

## Description

The **SPX2431** is a 3-terminal adjustable shunt voltage regulator providing a highly accurate bandgap reference. The SPX2431 acts as an open-loop error amplifier with a 2.5V temperature compensation reference. The SPX2431'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. SPX2431A 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 lines and contribute a significant cost savings.

The output voltage may be adjusted to any value between  $V_{REF}$  and 20 volts with two external resistors. 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 SPX2431 is available in a SOT-23-3 package.

## FEATURES

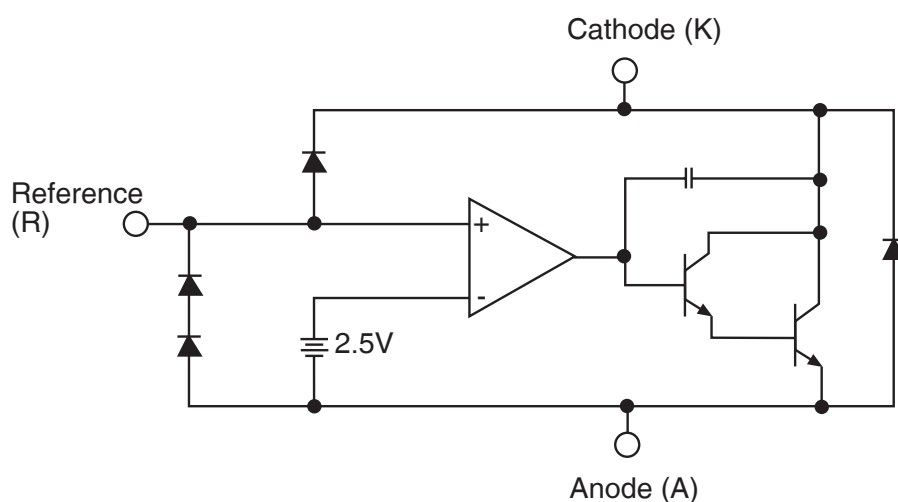
- Trimmed bandgap to 0.5% and 1.0%
- Wide operating current 1mA to 100mA
- Extended temperature range: 0°C to 105°C
- Low temperature coefficient: 30 ppm/°C
- Offered in 3 Pin SOT-23 (M)
- Replacement for TL431, AS2431
- Low noise output

## APPLICATIONS

- Battery operating equipment
- Adjustable supplies
- Switching power supplies
- Error amplifiers
- Single supply amplifier
- Monitors / VCRs / TVs
- Personal computers

Ordering Information - [Back Page](#)

## Functional Block Diagram



## Absolute Maximum Ratings

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.

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  $P_D$   
     SOT-23 ..... 200mW  
 Junction Temperature  $T_J$  ..... 150°C  
 Storage Temperature  $T_{STG}$  ..... -65°C to 150°C

## Recommended Conditions

Cathode Voltage  $V_{KA}$  .....  $V_{REF}$  to 20V  
 Cathode Current  $I_K$  ..... 10mA

## Typical Thermal Resistances

SOT-23

$\Theta_{JA}$  ..... 575°C/W

$\Theta_{JC}$  ..... 150°C/W

Typical Derating ..... 1.7mW/°C

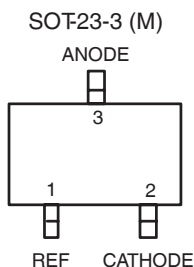
Typical deratings of the thermal resistances are given for ambient temperature >25°C.

