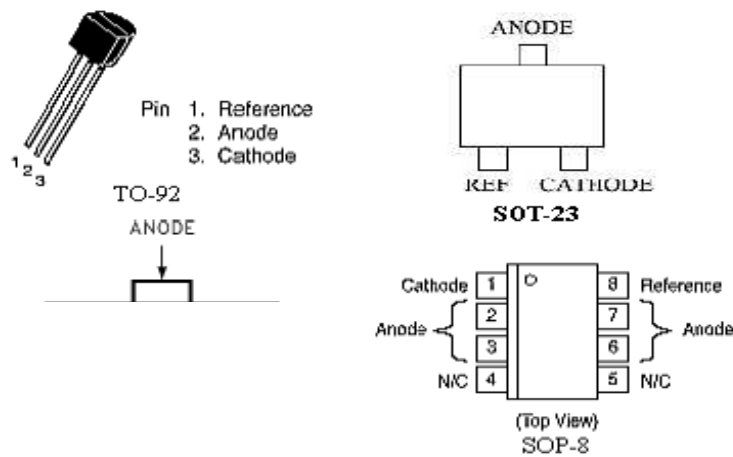


The TL431 integrated circuits are three-terminal programmable shunt regulator diodes. These monolithic IC voltage references operate as a low temperature coefficient zener which is programmable from Vref to 36 volts with two external resistors. This device exhibits a wide operating current range of 1.0 to 100 mA with a typical dynamic impedance of 0.22 . 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 TL431 operates as a shunt regulator, it can be used as either a positive or negative voltage reference.

FEATURES

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

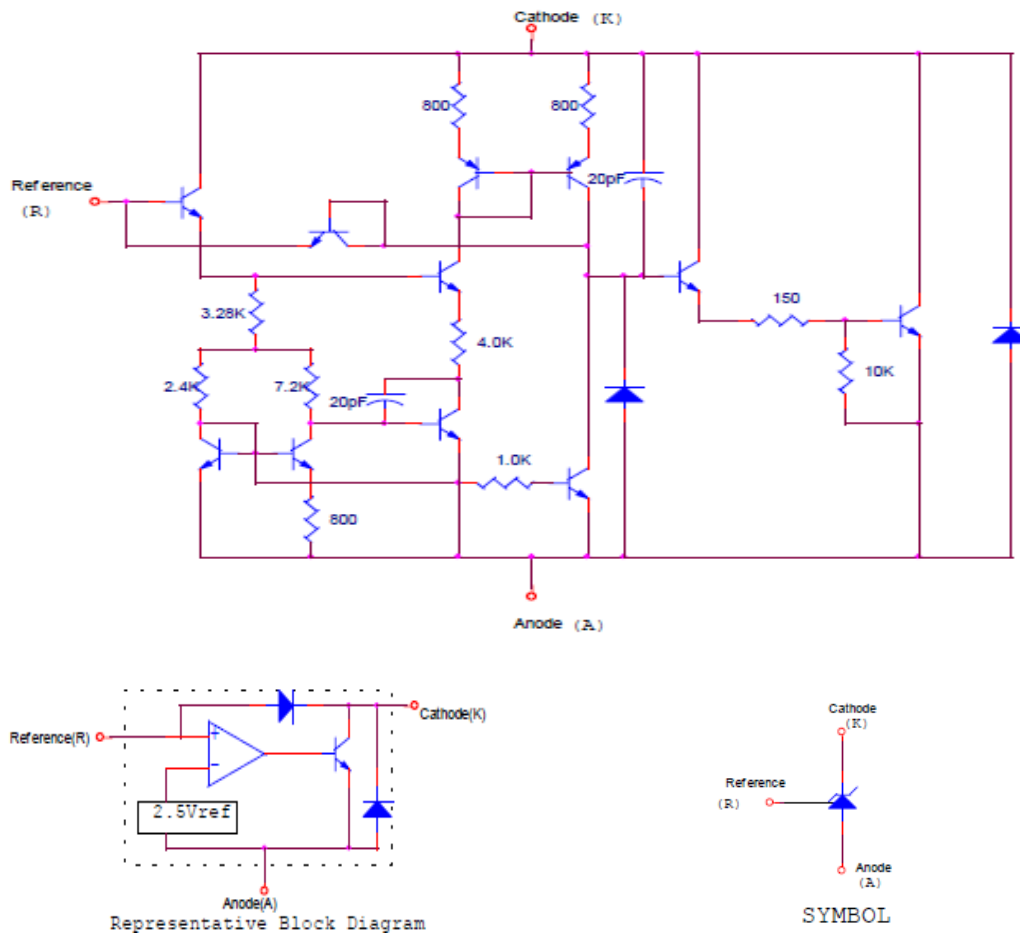
PIN ARRANGEMENT



ORDERING INFORMATION

	PACKAGE TYPE				OPERATING
	TO-92	SOT-23	SOP-8	---	
± 0.5%	TL431-AJ	E431-AJ	TL431-AJ	---	-40° to 105°C
± 1.0%	TL431-BJ	E431-BJ	TL431-BJ	---	-40° to 105°C

BLOCK DIAGRAM



This device contains 12 active transistor

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies, unless otherwise noted)

