

## TEMPERATURE CONTROLLER IC

### FEATURES

- Internal Temperature Sensor, Voltage Reference and Comparator
- Temperature Threshold and Hysteresis Set by Only Two External Resistors
- Output Logic: Low to High with Increasing Temp.
- Active High On/Off Control
- 2.7 to 6.0 V Supply Range
- Miniature Package (SOT-23L-6)
- Minimum External Parts Count
- Low Power Consumption
- Very Wide Temperature Range

### DESCRIPTION

The TK11050 is an accurate temperature controller IC for use over the -30 to +105 °C temperature range. The TK11050 monolithic bipolar integrated circuit contains a temperature sensor, stable voltage reference and a comparator, making the device very useful as an on/off temperature controller. Two external resistors easily set the sensing temperature threshold and hysteresis. Its wide operating voltage range of 2.7 to 6.0 V makes this IC suitable for a number of applications requiring accurate temperature control. The device is in the "on" state when the control pin is pulled to a logic high level.

The TK11050 is available in a miniature SOT-23L-6 surface mount package.

### APPLICATIONS

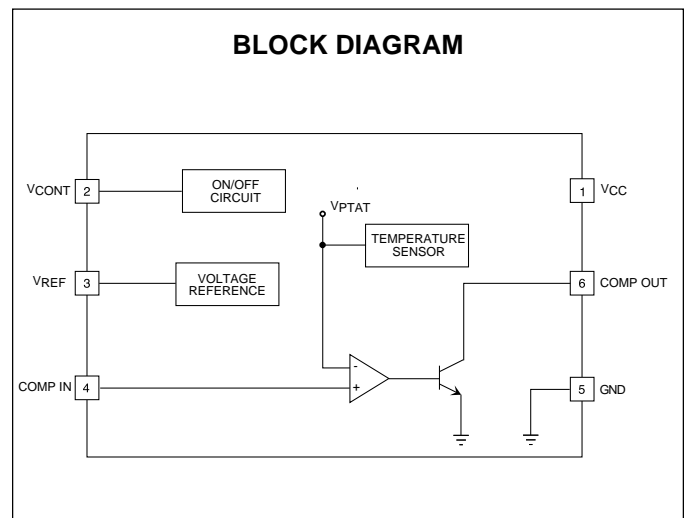
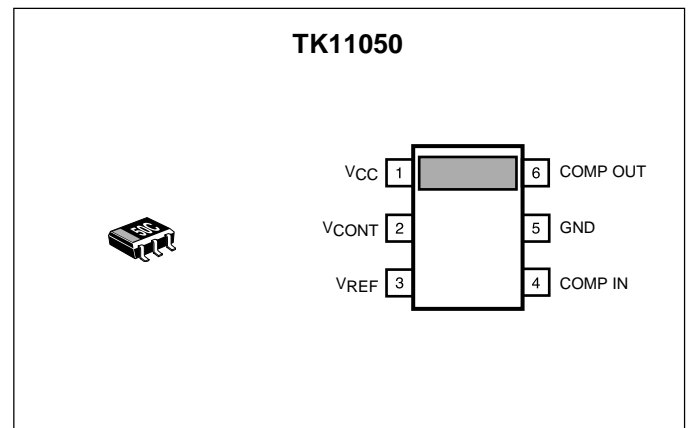
- Home and Industrial Thermostats
- Home Appliance Temperature Control
- Notebook Computer Temperature Monitor
- Pentium Processor Temperature Monitor
- Power Supply Overtemperature Protection
- Copy Machine Overtemperature Protection
- System Overtemperature Protection

**ORDERING INFORMATION**

**TK11050MTL**

└─ Tape/Reel Code

TAPE/REEL CODE  
TL: Tape Left



# TK11050

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage .....	10 V	Operating Voltage Range .....	2.7 to 6 V
Power Dissipation (Note 1) .....	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		

