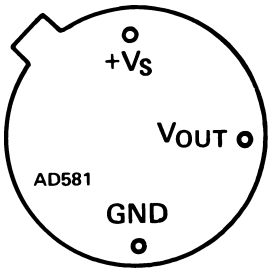
High Precision 10 V IC Reference

AD581*

FEATURES

Laser Trimmed to High Accuracy:
10.000 Volts ±5 mV (L and U)
Trimmed Temperature Coefficient:
5 ppm/°C max, 0°C to +70°C (L)
10 ppm/°C max, –55°C to +125°C (U)
Excellent Long-Term Stability:
25 ppm/1000 hrs. (Noncumulative)
Negative 10 Volt Reference Capability
Low Quiescent Current: 1.0 mA max
10 mA Current Output Capability
3-Terminal TO-5 Package
MIL-STD-883 Compliant Versions Available

FUNCTIONAL BLOCK DIAGRAM



TO-5

BOTTOM VIEW

PRODUCT DESCRIPTION

The AD581 is a three-terminal, temperature compensated, monolithic bandgap voltage reference which provides a precise 10.00 volt output from an unregulated input level from 12 to 30 volts. Laser Wafer Trimming (LWT) is used to trim both the initial error at +25°C as well as the temperature coefficient, which results in high precision performance previously available only in expensive hybrids or oven-regulated modules. The 5 mV initial error tolerance and 5 ppm/°C guaranteed temperature coefficient of the AD581L represent the best performance combination available in a monolithic voltage reference.

The bandgap circuit design used in the AD581 offers several advantages over classical Zener breakdown diode techniques. Most important, no external components are required to achieve full accuracy and stability of significance to low power systems. In addition, total supply current to the device, including the output buffer amplifier (which can supply up to 10 mA) is typically 750 μA. The long-term stability of the bandgap design is equivalent or superior to selected Zener reference diodes.

The AD581 is recommended for use as a reference for 8-, 10- or 12-bit D/A converters which require an external precision reference. The device is also ideal for all types of A/D converters up to 14-bit accuracy, either successive approximation or integrating designs, and in general can offer better performance than that provided by standard self-contained references.

The AD581J, K, and L are specified for operation from 0°C to +70°C; the AD581S, T, and U are specified for the –55°C to +125°C range. All grades are packaged in a hermetically sealed three-terminal TO-5 metal can.

***Covered by Patent Nos. 3,887,863; RE 30,586.**

PRODUCT HIGHLIGHTS

1. Laser trimming of both initial accuracy and temperature coefficient results in very low errors over temperature without the use of external components. The AD581L has a maximum deviation from 10.000 volts of ±7.25 mV from 0°C to +70°C, while the AD581U guarantees ±15 mV maximum total error without external trims from –55°C to +125°C.
2. Since the laser trimming is done on the wafer prior to separation into individual chips, the AD581 will be extremely valuable to hybrid designers for its ease of use, lack of required external trims, and inherent high performance.
3. The AD581 can also be operated in a two-terminal "Zener" mode to provide a precision negative 10 volt reference with just one external resistor to the unregulated supply. The performance in this mode is nearly equal to that of the standard three-terminal configuration.
4. Advanced circuit design using the bandgap concept allows the AD581 to give full performance with an unregulated input voltage down to 13 volts. With an external resistor, the device will operate with a supply as low as 11.4 volts.
5. The AD581 is available in versions compliant with MIL-STD-883. Refer to the Analog Devices Military Products Databook or current AD581/883B data sheet for detailed specifications.

AD581—SPECIFICATIONS (@ V_{IN} = +15 V and +25°C)

