# 2.5-V INTEGRATED REFERENCE CIRCUIT

**Check for Samples: LT1009M**

## FEATURES

- **Excellent Temperature Stability**
- **Initial Tolerance: 0.2% Typical**
- **Dynamic Impedance: 0.6 Ω Typical**
- **Wide Operating Current Range**
- **Directly Interchangeable With LM136**
- **Needs No Adjustment for Minimum Temperature Coefficient**
- **Available in Military (–55°C/125°C) Temperature Range** (1)

(1) Custom temperature ranges available

## DESCRIPTION/ORDERING INFORMATION

The LT1009 reference circuit is a precision-trimmed 2.5-V shunt regulator featuring low dynamic impedance and a wide operating current range. The reference tolerance is achieved by on-chip trimming, which minimizes the initial voltage tolerance and the temperature coefficient, $\alpha_{VZ}$.

Although the LT1009 needs no adjustments, a third terminal (ADJ) allows the reference voltage to be adjusted ±5% to eliminate system errors. In many applications, the LT1009 can be used as a terminal-for-terminal replacement for the LM136-2.5, which eliminates the external trim network.

The LT1009 uses include 5-V system references, 8-bit analog-to-digital converter (ADC) and digital-to-analog converter (DAC) references, and power-supply monitors. The device also can be used in applications such as digital voltmeters and current-loop measurement and control systems.

The LT1009 is characterized for operation from –55°C to 125°C.

**Figure 1. SYMBOL**


### ORDERING INFORMATION(1)

| $T_A$ | PACKAGE(BARE DIE)(2) | ORDERABLE PART NUMBER |
|---|---|---|
| –55°C to 125°C | CHIPTRAY | LT1009MKGD1 |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

### BARE DIE INFORMATION

| DIE THICKNESS | BACKSIDE FINISH | BOND PAD METALIZATION COMPOSITION |
|---|---|---|
| 15 Mils | Silicon with backgrind | AlCu/TiW |

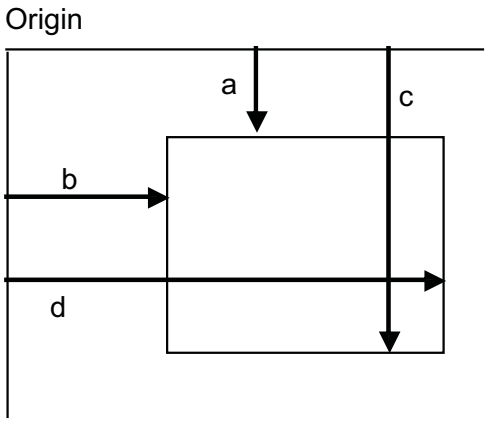



**Table 1. Bond Pad Coordinates in Microns - Rev A**

| DISCRIPTION | PAD NUMBER | a | b | c | d |
|---|---|---|---|---|---|
| ANODE | 1 | 127.000 | 127.000 | 243.840 | 243.840 |
| ANODE | 2 | 335.280 | 127.000 | 439.420 | 231.140 |
| ADJ | 3 | 716.280 | 130.810 | 833.120 | 243.840 |
| Do not connect | 4 | 1073.150 | 133.350 | 1169.670 | 229.870 |
| Do not connect | 5 | 1217.930 | 133.350 | 1314.450 | 229.870 |
| Do not connect | 6 | 1075.690 | 316.230 | 1172.210 | 412.750 |
| Do not connect | 7 | 1197.610 | 420.370 | 1294.130 | 516.890 |
| Do not connect | 8 | 1073.150 | 567.690 | 1169.670 | 664.210 |
| Do not connect | 9 | 1200.150 | 890.270 | 1296.670 | 986.790 |
| Do not connect | 10 | 1116.330 | 1032.510 | 1212.850 | 1129.030 |
| CATHODE | 11 | 902.970 | 929.640 | 1004.570 | 1066.800 |
| CATHODE | 12 | 703.580 | 1115.060 | 820.420 | 1229.360 |

