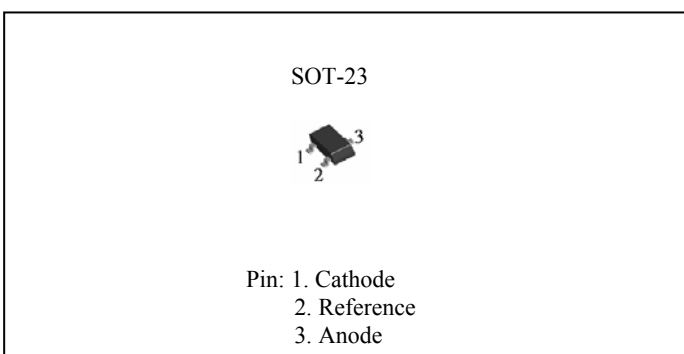# Programmable Precision References

The PJ1431 integrated circuits are three-terminal programmable shunt regulator diodes. These monolithic IC voltage references operate as a low temperature coefficient zener which is programmable from Vref to 36 volts with two external resistors. These devices exhibit a wide operating current range of 1.0 to 100mA with a typical dynamic impedance of 0.22Ω.The characteristics of these references make them excellent replacements for zener diodes in many applications such as digital voltmeters, power supplies , and op amp circuitry. The 2.5 volt reference makes it convenient to obtain a stable reference from 5.0 volt logic supplies, and since The PJ1431 operates as a shunt regulator, it can be used as either a positive or negative tage reference.
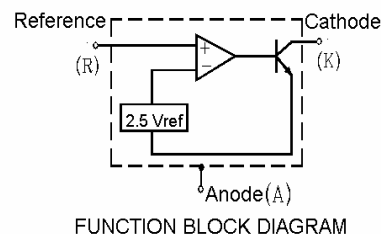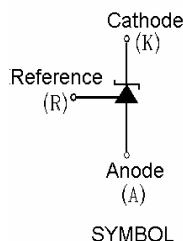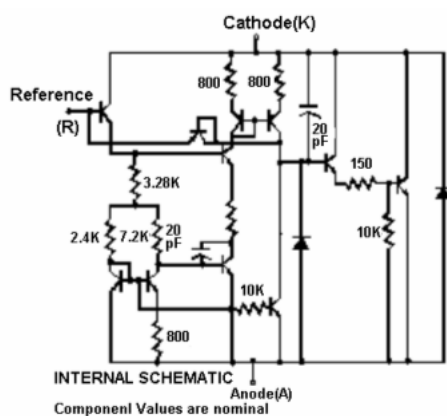
FEATURES

- Programmable Output Voltage to 36 Volts
- Low Dynamic Output Impedance, 0.22 Ω Type
- Sink Current Capability of 1.0 to 100 mA
- Equivalent Full-Range Temperature
- Coefficient of 50 ppm/ ℃ Typical
- Temperature Compensated for Operation over
- Full Rated Operating Temperature Range
- Low Output Noise Voltage

CIRCUIT SCHEMATIC

INTERNAL SCHEMATIC
Componenl Values are nominal

SOT-23

Pin: 1. Cathode
2. Reference
3. Anode

QRDERING INFORMATION

Device	Operating Temperature (Ambient)	Package
PJ1431CX	-20℃～+85℃	SOT-23

SYMBOL

FUNCTION BLOCK DIAGRAM

MAXIMUM RATINGS (Full operating ambient temperature range applies unless otherwise noted.)

Rating	Symbol	Value	Unit
Cathode To Anode Voltage	V_{KA}	37	V
Cathode Current Range, Continuous	I_K	-100 to +150	mA
Reference Input Current Range, Continuous	I_{ref}	-0.05 to +10	mA
Operating Junction Temperature	T_J	150	℃
Operating Ambient Temperature Range	T_A	-20 to +85	℃
Storage Temperature Range	T_{stg}	-65 to +150	℃
Total Power Dissipation @ T_A = 25℃ Derate above 25℃ Ambient Temperature PJ1431CX	P_D	0.30	W
Total Power Dissipation @ T_C = 25℃ Derate above 25℃ Case Temperature PJ1431CX	P_D	0.7	W

THERMAL CHARACTERISTICS

Characteristics	Symbol	Min	Max	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	178	114	℃/W
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83	41	℃/W