Model	AD581J Min	AD581J Typ	AD581J Max	AD581K Min	AD581K Typ	AD581K Max	AD581L Min	AD581L Typ	AD581L Max	Units
OUTPUT VOLTAGE TOLERANCE (Error from Nominal 10,000 V Output)			**±30**			**±10**			**±5**	mV
OUTPUT VOLTAGE CHANGE										
Maximum Deviation from +25°C			**±13.5**			**±6.75**			**±2.25**	mV
Value, T_{MIN} to T_{MAX} (Temperature Coefficient)			30			15			5	ppm/°C
LINE REGULATION										
15 V ≤ V_{IN} ≤ 30 V			**3.0**			**3.0**			**3.0**	mV
			(0.002)			(0.002)			(0.002)	%/V
13 V ≤ V_{IN} ≤ 15 V			**1.0**			**1.0**			**1.0**	mV
			(0.005)			(0.005)			(0.005)	%/V
LOAD REGULATION										
0 ≤ I_{OUT} ≤ 5 mA		200	**500**		200	**500**		200	**500**	µV/mA
QUIESCENT CURRENT		0.75	**1.0**		0.75	**1.0**		0.75	**1.0**	mA
TURN-ON SETTLING TIME TO 0.1%[1]		200			200			200		µs
NOISE (0.1 Hz to 10 Hz)		40			40			40		µV (p-p)
LONG-TERM STABILITY		25			25			25		ppm/1000 hrs.
SHORT-CIRCUIT CURRENT		30			30			30		mA
OUTPUT CURRENT										
Source @ +25°C	10			10			10			mA
Source T_{MIN} to T_{MAX}	5			5			5			mA
Sink T_{MIN} to T_{MAX}	5			5			5			µA
Sink –55°C to +85°C	–			–			–			mA
TEMPERATURE RANGE										
Specified	0		+70	0		+70	0		+70	°C
Operating	–65		+150	–65		+150	–65		+150	°C
PACKAGE OPTION[2]										
TO-5 (H-03B)		AD581JH			AD581KH			AD581LH		

Model	AD581S Min	AD581S Typ	AD581S Max	AD581T Min	AD581T Typ	AD581T Max	AD581U Min	AD581U Typ	AD581U Max	Units
OUTPUT VOLTAGE TOLERANCE (Error from Nominal 10,000 V Output)			**±30**			**±10**			**±5**	mV
OUTPUT VOLTAGE CHANGE										
Maximum Deviation from +25°C			**±30**			**±15**			**±10**	mV
Value, T_{MIN} to T_{MAX} (Temperature Coefficient)			30			15			10	ppm/°C
LINE REGULATION										
15 V ≤ V_{IN} ≤ 30 V			**3.0**			**3.0**			**3.0**	mV
			(0.002)			(0.002)			(0.002)	%/V
13 V ≤ V_{IN} ≤ 15 V			**1.0**			**1.0**			**1.0**	mV
			(0.005)			(0.005)			(0.005)	%/V
LOAD REGULATION										
0 ≤ I_{OUT} ≤ 5 mA		200	**500**		200	**500**		200	**500**	µV/mA
QUIESCENT CURRENT		0.75	**1.0**		0.75	**1.0**		0.75	**1.0**	mA
TURN-ON SETTLING TIME TO 0.1%[1]		200			200			200		µs
NOISE (0.1 Hz to 10 Hz)		40			40			40		µV (p-p)
LONG-TERM STABILITY		25			25			25		ppm/1000 hrs.
SHORT-CIRCUIT CURRENT		30			30			30		mA
OUTPUT CURRENT										
Source @ +25°C	10			10			10			mA
Source T_{MIN} to T_{MAX}	5			5			5			mA
Sink T_{MIN} to T_{MAX}	200			200			200			µA
Sink –55°C to +85°C	5			5			5			mA
TEMPERATURE RANGE										
Specified	–55		+125	–55		+125	–55		+125	°C
Operating	–65		+150	–65		+150	–65		+150	°C
PACKAGE OPTION[2]										
TO-5 (H-03B)		AD581SH			AD581TH			AD581UH		

NOTES

[1]See Figure 7.

[2]H = Hermetic Metal Can.

Specifications subject to change without notice.

Specifications shown in **boldface** are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels. All min and max specifications are guaranteed, although only those shown in **boldface** are tested on all production units.

ABSOLUTE MAXIMUM RATINGS

Input Voltage . . . . . 40 V
Power Dissipation @ +25°C . . . . . 600 mW
Operating Junction Temperature Range . . . . –55°C to +150°C
Lead Temperature (Soldering 10 sec) . . . . . +300°C
Thermal Resistance
Junction-to-Ambient . . . . . 150°C/W

APPLYING THE AD581

The AD581 is easy to use in virtually all precision reference applications. The three terminals are simply primary supply, ground, and output, with the case grounded. No external components are required even for high precision applications; the degree of desired absolute accuracy is achieved simply by selecting the required device grade. The AD581 requires less than 1 mA quiescent current from an operating supply range of 12 to 30 volts.

