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**

APPLICATIONS

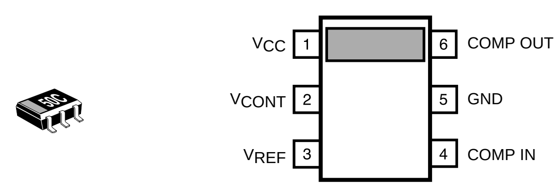
- **Home and Industrial Thermostats**
- **Home Appliance Temperature Control**
- **Notebook Computer Temperature Monitor**
- **Pentium Processor Temperature Monitor**
- **Power Supply Overtemperature Protection**
- **Copy Machine Overtemperature Protection**
- **System Overtemperature Protection**

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.

TK11050

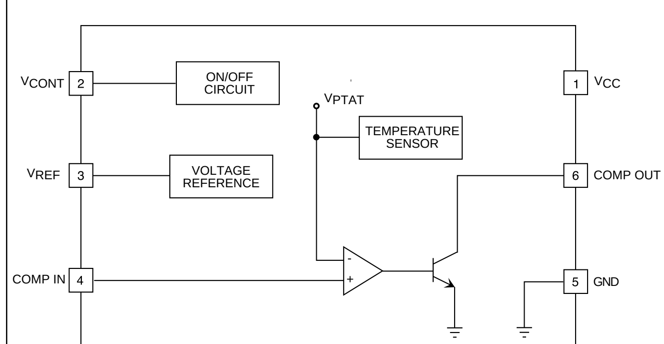


ORDERING INFORMATION

TK11050MTL — Tape/Reel Code

TAPE/REEL CODE
TL: Tape Left

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... 10 V
Power Dissipation (Note 1) .... 200 mW
Storage Temperature Range .... -55 to +150 °C
Operating Temperature Range ....-30 to +105 °C
Operating Voltage Range................................. 2.7 to 6 V
Junction Temperature .... 150 °C
Lead Soldering Temperature (10 s) .... 235 °C

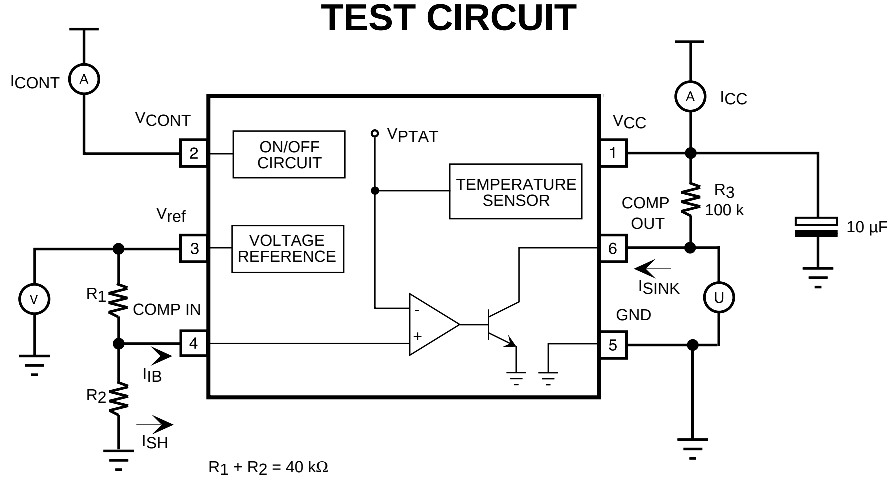
TK11050 ELECTRICAL CHARACTERISTICS

Test conditions: T_A = 25 °C, V_{CC} = 3.0 V, V_{CONT} = 2.4 V, I_{OUT} = 40 µA, R_3 = 100 kΩ, 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	$V_{CONT} \le 0.6$ V			1	µA
V_{PTAT}	Temperature Sensor Voltage (Note 4)	T_A = 25 ° C		1.192		V
		T_A = 85 ° C		1.432		V
		T_A = -30 ° C		0.972		V
T_C	Temperature Coefficient	T_A = 0 to 85 ° C		4.0		mV/° C
T_{ERR}	Temperature Error	T_A = 0 to 85 ° C, (Note 2)	-4.0	0	4.0	° C
C_{LH}	Comparator Output HIGH	(Note 3)	2.8			V
C_{LL}	Comparator Output LOW	$R_3 \ge$ 10 kΩ, (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	$C_{LL} \le 0.3$ V		30	300	µA
V_{ref} TERMINAL CHARACTERISTICS						
V_{ref}	Reference Voltage	T_A = 25 ° C		1.6		V
I_{ref}	Reference Output Current	$R_1 + R_2$ = 40 kΩ		40	500	µA
Line Reg	Line Regulation	V_{CC} = 3 to 6 V		2	8	mV
Load Reg	Load Regulation	I_{OUT} = 0 to 500 µA		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

