



A New Direction in Mixed-Signal

July 2013

**SPX431L**

## Precision Adjustable Shunt Regulator

Rev. 2.0.1

### GENERAL 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 VREF and 20V with two external resistors. The SPX431L is available in TO-92, and SOT-89 packages.

### APPLICATIONS

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

### 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**

### TYPICAL BLOCK DIAGRAM

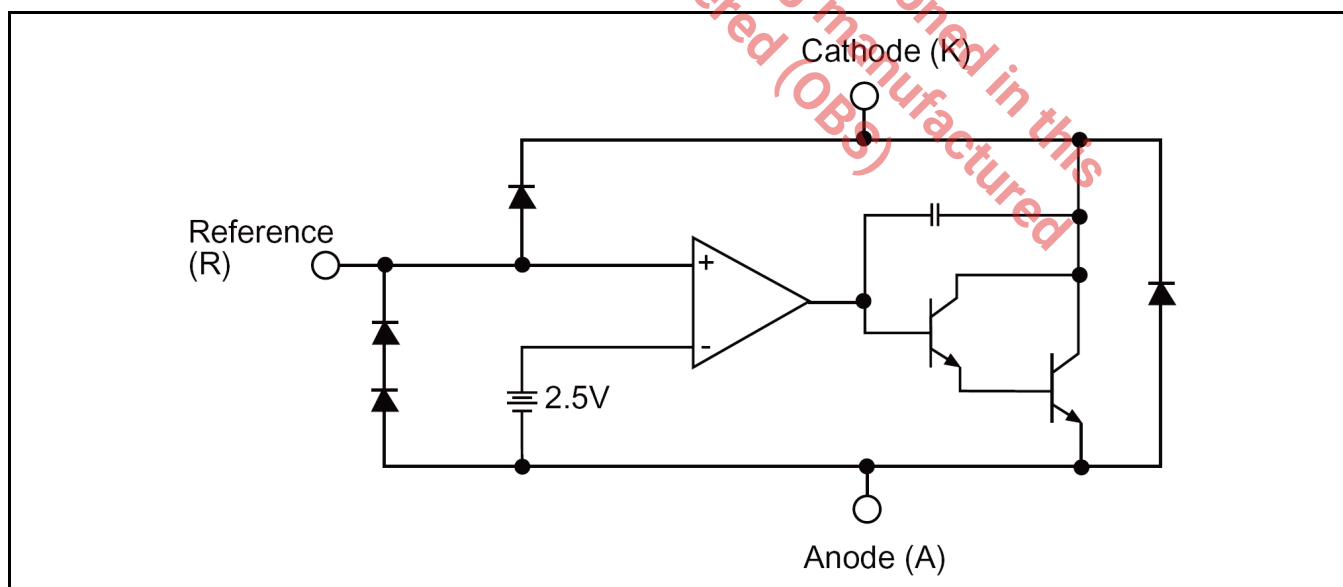


Fig. 1: SPX431L Precision Adjustable Shunt Regulator

## ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

Cathode-Anode Reverse Breakdown  $V_{KA}$  ..... 20V  
 Anode-Cathode Forward Current, ( $<10\text{ms}$ )  $I_{AK}$  ..... 1A  
 Operating Cathode Current  $I_{KA}$  ..... 100mA  
 Reference Input Current  $I_{REF}$  ..... 10mA  
 Continuous Power Dissipation at 25°C PD  
     TO-92 ..... 775mW  
     SOT-89 ..... 1000mW  
 Storage Temperature  $T_{STG}$  ..... -65 to 150°C  
 Lead Temperature (Soldering 10 sec.)  $T_L$  ..... 300°C

## OPERATING RATINGS

Input Voltage Range  $V_{KA}$  .....  $V_{REF}$  to 20V  
 Cathode Current  $I_K$  ..... 10mA  
 Junction Temperature Range ..... 150 °C  
 Thermal Resistance  
      $\theta_{JA}$  (TO-92) ..... 160°C/W  
      $\theta_{JC}$  (TO-92) ..... 80°C/W  
     Typical Derating (TO-92) ..... 6.3 mW/°C  
      $\theta_{JA}$  (SOT-89) ..... 110°C/W  
      $\theta_{JC}$  (SOT-89) ..... 8°C/W  
     Typical Derating (SOT-89) ..... 9.1 mW/°C

## ELECTRICAL SPECIFICATIONS

Specifications with standard type are for an Operating Junction Temperature of  $T_A = 25^\circ\text{C}$  only; limits applying over the full Operating Junction Temperature range are denoted by a "•". Minimum and Maximum limits are guaranteed through test, design, or statistical correlation. Typical values represent the most likely parametric norm at  $T_A = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise indicated,  $I_K = 10\text{mA}$ ,  $V_K = V_{REF}$ .

