

## Absolute Maximum Ratings

IN to GND ..... -0.3V to +42V  
 OUT, TRIM, TEMP to GND ..... -0.3V to ( $V_{IN} + 0.3V$ )  
 Output Short-Circuit to GND ..... 5s  
 Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ ) (Note 1)  
     8-Pin SO (derate 7.6mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) ..... 606mW

Operating Temperature Range .....  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$   
 Junction Temperature .....  $+150^\circ\text{C}$   
 Storage Temperature Range .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Lead Temperature (soldering, 10s) .....  $+300^\circ\text{C}$   
 Soldering Temperature (reflow) .....  $+260^\circ\text{C}$

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

## Package Thermal Characteristics (Note 1)

### 8 SO

| PACKAGE CODE                                  | S8+4                    |
|-----------------------------------------------|-------------------------|
| Outline Number                                | <a href="#">21-0041</a> |
| Land Pattern Number                           | <a href="#">90-0096</a> |
| <b>Thermal Resistance, Single-Layer Board</b> |                         |
| Junction to Ambient - $\theta_{JA}$           | 170                     |
| Junction to Case - $\theta_{JC}$              | 40                      |
| <b>Thermal Resistance, Multi-Layer Board</b>  |                         |
| Junction to Ambient - $\theta_{JA}$           | 132 $^\circ\text{C/W}$  |
| Junction to Case - $\theta_{JC}$              | 38 $^\circ\text{C/W}$   |

### 8 SO

| PACKAGE CODE                                  | S8+22                   |
|-----------------------------------------------|-------------------------|
| Outline Number                                | <a href="#">21-0041</a> |
| Land Pattern Number                           | <a href="#">90-0096</a> |
| <b>Thermal Resistance, Single-Layer Board</b> |                         |
| Junction to Ambient - $\theta_{JA}$           | 170 $^\circ\text{C/W}$  |
| Junction to Case - $\theta_{JC}$              | 40 $^\circ\text{C/W}$   |
| <b>Thermal Resistance, Multi-Layer Board</b>  |                         |
| Junction to Ambient - $\theta_{JA}$           | 132 $^\circ\text{C/W}$  |
| Junction to Case - $\theta_{JC}$              | 38 $^\circ\text{C/W}$   |

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—MAX6173 ( $V_{OUT} = 2.5V$ )**(V<sub>IN</sub> = +5V, T<sub>A</sub> = -40°C to +125°C, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                       | SYMBOL                               | CONDITIONS                                                         |                                  | MIN    | TYP | MAX               | UNITS  |
|-------------------------------------------------|--------------------------------------|--------------------------------------------------------------------|----------------------------------|--------|-----|-------------------|--------|
| OUTPUT                                          |                                      |                                                                    |                                  |        |     |                   |        |
| Output Voltage                                  | V <sub>OUT</sub>                     | No load, T <sub>A</sub> = +25°C                                    | MAX6173A (0.06%)                 | 2.4985 | 2.5 | 2.5015            | V      |
|                                                 |                                      |                                                                    | MAX6173B (0.1%)                  | 2.4975 | 2.5 | 2.5025            |        |
| Output Adjustment Range                         | ΔV <sub>TRIM</sub>                   | R <sub>POT</sub> = 10kΩ                                            |                                  | ±3     | ±6  |                   | %      |
| Output-Voltage Temperature Coefficient (Note 3) | TCV <sub>OUT</sub>                   | T <sub>A</sub> = -40°C to +125°C                                   | MAX6173AASA                      | 1.5    |     | 3                 | ppm/°C |
|                                                 |                                      |                                                                    | MAX6173BASA                      | 3      |     | 10                |        |
| Line Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | 4.5V ≤ V <sub>IN</sub> ≤ 40V                                       | T <sub>A</sub> = +25°C           | 0.6    |     | 5                 | ppm/V  |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 0.8    |     | 10                |        |
| Load Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Sourcing:<br>0 ≤ I <sub>OUT</sub> ≤ 10mA                           | T <sub>A</sub> = +25°C           | 2      |     | 10                | ppm/mA |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 2      |     | 15                |        |
|                                                 |                                      | Sinking:<br>-0.6mA ≤ I <sub>OUT</sub> ≤ 0                          | T <sub>A</sub> = +25°C           | 50     |     | 500               |        |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 90     |     | 900               |        |
| Output Short-Circuit Current                    | I <sub>SC</sub>                      | OUT shorted to GND                                                 |                                  | 60     |     | mA                |        |
|                                                 |                                      | OUT shorted to IN                                                  |                                  | 3      |     |                   |        |
| Temperature Hysteresis (Note 5)                 | ΔV <sub>OUT</sub> /cycle             |                                                                    |                                  | 120    |     | ppm               |        |
| Long-Term Stability                             | ΔV <sub>OUT</sub> /time              | 1000 hours at T <sub>A</sub> = +25°C                               |                                  | 50     |     | ppm               |        |
| DYNAMIC                                         |                                      |                                                                    |                                  |        |     |                   |        |
| Noise Voltage                                   | e <sub>OUT</sub>                     | f = 0.1Hz to 10Hz                                                  |                                  | 3.8    |     | μV <sub>P-P</sub> |        |
|                                                 |                                      | f = 10Hz to 1kHz                                                   |                                  | 6.8    |     | μV <sub>RMS</sub> |        |
| Turn-On Settling Time                           | t <sub>R</sub>                       | To V <sub>OUT</sub> = 0.1% of final value, C <sub>OUT</sub> = 50pF |                                  | 150    |     | μs                |        |
| INPUT                                           |                                      |                                                                    |                                  |        |     |                   |        |
| Supply Voltage Range                            | V <sub>IN</sub>                      | Guaranteed by line regulation test                                 |                                  | 4.5    |     | 40.0              | V      |
| Quiescent Supply Current                        | I <sub>IN</sub>                      | No load                                                            | T <sub>A</sub> = +25°C           | 300    |     | 450               | μA     |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 600    |     |                   |        |
| TEMP OUTPUT                                     |                                      |                                                                    |                                  |        |     |                   |        |
| TEMP Output Voltage                             | V <sub>TEMP</sub>                    |                                                                    |                                  | 570    |     |                   | mV     |
| TEMP Temperature Coefficient                    | TC <sub>TEMP</sub>                   |                                                                    |                                  | 1.9    |     |                   | mV/°C  |

**Electrical Characteristics—MAX6177 ( $V_{OUT} = 3.3V$ )**(V<sub>IN</sub> = +10V, T<sub>A</sub> = -40°C to +125°C, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                       | SYMBOL                               | CONDITIONS                                                         |                                  | MIN    | TYP  | MAX               | UNITS  |
|-------------------------------------------------|--------------------------------------|--------------------------------------------------------------------|----------------------------------|--------|------|-------------------|--------|
| OUTPUT                                          |                                      |                                                                    |                                  |        |      |                   |        |
| Output Voltage                                  | V <sub>OUT</sub>                     | No load, T <sub>A</sub> = +25°C                                    | MAX6177A (0.06%)                 | 3.2980 | 3.3  | 3.3020            | V      |
|                                                 |                                      |                                                                    | MAX6177B (0.1%)                  | 3.2967 | 3.3  | 3.3033            |        |
| Output Adjustment Range                         | ΔV <sub>TRIM</sub>                   | R <sub>POT</sub> = 10kΩ                                            |                                  | ±3     | ±6   |                   | %      |
| Output-Voltage Temperature Coefficient (Note 3) | TCV <sub>OUT</sub>                   | T <sub>A</sub> = -40°C to +125°C                                   | MAX6177AASA                      | 1.5    |      | 3                 | ppm/°C |
|                                                 |                                      |                                                                    | MAX6177BASA                      | 3      |      | 10                |        |
| Line Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | 5.3V ≤ V <sub>IN</sub> ≤ 40V                                       | T <sub>A</sub> = +25°C           | 0.6    |      | 5                 | ppm/V  |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 0.8    |      | 10                |        |
| Load Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Sourcing:<br>0 ≤ I <sub>OUT</sub> ≤ 10mA                           | T <sub>A</sub> = +25°C           | 2      |      | 10                | ppm/mA |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 2      |      | 15                |        |
|                                                 |                                      | Sinking:<br>-0.6mA ≤ I <sub>OUT</sub> ≤ 0                          | T <sub>A</sub> = +25°C           | 50     |      | 500               |        |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 90     |      | 900               |        |
| Output Short-Circuit Current                    | I <sub>SC</sub>                      | OUT shorted to GND                                                 |                                  | 60     |      | mA                |        |
|                                                 |                                      | OUT shorted to IN                                                  |                                  | 3      |      |                   |        |
| Temperature Hysteresis (Note 5)                 | ΔV <sub>OUT</sub> /cycle             |                                                                    |                                  | 120    |      | ppm               |        |
| Long-Term Stability                             | ΔV <sub>OUT</sub> /time              | 1000 hours at T <sub>A</sub> = +25°C                               |                                  | 50     |      | ppm               |        |
| DYNAMIC                                         |                                      |                                                                    |                                  |        |      |                   |        |
| Noise Voltage                                   | e <sub>OUT</sub>                     | f = 0.1Hz to 10Hz                                                  |                                  | 5      |      | μV <sub>P-P</sub> |        |
|                                                 |                                      | f = 10Hz to 1kHz                                                   |                                  | 9.3    |      | μV <sub>RMS</sub> |        |
| Turn-On Settling Time                           | t <sub>R</sub>                       | To V <sub>OUT</sub> = 0.1% of final value, C <sub>OUT</sub> = 50pF |                                  | 180    |      | μs                |        |
| INPUT                                           |                                      |                                                                    |                                  |        |      |                   |        |
| Supply Voltage Range                            | V <sub>IN</sub>                      | Guaranteed by line regulation test                                 |                                  | 5.3    | 40.0 |                   | V      |
| Quiescent Supply Current                        | I <sub>IN</sub>                      | No load                                                            | T <sub>A</sub> = +25°C           | 320    | 500  |                   | μA     |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 650    |      |                   |        |
| TEMP OUTPUT                                     |                                      |                                                                    |                                  |        |      |                   |        |
| TEMP Output Voltage                             | V <sub>TEMP</sub>                    |                                                                    |                                  | 630    |      | mV                |        |
| TEMP Temperature Coefficient                    | TC <sub>TEMP</sub>                   |                                                                    |                                  | 2.1    |      | mV/°C             |        |

