

## Precision Adjustable Shunt Regulator

### FEATURES

- Trimmed Bandgap to 0.5% and 1.0%
- Wide Operating Current 160 $\mu$ A to 100mA
- Extended Temperature Range: 0°C to 105°C
- Low Temperature Coefficient 30 ppm/°C
- Offered in TO-92, SOIC, SOT-23-3
- Replacement for TL431 and AS2431L
- Low Cost Solution

### APPLICATIONS

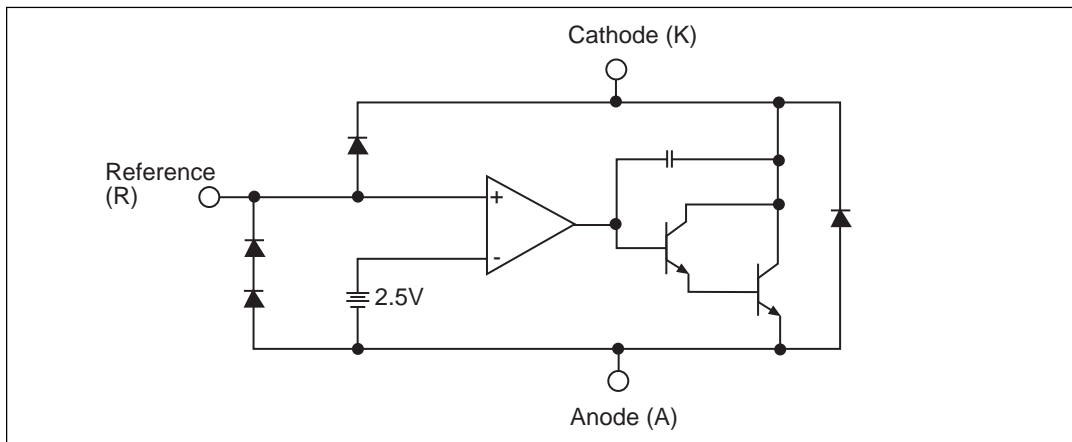
- Battery Operating Equipment
- Adjustable Supplies
- Switching Power Supplies
- Error Amplifiers
- Single Supply Amplifier
- Monitors / VCRs / TVs
- Personal Computers

### DESCRIPTION

The SPX2431L is a 3-terminal adjustable shunt voltage regulator providing a highly accurate bandgap reference (0.5%) and extremely low operating current (100 $\mu$ A). The SPX2431L acts as an open-loop error amplifier with a 2.5V temperature compensated reference. The SPX2431L's thermal stability, wide operating current (100mA) and temperature range (0°C to 150°C) makes it suitable for a variety of applications. SPX2431LA tolerance of 0.5% is proven to be sufficient to overcome all the other errors in the system to virtually eliminate the need for trimming in the power supply manufacturer's assembly lines and contributes a significant cost savings.

In the standard shunt configuration, the combination of a low temperature coefficient, sharp turn on characteristics, low output impedance, and programmable output voltage makes this precision reference an excellent error amplifier. The SPX2431L is available in TO-92, SOIC-8, and SOT-23-3 package.

### BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Cathode-Anode Reverse Breakdown $V_{KA}$	20V
Anode-Cathode Forward Current, (<10ms) $I_{AK}$	1A
Operating Cathode Current $I_{KA}$	100mA
Reference Input Current $I_{REF}$	1.0mA
Continuous Power Dissipation at 25°C $P_D$	
TO-92	775mW
SOT-23	200 mW
SOIC-8	750mW

Junction Temperature $T_J$	150 °C
Storage Temperature $T_{STG}$	-65 to 150 °C
Lead Temperature (Soldering 10 sec.) $T_L$	300°C

**NOTE:** Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## RECOMMENDED CONDITIONS

PARAMETER	SYMBOL	RATING	UNIT
Cathode Voltage	$V_{KA}$	$V_{REF}$ to 20	V
Cathode Current	$I_K$	10	mA

## TYPICAL THERMAL RESISTANCES

PACKAGE	$\theta_{JA}$	$\theta_{JC}$	TYPICAL DERATING
TO-92	160°C/W	80°C/W	6.3 mW/°C
SOT-23	575°C/W	150°C/W	1.7 mW/°C
SOIC-8	175°C/W	45°C/W	5.7 mW/°C

Typical deratings of the thermal resistances are given for ambient temperature >25°.