| Parameter                                       | Min.         | Typ.         | Max.  | Units | Conditions                                            |
|-------------------------------------------------|--------------|--------------|-------|-------|-------------------------------------------------------|
| <b>SPX431LA</b>                                 |              |              |       |       |                                                       |
| Reference Voltage                               | 2.490        | 2.503        | 2.515 | V     |                                                       |
| $\Delta V_{REF}$ with Temp. <sup>1</sup>        |              | 0.07         | 0.20  | mV/°C |                                                       |
| Ratio of Change in $V_{REF}$ to Cathode Voltage | -2.7<br>-2.0 | -1.0<br>-0.4 | 0.3   | mV/V  | $V_{REF}$ to 10V<br>$V_{REF}$ to 10V                  |
| Reference Input Current                         |              | 0.7          | 4.0   | μA    |                                                       |
| $I_{REF}$ Temp Deviation                        |              | 0.4          | 1.2   | μA    | $T_J = 0^\circ\text{C}$ to $105^\circ\text{C}$        |
| Min $I_K$ for Regulation                        |              | 0.4          | 1.0   | mA    |                                                       |
| Off State Leakage                               |              | 0.04         | 1.0   | μA    | $V_{REF} = 0\text{V}$ , $V_{KA} = 20\text{V}$         |
| Dynamic Output Impedance                        |              | 0.15         | 0.5   | Ω     | $f_z \leq 1\text{kHz}$<br>$I_K = 1$ to $100\text{mA}$ |
| <b>SPX431L</b>                                  |              |              |       |       |                                                       |
| Reference Voltage                               | 2.470        | 2.495        | 2.520 | V     |                                                       |
| $\Delta V_{REF}$ with Temp. <sup>1</sup>        |              | 0.07         | 0.20  | mV/°C |                                                       |
| Ratio of Change in $V_{REF}$ to Cathode Voltage | -2.7<br>-2.0 | -1.0<br>-0.4 | 0.3   | mV/V  | $V_{REF}$ to 10V<br>$V_{REF}$ to 10V                  |
| Reference Input Current                         |              | 0.7          | 4.0   | μA    |                                                       |
| $I_{REF}$ Temp Deviation                        |              | 0.4          | 1.2   | μA    | $T_J = 0^\circ\text{C}$ to $105^\circ\text{C}$        |
| Min $I_K$ for Regulation                        |              | 0.4          | 1.0   | mA    |                                                       |
| Off State Leakage                               |              | 0.04         | 1.0   | μA    | $V_{REF} = 0\text{V}$ , $V_{KA} = 20\text{V}$         |
| Dynamic Output Impedance                        |              | 0.15         | 0.5   | Ω     | $f_z \leq 1\text{kHz}$<br>$I_K = 1$ to $100\text{mA}$ |
| <b>SPX431LC</b>                                 |              |              |       |       |                                                       |
| Reference Voltage                               | 2.445        | 2.495        | 2.520 | V     |                                                       |
| $\Delta V_{REF}$ with Temp. <sup>1</sup>        |              | 0.07         | 0.20  | mV/°C |                                                       |
| Ratio of Change in $V_{REF}$ to Cathode Voltage | -2.7<br>-2.0 | -1.0<br>-0.4 | 0.3   | mV/V  | $V_{REF}$ to 10V<br>$V_{REF}$ to 10V                  |
| Reference Input Current                         |              | 0.7          | 4.0   | μA    |                                                       |
| $I_{REF}$ Temp Deviation                        |              | 0.4          | 1.2   | μA    | $T_J = 0^\circ\text{C}$ to $105^\circ\text{C}$        |

## Precision Adjustable Shunt Regulator

| Parameter                | Min. | Typ. | Max. | Units | Conditions                   |
|--------------------------|------|------|------|-------|------------------------------|
| Min IK for Regulation    |      | 0.4  | 1.0  | mA    |                              |
| Off State Leakage        |      | 0.04 | 1.0  | μA    | VREF = 0V, VKA = 20V         |
| Dynamic Output Impedance |      | 0.15 | 0.5  | Ω     | fz ≤ 1kHz<br>Ik = 1 to 100mA |

Note 1: See appropriate test circuit (Figures 25, 26, 27)

### PIN ASSIGNMENT

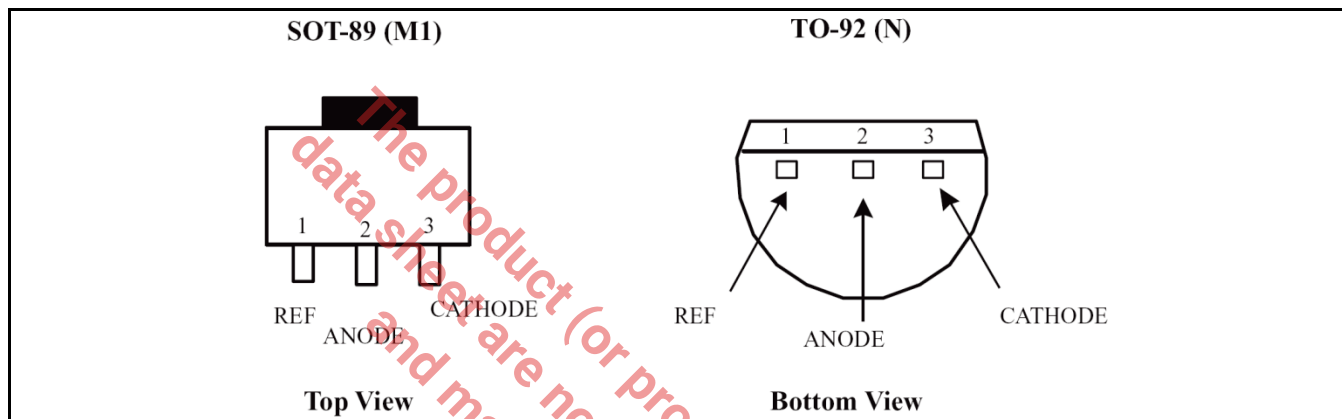


Fig. 2: SPX431L Pin Assignment

### PIN DESCRIPTION

| Name | Pin Number | Description |
|------|------------|-------------|
| NAME | 1          | Reference   |
| NAME | 2          | Anode       |
| NAME | 3          | Cathode     |

