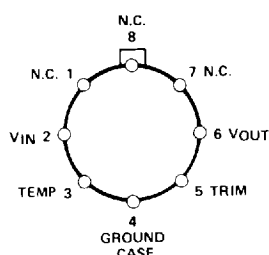


FEATURES

- 5 Volt Output
- Guaranteed Long-Term Stability 100ppm/1000 Hrs Max
- Excellent Temperature Stability 8.5ppm/°C Max
- Low Noise 15 μ V_{p-p} Max
- Low Supply Current 1.4mA Max
- Wide Input Voltage Range 7V to 40V
- High Load-Driving Capability 20mA
- Short-Circuit Proof
- Processed Per MIL-STD-883

PIN CONNECTIONS & ORDERING INFORMATION



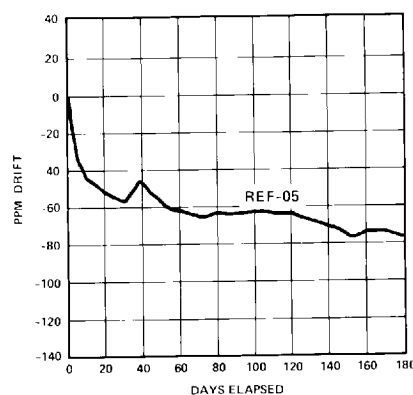
TO-99 (J-Suffix)
REF-05AJ/883
REF-05BJ/883

GENERAL DESCRIPTION

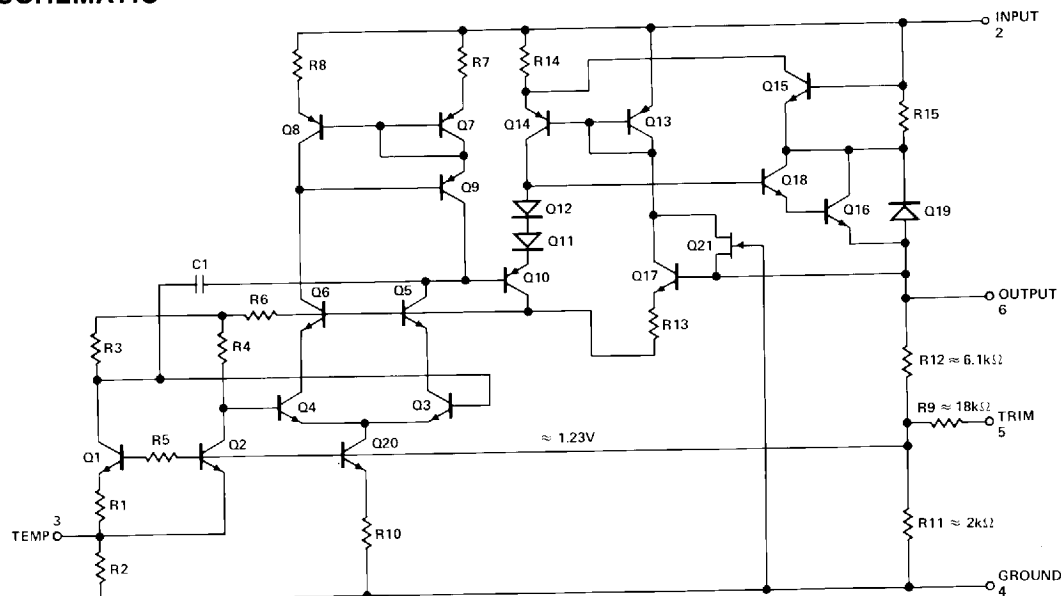
The REF-05 precision voltage reference provides a stable +5V output which can be adjusted over a $\pm 6\%$ range with minimal effect on temperature stability. Long-term drift is guaranteed

at 100ppm/1000 hrs. maximum. Single-supply operation over an input voltage range of 7V to 40V, low current drain of 1mA, and excellent temperature stability are achieved with an improved bandgap design. Low cost, low noise, and low power make the REF-05 an excellent choice whenever a stable voltage reference is required. Applications include D/A and A/D converters, portable instrumentation, and digital voltmeters. The versatility of the REF-05 is enhanced by its use as a monolithic temperature transducer. For +10V Precision Voltage References see the REF-10 data sheet.

