Resistor-Programmable SOT Temperature Switches

General Description

The MAX6509/MAX6510 are fully integrated, resistor-programmable temperature switches with thresholds set by an external resistor. They require only one external resistor to set the temperature threshold within a wide -40°C to +125°C temperature range. The MAX6509 provides an open-drain output. The MAX6510 features three selectable output options: active-low, active-high, and open drain with an internal pull-up resistor.

These switches operate with a +2.7V to +5.5V single supply while providing a temperature threshold accuracy of ±0.5°C (typ) or ±4.7°C (max). They typically consume 32µA supply current. Hysteresis is pin selectable to 2°C or 10°C.

The MAX6509/MAX6510 re available in 5-pin and 6-pin SOT23 packages, respectively.

Applications

- µP Temperature Monitoring in High-Speed Computers
- Temperature Control
- Temperature Alarms
- Fan Control

Features

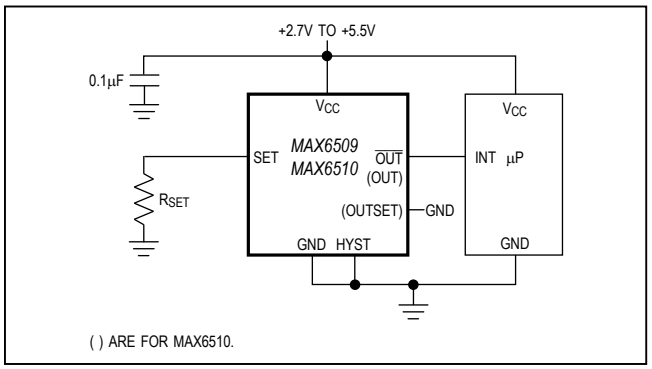
- ±0.5°C Threshold Accuracy
- ±4.7°C (max) Threshold Accuracy (-40°C to +125°C)
- Temperature Threshold Set by a 1% External Resistor
- Set-Hot or Set-Cold Option
- Low 32µA Supply Current
- Open-Drain, Push-Pull Outputs; Open-Drain with Internal Pull-Up Resistor
- Pin-Selectable 2°C or 10°C Hysteresis
- SOT23 Packages

Ordering Information

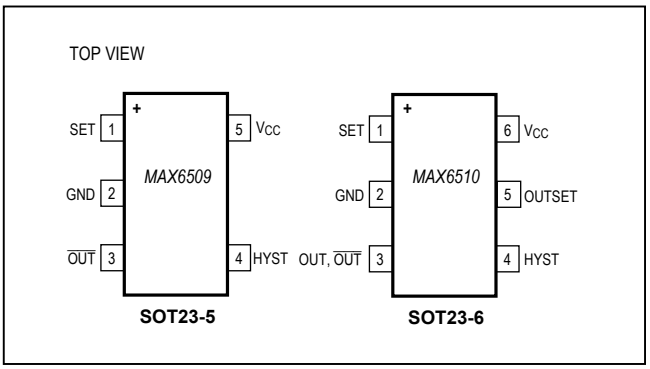
PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX6509CAUK+T	-40°C to +125°C	5 SOT23-5	ADNT
MAX6509HAUK+T	-40°C to +125°C	5 SOT23-5	ADNU
MAX6510CAUT+T**	-40°C to +125°C	6 SOT23-6	AAHA
MAX6510HAUT+T**	-40°C to +125°C	6 SOT23-6	AAHB

+Denotes a lead(Pb)-free/RoHS-compliant package.
**A minimum order of 2500 pc. is required for SOT packages.*
***See Table 1 for selectable output options.*

Typical Operating Circuit



Pin Configurations



maxim integrated™

Absolute Maximum Ratings

Reference to GND Supply Voltage (V_{CC}) ..... -0.3V to +6V
$\overline{OUT}$ (MAX6509) ..... -0.3V to +6V
$\overline{OUT}$, OUT (MAX6510) ..... -0.3V to (V_{CC} + 0.3V)
SET, HYST, OUTSET ..... -0.3V to (V_{CC} + 0.3V)
Output Current (all pins) 20mA
Input Current (all pins) 20mA

Continuous Power Dissipation (T_A = +70°C)
5-Pin SOT23 (derate 7.1mW/°C above +70°C) 571mW
6-Pin SOT23 (derate 8.7mW/°C above +70°C) 696mW
Operating Temperature Range ..... -40°C to +125°C
Junction Temperature ..... +150°C
Storage Temperature Range ..... -65°C to +150°C
Soldering Temperature (reflow) ..... +260vC
Lead Temperature (soldering, 10s) ..... +300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

