

Adjustable Precision Shunt Regulators

FEATURES

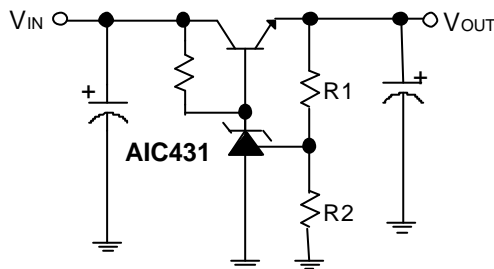
- Unconditionally Stable.
- Precision Reference Voltage.
 AIC431 :2.495V \pm 0.5%
 TL431A :2.495V \pm 1.0%
 TL431 :2.495V \pm 1.6%
- Sink Current Capability: 200mA.
- Minimum Cathode Current for Regulation: 250 μ A.
- Equivalent Full-Range Temperature Coefficient: 50 ppm/ $^{\circ}$ C.
- Fast Turn-On Response.
- Low Dynamic Output Impedance: 0.08 Ω .
- Adjustable Output Voltage.
- Low Output Noise.
- Space Saving SOT-89, SOT-23, TO-92 and SO8 packages.

DESCRIPTION

The AIC431/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 2.495V (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 characteristics, 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



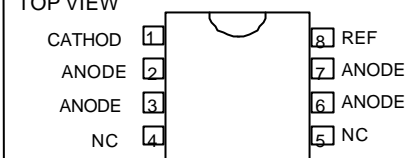
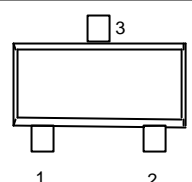
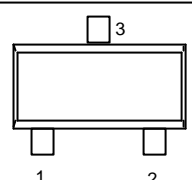
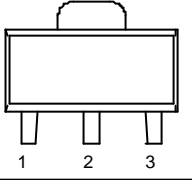
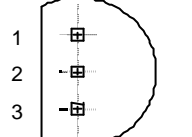
$$V_{OUT} = (1 + R1/R2)V_{REF}$$

Precision Regulator

ORDERING INFORMATION

AIC431 CX
 TL431A CX
 TL431 CX

PACKAGING TYPE
 S: SMALL OUTLINE
 U: SOT-23
 X: SOT-89
 Z: TO-92

| ORDER NUMBER | PIN CONFIGURATION |
|--|--|
| AIC431CS TL431ACS TL431CS (SO-8) | TOP VIEW  |
| AIC431CUN TL431ACUN TL431CUN (SOT-23) | FRONT VIEW 1: CATHODE 2: VREF 3: ANODE  |
| AIC431CUS TL431ACUS TL431CUS (SOT-23) | FRONT VIEW 1: VREF 2: CATHODE 3: ANODE  |
| AIC431CX TL431ACX TL431CX (SOT-89) | FRONT VIEW 1: VREF 2: ANODE 3: CATHODE  |
| AIC431CZ TL431ACZ TL431CZ (TO-92) | FRONT VIEW 1: VREF 2: ANODE 3: CATHODE  |

ABSOLUTE MAXIMUM RATINGS

| | |
|---|---------------|
| Cathode Voltage | 30V |
| Continuous Cathode Current | -10mA ~ 250mA |
| Reference Input Current Range | 10mA |
| Operating Temperature Range | -40°C ~ 85°C |
| Lead Temperature | 260°C |
| Storage Temperature | -65°C ~ 150°C |
| Power Dissipation (Notes 1, 2) | |
| SOT-89 Package | 0.80W |
| TO-92 Package | 0.78W |

Note 1: $T_{J, max} = 150^{\circ}C$.

Note 2: Ratings apply to ambient temperature at 25°C.

TEST CIRCUITS

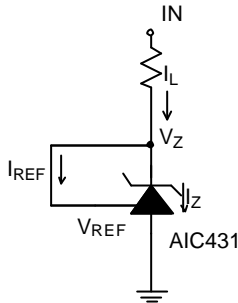
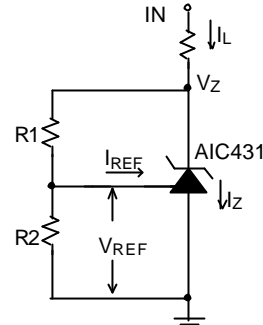


