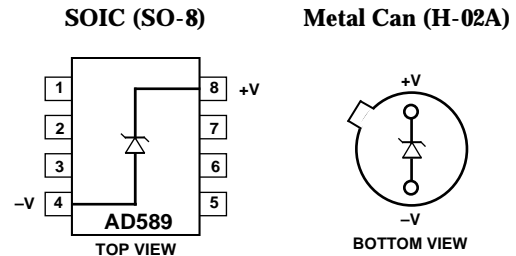


## AD589

### FEATURES

Superior Replacement for Other 1.2 V References  
 Wide Operating Range: 50  $\mu$ A to 5 mA  
 Low Power: 60  $\mu$ W Total  $P_D$  at 50  $\mu$ A  
 Low Temperature Coefficient:  
     10 ppm/ $^{\circ}$ C max, 0 $^{\circ}$ C to +70 $^{\circ}$ C (AD589M)  
     25 ppm/ $^{\circ}$ C max, -55 $^{\circ}$ C to +125 $^{\circ}$ C (AD589U)  
 Two-Terminal "Zener" Operation  
 Low Output Impedance: 0.6  $\Omega$   
 No Frequency Compensation Required  
 Low Cost  
 MIL-STD-883 Compliant Versions Available

### FUNCTIONAL BLOCK DIAGRAMS



### PRODUCT DESCRIPTION

The AD589 is a two-terminal, low cost, temperature compensated bandgap voltage reference which provides a fixed 1.23 V output voltage for input currents between 50  $\mu$ A and 5.0 mA.

The high stability of the AD589 is primarily dependent upon the matching and thermal tracking of the on-chip components. Analog Devices' precision bipolar processing and thin-film technology combine to provide excellent performance at low cost.

Additionally, the active circuit produces an output impedance ten times lower than typical low-TC Zener diodes. This feature allows operation with no external components required to maintain full accuracy under changing load conditions.

The AD589 is available in seven versions. The AD589J, K, L and M grades are specified for 0 $^{\circ}$ C to +70 $^{\circ}$ C operation, while the S, T, and U grades are rated for the full -55 $^{\circ}$ C to +125 $^{\circ}$ C temperature range. All grades are available in a metal can (H-02A) package. The AD589J is also available in an 8-pin SOIC package.

### PRODUCT HIGHLIGHTS

1. The AD589 is a two-terminal device which delivers a constant reference voltage for a wide range of input current.
2. Output impedance of 0.6  $\Omega$  and temperature coefficients as low as 10 ppm/ $^{\circ}$ C insure stable output voltage over a wide range of operating conditions.
3. The AD589 can be operated as a positive or negative reference. "Floating" operation is also possible.
4. The AD589 will operate with total current as low as 50  $\mu$ A (60  $\mu$ W total power dissipation), ideal for battery powered instrument applications.
5. The AD589 is an exact replacement for other 1.2 V references, offering superior temperature performance and reduced sensitivity to capacitive loading.
6. The AD589 is available in versions compliant with MIL-STD-883. Refer to the Analog Devices Military Products Databook or current AD589/883B data sheet for detailed specifications.

### REV. B

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# AD589—SPECIFICATIONS (typical @ $I_{IN} = 500 \mu\text{A}$ and $T_A = +25^\circ\text{C}$ unless otherwise noted)