(V_{CC} = +2.7V to +5.5V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

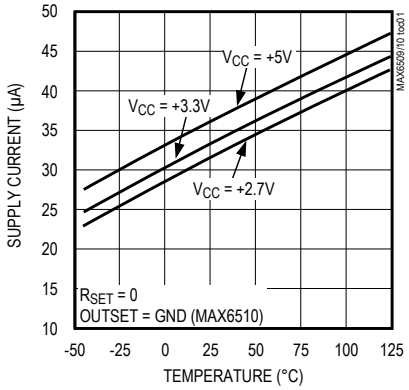
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}			2.7		5.5	V
Supply Current	I_{CC}	MAX6509			32	50	µA
		OUTSET = GND or V_{CC} (MAX6510)			47	80	
		OUTSET = unconnected, OUT = low			97	165	
Temperature Threshold Accuracy	ΔT_{TH}	T_A = 0°C to +125°C			±0.5	±4.7	°C
		T_A = -40°C to 0°C			±0.5	±3.7	
Temperature Threshold Hysteresis	T_{HYST}	HYST = GND			2		°C
		HYST = V_{CC}			10		
HYST Input Leakage					1		µA
HYST Input Threshold	V_{IH}				V_{CC} - 0.4		V
	V_{IL}				0.4		
OUT Impedance to V_{CC}		OUTSET = unconnected (MAX6510)		60	100	160	kΩ
Output Voltage High	V_{OH}	I_{OUT} = 5mA, OUTSET = GND or V_{CC}			V_{CC} - 0.4		V
Output Voltage Low	V_{OL}	I_{OUT} = 5mA				0.3	V
Open-Drain Output Leakage Current	I_{OUT}	V_{OUT} = V_{CC} (MAX6509)				10	µA
OUTSET Voltage	V_{OUTSET}	MAX6510	OUT, active low			0.2 · V_{CC}	V
			OUT, active high	0.85 · V_{CC}			
			OUT, open drain	0.72 · VCC		0.55 · V_{CC}	
OUTSET Current	I_{OUTSET}	MAX6510	V_{OUTSET} = GND		-5.5		µA
			V_{OUTSET} = V_{CC}		5.5		
			OUTSET = unconnected		±0.1		

Note 1: 100% production tested at T_A = +25°C. Specifications over temperature limits are guaranteed by design.

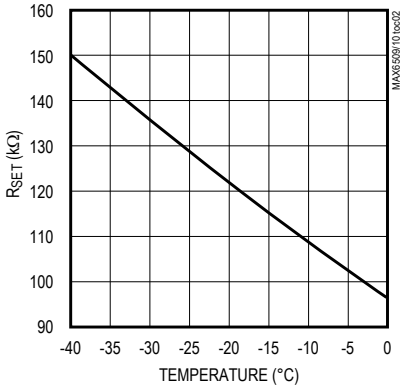
Typical Operating Characteristics

(V_{CC} = +5V, $R_{PULL-UP}$ = 10kΩ (MAX6509 only), T_A = +25°C, unless otherwise noted.)

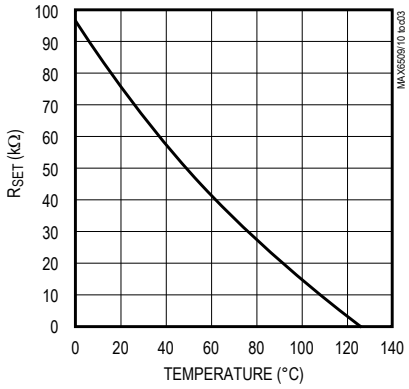
SUPPLY CURRENT vs. TEMPERATURE



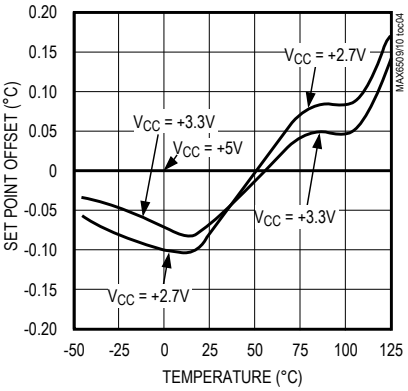
RSET vs. TEMPERATURE (TA = -40°C TO 0°C)



