

LM4050/LM4051

50ppm/°C Precision Micropower Shunt Voltage References with Multiple Reverse Breakdown Voltages

General Description

The LM4050/LM4051 are precision two-terminal, shunt-mode, bandgap voltage references available in fixed reverse breakdown voltages of 1.225V, 2.048V, 2.500V, 3.000V, 3.3V, 4.096V, and 5.000V. Ideal for space-critical applications, the LM4050/LM4051 are offered in the sub miniature 3-pin SC70 surface-mount packages (1.8mm x 1.8mm), 50% smaller than comparable devices in SOT23 surface-mount package (SOT23 versions are also available).

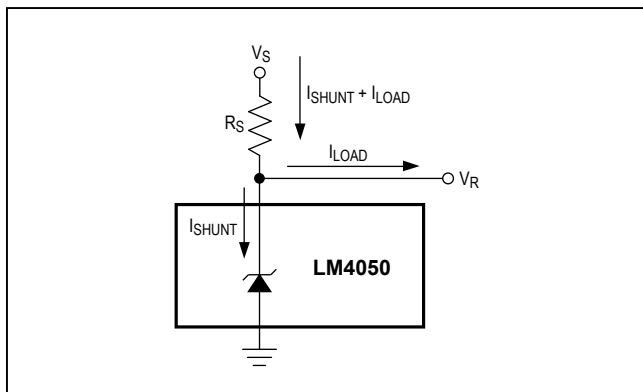
Laser-trimmed resistors ensure excellent initial accuracy. With a 50ppm/°C temperature coefficient, these devices are offered in three grades of initial accuracy ranging from 0.1% to 0.5%. The LM4050/LM4051 have a 60µA to 15mA shunt-current capability with low dynamic impedance, ensuring stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents. The LM4050/LM4051 do not require an external stabilizing capacitor while ensuring stability with any capacitive loads.

The LM4050/LM4051 specifications are guaranteed over the temperature range of -40°C to +125°C.

Applications

- Portable, Battery-Powered Equipment
- Notebook Computers
- Cell Phones
- Industrial Process Controls
- Automotive

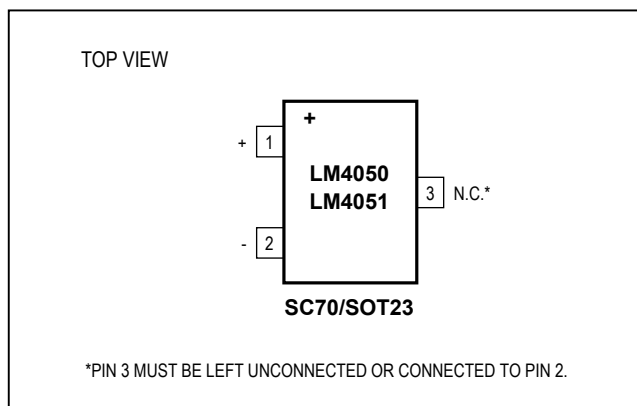
Pin Configuration



Features

- 50ppm/°C (max) Temperature Coefficient Guaranteed over the -40°C to +125°C Temperature Range
- Ultra-Small 3-Pin SC70 Package
- 0.1% (max) Initial Accuracy
- Wide Operating Current Range: 60µA to 15mA
- Low 28µV_{RMS} Output Noise (10Hz to 10kHz)
- 1.225V, 2.048V, 2.500V, 3.000V, 3.3V, 4.096V, and 5.000V Fixed Reverse Breakdown Voltages
- No Output Capacitors Required
- Tolerates Capacitive Loads
- AEC-Q100 Qualified, Refer to Ordering Information for the Specific /V Versions

Pin Configuration



Ordering Information appears at end of data sheet.

Absolute Maximum Ratings

| | | | | |
|---|---------|--|--------------------------|-----------------|
| Reverse Current (cathode to anode)..... | 20mA | Operating Temperature Range | LM4050/LM4051_E_ _ | -40°C to +125°C |
| Forward Current (anode to cathode)..... | 10mA | Storage Temperature Range | | -65°C to +150°C |
| Continuous Power Dissipation (T _A = +70°C) | | Junction Temperature | | +150°C |
| 3-Pin SC70 (derate 2.9mW/°C above +70°C)..... | 235.3mW | Lead Temperature (soldering, 10s)..... | | +300°C |
| 3-Pin SOT23 (derate 3mW/°C above +70°C) | 238.1mW | Soldering Temperature (reflow)..... | | +260°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

3 SOT23

| PACKAGE CODE | U3+1 |
|--|-------------------------|
| Outline Number | 21-0051 |
| Land Pattern Number | 90-0179 |
| Thermal Resistance, Four-Layer Board: | |
| Junction to Ambient (θ _{JA}) | 336°C/W |
| Junction to Case (θ _{JC}) | 110.10°C/W |

3 SC70

| PACKAGE CODE | X3+2 |
|--|-------------------------|
| Outline Number | 21-0075 |
| Land Pattern Number | 90-0208 |
| Thermal Resistance, Four-Layer Board: | |
| Junction to Ambient (θ _{JA}) | 340.40°C/W |
| Junction to Case (θ _{JC}) | 120°C/W |

For the latest package outline information and land patterns (footprints), go to 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.

