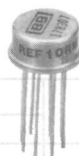


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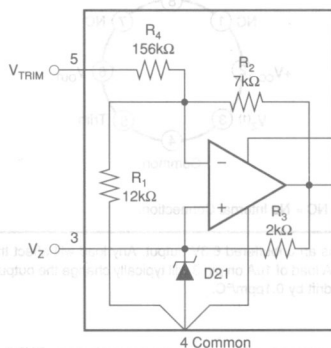
Precision VOLTAGE REFERENCE

FEATURES

- **+10.00V OUTPUT**
- **HIGH ACCURACY:** $\pm 0.005V$ Untrimmed
- **VERY-LOW DRIFT:** 1ppm/ $^{\circ}C$ max
- **EXCELLENT STABILITY:** 10ppm/1000hrs typ
- **LOW NOISE:** 6 μV p-p typ, 0.1Hz to 10Hz
- **WIDE SUPPLY RANGE:** Up to 35V

APPLICATIONS

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



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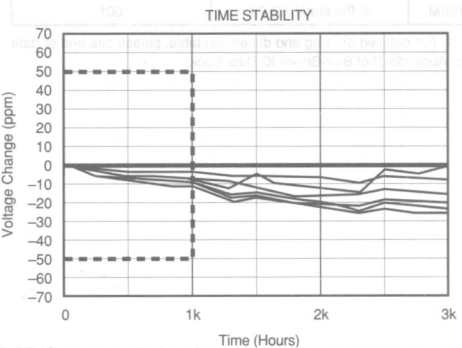


PDS-528B

DESCRIPTION

The REF10 is a precision voltage reference which provides a +10.00V output. The drift is laser-trimmed to 1ppm/ $^{\circ}C$ max (KM grade) over the full specification range. This is in contrast to some references which guarantee drift over a limited portion of their specification temperature range. The REF10 achieves its precision without a heater. This results in low quiescent current, fast warm-up, excellent stability, and low noise.

The output can be adjusted with minimal effect on drift or stability. Single supply operation over 13.5V to 35V supply range and excellent overall specifications make the REF10 an ideal choice for the most demanding applications such as precision system standard, D/A and A/D references, transducer excitation, etc.



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REFERENCES AND REGULATORS

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SPECIFICATIONS

ELECTRICAL

T_A = +25°C, and ±15VDC power supply, unless otherwise noted.

PARAMETER	CONDITIONS	REF10JM, KM, RM, SM			UNITS
		MIN	TYP	MAX	
OUTPUT VOLTAGE Initial Trim Range ⁽¹⁾ vs Temperature ⁽²⁾ : KM JM SM RM vs Supply (line regulation) vs Output Current (load regulation) vs Time ⁽³⁾	T _A = +25°C	9.995	10.000	10.005	V
		-0.100		+0.250	V
	0°C to +70°C			1	ppm/°C
	0°C to +70°C			3	ppm/°C
	-55°C to +125°C			3	ppm/°C
	-55°C to +125°C			6	ppm/°C
NOISE	V _{CC} = 13.5 to 35V		0.001	0.002	%V
	I _L = 0 to ±10mA		0.001	0.002	%mA
	T _A = +25°C		10	±50	ppm/1000hr
OUTPUT CURRENT	0.1Hz to 10Hz		6	25	μVp-p
INPUT VOLTAGE RANGE	Source or Sink	±10			mA
QUIESCENT CURRENT	I _{OUT} = 0	13.5	4.5	35	V
WARM-UP TIME	To 0.1%		10		μs
TEMPERATURE RANGE Specification: JM, KM RM, SM Operating: JM, KM RM, SM Storage		0		+70	°C
		-55		+125	°C
		-25		+85	°C
		-55		+125	°C
		-65		+125	°C

NOTES: (1) Trimming the offset voltage will affect the drift slightly. See Installation and Operating Instructions for details. (2) The "box method" is used to specify output voltage drift vs temperature. See the Discussion of Performance section. (3) Sample tested with power applied continuously.