## ELECTRICAL CHARACTERISTICS

Electrical characteristics at 25°C  $I_K = 10mA$   $V_K = V_{REF}$ , unless otherwise specified.

PARAMETER	SYMBOL	FIGURE	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
				<b>SPX2431LA</b>			<b>SPX2431</b>			
Reference Voltage	$V_{REF}$	2	$T_J = 0^\circ\text{C to } 150^\circ\text{C}$	2.490 2.469	2.503	2.515 2.536	2.470 2.449	2.495	2.520 2.541	V V
$\Delta V_{REF}$ with Temp.*	TC	2			0.07	0.20		0.07	0.20	mV/°C
Ratio of Change in $V_{REF}$ to Cathode Voltage	$\frac{\Delta V_{REF}}{\Delta V_K}$	3	$V_{REF}$ to 10V 10V to 20V	-2.7 -2.0	-1.01 -0.4	0.3	-2.7 -2.0	-1.01 -0.4	0.3	mV/V
Reference Input Current	$I_{REF}$	3			0.7	4.0		0.7	4.0	$\mu\text{A}$
$I_{REF}$ Temp Deviation	$\Delta I_{REF}$	3	$T_J = 0^\circ\text{C to } 105^\circ\text{C}$		0.4	1.2		0.4	1.2	$\mu\text{A}$
Min $I_K$ for Regulation	$I_{K(MIN)}$	2				160			160	$\mu\text{A}$
Off State Leakage	$I_{K(OFF)}$	4	$V_{REF} = 0V,$ $V_{KA} = 20V$		0.04	500		0.04	500	nA
Dynamic Output Impedance	$Z_{KA}$	2	$f_z \leq 1\text{kHz}$ $I_K = 0.16$ to 100mA		0.15	0.5		0.15	0.5	$\Omega$

**Operating Range ( $T_J$ ) = -40°C to 125°C.**

**\* See appropriate test circuit (Figure 2)**

# CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)

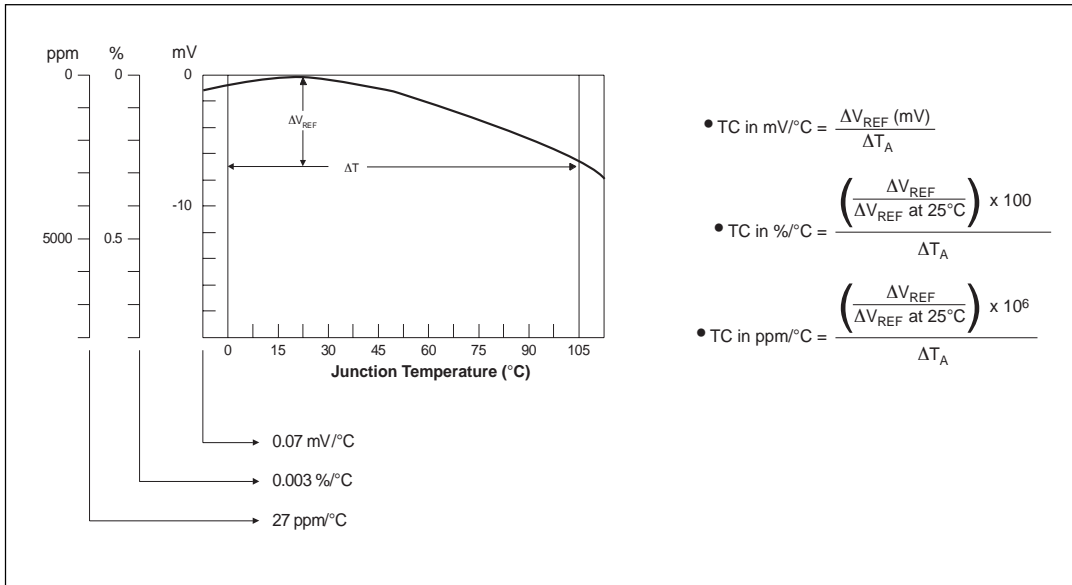


Figure 1.  $V_{REF}$  VS Temperature.

