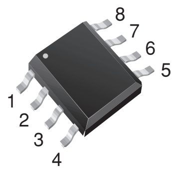
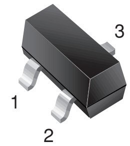
Adjustable Precision Shunt Regulators

SO-8



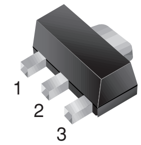
S Suffix

SOT-23



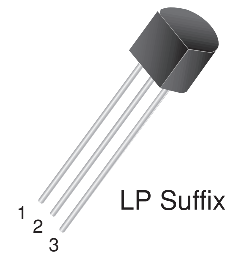
U Suffix

SOT-89



X Suffix

TO-92

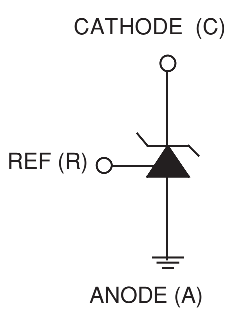


LP Suffix

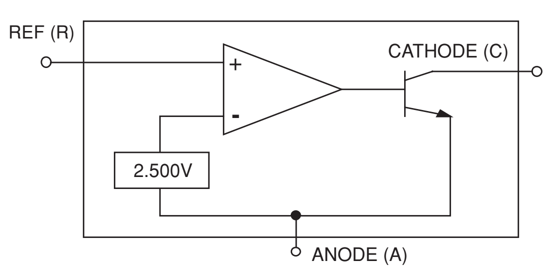
Features

- Programmable Output Voltage to 30V
- Precision Reference Voltage
  GS431B: 2.500V ±0.5%
  TL431A: 2.500V ±1.0%
  TL431: 2.500V ±2.0%
- Sink Current Capability: 100mA.
- Minimum Cathode Current for Regulation: 0.5mA
- Equivalent Full-Range Temperature Coefficient: 50 ppm/°C
- Fast Turn-On Response
- Low Dynamic Output Impedance: 0.22Ω
- Low Output Noise

Symbol



Block Diagram



Description

The GS431B/TL431A/TL431 are 3-terminal adjustable precision shunt regulators with guaranteed temperature stability over the applicable extended commercial temperature range. The output voltage may be set at any level greater than 2.500V (V_{REF}) up to 36V merely by selecting two external resistors that act as a voltage divider network. These devices have a typical output impedance of 0.08Ω. Active output circuitry provides very sharp turn-on characteristics, making these devices excellent improved replacements for zener diodes in many applications.

The precise ±0.5% reference voltage tolerance of the GS431B makes it possible in many applications to avoid the use of a variable resistor, consequently saving cost and eliminating drift and reliability problems associated with it.

Applications

- Voltage Monitor
- Delay Timer
- Constant-Current Source/Sink
- High-Current Shunt Regulator
- Crow Bar
- Over-Voltage/Under-Voltage Protection

Mechanical Data

Case: SO-8, SOT-23, SOT-89, TO-92

High temperature soldering guaranteed:

260°C/10 seconds at terminals

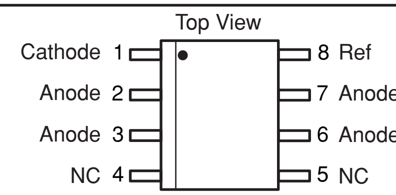
Case outlines are on the back pages

Ordering Information

Part Number	Package	V_{ref} Tolerance	Packing Method
GS431BIS/5H-E3	SO-8	0.5%	T/R, 2500
TL431AIS/5-E3		1.0%	
TL431IS/5H-E3		2.0%	
GS431BIX/11H-E3	SOT-89	0.5%	T/R, 1000
TL431AIX/11H-E3		1.0%	
TL431IX/11H-E3		2.0%	
GS431BIU1/48H	SOT-23	0.5%	T/R, 3000
TL431AIU1/48H		1.0%	
TL431IU1/48H		2.0%	
GS431BIU2/48H		0.5%	
TL431AIU2/48H		1.0%	
TL431IU2/48H		2.0%	
GS431BILP/1H	TO-92	0.5%	Bulk, 1000
TL431AILP/1H		1.0%	
TL431ILP/1H		2.0%	
GS431BILP/1H		0.5%	Ammo Pack, 2000
TL431AILP/1H		1.0%	
TL431ILP/1H		2.0%	

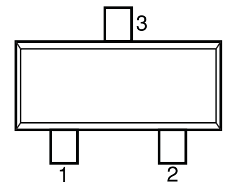
E3 designates a Lead (pb) Free Part.

SO-8



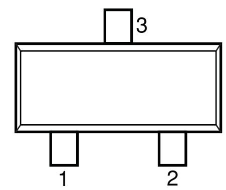
SOT-23 (U1)

Top View
1. Cathode
2. V_{ref}
3. Anode



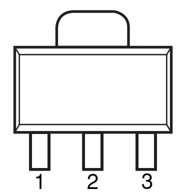
SOT-23 (U2)

Top View
1. V_{ref}
2. Cathode
3. Anode



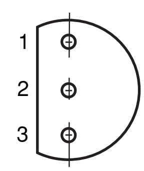
SOT-89

Top View
1. V_{ref}
2. Anode (tab)
3. Cathode



TO-92

Top View
1. V_{ref}
2. Anode
3. Cathode



Marking Information

SOT-23		
GS431B,	(U1)	DAxx*
TL431A,	(U1)	DBxx
TL431,	(U1)	DCxx
GS431B,	(U2)	DDxx
TL431A,	(U2)	DExx
TL431,	(U2)	DGxx

*Last two digits denote year and week code.