Rating	Symbol	Value	Unit
Cathode To Anode Voltage	VKA	37	V
Cathode Current Range, Continuous	Ik	-100 to +150	mA
Reference Input Current Range, Continuous	Iref	-0.05 to +10	mA
Operating Junction Temperature	TJ	150	°C
Operating Ambient Temperature Range	TA	-40 to +105	°C
Storage temperature Range	Tstg	-65 to +150	°C
Total Power Dissipation @TA=25°C	Pd		
Derate above 25°C Ambient Temperature			W
EST 431L/ EST 431J		0.70	
EST 431N/ EST 431T		0.28	
Total Power Dissipation @TC=25°C	Pd		
Derate above 25°C Case Temperature			W
EST 431L/ EST 431J		1.5	
EST 431N/ EST 431T		0.6	

THERMAL CHARACTERISTICS

Characteristics	Symbol	E431	TL 431	Unit
Thermal Resistance, Junction to Ambient	R JA	178	114	°C /W
Thermal Resistance, Junction to Case	R JC	105	85	°C /W

Recommended operating conditions

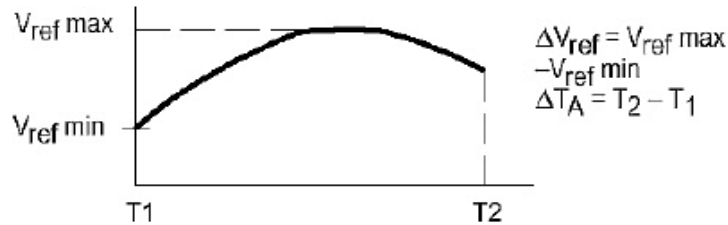
Condition/Value	Symbol	Min	Max	Unit
Cathode to Anode Voltage	V _{KA}	V _{ref}	36	V
Cathode Current	I _k	1.0	100	mA

ELECTRICAL CHARACTERISTICS (Ambient temperature at 25°C unless otherwise noted)

Characteristic	Symbol	TL431			Unit
		Min	Typ	Max	
Reference Input Voltage (Fig 1) V _{KA} =V _{ref} , I _k =10mA TA=+25°C TL431, A --0.5% TL431, B --1.0% TA=Tlow to Thigh (Note 1) TL431, A--0.5% TL431, B--1.0%	V _{ref}	2.488 2.475 2.471 2.458	2.500	2.512 2.525 2.529 2.542	V
Reference Input Voltage Deviation Over Temperature Range (Fig 1, Note 1,2) V _{KA} =V _{ref} . I _k =10mA	ΔV _{ref}	--	3.0	17	mV
Ratio of Change in Reference Input Voltage To Change in Cathode to Anode Voltage I _k =10mA (Figure 2), ΔV _{KA} =10V to V _{ref} ΔV _{KA} =36V to 10V	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	-- --	-1.4 -1.0	-2.7 -2.0	mV/V
Reference Input Current (Figure 2) I _k =10mA, R1=10k, R2=∞ TA=+25°C TA=Tlow to Thigh (Note 1)	I _{ref}	-- --	1.8 --	4.0 5.2	μA
Reference Input Current Deviation Over Temperature Range (Figure 2, Note 1) I _k =10mA, R1=10k, R2=∞	ΔI _{ref}	--	0.4	1.2	μA
Minimum Cathode Current for Regulation V _{KA} =V _{ref} (Figure 1)	I _{min}	--	0.27	1.0	mA
Off-State Cathode Current (Figure 3) V _{KA} =36V, V _{ref} =0V	I _{off}	--	260	1000	nA
Dynamic Impedance (Figure 1, Note 3) V _{KA} =V _{ref} , I _k =1.0mA to 100mA, f< 1.0kHz	Z _{KA}	--	0.22	0.5	Ω

1 Tlow=0°C , Thigh=+70°C

2 The deviation parameter ΔVref 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, α Vref, is defined as:

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

α Vref can be positive or negative depending on whether Vref Min or Vref Max occurs at the lower ambient temperature. (Refer to Figure 6)

Example: ΔVref =8.0mV and slope is positive, Vref @25°C =2.495V, ΔTA=70°C

$$\alpha V_{ref} = \frac{0.008 \times 10^6}{70(2.495)} = 45.8 \text{ ppm/}^{\circ}C$$

3 The dynamic impedance ZKA 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:

$$|Z_{KA}'| \approx |Z_{KA}| \left(1 + \frac{R1}{R2}\right)$$

TEST CIRCUITS

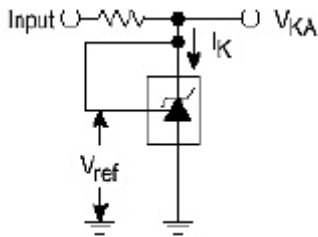
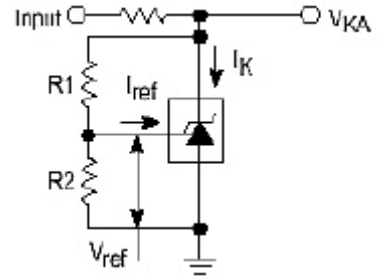


