } R_d = \frac{V_{REF} \times T_{SH} \times T_C}{(V_{REF} - 0.4925 - T_{SET} \times T_C) \times I_{SH}}$$

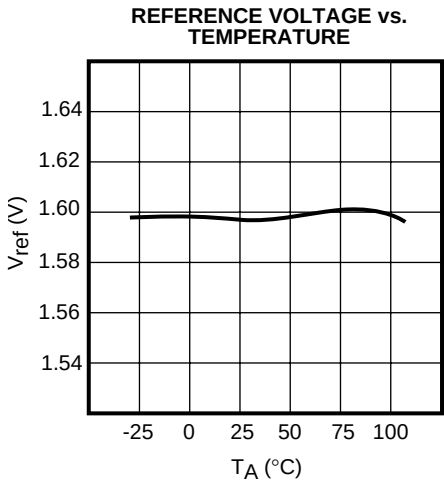
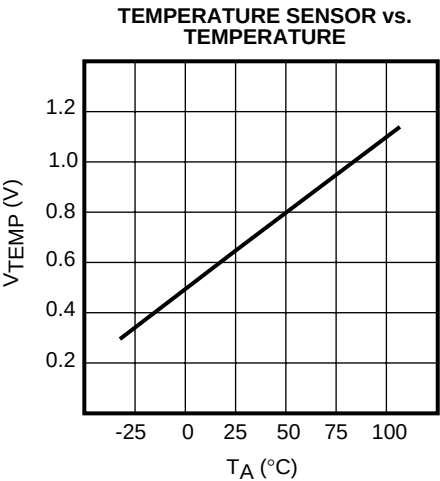
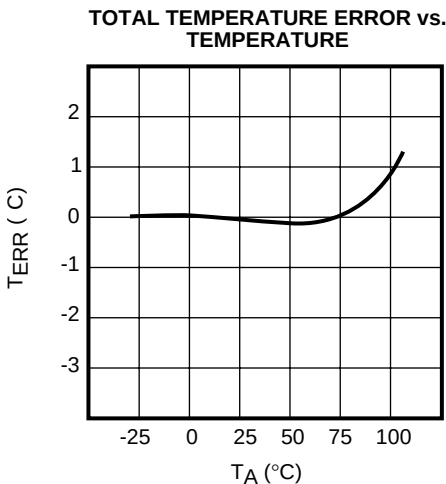
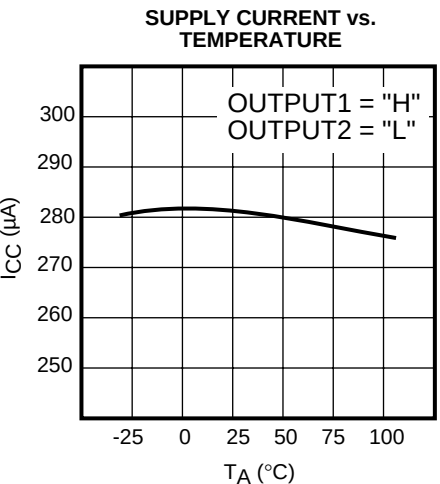
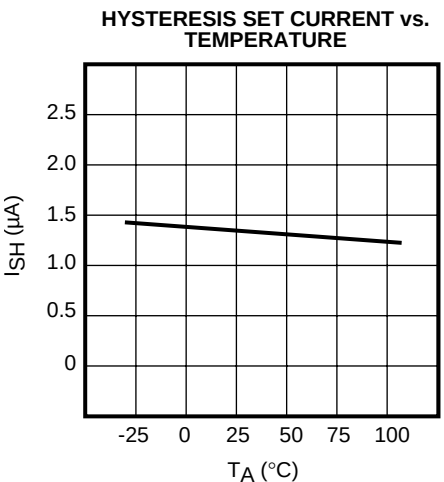
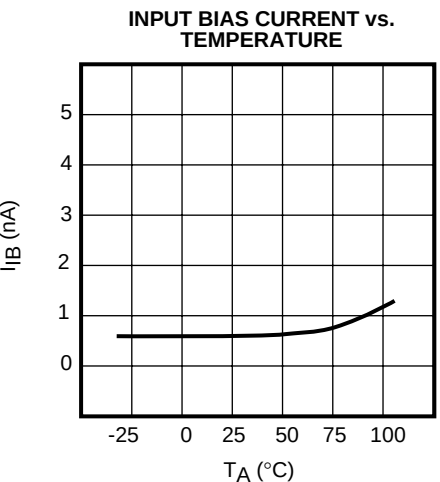
Note 2: When $V_{TEMP} < \text{INPUT1}$, $\text{OUTPUT1} > 2.8\text{ V}$ (C_{LH}). When $V_{TEMP} > \text{INPUT1}$, $\text{OUTPUT1} < 0.3\text{ V}$ (C_{LL}).
When $V_{TEMP} < \text{INPUT2}$, $\text{OUTPUT2} < 0.3\text{ V}$ (C_{LL}). When $V_{TEMP} > \text{INPUT2}$, $\text{OUTPUT2} > 2.8\text{ V}$ (C_{LH}).