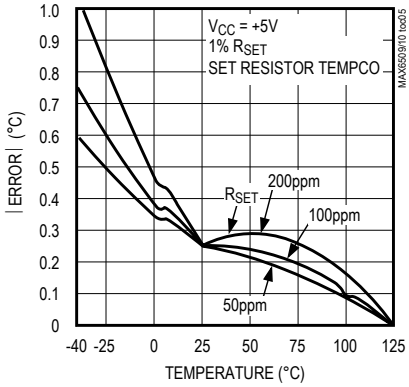
RSET vs. TEMPERATURE (TA = 0°C TO +125°C)



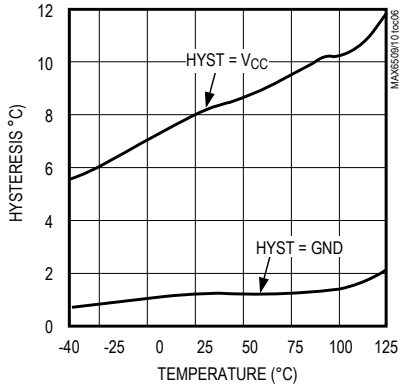
TRIP THRESHOLD OFFSET vs. TEMPERATURE



TRIP POINT ERROR vs. SET TEMPERATURE



HYSTERESIS vs. TEMPERATURE



Pin Description

PIN		NAME	FUNCTION
MAX6509	MAX6510		
1	1	SET	Temperature Set Point. Connect an external 1% resistor from SET to GND to set trip point.
2	2	GND	Ground
3	—	$\overline{OUT}$	Open-Drain Output. Reset to high impedance during power-on.
—	3	OUT, $\overline{OUT}$	Open-Drain with Internal Pull-Up Resistor, Active-High, or Active-Low Output. See Table 1. Reset to deassert during power-on.
4	4	HYST	Hysteresis Selection. Hysteresis is 10°C for HYST = V_{CC} , 2°C for HYST = GND.
5	6	V_{CC}	Power-Supply Input
—	5	$\overline{OUTSET}$	Trilevel Control Input: OUTSET = V_{CC} sets OUT to active high. OUTSET = GND sets OUT to active low. OUTSET = Unconnected sets OUT to open drain with internal pull-up resistor.

Detailed Description

The MAX6509/MAX6510 fully integrated temperature switches incorporate two temperature-dependent references and one comparator. One reference exhibits a positive temperature coefficient, and the other has a negative temperature coefficient. The temperature at which the two reference voltages are equal determines the temperature trip point. Pin-selectable 2°C or 10°C hysteresis keeps the output from oscillating when the temperature is close to the threshold. The MAX6509 has an active-low, open-drain output structure that can only sink current. The MAX6510 has three different output options from which to choose (Table 1).

The MAX6509/MAX6510 are programmable for a wide range of temperature thresholds from -40°C to +125°C. The temperature threshold is set by an external resistor between SET and GND. The MAX6509 output easily interfaces with a microprocessor (µP) reset input (Figure 2). The MAX6510 output is intended for applications such as driving a fan control switch (Figure 3).

Table 1. MAX6510 OUTSET-Selectable Outputs

OUTSET	OUT
Connected to VCC	Active high
Connected to GND	Active low
Unconnected	Open drain with internal pull-up resistor

Hysteresis Input

The HYST pin is a CMOS-compatible input that selects hysteresis at either a high level (10°C for HYST = V_{CC}) or a low level (2°C for HYST = GND). Hysteresis prevents the output from oscillating when the temperature is near the trip point. Do not leave HYST unconnected. Connect HYST to GND or V_{CC}. Other input voltages cause increased supply current.

Choose the set-hot temperature (H) or set-cold temperature (C) option to ensure that the trip point is accurate and the hysteresis is in the right direction. A MAX6509 or MAX6510 with the H suffix will first trip at the correct point when temperature is increasing. For example, a MAX6509HAUK+T or MAX6510HAUT+T with its trip point set to 100°C will assert when its temperature rises above +100°C, and will not deassert until its temperature drops below +100°C minus the selected hysteresis value (e.g., +98°C if 2°C hysteresis is chosen). Conversely, if the trip temperature of a MAX6509CAUK+T or MAX6510CAUT+T is -40°C, the output asserts at -40°C as temperature falls, and deasserts when temperature rises above -40°C plus the hysteresis value (e.g., -38°C if 2°C hysteresis is chosen) as shown in Figure 4.

Output Selection

The MAX6509 provides an open-drain output. The MAX6510 features three output options selectable by OUTSET (Table 1).

