

## 2.5-V INTEGRATED REFERENCE CIRCUIT

Check for Samples: [LT1009M](#)

### FEATURES

- Excellent Temperature Stability
  - Initial Tolerance: 0.2% Typical
  - Dynamic Impedance: 0.6  $\Omega$  Typical
  - Wide Operating Current Range
  - Directly Interchangeable With LM136
  - Needs No Adjustment for Minimum Temperature Coefficient
  - Available in Military ( $-55^{\circ}\text{C}/125^{\circ}\text{C}$ ) Temperature Range <sup>(1)</sup>
- (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  $\pm 5\%$  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  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

**Figure 1. SYMBOL**



### ORDERING INFORMATION<sup>(1)</sup>

$T_A$	PACKAGE(BARE DIE) <sup>(2)</sup>	ORDERABLE PART NUMBER
$-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$	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](http://www.ti.com).

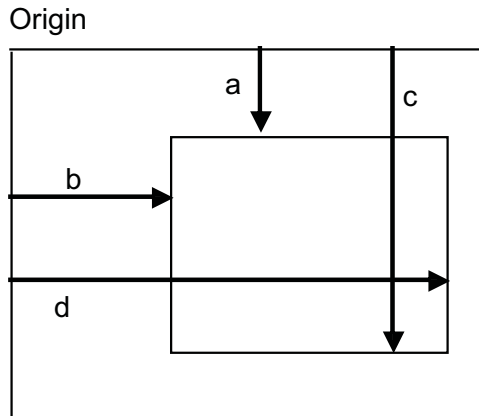
(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

### BARE DIE INFORMATION

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



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



**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

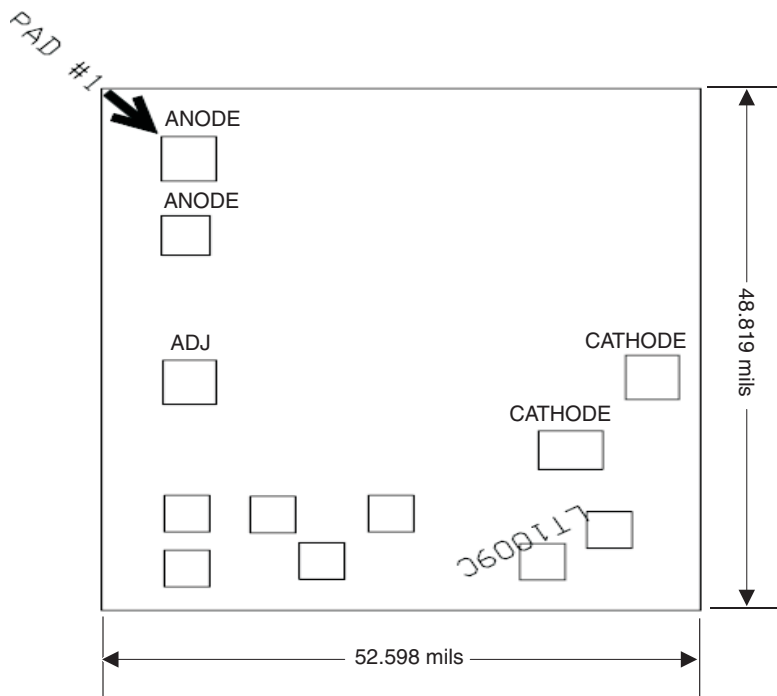
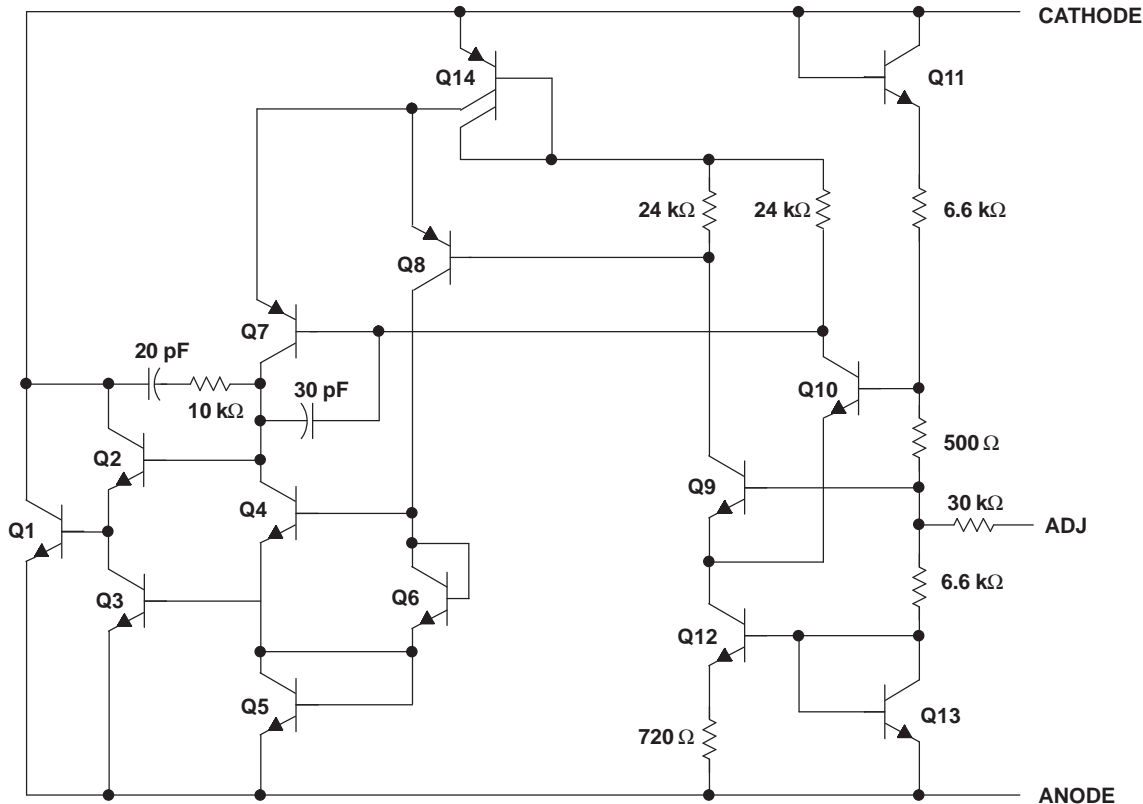


