Adjustable High-Precision Shunt Regulator

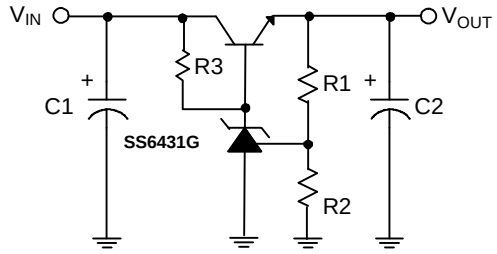
FEATURES

- Precision reference voltage.
  - SS6431G: 2.495V ±0.5%
- Sink current capability of 200mA.
- Minimum cathode current for regulation of 250μA.
- Equivalent full-range temperature coefficient of 50 ppm/°C.
- Fast turn-on response.
- Low dynamic output impedance of 80 milliohms.
- Adjustable output voltage.
- Low output noise.
- Space saving packages: SOT-89, SOT-23, TO-92 and SO-8.
- **Pb-free lead finish (second-level interconnect).**

APPLICATIONS

- Linear regulators.
- Adjustable supplies.
- Switching power supplies.
- Battery operated computers.
- Instrumentation.
- Computer disk drives.

TYPICAL APPLICATION CIRCUIT



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

Precision Regulator

DESCRIPTION

The SS6431G is a three-terminal adjustable precision shunt regulator 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. This device has a typical output impedance of 0.08Ω. Active output circuitry provides a very sharp turn-on characteristic, making this device an excellent improved replacement for zener diodes in many applications.

The precise ±0.5% reference voltage tolerance of the SS6431G makes it possible in many applications to avoid the use of a variable resistor, consequently saving cost and eliminating the drift and reliability problems associated with it.

ORDERING INFORMATION

SS6431GXXXX

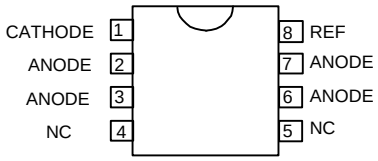
- Packing type
  - TR: Tape and reel
  - TB: Tube (for SO-8)
- Package type
  - S: Small outline
  - US: SOT-23
  - UN: SOT-23
  - X: SOT-89
  - Z: TO-92

Example: SS6431GSTR

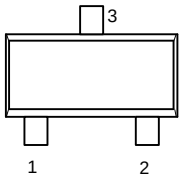
→ in SO-8 package, with Pb-free lead finish, shipped on tape and reel.

PIN CONFIGURATION

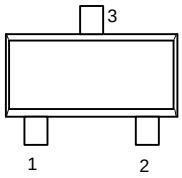
SO-8 (GS)
TOP VIEW



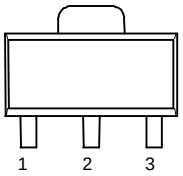
SOT-23 (GUN)
FRONT VIEW
1: CATHODE
2: VREF
3: ANODE



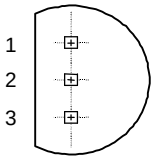
SOT-23 (GUS)
FRONT VIEW
1: VREF
2: CATHODE
3: ANODE



SOT-89 (GX)
FRONT VIEW
1: VREF
2: ANODE
3: CATHODE



TO-92 (GZ)
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, T_A		-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°C.
Note 2: Ratings apply to ambient temperature at 25°C.

TEST CIRCUITS

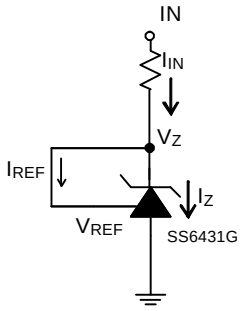
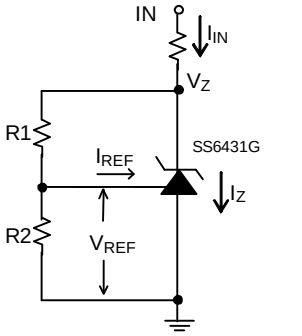


