

### 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

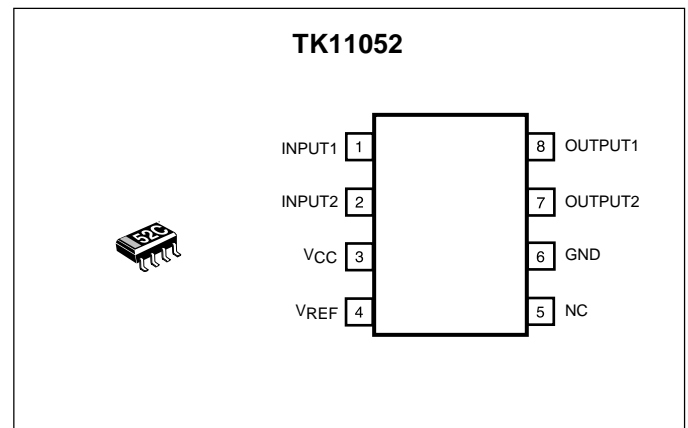
### DESCRIPTION

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

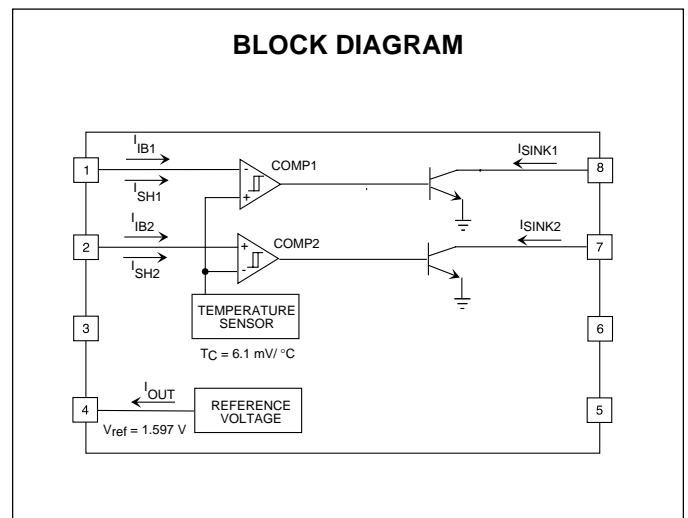


**ORDERING INFORMATION**

**TK11052MTL**

└─ Tape/Reel Code

TAPE/REEL CODE  
TL: Tape Left



# TK11052

## 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	$\mu\text{A}$
$V_{ref}$	Reference Voltage	(Pin 4)		1.597		V
$I_{OUT}$	Output Current ( $V_{ref}$ )	Load Reg < 12 mV (Pin 4)		80	500	$\mu\text{A}$
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	$\mu\text{A}$
$I_{IB2}$	Input Bias Current 2	OUT2: $C_{LL}$	-50	0	50	$\mu\text{A}$
$I_{SH2}$	Hysteresis Set Current 2	OUT2: $C_{LH}$	0.9	1.35	1.8	$\mu\text{A}$
$I_{SINK}$	Output Sink Current	$C_{LL} \leq 0.3\text{ V}$ , (Pin 7, Pin 8)		10	500	$\mu\text{A}$