Figure 2. SCHEMATIC



NOTE: All component values shown are nominal.

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

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 <sup>(2)</sup>		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

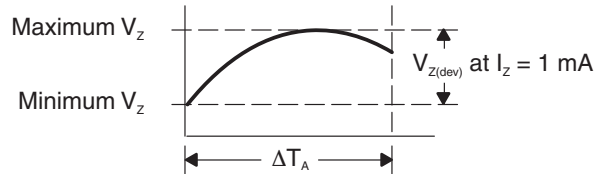
## ELECTRICAL CHARACTERISTICS

at specified free-air temperature

PARAMETER	TEST CONDITIONS	T <sub>A</sub>	LT1009M			UNIT	
			MIN	TYP	MAX		
V <sub>Z</sub>	Reference voltage	I <sub>Z</sub> = 1 mA	25°C	2.49	2.5	2.51	V
			Full range	2.46		2.535	
V <sub>F</sub>	Forward voltage	I <sub>F</sub> = 2 mA	25°C	0.4		1	V
Adjustment range		I <sub>Z</sub> = 1 mA, V <sub>ADJ</sub> = GND to V <sub>Z</sub>	25°C	125			mV
		I <sub>Z</sub> = 1 mA, V <sub>ADJ</sub> = 0.6 V to V <sub>Z</sub> – 0.6 V		45			
ΔV <sub>Z(temp)</sub>	Change in reference voltage with temperature		Full range			15	mV
αV <sub>Z</sub>	Average temperature coefficient of reference voltage <sup>(1)</sup>	I <sub>Z</sub> = 1 mA, V <sub>ADJ</sub> = open	Full range		20	35	ppm/ °C
ΔV <sub>Z</sub>	Change in reference voltage with current	I <sub>Z</sub> = 400 μA to 10 mA	25°C	6		10	mV
			Full range			12	
ΔV <sub>Z</sub> /Δt	Long-term change in reference voltage	I <sub>Z</sub> = 1 mA	25°C	20			ppm/ khr
Z <sub>Z</sub>	Reference impedance	I <sub>Z</sub> = 1 mA	25°C	0.6		1.6	Ω
			Full range			1.8	