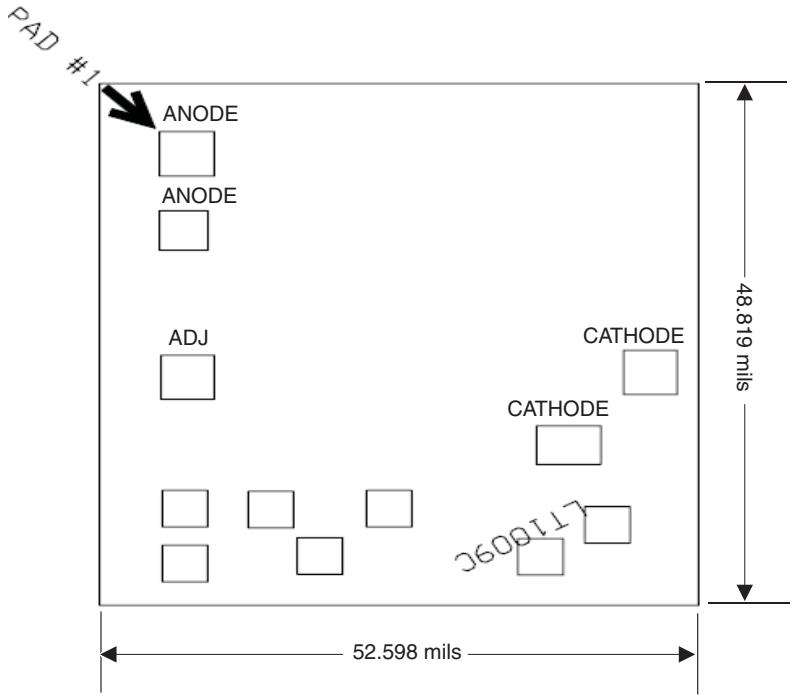
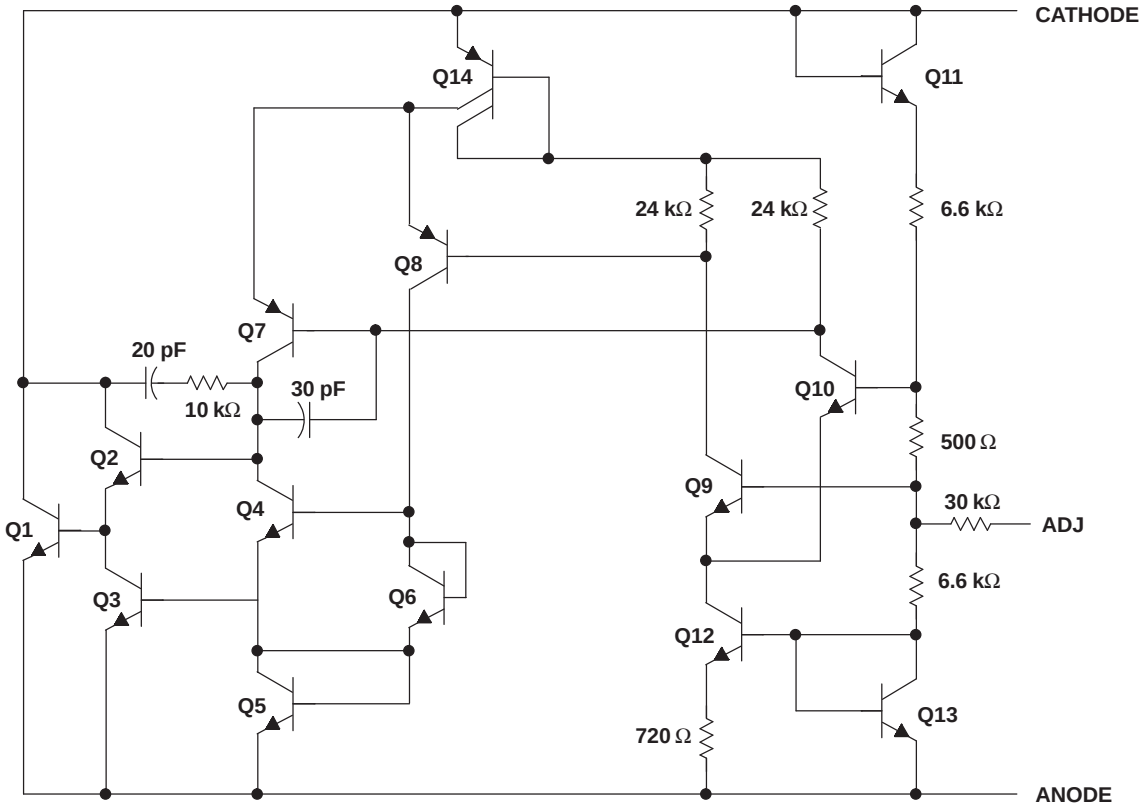