Fig 1. Test Circuit for $V_{KA} = V_{ref}$



$$V_{KA} = V_{ref} \left(1 + \frac{R1}{R2}\right) + I_{ref} R1$$

Fig 2. Test Circuit for $V_{KA} > V_{ref}$

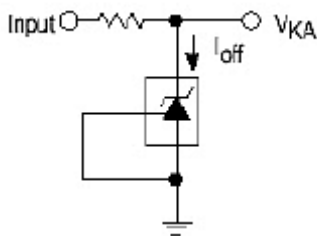


Fig 3. Test Circuit for I_{off}

APPLICATION EXAMPLE

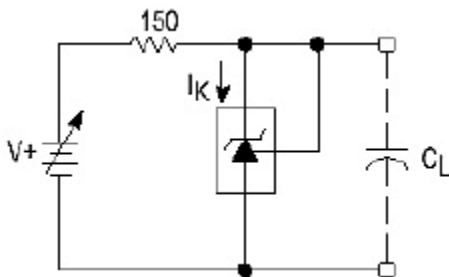


Fig 4. Test circuit for curves A of stability boundary conditions

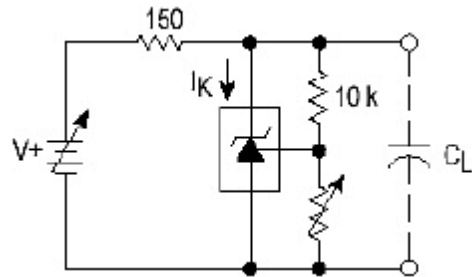


Fig 5. Test circuit for curves B, C and D of stability boundary conditions

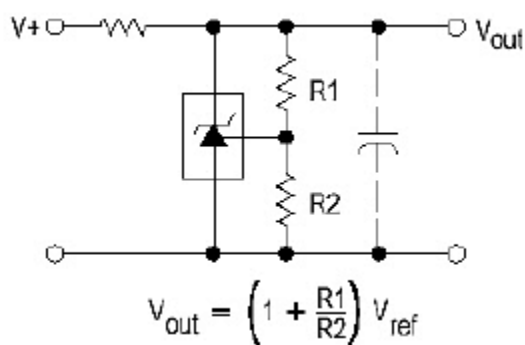


Fig 6. Shunt regulator

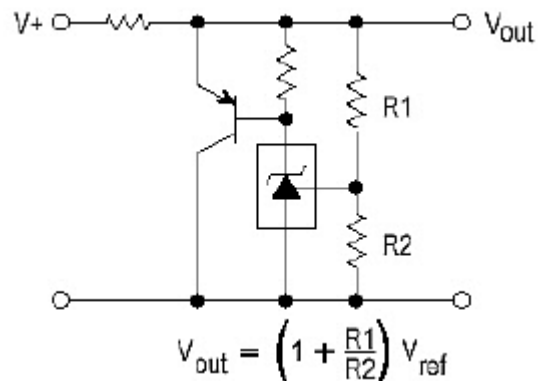


Fig 7. High current shunt regulator

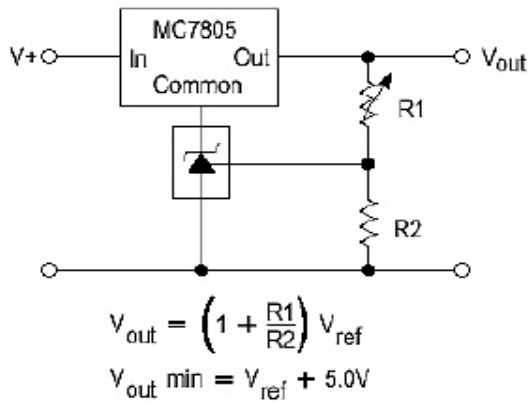