ORDERING INFORMATION

MODEL	PACKAGE	TEMPERATURE RANGE	MAX DRIFT (ppm/°C)
REF10JM	Metal TO-99	0°C to +70°C	3
REF10KM	Metal TO-99	0°C to +70°C	1
REF10RM	Metal TO-99	-55°C to +125°C	6
REF10SM	Metal TO-99	-55°C to +125°C	3

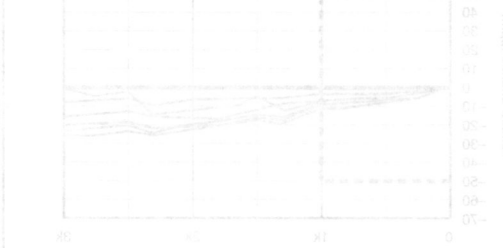
ABSOLUTE MAXIMUM RATINGS

Input Voltage	40V
Power Dissipation at +25°C	200mW
Operating Temperature	
J, K	-25°C to +85°C
R, S	-55°C to +125°C
Storage Temperature Range	-65°C to +125°C
Lead Temperature (soldering, 10s)	+300°C
Short-Circuit Protection at +25°C	
to Common or +15VDC	Continuous

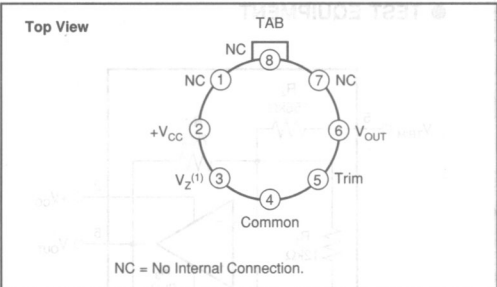
PACKAGE INFORMATION⁽¹⁾

MODEL	PACKAGE	PACKAGE DRAWING NUMBER
REF10JM	8-Pin Metal TO-99	001
REF10KM	8-Pin Metal TO-99	001
REF10RM	8-Pin Metal TO-99	001
REF10SM	8-Pin 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.



PIN CONFIGURATION



NOTE: (1) Pin 3 is an unbuffered 6.3V output. Any load will affect the output voltage and drift. A load of 1μA on pin 3 will typically change the output voltage by 50μV and the drift by 0.1ppm/°C.

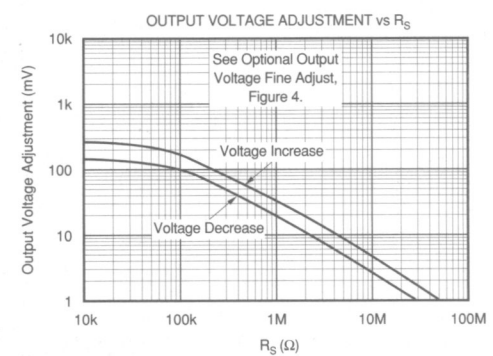
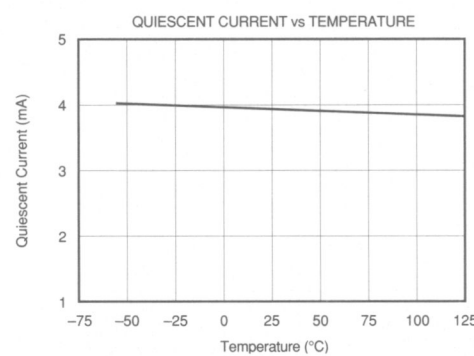
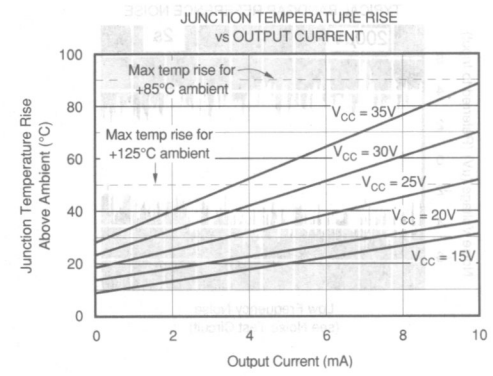
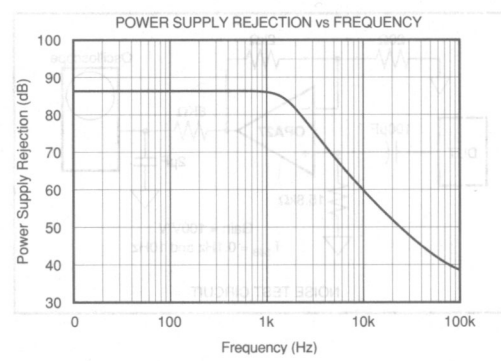
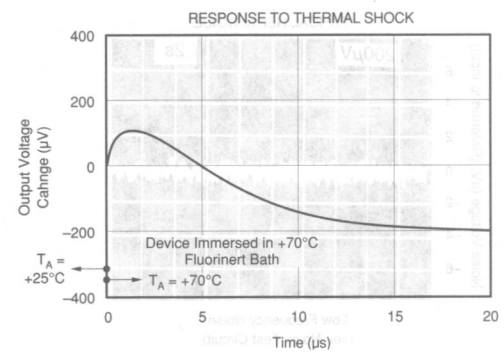
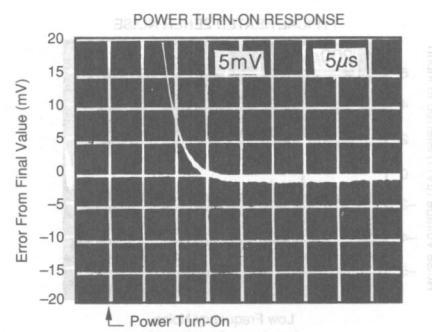
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TYPICAL PERFORMANCE CURVES

