



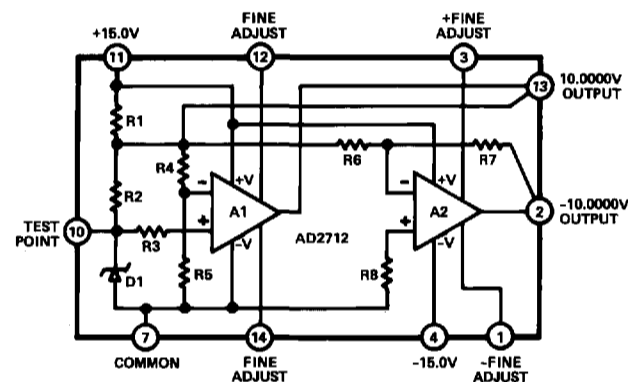
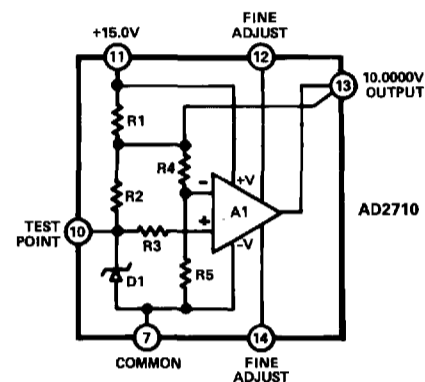
## $\pm 10.000$ Volt Ultrahigh Precision Reference Series

### AD2710/AD2712

#### FEATURES

- Laser Trimmed to High Accuracy:  $10.000\text{V} \pm 1.0\text{mV}$
- Low Temperature Coefficient:  $1\text{ppm}/^\circ\text{C}$  (L Grade)
- Excellent Long Term Stability:  $25\text{ppm}/1000\text{hrs.}$
- 5mA Output Current Capability
- Low Noise:  $30\mu\text{V}$  p-p
- Short Circuit Protected
- No Heater Utilized
- Small Size (Standard 14-Pin DIP Package)

#### FUNCTIONAL BLOCK DIAGRAMS



#### PRODUCT DESCRIPTION

The AD2710 and AD2712 are temperature-compensated, hybrid voltage references which provide precise  $10.000\text{V}$  output from an unregulated input level from  $13.5$  to  $16.5$  volts. Active laser trimming is used to trim both the initial error at  $+25^\circ\text{C}$  as well as the temperature coefficient, which results in ultra high precision performance previously available only in oven-regulated modules. The  $1.0\text{mV}$  maximum initial error and  $1\text{ppm}/^\circ\text{C}$  guaranteed maximum temperature coefficient of the AD2710L and AD2712L represent the best performance combination available without using ovens or heated substrates for temperature regulation.

The AD2710 series of precision  $10.000$  volt references offer the user unequalled accuracy and stability with performance guaranteed over the  $0$  to  $+70^\circ\text{C}$  temperature range. The devices combine the recognized advantages of thin film technology and active laser trimming with a unique integrated ceramic package design to provide an excellent reference for use in applications requiring high accuracy and stability.

The AD2710 is recommended for use as a reference for 10-, 12- and 14-bit D/A converters which require an external reference. The device is also suitable for many types of high resolution A/D converters, either successive approximation or integrating designs. The  $5\text{mA}$  output drive capability of the device also makes the AD2710 ideal for use as a master system reference.

For systems requiring a dual tracking reference, the AD2712 offers both positive and negative outputs in a single package. All units are packaged in an integrated ceramic 14-pin side-brazed package offering superior reliability over other package designs.

#### REV. A

Information furnished by Analog Devices is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices.

#### PRODUCT HIGHLIGHTS

- Active laser trimming of both initial accuracy and temperature coefficient results in very high accuracy over the temperature range without the use of external components. AD2710 has a maximum deviation from  $10.000$  volts of  $\pm 1.00\text{mV}$  at  $25^\circ\text{C}$  with no external adjustments.
- The AD2710 and AD2712 are well suited for a broad range of applications requiring an accurate, stable reference source such as data converters, test and measurement systems and calibration standards.
- The performance of the AD2710 series is achieved by a well-characterized design and close control over the manufacturing process. This eliminates the need for temperature-controlled ovens to provide stability.
- The advanced multilayer integrated ceramic package results in superior electrical performance as well as inherent high reliability.

