# Adjustable Precision Shunt Regulator

## FEATURES

- Low voltage operation (2.5V)
- Adjustable output voltage from $V_O = V_{REF}$ to 18V
- Wide operating current range from 0.4mA to 100mA
- Low dynamic output impedance 0.5Ω max.
- ESD rating is 5.5kV (per MIL-STD 883D)
- **Pb-free lead finish available.**

## APPLICATIONS

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

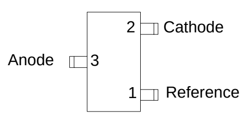
## DESCRIPTION

The SS431 is a low-voltage three-terminal adjustable shunt regulator with a guaranteed thermal stability over the applicable temperature range. The output voltage can be set to any value between $V_{REF}$ (approximately 2.5V) to 18V with two external resistors (see application circuit). This device has a typical output impedance of 0.2 ohms. Active output circuitry provides very sharp turn-on characteristics, making this device an excellent replacement for Zener diodes in many applications.

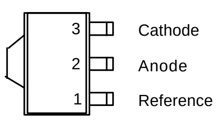
The SS431 is characterized for operation from 0°C to 105°C, and three package options (SOT-23, SOT-89, and TO-92) allow the designer the opportunity to select the proper package for his application. **The SS431 is available with a Pb-free lead finish - order as SS431Gxx.**

## PIN CONFIGURATION

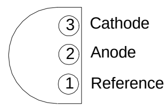
SOT-23 (Top view)



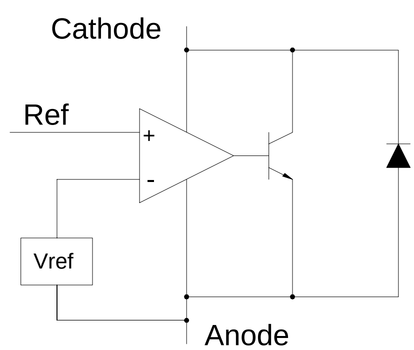

SOT-89 (Top view)



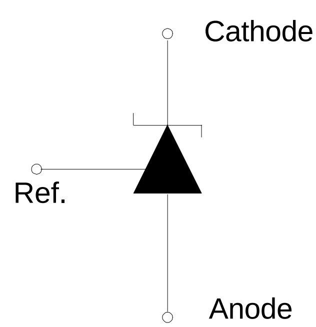

TO-92 (Top view)




## BLOCK DIAGRAM




## SYMBOL



## ABSOLUTE MAXIMUM RATINGS over ambient temp. range.

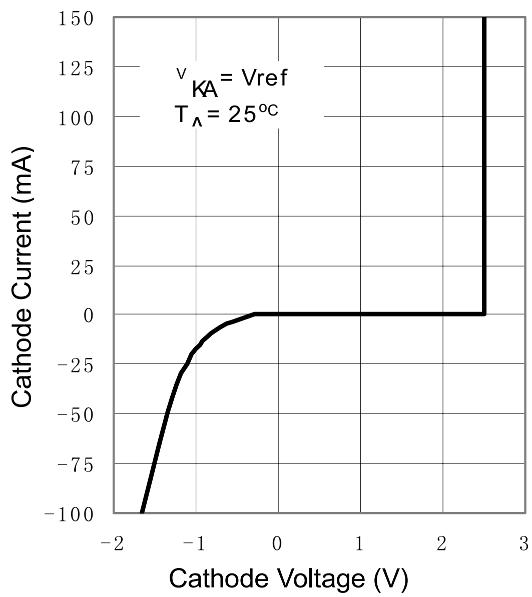
| Parameter | Symbol | Maximum | Units |
|---|---|---|---|
| Cathode Voltage | $V_{KA}$ | 18 | V |
| Continuous Cathode Current | $I_{KA}$ | 150 | mA |
| Reference Current | $I_{REF}$ | 10 | mA |
| Operating Junction Temperature | $T_J$ | 125 | ℃ |
| Storage Temperature Range | $T_{STG}$ | -65 to 150 | ℃ |
| Thermal Resistance | $\theta_{JA}$ | 156 | ℃/W |
| Lead Temperature (Soldering) 10 seconds | $T_{LEAD}$ | 260 | ℃ |

