LM431SAI

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 LM431SAI is three terminal output adjustable regulator with thermal stability over operating temperature range from -40°C to +85°C. The output voltage can be set any value between V_{REF} (approximately 2.5 volts) and 36 volts with two external resistors. This device has a typical dynamic output impedance of 0.2Ω Active output circuit provides a sharp turn-on characteristic, making this device excellent replacement for Zener Diodes in many applications.

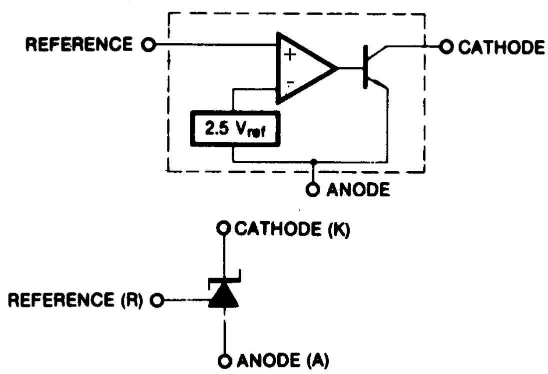
SOT-23F

3

1 2

1. Cathode 2. Ref 3. Anode

Internal Block Diagram



Rev. 1.0.0

Absolute Maximum Ratings

(Operating temperature range applies unless otherwise specified.)

Parameter	Symbol	Value	Unit
Cathode Voltage	V_{KA}	37	V
Cathode current Range (Continuous)	I_{KA}	-100 ~ +150	mA
Reference Input Current Range	I_{REF}	-0.05 ~ +10	mA
Thermal Resistance Junction-Air (Note1,2) MF Suffix Package	$R_{\theta JA}$	350	°C/W
Power Dissipation (Note3,4) MF Suffix Package	P_D	350	mW
Junction Temperature	T_J	150	°C
Operating Temperature Range	T_{OPR}	-40 ~ +85	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Note:

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

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Cathode Voltage	V_{KA}	V_{REF}	-	36	V
Cathode Current	I_{KA}	1.0	-	100	mA

Electrical Characteristics

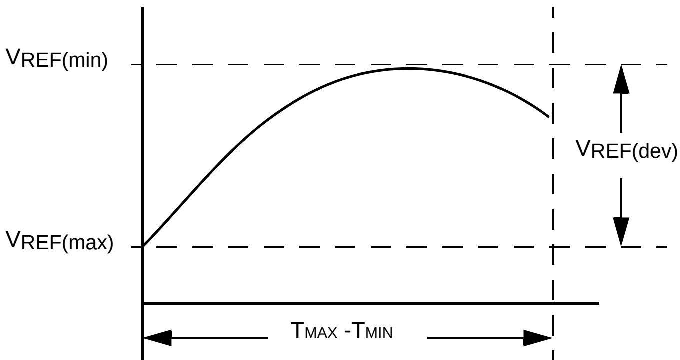
(T_A = +25°C, unless otherwise specified)

Parameter	Symbol	Conditions		LM431SAI Min.	LM431SAI Typ.	LM431SAI Max.	Unit
Reference Input Voltage	V_{REF}	$V_{KA}=V_{REF}$, I_{KA}=10mA		2.450	2.500	2.550	V
Deviation of Reference Input Voltage Over-Temperature	$V_{REF(dev)}$	$V_{KA}=V_{REF}$, I_{KA}=10mA $T_{MIN} \le T_A \le T_{MAX}$		-	5	20	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	I_{KA} =10mA	ΔV_{KA}=10V-V_{REF}	-	-1.0	-2.7	mV/V
			ΔV_{KA}=36V-10V	-	-0.5	-2.0	
Reference Input Current	I_{REF}	I_{KA}=10mA, R_1=10KΩ,R_2=∞		-	1.5	4	μA
Deviation of Reference Input Current Over Full Temperature Range	$I_{REF(dev)}$	I_{KA}=10mA, R_1=10KΩ,R_2=∞ $T_{MIN} \le T_A \le T_{MAX}$		-	0.8	2	μA
Minimum Cathode Current for Regulation	$I_{KA(MIN)}$	$V_{KA}=V_{REF}$		-	0.45	1.0	mA
Off -Stage Cathode Current	$I_{KA(OFF)}$	V_{KA}=36V, V_{REF}=0		-	0.05	1.0	μA
Dynamic Impedance	Z_{KA}	$V_{KA}=V_{REF}$, I_{KA}=1 to 100mA ,f ≥1.0kHz		-	0.15	0.5	Ω