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.  
Tel: 617/329-4700 Fax: 617/326-8703 Twx: 710/394-6577  
Telex: 924491 Cable: ANALOG NORWOODMASS

## AD2710/AD2712—SPECIFICATIONS (typical @ $V_S \pm 15V$ after a 5 minute warm-up at $+25^\circ C$ , no load condition unless otherwise specified)

Model	AD2710KN	AD2710LN	AD2712KN	AD2712LN
<b>ABSOLUTE MAXIMUM RATINGS</b>				
Input Voltage (for applicable supply)	$\pm 18V$	*	*	*
Power Dissipation @ $+25^\circ C$	300mW	*	450mW	**
Operating Temperature Range	0 to $+70^\circ C$	*	*	*
Storage Temperature Range	$-55^\circ C$ to $+100^\circ C$	*	*	*
Lead Temperature (soldering, 20s)	$+260^\circ C$	*	*	*
Short Circuit Protection (to GND)	Continuous	*	*	*
<b>OUTPUT VOLTAGE ERROR<sup>1</sup></b>				
$+25^\circ C$	$\pm 1.0mV$ max	*	*	*
<b>OUTPUT VOLTAGE TEMPERATURE COEFFICIENT<sup>2</sup></b>				
+10V Output	$+25^\circ C$ to $+70^\circ C$ 0 to $+25^\circ C$	$\pm 2ppm/^\circ C$ max $\pm 5ppm/^\circ C$ max	$\pm 1ppm/^\circ C$ max * <sup>3</sup>	$\pm 2ppm/^\circ C$ max *
-10V Output <sup>4</sup>	$+25^\circ C$ to $+70^\circ C$ 0 to $+25^\circ C$	Not Applicable Not Applicable	Not Applicable Not Applicable	$\pm 3ppm/^\circ C$ max $\pm 5ppm/^\circ C$ max **
<b>LINE REGULATION</b>				
$V_S = \pm 13.5$ to $\pm 16.5^5$	$125\mu V/V$ ( $200\mu V/V$ max)	*	*	*
<b>OUTPUT CURRENT</b>				
	10mA	*	*	*
<b>LOAD REGULATION</b>				
$I_O = 0$ to $\pm 5mA$	$50\mu V/mA$ ( $100\mu V/mA$ max)	*	*	*
<b>OUTPUT RESISTANCE</b>				
	$0.05\Omega$	*	*	*
<b>INPUT VOLTAGE<sup>5</sup></b>				
Operating Range	$\pm 13V$ to $\pm 18V$	*	*	*
Specified Performance	$\pm 13.5V$ to $\pm 16.5V$	*	*	*
<b>QUIESCENT SUPPLY CURRENT</b>				
$V_{S+}$	9mA (14mA max)	*	12mA (16mA max)	**
$V_{S-}^5$	Not Applicable	Not Applicable	2mA (4mA max)	**
<b>NOISE</b>				
0.1 to 10Hz	$30\mu V$ p-p	*	*	*
<b>LONG-TERM STABILITY</b>				
$T_A = +25^\circ C$	25ppm/1000 Hours	*	*	*
<b>EXTERNAL TRIM RANGE<sup>6</sup></b>				
	$\pm 10mV$	*	*	*
<b>PACKAGE OPTION<sup>7</sup></b>				
	DH-14D	*	*	*

### NOTES

\*Same as AD2710KN. \*\*Same as AD2712KN performance.

<sup>1</sup> Specifications apply to both outputs of the AD2712.

<sup>2</sup> Refer to next page for definition of temperature-related error specifications.

<sup>3</sup> The AD2710LN and AD2712LN outputs are guaranteed for a maximum  $\pm 2ppm/^\circ C$  temperature coefficient over the  $+15^\circ C$  to  $+25^\circ C$  temperature range. Refer to Figure 1.

<sup>4</sup> The  $+10V$  and  $-10V$  outputs of the AD2712 typically track within  $\pm 1ppm/^\circ C$  over the specified temperature range.

<sup>5</sup> Negative power supply not required for AD2710.

<sup>6</sup> Use of the output trim will change the temperature coefficient approximately  $0.3ppm/^\circ C$  for each millivolt of adjustment.

<sup>7</sup> For outline information see Package Information section.

Specifications subject to change without notice.

## Applying the AD2710/AD2712

### UNDERSTANDING THE SPECIFICATIONS

The AD2710 and AD2712 precision references are designed for applications requiring both the lowest possible initial error at room temperature and the lowest possible temperature drift. The specification for initial error is relatively straight-forward, and is the absolute error from exactly 10.000V. The specification for temperature drift, however, must be explained.