LONG-TERM DRIFT PLOT (Average of 20 Devices)



SIMPLIFIED SCHEMATIC



REV. B

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Telex: 924491 Cable: ANALOG NORWOODMASS

ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Voltage	
REF-05A, B	40V
Output Short-Circuit Duration (to Ground or V_{IN})	Indefinite
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 60 sec)	+300°C

Operating Temperature Range

REF-05A, REF-05B -55°C to +125°C

PACKAGE TYPE	θ_{JA} (NOTE 2)	θ_{JC}	UNITS
TO-99 (J)	170	24	°C/W

NOTES:

1. Derate at 7.1 mW/°C above 80°C ambient temperature for TO-99 (J) package.
2. θ_{JA} is specified for worst case mounting conditions, i.e., θ_{JA} is specified for device in socket for TO package.

ELECTRICAL CHARACTERISTICS at $V_{IN} = +15V$, $T_A = 25^\circ C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	REF-05A			REF-05B			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage	V_O	$I_L = 0$	4.985	5.0	5.015	4.975	5.0	5.025	V
Output Adjustment Range	ΔV_{trim}	$R_P = 10k\Omega$	±3	±6	—	±3	±6	—	%
Output Voltage Noise	e_{np-p}	0.1Hz to 10Hz (Note 1)	—	10	15	—	10	15	μV_{p-p}
Long-Term Stability		(Note 1)	—	65	100	—	65	100	ppm/1kHrs
Line Regulation (Note 2)		$V_{IN} = 8V$ to 33V	—	0.006	0.010	—	0.006	0.010	%/V
Load Regulation (Note 2)		$I_L = 0$ to 10mA	—	0.005	0.010	—	0.006	0.010	%/mA
Turn-On Settling Time	t_{on}	To ±0.1% of final value	—	5	—	—	5	—	μs
Quiescent Supply Current	I_{SY}	No Load	—	1	1.4	—	1	1.4	mA
Load Current	I_L		10	21	—	10	21	—	mA
Sink Current	I_S	(Note 7)	-0.3	-0.5	—	-0.3	-0.5	—	mA
Short-Circuit Current	I_{SC}	$V_O = 0$	15	30	60	15	30	60	mA
Temperature Voltage Output	V_T	(Note 3)	—	630	—	—	630	—	mV

ELECTRICAL CHARACTERISTICS at $V_{IN} = +15V$, $-55^\circ C \leq T_A \leq +125^\circ C$ and $I_L = 0mA$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	REF-05A			REF-05B			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Output Voltage Change with Temperature (Notes 4 & 5)	ΔV_{OT}	$-55^\circ C \leq T_A \leq +125^\circ C$	—	0.06	0.15	—	0.18	0.45	%
Output Voltage Temperature Coefficient	TCV_O	(Note 6)	—	3	8.5	—	10	25	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		$R_P = 10k\Omega$	—	0.7	—	—	0.7	—	ppm/%
Line Regulation ($V_{IN} = 8V$ to 33V) (Note 2)		$-55^\circ C \leq T_A \leq +125^\circ C$	—	0.009	0.015	—	0.009	0.015	%/V
Load Regulation ($I_L = 0$ to 8mA) (Note 2)		$-55^\circ C \leq T_A \leq +125^\circ C$	—	0.007	0.012	—	0.009	0.015	%/mA
Temperature Voltage Output Temperature Coefficient	TCV_T	(Note 3)	—	2.1	—	—	2.1	—	mV/°C
Quiescent Supply Current	I_{SY}	No Load	—	1.6	2.0	—	1.6	2.0	mA

NOTES:

1. Sample tested. Long-term stability is tested with power applied continuously.
2. Line and Load Regulation specifications include the effect of self heating.
3. Limit current in or out of pin 3 to 50nA and capacitance on pin 3 to 30pF.
4. ΔV_{OT} is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 5V.

