

# High-Voltage, Low-Current Voltage Monitors in SOT Packages

## General Description

The MAX6457-MAX6460 high supply voltage, low-power voltage monitors operate over a 4V to 28V supply voltage range. Each device includes a precision bandgap reference, one or two low-offset voltage comparators, internal threshold hysteresis, power-good or reset timeout options, and one or two high-voltage open-drain outputs. Two external resistors (three for window detection) set the trip threshold voltages.

The MAX6457 is a single voltage monitor for undervoltage or overvoltage detection. A logic-based clear input either latches the output for overvoltage applications or allows the device to operate in transparent mode. The MAX6458 includes two comparators (one overvoltage and one undervoltage) for window detection and a single output to indicate if the monitored input is within an adjustable voltage window. The MAX6459 includes dual overvoltage/undervoltage comparators with two independent comparator outputs. Use the MAX6459 as a window comparator with separate undervoltage and overvoltage outputs or as two independent, single voltage monitors. The MAX6460 includes a single comparator and an internal reference, and can also accept an external reference. The inverting and noninverting inputs of the comparator are externally accessible to support positive or negative voltage monitors and to configure the device for active-high or active-low output logic.

The MAX6457/MAX6458 offer fixed timing options as a voltage detector with a 50μs typical delay or as a reset circuit with a 90ms minimum reset timeout delay. The monitored input must be above the adjusted trip threshold (or within the adjusted voltage window for the MAX6458) for the selected timeout period before the output changes state. The MAX6459/MAX6460 offer only a fixed 50μs timeout period. Internal threshold hysteresis options (0.5%, 5%, and 8.3% for the MAX6457/MAX6458/MAX6459, and 0.5% for the MAX6460) reduce output chatter in noise-sensitive applications. Each device is available in a small SOT23 package and specified over the extended temperature range of -40°C to +125°C.

## Applications

Undervoltage Monitoring/Shutdown  
 Overvoltage Monitoring/Protection  
 Window Voltage Detection Circuitry  
 Multicell Battery-Stack Powered Equipment  
 Notebooks, eBooks  
 Automotive  
 Industrial  
 Telecom  
 Networking

## Features

- ♦ Wide Supply Voltage Range, 4V to 28V
- ♦ Internal 2.25V ±2.5% Reference
- ♦ Low Current (3.5μA, typ at 12V)
- ♦ Open-Drain n-Channel Output (28V Compliant)
- ♦ Internal Threshold Hysteresis Options (0.5%, 5%, 8.3%)
- ♦ Two IN-to-OUT Timeout Period Options (50μs, 150ms)
- ♦ Internal Undervoltage Lockout
- ♦ Immune to Short Voltage Transients
- ♦ Small SOT23 Packages
- ♦ Few External Components
- ♦ Fully Specified from -40°C to +125°C

## Ordering Information

| PART           | TEMP RANGE      | PIN-PACKAGE |
|----------------|-----------------|-------------|
| MAX6457UKD__-T | -40°C to +125°C | 5 SOT23     |
| MAX6458UKD__-T | -40°C to +125°C | 5 SOT23     |
| MAX6459UT_-T   | -40°C to +125°C | 6 SOT23     |
| MAX6459UT_+V   | -40°C to +125°C | 6 SOT23     |
| MAX6460UT-T    | -40°C to +125°C | 6 SOT23     |

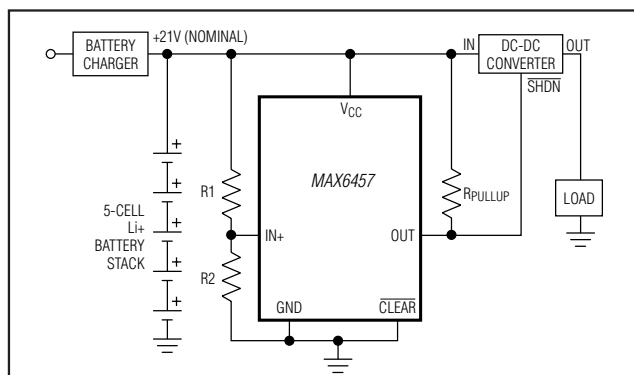
**Note:** The MAX6457/MAX6458/MAX6459 are available with factory-trimmed internal hysteresis options. The MAX6457 and MAX6458 offer two fixed timing options. Select the desired hysteresis and timing options using Table 1 or the Selector Guide at the end of the data sheet, and enter the corresponding letters and numbers in the part number by replacing “\_\_” or “\_”. These devices are offered in tape-and-reel only and must be ordered in 2500-piece increments.

Devices are available in both leaded and lead(Pb)-free/RoHS-compliant packaging. Specify lead(Pb)-free by replacing “-T” with “+T” when ordering.

V denotes an automotive qualified part.

Pin Configurations appear at end of data sheet.

## Typical Operating Circuit



# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### ABSOLUTE MAXIMUM RATINGS

V<sub>CC</sub>, OUT, OUTA, OUTB,  $\overline{\text{CLEAR}}$  to GND .....-0.3V to +30.0V  
 IN+, IN- to GND.....-0.3V to (V<sub>CC</sub> + 0.3V)  
 REF to GND.....-0.3V to the lower of +6V and (V<sub>CC</sub> + 0.3V)  
 Input Currents (V<sub>CC</sub>, IN+, IN-) .....20mA  
 Sink Current (OUT, OUTA, OUTB) .....20mA  
 Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
   5-Pin SOT23 (derate 7.1 mW/°C above +70°C) .....571mW  
   6-Pin SOT23 (derate 8.7 mW/°C above +70°C) .....696mW

Junction Temperature .....+150°C  
 Operating Temperature Range .....-40°C to +125°C  
 Storage Temperature Range .....-65°C to +150°C  
 Lead Temperature (soldering, 10s) .....+300°C  
 Soldering Temperature (reflow)  
   Lead(Pb)-free .....+260°C  
   Containing lead (Pb) .....+240°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<sub>CC</sub> = 4V to 28V, T<sub>A</sub> = -40°C to +125°C, unless otherwise specified. Typical values are at T<sub>A</sub> = +25°C.) (Note 1)