**Figure 2. SCHEMATIC**




NOTE: All component values shown are nominal.

## ABSOLUTE MAXIMUM RATINGS(1)

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $I_R$ | Reverse current | | 20 | mA |
| $I_F$ | Forward current | | 10 | mA |
| $T_J$ | Operating virtual junction temperature(2) | | 150 | °C |
| $T_{stg}$ | Storage temperature range | –65 | 150 | °C |

(1) 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Maximum power dissipation is a function of $T_J(max)$, $\theta_{JA}$, and $T_A$. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum $T_J$ of 150°C can affect reliability.

## RECOMMENDED OPERATING CONDITIONS

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $T_A$ | Operating free-air temperature range | –55 | 125 | °C |

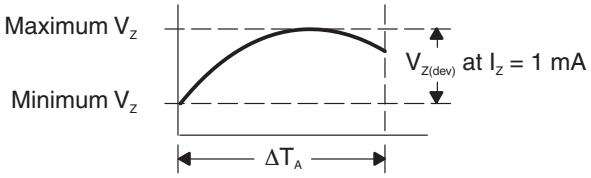
## ELECTRICAL CHARACTERISTICS

at specified free-air temperature

| PARAMETER | | TEST CONDITIONS | $T_A$ | LT1009M | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $V_Z$ | Reference voltage | $I_Z$ = 1 mA | 25°C | 2.49 | 2.5 | 2.51 | V |
| | | | Full range | 2.46 | | 2.535 | |
| $V_F$ | Forward voltage | $I_F$ = 2 mA | 25°C | 0.4 | | 1 | V |
| | Adjustment range | $I_Z$ = 1 mA, $V_{ADJ}$ = GND to $V_Z$ | 25°C | 125 | | | mV |
| | | $I_Z$ = 1 mA, $V_{ADJ}$ = 0.6 V to $V_Z$ – 0.6 V | | 45 | | | |
| $\Delta V_{Z(temp)}$ | Change in reference voltage with temperature | | Full range | | | 15 | mV |
| $\alpha V_Z$ | Average temperature coefficient of reference voltage(1) | $I_Z$ = 1 mA, $V_{ADJ}$ = open | Full range | | 20 | 35 | ppm/ °C |
| $\Delta V_Z$ | Change in reference voltage with current | $I_Z$ = 400 µA to 10 mA | 25°C | | 6 | 10 | mV |
| | | | Full range | | | 12 | |
| $\Delta V_Z/\Delta t$ | Long-term change in reference voltage | $I_Z$ = 1 mA | 25°C | | 20 | | ppm/ khr |
| $Z_Z$ | Reference impedance | $I_Z$ = 1 mA | 25°C | | 0.6 | 1.6 | Ω |
| | | | Full range | | | 1.8 | |

(1) The deviation parameter $V_{Z(dev)}$ is defined as the difference between the maximum and minimum values obtained over the recommended operating temperature range, measured at $I_Z$ = 1 mA. The average full-range temperature coefficient of the reference voltage ($\alpha V_Z$) is defined as:

$$|\alpha V_z| \left(\frac{ppm}{°C}\right) = \frac{\left(\frac{V_{Z(dev)}}{V_Z \text{ at } 25°C}\right) \times 10^6}{\Delta T_A}$$




$\alpha V_Z$ can be positive or negative, depending upon whether the minimum $V_Z$ or maximum $V_Z$, respectively, occurs at the lower temperature.