$$\Delta V_{OT} = \left| \frac{V_{MAX} - V_{MIN}}{5V} \right| \times 100$$

5. ΔV_{OT} specification applied trimmed to +5V or untrimmed.
6. TCV_O is defined as ΔV_{OT} divided by the temperature range, i.e.,

$$TCV_O = \frac{\Delta V_{OT}}{180^\circ C}$$

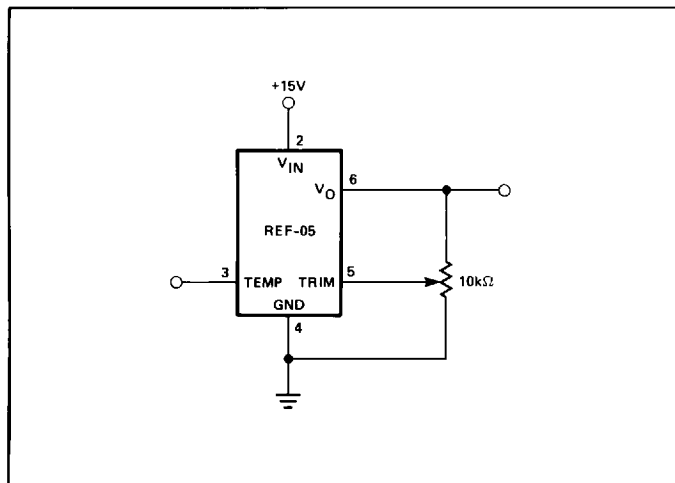
7. During sink current test the device meets the output voltage specified.

OUTPUT ADJUSTMENT

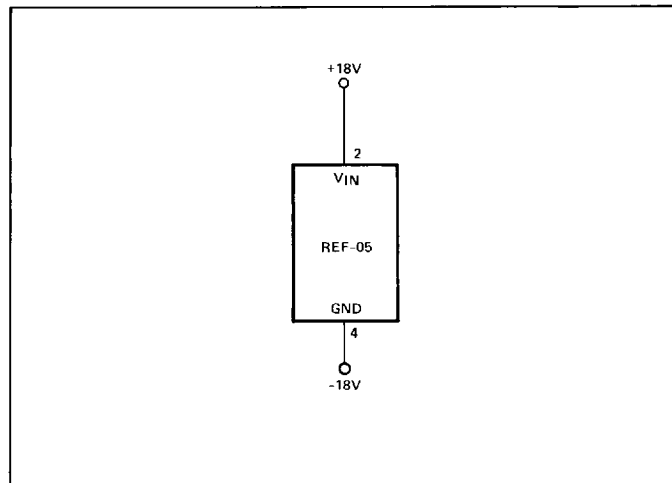
The REF-05 trim terminal can be used to adjust the output voltage over a $5V \pm 300mV$ range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 5V. Of course, the output can also be set to exactly 5V or to 5.12V for binary applications.

Adjustment of the output does not significantly affect the temperature performance of the device. Typically the temperature coefficient change is $0.7ppm/^{\circ}C$ for 100mV of output adjustment.