| PARAMETER                              | SYMBOL           | CONDITIONS                                                                        |                                                        |                                  | MIN   | TYP   | MAX             | UNITS             |
|----------------------------------------|------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------|----------------------------------|-------|-------|-----------------|-------------------|
| Operating Voltage Range                | V <sub>CC</sub>  | (Note 2)                                                                          |                                                        |                                  | 4     |       | 28              | V                 |
| Supply Current                         | I <sub>CC</sub>  | V <sub>CC</sub> = 5V, no load                                                     |                                                        |                                  |       | 2     | 5               | μA                |
|                                        |                  | V <sub>CC</sub> = 12V, no load                                                    |                                                        |                                  |       | 3.5   | 7.5             |                   |
|                                        |                  | V <sub>CC</sub> = 24V, no load                                                    |                                                        |                                  |       | 6.5   | 12.5            |                   |
| Threshold Voltage                      | V <sub>TH+</sub> | V <sub>IN</sub><br>rising                                                         | T <sub>A</sub> = -40°C to +85°C, V <sub>CC</sub> ≥ 4V  |                                  | 1.195 | 1.228 | 1.255           | V                 |
|                                        |                  |                                                                                   | T <sub>A</sub> = +85°C to +125°C, V <sub>CC</sub> ≥ 4V |                                  | 1.170 |       | 1.255           |                   |
|                                        | V <sub>TH-</sub> | V <sub>IN</sub><br>falling                                                        | MAX645_U_D_A                                           | T <sub>A</sub> = -40°C to +85°C  | 1.180 |       | 1.255           |                   |
|                                        |                  |                                                                                   |                                                        | T <sub>A</sub> = +85°C to +125°C | 1.155 |       | 1.255           |                   |
|                                        |                  |                                                                                   | MAX645_U_D_B                                           | T <sub>A</sub> = -40°C to +85°C  | 1.133 |       | 1.194           |                   |
|                                        |                  |                                                                                   |                                                        | T <sub>A</sub> = +85°C to +125°C | 1.111 |       | 1.194           |                   |
|                                        |                  |                                                                                   | MAX645_U_D_C                                           | T <sub>A</sub> = -40°C to +85°C  | 1.093 |       | 1.151           |                   |
|                                        |                  |                                                                                   |                                                        | T <sub>A</sub> = +85°C to +125°C | 1.071 |       | 1.151           |                   |
| Threshold Voltage Hysteresis           |                  | MAX64_ _U_D_A                                                                     |                                                        |                                  |       | 0.5   |                 | %V <sub>TH+</sub> |
|                                        |                  | MAX64_ _U_D_B                                                                     |                                                        |                                  |       | 5     |                 |                   |
|                                        |                  | MAX64_ _U_D_C                                                                     |                                                        |                                  |       | 8.3   |                 |                   |
| IN Operating Voltage Range             | V <sub>IN</sub>  | (Note 2)                                                                          |                                                        |                                  | 0     |       | V <sub>CC</sub> | V                 |
| IN Leakage Current                     | I <sub>IN</sub>  | V <sub>IN</sub> = 1.25V, V <sub>CC</sub> = +28V                                   |                                                        |                                  | -55   |       | +55             | nA                |
| OUT Timeout Period                     | t <sub>TP</sub>  | MAX645_UKD0_<br>MAX6459UT_<br>MAX6460UT                                           |                                                        |                                  |       | 50    |                 | μs                |
|                                        |                  | MAX6457 and MAX6458 only,<br>D3 option                                            |                                                        |                                  | 90    | 150   | 210             | ms                |
| Startup Time                           |                  | V <sub>CC</sub> rising from GND to V <sub>CC</sub> ≥ 4V in less than 1μs (Note 3) |                                                        |                                  |       | 2     |                 | ms                |
| CLEAR Input Logic Voltage<br>(MAX6457) | V <sub>IL</sub>  |                                                                                   |                                                        |                                  |       |       | 0.4             | V                 |
|                                        | V <sub>IH</sub>  |                                                                                   |                                                        |                                  | 2     |       |                 |                   |

# MAX6457–MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 4V$  to  $28V$ ,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise specified. Typical values are at  $T_A = +25^{\circ}C$ .) (Note 1)

| PARAMETER                               | SYMBOL       | CONDITIONS                                                                                        | MIN   | TYP  | MAX   | UNITS         |
|-----------------------------------------|--------------|---------------------------------------------------------------------------------------------------|-------|------|-------|---------------|
| Output Voltage Low                      | $V_{OL}$     | $V_{CC} \geq 1.5V$ , $I_{SINK} = 250\mu A$ , OUT asserted, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ |       |      | 0.4   | V             |
|                                         |              | $V_{CC} \geq 4.0V$ , $I_{SINK} = 1mA$ , OUT asserted, $T_A = -40^{\circ}C$ to $+125^{\circ}C$     |       |      | 0.4   |               |
| Output Leakage Current                  | $I_{LKG}$    | $V_{CC} = 5V$ , $V_{OUT} = 28V$ (Note 4)                                                          |       |      | 500   | nA            |
| Output Short-Circuit Sink               | $I_{SC}$     | OUT asserted, $OUT = V_{CC}$                                                                      |       | 10   |       | mA            |
| <b>MAX6460</b>                          |              |                                                                                                   |       |      |       |               |
| Reference Short-Circuit Current         |              | REF = GND                                                                                         |       | 7    |       | mA            |
| Reference Output Voltage                | $V_{REF}$    | $T_A = -40^{\circ}C$ to $+85^{\circ}C$                                                            | 2.183 | 2.25 | 2.303 | V             |
|                                         |              | $T_A = +85^{\circ}C$ to $+125^{\circ}C$                                                           | 2.171 | 2.25 | 2.303 |               |
| Load Regulation                         |              | Sourcing: $0 \leq I_{REF} \leq 100\mu A$ ,<br>sinking: $0 \leq  I_{REF}  \leq 300nA$              |       | 50   |       | $\mu V/\mu A$ |
| Input Offset Voltage                    | $V_{OFFSET}$ |                                                                                                   | -4.5  |      | +4.5  | mV            |
| Input Hysteresis                        |              |                                                                                                   |       | 6    |       | mV            |
| Input Bias Current                      | $I_{BIAS}$   | $V_{IN+} = 1.4V$ , $V_{IN-} = 1V$                                                                 | -25   |      | +25   | nA            |
| Input Offset Current                    | $I_{OFFSET}$ |                                                                                                   |       | 2    |       | pA            |
| Common-Mode Voltage Range               | CMVR         |                                                                                                   | 0     |      | 1.4   | V             |
| Common-Mode Rejection Ratio             | CMRR         |                                                                                                   |       | 80   |       | dB            |
| Comparator Power-Supply Rejection Ratio | PSRR         | $V_{IN+} = V_{IN-} = 1.4V$                                                                        |       | 80   |       | dB            |

**Note 1:** Devices are production tested at  $T_A = +25^{\circ}C$ . Overtemperature limits are guaranteed by design.

**Note 2:** IN voltage monitoring requires that  $V_{CC} \geq 4V$ , but OUT remains asserted in the correct undervoltage lockout state for  $V_{CC}$  down to 1.5V.

**Note 3:** Startup time is the time required for the internal regulator and reference to reach specified accuracy after the monitor is powered up from GND.

