

REF102

## Precision VOLTAGE REFERENCE

### FEATURES

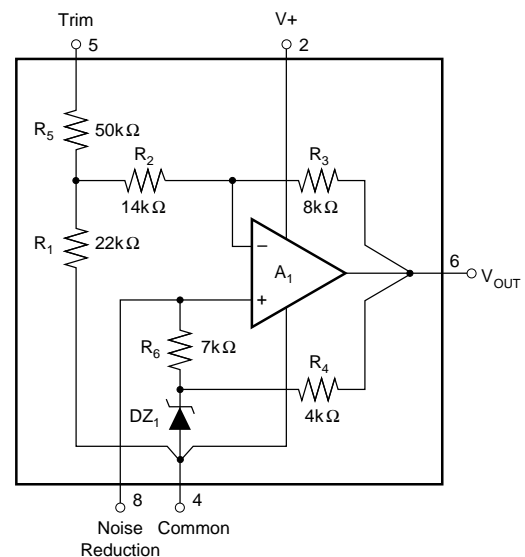
- **+10V  $\pm 0.0025V$  OUTPUT**
- **VERY LOW DRIFT: 2.5ppm/ $^{\circ}C$  max**
- **EXCELLENT STABILITY: 5ppm/1000hr typ**
- **EXCELLENT LINE REGULATION: 1ppm/V max**
- **EXCELLENT LOAD REGULATION: 10ppm/mA max**
- **LOW NOISE: 5 $\mu$ Vp-p typ, 0.1Hz to 10Hz**
- **WIDE SUPPLY RANGE: 11.4VDC to 36VDC**
- **LOW QUIESCENT CURRENT: 1.4mA max**
- **PACKAGE OPTIONS: HERMETIC TO-99, PLASTIC DIP, SOIC**

### DESCRIPTION

The REF102 is a precision 10V voltage reference. The drift is laser-trimmed to 2.5ppm/ $^{\circ}C$  max (CM grade) over the industrial temperature range and 5ppm/ $^{\circ}C$  max (SM grade) over the military temperature range. The REF102 achieves its precision without a heater. This results in low power, fast warm-up, excellent stability, and low noise. The output voltage is extremely insensitive to both line and load variations and can be externally adjusted with minimal effect on drift and stability. Single supply operation from 11.4V to 36V and excellent overall specifications make the REF102 an ideal choice for demanding instrumentation and system reference applications.

### APPLICATIONS

- **PRECISION-CALIBRATED VOLTAGE STANDARD**
- **D/A AND A/D CONVERTER REFERENCE**
- **PRECISION CURRENT REFERENCE**
- **ACCURATE COMPARATOR THRESHOLD REFERENCE**
- **DIGITAL VOLTMETERS**
- **TEST EQUIPMENT**
- **PC-BASED INSTRUMENTATION**



# SPECIFICATIONS

## ELECTRICAL

At  $T_A = +25^\circ\text{C}$  and  $V_S = +15\text{V}$  power supply unless otherwise noted.

PARAMETER	CONDITIONS	REF102A, R			REF102B, S			REF102C, M			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
<b>OUTPUT VOLTAGE</b>											
Initial	$T_A = 25^\circ\text{C}$	9.99		10.01	9.995		10.005	9.9975		10.0025	V
vs Temperature <sup>(1)</sup>				10			5			2.5	ppm/ $^\circ\text{C}$
vs Supply (Line Regulation)	$V_S = 11.4\text{V to }36\text{V}$			2			1			1	ppm/V
vs Output Current (Load Regulation)	$I_L = 0\text{mA to }+10\text{mA}$			20			10			10	ppm/mA
	$I_L = 0\text{mA to }-5\text{mA}$			40			20			20	ppm/mA
vs Time	$T_A = 25^\circ$										
M Package				5			*			*	ppm/1000hr
P, U Packages <sup>(2)</sup>				20			*			*	ppm/1000hr
Trim Range <sup>(3)</sup>		$\pm 3$			*			*			%
Capacitive Load, max				1000				*		*	pF
<b>NOISE</b>	(0.1Hz to 10Hz)			5				*		*	$\mu\text{Vp-p}$
<b>OUTPUT CURRENT</b>		+10, -5			*			*			mA
<b>INPUT VOLTAGE RANGE</b>		+11.4		+36	*		*	*		*	V
<b>QUIESCENT CURRENT</b>	( $I_{\text{OUT}} = 0$ )			+1.4			*			*	mA
<b>WARM-UP TIME <sup>(4)</sup></b>	( $T_0$ 0.1%)			15			*			*	$\mu\text{s}$
<b>TEMPERATURE RANGE</b>											
Specification											
REF102A, B, C		-25		+85	*		*	*		*	$^\circ\text{C}$
REF102R, S		-55		+125	*		*			*	$^\circ\text{C}$

\*Specifications same as REF102A/R.

