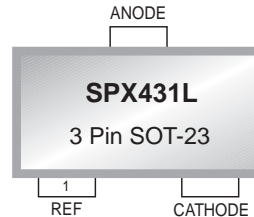


## Precision Adjustable Shunt Regulator

### FEATURES

- Tight Voltage Tolerance 0.5% at 10mA
- Wide Operating Current 1mA to 100mA
- Extended Temperature Range: 0°C to 105°C
- Low Temperature Coefficient 30 ppm/°C
- Improved Replacement in Performance for TL431 and AS431
- Low Cost Solution



*Now Available in Lead Free Packaging*

### APPLICATIONS

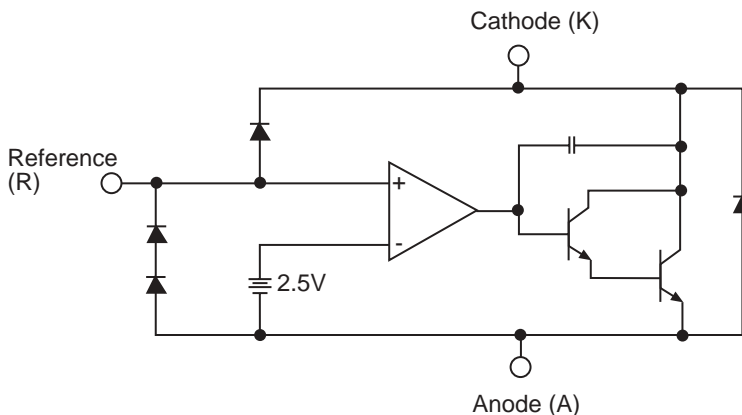
- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>■ Battery Operating Equipment</li> <li>■ Adjustable Supplies</li> <li>■ Switching Power Supplies</li> </ul> | <ul style="list-style-type: none"> <li>■ Error Amplifiers</li> <li>■ Single Supply Amplifier</li> <li>■ Monitors / VCRs / TVs</li> <li>■ Personal Computers</li> </ul> |
|--|--|

### DESCRIPTION

The SPX431L is a 3-terminal adjustable shunt voltage regulator providing a highly accurate bandgap reference. The SPX431L acts as an open-loop error amplifier with a 2.5V temperature compensation reference. The SPX431L's thermal stability, wide operating current (100mA) and temperature range (0°C to 105°C) makes it suitable for a variety of applications that require a low cost, high performance solution. SPX431L tolerance of 0.5% is proven to be sufficient to overcome all of the other errors in the system to virtually eliminate the need for trimming in the power supply manufacturer's assembly line and contribute a significant cost savings.

The output voltage may be adjusted to any value between  $V_{REF}$  and 20V with two external resistors. The SPX431L is available in TO-92, SOIC-8, SOT-89, and SOT-23-3 packages.

### 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 $I_{REF}$ .....	10mA
Continuous Power Dissipation at 25°C $P_D$	
TO-92 .....	775mW
SOT-23 .....	200 mW
SOIC-8 .....	750mW
SOT-89 .....	1000mW

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
SOT-89	110°C/W	8°C/W	9.1 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	UNITS
<b>SPX431LA</b>							
Reference Voltage	$V_{REF}$	2		2.490	2.503	2.515	V
$\Delta V_{REF}$ with Temp.*	TC	2			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	-1.0 -0.4	0.3	mV/V
Reference Input Current	$I_{REF}$	3			0.7	4.0	$\mu A$
$I_{REF}$ Temp Deviation	$\Delta I_{REF}$	3	$T_J = 0^\circ C$ to $105^\circ C$		0.4	1.2	$\mu A$
Min $I_K$ for Regulation	$I_{K(MIN)}$	2			0.4	1.0	mA
Off State Leakage	$I_{K(OFF)}$	4	$V_{REF} = 0V$ , $V_{KA} = 20V$		0.04	1.0	$\mu A$
Dynamic Output Impedance	$Z_{KA}$	2	$f_z \leq 1kHz$ $I_K = 1$ to $100mA$		0.15	0.5	$\Omega$
<b>SPX431L</b>							
Reference Voltage	$V_{REF}$	2		2.470	2.495	2.520	V
$\Delta V_{REF}$ with Temp.*	TC	2			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	-1.0 -0.4	0.3	mV/V
Reference Input Current	$I_{REF}$	3			0.7	4.0	$\mu A$
$I_{REF}$ Temp Deviation	$\Delta I_{REF}$	3	$T_J = 0^\circ C$ to $105^\circ C$		0.4	1.2	$\mu A$
Min $I_K$ for Regulation	$I_{K(MIN)}$	2			0.4	1.0	mA
Off State Leakage	$I_{K(OFF)}$	4	$V_{REF} = 0V$ , $V_{KA} = 20V$		0.04	1.0	$\mu A$
Dynamic Output Impedance	$Z_{KA}$	2	$f_z \leq 1kHz$ $I_K = 1$ to $100mA$		0.15	0.5	$\Omega$