## TEST CIRCUITS

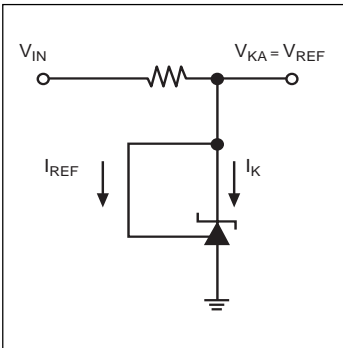


Figure 2. Test Circuit for  $V_{KA} = V_{REF}$

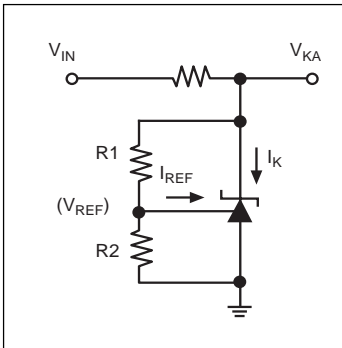


Figure 3. Test Circuit for  $V_{KA} > V_{REF}$

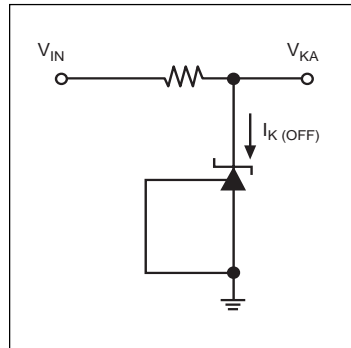


Figure 4. Test Circuit for  $I_{KOFF}$

# TYPICAL PERFORMANCE CHARACTERISTICS

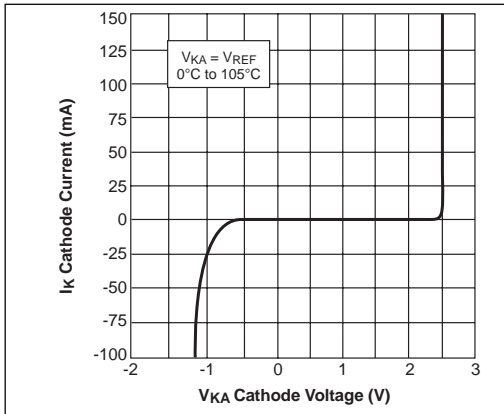


Figure 5. High Current Operating Characteristics

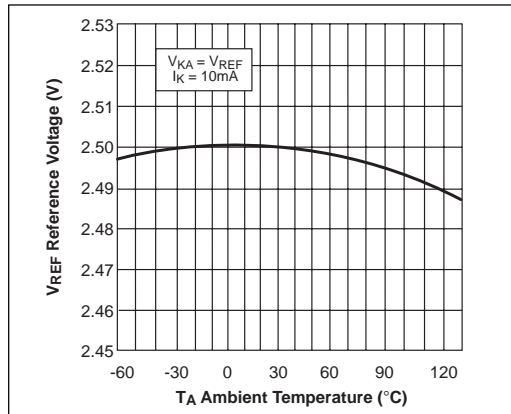


Figure 6. Reference Voltage VS Ambient Temperature

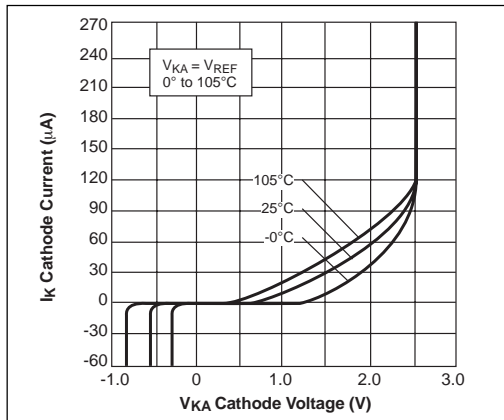


Figure 7. Low Current Operating Characteristics

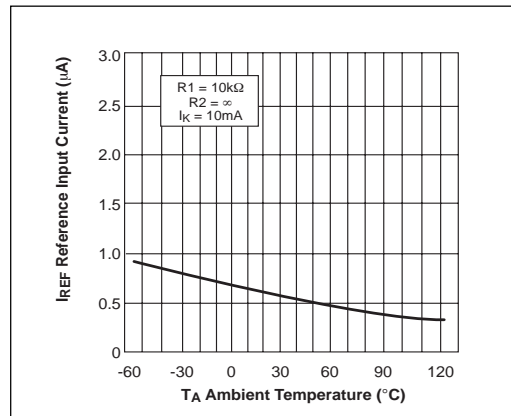


Figure 8. Reference Input Current VS Ambient Temperature

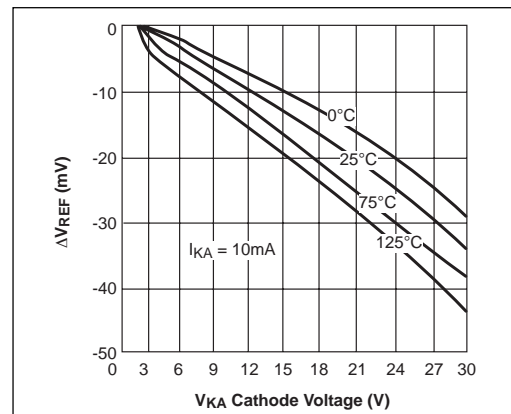


