



# Local/Remote Temperature Switches in a $\mu$ MAX Package

## General Description

The MAX6687/MAX6688 comprise a remote-junction temperature switch and a local temperature switch in a single package. The remote-junction switch uses an external P-N junction (typically a diode-connected transistor on the die of an external CPU, ASIC, or FPGA) as a sensing element to measure the remote temperature. The remote-junction temperature switch has a factory-programmed trip temperature threshold of either +120°C or +125°C. The local temperature switch has a pin-programmable temperature threshold that is set by connecting pins S1 and S2 to ground, to V<sub>DD</sub>, or leaving them floating. Hysteresis for both local and remote thresholds is 5°C. The MAX6687/MAX6688 do not assert on transient (single-sample) faults or when power is first applied.

The MAX6687 has two open-drain active-low outputs while the MAX6688 has two push-pull active-high outputs. T<sub>REMOTE</sub> asserts a logic signal when the remote temperature exceeds the factory-programmed +120°C or +125°C trip threshold. T<sub>LOCAL</sub> is asserted when the die temperature exceeds the pin-programmed threshold, which is controlled by pins S1 and S2. The local thresholds are available in two ranges in 5°C increments. The two ranges are +40°C to +80°C and +75°C to +115°C.

The MAX6687/MAX6688 operate from a 3.0V to 5.5V power supply and are available in a space-saving 8-pin  $\mu$ MAX package.

## Applications

CPU Temperature Protection  
FPGA Temperature Protection  
Fan Control  
Temperature Alarms

## Features

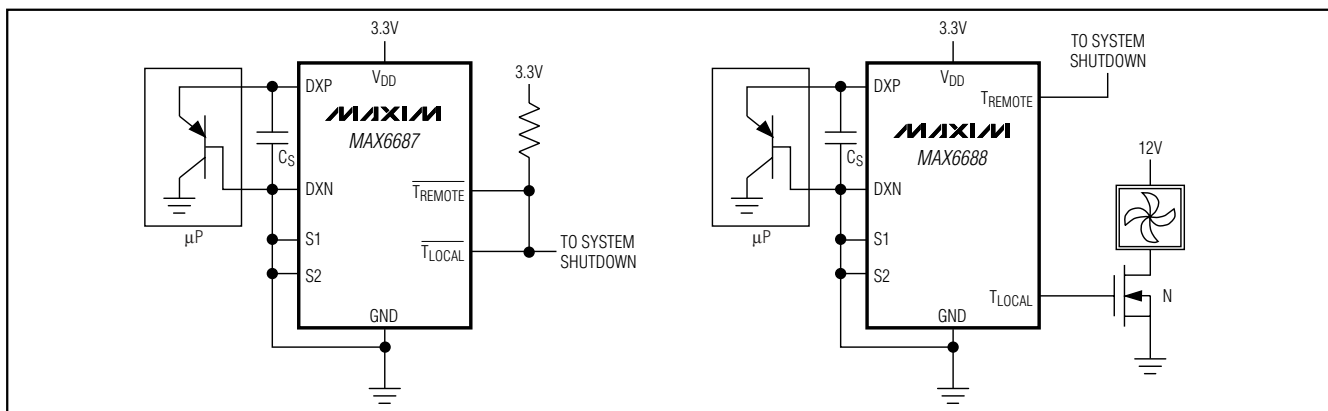
- ◆ Pin-Programmable Local Temperature Threshold in 5°C Increments in Two Distinct Ranges: +40°C to +80°C and +75°C to +115°C
- ◆ Factory-Programmed Remote Threshold: +120°C (L Suffix) or +125°C (H Suffix)
- ◆ Open-Drain Active-Low Outputs (MAX6687)
- ◆ CMOS Push-Pull, Active-High Outputs (MAX6688)
- ◆  $\pm 1.5^\circ\text{C}$  Accuracy
- ◆ 2Hz Temperature Sampling Rate
- ◆ 215 $\mu\text{A}$  Average Supply Current
- ◆ 3.0V to 5.5V Power-Supply Voltage
- ◆ 8-Pin  $\mu$ MAX Package

## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX6687AU40L	-40°C to +125°C	8 $\mu$ MAX
MAX6687AU40H	-40°C to +125°C	8 $\mu$ MAX
MAX6687AU75L	-40°C to +125°C	8 $\mu$ MAX
MAX6687AU75H	-40°C to +125°C	8 $\mu$ MAX
MAX6688AU40L	-40°C to +125°C	8 $\mu$ MAX
MAX6688AU40H	-40°C to +125°C	8 $\mu$ MAX
MAX6688AU75L	-40°C to +125°C	8 $\mu$ MAX
MAX6688AU75H	-40°C to +125°C	8 $\mu$ MAX

Pin Configurations/Functional Diagrams/Selector Guide appear at end of data sheet.

## Typical Operating Circuit



# Local/Remote Temperature Switches in a $\mu$ MAX Package

## ABSOLUTE MAXIMUM RATINGS

Voltages Referenced to GND

$V_{DD}$ , $T_{LOCAL}$ , $T_{REMOTE}$ .....	-0.3V to +6V
DXN .....	-0.3V to +0.8V
All Other Pins .....	-0.3V to ( $V_{DD}$ + 0.3V)
Input Current .....	5mA
Output Current .....	20mA

Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )

8-Pin $\mu$ MAX (derate 4.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$ ) .....	330mW
Operating Temperature Range .....	$-40^\circ\text{C}$ to $+125^\circ\text{C}$
Junction Temperature .....	$+150^\circ\text{C}$
Storage Temperature Range .....	$-65^\circ\text{C}$ to $+165^\circ\text{C}$
Lead Temperature (soldering, 10s) .....	$+300^\circ\text{C}$

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

( $V_{DD} = 3\text{V}$  to  $5.5\text{V}$ ,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise noted. Typical values are at  $V_{DD} = 3.3\text{V}$  and  $T_A = +25^\circ\text{C}$ .) (Note 1)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS
Power-Supply Range	$V_{DD}$		3		5.5	V
Average Supply Current	$I_{DD}$			215	500	$\mu\text{A}$
Supply Current During Conversion				400	800	$\mu\text{A}$
Power-On Reset (POR) Threshold	POR	$V_{DD}$ falling edge	1	1.5	2.0	V
POR Threshold Hysteresis				50		mV
Remote-Diode Temperature Threshold Accuracy, Rising Temperature	$\Delta T_{TH}$	$T_A = +25^\circ\text{C}$ , $V_{DD} = 3.3\text{V}$	-1.5		+1.5	$^\circ\text{C}$
		$T_A = 0^\circ\text{C}$ to $+85^\circ\text{C}$ , $V_{DD} = 3.3\text{V}$	-3.0		+3.0	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$ , $V_{DD} = 3.3\text{V}$	-5.0		+5.0	
Internal Temperature Threshold Accuracy, Rising Temperature	$\Delta T_{TH}$	Temperature trip thresholds from $+40^\circ\text{C}$ to $+105^\circ\text{C}$ , $V_{DD} = 3.3\text{V}$	-3.0		+3.0	$^\circ\text{C}$
		Temperature trip thresholds $+110^\circ\text{C}$ and $+115^\circ\text{C}$ , $V_{DD} = 3.3\text{V}$	-3.5		+3.5	
Temperature Threshold Hysteresis	$T_{HYST}$			5.0		$^\circ\text{C}$
Temperature Threshold Supply Sensitivity					0.6	$^\circ\text{C}/\text{V}$
Output Voltage High	$V_{OH}$	$I_{SOURCE} = 1\text{mA}$ , MAX6688	$V_{DD} - 0.2$			V
Output Voltage Low	$V_{OL}$	$I_{SINK} = 1\text{mA}$			0.2	V
Logic Input Low Voltage (S1, S2)	$V_{IL}$				0.4	V
Logic Input High Voltage (S1, S2)	$V_{IH}$		1.8			V
Input Current (S1, S2)					10	$\mu\text{A}$
Open-Drain Output Leakage Current		$V_{OUT} = 5.5\text{V}$ , MAX6687			1	$\mu\text{A}$