Note:

1. T_{MIN} = -40°C, T_{MAX} = +85°C
2. The deviation parameters $V_{REF(dev)}$ and $I_{REF(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage, αV_{REF}, is defined as:

$$\left|\alpha V_{REF}\right|\left(\frac{ppm}{°C}\right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF}(at25°C)}\right) \cdot 10^6}{T_{MAX} - T_{MIN}}$$



where T_{MAX} -T_{MIN} is the rated operating free-air temperature range of the device.
αV_{REF} can be positive or negative depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

Example: $V_{REF(dev)}$ = 4.5mV, V_{REF} = 2500 mV at 25 °C, T_{MAX} -T_{MIN} = 125 °C for LM431SAI.

$$\left|\alpha V_{REF}\right| = \frac{\left(\frac{4.5mV}{2500mV}\right) \cdot 10^6}{125°C} = 14.4ppm/°C$$

Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

Test Circuits

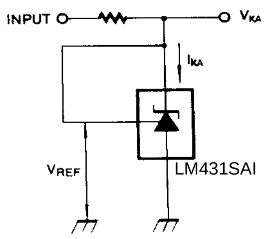


Figure 1. Test Circuit for V_{KA}=V_{REF}

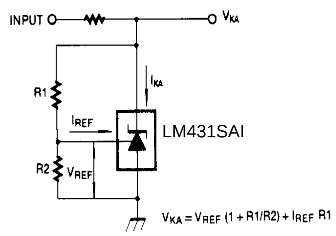


Figure 2. Test Circuit for $V_{KA} \geq V_{REF}$

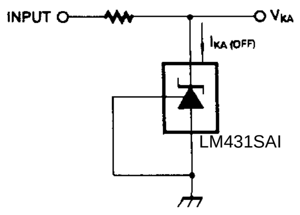


Figure 3. Test Circuit for $I_{KA(OFF)}$

Typical Performance Characteristics

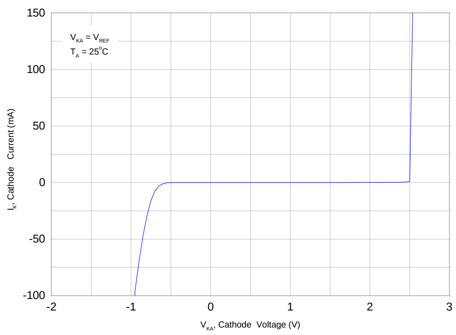


Figure 4. Cathode Current vs. Cathode Voltage

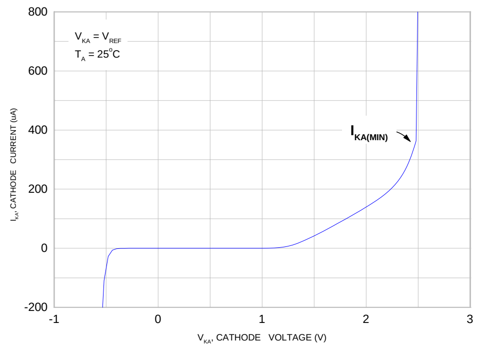


Figure 5. Cathode Current vs. Cathode Voltage

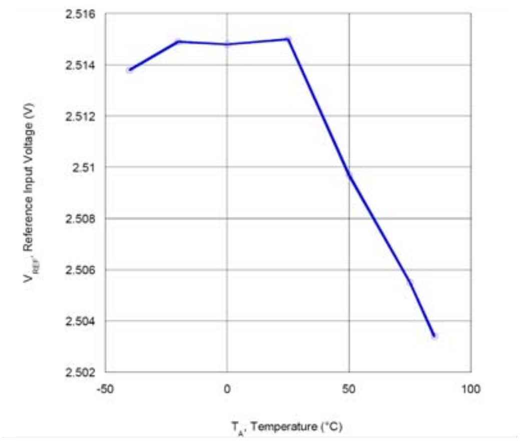


Figure 6. Reference Input Voltage vs. Ambient Temperature

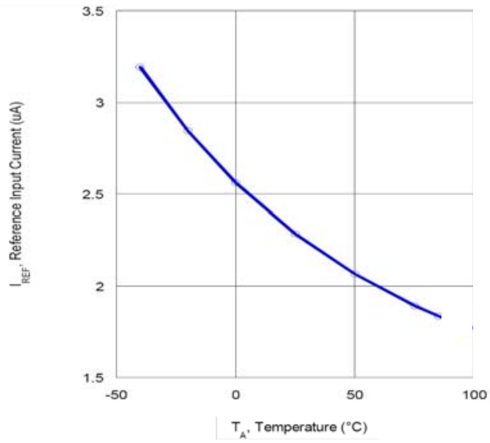


Figure7. Reference Input Current vs. Ambient Temperature

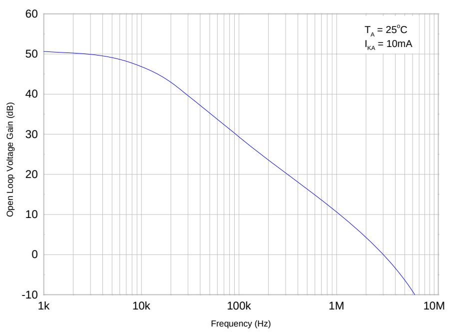


Figure 8. Small Signal Voltage Amplification vs. Frequency

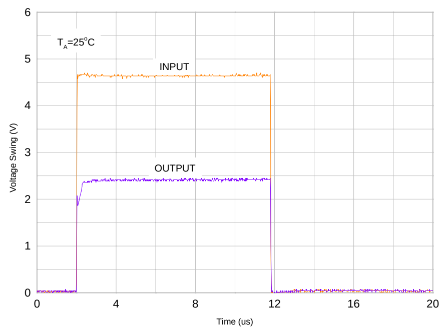


Figure 9. Pulse Response

Typical Performance Characteristics (Continued)