Absolute Maximum Ratings $T_A = 25°C$ unless otherwise noted.

Parameter		Symbol	Value	Unit
Cathode voltage		V_Z	37	V
Continuous cathode current		I_Z	–10 to 150	mA
Reference Input Current Range		I_{REF}	–0.05 to10	mA
Operating Temperature Range		T_{oper}	–20 to 85	°C
Junction Temperature		T_J	150	°C
Lead Temperature		T_L	260	°C
Storage Temperature		Tstg	–65 to 150	°C
Thermal Resistance	TO-92 Package SOT-23 Package SO-8 Package SOT-89 Package	$R_{\theta JA}$	160 400 163 52*	°C/W

*Measured according to JESD Si-7 guidelines

Electrical Characteristics $T_A = 25°C$ unless otherwise noted.

Parameter	Symbol	Test Conditions			Min	Typ	Max	Unit
Reference Voltage	V_{REF}	$V_Z = V_{REF}$ $I_L = 10mA$ (Fig. 1) $T_A = 25°C$		GS431B	2.487	2.500	2.513	V
				TL431A	2.475	2.500	2.525	
				TL431	2.450	2.500	2.550	
		$V_Z = V_{REF}$ $I_L = 10mA$ (Fig. 1) $T_A = -20°C$ to $+85°C$		GS431B	2.475	–	2.525	
				TL431A	2.445	–	2.545	
				TL431	2.430	–	2.560	
Deviation of reference Input voltage over temperature (1)	ΔV_{REF}	$V_Z = V_{REF}$ $I_L = 10mA$	$T_A = -20°C$ to $+85°C$ (Fig. 1)		–	3.0	17	mV
Ratio of the change in reference voltage to the change in cathode voltage	$\frac{\Delta V_{REF}}{\Delta V_Z}$	$I_Z = 10mA$ (Fig. 2)	$V_Z = V_{REF}$ ~ 10V		–	1.4	2.7	mV/V
			$V_Z = 10V$ ~ 30V		–	1.0	2.0	
Reference input current	I_{REF}	$R1 = 10K\Omega$, $R2 = \infty$ $I_L = 10mA$ (Fig. 2)	$T_A = 25°C$		–	0.7	4.0	µA
			$T_A = -20°C$ to $+85°C$		–	–	5.2	
Deviation of reference input current over temperature	αI_{REF}	$R1 = 10K\Omega$, $R2 = \infty$ $I_L = 10mA$ $T_A = -20°C$ to $+85°C$ (Fig. 2)			–	0.4	1.2	µA
Minimum cathode current for regulation	$I_{Z(MIN)}$	$V_Z = V_{REF}$ (Fig. 1)			–	0.5	1.0	mA
Off-state current	$I_{Z(OFF)}$	$V_Z = 36V$, $V_{REF} = 0V$ (Fig 3)			–	2.6	1000	nA
Dynamic output impedance (2)	R_Z	$V_Z = V_{REF}$, f = 1.0KHz $\Delta I_Z = 1.0mA$ to 50mA			–	0.22	0.5	Ω

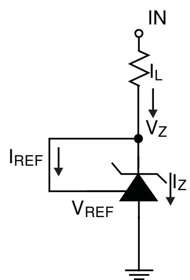
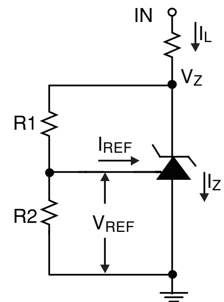


Fig. 1 Test Circuit for $V_Z = V_{REF}$



Note: $V_Z = V_{REF}(1 + R1/R2) + I_{REF} \times R1$

Fig. 2 Test Circuit for $V_Z > V_{REF}$

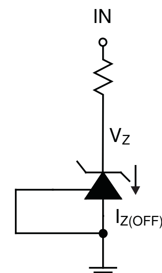
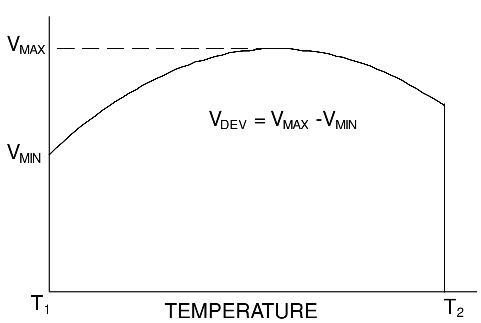


Fig. 3 Test Circuit for off-state current

Note 1. Deviation of reference input voltage, ΔV_{REF}, is defined as the maximum variation of the reference input voltage over the full temperature range.



The average temperature coefficient of the reference input voltage, αV_{REF} is defined as:

$$\alpha V_{REF}\frac{ppm}{^\circ C} = \frac{\pm\left[\dfrac{V_{MAX} - V_{MIN}}{V_{REF}(at\ 25^\circ C)}\right]10^6}{T2 - T1} = \frac{\pm\left[\dfrac{V_{DEV}}{V_{REF}(at\ 25^\circ C)}\right]10^6}{T2 - T1}$$

Where:

$T_2 - T_1$ = full temperature change.

The slope can be positive or negative depending on whether V_{MAX} or V_{MIN} occurs at the lower ambient temperature.

