

TEMPERATURE CONTROLLER IC

FEATURES

- Internal Temperature Sensor, Voltage Reference and Comparator
- Temperature Threshold and Hysteresis Set by Only Two External Resistors
- Output Logic: High to Low 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

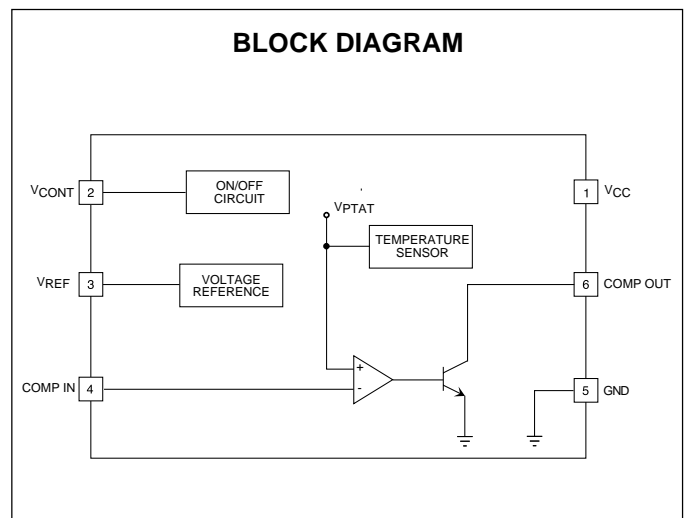
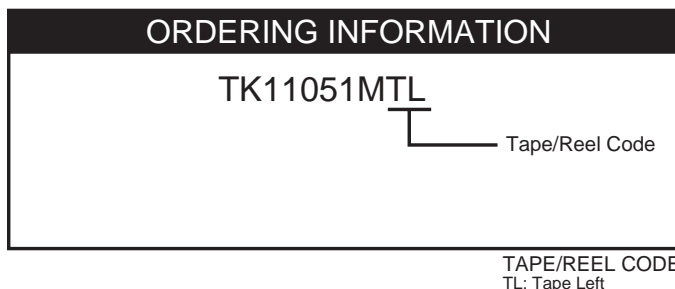
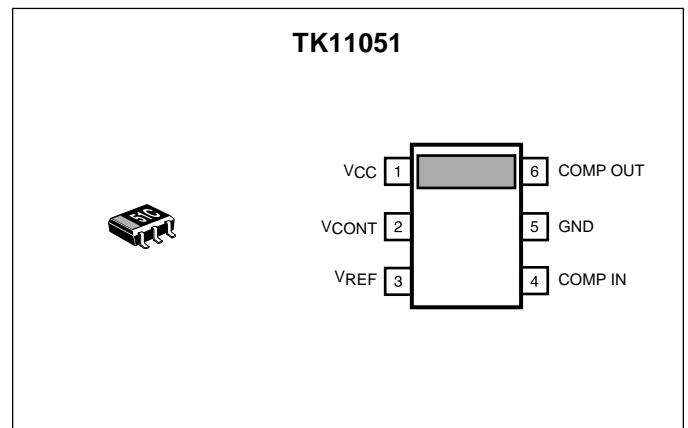
DESCRIPTION

The TK11051 is an accurate temperature controller IC for use over the -30 to +105 °C temperature range. The TK11051 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 TK11051 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



TK11051

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	12 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.