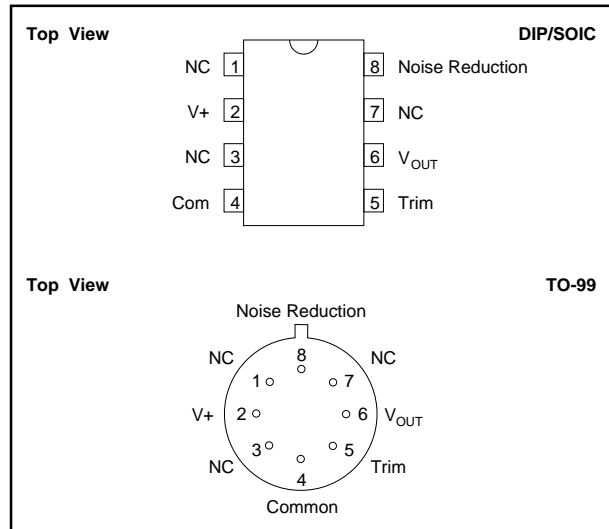
NOTES: (1) The "box" method is used to specify output voltage drift vs temperature. See the Discussion of Performance section. (2) Typically 5ppm/1000hrs after 168hr powered stabilization. (3) Trimming the offset voltage affects drift slightly. See Installation and Operating Instructions for details. (4) With noise reduction pin floating. See Typical Performance Curves for details.

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## ORDERING INFORMATION

MODEL	PACKAGE	TEMPERATURE RANGE	MAX INITIAL ERROR (mV)	MAX DRIFT (ppm/°C)
REF102AU	8-Pin SOIC	-25°C to +85°C	±10	±10
REF102AP	8-Pin Plastic DIP	-25°C to +85°C	±10	±10
REF102BP	8-Pin Plastic DIP	-25°C to +85°C	±5	±5
REF102AM	Metal TO-99	-25°C to +85°C	±10	±10
REF102BM	Metal TO-99	-25°C to +85°C	±5	±5
REF102CM	Metal TO-99	-25°C to +85°C	±2.5	±2.5
REF102RM	Metal TO-99	-55°C to +125°C	±10	±10
REF102SM	Metal TO-99	-55°C to +125°C	±5	±5

## PIN CONFIGURATIONS



## ABSOLUTE MAXIMUM RATINGS

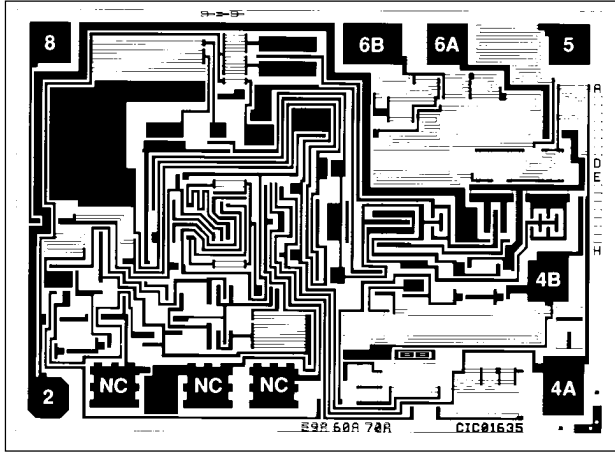
Input Voltage	+40V
Operating Temperature	
P,U	-25°C to +85°C
M	-55°C to +125°C
Storage Temperature Range	
P,U	-40°C to +85°C
M	-65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C
(SOIC, 3s)	+260°C
Short-Circuit Protection to Common or V+	Continuous

## PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER <sup>(1)</sup>
REF102AU	8-Pin SOIC	182
REF102AP	8-Pin Plastic DIP	006
REF102BP	8-Pin Plastic DIP	006
REF102AM	Metal-TO-99	001
REF102BM	Metal-TO-99	001
REF102CM	Metal-TO-99	001
REF102RM	Metal-TO-99	001
REF102SM	Metal-TO-99	001

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

## DICE INFORMATION



REF102 DIE TOPOGRAPHY

PAD	FUNCTION
2	$V_{CC}$
3A	NC
3B	NC
3C	NC
4A	Common (Sense)
4B	Common (Force)
5	Trim
6A	$V_{OUT}$
6B	$V_{OUT}$ (Feedback)
8	Noise Reduction