## TYPICAL CHARACTERISTICS

Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

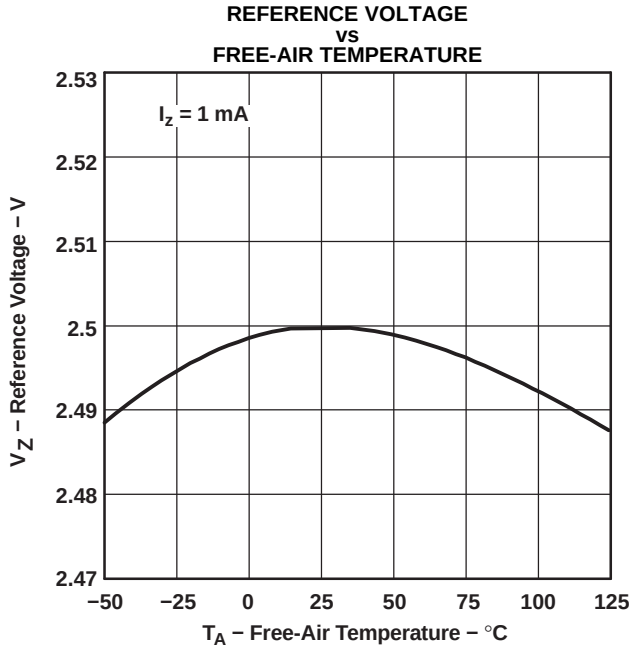



Figure 3.

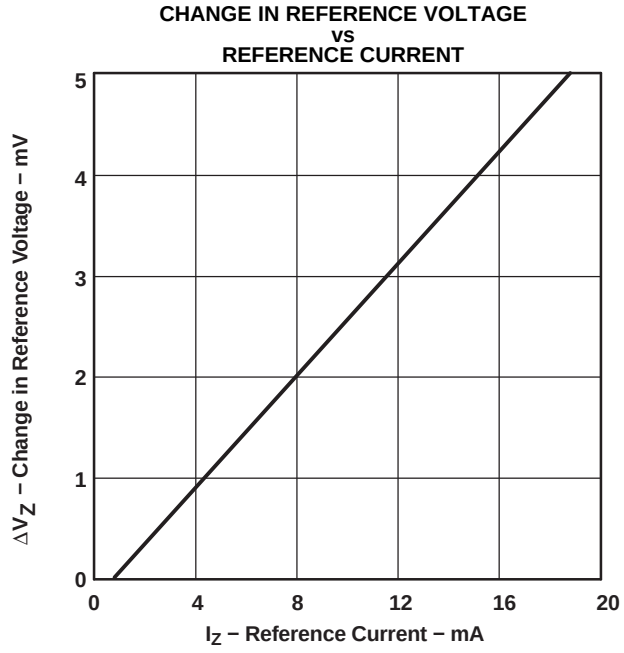



Figure 4.