## Electrical Characteristics

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

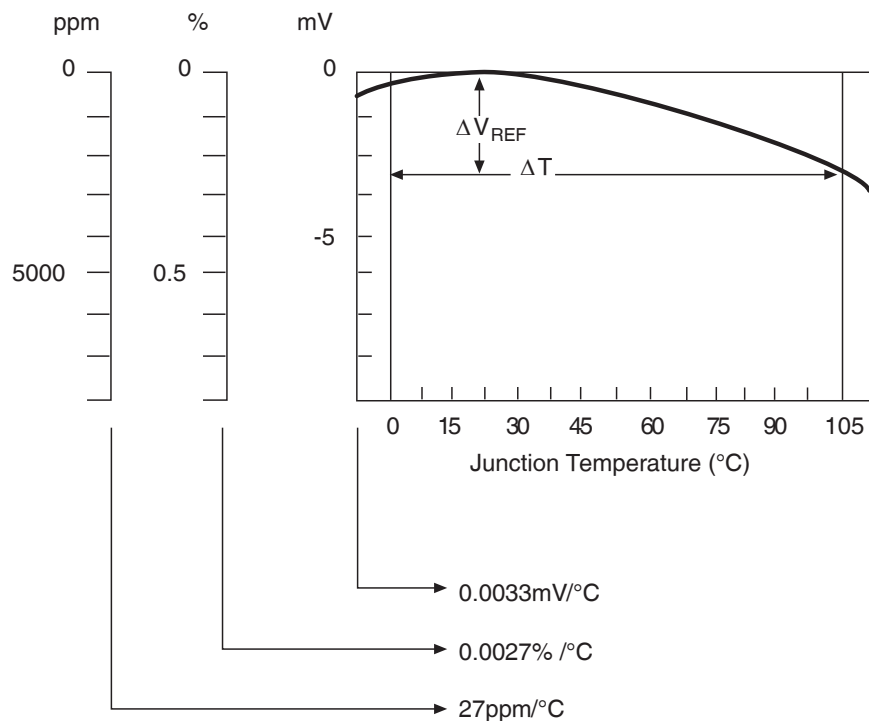
PARAMETERS	SYMBOL	FIGURE	CONDITIONS	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	UNITS
				SPX2431A			SPX2431			
Reference voltage	$V_{REF}$	2		2.487	2.500	2.513	2.474	2.500	2.526	V
		2	$T_J = 0^\circ\text{C to } 105^\circ\text{C}$	2.480		2.520	2.460		2.540	
$\Delta V_{REF}$ with temp.	TC	2			0.07	0.20		0.07	0.20	mV/°C
Ratio of change in $V_{REF}$ to cathode voltage	$\frac{\Delta V_{REF}}{\Delta V_K}$		$V_{REF}$ to 10V	-2.7	-1.01		-2.7	-1.01		mV/V
		3	10V to 20V	-2.0	-0.4	0.3	-2.0	-0.4	0.3	
Reference input current	$I_{REF}$	3			0.7	4.0		0.7	4.0	μA
$I_{REF}$ 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	μA
Min $I_K$ for regulation	$I_{K(MIN)}$	2			0.4	1.0		0.4	1.0	mA
Off state leakage	$I_{K(OFF)}$	4	$V_{REF} = 0V$ , $V_{KA} = 20V$		0.04			0.04	500	nA
Dynamic output impedance	$Z_{KA}$	2	$f_z \leq 1kHz$ $I_K = 1$ to 100mA		0.15	0.5		0.15	0.5	Ω

## Pin Configuration



Top View

## Calculating Average Temperature Coefficient (TC)



$$\begin{aligned} \bullet \text{ TC in mV } / ^\circ\text{C} &= \frac{\Delta V_{REF}(\text{mV})}{\Delta T_A} \\ \bullet \text{ TC in \% } / ^\circ\text{C} &= \frac{\left( \frac{\Delta V_{REF}}{\Delta V_{REF} \text{ at } 25^\circ\text{C}} \right) \times 100}{\Delta T_A} \\ \bullet \text{ TC in ppm } / ^\circ\text{C} &= \frac{\left( \frac{\Delta V_{REF}}{\Delta V_{REF} \text{ at } 25^\circ\text{C}} \right) \times 10^6}{\Delta T_A} \end{aligned}$$

