

## MAX6078A/MAX6078B

## Low-Power, Low-Drift, Low-Noise Voltage Reference

### General Description

The MAX6078 precision voltage reference family provides low drift and low noise at a maximum power supply current of only 15 $\mu$ A. Low-frequency noise is less than 12 $\mu$ V<sub>P-P</sub> (2.5V output voltage option) and the temperature coefficient of the output voltage is less than 10ppm/ $^{\circ}$ C.

The reference output can sink and source up to 3mA of load current and the top grade provides an initial accuracy of 0.04%. The low-drift and low-noise specifications enable enhanced system accuracy, making these devices ideal for high-precision industrial applications. A noise reduction (NR) input pin allows connection of an external capacitor to reduce wideband noise. Available output voltages include 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V, and 5.0V.

The tiny, 6-bump WLP and small, 8-pin TDFN-EP packages are suitable for systems where circuit board area is limited. The operating input voltage can range from 2.3V to 5.5V. Operation is specified over the extended industrial temperature range of -55 $^{\circ}$ C to +125 $^{\circ}$ C.

### Applications

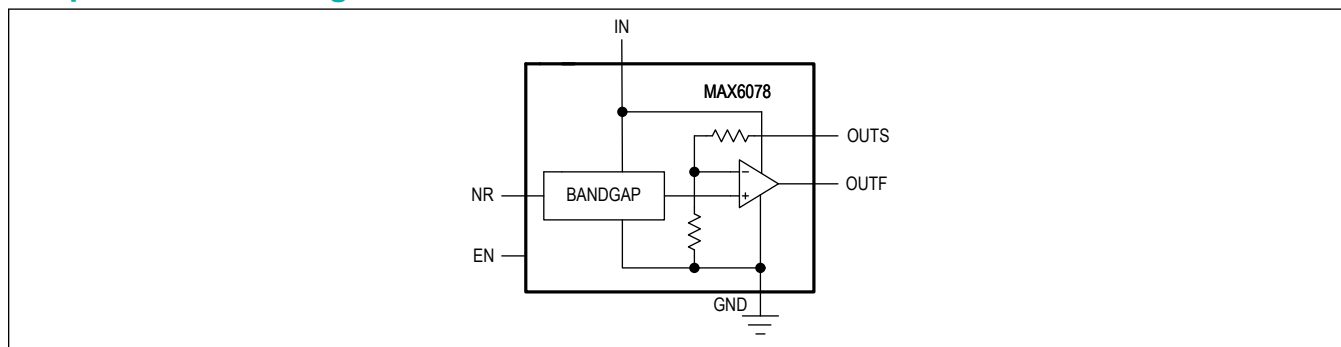
- High-Accuracy Industrial and Process Control
- Precision Instrumentation
- High-Resolution ADCs and DACs
- Portable and Handheld Systems

### Benefits and Features

- $\pm 0.04\%$  Initial Accuracy
- 10ppm/ $^{\circ}$ C (max) Temperature Drift
- 12 $\mu$ V<sub>P-P</sub> Noise (0.1Hz to 10Hz) at 2.5V
- 15 $\mu$ A Supply Current
- Long-Term Drift: 16ppm (typ, 4000hrs)
- 3mA Source/Sink Load Current
- Filter Option Reduces High-Frequency Noise
- 100mV Dropout Voltage
- 1.5mm x 1.3mm (0.5mm pitch), 6-Bump WLP and 2mm x 3mm, 8-Pin TDFN-EP Packages
- Voltage Output Options: 1.25V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V, and 5.0V

Ordering Information appears at end of data sheet.

### Simplified Block Diagram



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## Absolute Maximum Ratings

|                                  |                              |                                                                             |                                                 |
|----------------------------------|------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------|
| OUTF to GND .....                | -0.3V to ( $V_{IN} + 0.3$ )V | Maximum Continuous Power Dissipation ( $T_A = +70^{\circ}\text{C}$ ) .      |                                                 |
| OUTS to GND .....                | -0.3V to +6V                 | TDFN (derate 16.7mW/ $^{\circ}\text{C}$ above $+70^{\circ}\text{C}$ ) ..... | 1333.3mW                                        |
| IN to GND .....                  | -0.3V to +6V                 | WLP (derate 12.34mW/ $^{\circ}\text{C}$ above $+70^{\circ}\text{C}$ ) ..... | 987.2mW                                         |
| EN to GND .....                  | -0.3V to +6V                 | Operating Temperature Range .....                                           | $-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ |
| NR to GND .....                  | -0.3V to ( $V_{IN} + 0.3$ )V | Storage Temperature Range .....                                             | $-65^{\circ}\text{C}$ to $+150^{\circ}\text{C}$ |
| Current to/from OUTF .....       | 50mA                         | Lead Temperature (soldering, 10s) .....                                     | $+300^{\circ}\text{C}$                          |
| Current to/from OUTS/NR/EN ..... | 20mA                         | 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 Information

### 8 TDFN

|                                             |                         |
|---------------------------------------------|-------------------------|
| Package Code                                | T823+1C                 |
| Outline Number                              | <a href="#">21-0174</a> |
| Land Pattern Number                         | <a href="#">90-0091</a> |
| <b>Thermal Resistance, Four-Layer Board</b> |                         |
| Junction to Ambient ( $\theta_{JA}$ )       | $60^{\circ}\text{C/W}$  |
| Junction to Case ( $\theta_{JC}$ )          | $11^{\circ}\text{C/W}$  |

### 8 WLP

|                                             |                                                |
|---------------------------------------------|------------------------------------------------|
| Package Code                                | W61L1+1                                        |
| Outline Number                              | <a href="#">21-100365</a>                      |
| Land Pattern Number                         | Refer to <a href="#">Application Note 1891</a> |
| <b>Thermal Resistance, Four-Layer Board</b> |                                                |
| Junction to Ambient ( $\theta_{JA}$ )       | $81.03^{\circ}\text{C/W}$                      |
| Junction to Case ( $\theta_{JC}$ )          | N/A                                            |

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 – 2.5V

( $V_{IN} = +3.3\text{V}$ ,  $I_{OUT} = 0\text{mA}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , unless otherwise specified. Typical values are at  $T_A = +25^{\circ}\text{C}$  ([Note 1](#)))

| PARAMETER                        | SYMBOL      | CONDITIONS                                                                 | MIN   | TYP | MAX   | UNITS                   |
|----------------------------------|-------------|----------------------------------------------------------------------------|-------|-----|-------|-------------------------|
| Output Voltage Accuracy          |             | $T_A = +25^{\circ}\text{C}$                                                | -0.04 |     | +0.04 | %                       |
| Output Voltage Temperature Drift | $TCV_{OUT}$ | $-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ ( <a href="#">Note 2</a> ) |       | 2   | 10    | ppm/ $^{\circ}\text{C}$ |
|                                  |             | $-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ ( <a href="#">Note 2</a> ) |       | 2   | 10    |                         |