Fig. 1 Test Circuit for VZ=VREF



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

Fig. 2 Test Circuit for VZ>VREF

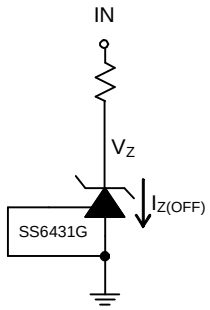


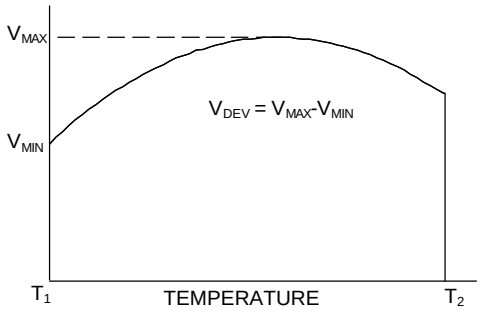
Fig. 3 Test Circuit for off-state Current

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

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Reference Voltage	$V_Z=V_{REF}$, I_{IN} =10mA (Fig.1)	V_{REF}	2.482	2.495	2.508	V
Deviation of Reference Input Voltage Over Temperature **(Note 3)**	$V_Z = V_{REF}$, 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) ΔV_Z=10V-V_{REF}	$\frac{\Delta V_{REF}}{\Delta V_Z}$		-0.5	-2.0	mV/V
	ΔV_Z=30V-10V			-0.35	-1.5	mV/V

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
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 4)**	V_Z=V_{REF} F<1kHz (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:

$$\Delta VREF\frac{ppm}{°C} = \frac{\pm\left[\frac{VMAX - VMIN}{VREF(at\ 25°C)}\right]10^6}{T2-T1} = \frac{\pm\left[\frac{VDEV}{VREF(at\ 25°C)}\right]10^6}{T2-T1}$$

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}= 9.0mV, V_{REF}= 2495mV,

T_2–T_1= 70°C, slope is negative.

$$aVREF = \frac{\left[\frac{9.0mV}{2495mV}\right]10^6}{70°C} = -50ppm/°C$$

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:

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

TYPICAL PERFORMANCE CHARACTERISTICS

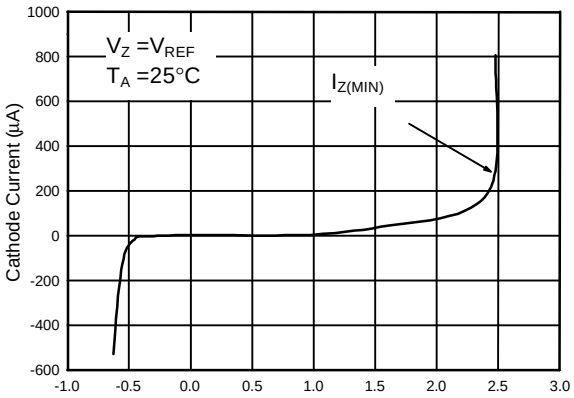


Fig. 4 Cathode Current vs. Cathode Voltage

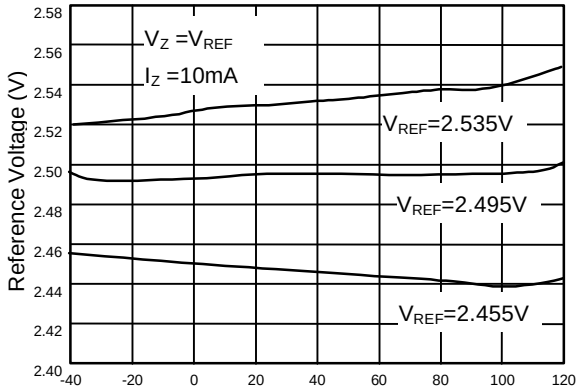


Fig. 5 Reference Voltage vs. Temperature

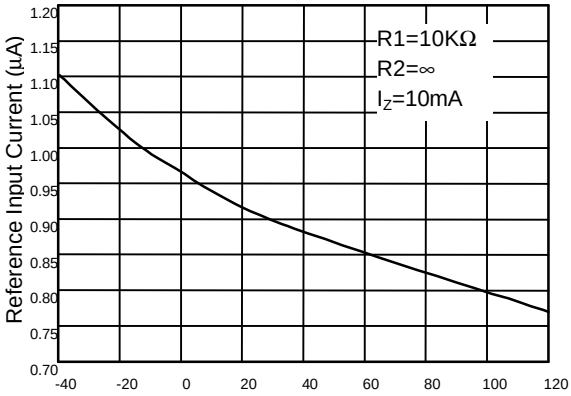


Fig. 6 Reference Input Current vs. Temperature

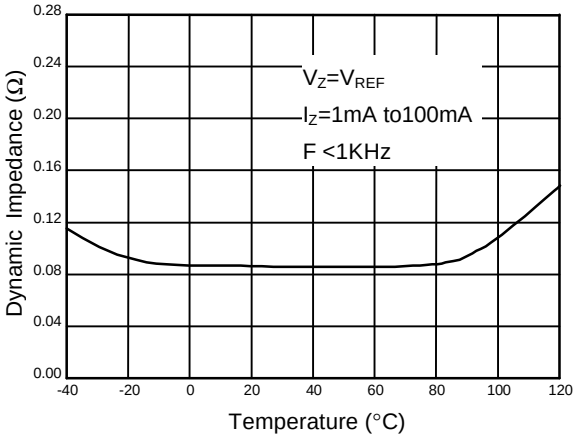


Fig. 7 Dynamic Impedance vs. Temperature

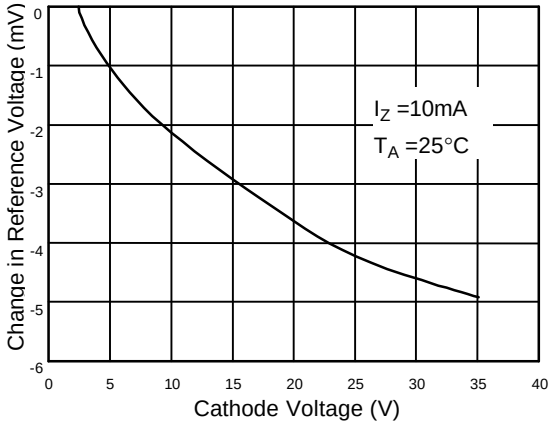


Fig. 8 Change in Reference Voltage vs. Cathode Voltage

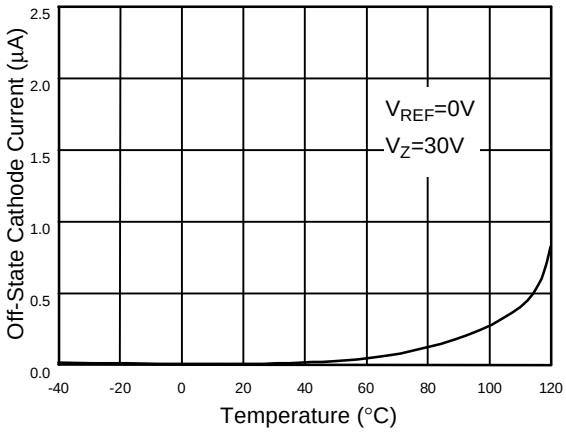


Fig. 9 Off-State Cathode Current vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