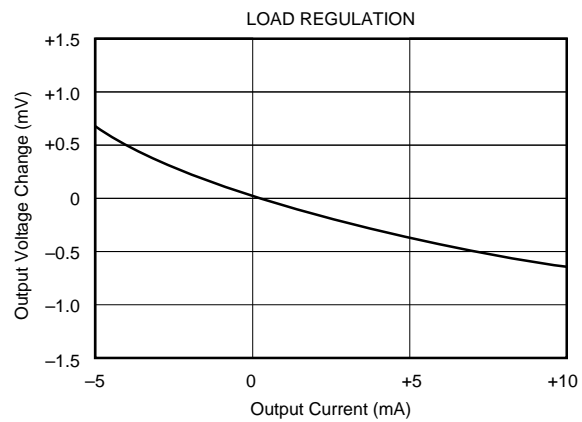
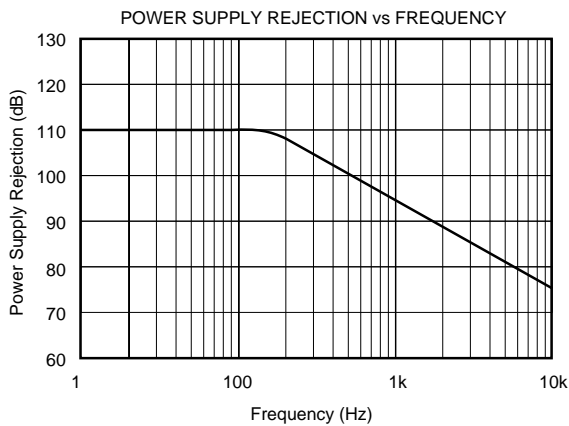
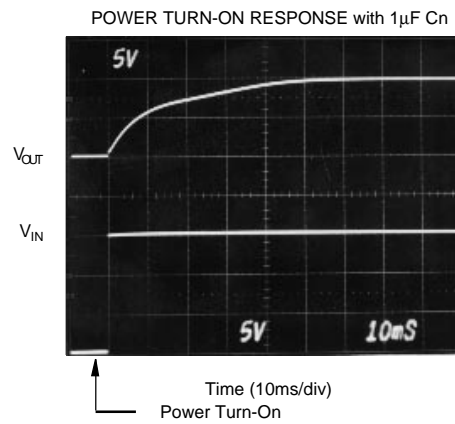
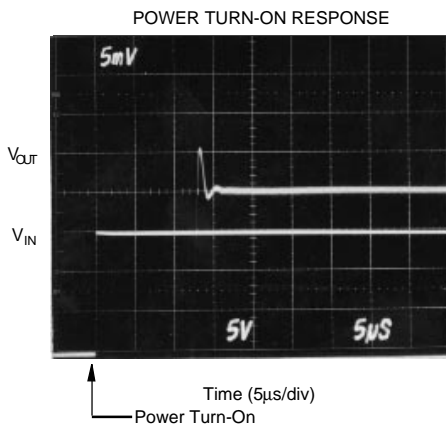
Substrate Bias:  $-V_{CC}$ .

## MECHANICAL INFORMATION

	MILS (0.001")	MILLIMETERS
Die Size	55 x 75 $\pm$ 5	1.40 x 1.91 $\pm$ 13
Die Thickness	20 $\pm$ 3	0.51 $\pm$ 0.08
Min. Pad Size	4 x 4	0.10 x 0.10
Backing		Gold

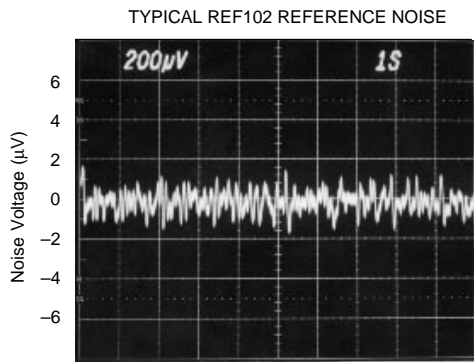
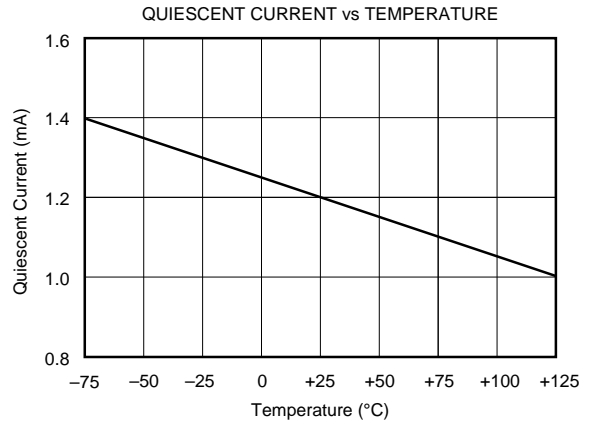
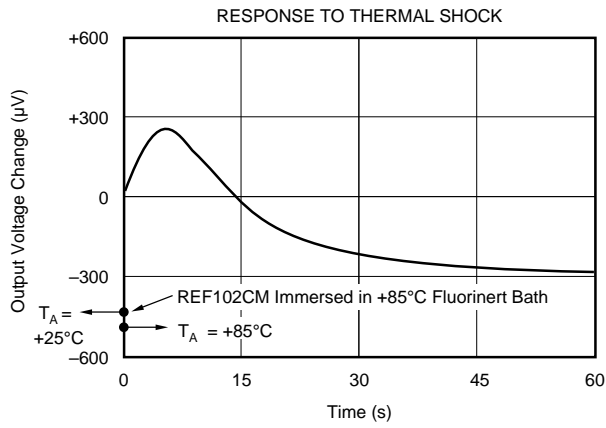
## TYPICAL PERFORMANCE CURVES

$T_A = +25^\circ\text{C}$ ,  $V_S = +15\text{V}$  unless otherwise noted.