Fig. 1 Test Circuit for $V_Z=V_{REF}$



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

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

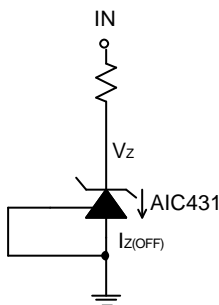


Fig. 3 Test circuit for off-state Current

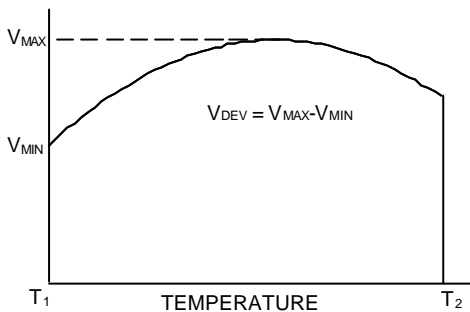
ELECTRICAL CHARACTERISTICS (Ta=25°C, unless otherwise specified.)

| PARAMETER | TEST CONDITIONS | SYMBOL | MIN. | TYP. | MAX. | UNIT | |
|---|--|--|-------------------------------------|-------|-------|---------------|------|
| Reference Voltage | $V_Z=V_{REF}$, $I_L = 10\text{mA}$ (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 3) | $V_Z = V_{REF}$, $I_L = 10\text{mA}$, $T_a = 0^\circ\text{C} \sim +85^\circ\text{C}$ (Fig. 1) | V_{DEV} | | 9.0 | 20 | mV | |
| Ratio of the Change in Reference Voltage to the Change in Cathode voltage | $I_Z = 10\text{mA}$ (Fig. 2) | $\Delta V_Z = 10\text{V} - V_{REF}$ | $\frac{\Delta V_{REF}}{\Delta V_Z}$ | | -0.5 | -2.0 | mV/V |
| | | $\Delta V_Z = 30\text{V} - 10\text{V}$ | | | -0.35 | -1.5 | mV/V |
| Reference Input Current | $R1 = 10\text{K}\Omega$, $R2 = \infty$, $I_L = 10\text{mA}$ (Fig. 2) | I_{REF} | | 0.8 | 3.5 | μA | |

| | | | | | |
|---|---|------------------|-----|-----|---------|
| Deviation of Reference Input Current over Temperature | R1 = 10K Ω , R2 = ∞ , I _L = 10mA T _a = -20°C ~ +85°C (Fig. 2) | αI_{REF} | 0.3 | 1.2 | μA |
|---|---|------------------|-----|-----|---------|

ELECTRICAL CHARACTERISTICS (Continued)

| PARAMETER | TEST CONDITIONS | SYMBOL | MIN. | TYP. | MAX. | UNIT |
|---|---|--------------|------|------|------|----------|
| 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 4) | $V_Z = V_{REF}$ Frequency = 0Hz (Fig. 1) | R_Z | | 0.08 | 0.3 | Ω |



Note 3. 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:

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

Where:

$T_2 - T_1$ = full temperature change.

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

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

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

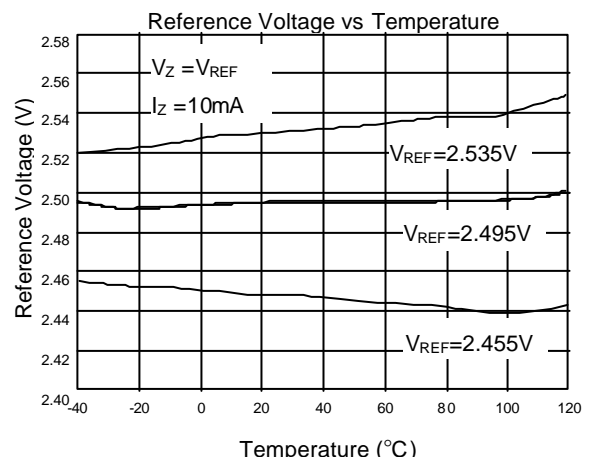
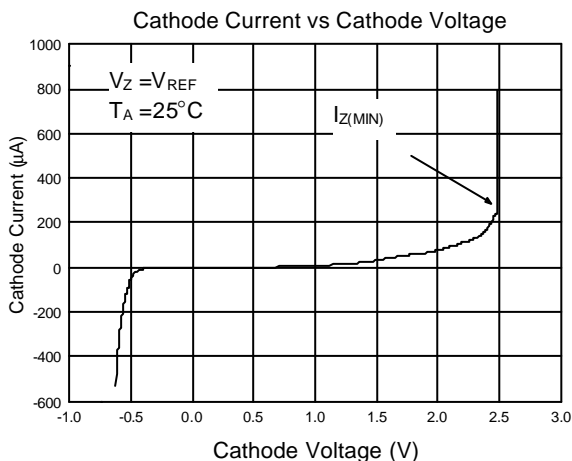
Note 4. The dynamic output impedance, R_Z , is defined as:

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

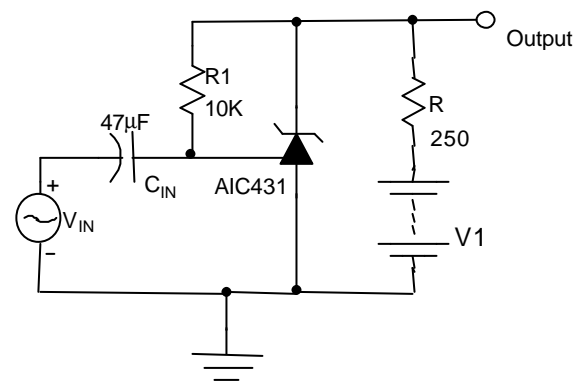
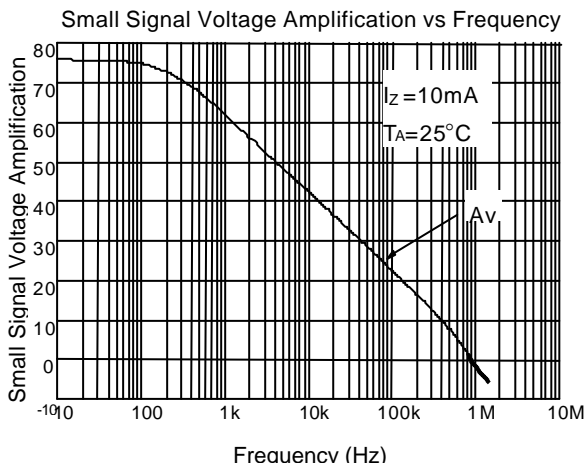
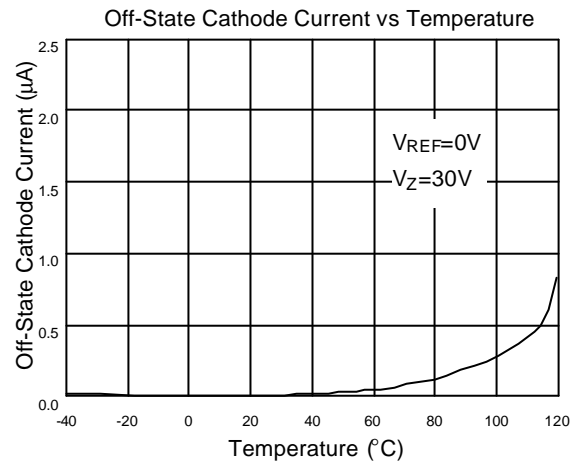
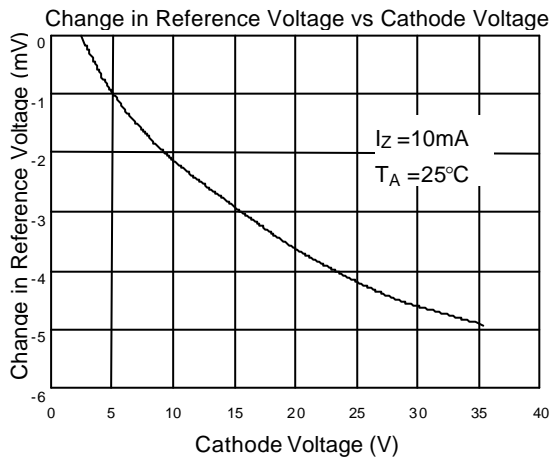
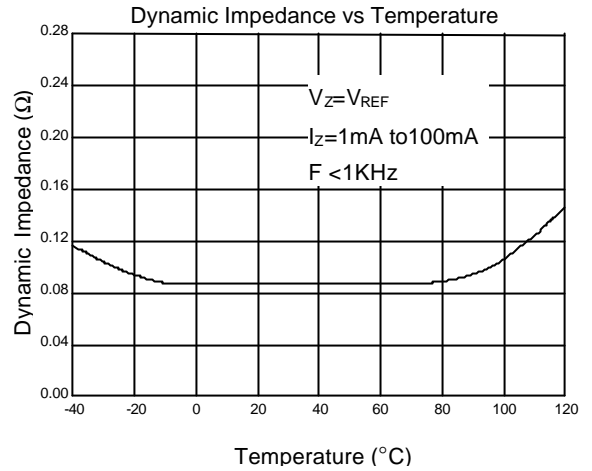
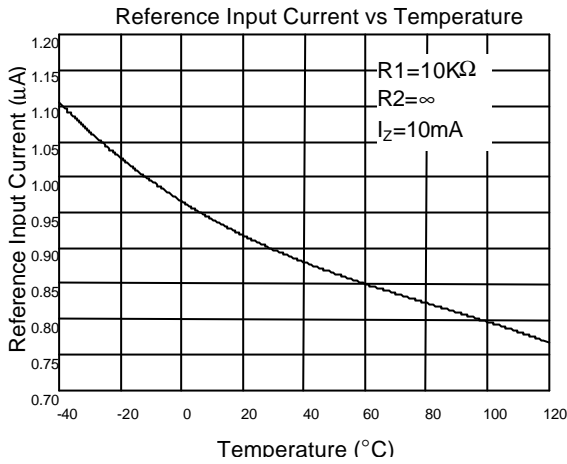
When the device is programmed with two external resistors, R_1 and R_2 , (see Fig. 2), the dynamic output impedance of the overall circuit, is defined as:

$$r_z = \frac{\Delta V_Z}{\Delta I_Z} \cong R_Z \left[1 + \frac{R_1}{R_2} \right]$$

TYPICAL PERFORMANCE CHARACTERISTICS

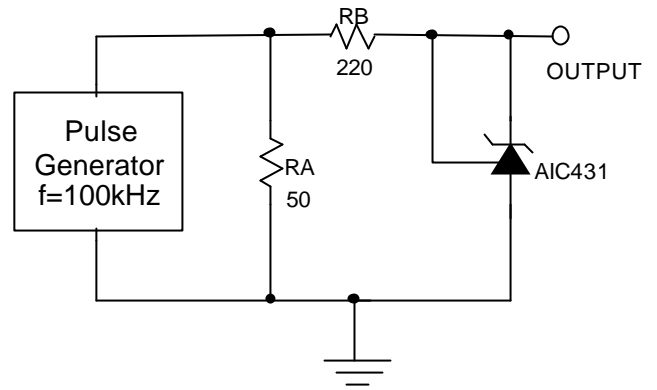
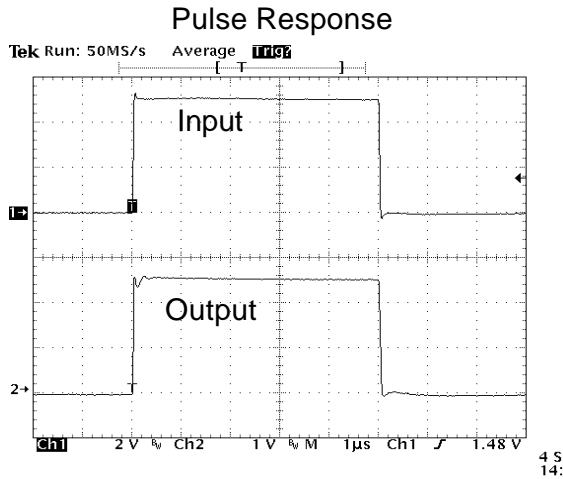


TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

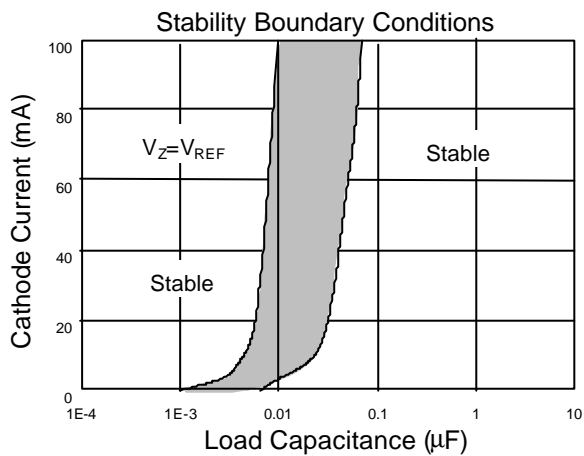


Test Circuit For Frequency Response

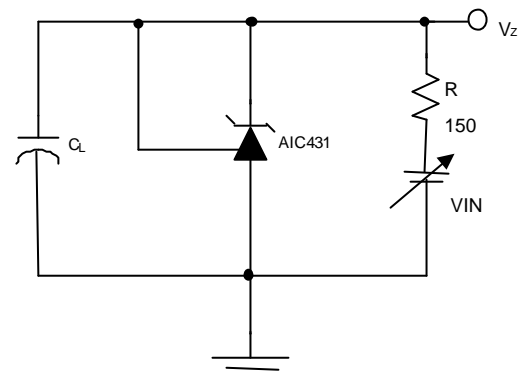
TYPICAL PERFORMANCE CHARACTERISTICS (Continued)



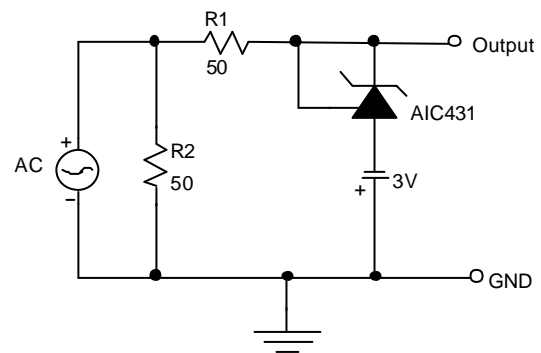
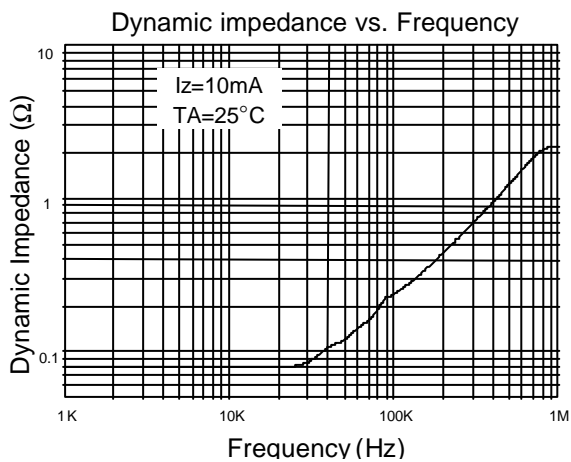
Test Circuit For Pulse Response



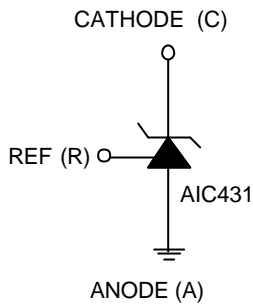
The areas between the curves represent condition that may cause the device oscillate



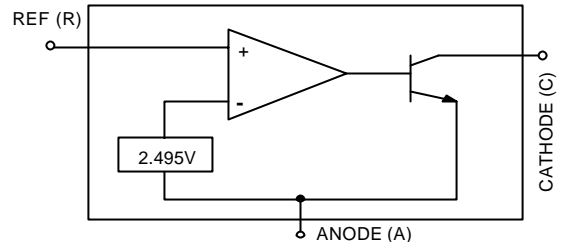
Test Circuit for Stability Boundary Conditions



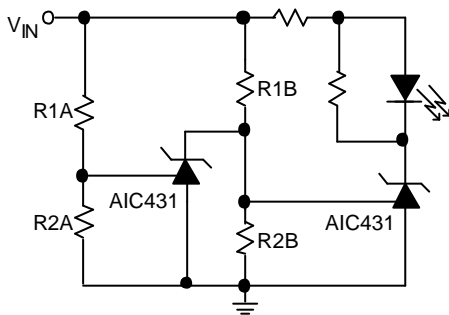
■ SYMBOL



■ BLOCK DIAGRAM



■ APPLICATION EXAMPLES



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

$$Low\ Limit \cong V_{REF} (1 + R1B/R2B) \quad Delay = R \times C \times \ln \left(\frac{V_{IN}}{V_{IN} - V_{REF}} \right)$$