**Electrical Characteristics—MAX6174 ( $V_{OUT} = 4.096V$ )**(V<sub>IN</sub> = +10V, T<sub>A</sub> = -40°C to +125°C, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                       | SYMBOL                               | CONDITIONS                                                         |                                  | MIN    | TYP   | MAX    | UNITS             |
|-------------------------------------------------|--------------------------------------|--------------------------------------------------------------------|----------------------------------|--------|-------|--------|-------------------|
| OUTPUT                                          |                                      |                                                                    |                                  |        |       |        |                   |
| Output Voltage                                  | V <sub>OUT</sub>                     | No load, T <sub>A</sub> = +25°C                                    | MAX6174A (0.06%)                 | 4.0935 | 4.096 | 4.0985 | V                 |
|                                                 |                                      |                                                                    | MAX6174B (0.1%)                  | 4.0919 | 4.096 | 4.1001 |                   |
| Output Adjustment Range                         | ΔV <sub>TRIM</sub>                   | R <sub>POT</sub> = 10kΩ                                            |                                  | ±3     | ±6    |        | %                 |
| Output-Voltage Temperature Coefficient (Note 3) | TCV <sub>OUT</sub>                   | T <sub>A</sub> = -40°C to +125°C                                   | MAX6174AASA                      |        | 1.5   | 3      | ppm/°C            |
|                                                 |                                      |                                                                    | MAX6174BASA                      |        | 3     | 10     |                   |
| Line Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | 6.1V ≤ V <sub>IN</sub> ≤ 40V                                       | T <sub>A</sub> = +25°C           |        | 0.6   | 5      | ppm/V             |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C |        | 0.8   | 10     |                   |
| Load Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Sourcing:<br>0 ≤ I <sub>OUT</sub> ≤ 10mA                           | T <sub>A</sub> = +25°C           |        | 2     | 10     | ppm/mA            |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C |        | 2     | 15     |                   |
|                                                 |                                      | Sinking:<br>-0.6mA ≤ I <sub>OUT</sub> ≤ 0                          | T <sub>A</sub> = +25°C           |        | 50    | 500    |                   |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C |        | 90    | 900    |                   |
| Output Short-Circuit Current                    | I <sub>SC</sub>                      | OUT shorted to GND                                                 |                                  |        | 60    |        | mA                |
|                                                 |                                      | OUT shorted to IN                                                  |                                  |        | 3     |        |                   |
| Temperature Hysteresis (Note 5)                 | ΔV <sub>OUT</sub> /cycle             |                                                                    |                                  |        | 120   |        | ppm               |
| Long-Term Stability                             | ΔV <sub>OUT</sub> /time              | 1000 hours at T <sub>A</sub> = +25°C                               |                                  |        | 50    |        | ppm               |
| DYNAMIC                                         |                                      |                                                                    |                                  |        |       |        |                   |
| Noise Voltage                                   | e <sub>OUT</sub>                     | f = 0.1Hz to 10Hz                                                  |                                  |        | 7     |        | μV <sub>P-P</sub> |
|                                                 |                                      | f = 10Hz to 1kHz                                                   |                                  |        | 11.5  |        | μV <sub>RMS</sub> |
| Turn-On Settling Time                           | t <sub>R</sub>                       | To V <sub>OUT</sub> = 0.1% of final value, C <sub>OUT</sub> = 50pF |                                  |        | 200   |        | μs                |
| INPUT                                           |                                      |                                                                    |                                  |        |       |        |                   |
| Supply Voltage Range                            | V <sub>IN</sub>                      | Guaranteed by line regulation test                                 |                                  | 6.1    |       | 40.0   | V                 |
| Quiescent Supply Current                        | I <sub>IN</sub>                      | No load                                                            | T <sub>A</sub> = +25°C           |        | 320   | 500    | μA                |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C |        |       | 650    |                   |
| TEMP OUTPUT                                     |                                      |                                                                    |                                  |        |       |        |                   |
| TEMP Output Voltage                             | V <sub>TEMP</sub>                    | T <sub>A</sub> = +25°C                                             |                                  | 475    | 630   | 785    | mV                |
|                                                 |                                      | T <sub>A</sub> = -40°C to +125°C                                   |                                  | 300    |       | 1130   |                   |
| TEMP Temperature Coefficient                    | TC <sub>TEMP</sub>                   |                                                                    |                                  |        | 2.1   |        | mV/°C             |

**Electrical Characteristics—MAX6175 ( $V_{OUT} = 5.0V$ )**(V<sub>IN</sub> = +15V, T<sub>A</sub> = -40°C to +125°C, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                       | SYMBOL                               | CONDITIONS                                                         |                                  | MIN    | TYP | MAX    | UNITS             |
|-------------------------------------------------|--------------------------------------|--------------------------------------------------------------------|----------------------------------|--------|-----|--------|-------------------|
| OUTPUT                                          |                                      |                                                                    |                                  |        |     |        |                   |
| Output Voltage                                  | V <sub>OUT</sub>                     | No load, T <sub>A</sub> = +25°C                                    | MAX6175A (0.06%)                 | 4.9970 | 5.0 | 5.0030 | V                 |
|                                                 |                                      |                                                                    | MAX6175B (0.1%)                  | 4.9950 | 5.0 | 5.0050 |                   |
| Output Adjustment Range                         | ΔV <sub>TRIM</sub>                   | R <sub>POT</sub> = 10kΩ                                            |                                  | ±3     | ±6  |        | %                 |
| Output-Voltage Temperature Coefficient (Note 3) | TCV <sub>OUT</sub>                   | T <sub>A</sub> = -40°C to +125°C                                   | MAX6175AASA                      | 1.5    |     | 3      | ppm/°C            |
|                                                 |                                      |                                                                    | MAX6175BASA                      | 3      |     | 10     |                   |
| Line Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | 7V ≤ V <sub>IN</sub> ≤ 40V                                         | T <sub>A</sub> = +25°C           | 0.6    |     | 5      | ppm/V             |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 0.8    |     | 10     |                   |
| Load Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Sourcing:<br>0 ≤ I <sub>OUT</sub> ≤ 10mA                           | T <sub>A</sub> = +25°C           | 2      |     | 10     | ppm/mA            |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 2      |     | 15     |                   |
|                                                 |                                      | Sinking:<br>-0.6mA ≤ I <sub>OUT</sub> ≤ 0                          | T <sub>A</sub> = +25°C           | 50     |     | 500    |                   |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 90     |     | 900    |                   |
| Output Short-Circuit Current                    | I <sub>SC</sub>                      | OUT shorted to GND                                                 |                                  | 60     |     |        | mA                |
|                                                 |                                      | OUT shorted to IN                                                  |                                  | 3      |     |        |                   |
| Temperature Hysteresis (Note 5)                 | ΔV <sub>OUT</sub> /cycle             |                                                                    |                                  | 120    |     |        | ppm               |
| Long-Term Stability                             | ΔV <sub>OUT</sub> /time              | 1000 hours at T <sub>A</sub> = +25°C                               |                                  | 50     |     |        | ppm               |
| DYNAMIC                                         |                                      |                                                                    |                                  |        |     |        |                   |
| Noise Voltage                                   | e <sub>OUT</sub>                     | f = 0.1Hz to 10Hz                                                  |                                  | 9      |     |        | μV <sub>P-P</sub> |
|                                                 |                                      | f = 10Hz to 1kHz                                                   |                                  | 14.5   |     |        | μV <sub>RMS</sub> |
| Turn-On Settling Time                           | t <sub>R</sub>                       | To V <sub>OUT</sub> = 0.1% of final value, C <sub>OUT</sub> = 50pF |                                  | 230    |     |        | μs                |
| INPUT                                           |                                      |                                                                    |                                  |        |     |        |                   |
| Supply Voltage Range                            | V <sub>IN</sub>                      | Guaranteed by line regulation test                                 |                                  | 7.0    |     | 40.0   | V                 |
| Quiescent Supply Current                        | I <sub>IN</sub>                      | No load                                                            | T <sub>A</sub> = +25°C           | 320    |     | 550    | μA                |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 700    |     |        |                   |
| TEMP OUTPUT                                     |                                      |                                                                    |                                  |        |     |        |                   |
| TEMP Output Voltage                             | V <sub>TEMP</sub>                    | T <sub>A</sub> = +25°C                                             |                                  | 475    | 630 | 785    | mV                |
|                                                 |                                      | T <sub>A</sub> = -40°C to +125°C                                   |                                  | 300    |     | 1130   |                   |
| TEMP Temperature Coefficient                    | TC <sub>TEMP</sub>                   |                                                                    |                                  | 2.1    |     |        | mV/°C             |