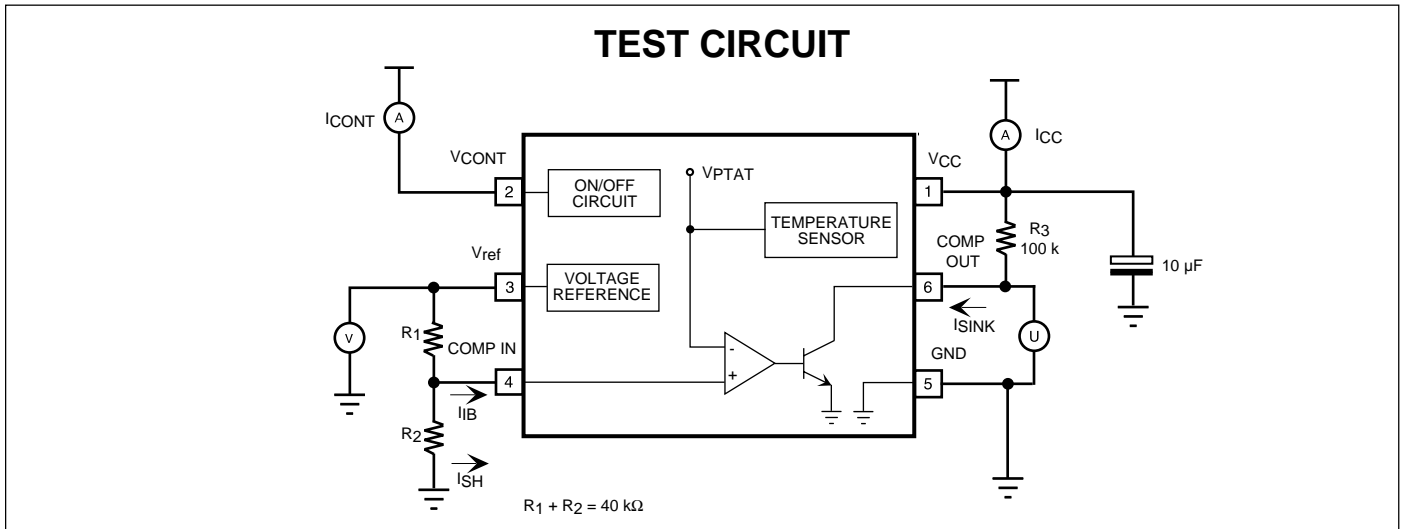
SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
I_{CC}	Quiescent Current	Comparator Output LOW		250	350	μA
		Comparator Output HIGH		210	350	μA
I_{STBY}	Standby Current	$V_{CONT} \leq 0.6\text{ V}$			1	μA
V_{PTAT}	Temperature Sensor Voltage (Note 4)	$T_A = 25\text{ °C}$		1.192		V
		$T_A = 85\text{ °C}$		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	°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	μA
I_{SH}	Hysteresis Set Current	Comparator IN $< V_{PTAT}$	0.9	1.25	1.6	μA
I_{OUT}	Output Sink Current	$C_{LL} \leq 0.3\text{ V}$		30	300	μA
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	μA
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	μA
$V_{CONT(ON)}$	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 μA and I_{SH} is 1.25 μA .

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

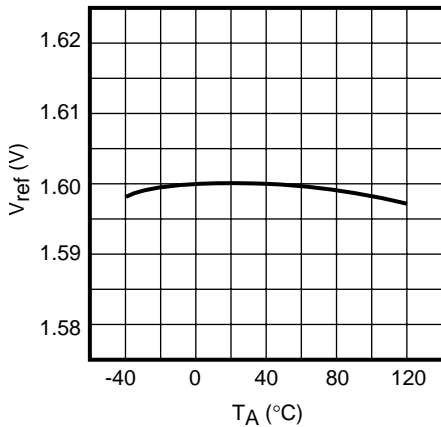
Note 4: V_{PTAT} does not have an output pin.



