

Adjustable Precision Shunt Regulator

FEATURES

- Precision Reference Voltage.
AIC431 :2.495V \pm 0.5%
TL431A :2.495V \pm 1.0%
TL431 :2.495V \pm 1.6%
- Sink Current Capability: 200mA.
- Minimum Cathode Current for Regulation: 250 μ A.
- Equivalent Full-Range Temperature Coefficient: 50 ppm/ $^{\circ}$ C.
- Fast Turn-On Response.
- Low Dynamic Output Impedance: 0.08 Ω .
- Adjustable Output Voltage.
- Low Output Noise.
- Space Saving Packages: SOT-89, SOT-23, TO-92 and SO-8.

APPLICATIONS

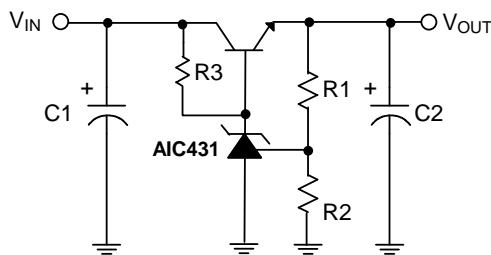
- Linear Regulators.
- Adjustable Supplies.
- Switching Power Supplies.
- Battery Operated Computers.
- Instrumentation.
- Computer Disk Drivers.

DESCRIPTION

The AIC431, TL431A and 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 2.495V (V_{REF}) up to 30V merely by selecting two external resistors that act as a voltage divider network. These devices have a typical output impedance of 0.08 Ω . Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent improved replacements for zener diodes in many applications.

The precise \pm 0.5% reference voltage tolerance of the AIC431 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.

TYPICAL APPLICATION CIRCUIT



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

Precision Regulator

ORDERING INFORMATION

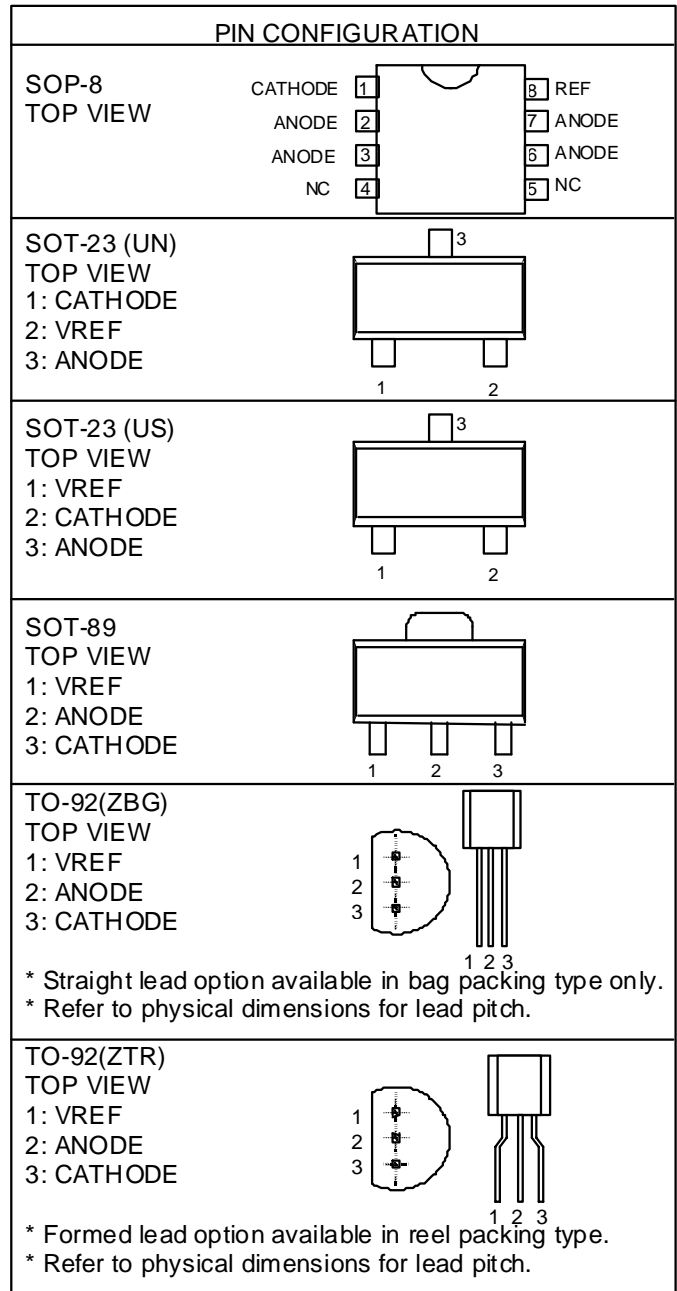
AIC431 XXXX
 TL431A XXXX
 TL431 XXXX

PACKING TYPE
 TR: REEL
 TB: TUBE (for SOP-8)
 BG: BAG

PACKAGE TYPE
 S: SOP-8
 US: SOT-23
 UN: SOT-23
 X: SOT-89
 Z: TO-92

P: Lead Free Commercial
 G: Green Package

Example: AIC431PSTR
 → in Lead Free SOP-8 Package & Taping & Reel Packing Type (CS/PS is not available in BAG packing type.)



