2.5 V Precision Voltage Reference

REF03

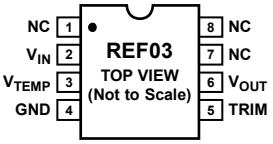
FEATURES

2.5 voltage output, ±0.6% maximum
Wide input voltage range: 4.5 V to 33 V
Supply current: 1.4 mA maximum
Output voltage temperature coefficient: 50 ppm/°C maximum
Line regulation: 50 ppm/V maximum
Load regulation: 100 ppm/mA maximum
Extended industrial temperature range: −40°C to +85°C
Low cost

GENERAL DESCRIPTION

The REF03 precision voltage reference provides a stable 2.5 V output, with minimal change for variations in supply voltage, ambient temperature, or loading conditions. Single-supply operation over an input voltage range of 4.5 V to 33 V with a current drain of 1 mA and good temperature stability is achieved using an improved band gap design. Primarily targeted at price sensitive applications, the REF03 is available in plastic PDIPs and surface-mount small outline plastic packages. For improved performance or −40°C to +125°C operation, see the ADR03 data sheet.

PIN CONFIGURATION



NOTES
1. NC = NO CONNECT. DO NOT CONNECT ANYTHING ON THESE PINS. SOME OF THEM ARE RESERVED FOR FACTORY TESTING PURPOSES.
2. TRIM PIN AND V_{TEMP} PIN SHOULD BE LEFT FLOATING IF THEY ARE NOT BEING USED.

00372-001

Figure 1. 8-Lead PDIP (P-Suffix), 8-Lead SOIC (S-Suffix)

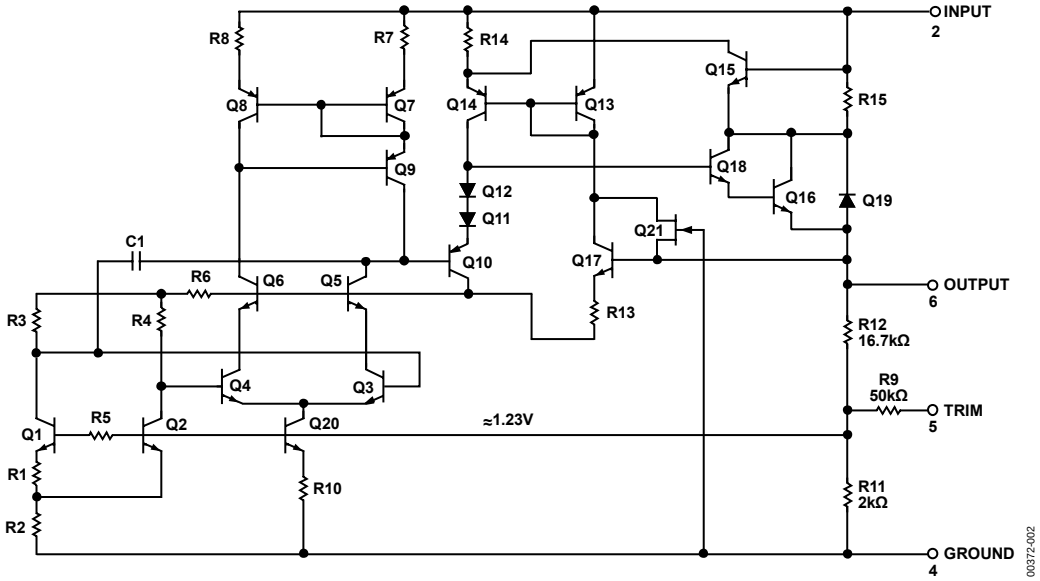


Figure 2. Simplified Schematic

Rev. G

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6/04—Data Sheet changed from Rev. E to Rev. F

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2/04—Data Sheet changed from Rev. D to Rev. E

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8/03—Data Sheet changed from Rev. C to Rev. D

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ELECTRICAL SPECIFICATIONS

@ V_{IN} = 15 V, −40°C ≤ T_A ≤ +85°C, unless otherwise noted.