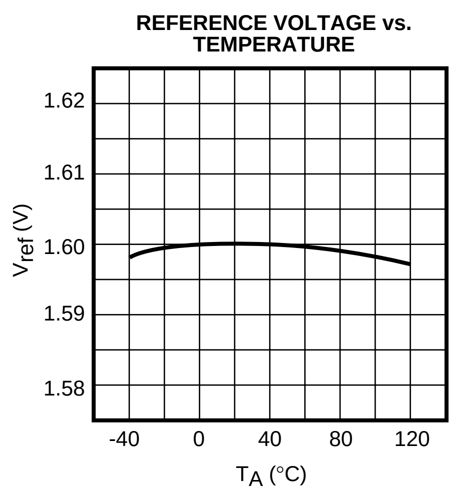
Note 1: Power dissipation is 200 mW when in Free Air. Derate at 1.6 mW/°C for operation above 25 °C.
Note 2: The resistance values of R_1 and R_2 can be calculated as follows: $R_1 = V_{ref} \times T_{SH} / (T_{SET} \times I_{SH} - (T_{SET} - T_{SH}) \times I_{IB})$, $R_2 = T_{SET} \times T_C \times R_1 / (V_{ref} - R_1 \times I_{IB} - T_{SET} \times T_C)$. I_{IB} is 0.1 µA and I_{SH} is 1.25 µA.
Note 3: When V_{PTAT} < COMP IN, COMP OUT < 0.3 V (Low Level). When V_{PTAT} > COMP IN, COMP OUT > 2.8 V (High Level).
Note 4: V_{PTAT} does not have an output pin.