### ORDERING INFORMATION

| Part Number    | Temperature Range | Marking                         | Package  | Packing Quantity | Note 1                                                                   | Note 2             |
|----------------|-------------------|---------------------------------|----------|------------------|--------------------------------------------------------------------------|--------------------|
| SPX431LAN-L    | 0°C to 105°C      | Sipex<br>431LAN<br>25<br>YYWWLX | TO-92-3  | Bulk             | Halogen Free                                                             | 2.503V<br>0.5% Acc |
| SPX431LAN-L/TR |                   |                                 |          | Tape & Reel      |                                                                          |                    |
| SPX431LM1-L    | 0°C to 105°C      | P011<br>YWXXXX                  | SOT-89-3 | Bulk             | Halogen Free, bar on left side of marking denotes "-L" lead free product | 2.495V<br>1.0% Acc |
| SPX431LM1-L/TR |                   |                                 |          | Tape & Reel      |                                                                          |                    |
| SPX431LN-L     | 0°C to 105°C      | Sipex<br>431LN<br>25<br>YYWWLX  | TO-92-3  | Bulk             | Halogen Free                                                             | 2.495V<br>1.0% Acc |
| SPX431LN-L/TR  |                   |                                 |          | Tape & Reel      |                                                                          |                    |

"YY" = Year (Last 2 digits) – "Y" = Year (Last Digit)

"WW" = Work Week

"L" = Lead free designator

"X" = Lot Number (example AA234567) – "XXX" = Lot Number (example AA23456Z)

No bottom marking

## TYPICAL PERFORMANCE CHARACTERISTICS

Schematic and BOM from Application Information section of this datasheet. Resistor values are chosen such that the effect to  $I_{REF}$  is negligible.

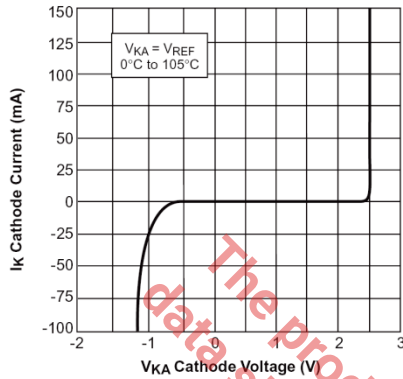


Fig. 3: High Current Operating Characteristics

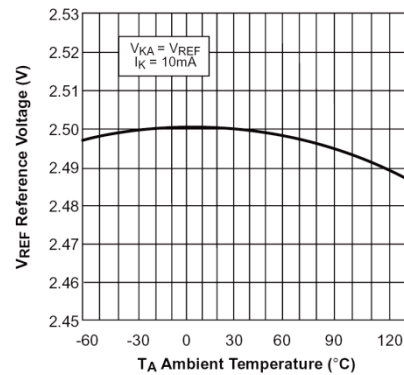


Fig. 4: Reference Voltage VS Ambient Temperature

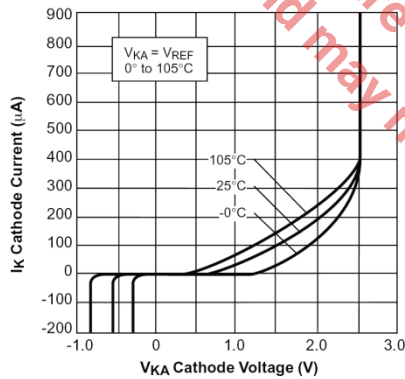


Fig. 5 Low Current Operating Characteristics.