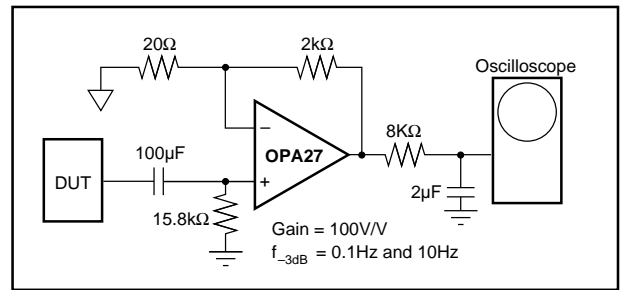


# TYPICAL PERFORMANCE CURVES (CONT)

$T_A = +25^\circ\text{C}$ ,  $V_S = +15\text{V}$  unless otherwise noted.



Low Frequency Noise (1s/div)  
(See Noise Test Circuit)



Noise Test Circuit.

## THEORY OF OPERATION

Refer to the diagram on the first page of this data sheet. The 10V output is derived from a compensated buried zener diode  $DZ_1$ , op amp  $A_1$ , and resistor network  $R_1$ – $R_6$ .

Approximately 8.2V is applied to the non-inverting input of  $A_1$  by  $DZ_1$ .  $R_1$ ,  $R_2$ , and  $R_3$  are laser-trimmed to produce an exact 10V output. The zener bias current is established from the regulated output voltage through  $R_4$ .  $R_5$  allows user-trimming of the output voltage by providing for small external adjustment of the amplifier gain. Because the TCR of  $R_5$  closely matches the TCR of  $R_1$ ,  $R_2$  and  $R_3$ , the voltage trim has minimal effect on the reference drift. The output voltage noise of the REF102 is dominated by the noise of the zener diode. A capacitor can be connected between the Noise Reduction pin and ground to form a low-pass filter with  $R_6$  and roll off the high-frequency noise of the zener.

## DISCUSSION OF PERFORMANCE

The REF102 is designed for applications requiring a precision voltage reference where both the initial value at room temperature and the drift over temperature are of importance to the user. Two basic methods of specifying voltage reference drift versus temperature are in common usage in the industry—the “butterfly method” and the “box method.” The REF102 is specified with the more commonly used “box method.” The “box” is formed by the high and low specification temperatures and a diagonal, the slope of which is equal to the maximum specified drift.

Since the shape of the actual drift curve is not known, the vertical position of the box is not exactly known either. It is, however, bounded by  $V_{UPPER\ BOUND}$  and  $V_{LOWER\ BOUND}$  (see Figure 1). Figure 1 uses the REF102CM as an example. It has a drift specification of 2.5ppm/°C maximum and a specification temperature range of –25°C to +85°C. The “box” height,  $V_1$  to  $V_2$ , is 2.75mV.

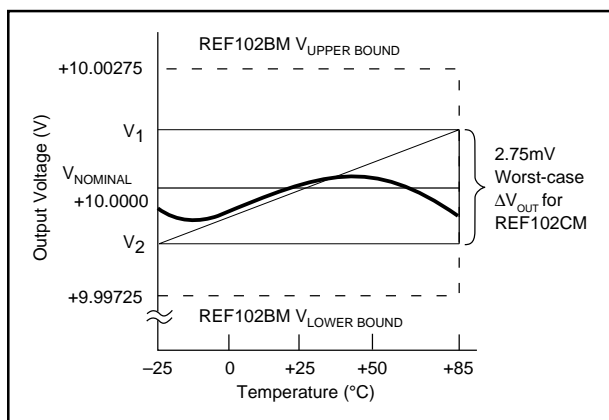


FIGURE 1. REF102CM Output Voltage Drift.

## INSTALLATION AND OPERATING INSTRUCTIONS

### BASIC CIRCUIT CONNECTION

Figure 2 shows the proper connection of the REF102. To achieve the specified performance, pay careful attention to layout. A low resistance star configuration will reduce voltage errors, noise pickup, and noise coupled from the power supply. Commons should be connected as indicated being sure to minimize interconnection resistances.

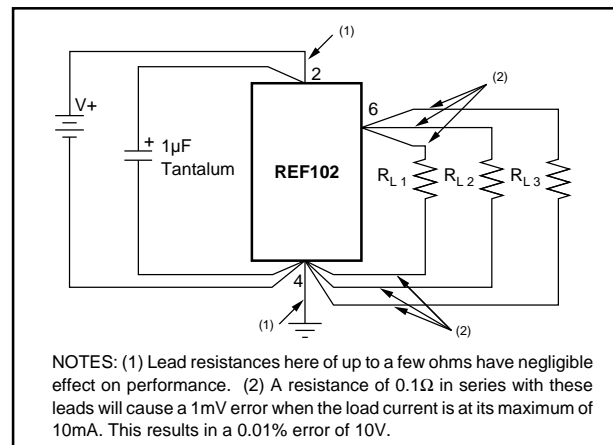


FIGURE 2. REF102 Installation.