Figure 9. Reference Voltage Line Regulation VS Cathode Voltage and  $T_{AMBIENT}$

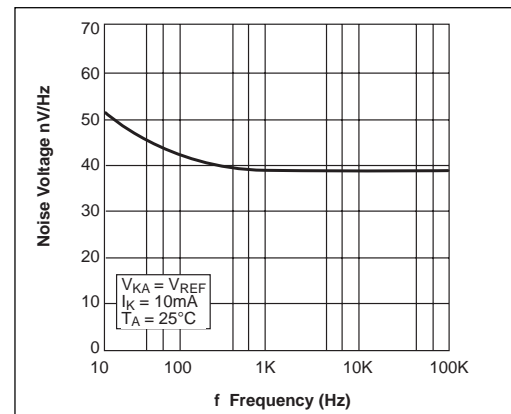


Figure 10. Noise Voltage VS Frequency

# TYPICAL PERFORMANCE CHARACTERISTICS (continued)

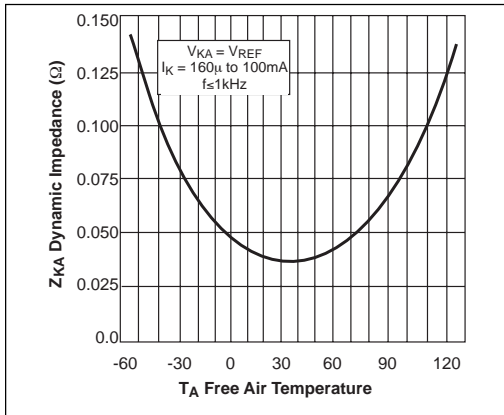


Figure 11. Low Frequency Dynamic Output Impedance VS  $T_{AMBIENT}$

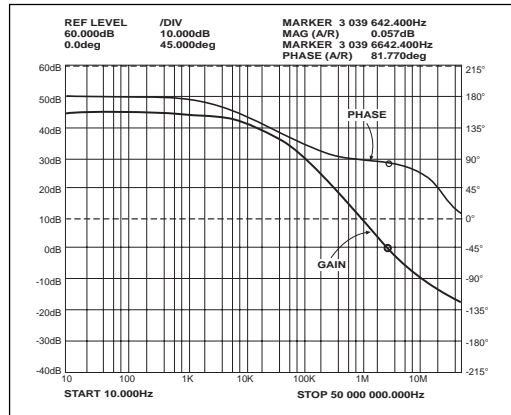


Figure 12. Small Signal Gain and Phase VS Frequency;  $I_K = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

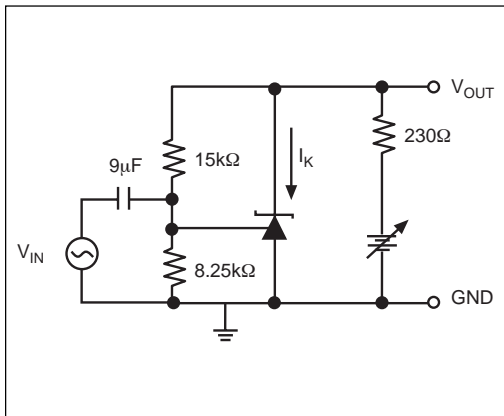


Figure 13. Test Circuit for Gain and Phase Frequency Response

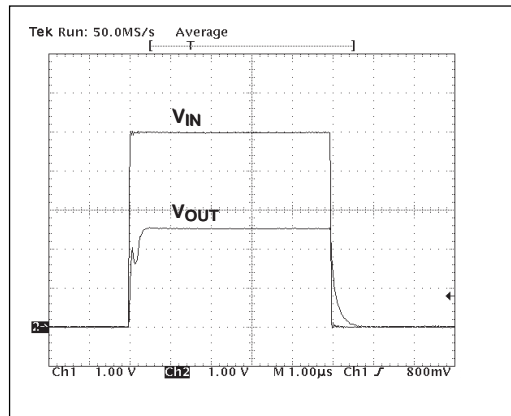


Figure 14. Frequency = 100kHz,  $I_K = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