Electrical Characteristics —1.225V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--|---------------------|--|----------------|--------|--------|-------------------|-------|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4051A (0.1%) | 1.2238 | 1.2250 | 1.2262 | V |
| | | | LM4051B (0.2%) | 1.2226 | 1.2250 | 1.2275 | |
| | | | LM4051C (0.5%) | 1.2189 | 1.2250 | 1.2311 | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4051A | | ±1.2 | ±7 | mV | |
| | | LM4051B | | ±2.4 | ±9 | | |
| | | LM4051C | | ±6.0 | ±12 | | |
| Minimum Operating Current | I _{RMIN} | | | 45 | 60 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±20 | | ppm/°C | |
| | | I _R = 1mA | | ±15 | ±50 | | |
| | | I _R = 100μA | | ±15 | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.7 | 1.5 | mV | |
| | | 1mA ≤ I _R ≤ 12mA | | 2.5 | 8.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | | 0.5 | 1.5 | Ω | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 20 | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | ppm | |

Electrical Characteristics —2.048V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--|---------------------|--|----------------|--------|--------|-------------------|-------|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4050A (0.1%) | 2.0460 | 2.0480 | 2.0500 | V |
| | | | LM4050B (0.2%) | 2.0439 | 2.0480 | 2.0521 | |
| | | | LM4050C (0.5%) | 2.0378 | 2.0480 | 2.0582 | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4050A | | ±2.0 | ±12 | mV | |
| | | LM4050B | | ±4.0 | ±14 | | |
| | | LM4050C | | ±10 | ±20 | | |
| Minimum Operating Current | I _{RMIN} | | | 45 | 65 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±20 | | ppm/°C | |
| | | I _R = 1mA | | ±15 | ±50 | | |
| | | I _R = 100μA | | ±15 | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.3 | 1.0 | mV | |
| | | 1mA ≤ I _R ≤ 15mA | | 2.5 | 8.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | LM4050A/B | | 0.3 | 0.8 | Ω |
| | | | LM4050C | | 0.3 | 0.9 | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 28 | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | ppm | |

Electrical Characteristics—2.500V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS | |
|--|---------------------|---|----------------|--------|--------|--------|-------------------|---|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4050A (0.1%) | 2.4975 | 2.5000 | 2.5025 | V | |
| | | | LM4050B (0.2%) | 2.4950 | 2.5000 | 2.5050 | | |
| | | | LM4050C (0.5%) | 2.4875 | 2.5000 | 2.5125 | | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4050A | | ±2.5 | | ±15 | mV | |
| | | LM4050B | | ±5.0 | | ±18 | | |
| | | LM4050C | | ±13 | | ±25 | | |
| Minimum Operating Current | I _{RMIN} | | | 45 | | 65 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±20 | | | ppm/°C | |
| | | I _R = 1mA | | ±15 | | ±50 | | |
| | | I _R = 100μA | | ±15 | | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.3 | | 1.0 | mV | |
| | | 1mA ≤ I _R ≤ 15mA | | 2.5 | | 8.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | LM4050A/B | | 0.3 | | 0.8 | Ω |
| | | | LM4050C | | 0.3 | | 0.9 | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 35 | | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | | ppm | |

Electrical Characteristics—3.000V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--|---------------------|---|----------------|--------|--------|-------------------|-------|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4050A (0.1%) | 2.9970 | 3.0000 | 3.0030 | V |
| | | | LM4050B (0.2%) | 2.9940 | 3.0000 | 3.0060 | |
| | | | LM4050C (0.5%) | 2.9850 | 3.0000 | 3.0150 | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4050A | | ±3.0 | ±18 | mV | |
| | | LM4050B | | ±6.0 | ±21 | | |
| | | LM4050C | | ±15 | ±30 | | |
| Minimum Operating Current | I _{RMIN} | | | 45 | 67 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±20 | | ppm/°C | |
| | | I _R = 1mA | | ±15 | ±50 | | |
| | | I _R = 100μA | | ±15 | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.3 | 1.0 | mV | |
| | | 1mA ≤ I _R ≤ 15mA | | 2.5 | 8.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | LM4050A/B | | 0.3 | 0.8 | Ω |
| | | | LM4050C | | 0.3 | 0.9 | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 45 | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | ppm | |