OUTPUT ADJUSTMENT CIRCUIT

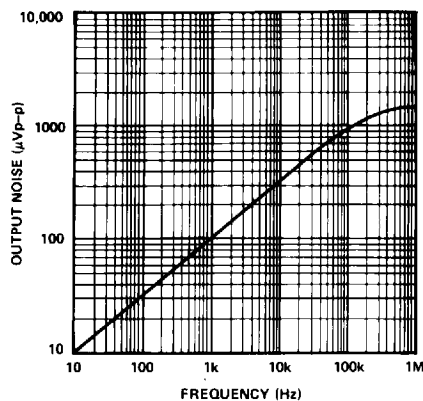


BURN-IN CIRCUIT

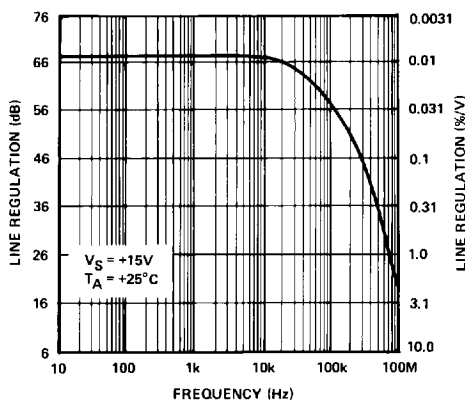


TYPICAL PERFORMANCE CHARACTERISTICS

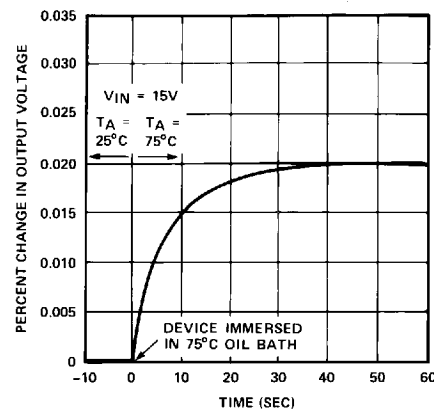
**OUTPUT WIDEBAND NOISE
vs BANDWIDTH (0.1Hz
TO FREQUENCY INDICATED)**