$T_A = +25^\circ\text{C}$, and $\pm 15\text{VDC}$ power supply, unless otherwise noted.



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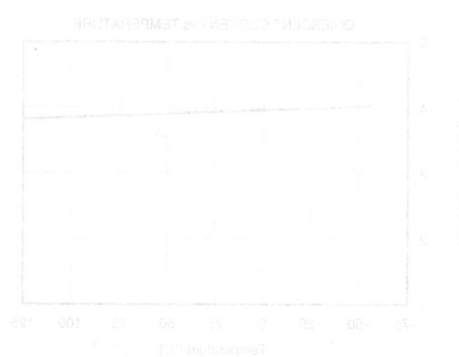
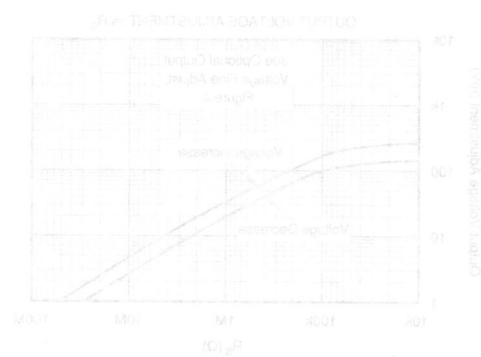
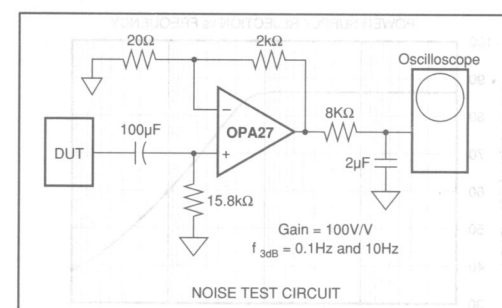
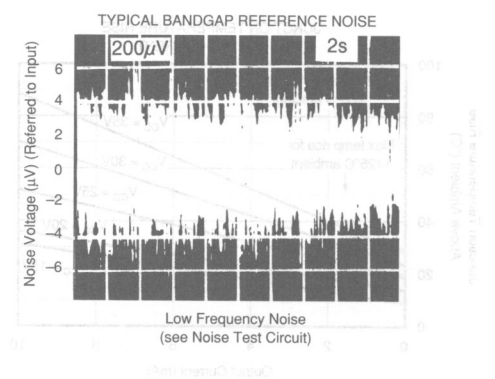
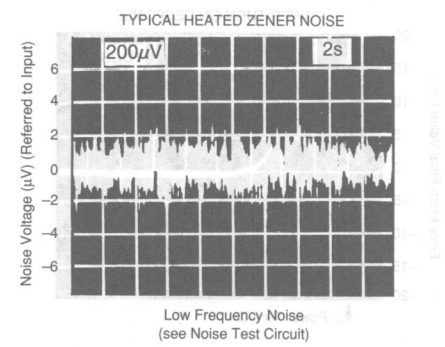
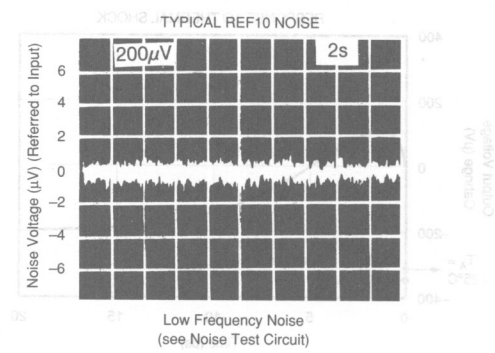
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TYPICAL PERFORMANCE CURVES (CONT)

$T_A = +25^\circ\text{C}$, and $\pm 15\text{VDC}$ power supply, unless otherwise noted.