## TK11050 ELECTRICAL CHARACTERISTICS

Test conditions:  $T_A = 25\text{ °C}$ ,  $V_{CC} = 3.0\text{ V}$ ,  $V_{CONT} = 2.4\text{ V}$ ,  $I_{OUT} = 40\text{ }\mu\text{A}$ ,  $R_3 = 100\text{ k}\Omega$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
$I_{CC}$	Quiescent Current	Comparator Output LOW		250	350	$\mu\text{A}$
		Comparator Output HIGH		210	350	$\mu\text{A}$
$I_{STBY}$	Standby Current	$V_{CONT} \leq 0.6\text{ V}$			1	$\mu\text{A}$
$V_{PTAT}$	Temperature Sensor Voltage (Note 4)	$T_A = 25\text{ °C}$		1.192		V
		$T_A = 85\text{ °C}$		1.432		V
		$T_A = -30\text{ °C}$		0.972		V
$T_C$	Temperature Coefficient	$T_A = 0\text{ to }85\text{ °C}$		4.0		$\text{mV}/\text{°C}$
$T_{ERR}$	Temperature Error	$T_A = 0\text{ to }85\text{ °C}$ , (Note 2)	-4.0	0	4.0	$\text{°C}$
$C_{LH}$	Comparator Output HIGH	(Note 3)	2.8			V
$C_{LL}$	Comparator Output LOW	$R_3 \geq 10\text{ k}\Omega$ , (Note 3)			0.3	V
$I_{IB}$	Input Bias Current	Comparator IN $> V_{PTAT}$		0.1	0.3	$\mu\text{A}$
$I_{SH}$	Hysteresis Set Current	Comparator IN $< V_{PTAT}$	0.9	1.25	1.6	$\mu\text{A}$
$I_{OUT}$	Output Sink Current	$C_{LL} \leq 0.3\text{ V}$		30	300	$\mu\text{A}$

### $V_{ref}$ TERMINAL CHARACTERISTICS

$V_{ref}$	Reference Voltage	$T_A = 25\text{ °C}$		1.6		V
$I_{ref}$	Reference Output Current	$R_1 + R_2 = 40\text{ k}\Omega$		40	500	$\mu\text{A}$
Line Reg	Line Regulation	$V_{CC} = 3\text{ to }6\text{ V}$		2	8	mV
Load Reg	Load Regulation	$I_{OUT} = 0\text{ to }500\text{ }\mu\text{A}$		1	8	mV

### CONTROL TERMINAL SPECIFICATIONS

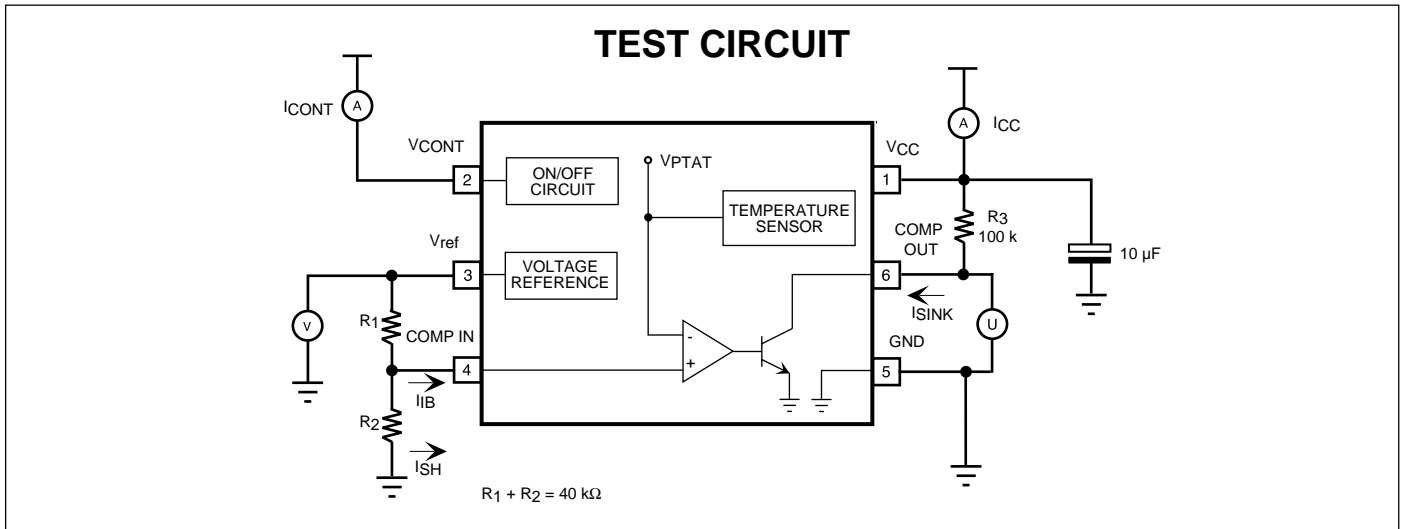
$I_{CONT}$	Control Current		1	3.5	6	$\mu\text{A}$
$V_{CONT(ON)}$	Control Voltage (ON)	Output ON	1.8		$V_{CC}$	V
$V_{CONT(OFF)}$	Control Voltage (OFF)	Output OFF	GND		0.6	V

Note 1: Power dissipation is 200 mW when in Free Air. Derate at 1.6 mW/°C for operation above 25 °C.