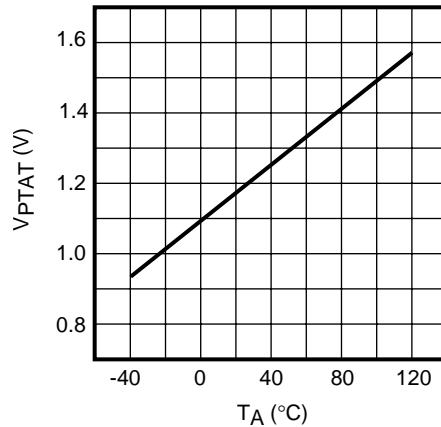
TYPICAL PERFORMANCE CHARACTERISTICS

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

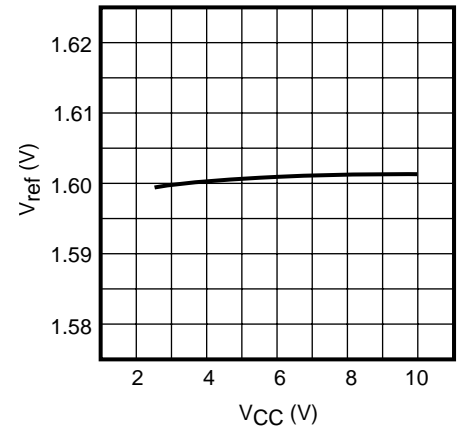
REFERENCE VOLTAGE vs. TEMPERATURE



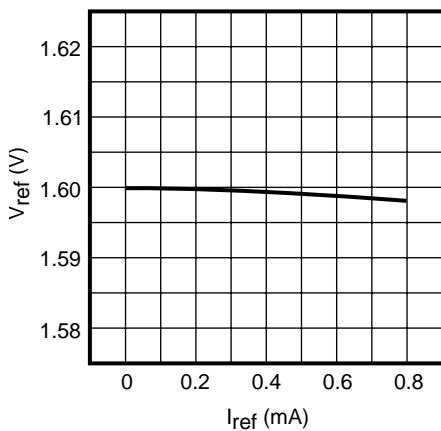
REFERENCE VOLTAGE vs. TEMPERATURE



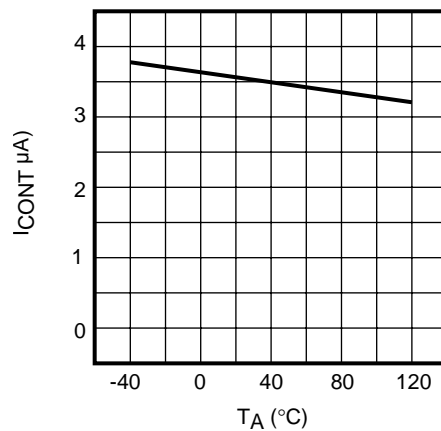
LINE REGULATION



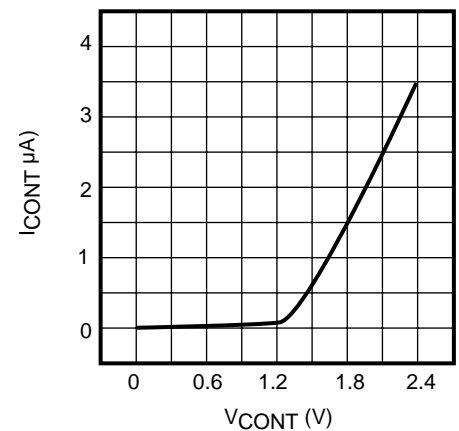
LOAD REGULATION