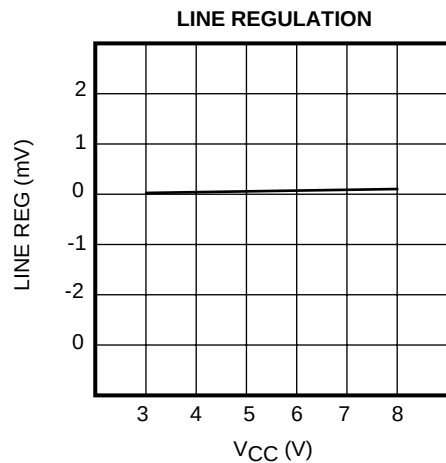
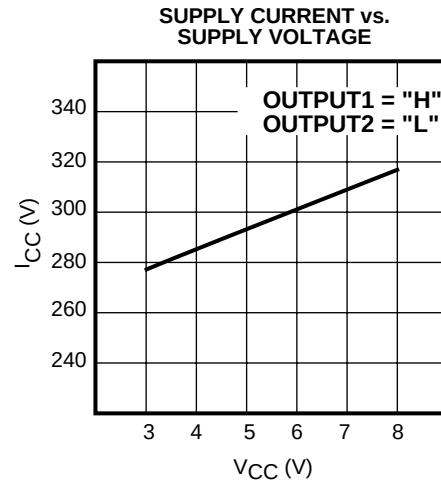
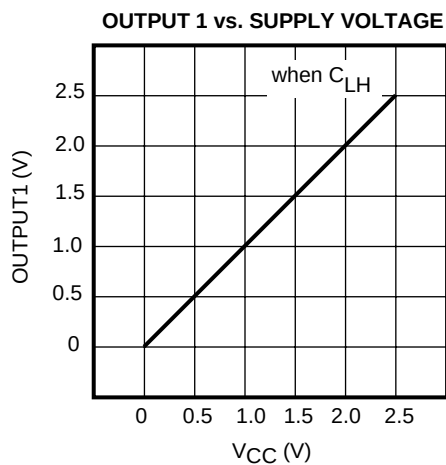
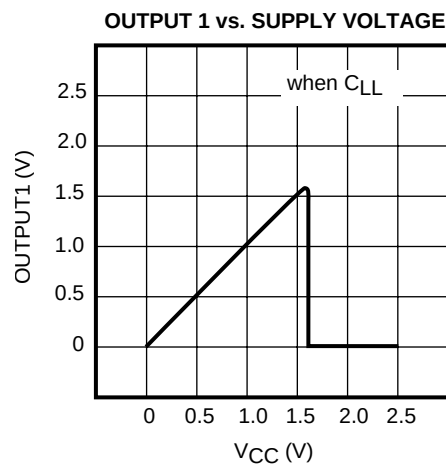
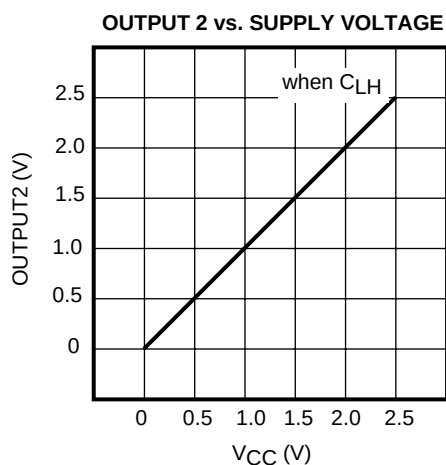
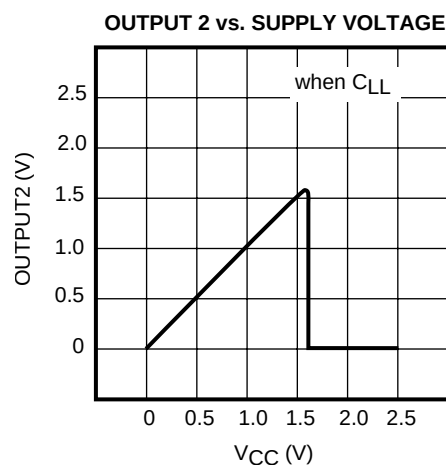
TEST CIRCUIT

