

# MAXIM

## 10 Volt Precision References

AD2700/2701/2710

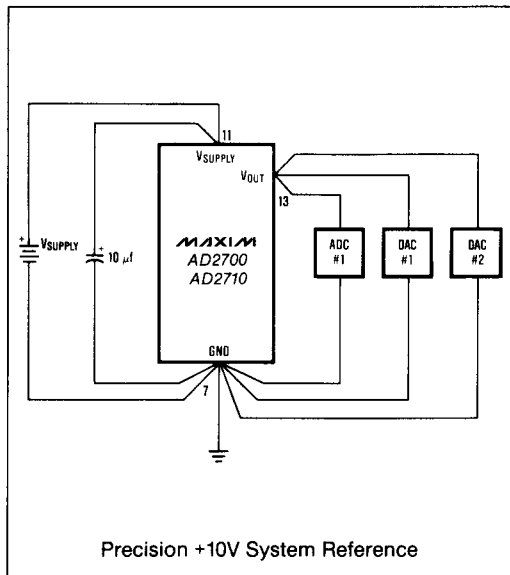
### General Description

The AD2700 series of precision 10 volt reference sources offers excellent accuracy and stability. Laser trimming of both initial accuracy and temperature drift ensures high precision over the commercial (0°C to +70°C), industrial (-25°C to +85°C) and military (-55°C to +125°C) temperature ranges. The guaranteed absolute accuracy allows the user to configure systems without the need for ovens or chip heaters for temperature regulation. The AD2700 is a +10 volt output reference while the AD2701 is a -10 volt output. Both devices are guaranteed to 3ppm/°C max with 2.5mV initial accuracy. The AD2710, with a +10 volt output, is guaranteed to 1ppm/°C max with 1mV initial accuracy. These products are designed to interface with high accuracy, high resolution A to D and D to A converters, precision instrumentation, and data acquisition systems.

### Applications

- Precision D/A and A/D Converter Reference
- Digital Voltmeters
- Precision Test and Measurement Systems
- Precision Calibrated Voltage Reference Standard
- High Accuracy Transducers

### Typical Operating Circuit



### Features

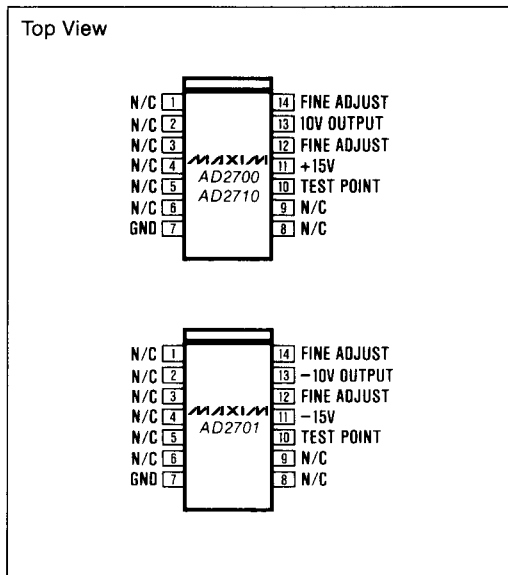
- ◆ Pin-for-Pin 2nd Source!
- ◆ Excellent Initial Accuracy
- ◆ Low Temperature Coefficient
- ◆ Excellent Long-Term Stability, 50ppm/1000hrs.
- ◆ 10mA Output Current Capability
- ◆ Superior Line Regulation: 100µV/V max.
- ◆ Standard Ceramic Side Brazed DIP

### Ordering Information

PART	OUTPUT VOLTAGE	TEMP. RANGE
AD2700JD	+10V, 10 ppm/°C	-25°C to +85°C
AD2700LD	+10V, 3 ppm/°C	-25°C to +85°C
AD2700SD	+10V, 3 ppm/°C	-55°C to +125°C
AD2700UD	+10V, 3 ppm/°C	-55°C to +125°C
AD2701JD	-10V, 10 ppm/°C	-25°C to +85°C
AD2701LD	-10V, 3 ppm/°C	-25°C to +85°C
AD2701SD	-10V, 3 ppm/°C	-55°C to +125°C
AD2701UD	-10V, 3 ppm/°C	-55°C to +125°C
AD2710LD	+10V, 1 ppm/°C	0°C to +70°C
AD2710KD	+10V, 2 ppm/°C	0°C to +70°C

All devices are available in a 14 lead ceramic side brazed DIP.