RECOMMENDED OPERATING CONDITIONS

Condition/Value	Symbol	Min	Max	Unit
Cathode To Anode Voltage	V_{KA}	V_{ref}	36	V
Cathode Current	I_K	1.0	100	mA

ELECTRICAL CHARACTERISTICS (Ambient temperature at 25℃ unless otherwise noted)

Characteristic	Symbol	PJ1431			Unit
		Min	Typ	Max	
Reference Input Voltage (Figure 1) $V_{KA} = V_{ref}$, $I_K = 10$ mA $T_A = +25℃$ $T_A = T_{low}$ to T_{high} (Note 1)	V_{ref}	2.475 2.458	2.500 --	2.525 2.542	V
Reference Input Voltage Deviation Over Temperature Range (Figure 1, Note 1,2,4) $V_{KA} = V_{ref}$, $I_K = 10$ mA	$\triangle V_{ref}$	--	3.0	17	mV
Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage $I_K = 10$ mA (Figure 2), $\triangle V_{KA} = 10V$ to V_{ref} $\triangle V_{KA} = 36V$ to 10V	$\dfrac{\Delta V_{ref}}{\Delta V_{kA}}$	-- --	- 1.4 - 1.0	- 2.7 -.2.0	mV
Reference Input Current (Figure 2) $I_K = 10$ mA, R1 = 10 k, R2 = ∞ $T_A = +25℃$ $T_A = T_{low}$ to T_{high} (Note 1)	I_{ref}	-- --	0.7 --	4.0 5.2	μA
Reference Input Current Deviation Over Temperature Range (Figure 2, Note 1,4) $I_K = 10$ mA, R1 = 10 k, R2 = ∞	$\triangle I_{ref}$	--	0.4	1.2	μA
Minimum Cathode Current for Regulation $V_{KA} = V_{ref}$ (Figure 1)	I_{min}	--	0.5	1.0	mA
Off-State Cathode Current (Figure 3) $V_{KA} = 36$ V, $V_{ref} = 0V$	I_{off}	--	2.6	1000	nA
Dynamic Impedance (Figure 1, Note 3) $V_{KA} = V_{ref}$, $\triangle I_K = 1.0$ mA to 100 mA, f ≤1.0 kHz	$|Z_{ke}|$	--	0.22	0.5	Ω

1

$T_{low} = -20\,°C, \quad T_{high} = +85°C$

2

The deviation parameter $\triangle V_{ref}$ is defined as the differences between the maximum and minimum values obtained over the full operating ambient temperature range the applies.
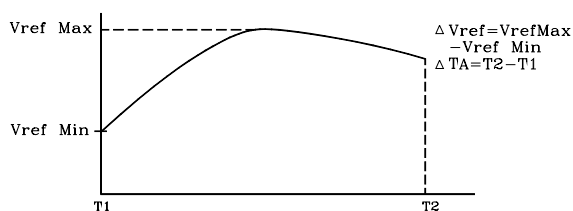
The average temperature coefficient of the reference input voltage, αV_{ref}, is defined as :

$$\alpha V_{ref}\ \frac{ppm}{°C} = \frac{V_{ref}\,@\,25°C}{\Delta T_A} \times 10^6 = \frac{\Delta V_{ref} \times 10^6}{\Delta T_A (V_{ref}\,@\,25°C)}$$

αV_{ref} can be positive of negative depending on whether V_{ref} Min of V_{ref} Max occurs at the lower ambient temperature. (Refer to Figure 6)

Example: $\triangle V_{ref}$ = 8.0 mV and slope is positive,
$V_{ref}\,@\,25\,°C$ = 2.5V, $\quad \triangle T_A$ = 85℃

$$\alpha V_{ref} = \frac{0.008 \times 10^6}{70(2.5)} = 45.8 ppm\,/\,°C$$

3

The dynamic impedance Z_{ka} is defined as:

$$|Z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

When the device is programmed with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is defined as:

$$|Z_{ka}| \approx |Z_{ka}|\left(1 + \frac{R_1}{R_2}\right)$$

4

This test is not applicable to surface mount (D suffix) devices.