## ELECTRICAL CHARACTERISTICS

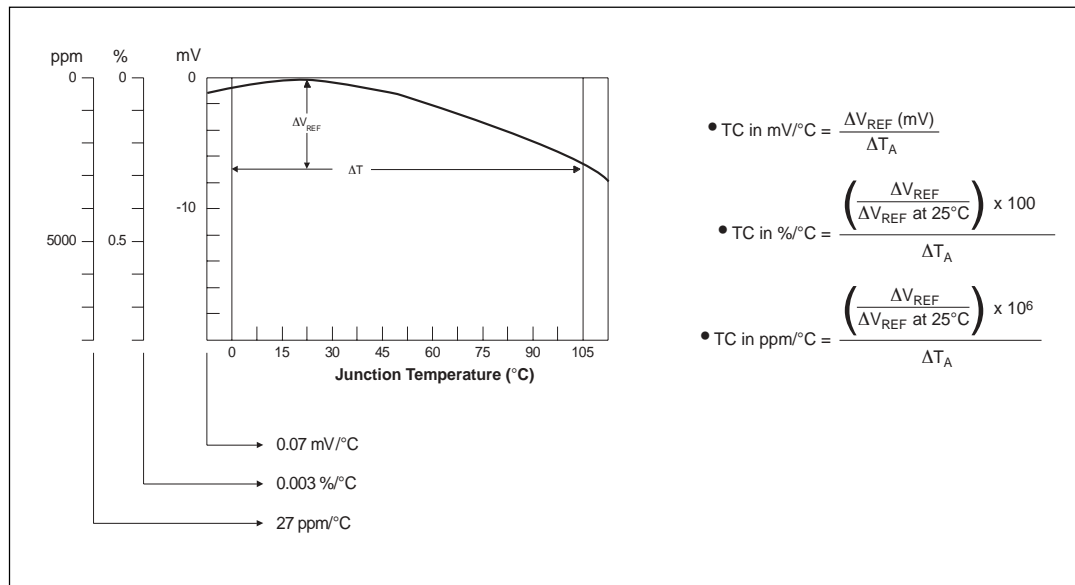
Electrical characteristics at 25°C  $I_K = 10\text{mA}$   $V_K = V_{REF}$ , unless otherwise specified.

PARAMETER	SYMBOL	FIGURE	CONDITIONS	MIN	TYP	MAX	UNITS
<b>SPX431LC</b>							
Reference Voltage	$V_{REF}$	2		2.445	2.495	2.545	V
$\Delta V_{REF}$ with Temp.*	TC	2			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	-1.0 -0.4	0.3	mV/V
Reference Input Current	$I_{REF}$	3			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	$\mu\text{A}$
Min $I_K$ for Regulation	$I_{K(MIN)}$	2			0.4	1.0	mA
Off State Leakage	$I_{K(OFF)}$	4	$V_{REF} = 0\text{V}$ , $V_{KA} = 16\text{V}$		0.04	1.0	$\mu\text{A}$
Dynamic Output Impedance	$Z_{KA}$	2	$f_z \leq 1\text{kHz}$ $I_K = 1$ to $100\text{mA}$		0.15	0.5	$\Omega$

**Operating Range ( $T_J$ ) = 0°C to 105°C.**

\* See appropriate test circuit (Figure 2)

## CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)



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

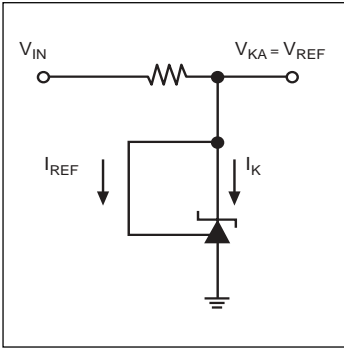


Figure 2. Test Circuit for  $V_{KA} = V_{REF}$

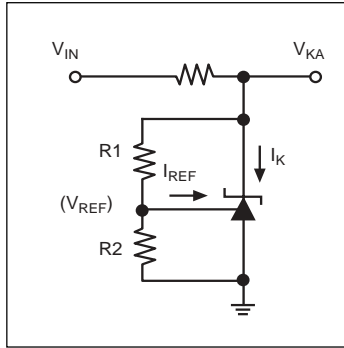


Figure 3. Test Circuit for  $V_{KA} > V_{REF}$

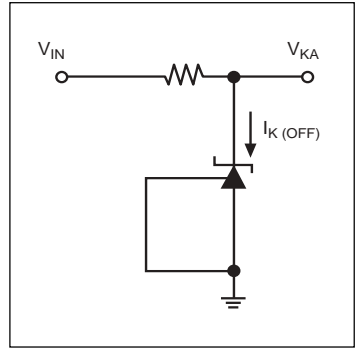


Figure 4. Test Circuit for  $I_{KOFF}$

TYPICAL PERFORMANCE CHARACTERISTICS

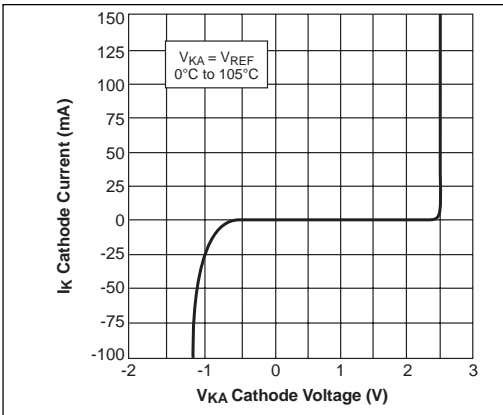


Figure 5. High Current Operating Characteristics

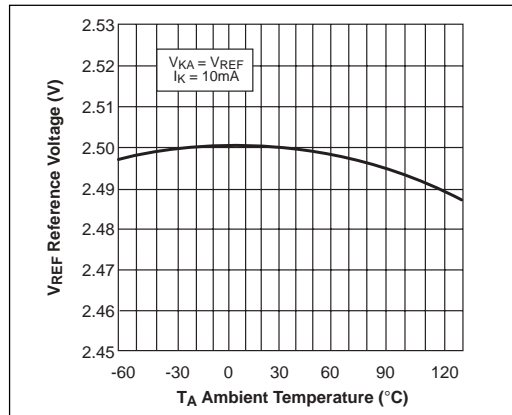


Figure 6. Reference Voltage VS Ambient Temperature

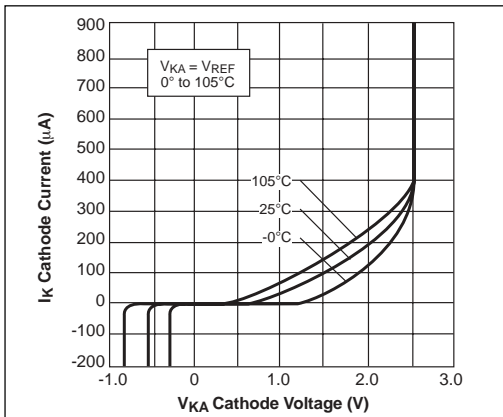


Figure 7. Low Current Operating Characteristics.

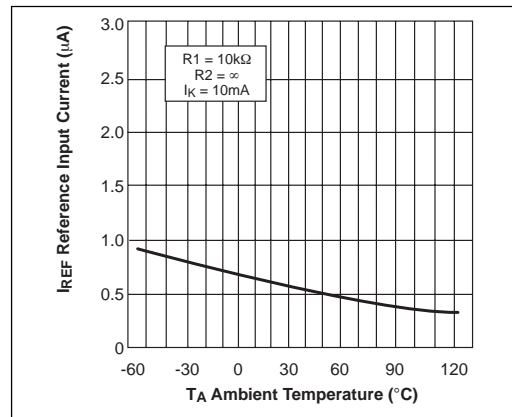


Figure 8. Reference Input Current VS Ambient Temperature.

# TYPICAL PERFORMANCE CHARACTERISTICS

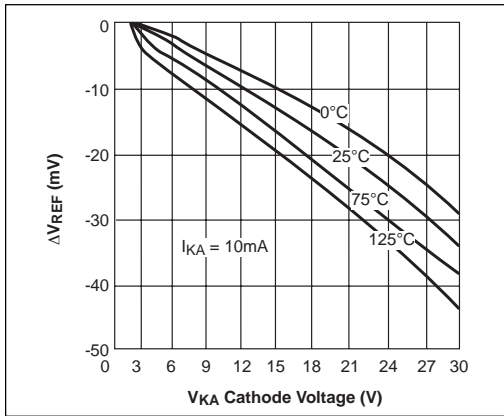


Figure 9. Reference Voltage Line Regulation VS Cathode Voltage and  $T_{AMBIENT}$

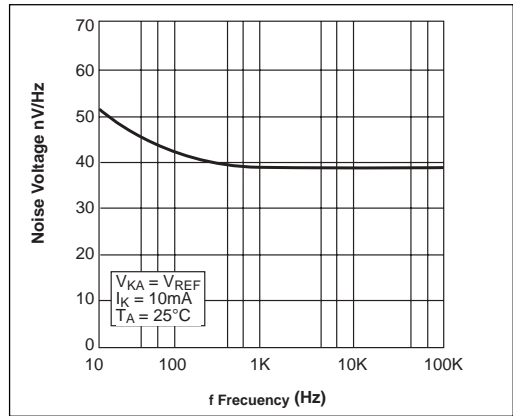


Figure 10. Noise Voltage VS Frequency

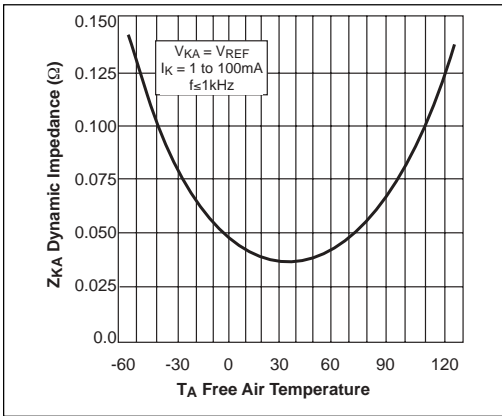


Figure 11. Low Frequency Dynamic Output Impedance VS  $T_{AMBIENT}$

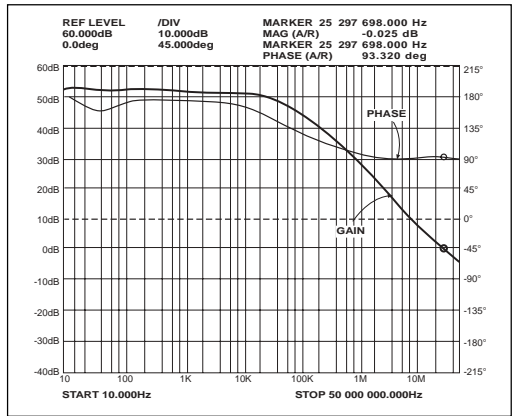


Figure 12. Small Signal Gain and Phase VS Frequency;  $I_K = 10mA$ ,  $T_A = 25^\circ C$

