

# LM431SA/LM431SB/LM431SC

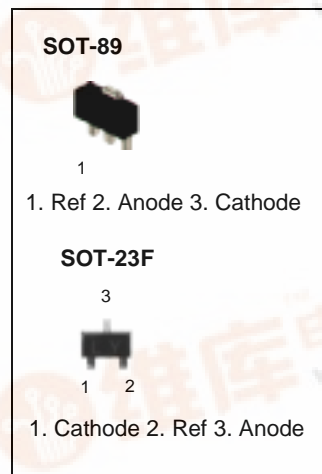
## Programmable Shunt Regulator

### Features

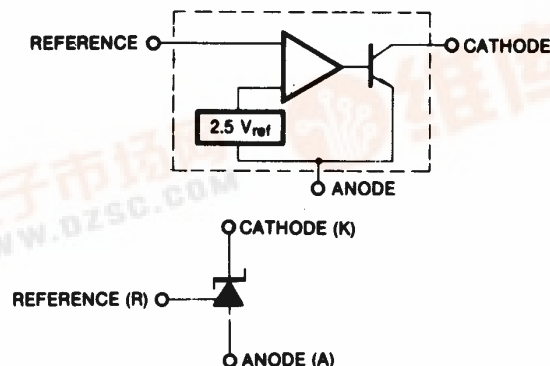
- Programmable Output Voltage to 36 Volts
- Low Dynamic Output Impedance 0.20 Typical
- Sink Current Capability of 1.0 to 100mA
- Equivalent Full-Range Temperature Coefficient of 50ppm/°C Typical
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response

### Description

The LM431SA/LM431SB/LM431SC are three terminal output adjustable regulators with thermal stability over operating temperature range. The output voltage can be set any value between  $V_{REF}$  (approximately 2.5 volts) and 36 volts with two external resistors. These devices have a typical dynamic output impedance of  $0.2\Omega$ . Active output circuit provides a sharp turn-on characteristic, making these devices excellent replacement for Zener Diodes in many applications.



### Internal Block Diagram



## Absolute Maximum Ratings

(Operating temperature range applies unless otherwise specified.)

Parameter	Symbol	Value	Unit
Cathode Voltage	V <sub>KA</sub>	37	V
Cathode current Range (Continuous)	I <sub>KA</sub>	-100 ~ +150	mA
Reference Input Current Range	I <sub>REF</sub>	0.05 ~ +10	mA
Thermal Resistance Junction-Air (Note1,2) MF Suffix Package ML Suffix Package	R <sub>θJA</sub>	350 220	°C/W
Power Dissipation (Note3,4) MF Suffix Package ML Suffix Package	P <sub>D</sub>	350 560	mW
Junction Temperature	T <sub>J</sub>	150	°C
Operating Temperature Range	T <sub>OPR</sub>	-25 ~ +85	°C
Storage Temperature Range	T <sub>STG</sub>	-65 ~ +150	°C

### Note:

- Thermal resistance test board  
Size: 76.2mm \* 114.3mm \* 1.6mm (1S0P)  
JEDEC Standard: JESD51-3, JESD51-7
- Assume no ambient airflow.
- T<sub>JMAX</sub> = 150°C, Ratings apply to ambient temperature at 25°C
- Power dissipation calculation:  $P_D = (T_J - T_A)/R_{\theta JA}$

## Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Cathode Voltage	V <sub>KA</sub>	V <sub>REF</sub>	-	36	V
Cathode Current	I <sub>KA</sub>	1.0	-	100	mA

## Electrical Characteristics

(T<sub>A</sub> = +25°C, unless otherwise specified)