Various methods have been used to specify the temperature drift of voltage references, including the "butterfly", "box", and "modified-box" (or total error) methods. The AD2710 and AD2712 are specified with the "butterfly" method.

Using three or more temperatures provides the user with a tighter drift specification, eliminating possible mid-range excursions. The AD2710 and AD2712 have been designed and characterized as having a smooth drift curve with a virtually straight segment from +25°C to +70°C. The typical curve as shown is concave downward and gradually increases slope near 0°C.

As can be seen from Figure 1, the AD2710L and AD2712L +10V outputs will exhibit a maximum temperature coefficient of  $\pm 1\text{ppm}/^\circ\text{C}$  ( $\pm 2\text{ppm}/^\circ\text{C}$  for "K" grade) from +25°C to +70°C. Over the short range between +15°C and +25°C, the AD2710L and AD2712L +10V outputs have a maximum drift of only  $\pm 2\text{ppm}/^\circ\text{C}$  and a maximum drift of  $\pm 5\text{ppm}/^\circ\text{C}$  from 0 to +15°C. The negative output of the AD2712L has a similar temperature coefficient characteristic with a maximum slope of  $\pm 2\text{ppm}/^\circ\text{C}$  from +25°C to +70°C. This limit continues from +25°C to +15°C and then increases to a  $\pm 5\text{ppm}/^\circ\text{C}$  maximum slope from +15°C and 0°C. Every unit is 100 percent tested and guaranteed to meet these specifications over the full 0 to +70°C temperature range.

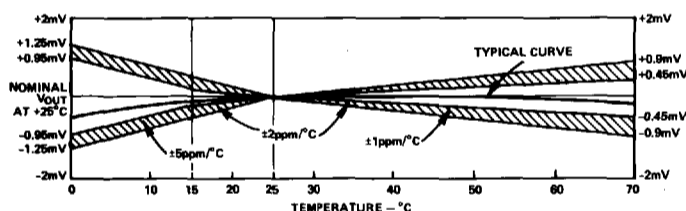


Figure 1. Maximum Change from +10V Output from +25°C Value vs. Temperature

All grades of the AD2710 and AD2712 are tested after a five minute warm-up period. This warm-up allows the entire circuit to attain thermal equilibrium. The warm-up drift is approximately 500 microvolts and is completely settled approximately three minutes after turn-on. Figure 2 shows the typical warm-up characteristics of the AD2710.

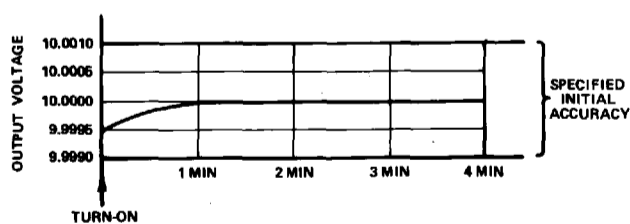


Figure 2. AD2710 Typical Warm-Up Drift

### USING THE AD2710 AS A DAC REFERENCE

Digital-to-analog converters require a reference to establish

the full scale output range. It is this reference which will ultimately determine the absolute accuracy of the converter. While many converters include internal reference sources, better overall performance can be obtained if a higher precision external reference is used.

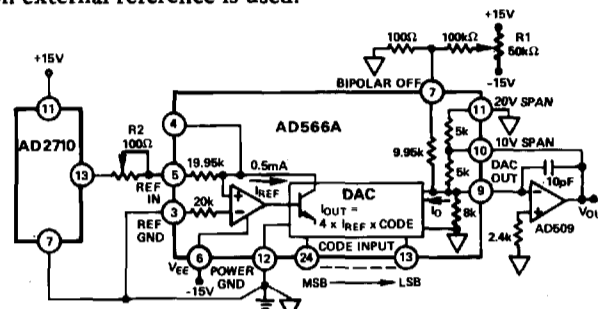


Figure 3. Low Drift 12-Bit D/A Converter

Figure 3 shows the AD2710 used with the AD566A high-speed 12-bit DAC. The AD566AKD is laser trimmed for  $\pm 1/4\text{LSB}$  maximum nonlinearity, and exhibits a gain temperature coefficient of  $3\text{ppm}/^\circ\text{C}$ . Use of the AD2710LN reference will result in a worst case total gain temperature coefficient of  $4\text{ppm}/^\circ\text{C}$ . After initial calibration of the DAC scale factor at room temperature, 12-bit absolute accuracy can be maintained over the +15°C to +70°C temperature range. The high output current capability of the AD2710 allows it to serve as a reference for up to 10 such converters in a system.