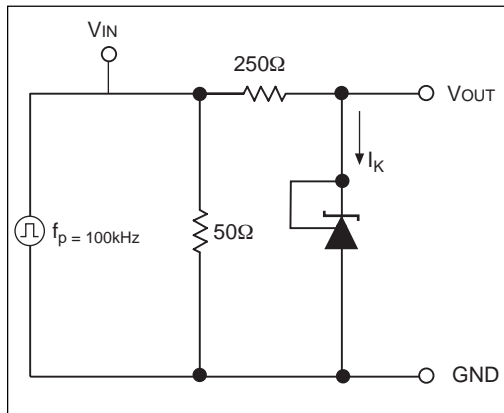


Figure 15. Test Circuit for Pulse Response

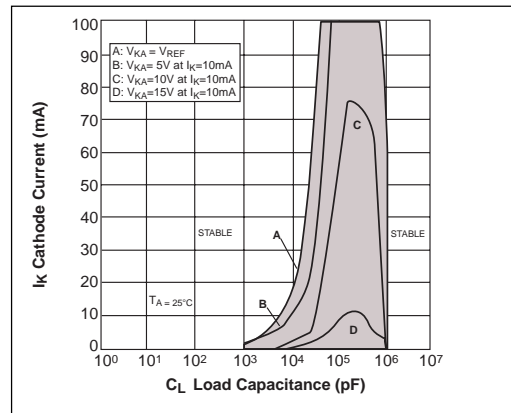


Figure 16. Stability Boundary Conditions

# TYPICAL PERFORMANCE CHARACTERISTICS (continued)

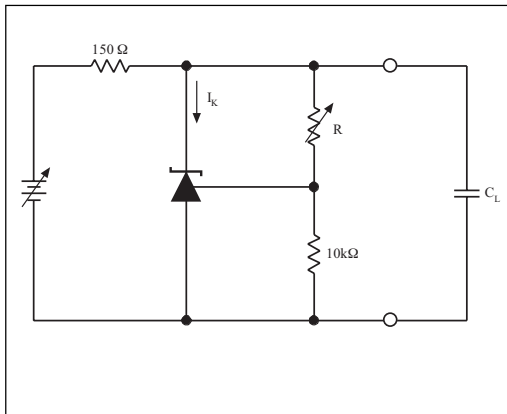


Figure 17. Test Circuit for Stability

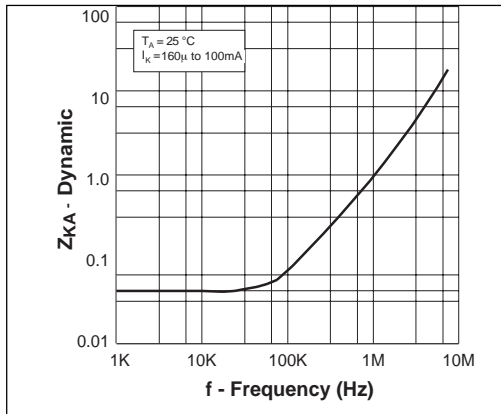


Figure 18. Dynamic Output Impedance T<sub>A</sub> = 25 °C, I<sub>k</sub> = 160 μA to 100mA

