# Precision Adjustable Shunt Regulator

July 2013 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

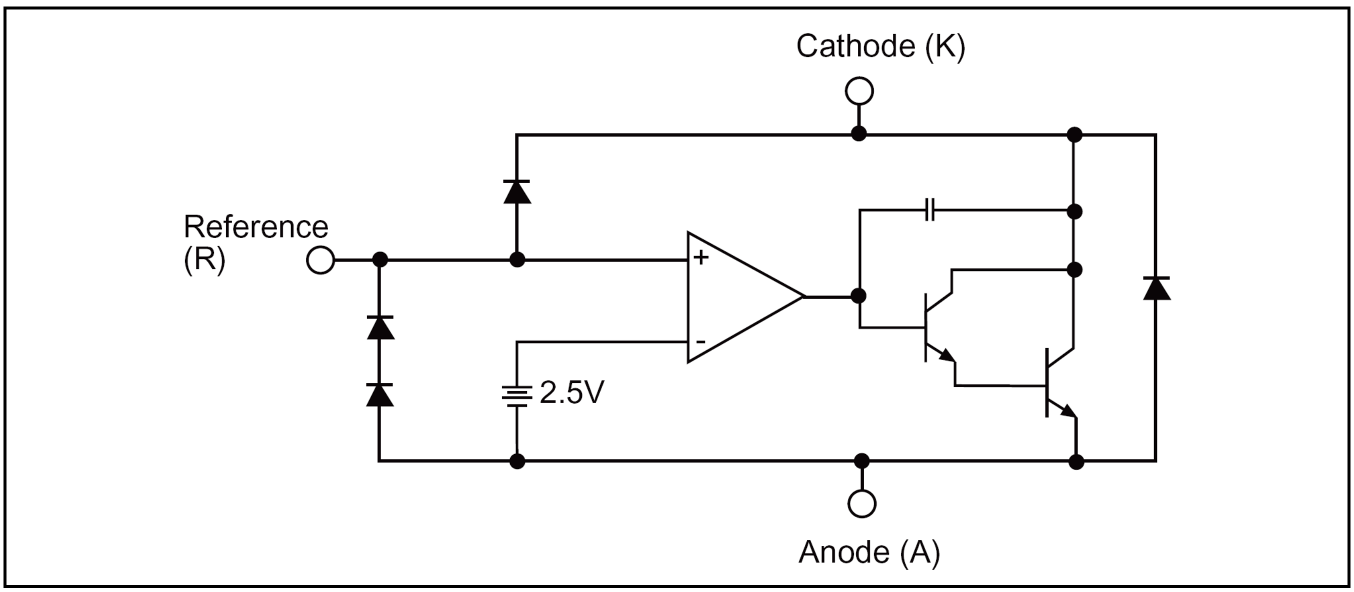



Fig. 1: SPX431L Precision Adjustable Shunt Regulator

## 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, (<10ms) $I_{AK}$ .......... 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
  $0_{JA}$ (TO-92) ...............................................160°C/W
  $0_{JC}$ (TO-92) ............................................... 80°C/W
  Typical Derating (TO-92) ..........................6.3 mW/°C

  $0_{JA}$ (SOT-89) .............................................110°C/W
  $0_{JC}$ (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°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°C, and are provided for reference purposes only. Unless otherwise indicated, $I_K$ = 10mA $V_K$ = $V_{REF}$.

