

## MAX6457–MAX6460

## 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 50 $\mu$ s 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 50 $\mu$ s 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

### Benefits and Features

- Wide Supply Voltage Range, 4V to 28V
- Internal 2.25V  $\pm$ 2.5% Reference
- Low Current (3.5 $\mu$ A, 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 (50 $\mu$ s, 150ms)
- Internal Undervoltage Lockout
- Immune to Short Voltage Transients
- Small SOT23 Packages
- Few External Components
- Fully Specified from -40°C to +125°C
- AEC-Q100 Qualified (MAX6459UT/V+ only)

### 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/V-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     |

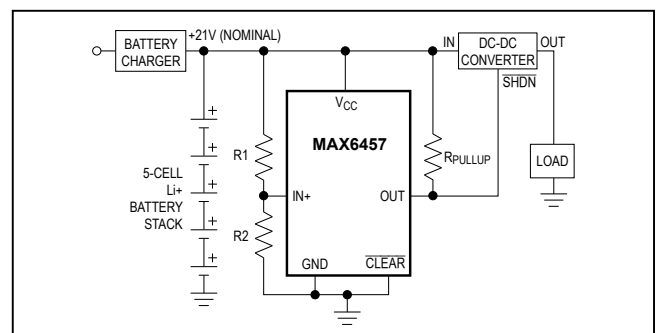
**Note:** The MAX6457/MAX6458/MAX6459 are available with factory-trimmed internal hysteresis options. The MAX6457 and MAX6458 offer two fixed timing options. Select the desired hysteresis and timing options using Table 1 or the Selector Guide at the end of the data sheet, and enter the corresponding 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** appears at end of data sheet.

### Typical Operating Circuit



## Absolute Maximum Ratings

$V_{CC}$ , OUT, OUTA, OUTB,  $\overline{CLEAR}$  to GND ..... -0.3V to +30.0V  
 IN+, IN- to GND ..... -0.3V to ( $V_{CC}$  + 0.3V)  
 REF to GND ..... -0.3V to the lower of +6V and ( $V_{CC}$  + 0.3V)  
 Input Currents ( $V_{CC}$ , IN+, IN-) ..... 20mA  
 Sink Current (OUT, OUTA, OUTB) ..... 20mA  
 Continuous Power Dissipation ( $T_A$  = +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.

## Package Information

### 5 SOT23

| PACKAGE CODE                                   | U5+1                    |
|------------------------------------------------|-------------------------|
| Outline Number                                 | <a href="#">21-0057</a> |
| Land Pattern Number                            | <a href="#">90-0174</a> |
| <b>Thermal Resistance, Single-Layer Board:</b> |                         |
| Junction to Ambient ( $\theta_{JA}$ )          | 324.3°C/W               |
| Junction to Case ( $\theta_{JC}$ )             | 82°C/W                  |
| <b>Thermal Resistance, Multi-Layer Board:</b>  |                         |
| Junction to Ambient ( $\theta_{JA}$ )          | 255.9°C/W               |
| Junction to Case ( $\theta_{JC}$ )             | 81°C/W                  |

### 6 SOT23

| PACKAGE CODE                                   | U6+1/U6+1A              |
|------------------------------------------------|-------------------------|
| Outline Number                                 | <a href="#">21-0058</a> |
| Land Pattern Number                            | <a href="#">90-0175</a> |
| <b>Thermal Resistance, Single-Layer Board:</b> |                         |
| Junction to Case ( $\theta_{JC}$ )             | 80°C/W                  |
| <b>Thermal Resistance, Four-Layer Board:</b>   |                         |
| Junction to Ambient ( $\theta_{JA}$ )          | 115°C/W                 |
| Junction to Case ( $\theta_{JC}$ )             | 80°C/W                  |

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://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 thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