Table 1.

Parameter	Symbol	Conditions	REF03G			Unit
			Min	Typ	Max	
Output Voltage	V_O	No load	2.485	2.500	2.515	V
Output Voltage Tolerance		No load		0.2	0.6	%
Output Voltage Temperature Coefficient[1]	TCV_O			10	50	ppm/°C
Line Regulation		V_{IN} = 4.5 V to 33 V		20	50	ppm/V
				0.002	0.005	%/V
Load Regulation		I_L = 0 mA to 10 mA		60	100	ppm/mA
				0.006	0.010	%/mA
Load Current (Sourcing)	I_L		10			mA
Load Current (Sinking)	I_S		−0.3	−0.5		mA
Short-Circuit Output Current	I_{SC}	Output shorted to ground		24		mA
Quiescent Supply Current	I_{SY}	No load		1.0	1.4	mA
Turn-On Settling Time[2]	t_{ON}	To ±0.1% of final value		5		µs
Output Voltage Noise	e_n p-p	0.1 Hz to 10 Hz		6		µV p-p
Output Adjustment Range	ΔV_{TRIM}	R_{POT} = 10 kΩ	±6	±11		%
Input Voltage Range			4.5	15	33	V
Temperature Voltage Output[3]	V_T			620		mV

[1] TCV_O is measured by the endpoint method, and is equal to

$$\frac{\left|V(85^\circ C) - V(-40^\circ C)\right|}{(2.5\times10^{-6})(125^\circ C)} \text{ in ppm/°C}$$

[2] Guaranteed by design.
[3] Limit current in or out of Pin 3 to 50 nA and capacitance on Pin 3 to 30 pF.

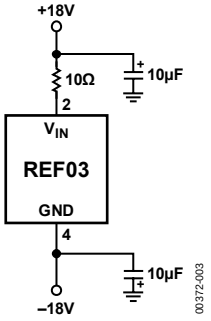


Figure 3. Burn-In Circuit

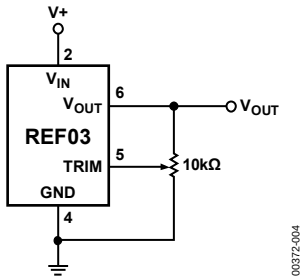


Figure 4. Output Voltage Trim Method

ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted. Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.

Table 2.

Parameter	Rating
Input Voltage	40 V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	
REF03G (P-Suffix, S-Suffix)	−40°C to +85°C
Storage Temperature Range	−65°C to +175°C
Junction Temperature Range	−65°C to +175°C
Lead Temperature (Soldering, 10 sec)	300°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 3. Package Thermal Resistance

Package Type	θ_{JA}[1]	θ_{JC}	Unit
8-Lead PDIP (P-Suffix)	110	50	°C/W
8-Lead SOIC (S-Suffix)	160	44	°C/W

[1] θ_{JA} is specified for worst-case mounting conditions, that is, θ_{JA} is specified for the device in socket for a PDIP package. θ_{JA} is specified for the device soldered to printed circuit board for a SOIC package.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