Note: For information on C_b and C_d , see Applications Hints Section.

TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

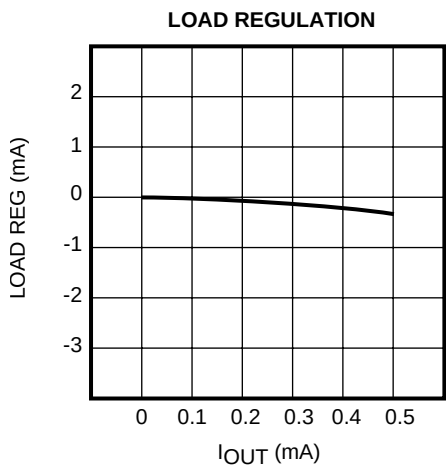
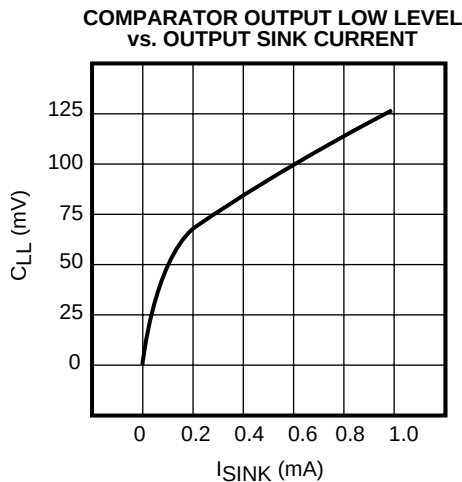
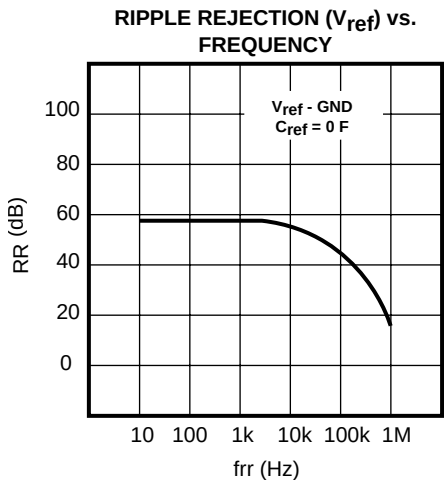
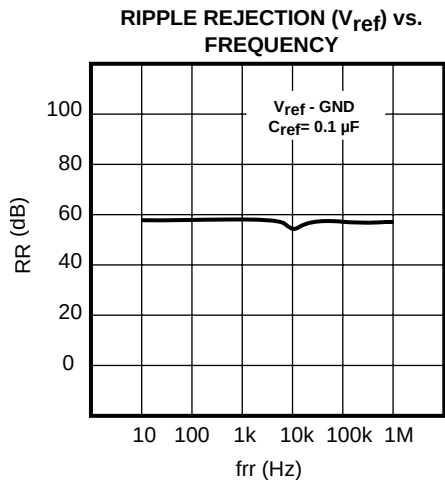
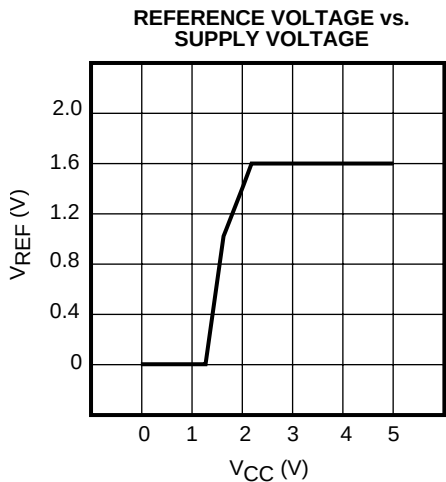
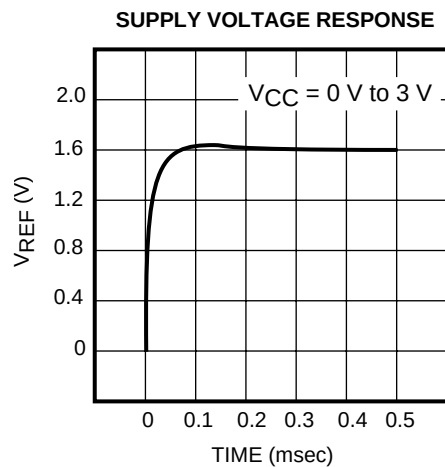
$T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 3\text{ V}$, $I_{OUT} = 80\text{ }\mu\text{A}$, unless otherwise specified.