| Parameter | Min. | Typ. | Max. | Units | | Conditions |
|---|---|---|---|---|---|---|
| **SPX431LA** | | | | | | |
| Reference Voltage | 2.490 | 2.503 | 2.515 | V | | |
| ΔVREF withTemp.[1] | | 0.07 | 0.20 | mV/°C | | |
| Ratio of Change in VREF<br>to Cathode Voltage | -2.7<br>-2.0 | -1.0<br>-0.4 | 0.3 | mV/V | | VREF to 10V<br>VREF to 10V |
| Reference Input Current | | 0.7 | 4.0 | µA | | |
| IREF Temp Deviation | | 0.4 | 1.2 | µA | | TJ = 0°C to 105°C |
| Min IK for Regulation | | 0.4 | 1.0 | mA | | |
| Off State Leakage | | 0.04 | 1.0 | µA | | VREF = 0V, VKA = 20V |
| Dynamic Output<br>Impedance | | 0.15 | 0.5 | Ω | | ƒz ≤ 1kHz<br>IK = 1 to 100mA |
| **SPX431L** | | | | | | |
| Reference Voltage | 2.470 | 2.495 | 2.520 | V | | |
| ΔVREF withTemp.[1] | | 0.07 | 0.20 | mV/°C | | |
| Ratio of Change in VREF<br>to Cathode Voltage | -2.7<br>-2.0 | -1.0<br>-0.4 | 0.3 | mV/V | | VREF to 10V<br>VREF to 10V |
| Reference Input Current | | 0.7 | 4.0 | µA | | |
| IREF Temp Deviation | | 0.4 | 1.2 | µA | | TJ = 0°C to 105°C |
| Min IK for Regulation | | 0.4 | 1.0 | mA | | |
| Off State Leakage | | 0.04 | 1.0 | µA | | VREF = 0V, VKA = 20V |
| Dynamic Output<br>Impedance | | 0.15 | 0.5 | Ω | | ƒz ≤ 1kHz<br>IK = 1 to 100mA |
| **SPX431LC** | | | | | | |
| Reference Voltage | 2.445 | 2.495 | 2.520 | V | | |
| ΔVREF withTemp.[1] | | 0.07 | 0.20 | mV/°C | | |
| Ratio of Change in VREF<br>to Cathode Voltage | -2.7<br>-2.0 | -1.0<br>-0.4 | 0.3 | mV/V | | VREF to 10V<br>VREF to 10V |
| Reference Input Current | | 0.7 | 4.0 | µA | | |
| IREF Temp Deviation | | 0.4 | 1.2 | µA | | TJ = 0°C to 105°C |

| 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 | | $f_z \leq$ 1kHz<br>$I_K$ = 1 to 100mA |

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

## PIN ASSIGNMENT

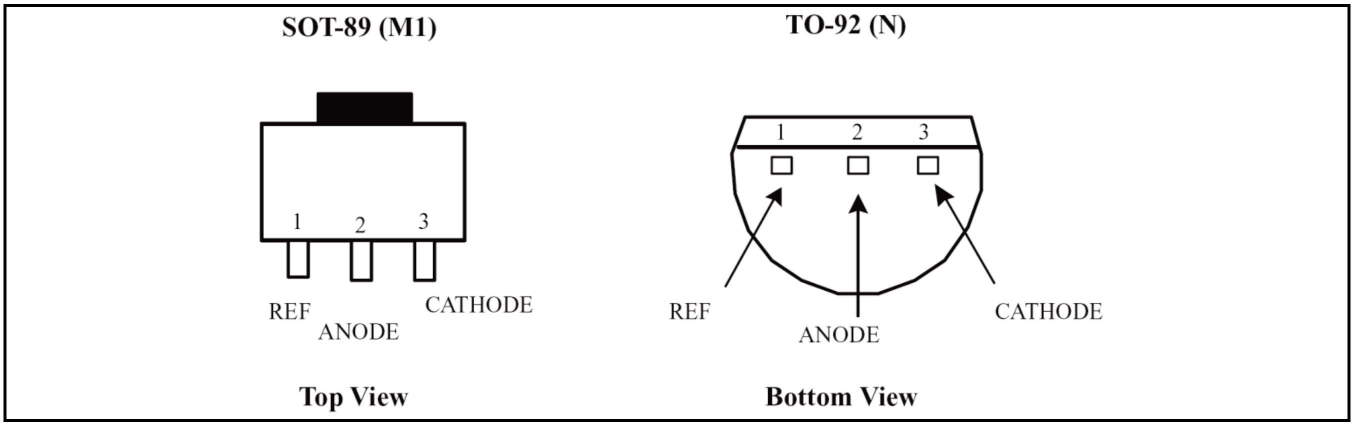



Fig. 2: SPX431L Pin Assignment

## 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>YWWXXX | 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 AA234567)

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.