SOT-23 Marking

Part No.	PUN	GUN
AIC431	AC1NP	AC1NG
TL431	AC2NP	AC2NG
TL431A	AC3NP	AC3NG

Part No.	PUS	GUS
AIC431	AC1SP	AC1SG
TL431	AC2SP	AC2SG
TL431A	AC3SP	AC3SG

● **SOT-89 Marking**

Part No.	PX	GX
AIC431	AC1BP	AC1BG
TL431	AC2BP	AC2BG
TL431A	AC3BP	AC3BG

■ **ABSOLUTE MAXIMUM RATINGS**

Cathode Voltage	.....	30V
Continuous Cathode Current	.....	-10mA ~ 250mA
Reference Input Current Range	.....	10mA
Operating Temperature Range	.....	-40°C to 85°C
Maximum Junction Temperature	.....	125°C
Storage Temperature Range	.....	-65°C to 150°C
Lead Temperature (Soldering, 10 sec)	.....	260°C
Power Dissipation	SOT-89 Package	..... 0.80W
	TO-92 Package	..... 0.78W

Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

■ **TEST CIRCUIT**

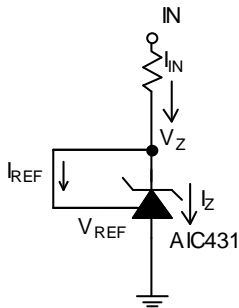
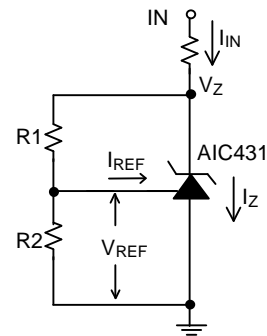


Fig. 1 Test Circuit for $V_Z=V_{REF}$



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

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

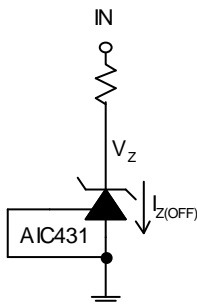


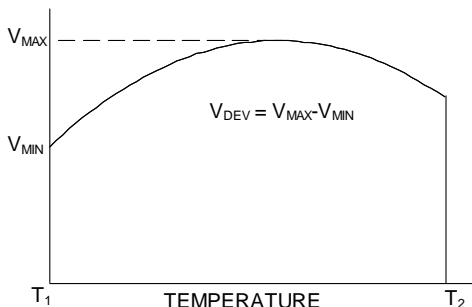
Fig. 3 Test Circuit for off-state Current

ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified.) (Note 1)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Reference Voltage	V _Z =V _{REF} , I _{IN} =10mA (Fig. 1)	AIC431	2.482	2.495	2.508	V
		TL431A	2.470	2.495	2.520	
		TL431	2.455	2.495	2.535	
Deviation of Reference Input Voltage Over Temperature (Note 2)	V _Z = V _{REF} , I _{IN} =10mA, T _A = 0°C~ +70°C (Fig. 1)	V _{DEV}		9.0	20	mV
	T _A = -40°C~ +85°C (Fig. 1)			9.0	50	
Ratio of the Change in Reference Voltage to the Change in Cathode voltage	I _Z =10mA (Fig. 2)	$\frac{\Delta V_Z}{V_Z} = \frac{10V - V_{REF}}{V_{REF}}$	$\frac{\Delta V_{REF}}{V_{REF}}$	-0.5	-2.0	mV/V
		$\frac{\Delta V_Z}{V_Z} = \frac{30V - 10V}{V_{REF}}$	$\frac{\Delta V_Z}{V_Z}$	-0.35	-1.5	mV/V
Reference Input Current	R1 =10KΩ, R2=∞, I _{IN} =10mA (Fig. 2)	I _{REF}		0.8	3.5	μA
Deviation of Reference Input Current over Temperature	R1 =10KΩ, R2=∞, I _{IN} =10mA T _A =-40°C ~ +85°C (Fig. 2)	αI _{REF}		0.3	1.2	μA
Minimum Cathode current for Regulation	V _Z =V _{REF} (Fig. 1)	I _{Z(MIN)}		0.25	0.5	mA
Off-State Current	V _Z =20V, V _{REF} =0V (Fig. 3)	I _{Z(OFF)}		0.1	1.0	μA
Dynamic Output Impedance (Note 3)	V _Z =V _{REF} F<1KHz (Fig. 1)	R _Z		0.08	0.3	Ω

Note 1: Specifications are production tested at T_A=25°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).



Note 2: Deviation of reference input voltage, V_{DEV}, 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:

$$\alpha V_{REF} \frac{\text{ppm}}{^{\circ}\text{C}} = \pm \left[\frac{V_{MAX} - V_{MIN}}{V_{REF}(\text{at } 25^{\circ}\text{C})} \right] 10^6 = \pm \left[\frac{V_{DEV}}{V_{REF}(\text{at } 25^{\circ}\text{C})} \right] \frac{1}{T_2 - T_1}$$

Where:

T₂-T₁=full temperature change.

αV_{REF} can be positive or negative depending on whether the slope is positive or negative.

Example: V_{DEV}= 9.0mV, V_{REF}= 2495mV,

T₂-T₁= 70°C, slope is negative.