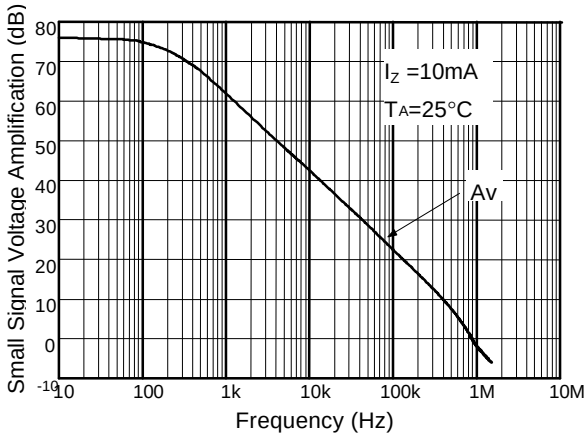


Fig. 10 Small Signal Voltage Amplification vs. Frequency

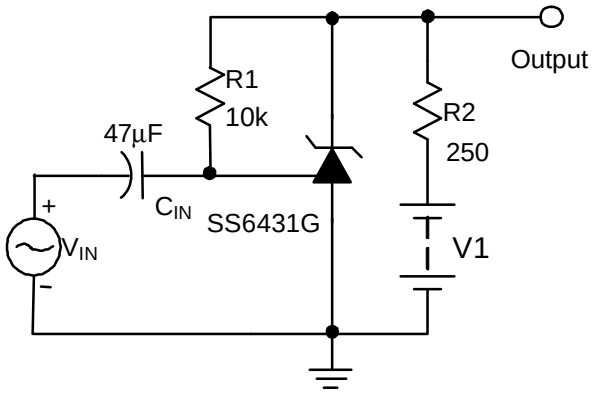


Fig. 11 Test Circuit For Frequency Response

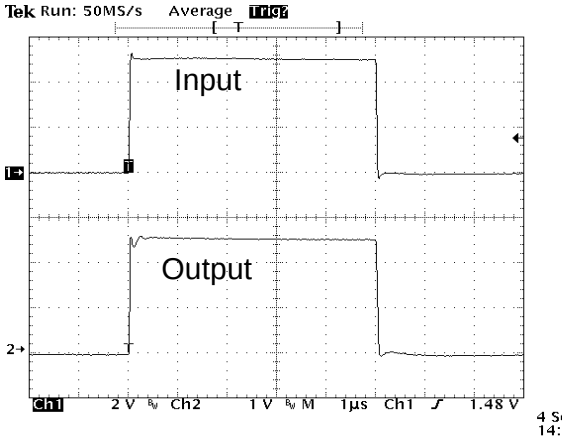


Fig. 12 Pulse Response

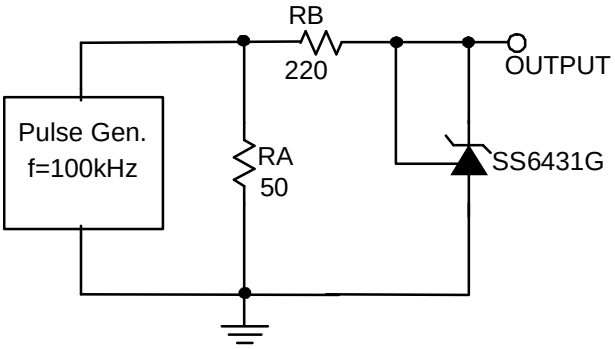


Fig. 13 Test Circuit For Pulse Response

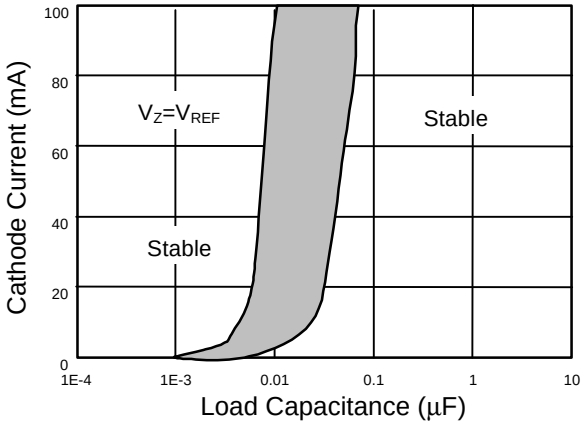


Fig. 14 Stability Boundary Conditions

The areas between the curves represent conditions that may cause the device to oscillate.

