

Technical Data  
Data Sheet N1595 Rev. -

## Adjustable Precision Shunt Regulator

### Description:

The SMC431, 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 (VREF) up to 30V merely by selecting two external resistors that act as a voltage divider network. These devices have a typical output impedance of 0.08Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent improved replacements for zener diodes in many applications. The precise ±0.5% reference voltage tolerance of the SMC431 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.

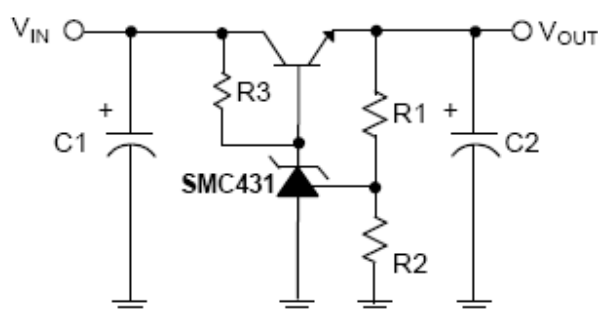
### Features:

- Precision Reference Voltage.  
SMC431 : 2.495V ±0.5%  
TL431A : 2.495V ±1.0%  
TL431 : 2.495V ±1.6%
- Sink Current Capability: 200mA.
- Minimum Cathode Current for Regulation: 250µA.
- Equivalent Full-Range Temperature Coefficient: 50 ppm/°C.
- Fast Turn-On Response.
- Low Dynamic Output Impedance: 0.08Ω.
- Adjustable Output Voltage.
- Low Output Noise.
- Space Saving Packages: SOT-23

### Applications:

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

### Typical application circuit:



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

### Precision Regulator

- China - Germany - Korea - Singapore - United States •
- <http://www.smc-diodes.com> - [sales@smc-diodes.com](mailto:sales@smc-diodes.com) •



SMC431  
TL431  
TL431A

Technical Data  
Data Sheet N1595 Rev. -

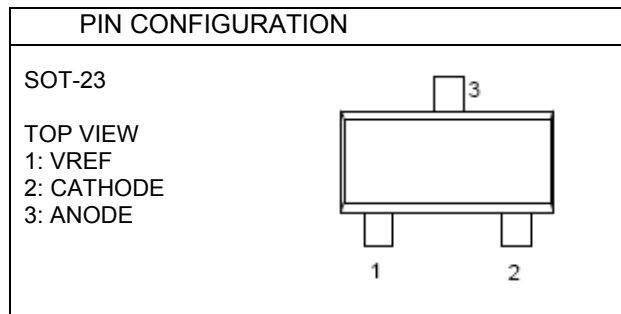
**Adjustable Precision Shunt Regulator**

**Ordering Information:**

SMC431 -XXX  
SMC431- XXX  
TL431A -XXX

PACKING TYPE  
TB: TUBE  
TR: TAPING & REEL  
TA: BAG

PACKAGING TYPE  
F: SOT-23



**Marking Diagram:**

Part No.	Marking
SMC431FTA	AC1SG
TL431FTA	AC2SG
TL431AFTA	AC3SG

**Absolute Maximum Ratings:**

Cathode Voltage.....30V  
 Continuous Cathode Current..... -10mA~250mA  
 Reference Input Current Range.....10mA  
 Operating Temperature Range ..... -40°C to 85°C  
 Storage Temperature Range .....-65°C ~ 150°C  
 Maximum Junction Temperature .....125°C  
 Lead Temperature (Soldering) 10 sec. ....260°C

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

Test Circuit

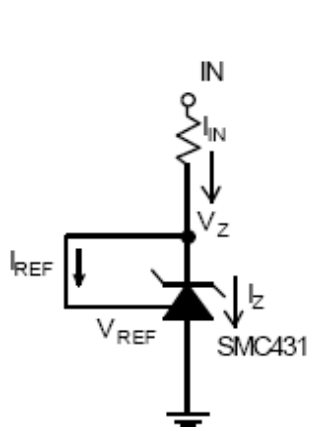
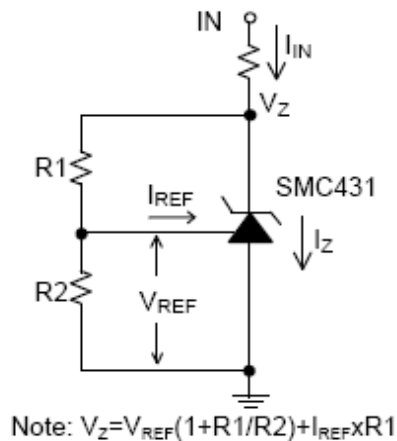