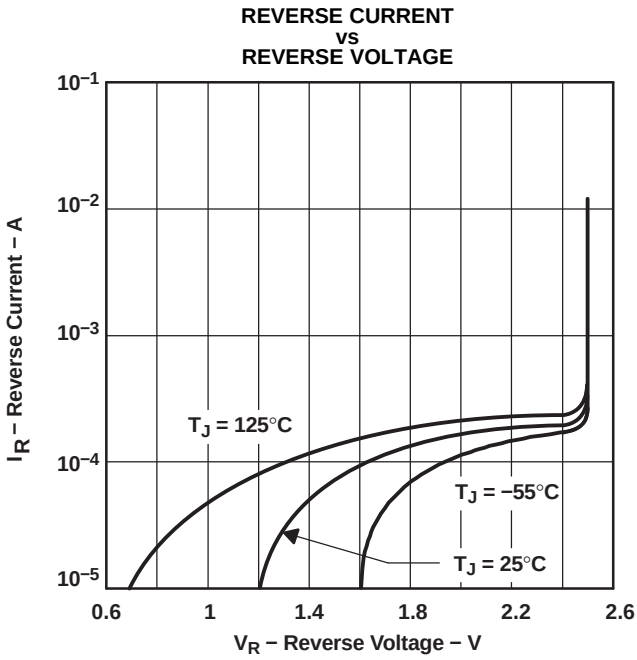



Figure 5.

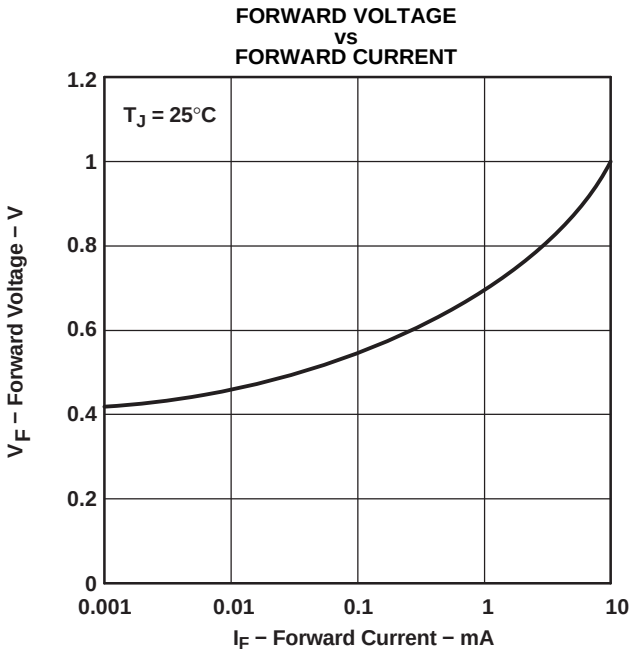



Figure 6.

## TYPICAL CHARACTERISTICS (continued)

REFERENCE IMPEDANCE
vs
FREQUENCY

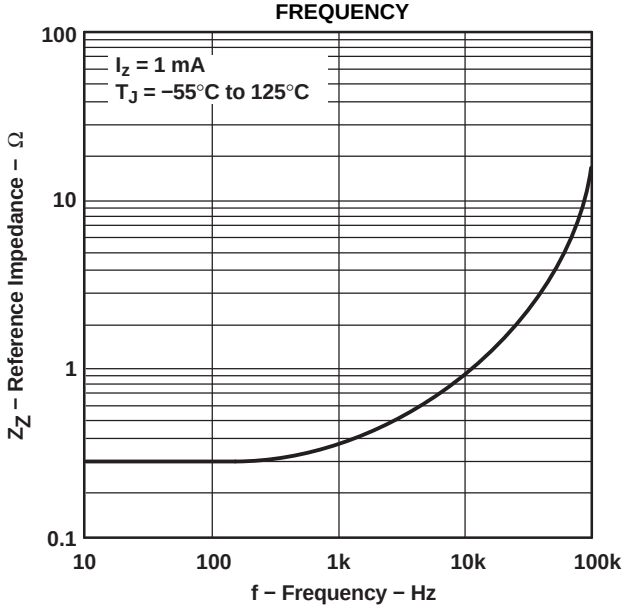



Figure 7.