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

Note 3: 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:

$$r_Z = \frac{\Delta V}{\Delta I} \cong R_Z \left[1 + \frac{R_1}{R_2} \right]$$

TYPICAL PERFORMANCE CHARACTERISTICS

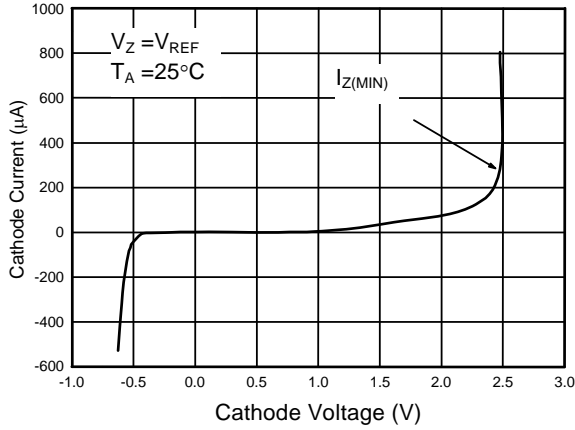


Fig. 4 Cathode Current vs. Cathode Voltage

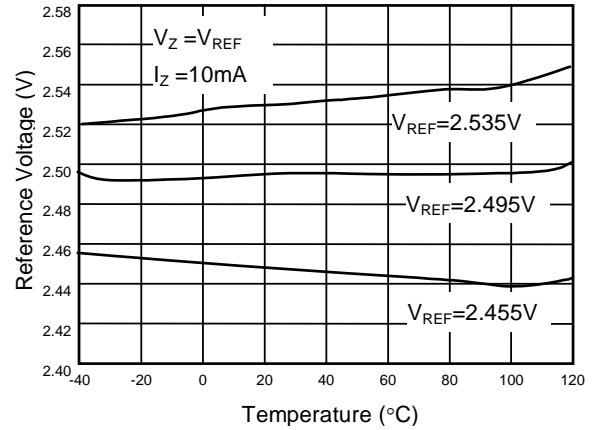


Fig. 5 Reference Voltage vs. Temperature

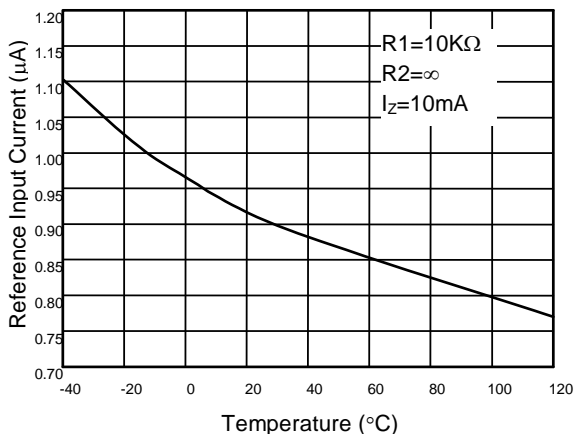


Fig. 6 Reference Input Current vs. Temperature

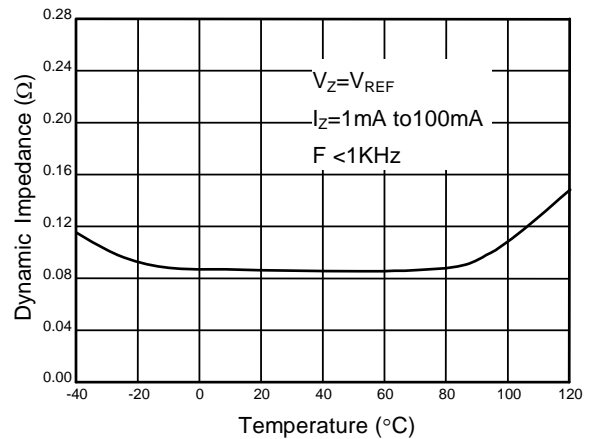


Fig. 7 Dynamic Impedance vs. Temperature

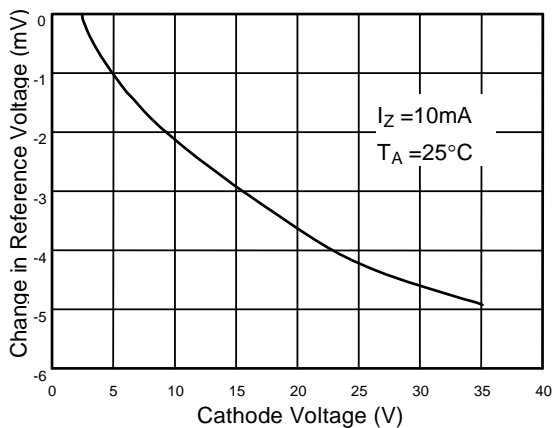


Fig. 8 Change in Reference Voltage vs. Cathode Voltage

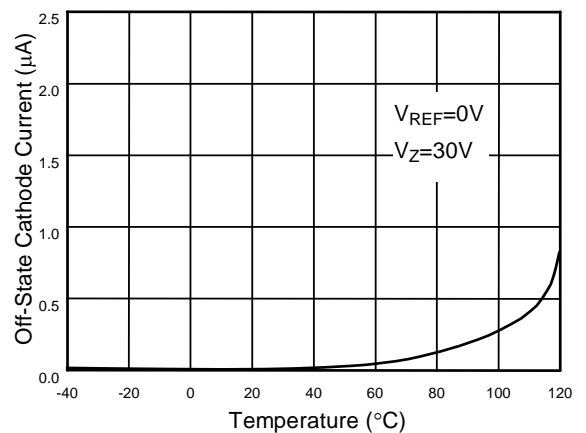


Fig. 9 Off-State Cathode Current vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