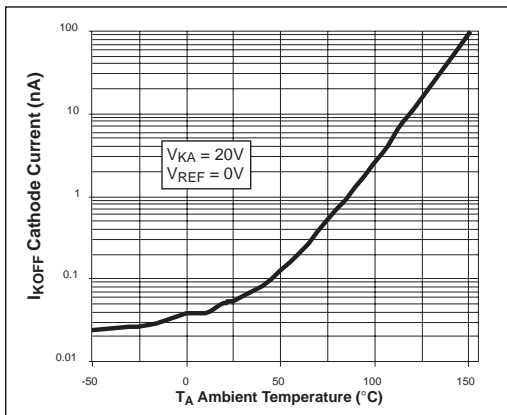


Figure 19. Off State Leakage

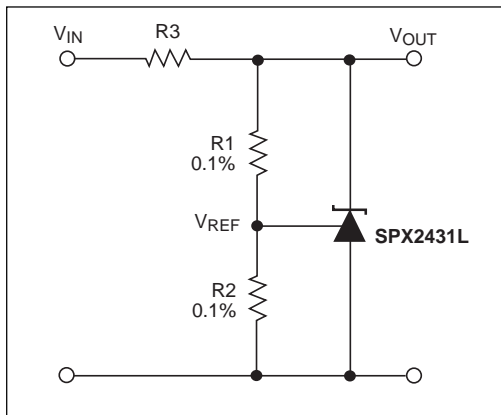


Figure 20. Shunt Regulator V<sub>OUT</sub> = (1+R<sub>1</sub>/R<sub>2</sub>)V<sub>REF</sub>

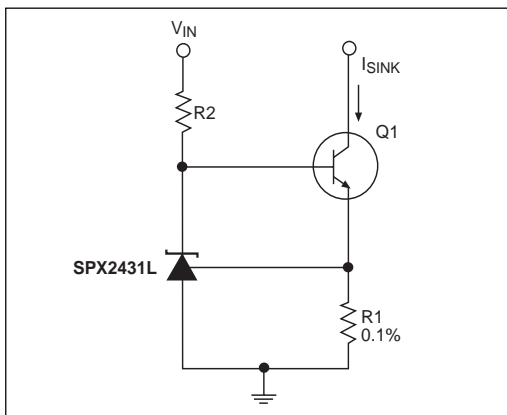


Figure 21. Constant Current Sink, I<sub>SINK</sub> = V<sub>REF</sub>/R<sub>1</sub>

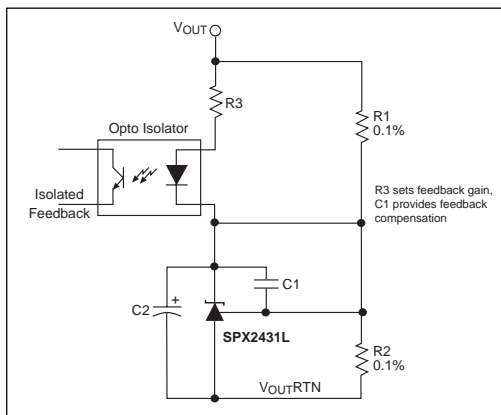
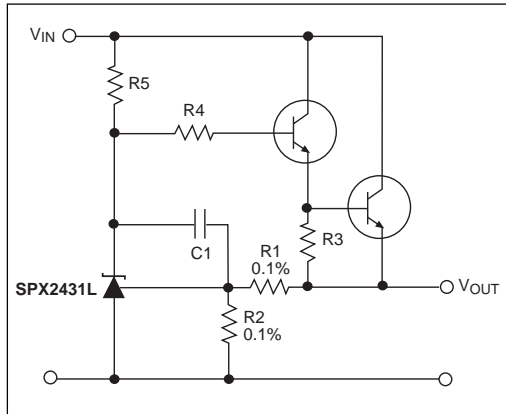
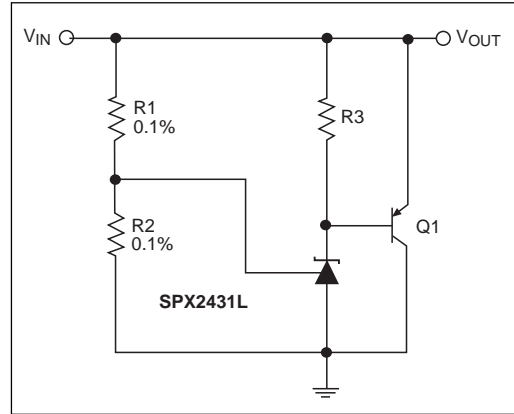


Figure 22. Reference Amplifier for Isolated Feedback in Off-Line DC-DC Converters

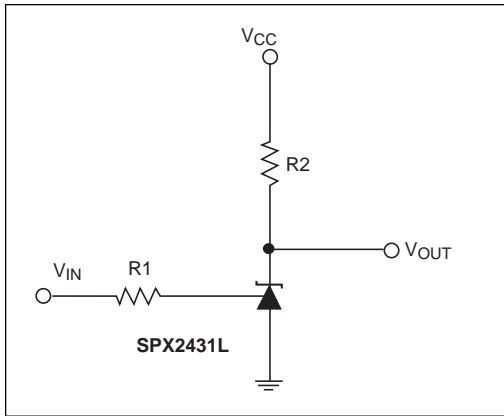
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)