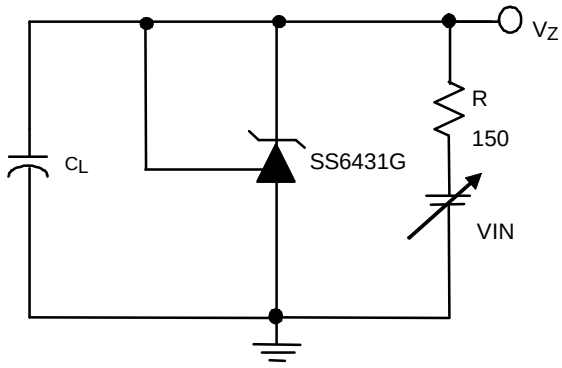


Fig. 15 Test Circuit for Stability Boundary Conditions

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

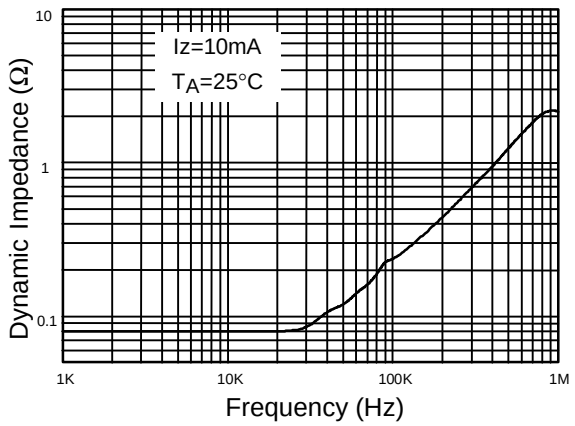


Fig. 16 Dynamic impedance vs. Frequency

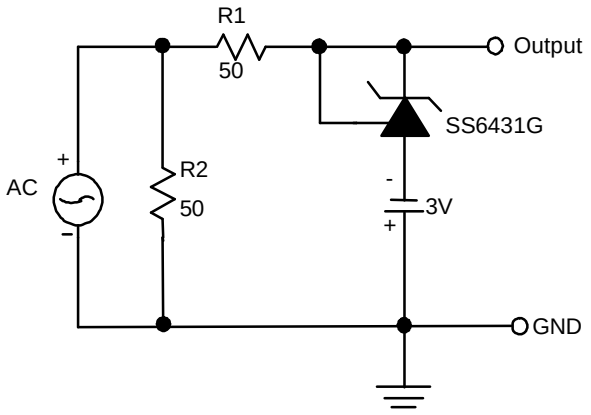
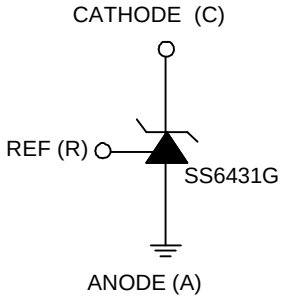
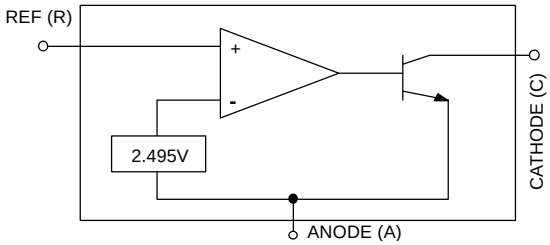


Fig. 17 Test Circuit for Dynamic Impedance

SYMBOL



BLOCK DIAGRAM



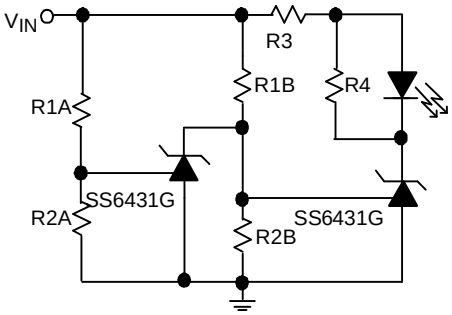
PIN DESCRIPTIONS

CATHODE Pin - Sinks current with a range from 250μA 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

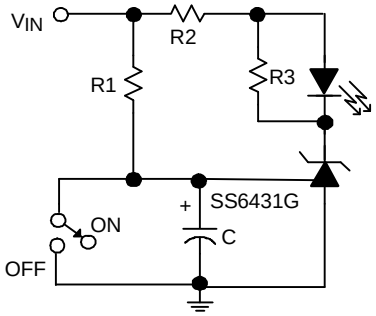


LED Turns on when Low Limit<V_{IN}< High Limit

Low Limit ≅ V_{REF} (1+R1B/R2B)