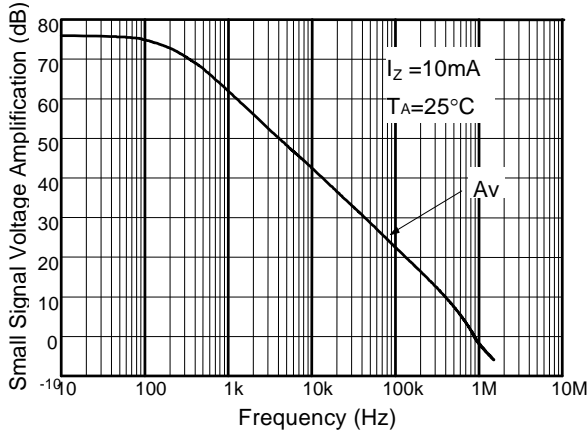


Fig. 10 Small Signal Voltage Amplification vs. Frequency

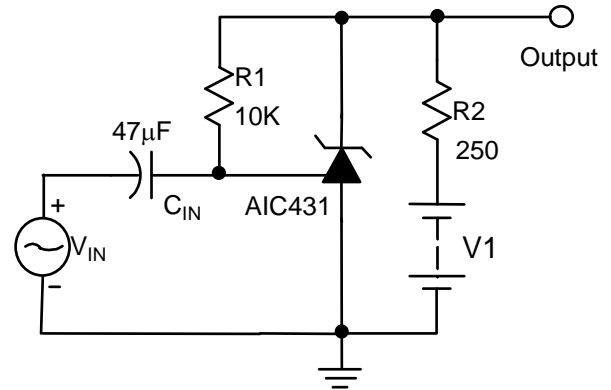


Fig. 11 Test Circuit For Frequency Response

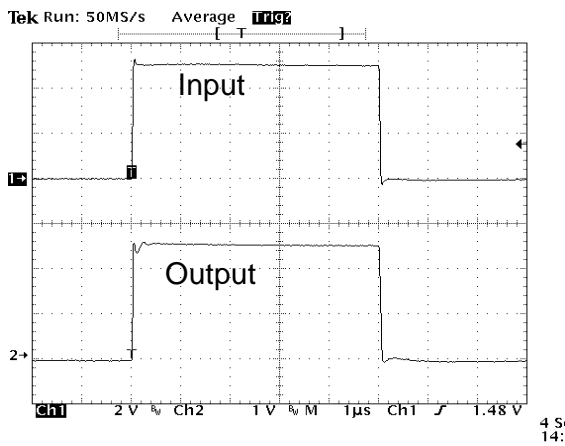


Fig. 12 Pulse Response

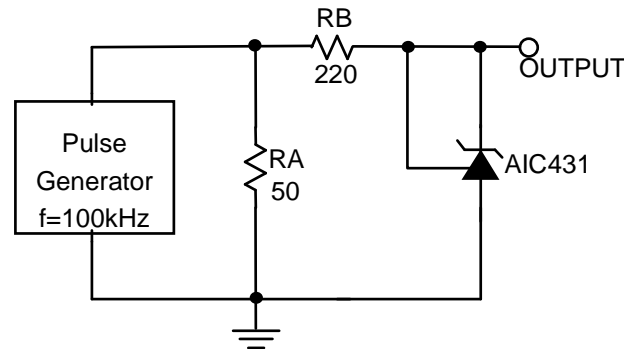


Fig. 13 Test Circuit For Pulse Response

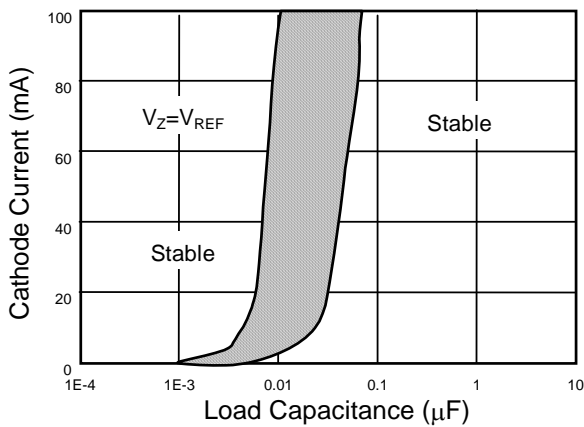


Fig. 14 Stability Boundary Conditions

The areas between the curves represent condition that may cause the device oscillate