Figure 1:  $V_{REF}$  vs. Temperature

## Test Circuits

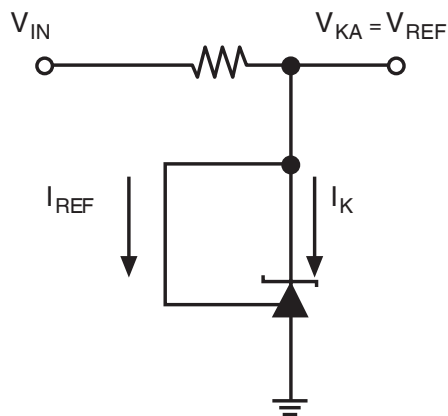


Figure 2: Test Circuit for  $V_{KA} = V_{REF}$

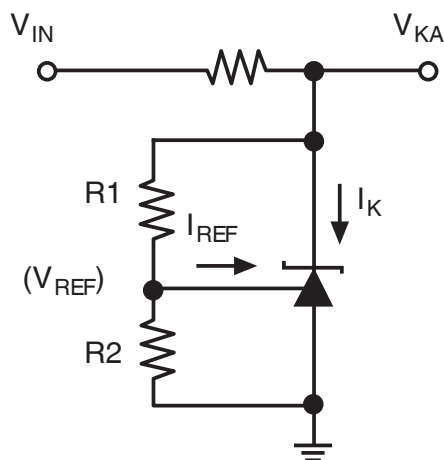


Figure 3: Test Circuit for  $V_{KA} > V_{REF}$

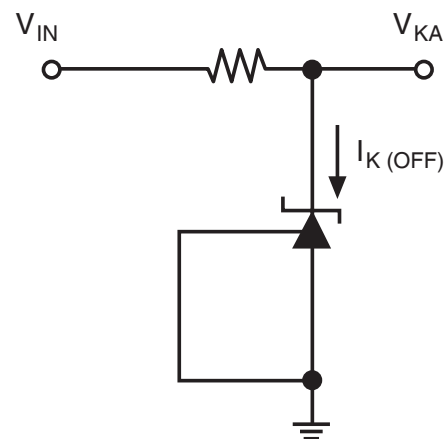


Figure 4: Test Circuit for  $I_{K(OFF)}$

## Typical Performance Characteristics

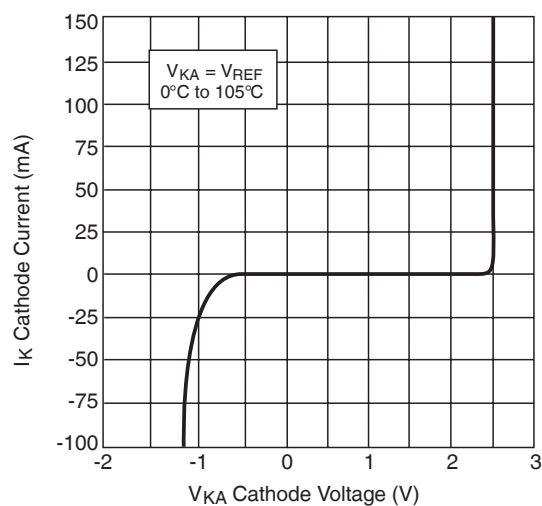


Figure 5: High Current Operating Characteristics

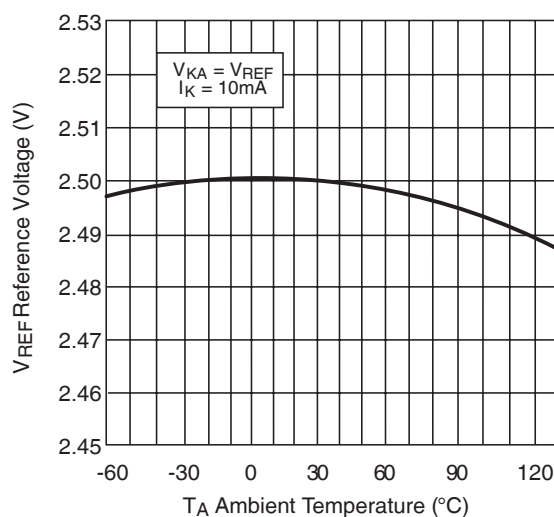


Figure 6: Reference Voltage vs. Ambient Temperature

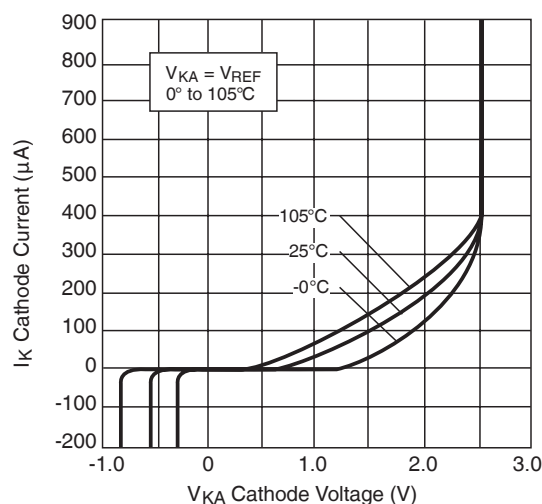


Figure 7: Low Current Operating Characteristics