TYPICAL PERFORMANCE CHARACTERISTICS

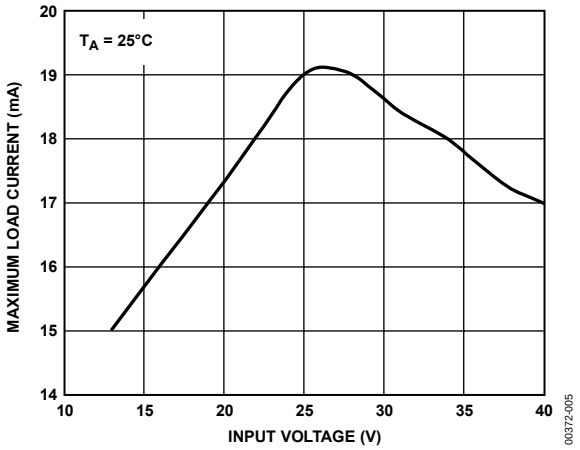


Figure 5. Maximum Load Current vs. Input Voltage

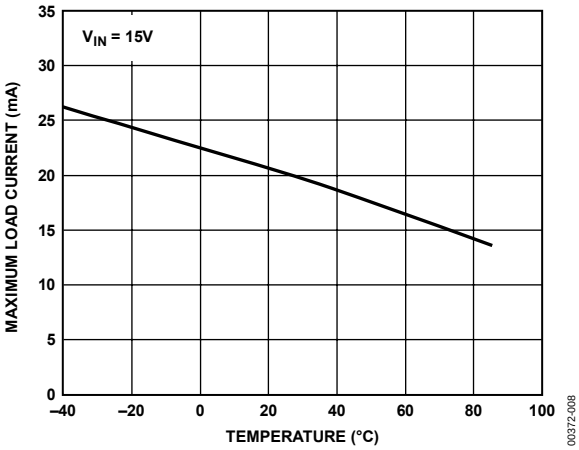


Figure 8. Maximum Load Current vs. Temperature

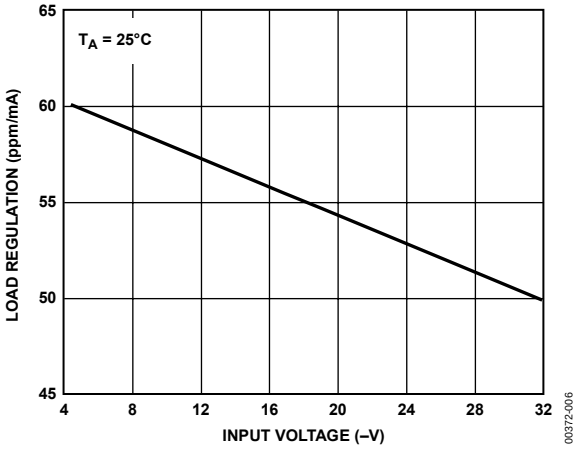


Figure 6. Load Regulation (ΔI_L = 10 mA) vs. Input Voltage

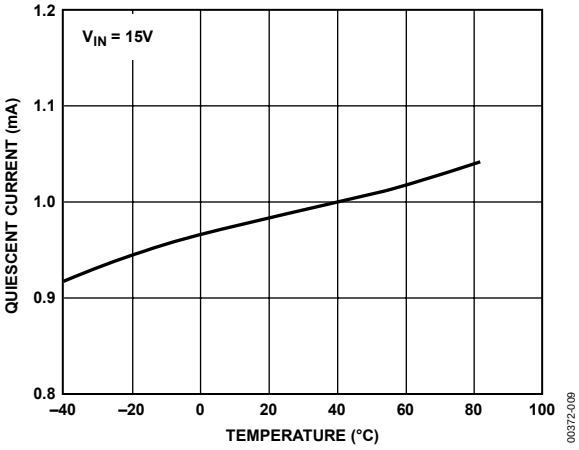


Figure 9. Quiescent Current vs. Temperature

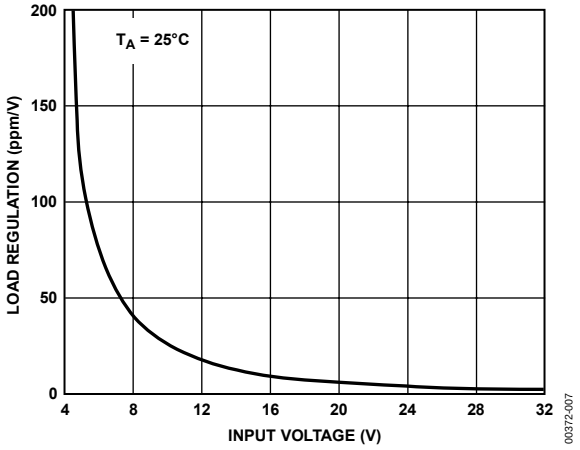