FIGURE 1 -- TEST CIRCUIT FOR $V_{KA} = v_{ref}$
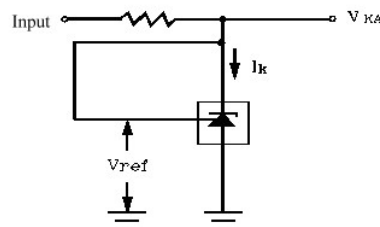
FIGURE 2 -- TEST CIRCUIT FOR $V_{KA} > V_{ref}$
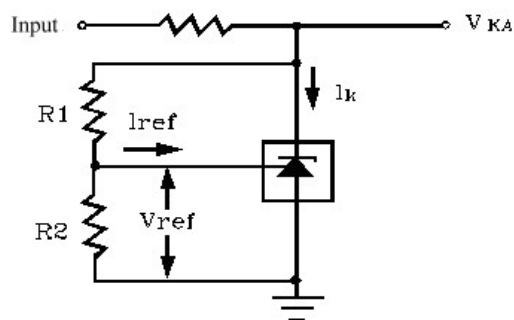
$$V_{kA} = V_{ref}\left(1 + \frac{R_1}{R_2}\right) + I_{ref} \bullet R_1$$

FIGURE 3 -- TEST CIRCUIT FOR I_{off}
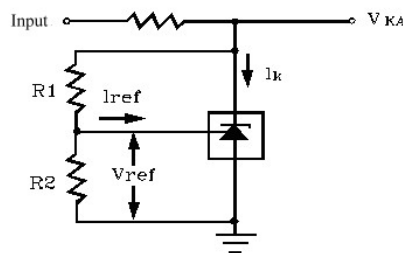
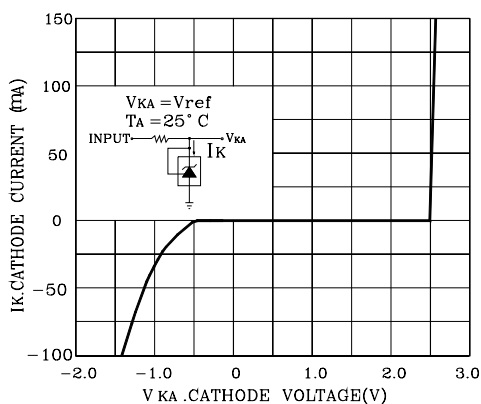**FIGURE 4-CATHODE CURRENT versus CATHODE VOLTAGE**

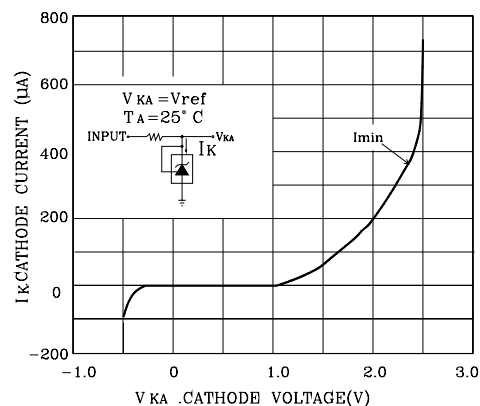**FIGURE 5-CATHODE CURRENT versus CATHODE VOLTAGE**

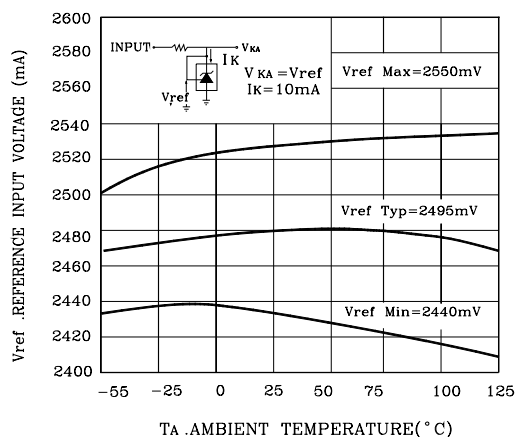**FIGURE 6-REFERENCE INPUT VOLTAGE versus AMBIENT TEMPERATURE**