## Electrical Characteristics – 2.5V (continued)

( $V_{IN} = +3.3V$ ,  $I_{OUT} = 0mA$ ,  $C_{OUT} = 0.1\mu F$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise specified. Typical values are at  $T_A = +25^{\circ}C$  ([Note 1](#)))

| PARAMETER                       | SYMBOL    | CONDITIONS                                                 |                      | MIN | TYP  | MAX | UNITS          |
|---------------------------------|-----------|------------------------------------------------------------|----------------------|-----|------|-----|----------------|
| Line Regulation                 |           | Over specified operating input voltage range               |                      |     | 10   | 175 | $\mu V/V$      |
| Load Regulation                 |           | $-3mA \leq I_{OUT} \leq +3mA$                              |                      |     | 5    | 125 | $\mu V/mA$     |
| Dropout Voltage                 |           | $I_{OUT} = 3mA$ ( <a href="#">Note 3</a> )                 |                      |     |      | 100 | mV             |
|                                 |           | $I_{OUT} = 100\mu A$ ( <a href="#">Note 3</a> )            |                      |     |      | 10  |                |
| Output Current                  | $I_{OUT}$ | Guaranteed by load regulation                              |                      | -3  |      | +3  | mA             |
| Short-Circuit Current           | $I_{SC}$  | Sourcing to ground                                         |                      |     | 36   |     | mA             |
|                                 |           | Sinking current from $V_{IN}$                              |                      |     | 24   |     |                |
| Long-Term Stability             |           | $T_A = +35^{\circ}C$                                       | 0 to 4000hrs         |     | 16   |     | ppm            |
|                                 |           |                                                            | 0 to 1000hrs         |     | 9.8  |     |                |
|                                 |           |                                                            | 1000hrs to 2000hrs   |     | 2.5  |     |                |
|                                 |           |                                                            | 2000hrs to 3000hrs   |     | 1.89 |     |                |
|                                 |           |                                                            | 3000hrs to 4000hrs   |     | 1.96 |     |                |
| Thermal Hysteresis              |           | ( <a href="#">Note 4</a> )                                 |                      |     | 20   |     | ppm            |
| Output Noise Voltage            | $e_{OUT}$ | 0.1Hz to 10Hz, $C_{OUT} = 0.1\mu F$                        |                      |     | 12   |     | $\mu V_{P-P}$  |
|                                 |           | 10Hz to 10kHz, $C_{OUT} = 0.1\mu F$                        |                      |     | 30   |     | $\mu V_{RMS}$  |
|                                 |           | 10Hz to 10kHz, $C_{OUT} = 0.1\mu F$ , $C_{NR} = 0.01\mu F$ |                      |     | 20   |     |                |
| Output Noise Spectral Density   |           | $f = 100Hz$ , $C_{OUT} = 0.1\mu F$                         |                      |     | 580  |     | $nV/\sqrt{Hz}$ |
|                                 |           | $f = 100Hz$ , $C_{OUT} = 0.1\mu F$ , $C_{NR} = 0.01\mu F$  |                      |     | 385  |     |                |
| Ripple Rejection                |           | $f = 60Hz$                                                 |                      |     | 50   |     | dB             |
| Turn-On Settling Time           |           | Settling to 0.1%,<br>$C_{OUT} = 0.1\mu F$                  | $C_{NR} = 0.01\mu F$ |     | 50   |     | ms             |
|                                 |           | Settling to 0.1%,<br>$C_{OUT} = 0.1\mu F$                  | No $C_{NR}$          |     | 5    |     |                |
| Enable Settling Time            | $t_{EN}$  | Settling to 0.1%,<br>$C_{OUT} = 0.1\mu F$                  | $C_{NR} = 0.01\mu F$ |     | 30   |     | ms             |
|                                 |           | Settling to 0.1%,<br>$C_{OUT} = 0.1\mu F$                  | No $C_{NR}$          |     | 3    |     |                |
| Capacitive-Load Stability Range |           |                                                            |                      | 0.1 |      | 4.7 | $\mu F$        |
| Supply Voltage                  | $V_{IN}$  |                                                            |                      | 2.7 |      | 5.5 | V              |

**Electrical Characteristics – 2.5V (continued)**

( $V_{IN} = +3.3V$ ,  $I_{OUT} = 0mA$ ,  $C_{OUT} = 0.1\mu F$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise specified. Typical values are at  $T_A = +25^{\circ}C$  ([Note 1](#)))

| PARAMETER                | SYMBOL   | CONDITIONS      |                                         | MIN                 | TYP                 | MAX  | UNITS   |
|--------------------------|----------|-----------------|-----------------------------------------|---------------------|---------------------|------|---------|
| Quiescent Supply Current | $I_{IN}$ | $V_{IN} = 5V$   | $T_A = +25^{\circ}C$                    |                     | 10                  | 15   | $\mu A$ |
|                          |          |                 | $T_A = -55^{\circ}C$ to $+85^{\circ}C$  |                     |                     | 16.5 |         |
|                          |          |                 | $T_A = -55^{\circ}C$ to $+125^{\circ}C$ |                     |                     | 18   |         |
|                          |          | $V_{IN} = 3.3V$ | $T_A = +25^{\circ}C$                    |                     | 9                   | 14   |         |
|                          |          |                 | $T_A = -55^{\circ}C$ to $+85^{\circ}C$  |                     |                     | 15.5 |         |
|                          |          |                 | $T_A = -55^{\circ}C$ to $+125^{\circ}C$ |                     |                     | 17   |         |
| Shutdown Supply Current  | $I_{SD}$ |                 |                                         |                     | 0.1                 | 2    | $\mu A$ |
| Enable Input Current     | $I_{EN}$ |                 |                                         |                     |                     | 0.1  | $\mu A$ |
| Enable Logic-High        | $V_{IH}$ |                 |                                         | $0.7 \times V_{IN}$ |                     |      | V       |
| Enable Logic-Low         | $V_{IL}$ |                 |                                         |                     | $0.3 \times V_{IN}$ |      | V       |

**Electrical Characteristics – 3.0V**

( $V_{IN} = +5V$ ,  $I_{OUT} = 0mA$ ,  $C_{OUT} = 0.1\mu F$ ,  $T_A = -55^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise specified. Typical values are at  $T_A = +25^{\circ}C$  ([Note 1](#)))

| PARAMETER                        | SYMBOL      | CONDITIONS                                                   |                    | MIN   | TYP  | MAX   | UNITS            |
|----------------------------------|-------------|--------------------------------------------------------------|--------------------|-------|------|-------|------------------|
| Output Voltage Accuracy          |             | $T_A = +25^{\circ}C$                                         |                    | -0.04 |      | +0.04 | %                |
| Output Voltage Temperature Drift | $TCV_{OUT}$ | $-40^{\circ}C$ to $+125^{\circ}C$ ( <a href="#">Note 2</a> ) |                    |       | 2    | 10    | ppm/ $^{\circ}C$ |
|                                  |             | $-55^{\circ}C$ to $+125^{\circ}C$ ( <a href="#">Note 2</a> ) |                    |       | 2    | 10    |                  |
| Line Regulation                  |             | Over specified operating input voltage range                 |                    |       | 10   | 175   | $\mu V/V$        |
| Load Regulation                  |             | $-3mA \leq I_{OUT} \leq +3mA$                                |                    |       | 5    | 125   | $\mu V/mA$       |
| Dropout Voltage                  |             | $I_{OUT} = 3mA$ ( <a href="#">Note 3</a> )                   |                    |       |      | 100   | mV               |
|                                  |             | $I_{OUT} = 100\mu A$ ( <a href="#">Note 3</a> )              |                    |       |      | 10    |                  |
| Output Current                   | $I_{OUT}$   | Guaranteed by load regulation                                |                    | -3    |      | +3    | mA               |
| Short-Circuit Current            | $I_{SC}$    | Sourcing to ground                                           |                    |       | 36   |       | mA               |
|                                  |             | Sinking current from $V_{IN}$                                |                    |       | 24   |       |                  |
| Long-Term Stability              |             | $T_A = +35^{\circ}C$                                         | 0 to 4000hrs       |       | 16   |       | ppm              |
|                                  |             |                                                              | 0 to 1000hrs       |       | 9.8  |       |                  |
|                                  |             |                                                              | 1000hrs to 2000hrs |       | 2.5  |       |                  |
|                                  |             |                                                              | 2000hrs to 3000hrs |       | 1.89 |       |                  |
|                                  |             |                                                              | 3000hrs to 4000hrs |       | 1.96 |       |                  |
| Thermal Hysteresis               |             | ( <a href="#">Note 4</a> )                                   |                    |       | 20   |       | ppm              |