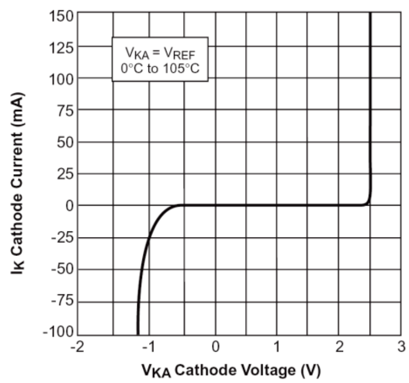



Fig. 3: High Current Operating Characteristics

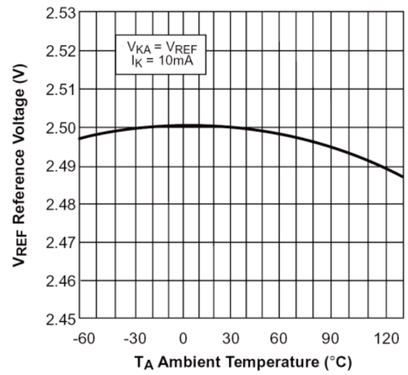



Fig. 4: Reference Voltage VS Ambient Temperature

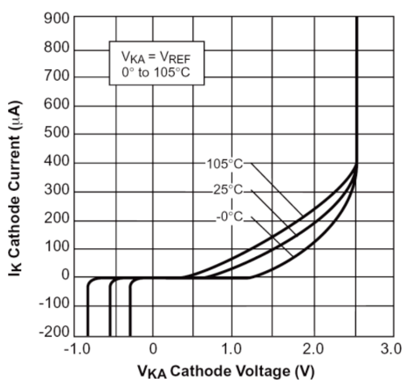



Fig. 5 Low Current Operating Characteristics.

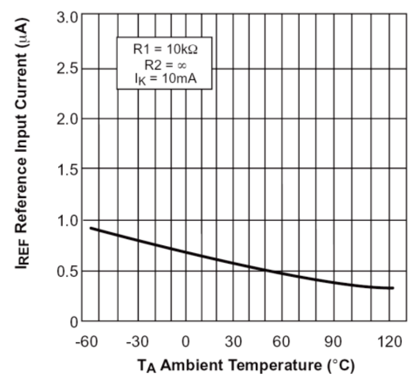



Fig. 6 Reference Input Current VS Ambient Temperature.