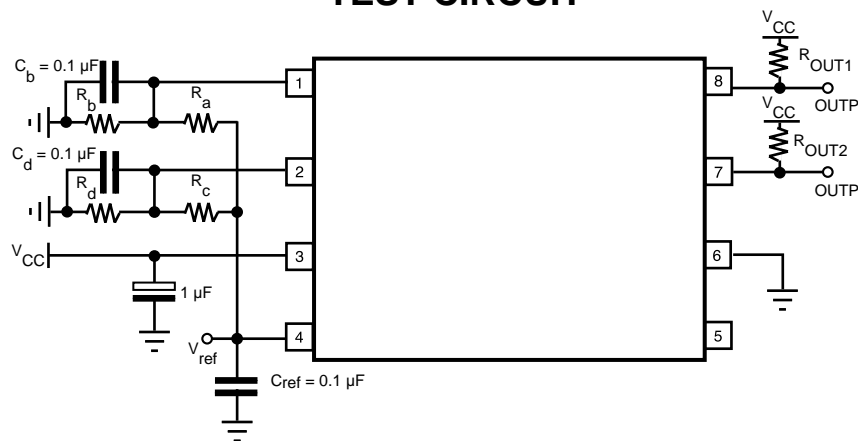
Note 1: This spec. is an error between a temp. to which the comparator reverses and a set temp. The resistance values of  $R_a$ ,  $R_b$ ,  $R_c$ ,  $R_d$  can be calculated as follows:

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

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

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

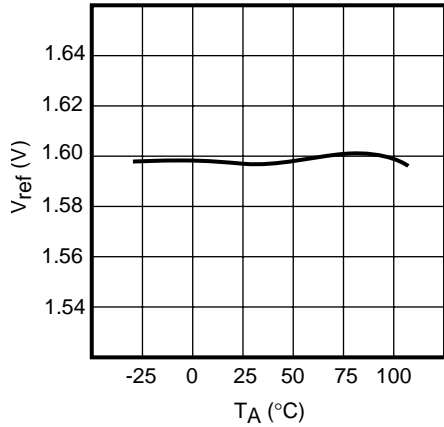


Note: For information on  $C_b$  and  $C_d$ , see Applications Hints Section.

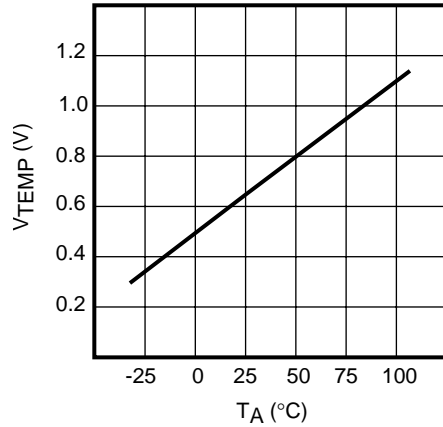
**TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)**

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

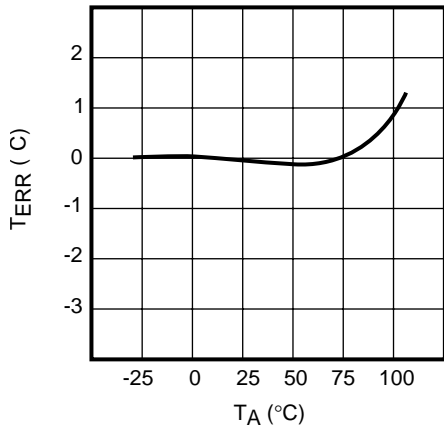
**REFERENCE VOLTAGE vs. TEMPERATURE**



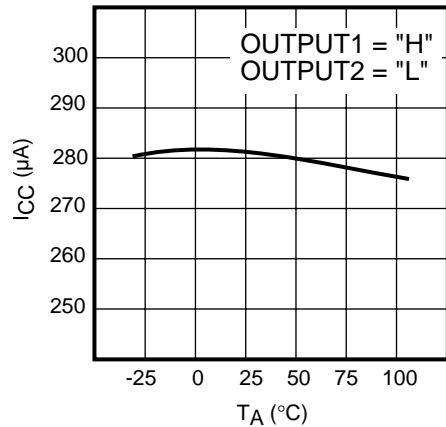
**TEMPERATURE SENSOR vs. TEMPERATURE**



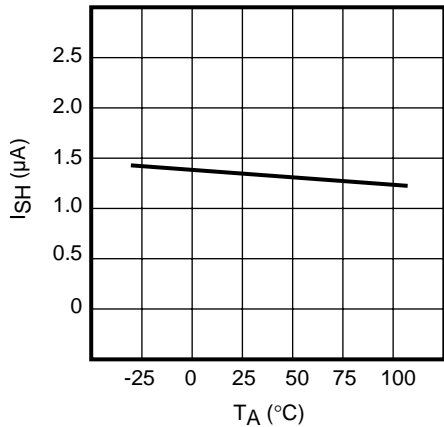
**TOTAL TEMPERATURE ERROR vs. TEMPERATURE**