NOISE VOLTAGE
vs
FREQUENCY

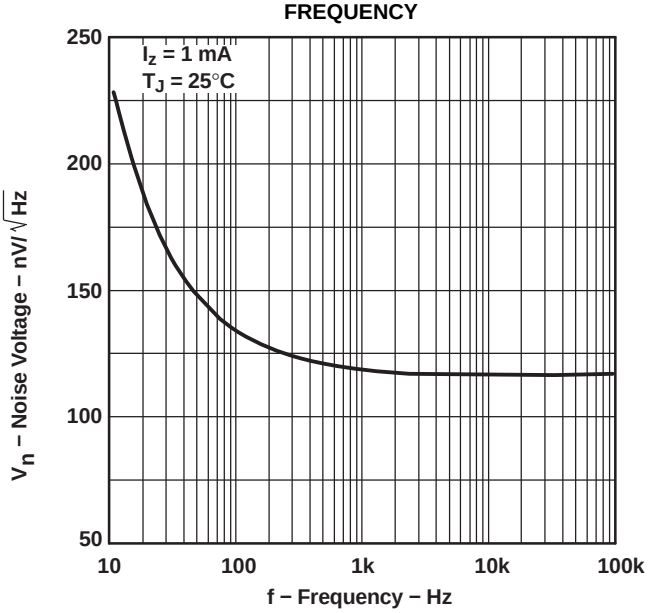



Figure 8.

TRANSIENT RESPONSE

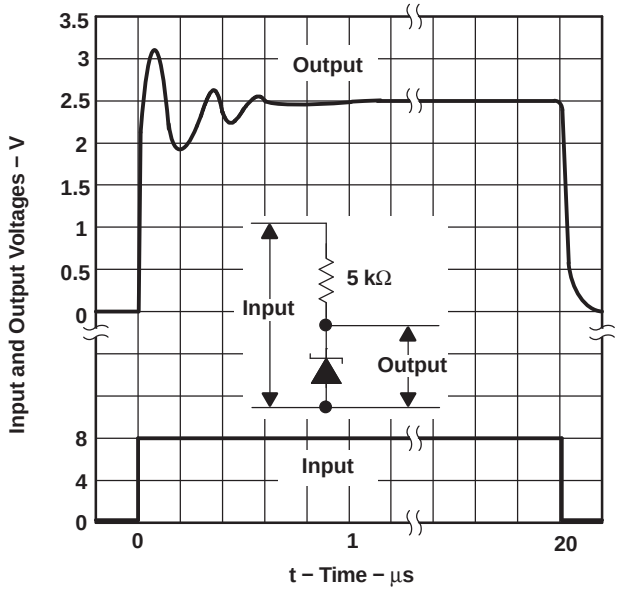
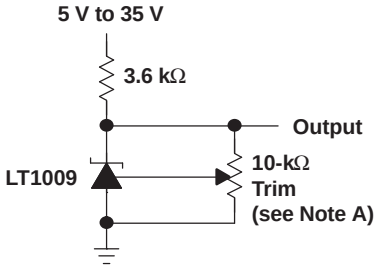



Figure 9.