Fig. 1 Test Circuit for  $V_Z = V_{REF}$



Note:  $V_Z = V_{REF}(1 + R_1/R_2) + I_{REF} \times R_1$

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

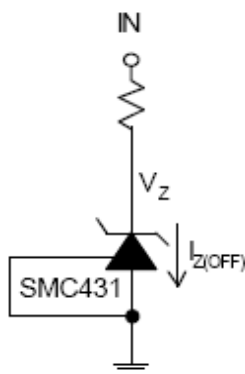
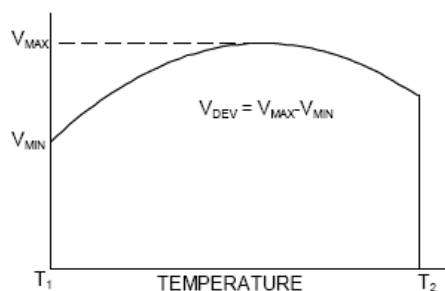


Fig. 3 Test Circuit for off-state Current

**Electrical Characteristics (T<sub>A</sub>=25°C, unless otherwise specified.) (Note 1)**

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT	
Reference Voltage	V <sub>Z</sub> =V <sub>REF</sub> , I <sub>IN</sub> =10mA (Fig. 1)	SMC431	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 <sub>Z</sub> = V <sub>REF</sub> , I <sub>IN</sub> =10mA, T <sub>A</sub> = 0°C~ +70°C (Fig. 1) T <sub>A</sub> = -40°C~ +85°C (Fig. 1)	V <sub>DEV</sub>		9.0	20	mV	
				9.0	50		
Ratio of the Change in Reference Voltage to the Change in Cathode voltage	I <sub>Z</sub> =10mA (Fig. 2)	ΔV <sub>Z</sub> =10V-V <sub>REF</sub>	ΔV <sub>REF</sub>		-0.5	-2.0	mV/V
		ΔV <sub>Z</sub> =30V-10V	ΔV <sub>Z</sub>		-0.35	-1.5	mV/V
Reference Input Current	R1 =10KΩ, R2=∞, I <sub>IN</sub> =10mA (Fig. 2)	I <sub>REF</sub>		0.8	3.5	μA	
Deviation of Reference Input Current over Temperature	R1 =10KΩ, R2=∞, I <sub>IN</sub> =10mA T <sub>A</sub> =-40°C ~ +85°C (Fig. 2)	αI <sub>REF</sub>		0.3	1.2	μA	
Minimum Cathode current for Regulation	V <sub>Z</sub> =V <sub>REF</sub> (Fig. 1)	I <sub>Z(MIN)</sub>		0.25	0.5	mA	
Off-State Current	V <sub>Z</sub> =20V, V <sub>REF</sub> =0V (Fig. 3)	I <sub>Z(OFF)</sub>		0.1	1.0	μA	
Dynamic Output Impedance (Note 3)	V <sub>Z</sub> =V <sub>REF</sub> F<1KHZ (Fig. 1)	R <sub>Z</sub>		0.08	0.3	Ω	

**Note 1:** Specifications are production tested at T<sub>A</sub>=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<sub>DEV</sub>, 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<sub>REF</sub> is defined as:

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

Where:

T<sub>2</sub>-T<sub>1</sub>=full temperature change.

αV<sub>REF</sub> can be positive or negative depending on whether the slope is positive or negative.

