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.

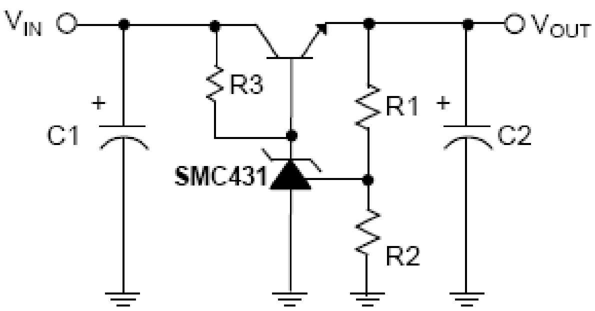
Features:

- 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/℃.
- 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) VREF

Precision Regulator

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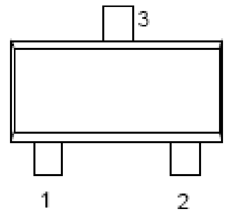
Ordering Information:

SMC431 -XXX
SMC431- XXX
TL431A - XXX

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

PACKAGING TYPE
F: SOT-23

PIN CONFIGURATION
SOT-23 TOP VIEW 1: VREF 2: CATHODE 3: ANODE



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

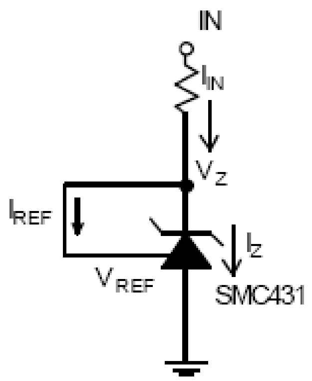


Fig. 1 Test Circuit for $V_Z=V_{REF}$

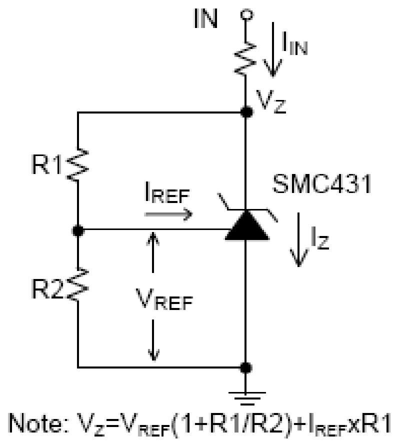


Fig. 2 Test Circuit for $V_Z>V_{REF}$

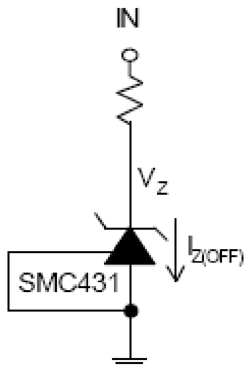


Fig. 3 Test Circuit for off-state Current

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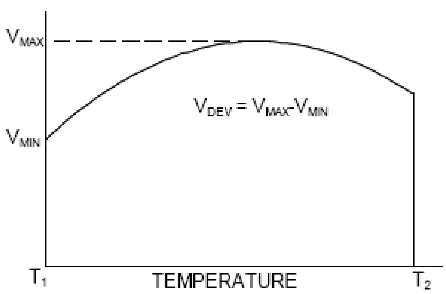
Electrical Characteristics (T_A=25°C, unless otherwise specified.) (Note 1)

PARAMETER	TEST CONDITIONS		SYMBOL	MIN.	TYP.	MAX.	UNIT
Reference Voltage	$V_Z=V_{REF}$, I_{IN} =10mA (Fig. 1)	SMC431	V_{REF}	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,		V_{DEV}				mV
	T_A = 0°C~ +70°C (Fig. 1)				9.0	20	
	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)	$\Delta V_Z=10V-V_{REF}$	$\frac{\Delta V_{REF}}{\Delta V_Z}$		-0.5	-2.0	mV/V
		ΔV_Z=30V-10V			-0.35	-1.5	mV/V
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:

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

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.