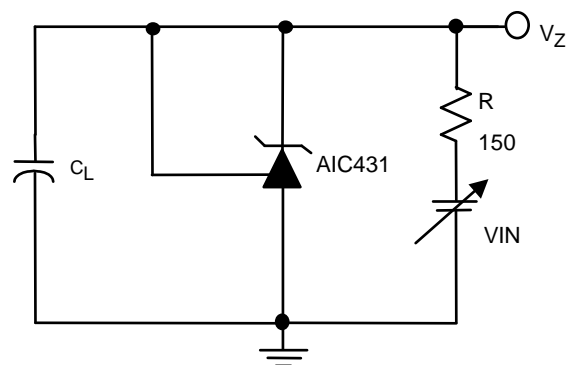


Fig. 15 Test Circuit for Stability Boundary

■ **TYPICAL PERFORMANCE CHARACTERISTICS (Continued)**

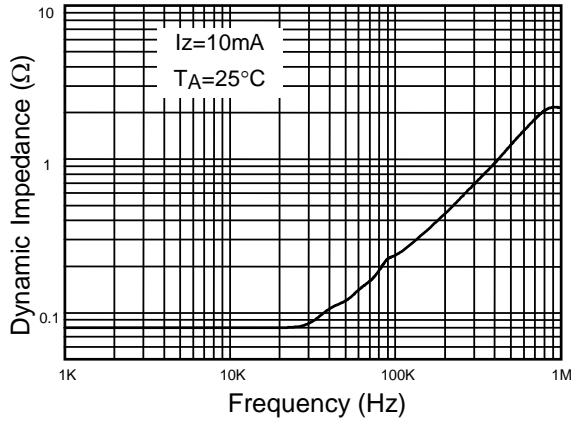


Fig. 16 Dynamic impedance vs. Frequency

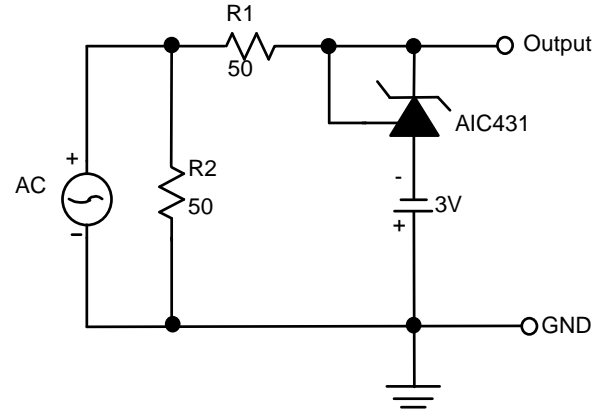
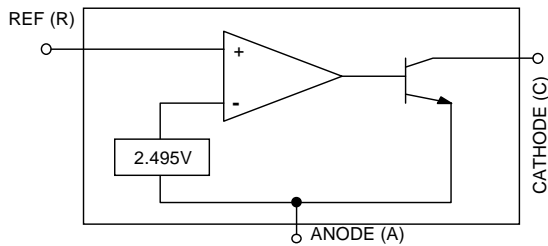
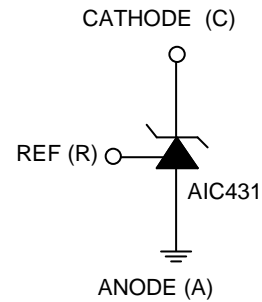


Fig. 17 Test Circuit for Dynamic Impedance

■ **BLOCK DIAGRAM**



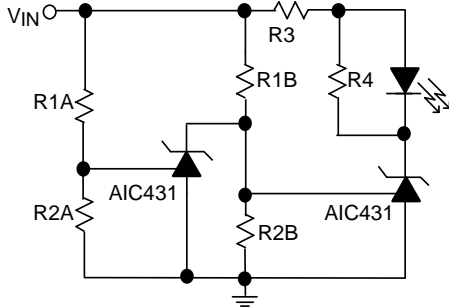
● **SYMBOL**



■ **PIN DESCRIPTIONS**

- CATHODE Pin - Sinks current with a range from 250 μ A to 200mA for normal applications.
- VREF Pin - Providing $V_{REF}=2.495V$ (typ.) for adjustable output voltage.
- ANODE Pin - Anode pin sources current for normal application. The current value is the same as Cathode pin.

APPLICATION EXAMPLES

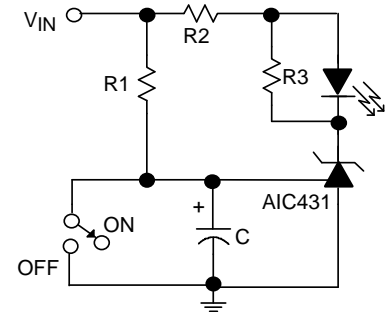


LED Turn on when Low Limit $< V_{IN} <$ High Limit

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

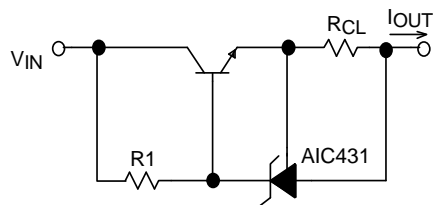
$$\text{High Limit} \cong V_{REF} (1 + R1A/R2A)$$

Fig. 18 Voltage Monitor



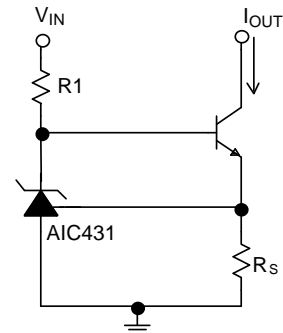
$$\text{Delay} = R \times C \times \ln \left(\frac{V_{IN}}{V_{IN} - V_{REF}} \right)$$