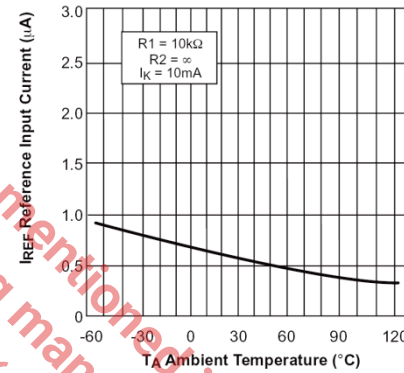


Fig. 6 Reference Input Current VS Ambient Temperature

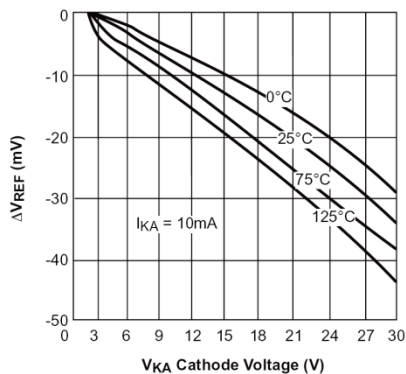


Fig. 7 Reference Voltage Line Regulation VS Cathode Voltage and  $T_{AMBIENT}$

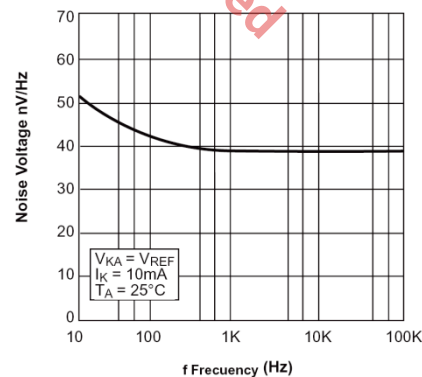


Fig. 8 Noise Voltage VS Frequency

# Precision Adjustable Shunt Regulator

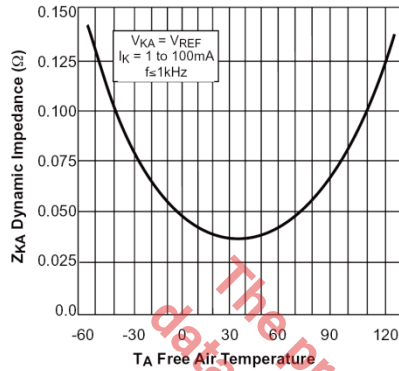


Fig. 9 Low Frequency Dynamic Output Impedance  
VS T<sub>AMBIENT</sub>

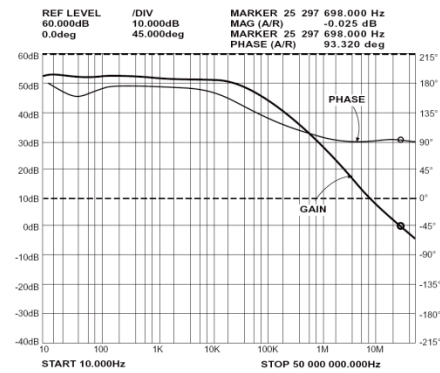


Fig. 10 Small Signal Gain and Phase VS Frequency;  
I<sub>K</sub> = 10mA, T<sub>A</sub> = 25°C

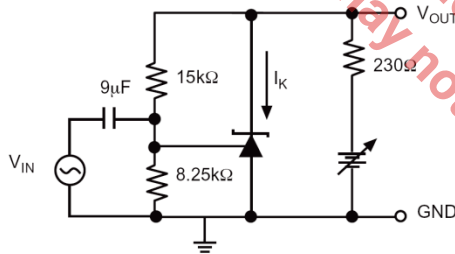


Fig. 11 Test Circuit for Gain and Phase Frequency  
Response

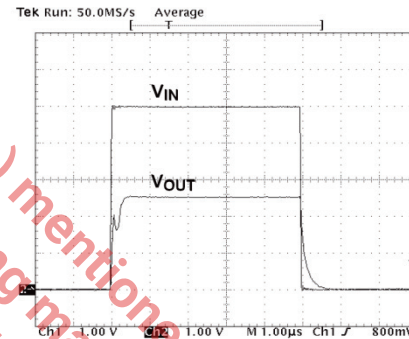


Fig. 2 F<sub>z</sub> = 100kHz, I<sub>K</sub> = 10mA, T<sub>A</sub> = 25°C

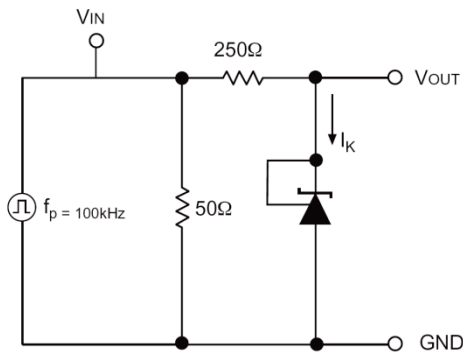


Fig. 33 Test Circuit for Pulse Response

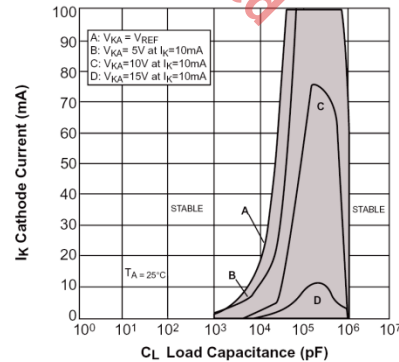


Fig. 44 Stability Boundry Conditions

**Precision Adjustable Shunt Regulator**

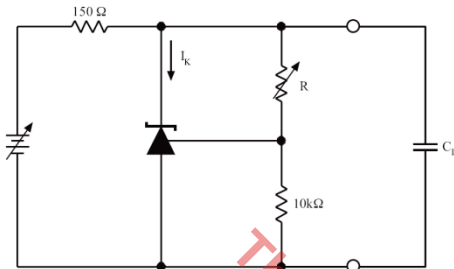


Fig. 55 Test Circuit for Stability

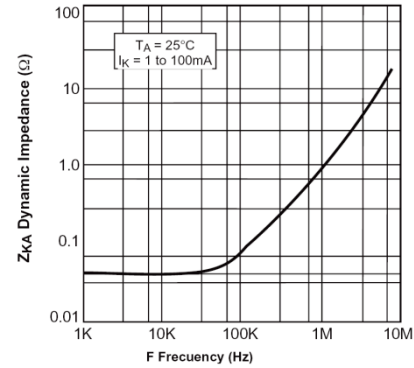


Fig. 66 Dynamic Output Impedance  $T_A = 25^\circ\text{C}$ ,  
 $I_K = 1$  to 100mA