### OPTIONAL OUTPUT VOLTAGE ADJUSTMENT

Optional output voltage adjustment circuits are shown in Figures 3 and 4. Trimming the output voltage will change the voltage drift by approximately 0.008ppm/°C per mV of trimmed voltage. In the circuit in Figure 3, any mismatch in TCR between the two sections of the potentiometer will also affect drift, but the effect of the  $\Delta TCR$  is reduced by a factor of five by the internal resistor divider. A high quality potentiometer, with good mechanical stability, such as a cermet, should be used. The circuit in Figure 3 has a minimum trim range of  $\pm 300$ mV. The circuit in Figure 4 has less range but provides higher resolution. The mismatch in TCR between  $R_5$  and the internal resistors can introduce some slight drift. This effect is minimized if  $R_5$  is kept significantly larger than the 50k $\Omega$  internal resistor. A TCR of 100ppm/°C is normally sufficient.

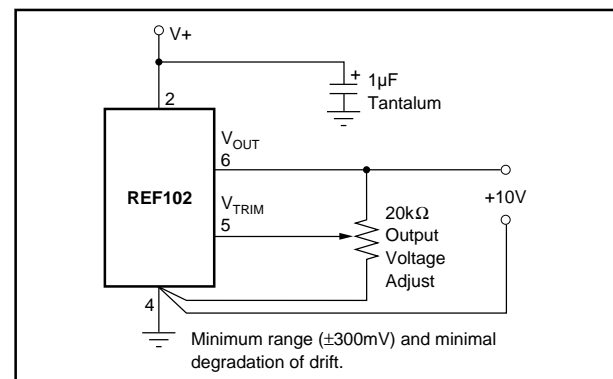


FIGURE 3. REF102 Optional Output Voltage Adjust.

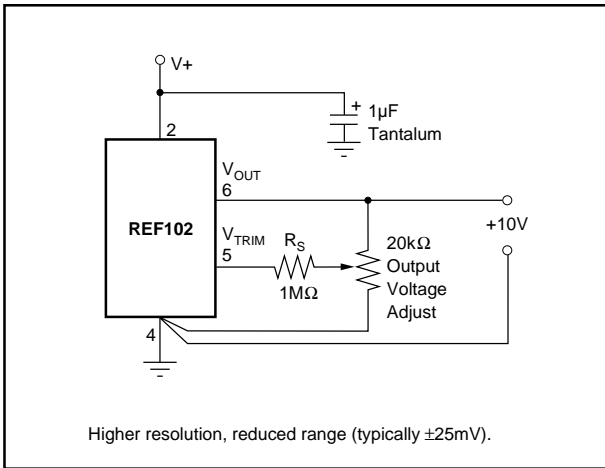


FIGURE 4. REF102 Optional Output Voltage Fine Adjust.

### OPTIONAL NOISE REDUCTION

The high-frequency noise of the REF102 is dominated by the zener diode noise. This noise can be greatly reduced by connecting a capacitor between the Noise Reduction pin and ground. The capacitor forms a low pass filter with  $R_6$  (refer to the figure on the first page of the data sheet) and attenuates the high-frequency noise generated by the zener. Figure 5 shows the effect of a  $1\mu\text{F}$  noise reduction capacitor on the high frequency noise of the REF102.  $R_6$  is typically  $7\text{k}\Omega$  so the filter has a  $-3\text{dB}$  frequency of about  $22\text{Hz}$ . The result is a reduction in noise from about  $800\mu\text{Vp-p}$  to under  $200\mu\text{Vp-p}$ . If further noise reduction is required, use the circuit in Figure 14.

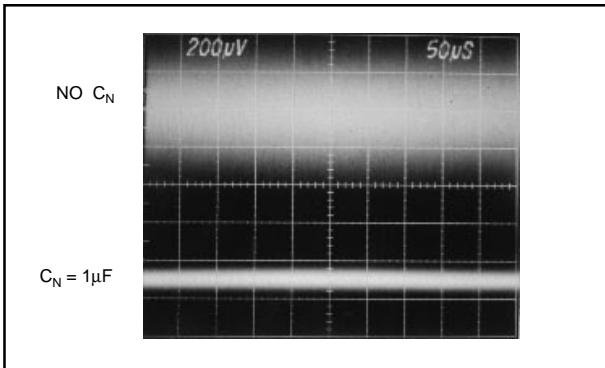


FIGURE 5. Effect of  $1\mu\text{F}$  Noise Reduction Capacitor on Broadband Noise ( $f_{-3\text{dB}} = 1\text{MHz}$ ).

## APPLICATIONS INFORMATION

High accuracy, extremely low drift, outstanding stability, and low cost make the REF102 an ideal choice for all instrumentation and system reference applications. Figures 6 through 14 show a variety of useful application circuits.