- (1) The deviation parameter V<sub>Z(dev)</sub> is defined as the difference between the maximum and minimum values obtained over the recommended operating temperature range, measured at I<sub>Z</sub> = 1 mA. The average full-range temperature coefficient of the reference voltage (αV<sub>Z</sub>) is defined as:

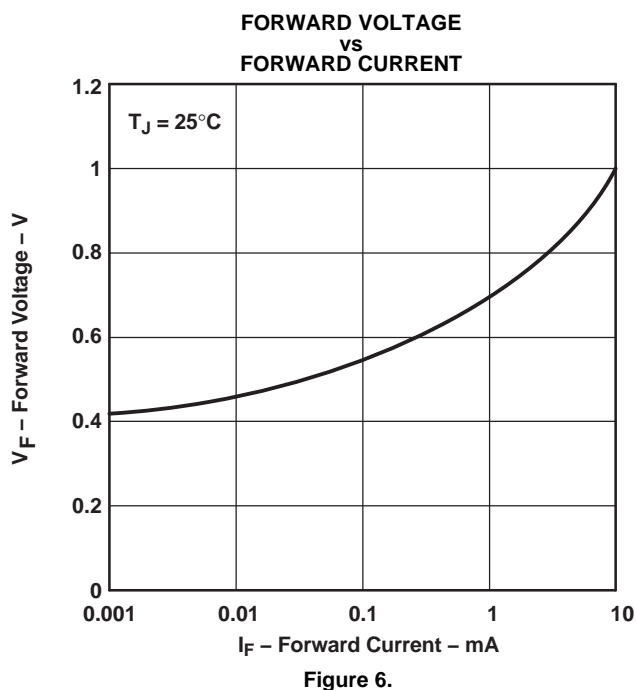
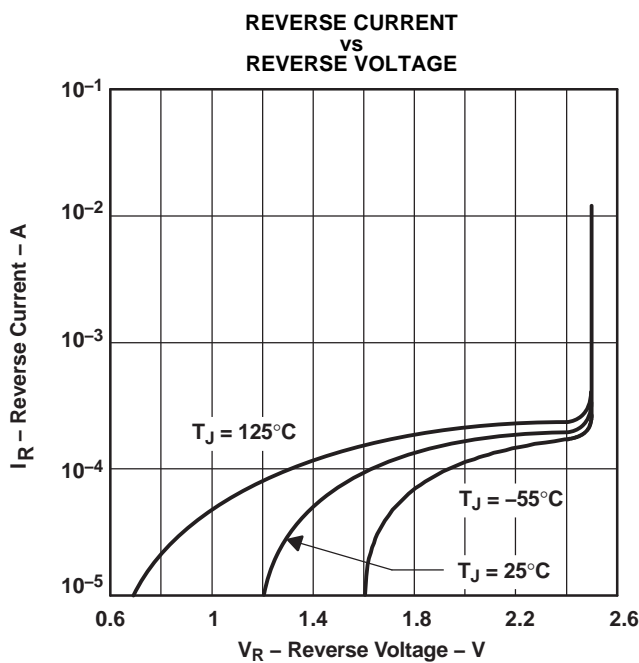
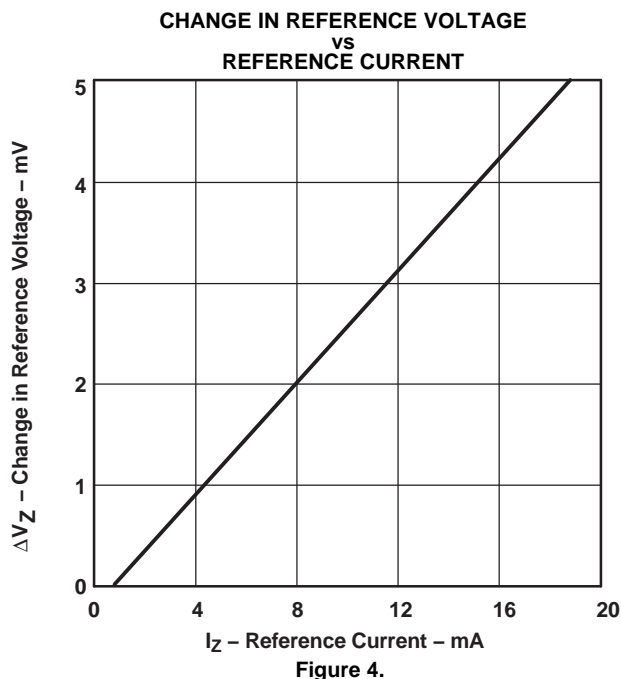
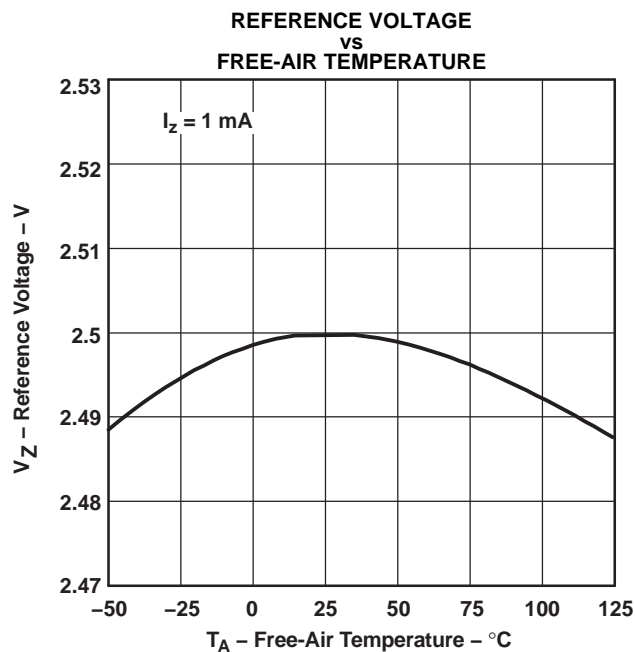
$$|\alpha V_Z| \left( \frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{\left( \frac{V_{Z(\text{dev})}}{V_Z \text{ at } 25^\circ\text{C}} \right) \times 10^6}{\Delta T_A}$$