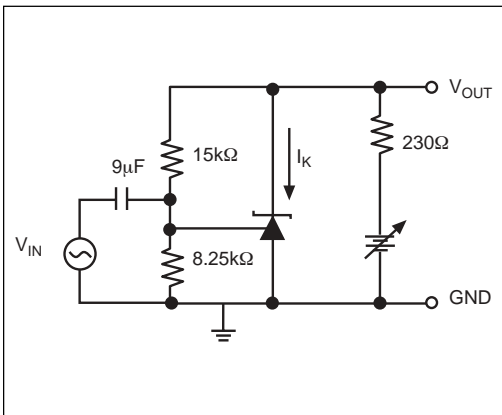


Figure 13. Test Circuit for Gain and Phase Frequency Response

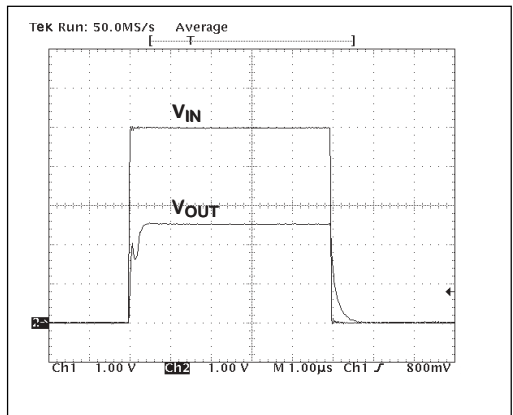


Figure 14.  $F_z = 100kHz$ ,  $I_K = 10mA$ ,  $T_A = 25^\circ C$

# TYPICAL PERFORMANCE CHARACTERISTICS

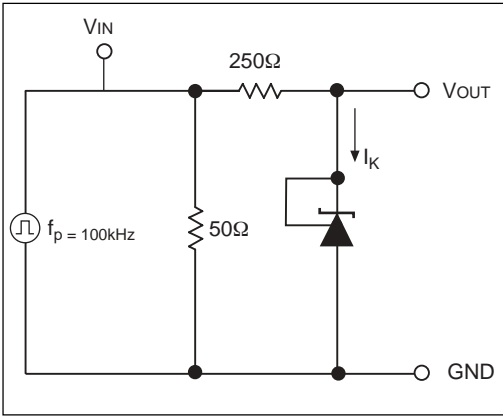


Figure 15. Test Circuit for Pulse Response

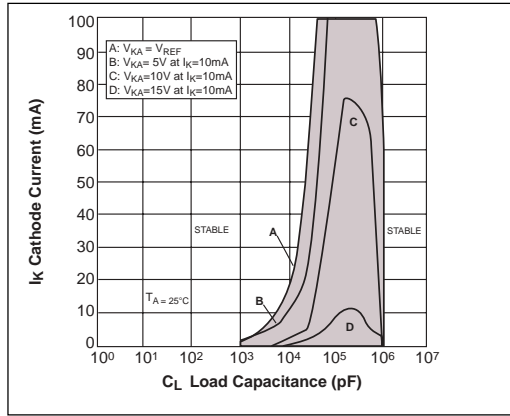


Figure 16. Stability Boundry Conditions

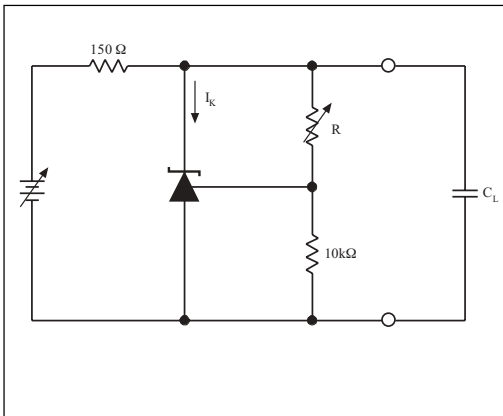


Figure 17. Test Circuit for Stability

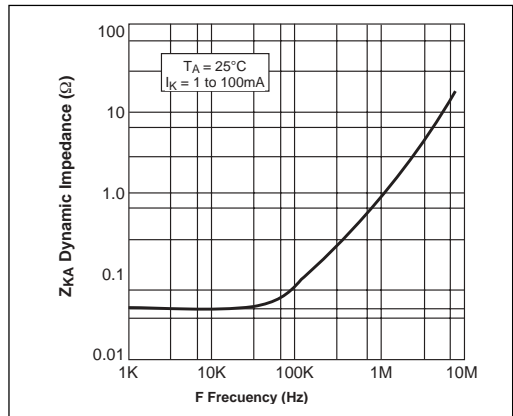


Figure 18. Dynamic Output Impedance  $T_A = 25^\circ C$ ,  $I_K = 1$  to  $100mA$

