



# Low-Cost, Remote SOT Temperature Switches

## General Description

The MAX6511/MAX6512/MAX6513 are fully integrated, remote temperature switches that use an external P-N junction (typically a diode-connected transistor) as the sensing element to measure the remote temperature. These devices assert a logic signal when the temperature crosses a factory-programmed threshold. Available trip thresholds are from +45°C to +125°C in 10°C increments. Accuracy is within  $\pm 3^\circ\text{C}$  ( $T_A = -5^\circ\text{C}$  to  $+55^\circ\text{C}$ ) or  $\pm 5^\circ\text{C}$  ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ). Hysteresis is pin selectable to 5°C or 10°C.

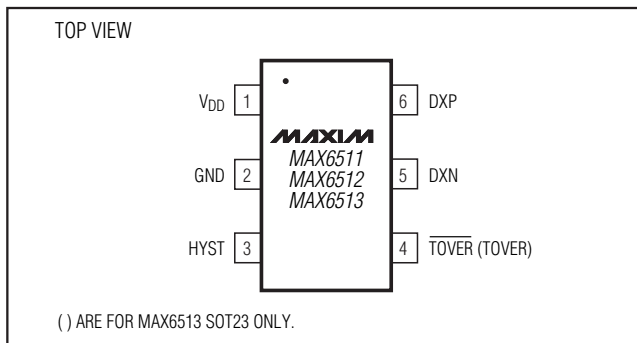
The MAX6511 has an active-low CMOS output and the MAX6513 has an active-high CMOS output. The MAX6512 has an open-drain output. The output is asserted when the temperature exceeds the threshold value. The active-low open-drain output is intended to interface with a microprocessor ( $\mu\text{P}$ ) reset or interrupt input. The active-high CMOS output can directly drive a power FET to control a cooling fan.

The MAX6511/MAX6512/MAX6513 operate from a +3.0V to +5.5V supply and typically consume 400 $\mu\text{A}$  of supply current. They are available in the small 6-pin SOT23. The MAX6513 is also available in a 6-pin lead-free TDFN package.

## Applications

CPU Temperature Monitoring in High-Speed Computers  
 Multichip Modules  
 Battery Packs  
 Temperature Control  
 Temperature Alarms  
 Fan Control

## Pin Configuration



## Features

- ◆ Continuously Measure External Junction Temperature
- ◆ Factory-Programmed Temperature Threshold from +45°C to +125°C in 10°C Increments
- ◆ Insensitive to Series Parasitic Resistance
- ◆ Active-Low CMOS Output (MAX6511) or Open-Drain Output for Overtemperature Alarm (MAX6512) or Active-High Output (MAX6513) for Direct Fan Control
- ◆ <100ms Response Time
- ◆ Accuracy
  - $\pm 3^\circ\text{C}$  (TREMOTE = +45°C to +125°C,  $T_A = -5^\circ\text{C}$  to  $+55^\circ\text{C}$ )
  - $\pm 5^\circ\text{C}$  (TREMOTE = +45°C to +125°C,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ )
- ◆ Pin-Selectable 5°C or 10°C Hysteresis
- ◆ 400 $\mu\text{A}$  Average Current Consumption
- ◆ +3.0V to +5.5V Supply Range
- ◆ 6-Pin SOT23 Package
- ◆ 6-Pin TDFN Package (Lead Free)

## Ordering Information

| PART*          | TEMP RANGE     | PIN-PACKAGE | OUTPUT            |
|----------------|----------------|-------------|-------------------|
| MAX6511UT___-T | -40°C to +85°C | 6 SOT23-6   | CMOS (active low) |
| MAX6512UT___-T | -40°C to +85°C | 6 SOT23-6   | Open-drain        |
| MAX6513_T___-T | -40°C to +85°C | 6 TDFN      | CMOS              |
|                | -40°C to +85°C | 6 SOT23-6   | (active high)     |

\*These parts are offered in nine standard temperature versions with a minimum order of 2500 pieces. To complete the suffix information, select an available trip point in degrees centigrade from the device marking codes table. For example, the MAX6511UT065-T describes a MAX6511 in a 6-pin SOT23 package with a +65°C threshold.