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THEORY OF OPERATION

The following discussion refers to the diagram on the first page.

In operation, approximately 6.3V is applied to the noninverting input of op amp A₁ by zener diode D_{Z1}. This voltage is amplified by A₁ to produce the 10.00V output. The gain is determined by R₁ and R₂: $G = (R_1 + R_2)/R_1$. R₁ and R₂ are actively laser-trimmed to produce an exact 10.00V output. The zener operating current is derived from the regulated output voltage through R₃. This feedback arrangement provides closely regulated zener current. R₃ is actively laser-trimmed to set the zener current to a level which results in low drift at the output of A₁. R₄ allows user-trimming of the output voltage by providing for a small external adjustment of amplifier gain. Since the TCR of R₄ closely matches the TCR of the gain setting resistors, the voltage trim has minimal effect on the drift of the reference.

DISCUSSION OF PERFORMANCE

The REF10 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 REF10 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.

For the REF10, each J and K unit is tested at temperatures of 0°C, +25°C, +50°C, and +70°C. Each R and S unit is tested at -55°C, -25°C, 0°C, +25°C, +50°C, +75°C, +100°C and +125°C. The minimum and maximum test voltages must meet this condition:

$$\left[\frac{(V_{OUT\ MAX} - V_{OUT\ MIN}) / 10V}{T_{HIGH} - T_{LOW}} \right] \times 10^6 \leq \text{Drift Specification}$$

This assures the user that the variations of output voltage that occur as the temperature changes within the specification range, T_{LOW} to T_{HIGH}, will be contained within a box whose diagonal has a slope 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 REF10KM as an example. It has a drift specification of 1ppm/°C maximum and a specification temperature range of 0°C to +70°C. The “box” height (V₁ to V₂) is 700μV, and upper bound and lower bound voltages are a maximum of 700μV away from the voltage at +25°C.

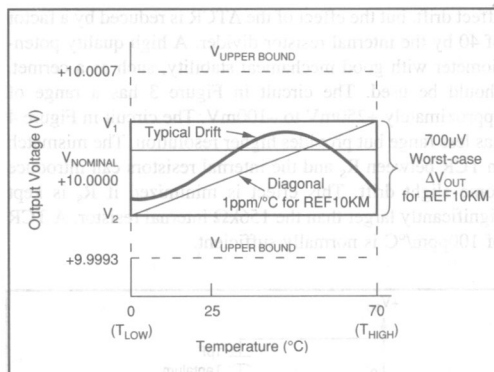
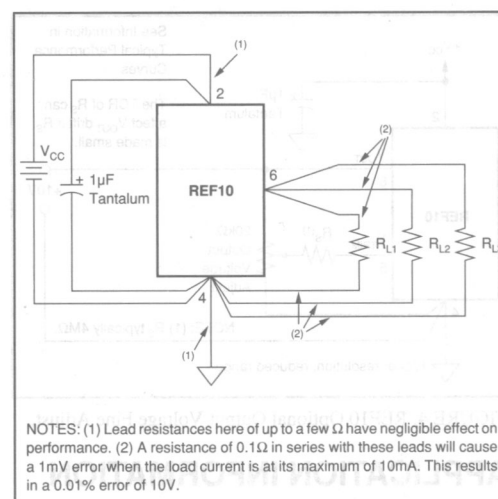


FIGURE 1. REF10KM Output Voltage Drift.

INSTALLATION AND OPERATING INSTRUCTIONS

BASIC CIRCUIT CONNECTION

Figure 2 shows the proper connection of the REF10. 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.



NOTES: (1) Lead resistances here of up to a few Ω have negligible effect on performance. (2) A resistance of 0.1Ω in series with these leads will cause a 1mV error when the load current is at its maximum of 10mA. This results in a 0.01% error of 10V.

FIGURE 2. REF10 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 0.01ppm/°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

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affect drift, but the effect of the ΔTCR is reduced by a factor of 40 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 range of approximately +250mV to -100mV. The circuit in Figure 4 has less range but provides higher resolution. The mismatch in TCR between R_S and the internal resistors can introduce some slight drift. This effect is minimized if R_S is kept significantly larger than the 156k Ω internal resistor. A TCR of 100ppm/ $^{\circ}$ C is normally sufficient.