## APPLICATION INFORMATION




A. This does not affect temperature coefficient. It provides ±5% trim range.

**Figure 10. 2.5-V Reference**

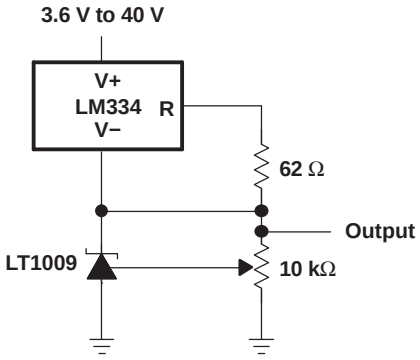



**Figure 11. Adjustable Reference With Wide Supply Range**

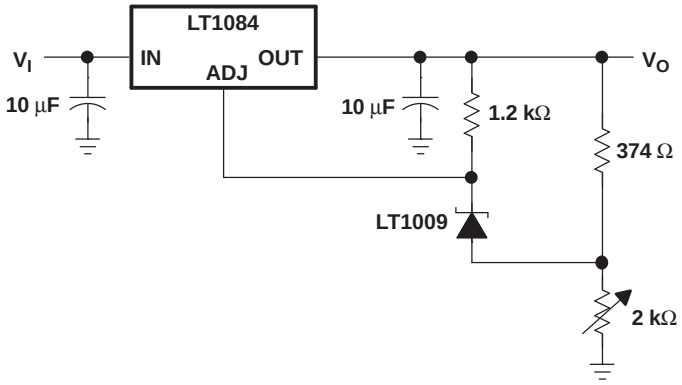



**Figure 12. Power Regulator With Low Temperature Coefficient**

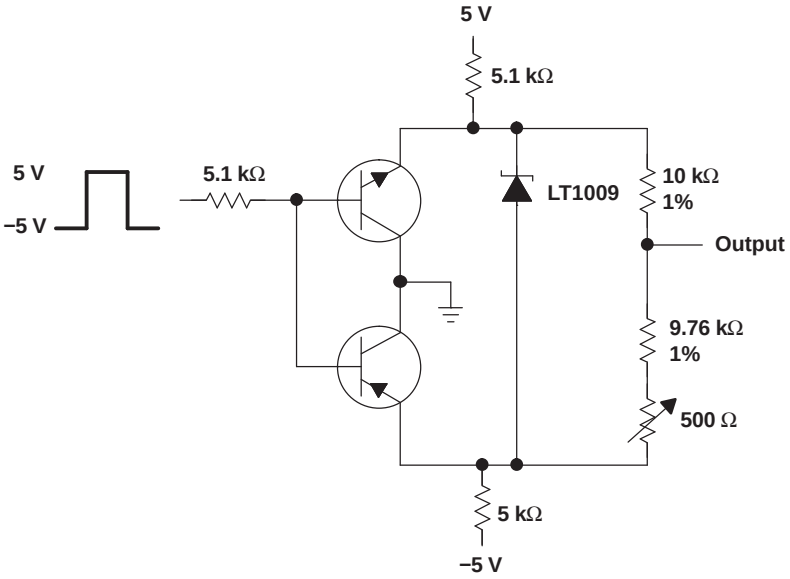



**Figure 13. Switchable ±1.25-V Bipolar Reference**

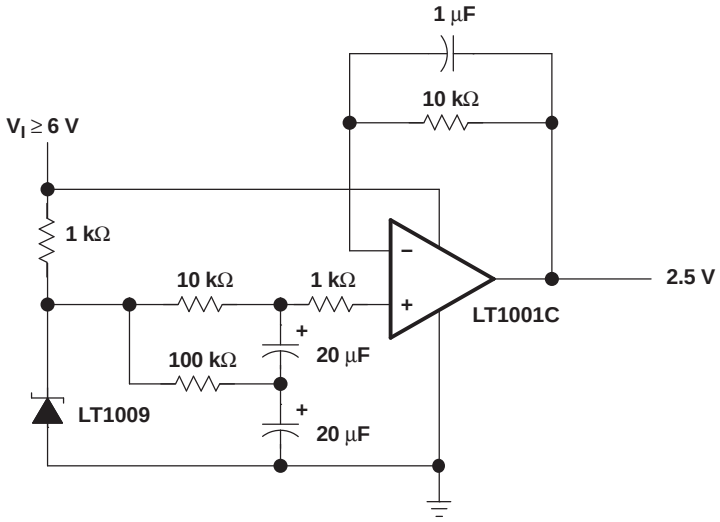



**Figure 14. Low-Noise 2.5-V Buffered Reference**

## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LT1009MKGD1 | Active | Production | XCEPT (KGD) \| 0 | 100 \| NOT REQUIRED | Yes | Call TI | N/A for Pkg Type | -55 to 125 | |
| LT1009MKGD1.A | Active | Production | XCEPT (KGD) \| 0 | 100 \| NOT REQUIRED | Yes | Call TI | N/A for Pkg Type | -55 to 125 | |

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.



**OTHER QUALIFIED VERSIONS OF LT1009M :**

- Catalog : LT1009

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

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