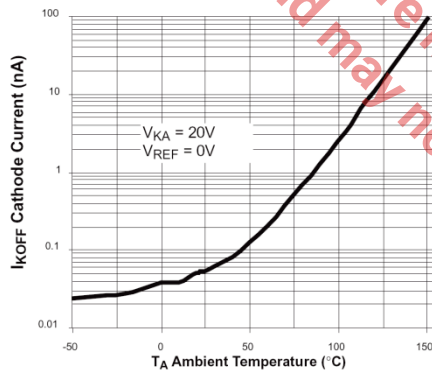


Fig. 77 Off State Leakage

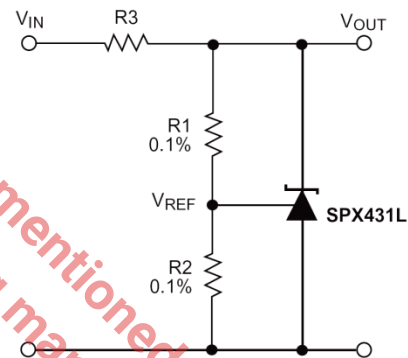


Fig. 88 Shunt Regulator  $V_{OUT} = (1 + R1/R2)V_{REF}$

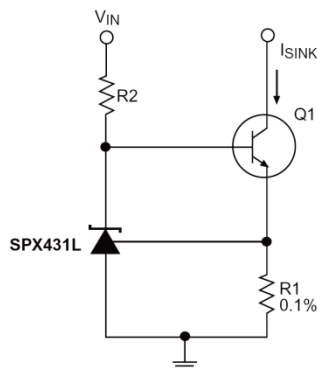


Fig. 199 Constant Current Sink,  $I_{SINK} = V_{REF}/R1$

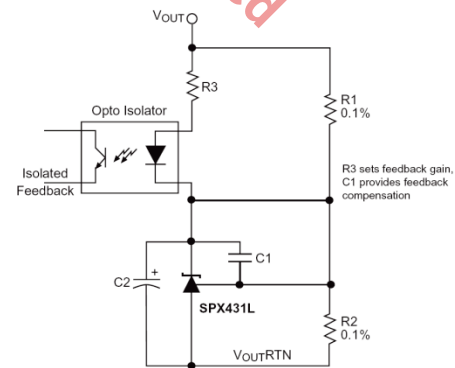


Fig. 100 Reference Amplifier for Isolated Feedback in  
Off-Line DC-DC Converters

**Precision Adjustable Shunt Regulator**

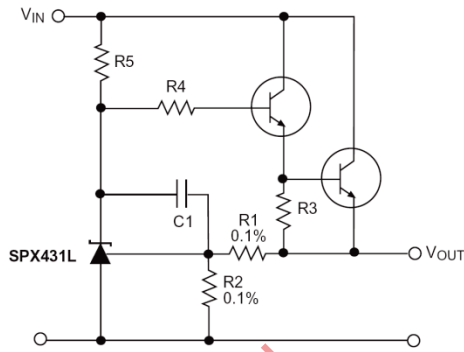


Fig. 111 Precision High Current Series Regulator

$$V_{OUT} = (1 + R1/R2)V_{REF}$$

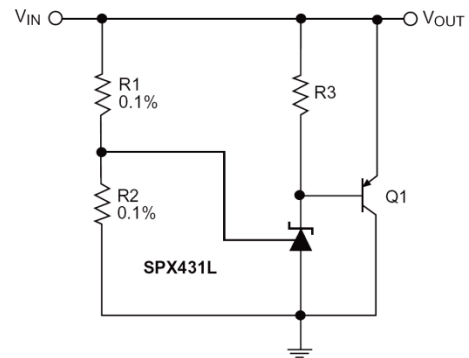


Fig. 122 High Current Shunt regulator

$$V_{OUT} = (1 + R1/R2)V_{REF}$$

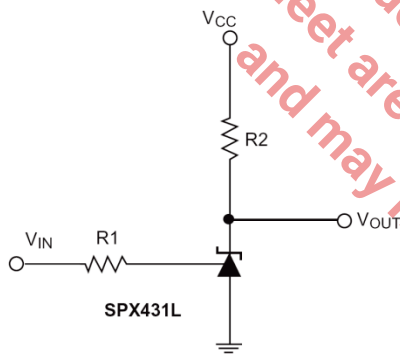


Fig. 133 Single Supply Comparator with Temperature Compensated Threshold.  $V_{IN}$  threshold = 2.5V.