## 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)

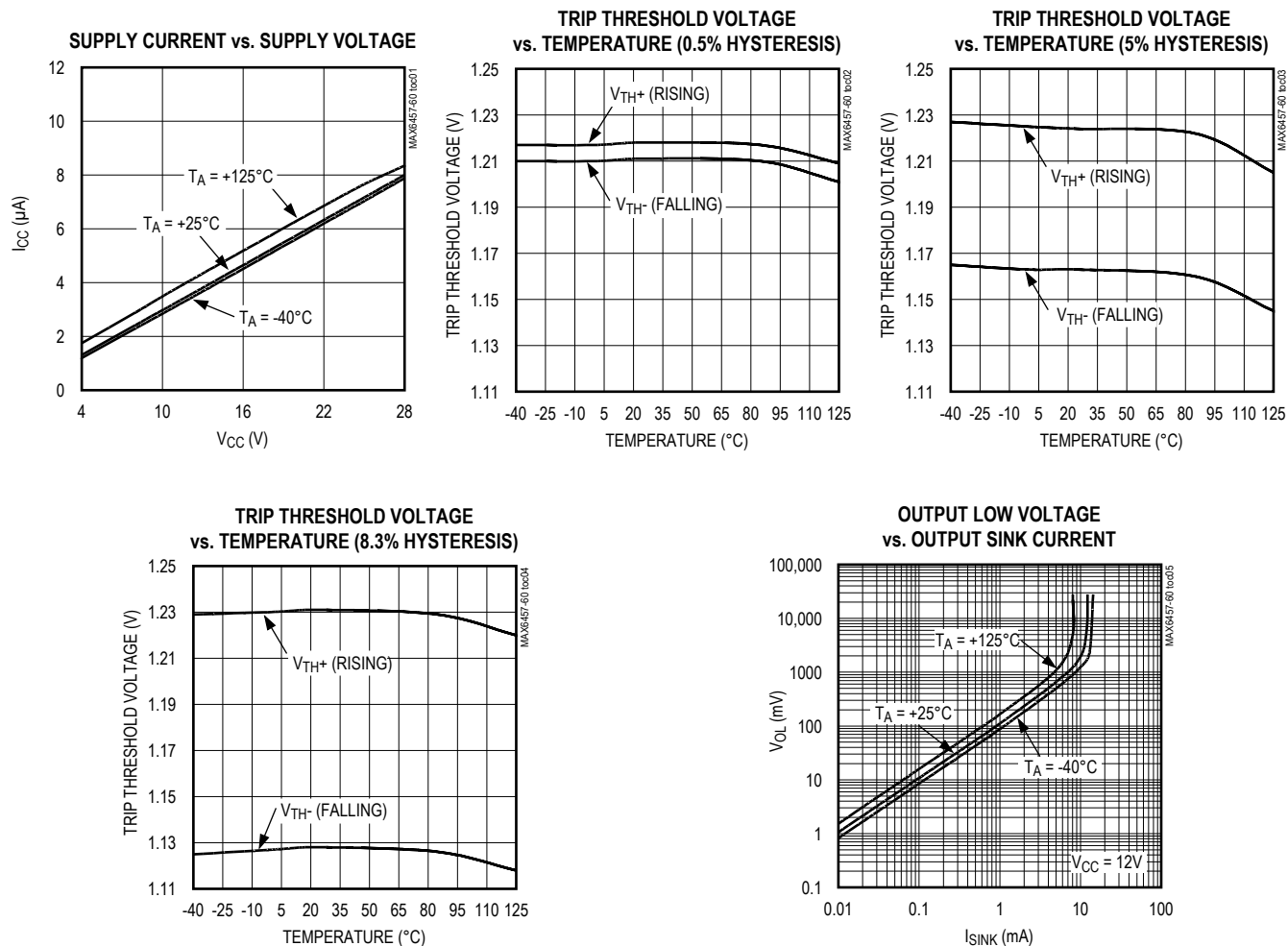
| PARAMETER                              | SYMBOL           | CONDITIONS                                                                           |                                                        | MIN   | TYP   | MAX             | UNITS             |
|----------------------------------------|------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------|-------|-------|-----------------|-------------------|
| 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> 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> falling                                                              | MAX645_U_D_A T <sub>A</sub> = -40°C to +85°C           | 1.180 |       | 1.255           |                   |
|                                        |                  |                                                                                      | MAX645_U_D_A 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           |                   |
|                                        |                  |                                                                                      | MAX645_U_D_B 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           |                   |
|                                        |                  |                                                                                      | MAX645_U_D_C 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<br>(Note 3) |                                                        |       | 2     |                 | ms                |
| CLEAR Input Logic Voltage<br>(MAX6457) | V <sub>IL</sub>  |                                                                                      |                                                        |       |       | 0.4             | V                 |
|                                        | V <sub>IH</sub>  |                                                                                      |                                                        | 2     |       |                 |                   |

**Electrical Characteristics (continued)**(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)

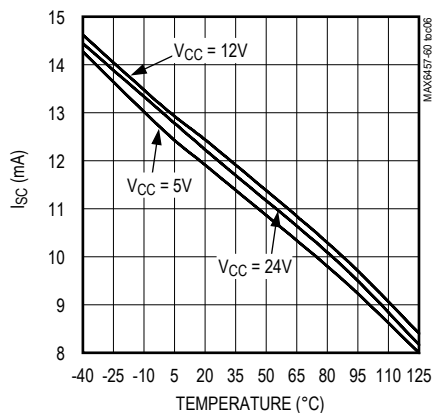
| PARAMETER                               | SYMBOL              | CONDITIONS                                                                                       | MIN   | TYP  | MAX   | UNITS |
|-----------------------------------------|---------------------|--------------------------------------------------------------------------------------------------|-------|------|-------|-------|
| Output Voltage Low                      | V <sub>OL</sub>     | V <sub>CC</sub> ≥ 1.5V, I <sub>SINK</sub> = 250μA, OUT asserted, T <sub>A</sub> = -40°C to +85°C |       |      | 0.4   | V     |
|                                         |                     | V <sub>CC</sub> ≥ 4.0V, I <sub>SINK</sub> = 1mA, OUT asserted, T <sub>A</sub> = -40°C to +125°C  |       |      | 0.4   |       |
| Output Leakage Current                  | I <sub>LKG</sub>    | V <sub>CC</sub> = 5V, V <sub>OUT</sub> = 28V (Note 4)                                            |       |      | 500   | nA    |
| Output Short-Circuit Sink               | I <sub>SC</sub>     | OUT asserted, OUT = V <sub>CC</sub>                                                              |       | 10   |       | mA    |
| <b>MAX6460</b>                          |                     |                                                                                                  |       |      |       |       |
| Reference Short-Circuit Current         |                     | REF = GND                                                                                        |       | 7    |       | mA    |
| Reference Output Voltage                | V <sub>REF</sub>    | T <sub>A</sub> = -40°C to +85°C                                                                  | 2.183 | 2.25 | 2.303 | V     |
|                                         |                     | T <sub>A</sub> = +85°C to +125°C                                                                 | 2.171 | 2.25 | 2.303 |       |
| Load Regulation                         |                     | Sourcing: 0 ≤ I <sub>REF</sub> ≤ 100μA, sinking: 0 ≤  I <sub>REF</sub>   ≤ 300nA                 |       | 50   |       | μV/μA |
| Input Offset Voltage                    | V <sub>OFFSET</sub> |                                                                                                  | -4.5  |      | +4.5  | mV    |
| Input Hysteresis                        |                     |                                                                                                  |       | 6    |       | mV    |
| Input Bias Current                      | I <sub>BIAS</sub>   | V <sub>IN+</sub> = 1.4V, V <sub>IN-</sub> = 1V                                                   | -25   |      | +25   | nA    |
| Input Offset Current                    | I <sub>OFFSET</sub> |                                                                                                  |       | 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 <sub>IN+</sub> = V <sub>IN-</sub> = 1.4V                                                       |       | 80   |       | dB    |