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

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:

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

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Typical Performance Characteristics

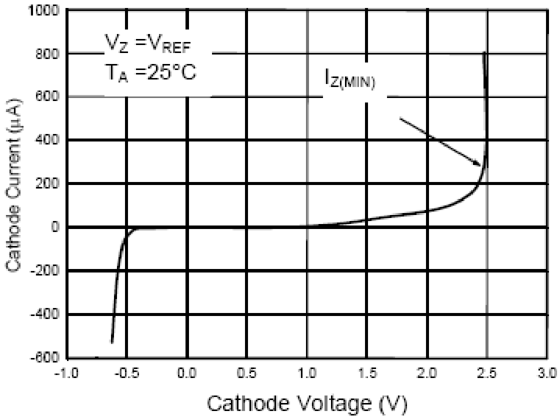

Fig. 4 Cathode Current vs. Cathode Voltage

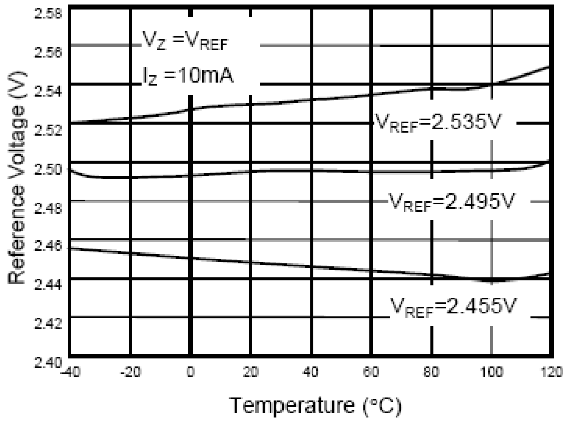

Fig. 5 Reference Voltage vs. Temperature

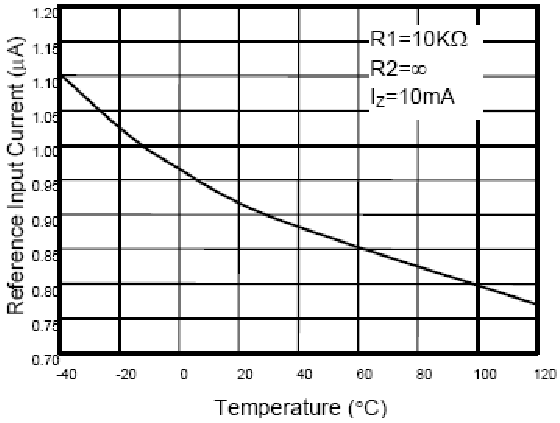

Fig. 6 Reference Input Current vs. Temperature