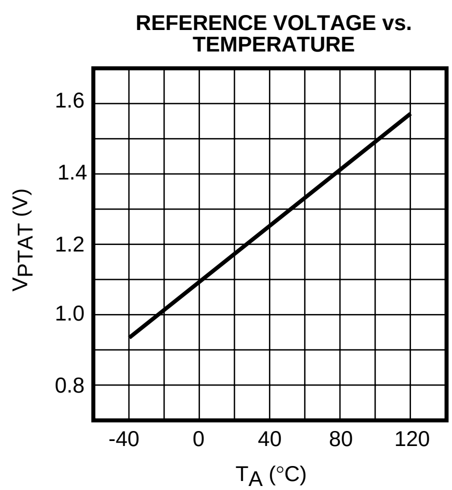
TEST CIRCUIT

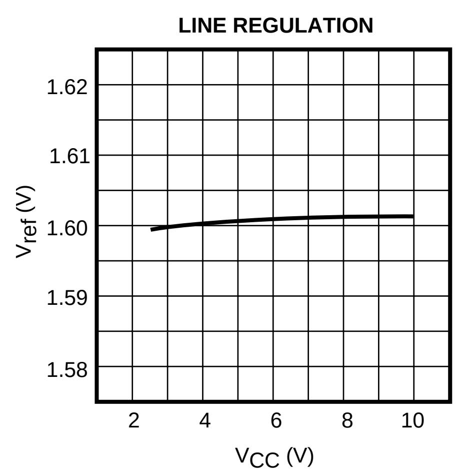


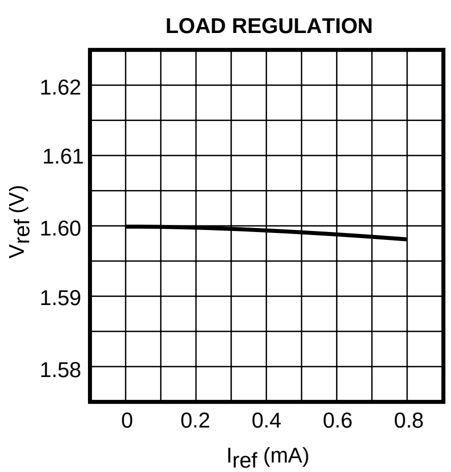
TYPICAL PERFORMANCE CHARACTERISTICS

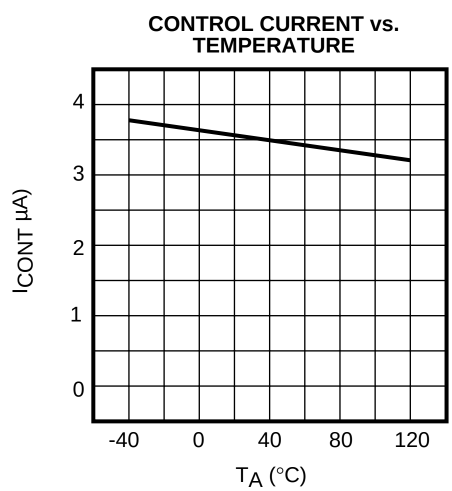
T_A = 25 °C, V_{CC} = 3 V, V_{CONT} = 2.4 V, I_{OUT} = 40 µA, unless otherwise specified.

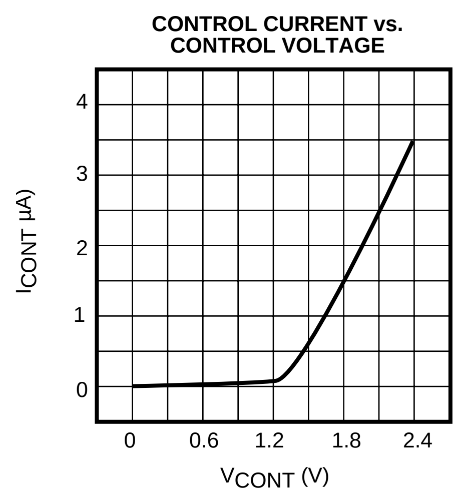








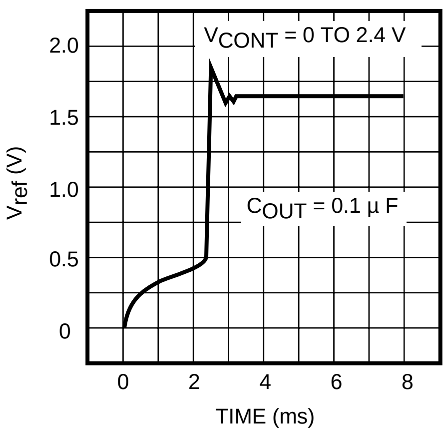




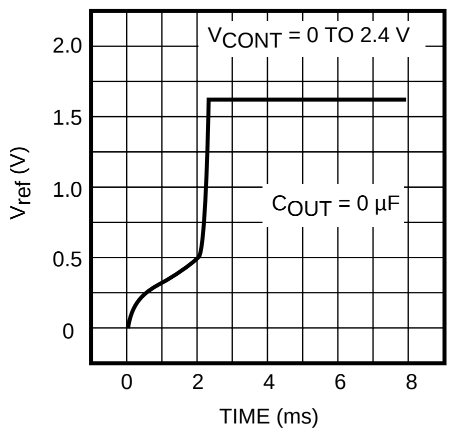
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

T_A = 25 °C, V_{CC} = 3 V, V_{CONT} = 2.4 V, I_{OUT} = 40 µA, unless otherwise specified.