Note 2: The resistance values of  $R_1$  and  $R_2$  can be calculated as follows:  $R_1 = V_{ref} \times T_{SH} / (T_{SET} \times I_{SH} - (T_{SET} - T_{SH}) \times I_{IB})$ ,  $R_2 = T_{SET} \times T_C \times R_1 / (V_{ref} - R_1 \times I_{IB} - T_{SET} \times T_C)$ .  $I_{IB}$  is 0.1  $\mu\text{A}$  and  $I_{SH}$  is 1.25  $\mu\text{A}$ .

Note 3: When  $V_{PTAT} < \text{COMP IN}$ , COMP OUT  $< 0.3\text{ V}$  (Low Level). When  $V_{PTAT} > \text{COMP IN}$ , COMP OUT  $> 2.8\text{ V}$  (High Level).

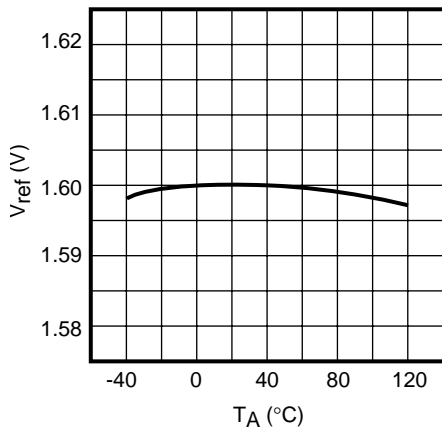
Note 4:  $V_{PTAT}$  does not have an output pin.



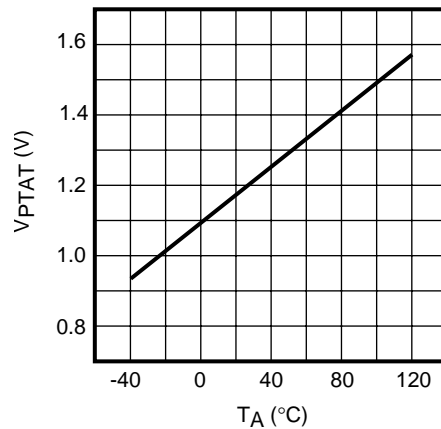
## TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25\text{ }^\circ\text{C}$ ,  $V_{CC} = 3\text{ V}$ ,  $V_{CONT} = 2.4\text{ V}$ ,  $I_{OUT} = 40\text{ }\mu\text{A}$ , unless otherwise specified.