Example: ΔV_{REF} = 9.0mV, V_{REF} = 2495mV,
$T_2 - T_1 = 70^\circ C$, slope is positive.

$$\alpha V_{REF} = \frac{\left[\dfrac{9.0mV}{2495mV}\right]10^6}{70^\circ C} = 50ppm/^\circ C$$

Note 2. The dynamic output impedance, R_Z, is defined as:

$$R_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

When the device is programmed with two external resistors, R1 and R2, (see Fig. 2), the dynamic output impedance of the overall circuit, is defined as:

$$r_Z = \frac{\Delta V_Z}{\Delta I_Z} \approx R_Z\left[1 + \frac{R1}{R2}\right]$$

Typical Performance Characteristics

Fig. 4 – Cathode Current vs. Cathode Voltage

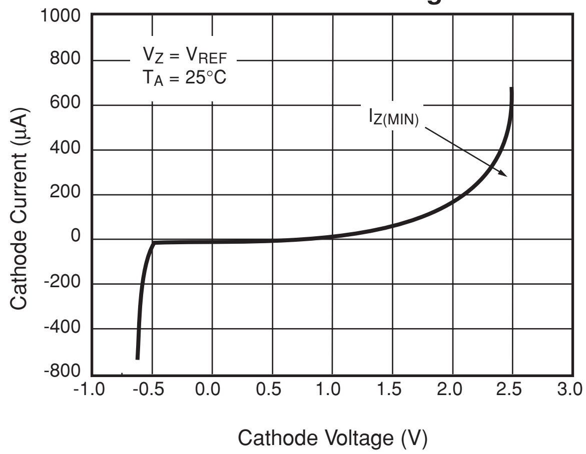


Fig. 5 – Reference Voltage vs. Temperature

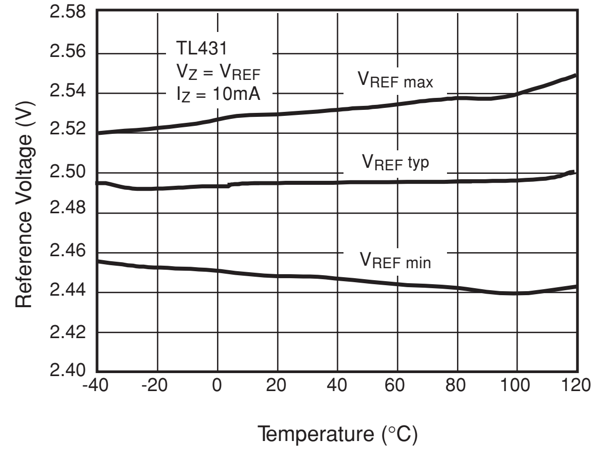


Fig. 6 – Reference Input Current vs. Temperature

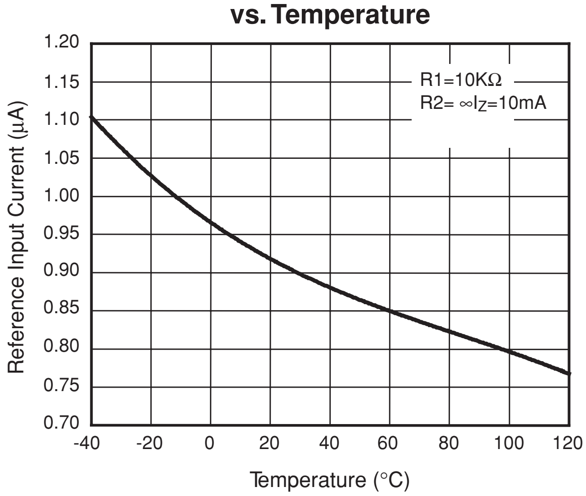