Parameter	Symbol	Conditions	LM431SA			LM431SB			LM431SC			Unit		
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.			
Reference Input Voltage	V <sub>REF</sub>	V <sub>KA</sub> =V <sub>REF</sub> , I <sub>KA</sub> =10mA	2.450	2.500	2.550	2.470	2.495	2.520	2.482	2.495	2.508	V		
Deviation of Reference Input Voltage Over-Temperature	$\Delta V_{REF}/\Delta T$	V <sub>KA</sub> =V <sub>REF</sub> , I <sub>KA</sub> =10mA T <sub>MIN</sub> ≤T <sub>A</sub> ≤T <sub>MAX</sub>	-	4.5	17	-	4.5	17	-	4.5	17	mV		
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	I <sub>KA</sub> =10mA	$\Delta V_{KA}=10V-V_{REF}$		-	-1.0	-2.7	-	-1.0	-2.7	-	-1.0	-2.7	mV/V
			$\Delta V_{KA}=36V-10V$		-	-0.5	-2.0	-	-0.5	-2.0	-	-0.5	-2.0	
Reference Input Current	I <sub>REF</sub>	I <sub>KA</sub> =10mA, R <sub>1</sub> =10KΩ, R <sub>2</sub> =∞	-	1.5	4	-	1.5	4	-	1.5	4	μA		
Deviation of Reference Input Current Over Full Temperature Range	$\Delta I_{REF}/\Delta T$	I <sub>KA</sub> =10mA, R <sub>1</sub> =10KΩ, R <sub>2</sub> =∞ T <sub>A</sub> =Full Range	-	0.4	1.2	-	0.4	1.2	-	0.4	1.2	μA		
Minimum Cathode Current for Regulation	I <sub>KA(MIN)</sub>	V <sub>KA</sub> =V <sub>REF</sub>	-	0.45	1.0	-	0.45	1.0	-	0.45	1.0	mA		
Off -Stage Cathode Current	I <sub>KA(OFF)</sub>	V <sub>KA</sub> =36V, V <sub>REF</sub> =0	-	0.05	1.0	-	0.05	1.0	-	0.05	1.0	μA		
Dynamic Impedance	Z <sub>KA</sub>	V <sub>KA</sub> =V <sub>REF</sub> , I <sub>KA</sub> =1 to 100mA, f ≥1.0kHz	-	0.15	0.5	-	0.15	0.5	-	0.15	0.5	Ω		