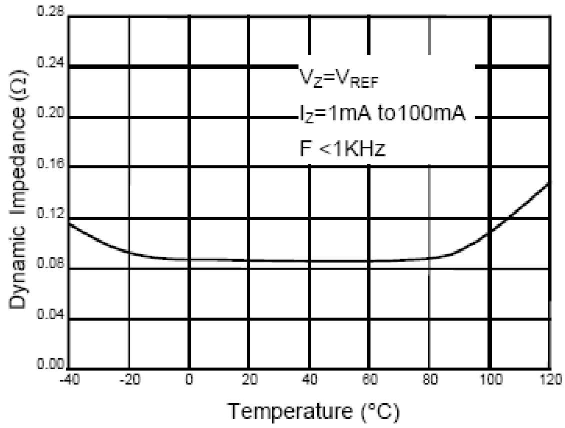

Fig. 7 Dynamic Impedance vs. Temperature

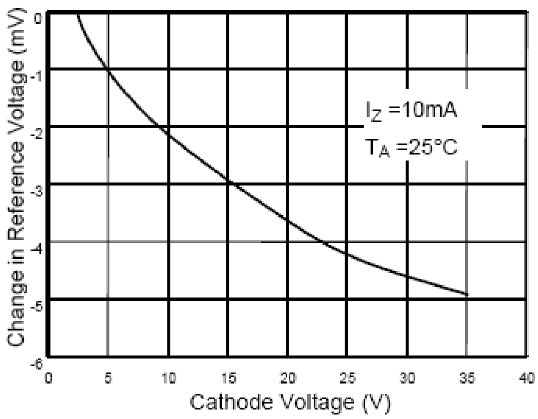

Fig. 8 Change in Reference Voltage vs. Cathode Voltage

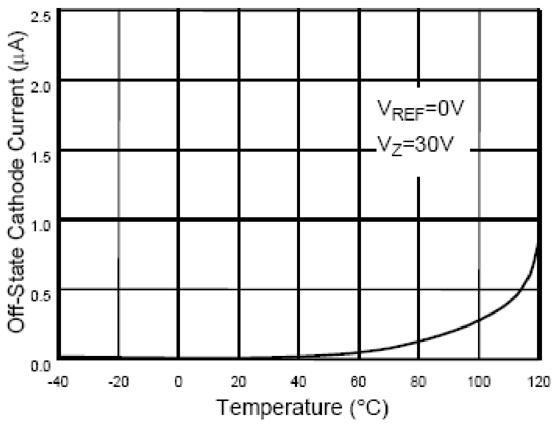

Fig. 9 Off-State Cathode Current vs. Temperature

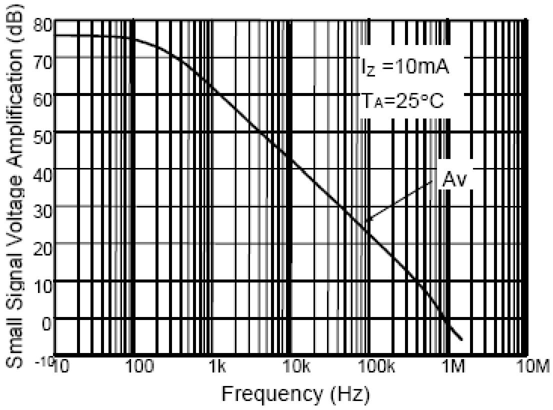

Fig. 10 Small Signal Voltage Amplification vs. Frequency

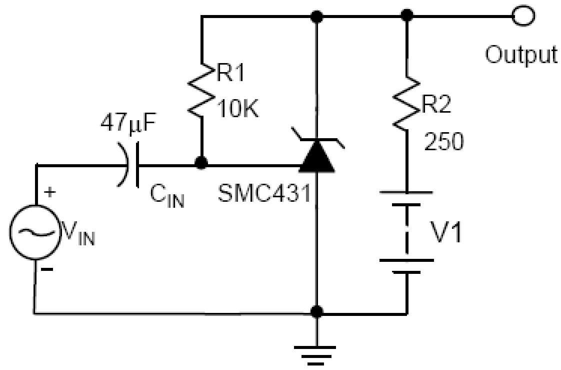

Fig. 11 Test Circuit For Frequency Response

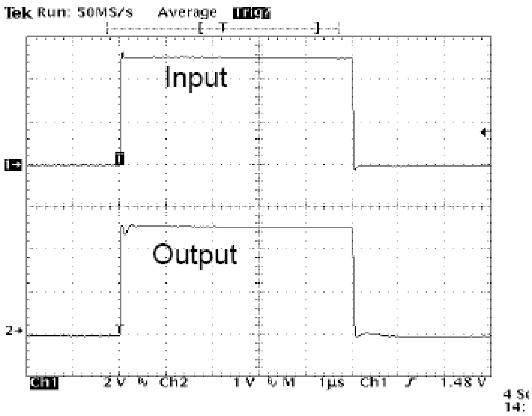

Fig. 12 Pulse Response

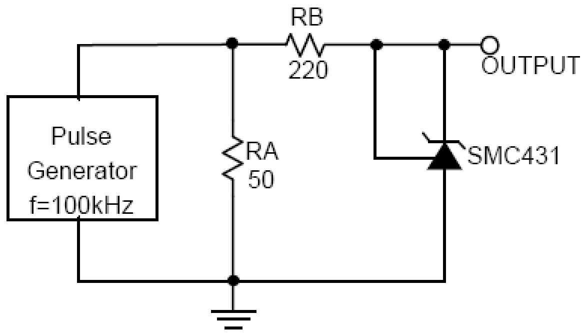