Electrical Characteristics—3.300V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--|---------------------|---|----------------|--------|--------|-------------------|-------|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4050A (0.1%) | 3.2967 | 3.3000 | 3.3033 | V |
| | | | LM4050B (0.2%) | 3.2934 | 3.3000 | 3.3066 | |
| | | | LM4050C (0.5%) | 3.2835 | 3.3000 | 3.3165 | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4050A | | ±3.0 | ±18 | mV | |
| | | LM4050B | | ±6.0 | ±21 | | |
| | | LM4050C | | ±15 | ±30 | | |
| Minimum Operating Current | I _{RMIN} | | | 45 | 67 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±20 | | ppm/°C | |
| | | I _R = 1mA | | ±15 | ±50 | | |
| | | I _R = 100μA | | ±15 | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.3 | 1.0 | mV | |
| | | 1mA ≤ I _R ≤ 15mA | | 2.5 | 8.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | LM4050A/B | | 0.3 | 0.8 | Ω |
| | | | LM4050C | | 0.3 | 0.9 | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 50 | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | ppm | |

Electrical Characteristics—4.096V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS | |
|--|---------------------|--|----------------|--------|--------|-------------------|---|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4050A (0.1%) | 4.0919 | 4.0960 | 4.1001 | V |
| | | | LM4050B (0.2%) | 4.0878 | 4.0960 | 4.1042 | |
| | | | LM4050C (0.5%) | 4.0755 | 4.0960 | 4.1165 | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4050A | | ±4.1 | ±25 | mV | |
| | | LM4050B | | ±8.2 | ±29 | | |
| | | LM4050C | | ±20 | ±41 | | |
| Minimum Operating Current | I _{RMIN} | | | 50 | 73 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±30 | | ppm/°C | |
| | | I _R = 1mA | | ±20 | ±50 | | |
| | | I _R = 100μA | | ±15 | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.5 | 1.2 | mV | |
| | | 1mA ≤ I _R ≤ 15mA | | 3.0 | 10.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | | 0.5 | 1.0 | Ω | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 64 | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | ppm | |

Electrical Characteristics—5.000V(I_R = 100μA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS | |
|--|---------------------|--|----------------|--------|--------|-------------------|---|
| Reverse Breakdown Voltage | V _R | T _A = +25°C | LM4050A (0.1%) | 4.9950 | 5.0000 | 5.0050 | V |
| | | | LM4050B (0.2%) | 4.9900 | 5.0000 | 5.0100 | |
| | | | LM4050C (0.5%) | 4.9750 | 5.0000 | 5.0250 | |
| Reverse Breakdown Voltage Tolerance (Note 3) | V _{RTOL} | LM4050A | | ±5.0 | ±30 | mV | |
| | | LM4050B | | ±10 | ±35 | | |
| | | LM4050C | | ±25 | ±50 | | |
| Minimum Operating Current | I _{RMIN} | | | 54 | 80 | μA | |
| Average Reverse Voltage Temperature Coefficient (Notes 3, 4) | ΔV _R /ΔT | I _R = 10mA | | ±30 | | ppm/°C | |
| | | I _R = 1mA | | ±20 | ±50 | | |
| | | I _R = 100μA | | ±15 | | | |
| Reverse Breakdown Voltage Change with Operating Current Change | | I _{RMIN} ≤ I _R ≤ 1mA | | 0.5 | 1.4 | mV | |
| | | 1mA ≤ I _R ≤ 15mA | | 3.5 | 12.0 | | |
| Reverse Dynamic Impedance (Note 4) | Z _R | I _R = 1mA, f = 120Hz, I _{AC} = 0.1I _R | | 0.5 | 1.1 | Ω | |
| Wideband Noise | e _N | I _R = 100μA, 10Hz ≤ f ≤ 10kHz | | 80 | | μV _{RMS} | |
| Reverse Breakdown Voltage Long-Term Stability | ΔV _R | T = 1000h | | 120 | | ppm | |

Note 2: All devices are 100% production tested at +25°C and are guaranteed by design for T_A = T_{MIN} to T_{MAX}, as specified.**Note 3:** The limit over the full temperature range for the reverse breakdown voltage tolerance is defined as:

$$[V_{RTOL}] \pm [(\Delta V_R / \Delta T) \times (\max \Delta T) \times (V_R)]$$

where ΔV_R / ΔT is the V_R temperature coefficient, maxΔT is the difference from the +25°C reference point to T_{MIN} or T_{MAX}, and V_R is the reverse breakdown voltage.