Example: V<sub>DEV</sub>= 9.0mV, V<sub>REF</sub>= 2495mV,  
T<sub>2</sub>-T<sub>1</sub>= 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<sub>Z</sub>, 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:

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

**Technical Data**  
**Data Sheet N1595 Rev. -**  
**Typical Performance Characteristics**

**Adjustable Precision Shunt Regulator**

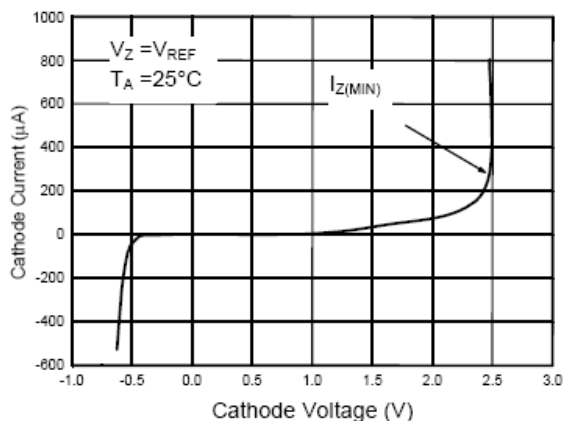


Fig. 4 Cathode Current vs. Cathode Voltage

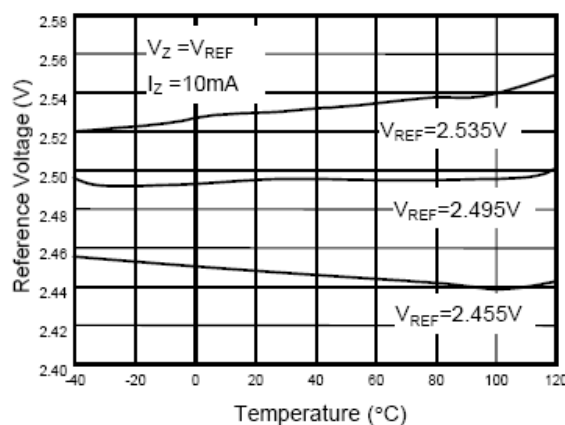


Fig. 5 Reference Voltage vs. Temperature

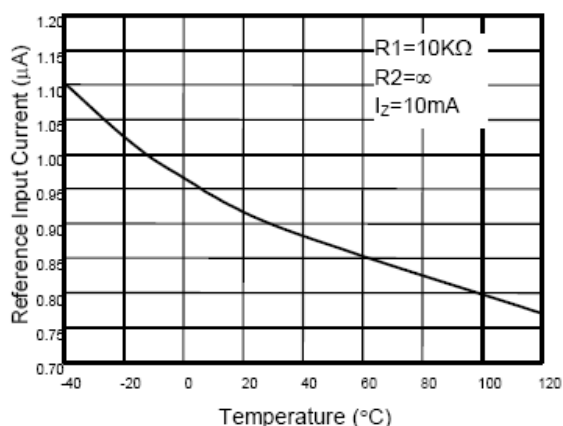