## ELECTRICAL CHARACTERISTICS $T_A = 25$℃

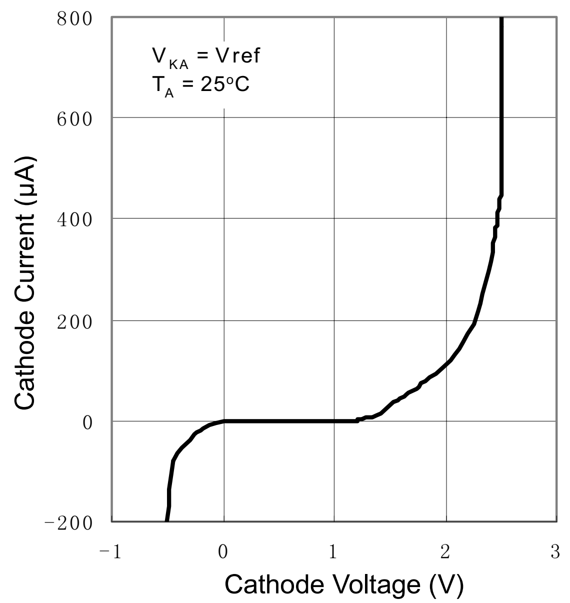
| PARAMETER | | | TEST CIRCUIT | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| **Reference voltage** | 1% | Vref | 1 | $V_{KA}$ = Vref   $I_{KA}$ = 10mA | 2470 | 2495 | 2520 | mV |
| Deviation of reference voltage Over full temperature range | | $V_{I(dev)}$ | 1 | $V_{KA}$ = Vref ,   $I_{KA}$ = 10mA<br>$T_A$ = full range | | 4 | 25 | mV |
| Ratio of change in reference voltage to the change in cathode voltage | | $\frac{\Delta V_{ref}}{\Delta V_{KA}}$ | 2 | $I_{KA}$ = 10mA<br>$\Delta V_{KA}$ = 10 V - Vref | | -1.4 | -2.7 | mV/V |
| Reference current | | Iref | 2 | $I_{KA}$ = 10mA, R1=10kΩ, R2 = ∞ | | 2 | 4 | µA |
| Deviation of Reference current over full temperature range | | $I_{I(dev)}$ | 2 | $I_{KA}$ = 10mA, R1=10kΩ, R2 = ∞<br>$T_A$ = full range | | 0.4 | 1.2 | µA |
| Minimum cathode current for regulation | | Imin | 1 | $V_{KA}$ = Vref | | 0.4 | 1 | mA |
| Off-state cathode current | | Ioff | 3 | $V_{KA}$ = 18V,   Vref = 0 | | 0.1 | 1 | µA |
| Dynamic impedance | | $r_Z$ | 1 | $I_{KA}$ = 1mA to 100mA, $V_{KA}$ = Vref<br>f ≤ 1kHz | | 0.2 | 0.5 | Ω |