TYPICAL PERFORMANCE CHARACTERISTICS (CONT.) $T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 3\text{ V}$, $I_{OUT} = 80\text{ }\mu\text{A}$, unless otherwise specified.

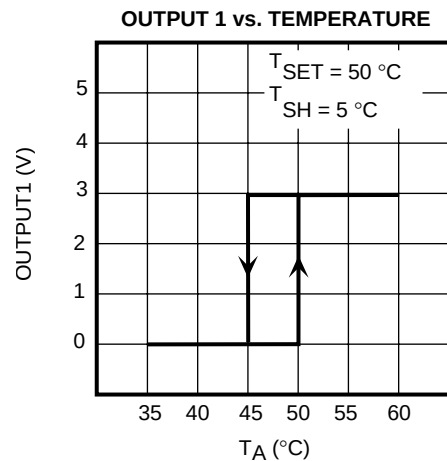
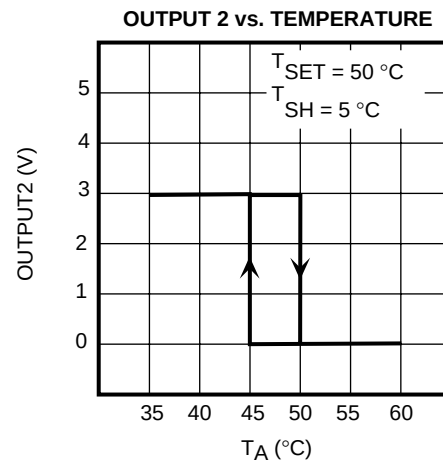
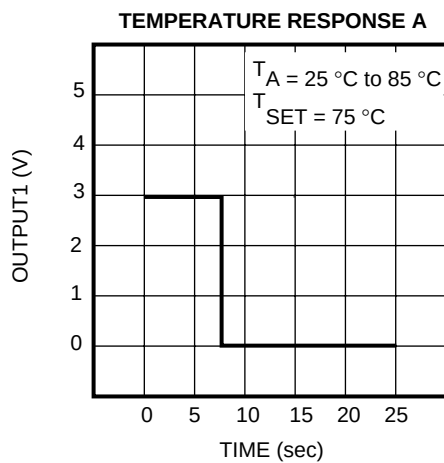
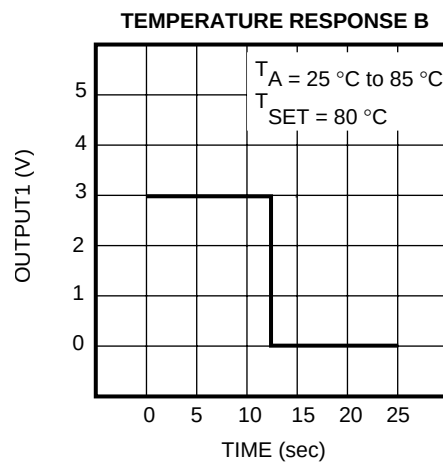
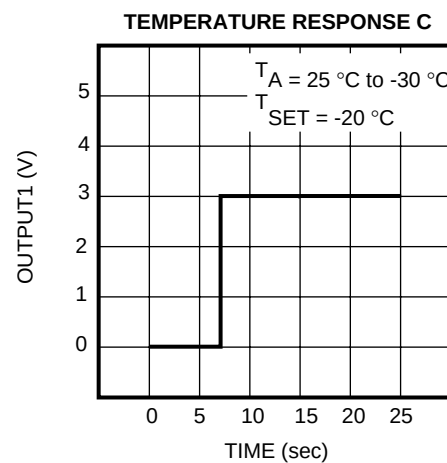
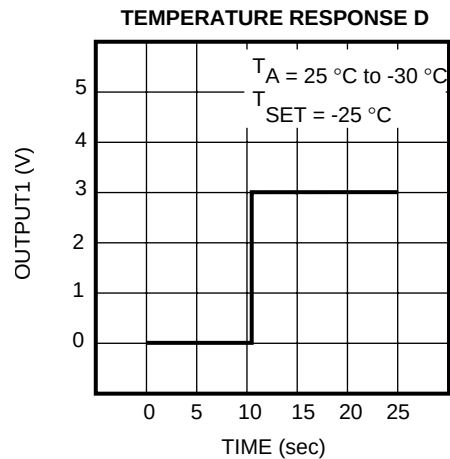
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

$T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 3\text{ V}$, $I_{OUT} = 80\text{ }\mu\text{A}$, unless otherwise specified.



TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

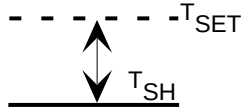
$T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 3\text{ V}$, $I_{OUT} = 80\text{ }\mu\text{A}$, unless otherwise specified.



APPLICATION HINTS

EXTERNAL RESISTORS R_a , R_b , R_c , and R_d

The temperature set point (T_{SET}) and hysteresis (T_{SH}) of the TK11052 are easily set by external resistors R_a , R_b , R_c , and R_d . See Figure 1 for clarification of T_{SET} and T_{SH} .

**FIGURE 1**

The set voltage (V_{SET}) of the comparator at the set temperature (T_{SET}) is calculated as follows:

$$(1) \quad V_{SET} = 0.4925 + T_{SET} \times T_C$$

where $T_C = 6.1 \text{ mV}/^\circ\text{C}$

1. For Set Temperatures $\geq 25^\circ\text{C}$

The set voltage (V_{SET}) of the comparator at the reference voltage and external resistances is calculated as follows:

$$(2) \quad V_{SET} = \frac{R_b}{R_a + R_b} \times V_{REF}$$

R_b is calculated by Equations (1) and (2), resulting in:

$$(3) \quad R_b = \frac{0.4925 + T_{SET} \times T_C}{V_{REF} - 0.4925 - T_{SET} \times T_C} \times R_a$$

