1.2875 V Micropower, Shunt Voltage Reference

ADR1500

FEATURES

Wide operating range: 50 µA to 10 mA
Initial accuracy: ±0.2% max
Output impedance: 1 Ω max
Wideband noise (10 Hz to 10 kHz): 20 µV rms
Operating temperature: −40°C to +85°C
Compact, surface-mount SC70 package

APPLICATIONS

Computer servers
Battery-powered instrumentation
Portable medical equipment
Automotive

GENERAL DESCRIPTION

The ADR1500 is a low cost, 2-terminal (shunt), precision band gap reference. It provides an accurate 1.2875 V output for input currents between 50 µA to 10 mA.

The low minimum operating current makes the ADR1500 ideal for use in battery-powered 3 V or 5 V systems. However, the wide operating current range means the ADR1500 is extremely versatile and suitable for use in a wide variety of high current applications.

The ADR1500 is available in the tiny SC70 package and is specified over the −40°C to +85°C operating temperature range.

PIN CONFIGURATION

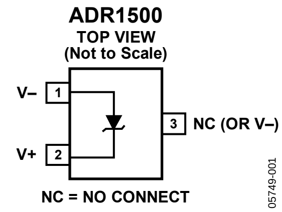

Figure 1. 3-Lead SC70 (KS Suffix)

Rev. 0

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REVISION HISTORY

1/06—Revision 0: Initial Version

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

T_A = 25°C, I_{IN} = 100 µA, unless otherwise noted.

Table 1.

Parameter	Min	Typ	Max	Unit
REVERSE VOLTAGE OUTPUT	1.2849	1.2875	1.2901	V
REVERSE VOLTAGE TEMPERATURE DRIFT, −40°C to +85°C		170	220	ppm/°C
MINUMUM OPERATING CURRENT, −40°C to +85°C			50	µA
REVERSE VOLTAGE CHANGE WITH REVERSE CURRENT				
50 µA < I_{IN} < 10 mA, −40°C to +85°C		3.0	6	mV
50 µA < I_{IN} < 1 mA, −40°C to +85°C		0.7		mV
DYNAMIC OUTPUT IMPEDANCE ($\Delta V_R/\Delta I_R$)				
I_{IN} = 1 mA ± 100 µA (f = 120 Hz)		0.4	1	Ω
OUTPUT NOISE				
RMS Noise Voltage: 10 Hz to 10 kHz		20		µV rms
Low Frequency Noise Voltage: 0.1 Hz to 10 Hz		5		µV p-p
TURN-ON SETTLING TIME TO 0.1%, NO C_{OUT}		5		µs
OUTPUT VOLTAGE HYSTERESIS		80		µV
TEMPERATURE RANGE				
Specified Range	−40		+85	°C
Operating Range	−55		+125	°C

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
Reverse Current	25 mA
Forward Current	20 mA
SC70 (KS) Package Dissipation	
θ_{JA}	376°C/W
θ_{JC}	189°C/W
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +150°C
Lead Temperature, Soldering	
Vapor Phase (60 sec)	215°C
Infrared (15 sec)	220°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.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

WARNING!