Fig 8. Output control of a three-Terminal fixed regulator

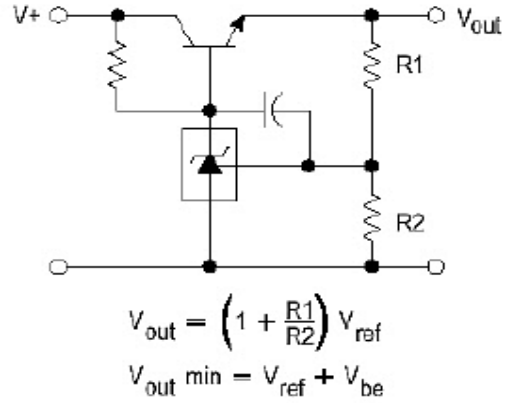


Fig 9. Series pass regulator

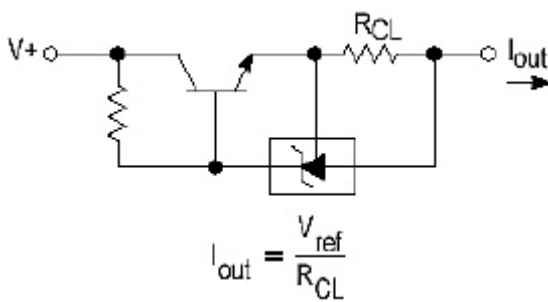


Fig 10 .Constant current source

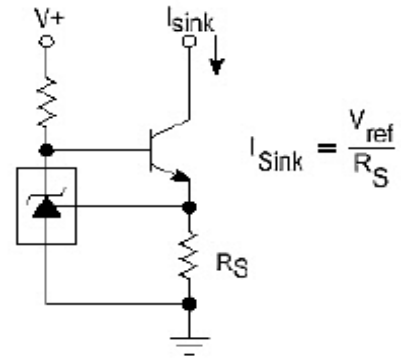


Fig 11 .Constant current sink

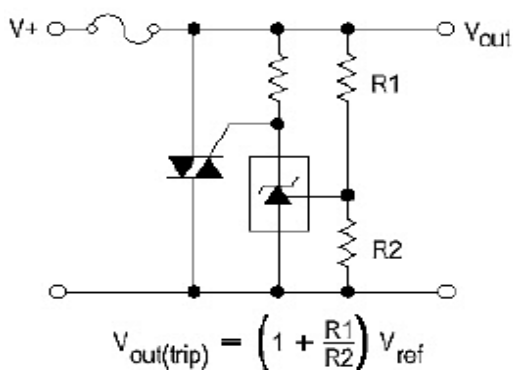


Fig 12 .Triac crowbar

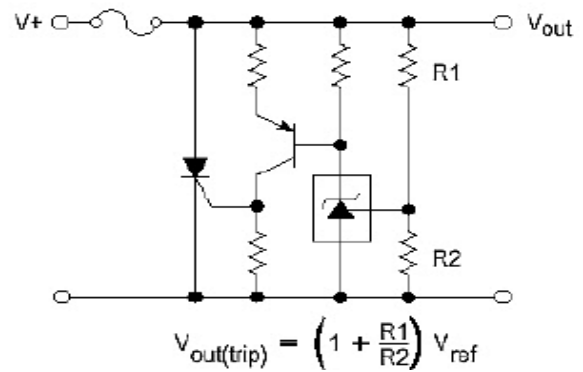
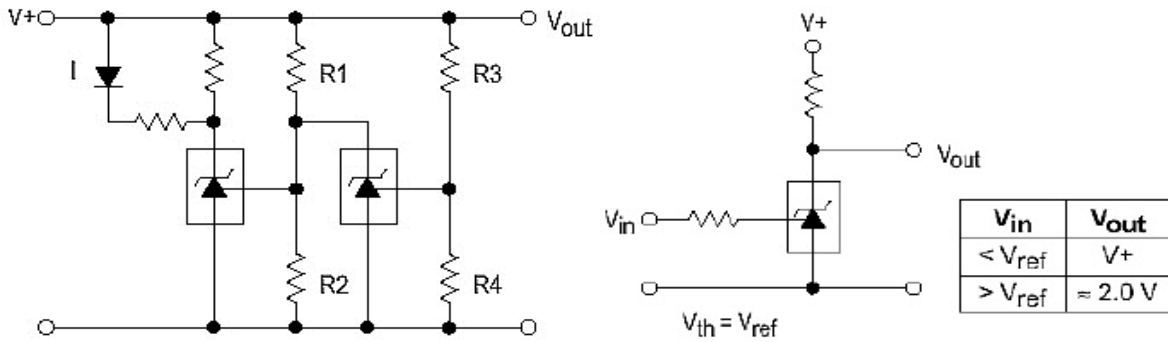


Fig 13.SCR crowbar



L.E.D. indicator is 'on' when V_{+} is between the upper and lower limits.

$$\text{Upper Limit} = \left(1 + \frac{R3}{R4}\right) V_{ref} \quad \text{Lower Limit} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