Typical Operating Circuit appears at end of data sheet.



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## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{DD}$ ) .....-0.3V to +6V  
 DXP, DXN, HYST, TOVER (MAX6513),  
 TOVER (MAX6511/MAX6512) .....-0.3V to ( $V_{DD} + 0.3V$ )  
 TOVER (MAX6513), TOVER (MAX6511)  
 Output Current .....-1mA/+50mA  
 DXN Input Current.....-1mA/+50mA  
 Current (all other pins)..... $\pm 20$ mA  
 Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )  
 6-Pin SOT23-6 (derate 9.1mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) .....727mW  
 6-Pin TDFN (derate 24.4mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) .....1951mW

Operating Temperature Range .....-40 $^\circ\text{C}$  to +85 $^\circ\text{C}$   
 Storage Temperature Range .....-65 $^\circ\text{C}$  to +150 $^\circ\text{C}$   
 Junction Temperature .....+150 $^\circ\text{C}$   
 Lead Temperature  
 Vapor Phase (60s) .....+215 $^\circ\text{C}$   
 Infrared (15s) .....+220 $^\circ\text{C}$

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

( $V_{DD} = +3.0\text{V}$  to  $+5.5\text{V}$ ,  $C_S = 2200\text{pF}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $T_{\text{REMOTE}} = +45^\circ\text{C}$  to  $+125^\circ\text{C}$  (Note 1), unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .) (Note 2)

| PARAMETER   | SYMBOL                 | CONDITIONS  | MIN            | TYP  | MAX  | UNITS                     |
|---|------------------------|---|----------------|------|------|---------------------------|
| Supply Voltage Range                                | $V_{DD}$               |   | 3.0            |      | 5.5  | V                         |
| Supply Current                                      | $I_{DD}$               |   |                | 400  | 600  | $\mu\text{A}$             |
| Temperature Threshold Accuracy (Note 3)             | $\Delta T_{\text{TH}}$ | $T_A = -5^\circ\text{C}$ to $+55^\circ\text{C}$                 | -3.0           |      | +3.0 | $^\circ\text{C}$          |
|   |                        | $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$                | -5.0           |      | +5.0 |                           |
| Power-Supply Sensitivity for Temperature Trip Point |                        |   |                | -0.6 |      | $^\circ\text{C}/\text{V}$ |
| Temperature Threshold Hysteresis                    | $T_{\text{HYST}}$      | $\text{HYST} = V_{\text{IL}}$                                   |                | 5    |      | $^\circ\text{C}$          |
|   |                        | $\text{HYST} = V_{\text{IH}}$                                   |                | 10   |      |                           |
| Response Time                                       |                        |   |                | 70   | 120  | ms                        |
| Input Voltage High                                  | $V_{\text{IH}}$        |   | $V_{DD} - 0.2$ |      |      | V                         |
| Input Voltage Low                                   | $V_{\text{IL}}$        |   |                |      | 0.2  | V                         |
| Output Voltage High                                 | $V_{\text{OH}}$        | MAX6511/MAX6513, $I_{\text{OUT}} = 1\text{mA}$                  | $V_{DD} - 0.2$ |      |      | V                         |
| Output Voltage Low                                  | $V_{\text{OL}}$        | $I_{\text{OUT}} = 1\text{mA}$                                   |                |      | 0.2  | V                         |
| Maximum DXP Source Current                          |                        | $0.4\text{V} \leq V_{\text{DXP}} \leq 2\text{V}$ ,<br>DXN = GND |                | 270  |      | $\mu\text{A}$             |
| Minimum DXP Source Current                          |                        | $0.4\text{V} \leq V_{\text{DXP}} \leq 2\text{V}$ ,<br>DXN = GND |                | 9    |      | $\mu\text{A}$             |

**Note 1:**  $T_{\text{REMOTE}}$  refers to the temperature of the remote-sensing junction.  $T_A$  refers to the temperature of the MAX6511/MAX6512/MAX6513 package.

**Note 2:** All parameters are 100% production tested at  $T_A = +25^\circ\text{C}$ . Specifications over temperature limits are guaranteed by design.