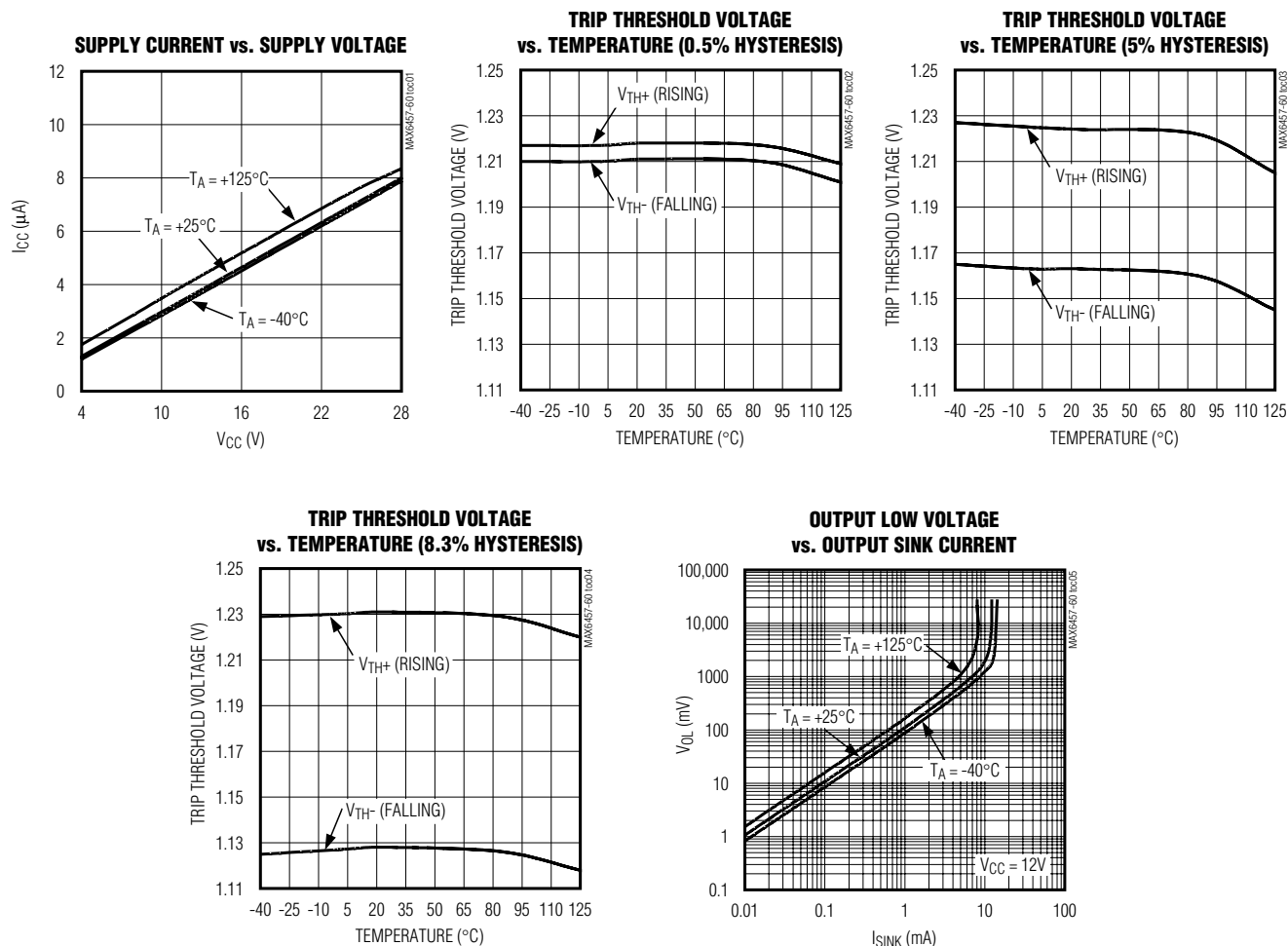
**Note 4:** The open-drain output can be pulled up to a voltage greater than  $V_{CC}$  but cannot exceed +28V.

# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Typical Operating Characteristics

(GND = 0, R<sub>PULLUP</sub> = 10k $\Omega$ , and T<sub>A</sub> = +25°C, unless otherwise noted.)

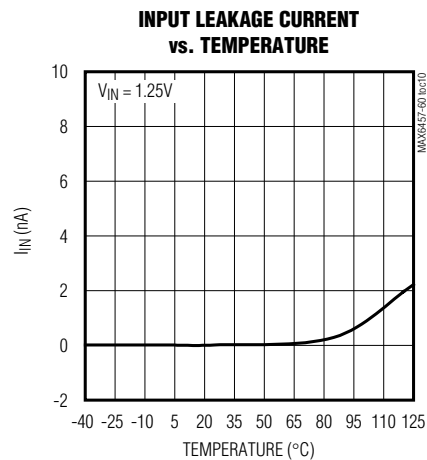
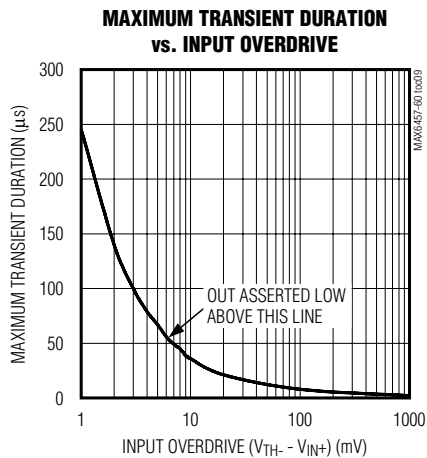
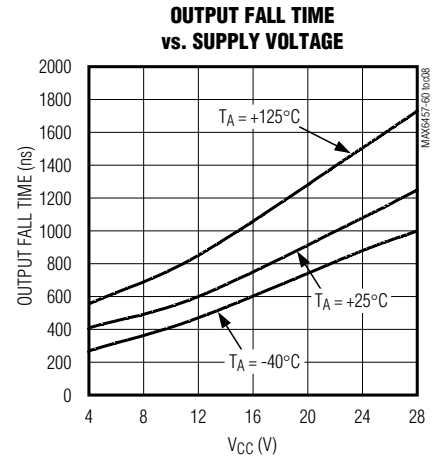
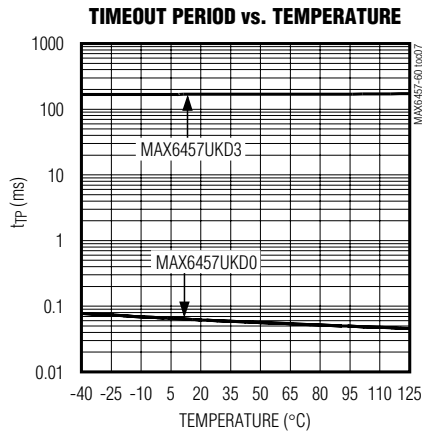
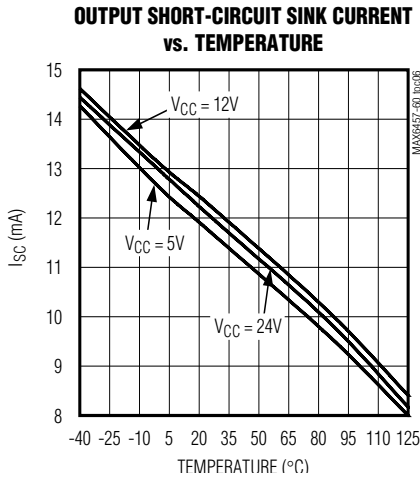


# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Typical Operating Characteristics (continued)

(GND = 0, R<sub>PULLUP</sub> = 10k $\Omega$ , and T<sub>A</sub> = +25°C, unless otherwise noted.)



# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Pin Description

| PIN     |         |         |         | NAME               | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------|---------|---------|---------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAX6457 | MAX6458 | MAX6459 | MAX6460 |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 1       | 1       | —       | 1       | OUT                | <p><b>MAX6457:</b> Open-Drain Monitor Output. OUT requires an external pullup resistor. OUT asserts low for <math>V_{CC}</math> between 1.5V and 4V. OUT asserts low when <math>V_{IN+}</math> drops below <math>V_{TH-}</math> and goes high after the timeout period (<math>t_{TP}</math>) when <math>V_{IN+}</math> exceeds <math>V_{TH+}</math>.</p> <p><b>MAX6458:</b> Open-Drain Monitor Output. OUT requires an external pullup resistor. OUT asserts low for <math>V_{CC}</math> between 1.5V and 4V. OUT asserts low when <math>V_{IN+}</math> drops below <math>V_{TH-}</math> or when <math>V_{IN-}</math> exceeds <math>V_{TH+}</math>. OUT goes high after the timeout period (<math>t_{TP}</math>) when <math>V_{IN+}</math> exceeds <math>V_{TH+}</math> and <math>V_{IN-}</math> drops below <math>V_{TH-}</math>.</p> <p><b>MAX6460:</b> Open-Drain Monitor Output. OUT requires an external pullup resistor. OUT asserts low for <math>V_{CC}</math> between 1.5V and 4V. OUT asserts low when <math>V_{IN+}</math> drops below <math>V_{IN-}</math>. OUT goes high when <math>V_{IN+}</math> is above <math>V_{IN-}</math>.</p> |
| —       | —       | 1       | —       | OUTA               | Open-Drain Monitor A Undervoltage Output. OUTA requires an external pullup resistor. OUTA goes low when $V_{IN+}$ drops below $V_{TH-}$ and goes high when $V_{IN+}$ exceeds $V_{TH+}$ . OUTA also goes low for $V_{CC}$ between 1.5V and 4V.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| —       | —       | 5       | —       | OUTB               | Open-Drain Monitor B Overvoltage Output. OUTB requires an external pullup resistor. OUTB goes low when $V_{IN-}$ exceeds $V_{TH+}$ and goes high when $V_{IN-}$ drops below $V_{TH-}$ . OUTB also goes low when $V_{CC}$ drops below 4V.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 2       | 2       | 2       | 2       | GND                | Ground                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 3       | 3       | 3       | 3       | IN+                | Adjustable Undervoltage Monitor Threshold Input. Noninverting input for MAX6460.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| —       | 4       | 4       | 4       | IN-                | Adjustable Overvoltage Monitor Threshold Input. Inverting input for MAX6460.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 4       | —       | —       | —       | $\overline{CLEAR}$ | Clear Input. For $V_{IN+} > V_{TH+}$ , drive $\overline{CLEAR}$ high to latch OUT high. Connect $\overline{CLEAR}$ to GND to make the latch transparent. $\overline{CLEAR}$ must be low when powering up the device. Connect $\overline{CLEAR}$ to GND when not used.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| —       | —       | —       | 5       | REF                | Reference. Internal 2.25V reference output. Connect REF to IN+ through a voltage divider for active-low output. Connect REF to IN- through a voltage divider for active-high output. REF can source up to 100 $\mu$ A and sink up to 300nA. Leave REF floating when not used. REF output is stable with capacitive loads from 0 to 50pF or greater than 1 $\mu$ F.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 5       | 5       | 6       | 6       | VCC                | Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Functional Diagrams