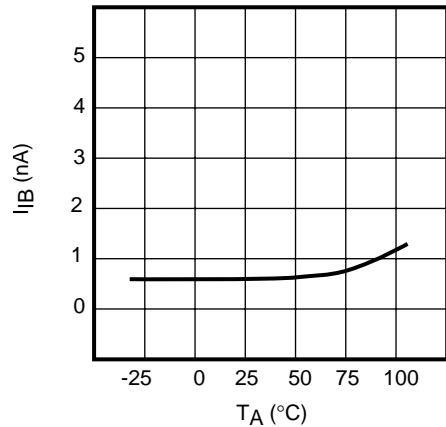
**SUPPLY CURRENT vs. TEMPERATURE**



**HYSTERESIS SET CURRENT vs. TEMPERATURE**

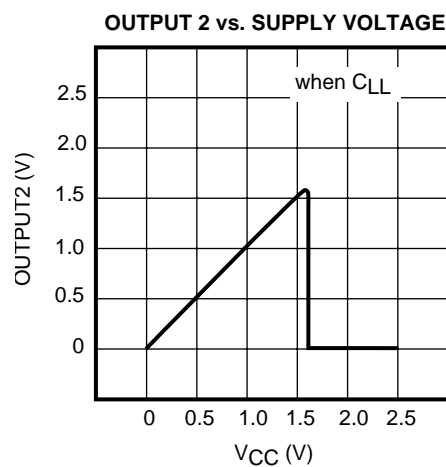
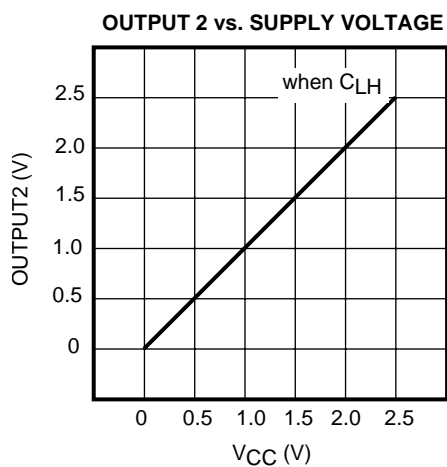
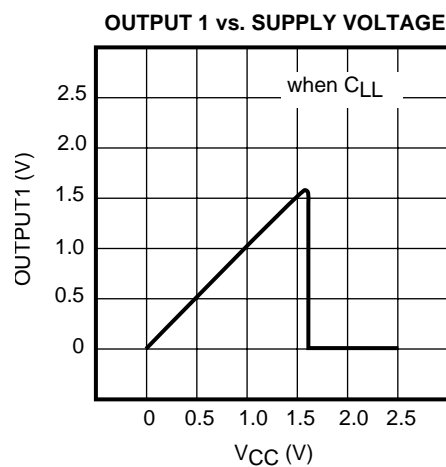
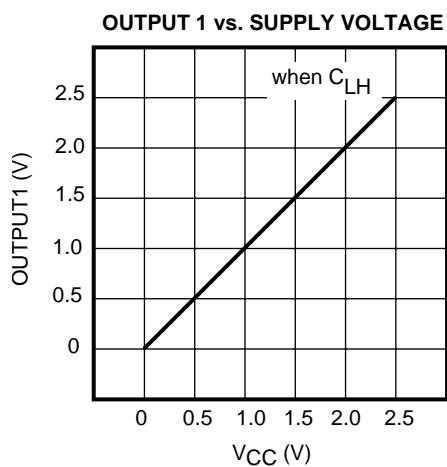
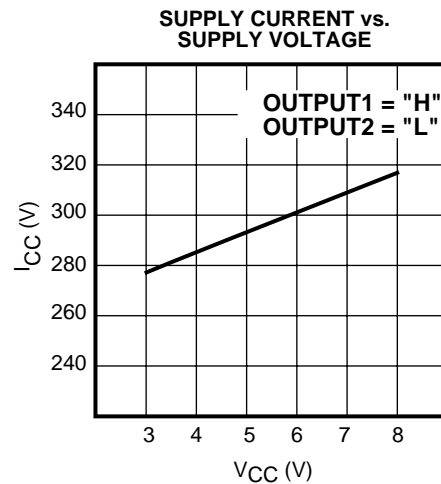
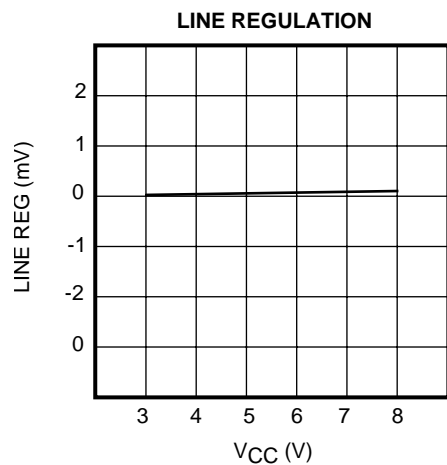