**Electrical Characteristics – 3.0V (continued)**(V<sub>IN</sub> = +5V, I<sub>OUT</sub> = 0mA, C<sub>OUT</sub> = 0.1μF, T<sub>A</sub> = -55°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 Noise Voltage            | e <sub>OUT</sub> | 0.1Hz to 10Hz, C <sub>OUT</sub> = 0.1μF                           |                          |                       | 12  |                       | μV <sub>P-P</sub> |
|                                 |                  | 10Hz to 10kHz, C <sub>OUT</sub> = 0.1μF                           |                          |                       | 30  |                       | μV <sub>RMS</sub> |
|                                 |                  | 10Hz to 10kHz, C <sub>OUT</sub> = 0.1μF, C <sub>NR</sub> = 0.01μF |                          |                       | 20  |                       |                   |
| Output Noise Spectral Density   |                  | f = 100Hz, C <sub>OUT</sub> = 0.1μF                               |                          |                       | 580 |                       | nV/√Hz            |
|                                 |                  | f = 100Hz, C <sub>OUT</sub> = 0.1μF, C <sub>NR</sub> = 0.01μF     |                          |                       | 385 |                       |                   |
| Ripple Rejection                |                  | f = 60Hz                                                          |                          |                       | 50  |                       | dB                |
| Turn-On Settling Time           |                  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | C <sub>NR</sub> = 0.01μF |                       | 50  |                       | ms                |
|                                 |                  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | No C <sub>NR</sub>       |                       | 5   |                       |                   |
| Enable Settling Time            | t <sub>EN</sub>  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | C <sub>NR</sub> = 0.01μF |                       | 30  |                       | ms                |
|                                 |                  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | No C <sub>NR</sub>       |                       | 3   |                       |                   |
| Capacitive-Load Stability Range |                  |                                                                   |                          | 0.1                   |     | 4.7                   | μF                |
| Supply Voltage                  | V <sub>IN</sub>  |                                                                   |                          | 3.2                   |     | 5.5                   | V                 |
| Quiescent Supply Current        | I <sub>IN</sub>  | T <sub>A</sub> = +25°C                                            |                          |                       | 10  | 15                    | μA                |
|                                 |                  | T <sub>A</sub> = -55°C to +85°C                                   |                          |                       |     | 16.5                  |                   |
|                                 |                  | T <sub>A</sub> = -55°C to +125°C                                  |                          |                       |     | 18                    |                   |
| Shutdown Supply Current         | I <sub>SD</sub>  |                                                                   |                          |                       | 0.1 | 2                     | μA                |
| Enable Input Current            | I <sub>EN</sub>  |                                                                   |                          |                       |     | 0.1                   | μA                |
| Enable Logic-High               | V <sub>IH</sub>  |                                                                   |                          | 0.7 × V <sub>IN</sub> |     |                       | V                 |
| Enable Logic-Low                | V <sub>IL</sub>  |                                                                   |                          |                       |     | 0.3 × V <sub>IN</sub> | V                 |

**Electrical Characteristics – 3.3V**(V<sub>IN</sub> = +5V, I<sub>OUT</sub> = 0mA, C<sub>OUT</sub> = 0.1μF, T<sub>A</sub> = -55°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 Accuracy          |                    | T <sub>A</sub> = +25°C                              |  | -0.04 |     | +0.04 | %      |
| Output Voltage Temperature Drift | TCV <sub>OUT</sub> | -40°C to +125°C ( <a href="#">Note 2</a> )          |  |       | 2   | 10    | ppm/°C |
|                                  |                    | -55°C to +125°C ( <a href="#">Note 2</a> )          |  |       | 2   | 10    |        |
| Line Regulation                  |                    | Over specified operating input voltage range        |  |       | 10  | 175   | μV/V   |
| Load Regulation                  |                    | -3mA ≤ I <sub>OUT</sub> ≤ +3mA                      |  |       | 5   | 125   | μV/mA  |
| Dropout Voltage                  |                    | I <sub>OUT</sub> = 3mA ( <a href="#">Note 3</a> )   |  |       |     | 100   | mV     |
|                                  |                    | I <sub>OUT</sub> = 100μA ( <a href="#">Note 3</a> ) |  |       |     | 10    |        |
| Output Current                   | I <sub>OUT</sub>   | Guaranteed by load regulation                       |  | -3    |     | +3    | mA     |