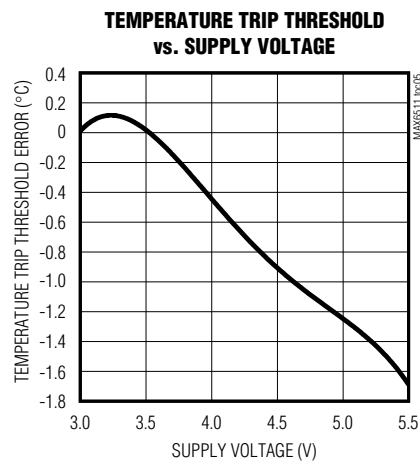
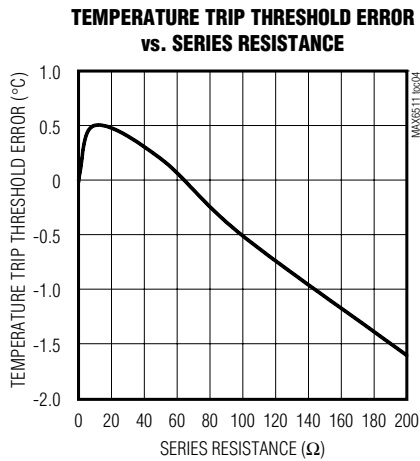
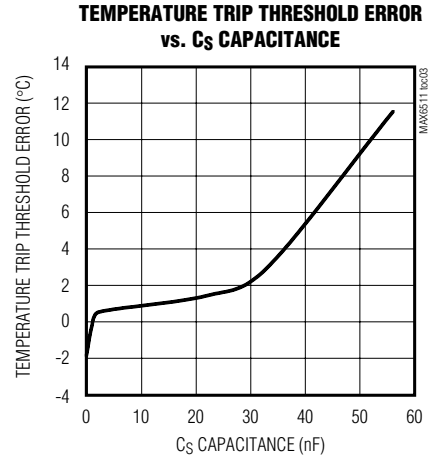
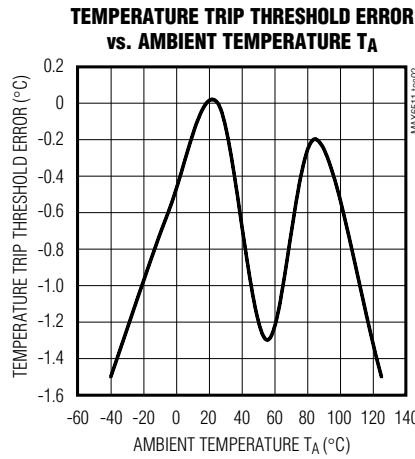
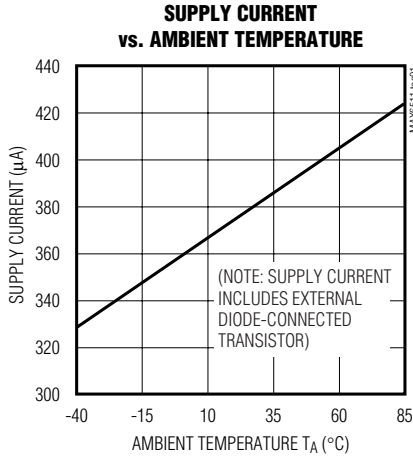
**Note 3:** This parameter is guaranteed by design to  $\pm 3.5$  sigma.