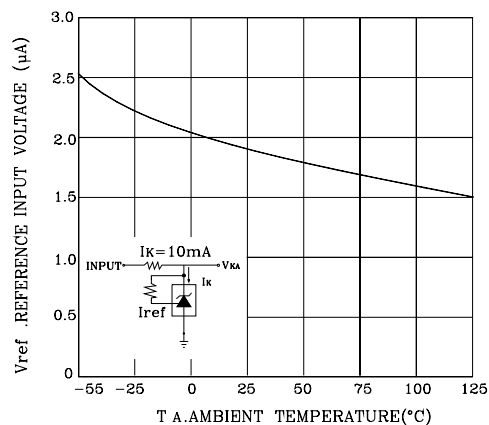**FIGURE 7-REFERENCE INPUT CURRENT versus AMBIENT TEMPERATURE**

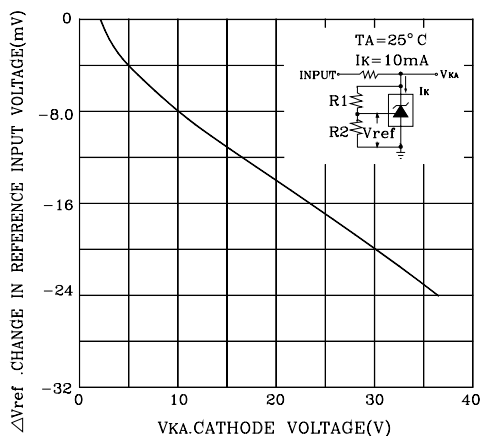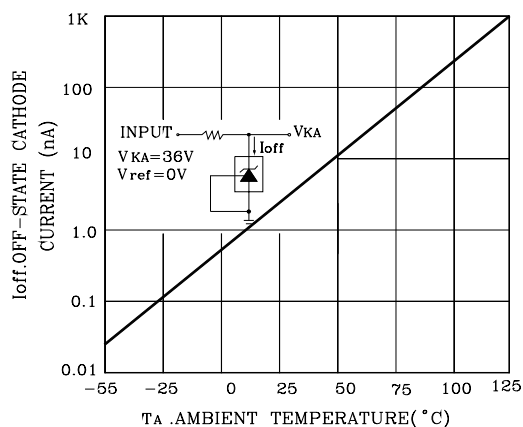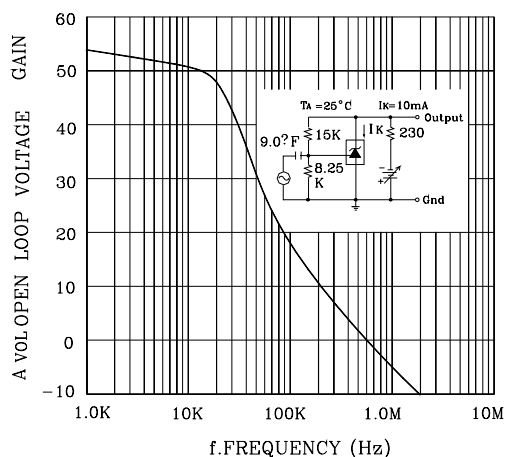**FIGURE 8-CHANGE IN REFERENCE INPUT VOLTAGE versus CATHODE VOLTAGE**

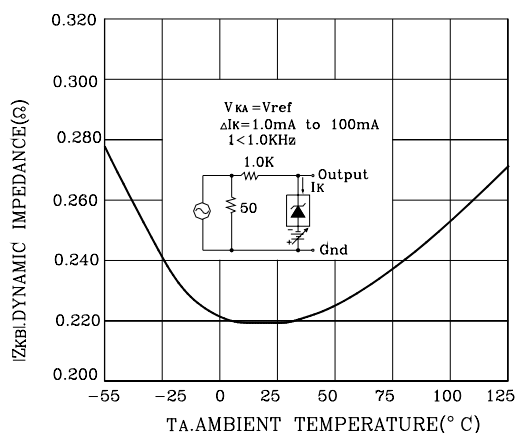**FIGURE 9 –OFF.STATE CATHODE CURRENT versus AMBIENT TEMPERATURE**