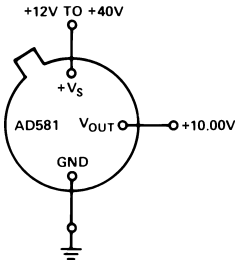


Figure 1. AD581 Pin Configuration (Bottom View)

An external fine trim may be desired to set the output level to exactly 10.000 volts within less than a millivolt (calibrated to a main system reference). System calibration may also require a reference slightly different from 10.00 volts. In either case, the optional trim circuit shown in Figure 2 can offset the output by up to ±30 millivolts (with the 22 Ω resistor), if needed, with minimal effect on other device characteristics.

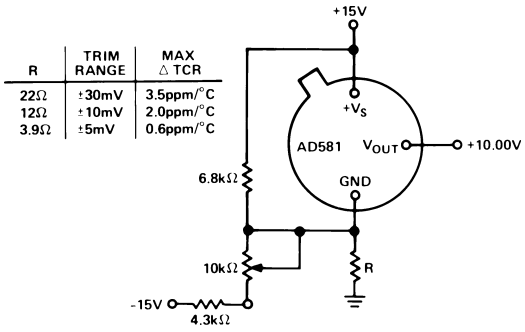


Figure 2. Optional Fine Trim Configuration

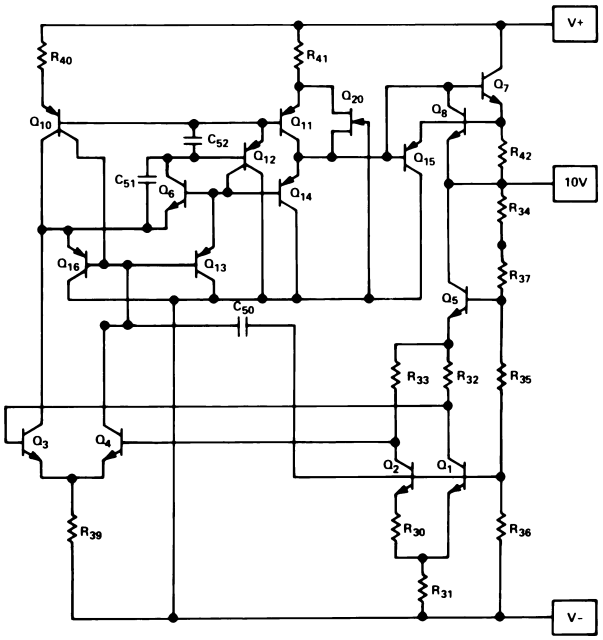


Figure 3. Simplified Schematic

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 voltage will fall within the given error band. The temperature characteristic of the AD581 consistently follows the S-curve shown in Figure 4. Three-point measurement of each device guarantees the error band over the specified temperature range.

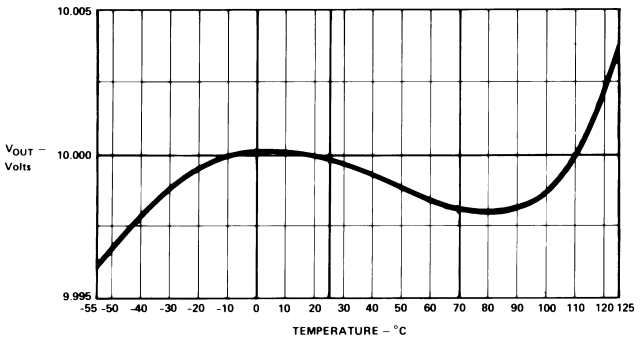


Figure 4. Typical Temperature Characteristic

The error band which is guaranteed with the AD581 is the maximum deviation from the initial value at +25°C; this error band is of more use to a designer than one which simply guarantees the maximum total change over the entire range (i.e., in the latter definition, all of the changes could occur in the positive direction). Thus, with a given grade of the AD581, the designer can easily determine the maximum total error from initial tolerance plus temperature variation (e.g., for the AD581T,