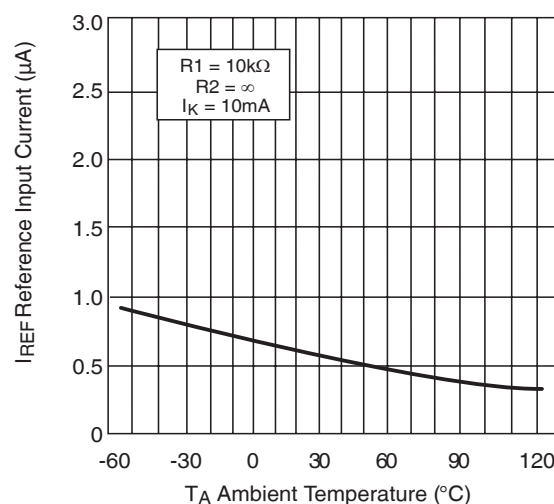


Figure 8: Reference Input Current vs. Ambient Temperature

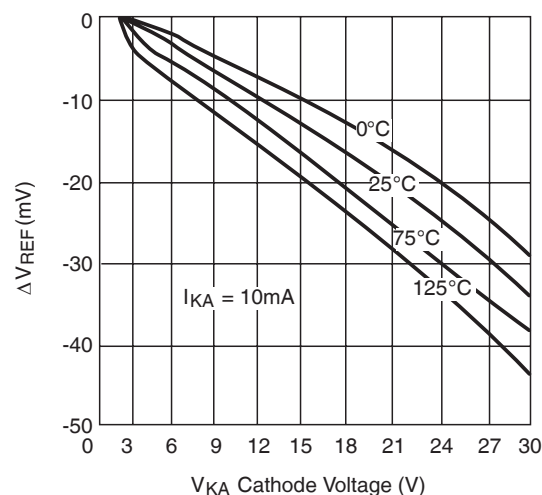
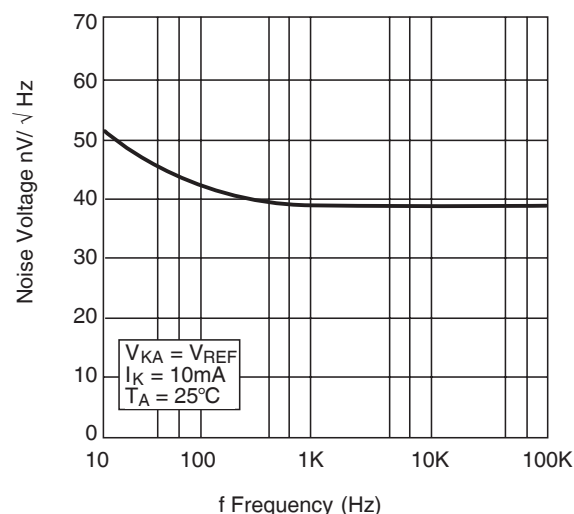
Figure 9: Reference Voltage Line Regulation vs. Cathode Voltage and  $T_{AMBIENT}$ 

Figure 10: Noise Voltage vs. Frequency

## Typical Performance Characteristics (continued)

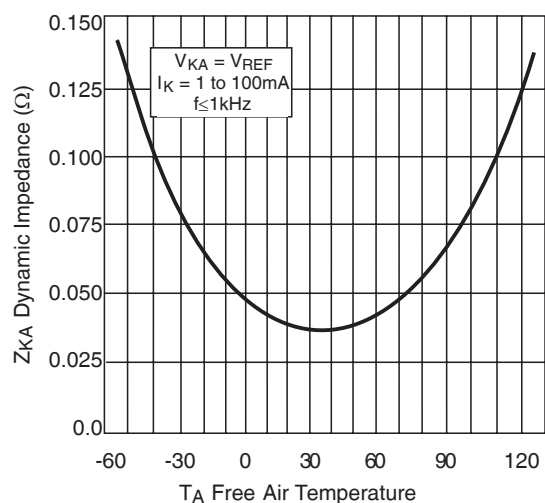


Figure 11: Low Frequency Dynamic Output Impedance vs.  $T_{\text{AMBIENT}}$

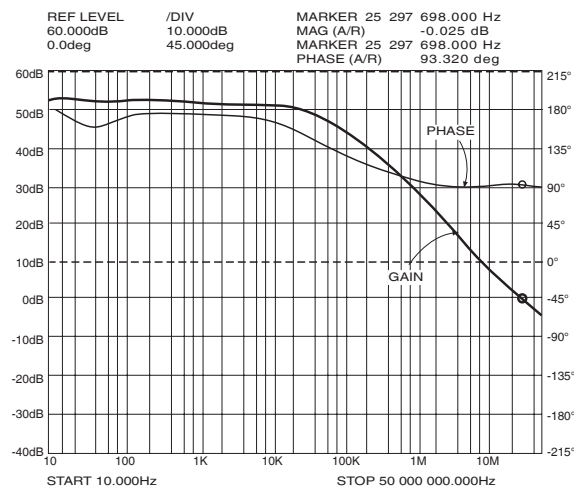


Figure 12: Small Signal Gain and Phase vs. Frequency;  $I_K = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