# Local/Remote Temperature Switches in a $\mu$ MAX Package

MAX6687/MAX6688

## ELECTRICAL CHARACTERISTICS (continued)

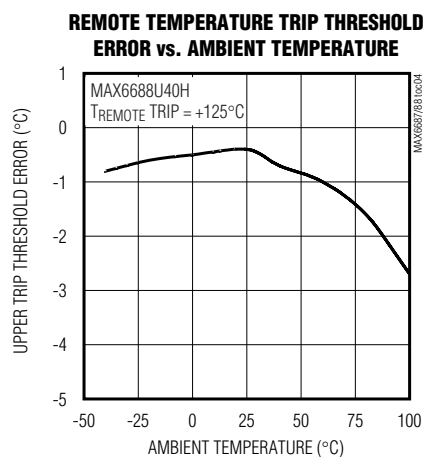
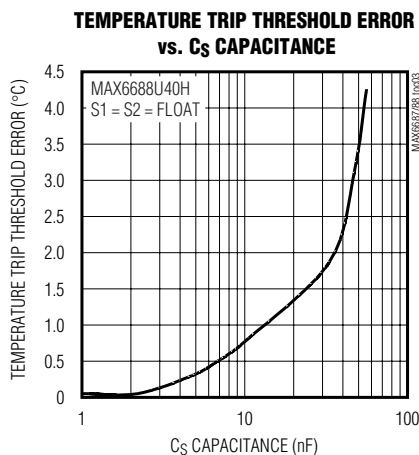
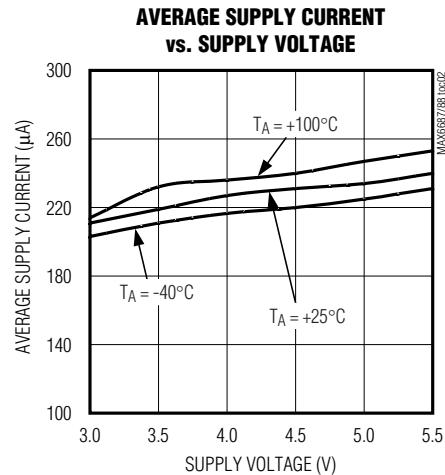
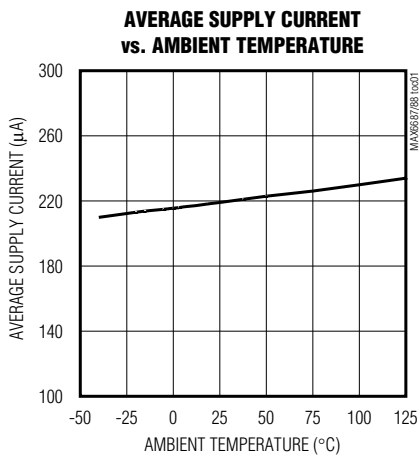
( $V_{DD} = 3V$  to  $5.5V$ ,  $T_A = -40^\circ C$  to  $+125^\circ C$ , unless otherwise noted. Typical values are at  $V_{DD} = 3.3V$  and  $T_A = +25^\circ C$ .) (Note 1)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS
Temperature Conversion Time			0.2	0.25	0.3	s
Temperature Sample Period			0.4	0.5	0.6	s
Current Sourcing for External Diode		High level	80	100	120	$\mu A$
		Low level	8	10	12	

**Note 1:** All parameters are tested at  $+25^\circ C$ . Temperature specifications over a range of  $-40^\circ C$  to  $+125^\circ C$  are guaranteed by design.