Figure 7. Line Regulation vs. Input Voltage

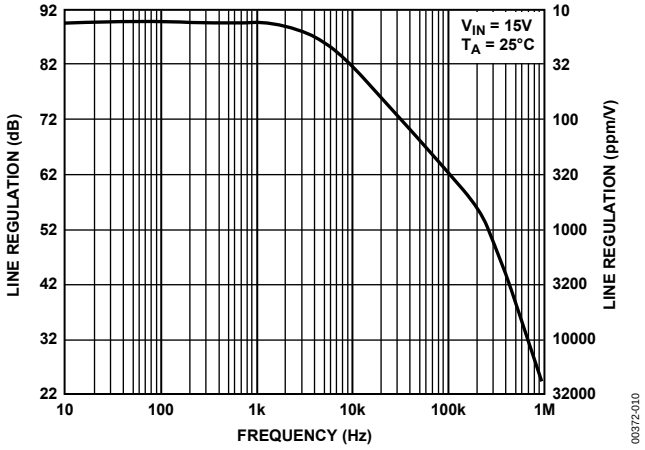


Figure 10. Line Regulation vs. Frequency

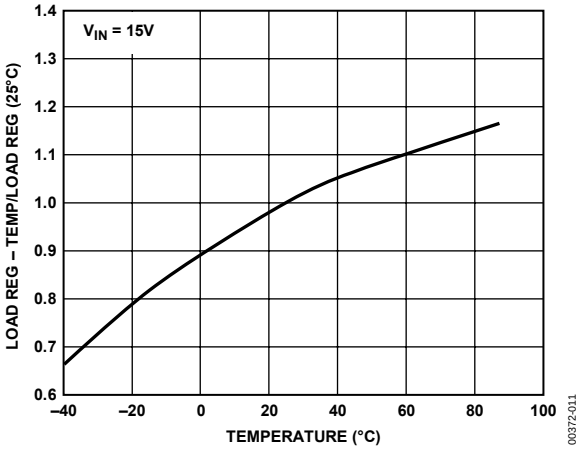


Figure 11. Normalized Load Regulation (ΔI_L = 10 mA) vs. Temperature

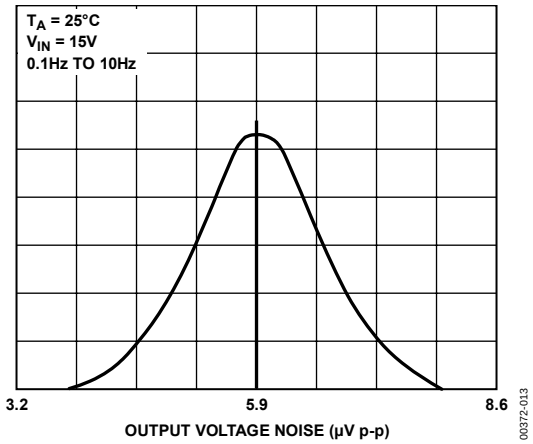


Figure 13. Typical Distribution of Output Voltage Noise

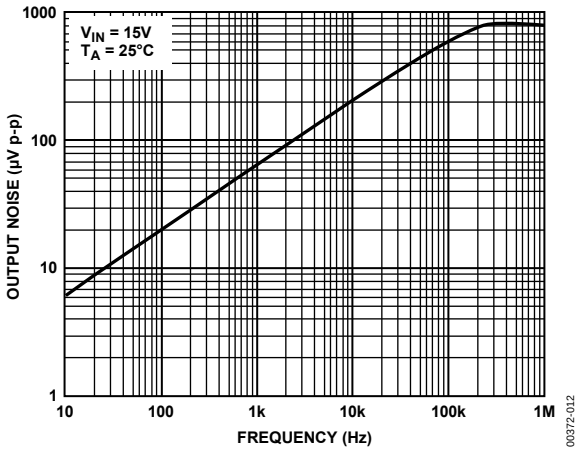


Figure 12. Wideband Output Noise vs. Bandwidth (0.1 Hz to Frequency Indicated)