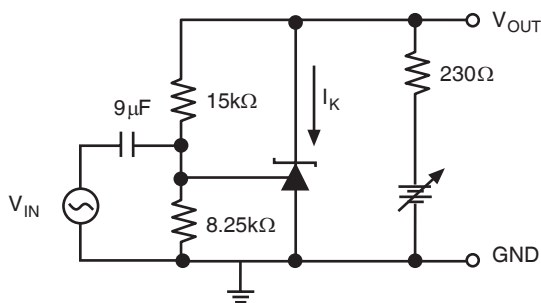


Figure 13: Test Circuit for Gain and Phase Frequency Response

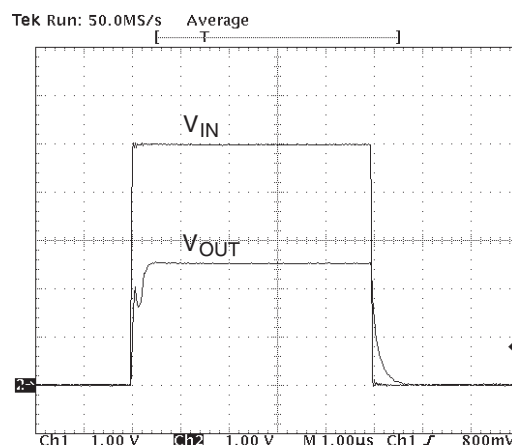


Figure 14: Frequency = 100kHz,  $I_K = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