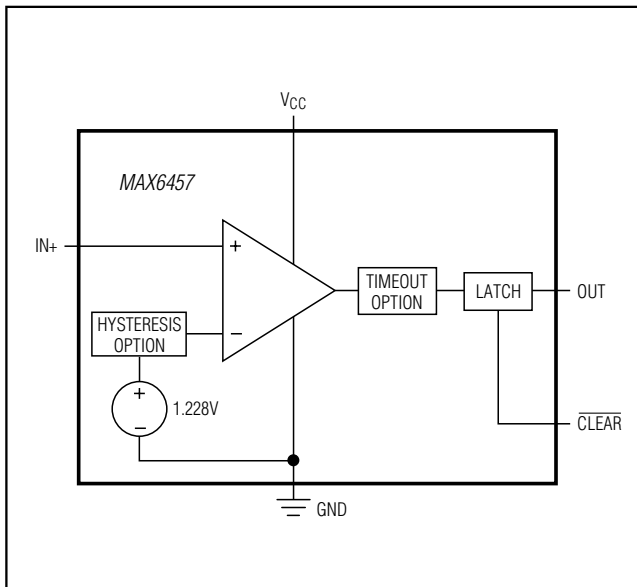


Figure 1. MAX6457 Functional Diagram

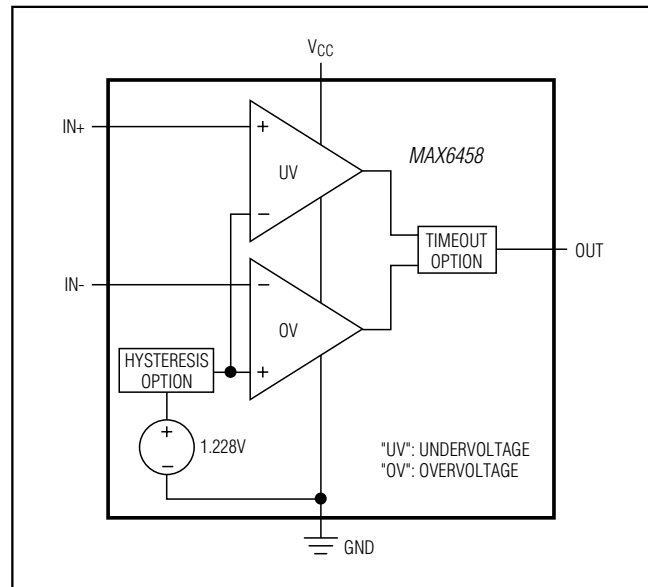


Figure 2. MAX6458 Functional Diagram

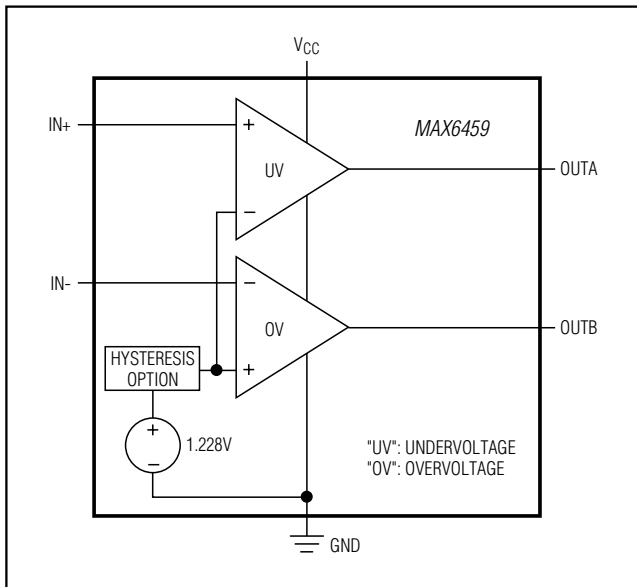


Figure 3. MAX6459 Functional Diagram

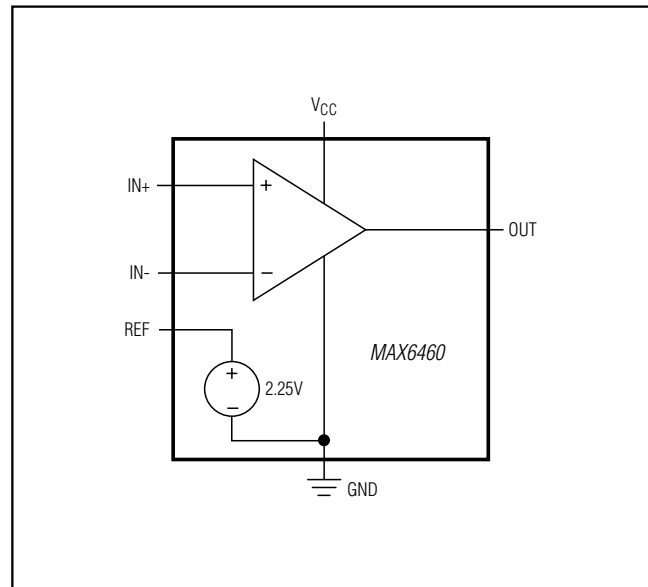


Figure 4. MAX6460 Functional Diagram

# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Detailed Description

Each of the MAX6457-MAX6460 high-voltage (4V to 28V), low-power voltage monitors include a precision bandgap reference, one or two low-offset-voltage comparators, internal threshold hysteresis, internal timeout period, and one or two high-voltage open-drain outputs.

#### Programming the Trip Voltage (V<sub>TRIP</sub>)

Two external resistors set the trip voltage, V<sub>TRIP</sub> (Figure 5). V<sub>TRIP</sub> is the point at which the applied voltage (typically V<sub>CC</sub>) toggles OUT. The MAX6457/MAX6458/MAX6459/MAX6460's high input impedance allows large-value resistors without compromising trip-voltage accuracy. To minimize current consumption, select a value for R2 between 10kΩ and 1MΩ, then calculate R1 as follows:

$$R1 = R2 \left( \frac{V_{TRIP}}{V_{TH}} - 1 \right)$$

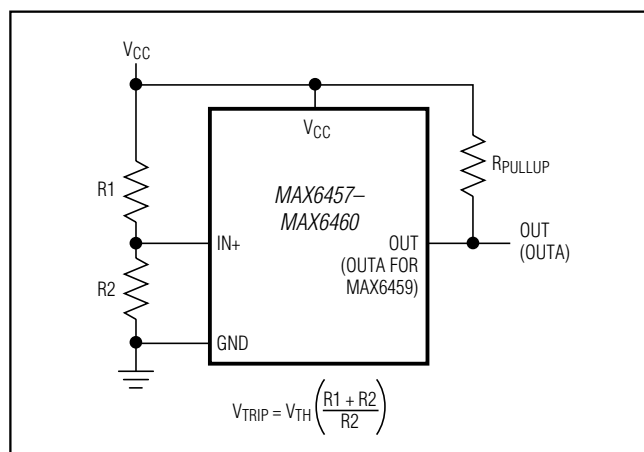


Figure 5a. Programming the Trip Voltage

where V<sub>TRIP</sub> = desired trip voltage (in volts), V<sub>TH</sub> = threshold trip voltage (V<sub>TH+</sub> for overvoltage detection or V<sub>TH-</sub> for undervoltage detection).

Use the MAX6460 voltage reference (REF) to set the trip threshold by connecting IN+ or IN- through a voltage divider (within the inputs common-mode voltage range) to REF. Do not connect REF directly to IN+ or IN- since this violates the input common-mode voltage range. Small leakage currents into the comparators inputs allows use of large value resistors to prevent loading the reference and affecting its accuracy. Figure 5b shows an active-high power-good output. Use the following equation to determine the resistor values when connecting REF to IN-:

$$V_{REFD} = V_{REF} \left( \frac{R4}{R3 + R4} \right)$$

$$R1 = R2 \left( \frac{V_{TRIP}}{V_{REFD}} - 1 \right)$$

where V<sub>REF</sub> = reference output voltage (2.25V, typ), V<sub>REFD</sub> = divided reference, V<sub>TRIP</sub> = desired trip threshold in (in volts).

For an active-low power-good output, connect the resistor divider R1 and R2 to the inverting input and the reference-divider network to the noninverting input. Alternatively, connect an external reference less than 1.4V to either input.

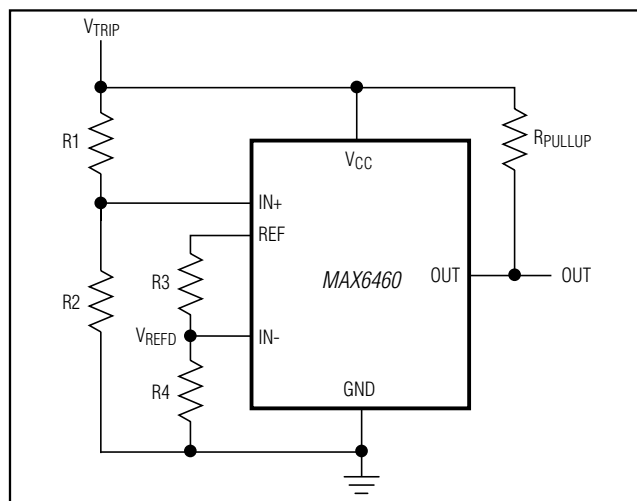


Figure 5b. Programming the MAX6460 Trip Voltage

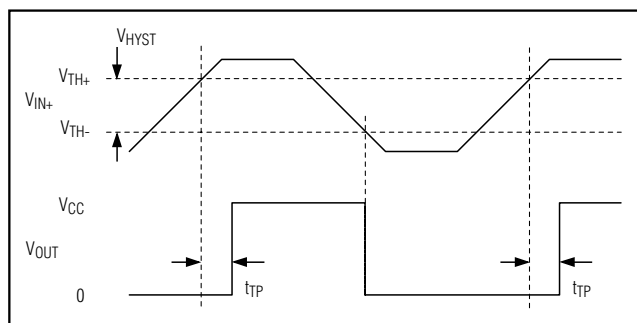


Figure 6. Input and Output Waveforms (Noninverting Input Varied)