## Electrical Characteristics – 3.3V (continued)

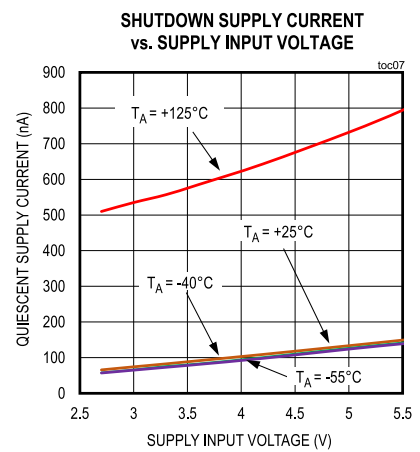
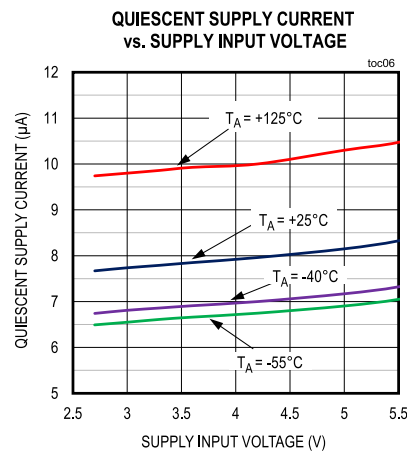
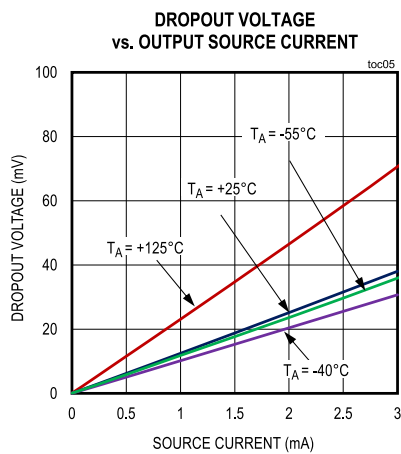
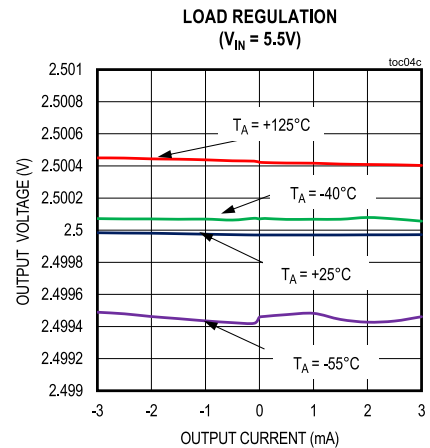
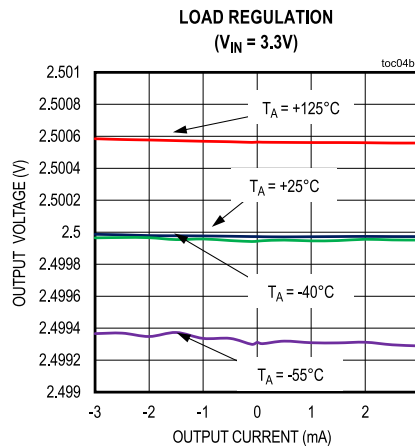
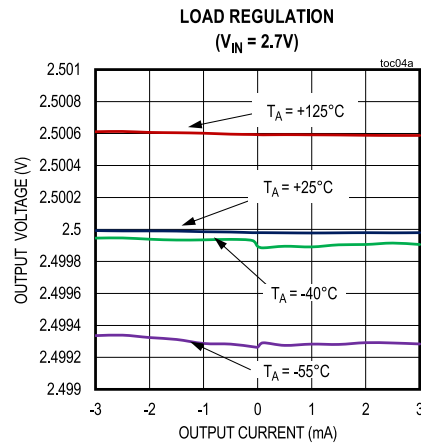
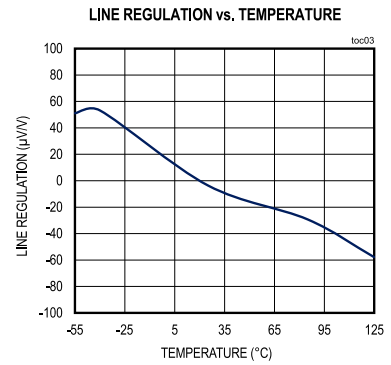
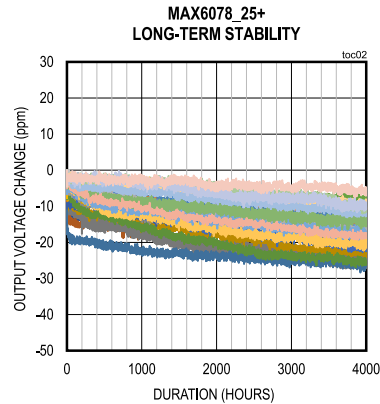
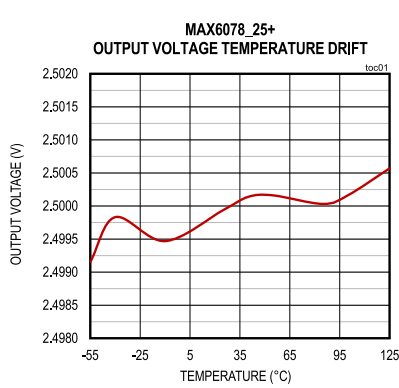
(V<sub>IN</sub> = +5V, I<sub>OUT</sub> = 0mA, C<sub>OUT</sub> = 0.1μF, T<sub>A</sub> = -55°C to +125°C, unless otherwise specified. Typical values are at T<sub>A</sub> = +25°C ([Note 1](#)))

| PARAMETER                       | SYMBOL           | CONDITIONS                                                        |                          | MIN                   | TYP  | MAX                   | UNITS             |
|---------------------------------|------------------|-------------------------------------------------------------------|--------------------------|-----------------------|------|-----------------------|-------------------|
| Short-Circuit Current           | I <sub>SC</sub>  | Sourcing to ground                                                |                          |                       | 36   |                       | mA                |
|                                 |                  | Sinking current from V <sub>IN</sub>                              |                          |                       | 24   |                       |                   |
| Long-Term Stability             |                  | T <sub>A</sub> = +35°C                                            | 0 to 4000hrs             |                       | 16   |                       | ppm               |
|                                 |                  |                                                                   | 0 to 1000hrs             |                       | 9.8  |                       |                   |
|                                 |                  |                                                                   | 1000hrs to 2000hrs       |                       | 2.5  |                       |                   |
|                                 |                  |                                                                   | 2000hrs to 3000hrs       |                       | 1.89 |                       |                   |
|                                 |                  |                                                                   | 3000hrs to 4000hrs       |                       | 1.96 |                       |                   |
| Thermal Hysteresis              |                  | <a href="#">(Note 4)</a>                                          |                          |                       | 20   |                       | ppm               |
| Output Noise Voltage            | e <sub>OUT</sub> | 0.1Hz to 10Hz, C <sub>OUT</sub> = 0.1μF                           |                          |                       | 12   |                       | μV <sub>P-P</sub> |
|                                 |                  | 10Hz to 10kHz, C <sub>OUT</sub> = 0.1μF                           |                          |                       | 30   |                       | μV <sub>RMS</sub> |
|                                 |                  | 10Hz to 10kHz, C <sub>OUT</sub> = 0.1μF, C <sub>NR</sub> = 0.01μF |                          |                       | 20   |                       |                   |
| Output Noise Spectral Density   |                  | f = 100Hz, C <sub>OUT</sub> = 0.1μF                               |                          |                       | 580  |                       | nV/√Hz            |
|                                 |                  | f = 100Hz, C <sub>OUT</sub> = 0.1μF, C <sub>NR</sub> = 0.01μF     |                          |                       | 385  |                       |                   |
| Ripple Rejection                |                  | f = 60Hz                                                          |                          |                       | 50   |                       | dB                |
| Turn-On Settling Time           |                  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | C <sub>NR</sub> = 0.01μF |                       | 50   |                       | ms                |
|                                 |                  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | No C <sub>NR</sub>       |                       | 5    |                       |                   |
| Enable Settling Time            | t <sub>EN</sub>  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | C <sub>NR</sub> = 0.01μF |                       | 30   |                       | ms                |
|                                 |                  | Settling to 0.1%, C <sub>OUT</sub> = 0.1μF                        | No C <sub>NR</sub>       |                       | 3    |                       |                   |
| Capacitive-Load Stability Range |                  |                                                                   |                          | 0.1                   |      | 4.7                   | μF                |
| Supply Voltage                  | V <sub>IN</sub>  |                                                                   |                          | 3.5                   |      | 5.5                   | V                 |
| Quiescent Supply Current        | I <sub>IN</sub>  | T <sub>A</sub> = +25°C                                            |                          |                       | 10   | 15                    | μA                |
|                                 |                  | T <sub>A</sub> = -40°C to +125°C                                  |                          |                       |      | 16.5                  |                   |
|                                 |                  | T <sub>A</sub> = -55°C to +125°C                                  |                          |                       |      | 18                    |                   |
| Shutdown Supply Current         | I <sub>SD</sub>  |                                                                   |                          |                       | 0.1  | 2                     | μA                |
| Enable Input Current            | I <sub>EN</sub>  |                                                                   |                          |                       |      | 0.1                   | μA                |
| Enable Logic-High               | V <sub>IH</sub>  |                                                                   |                          | 0.7 x V <sub>IN</sub> |      |                       | V                 |
| Enable Logic-Low                | V <sub>IL</sub>  |                                                                   |                          |                       |      | 0.3 x V <sub>IN</sub> | V                 |