Model	AD589JH/JR			AD589KH			AD589LH			AD589MH			Unit
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
OUTPUT VOLTAGE, $T_A = +25^\circ\text{C}$	<b>1.200</b>	1.235	<b>1.250</b>	<b>1.200</b>	1.235	<b>1.250</b>	<b>1.200</b>	1.235	<b>1.250</b>	<b>1.200</b>	1.235	<b>1.250</b>	V
OUTPUT VOLTAGE CHANGE vs. CURRENT (50 $\mu\text{A}$ –5 mA)			5			5			5			5	mV
DYNAMIC OUTPUT IMPEDANCE		0.6	2		0.6	2		0.6	2		0.6	2	$\Omega$
RMS NOISE VOLTAGE 10 Hz < f < 10 kHz		5			5			5			5		$\mu\text{V}$
TEMPERATURE COEFFICIENT <sup>1</sup>			100			<b>50</b>			25			<b>10</b>	ppm/ $^\circ\text{C}$
TURN-ON SETTTLING TIME TO 0.1%		25			25			25			25		$\mu\text{s}$
OPERATING CURRENT <sup>2</sup>	<b>0.05</b>		5	<b>0.05</b>		5	<b>0.05</b>		5	<b>0.05</b>		5	mA
OPERATING TEMPERATURE	0		+70	0		+70	0		+70	0		+70	$^\circ\text{C}$
PACKAGE OPTION <sup>3</sup> Metal Can (H-02A) SOIC (R-8)		AD589JH AD589JR			AD589KH			AD589LH			AD589MH		

Model	AD589SH			AD589TH			AD589UH			Unit
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
OUTPUT VOLTAGE, $T_A = +25^\circ\text{C}$	<b>1.200</b>	1.235	<b>1.250</b>	<b>1.200</b>	1.235	<b>1.250</b>	<b>1.200</b>	1.235	<b>1.250</b>	V
OUTPUT VOLTAGE CHANGE vs. CURRENT (50 $\mu\text{A}$ –5 mA)			5			5			5	mV
DYNAMIC OUTPUT IMPEDANCE		0.6	2		0.6	2		0.6	2	$\Omega$
RMS NOISE VOLTAGE 10 Hz < f < 10 kHz		5			5			5		$\mu\text{V}$
TEMPERATURE COEFFICIENT <sup>1</sup>			<b>100</b>			<b>50</b>			<b>25</b>	ppm/ $^\circ\text{C}$
TURN-ON SETTTLING TIME TO 0.1%		25			25			25		$\mu\text{s}$
OPERATING CURRENT <sup>2</sup>	<b>0.05</b>		5	<b>0.05</b>		5	<b>0.05</b>		5	mA
OPERATING TEMPERATURE	-55		+125	-55		+125	-25		+125	$^\circ\text{C}$
PACKAGE OPTION <sup>3</sup> Metal Can (H-02A) SOIC (SO-8)		AD589SH AD589JR			AD589TH			AD589UH		

## NOTES

<sup>1</sup>See the following page for explanation of temperature coefficient measurement method.

<sup>2</sup>Optimum performance is obtained at currents below 500  $\mu\text{A}$ . For current operation below 200  $\mu\text{A}$ , stray shunt capacitances should be limited to 20 pF or increased to 1  $\mu\text{F}$ . If strays can not be avoided, operation at 500  $\mu\text{A}$  and a shunt capacitor of at least 1000 pF are recommended.

<sup>3</sup>H = Hermetic Metal Can; SO = SOIC.

Specifications shown in **boldface** are tested on all production units at final electrical test.

Specifications subject to change without notice.

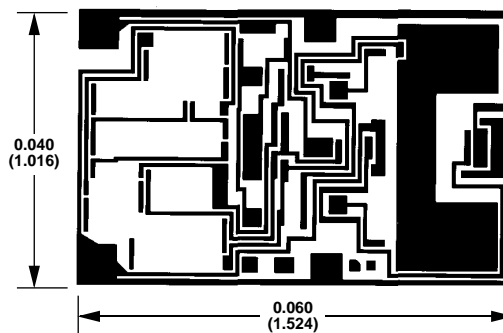
## ABSOLUTE MAXIMUM RATINGS

Current	10 mA
Reverse Current	10 mA
Power Dissipation <sup>1</sup>	125 mW
Storage Temperature	-65 $^\circ\text{C}$ to +175 $^\circ\text{C}$
Operating Junction Temperature Range	-55 $^\circ\text{C}$ to +150 $^\circ\text{C}$
Lead Temperature (Soldering, 10 sec)	+300 $^\circ\text{C}$

## NOTE

<sup>1</sup>Absolute maximum power dissipation is limited by maximum current through the device. Maximum rating at elevated temperatures must be computed assuming  $T_j \leq 150^\circ\text{C}$ , and  $\theta_{JA} = 400 = \text{C}/\text{W}$ .