Fig 14. Voltage monitor

Fig 15 . Single-supply comparator with temperature-compensated threshold

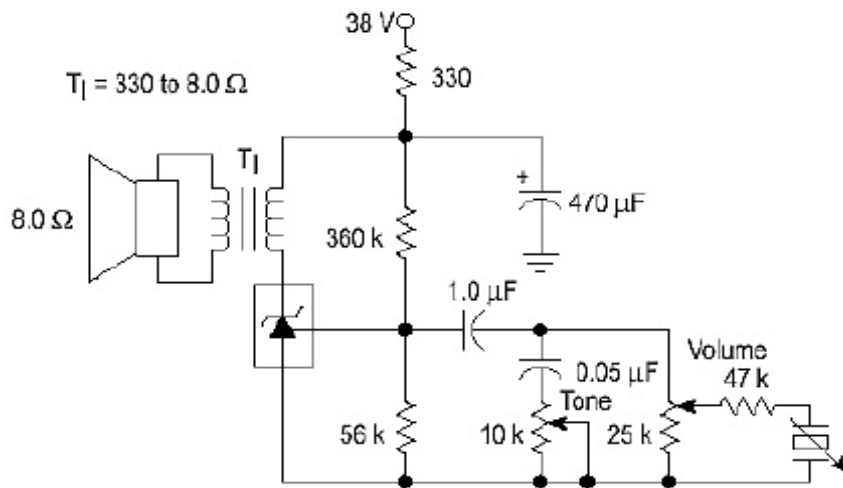


Fig 16 .Simple 400mW phone amplifier

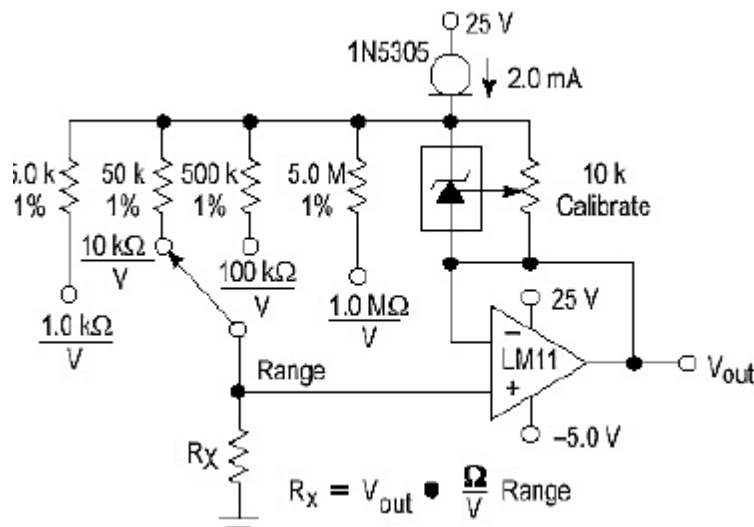
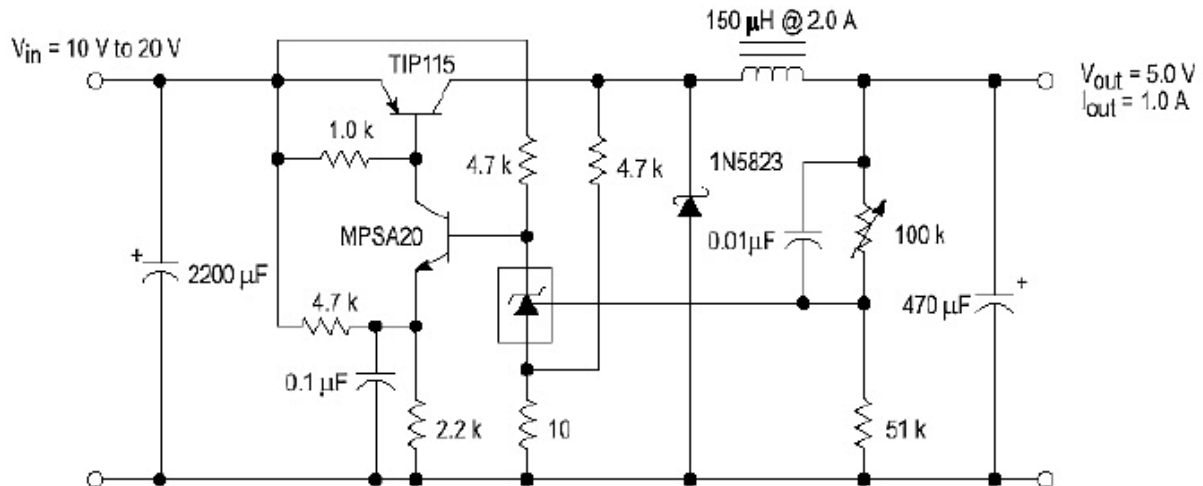


Fig 17. Linear ohmmeter



Test	Conditions	Results
Line Regulation	Vin=10V to 20V, I _o =1.0A	53mV (1.1%)
Load Regulation	Vin=15V, I _o =0A to 1.0A	25mV (0.5%)
Output Ripple	Vin=10V, I _o =1.0A	50mV _{P.P} P.A.R.D
Output Ripple	Vin=20V, I _o =1.0A	100mV _{P.P} P.A.R.D
Efficiency	Vin=15V, I _o =1.0A	82%