αV<sub>Z</sub> can be positive or negative, depending upon whether the minimum V<sub>Z</sub> or maximum V<sub>Z</sub>, 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.



TYPICAL CHARACTERISTICS (continued)

REFERENCE IMPEDANCE  
VS  
FREQUENCY

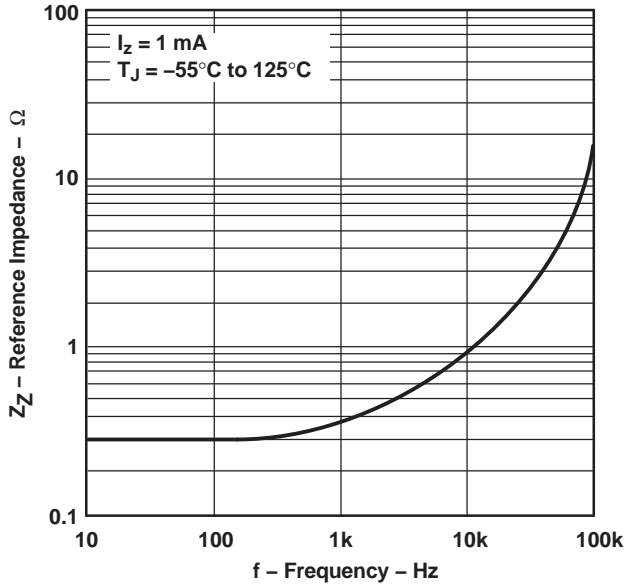


Figure 7.