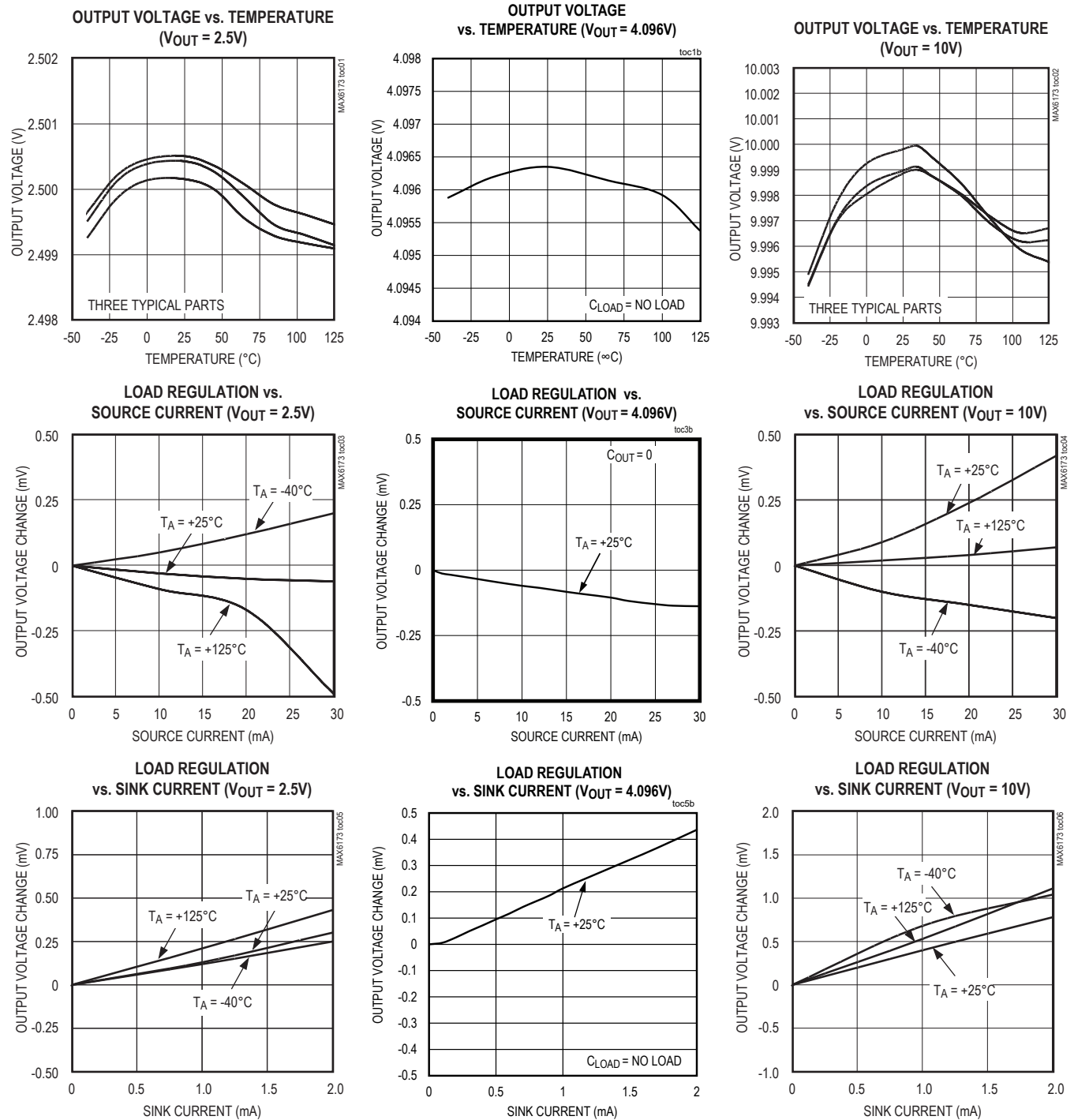
**ELECTRICAL CHARACTERISTICS—MAX6176 ( $V_{OUT} = 10V$ )**(V<sub>IN</sub> = +15V, T<sub>A</sub> = -40°C to +125°C, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                       | SYMBOL                               | CONDITIONS                                                         |                                  | MIN    | TYP  | MAX               | UNITS  |
|-------------------------------------------------|--------------------------------------|--------------------------------------------------------------------|----------------------------------|--------|------|-------------------|--------|
| OUTPUT                                          |                                      |                                                                    |                                  |        |      |                   |        |
| Output Voltage                                  | V <sub>OUT</sub>                     | No load, T <sub>A</sub> = +25°C                                    | MAX6176A (0.05%)                 | 9.9950 | 10.0 | 10.0050           | V      |
|                                                 |                                      |                                                                    | MAX6176B (0.1%)                  | 9.9900 | 10.0 | 10.0100           |        |
| Output Adjustment Range                         | ΔV <sub>TRIM</sub>                   | R <sub>POT</sub> = 10kΩ                                            |                                  | ±3     | ±6   |                   | %      |
| Output-Voltage Temperature Coefficient (Note 3) | TCV <sub>OUT</sub>                   | T <sub>A</sub> = -40°C to +125°C                                   | MAX6176AASA                      | 1.5    |      | 3                 | ppm/°C |
|                                                 |                                      |                                                                    | MAX6176BASA                      | 3      |      | 10                |        |
| Line Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔV <sub>IN</sub>  | 12V ≤ V <sub>IN</sub> ≤ 40V                                        | T <sub>A</sub> = +25°C           | 0.6    |      | 5                 | ppm/V  |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 0.8    |      | 10                |        |
| Load Regulation (Note 4)                        | ΔV <sub>OUT</sub> /ΔI <sub>OUT</sub> | Sourcing:<br>0 ≤ I <sub>OUT</sub> ≤ 10mA                           | T <sub>A</sub> = +25°C           | 2      |      | 10                | ppm/mA |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 2      |      | 15                |        |
|                                                 |                                      | Sinking:<br>-0.6mA ≤ I <sub>OUT</sub> ≤ 0                          | T <sub>A</sub> = +25°C           | 50     |      | 500               |        |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 90     |      | 900               |        |
| Output Short-Circuit Current                    | I <sub>SC</sub>                      | OUT shorted to GND                                                 |                                  | 60     |      | mA                |        |
|                                                 |                                      | OUT shorted to IN                                                  |                                  | 3      |      |                   |        |
| Temperature Hysteresis (Note 5)                 | ΔV <sub>OUT</sub> /cycle             |                                                                    |                                  | 120    |      | ppm               |        |
| Long-Term Stability                             | ΔV <sub>OUT</sub> /time              | 1000 hours at T <sub>A</sub> = +25°C                               |                                  | 50     |      | ppm               |        |
| DYNAMIC                                         |                                      |                                                                    |                                  |        |      |                   |        |
| Noise Voltage                                   | e <sub>OUT</sub>                     | f = 0.1Hz to 10Hz                                                  |                                  | 18     |      | μV <sub>P-P</sub> |        |
|                                                 |                                      | f = 10Hz to 1kHz                                                   |                                  | 29     |      | μV <sub>RMS</sub> |        |
| Turn-On Settling Time                           | t <sub>R</sub>                       | To V <sub>OUT</sub> = 0.1% of final value, C <sub>OUT</sub> = 50pF |                                  | 400    |      | μs                |        |
| INPUT                                           |                                      |                                                                    |                                  |        |      |                   |        |
| Supply Voltage Range                            | V <sub>IN</sub>                      | Guaranteed by line regulation test                                 |                                  | 12.0   |      | 40.0              | V      |
| Quiescent Supply Current                        | I <sub>IN</sub>                      | No load                                                            | T <sub>A</sub> = +25°C           | 340    |      | 550               | μA     |
|                                                 |                                      |                                                                    | T <sub>A</sub> = -40°C to +125°C | 700    |      |                   |        |
| TEMP OUTPUT                                     |                                      |                                                                    |                                  |        |      |                   |        |
| TEMP Output Voltage                             | V <sub>TEMP</sub>                    |                                                                    |                                  | 630    |      |                   | mV     |
| TEMP Temperature Coefficient                    | TC <sub>TEMP</sub>                   |                                                                    |                                  | 2.1    |      |                   | mV/°C  |

**Note 2:** All devices are 100% production tested at T<sub>A</sub> = +25°C and guaranteed by design over T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, as specified.**Note 3:** Temperature coefficient is defined as ΔV<sub>OUT</sub> divided by the temperature range.**Note 4:** Line and load regulation specifications do not include the effects of self-heating.**Note 5:** Thermal hysteresis is defined as the change in +25°C output voltage before and after cycling the device from T<sub>MAX</sub> to T<sub>MIN</sub>.

## Typical Operating Characteristics

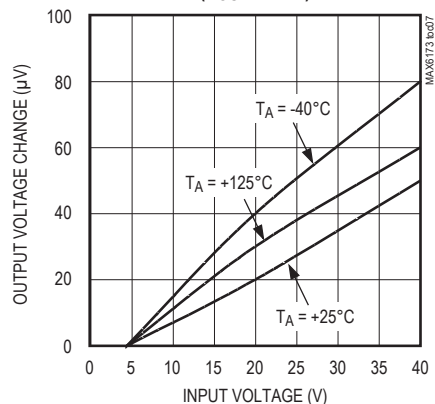
( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



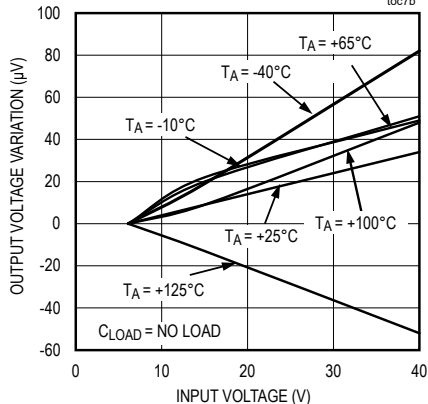
## Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

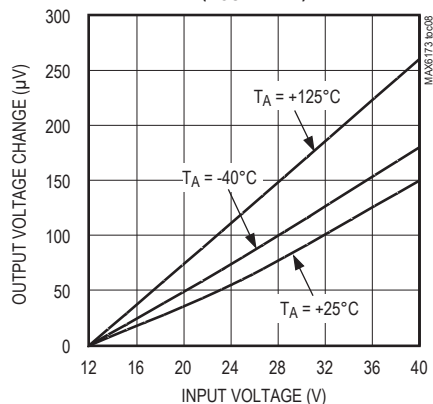
LINE REGULATION vs. TEMPERATURE  
( $V_{OUT} = 2.5V$ )