Fig. 19 Delay Timer



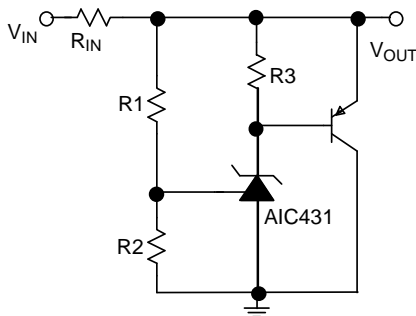
$$I_{OUT} = V_{REF} / R_{CL}$$

Fig. 20 Current Limiter or Current Source



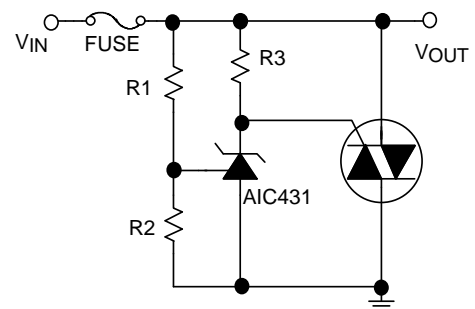
$$I_{OUT} = V_{REF} / R_s$$

Fig. 21 Constant-Current Sink



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

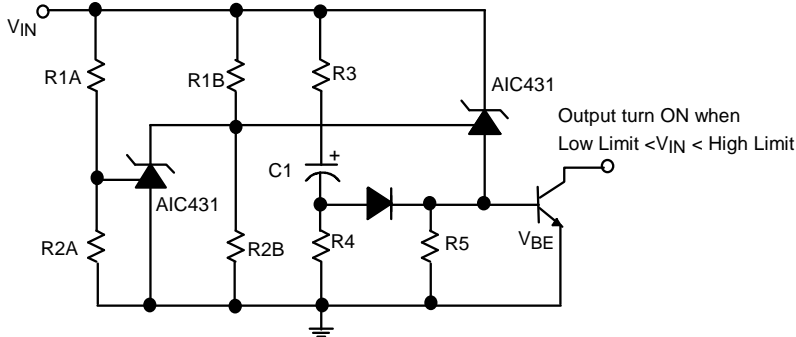
Fig. 22. Higher-Current Shunt Regulator



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

Fig. 23 Crow Bar

■ APPLICATION EXAMPLES (Continued)

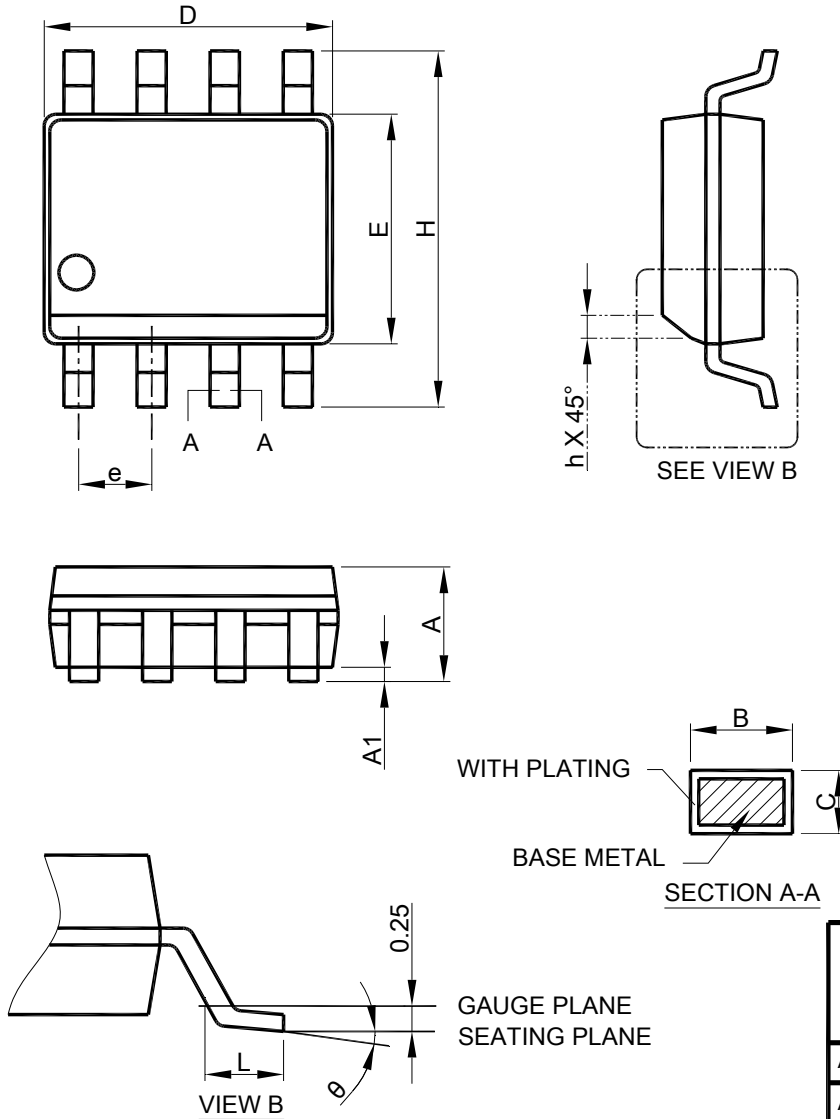


Low Limit $\cong V_{REF} (1 + R1B / R2B) + V_{BE}$
 High Limit $\cong V_{REF} (1 + R1A / R2A)$

Fig 24. Over-Voltage/Under-Voltage Protection Circuit

■ PHYSICAL DIMENSIONS (unit: mm)

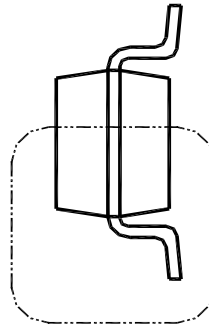
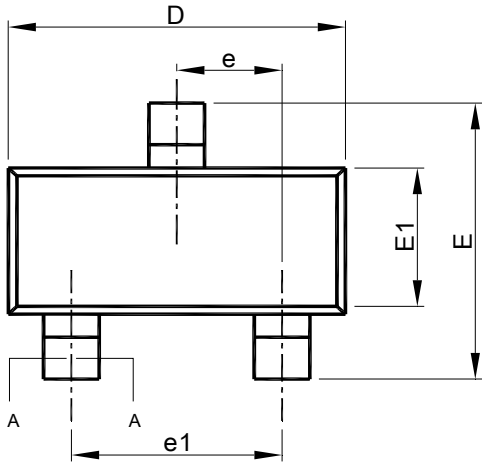
● SOP-8