FIGURE 10 - DYNAMIC IMPEDANCE VERSUS FREQUENCY

FIGURE 11 - DYNAMIC IMPEDANCE VERSUS AMBIENT TEMPERATURE

FIGURE 12 - OPEN LOOP VOLTAGE GAIN VERSUS FREQUENCY
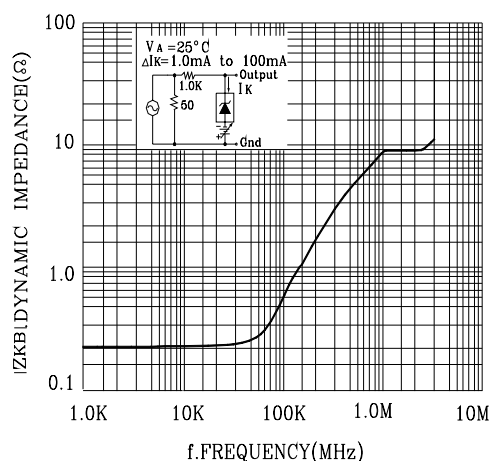
FIGURE 13 - SPECTRAL NOISE DENSITY
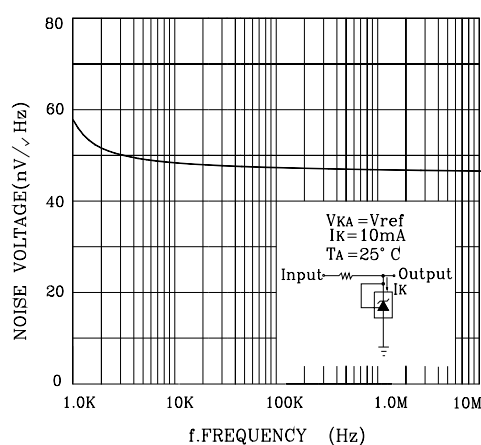
FIGURE 14 - PULSE RESPONSE
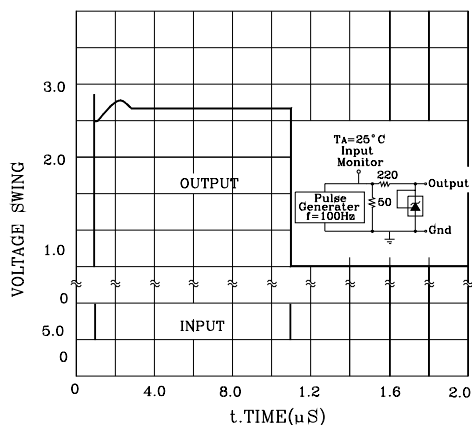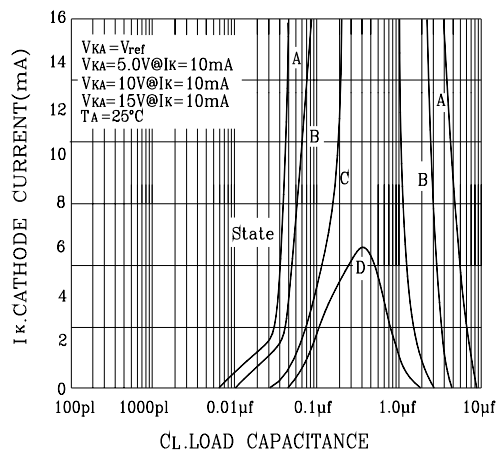