ESD SENSITIVE DEVICE

TYPICAL PERFORMANCE CHARACTERISTICS

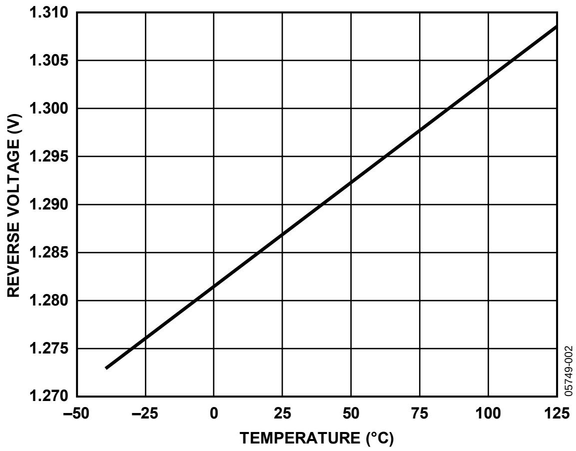

Figure 2. Output Drift for Different Temperature Characteristics

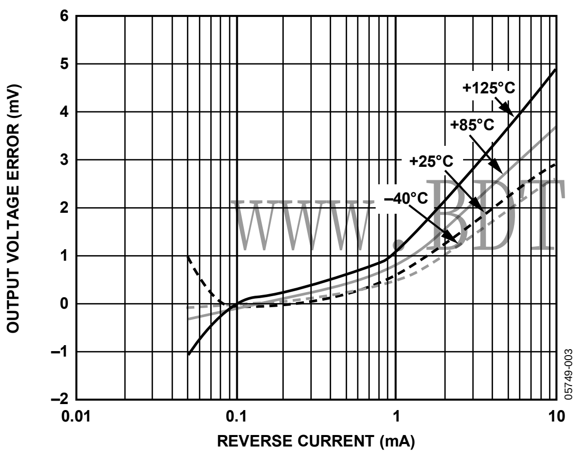

Figure 3. Output Voltage Error vs. Reverse Current

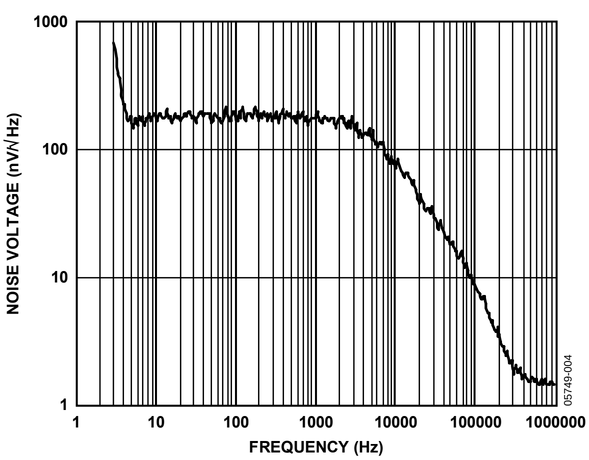

Figure 4. Noise Spectral Density

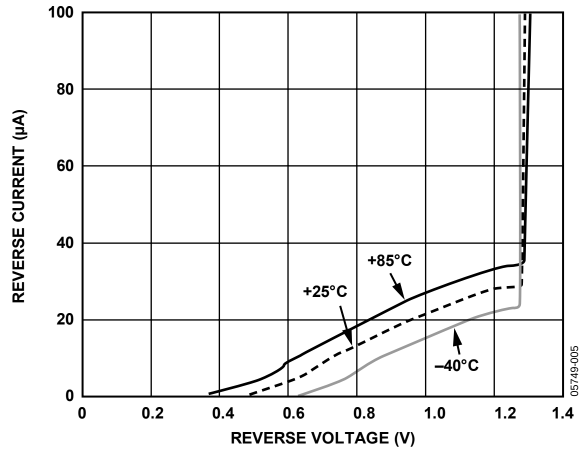

Figure 5. Reverse Current vs. Reverse Voltage

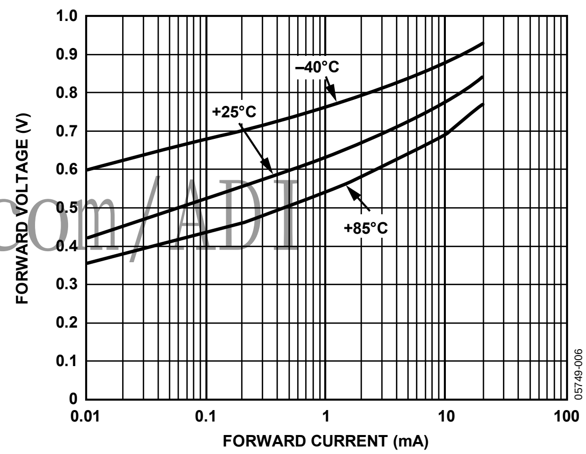

Figure 6. Forward Voltage vs. Forward Current

THEORY OF OPERATION

The ADR1500 uses the band gap concept to produce a stable voltage reference suitable for high accuracy data acquisition components and systems. This device makes use of the underlying physical nature of the silicon transistor base emitter voltage in the forward-biased operating region. All such transistors have an approximate −2 mV/°C temperature coefficient, which is not suitable for use as a low TC reference; however, extrapolation of the temperature characteristic of any one of these devices to absolute zero (with collector current proportional to absolute temperature) reveals that V_{BE} goes to approximately the silicon band gap voltage. Therefore, if a voltage could be developed with an opposing temperature coefficient to the sum with the V_{BE}, than a zero TC reference would result. The ADR1500 circuit in Figure 7 provides such a compensating voltage, V1, by deriving two transistors at different current densities and amplifying the resultant V_{BE} difference (ΔV_{BE}, which has a positive TC). The sum of the V_{BE} and V1 provides a stable voltage reference.

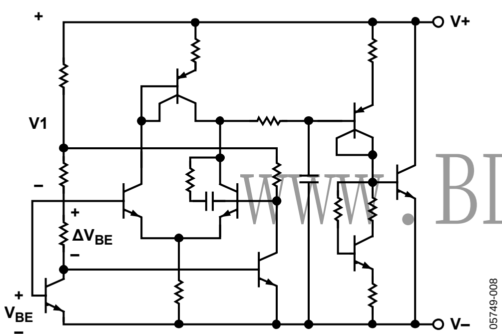

Figure 7. Schematic Diagram

APPLYING THE ADR1500

The ADR1500 is simple to use in virtually all applications. To operate the ADR1500 as a conventional shunt reference, see Figure 8. An external series resistor is connected between the supply voltage and the ADR1500.