Fig. 7 – Dynamic Impedance vs. Temperature

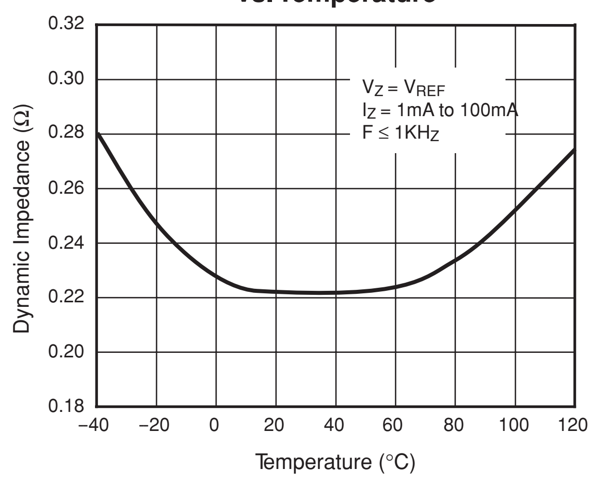


Fig. 8 – Change in Reference Voltage vs. Cathode Voltage

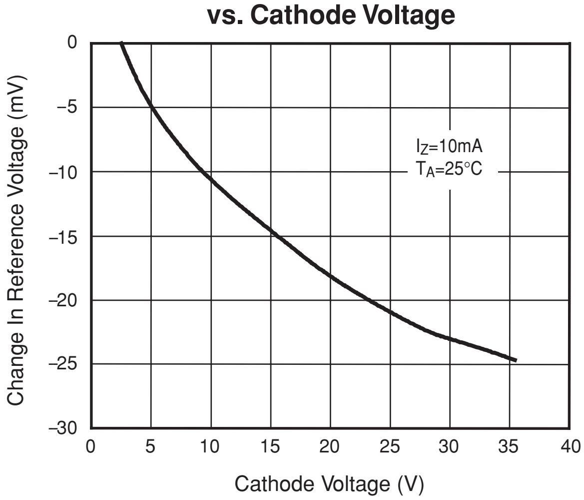


Fig. 9 – Off-State Cathode Current vs. Temperature

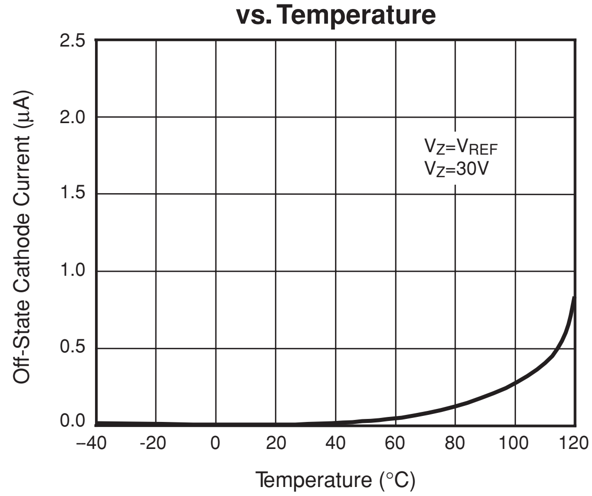


Fig. 10 – Small Signal Voltage Amplification vs. Frequency

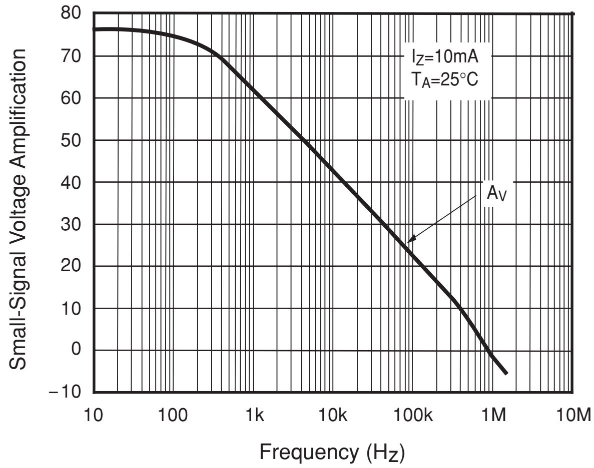


Fig. 11 – Test Circuit Frequency Response

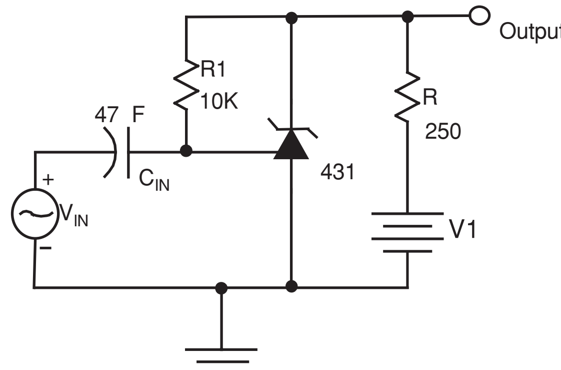


Fig. 12 – Pulse Response

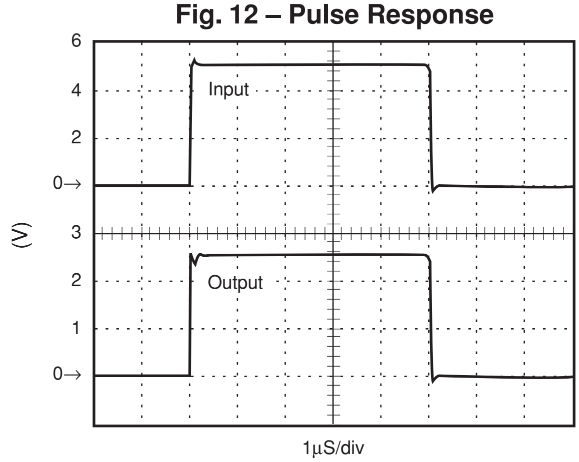


Fig. 13 – Test Circuit For Pulse Response

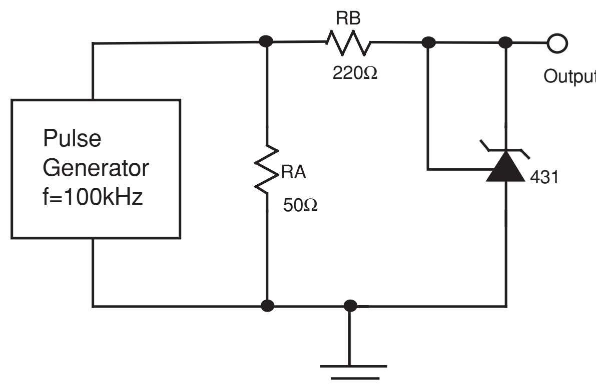


Fig. 14 – Dynamic Impedance vs. Frequency

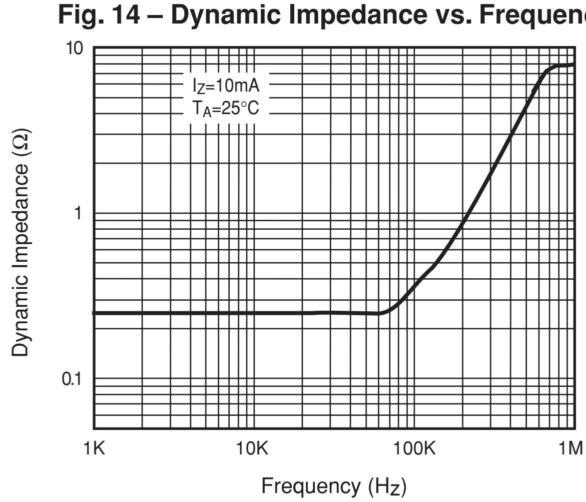
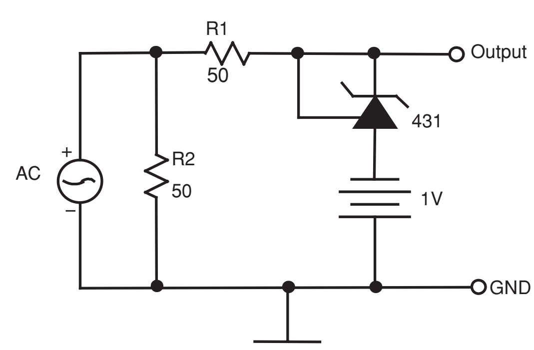
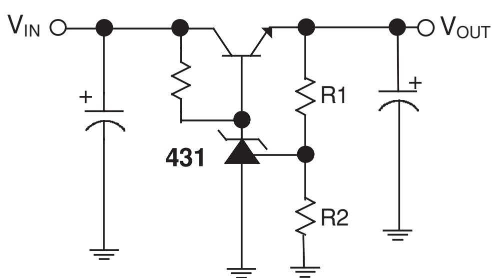