## APPLICATION INFORMATION

### CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)

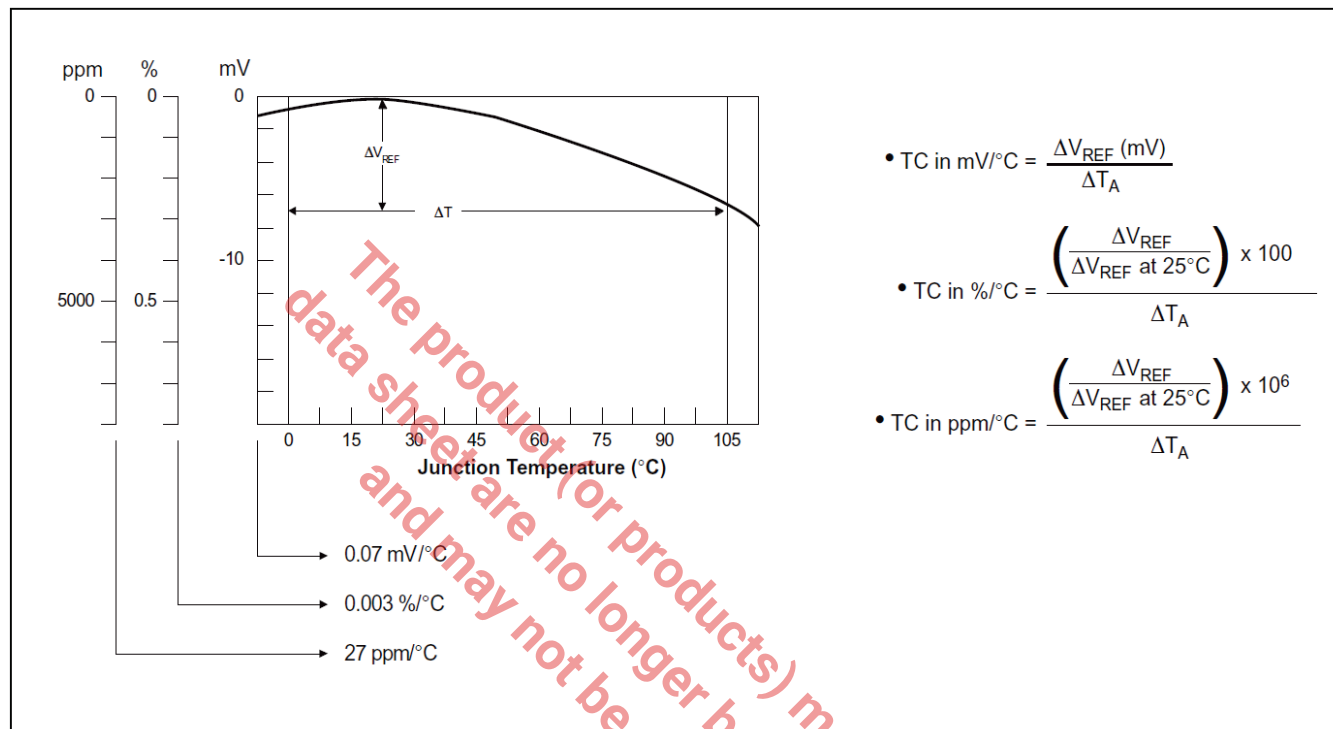


Fig. 24:  $V_{REF}$  VS Temperature.