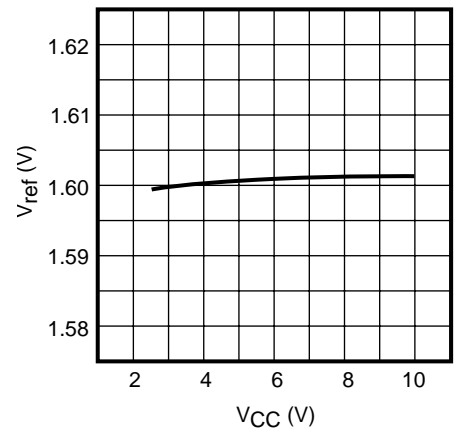
**REFERENCE VOLTAGE vs. TEMPERATURE**



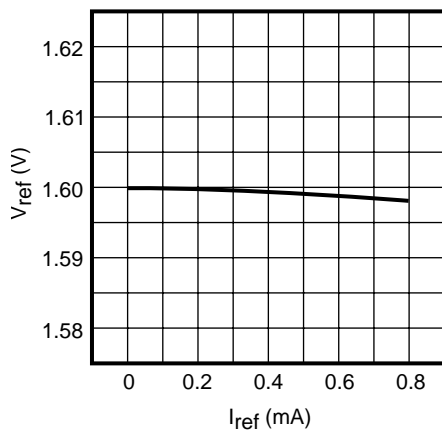
**REFERENCE VOLTAGE vs. TEMPERATURE**



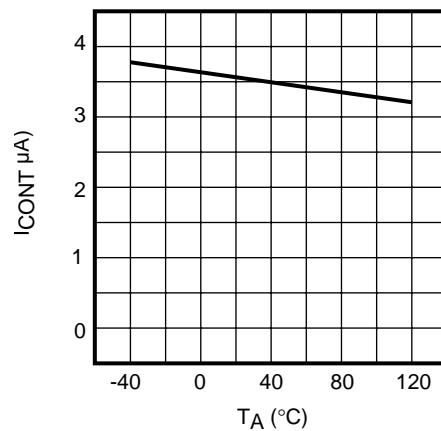
**LINE REGULATION**



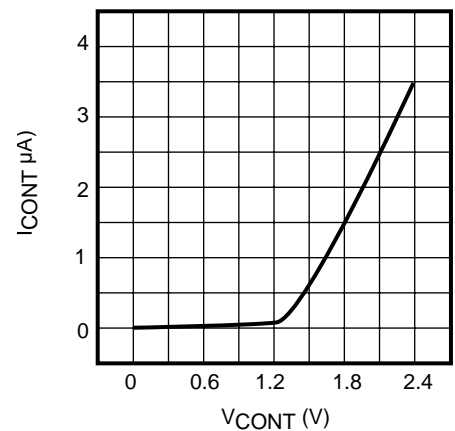
**LOAD REGULATION**



**CONTROL CURRENT vs. TEMPERATURE**

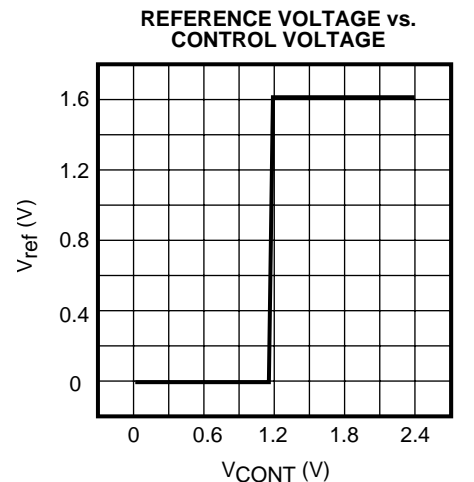
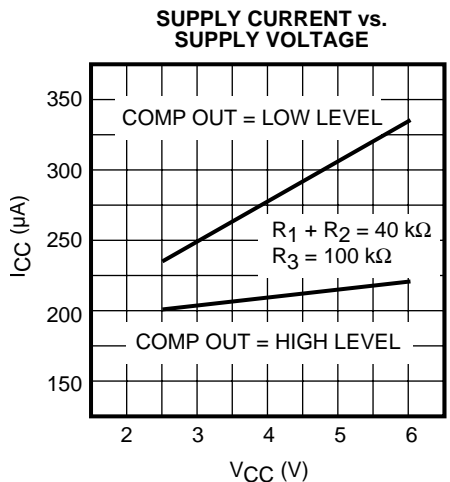
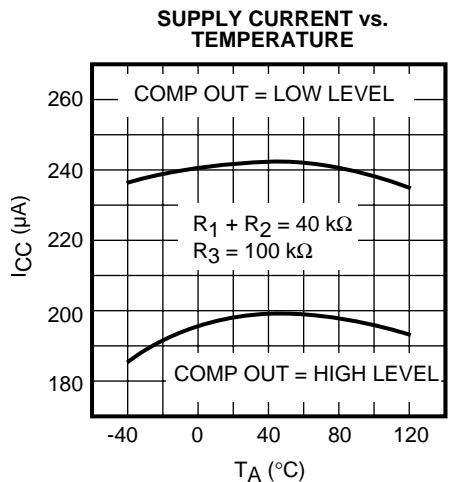
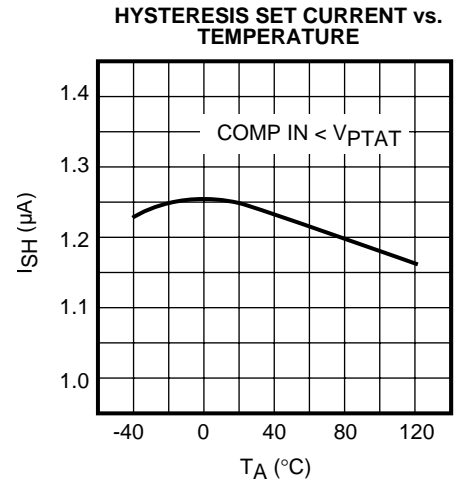
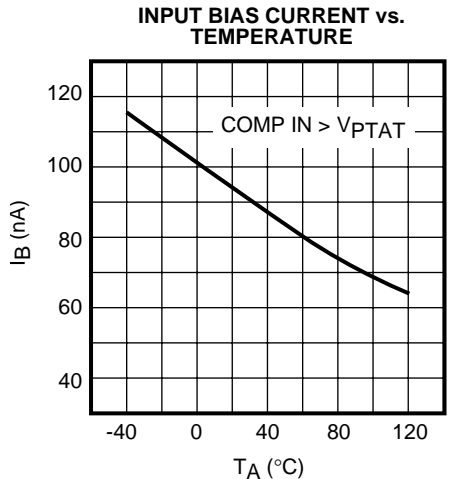
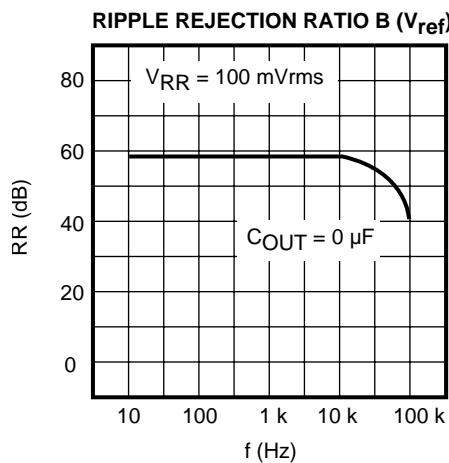
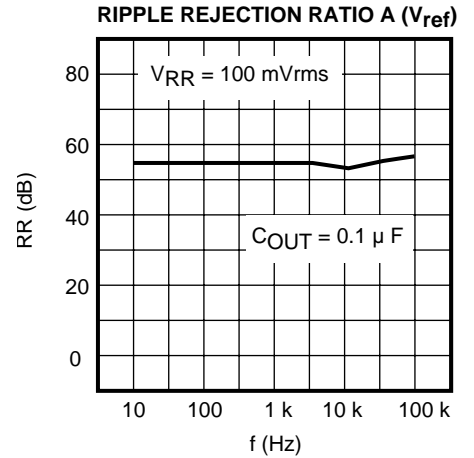
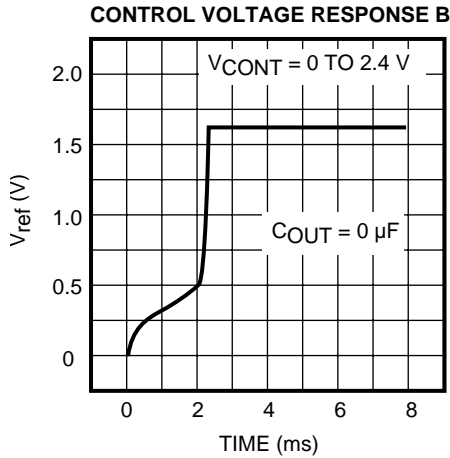
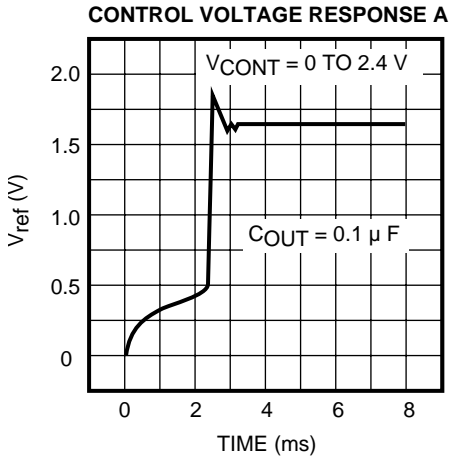