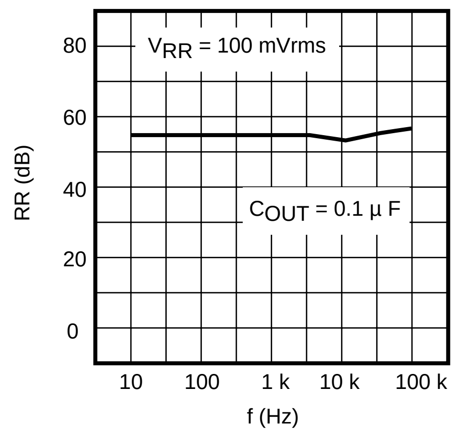
CONTROL VOLTAGE RESPONSE A



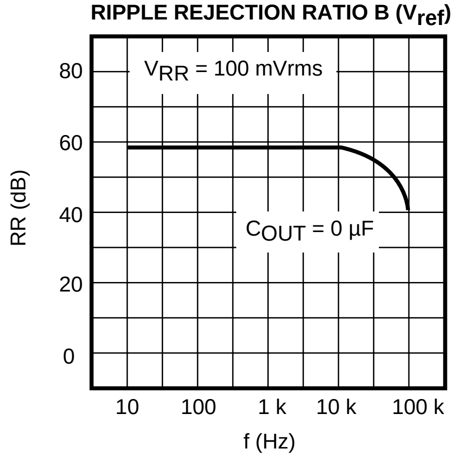
CONTROL VOLTAGE RESPONSE B



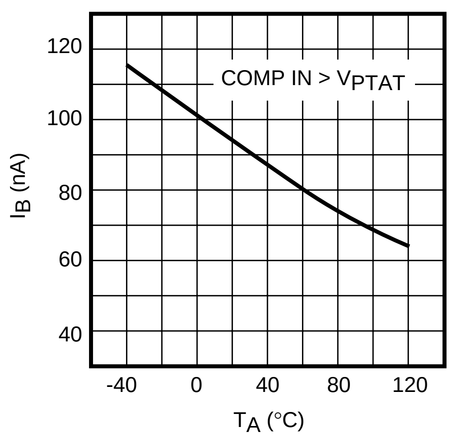
RIPPLE REJECTION RATIO A (V_{ref})



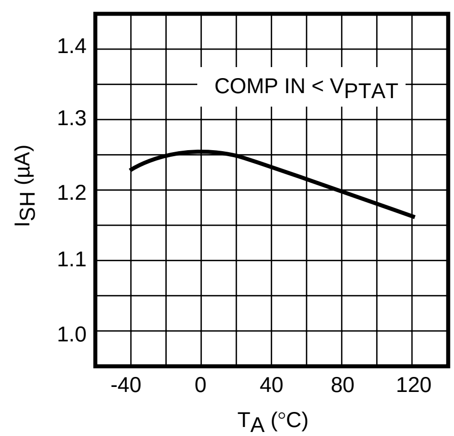
RIPPLE REJECTION RATIO B (V_{ref})