# Low-Cost, Remote SOT Temperature Switches

## Typical Operating Characteristics

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

**MAX6511/MAX6512/MAX6513**



# Low-Cost, Remote SOT Temperature Switches

## Pin Description

| PIN                |         | NAME                      | FUNCTION   |
|--------------------|---------|---------------------------|--|
| MAX6511<br>MAX6512 | MAX6513 |                           |  |
| 1                  | 1       | V <sub>DD</sub>           | Power-Supply Input, +3.0V to +5.5V. Bypass V <sub>DD</sub> to GND with a 0.1μF capacitor.  |
| 2                  | 2       | GND                       | Ground   |
| 3                  | 3       | HYST                      | Hysteresis Selection. Hysteresis is 10°C for HYST = V <sub>DD</sub> , 5°C for HYST = GND.  |
| 4                  | —       | $\overline{\text{TOVER}}$ | CMOS Active-Low Output (MAX6511) or Open-Drain Active-Low Output (MAX6512). $\overline{\text{TOVER}}$ goes low when the temperature exceeds the factory-programmed temperature threshold. This pin can only sink current in the MAX6512. |
| —                  | 4       | TOVER                     | CMOS Active-High Output (MAX6513). TOVER goes high when the temperature exceeds the factory-programmed temperature threshold.  |
| 5                  | 5       | DXN                       | This pin connects to the negative (cathode) terminal of the external P-N sense junction. DXN must be connected to GND.   |
| 6                  | 6       | DXP                       | This pin connects to the positive (anode) terminal of the external P-N sense junction.   |

## Detailed Description

The MAX6511/MAX6512/MAX6513 fully integrated temperature switches incorporate a precision bandgap reference, a conversion block, a current source, and a comparator (Figure 1). These devices use an external P-N junction as the temperature-sensing element. They steer bias currents through the external diode, measure the forward voltages, and compute the temperature using a precision chopper stabilized amplifier.

Resistance values of less than 100Ω in series with the external sense junction will result in trip-point errors <1°C. The MAX6511/MAX6512/MAX6513 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 ground plane whenever possible.

In applications where the temperature changes rapidly, the measured temperature will be approximately equal to the average value of the temperature during the measurement period.

The MAX6512 has an active-low, open-drain output structure that can only sink current. The MAX6511 has an active-low CMOS output structure, and the MAX6513 has an active-high CMOS output.

The MAX6511/MAX6512/MAX6513 are available with preset temperature thresholds from +45°C to +125°C in 10°C increments.

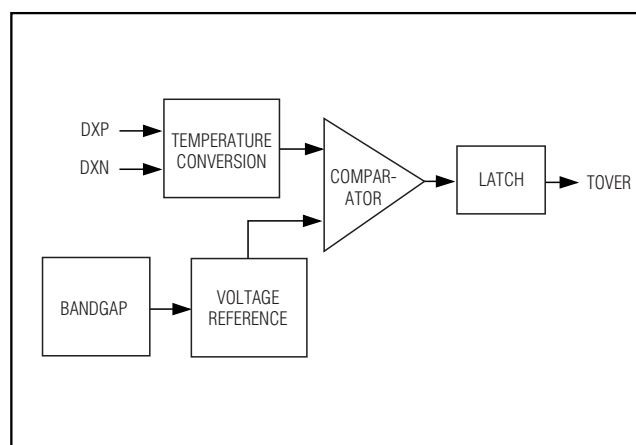


Figure 1. Functional Block Diagram

# Low-Cost, Remote SOT Temperature Switches

MAX6511/MAX6512/MAX6513

**Table 1. Sensor Transistor Manufacturers**

| MANUFACTURER                | MODEL NUMBER  |
|-----------------------------|---------------|
| Central Semiconductor (USA) | CMPT3904      |
| ON (USA)                    | MMBT3904      |
| Rohm Semiconductor (Japan)  | SST3904       |
| Samsung (Korea)             | KST3904-TF    |
| Siemens (Germany)           | SMBT3904      |
| Zetex (England)             | FMMT3904CT-ND |

**Note:** Transistors must be diode connected (base shorted to collector).

### Hysteresis Input

The HYST pin is a CMOS-compatible input that selects hysteresis at either a high level (10°C for HYST = V<sub>DD</sub>) or a low level (5°C for HYST = GND). Hysteresis prevents the output from chattering when the temperature is near the trip point. The HYST pin must not float.

The output asserts when the temperature exceeds the trip point and deasserts when the temperature falls back below the trip point minus the hysteresis. For example, if the trip point is 105°C, the output will assert at 105°C and will not deassert until temperature falls below 105°C minus the hysteresis (e.g., 95°C if 10°C hysteresis is chosen) (Figure 2).