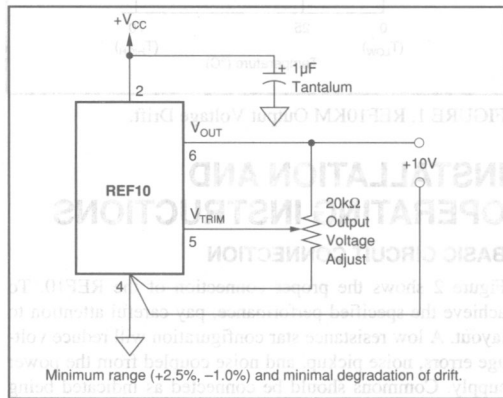


FIGURE 3. REF10 Optional Output Voltage Adjust.

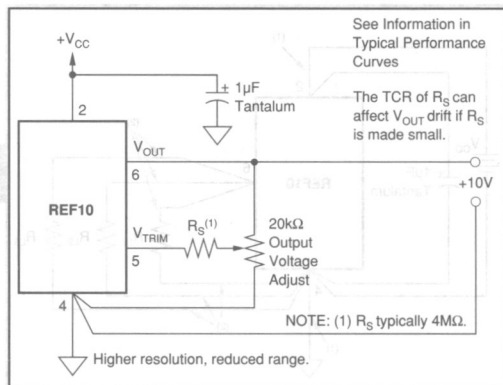


FIGURE 4. REF10 Optional Output Voltage Fine Adjust.

APPLICATION INFORMATION

High accuracy, extremely-low drift, and small size make the REF10 ideal for demanding instrumentation and system voltage reference applications. Since no heater is required, low power supply current designs are readily achievable. Also the REF10 has lower output noise and much faster warm-up times than heated references, permitting high precision without extra power or additional supplies. It should be considered that operating any integrated circuit at an elevated temperature will reduce its MTTF.

A variety of application circuits are shown in Figures 5 through 11.

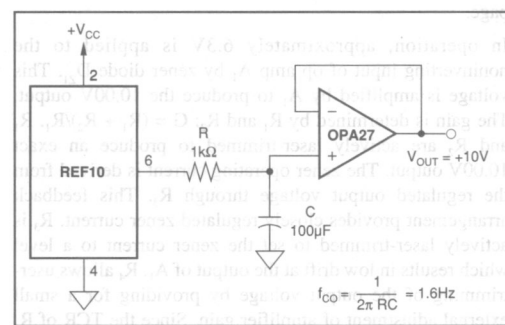


FIGURE 5. Precision Reference with Filtering.

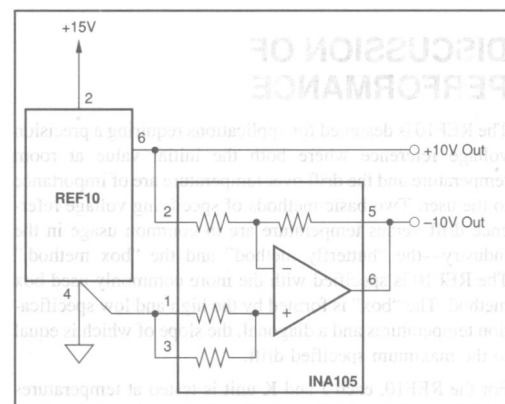


FIGURE 6. $\pm 10V$ Reference.

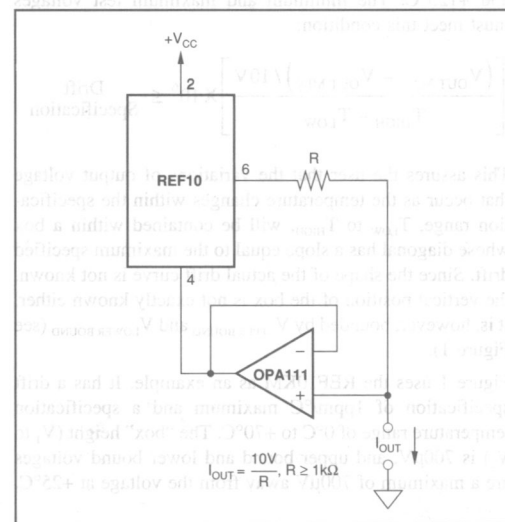


FIGURE 7. Positive Precision Current Source.