Fig. 15 – Test Circuit for Dynamic Impedance



Application Examples

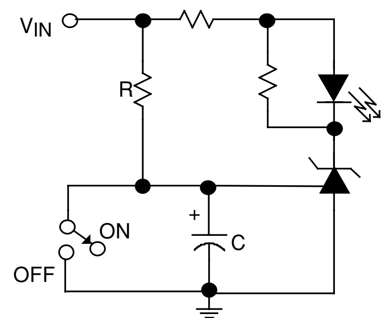
Fig. 16 – Typical Application Circuit



$V_{OUT} = (1 + R1/R2) \times V_{REF}$

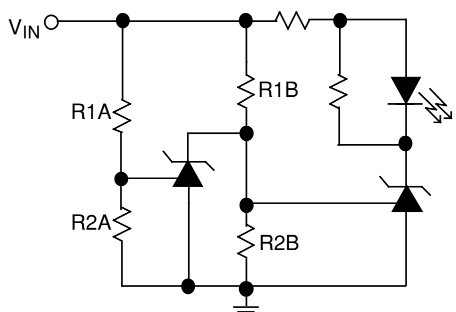
Precision Regulator

Fig. 17 – Delay Timer



$Delay = R \times C \times n\left(\frac{V_{IN}}{V_{IN}\ \ V_{REF}}\right)$

Fig. 18 – Voltage Monitor

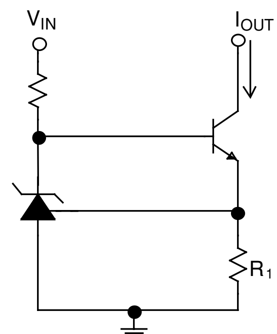


LED on when Low Limit < V_{IN} < High Limit

Low Limit $\cong V_{REF}$ (1+R1B/R2B)

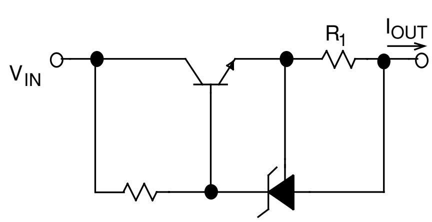
High Limit $\cong V_{REF}$ (1+R1A/R2A)

Fig. 19 – Constant-Current Sink



$I_{OUT} = V_{REF} / R_1$

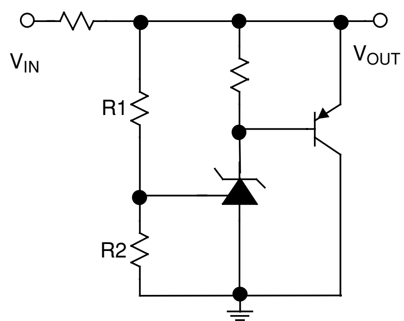
Fig. 20 – Current Limiter or Current Source



$I_{OUT} = V_{REF} / R_1$

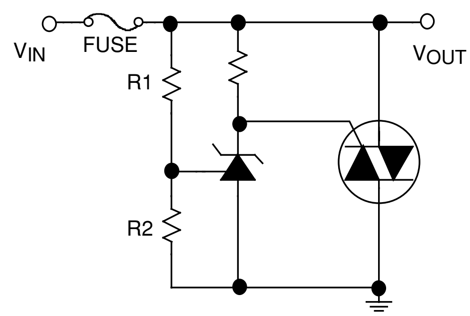
Application Examples
(continued)