For a given supply voltage, the series resistor, R_S, determines the reverse current flowing through the ADR1500. The value of R_S must be chosen to accommodate the expected variations of the supply voltage, V_S, load current, I_L, and the ADR1500 reverse voltage, V_R, while maintaining an acceptable reverse current, I_R, through the ADR1500.

The minimum value for R_S should be enough to limit I_R to 10 mA when V_S is at its maximum, and I_L and V_R are at their minimum. The equation for selecting R_S is

$$R_S = \frac{(V_S - V_R)}{(I_R + I_L)}$$

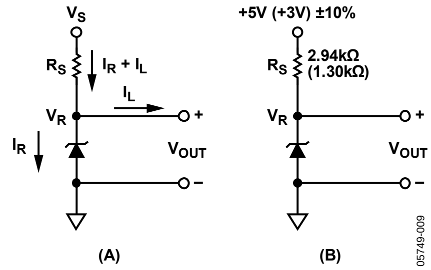

Figure 8. Typical Connection Diagram

Figure 8 shows a typical connection of the ADR1500 operating at a minimum of 100 µA. This connection can provide ±1 mA to the load, while accommodating ±10% power supply variations.

TURN-ON TIME

The turn-on time is a critical parameter for applications demanding a large amount of processing. Figure 9 shows the turn-on characteristics of the ADR1500.

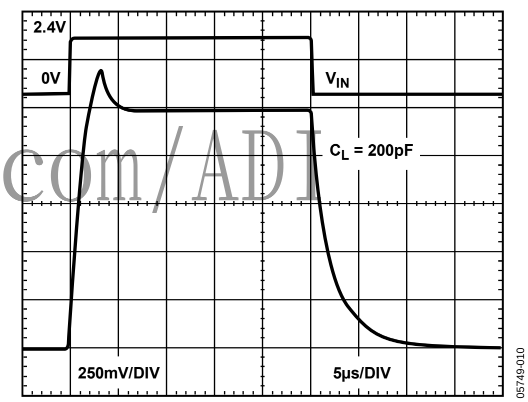

Figure 9. Response Time

Upon application of power (cold start), the time required for the output voltage to reach its final value within a specified error is the turn-on settling time. Tow components are normally associated with the time for active circuits to settle and the time for the thermal gradients on the chip to stabilize. This characteristic is generated from cold start operation and represents the true turn-on waveform after power up. Figure 10 shows both the course and fine turn-on settling characteristics of the device; the total settling time to within 1.0 mV is about 6 µs, and there is no long thermal tail when the horizontal scale is expanded to 2 µs/DIV. The output turn-on time is modified when an external noise reduction filter is used. When present, the time constant of the filter dominates the overall settling.