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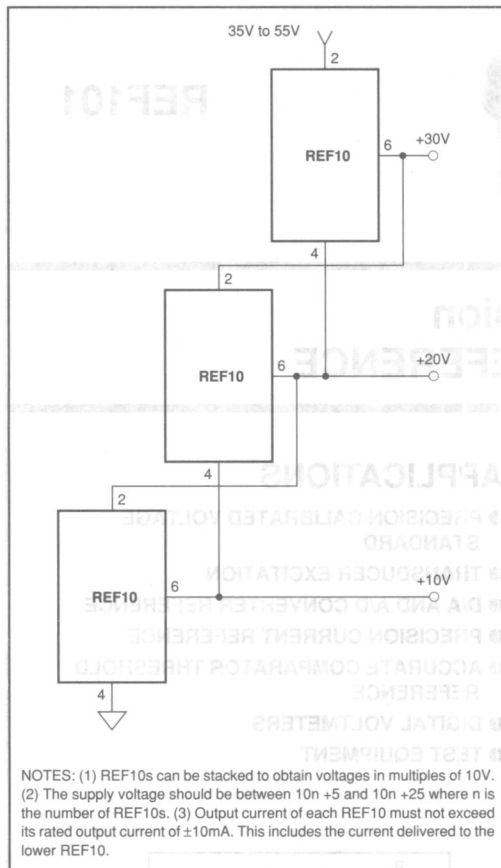


FIGURE 8. Stacked References.

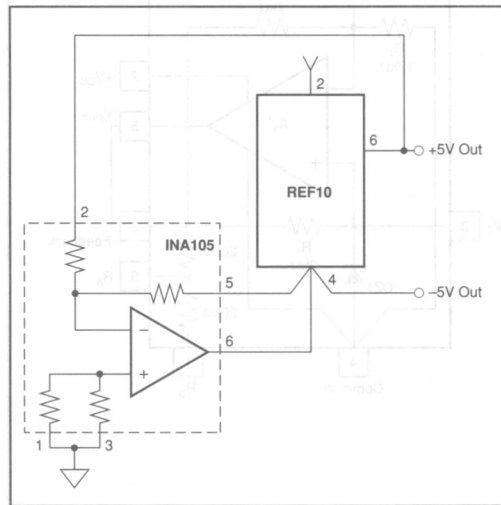


FIGURE 9. $\pm 5\text{V}$ Reference.

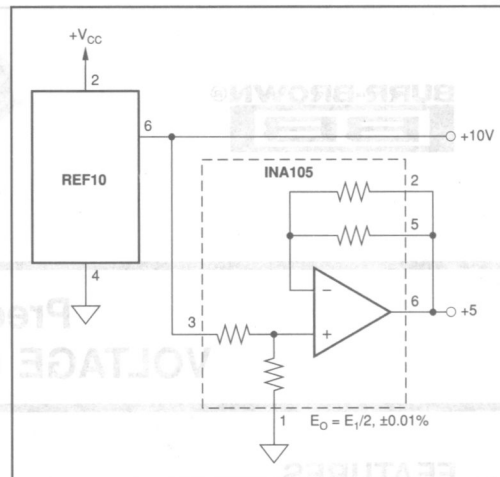


FIGURE 10. +5V and +10V Reference.

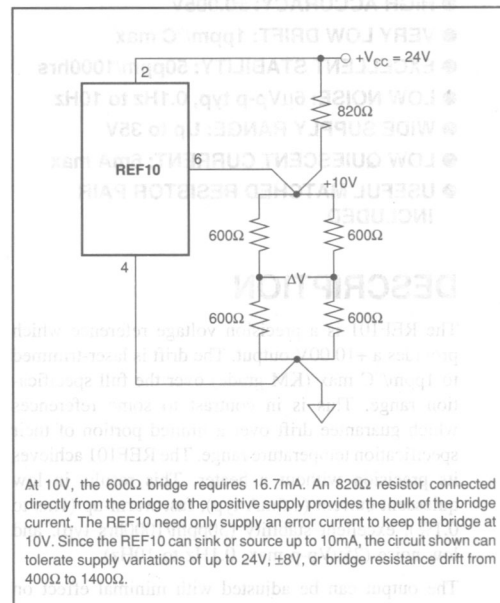


FIGURE 11. +10V Reference with Output Current Boost Using a Resistor to Drive a 600Ω Bridge.