The hysteresis voltage (V_{SH}) of the comparator can be calculated as follows:

$$(4) \quad V_{SH} = \left(\frac{R_a \times R_b}{R_a + R_b} \right) \times I_{SH}$$

where $I_{SH} = 1.35 \mu\text{A}$

R_b is calculated by Equation (4)

$$(5) \quad R_b = \frac{R_a \times V_{SH}}{R_a \times I_{SH} - V_{SH}}$$

R_a is calculated by Equations (3) and (5)

$$(6) \quad R_a = \frac{V_{ref} \times T_{SH} \times T_C}{(0.4925 + T_{SET} \times T_C) \times I_{SH}}$$

$$= \frac{1.597 \times T_{SH} \times 6.1 \text{ m}}{(0.4925 + T_{SET} \times 6.1 \text{ m}) \times 1.35 \mu}$$

$$\approx \frac{1183 \times T_{SH}}{80.74 + T_{SET}} \times 10^3$$

where $I_{SH} = 1.35 \mu\text{A}$, $T_C = 6.1 \text{ mV}$ and $V_{REF} = 1.597 \text{ V}$

R_b is calculated by Equations (3) and (6)

$$(7) \quad R_b = \frac{V_{ref} \times T_{SH} \times T_C}{(V_{REF} - 0.4925 - T_{SET} \times T_C) \times I_{SH}}$$

$$= \frac{1.597 \times T_{SH} \times 6.1 \text{ m}}{(1.597 - 0.4925 - T_{SET} \times 6.1 \text{ m}) \times 1.35 \mu}$$

$$\approx \frac{1183 \times T_{SH}}{181.07 - T_{SET}} \times 10^3$$

Example:

R_a and R_b when set temperature is 85°C and temperature hysteresis is 5°C .

$$R_a = \frac{1183 \times T_{SH}}{80.74 + T_{SET}} \times 10^3 = \frac{1183 \times 5}{80.74 + 85} \times 10^3$$

$$= 35.69 \text{ k} \approx 36 \text{ k}\Omega$$

$$R_b = \frac{1183 \times T_{SH}}{181.07 - T_{SET}} \times 10^3 = \frac{1183 \times 5}{181.07 - 85} \times 10^3$$

$$= 61.57 \text{ k} \approx 62 \text{ k}\Omega$$

2. For Set Temperatures $< 25^\circ\text{C}$

$$(8) \quad R_a = \frac{V_{REF} \times T_{SH} \times T_C}{(0.4925 + T_{SET} \times T_C - T_{SH} \times T_C) \times I_{SH}}$$

$$= \frac{1183 \times T_{SH}}{80.74 + (T_{SET} - T_{SH})} \times 10^3$$

APPLICATION HINTS (CONT.)

$$(9) \quad R_b = \frac{V_{REF} \times T_{SH} \times T_C}{(0.4925 + T_{SET} \times T_C - T_{SH} \times T_C) \times I_{SH}} = \frac{1183 \times T_{SH}}{181.07 - (T_{SET} - T_{SH})} \times 10^3$$

Example:

R_a and R_b when set temperature is 0 °C and temperature hysteresis is 5 °C.

$$R_a = \frac{1183 \times T_{SH}}{80.74 + (T_{SET} - T_{SH})} \times 10^3 = 78.096 \times 10^3 \approx 78.1 \text{ k}\Omega$$

$$R_b = \frac{1183 \times T_{SH}}{181.07 - (T_{SET} - T_{SH})} \times 10^3 = 31.789 \times 10^3 \approx 31.8 \text{ k}\Omega$$