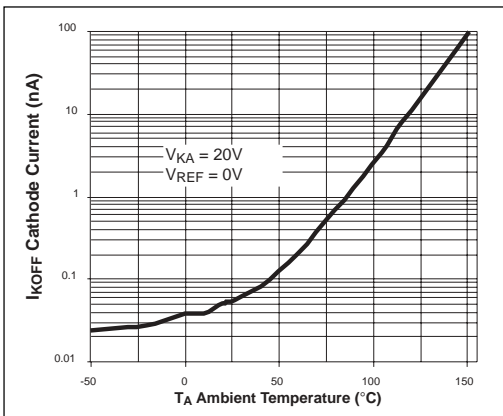


Figure 19. Off State Leakage

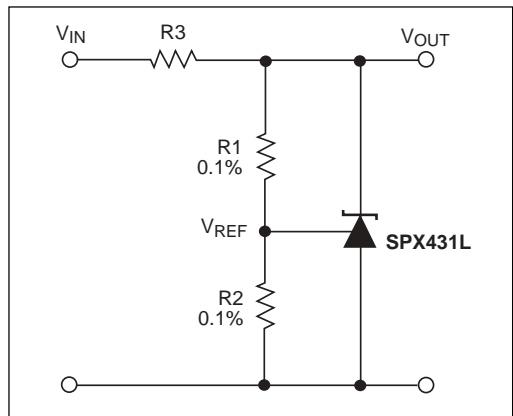


Figure 20. Shunt Regulator  $V_{OUT} = (1 + R1/R2)V_{REF}$

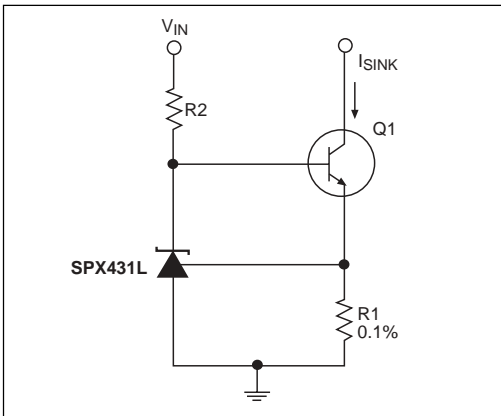


Figure 21. Constant Current Sink,  $I_{SINK} = V_{REF}/R1$

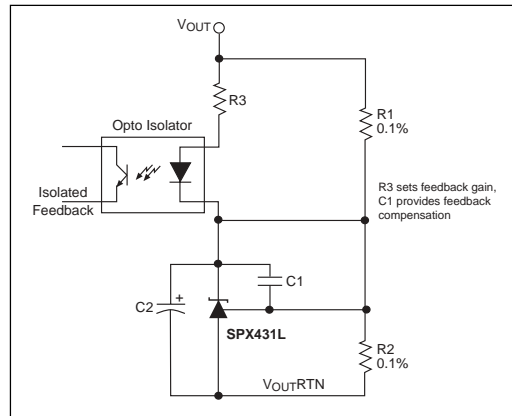


Figure 22. Reference Amplifier for Isolated Feedback in Off-Line DC-DC Converters

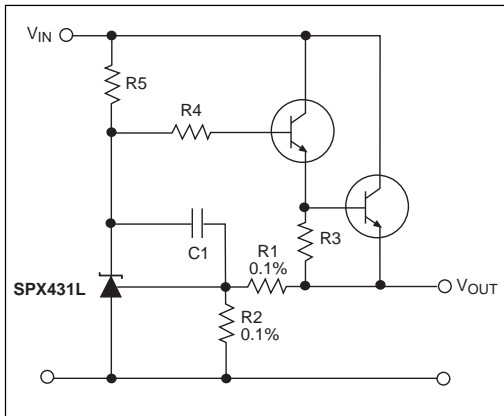


Figure 23. Precision High Current Series Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

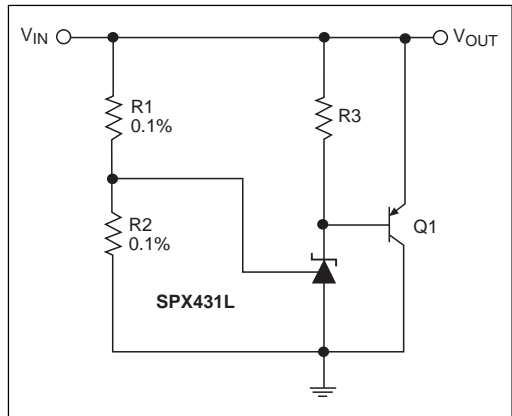


Figure 24. High Current Shunt regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