## High-Voltage, Low-Current Voltage Monitors in SOT Packages



# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

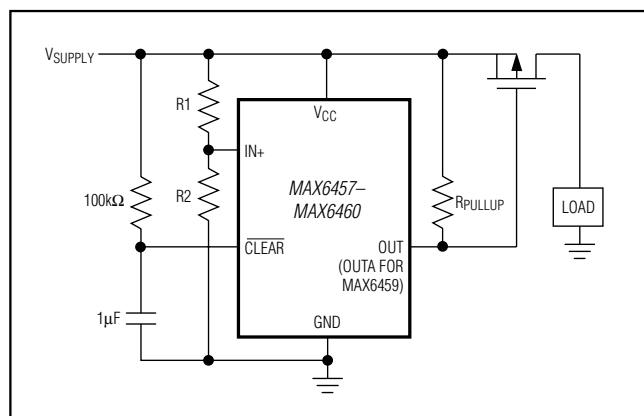


Figure 9. Overvoltage Shutdown Circuit (with External Pass MOSFET)

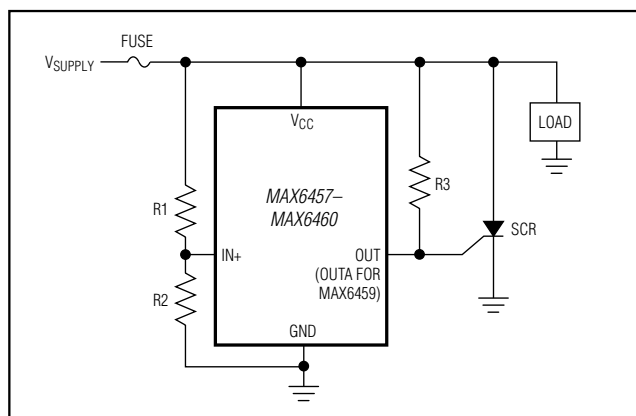


Figure 10. Overvoltage Shutdown Circuit (with SCR Fuse)

### Applications Information

#### Undervoltage Lockout

Figure 8 shows the typical application circuit for detecting an undervoltage event of a 5-cell Li+ battery stack. Connect OUT of the MAX6457/MAX6458/MAX6460 (OUTA of the MAX6459) to the shutdown input of the DC-DC converter to cut off power to the load in case of an undervoltage event. Select R1 and R2 to set the trip voltage (see the *Programming the Trip Voltage (VTRIP)* section). When the voltage of the battery stack decreases so that  $V_{IN+}$  drops below  $V_{TH-}$  of the MAX6457-MAX6460, then OUT (OUTA) goes low and disables the power supply to the load. When the battery charger restores the voltage of the 5-cell stack so that  $V_{IN+} > V_{TH+}$ , OUT (OUTA) goes high and the power supply resumes driving the load.

#### Overvoltage Shutdown

The MAX6457-MAX6460 are ideal for overvoltage shutdown applications. Figure 9 shows a typical circuit for this application using a pass P-channel MOSFET. The MAX6457-MAX6460 are powered directly from the system voltage supply. Select R1 and R2 to set the trip voltage (see the *Programming the Trip Voltage (VTRIP)* section). When the supply voltage remains below the selected threshold, a low logic level on OUT (OUTB for MAX6459) turns on the p-channel MOSFET. In the case of an overvoltage event, OUT (OUTB) asserts high, turns off the MOSFET, and shuts down the power to the load.

Figure 10 shows a similar application using a fuse and a silicon-controlled rectifier (SCR). An overvoltage event turns on the SCR and shorts the supply to ground. The surge of current through the short circuit blows the fuse and terminates the current to the load. Select R3 so that the gate of the SCR is properly biased when OUT (OUTB) goes high impedance.

#### Window Detection

The MAX6458/MAX6459 include undervoltage and overvoltage comparators for window detection (Figures 2 and 3). The circuit in Figure 11 shows the typical configuration for this application. For the MAX6458, OUT asserts high when  $V_{CC}$  is within the selected "window." When  $V_{CC}$  falls below the lower limit of the window ( $V_{TRIPLOW}$ ) or exceeds the upper limit ( $V_{TRIPHIGH}$ ), OUT asserts low.

The MAX6459 features two independent open-drain outputs: OUTA (for undervoltage events) and OUTB (for overvoltage events). When  $V_{CC}$  is within the selected window, OUTA and OUTB assert high. When  $V_{CC}$  falls below  $V_{TRIPLOW}$ , OUTA asserts low while OUTB

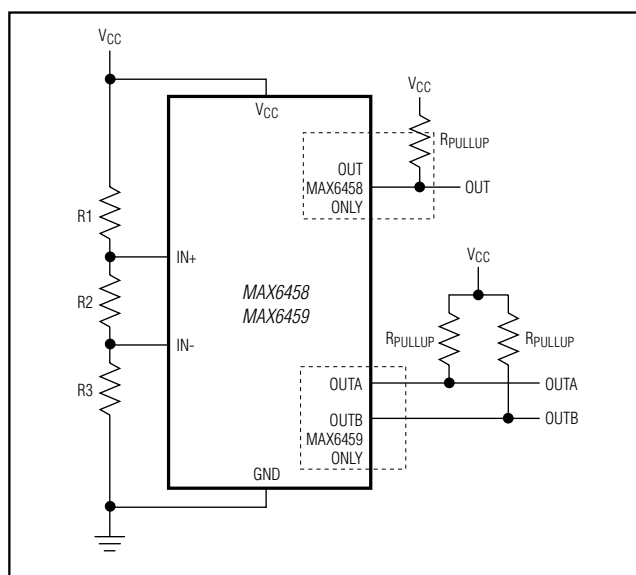


Figure 11. Window Detection

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remains high. When  $V_{CC}$  exceeds  $V_{TRIPHIGH}$ ,  $OUTB$  asserts low while  $OUTA$  remains high.  $V_{TRIPLOW}$  and  $V_{TRIPHIGH}$  are given by the following equations:

$$V_{TRIPLOW} = V_{TH-} \left( \frac{R_{TOTAL}}{R_2 + R_3} \right)$$

$$V_{TRIPHIGH} = V_{TH+} \left( \frac{R_{TOTAL}}{R_3} \right)$$

where  $R_{TOTAL} = R_1 + R_2 + R_3$ .

Use the following steps to determine the values for  $R_1$ ,  $R_2$ , and  $R_3$ .