Fig. 21 – High-Current Shunt Regulator



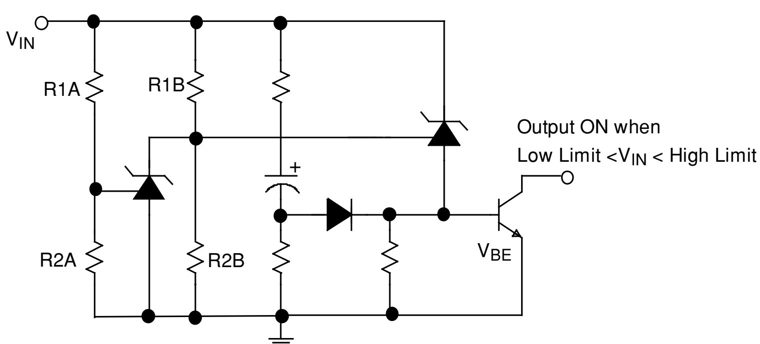
$V_{OUT} = (1+R1/R2) \times V_{REF}$

Fig. 22 – Crow Bar



$V_{LIMIT} = (1+R1/R2) \times V_{REF}$

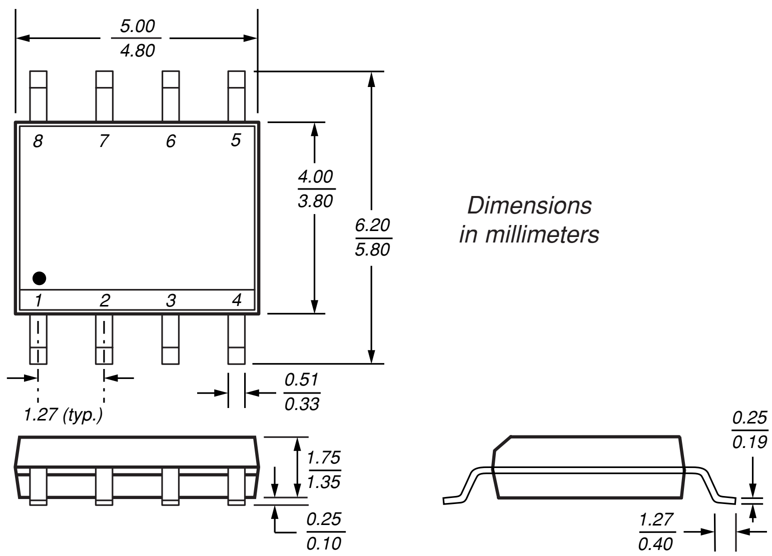
Fig. 23 – Over-Voltage / Under-Voltage Protection Circuit



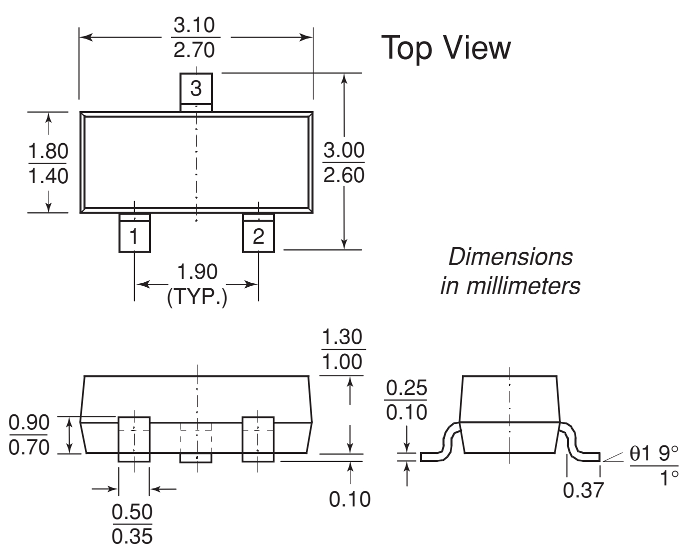
Low Limit $\cong V_{REF}$ (1+R1B/R2B) + V_{BE}

High Limit $\cong V_{REF}$ (1+R1A/R2A)