The resolution of the AD566A can be extended as shown in Figure 3 by summing the output of another DAC. In this example, an AD559 is used to provide 4 additional bits. Since the AD559 is driven from the same AD2710 reference as the AD566A which provides the higher-order bits, and uses a similar internal thin-film resistor ladder, it will exhibit first-order temperature tracking. While this circuit provides 16-bits of resolution, it is only as accurate as the AD566A used for the most significant bits. Use of an AD566AKD will typically achieve  $\pm 0.003\%$  accuracy ( $\pm 1/2\text{LSB}$  at 14 bits).

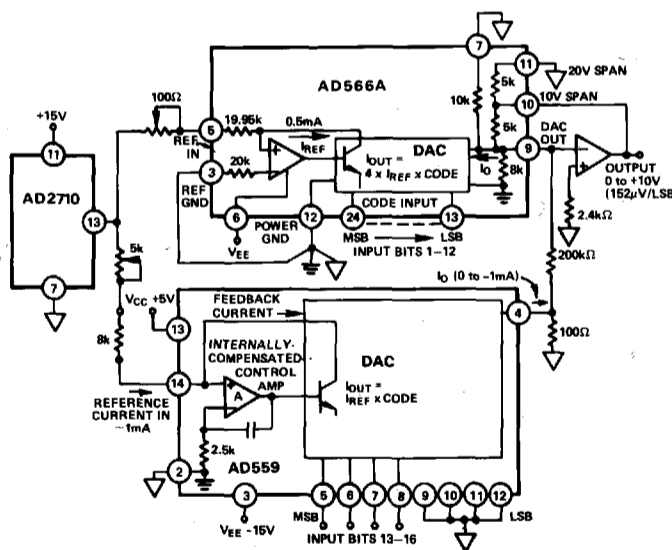
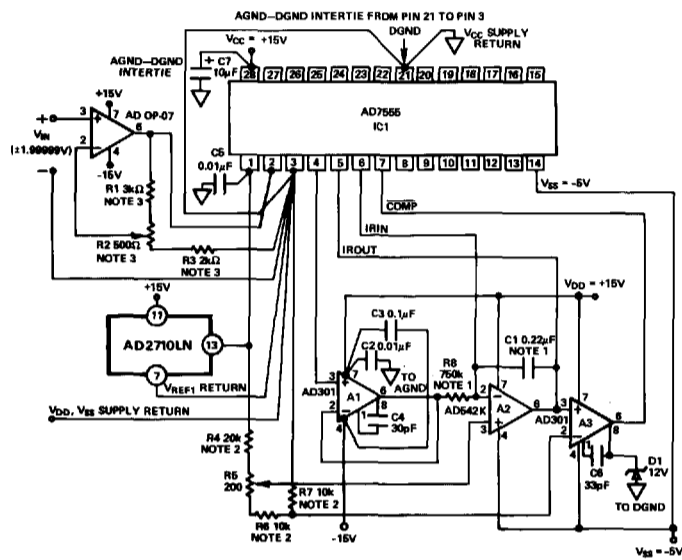


Figure 4. 16-Bit Binary DAC with AD2710 Reference

# AD2710/AD2712

**HIGH RESOLUTION ANALOG-TO-DIGITAL CONVERSION**  
 The AD2710 is well-suited to both system and instrument-level analog-to-digital converter reference requirements. The excellent absolute accuracy and low temperature drift allow low-cost measurement systems to offer high levels of performance. The AD7555 is a 4 1/2 digit ADC subsystem which uses the quad-slope conversion technique to achieve high accuracy at

low cost. This patented conversion process performs automatic correction for offsets and other errors in the analog circuitry as a part of each conversion. Total scale factor drift 1.2ppm/°C is possible using the AD2710L reference and medium-precision external amplifiers. This represents a full scale drift of less than ±10 counts in ±200,000 from +15°C to +45°C. Less than 1 count of drift will occur in the 4 1/2 digit mode.