FIGURE 15 - STABILITY BOUNDARY CONDITIONS

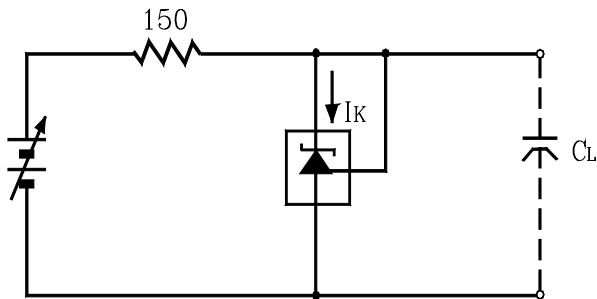**FIGURE 16-TEST CIRCUIT FOR CURVE A OF STABILITY BOUNDARY CONDITIONS**

FIGURE 17-TEST CIRCUIT FOR CURVES B.C. AND D OF STABILITY BOUNDARY CONDITIONS
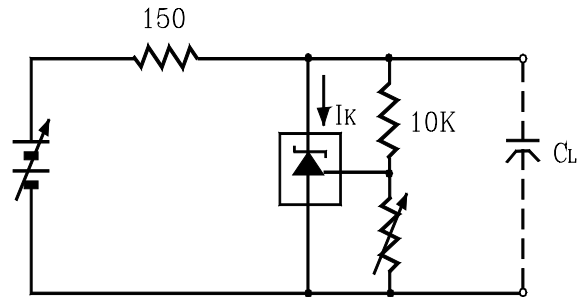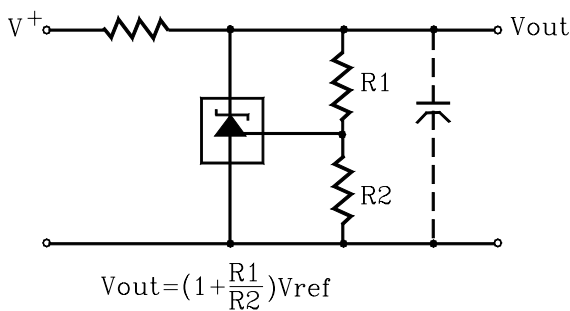
FIGURE 18-SHUNT REGULATOR

$$Vout=(1+\frac{R1}{R2})Vref$$

FIGURE 19-HIGH CURRENT SHUNT REGULATOR

$$Vout=(1+\frac{R1}{R2})Vref$$
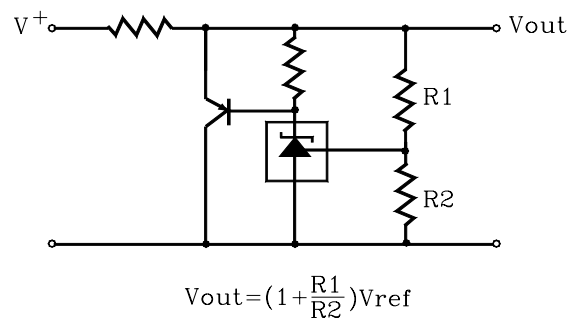
FIGURE 20-OUTPUT CONTROL OF A THREE-TERMINAL FIXED EGULATOR

$$Vout=(1+\frac{R1}{R2})Vref$$
$$Voutmin=Vref+5.0V$$
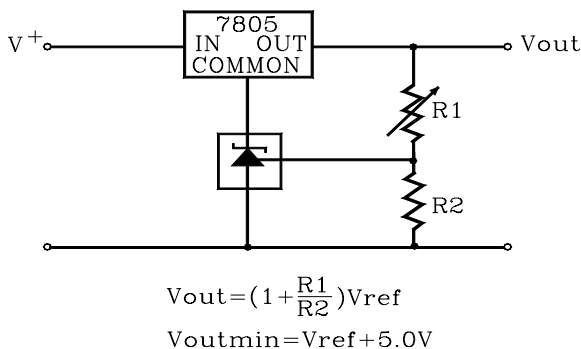
FIGURE 21-SERIES PASSEGULATOR

$$Vout=(1+\frac{R1}{R2})Vref$$
$$Voutmin=Vref+V_{BE}$$

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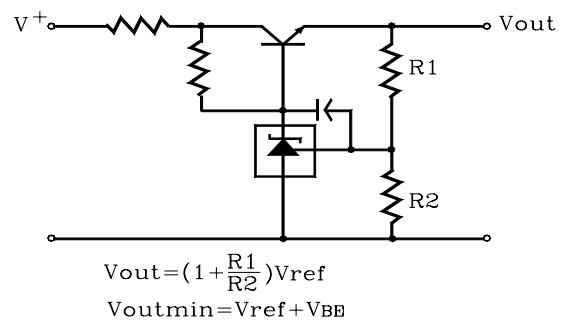
FIGURE 22-CONSTANT CURRENT SOURCE

$$Iout = \frac{Vref}{Rcl}$$
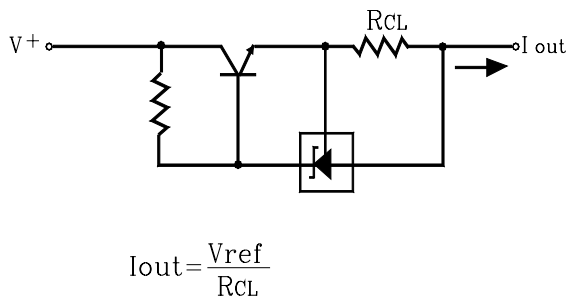
FIGURE 23-CONSTANT CURRENT SINK