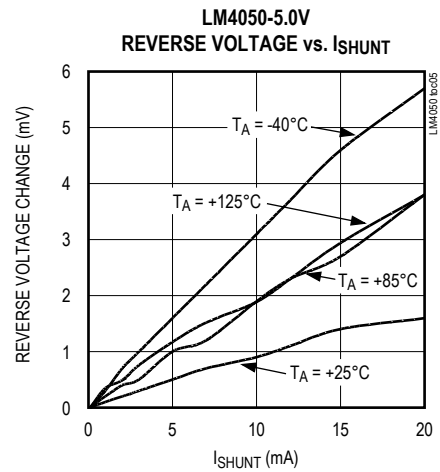
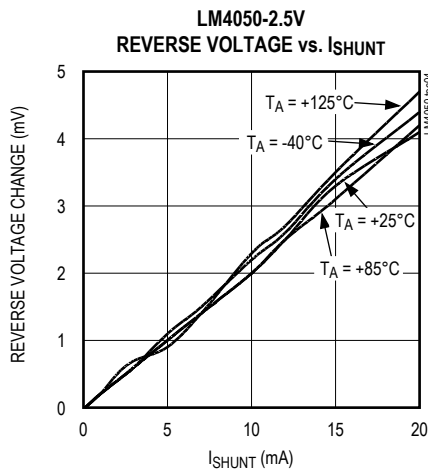
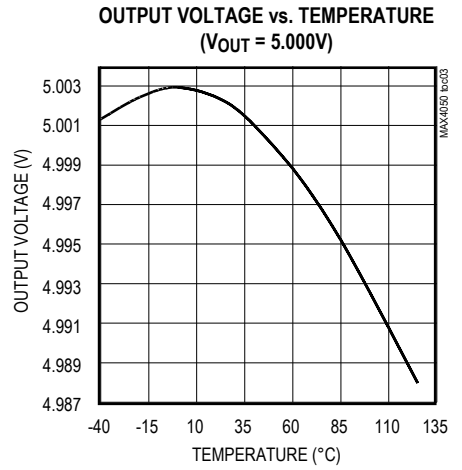
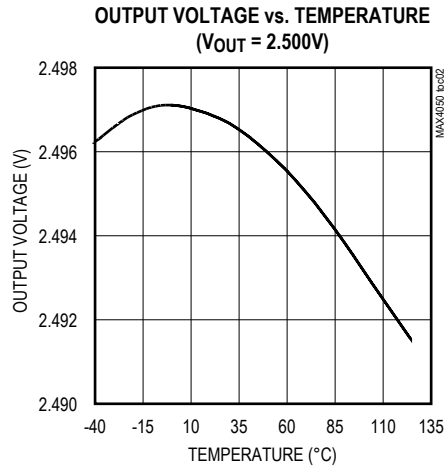
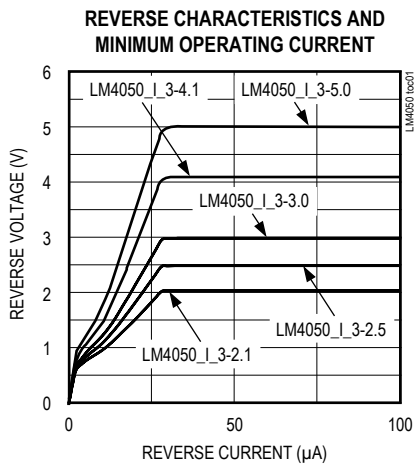
The total tolerance over the full temperature range for the different grades where maxΔT = +100°C is shown below:

- A grade: ±0.6% = ±0.1% ±50ppm/°C x 100°C
- B grade: ±0.7% = ±0.2% ±50ppm/°C x 100°C
- C grade: ±1.0% = ±0.5% ±50ppm/°C x 100°C

Note 4: Guaranteed by design.

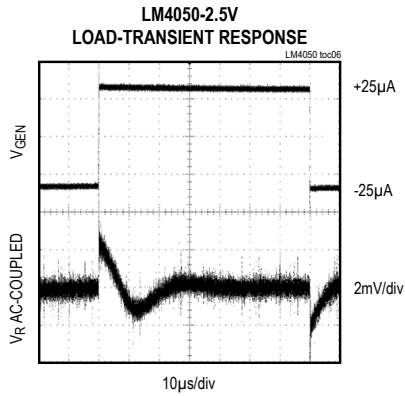
Typical Operating Characteristics

($I_R = 100\mu A$, SC70-3 package, $T_A = +25^\circ C$, unless otherwise noted.)

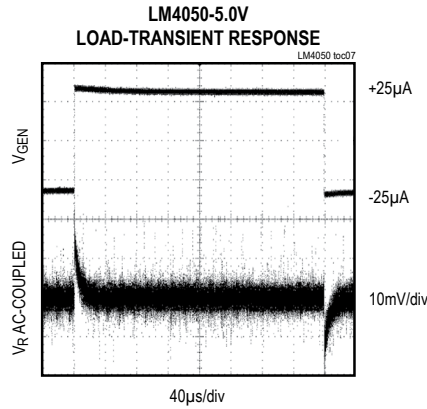


Typical Operating Characteristics (continued)

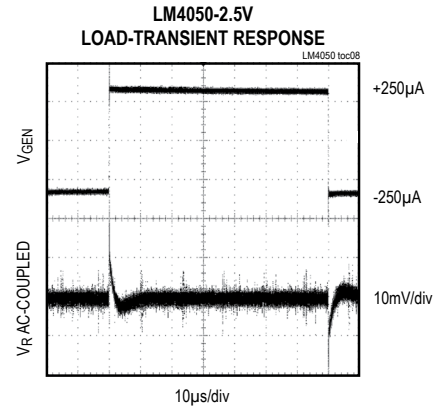
($I_R = 100\mu A$, SC70-3 package, $T_A = +25^\circ C$, unless otherwise noted.)