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

Fig. 4 Voltage Monitor

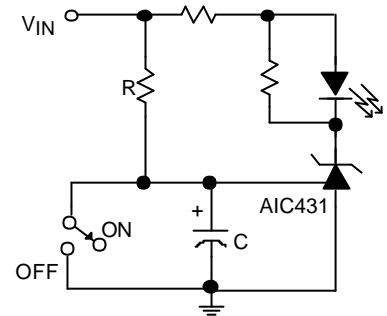
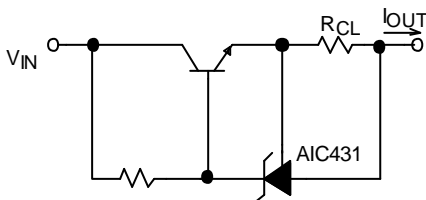
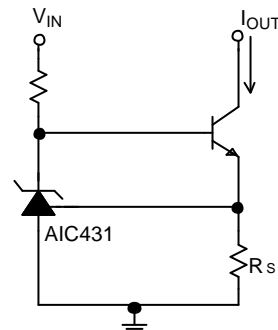


Fig. 5 Delay Timer



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

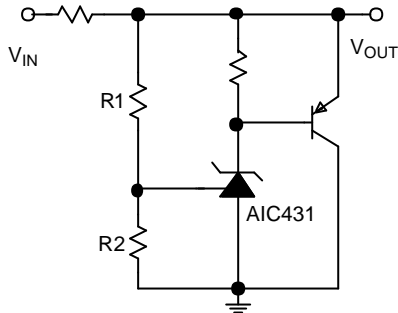
Fig. 6 Current Limiter or Current Source



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

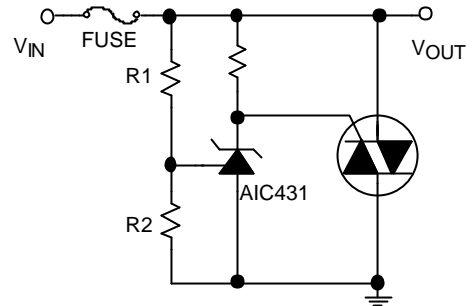
Fig. 7 Constant-Current Sink

APPLICATION EXAMPLES (Continued)



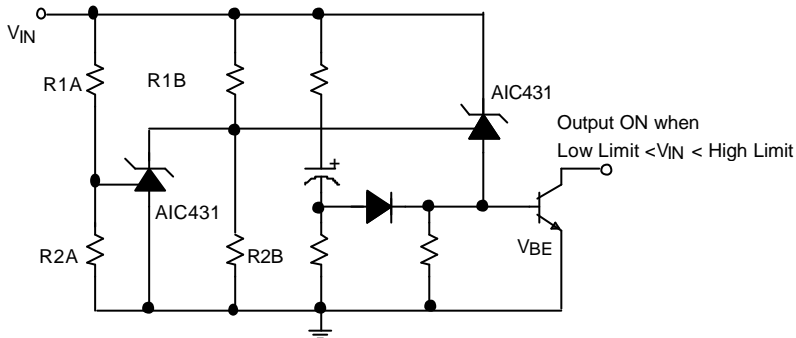
$$V_{OUT} \cong (1+R1/R2) \times V_{REF}$$

Fig 8. Higher-Current Shunt Regulator



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

Fig 9. Crow Bar



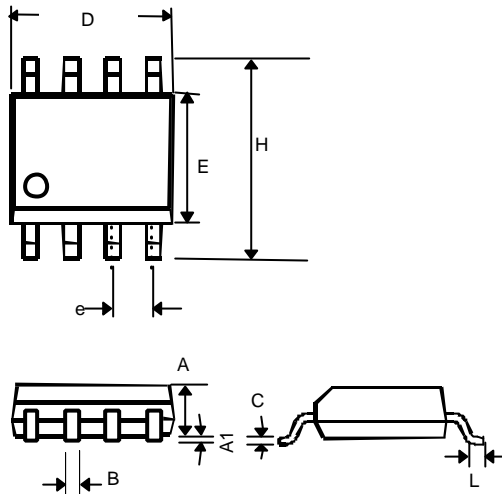
$$\text{Low Limit} \cong V_{REF} (1 + R1B/ R2B) + V_{BE}$$