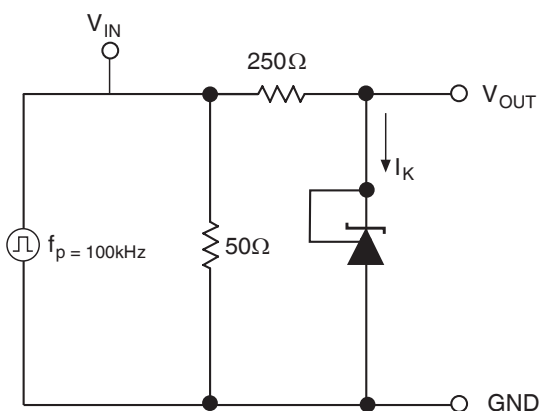


Figure 15: Test Circuit for Pulse Response

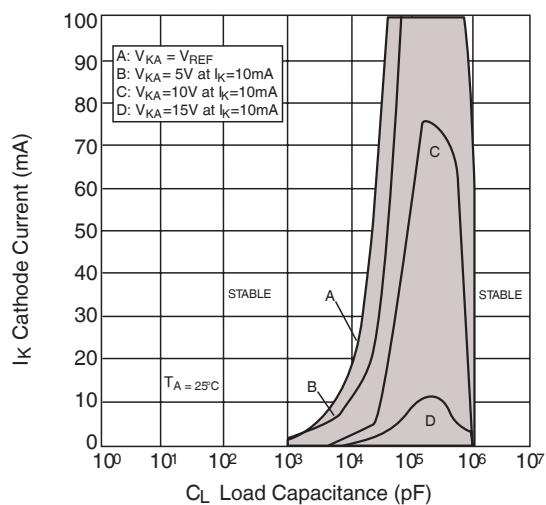


Figure 16: Stability Boundry Conditions

## Typical Performance Characteristics (continued)

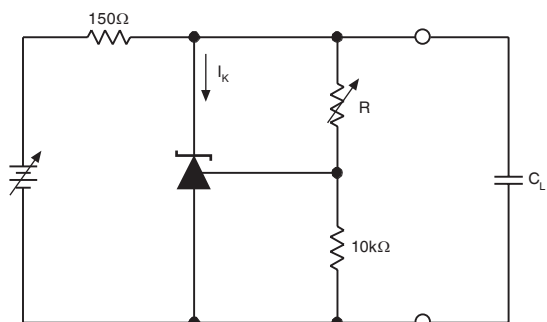


Figure 17: Test Circuit for Stability

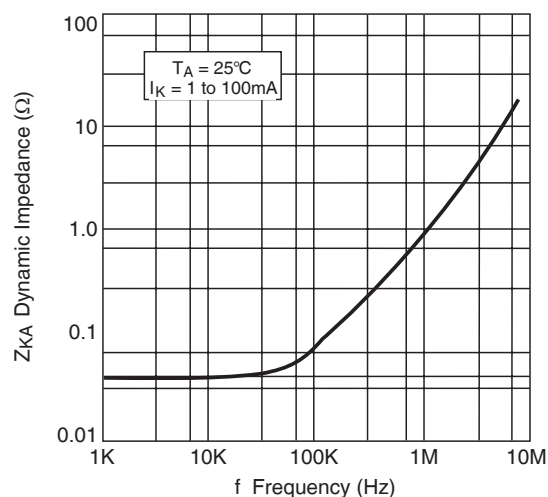


Figure 18: Dynamic Output Impedance  $T_A = 25^\circ\text{C}$ ,  $I_K = 1$  to  $100\text{mA}$

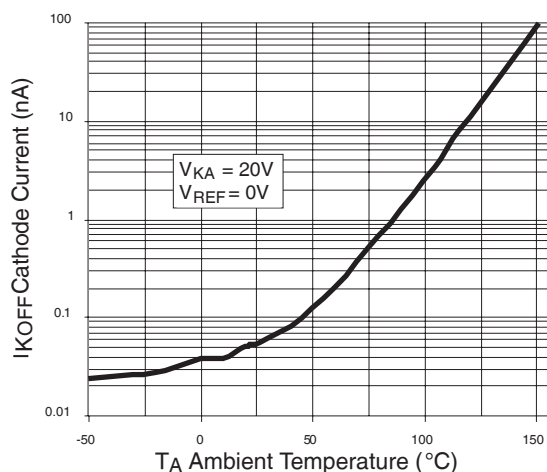


Figure 19: Off State Leakage

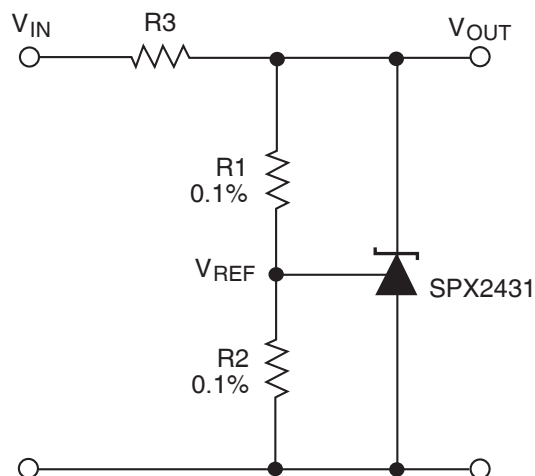


Figure 20: Shunt Regulator  $V_{OUT} = (1 + R1/R2)V_{REF}$

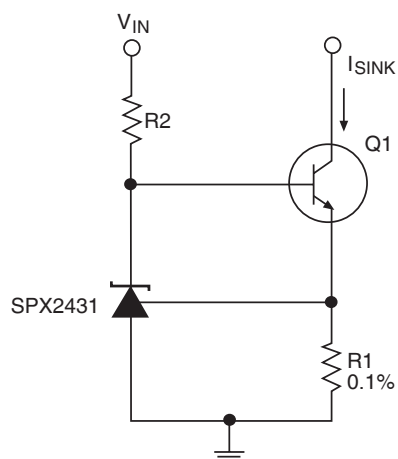


Figure 21: Constant Current, Sink,  $I_{SINK} = V_{REF}/R1$

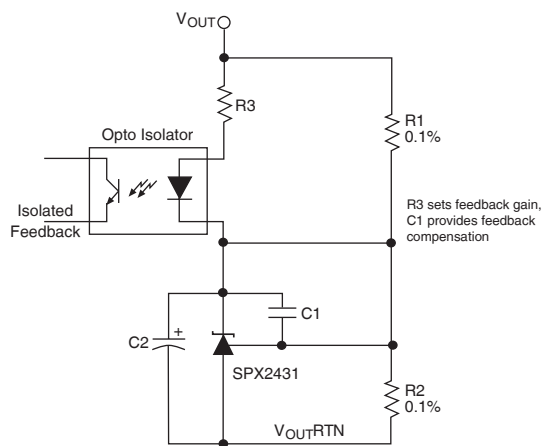


Figure 22: Reference Amplifier for Isolated Feedback in Off-Line DC-DC Converters