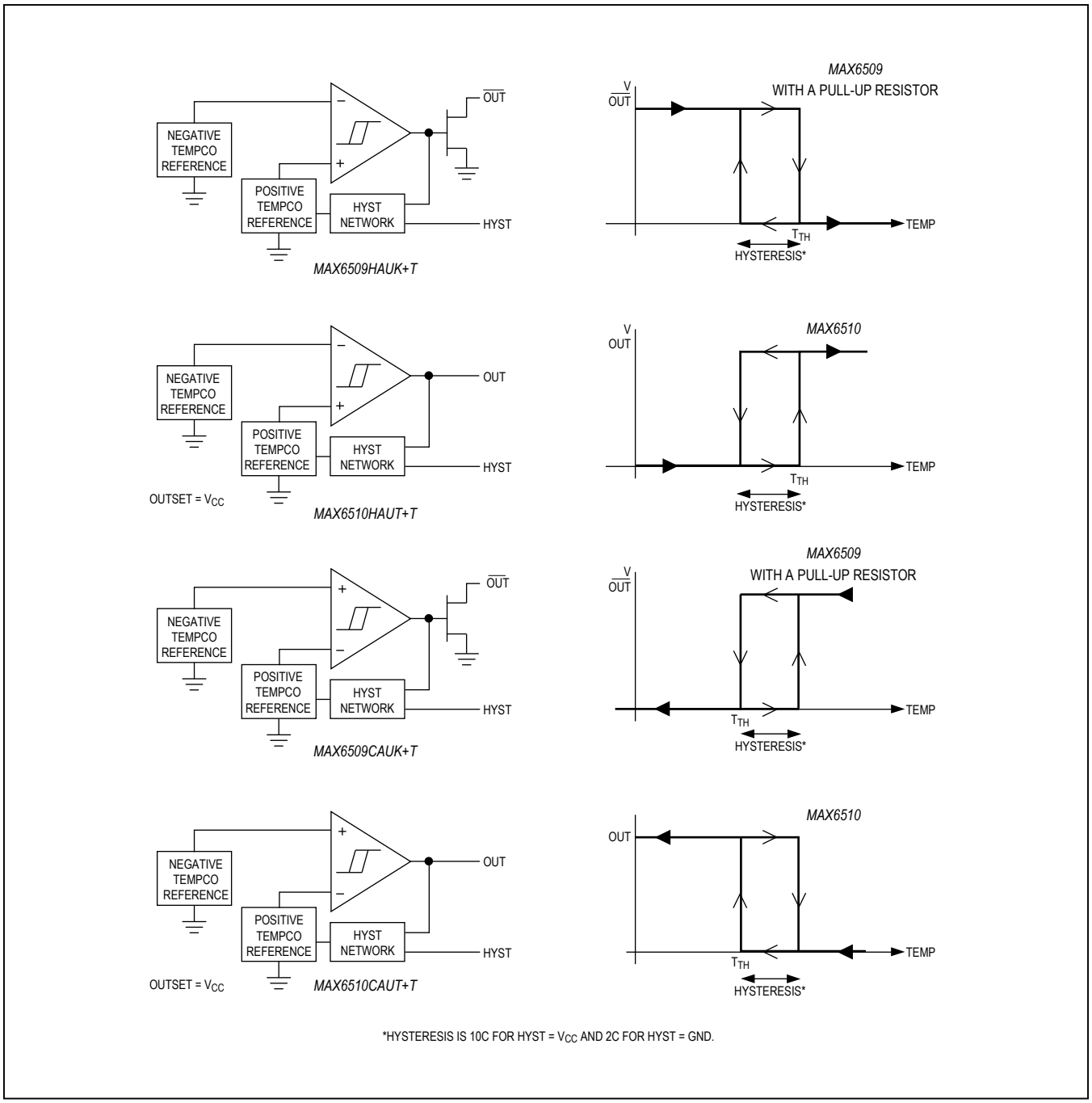


Figure 1. Block and Functional Diagrams

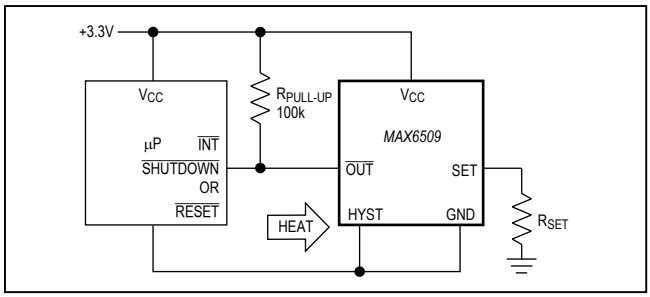


Figure 2. Microprocessor Alarm/Reset

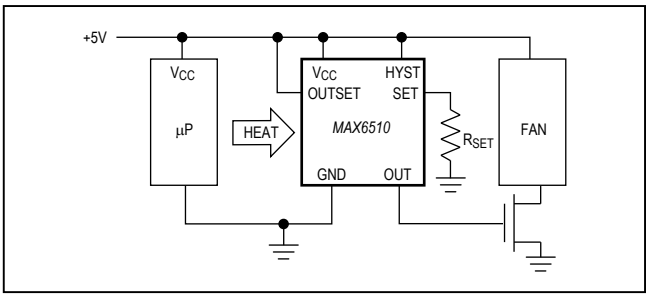


Figure 3. Overtemperature Fan Control

Applications Information

Thermal Considerations

The MAX6509/MAX6510 supply current is typically 32µA. When used to drive high-impedance loads, the devices dissipate negligible power; therefore, the die temperature is essentially the same as the package temperature. The key to accurate temperature monitoring is good thermal contact between the MAX6509/MAX6510 package and the device being monitored. In some applications, the SOT23-5 and SOT23-6 packages may be small enough to fit underneath a socketed ?P, allowing the device to monitor the µP's temperature directly. Use the monitor's output to reset the µP, assert an interrupt, or trigger an external alarm. Accurate temperature monitoring depends on the thermal resistance between the device being monitored and the MAX6509/MAX6510 die.

The rise in die temperature due to self-heating is given by the following formula:

$$\Delta T_J = P_{DISS} \cdot \theta JA$$

where PDISS is the power dissipated by the MAX6509/MAX6510, and qJA is the package's thermal resistance. The typical thermal resistance is 115°C/W for the SOT23-6 package. To limit the effects of self-heating, minimize