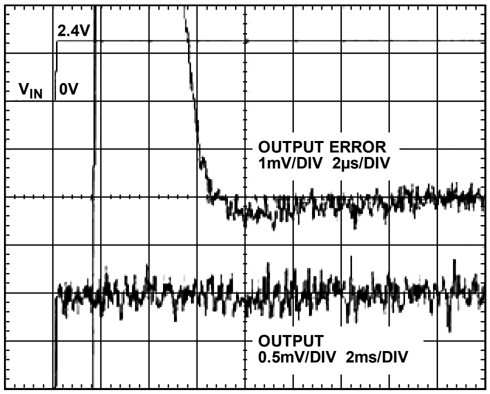

Figure 10. Turn-On Settling Time

Attempts to drive a large capacitive load (in excess of 1000 pF) can result in ringing. This is due to the additional poles formed by the load capacitance and the output impedance of the reference. A recommended method for driving capacitive loads of this magnitude is shown in Figure 11.

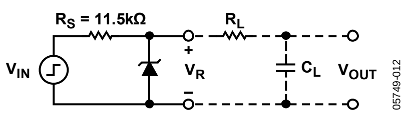

Figure 11. Turn-On, Settling, and Transient Test Circuit

TRANSIENT RESPONSE

Many ADCs and DACs present transient current loads to the reference. Poor reference response can degrade the converter's performance. Figure 12 displays both the coarse and fine settling characteristics of the device to load transient of ±50 µA.

It shows the settling characteristics of the device for an increased reverse current of 50 µA and the response when the reverse current is decreased by 50 µA. The transients settle to 1 mV in about 3 µs.

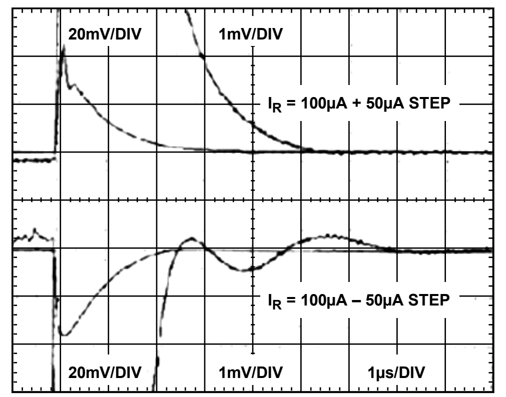

Figure 12. Transient Settling Time

A resistor isolates the capacitive load from the output stage, while the capacitor provides a single-pole, low-pass filter and lowers the output noise.

OUTLINE DIMENSIONS

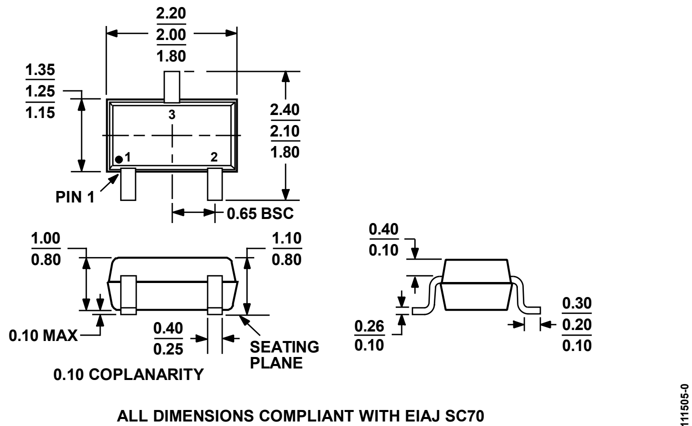

Figure 13. 3-Lead Thin Shrink Small Outline Transistor Package [SC70]
(KS-3)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Initial Output Error	Temperature Coefficient (Typ)	Temperature Range	Package Description	Package Option	Branding
ADR1500BKSZ-REEL[1]	2.6 mV	170 ppm/°C	–40°C to +85°C	3-Lead SC70	KS-3	R2F

[1] Z = Pb-free part.

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