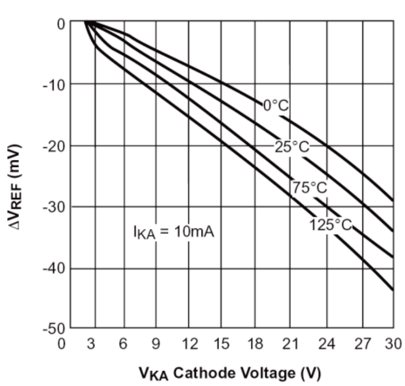



Fig. 7 Reference Voltage Line Regulation VS Cathode Voltage and TAMBIENT

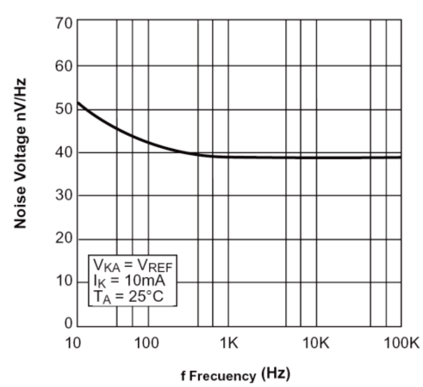



Fig. 8 Noise Voltage VS Frequency

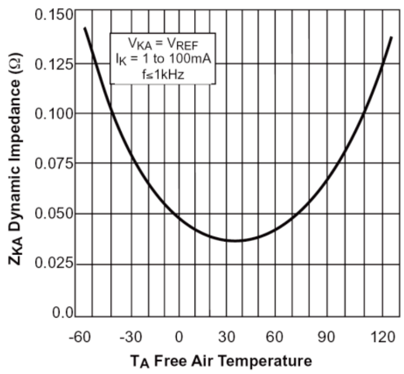



Fig. 9 Low Frequency Dynamic Output Impedance VS $T_{AMBIENT}$

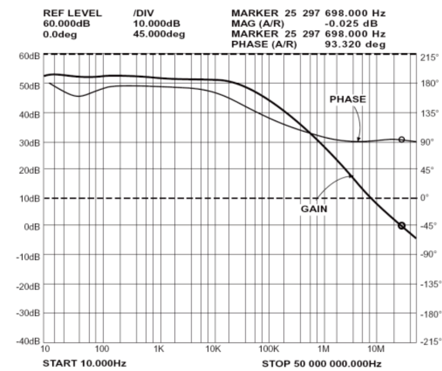



Fig. 10 Small Signal Gain and Phase VS Frequency; $I_K$ = 10mA, $T_A$ = 25°C

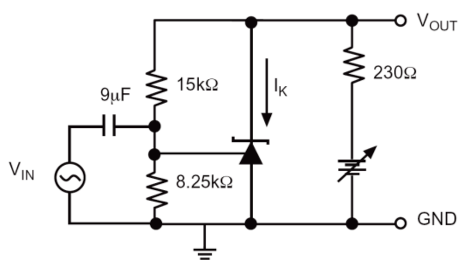



Fig. 11 Test Circuit for Gain and Phase Frequency Response

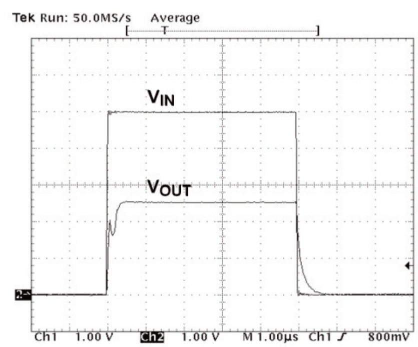



Fig. 2 $F_Z$ = 100kHz, $I_K$ = 10mA, $T_A$ = 25°C

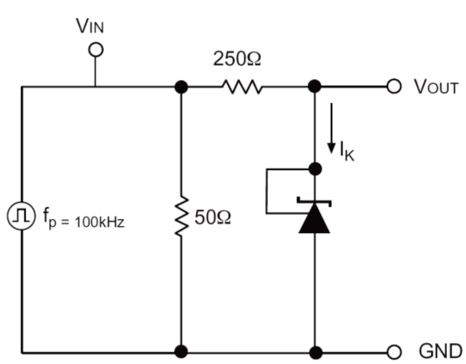



Fig. 33 Test Circuit for Pulse Response

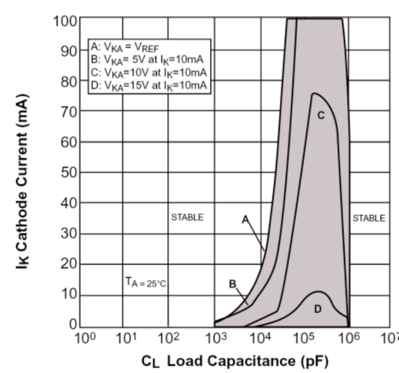



Fig. 44 Stability Boundry Conditions

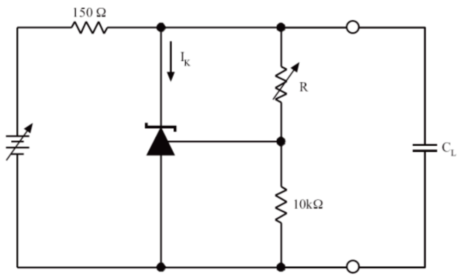



Fig. 55 Test Circuit for Stability

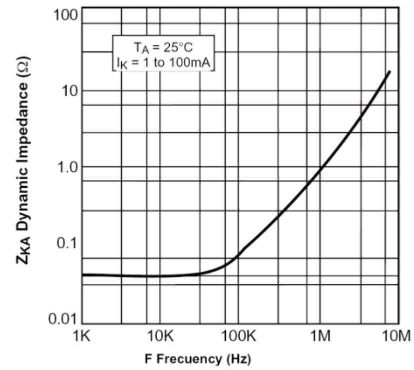