**Note 1:** Devices are production tested at T<sub>A</sub> = +25°C. Overtemperature limits are guaranteed by design.**Note 2:** IN voltage monitoring requires that V<sub>CC</sub> ≥ 4V, but OUT remains asserted in the correct undervoltage lockout state for V<sub>CC</sub> 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<sub>CC</sub> but cannot exceed +28V.

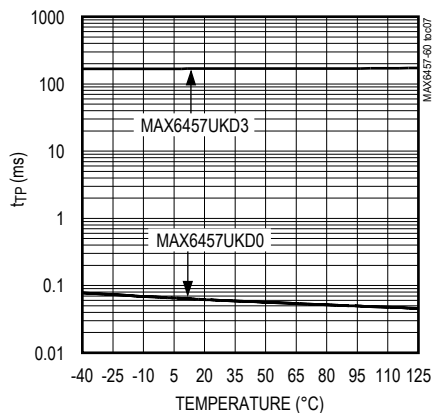
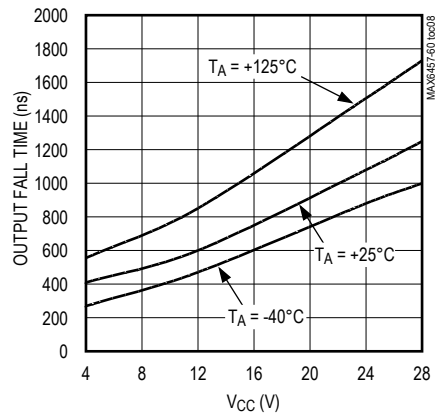
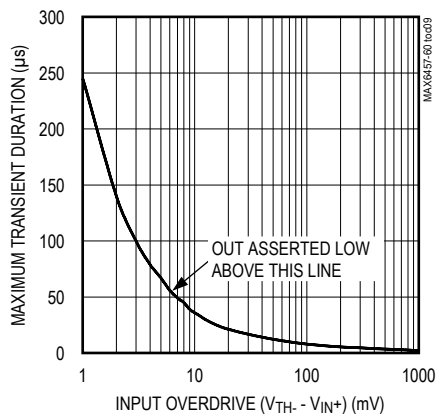
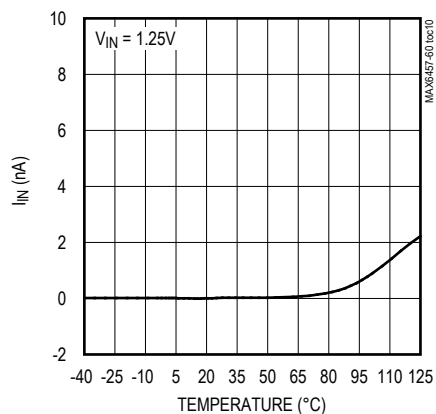
## Typical Operating Characteristics

(GND = 0,  $R_{PULLUP} = 10k\Omega$ , and  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

## Typical Operating Characteristics (continued)

(GND = 0, R<sub>PULLUP</sub> = 10k $\Omega$ , and T<sub>A</sub> = +25°C, unless otherwise noted.)OUTPUT SHORT-CIRCUIT SINK CURRENT  
vs. TEMPERATURE

TIMEOUT PERIOD vs. TEMPERATURE

OUTPUT FALL TIME  
vs. SUPPLY VOLTAGEMAXIMUM TRANSIENT DURATION  
vs. INPUT OVERDRIVEINPUT LEAKAGE CURRENT  
vs. TEMPERATURE

## 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       | —       | —       | —       | $\overline{\text{CLEAR}}$ | Clear Input. For $V_{IN+} > V_{TH+}$ , drive $\overline{\text{CLEAR}}$ high to latch OUT high. Connect CLEAR to GND to make the latch transparent. $\overline{\text{CLEAR}}$ must be low when powering up the device. Connect 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       | $V_{CC}$                  | Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