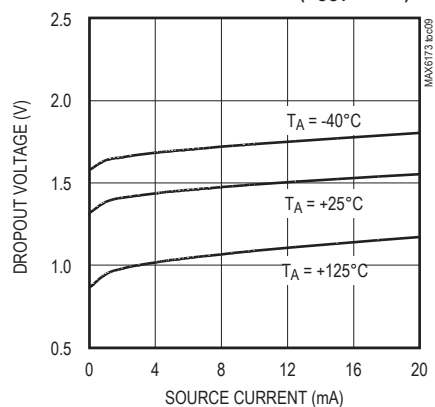
LINE REGULATION  
vs. TEMPERATURE ( $V_{OUT} = 4.096V$ )



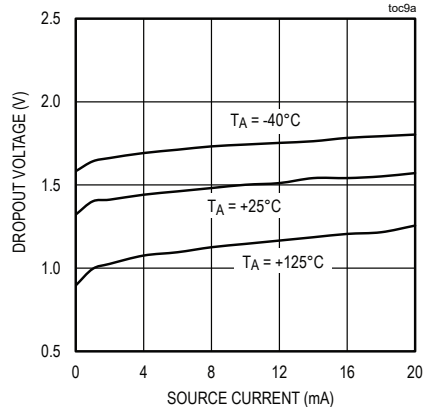
LINE REGULATION vs. TEMPERATURE  
( $V_{OUT} = 10V$ )



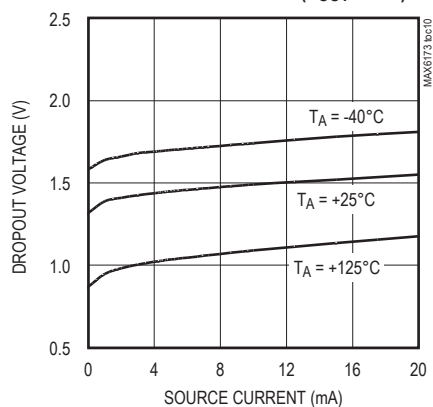
MINIMUM INPUT-OUTPUT DIFFERENTIAL  
vs. SOURCE CURRENT ( $V_{OUT} = 2.5V$ )



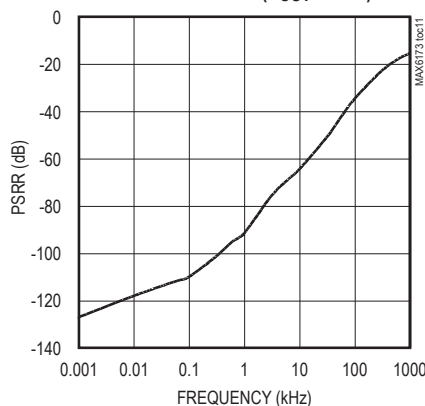
MINIMUM INPUT-OUTPUT DIFFERENTIAL  
vs. SOURCING CURRENT ( $V_{OUT} = 4.096V$ )



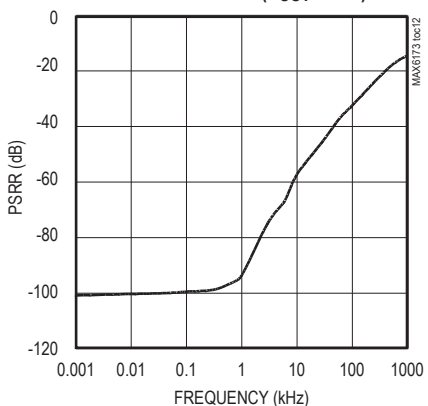
MINIMUM INPUT-OUTPUT DIFFERENTIAL  
vs. SOURCE CURRENT ( $V_{OUT} = 10V$ )



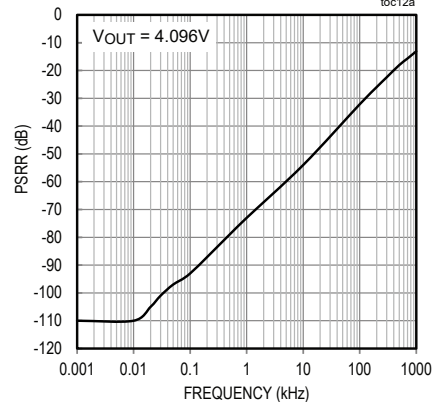
POWER-SUPPLY REJECTION RATIO  
vs. FREQUENCY ( $V_{OUT} = 2.5V$ )



POWER-SUPPLY REJECTION RATIO  
vs. FREQUENCY ( $V_{OUT} = 10V$ )