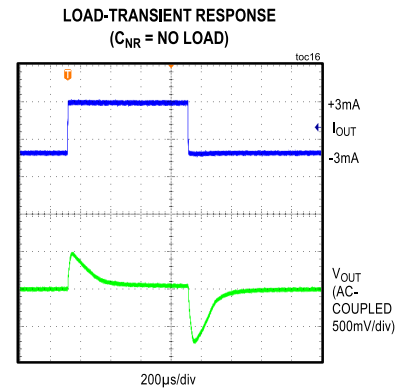
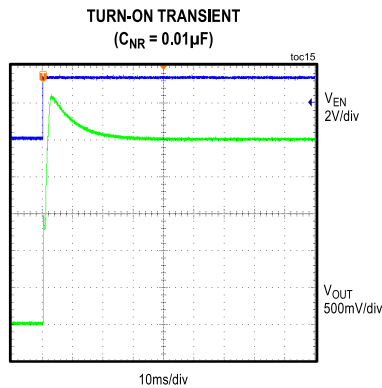
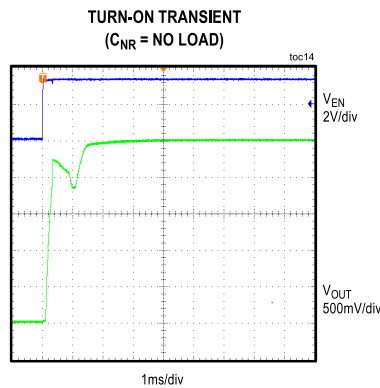
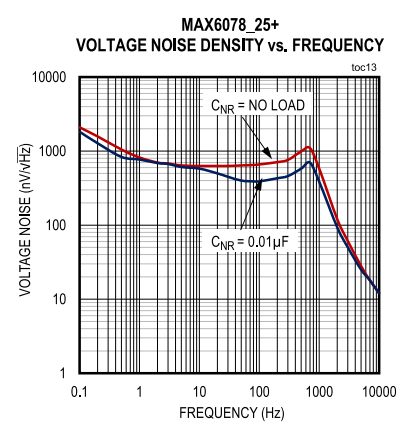
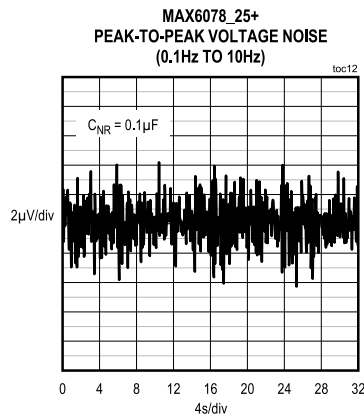
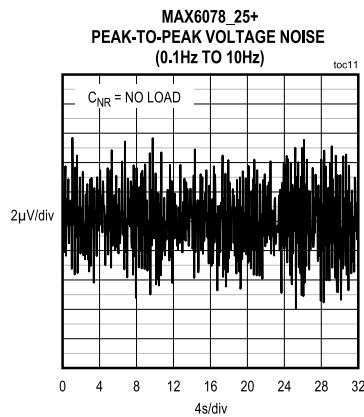
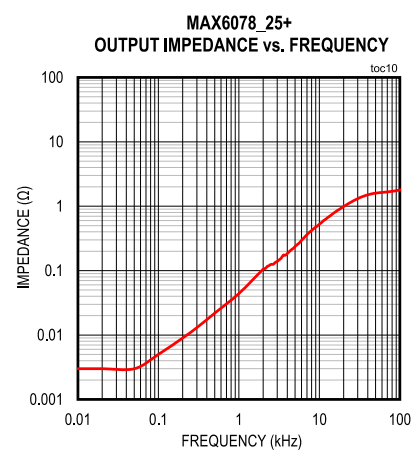
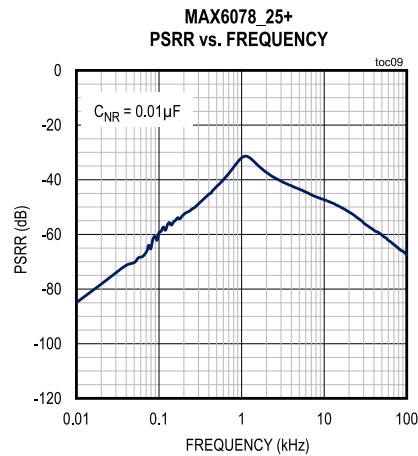
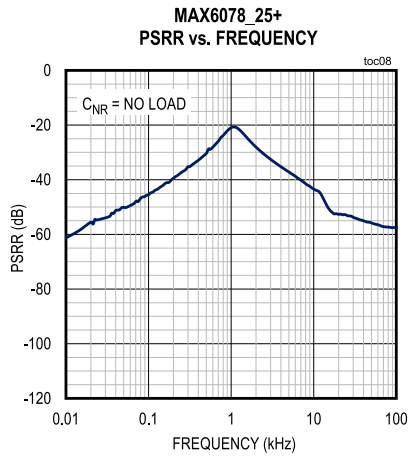
**Note 1:** Limits are 100% tested at T<sub>A</sub> = +25°C. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization.**Note 2:** Temperature coefficient is calculated using the “box method” which measures temperature drift as the maximum voltage variation over a specified temperature range.**Note 3:** Dropout voltage is defined as the minimum differential voltage (V<sub>IN</sub> - V<sub>OUT</sub>) at which V<sub>OUT</sub> decreases by 0.2% from its original value. V<sub>IN</sub> = 3.3V for output voltages of 1.25V, 2.048V, and 2.5V; V<sub>IN</sub> = 5V for output voltages of 3V, 3.3V, 4.096V; V<sub>IN</sub> = 5.5V for output voltage of 5V.**Note 4:** 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>.