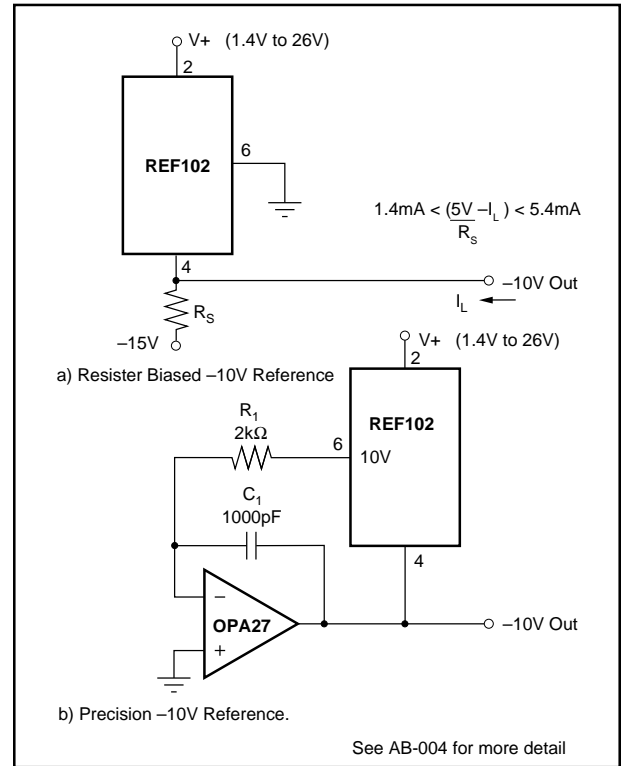


FIGURE 6.  $-10\text{V}$  Reference Using a) Resistor or b) OPA27.

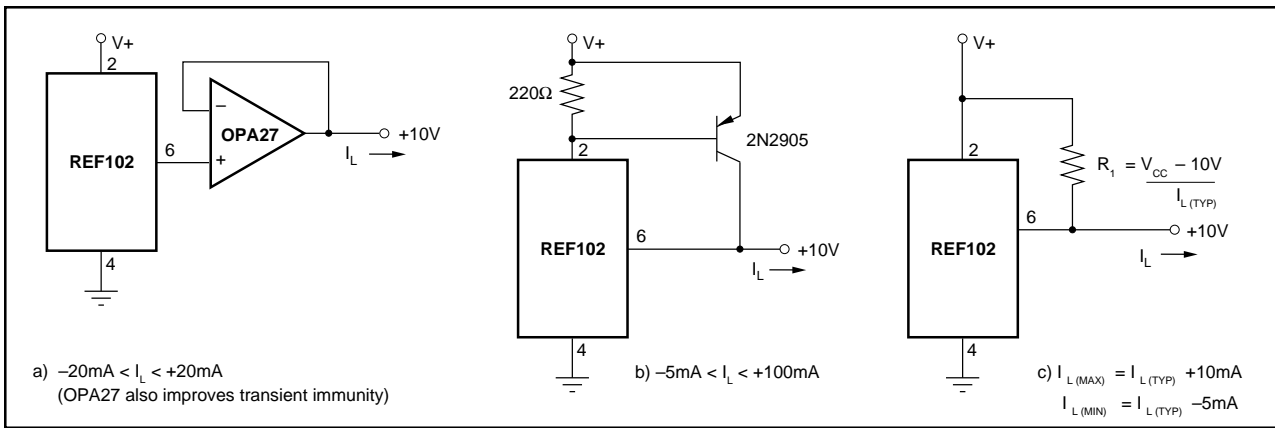


FIGURE 7. +10V Reference With Output Current Boosted to: a)  $\pm 20\text{mA}$ , b)  $+100\text{mA}$ , and c)  $I_{L(\text{TYP})} + 10\text{mA}$ ,  $-5\text{mA}$ .