## AD589 CHIP DIMENSIONS AND PAD LAYOUT



THE AD589 IS AVAILABLE IN CHIP FORM WITH FULLY TESTED AND GUARANTEED SPECIFICATIONS. CONSULT FACTORY FOR AVAILABLE GRADES AND PRICING.

## VOLTAGE VARIATION VS. TEMPERATURE

Some confusion exists in the area of defining and specifying reference voltage error over temperature. Historically, references have been characterized using a maximum deviation per degree Centigrade; i.e., 10 ppm/°C. However, because of nonlinearities in temperature characteristics, which originated in standard Zener references (such as “S” type characteristics) most manufacturers have begun to use a maximum limit error band approach to specify devices. This technique involves measurement of the output at 3, 5 or more different temperatures to guarantee that the output will fall within the given error band. The temperature characteristics of the AD589 consistently follows the curve shown in Figure 1. Three-point measurement guarantees the error band over the specified temperature range. The temperature coefficients specified on the previous page represent the slopes of the diagonals of the error band from +25°C to  $T_{MIN}$  and +25°C to  $T_{MAX}$ .

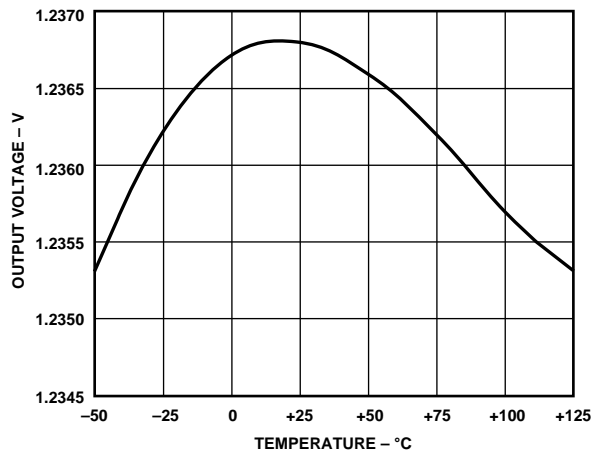


Figure 1. Typical AD589 Temperature Characteristics

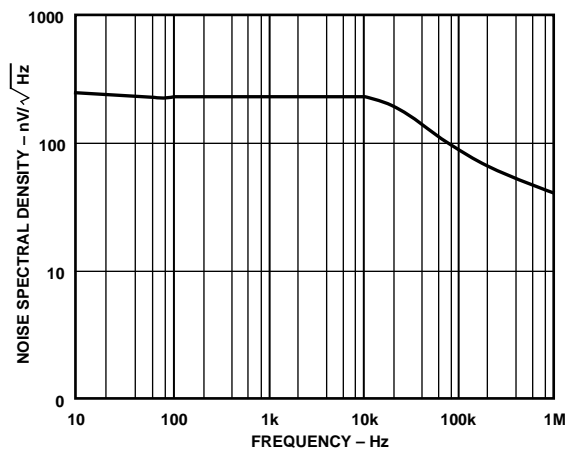


Figure 2. Noise Spectral Density

## DYNAMIC PERFORMANCE

Many low power instrument manufacturers are becoming increasingly concerned with the turn-on characteristics of the components being used in their systems. Fast turn-on components often enable the end user to keep power off when not needed, and yet respond quickly when the power is turned on for operation. Figure 3 displays the turn-on characteristics of the AD589. This characteristic is generated from cold-start operation and represents the true turn-on waveform after an extended period with the supplies off. The figure shows both the coarse and fine transient characteristics of the device; the total settling time to within  $\pm 1$  millivolt is about 25  $\mu$ s, and there is no long thermal tail appearing after that point.