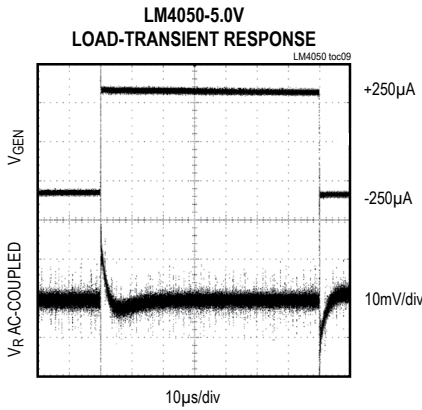
LM4050-2.5V
LOAD-TRANSIENT RESPONSE
LM4050 tcc06
CH1: V_{GEN} 2V/div
CH2: V_R AC-COUPLED 2mV/div
 $I_{SHUNT} = 100\mu A$, $25\mu A$, $R_L = 100k\Omega$, SEE FIGURE 1.



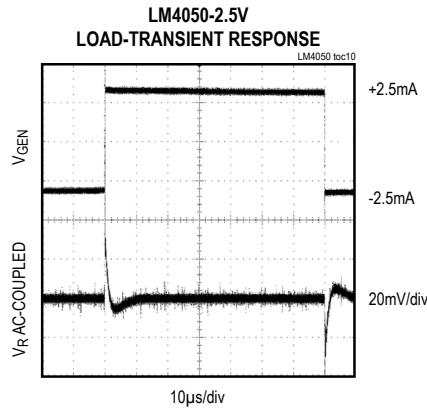
LM4050-5.0V
LOAD-TRANSIENT RESPONSE
LM4050 tcc07
 $I_{SHUNT} = 100\mu A \pm 25\mu A$
 $R_L = 100k\Omega$, SEE FIGURE 1.



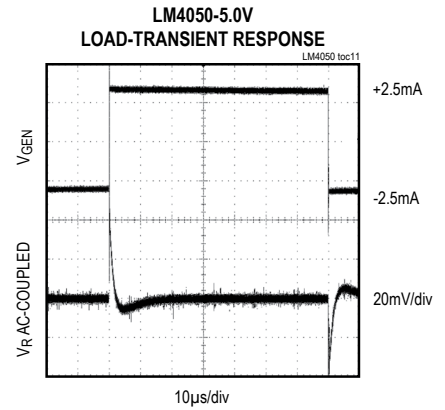
LM4050-2.5V
LOAD-TRANSIENT RESPONSE
LM4050 tcc08
 $I_{SHUNT} = 1mA \pm 250\mu A$
 $R_L = 10k\Omega$, SEE FIGURE 1.



LM4050-5.0V
LOAD-TRANSIENT RESPONSE
LM4050 tcc09
 $I_{SHUNT} = 1mA \pm 250\mu A$
 $R_L = 10k\Omega$, SEE FIGURE 1.



LM4050-2.5V
LOAD-TRANSIENT RESPONSE
LM4050 tcc10
 $I_{SHUNT} = 10mA \pm 2.5\mu A$
 $R_L = 1k\Omega$, SEE FIGURE 1.



LM4050-5.0V
LOAD-TRANSIENT RESPONSE
LM4050 tcc11
 $I_{SHUNT} = 10mA \pm 2.5mA$
 $R_L = 1k\Omega$, SEE FIGURE 1.

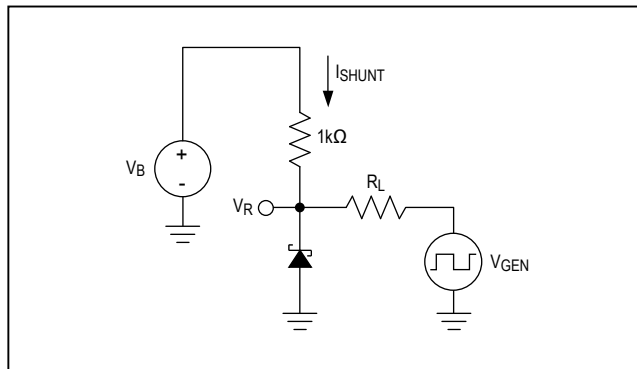


Figure 1. Load-Transient Test Circuit

Typical Operating Characteristics (continued)

($I_R = 100\mu A$, SC70-3 package, $T_A = +25^\circ C$, unless otherwise noted.)