**INPUT BIAS CURRENT vs. TEMPERATURE**



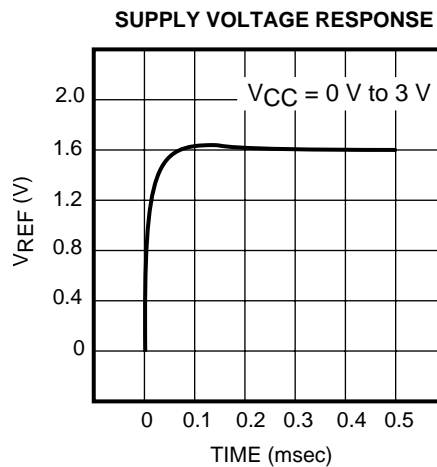
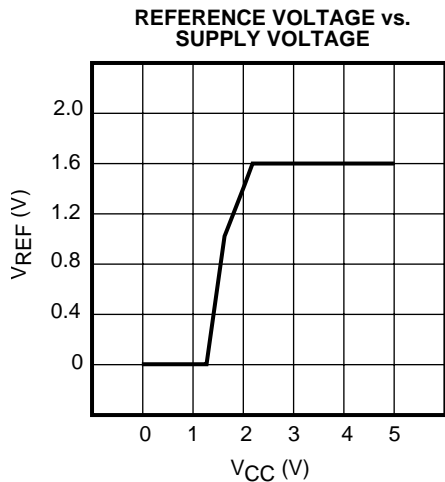
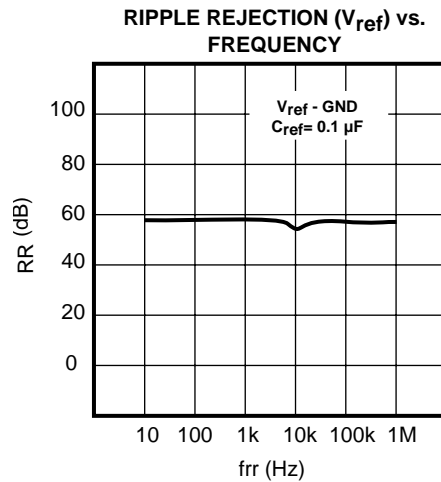
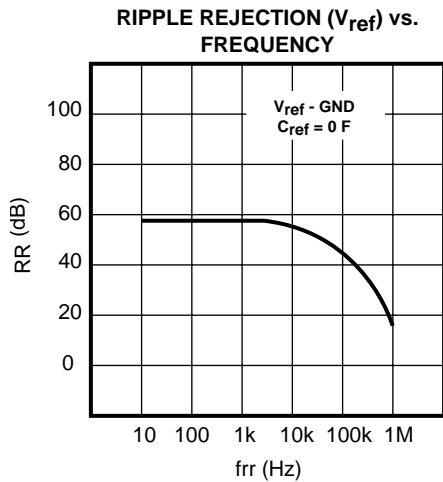
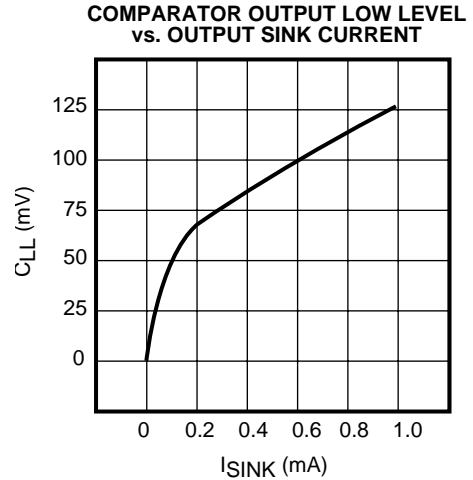
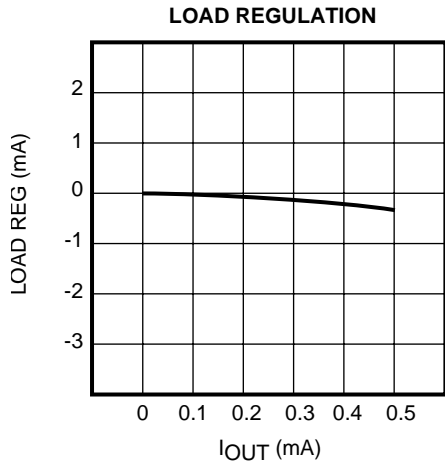
## TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