### TEST CIRCUITS

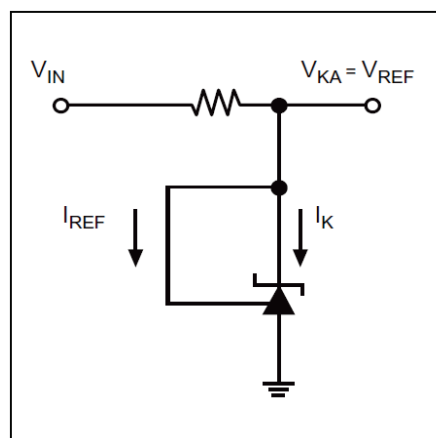


Fig. 25: Test Circuit for  $V_{KA} = V_{REF}$

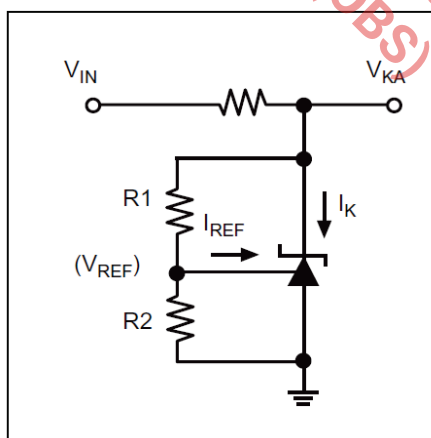


Fig. 26: Test Circuit for  $V_{KA} > V_{REF}$

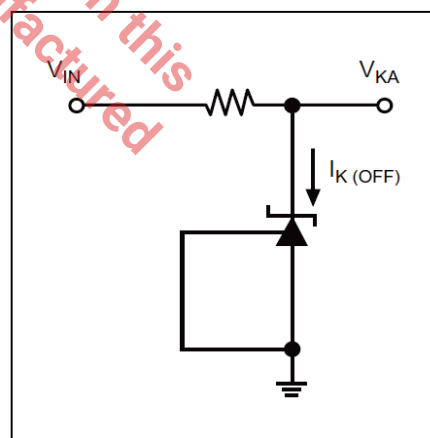
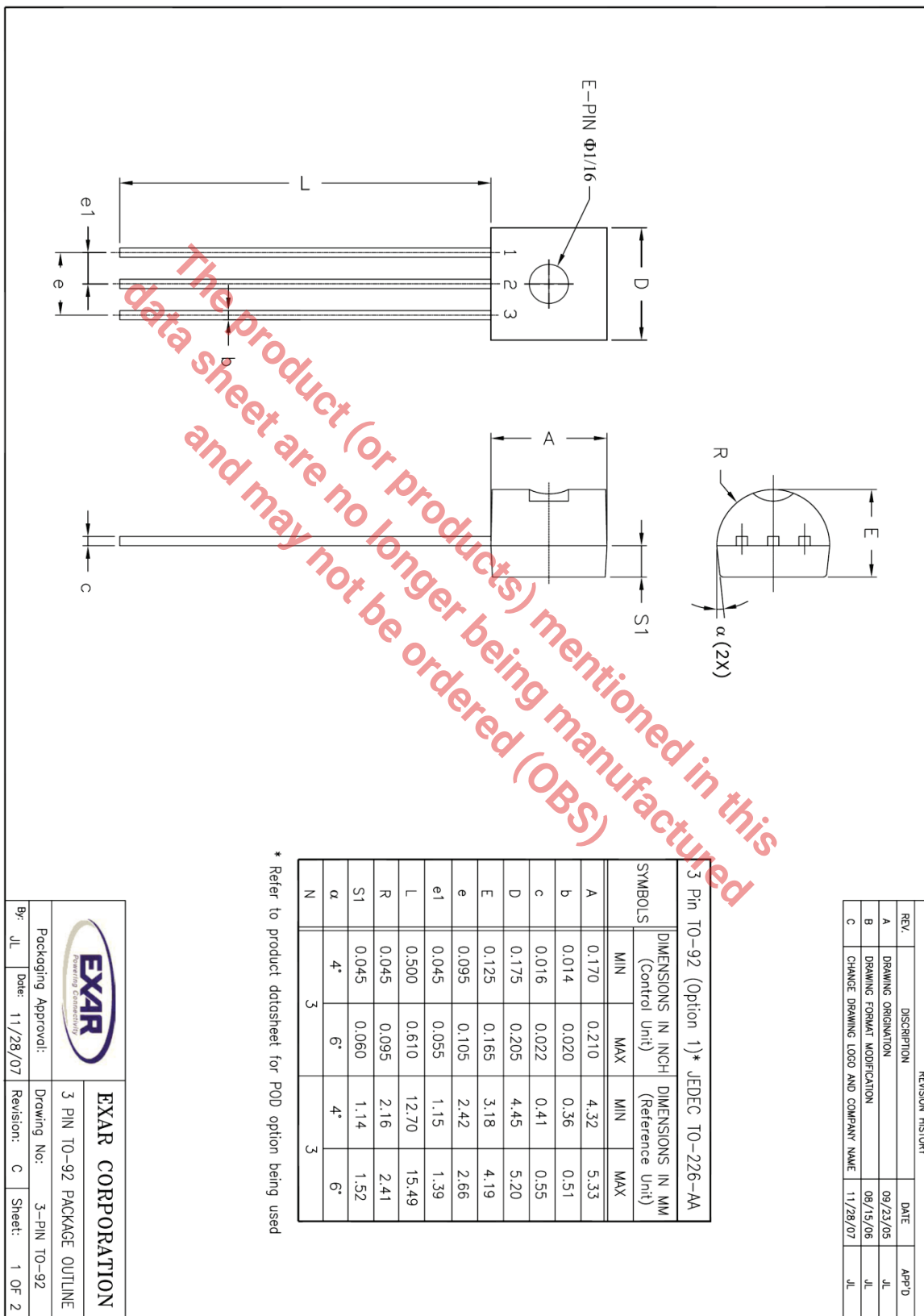