**Figure 23. Precision High Current Series Regulator**  
 $V_{OUT} = (1+R1/R2)V_{REF}$



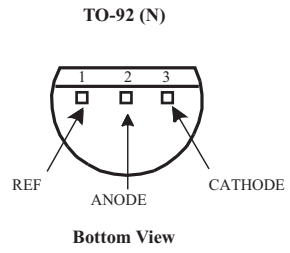
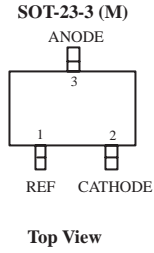
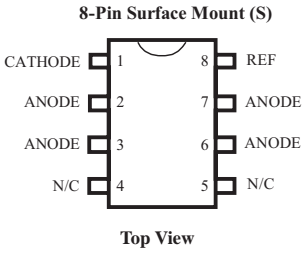
**Figure 24. High Current Shunt Regulator**  
 $V_{OUT} = (1+R1/R2)V_{REF}$



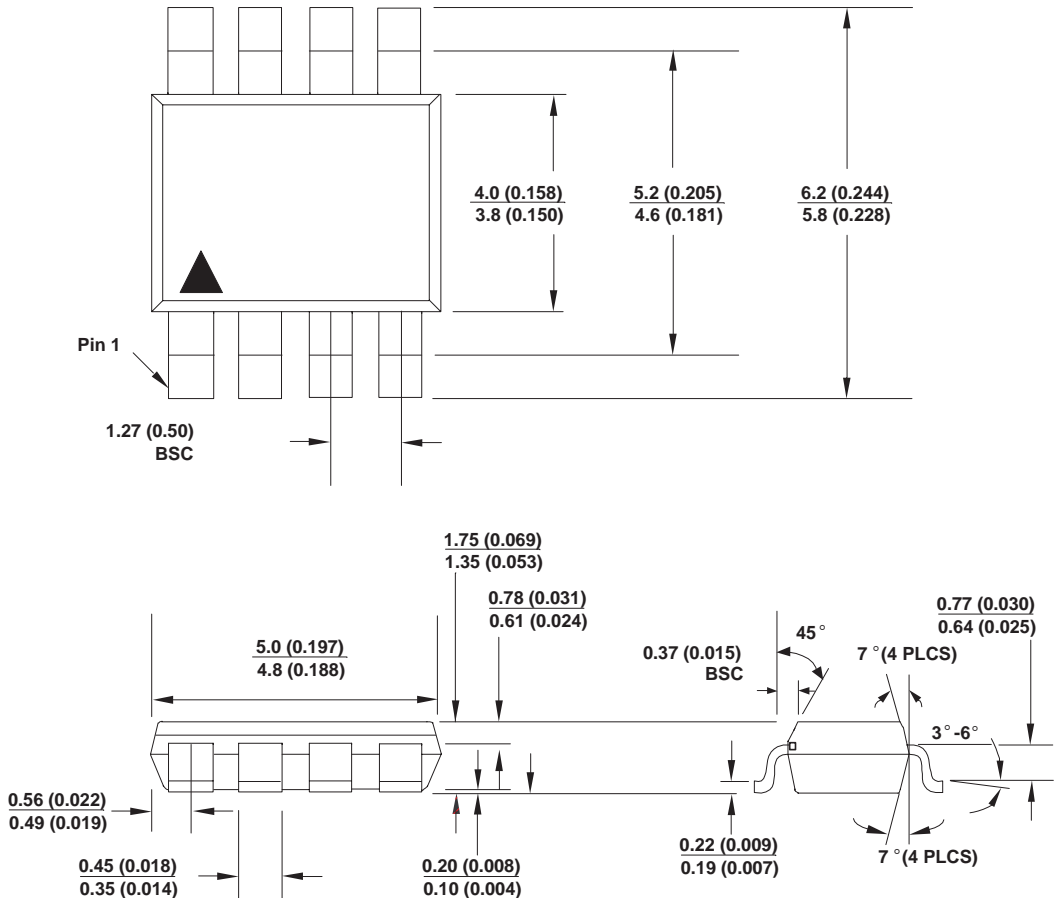
**Figure 25. Single Supply Comparator with Temperature Compensated Threshold.  $V_{IN}$  threshold = 2.5V**