## Functional Diagrams

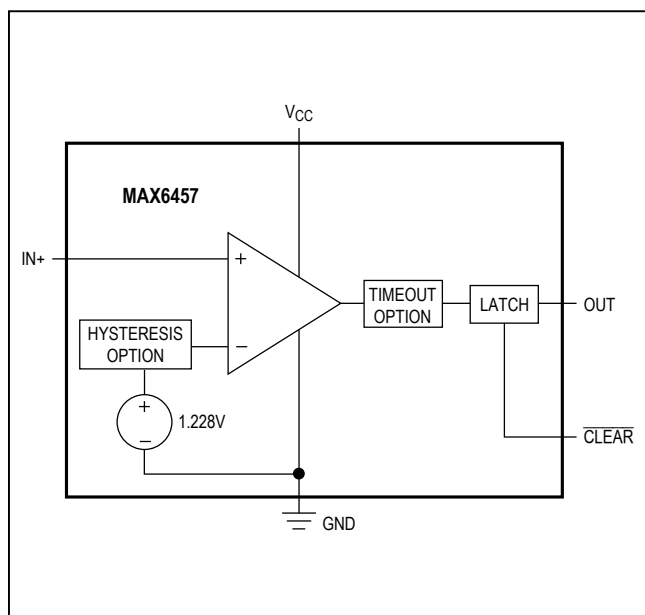


Figure 1. MAX6457 Functional Diagram

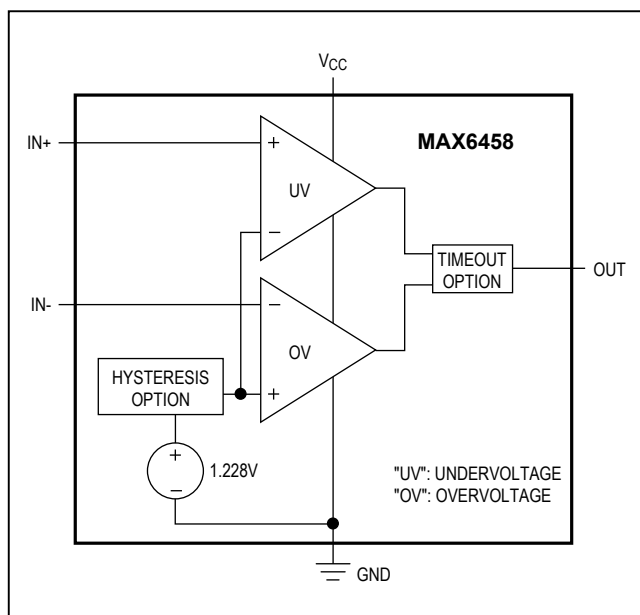


Figure 2. MAX6458 Functional Diagram

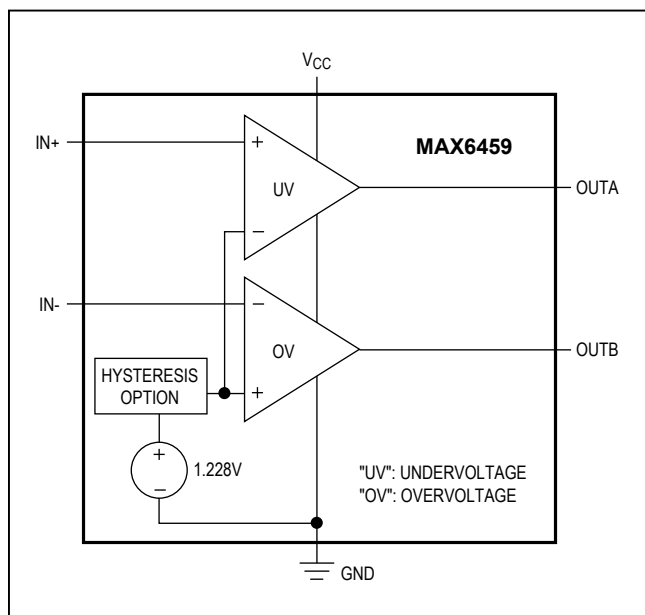


Figure 3. MAX6459 Functional Diagram

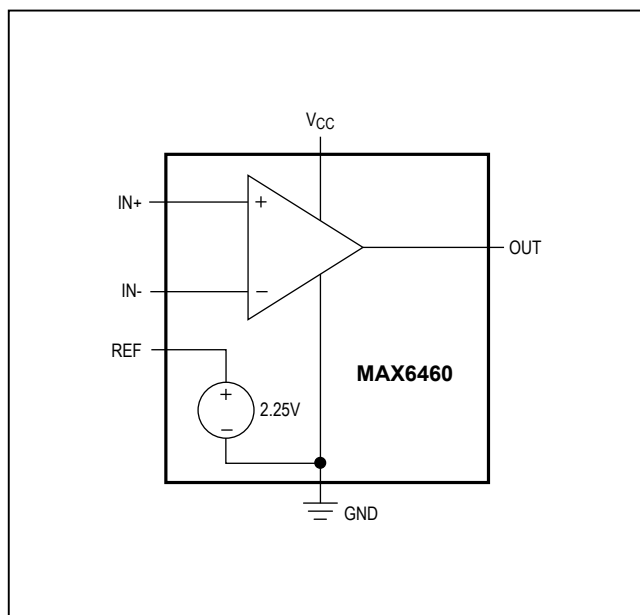


Figure 4. MAX6460 Functional Diagram

## 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 ( $V_{TRIP}$ )

Two external resistors set the trip voltage,  $V_{TRIP}$  (Figure 5).  $V_{TRIP}$  is the point at which the applied voltage (typically  $V_{CC}$ ) 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:

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

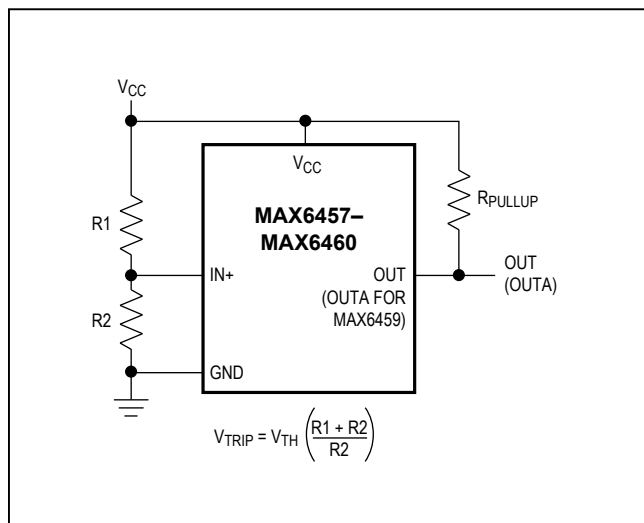


Figure 5a. Programming the Trip Voltage

where  $V_{TRIP}$  = desired trip voltage (in volts),  $V_{TH}$  = threshold trip voltage ( $V_{TH+}$  for overvoltage detection or  $V_{TH-}$  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  $V_{REF}$  = reference output voltage (2.25V, typ),  $V_{REFD}$  = divided reference,  $V_{TRIP}$  = 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.

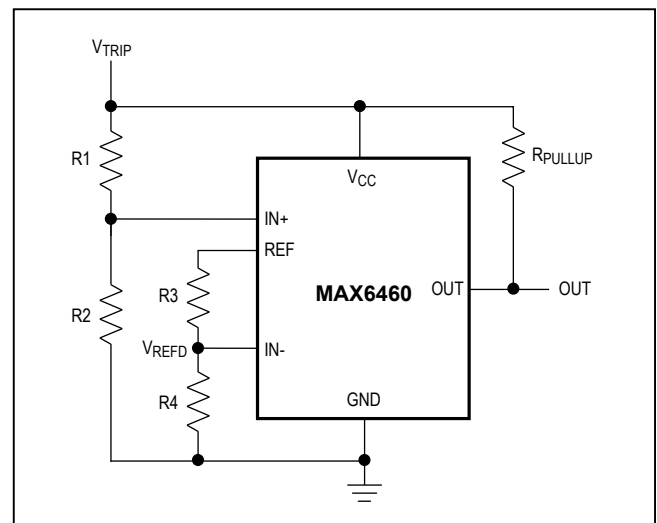


Figure 5b. Programming the MAX6460 Trip Voltage

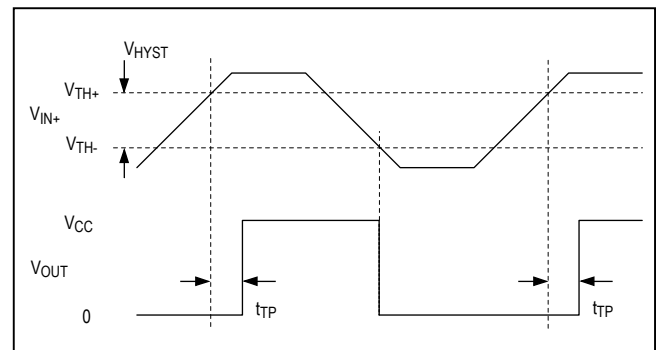


Figure 6. Input and Output Waveforms (Noninverting Input Varied)