### Pin Configuration



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## ABSOLUTE MAXIMUM RATINGS

Input Voltage .....	+20V	Storage Temperature .....	-65°C to +160°C
Power Dissipation .....	400mW	Lead Temperature .....	+300°C
Operating Temperature Range		(soldering, 10 seconds)	
AD2700JD, LD, AD2701JD, LD .....	-25°C to +85°C	Short Circuit to GND .....	Continuous
AD2700SD, UD, AD2701SD, UD .....	-55°C to +125°C		
AD2710KD, LD .....	0°C to +70°C		

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>IN</sub> = +15V for AD2700 and AD2710, V<sub>IN</sub> = -15V for AD2701, T<sub>A</sub> = +25°C, R<sub>L</sub> = 2kΩ, unless otherwise noted)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Initial Output Voltage	AD2700JD, SD	9.9950	10.0000	10.0050	V
	AD2700LD, UD	9.9975	10.0000	10.0025	V
	AD2701JD, SD	-10.0050	-10.0000	-9.9950	V
	AD2701LD, UD	-10.0025	-10.0000	-9.9975	V
	AD2710KD, LD	9.9990	10.0000	10.0010	V
Output Voltage Drift	AD2700,01JD T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			10	ppm/°C
	AD2700,01LD, SD, UD T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			3	ppm/°C
	AD2710KD T <sub>A</sub> = +25°C to +70°C			2	ppm/°C
	AD2710LD T <sub>A</sub> = +25°C to +70°C			1	ppm/°C
	AD2710KD T <sub>A</sub> = 0°C to +25°C			5	ppm/°C
	AD2710LD T <sub>A</sub> = 15°C to +25°C			2	ppm/°C
Output Voltage Range	AD2700JD, AD2701JD T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			±11.0	mV
	AD2700LD, AD2701LD T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			±4.3	mV
	AD2700SD, AD2701SD T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			±8.0	mV
	AD2700UD, AD2701UD T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>			±5.5	mV
Output Current	T <sub>A</sub> = 25°C, for Specified Load Regulation			10	mA
	T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> V <sub>IN</sub> = +13V to +18V (2700, 2710) V <sub>IN</sub> = -13V to -18V (2701)			5	mA
Line Regulation	V <sub>IN</sub> = +13.5V to +16.5V (2700, 2710)			100	μV/V
	V <sub>IN</sub> = -13.5V to -16.5V (2701)			100	μV/V
Load Regulation	0 to 10mA to GND			50	μV/mA
Output Resistance	0 to 10mA to GND			0.05	Ω
Input Voltage Range	AD2700, AD2710	+13		+18	V
	AD2701	-13		-18	V
Quiescent Current	No Load		9	14	mA
Noise (Note 1)	0.1 to 10Hz		6	50	μV <sub>P-P</sub>
Long Term Stability	T <sub>A</sub> = +55°C		50		ppm/1000 hrs.
Output Adjust Range	See Figure 1 and 2		±20		mV
Output Adjust Temperature Drift Effect			±4		μV/°C per mV of adjust

Note 1: QA sample tested.

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## Theory of Operation

A zener voltage of approximately 6.3V is applied to the non-inverting input of an operational amplifier. This voltage is accurately amplified to produce a precise 10.000V output. The amplifier's gain setting resistors are actively laser-trimmed to produce the desired output voltage. The zener operating current is derived from the regulated output voltage, and actively laser-trimmed to produce the lowest drift over temperature at the output of the amplifier.

## Discussion of Performance

The Maxim AD2700 and AD2701 are designed for applications requiring a precision voltage reference, where initial accuracy at room temperature and drift over temperature are of prime importance.