### Note1

T<sub>MIN</sub> = -25°C, T<sub>MAX</sub> = +85°C

## Test Circuits

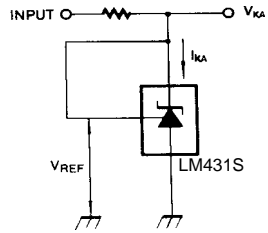


Figure 1. Test Circuit for  $V_{KA} = V_{REF}$

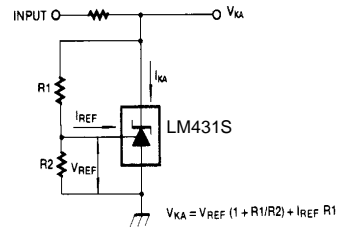


Figure 2. Test Circuit for  $V_{KA} \geq V_{REF}$

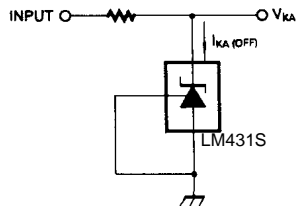


Figure 3. Test Circuit for  $I_{KA(OFF)}$

# Typical Performance Characteristics

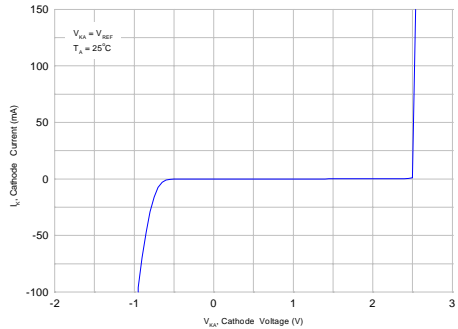


Figure 4. Cathode Current vs. Cathode Voltage

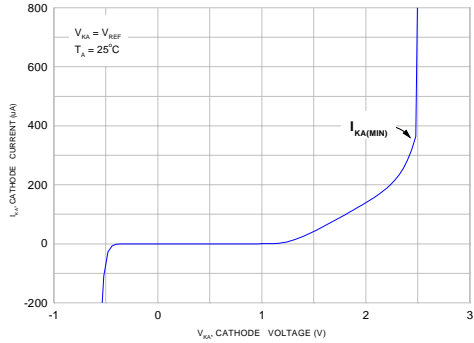


Figure 5. Cathode Current vs. Cathode Voltage

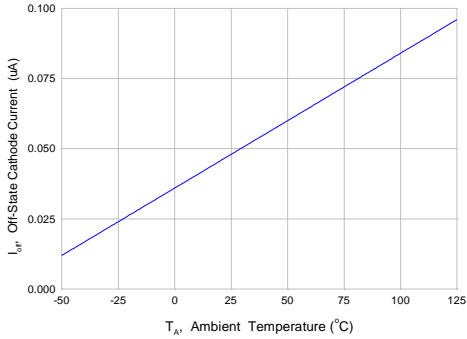


Figure 6. OFF-State Cathode Current vs. Ambient Temperature

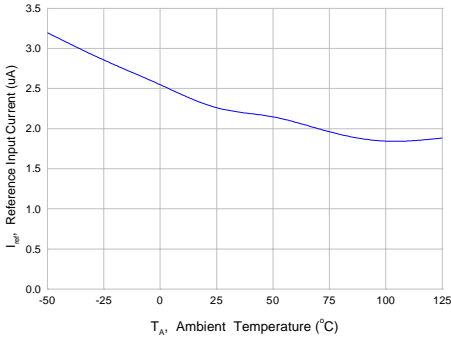


Figure 7. Reference Input Current vs. Ambient Temperature

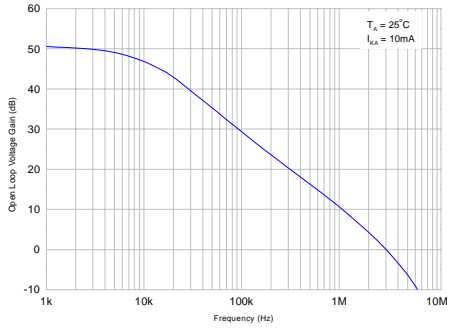


Figure 8. Small Signal Voltage Amplification vs. Frequency