## TYPICAL PERFORMANCE CHARACTERISTICS

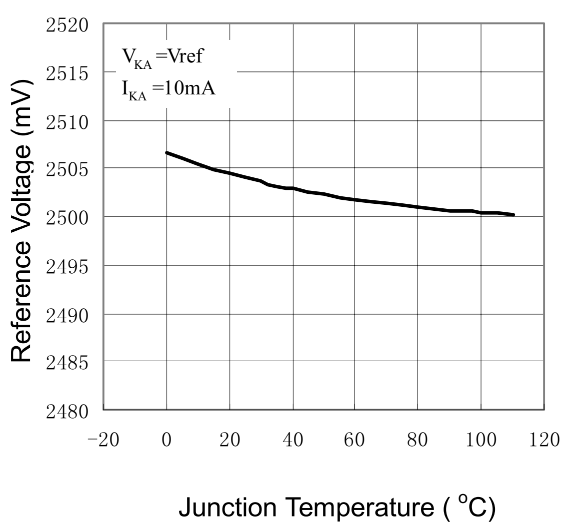
CATHODE CURRENT
Vs.
CATHODE VOLTAGE



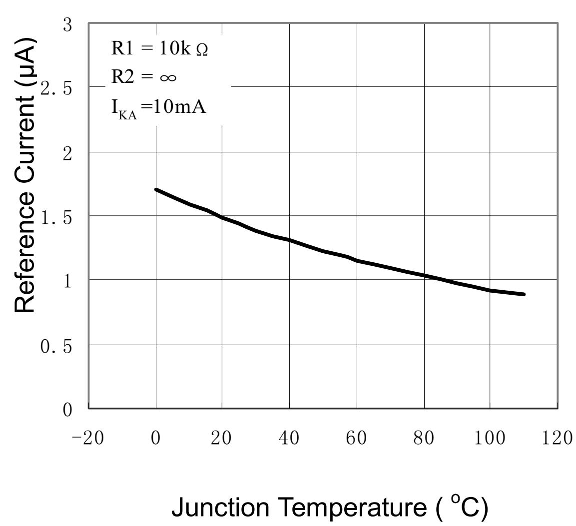

CATHODE CURRENT
Vs.
CATHODE VOLTAGE



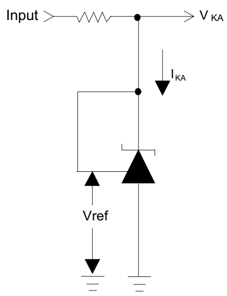

REFERENCE VOLTAGE
Vs.
JUNCTION TEMPERATURE



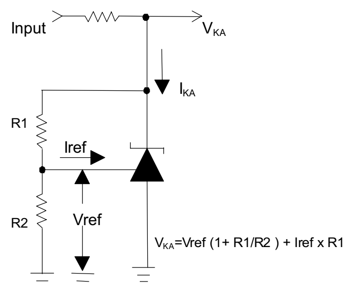

REFERENCE INPUT CURRENT
Vs.
JUNCTION TEMPERATURE



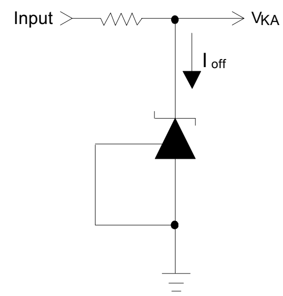
## TEST CIRCUITS




**Test Circuit 1:**
**$V_{KA}$ = Vref**

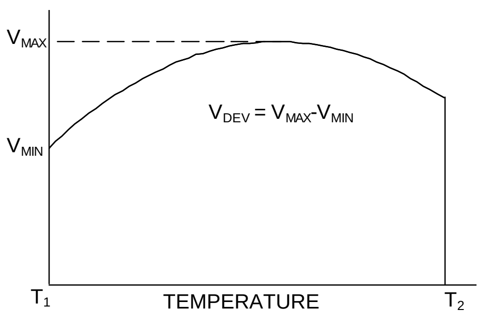



**Test Circuit 2:**
**$V_{KA}$ > Vref**




**Test Circuit 3:**
**Off State Current**

## APPLICATION INFORMATION




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, $\alpha V_{REF}$ is defined as:

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

Where:
$T_2$–$T_1$=full temperature change.
$\alpha V_{REF}$ can be positive or negative depending on whether the slope is positive or negative.
Example: $V_{DEV}$= 7.0mV, $V_{REF}$= 2495mV,
$T_2$–$T_1$= 105°C, slope is negative.

$$aV_{REF} = \frac{\left[\frac{7.0mV}{2495mV}\right]10^6}{105°C} = -27ppm/°C$$

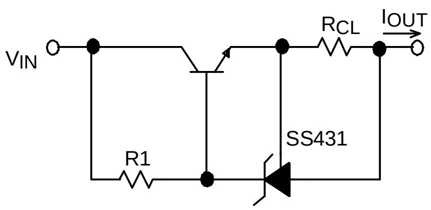
**Note 4.** The dynamic output impedance, $R_Z$, is defined as:

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

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

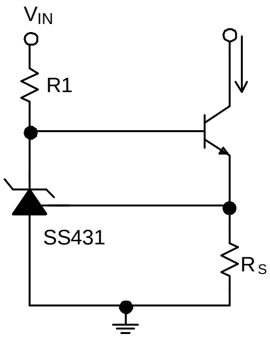
$$r_Z = \frac{\Delta V}{\Delta I} \cong R_Z\left[1+\frac{R1}{R2}\right]$$