Fig. 66 Dynamic Output Impedance $T_A$ = 25°C, $I_K$ = 1 to 100mA

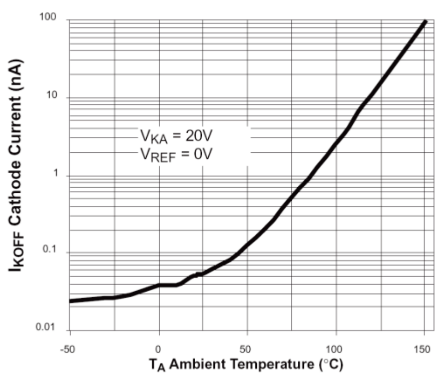



Fig. 77 Off State Leakage

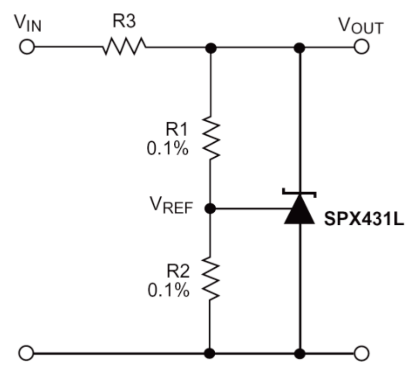



Fig. 88 Shunt Regulator $V_{OUT}$ = (1+R1/R2)$V_{REF}$

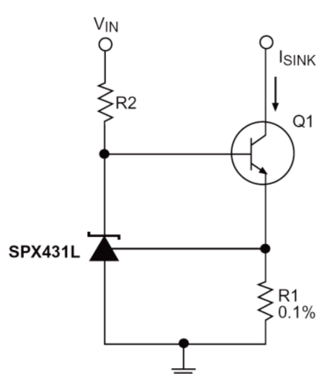



Fig. 199 Constant Current Sink, $I_{SINK}$ = $V_{REF}$/R1

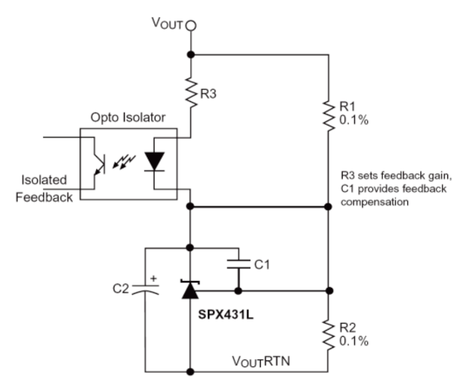



Fig. 100 Reference Amplifier for Isolated Feedback in Off-Line DC-DC Converters

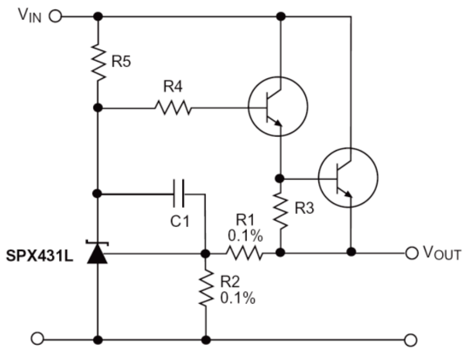



Fig. 111 Precision High Current Series Regulator
$V_{OUT} = (1+R1/R2)V_{REF}$

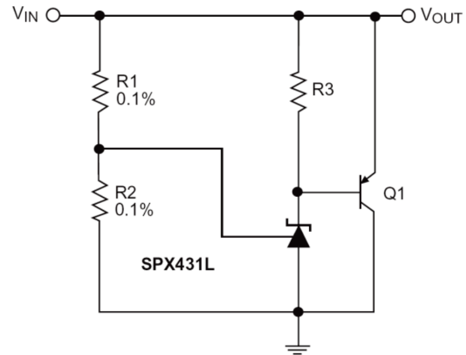



Fig. 122 High Current Shunt regulator
$V_{OUT} = (1+R1/R2)V_{REF}$

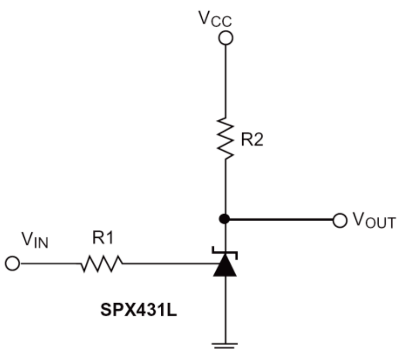
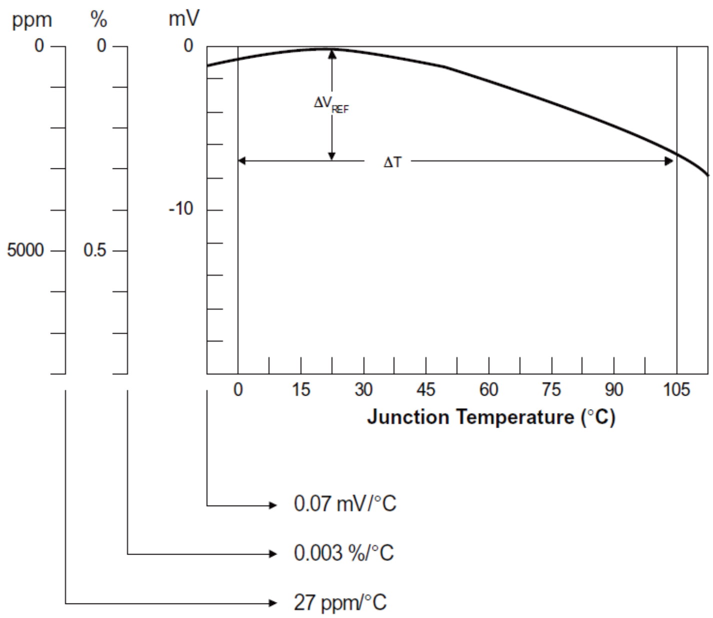



Fig. 133 Single Supply Comparator with Temperature Compensated Threshold. $V_{IN}$ threshold = 2.5V.