**CONTROL CURRENT vs. CONTROL VOLTAGE**



**TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)**

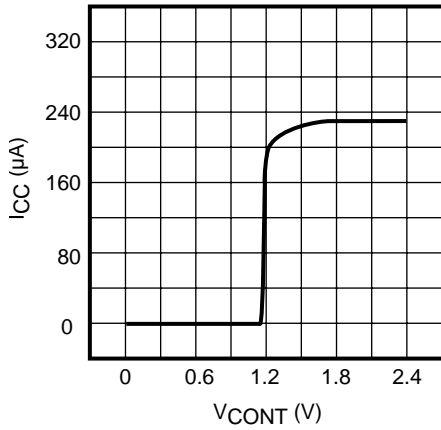
$T_A = 25\text{ }^\circ\text{C}$ ,  $V_{CC} = 3\text{ V}$ ,  $V_{CONT} = 2.4\text{ V}$ ,  $I_{OUT} = 40\text{ }\mu\text{A}$ , unless otherwise specified.



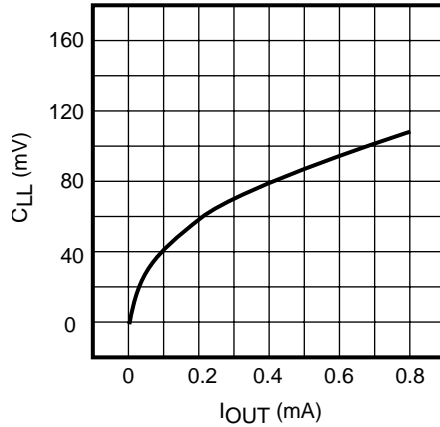
**TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)**

$T_A = 25\text{ }^\circ\text{C}$ ,  $V_{CC} = 3\text{ V}$ ,  $V_{CONT} = 2.4\text{ V}$ ,  $I_{OUT} = 40\text{ }\mu\text{A}$ , unless otherwise specified.