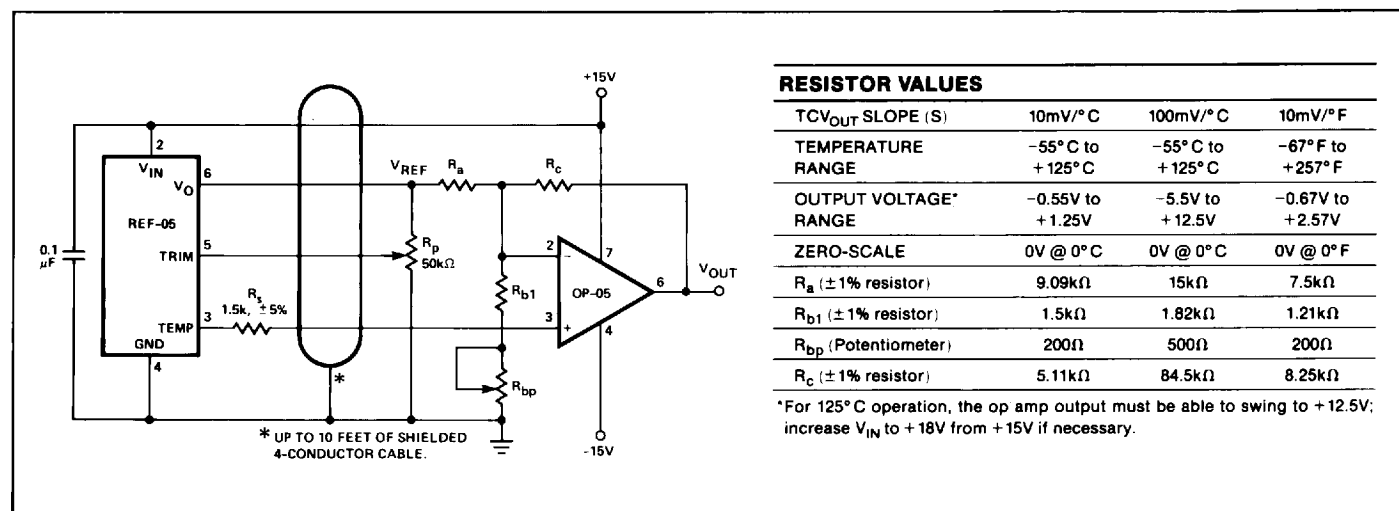
**LINE REGULATION
vs FREQUENCY**



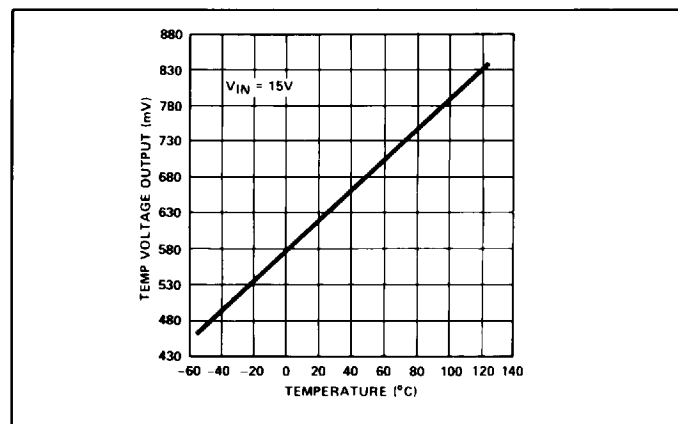
**OUTPUT CHANGE DUE TO
THERMAL SHOCK**



PRECISION TEMPERATURE TRANSDUCER WITH REMOTE SENSOR



TYPICAL TEMPERATURE VOLTAGE OUTPUT vs TEMPERATURE (REF-05A)

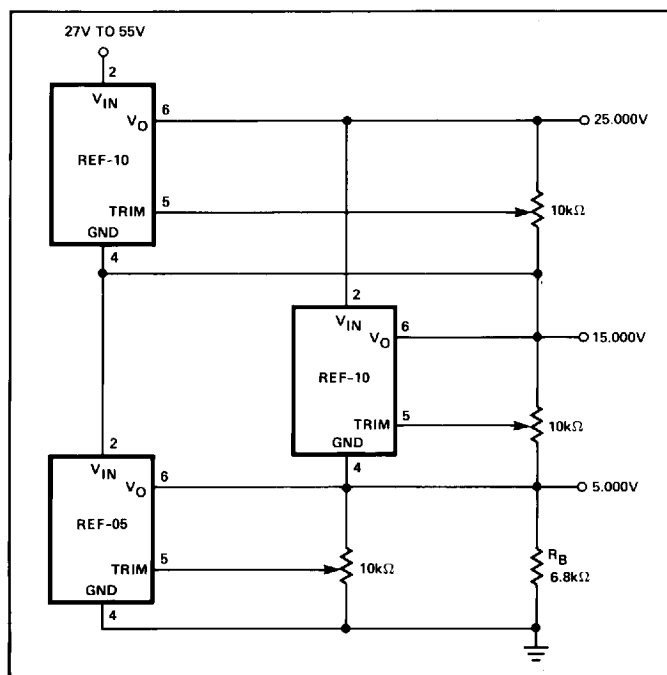
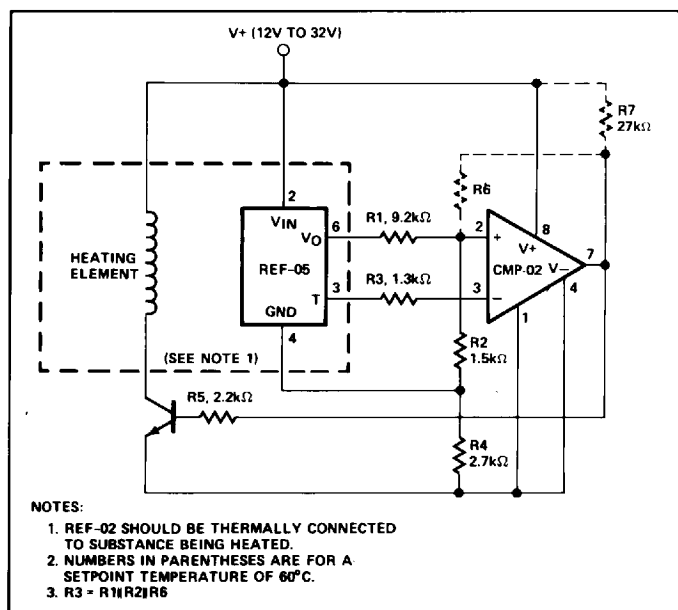