NOISE VOLTAGE  
VS  
FREQUENCY

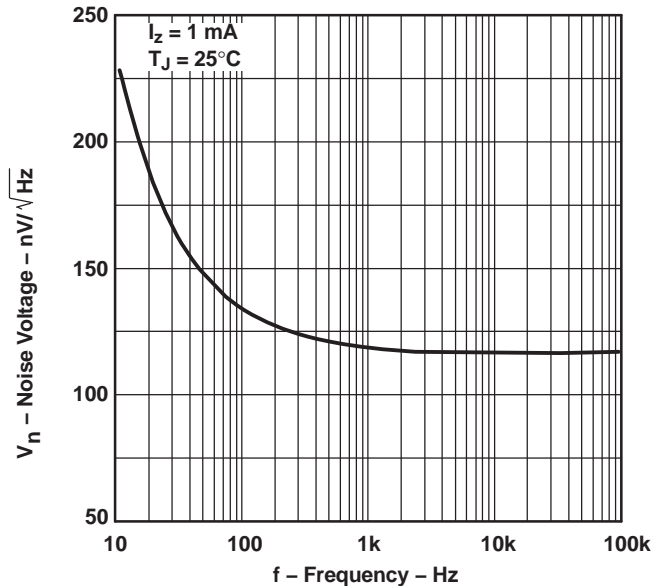


Figure 8.

TRANSIENT RESPONSE

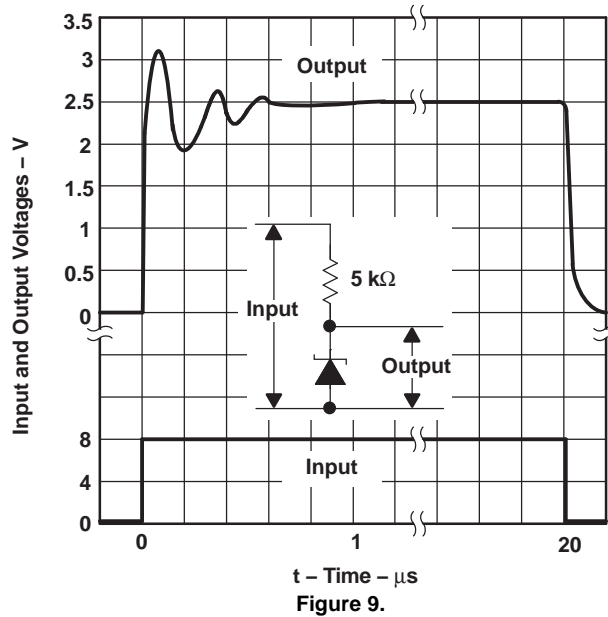
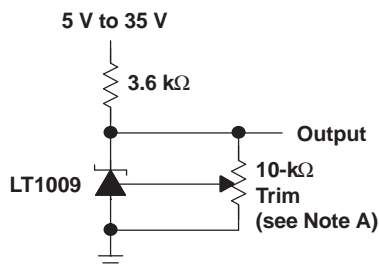


Figure 9.