The drift specification of the AD2700 and AD2701 are guaranteed by making precise voltage measurements at  $-55^{\circ}\text{C}$ ,  $-25^{\circ}\text{C}$ ,  $+25^{\circ}\text{C}$ ,  $+85^{\circ}\text{C}$ , and  $-125^{\circ}\text{C}$ , while maintaining unit identity. In this way, three key specifications are guaranteed: initial accuracy, absolute accuracy over temperature, and drift. The upper and lower bound limits of absolute accuracy over temperature are established by the sum of the maximum initial output voltage error and the maximum drift from  $+25^{\circ}\text{C}$  to  $T_{\text{MAX}}$ . For example, the AD2700LD limit of 4.3mV is calculated from the addition of 2.5mV initial output voltage error plus the temperature drift error of 1.8mV [ $3\text{ppm}/^{\circ}\text{C} \times 10\text{V} \times (85^{\circ}\text{C} - 25^{\circ}\text{C})$ ].

The drift specification is defined using the "box method" (Fig. 3). The "box" is formed by the  $T_{\text{MAX}}$  and  $T_{\text{MIN}}$  temperatures and a diagonal with a slope equal to the maximum specified drift. The maximum and minimum output voltages must meet the following conditions:

$$\frac{(V_{\text{OUTMAX}} - V_{\text{OUTMIN}})/10\text{V}}{T_{\text{MAX}} - T_{\text{MIN}}} \times 10^6 \leq \text{drift specification}$$

This assures that the output voltage variation over the temperature change is contained within the box with  $V_{\text{OUTMAX}}$  and  $V_{\text{OUTMIN}}$  limits.

For example, the AD2700LD maximum drift specification of 3ppm/ $^{\circ}\text{C}$  from  $-25^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  restricts  $(V_{\text{OUTMAX}} - V_{\text{OUTMIN}})$  to less than 3.3mV.

The AD2710 drift specification is defined over the temperature range of  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  using the "butterfly" method (Fig. 4), where endpoint measurements are tested for temperature coefficient from  $25^{\circ}\text{C}$  independent of the nominal voltage. Each device is tested at  $0^{\circ}\text{C}$ ,  $+15^{\circ}\text{C}$ ,  $+25^{\circ}\text{C}$ , and  $+70^{\circ}\text{C}$  with the output voltage data recorded at each temperature. After the initial accuracy is checked for 1mV deviation from +10.000V at  $+25^{\circ}\text{C}$ , the devices are graded according to temperature coefficient (TC). The AD2710K has a temperature coefficient less than or equal to 2ppm/ $^{\circ}\text{C}$  from  $+25^{\circ}\text{C}$  to

$+70^{\circ}\text{C}$  and 5ppm/ $^{\circ}\text{C}$  from  $0^{\circ}\text{C}$  to  $+25^{\circ}\text{C}$ . These temperature coefficients correspond to a maximum change of 0.90mV and 1.25mV respectively (see Fig. 4a).

$$10\text{V} \times (70^{\circ}\text{C} - 25^{\circ}\text{C}) \times 2 \times 10^{-6} = 0.90\text{mV}$$

$$10\text{V} \times (25^{\circ}\text{C} - 0^{\circ}\text{C}) \times 5 \times 10^{-6} = 1.25\text{mV}$$

Similarly, the AD2710L is tested for 1ppm/ $^{\circ}\text{C}$  from  $+25^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ , 2ppm/ $^{\circ}\text{C}$  from  $+15^{\circ}\text{C}$  to  $+25^{\circ}\text{C}$ , and 5ppm/ $^{\circ}\text{C}$  from  $0^{\circ}\text{C}$  to  $+15^{\circ}\text{C}$  (see Fig. 4b). The corresponding voltage limits are 0.45mV from  $25^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ , 0.2mV from  $+15^{\circ}\text{C}$  to  $+25^{\circ}\text{C}$ , and 0.75mV from  $0^{\circ}\text{C}$  to  $+15^{\circ}\text{C}$  which, when added to the 0.2mV at  $+15^{\circ}\text{C}$ , allows for 0.95mV change at  $0^{\circ}\text{C}$ .

## Application Information

The Typical Operating Circuit shown on the front page shows the proper connection for the AD2700/2710. Special attention to layout is required to achieve the specified performance. A low resistance star configuration will reduce voltage errors, noise pickup, and noise coupled from the power supply.