## Applications Information

### Remote-Diode Selection

To ensure best accuracy, use a good-quality diode-connected transistor. Suggested devices are listed in Table 1. Large power transistors are not recommended. Tight specifications for forward current gain indi-

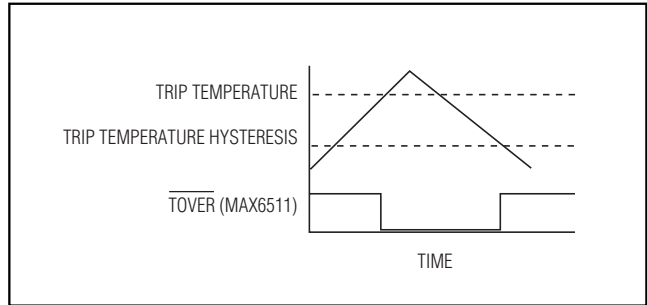


Figure 2. Temperature Trip Threshold Hysteresis

cate the manufacturer has good process controls and that the devices have consistent V<sub>be</sub> characteristics. The MAX6511/MAX6512/MAX6513 can also measure the die temperature of CPUs and other integrated circuits having on-board temperature-sensing diodes. Use the monitor's output to reset the μP, assert an interrupt, activate a cooling fan, or trigger an external alarm.

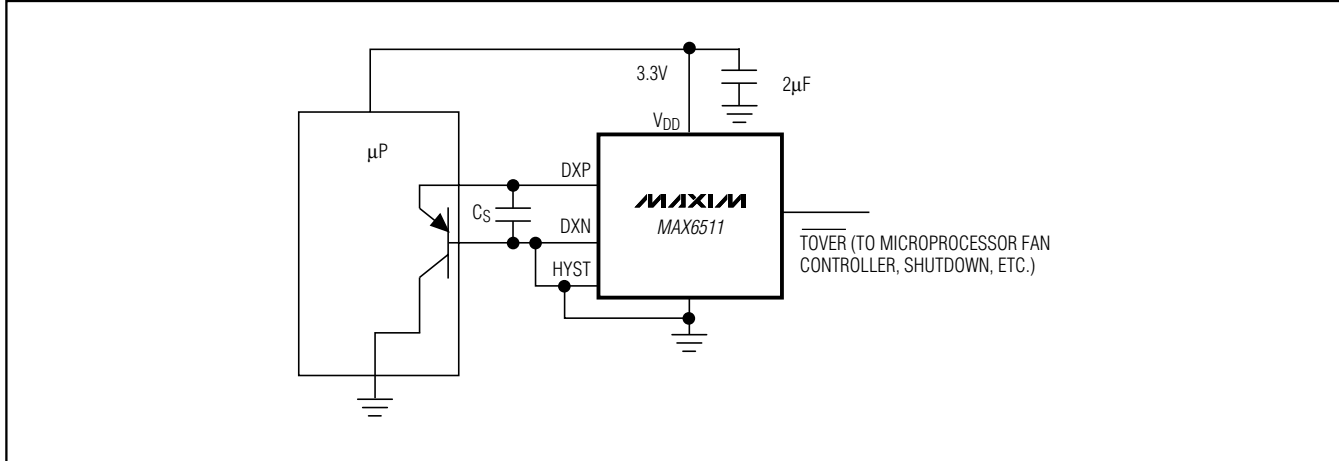
### Noise Filtering Capacitors

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% variation from the recommended capacitor value can cause up to ±1°C error.

# Low-Cost, Remote SOT Temperature Switches

MAX6511/MAX6512/MAX6513

## Typical Operating Circuit



## Device Marking Codes for SOT23-6 Package

| DEVICE       | CODE | TEMPERATURE TRIP THRESHOLD (°C) |
|--------------|------|---------------------------------|
| MAX6511UT045 | AAOA | 45                              |
| MAX6511UT055 | AAOB | 55                              |
| MAX6511UT065 | AAOC | 65                              |
| MAX6511UT075 | AAOD | 75                              |
| MAX6511UT085 | AAOE | 85                              |
| MAX6511UT095 | AAOF | 95                              |
| MAX6511UT105 | AAOG | 105                             |
| MAX6511UT115 | AAOH | 115                             |
| MAX6511UT125 | AAOI | 125                             |
| MAX6512UT045 | AAOJ | 45                              |
| MAX6512UT055 | AAOK | 55                              |
| MAX6512UT065 | AAOL | 65                              |
| MAX6512UT075 | AAOM | 75                              |
| MAX6512UT085 | AAON | 85                              |
| MAX6512UT095 | AAOO | 95                              |
| MAX6512UT105 | AAOP | 105                             |
| MAX6512UT115 | AAOQ | 115                             |
| MAX6512UT125 | AAOR | 125                             |