## APPLICATION INFORMATION

### CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)




- $\text{TC in mV/°C} = \dfrac{\Delta V_{REF}\ (\text{mV})}{\Delta T_A}$
- $\text{TC in \%/°C} = \dfrac{\left(\dfrac{\Delta V_{REF}}{\Delta V_{REF}\ \text{at } 25°\text{C}}\right) \times 100}{\Delta T_A}$
- $\text{TC in ppm/°C} = \dfrac{\left(\dfrac{\Delta V_{REF}}{\Delta V_{REF}\ \text{at } 25°\text{C}}\right) \times 10^6}{\Delta T_A}$

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

### TEST CIRCUITS

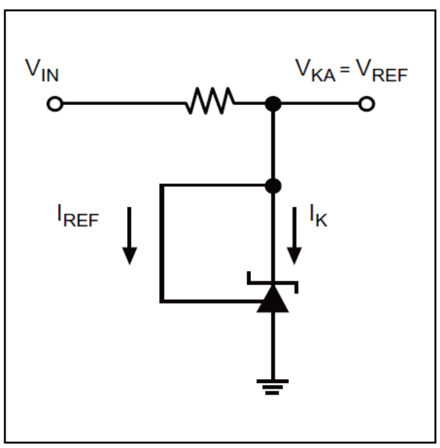



Fig. 25: Test Circuit for $V_{KA} = V_{REF}$

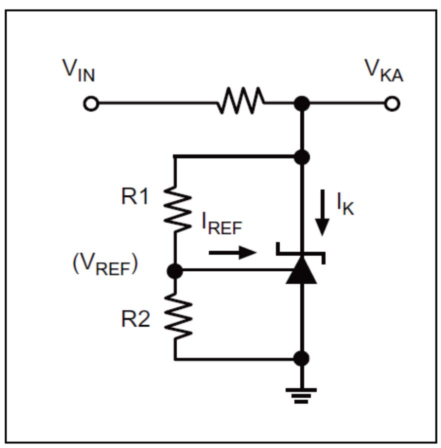



Fig. 26: Test Circuit for $V_{KA} > V_{REF}$

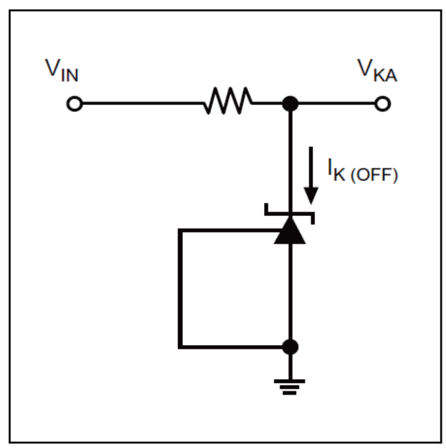
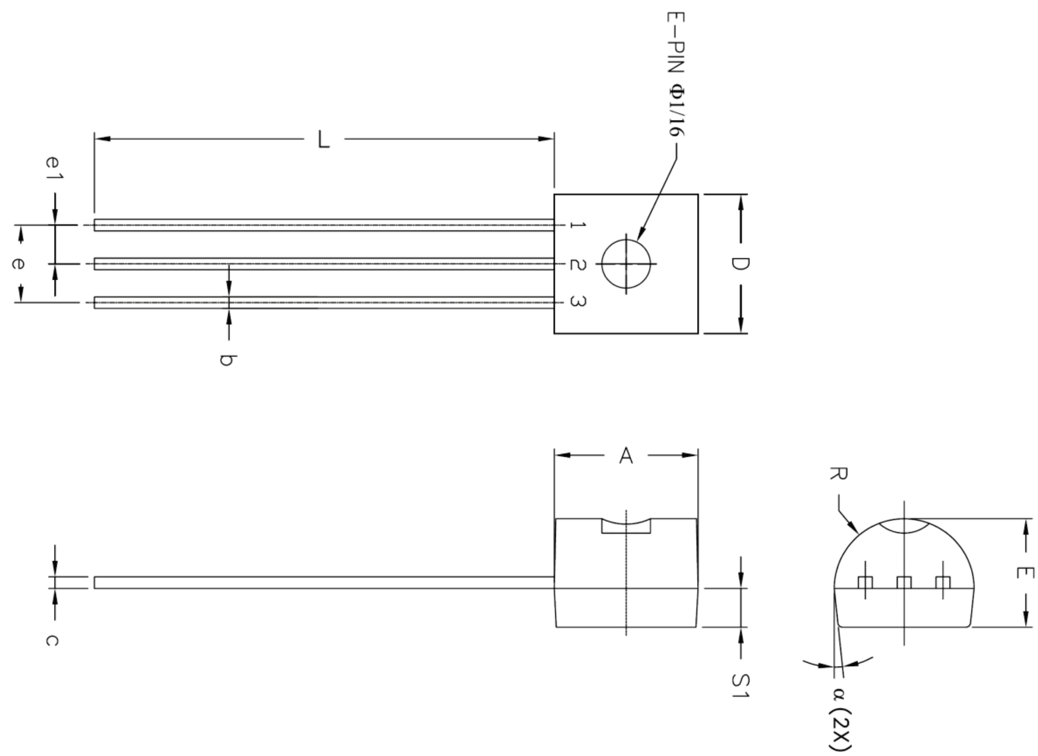