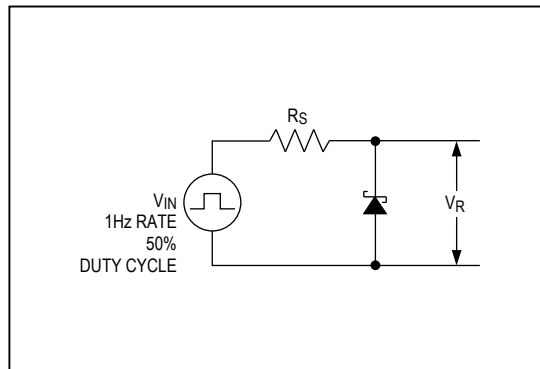
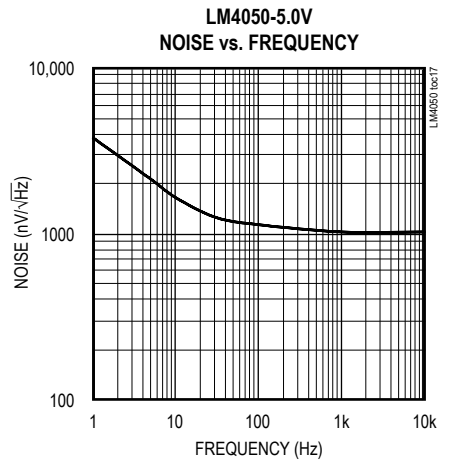
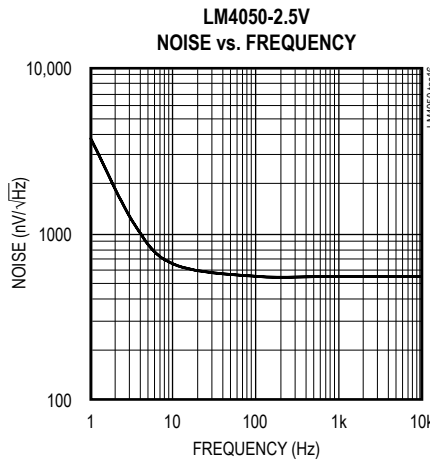
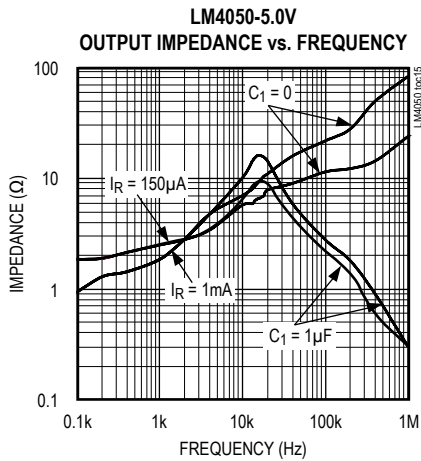
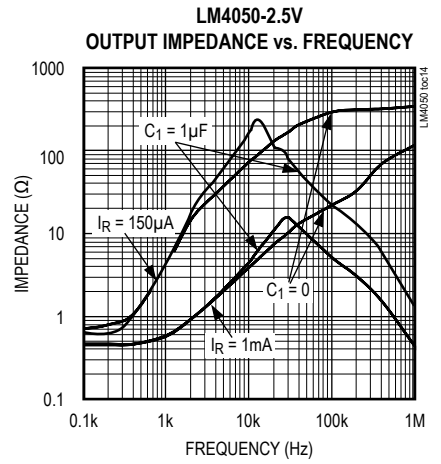
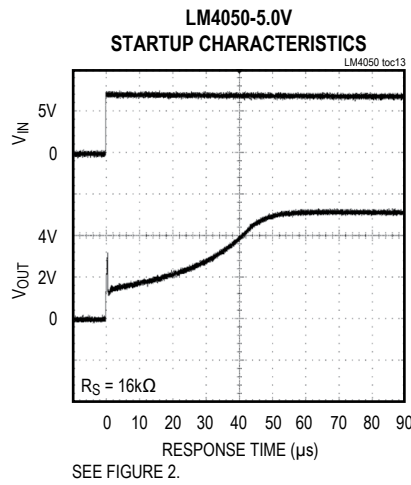
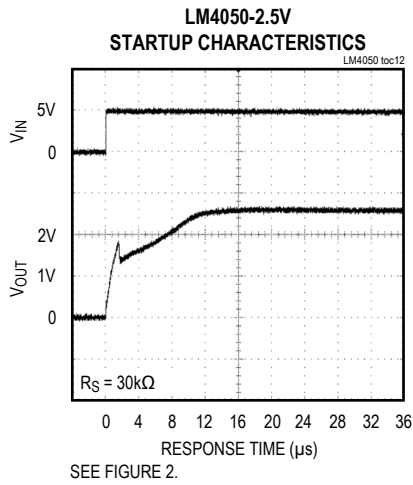


Figure 2. Startup Characteristics Test Circuit

Pin Description

| PIN | NAME | FUNCTION |
|-----|------|--|
| 1 | + | Positive Terminal of the Shunt Reference |
| 2 | - | Negative Terminal of the Shunt Reference |
| 3 | N.C. | No connection. Leave this pin unconnected or connected to pin 2. |

Detailed Description

The LM4050/LM4051 shunt references use the bandgap principle to produce a stable, accurate voltage. The device behaves similarly to an ideal zener diode; a fixed voltage is maintained across its output terminals when biased with 60µA to 15mA of reverse current. The LM4050/LM4051 clamps to a voltage of one diode drop below ground when biased with forward currents up to 10mA.

Figure 3 shows a typical operating circuit. The LM4050/LM4051 are ideal for providing stable references from a high-voltage power supply.