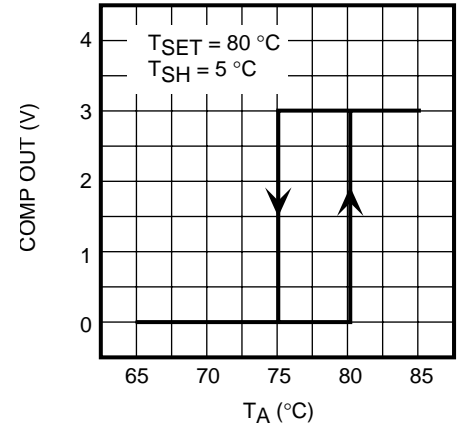
**SUPPLY CURRENT vs. CONTROL VOLTAGE**



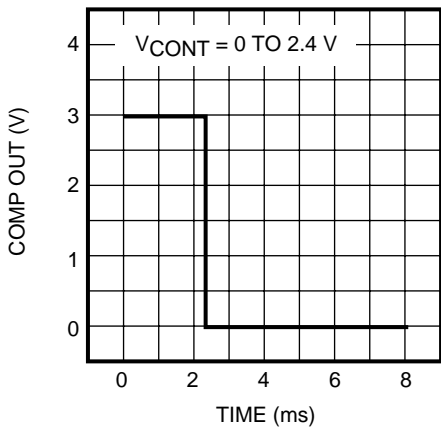
**COMPARATOR OUTPUT (LOW LEVEL) vs. OUTPUT SINK CURRENT**