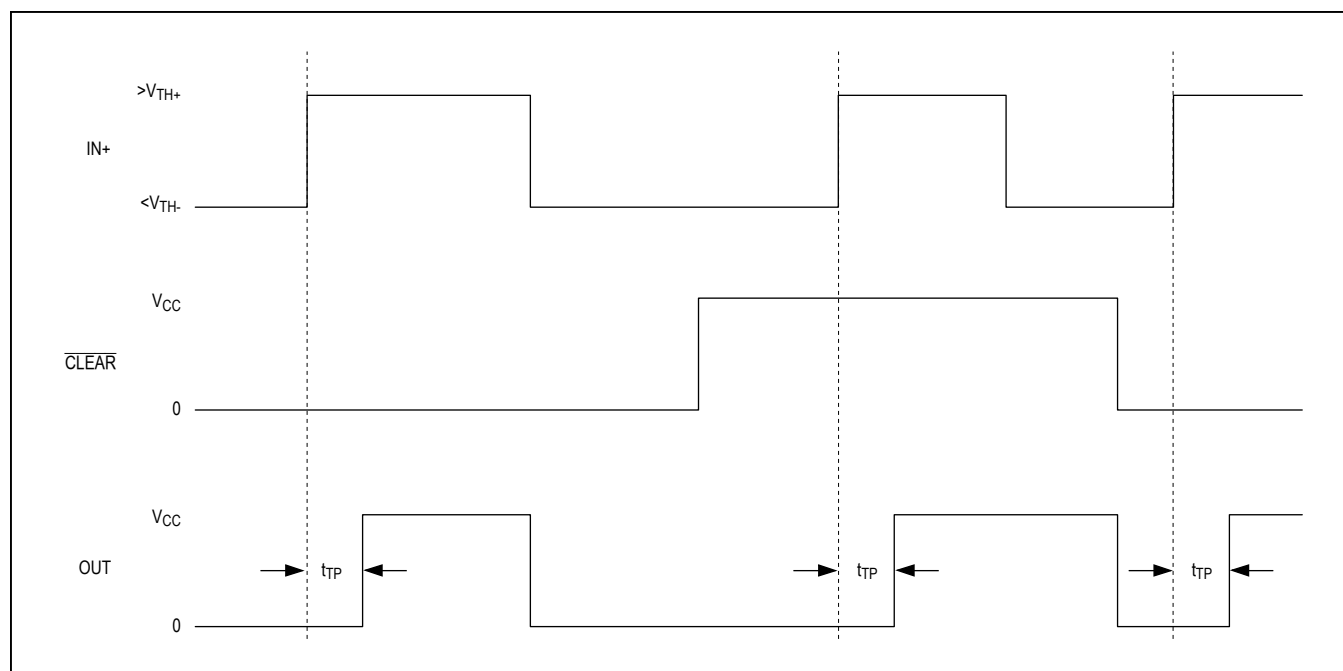


Figure 7. Timing Diagram (MAX6457)

## Hysteresis

Hysteresis adds noise immunity to the voltage monitors and prevents oscillation due to repeated triggering when  $V_{IN}$  is near the threshold trip voltage. The hysteresis in a comparator creates two trip points: one for the rising input voltage ( $V_{TH+}$ ) and one for the falling input voltage ( $V_{TH-}$ ). These thresholds are shown in Figure 6.

The internal hysteresis options of the MAX6457/MAX6458/MAX6459 are designed to eliminate the need for adding an external hysteresis circuit.

## Timeout Period

The timeout period ( $t_{TP}$ ) for the MAX6457 is the time from when the input ( $IN+$ ) crosses the rising input threshold ( $V_{TH+}$ ) to when the output goes high (see Figures 6 and 7). For the MAX6458, the monitored voltage must be in the “window” before the timeout starts. The MAX6459 and MAX6460 do not offer the extended timeout option (150ms). The extended timeout period is suitable for over-voltage protection applications requiring transient immunity to avoid false output assertion due to noise spikes.

## Latched-Output Operation

The MAX6457 features a digital latch input ( $\overline{CLEAR}$ ) to latch any overvoltage event. If the voltage on  $IN+$  ( $V_{IN+}$ ) is below the internal threshold ( $V_{TH-}$ ), or if  $V_{CC}$  is below

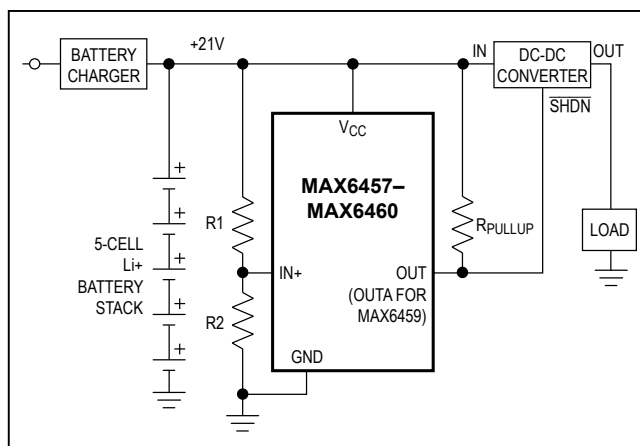


Figure 8. Undervoltage Lockout Typical Application Circuit

4V, OUT remains low regardless of the state of  $\overline{CLEAR}$ . Drive  $\overline{CLEAR}$  high to latch OUT high when  $V_{IN+}$  exceeds  $V_{TH+}$ . When  $\overline{CLEAR}$  is high, OUT does not deassert if  $V_{IN+}$  drops back below  $V_{TH-}$ . Toggle  $\overline{CLEAR}$  to deassert OUT. Drive  $\overline{CLEAR}$  low to make the latch transparent (Figure 7).  $\overline{CLEAR}$  must be low when powering up the MAX6457. To initiate self-clear at power-up, add a 100kΩ pullup resistor from  $\overline{CLEAR}$  to  $V_{CC}$  and a 1μF capacitor from  $\overline{CLEAR}$  to GND to hold  $\overline{CLEAR}$  low. Connect  $\overline{CLEAR}$  to GND when not used. See Figure 9.

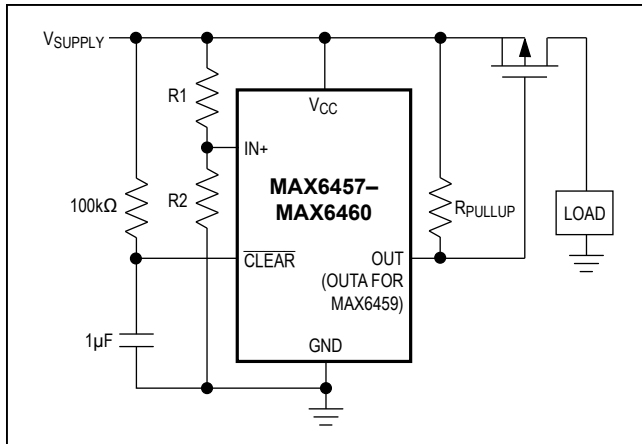


Figure 9. Overvoltage Shutdown Circuit (with External Pass MOSFET)

## 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 DCDC 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 ( $V_{TRIP}$ )* 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 ( $V_{TRIP}$ )* 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.