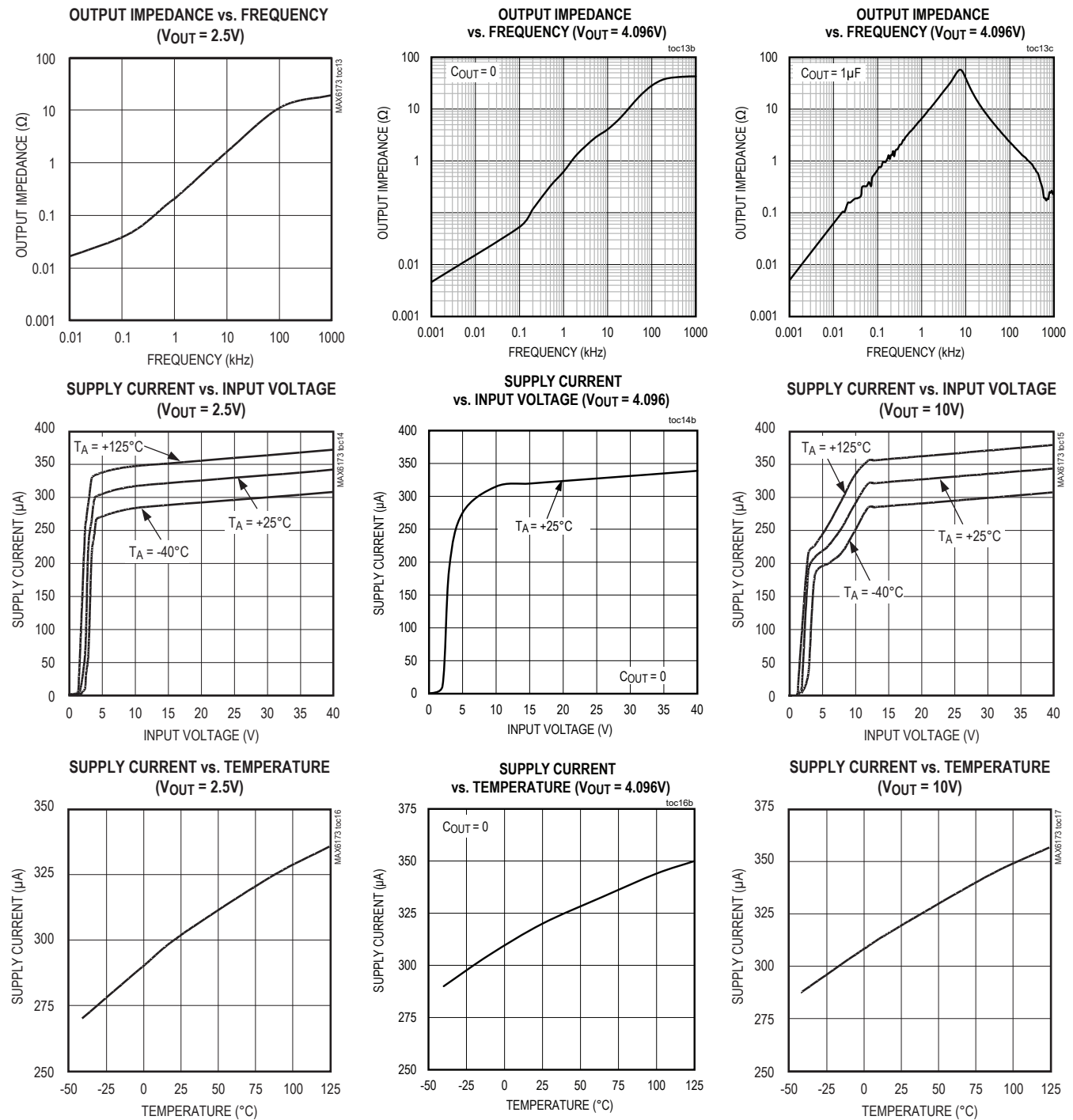


PSRR vs. FREQUENCY



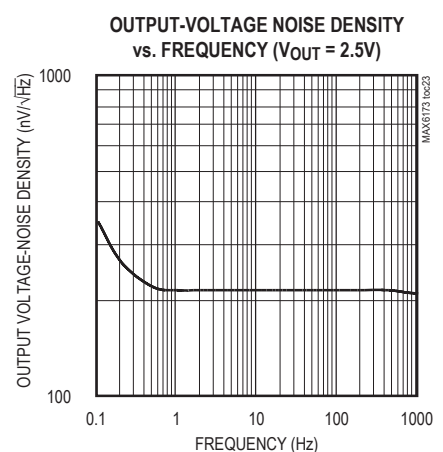
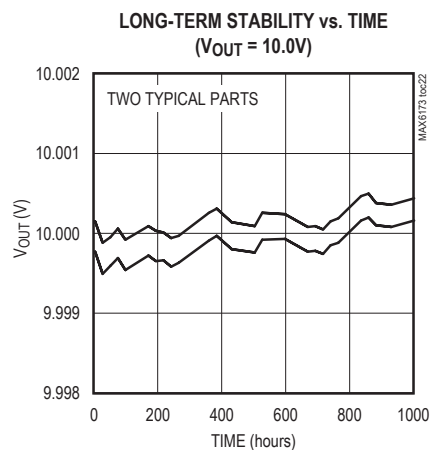
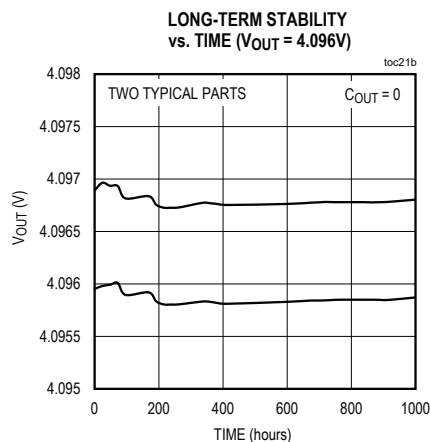
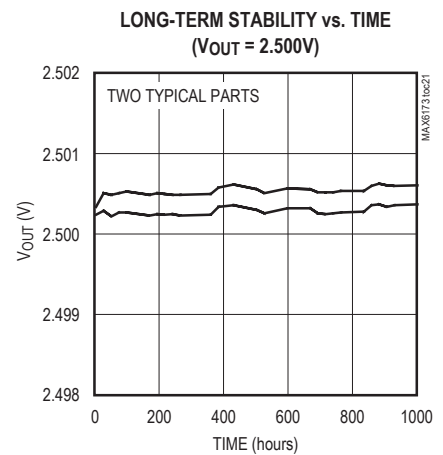
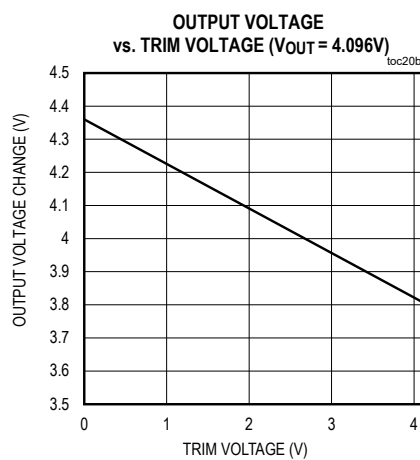
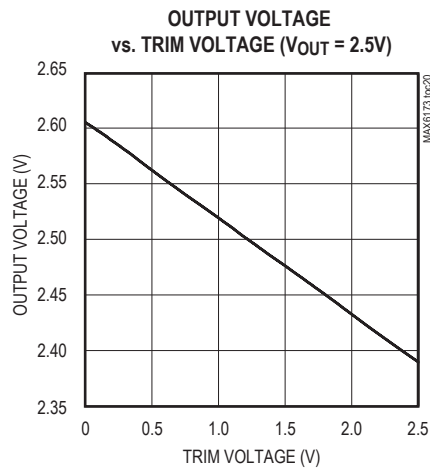
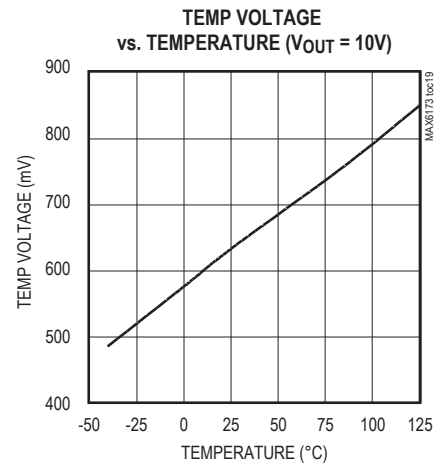
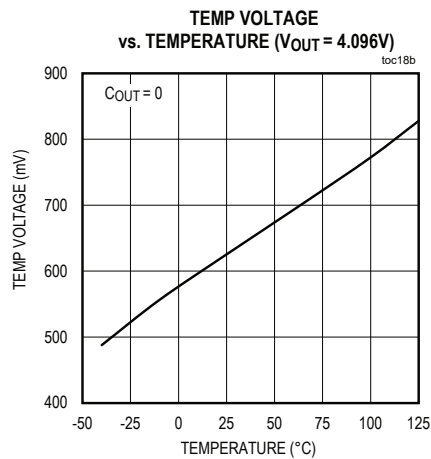
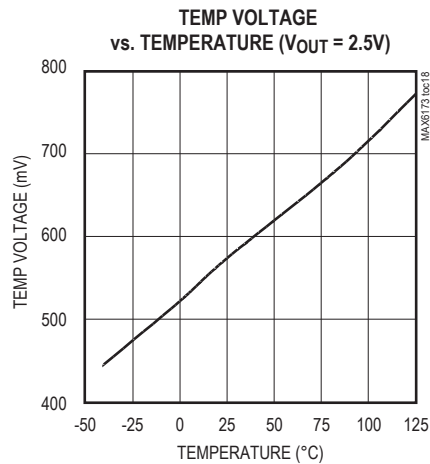
## Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



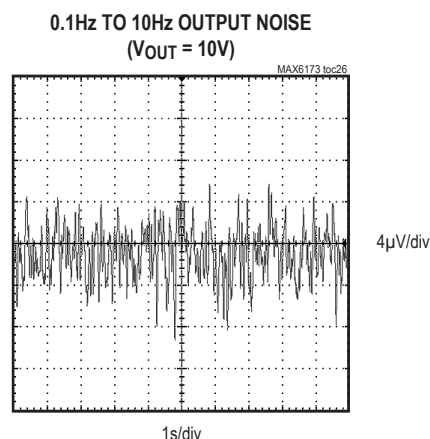
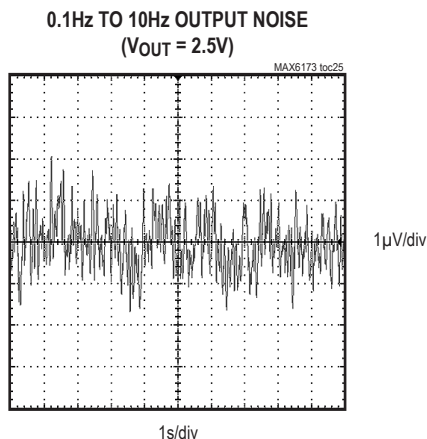
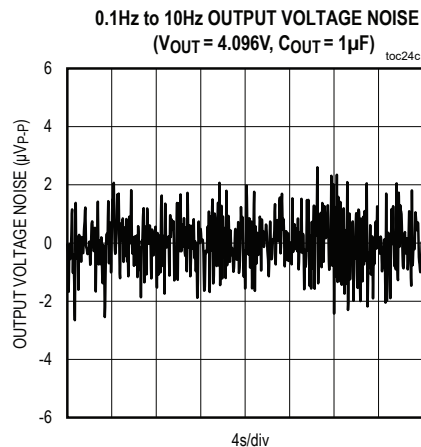
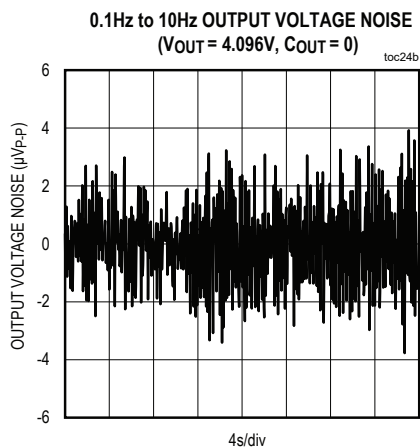
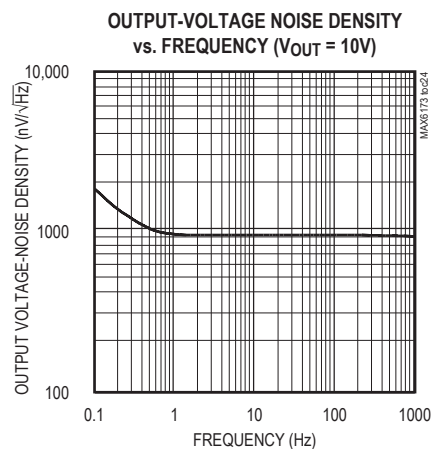
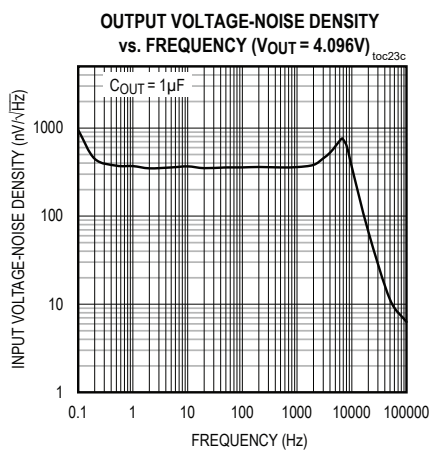
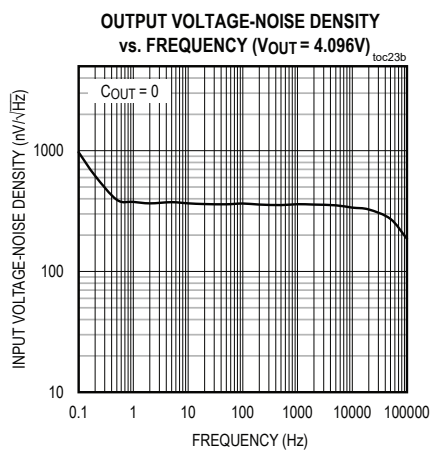
## Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## Typical Operating Characteristics (continued)