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

Fig 10. Over-Voltage/Under-Voltage Protection Circuit

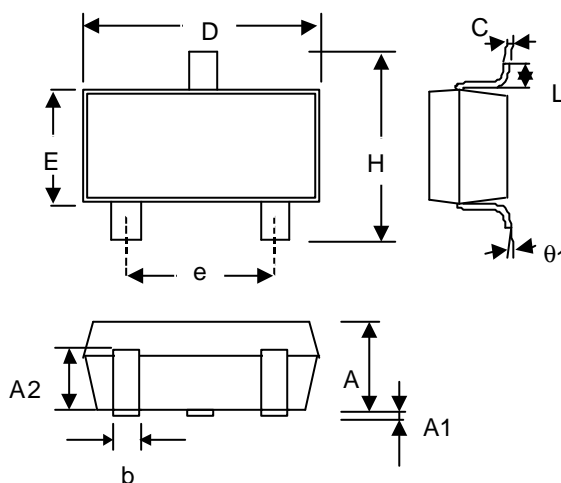
PHYSICAL DIMENSIONS

8 LEAD PLASTIC SO (unit: mm)



| SYMBOL | 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(TYP) | |
| H | 5.80 | 6.20 |
| L | 0.40 | 1.27 |

SOT-23 (unit: mm)



| SYMBOL | MIN | MAX |
|--------|------------|------|
| A | 1.00 | 1.30 |
| A1 | — | 0.10 |
| A2 | 0.70 | 0.90 |
| b | 0.35 | 0.50 |
| C | 0.10 | 0.25 |
| D | 2.70 | 3.10 |
| E | 1.40 | 1.80 |
| e | 1.90 (TYP) | |
| H | 2.60 | 3.00 |
| L | 0.37 | — |
| 1 | 1° | 9° |

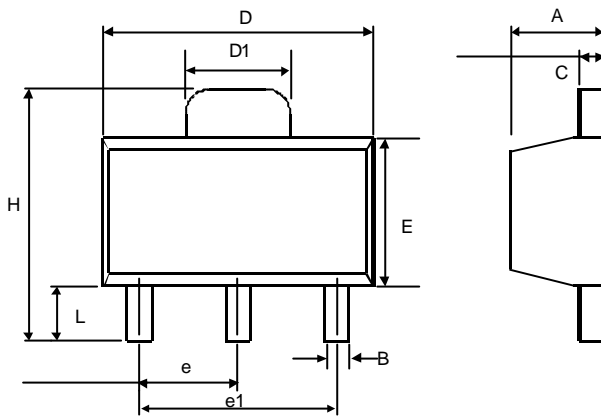
SOT-23 MARKING

| Part No. | Marking |
|-----------|---------|
| AIC431CUN | AC1N |
| TL431CUN | AC2N |
| TL431ACUN | AC3N |

| Part No. | Marking |
|-----------|---------|
| AIC431CUS | AC1S |
| TL431CUS | AC2S |
| TL431ACUS | AC3S |

PHYSICAL DIMENSIONS (Continued)

SOT-89 (unit: mm)

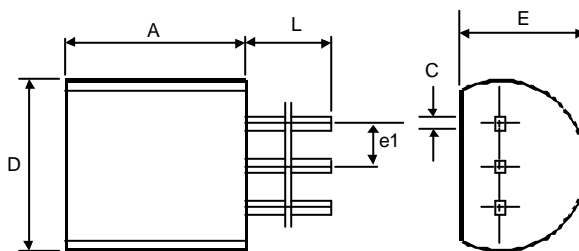


| SYMBOL | MIN | MAX |
|--------|-------------|------|
| A | 1.40 | 1.60 |
| B | 0.36 | 0.48 |
| C | 0.35 | 0.44 |
| D | 4.40 | 4.60 |
| D1 | 1.62 | 1.83 |
| E | 2.29 | 2.60 |
| e | 1.50 (TYP.) | |
| e1 | 3.00 (TYP.) | |
| H | 3.94 | 4.25 |
| L | 0.89 | 1.20 |

SOT-89 MARKING

| Part No. | Marking |
|----------|---------|
| AIC431CX | AC01B |
| TL431CX | AC02B |
| TL431ACX | AC03B |

TO-92 (unit: mm)



| SYMBOL | MIN | MAX |
|--------|-------------|------|
| A | 4.32 | 5.33 |
| C | 0.38 (TYP.) | |
| D | 4.40 | 5.20 |
| E | 3.17 | 4.20 |
| e1 | 1.27 (TYP.) | |
| L | 12.7 | - |