Fig. 6 Reference Input Current vs. Temperature

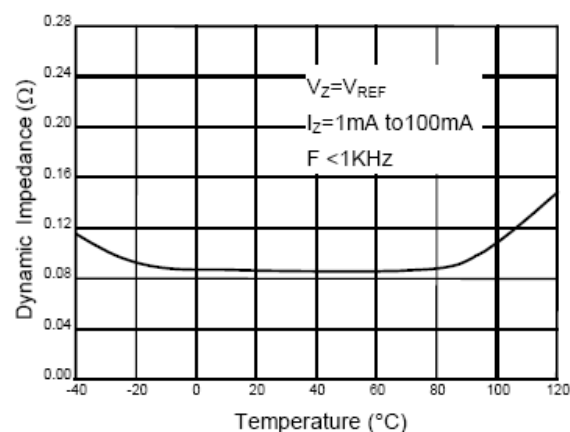


Fig. 7 Dynamic Impedance vs. Temperature

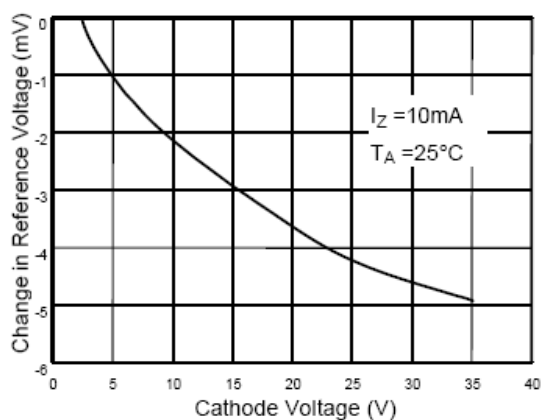


Fig. 8 Change in Reference Voltage vs. Cathode Voltage

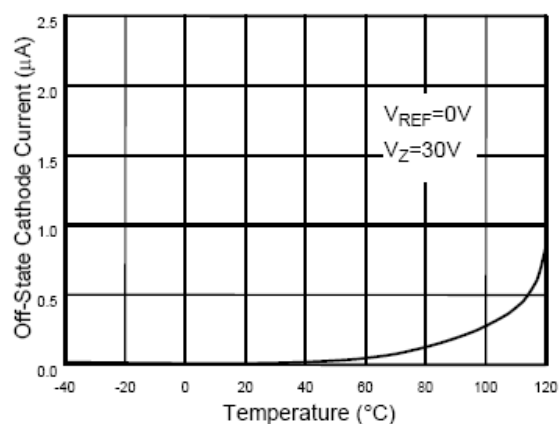


Fig. 9 Off-State Cathode Current vs. Temperature

**Technical Data**  
**Data Sheet N1595 Rev. -**

**Adjustable Precision Shunt Regulator**

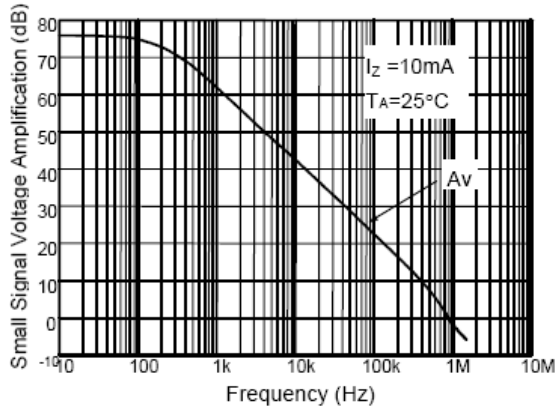


Fig. 10 Small Signal Voltage Amplification vs. Frequency

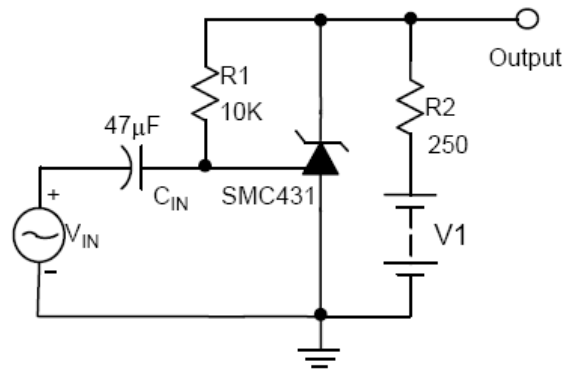


Fig. 11 Test Circuit For Frequency Response

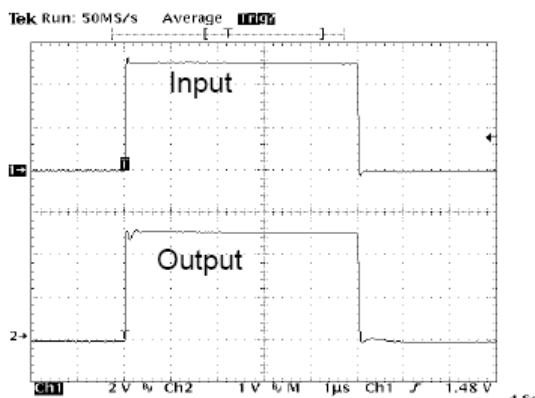