Fig. 13 Test Circuit For Pulse Response

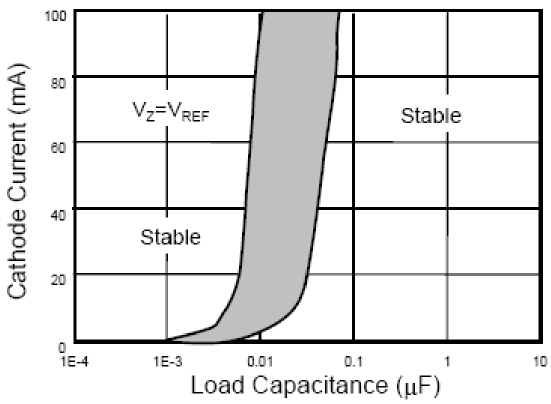

Fig. 14 Stability Boundary Conditions

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

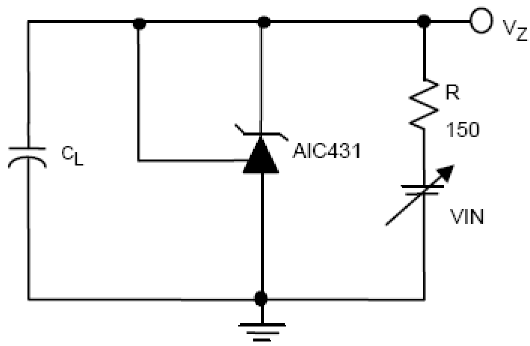

Fig. 15 Test Circuit for Stability Boundary

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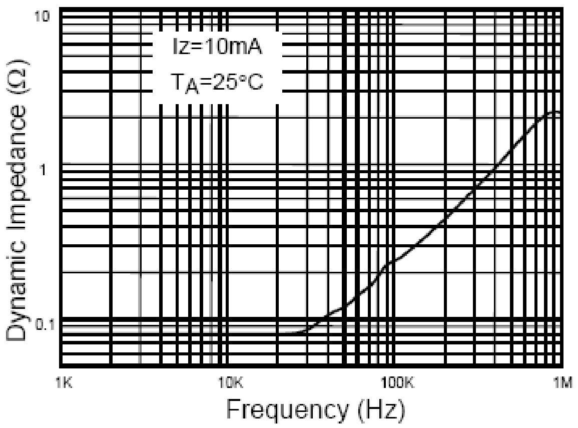


Fig. 16 Dynamic impedance vs. Frequency

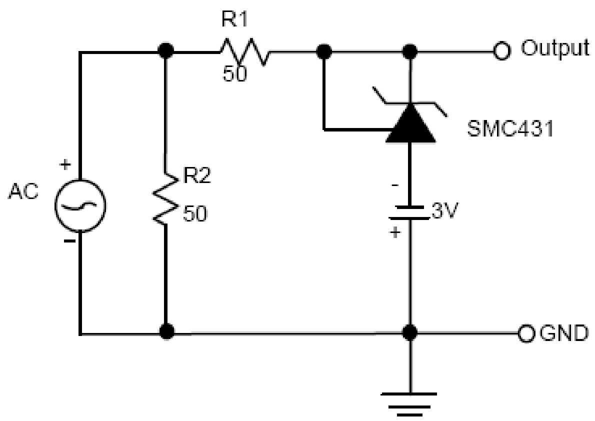
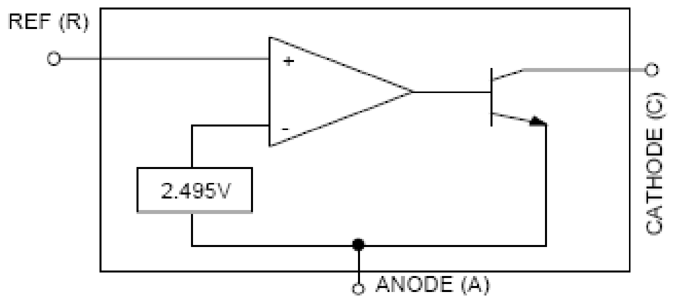
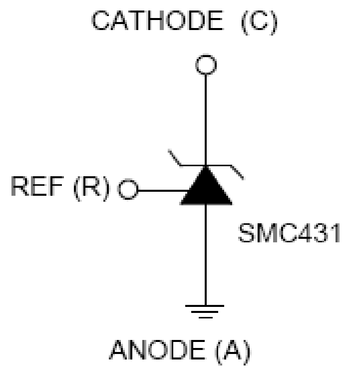