REFERENCE STACK WITH EXCELLENT LINE REGULATION

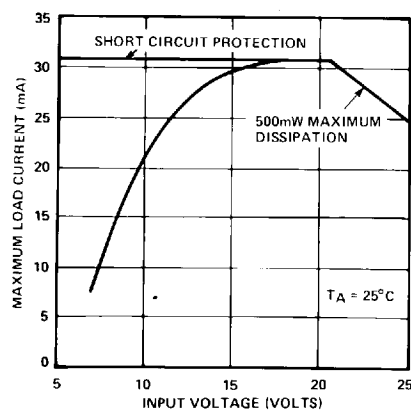
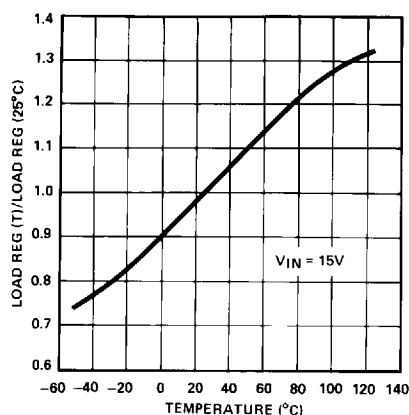
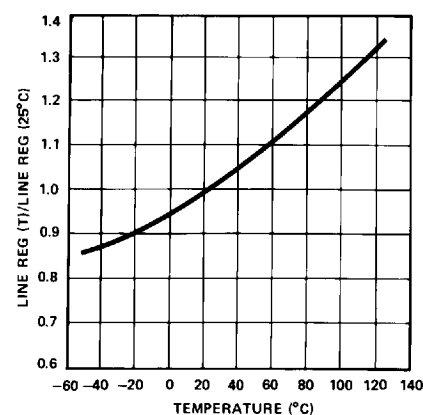
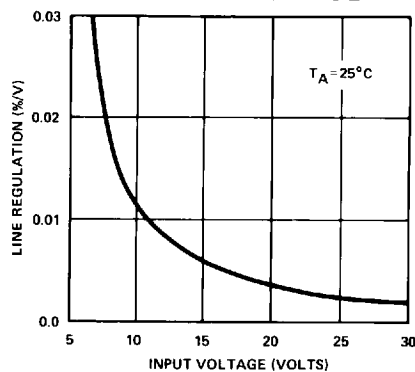
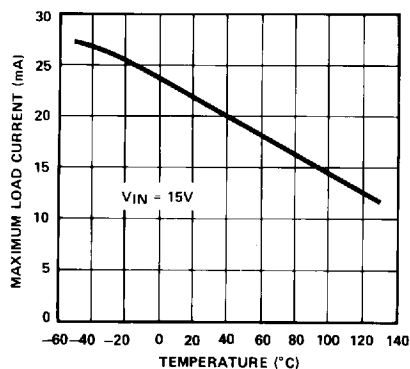
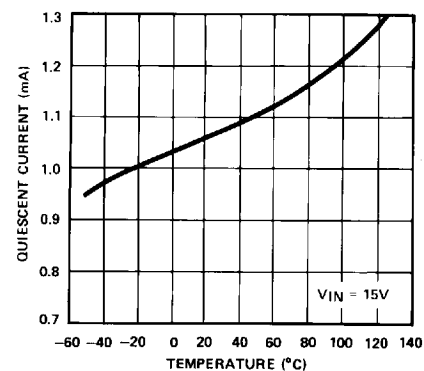
Two REF-10's and one REF-05 can be stacked to yield 5V, 15V and 25V outputs. An additional advantage is near-perfect line regulation of the 5V and 15V outputs. A 27V to 55V input change produces an output change which is less than the noise voltage of the devices. A load bypass resistor (R_G) provides a path for the supply current (I_{SY}) of the 15V regulator.

In general, any number of REF-10's and REF-05's can be stacked this way. For example, ten devices will yield ten outputs in 5V or 10V steps. The line voltage can range from 100V to 130V, however, care must be taken to ensure that the total load currents do not exceed the maximum usable current (typically 21mA).