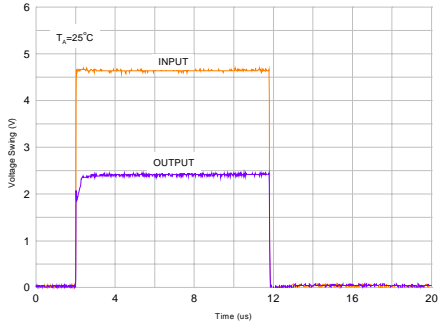


Figure 9. Pulse Response

## Typical Performance Characteristics (Continued)

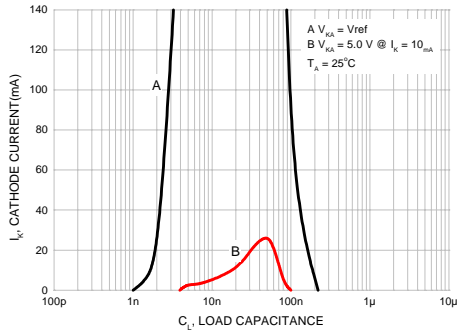


Figure 10. Stability Boundary Conditions

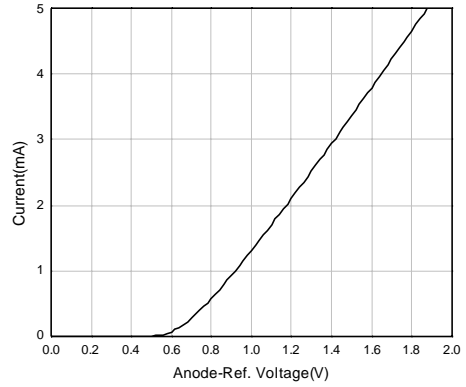


Figure 11. Anode-Reference Diode Curve

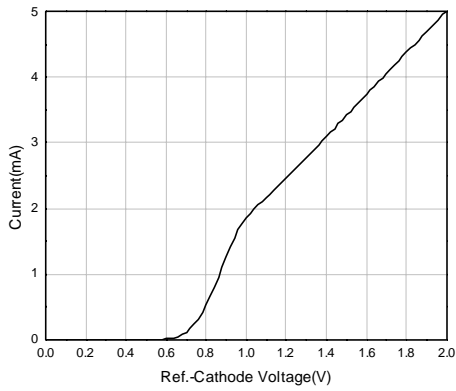


Figure 12. Reference-Cathode Diode Curve

Typical Application

$$V_O = \left(1 + \frac{R_1}{R_2}\right)V_{ref}$$

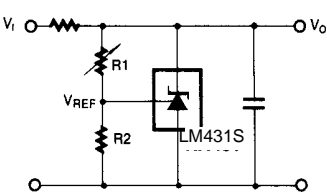


Figure 13. Shunt Regulator

$$V_O = V_{ref} \left(1 + \frac{R_1}{R_2}\right)$$

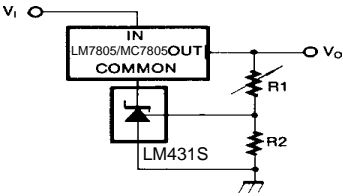


Figure 14. Output Control for Three-Termianl Fixed Regulator

$$V_O = \left(1 + \frac{R_1}{R_2}\right)V_{ref}$$

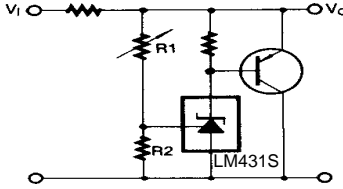


Figure 15. High Current Shunt Regulator

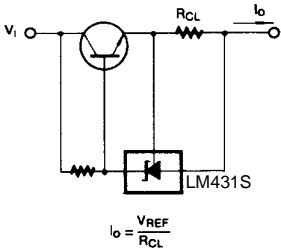