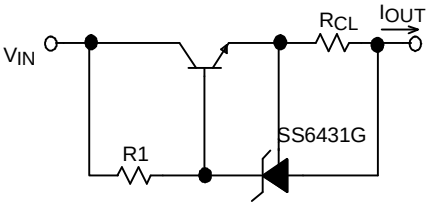
High Limit ≅ V_{REF} (1+R1A/R2A)

Fig. 18 Voltage Monitor



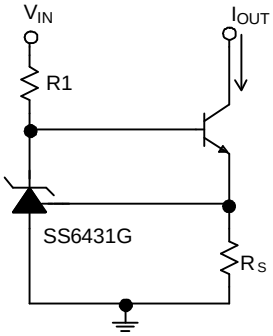
Delay=R x C x $\ell n\left(\frac{V_{IN}}{V_{IN}-V_{REF}}\right)$

Fig. 19 Delay Timer



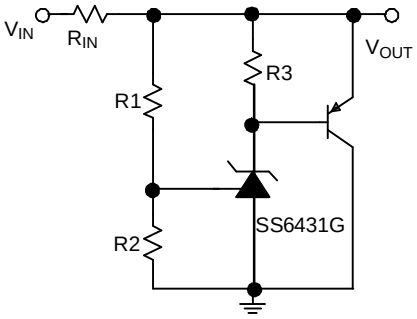
$I_{OUT}=V_{REF}/R_{CL}$

Fig. 20 Current Limiter or Current Source



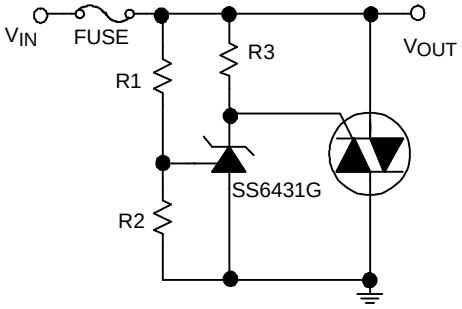
$I_{OUT}=V_{REF}/R_S$

Fig. 21 Constant-Current Sink



V_{OUT} ≅ (1+R1/R2) x V_{REF}

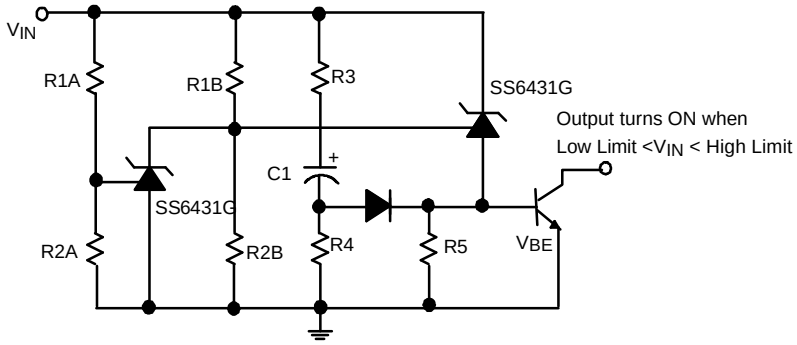
Fig 22 Higher-Current Shunt Regulator



V_{LIMIT} ≅ (1+R1/R2) x V_{REF}

Fig 23 Crow Bar

APPLICATION EXAMPLES (Continued)