CONTROL CURRENT vs. TEMPERATURE

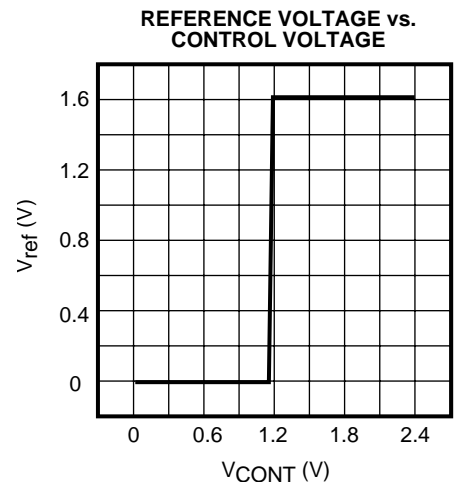
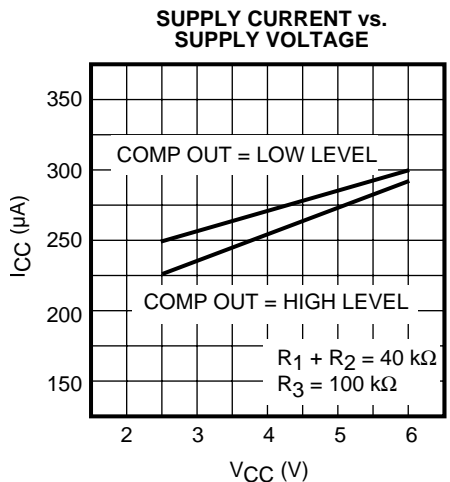
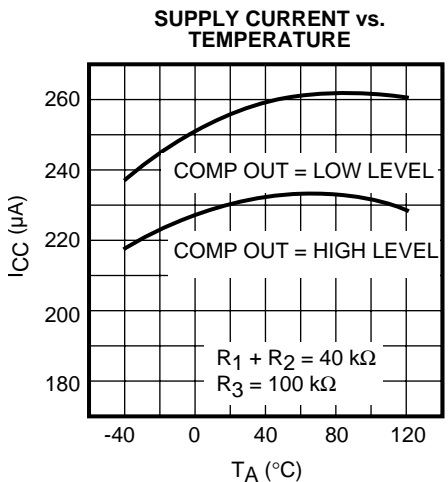
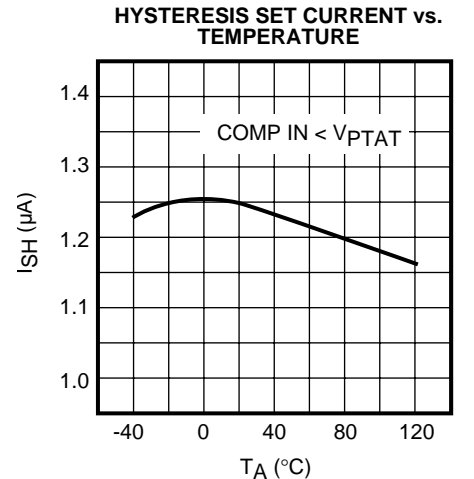
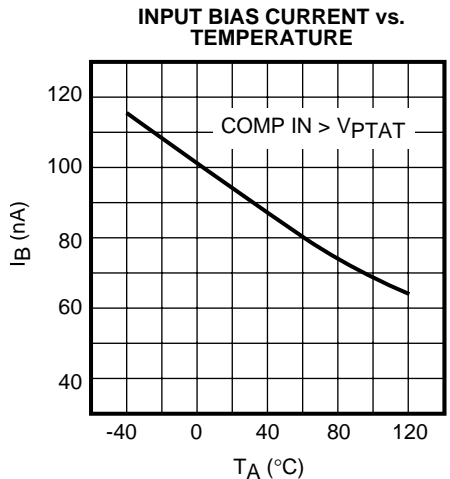
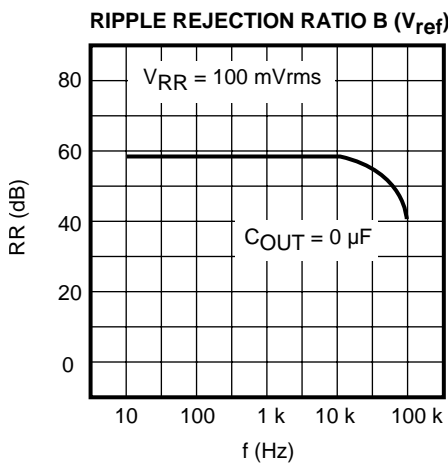
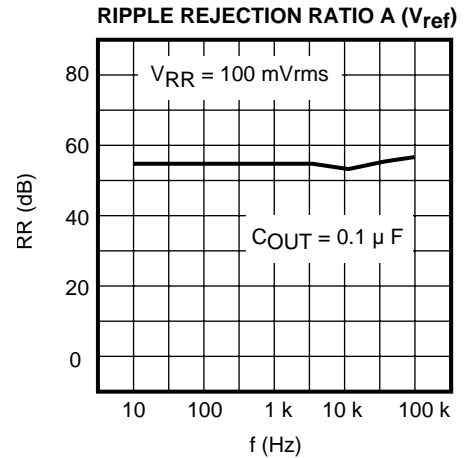
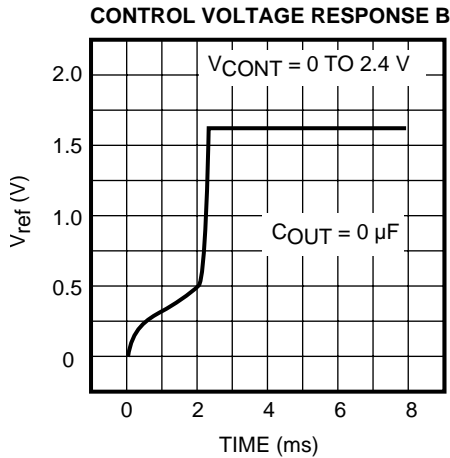
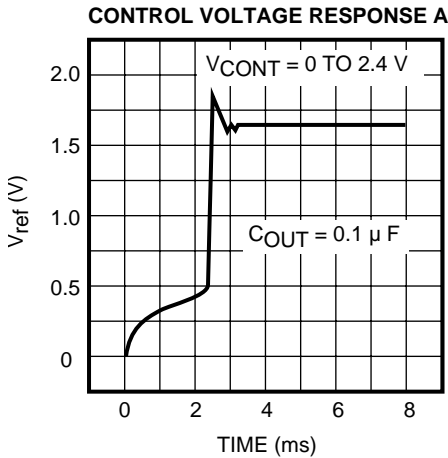