Fig. 17 Test Circuit for Dynamic Impedance

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.

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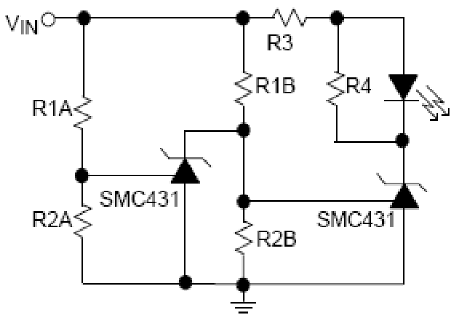
Application Examples

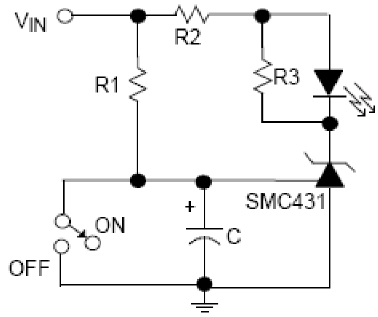


LED Turn on when Low Limit<V_{IN}< High Limit

Low Limit ≅ V_{REF} (1+R1B/R2B)

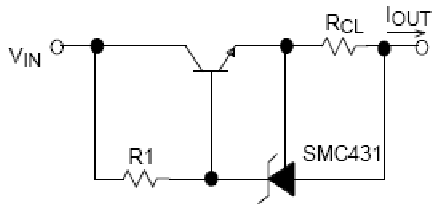
High Limit ≅ V_{REF} (1+R1A/R2A)

Fig. 18 Voltage Monitor



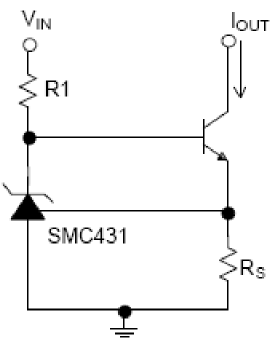
$$\text{Delay} = R \times C \times \ln\left(\frac{V_{IN}}{V_{IN} - V_{REF}}\right)$$