Fig 18.High efficiency step-down switching converter

ELECTRICAL CHARACTERISTICS CURVES

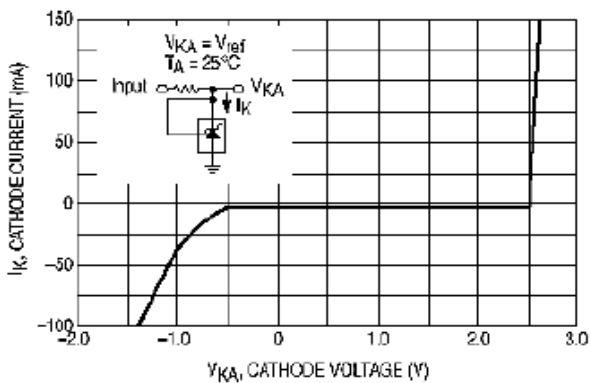


Fig 19.Cathode current versus cathode voltage

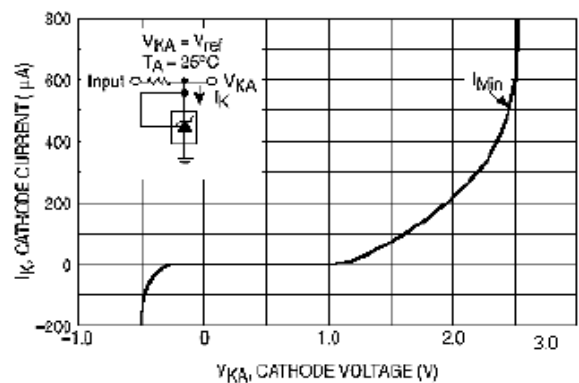


Fig 20.Cathode current versus cathode voltage

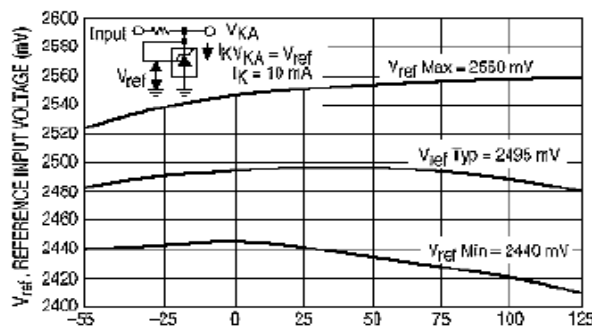


Fig 21.Reference input voltage versus ambient temperature

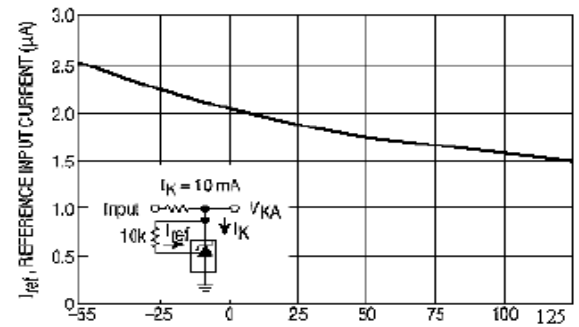


Fig 22.Reference input current versus ambient temperature

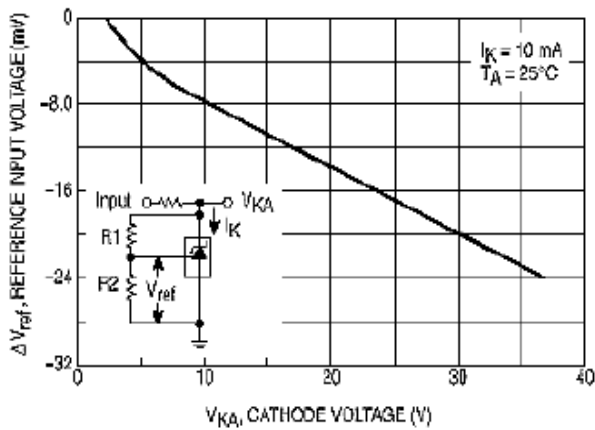


Fig 23. Change in reference input voltage versus Cathode voltage

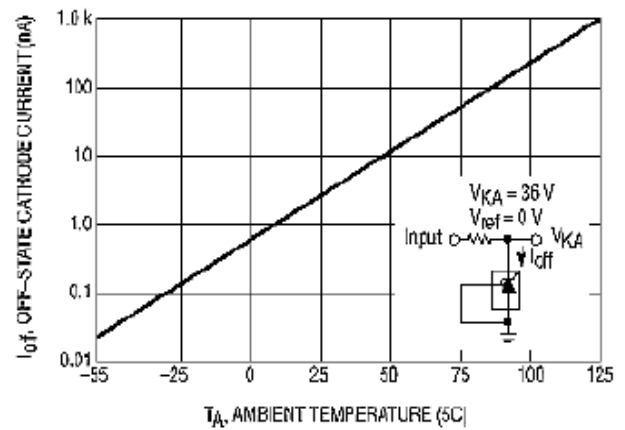


Fig 24. Off state cathode current versus ambient temperature