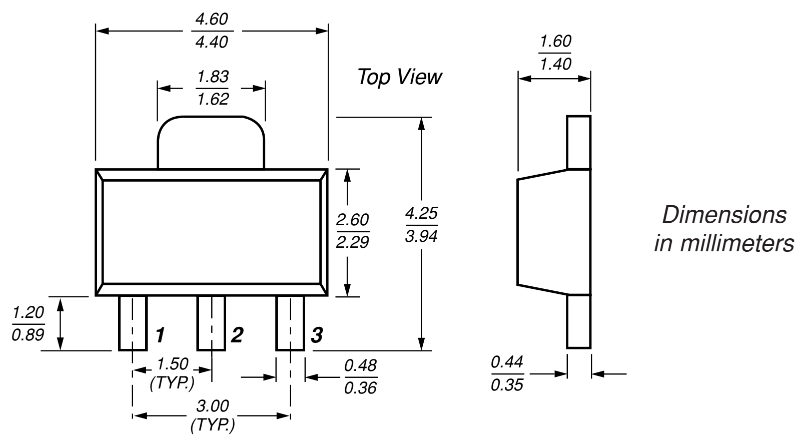
SO-8 Case Outline



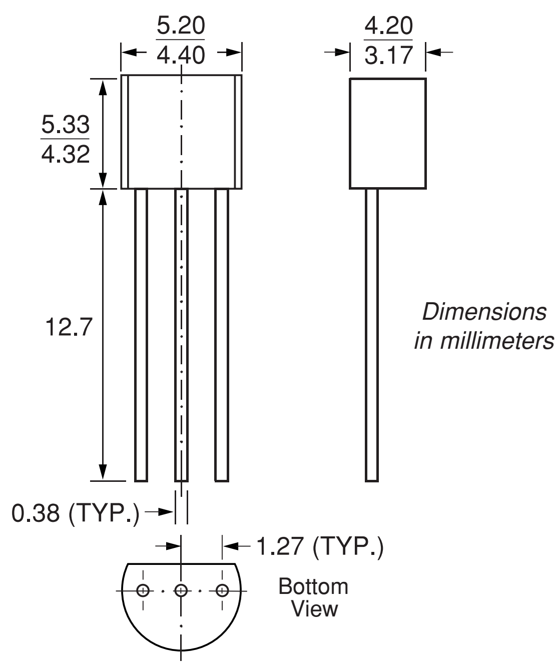
SOT-23 Case Outline



SOT-89 Case Outline



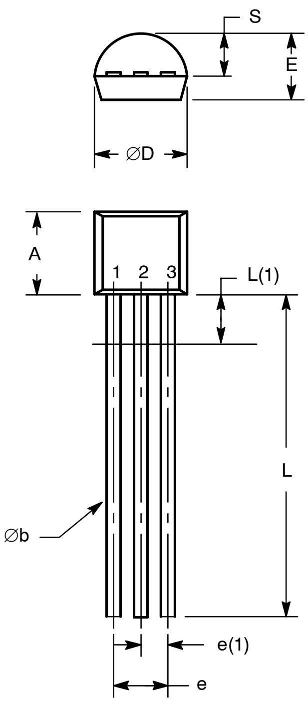
TO-92 Case Outline



ENVIRONMENTAL AND PACKAGE TESTING DATA FOR SOT-23 (AME)					
Stress	**Sample Size**	**Device Hr./Cyc**	**Condition**	**Total Fails**	**Fail Percentage**
BOND INT	120	250 hrs, 500 hrs	200°C + N2	0	0.00
DIE SHEAR	15		MIL-STD-750	0	0.00
HAST	165	100 hrs	130°C, 85%RH	0	0.00
Pressure Pot	66	96 hrs, 168 hrs	121°, 15 PSIG	0	0.00
Solderability	66	8 hrs	883 M2003	0	0.00
Temp Cycle	66	500 cyc, 1000 cyc	–65°C–150°C	0	0.00
	55	250 cyc		0	0.00

ENVIRONMENTAL AND PACKAGE TESTING DATA FOR TO-92 (P-J)					
Stress	**Sample Size**	**Device Hr./Cyc**	**Condition**	**Total Fails**	**Fail Percentage**
BOND INT	80	250 hrs, 500 hrs	200°C + N2	0	0.00
DIE PUNCH	30		MIL-STD-883	0	0.00
HAST	330	100 hrs	130°C, 85%RH	0	0.00
Pressure Pot	330	96 hrs, 168 hrs	121°, 15 PSIG	0	0.00
Solder DUNK	60		260°C, 10 SEC	0	0.00
Solderability	60	8 hrs	883 M2003	0	0.00
Temp Cycle	330	250 cyc, 500 cyc, 1000 cyc	−65°C−150°C	0	0.00

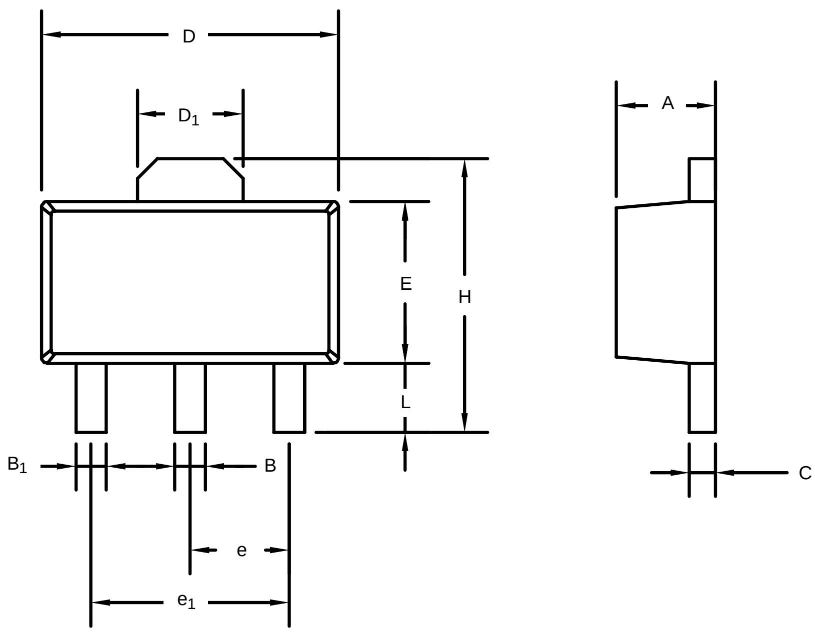
TO-226 (TO-92) (POWER ICS ONLY)



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	4.32	5.33	0.170	0.210
∅b	0.41	0.55	0.016	0.022
∅D	4.45	5.20	0.175	0.205
E	3.18	4.19	0.125	0.165
e	2.42	2.66	0.095	0.105
e(1)	1.15	1.39	0.045	0.055
L	12.7	—	0.500	—
L(1)	—	2.03	—	0.080
S	2.04	2.66	0.080	0.105
ECN: S-31068—Rev. A, 26-May-03 DWG: 5902				

NOTES:
1. Dimensions are in mm converted to inches.
2. Diameter uncontrolled inside L(1).