Fig. 19 Delay Timer



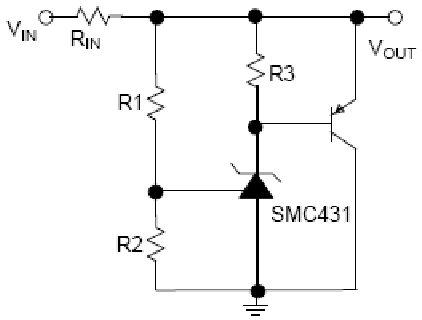
$I_{OUT}=V_{REF}/R_{CL}$

Fig. 20 Current Limiter or Current Source



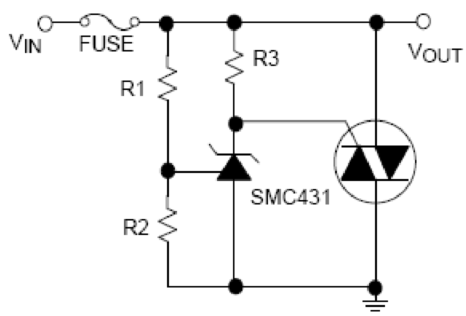
$I_{OUT}=V_{REF}/R_S$

Fig. 21 Constant-Current Sink



V_{OUT} ≅ (1+R1/R2) x V_{REF}

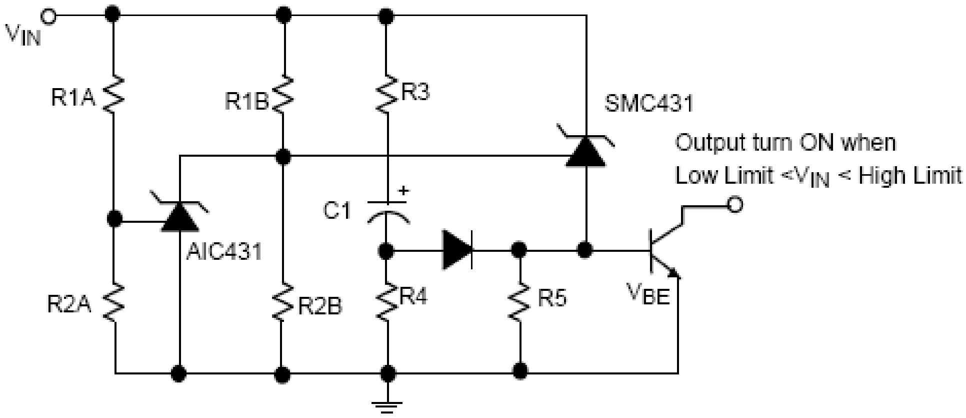
Fig 22. Higher-Current Shunt Regulator



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

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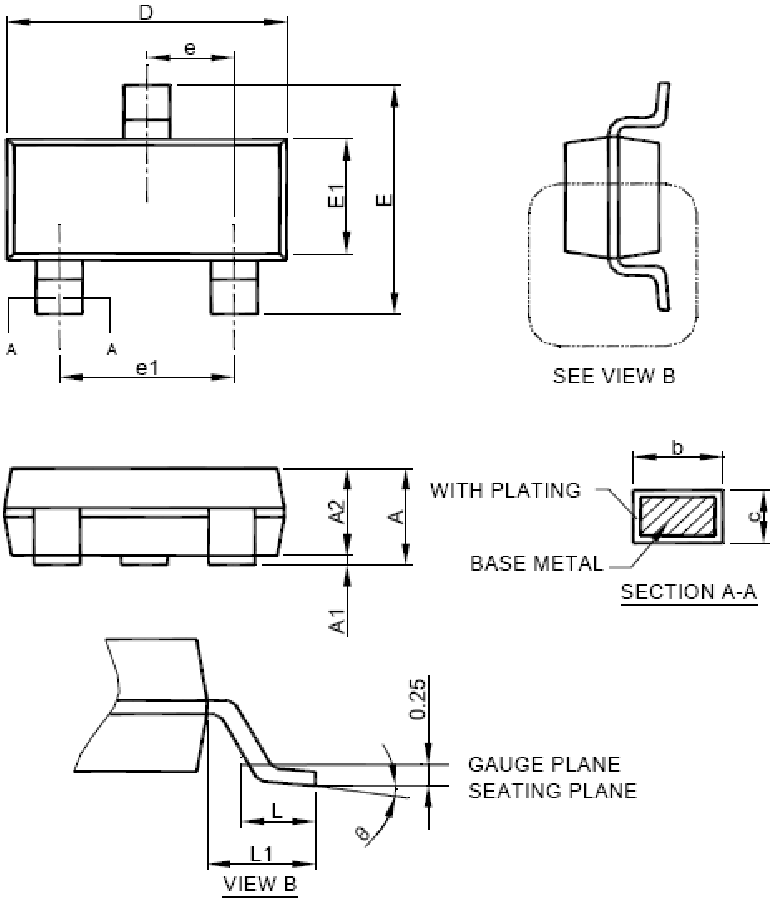
Physical Dimensions

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.

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