APPLICATION INFORMATION



A. This does not affect temperature coefficient. It provides  $\pm 5\%$  trim range.

Figure 10. 2.5-V Reference

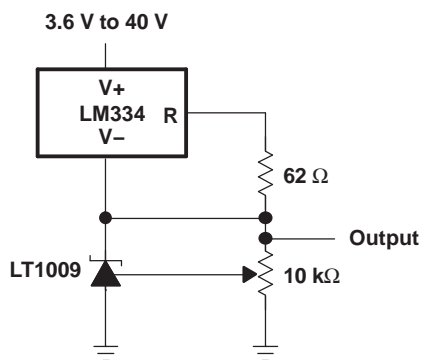


Figure 11. Adjustable Reference With Wide Supply Range

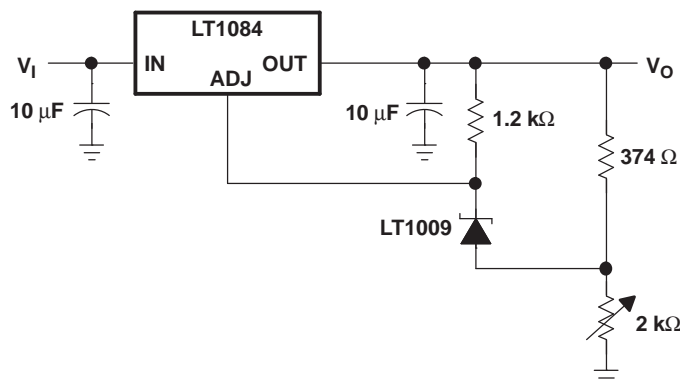


Figure 12. Power Regulator With Low Temperature Coefficient

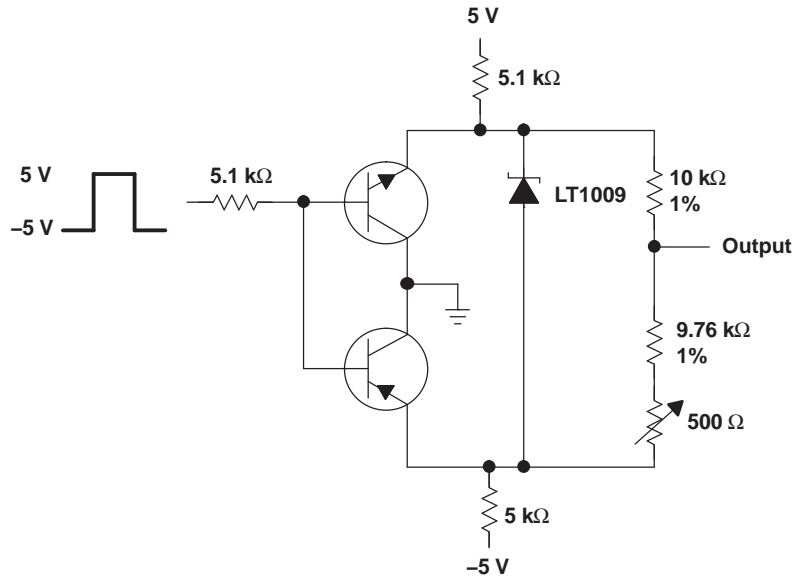


Figure 13. Switchable ±1.25-V Bipolar Reference

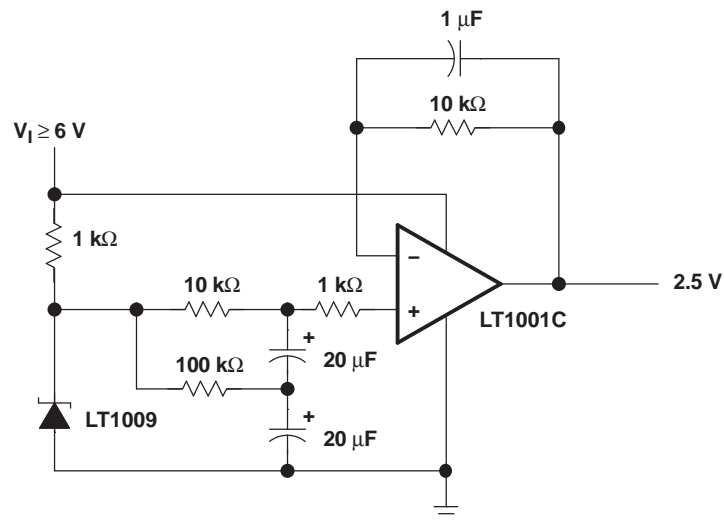


Figure 14. Low-Noise 2.5-V Buffered Reference



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LT1009MKGD1	ACTIVE	XCEPT	KGD	0	100	TBD	Call TI	N / A for Pkg Type	-55 to 125		Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF LT1009M :**

- Catalog: [LT1009](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)