CONTROL CURRENT vs. CONTROL VOLTAGE



TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

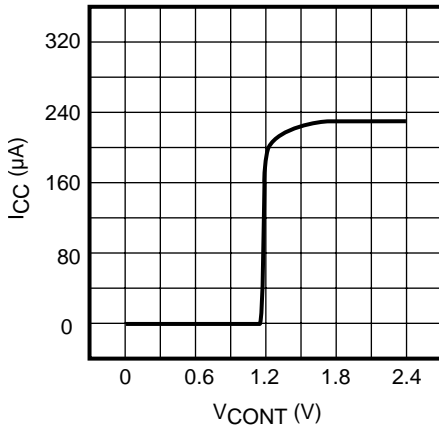
$T_A = 25\text{ }^\circ\text{C}$, $V_{CC} = 3\text{ V}$, $V_{CONT} = 2.4\text{ V}$, $I_{OUT} = 40\text{ }\mu\text{A}$, unless otherwise specified.



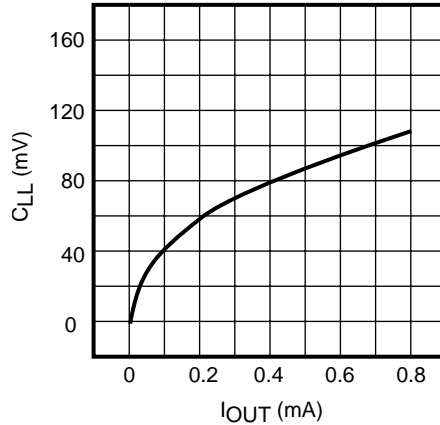
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

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

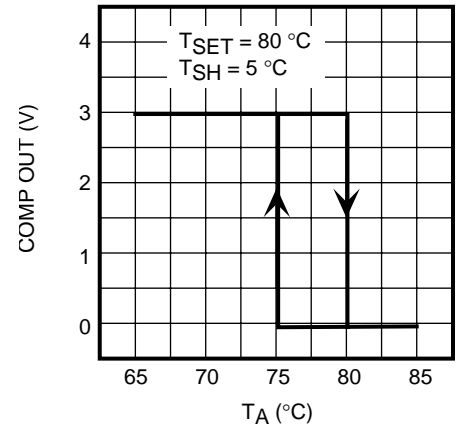
SUPPLY CURRENT vs. CONTROL VOLTAGE



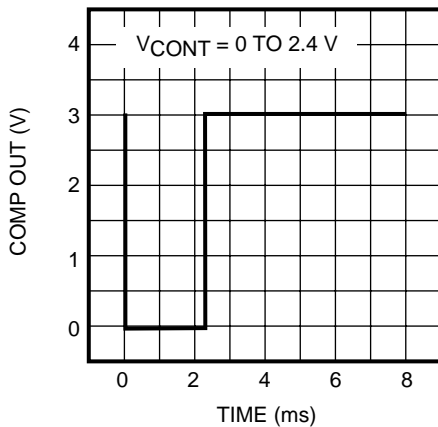
COMPARATOR OUTPUT (LOW LEVEL) vs. OUTPUT SINK CURRENT