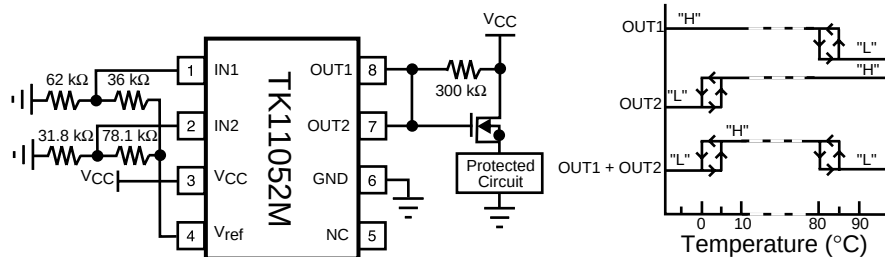
Thermostat IC Application

Example:

- WINDOW TYPE OUTPUT

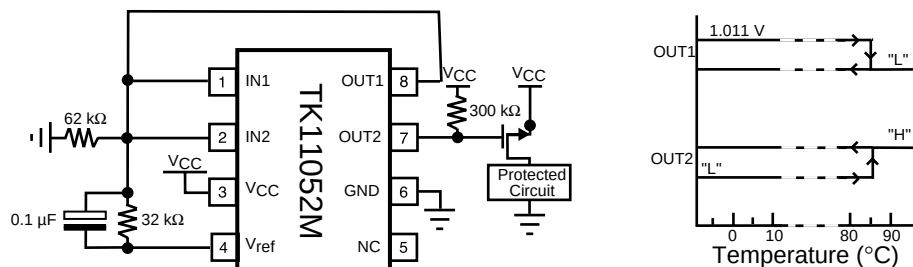
The following application protects the circuit within the operating temperature range of 0 to 85 °C. When the temperature is 0 °C or less, or 85 °C or more, the N channel Mos transistor is turned OFF.

When the temperature returns to between 5 and 80 °C by the hysteresis function, the N channel Mos transistor is turned ON.



- TEMPERATURE FUSE

The following application is a temperature fuse circuit. The output of the TK11052M becomes a High Level when the surrounding temperature exceeds 85 °C and the P channel Mos transistor is turned off. Even if the surrounding temperature drops, the P channel Mos transistor remains off.

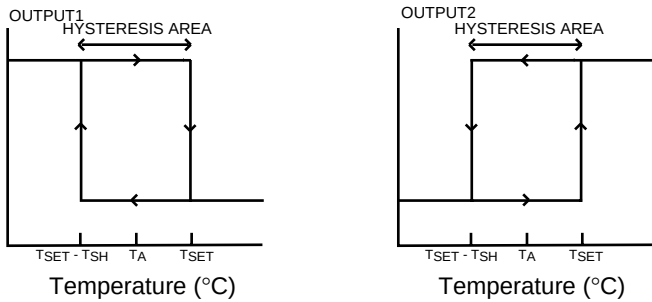


APPLICATION HINTS (CONT.)

Comparator Output Level in the Hysteresis Area

When the power supply voltage is applied with the ambient temperature in the hysteresis area, the state of the comparator output level is uncertain.

A capacitor is connected between Pin1 (Pin 2) to GND or Pin 4 to Pin 1 (Pin 2) to fix the comparator output level.