the output currents. For example, if the MAX6510 sinks 5mA, the output voltage is guaranteed to be less than 0.3V; therefore, an additional 1.5mW of power is dissipated within the IC. This corresponds to a 0.173°C shift in the die temperature in the SOT23-6.

Temperature-Window Detector

The MAX6509/MAX6510 temperature switch outputs assert when the die temperature is outside the programmed range. Combining the outputs of a set-cold and a set-hot device creates an over/undertemperature

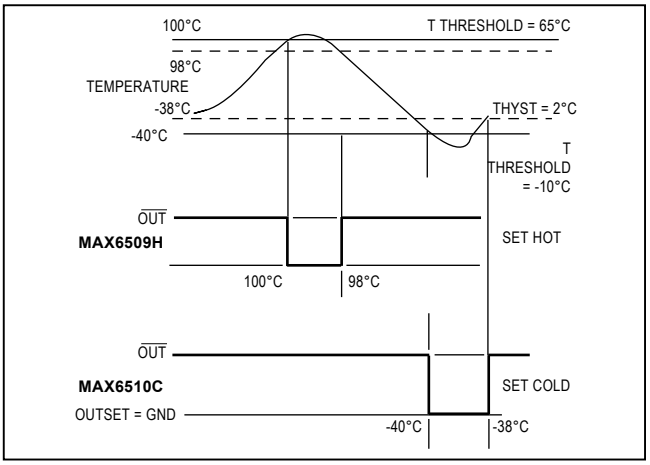


Figure 4. Temperature Response

detector. The MAX6509/MAX6510 are designed to form two complementary pairs, each containing one cold trip point output and one hot trip point output. The assertion of either output alerts the system to an out-of-range temperature. The MAX6510 push-pull output stages can be ORed to produce a thermal out-of-range alarm. More favorably, a MAX6509HAUK+T and MAX6509CAUK+T can be directly wire-ORed with a single external resistor to accomplish the same task (Figure 5).

The temperature window (alarms or detectors as in Figure 5) can be used to accurately determine when a device's temperature falls out of a programmed range, for example -3°C to +75°C as shown in Figure 5. The thermal overrange signal can be used to assert a thermal shutdown, power-up, recalibration, or other temperature-dependent function.