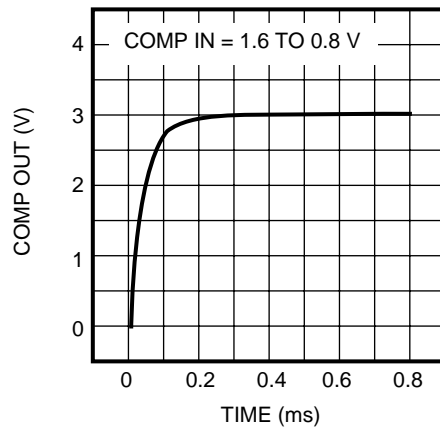
**COMPARATOR OUTPUT vs. TEMPERATURE**



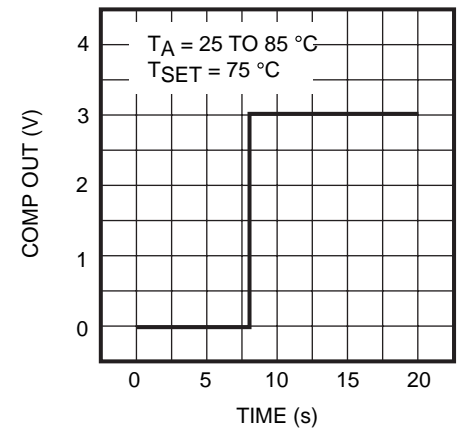
**CONTROL VOLTAGE RESPONSE**



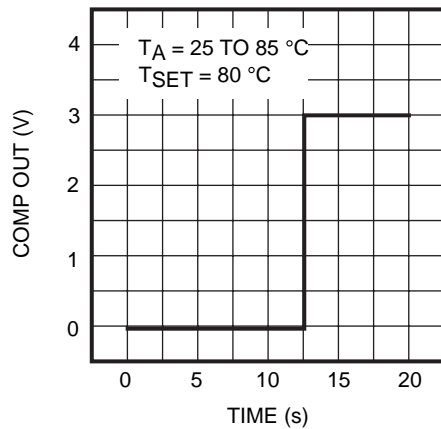
**COMPARATOR INPUT RESPONSE**



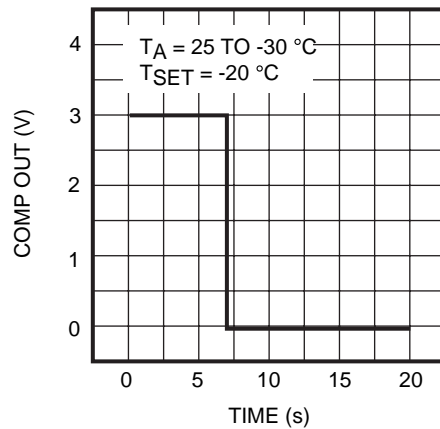
**TEMPERATURE RESPONSE A**



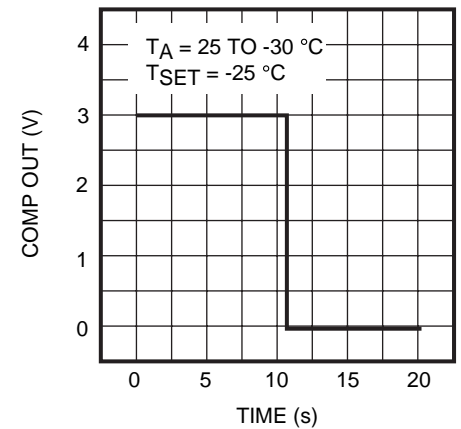
**TEMPERATURE RESPONSE B**



**TEMPERATURE RESPONSE C**



**TEMPERATURE RESPONSE D**



## APPLICATION HINTS

EXTERNAL RESISTORS  $R_1$  AND  $R_2$ 

The temperature set point ( $T_{SET}$ ) and hysteresis ( $T_{SH}$ ) of the TK11050 are easily set by two external resistors  $R_1$  and  $R_2$ . See Figure 1 for clarification of  $T_{SET}$  and  $T_{SH}$ .

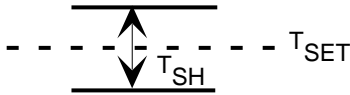


FIGURE 1

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

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

where  $T_{SET}$  is an absolute temperature ( $^{\circ}K$ ).  
That is,  $T_{SET} (^{\circ}K) = ^{\circ}C + 273$   
and  $T_C = 4 \text{ mV}/^{\circ}C$ .

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

$$V_{SET} = \frac{R_2 \times V_{ref}}{R_1 + R_2} - \frac{R_1 \times R_2 \times I_{IB}}{R_1 + R_2} = \frac{R_2}{R_1 + R_2} \times (V_{ref} - R_1 \times I_{IB}) \quad (2)$$

where  $V_{ref} = 1.6 \text{ V}$   
 $I_{IB} = 0.1 \mu\text{A}$

The temperature coefficient ( $T_C$ ) is calculated by Equations 1 and 2, resulting in:

$$T_C = \frac{R_2}{R_1 + R_2} \times \frac{V_{ref} - R_1 \times I_{IB}}{T_{SET}} \quad (3)$$

From Equation 3,  $R_2$  is calculated as follows:

$$R_2 = \frac{T_{SET} \times T_C \times R_1}{V_{ref} - R_1 \times I_{IB} - T_{SET} \times T_C} \quad (4)$$

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

$$V_{SH} = \left( \frac{R_1 \times R_2}{R_1 + R_2} \right) \times (I_{SH} - I_{IB}) \quad (5)$$

where  $I_{SH} = 1.25 \mu\text{A}$

The hysteresis represented as temperature is:

$$T_{SH} = \left( \frac{R_1 \times R_2}{R_1 + R_2} \right) \times \frac{(I_{SH} - I_{IB})}{T_C} \quad (6)$$

Solving for temperature coefficient ( $T_C$ ):

$$T_C = \left( \frac{R_1 \times R_2}{R_1 + R_2} \right) \times \frac{(I_{SH} - I_{IB})}{T_{SH}} \quad (7)$$

Solving for  $R_1$  from Equations 3 and 7:

$$R_1 = \frac{V_{ref} \times T_{SH}}{T_{SET} \times I_{SH} - (T_{SET} - T_{SH}) \times I_{IB}} \quad (8)$$

$R_2$  can now be calculated by substituting  $R_1$  into Equation 4:

Example:

$R_1$  and  $R_2$  when set temperature is  $80^{\circ}C$  ( $T_{SET} = 353^{\circ}K$ ) and temperature hysteresis ( $T_{SH}$ ) is  $5^{\circ}C$ .

$$R_1 = \frac{1.6 \times 5}{353 \times 1.25 \mu - (353 - 5) \times 0.1 \mu}$$

$$R_1 = 19.68 \text{ k} = 20 \text{ k}\Omega$$

$$R_2 = \frac{353 \times 4 \text{ m} \times 19.68 \text{ k}}{1.6 - 19.68 \text{ k} \times 0.1 \mu - 353 \times 4 \text{ m}}$$

$$R_2 = 149.39 \text{ k} = 150 \text{ k}\Omega$$

## APPLICATION HINTS (CONT.)

### 2. For Set Temperatures < 25 °C

$$R_1 = \frac{V_{\text{ref}} \times T_{\text{SH}}}{(T_{\text{SET}} + T_{\text{SH}}) \times I_{\text{SH}} - T_{\text{SET}} \times I_{\text{IB}}} \quad (9)$$

$$R_2 = \frac{T_{\text{SET}} \times T_{\text{C}} \times R_1}{V_{\text{ref}} - R_1 \times I_{\text{SH}} - T_{\text{SET}} \times T_{\text{C}}} \quad (10)$$

Example:

$R_1$  and  $R_2$  when set temperature is -25 °C ( $T_{\text{SET}} = 248$  °K) and temperature hysteresis ( $T_{\text{SH}}$ ) is 5 °C.