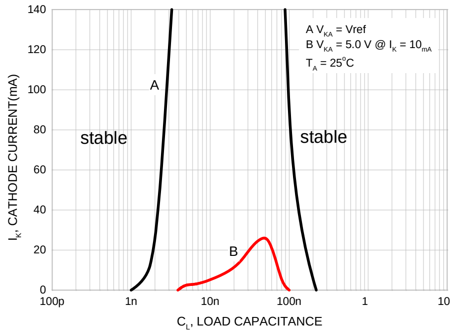


Figure 10. Stability Boundary Conditions

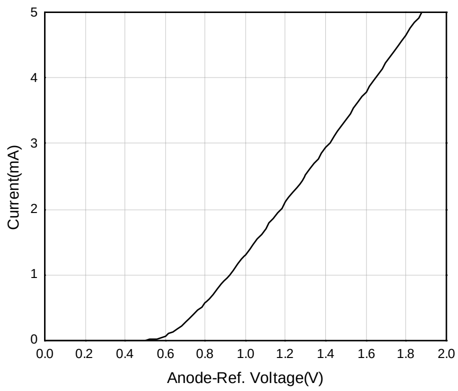


Figure 11. Anode-Reference Diode Curve

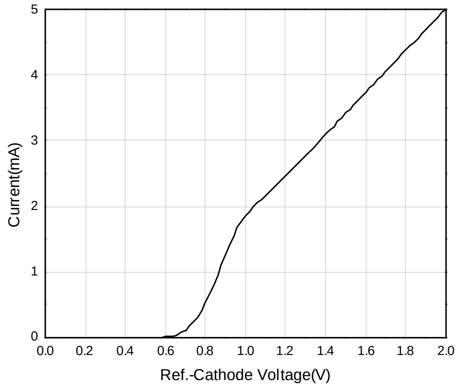


Figure 12. Reference-Cathode Diode Curve

Typical Application

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

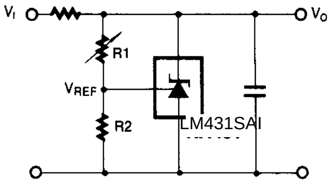


Figure 13. Shunt Regulator

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

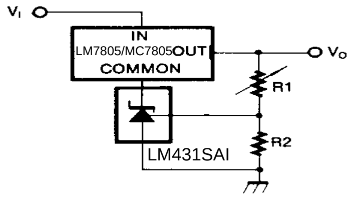


Figure 14. Output Control for Three-Termianl Fixed Regulator

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

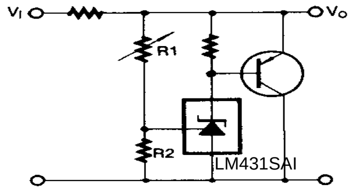


Figure 15. High Current Shunt Regulator

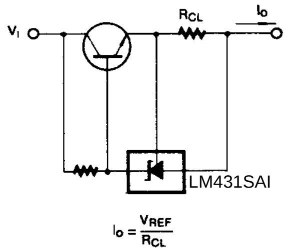


Figure 16. Current Limit or Current Source

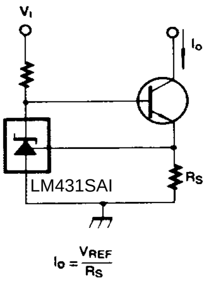


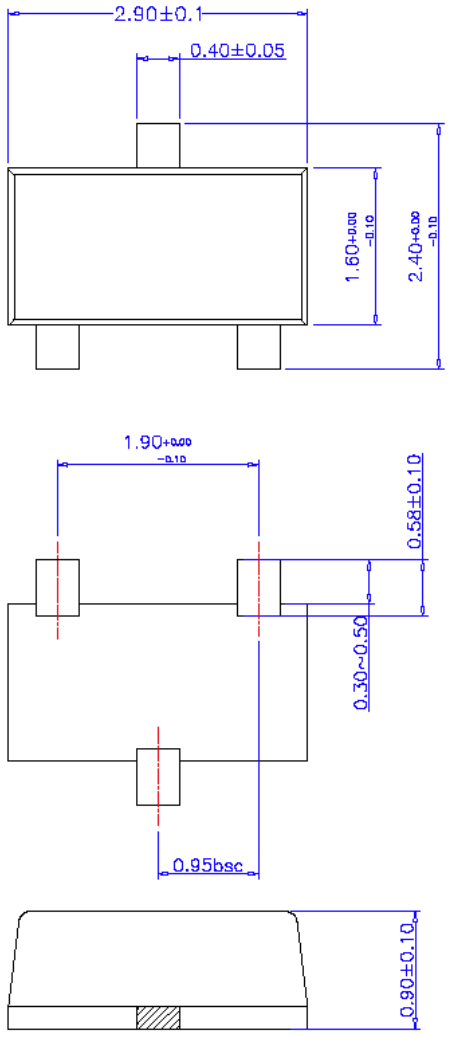
Figure 17. Constant-Current Sink

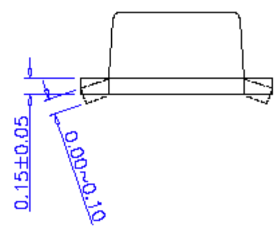
Mechanical Dimensions

Package

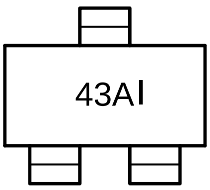
Dimensions in millimeters

SOT-23F





Marking



2% tolerance

Ordering Information

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM431SAIMFX	2%	SOT-23F	-40 ~ +85°C