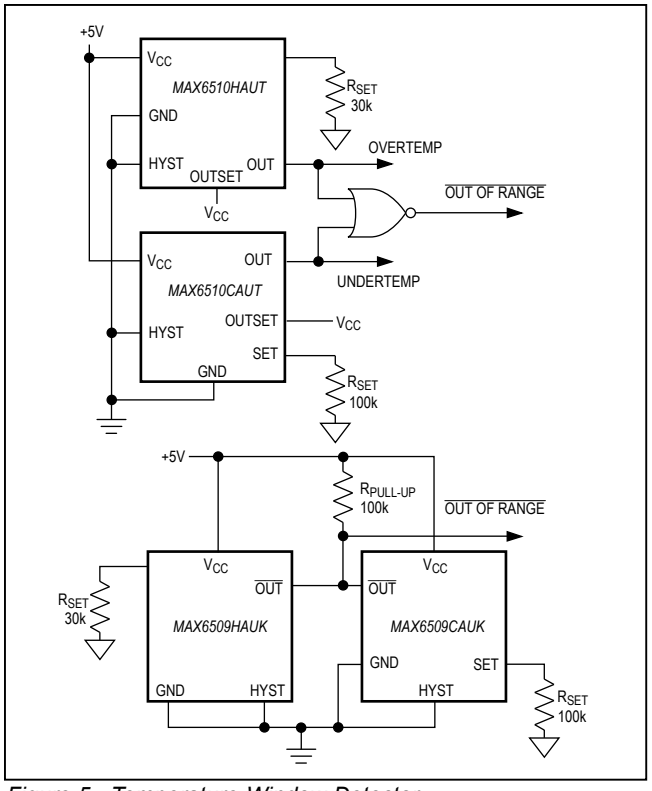


Figure 5. Temperature-Window Detector

Low-Cost, Fail-Safe Temperature Monitor

In high-performance/high-reliability applications, multiple temperature monitoring is important. The high-level integration and low cost of the MAX6509/MAX6510 facilitate the use of multiple temperature monitors to increase system reliability. Figure 6 shows two MAX6510s with different temperature thresholds. This ensures that fault conditions that can overheat the mon-itored device cause no permanent damage. The first temperature monitor activates the fan when the die temperature exceeds +45°C. The second MAX6510 triggers a system shutdown if the die temperature reaches +75°C. The second temperature monitor's output asserts when a wide variety of destructive fault conditions occur, including latchups, short circuits, and cooling-system failures.

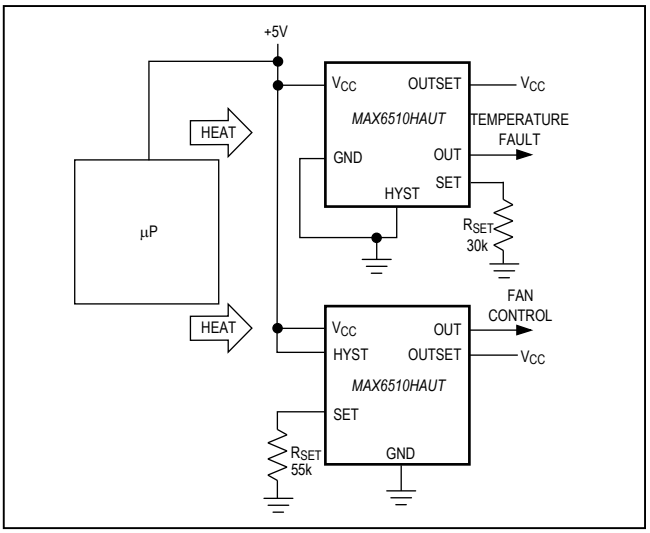


Figure 6. Low-Power, High-Reliability, Fail-Safe Temperature Monitor

Set-Point Resistor

To set the trip-point temperature, connect a resistor between SET and GND. The resistor's value is determined either from the R_{SET} vs. Temperature graphs (see *Typical Operating Characteristics*) or from the equations below.

To set the temperature trip point from -40°C to 0°C, use the following equation:

$$R_{SET}(k\Omega) = [(1.3258 \cdot 10^5) / (T+1.3)] - 310.1693 - [(5.7797 \cdot 10^6) / (T+1.3)^2]$$

To set the temperature trip point from 0°C to +125°C, use the following equation:

$$R_{SET}(k\Omega) = [(8.3793 \cdot 10^4) / T] - 211.3569 + [(1.2989 \cdot 10^5) / T^2]$$

where T is the trip temperature in Kelvin.

Chip Information

TRANSISTOR COUNT: 234

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
5 SOT23	U5+1	21-0057	90-0174
6 SOT23	U6+1	21-0058	90-0175

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
3	5/13	Converted OPNs in *Ordering Information* to lead(Pb)-free	1
4	4/14	No /V OPNs; removed Automotive reference from *Applications* section	1

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at www.maximintegrated.com.

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