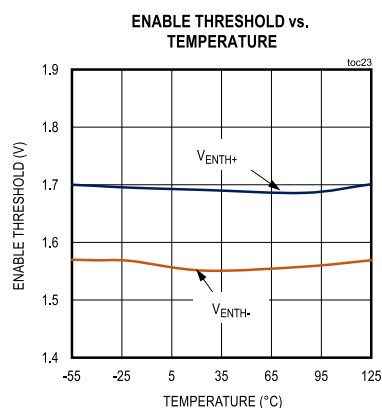
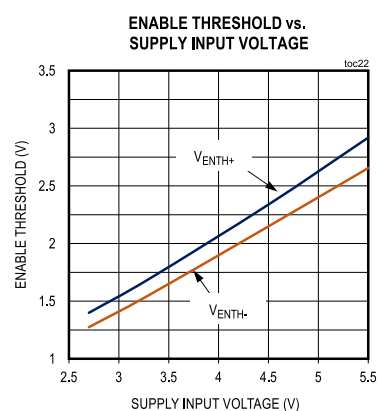
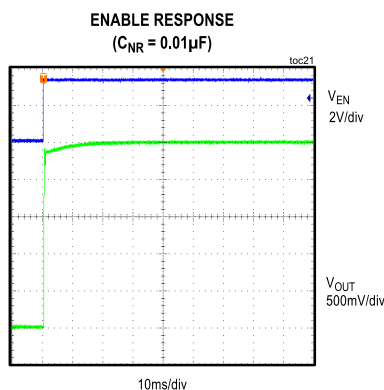
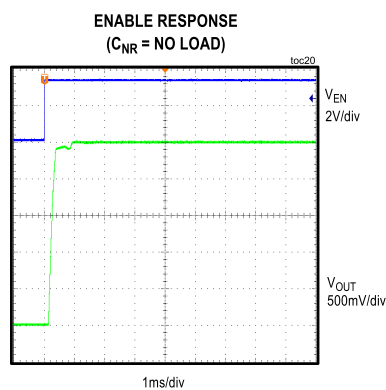
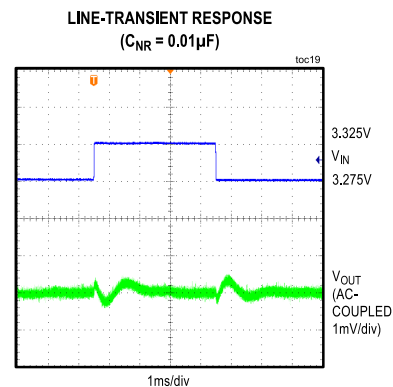
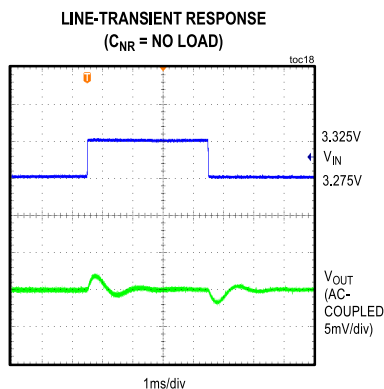
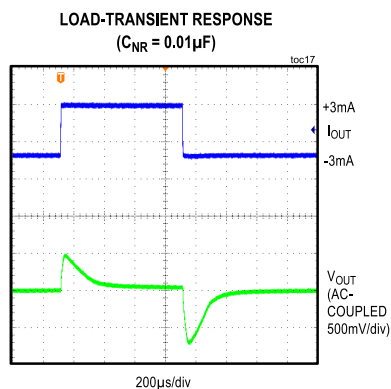
## Typical Operating Characteristics

(V<sub>IN</sub> = 3.3V, I<sub>OUT</sub> = 0mA, C<sub>OUT</sub> = 0.1μF to GND, T<sub>A</sub> = +25°C, unless otherwise noted.)

## Typical Operating Characteristics (continued)

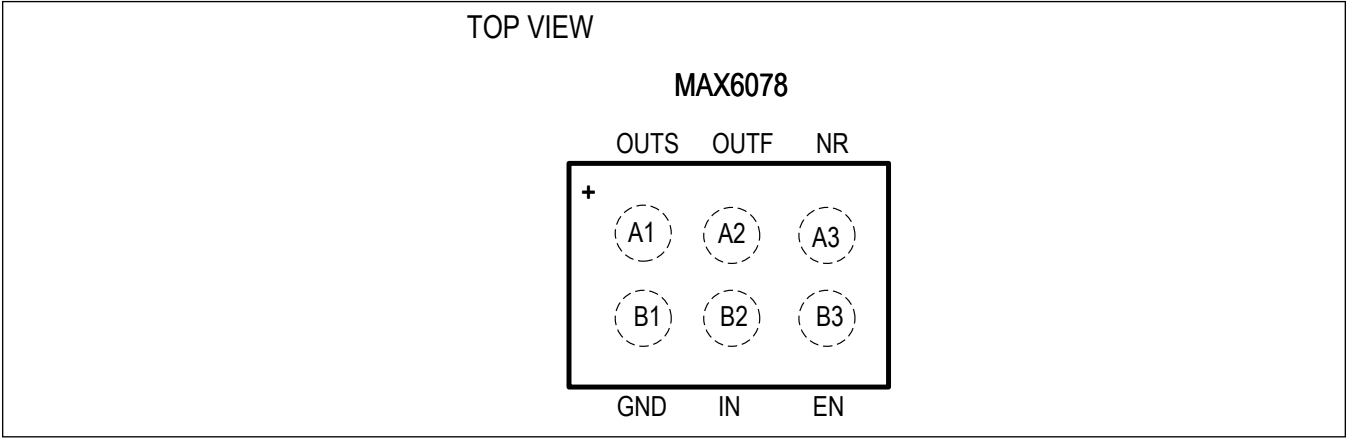
(V<sub>IN</sub> = 3.3V, I<sub>OUT</sub> = 0mA, C<sub>OUT</sub> = 0.1μF to GND, T<sub>A</sub> = +25°C, unless otherwise noted.)

## Typical Operating Characteristics (continued)

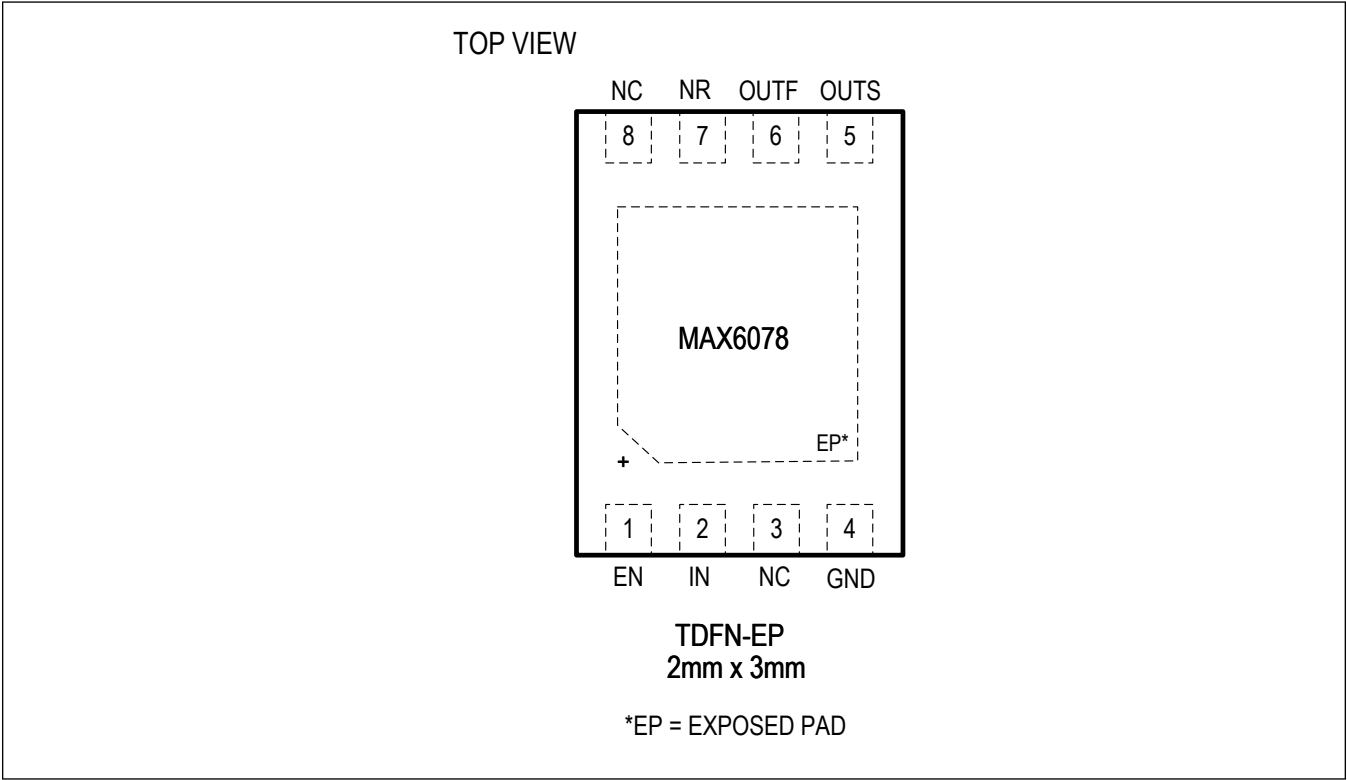
(V<sub>IN</sub> = 3.3V, I<sub>OUT</sub> = 0mA, C<sub>OUT</sub> = 0.1μF to GND, T<sub>A</sub> = +25°C, unless otherwise noted.)