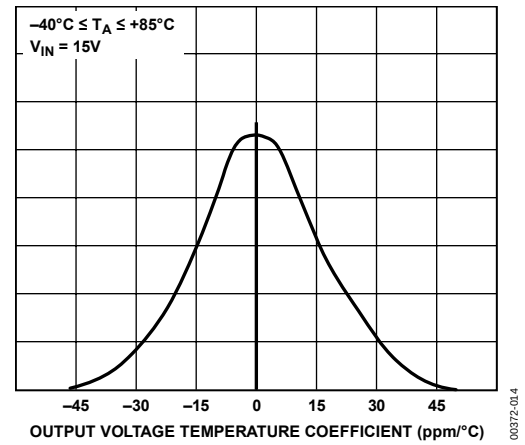


Figure 14. Typical Distribution of Output Voltage Temperature Coefficient

APPLICATIONS

The REF03 provides a stable 2.5 V output voltage with minimal dependence on load current, line voltage, or temperature. This voltage is typically used to set an absolute reference point in data conversion circuits, or in analog circuits such as log amps, 4 mA to 20 mA transmitters, and power supplies. The REF03 is of particular value in systems requiring a precision reference using a single 5 V supply rail.

Because an on-board operational amplifier is used to amplify the basic band gap cell voltage to 2.5 V, supply decoupling is critical to the transient performance of a voltage reference. The supply line should be bypassed with a 10 µF tantalum capacitor in parallel with a 0.01 µF to 0.1 µF ceramic capacitor for best results, as shown in Figure 15. The bypass capacitors should be located as close to the reference as possible. Inadequate bypassing can lead to instabilities.

Output bypass capacitors are not generally recommended. If necessary for high frequency output impedance reduction, the capacitance value used should be at least 1 µF.

If the V_{TEMP} and TRIM pins are not in use, then they should be left floating. However, when V_{TEMP} is being used for temperature compensation, it must be connected to a very high impedance node in the circuit, such as a noninverting input of a buffer.

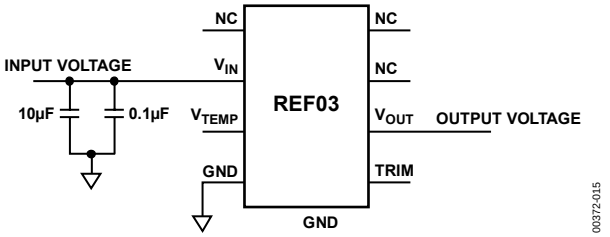


Figure 15. Basic Connections

GENERATING AN ADJUSTABLE BIPOLAR VOLTAGE REFERENCE

There is often a requirement for an adjustable bipolar reference. A simple method of generating such a reference is to connect the output of the REF03 to an op amp in an adjustable gain configuration, as shown in Figure 16. The trimmable resistor is then used to generate the desired output voltage from −2.5 V to +2.5 V.

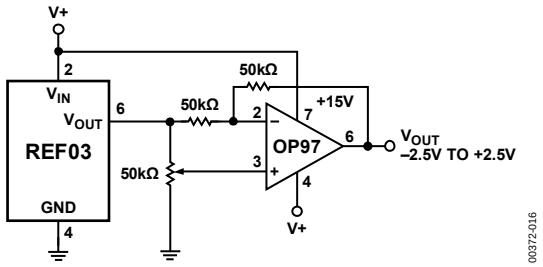


Figure 16. Adjustable Bipolar Reference

GENERATING A −2.5 V REFERENCE

Often, there is a requirement for a negative reference voltage. The simplest method of generating a −2.5 V reference with the REF03 is to connect an op amp in a gain of −1 to the output, as shown in Figure 17. This provides both positive and negative 2.5 V references. Figure 18 shows another method of obtaining a negative reference, in which the current-output element is a PNP transistor, with the REF03 in a servo loop to ensure that the output remains 2.5 V below ground.