Fig. 12 Pulse Response

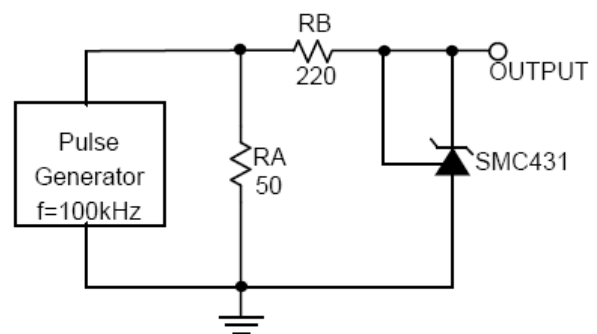


Fig. 13 Test Circuit For Pulse Response

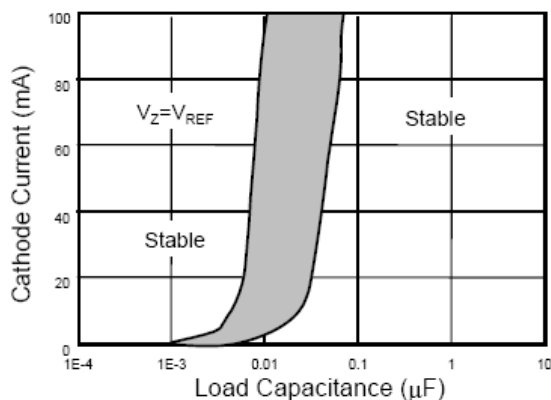


Fig. 14 Stability Boundary Conditions

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

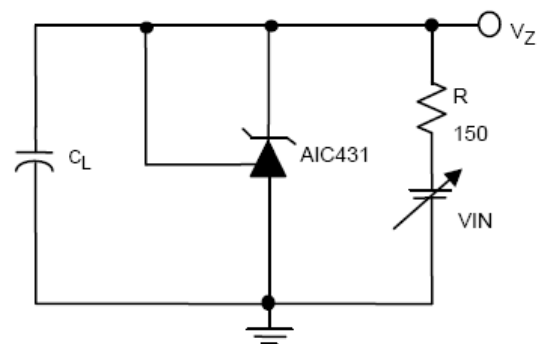


Fig. 15 Test Circuit for Stability Boundary

**Technical Data**  
**Data Sheet N1595 Rev. -**

**Adjustable Precision Shunt Regulator**

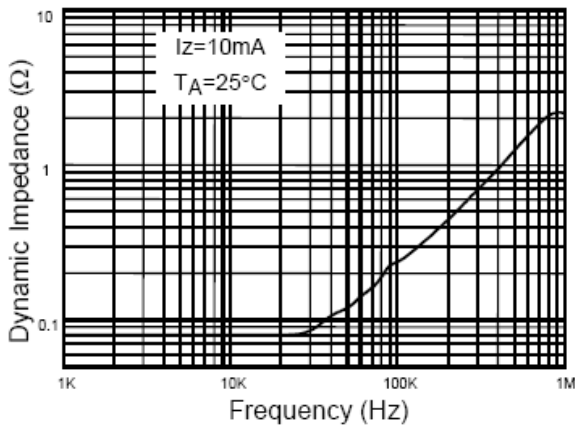


Fig. 16 Dynamic impedance vs. Frequency

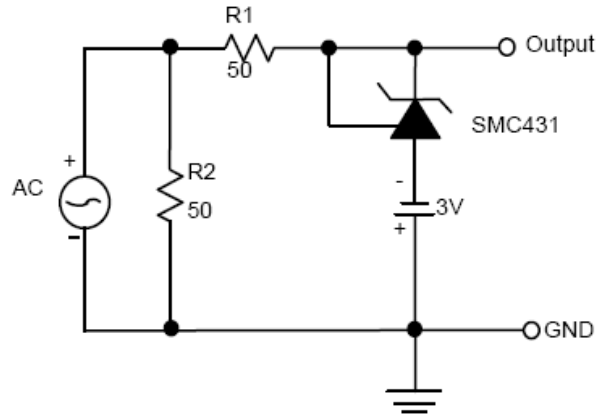
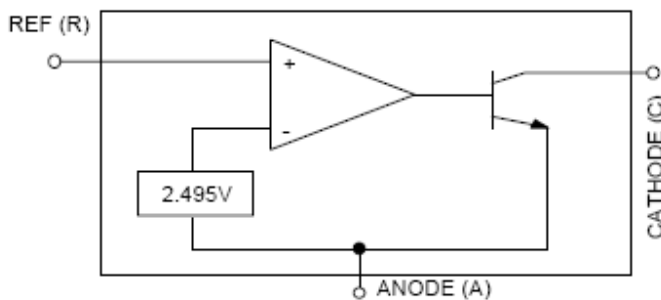
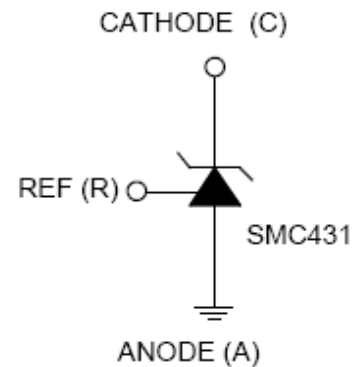