Pin Configurations

6 WLP



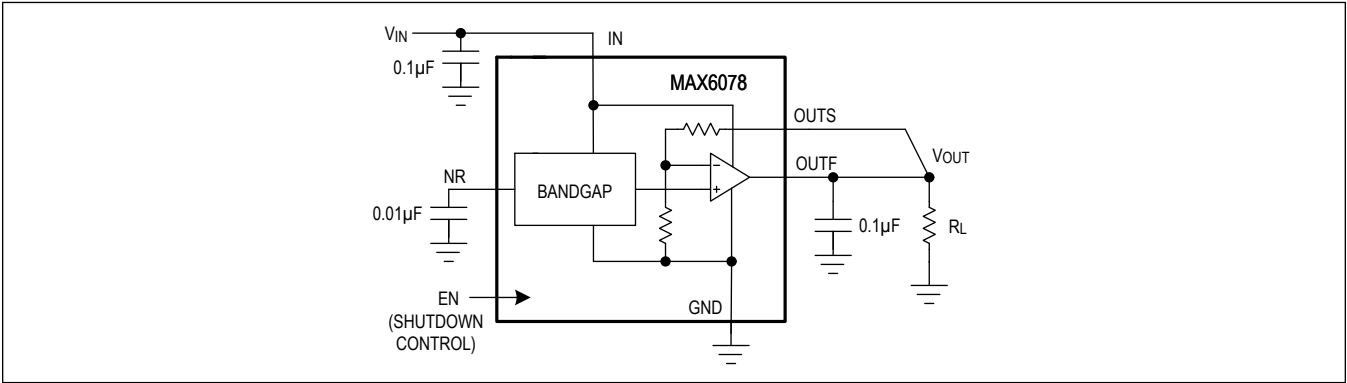
8 TDFN-EP



Pin Description

| PIN   |           | NAME | FUNCTION                                                                                                                                |
|-------|-----------|------|-----------------------------------------------------------------------------------------------------------------------------------------|
| 6 WLP | 8 TDFN-EP |      |                                                                                                                                         |
| A1    | 5         | OUTS | Voltage Reference Output Sense. Connect OUTF and OUTS as close as possible to the load.                                                 |
| A2    | 6         | OUTF | Voltage Reference Force Output. Connect OUTF and OUTS as close as possible to the load. Bypass OUTF with a capacitor to GND.            |
| A3    | 7         | NR   | Noise Reduction Input. Connect a 0.01μF capacitor from NR to ground to provide wideband noise filtering. Leave unconnected if not used. |
| B1    | 4         | GND  | Ground                                                                                                                                  |
| B2    | 2         | IN   | Supply Input                                                                                                                            |
| B3    | 1         | EN   | Enable. Drive high to enable. Drive low to disable.                                                                                     |
| —     | 3, 8      | NC   | No Connect. Not internally connected. May be connected to GND.                                                                          |
| —     | EP        | EP   | Exposed Pad. EP is internally connected to GND. Connect EP to GND.                                                                      |

Typical Operating Circuit



## Detailed Description

### Wideband Noise Reduction (NR)

To improve wideband noise and transient power supply noise, connect a  $0.01\mu\text{F}$  capacitor from NR to GND (see the [Typical Operating Characteristics](#)). Larger values do not appreciably improve noise reduction. A  $0.01\mu\text{F}$  capacitor reduces the spectral noise density at 100Hz from  $580\text{nV}/\sqrt{\text{Hz}}$  to  $385\text{nV}/\sqrt{\text{Hz}}$  for the 2.5V output version. Noise at the input pin can affect output noise, but can be reduced by connecting an optional bypass capacitor between IN and GND, as shown in [Figure 1](#).

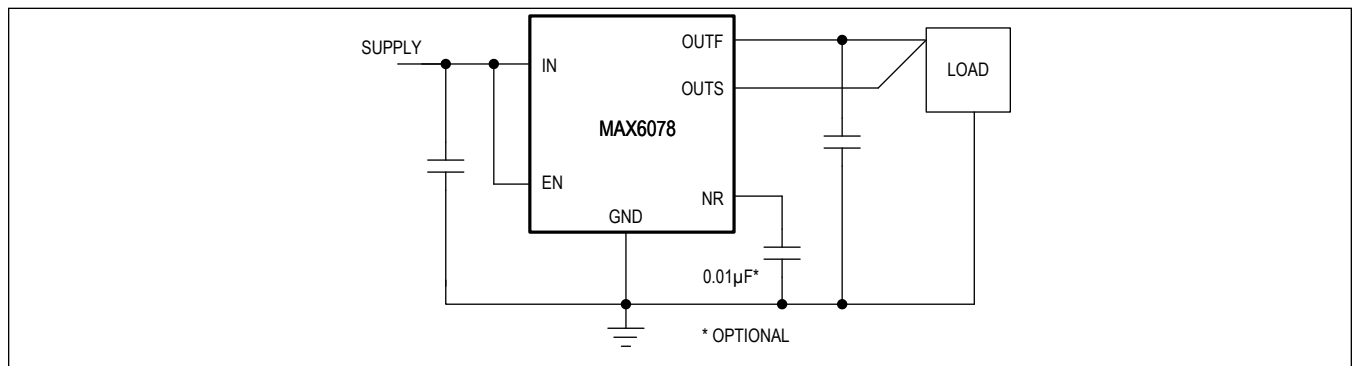


Figure 1. Noise Reduction Capacitor

### Output Bypassing

Use an output capacitor with a value between  $0.1\mu\text{F}$  and  $4.7\mu\text{F}$ . Place the output capacitor as close to OUTF as possible. For applications driving switching capacitive loads or rapidly changing load currents, use a  $0.1\mu\text{F}$  capacitor in parallel with a larger load capacitor to reduce equivalent series resistance (ESR). Larger capacitor values and lower ESR reduce transients on the reference output.