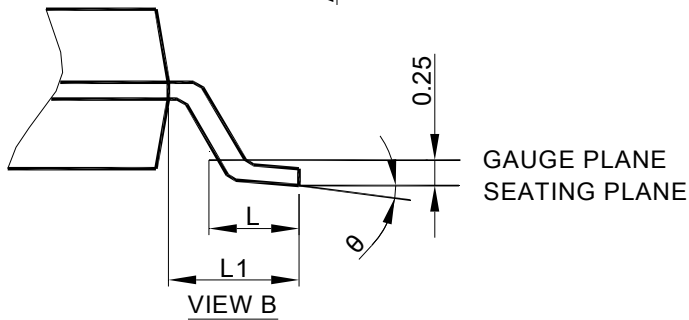
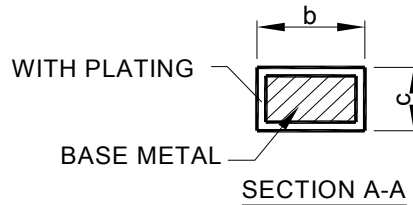
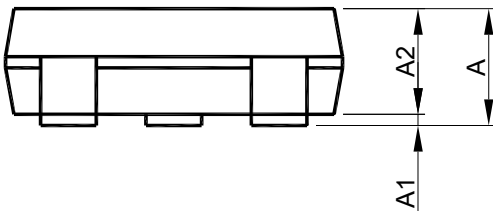
- Note: 1. Refer to JEDEC MS-012AA.
 2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side .
 3. Dimension "E" does not include inter-lead flash or protrusions.
 4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

SYMBOL	SOP-8	
	MILLIMETERS	
	MIN.	MAX.
A	1.35	1.75
A1	0.10	0.25
B	0.33	0.51
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.27
θ	0°	8°

● SOT-23



SEE VIEW B

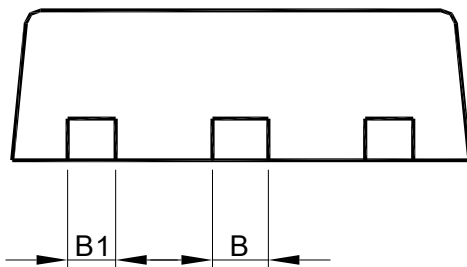
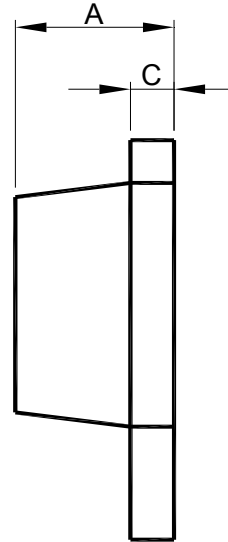
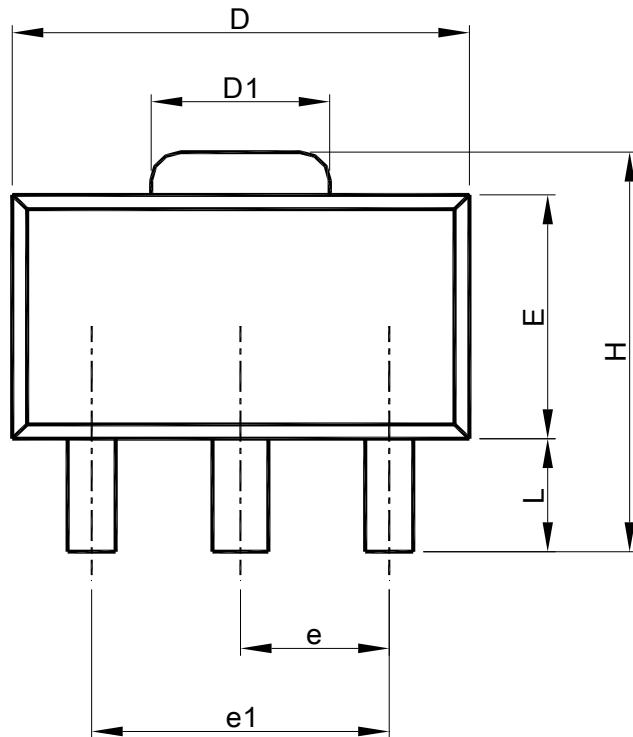


VIEW B

- Note: 1. Refer to JEDEC MO-178.
 2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.
 3. Dimension "E1" does not include inter-lead flash or protrusions.
 4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

SYMBOL	SOT-23	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

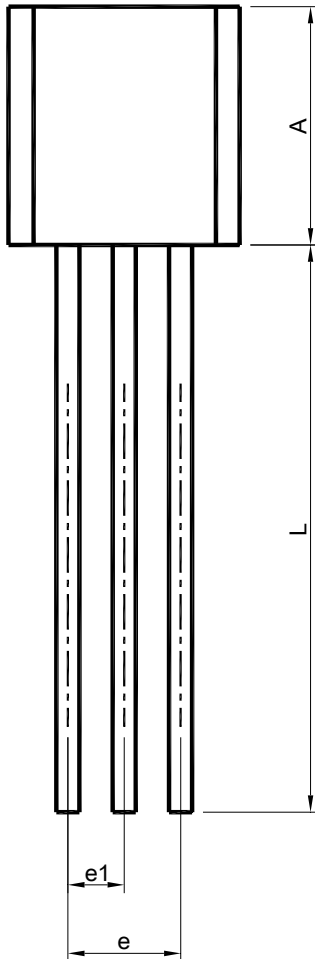
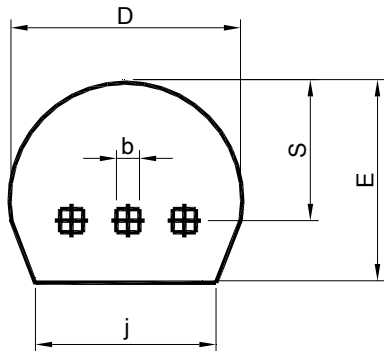
● SOT-89