## Typical Performance Characteristics (continued)

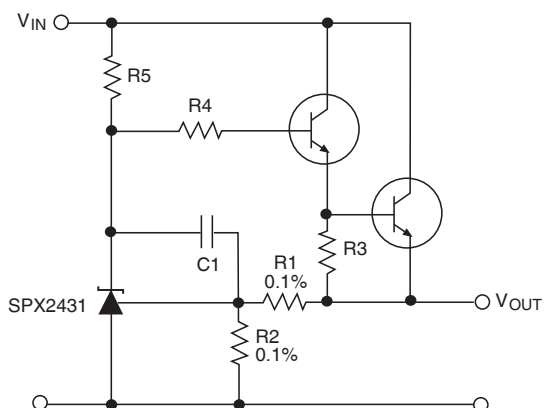


Figure 23: Precision High Current Series Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

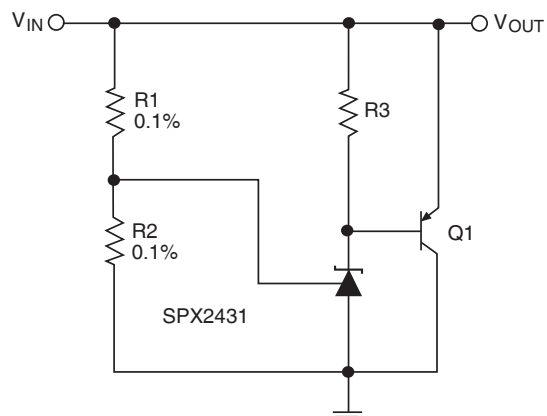


Figure 24: High Current Shunt Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

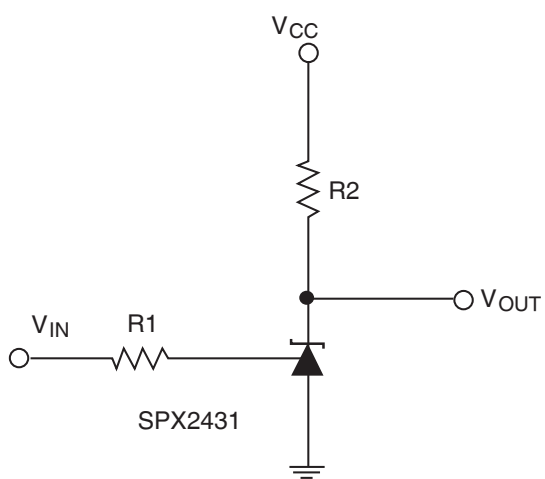
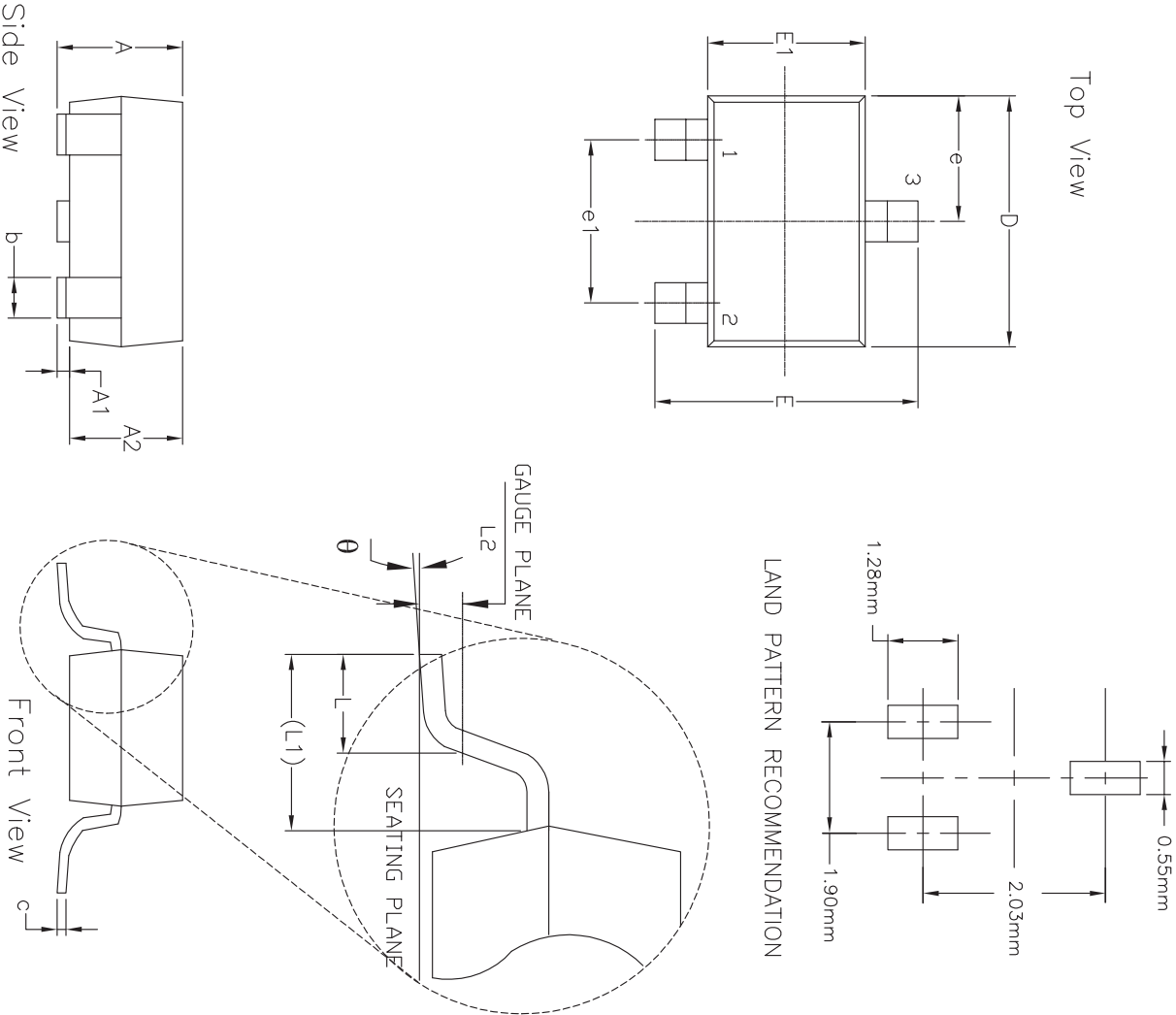