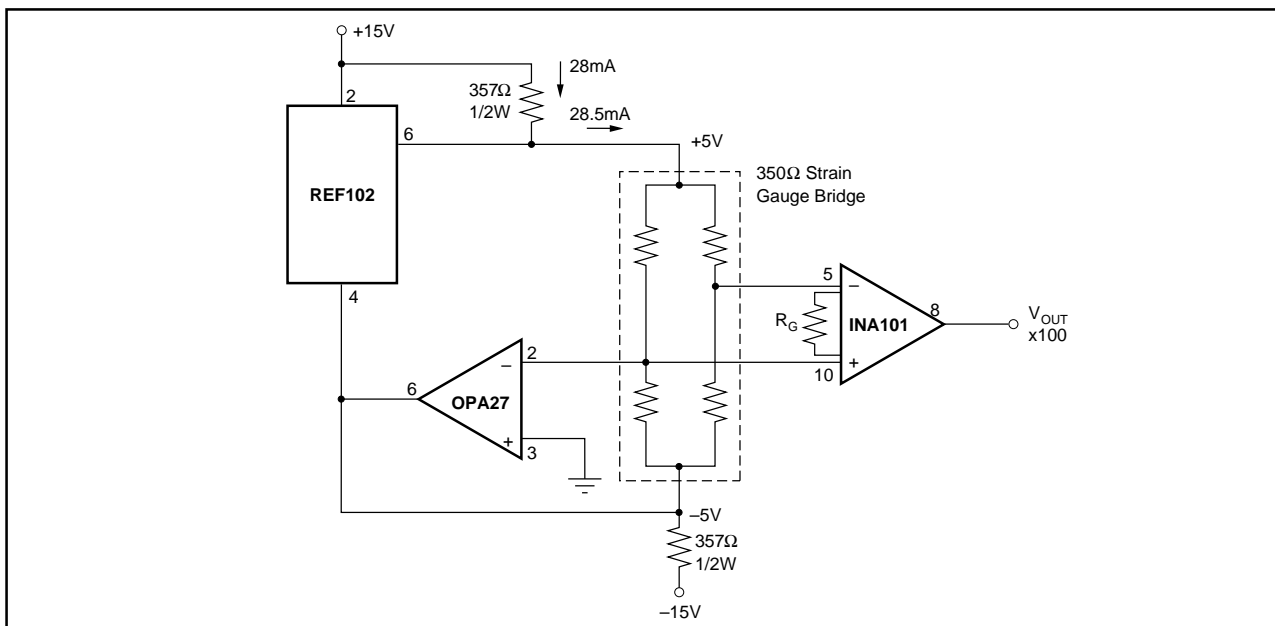


FIGURE 8. Strain Gauge Conditioner for 350Ω Bridge.

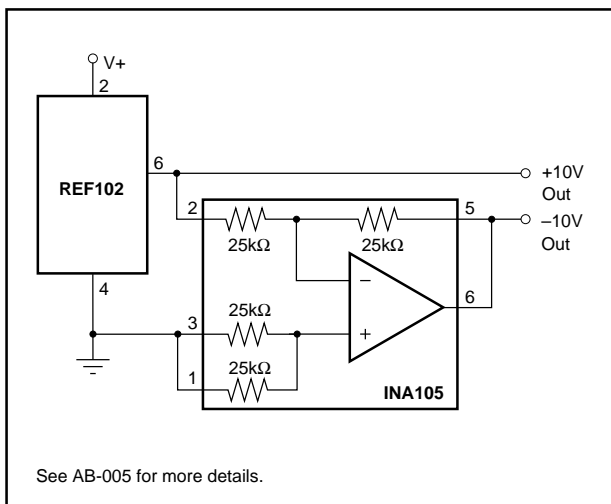


FIGURE 9.  $\pm 10\text{V}$  Reference.

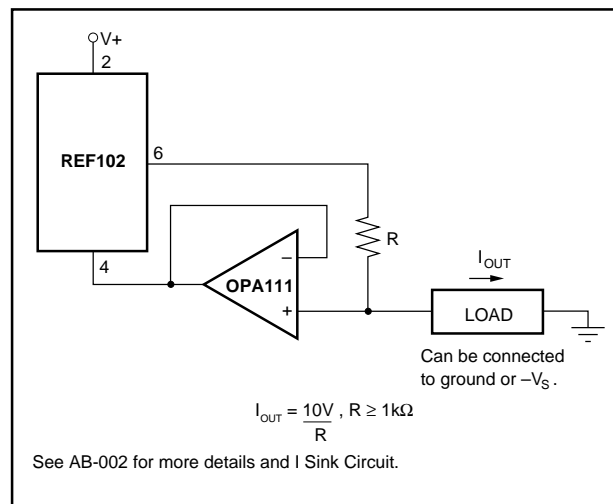


FIGURE 10. Positive Precision Current Source.



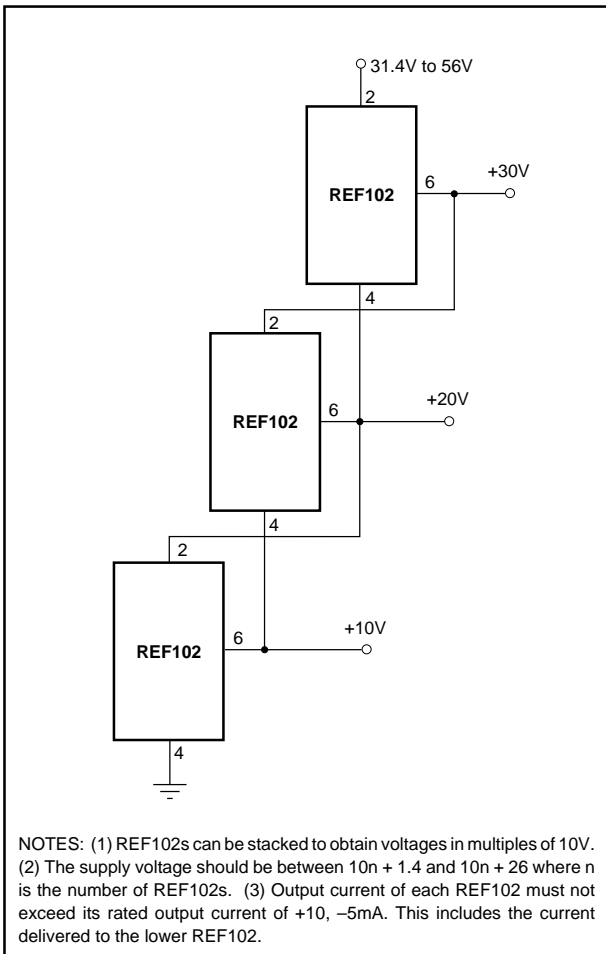


FIGURE 11. Stacked References.