Figure 16. Current Limit or Current Source

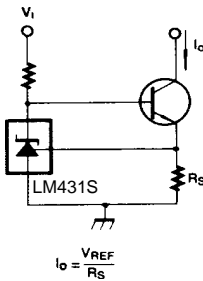


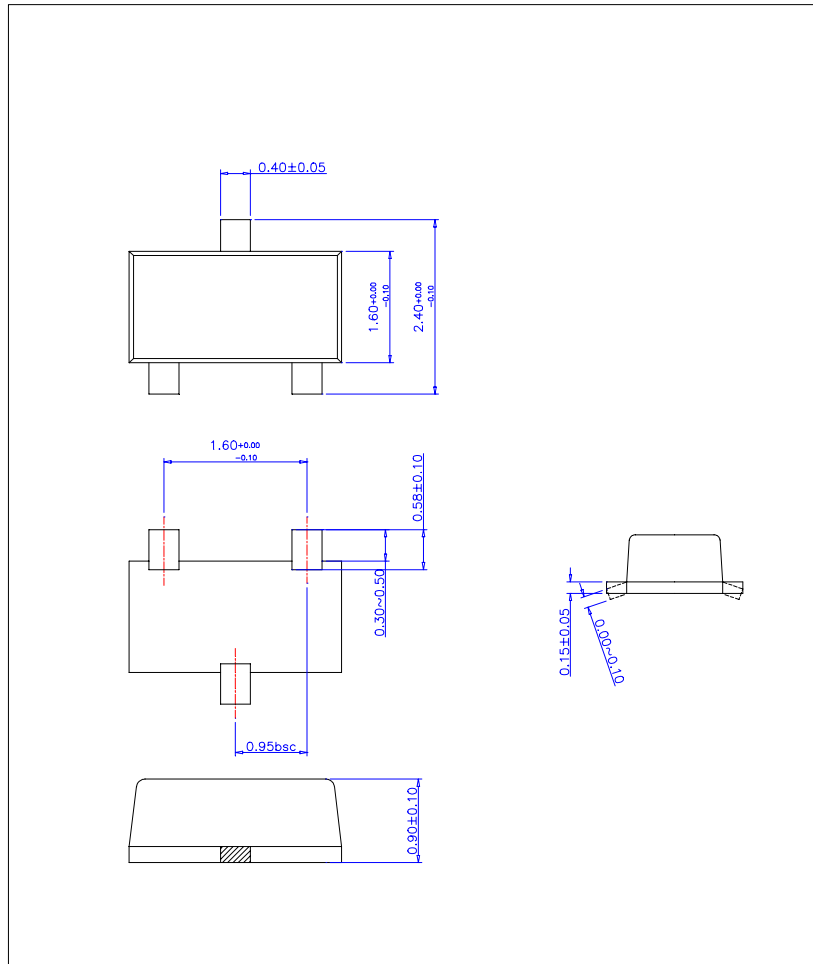
Figure 17. Constant-Current Sink

## Mechanical Dimensions

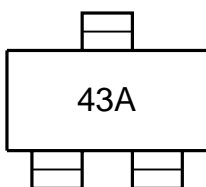
Package

Dimensions in millimeters

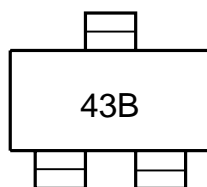
### SOT-23F



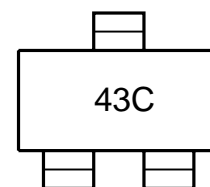
## Marking



2% tolerance



1% tolerance



0.5% tolerance

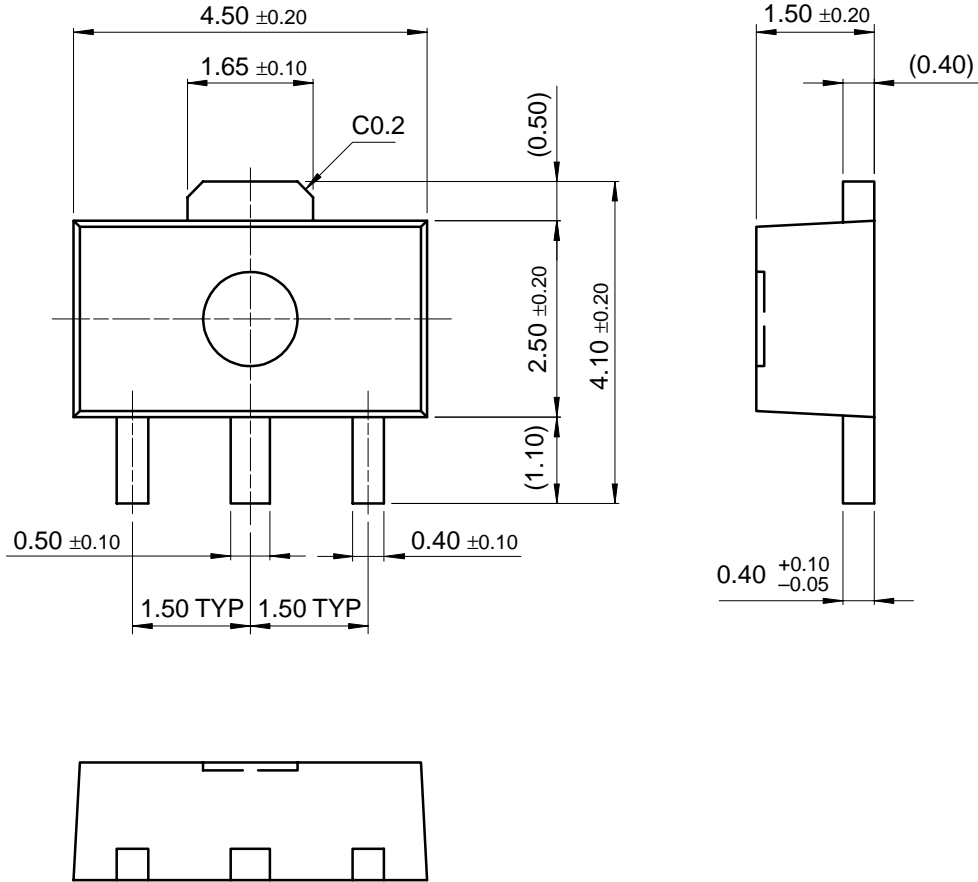


**Mechanical Dimensions** (Continued)

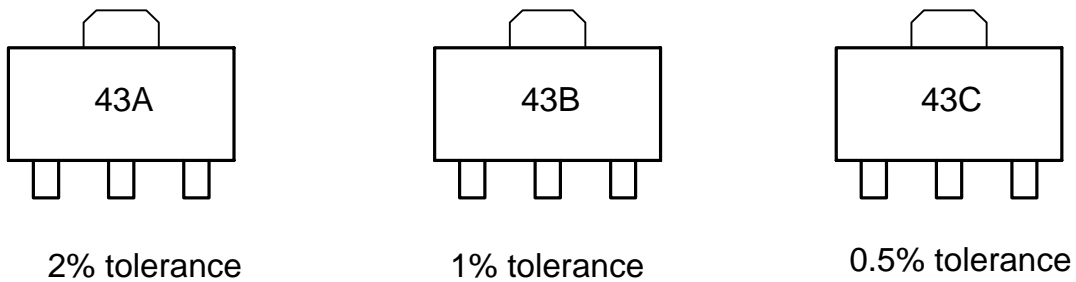
**Package**

Dimensions in millimeters

**SOT-89**



**Marking**



## Ordering Information

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM431SCCML	0.5%	SOT-89	-25 ~ +85°C
LM431SCCMF		SOT-23F	
LM431SBCML	1%	SOT-89	
LM431SBCMF		SOT-23F	
LM431SACML	2%	SOT-89	
LM431SACMF		SOT-23F	

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