## Typical Operating Characteristics

( $V_{DD} = 3.3V$ ,  $C_S = 2200pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Local/Remote Temperature Switches in a $\mu$ MAX Package

## Pin Description

PIN		NAME	FUNCTION
MAX6687	MAX6688		
1	1	V <sub>DD</sub>	Power-Supply Input. Bypass to GND with a 0.1 $\mu$ F capacitor.
2	2	GND	Ground
3	3	DXP	This pin connects to the positive (anode) terminal of the external P-N sense junction. It sources current into the external junction. A 2200pF capacitor should be connected across DXP and DXN.
4	4	DXN	This pin connects to the negative (cathode) terminal of the external P-N sense junction. It sinks current from the external junction. A 2200pF capacitor should be connected across DXP and DXN. DXN must be connected to the GND pin at the pin.
5	—	$\overline{T}_{REMOTE}$	Open-Drain Active-Low Output. $\overline{T}_{REMOTE}$ goes low when the temperature exceeds the factory-programmed temperature threshold, either +120°C or +125°C. Connect a pullup resistor (typically 10k $\Omega$ ) between $\overline{T}_{REMOTE}$ and a positive power supply up to 5.5V.
—	5	T <sub>REMOTE</sub>	CMOS Push-Pull, Active-High Output. T <sub>REMOTE</sub> goes high when the temperature exceeds the factory-programmed temperature threshold, either +120°C or +125°C.
6	—	$\overline{T}_{LOCAL}$	Open-Drain Active-Low Output. $\overline{T}_{LOCAL}$ goes low when the temperature exceeds the pin-programmable temperature threshold set by S1 and S2. Connect a pullup resistor (typically 10k $\Omega$ ) between $\overline{T}_{LOCAL}$ and a positive power supply up to 5.5V.
—	6	T <sub>LOCAL</sub>	CMOS Push-Pull, Active-High Output. T <sub>LOCAL</sub> goes high when the temperature exceeds the pin-programmable temperature threshold set by S1 and S2.
7	7	S1	Threshold Select Input. Used in conjunction with S2 to set the local threshold temperature (Table 1). It can be connected to V <sub>DD</sub> , GND, or left floating.
8	8	S2	Threshold Select Input. Used in conjunction with S1 to set the local threshold temperature (Table 1). It can be connected to V <sub>DD</sub> , GND, or left floating.

## Detailed Description

The MAX6687/MAX6688 sense the temperatures of both a remote P-N junction and their own die. The external P-N junction is typically a base-emitter junction of a substrate PNP on a microprocessor, FPGA, or ASIC die (see the *Typical Operating Circuit*).

The remote temperature switch has a factory-programmed trip temperature of either +120°C or +125°C and is intended to be used for system shutdown when the die temperature of a remote IC, such as a microprocessor, FPGA, or ASIC exceeds the factory-programmed thresholds.

The local temperature switch has a pin-programmable threshold temperature (Table 1). This temperature switch may be used for such functions as system shutdown or for turning on a cooling fan when board temperature exceeds the temperature limit. Two temperature ranges are available for the local trip

threshold: +40°C to +80°C and +75°C to +115°C. S1 and S2 pins must be set to the desired trip temperature before power is applied to the V<sub>DD</sub> pin. If S1 and S2 settings are changed after the power is turned on, the local trip threshold remains set to the point where S1 and S2 were when power was applied.

Since the MAX6687/MAX6688 are often used for system shutdown, they are designed so that the outputs do not change on transient faults or when power is first applied. This eliminates the possibility that the IC could erroneously shut a system down.

The MAX6687/MAX6688 provide noise immunity by integration and oversampling of the diode voltage, but good design practice includes routing the DXP and DXN lines away from noise sources, such as high-speed digital lines, switching regulators, inductors, and transformers. The DXP and DXN traces should be paired together and surrounded by a ground plane whenever possible.