Figure 25: Single Supply Comparator with Temperature Compensated Threshold.  $V_{IN}$  Threshold = 2.5V

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

Mechanical Dimensions

SOT-23-3



3 Pin SOT-23 JEDEC TO-236 Variation AB									
SYMBOLS	DIMENSIONS IN MM (Control Unit)				DIMENSIONS IN INCH (Reference Unit)				
	MIN	NOM	MAX		MIN	NOM	MAX		
A	0.89	—	1.12	0.035	—	0.044			
A1	0.01	—	0.10	0.000	—	0.004			
A2	0.88	0.95	1.02	0.035	0.037	0.040			
b	0.30	—	0.50	0.012	—	0.020			
c	0.08	—	0.20	0.003	—	0.008			
D	2.80	2.90	3.04	0.110	0.114	0.120			
E	2.10	—	2.64	0.083	—	0.104			
E1	1.20	1.30	1.40	0.047	0.051	0.055			
e	0.95 BSC				0.038 BSC				
e1	1.90 BSC				0.075 BSC				
L	0.40	0.50	0.60	0.016	0.020	0.024			
L1	0.54 REF				0.021 REF				
L2	0.25 BSC				0.010 BSC				
q	0°	—	8°	0°	—	8°			
N	3				3				

Drawing No: P0D-00000031  
Revision: A



Ordering Information<sup>(1)</sup>

Part Number	Operating Temperature Range	Lead-Free	Package	Packaging Method	Accuracy	Output Voltage
SPX2431AM-L/TR	0°C to 105°C	Yes <sup>(2)</sup>	3-pin SOT-23	Tape and Reel	0.5%	2.5V
SPX2431M-L/TR					1.0%	

## NOTE:

1. Refer to [www.exar.com/SPX2431](http://www.exar.com/SPX2431) for most up-to-date Ordering Information.
2. Visit [www.exar.com](http://www.exar.com) for additional information on Environmental Rating.

## Revision History

Revision	Date	Description
1A	11/17/2017	Added MaxLinear logo. Updated format and ordering information table from previous revision dated 1/19/05. Pinout moved to page 2. Corrected typo for E min in mechanical dimensions.



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