$$Isink = \frac{Vref}{Rs}$$
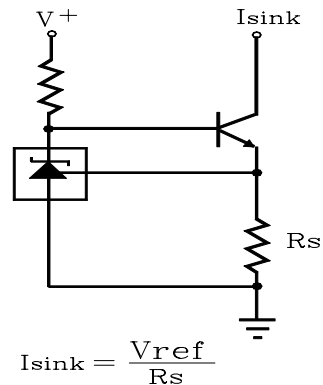
FIGURE 24-TRIAC CROWBAR

$$Vout(trip) = (1 + \frac{R1}{R2})Vref$$
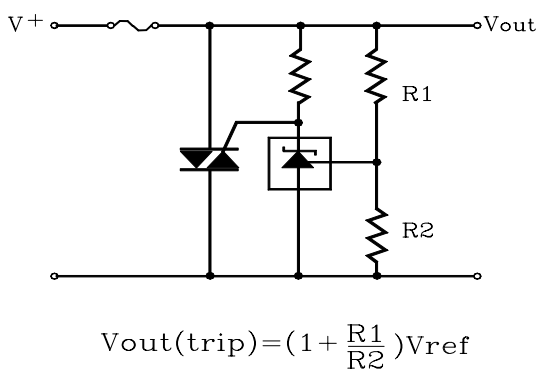
FIGURE 25-SCR CROWBAR

$$Vout(trip) = (1 + \frac{R1}{R2})Vref$$

FIGURE 26-VOLTAGE MONITOR

$$Lower\ Limit = (1 + \frac{R1}{R2})Vref$$

$$Upper\ Limit = (1 + \frac{R3}{R4})Vref$$

L.E.D. indicator is "on" when V+ is between the upper and lower limits.
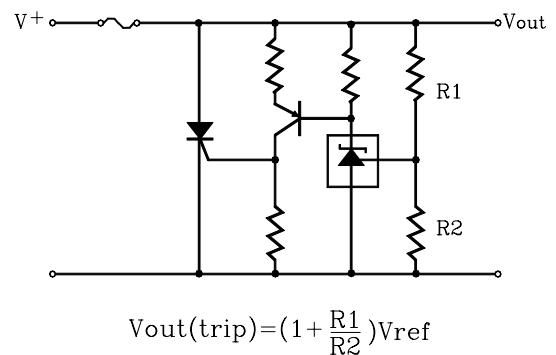
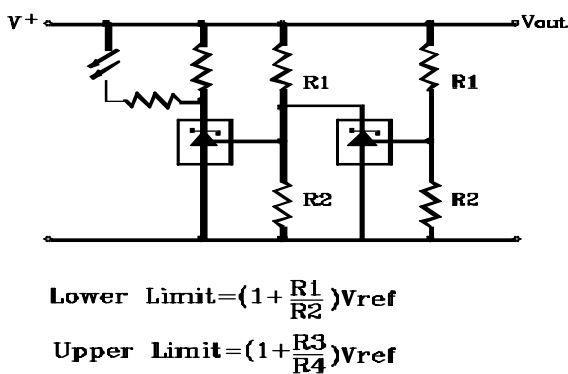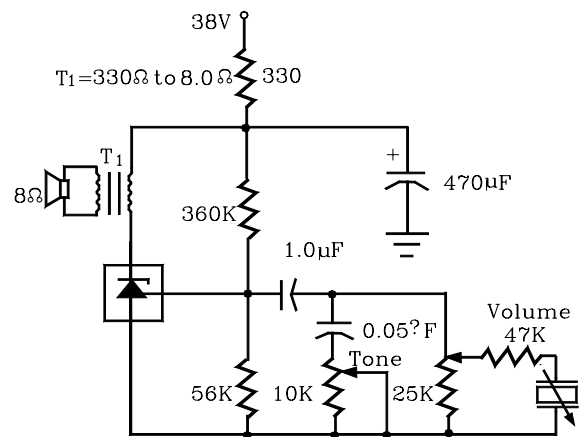### FIGURE 27-SINGLE-SUPPLY COMPARATOR WITH TEMPERATURE-COMPENSATED THRESHOLD