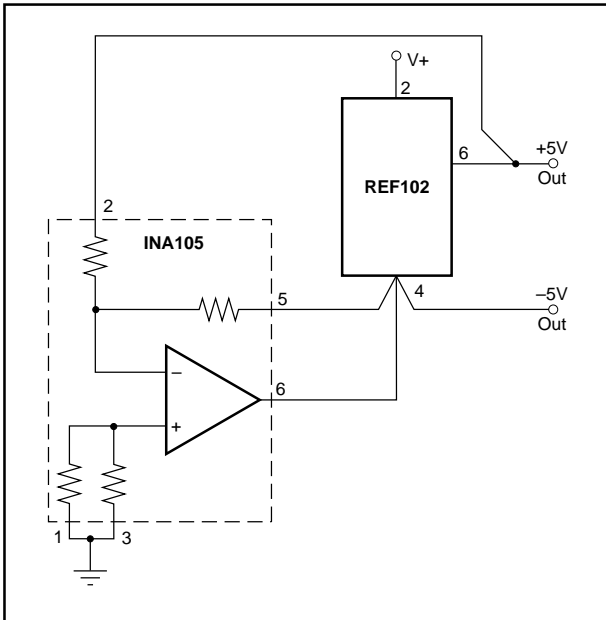


FIGURE 12. ±5V Reference.

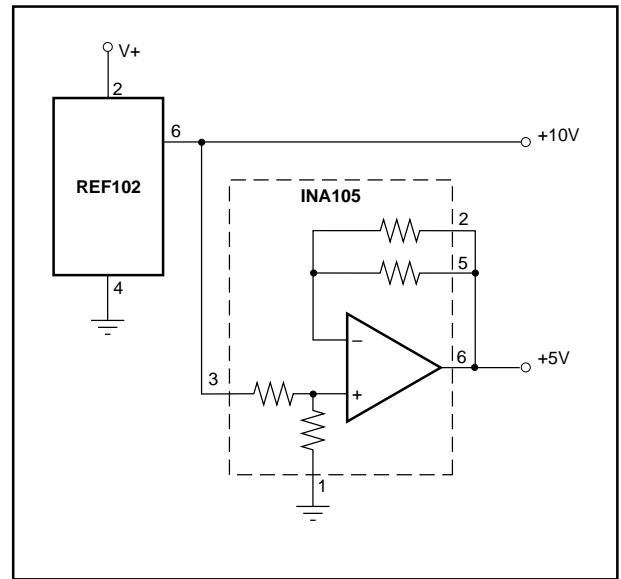


FIGURE 13. +5V and +10V Reference.

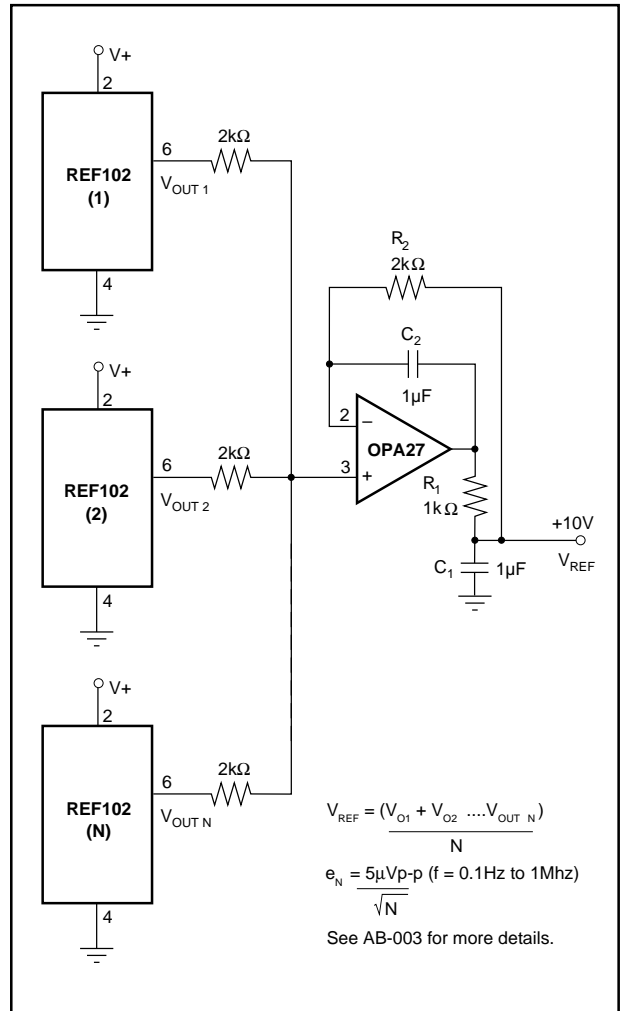


FIGURE 14. Precision Voltage Reference with Extremely Low Noise.