Fig. 27: Test Circuit for  $I_{KOFF}$



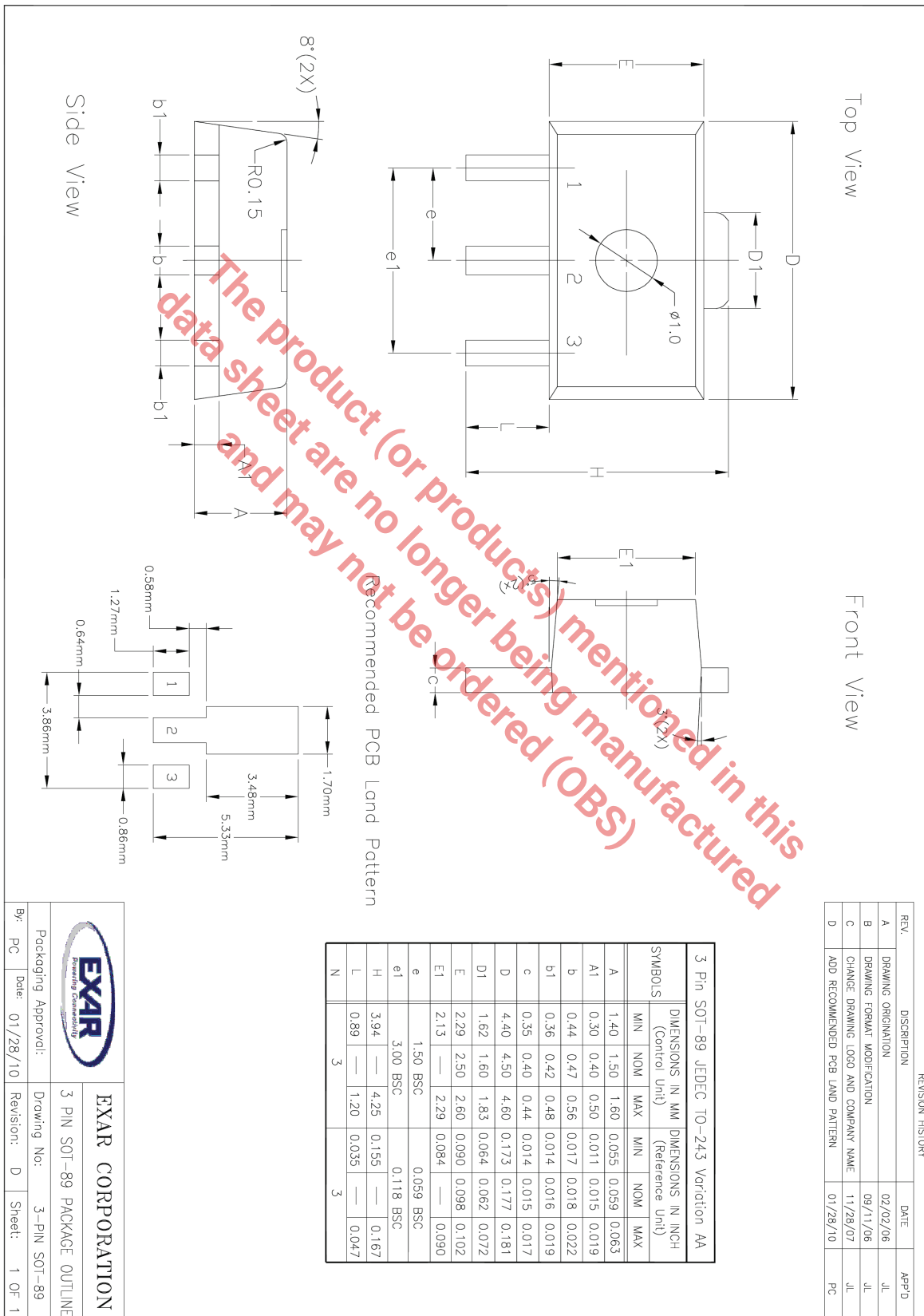
PACKAGE SPECIFICATION

3 PIN TO-92



**PACKAGE SPECIFICATION**

**3 PIN SOT-89**





A New Direction in Mixed-Signal

**SPX431L**

## Precision Adjustable Shunt Regulator

### REVISION HISTORY

| Revision | Date       | Description                                                    |
|----------|------------|----------------------------------------------------------------|
| 2.0.0    | 06/12/2012 | Reformatted Datasheet. Corrected Package Drawing               |
| 2.0.1    | 07/19/2013 | Update package marking information and updated corporate logo. |
|          |            |                                                                |
|          |            |                                                                |

### FOR FURTHER ASSISTANCE

Email:

[customersupport@exar.com](mailto:customersupport@exar.com)

Exar Technical Documentation:

<http://www.exar.com/TechDoc/default.aspx?>



A New Direction in Mixed-Signal

### EXAR CORPORATION

#### HEADQUARTERS AND SALES OFFICES

48720 Kato Road

Fremont, CA 94538 - USA

Tel.: +1 (510) 668-7000

Fax: +1 (510) 668-7030

[www.exar.com](http://www.exar.com)

### NOTICE

EXAR Corporation reserves the right to make changes to the products contained in this publication in order to improve design, performance or reliability. EXAR Corporation assumes no responsibility for the use of any circuits described herein, conveys no license under any patent or other right, and makes no representation that the circuits are free of patent infringement. Charts and schedules contained here in are only for illustration purposes and may vary depending upon a user's specific application. While the information in this publication has been carefully checked; no responsibility, however, is assumed for inaccuracies.

EXAR Corporation does not recommend the use of any of its products in life support applications where the failure or malfunction of the product can reasonably be expected to cause failure of the life support system or to significantly affect its safety or effectiveness. Products are not authorized for use in such applications unless EXAR Corporation receives, in writing, assurances to its satisfaction that: (a) the risk of injury or damage has been minimized; (b) the user assumes all such risks; (c) potential liability of EXAR Corporation is adequately protected under the circumstances.

Reproduction, in part or whole, without the prior written consent of EXAR Corporation is prohibited.