Vin	Vout
<Vuref	V+
>Vuref	≈2.0V

Programmable Precision References

FIGURE 28-LINER OHMMETER

$$Rx = Vout \frac{\Omega}{V} Range$$
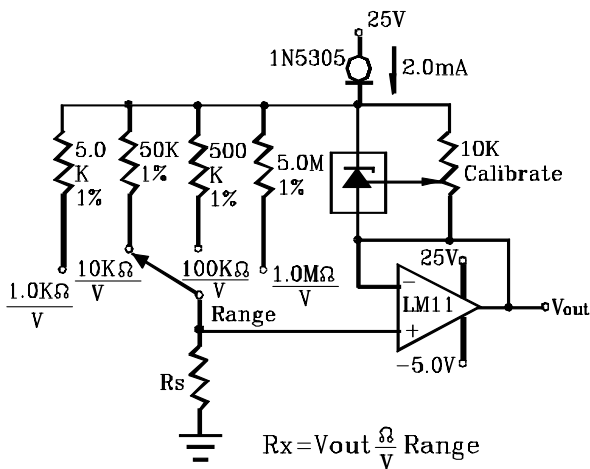
FIGURE 29-SIMPLE 400mW PHONO AMPLIFIER

**FIGURE 30-HIGH EFFICIENCY STEP-DOWN
SWITCHING CONVERTER**
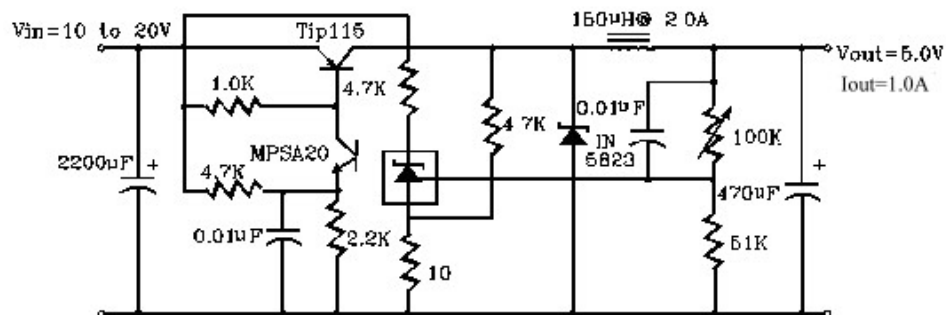
TEST	CONDITIONS	RESULTS
Line Regulation	Vin=10V to 20V, Io=1.0A	53mV (1.1%)
Load Regulation	Vin=15V, Io=0A to 1.0A	25mV (0.5%)
Output Ripple	Vin=10V,Io=1.0A	50mVp-p P.A.R.D.
Output Ripple	Vin=20V, Io=1.0A	100mVp-p P.A.R.D.
Efficiency	Vin=15V, Io=1.0A	82%

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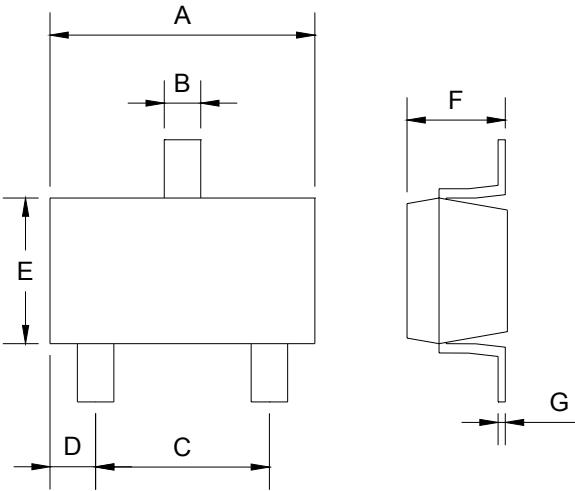
SOT-23 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.88	2.91	0.113	0.115
B	0.39	0.42	0.015	0.017
C	1.78	2.03	0.070	0.080
D	0.51	0.61	0.020	0.024
E	1.59	1.66	0.063	0.065
F	1.04	1.08	0.041	0.043
G	0.07	0.09	0.003	0.004