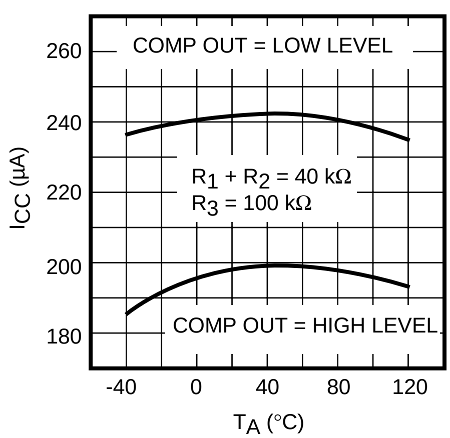
INPUT BIAS CURRENT vs. TEMPERATURE



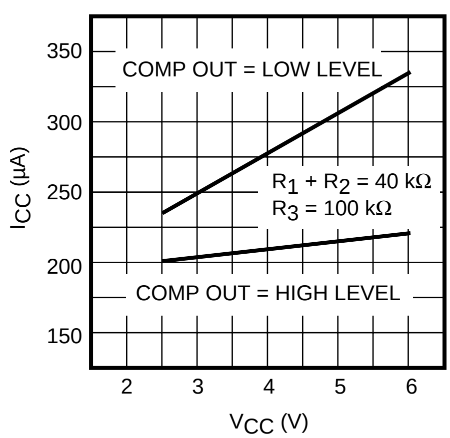
HYSTERESIS SET CURRENT vs. TEMPERATURE



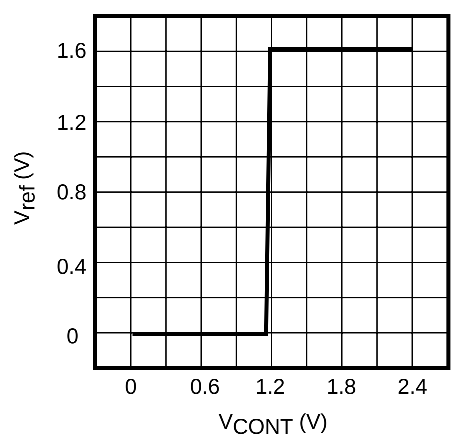
SUPPLY CURRENT vs. TEMPERATURE



SUPPLY CURRENT vs. SUPPLY VOLTAGE



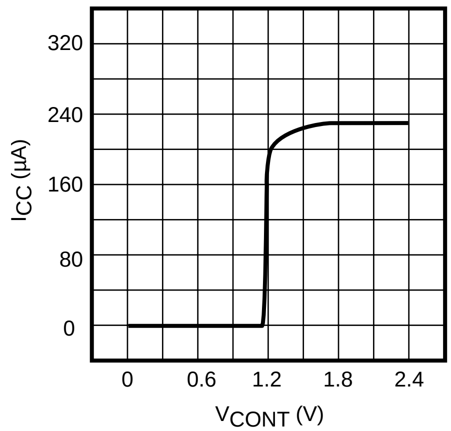
REFERENCE VOLTAGE vs. CONTROL VOLTAGE



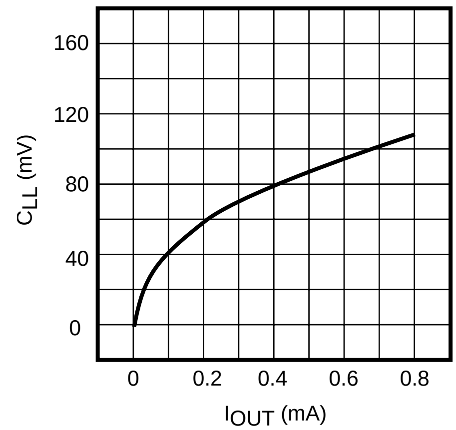
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

T_A = 25 °C, V_{CC} = 3 V, V_{CONT} = 2.4 V, I_{OUT} = 40 µA, unless otherwise specified.

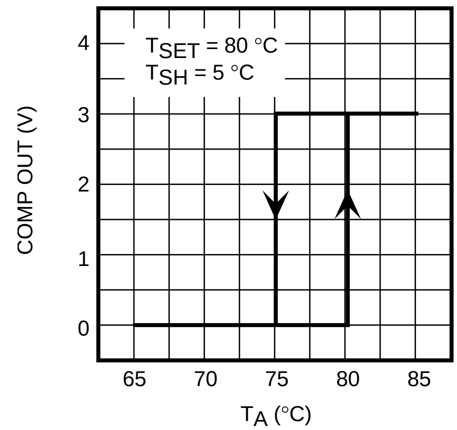
SUPPLY CURRENT vs. CONTROL VOLTAGE



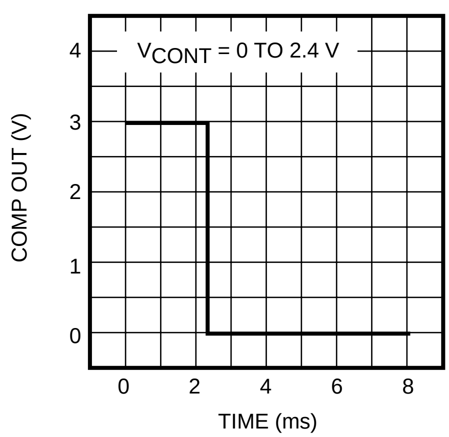
COMPARATOR OUTPUT (LOW LEVEL) vs. OUTPUT SINK CURRENT