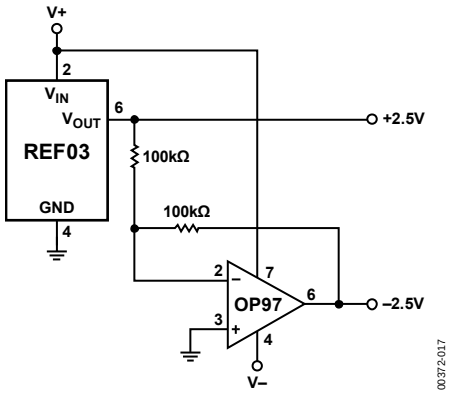


Figure 17. ±2.5 V Reference

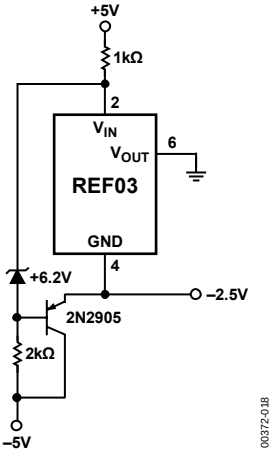


Figure 18. −2.5 V Reference

BOOST TRANSISTOR PROVIDES HIGH OUTPUT CURRENT

When applications require more than 10 mA current delivery, an external boost transistor may be added to the REF03 to pass the required current without dissipating excessive power within the IC. The maximum current output to the system is bounded only by the capabilities of the boost transistor. Figure 19 shows this technique, with and without current limiting.

Current limiting may be used to prevent damage to the boost transistor. Figure 19A is an example of no current limit, while Figure 19B shows the limit that occurs when the voltage dropped across R2 exceeds one V_{BE} (0.6 V). The current limit is sensitive to the variations of the forward drop of the diodes and the PNP's V_{BE} with temperature, and also decreases with increasing temperature.

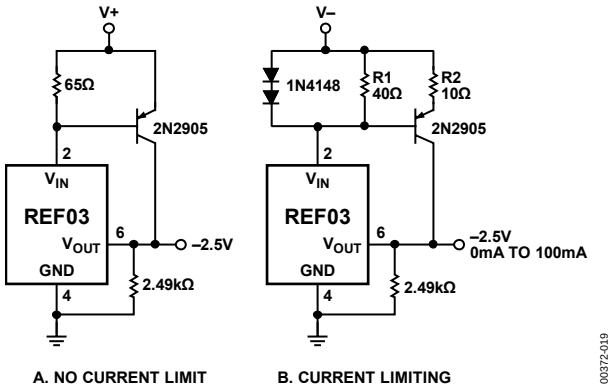


Figure 19. Output Current Boost

CMOS DAC REFERENCE

The REF03 makes an excellent reference for use with CMOS and bipolar DACs. Figure 20 shows the REF03 connected to the AD7393, a 12-bit CMOS DAC. An AD8603 with a common mode input range that extends to its positive rail can be a good combination with only 50 µA of maximum current consumption.

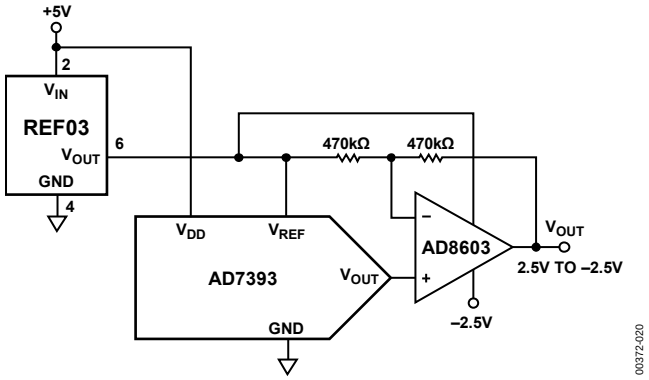
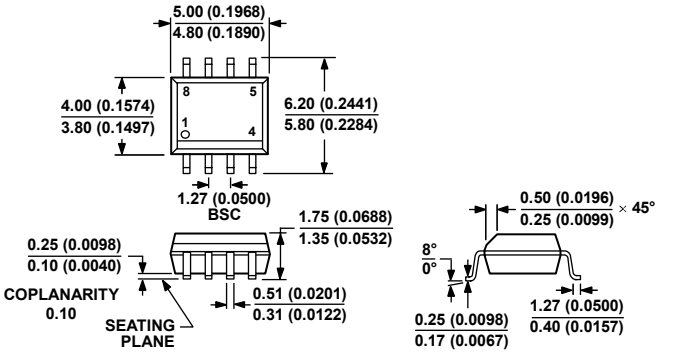