| DEVICE       | CODE | TEMPERATURE TRIP THRESHOLD (°C) |
|--------------|------|---------------------------------|
| MAX6513UT045 | AAPD | 45                              |
| MAX6513UT055 | AAPE | 55                              |
| MAX6513UT065 | AAPF | 65                              |
| MAX6513UT075 | AAPG | 75                              |
| MAX6513UT085 | AAPH | 85                              |
| MAX6513UT095 | AAPI | 95                              |
| MAX6513UT105 | AAPJ | 105                             |
| MAX6513UT115 | AAPK | 115                             |
| MAX6513UT125 | AAPL | 125                             |
| MAX6513TT045 | +ACU | 45                              |
| MAX6513TT055 | +ACV | 55                              |
| MAX6513TT065 | +ACW | 65                              |
| MAX6513TT075 | +ACX | 75                              |
| MAX6513TT085 | +ACY | 85                              |
| MAX6513TT095 | +ACZ | 95                              |
| MAX6513TT105 | +ADA | 105                             |
| MAX6513TT115 | +ADB | 115                             |
| MAX6513TT125 | +ADC | 125                             |

## Chip Information

TRANSISTOR COUNT: 3300

# Low-Cost, Remote SOT Temperature Switches

## 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).)

MAX6511/MAX6512/MAX6513

| SYMBOL | MIN  | MAX  |
|--------|------|------|
| A      | 0.90 | 1.45 |
| A1     | 0.00 | 0.15 |
| A2     | 0.90 | 1.30 |
| b      | 0.35 | 0.50 |
| C      | 0.08 | 0.20 |
| D      | 2.80 | 3.00 |
| E      | 2.60 | 3.00 |
| E1     | 1.50 | 1.75 |
| L      | 0.35 | 0.60 |
| L1     | 0.60 | REF. |
| e1     | 1.90 | BSC. |
| e      | 0.95 | BSC. |
| a      | 0°   | 10°  |

NOTES:

- ALL DIMENSIONS ARE IN MILLIMETERS.
- FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
- PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25 MM.
- PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
- PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
- PIN 1 I.D. DOT IS 0.3 MM Ø MIN. LOCATED ABOVE PIN 1.
- MEETS JEDEC MO178, VARIATION AB.
- SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
- LEAD TO BE COPLANAR WITHIN 0.1 MM.