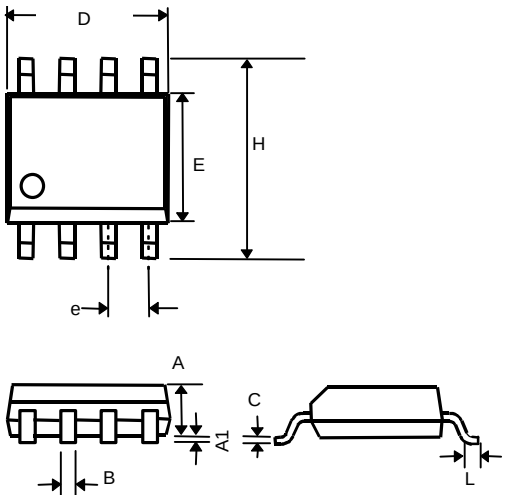
Low Limit≅ V_{REF} (1+ R1B/ R2B)+ V_{BE}
High Limit ≅ V_{REF} (1+ R1A/ R2A)

Fig 24 Over-Voltage/Under-Voltage Protection Circuit

PHYSICAL DIMENSIONS

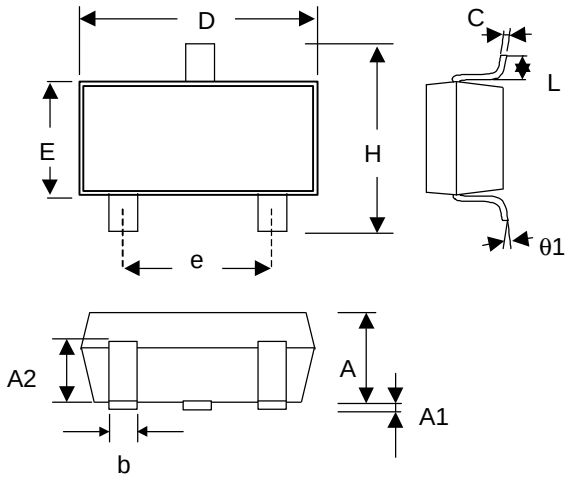
This device is shipped with Pb-free lead finish (second-level interconnect).

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)



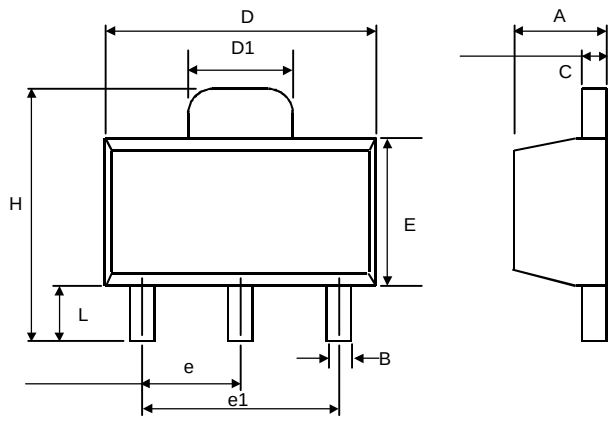
SYMBOL	MIN	MAX
A	1.00	1.30
A1	—	0.10
A2	0.70	0.90
b	0.35	0.50
C	0.10	0.25
D	2.70	3.10
E	1.40	1.80
e	1.90 (TYP)	
H	2.60	3.00
L	0.37	—
.1	1°	9°

SOT-23 MARKING

Part No.	Marking
SS6431GUN	AC1NP

Part No.	Marking
SS6431GUS	AC1SP

SOT-89 (unit: mm)

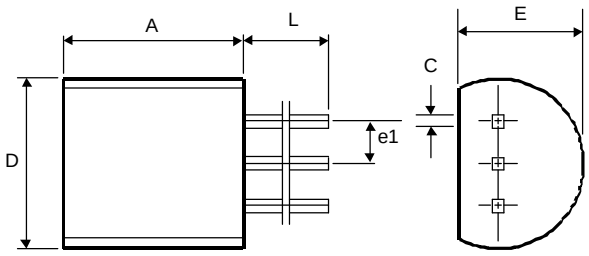


SYMBOL	MIN	MAX
A	1.40	1.60
B	0.36	0.48
C	0.35	0.44
D	4.40	4.60
D1	1.62	1.83
E	2.29	2.60
e	1.50 (TYP.)	
e1	3.00 (TYP.)	
H	3.94	4.25
L	0.89	1.20

SOT-89 MARKING

Part No.	Marking
SS6431GX	AC1BP

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	-

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