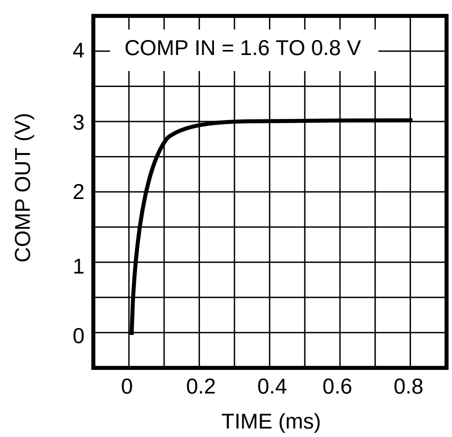
COMPARATOR OUTPUT vs. TEMPERATURE



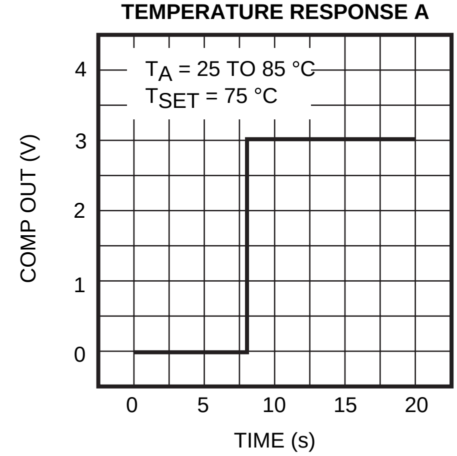
CONTROL VOLTAGE RESPONSE



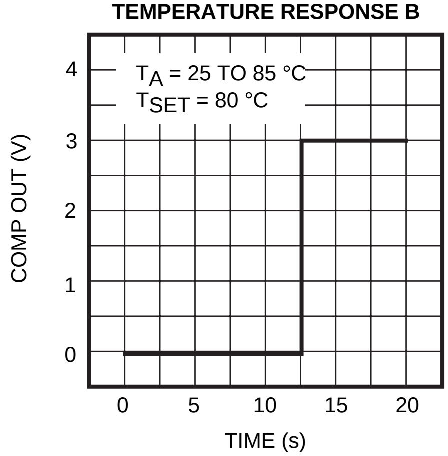
COMPARATOR INPUT RESPONSE



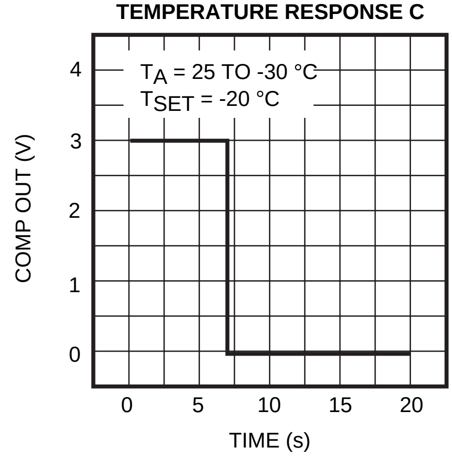
TEMPERATURE RESPONSE A



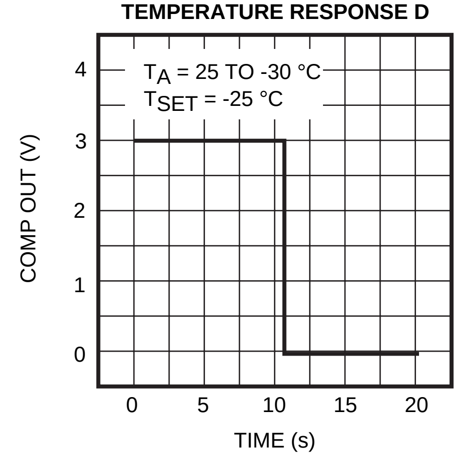
TEMPERATURE RESPONSE B



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}.

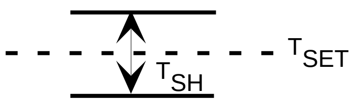


FIGURE 1

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

1. For Set Temperatures ≥ 25 °C

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

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:

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

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 µA

The hysteresis represented as temperature is:

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

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 °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

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

(9)

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

(10)

Example:

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

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

$$R_1 = 27.45\ k = 27\ k\Omega$$

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

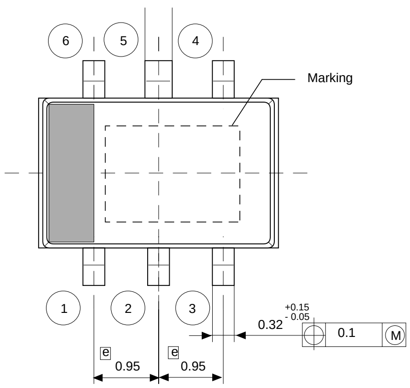
$$R_2 = 47.47\ k = 47\ k\Omega$$

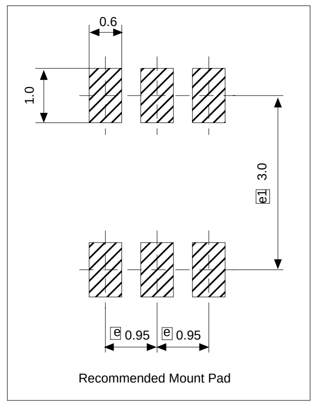
PACKAGE POWER DISSIPATION (P_D)

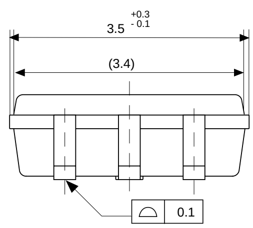
The power dissipation rating of 200 mW represents the amount of power the device can dissipate without damage to the IC. Power dissipation should be kept to a minimum to reduce temperature errors due to self-heating.

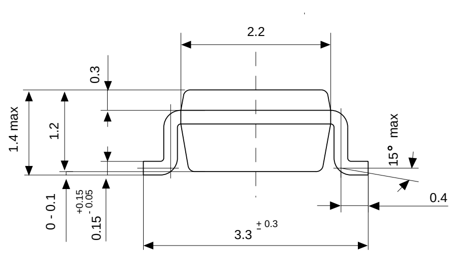
PACKAGE OUTLINE

SOT-23L (SOT-23L-6)









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

Marking Information

	Marking
TK11050	50C

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