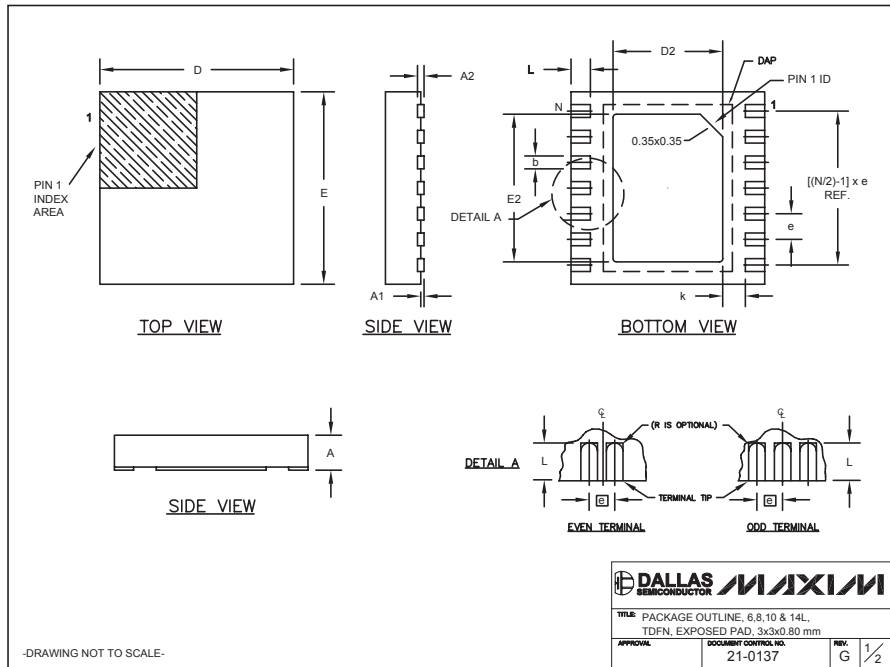
6LSOT.EPS

|                                    |                      |      |     |
|------------------------------------|----------------------|------|-----|
|                                    |                      |      |     |
| PROPRIETARY INFORMATION            |                      |      |     |
| TITLE: PACKAGE OUTLINE, SOT-23, 6L |                      |      |     |
| APPROVAL                           | DOCUMENT CONTROL NO. | REV. |     |
|                                    | 21-0058              | F    | 1/1 |

# Low-Cost, Remote SOT Temperature Switches

## Package Information (continued)

(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).)



| COMMON DIMENSIONS |           |      |  |  |  |  |  |  |  |
|-------------------|-----------|------|--|--|--|--|--|--|--|
| SYMBOL            | MIN.      | MAX. |  |  |  |  |  |  |  |
| A                 | 0.70      | 0.80 |  |  |  |  |  |  |  |
| D                 | 2.90      | 3.10 |  |  |  |  |  |  |  |
| E                 | 2.90      | 3.10 |  |  |  |  |  |  |  |
| A1                | 0.00      | 0.05 |  |  |  |  |  |  |  |
| L                 | 0.20      | 0.40 |  |  |  |  |  |  |  |
| k                 | 0.25 MIN. |      |  |  |  |  |  |  |  |
| A2                | 0.20 REF. |      |  |  |  |  |  |  |  |

| PACKAGE VARIATIONS |    |           |           |          |                |           |               |                   |  |
|--------------------|----|-----------|-----------|----------|----------------|-----------|---------------|-------------------|--|
| PKG. CODE          | N  | D2        | E2        | e        | JEDEC SPEC     | b         | [(N/2)-1] x e | DOWNBONDS ALLOWED |  |
| T633-1             | 6  | 1.50±0.10 | 2.30±0.10 | 0.95 BSC | MO229 / WEEA   | 0.40±0.05 | 1.90 REF      | NO                |  |
| T633-2             | 6  | 1.50±0.10 | 2.30±0.10 | 0.95 BSC | MO229 / WEEA   | 0.40±0.05 | 1.90 REF      | NO                |  |
| T833-1             | 8  | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC   | 0.30±0.05 | 1.95 REF      | NO                |  |
| T833-2             | 8  | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC   | 0.30±0.05 | 1.95 REF      | NO                |  |
| T833-3             | 8  | 1.50±0.10 | 2.30±0.10 | 0.65 BSC | MO229 / WEEC   | 0.30±0.05 | 1.95 REF      | YES               |  |
| T1033-1            | 10 | 1.50±0.10 | 2.30±0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25±0.05 | 2.00 REF      | NO                |  |
| T1433-1            | 14 | 1.70±0.10 | 2.30±0.10 | 0.40 BSC | ----           | 0.20±0.05 | 2.40 REF      | YES               |  |
| T1433-2            | 14 | 1.70±0.10 | 2.30±0.10 | 0.40 BSC | ----           | 0.20±0.05 | 2.40 REF      | NO                |  |

NOTES:  
 1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.  
 2. COPLANARITY SHALL NOT EXCEED 0.08 mm.  
 3. WARPAGE SHALL NOT EXCEED 0.10 mm.  
 4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).  
 5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.  
 6. "N" IS THE TOTAL NUMBER OF LEADS.  
 7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

-DRAWING NOT TO SCALE-

|          |                                 |      |   |     |
|----------|---------------------------------|------|---|-----|
| APPROVAL | DOCUMENT CONTROL NO.<br>21-0137 | REV. | G | 2/2 |
|----------|---------------------------------|------|---|-----|

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