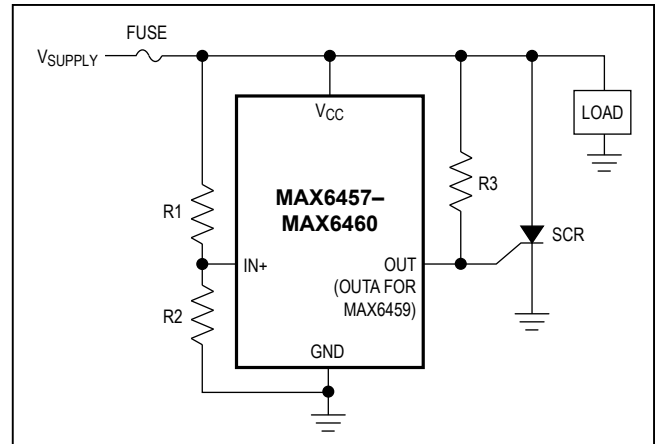


Figure 10. Overvoltage Shutdown Circuit (with SCR Fuse)

### 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 remains

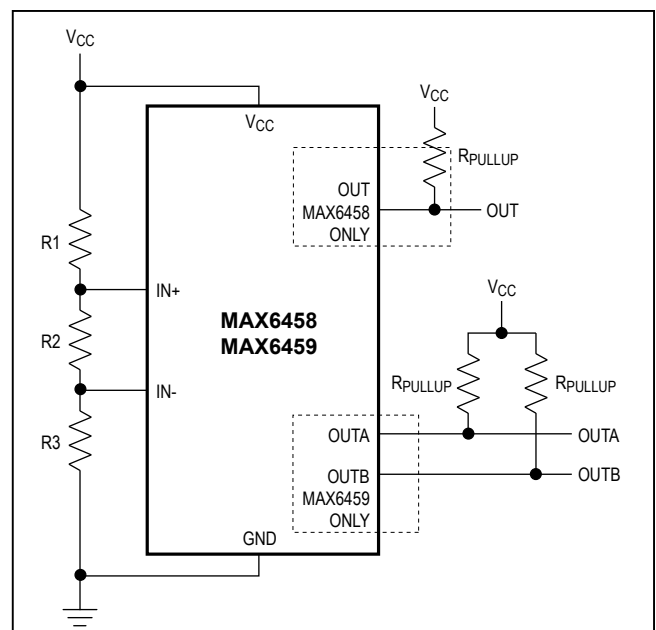


Figure 11. Window Detection

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 R1, R2, and R3.

- 1) Choose a value for  $R_{TOTAL}$ , the sum of R1, R2, and R3. Because the MAX6458/MAX6459 have very high input impedance,  $R_{TOTAL}$  can be up to 5M $\Omega$ .
- 2) Calculate R3 based on  $R_{TOTAL}$  and the desired upper trip point:

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

- 3) Calculate R2 based on  $R_{TOTAL}$ , R3, and the desired lower trip point:

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

- 4) Calculate R1 based on  $R_{TOTAL}$ , R3, and R2:

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

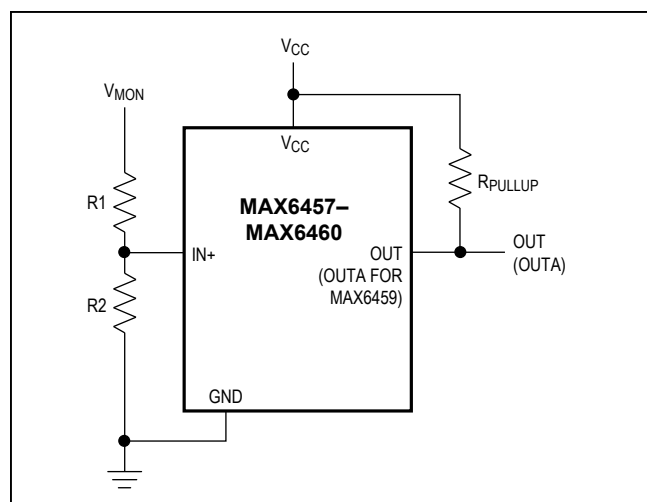


Figure 12. Monitoring Voltages Other than  $V_{CC}$

### Example Calculations for Window Detection

The following is an example for calculating R1, R2, and R3 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 R3