- 1) Choose a value for  $R_{TOTAL}$ , the sum of  $R_1$ ,  $R_2$ , and  $R_3$ . Because the MAX6457/MAX6459 have very high input impedance,  $R_{TOTAL}$  can be up to  $5M\Omega$ .
- 2) Calculate  $R_3$  based on  $R_{TOTAL}$  and the desired upper trip point:

$$R_3 = \frac{V_{TH+} \times R_{TOTAL}}{V_{TRIPHIGH}}$$

- 3) Calculate  $R_2$  based on  $R_{TOTAL}$ ,  $R_3$ , and the desired lower trip point:

$$R_2 = \frac{V_{TH-} \times R_{TOTAL}}{V_{TRIPLOW}} - R_3$$

- 4) Calculate  $R_1$  based on  $R_{TOTAL}$ ,  $R_3$ , and  $R_2$ :

$$R_1 = R_{TOTAL} - R_2 - R_3$$

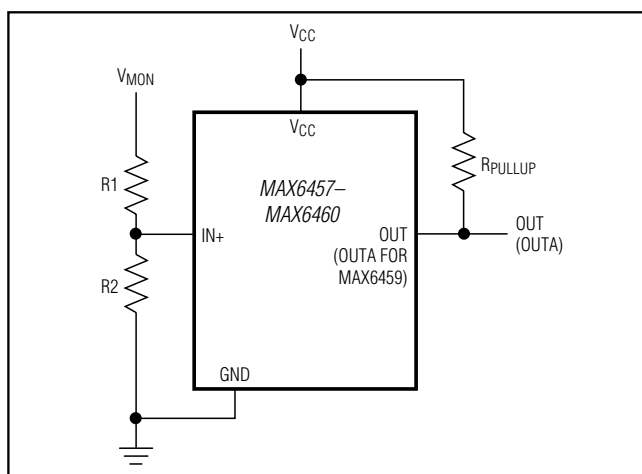


Figure 12. Monitoring Voltages Other than  $V_{CC}$

### Example Calculations for Window Detection

The following is an example for calculating  $R_1$ ,  $R_2$ , and  $R_3$  of Figure 11 for window detection. Select the upper and lower trip points ( $V_{TRIPHIGH}$  and  $V_{TRIPLOW}$ ).

$V_{CC} = 21V$

$V_{TRIPHIGH} = 23.1V$

$V_{TRIPLOW} = 18.9V$

For 5% hysteresis,  $V_{TH+} = 1.228$  and  $V_{TH-} = 1.167$ .

- 1) Choose  $R_{TOTAL} = 4.2M\Omega = R_1 + R_2 + R_3$
- 2) Calculate  $R_3$

$$R_3 = \frac{V_{TH+} \times R_{TOTAL}}{V_{TRIPHIGH}} = \frac{(1.228V)(4.2M\Omega)}{23.1V} = 223.273k\Omega$$

- 3) Calculate  $R_2$

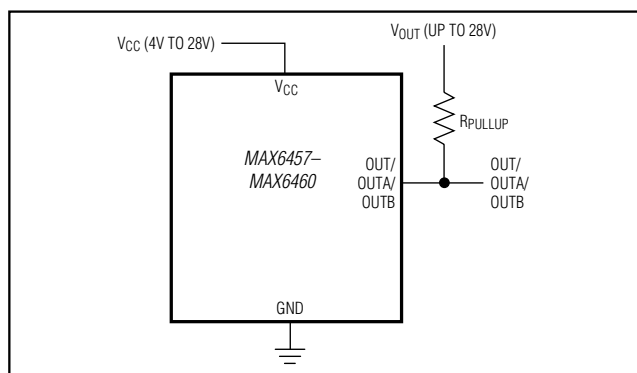


Figure 13. Interfacing to Voltages Other than  $V_{CC}$

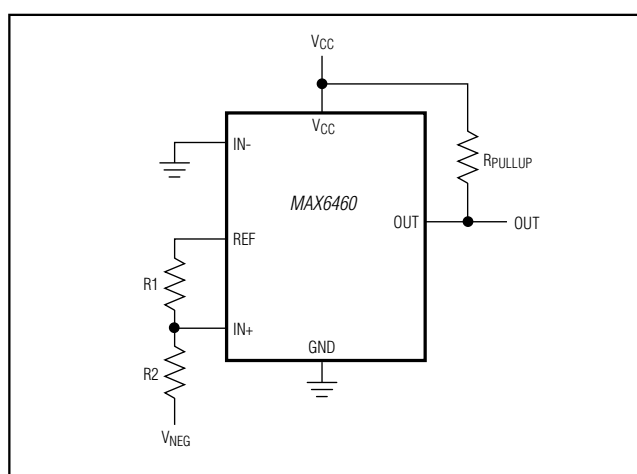


Figure 14. Monitoring Negative Voltages

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**Table 1. Factory-Trimmed Internal Hysteresis and Timeout Period Options**

| PART                           | SUFFIX | TIMEOUT OPTION | HYSTERESIS OPTION (%) |
|--------------------------------|--------|----------------|-----------------------|
| MAX6457UKD_-T<br>MAX6458UKD_-T | 0A     | 50µs           | 0.5                   |
|                                | 0B     | 50µs           | 5                     |
|                                | 0C     | 50µs           | 8.3                   |
|                                | 3A     | 150ms          | 0.5                   |
|                                | 3B     | 150ms          | 5                     |
|                                | 3C     | 150ms          | 8.3                   |
| MAX6459UT_-T                   | A      | 50µs           | 0.5                   |
|                                | B      | 50µs           | 5                     |
|                                | C      | 50µs           | 8.3                   |
| MAX6460UT-T                    | N/A    | 50µs           | 0.5                   |

### Selector Guide

| PART           | PIN COUNT | LATCHED OUTPUT | NUMBER OF OUTPUTS | HYSTERESIS (%V <sub>TH</sub> +) ) | TIMEOUT PERIOD | TOP MARK | COMPARATORS |
|----------------|-----------|----------------|-------------------|-----------------------------------|----------------|----------|-------------|
| MAX6457UKD0A-T | 5         | ✓              | 1                 | 0.5                               | 50µs           | AEAA     | 1           |
| MAX6457UKD3A-T | 5         | ✓              | 1                 | 0.5                               | 150ms          | AANN     | 1           |
| MAX6457UKD0B-T | 5         | ✓              | 1                 | 5                                 | 50µs           | AANL     | 1           |
| MAX6457UKD3B-T | 5         | ✓              | 1                 | 5                                 | 150ms          | AANO     | 1           |
| MAX6457UKD0C-T | 5         | ✓              | 1                 | 8.3                               | 50µs           | AANM     | 1           |
| MAX6457UKD3C-T | 5         | ✓              | 1                 | 8.3                               | 150ms          | ADZZ     | 1           |
| MAX6458UKD0A-T | 5         | —              | 1                 | 0.5                               | 50µs           | AANP     | 2           |
| MAX6458UKD3A-T | 5         | —              | 1                 | 0.5                               | 150ms          | AANS     | 2           |
| MAX6458UKD0B-T | 5         | —              | 1                 | 5                                 | 50µs           | AANQ     | 2           |
| MAX6458UKD3B-T | 5         | —              | 1                 | 5                                 | 150ms          | AEAB     | 2           |
| MAX6458UKD0C-T | 5         | —              | 1                 | 8.3                               | 50µs           | AANR     | 2           |
| MAX6458UKD3C-T | 5         | —              | 1                 | 8.3                               | 150ms          | AANT     | 2           |
| MAX6459UTA-T   | 6         | —              | 2                 | 0.5                               | 50µs           | ABML     | 2           |
| MAX6459UTB-T   | 6         | —              | 2                 | 5                                 | 50µs           | ABEJ     | 2           |
| MAX6459UTC-T   | 6         | —              | 2                 | 8.3                               | 50µs           | ABMM     | 2           |
| MAX6460UT-T    | 6         | —              | 1                 | 0.5                               | 50µs           | ABEG     | 1           |