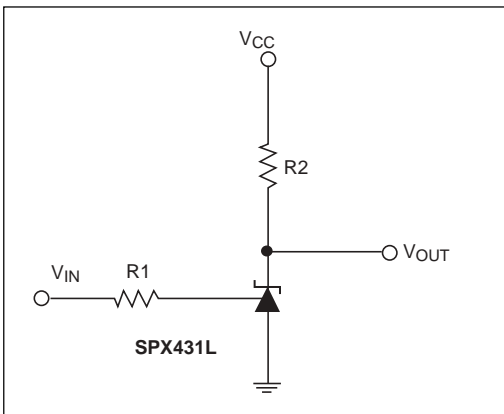
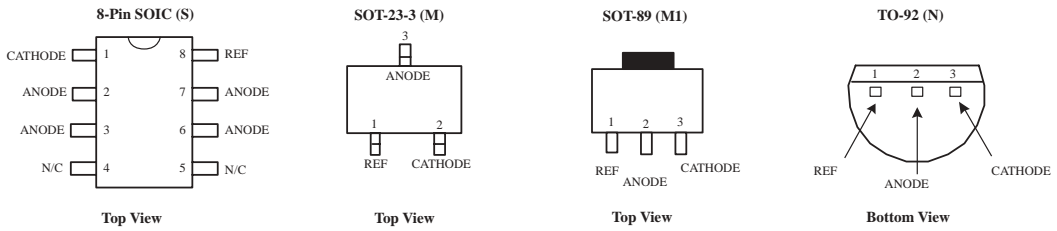
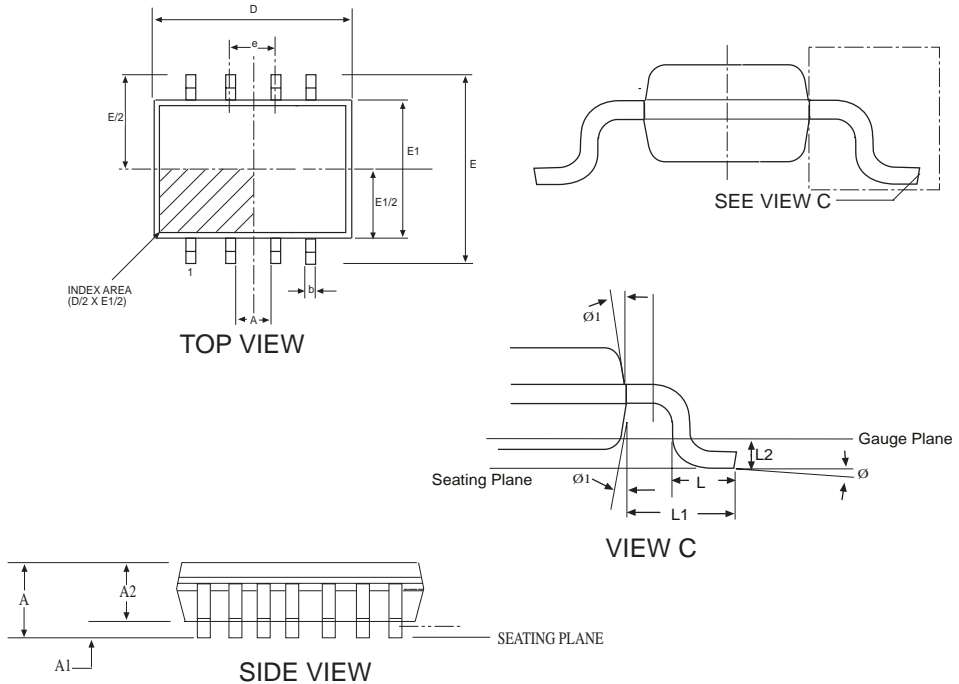


Figure 25. Single Supply Comparator with Temperature Compensated Threshold.  $V_{IN}$  threshold = 2.5V.

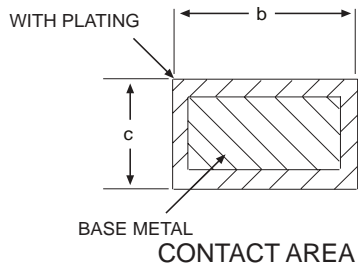
\* Resistor values are chosen such that the effect to  $I_{REF}$  is negligible.



**PACKAGE: 8 PIN NSOIC**

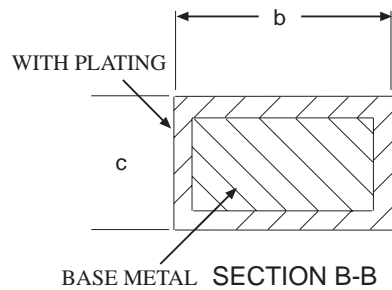
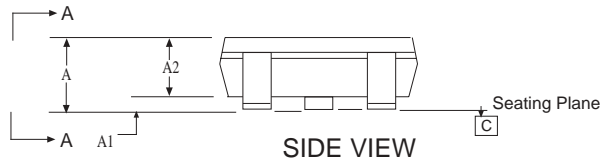
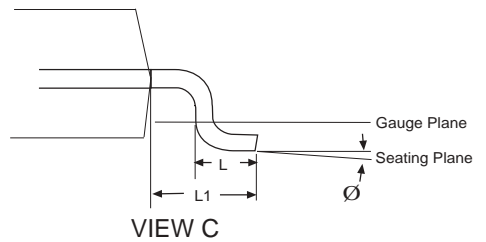
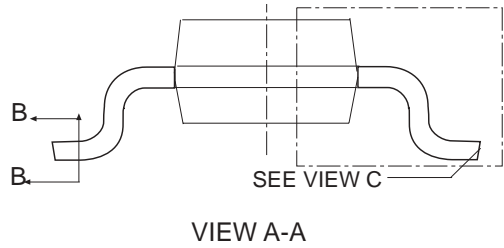
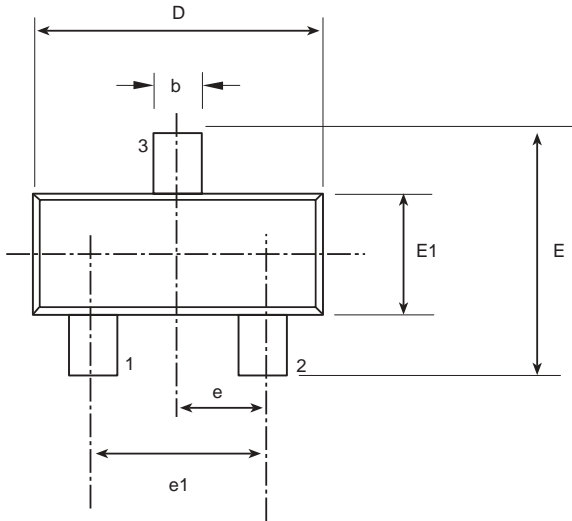