Fig. 27: Test Circuit for $I_{KOFF}$

## PACKAGE SPECIFICATION — 3 PIN TO-92




3 Pin TO-92 (Option 1)* JEDEC TO-226-AA

| SYMBOLS | DIMENSIONS IN INCH (Control Unit) MIN | MAX | DIMENSIONS IN MM (Reference Unit) MIN | MAX |
|---|---|---|---|---|
| A | 0.170 | 0.210 | 4.32 | 5.33 |
| b | 0.014 | 0.020 | 0.36 | 0.51 |
| c | 0.016 | 0.022 | 0.41 | 0.55 |
| D | 0.175 | 0.205 | 4.45 | 5.20 |
| E | 0.125 | 0.165 | 3.18 | 4.19 |
| e | 0.095 | 0.105 | 2.42 | 2.66 |
| e1 | 0.045 | 0.055 | 1.15 | 1.39 |
| L | 0.500 | 0.610 | 12.70 | 15.49 |
| R | 0.045 | 0.095 | 2.16 | 2.41 |
| S1 | 0.045 | 0.060 | 1.14 | 1.52 |
| α | 4° | 6° | 4° | 6° |
| N | 3 | | 3 | |

* Refer to product datasheet for POD option being used

REVISION HISTORY

| REV. | DESCRIPTION | DATE | APP'D |
|---|---|---|---|
| A | DRAWING ORIGINATION | 09/23/05 | JL |
| B | DRAWING FORMAT MODIFICATION | 08/15/06 | JL |
| C | CHANGE DRAWING LOGO AND COMPANY NAME | 11/28/07 | JL |