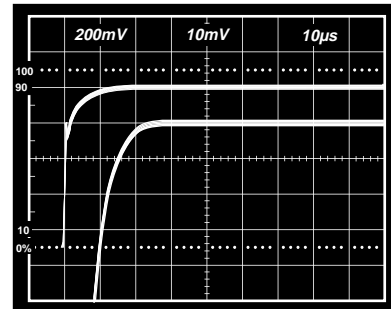


Figure 3. Output Settling Characteristics

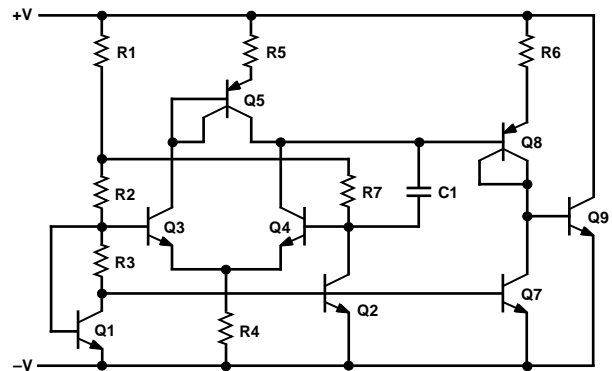


Figure 4. Schematic Diagram

# AD589

## APPLICATION INFORMATION

The AD589 functions as a two-terminal shunt-type regulator. It provides a constant 1.23 V output for a wide range of input current from 50  $\mu$ A to 5 mA. Figure 5 shows the simplest configuration for an output voltage of 1.2 V or less. Note that no frequency compensation is required. If additional filtering is desired for ultralow noise applications, minimum recommended capacitance is 1000 pF.

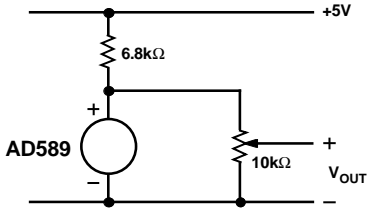


Figure 5. Basic Configuration for 1.2 V or Less

The AD589 can also be used as a building block to generate other values of reference voltage. Figure 6 shows a circuit which produces a buffered 10 V output. Total supply current for this circuit is approximately 2 mA.

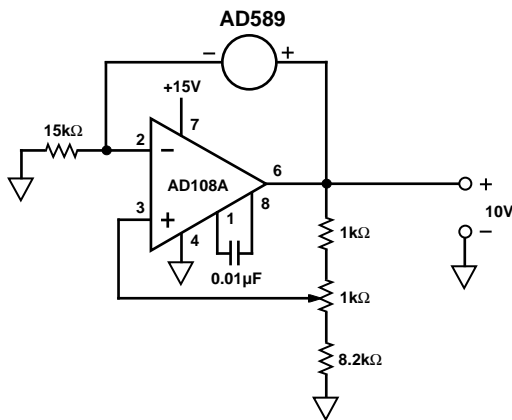
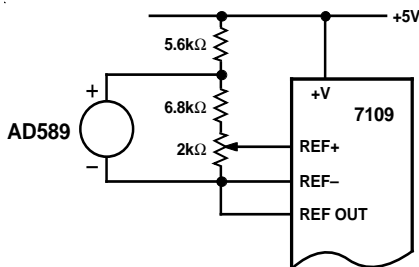
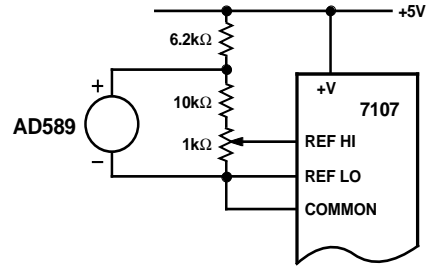


Figure 6. Single Supply Buffered 10 V Reference

The low power operation of the AD589 makes it ideal for use in battery operated portable equipment. It is especially useful as a reference for CMOS analog-to-digital converters. Figure 7 shows the AD589 used in conjunction with two popular integrating type CMOS A/D converters.



a. With 7109 12-Bit Binary A/D



b. With 7107 Panel Meter A/D

Figure 7. AD589 Used as Reference for CMOS A/D Converters

The AD589 also is useful as a reference for CMOS multiplying DACs such as the AD7533. These DACs require a negative reference voltage in order to provide a positive output range. Figure 8 shows the AD589 used to supply an equivalent  $-1.0$  V reference to an AD7533.