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

- 3) Calculate R2

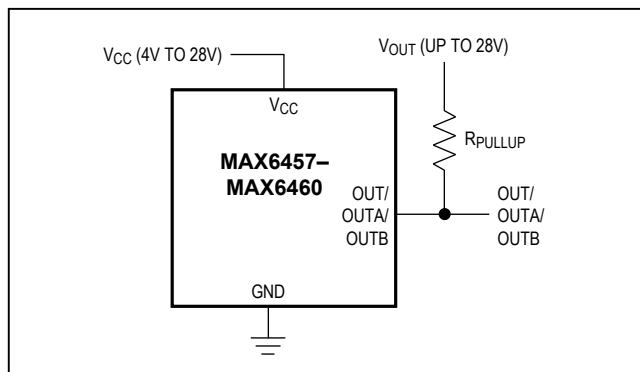


Figure 13. Interfacing to Voltages Other than  $V_{CC}$

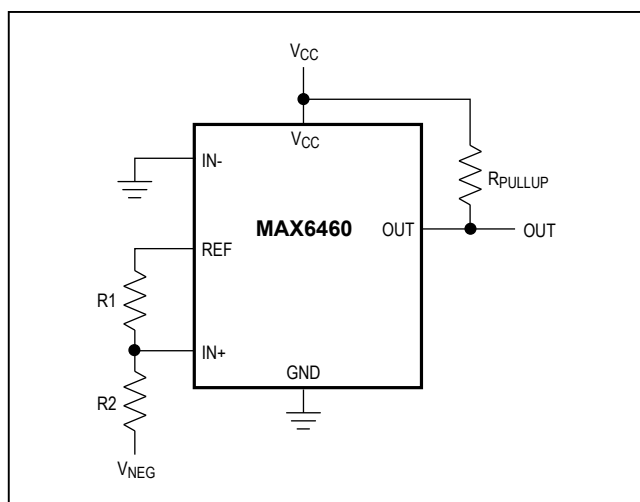


Figure 14. Monitoring Negative Voltages

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           |
| MAX6459UTA/V-T | 6         | —              | 2                 | 0.5                            | 50μs           | ACRY     | 2           |

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

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 V<sub>CC</sub>

The MAX6457–MAX6460 can monitor voltages other than V<sub>CC</sub> (Figure 12). Calculate V<sub>TRIP</sub> as shown in the *Programming the Trip Voltage (V<sub>TRIP</sub>)* section. The monitored voltage (V<sub>MON</sub>) is independent of V<sub>CC</sub>. V<sub>IN+</sub> must be within the specified operating range: 0 to V<sub>CC</sub>.

### Interfacing to Voltages Other than V<sub>CC</sub>

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

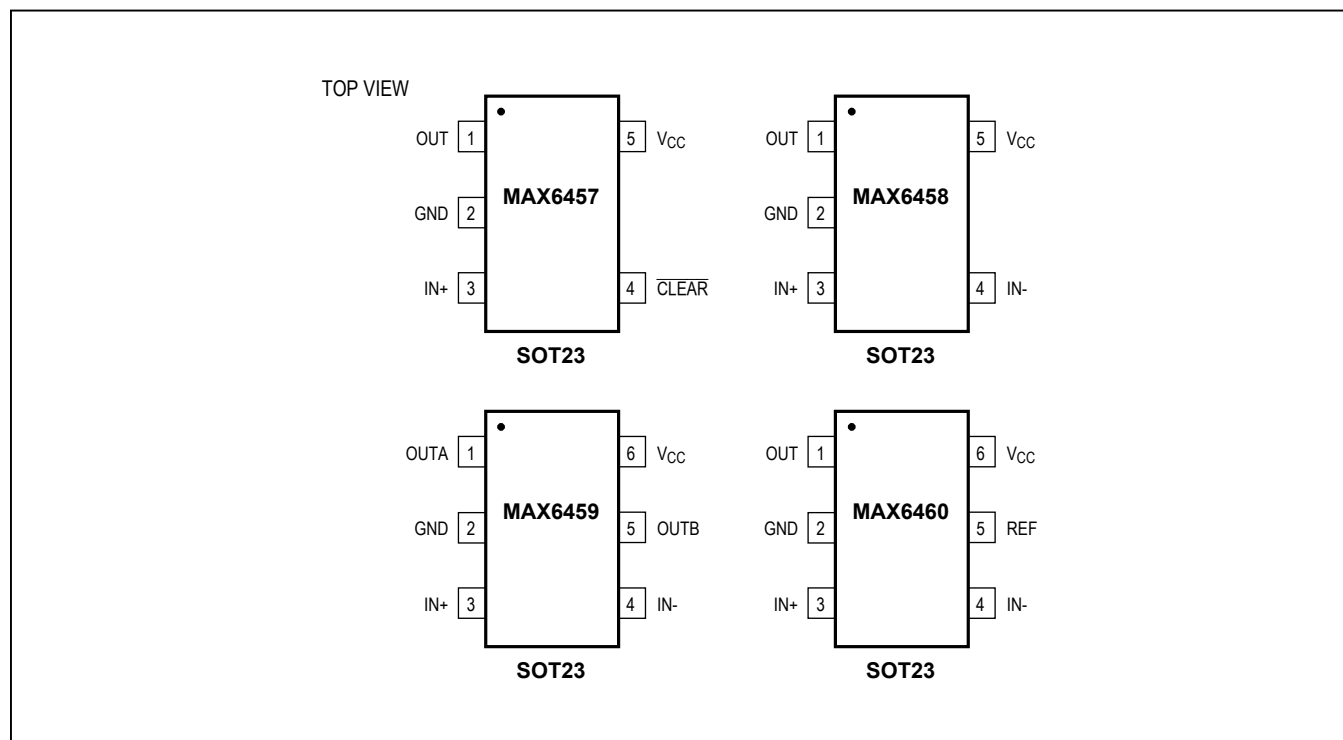
### Monitoring Negative Voltages

Figure 14 shows the typical application circuit for monitoring negative voltages (V<sub>NEG</sub>) 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 V<sub>REF</sub> = 2.25V and V<sub>NEG</sub> < 0. V<sub>IN+</sub> must always be within the specified operating range: 0 to V<sub>CC</sub>.

## Pin Configurations



## Chip Information

PROCESS: BiCMOS

## 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</i> ( $V_{TRIP}$ ) 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                   |
| 7               | 7/17          | Added AEC-Q100 to Benefits and Features section and /V part to <i>Ordering Information</i> and <i>Selector Guide</i> | 1, 12               |
| 8               | 1/19          | Added <i>Package Information</i> section                                                                             | 2                   |

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