- NOTES:**  
 1. R8, C1 VALUES SHOWN ARE FOR 5 1/2 DIGIT MODE. FOR 4 1/2 DIGIT MODE R8 = 360k, C1 = 0.22μF. SUITABLE CAPACITORS AVAILABLE FROM COMPONENT RESEARCH CO. INC., 1655 26th STREET, SANTA MONICA, CA, 90404. (STOCK NUMBER FOR 0.22μF CAPACITOR IS D11B224KXW).  
 2. R4, R6, R7 1% TOLERANCE  
 3. R1, R3 SHOULD TRACK WITHIN 0.5ppm/°C. EITHER BULK METAL OR WIRE-WOUND RESISTORS (OR A THIN-FILM NETWORK) SHOULD BE USED. R2 SHOULD BE A LOW-TC TYPE POTENTIOMETER OR A SELECTED LOW DRIFT FIXED RESISTOR.

Figure 5. High Accuracy Low Drift A/D Converter

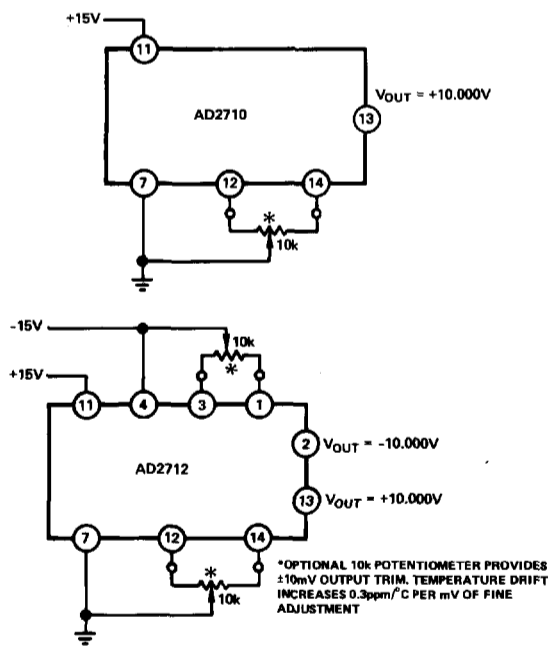


Figure 6. Optional Fine Trim Connections

The AD7555 was designed for use with a 4.096V reference, which produces a ±2 volt input range. When the AD2710 is used, the input range is increased to ±4.88281V (24.4μV/count). The new scaling can be handled either by using a precision gain stage before the AD7555 analog input as shown or by using a microprocessor to digitally correct the scale. The actual input signal value can be computed by multiplying the count produced by the AD7555 by VREF1 (10 volts in this case), and dividing the result by 409600. Details of the digital circuitry of the AD7555 can be found on the AD7555 data sheet.

It should be noted that when the AD7555 is used with the AD2710 10 volt reference, it is necessary to use a VCC greater than 10 volts. Thus the digital inputs and outputs of the ADC will be compatible with CMOS logic levels.

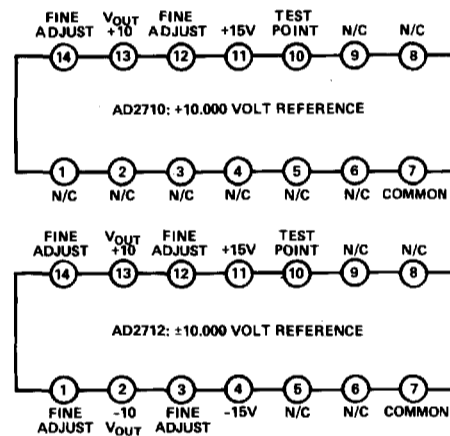
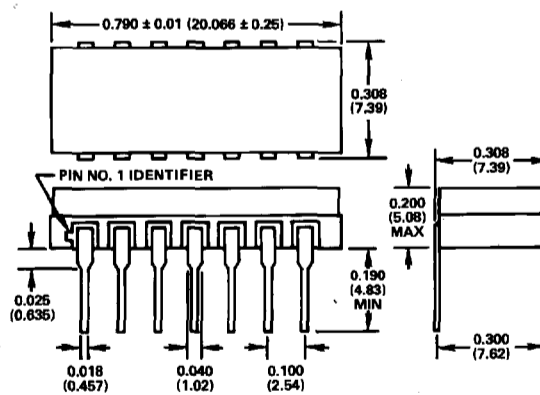


Figure 7. Pin Connections (Top View)

### OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



C6738-2-4/86

PRINTED IN U.S.A.