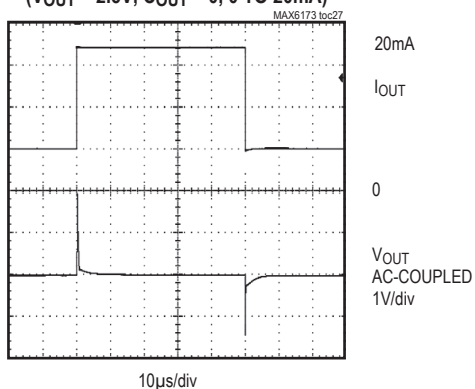
( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



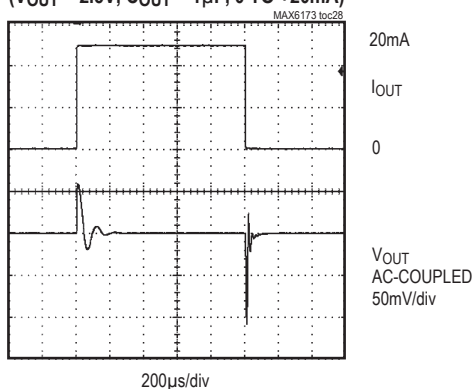
## Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

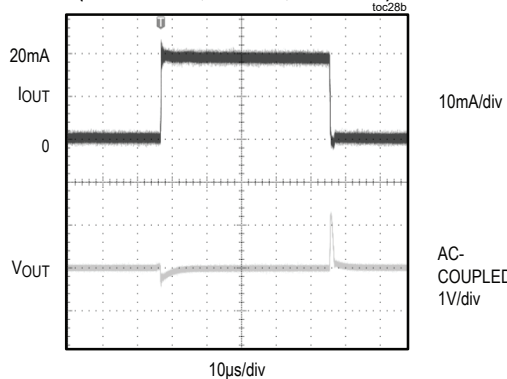
**LOAD TRANSIENT**  
( $V_{OUT} = 2.5V$ ,  $C_{OUT} = 0$ , 0 TO 20mA)



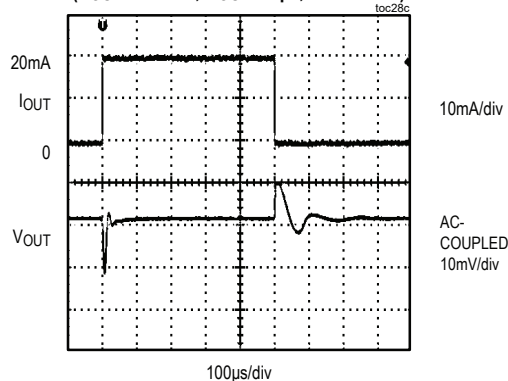
**LOAD TRANSIENT**  
( $V_{OUT} = 2.5V$ ,  $C_{OUT} = 1\mu F$ , 0 TO +20mA)



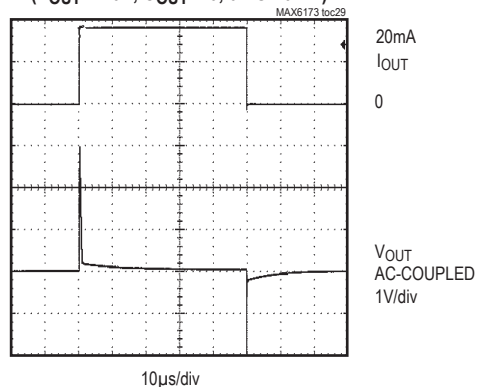
**LOAD TRANSIENT**  
( $V_{OUT} = 4.096V$ ,  $C_{OUT} = 0$ , 0 TO 20mA)



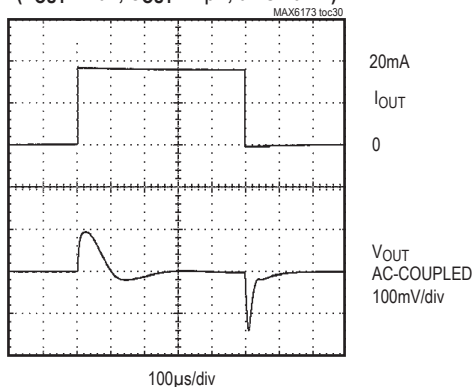
**LOAD TRANSIENT**  
( $V_{OUT} = 4.096V$ ,  $C_{OUT} = 1\mu F$ , 0 TO 20mA)



**LOAD TRANSIENT**  
( $V_{OUT} = 10V$ ,  $C_{OUT} = 0$ , 0 TO 20mA)

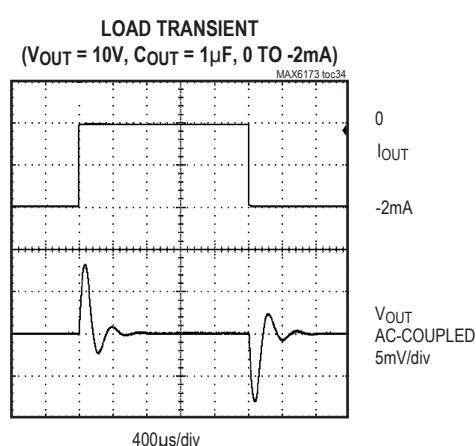
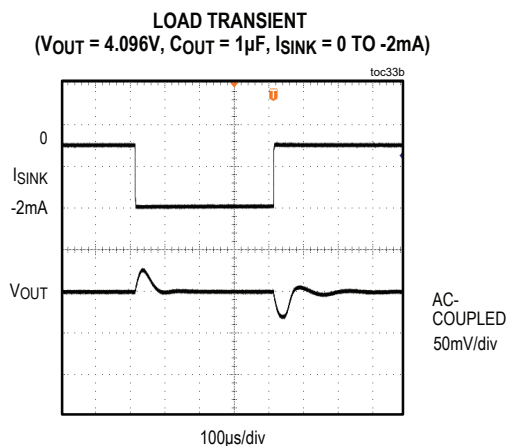
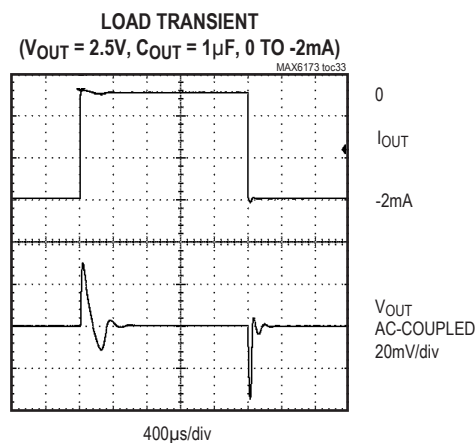
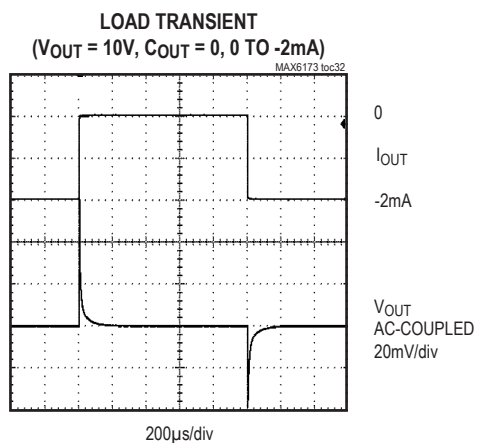
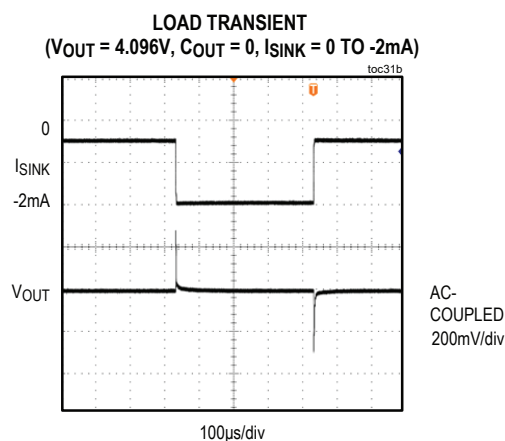
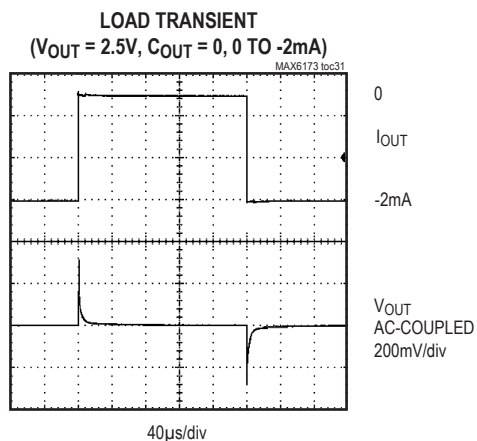