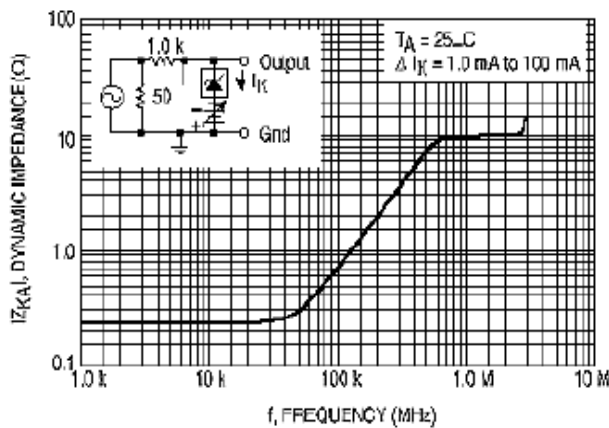


Fig 25. Dynamic impedance versus frequency

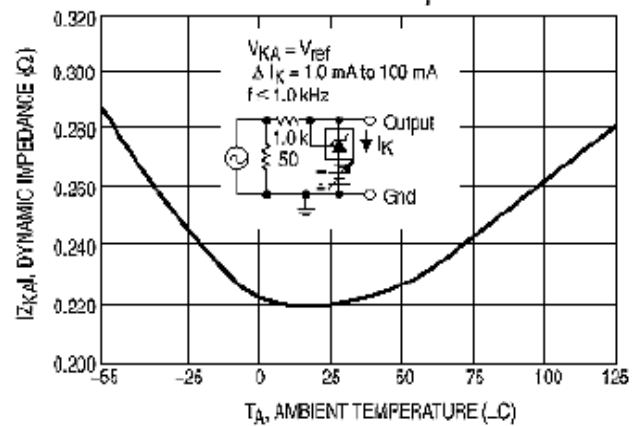


Fig 26. Dynamic impedance versus ambient temperature

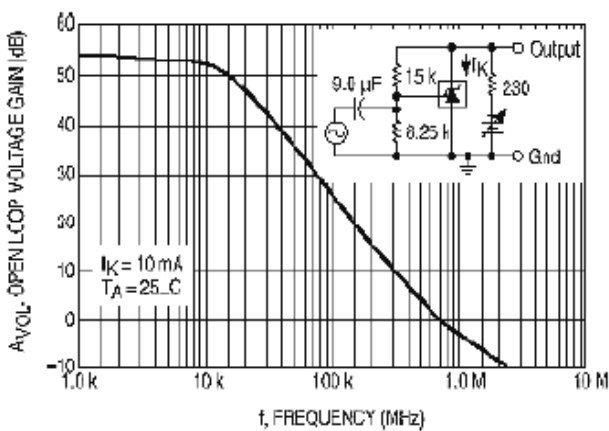


Fig 27. Open loop voltage gain versus frequency

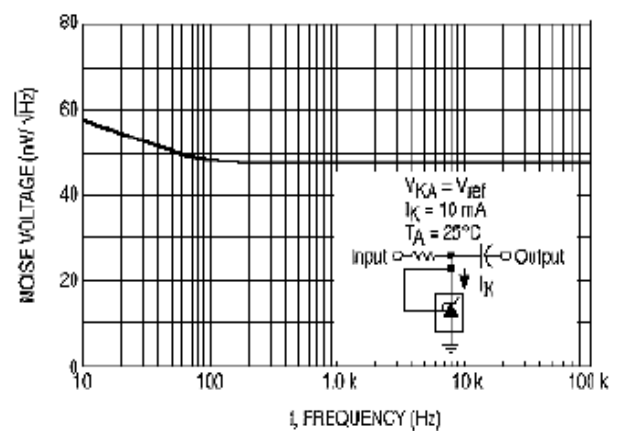


Fig 28. Spectral noise density

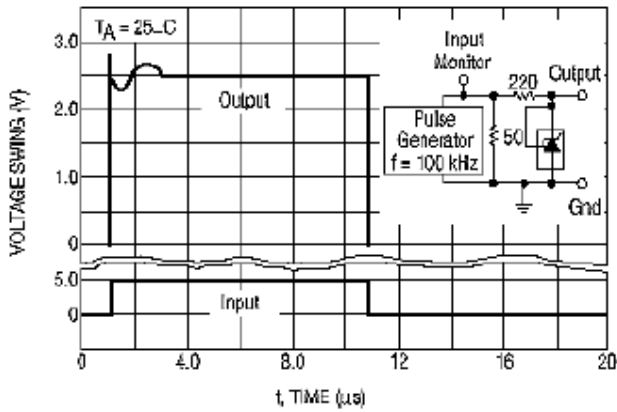


Fig 29. Pulse response

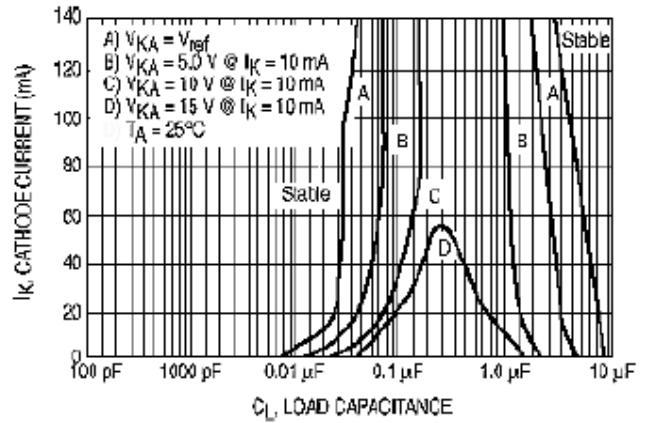
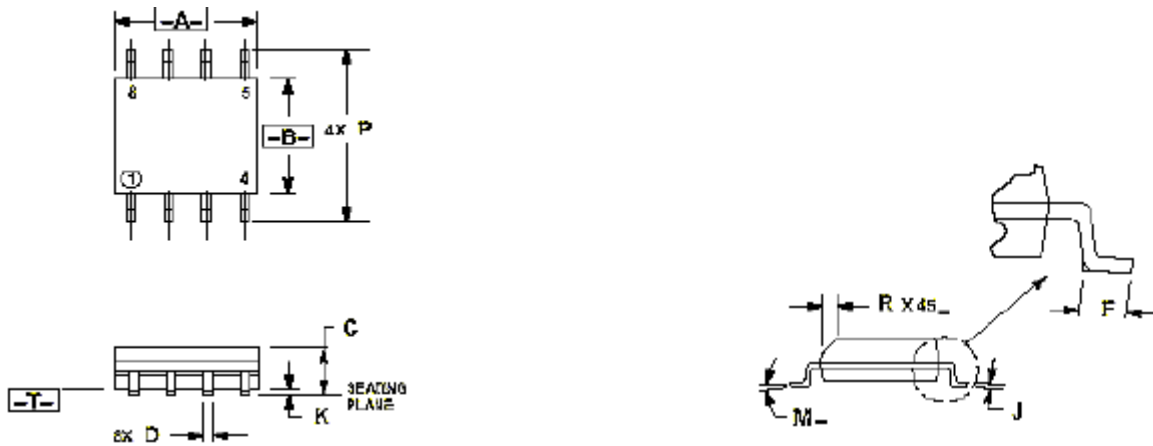


Fig 30. Stability boundary conditions

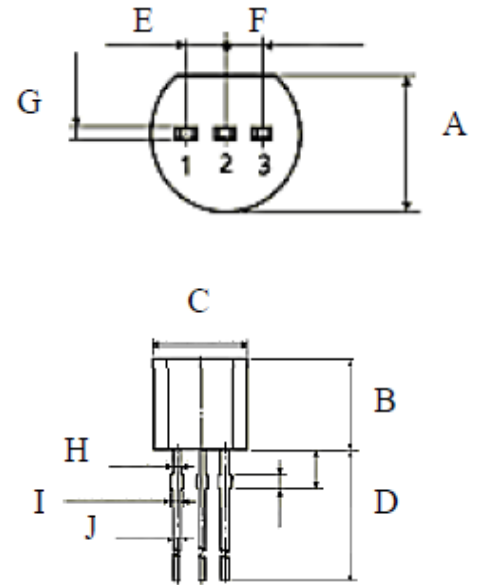
EXTERNAL DIMENSIONS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.18	0.25	0.007	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