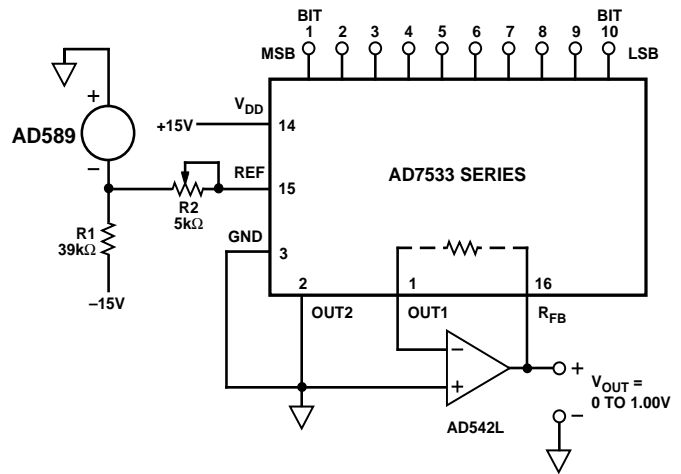
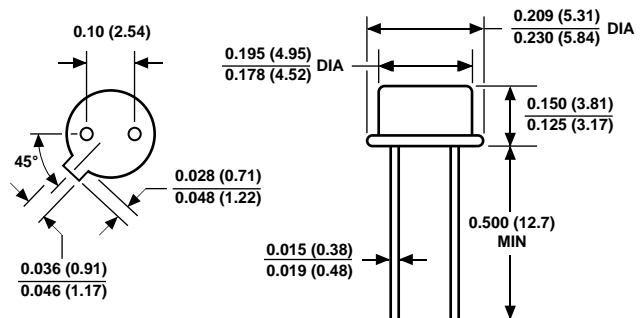


Figure 8. AD589 as Reference for 10-Bit CMOS DAC

## OUTLINE DIMENSIONS AND PIN DESIGNATIONS

Dimensions shown in inches and (mm).



## Package/Price Information

For detailed packaging information, please select the [Datasheets](#) button.

Two-Terminal IC 1.2 V Reference

Model	Status	Package Description	Pin Count	Temperature Range	Price* (100-499)
AD589JCHIPS	PRODUCTION	CHIPS/DIE SALES	2	COMMERCIAL	\$1.39
AD589JH	PRODUCTION	ROUND HEADER/METAL CAN	3	COMMERCIAL	\$4.02
AD589JH/+	OBSOLETE	ROUND HEADER/METAL CAN	3	COMMERCIAL	-
AD589JR	PRODUCTION	STD S.O. PKG (SOIC)	8	COMMERCIAL	\$1.72
AD589JR-REEL	PRODUCTION	STD S.O. PKG (SOIC)	8	COMMERCIAL	-
AD589KH	PRODUCTION	ROUND HEADER/METAL CAN	2	COMMERCIAL	\$4.35
AD589LH	PRODUCTION	ROUND HEADER/METAL CAN	3	COMMERCIAL	\$8.89
AD589MH	PRODUCTION	ROUND HEADER/METAL CAN	3	COMMERCIAL	\$19.32
AD589SH	PRODUCTION	ROUND HEADER/METAL CAN	3	MILITARY	\$4.76
AD589SH/883B	PRODUCTION	ROUND HEADER/METAL CAN	3	MILITARY	\$10.02
AD589TCHIPS	PRODUCTION	CHIPS/DIE SALES	2	MILITARY	\$4.48
AD589TH	PRODUCTION	ROUND HEADER/METAL CAN	3	MILITARY	\$6.92
AD589TH/883B	PRODUCTION	ROUND HEADER/METAL CAN	3	MILITARY	\$13.55

\* This price is provided for budgetary purposes as recommended list price in U.S. Dollars per unit the stated volume. Pricing displayed for Evaluation Boards and Kits is based on 1-piece pricing. View [Pricing and Availability](#) (currently available to North American customers) for further information.