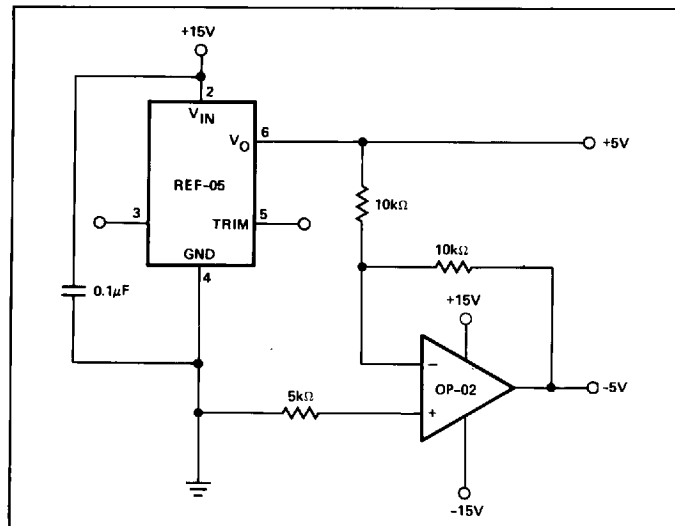
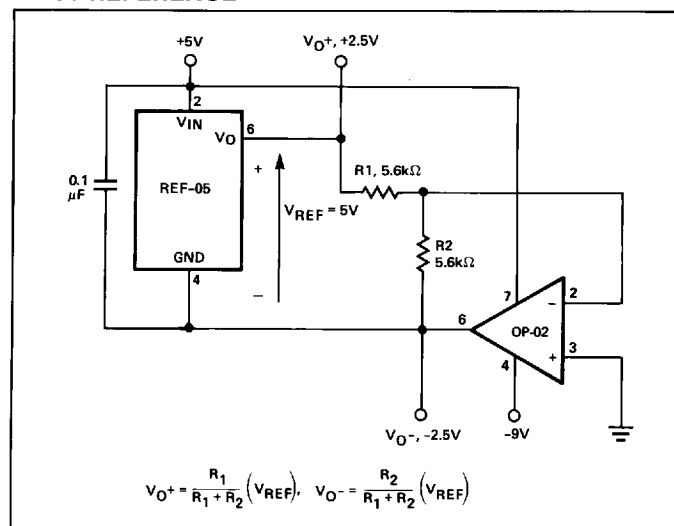
TEMPERATURE CONTROLLER



TYPICAL PERFORMANCE CHARACTERISTICS

MAXIMUM LOAD CURRENT
vs INPUT VOLTAGENORMALIZED LOAD
REGULATION ($\Delta I_L = 10\text{mA}$)
vs TEMPERATURENORMALIZED
LINE REGULATION
vs TEMPERATURELINE REGULATION
vs SUPPLY VOLTAGEMAXIMUM LOAD CURRENT
vs TEMPERATUREQUIESCENT CURRENT
vs TEMPERATURE

TYPICAL APPLICATIONS

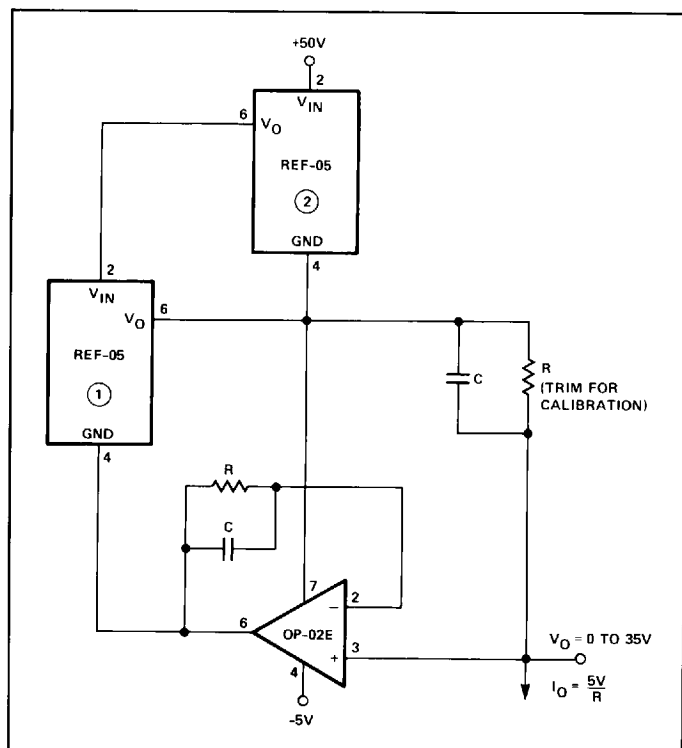
 $\pm 5\text{V}$ REFERENCE $\pm 2.5\text{V}$ REFERENCE