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## High-Voltage, Low-Current Voltage Monitors in SOT Packages

$$\begin{aligned}
 R2 &= \frac{V_{TH-} \times R_{TOTAL}}{V_{TRIPLOW}} - R3 \\
 &= \frac{(1.167V)(4.2M\Omega)}{18.9V} - 223.273k\Omega \\
 &= 36.06k\Omega
 \end{aligned}$$

4) Calculate R1

$$\begin{aligned}
 R1 &= R_{TOTAL} - R2 - R3 \\
 &= 4.2M\Omega - 223.273k\Omega - 36.06k\Omega \\
 &= 3.94067M\Omega
 \end{aligned}$$

### Monitoring Voltages Other than VCC

The MAX6457–MAX6460 can monitor voltages other than VCC (Figure 12). Calculate VTRIP as shown in the *Programming the Trip Voltage (VTRIP)* section. The monitored voltage (VMON) is independent of VCC. VIN+ must be within the specified operating range: 0 to VCC.

### Interfacing to Voltages Other than VCC

The open-drain outputs of the MAX6457–MAX6460 allow the output voltage to be selected independent of VCC. For systems requiring an output voltage other than VCC, connect the pullup resistor between OUT, OUTA, or OUTB and any desired voltage up to 28V (see Figure 13).

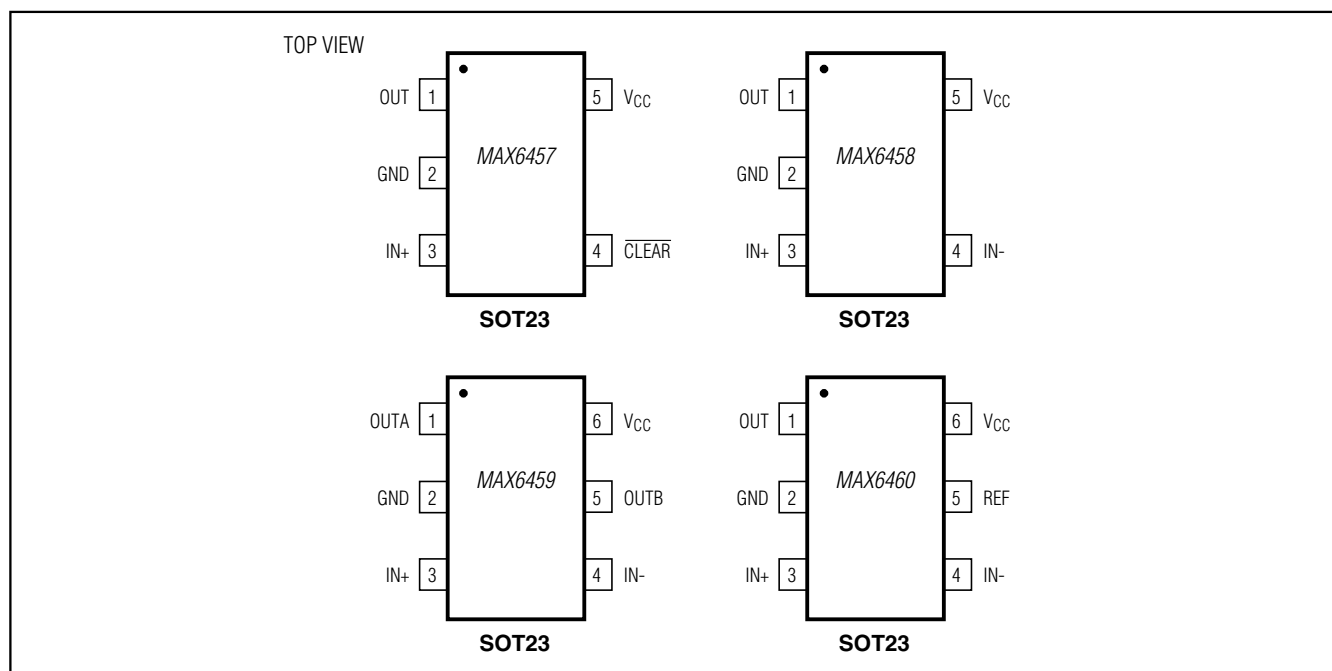
### Monitoring Negative Voltages

Figure 14 shows the typical application circuit for monitoring negative voltages (VNEG) using the MAX6460. Select a value for R1 between 25kΩ and 1MΩ. Use the following equation to select R2:

$$R2 = R1 \times \frac{-V_{NEG}}{V_{REF}}$$

where VREF = 2.25V and VNEG < 0. VIN+ must always be within the specified operating range: 0 to VCC.

## Pin Configurations



# MAX6457-MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Chip Information

PROCESS: BiCMOS

### Package Information

For the latest package outline information and land patterns (footprints), go to [www.maxim-integrated.com/packages](http://www.maxim-integrated.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         | <a href="#">21-0057</a> | <a href="#">90-0174</a> |
| 6 SOT23      | U6+1         | <a href="#">21-0058</a> | <a href="#">90-0175</a> |

# MAX6457–MAX6460

## High-Voltage, Low-Current Voltage Monitors in SOT Packages

### Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION                                                                  | PAGES CHANGED       |
|-----------------|---------------|------------------------------------------------------------------------------|---------------------|
| 0               | 7/02          | Initial release                                                              | —                   |
| 1               | 6/03          | Updated the <i>Pin Description</i> and <i>Detailed Description</i> sections. | 6, 8                |
| 2               | 12/05         | Added lead-free notation to <i>Ordering Information</i> .                    | 1                   |
| 3               | 1/07          | Updated the <i>Pin Description</i> and Figures 5a, 9, 12.                    | 6, 8, 10, 11, 13-16 |
| 4               | 3/09          | Updated the <i>Programming the Trip Voltage (V<sub>TRIP</sub>)</i> section.  | 8                   |
| 5               | 7/12          | Updated the <i>Package Information</i> table.                                | 14                  |
| 6               | 12/12         | Added MAX6459UT_/_V+ to <i>Ordering Information</i>                          | 1                   |



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