SOT-89: 3-LEAD (TO-243AA)

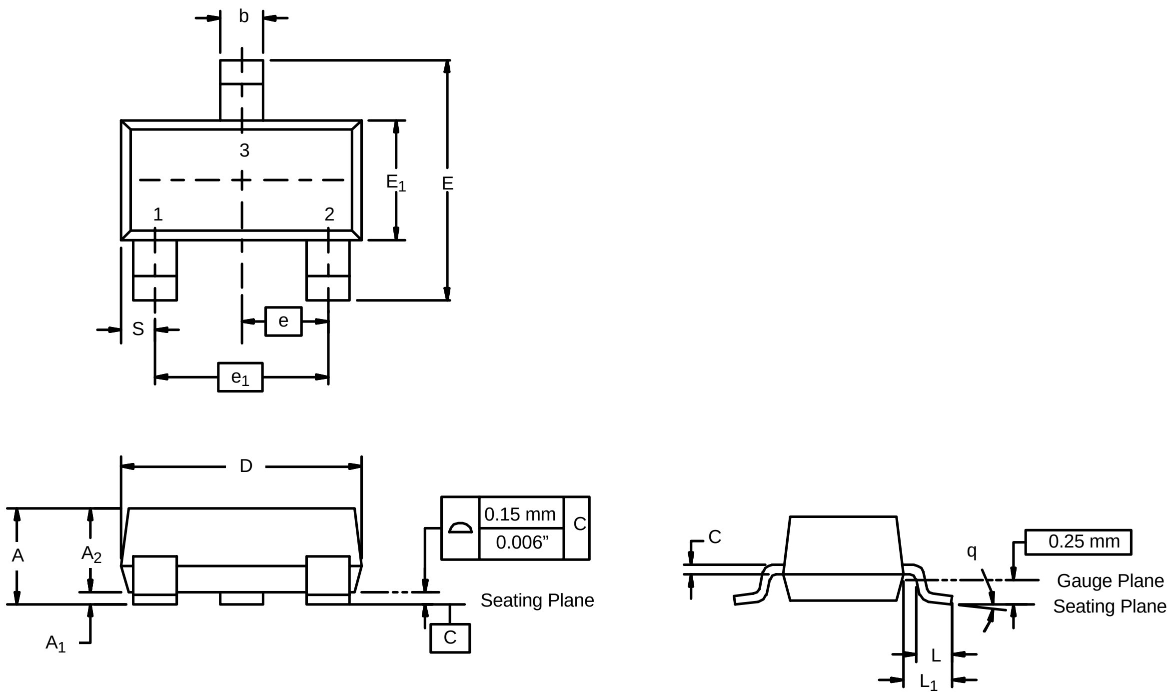


Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.40	1.60	0.055	0.063
B	0.44	0.56	0.017	0.022
B_1	0.36	0.48	0.014	0.019
C	0.35	0.44	0.013	0.018
D	4.40	4.60	0.170	0.182
D_1	1.40	1.75	0.055	0.069
E	2.29	2.60	0.090	0.103
e	1.5 Typ.		0.059 Typ.	
e_1	3.0 Typ.		0.118 Typ.	
H	3.94	4.25	0.155	0.168
L	0.89	1.20	0.035	0.048
ECN: S-32594—Rev. A, 29-Dec-03 DWG: 5906				

NOTE: Dimensions are in mm converted to inches.

SOT-23: 3-LEAD (POWER ICS ONLY)

JEDEC Equivalent Part Number: MO-78AA

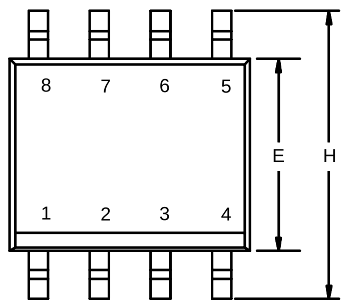


Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	—	1.45	—	0.057
A_1	0	0.15	0	0.006
A_2	0.90	1.30	0.035	0.052
b	0.30	0.50	0.012	0.020
c	0.08	0.25	0.003	0.010
D	2.70	3.10	0.100	0.122
E	2.40	3.00	0.090	0.120
E_1	1.40	1.80	0.055	0.071
e	0.95 TYP		0.037 TYP	
e_1	1.90 TYP		0.075 TYP	
L	0.35	0.55	0.013	0.022
L_1	0.64 TYP		0.025 TYP	
S	0.50 TYP		0.020 TYP	
q	0°	10°	0°	10°
ECN: S-31068—Rev. A, 26-May-03 DWG: 5901				

NOTE: Dimensions are in mm converted to inches.

SOIC: 8-LEAD (POWER ICS ONLY)

JEDEC Equivalent Part Number: MS-012AA



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A_1	0.10	0.25	0.004	0.010
B	0.33	0.51	0.013	0.020
C	0.19	0.25	0.0075	0.010
D	4.80	5.00	0.189	0.196
E	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
h	0.25	0.50	0.010	0.020
L	0.40	1.27	0.016	0.050
q	0°	8°	0°	8°
ECN: S-31068—Rev. A, 26-May-03 DWG: 5903				

NOTE: Dimensions are in mm converted to inches.