**LOAD TRANSIENT**  
( $V_{OUT} = 10V$ ,  $C_{OUT} = 1\mu F$ , 0 TO 20mA)



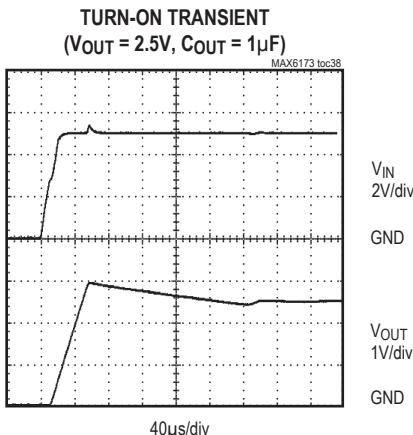
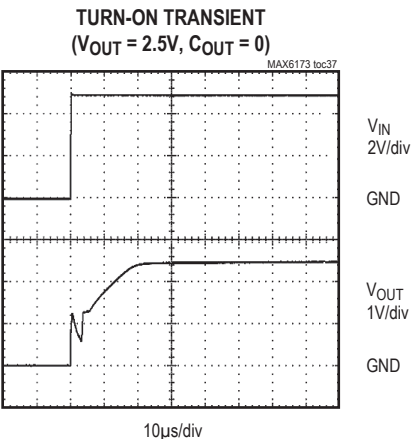
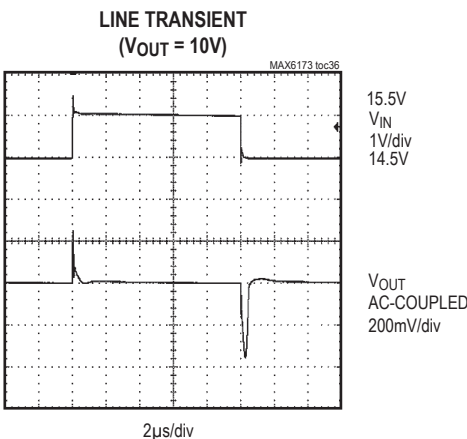
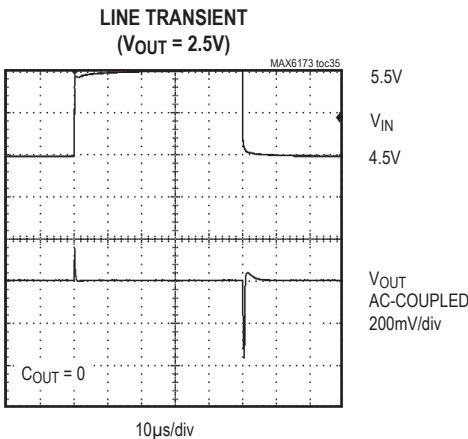
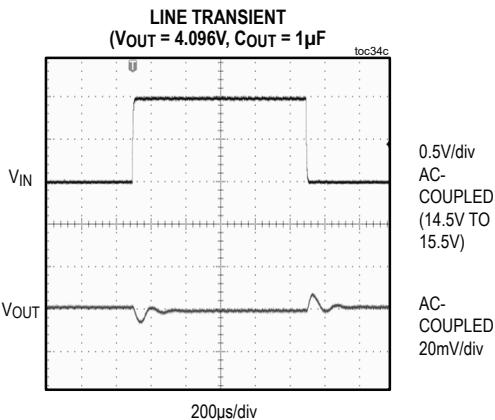
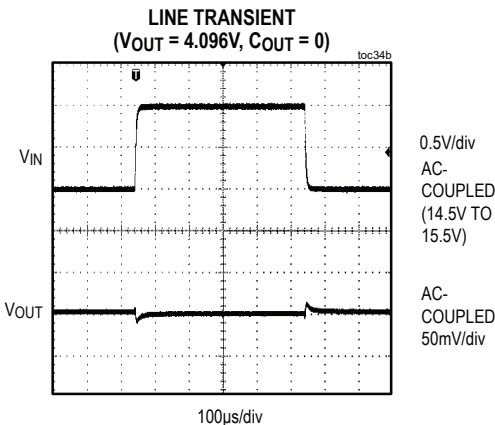
## Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



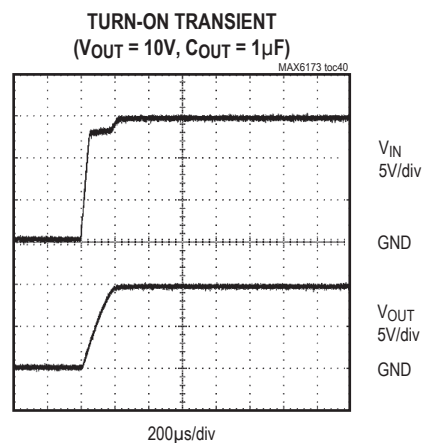
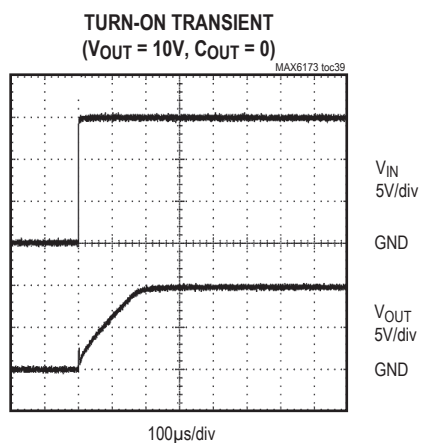
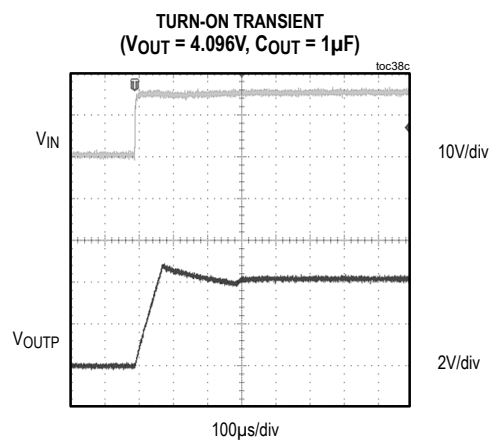
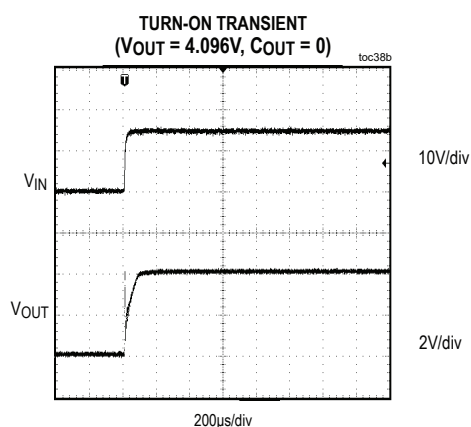
Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## Typical Operating Characteristics (continued)

( $V_{IN} = +5V$  for  $V_{OUT} = +2.5V$ ,  $V_{IN} = +15V$  for  $V_{OUT} = 4.096V$  and  $V_{OUT} = +10V$ ,  $I_{OUT} = 0$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## Pin Description

| PIN  | NAME | FUNCTION                                                                                                                                                   |
|------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 8 | I.C. | Internally Connected. Do not connect externally.                                                                                                           |
| 2    | IN   | Positive Power-Supply Input                                                                                                                                |
| 3    | TEMP | Temperature Proportional Output Voltage. TEMP generates an output voltage proportional to the die temperature.                                             |
| 4    | GND  | Ground                                                                                                                                                     |
| 5    | TRIM | Output Voltage Trim. Connect TRIM to the center of a voltage-divider between OUT and GND for trimming. Leave unconnected to use the preset output voltage. |
| 6    | OUT  | Output Voltage                                                                                                                                             |
| 7    | N.C. | No Connection. Not internally connected.                                                                                                                   |

## Detailed Description

The MAX6173–MAX6177 precision voltage references provide accurate preset +2.5V, +3.3V, +4.096V, +5.0V, and +10V reference voltages from up to +40V input voltages. These devices feature a proprietary temperature-coefficient curvature-correction circuit and laser-trimmed thin-film resistors that result in a very low 3ppm/°C temperature coefficient and excellent 0.05% initial accuracy. The MAX6173–MAX6177 draw 340μA of supply current and source 30mA or sink 2mA of load current.

### Trimming the Output Voltage

Trim the factory-preset output voltage on the MAX6173–MAX6177 by placing a resistive divider network between OUT, TRIM, and GND.

Use the following formula to calculate the change in output voltage from its preset value:

$$\Delta V_{OUT} = 2 \times (V_{TRIM} - V_{TRIM(open)}) \times k$$

where:

$$V_{TRIM} = 0V \text{ to } V_{OUT}$$

$$V_{TRIM(open)} = V_{OUT}(\text{nominal})/2 \text{ (typ)}$$

$$k = \pm 6\% \text{ (typ)}$$

For example, use a 50kΩ potentiometer (such as the MAX5436) between OUT, TRIM, and GND with the potentiometer wiper connected to TRIM (see Figure 2). As the TRIM voltage changes from  $V_{OUT}$  to GND, the output voltage changes accordingly. Set R2 to 1MΩ or less. Currents through resistors R1 and R2 add to the quiescent supply current.

### Temp Output

The MAX6173–MAX6177 provide a temperature output proportional to die temperature. TEMP can be calculated from the following formula:

$$TEMP(V) = T_J(^{\circ}K) \times n$$

where  $T_J$  = the die temperature,

$n$  = the temperature multiplier,

$$n = \frac{V_{TEMP}(\text{at } T_J = T_0)}{T_0} \cong 1.9mV/^{\circ}K$$

$T_A$  = the ambient temperature.

Self-heating affects the die temperature and conversely, the TEMP output. The TEMP equation assumes the output is not loaded. If device power dissipation is negligible, then  $T_J \approx T_A$ .

Applications Information

Bypassing/Output Capacitance

For the best line-transient performance, decouple the input with a 0.1μF ceramic capacitor as shown in the *Typical Operating Circuit*. Place the capacitor as close to IN as possible. When transient performance is less important, no capacitor is necessary.

The MAX6173–MAX6177 do not require an output capacitor for stability and are stable with capacitive loads up to 100μF. In applications where the load or the supply can experience step changes, a larger output capacitor reduces the amount of overshoot (undershoot) and improves the circuit's transient response. Place output capacitors as close to the devices as possible for best performance.

Supply Current

The MAX6173–MAX6177 consume 320μA (typ) of quiescent supply current. This improved efficiency reduces power dissipation and extends battery life.

Thermal Hysteresis

Thermal hysteresis is the change in the output voltage at  $T_A = +25^{\circ}\text{C}$  before and after the device is cycled over its entire operating temperature range. Hysteresis is caused by differential package stress appearing across the band-gap core transistors. The typical thermal hysteresis value is 120ppm.