Fig. 17 Test Circuit for Dynamic Impedance

**Block Diagram**



**Symbol**

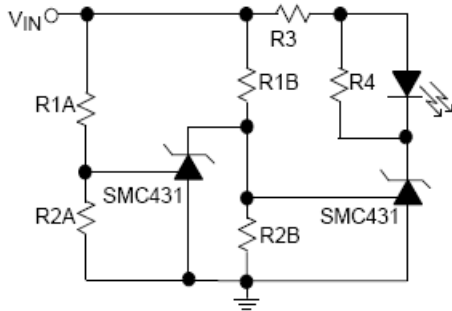


**Pin Descriptions**

- CATHODE Pin - Sinks current with a range from 250μA to 200mA for normal applications.
- VREF Pin - Providing VREF=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.

Technical Data  
Data Sheet N1595 Rev. -  
Application Examples

Adjustable Precision Shunt Regulator

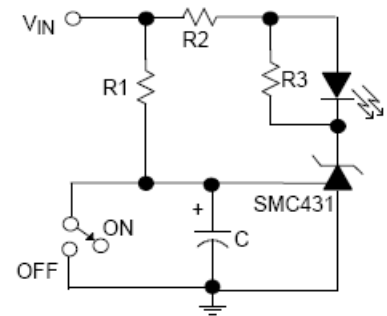


LED Turn on when Low Limit <math>V\_{IN}</math> <math>< V\_{REF}</math>

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

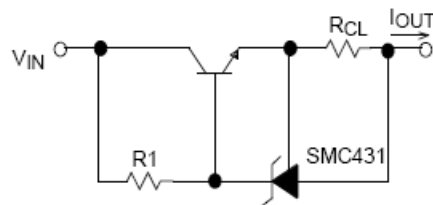
High Limit  $\cong V_{REF} (1+R1A/R2A)$

Fig. 18 Voltage Monitor



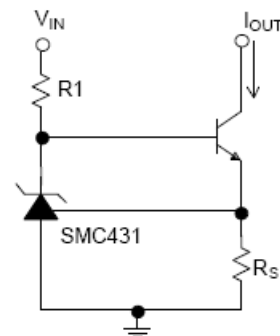
Delay =  $R \times C \times \ln \left( \frac{V_{IN}}{V_{IN}-V_{REF}} \right)$