$$R_1 = \frac{1.6 \times 5}{(248 + 5) \times 1.25 \mu - 248 \times 0.1 \mu}$$

$$R_1 = 27.45 \text{ k} = 27 \text{ k}\Omega$$

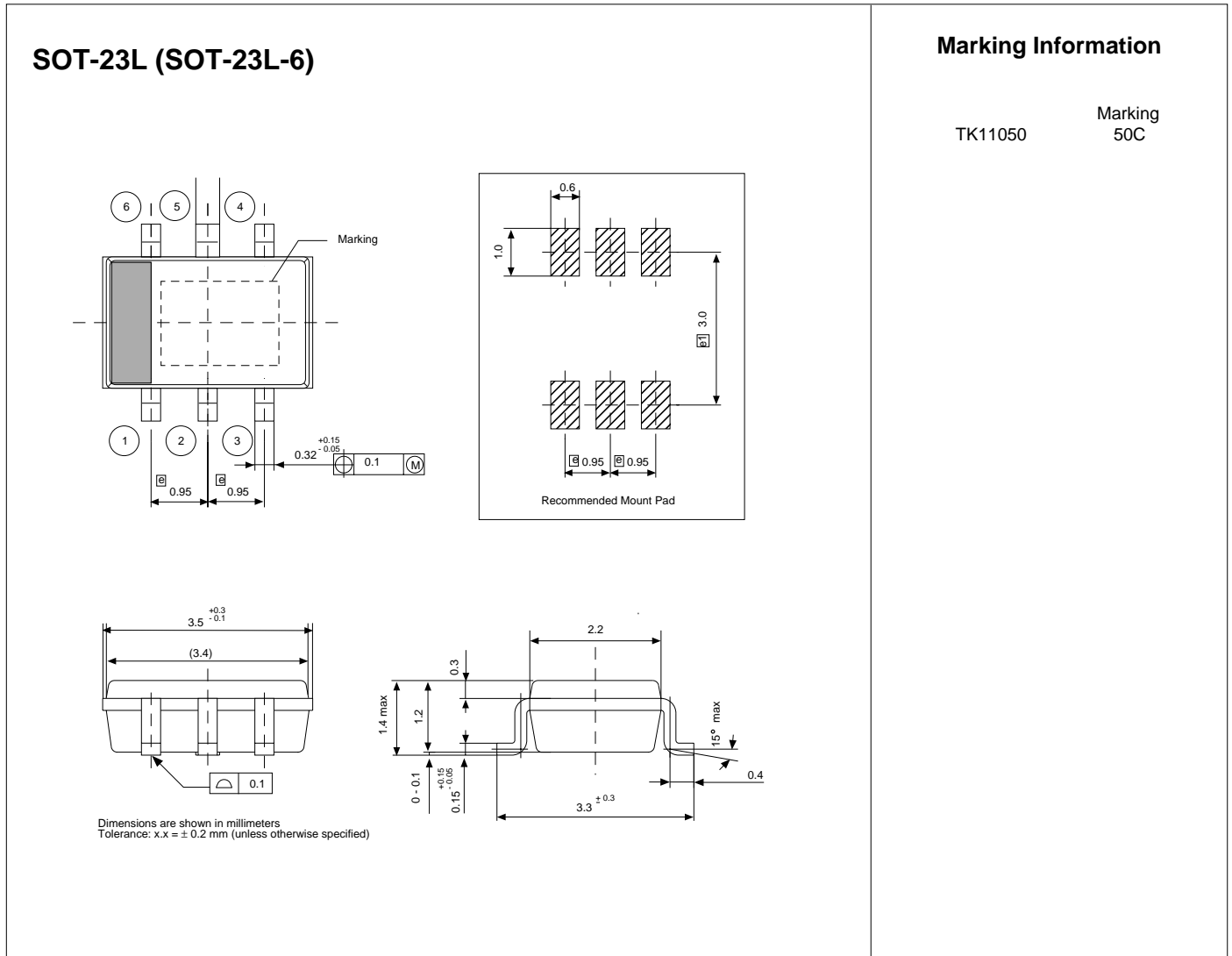
$$R_2 = \frac{248 \times 4 \text{ m} \times 27.45 \text{ k}}{1.6 - 27.45 \text{ k} \times 1.25 \mu - 248 \times 4 \text{ m}}$$

$$R_2 = 47.47 \text{ k} = 47 \text{ k}\Omega$$

### PACKAGE POWER DISSIPATION ( $P_D$ )

The power dissipation rating of 200 mW represents the amount of power the device can dissipate without damage to the IC. Power dissipation should be kept to a minimum to reduce temperature errors due to self-heating.

PACKAGE OUTLINE



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