# Local/Remote Temperature Switches in a $\mu$ MAX Package

MAX6687/MAX6688

**Table 1. Local Temperature Trip Threshold Selection**

S1	S2	MAX6687AUA40L/MAX6687AUA40H/ MAX6688AUA40L/MAX6688AUA40H	MAX6687AUA75L/MAX6687AUA75H/ MAX6688AUA75L/MAX6688AUA75H
		LOCALTEMPERATURE TRIP THRESHOLD (°C)	LOCAL TEMPERATURE TRIP THRESHOLD (°C)
GND	GND	+40	+75
GND	FLOAT	+45	+80
GND	V <sub>DD</sub>	+50	+85
FLOAT	GND	+55	+90
FLOAT	FLOAT	+60	+95
FLOAT	V <sub>DD</sub>	+65	+100
V <sub>DD</sub>	GND	+70	+105
V <sub>DD</sub>	FLOAT	+75	+110
V <sub>DD</sub>	V <sub>DD</sub>	+80	+115

## Applications Information

### Remote-Diode selection

The MAX6687/MAX6688 are optimized to measure the die temperature of CPUs and other ICs that have on-chip temperature-sensing diodes. These on-chip diodes are substrate PNPs with their collectors grounded. Connect the base of the PNP to DXN and the emitter to DXP. When using a discrete, diode-connected NPN or PNP as a sensing diode, use a good-quality small-signal device. Examples are listed in Table 2. Tight specifications for forward current gain indicate the manufacturer has good process controls and that the devices have consistent V<sub>BE</sub> characteristics. Always use a transistor for the sensing junction; diodes do not work.

The MAX6687/MAX6688 are optimized for use with thermal-sensing transistors with an ideality factor of 1.008. Different ideality factors cause predictable, usually small deviations in trip temperature thresholds.

**Table 2. Sensor Transistor Manufacturers**

MANUFACTURER	MODEL NO.
Central Semiconductor (USA)	CMPT3904
Rohm Semiconductor (Japan)	SST3904
Samsung (Korea)	KST3904-TF
Siemens (Germany)	SMBT3904

### Noise-Filtering Capacitors

A quality ceramic capacitor must be connected across the DXP/DXN inputs to maintain temperature threshold accuracy by filtering out noise. The capacitor should be located physically close to the DXP/DXN pins and

should typically have a value of 2200pF. Larger capacitor values can cause temperature measurement errors. A 50% increase from the recommended capacitor value can cause up to  $\pm 1^\circ\text{C}$  error.

### Sensing Circuit Board and Ambient Temperature

Temperature switches like the MAX6687/MAX6688 that sense their own die (local) temperatures must be mounted on or close to the object whose temperature they are intended to measure. The MAX6687/MAX6688 can accurately measure the temperature of a circuit board to which they are soldered because the package leads provide a good thermal path between the circuit board and their own die. If the MAX6687/MAX6688 are intended to be triggered by the temperature of a heat-generating component on the circuit board, they should be mounted as close as possible to that component and should share supply and ground traces (if they are not noisy) with that component where possible. The thermal path between the plastic package and the die is not as good as the path through the package leads, so the MAX6687/MAX6688 are less sensitive to the surrounding air temperature than they are to the temperature of their package leads, but they can be successfully used to respond to the ambient temperature if the circuit board is designed to track the ambient temperature.