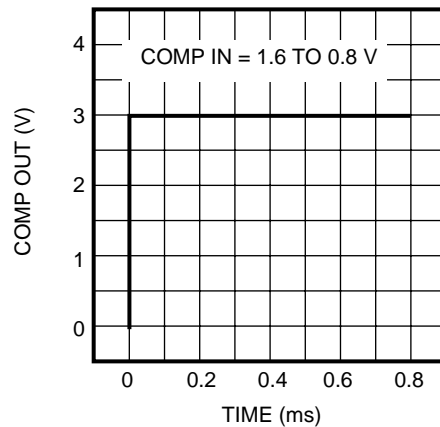
COMPARATOR OUTPUT vs. TEMPERATURE



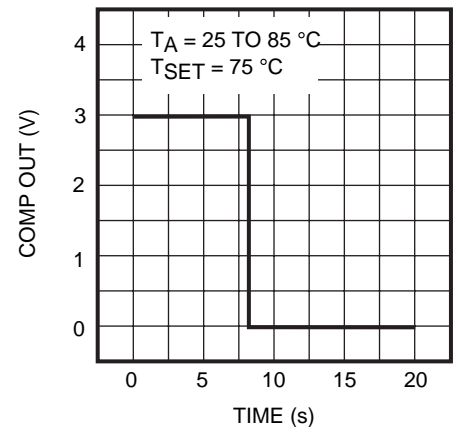
CONTROL VOLTAGE RESPONSE



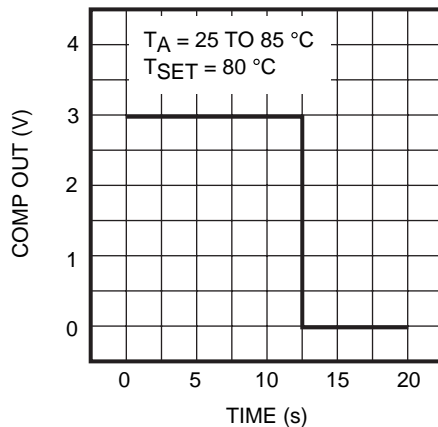
COMPARATOR INPUT RESPONSE



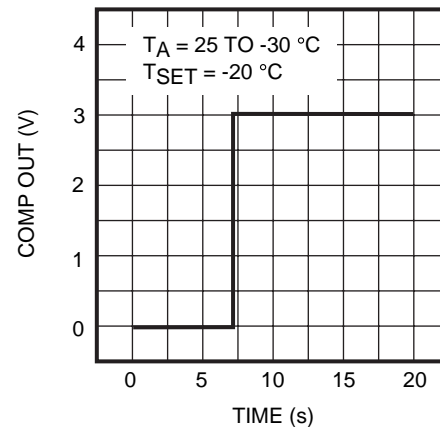
TEMPERATURE RESPONSE A



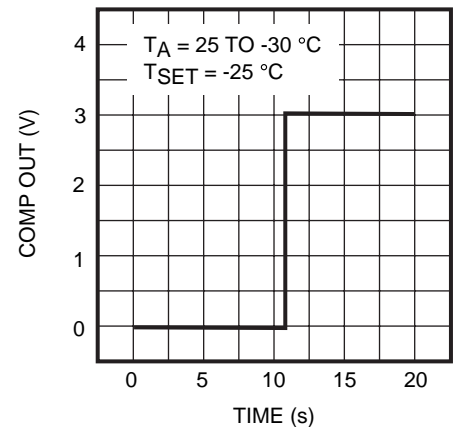
TEMPERATURE RESPONSE B



TEMPERATURE RESPONSE C



TEMPERATURE RESPONSE D



APPLICATION HINTS

EXTERNAL RESISTORS R₁ AND R₂

The temperature set point (T_{SET}) and hysteresis (T_{SH}) of the TK11051 are easily set by two external resistors R₁ and R₂. See Figure 1 for clarification of T_{SET} and T_{SH}.

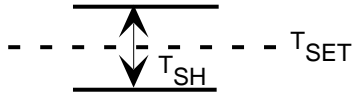


FIGURE 1

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

$$V_{SET} = T_{SET} \times T_C \tag{1}$$

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

1. For Set Temperatures ≥ 25 °C

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

where V_{ref} = 1.6 V
I_{IB} = 0.1 μA

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

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

From Equation 3, R₂ is calculated as follows:

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

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

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

where I_{SH} = 1.25 μA

The hysteresis represented as temperature is:

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

Solving for temperature coefficient (T_C):

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

Solving for R₁ from Equations 3 and 7:

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

R₂ can now be calculated by substituting R₁ into Equation 4:

Example:

R₁ and R₂ when set temperature is 80 °C (T_{SET} = 353 °K) and temperature hysteresis (T_{SH}) is 5 °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

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

(9)

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

(10)

Example:

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

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

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

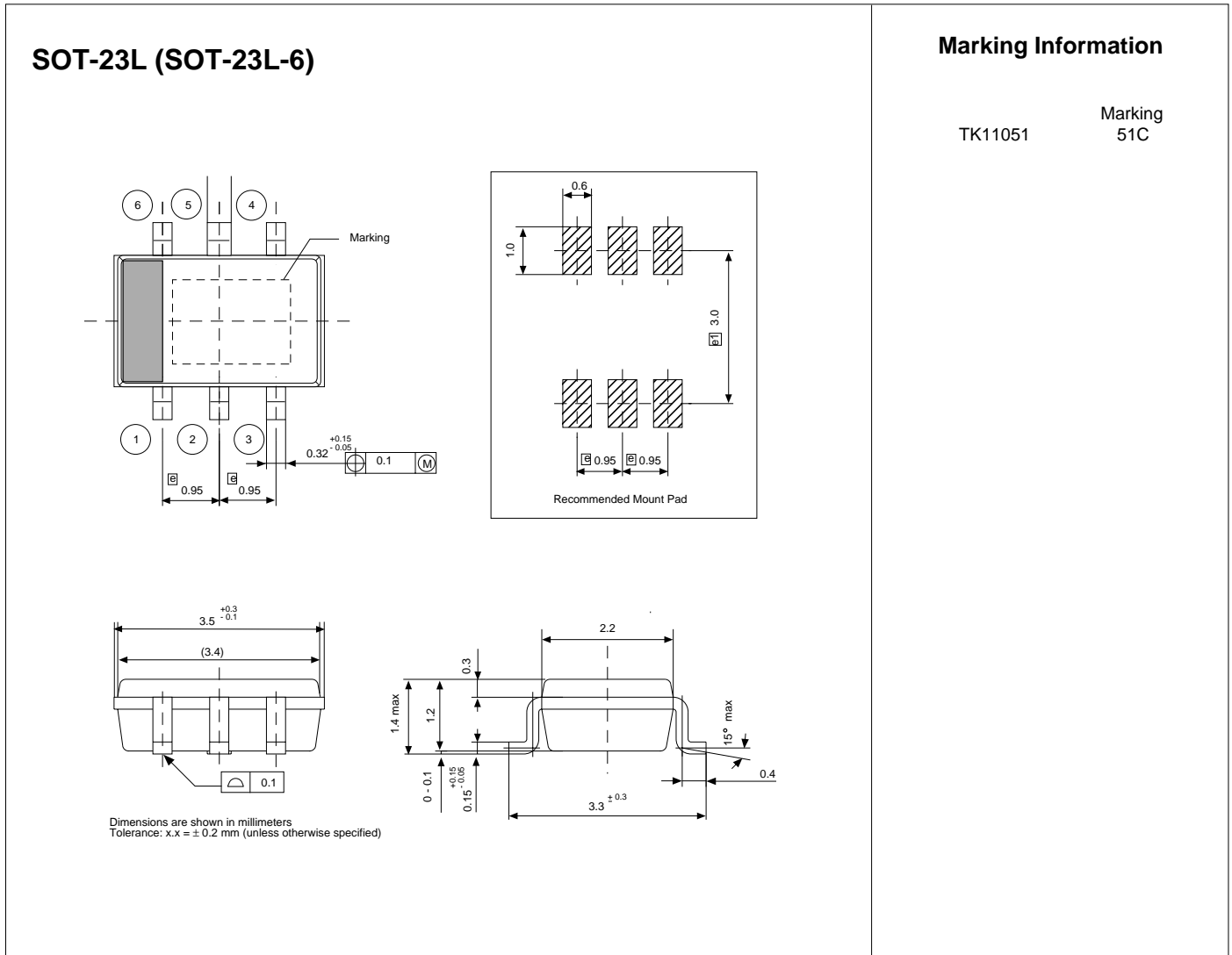
$$R_2 = \frac{248 \times 4 \text{ m} \times 27.45 \text{ k}}{1.6 - 27.45 \text{ k} \times 1.25 \mu - 248 \times 4 \text{ m}}$$

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

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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