### Turn-On Time

These references typically turn on and settle to within 0.1% of their final value in 5ms with no capacitive loads at NR pin. A  $0.1\mu\text{F}$  load capacitor at OUTF and a  $0.01\mu\text{F}$  noise reduction capacitor connected to the NR input increase the turn-on time to approximately 50ms.

### Output Force and Sense

These references provide independent connections for the force output (OUTF), which supplies current to the load and the feedback input that regulates the load voltage through the output sense pin (OUTS). This configuration allows for the cancellation of the voltage drop on the lines connecting the reference to the load. Connect OUTF to the load and connect OUTS to OUTF at the point where the voltage accuracy is needed ([Figure 1](#)).

### Shutdown

Although the operating power supply current of these references is very low, there are some cases that require even lower supply current during shutdown conditions. Pulling EN low disables the output with an internal resistive load to ground and forces the quiescent current to less than 100nA. Pulling EN high enables normal operation. The return to normal operation occurs within the 3ms enable time delay typically.

### Thermal Hysteresis

Thermal hysteresis is the change of output voltage at  $T_A = +25^\circ\text{C}$  before and after the device is cycled over its entire operating temperature range. The typical thermal hysteresis value is 20ppm.

## Applications Information

### Precision Current Source

Figure 2 shows a precision current source. The OUTF output provides the bias current for the bipolar transistor. OUTS and GND sense the voltage across the resistor and adjust the current sourced by OUTF accordingly. The voltage range of OUTF is set by the reference output voltage (OUTS) and the  $V_{BE}$  (BJT) of the output external device:

$$V_{OUTF} = V_{BE} + V_{REF}$$

where:

$V_{OUTF}$  is the voltage on the OUTF pin,

$V_{BE}$  is the base-emitter drop across BJT,

$V_{REF}$  is the actual voltage reference output this part is supposed to provide.

Therefore, the input supply voltage requirement for the MAX6078 is as follows:

$$V_{IN} \geq V_{DROP} \text{ (dropout voltage)} + V_{BE\max} + V_{REF}$$

where:

$V_{DROP}$  is the dropout voltage of the voltage reference.

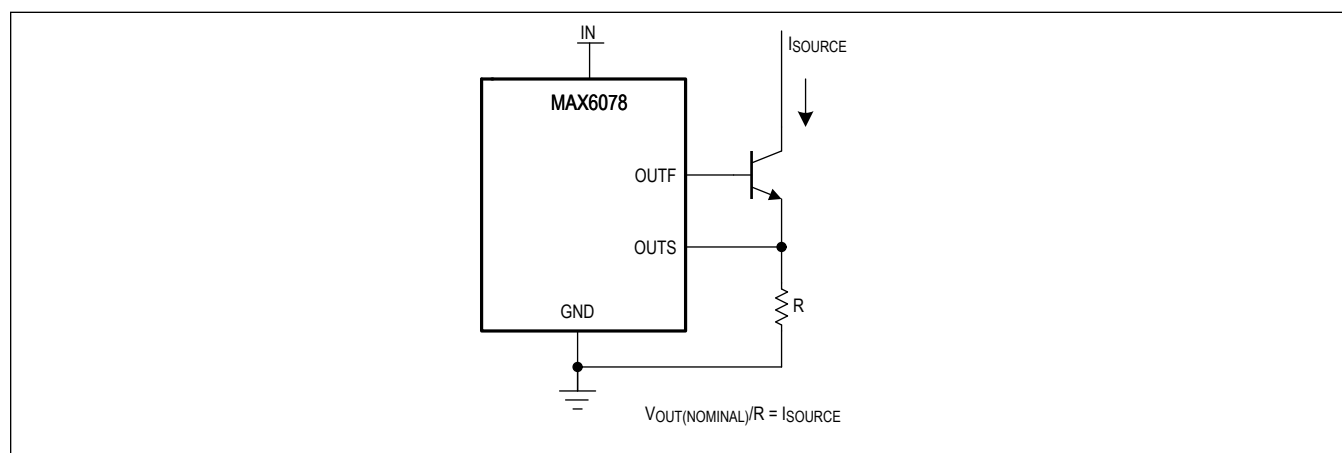


Figure 2. Precision Current Source

## Ordering Information

| PART NUMBER      | TEMP RANGE      | PIN-PACKAGE | V <sub>OUT</sub> (V) | ACCURACY (%) | TOP MARK |
|------------------|-----------------|-------------|----------------------|--------------|----------|
| MAX6078BMWT12+T* | -55°C to +125°C | 6 WLP       | 1.250                | 0.04         | —        |
| MAX6078AMWT21+T* | -55°C to +125°C | 6 WLP       | 2.048                | 0.04         | —        |
| MAX6078AMWT25+T  | -55°C to +125°C | 6 WLP       | 2.500                | 0.04         | +AAE     |
| MAX6078AMWT30+T  | -55°C to +125°C | 6 WLP       | 3.000                | 0.04         | +AAH     |
| MAX6078AMWT33+T  | -55°C to +125°C | 6 WLP       | 3.300                | 0.04         | +AAI     |
| MAX6078AMWT41+T* | -55°C to +125°C | 6 WLP       | 4.096                | 0.04         | —        |
| MAX6078AMWT50+T* | -55°C to +125°C | 6 WLP       | 5.000                | 0.04         | —        |
| MAX6078BMTA12+T* | -55°C to +125°C | 8 TDFN-EP   | 1.250                | 0.04         | —        |
| MAX6078AMTA21+T* | -55°C to +125°C | 8 TDFN-EP   | 2.048                | 0.04         | —        |
| MAX6078AMTA25+T* | -55°C to +125°C | 8 TDFN-EP   | 2.500                | 0.04         | —        |
| MAX6078AMTA30+T* | -55°C to +125°C | 8 TDFN-EP   | 3.000                | 0.04         | —        |
| MAX6078AMTA33+T* | -55°C to +125°C | 8 TDFN-EP   | 3.300                | 0.04         | —        |
| MAX6078AMTA41+T* | -55°C to +125°C | 8 TDFN-EP   | 4.096                | 0.04         | —        |
| MAX6078AMTA50+T* | -55°C to +125°C | 8 TDFN-EP   | 5.000                | 0.04         | —        |

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

T = Tape and reel.

\*Future product—contact factory for availability.



## Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION                                                                                                                                                 | PAGES<br>CHANGED |
|--------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| 0                  | 6/19             | Initial release                                                                                                                                             | —                |
| 1                  | 9/20             | Updated <i>Benefits and Features</i> , <i>Electrical Characteristics</i> , <i>Typical Operating Characteristics</i> , and <i>Ordering Information</i> table | 1, 4, 5, 7–9, 14 |
| 2                  | 3/21             | Updated the <i>Electrical Characteristics</i> and <i>Ordering Information</i> tables                                                                        | 6–8, 16          |

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