Applications Information

The LM4050/LM4051s' internal pass transistors are used to maintain a constant output voltage (V_{SHUNT}) by sinking the necessary amount of current across a source resistor. The source resistance (R_S) is determined from the load current (I_{LOAD}) range, supply voltage (V_S) variations, V_{SHUNT} , and desired quiescent current.

Choose the value of R_S when V_S is at a minimum and I_{LOAD} is at a maximum. Maintain a minimum I_{SHUNT} of 60µA at all times. The R_S value should be large enough to keep I_{SHUNT} less than 15mA for proper regulation when V_S is maximum and I_{LOAD} is at a minimum. To prevent damage to the device, I_{SHUNT} should never exceed 20mA.

Therefore, the value of R_S is bounded by the following equation:

$$\frac{[V_{S(MIN)} - V_R]}{[60\mu A + I_{LOAD(MAX)}]} > R_S > \frac{[V_{S(MAX)} - V_R]}{[20mA + I_{LOAD(MIN)}]}$$

Choosing a larger resistance minimizes the total power dissipation in the circuit by reducing the shunt current ($P_{D(TOTAL)} = V_S \times I_{SHUNT}$). Provide a safety margin to incorporate the worst-case tolerance of the resistor used. Ensure that the resistor's power rating is adequate, using the following general power equation:

$$P_{DR} = I_{SHUNT} \times (V_{S(MAX)} - V_{SHUNT})$$

Output Capacitance

The LM4050/LM4051 do not require external capacitors for frequency stability and are stable for any output capacitance.

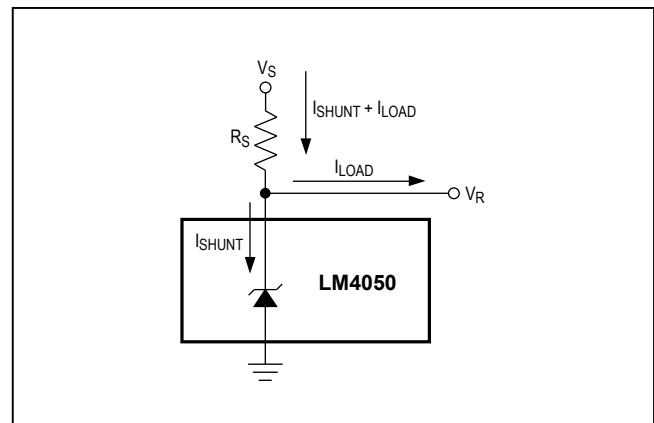


Figure 3. Typical Operating Circuit

Temperature Performance

The LM4050/LM4051 typically exhibit output voltage temperature coefficients within ± 15 ppm/°C. The polarity of the temperature coefficients may be different from one device to another; some may have positive coefficients, and others may have negative coefficients.

High Temperature Operation

The maximum junction temperature of the LM4050/LM4051 is +150°C. The maximum operating temperature for the LM4050/LM4051_E_ is +125°C. At a maximum load current of 15mA and a maximum output voltage of 5V, the parts dissipate 75mW of power. The power dissipation limits of the 3-pin SC70 call for a derating value of 2.17mW/°C above +70°C and thus for 75mW of power dissipation, the parts self-heat to 35.56°C above ambient temperature. If the ambient temperature is +125°C, the parts operate at 159.56°C, thereby exceeding the maximum junction temperature value of +150°C. For high-temperature operation, care must be taken to ensure the combination of ambient temperature, output power dissipation, and package thermal resistance does not conspire to raise the device temperature beyond that listed in the *Absolute Maximum Ratings*. Either reduce the output load current or the ambient temperature to keep the part within the limits.