Figure 20. CMOS DAC Reference

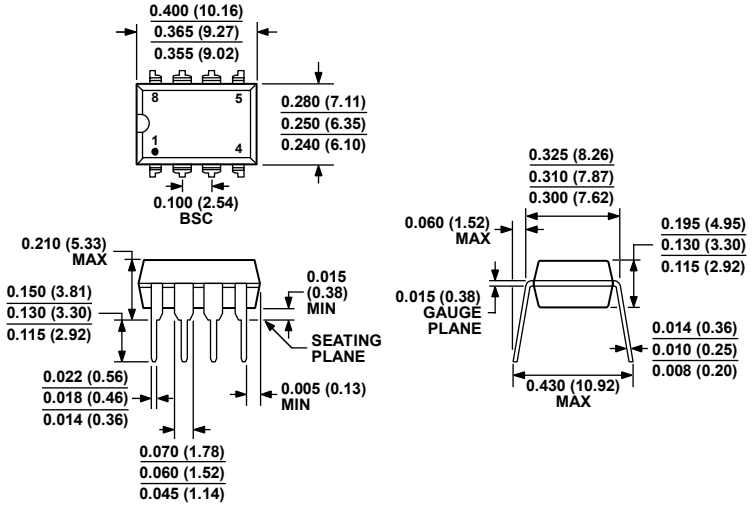
OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-012-AA
CONTROLLING DIMENSIONS ARE IN MILLIMETERS; INCH DIMENSIONS
(IN PARENTHESES) ARE ROUNDED-OFF MILLIMETER EQUIVALENTS FOR
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

012407-A

Figure 21. 8-Lead Standard Small Outline Package [SOIC_N]
Narrow Body
(R-8)
S-Suffix
Dimensions shown in millimeters and (inches)



COMPLIANT TO JEDEC STANDARDS MS-001
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS
(IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR
REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.
CORNER LEADS MAY BE CONFIGURED AS WHOLE OR HALF LEADS.

070606-A

Figure 22. 8-Lead Plastic Dual In-Line Package [PDIP]
(N-8)
P-Suffix
Dimensions shown in inches and (millimeters)

ORDERING GUIDE

Part Number	Initial Accuracy (%)	Temperature Coefficient	Temperature Range	Package Description	Package Option
REF03GP	0.2	10	−40°C to +85°C	8-Lead PDIP	N-8 (P-Suffix)
REF03GPZ[1]	0.2	10	−40°C to +85°C	8-Lead PDIP	N-8 (P-Suffix)
REF03GS	0.2	10	−40°C to +85°C	8-Lead SOIC_N	R-8 (P-Suffix)
REF03GS-REEL	0.2	10	−40°C to +85°C	8-Lead SOIC_N	R-8 (P-Suffix)
REF03GS-REEL7	0.2	10	−40°C to +85°C	8-Lead SOIC_N	R-8 (P-Suffix)
REF03GSZ[1]	0.2	10	−40°C to +85°C	8-Lead SOIC_N	R-8 (P-Suffix)
REF03GSZ-REEL[1]	0.2	10	−40°C to +85°C	8-Lead SOIC_N	R-8 (P-Suffix)
REF03GSZ-REEL7[1]	0.2	10	−40°C to +85°C	8-Lead SOIC_N	R-8 (P-Suffix)

[1] Z = RoHS Compliant Part.

NOTES

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