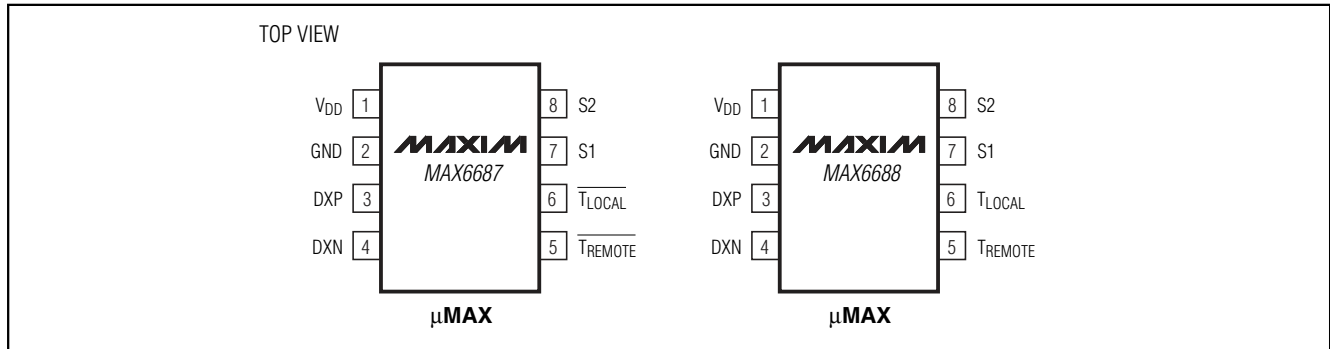
## Chip Information

TRANSISTOR COUNT: 7765

PROCESS: BiCMOS

# Local/Remote Temperature Switches in a $\mu$ MAX Package

## Pin Configurations



## Functional Block Diagrams

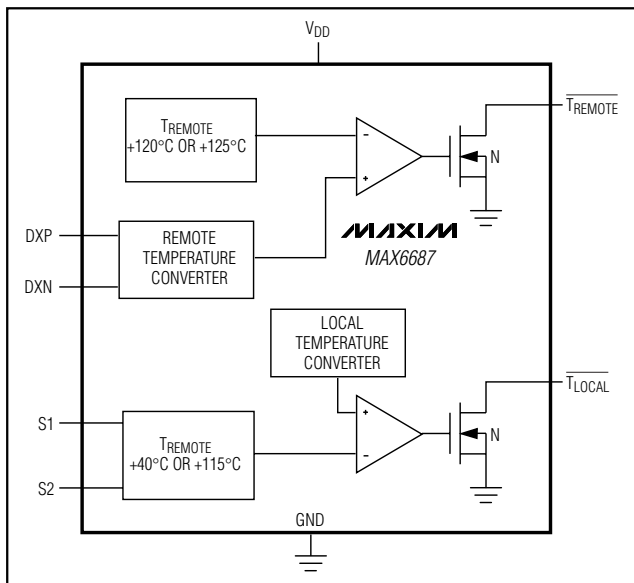


Figure 1a. MAX6687 Functional Block Diagram

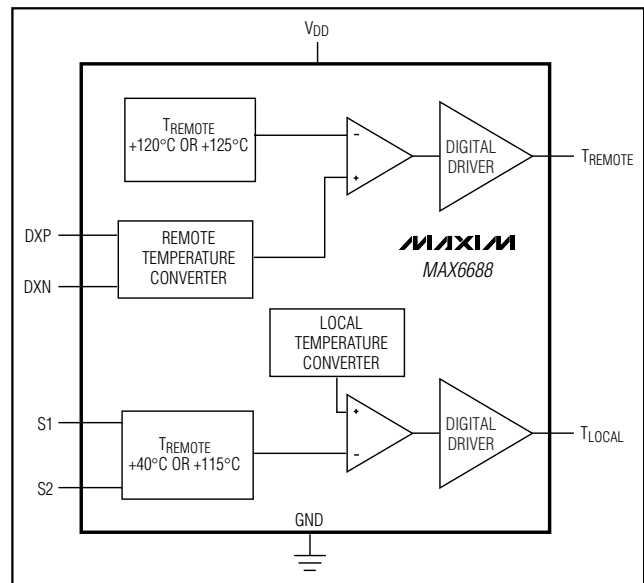


Figure 1b. MAX6688 Functional Block Diagram

## Selector Guide

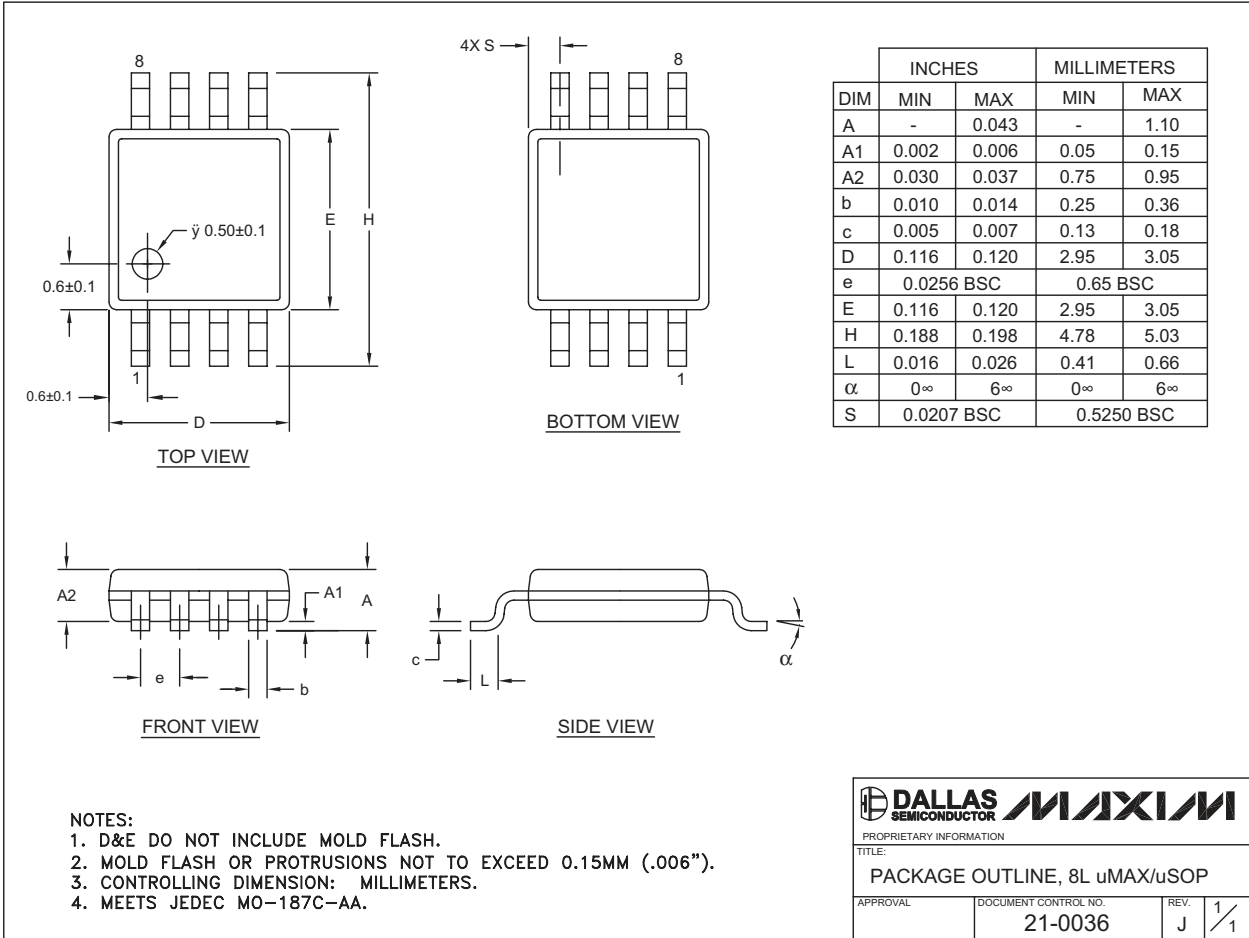
PART	OUTPUTS	REMOTE TRIP THRESHOLD (°C)	LOCAL TRIP THRESHOLD RANGE (°C)
<b>MAX6687AU40L</b>	Open drain, active low	+120	+40 to +80
MAX6687AU40H	Open drain, active low	+125	+40 to +80
MAX6687AU75L	Open drain, active low	+120	+75 to +115
MAX6687AU75H	Open drain, active low	+125	+75 to +115
<b>MAX6688AU40L</b>	Push pull, active high	+120	+40 to +80
MAX6688AU40H	Push pull, active high	+125	+40 to +80
MAX6688AU75L	Push pull, active high	+120	+75 to +115
MAX6688AU75H	Push pull, active high	+125	+75 to +115

# Local/Remote Temperature Switches in a $\mu$ MAX Package

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

MAX6687/MAX6688



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