Ordering Information

| PART | OUTPUT VOLTAGE (V) | INITIAL ACCURACY (%) | TEMPCO (ppm/°C) | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---------------------|--------------------|----------------------|-----------------|-----------------|-------------|----------|
| LM4050AEM3-2.1+T | 2.048 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | FZTR |
| LM4050AEM3-2.1/V+T | 2.048 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | +FZXW |
| LM4050AEX3-2.1+T | 2.048 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | ASM |
| LM4050BEM3-2.1+T | 2.048 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZTS |
| LM4050BEX3-2.1+T | 2.048 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | ASN |
| LM4050CEM3-2.1+T | 2.048 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | FZTT |
| LM4050CEX3-2.1+T | 2.048 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | ASO |
| LM4050AEM3-2.5+T | 2.500 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | FZTU |
| LM4050AEM3-2.5/V+T* | 2.500 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | --- |
| LM4050AEX3-2.5+T | 2.500 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | ASP |
| LM4050AEX3-2.5/V+T | 2.500 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | +AUE |
| LM4050BEM3-2.5+T | 2.500 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZTV |
| LM4050BEM3-2.5/V+T | 2.500 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZXS |
| LM4050BEX3-2.5+T | 2.500 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | ASQ |
| LM4050BEX3-2.5/V+T | 2.500 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | +AVN |
| LM4050CEM3-2.5+T | 2.500 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | FZTW |
| LM4050CEX3-2.5+T | 2.500 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | ASR |
| LM4050AEM3-3.0+T | 3.000 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | FZTX |
| LM4050AEX3-3.0+T | 3.000 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | ASS |
| LM4050BEM3-3.0+T | 3.000 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZTY |
| LM4050BEM3-3.0/V+T | 3.000 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | +FZVG |
| LM4050BEX3-3.0+T | 3.000 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | AST |
| LM4050CEM3-3.0+T | 3.000 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | FZTZ |
| LM4050CEX3-3.0+T | 3.000 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | ASU |
| LM4050AEX3-3.3+T | 3.300 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | AOJ |
| LM4050AEX3-3.3/V+T | 3.300 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | +AUE |
| LM4050BEX3-3.3+T | 3.300 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | AOK |
| LM4050CEX3-3.3+T | 3.300 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | AOL |
| LM4050CEX3-3.3/V+T | 3.300 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | +AUE |
| LM4050AEM3-4.1+T | 4.096 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | FZUA |
| LM4050AEM3-4.1/V+T | 4.096 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | +FZXU |
| LM4050AEX3-4.1+T | 4.096 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | ASV |
| LM4050BEM3-4.1+T | 4.096 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZUB |
| LM4050BEM3-4.1/V+T | 4.096 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | +FZVL |
| LM4050BEX3-4.1+T | 4.096 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | ASW |
| LM4050CEM3-4.1+T | 4.096 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | FZUC |

*Future product—contact factory for availability.

Ordering Information (continued)

| PART | OUTPUT VOLTAGE (V) | INITIAL ACCURACY (%) | TEMPCO (ppm/_C) | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|--------------------------|--------------------|----------------------|-----------------|-----------------|-------------|----------|
| LM4050CEX3-4.1+T | 4.096 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | ASX |
| LM4050AEM3-5.0+T | 5.000 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | FZUD |
| LM4050AEM3-5.0/V+T | 5.000 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | +FZXL |
| LM4050AEX3-5.0+T | 5.000 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | ASY |
| LM4050BEM3-5.0+T | 5.000 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZUE |
| LM4050BEX3-5.0+T | 5.000 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | ASZ |
| LM4050CEM3-5.0+T | 5.000 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | FZUF |
| LM4050CEM3-5.0/V+T | 5.000 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | +FZVM |
| LM4050CEX3-5.0+T | 5.000 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | ATA |
| LM4051 AEM3-1.2+T | 1.225 | 0.1 | 50 | -40°C to +125°C | 3 SOT23 | FZTO |
| LM4051AEX3-1.2+T | 1.225 | 0.1 | 50 | -40°C to +125°C | 3 SC70 | ASJ |
| LM4051BEM3-1.2+T | 1.225 | 0.2 | 50 | -40°C to +125°C | 3 SOT23 | FZTP |
| LM4051BEX3-1.2+T | 1.225 | 0.2 | 50 | -40°C to +125°C | 3 SC70 | ASK |
| LM4051CEM3-1.2+T | 1.225 | 0.5 | 50 | -40°C to +125°C | 3 SOT23 | FZTQ |
| LM4051CEX3-1.2+T | 1.225 | 0.5 | 50 | -40°C to +125°C | 3 SC70 | ASL |

Chip Information

PROCESS: BiCMOS

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 0 | 7/02 | Initial release | — |
| 4 | 5/09 | Added lead-free notation and corrected topmarks in the <i>Ordering Information</i> and <i>Selector Guide</i> sections | 1, 12 |
| 5 | 5/11 | Added automotive packages and updated the <i>Absolute Maximum Ratings</i> . | 1, 2 |
| 6 | 9/11 | Added automotive packages to <i>Selector Guide</i> and <i>Ordering Information</i> . | 1, 12 |
| 7 | 1/13 | Removed <i>Selector Guide</i> and revised <i>Ordering Information</i> . | 1, 12 |
| 8 | 11/14 | Added LM4050AEM3-5.0/V+T to <i>Ordering Information</i> . | 13 |
| 9 | 11/17 | Added AEC qualification statement to Benefits and Features and updated <i>Ordering Information</i> table | 1, 13 |
| 10 | 2/18 | Added <i>Package Thermal Characteristics</i> section, updated <i>Absolute Maximum Ratings</i> section, and <i>Electrical Characteristics</i> table | 2–5 |
| 11 | 4/18 | Updated <i>Ordering Information</i> table | 12 |
| 12 | 2/19 | Updated <i>Applications</i> and added <i>Package Information</i> | 1, 2 |
| 13 | 3/19 | Updated <i>Ordering Information</i> | 12 |
| 14 | 5/19 | Deleted <i>Package Thermal Characteristics</i> and old <i>Package Information</i> sections, updated <i>Ordering Information</i> | 2, 12, 13 |
| 15 | 7/20 | Updated <i>Package Information</i> and <i>Ordering Information</i> | 2, 12 |

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