DIMENSIONS Minimum/Maximum (mm)		8 Pin NSOIC (JEDEC MS-012, AA - VARIATION)		
COMMON HEIGHT DIMENSION				
SYMBOL	MIN	NOM	MAX	
A	1.35	-	1.75	
A1	0.10	-	0.25	
A2	1.25	-	1.65	
b	0.31	-	0.51	
c	0.17	-	0.25	
D	4.90 BSC			
E	6.00 BSC			
E1	3.90 BSC			
e	1.27 BSC			
L	0.40	-	1.27	
L1	1.04 REF			
L2	0.25 BSC			
Ø	0°	-	8°	
Ø1	5°	-	15°	



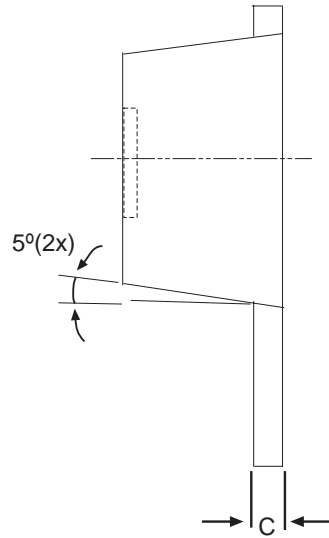
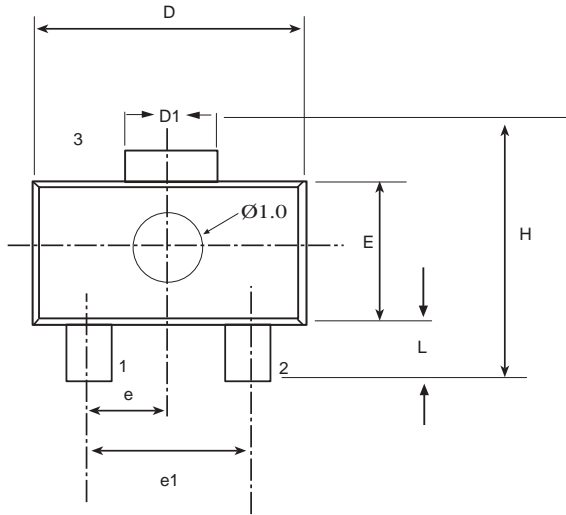
**PACKAGE: 8 PIN NSOIC**



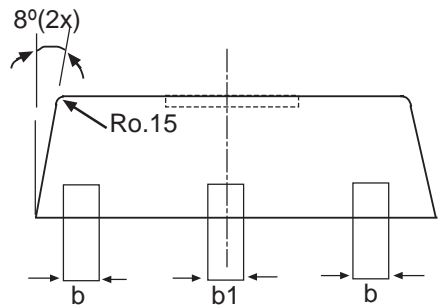


3 PIN SOT-23 JEDEC TO-236 (AB) Variation	Dimensions in (mm)		
	MIN	NOM	MAX
A	0.89	-	1.12
A1	0.01	-	0.10
A2	0.88	0.95	1.02
b	0.30	-	0.50
c	0.08	-	0.20
D	2.80	2.90	3.04
e	0.95 BSC		
e1	1.90 BSC		
E	2.10	-	2.64
E1	1.20	1.30	1.40
L	0.40	0.50	0.60
L1	0.54 REF		
Ø	0°	-	8°

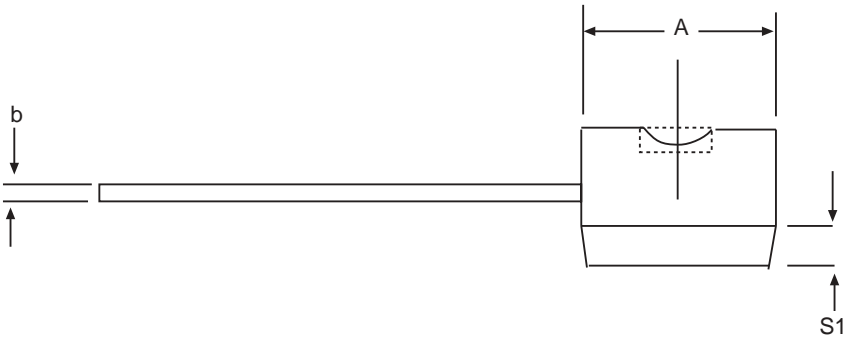
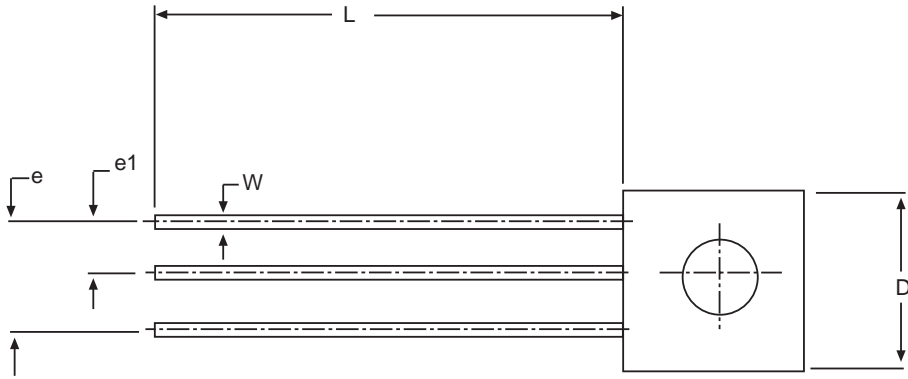
3 PIN SOT-23