Fig. 19 Delay Timer



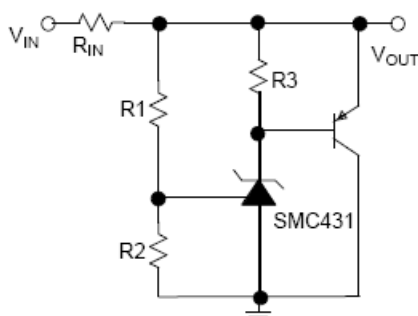
$I_{OUT} = V_{REF} / R_{CL}$

Fig. 20 Current Limiter or Current Source



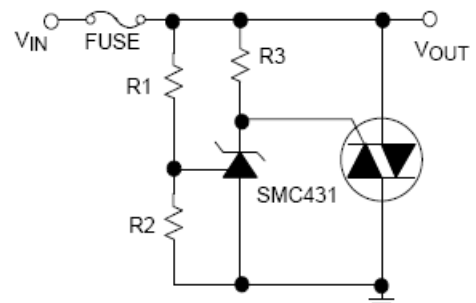
$I_{OUT} = V_{REF} / R_S$

Fig. 21 Constant-Current Sink



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

Fig 22. Higher-Current Shunt Regulator

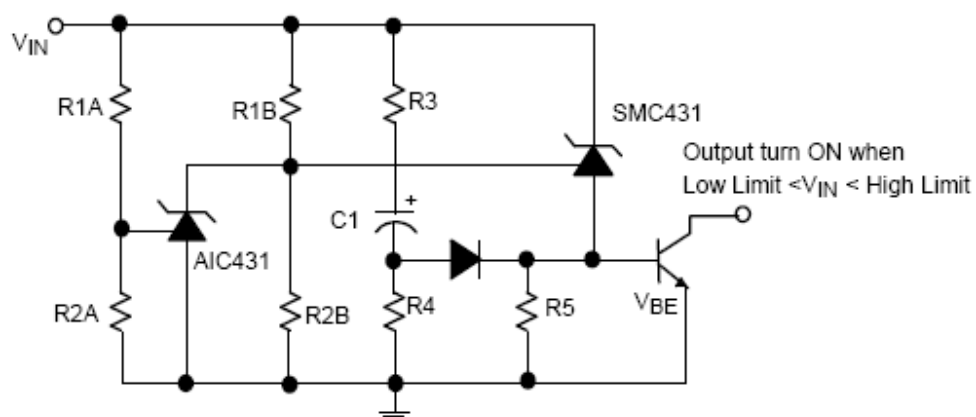


$V_{LIMIT} \cong (1+R1/R2) \times V_{REF}$

Fig 23 Crow Bar



Application Examples (Continued)



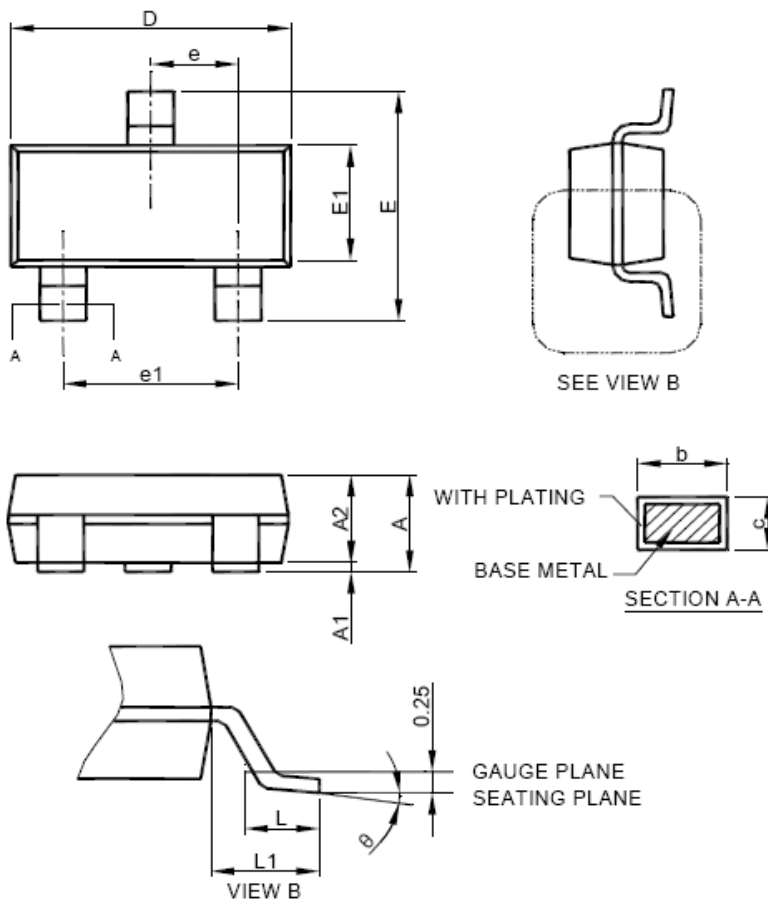
$$\text{Low Limit} \cong V_{REF} ( 1 + R1B / R2B ) + V_{BE}$$

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

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

Physical Dimensions

SOT-23 (unit: mm)



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°

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.



**SMC431  
TL431  
TL431A**

**Technical Data  
Data Sheet N1595 Rev. -**

## **Adjustable Precision Shunt Regulator**

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