EXAR CORPORATION

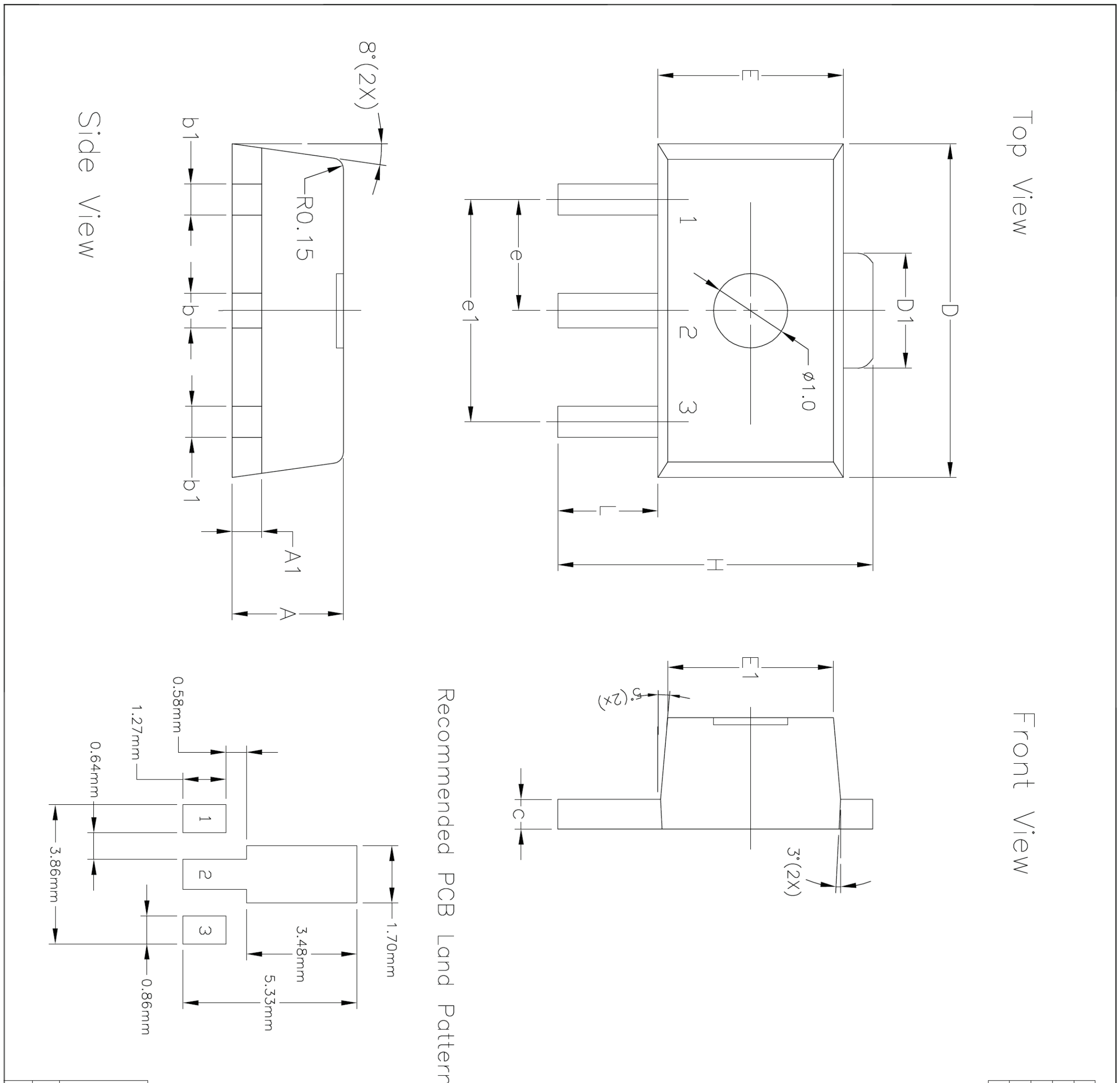
3 PIN TO-92 PACKAGE OUTLINE

Packaging Approval:

Drawing No: 3-PIN TO-92

By: JL | Date: 11/28/07 | Revision: C | Sheet: 1 OF 2

## PACKAGE SPECIFICATION — 3 PIN SOT-89




| 3 Pin SOT-89 JEDEC TO-243 Variation AA | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOLS | DIMENSIONS IN MM (Control Unit) | | | DIMENSIONS IN INCH (Reference Unit) | | |
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 1.40 | 1.50 | 1.60 | 0.055 | 0.059 | 0.063 |
| A1 | 0.30 | 0.40 | 0.50 | 0.011 | 0.015 | 0.019 |
| b | 0.44 | 0.47 | 0.56 | 0.017 | 0.018 | 0.022 |
| b1 | 0.36 | 0.42 | 0.48 | 0.014 | 0.016 | 0.019 |
| c | 0.35 | 0.40 | 0.44 | 0.014 | 0.015 | 0.017 |
| D | 4.40 | 4.50 | 4.60 | 0.173 | 0.177 | 0.181 |
| D1 | 1.62 | 1.60 | 1.83 | 0.064 | 0.062 | 0.072 |
| E | 2.29 | 2.50 | 2.60 | 0.090 | 0.098 | 0.102 |
| E1 | 2.13 | — | 2.29 | 0.084 | — | 0.090 |
| e | | 1.50 BSC | | | 0.059 BSC | |
| e1 | | 3.00 BSC | | | 0.118 BSC | |
| H | 3.94 | — | 4.25 | 0.155 | — | 0.167 |
| L | 0.89 | — | 1.20 | 0.035 | — | 0.047 |
| N | | 3 | | | 3 | |

REVISION HISTORY

| REV. | DISCRIPTION | DATE | APP'D |
|---|---|---|---|
| A | DRAWING ORIGINATION | 02/02/06 | JL |
| B | DRAWING FORMAT MODIFICATION | 09/11/06 | JL |
| C | CHANGE DRAWING LOGO AND COMPANY NAME | 11/28/07 | JL |
| D | ADD RECOMMENDED PCB LAND PATTERN | 01/28/10 | PC |

EXAR Powering Connectivity

EXAR CORPORATION

3 PIN SOT-89 PACKAGE OUTLINE

Packaging Approval: | Drawing No: 3-PIN SOT-89

By: PC | Date: 01/28/10 | Revision: D | Sheet: 1 OF 1

## REVSION 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

Exar Technical Documentation: http://www.exar.com/TechDoc/default.aspx?

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## NOTICE