REF-05

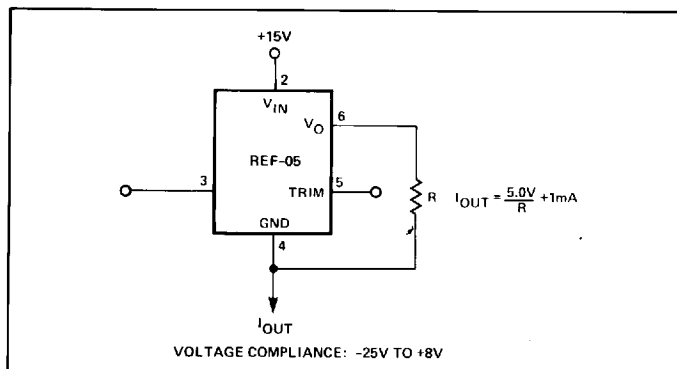
PRECISION CURRENT SOURCE

A current source with 35V output compliance and excellent output impedance can be obtained using this circuit. REF-05 ② keeps the line voltage and power dissipation constant in device ①; the only important error consideration at room temperature is the negative supply rejection of the op amp. The typical $3\mu\text{V/V}$ PSRR of the OP-02E will create a 20ppm change ($3\mu\text{V/V} \times 35\text{V}/5\text{V}$) in output current over a 35V range. For example, a 5mA current source can be built ($R = 1\text{k}\Omega$) with $350\text{M}\Omega$ output impedance.

$$R_O = \frac{35\text{V}}{20 \times 10^{-6} \times 5\text{mA}}$$



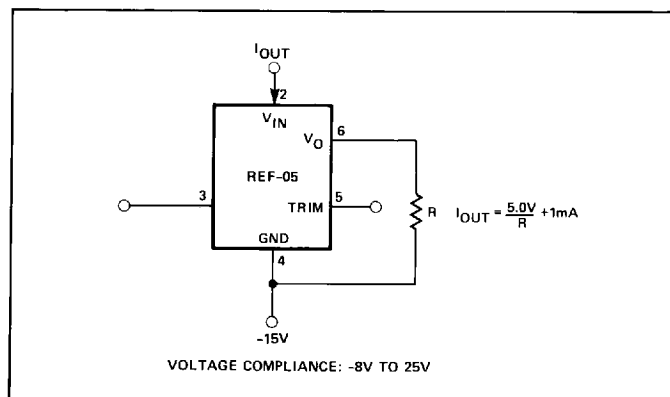
CURRENT SOURCE



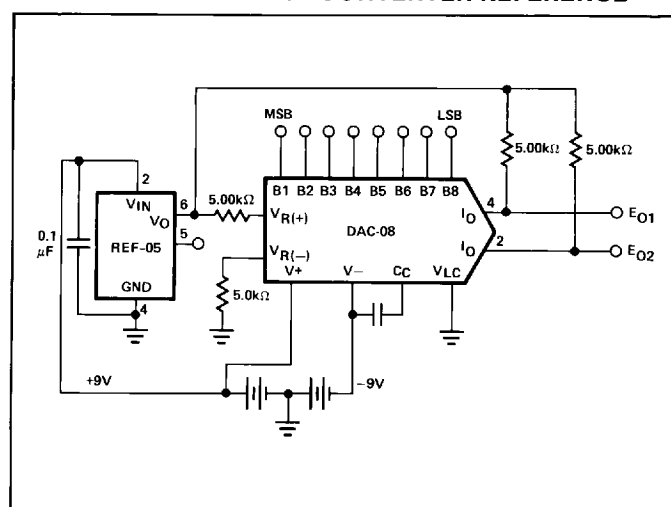
SUPPLY BYPASSING

For best results, it is recommended that the power supply pin is bypassed with a $0.1\mu\text{F}$ disc ceramic capacitor.

CURRENT SINK



BATTERY-OPERATED D/A CONVERTER REFERENCE



D/A CONVERTER REFERENCE