SYMBOL	SOT-89	
	MILLIMETERS	
	MIN.	MAX.
A	1.40	1.60
B	0.44	0.56
B1	0.36	0.48
C	0.35	0.44
D	4.40	4.60
D1	1.50	1.83
E	2.29	2.60
e	1.50 BSC	
e1	3.00 BSC	
H	3.94	4.25
L	0.89	1.20

- Note: 1. Refer to JEDEC TO-243AA.
 2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.
 3. Dimension "E" does not include inter-lead flash or protrusions.
 4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

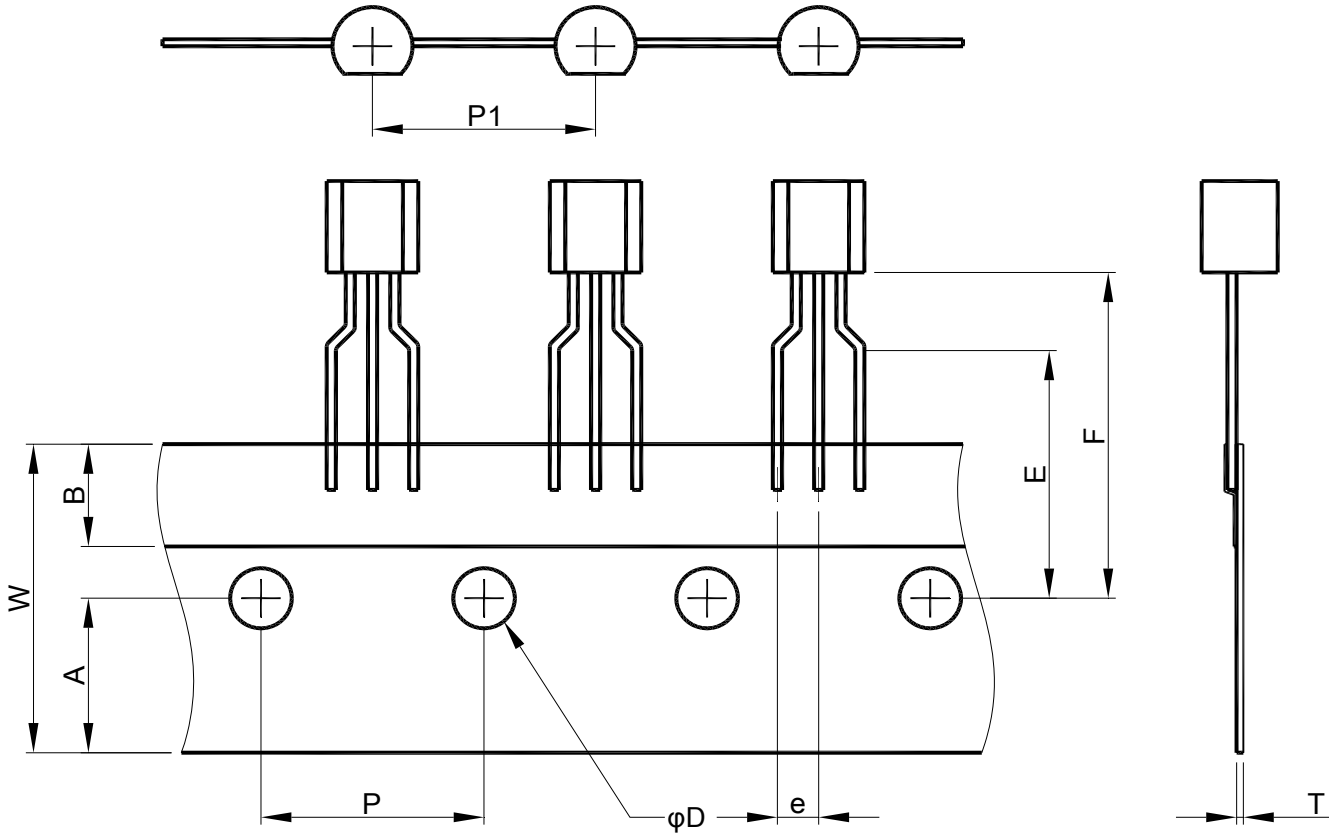
- TO-92 (Straight lead option available in Bag packing type only)



SYMBOL	TO-92	
	MILLIMETERS	
	MIN.	MAX.
A	4.32	5.33
b	0.36	0.47
D	4.45	5.20
E	3.18	4.19
e	2.42	2.66
e1	1.15	1.39
j	3.43	
L	12.70	
S	2.03	2.66

- Note: 1. Refer to JEDEC TO-226.
 2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side .
 3. Dimension "A" does not include inter-lead flash or protrusions.
 4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

- TO-92 (Formed lead option available in Reel packing)



SYMBOL	W	A	B	E	F
SPEC.	18.0±0.2	9.0±0.2	6.0±0.20	16.0±0.5	19.0±0.5
SYMBOL	P	P1	D	e	T
SPEC.	12.7 BSC	12.7 BSC	4.0±0.2	2.5 BSC	0.6±0.1

Note:

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