Turn-On Time

The MAX6173–MAX6177 typically turn on and settle to within 0.1% of the preset output voltage in 150μs (2.5V output). The turn-on time can increase up to 150μs with the device operating with a 1μF load.

Short-Circuited Outputs

The MAX6173–MAX6177 feature a short-circuit-protected output. Internal circuitry limits the output current to 60mA when short circuiting the output to ground. The output current is limited to 3mA when short circuiting the output to the input.

Temperature Coefficient vs. Operating  
Temperature Range for a  
1 LSB Maximum Error

In a data converter application, the reference voltage of the converter must stay within a certain limit to keep the error in the data converter smaller than the resolution limit through the operating temperature range. Figure 1 shows the maximum allowable reference-voltage temperature coefficient to keep the conversion error to less than 1 LSB, as a function of the operating temperature range ( $T_{\text{MAX}} - T_{\text{MIN}}$ ) with the converter resolution as a parameter. The graph assumes the reference-voltage temperature coefficient as the only parameter affecting accuracy.

In reality, the absolute static accuracy of a data converter is dependent on the combination of many parameters such as integral nonlinearity, differential nonlinearity, offset error, gain error, as well as voltage-reference changes.

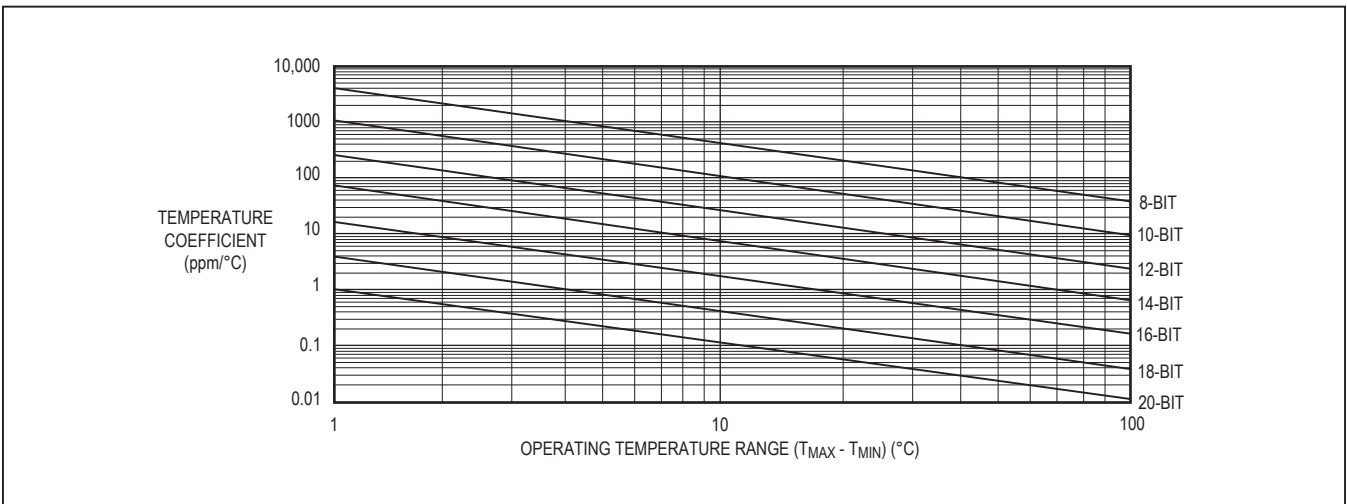


Figure 1. Temperature Coefficient vs. Operating Temperature Range for a 1 LSB Maximum Error

# MAX6173–MAX6177

# High-Precision Voltage References with Temperature Sensor

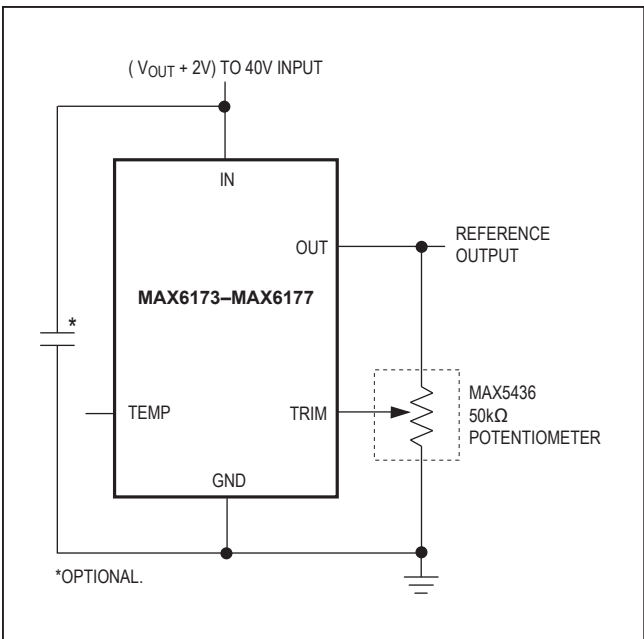
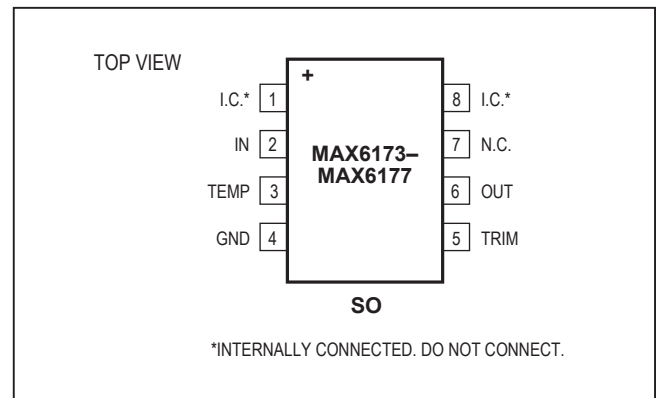


Figure 2. Applications Circuit Using the MAX5436 Potentiometer

## Pin Configuration



## Chip Information

PROCESS: BiCMOS

## Package Information

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 TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 8 SO         | S8+4         | <a href="#">21-0041</a> | <a href="#">90-0096</a> |
| 8 SO         | S8+22        | <a href="#">21-0041</a> | <a href="#">90-0096</a> |

## Ordering Information/Selector Guide

| PART            | TEMP RANGE      | PIN-PACKAGE | OUTPUT VOLTAGE (V) | TEMPERATURE COEFFICIENT (ppm/°C) -40°C TO +125°C | INITIAL ACCURACY (%) |
|-----------------|-----------------|-------------|--------------------|--------------------------------------------------|----------------------|
| MAX6173AASA+    | -40°C to +125°C | 8 SO        | 2.500              | 3                                                | 0.06                 |
| MAX6173BASA+    | -40°C to +125°C | 8 SO        | 2.500              | 10                                               | 0.10                 |
| MAX6173BASA/V+T | -40°C to +125°C | 8 SO        | 2.500              | 3                                                | 0.06                 |
| MAX6174AASA+    | -40°C to +125°C | 8 SO        | 4.096              | 3                                                | 0.06                 |
| MAX6174BASA+    | -40°C to +125°C | 8 SO        | 4.096              | 10                                               | 0.10                 |
| MAX6174BASA/V+  | -40°C to +125°C | 8 SO        | 4.096              | 10                                               | 0.10                 |
| MAX6174BASA/V+T | -40°C to +125°C | 8 SO        | 4.096              | 10                                               | 0.10                 |
| MAX6175AASA+    | -40°C to +125°C | 8 SO        | 5.000              | 3                                                | 0.06                 |
| MAX6175BASA+    | -40°C to +125°C | 8 SO        | 5.000              | 10                                               | 0.10                 |
| MAX6175BASA/V+  | -40°C to +125°C | 8 SO        | 5.000              | 10                                               | 0.10                 |
| MAX6176AASA+    | -40°C to +125°C | 8 SO        | 10.000             | 3                                                | 0.05                 |
| MAX6176BASA+    | -40°C to +125°C | 8 SO        | 10.000             | 10                                               | 0.10                 |
| MAX6177AASA+    | -40°C to +125°C | 8 SO        | 3.300              | 3                                                | 0.06                 |
| MAX6177BASA+    | -40°C to +125°C | 8 SO        | 3.300              | 10                                               | 0.10                 |

+Denotes a lead(Pb)-free/RoHS-compliant package.

/V denotes an automotive qualified part

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION                                                                                                                                       | PAGES CHANGED |
|-----------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 0               | 6/04          | Initial release                                                                                                                                   | —             |
| 1               | 2/11          | Added automotive grade part, lead-free information, and soldering temperature                                                                     | 1, 2          |
| 2               | 3/14          | Updated package code in <i>Package Information</i>                                                                                                | 14            |
| 3               | 6/14          | Updated <i>Ordering Information</i> , <i>Electrical Characteristics</i> , and <i>Typical Operating Characteristics</i>                            | 1, 4, 5, 8    |
| 4               | 9/14          | Updated <i>Typical Operating Characteristics</i>                                                                                                  | 7–14          |
| 5               | 9/14          | Updated <i>Typical Operating Characteristics</i>                                                                                                  | 7–15          |
| 6               | 12/17         | Added AEC statement to <i>Benefits and Features</i> section                                                                                       | 1             |
| 7               | 3/18          | Updated <i>Ordering Information</i> table                                                                                                         | 18            |
| 8               | 3/18          | Updated <i>Absolute Maximum Ratings</i> section and <i>Electrical Characteristics</i> table                                                       | 2–6           |
| 9               | 3/18          | Updated <i>Absolute Maximum Ratings</i> section                                                                                                   | 2             |
| 10              | 10/18         | Update <i>Applications</i> , <i>Package Thermal Characteristics</i> , <i>Package Information</i> , and <i>Ordering Information/Selector Guide</i> | 1, 2, 18      |
| 11              | 4/19          | Updated <i>General Description</i> section                                                                                                        | 1             |

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