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



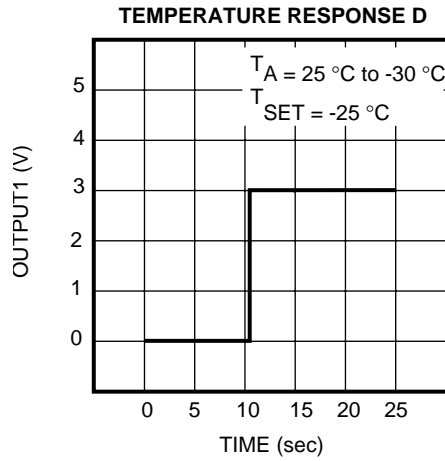
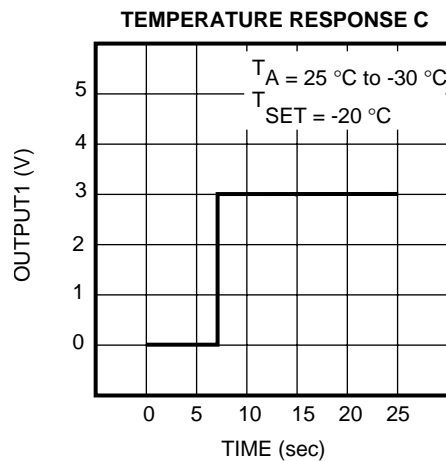
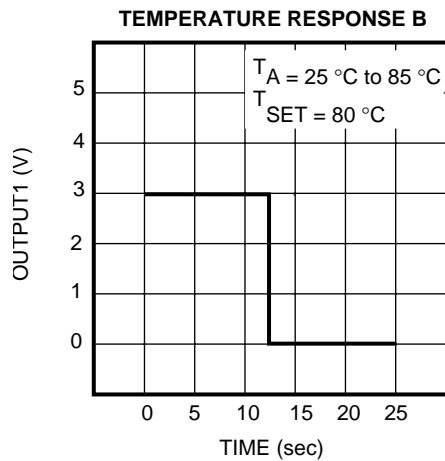
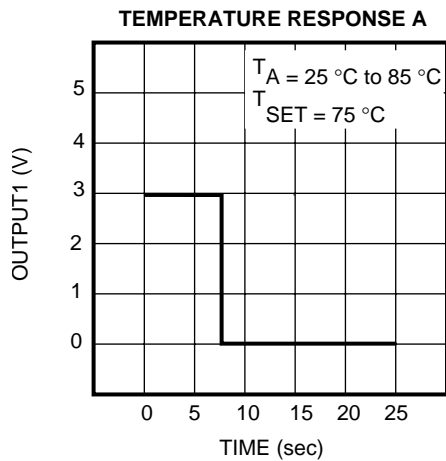
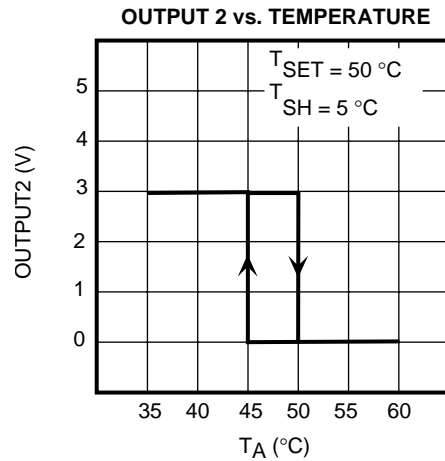
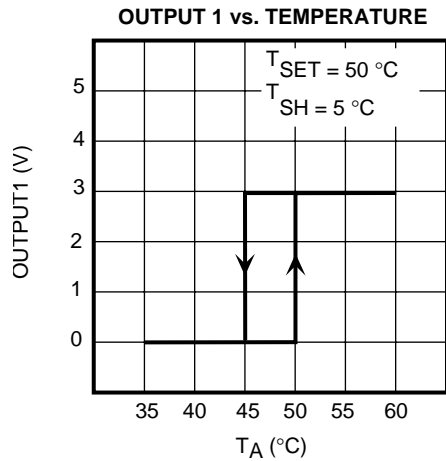
**TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)**

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

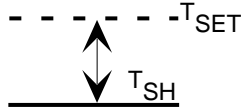


FIGURE 1

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  $85^\circ\text{C}$  and temperature hysteresis is  $5^\circ\text{C}$ .

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

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

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

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

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.

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

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

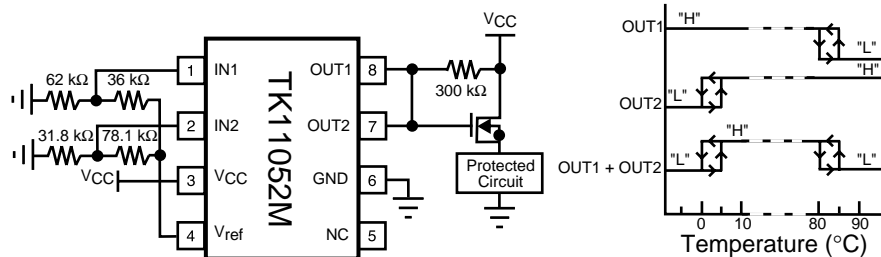
**Thermostat IC Application**

Example:

- WINDOW TYPE OUTPUT

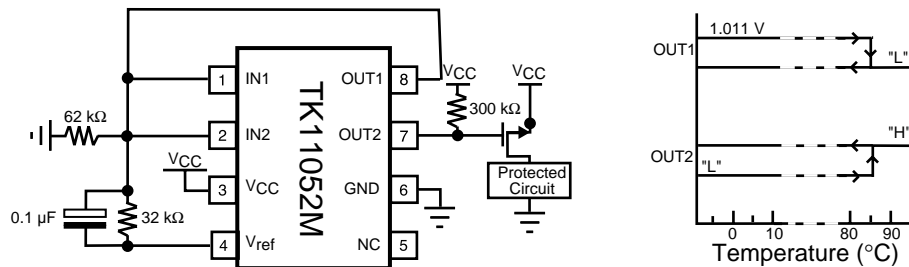
The following application protects the circuit within the operating temperature range of 0 to 85 °C. When the temperature is 0 °C or less, or 85 °C or more, the N channel Mos transistor is turned OFF.

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.

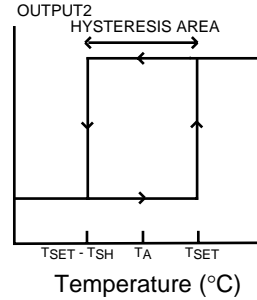
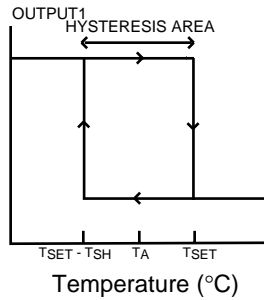


**APPLICATION HINTS (CONT.)**

**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.

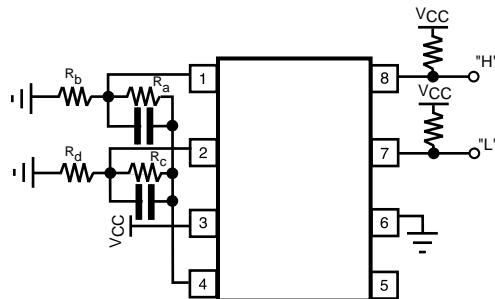
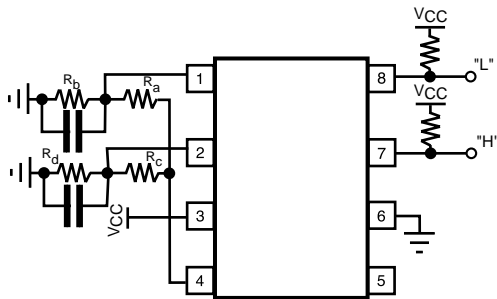


Pin1 to GND  
Pin 2 to GND

OUTPUT1: Low Level  
OUTPUT2: High Level

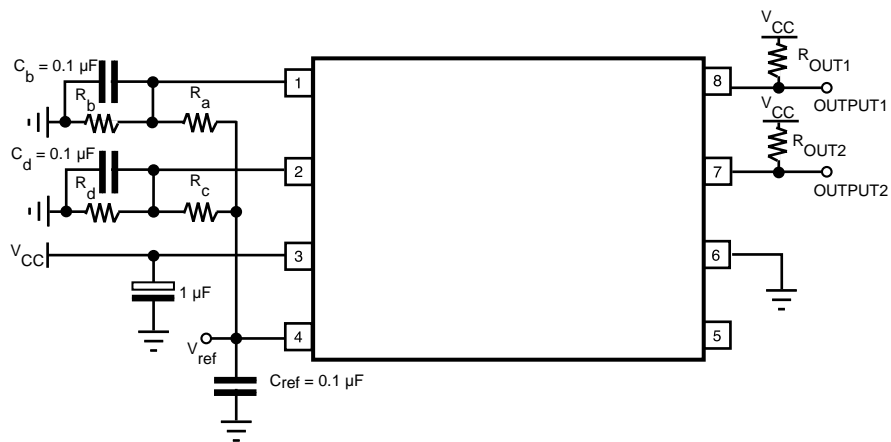
Pin 1 to Pin 4  
Pin 2 to Pin 4  
See following