## APPLICATION EXAMPLES



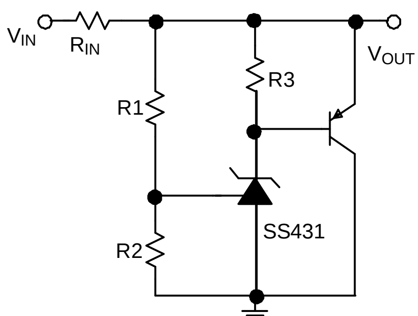

$I_{OUT}=V_{REF}/R_{CL}$

Current Limiter or Current Source



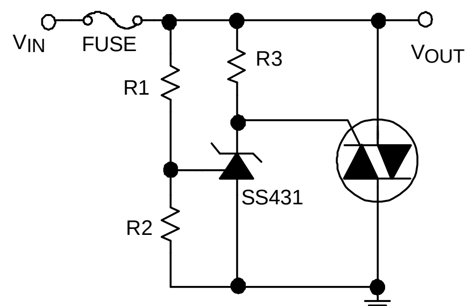

$I_{OUT}=V_{REF}/R_S$

Constant-Current Sink



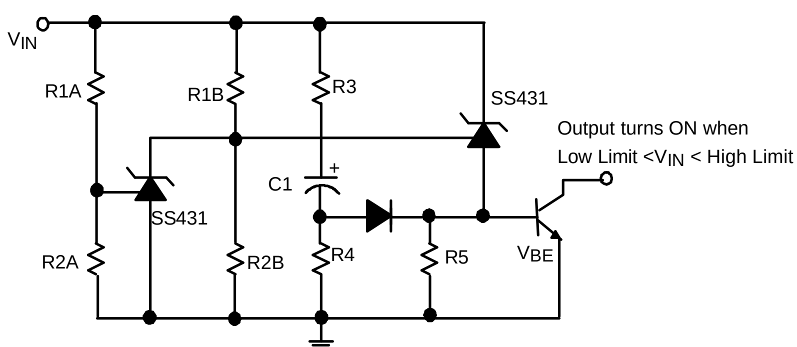

$V_{OUT} \cong (1+R1/R2) \times V_{REF}$

Higher-Current Shunt Regulator




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

Crow Bar

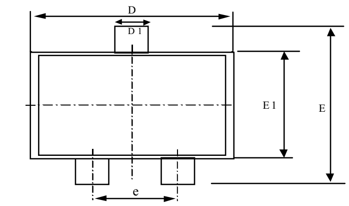


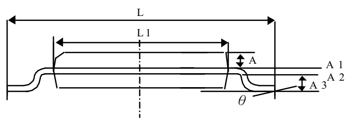

Low Limit $\cong V_{REF}$ ( 1+ R1B/ R2B )+ $V_{BE}$

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

Over-Voltage/Under-Voltage Protection Circuit

## PHYSICAL DIMENSIONS SOT-23

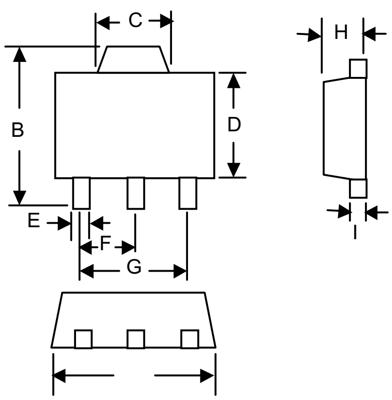



| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 0.20 | 0.30 | 0.40 |
| A1 | – | 0.00 | – |
| A2 | – | 0.10 | – |
| A3 | 0.70 | 0.80 | 0.90 |
| D1 | 0.30 | 0.40 | 0.50 |
| e | 1.70 | 2.00 | 2.30 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.25 | 2.50 | 2.75 |
| E1 | 1.40 | 1.50 | 1.60 |
| L | 2.25 | 2.50 | 2.75 |
| L1 | 1.40 | 1.50 | 1.60 |
| $\theta$ | – | $2^{\circ}$ | – |

Unit: :mm

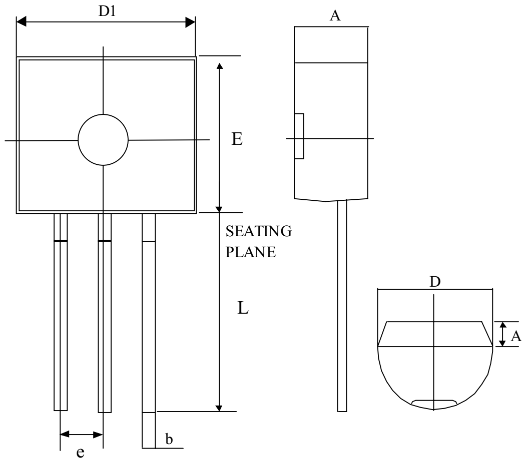
## SOT-89




| SYMBOL | MIN | MAX |
|---|---|---|
| A | 4.40 | 4.60 |
| B | 4.05 | 4.25 |
| C | 1.50 | 1.70 |
| D | 2.40 | 2.60 |
| E | 0.31 | 0.46 |
| F | 1.48 | 1.52 |
| G | 2.96 | 3.04 |
| H | 1.40 | 1.60 |
| I | 0.35 | 0.41 |

Unit: :mm

## PHYSICAL DIMENSIONS TO-92




| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 3.45 | 3.56 | 3.66 |
| A1 | 1.22 | 1.3 | 1.37 |
| b | - | 0.38 | - |
| D1 | 4.27 | 4.52 | 4.78 |
| D | 4.14 | 4.29 | 4.45 |
| E | 4.32 | 4.57 | 4.83 |
| e | - | 1.27 | - |
| L | 12.98 | 13.49 | 14.00 |

Unit: mm

## ORDERING INFORMATION

**SS431(G)xBxx**

- TR: Tape and Reel Packing
- Bandgap tolerance
  - B = 1%
- Package type
  - N = SOT-23-3
  - T = TO-92
  - G = SOT-89
- Lead finish option: G for Pb-free lead finish

Example: SS431GNBTR

SS431 with 1% tolerance in SOT-23-3 with pb-free lead finish shipped on tape and reel