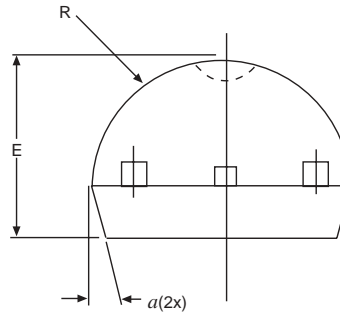
3 PIN SOT-89	Dimensions in (mm)		
	MIN	NOM	MAX
A	1.40	1.50	1.60
b	0.36	0.42	0.48
L	0.80	-	1.20
b1	0.41	0.47	0.53
C	0.38	0.40	0.43
D	4.40	4.50	4.60
D1	1.40	1.60	1.75
H	3.94	-	4.25
E	2.40	2.50	2.60
e	1.45	1.50	1.55
e1	2.90	3.00	3.10



**3 PIN SOT-89**



3 PIN TO-92	DIMENSIONS IN INCHES		
	MIN	NOM	MAX
A	.170	-	.195
b	.014	-	.020
E	.130	-	.155
e	.095	-	.105
e1	.045	-	.055
L	.500	-	.610
R	.085	-	.095
S1	.045	-	.060
W	.016	-	0.022
D	.175	-	.195
a	4°	-	6°



**3 PIN TO-92**

<b>PART NUMBER</b>	<b>ACCURACY</b>	<b>OUTPUT VOLTAGE</b>	<b>PACKAGES</b>
SPX431LAM .....	0.5% .....	2.503V .....	3-Pin SOT-23
SPX431LAM/TR .....	0.5% .....	2.503V .....	3-Pin SOT-23
SPX431LAM1 .....	0.5% .....	2.503V .....	3-Pin SOT-89
SPX431LAM1/TR .....	0.5% .....	2.503V .....	3-Pin SOT-89
SPX431LAS .....	0.5% .....	2.503V .....	8-Pin nSOIC
SPX431LAS/TR .....	0.5% .....	2.503V .....	8-Pin nSOIC
SPX431LAN .....	0.5% .....	2.503V .....	3-Pin TO-92
SPX431LAN/TR .....	0.5% .....	2.503V .....	3-Pin TO-92

SPX431LM .....	1.0% .....	2.495V .....	3-Pin SOT-23
SPX431LM/TR .....	1.0% .....	2.495V .....	3-Pin SOT-23
SPX431LM1 .....	1.0% .....	2.495V .....	3-Pin SOT-89
SPX431LM1/TR .....	1.0% .....	2.495V .....	3-Pin SOT-89
SPX431LS .....	1.0% .....	2.495V .....	8-Pin nSOIC
SPX431LS/TR .....	1.0% .....	2.495V .....	8-Pin nSOIC
SPX431LN .....	1.0% .....	2.495V .....	3-Pin TO-92
SPX431LN/TR .....	1.0% .....	2.495V .....	3-Pin TO-92

SPX431LCM .....	2.0% .....	2.495V .....	3-Pin SOT-23
SPX431LCM/TR .....	2.0% .....	2.495V .....	3-Pin SOT-23
SPX431LCM1 .....	2.0% .....	2.495V .....	3-Pin SOT-89
SPX431LCM1/TR .....	2.0% .....	2.495V .....	3-Pin SOT-89
SPX431LCS .....	2.0% .....	2.495V .....	8-Pin nSOIC
SPX431LCS/TR .....	2.0% .....	2.495V .....	8-Pin nSOIC
SPX431LCN .....	2.0% .....	2.495V .....	3-Pin TO-92
SPX431LCN/TR .....	2.0% .....	2.495V .....	3-Pin TO-92

Available in lead free packaging. To order add “-L” suffix to part number.

Example: SPX431LM/TR = standard; SPX431LM-L/TR = lead free

/TR = Tape and Reel

Pack quantity is 2,000 for TO-92, 2,500 for SOT-89, SOT-23, and SOT-23.



**ANALOG EXCELLENCE**

**Sipex Corporation**

**Headquarters and  
Sales Office**  
233 South Hillview Drive  
Milpitas, CA 95035  
TEL: (408) 934-7500  
FAX: (408) 935-7600

Sipex Corporation reserves the right to make changes to any products described herein. Sipex does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights nor the rights of others.