OUTPUT1: High Level  
OUTPUT 2: Low Level

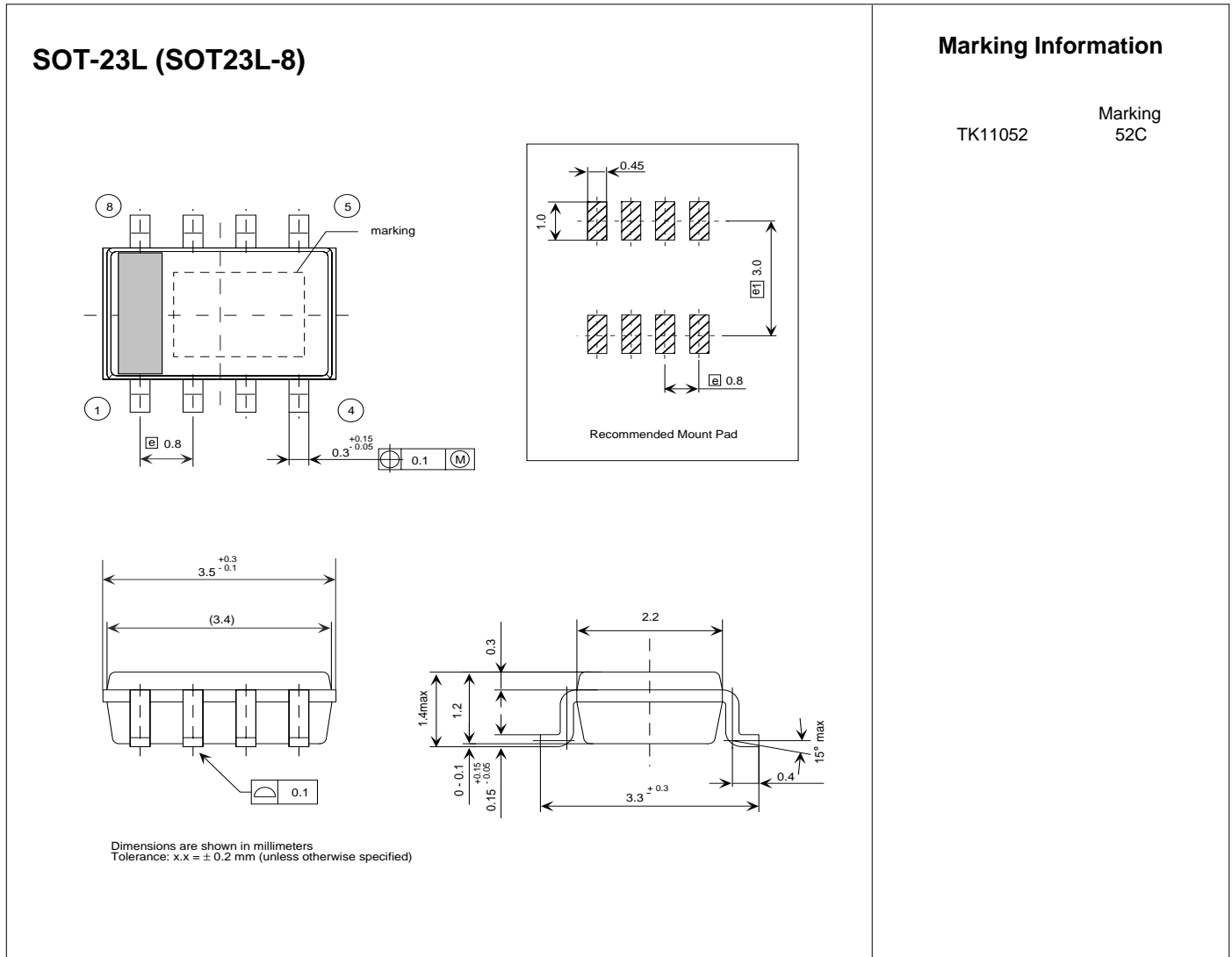


**APPLICATION HINTS (CONT.)****Noise Reduction**

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



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