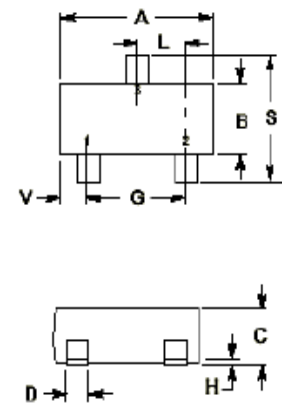
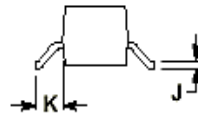
SOP-8

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.30	4.10	0.130	0.161
B	4.20	5.0	0.165	0.197
C	4.30	5.10	0.169	0.200
D	12.70		0.500	
E	1.25	1.35	0.049	0.053
F	1.25	1.35	0.049	0.053
G	0.35	0.45	0.014	0.018
H	0.35	0.45	0.014	0.018
I		0.55		0.022
J	0.35	0.45	0.014	0.018



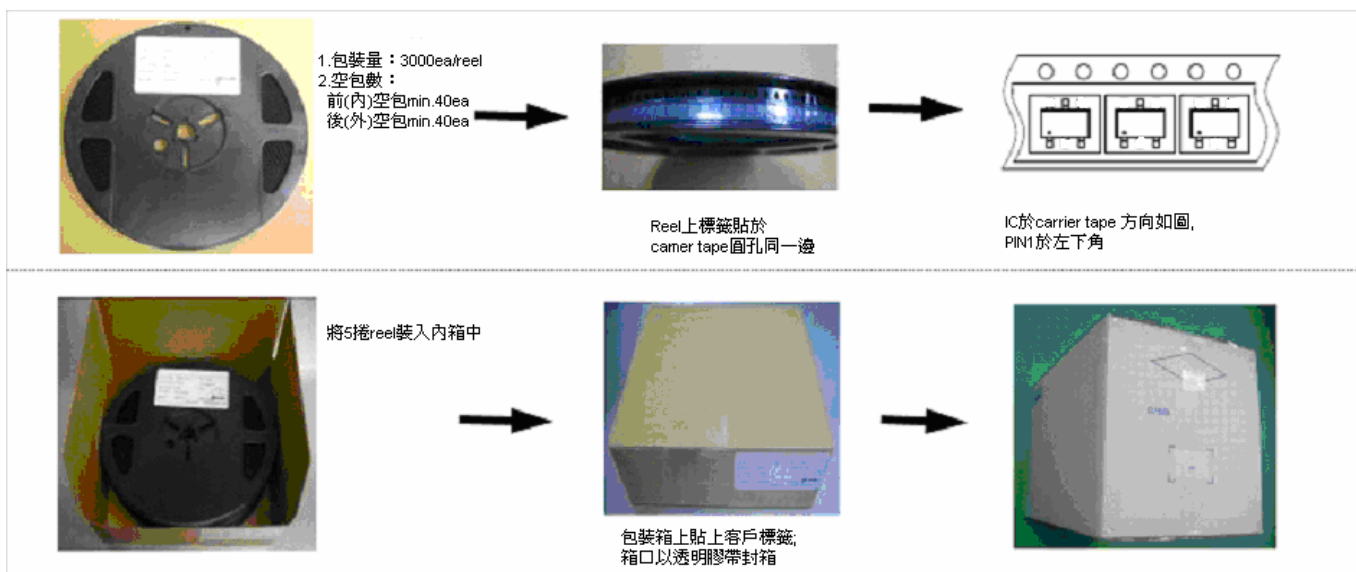
TO-92

	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.1102	0.1197	2.80	3.04
B	0.0472	0.0551	1.2	1.4
C	0.0350	0.0440	0.89	1.11
D	0.0150	0.0200	0.37	0.50
G	0.0701	0.0807	1.78	2.04
H	0.0005	0.0040	0.013	0.100
J	0.0034	0.0070	0.085	0.177
K	0.0180	0.0236	0.45	0.60
L	0.0350	0.0401	0.89	1.02
S	0.0830	0.0984	2.10	2.50
V	0.0177	0.0236	0.45	0.60

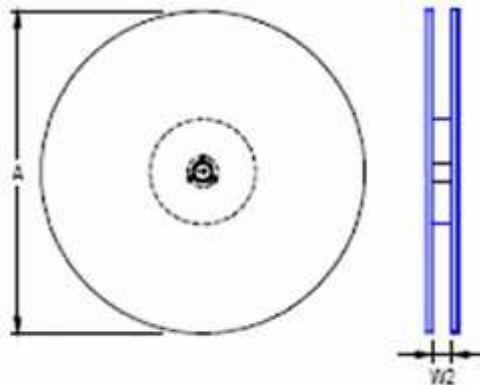
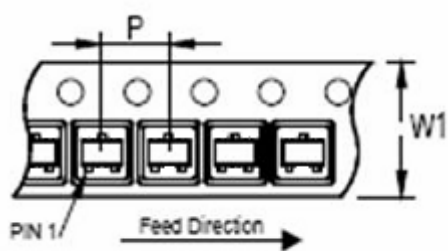


SOT23-3(N)

Shipping packing



Tape Reel Data



Package Type SOT-23	Tape Size (W1) (mm)	Pocket Pitch (P) (mm)	Reel Size (A) (mm)	Reel Width (W2) Min./Max. (mm)	Units Per Reel pcs.
3 Lead	8	4	180	8.4/9.9	3000