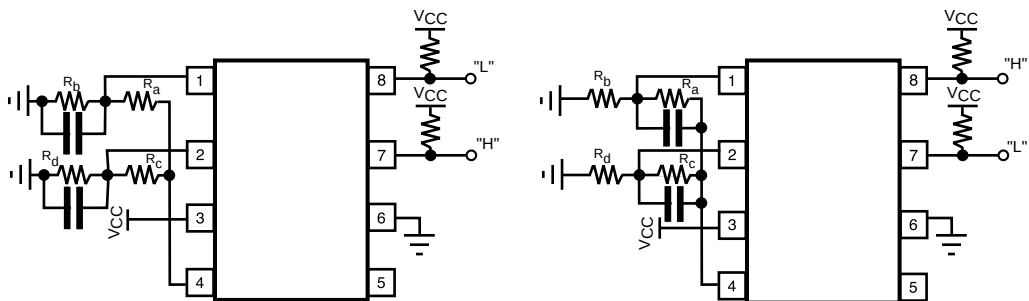


Pin1 to GND
Pin 2 to GND

OUTPUT1: Low Level
OUTPUT2: High Level

Pin 1 to Pin 4
Pin 2 to Pin 4
See following

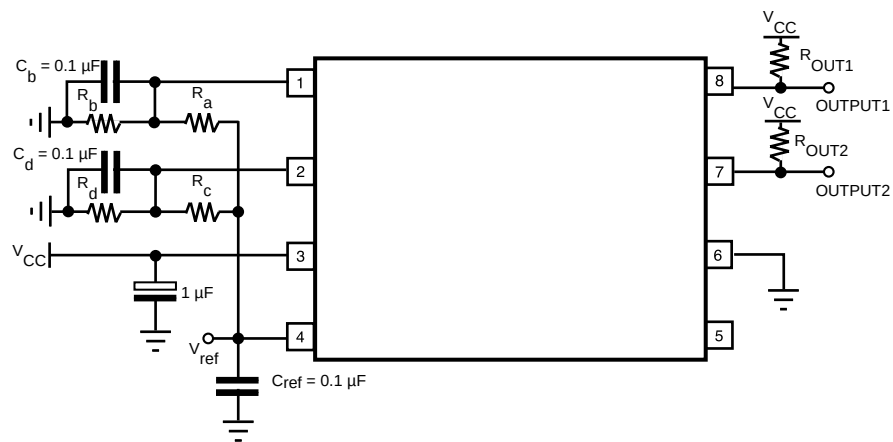
OUTPUT1: High Level
OUTPUT 2: Low Level



APPLICATION HINTS (CONT.)

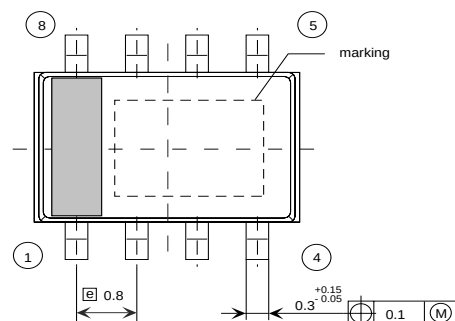
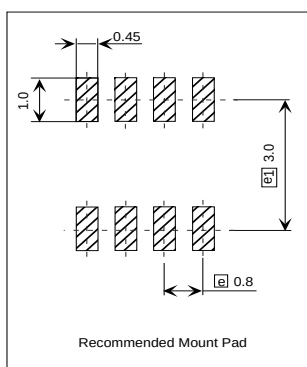
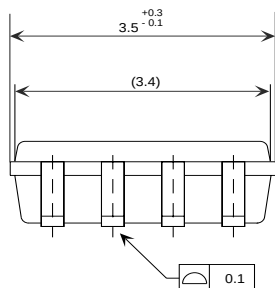
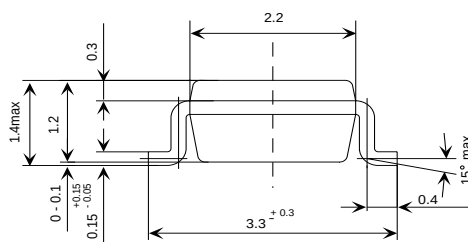
Noise Reduction

When the thermostat IC is operated in a noisy environment (e.g., motor, fan, etc.), the noise on the signal lines may exceed the limits of the comparator hysteresis window. This results in erratic comparator output levels. This can be corrected by adding $0.1\ \mu\text{F}$ capacitors from Pin 1 to GND (or Pin 4), Pin 2 to GND (or Pin 4), and Pin 4 to GND as shown below. The configuration is determined by the desired comparator output level during power-up in the hysteresis area as described earlier.



PACKAGE OUTLINE

SOT-23L (SOT23L-8)



Dimensions are shown in millimeters
Tolerance: x.x = ± 0.2 mm (unless otherwise specified)

Marking Information

TK11052

Marking
52C

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