THE PRECISION 12-BIT D/A CONVERTER REFERENCE

AD562, like most D/A converters, is designed to operate with a +10 volt reference element. In the AD562, this 10 volt reference voltage is converted into a reference current of approximately 0.5 mA via the internal 19.95 kΩ resistor (in series with the external 100 Ω trimmer). The gain temperature coefficient of the AD562 is primarily governed by the temperature tracking of the 19.95 kΩ resistor and the 5k/10k span resistors; gain TC is guaranteed to 3 ppm/°C. Thus, using the AD581L (at 5 ppm/°C) as the 10 volt reference guarantees a maximum full-scale temperature coefficient of 8 ppm/°C over commercial range. The 10 volt reference also supplies the normal 1 mA bipolar offset current through the 9.95k bipolar offset resistor. The bipolar offset TC thus depends only on TC matching of the bipolar offset resistor to the input reference resistor and is guaranteed to 3 ppm/°C.

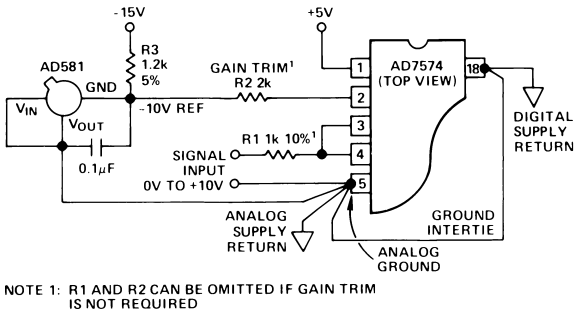


Figure 14. AD581 as Negative 10-Volt Reference for CMOS ADC

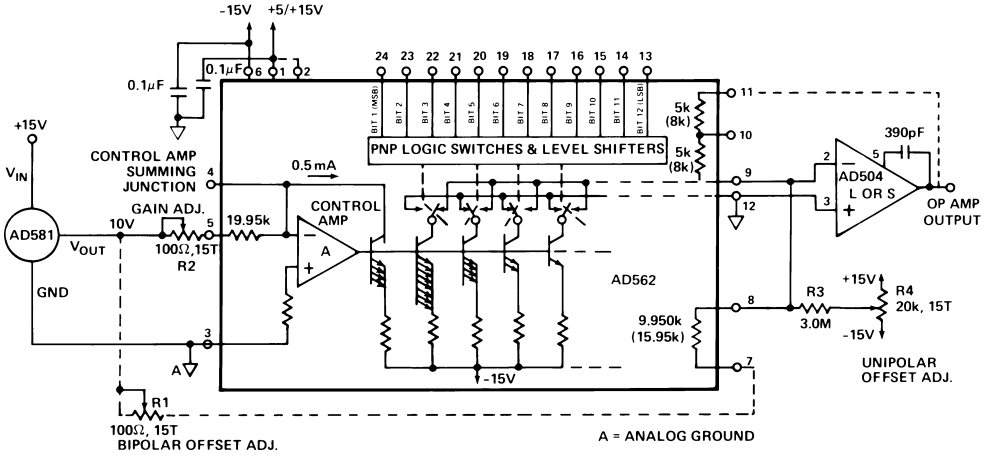
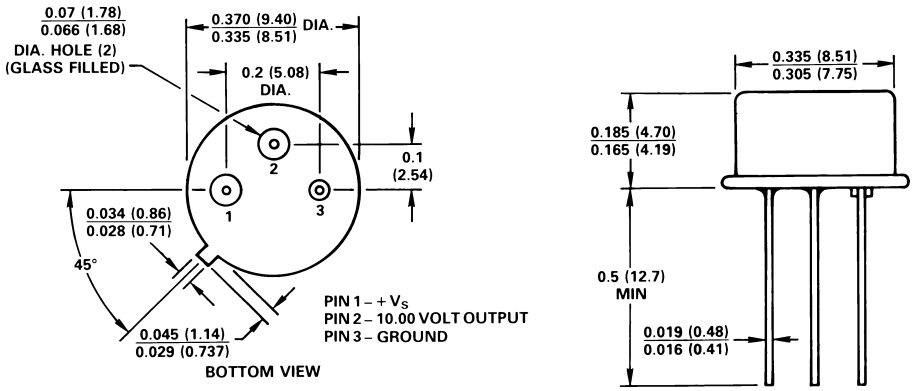


Figure 15. Precision 12-Bit D/A Converter

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



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