The output voltage of the AD2700 and AD2710 can be trimmed, as shown in Figure 1, by connecting an external potentiometer between pins 12 and 14 with the wiper connected to ground. This external potentiometer provides typically  $\pm 20\text{mV}$  of output adjustment. The voltage drift will change by approximately 0.4ppm/ $^{\circ}\text{C}$  (or  $4\mu\text{V}/^{\circ}\text{C}$ ) per mV of adjustment.

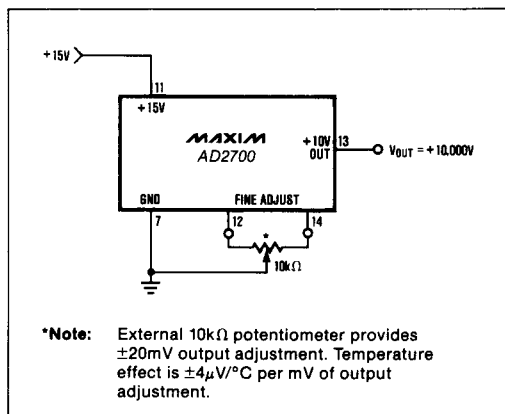


Figure 1. Fine Trim Connection, AD2700 and AD2710

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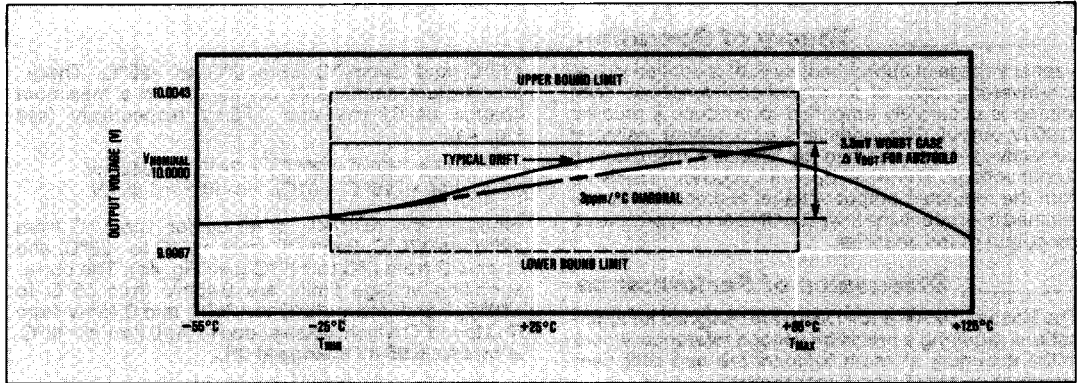


Figure 3. AD2700 Output Voltage Drift

The fine trim adjustment of the AD2701 is achieved by connecting the wiper of the potentiometer to V<sup>-</sup>, as shown in Figure 2.

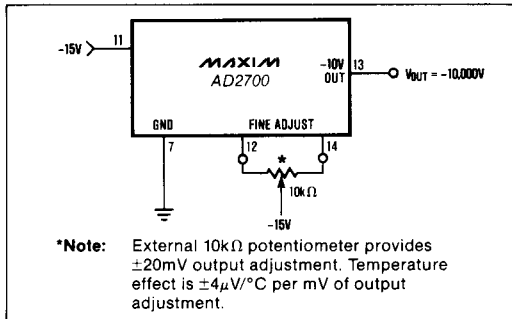


Figure 2. Fine Trim Connection, AD2701

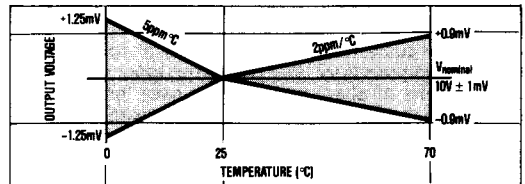


Figure 4a. AD2710K Output Voltage Drift

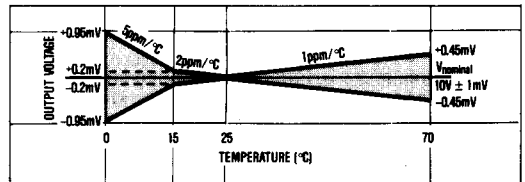


Figure 4b. AD2710L Output Voltage Drift