*\* Resistor values are chosen such that the effect to  $I_{REF}$  is negligible.*

# PACKAGES

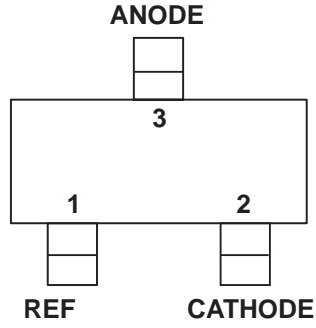


## PACKAGE: 8 PIN PLASTIC SMALL OUTLINE (SOIC) (NARROW)

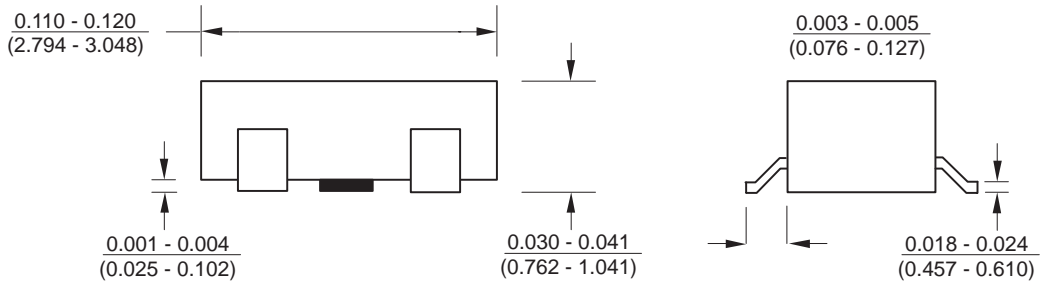
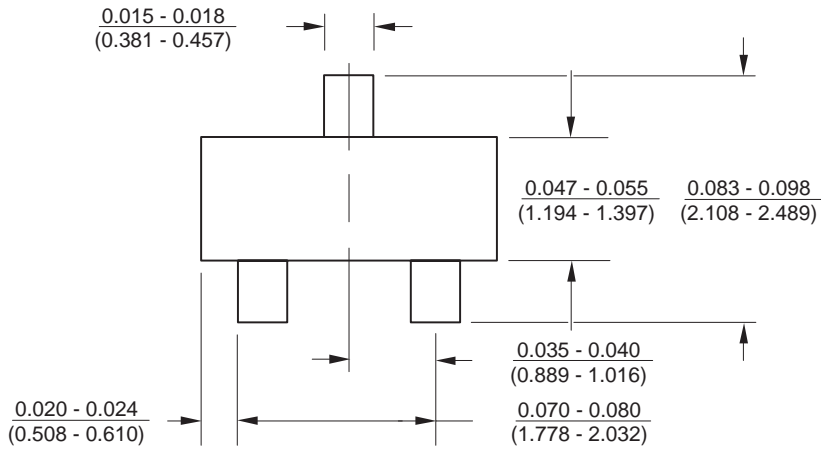




**PACKAGE: SOT23-3 (M)**



**Top View**





## ORDERING INFORMATION

<b>PART NUMBER</b>	<b>ACC</b>	<b>OUTPUT VOLTAGE</b>	<b>PACKAGES</b>
SPX2431LAM .....	0.5% .....	2.503V .....	3-Pin SOT-23
SPX2431LAS .....	0.5% .....	2.503V .....	8-Pin SOIC
SPX2431LAN .....	0.5% .....	2.503V .....	3-Pin TO-92
SPX2431LM .....	1.0% .....	2.495V .....	3-Pin SOT-23
SPX2431LS .....	1.0% .....	2.495V .....	8-Pin SOIC
SPX2431LN .....	1.0% .....	2.495V .....	3-Pin TO-92



SIGNAL PROCESSING EXCELLENCE

### Sipex Corporation

#### Headquarters and Sales Office

22 Linnell Circle  
Billerica, MA 01821  
TEL: (978) 667-8700  
FAX: (978) 670-9001  
e-mail: sales@sipex.com

#### Sales Office

233 South Hillview Drive  
Milpitas, CA 95035  
TEL: (408) 934-7500  
FAX: (408) 935-7600