

## Precision Adjustable Shunt Regulator

### FEATURES

- Trimmed Bandgap to 0.5% and 1.0%
- Wide Operating Current 1mA to 100mA
- Extended Temp. 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

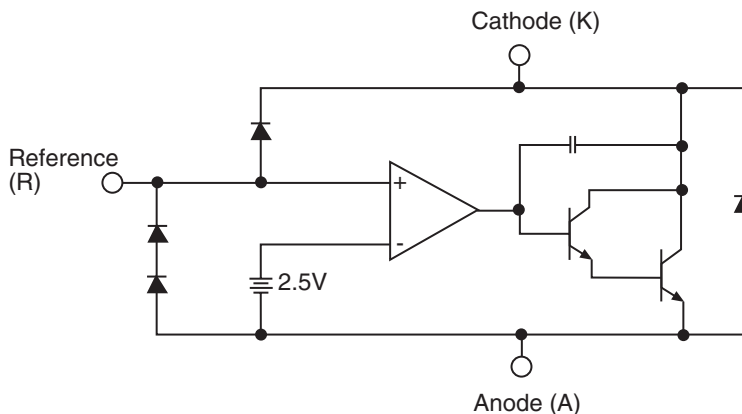
- Battery Operating Equipment
- Adjustable Supplies
- Switching Power Supplies
- Error Amplifiers
- Single Supply Amplifier
- Monitors / VCRs / TVs
- Personal Computers

### 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 line 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 SOT-23-3 package.

### FUNCTIONAL 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 $P_D$<br>SOT-23 ..... | 200 mW        |
| 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 |
|---------|---------------|---------------|------------------|
| SOT-23  | 575°C/W       | 150°C/W       | 1.7 mW/°C        |

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

## 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   | MIN            | TYP   | MAX   | UNITS |
|---|-------------------------------------|--------|---|-----------------|-------|-------|----------------|-------|-------|-------|
|   |                                     |        |   | <b>SPX2431A</b> |       |       | <b>SPX2431</b> |       |       |       |
| Reference Voltage                               | $V_{REF}$                           | 2      | $T_J = 0^\circ\text{C to } 105^\circ\text{C}$ | 2.487           | 2.500 | 2.513 | 2.474          | 2.500 | 2.526 | V     |
|   |                                     | 2      |   | 2.480           |       | 2.520 | 2.460          |       | 2.540 | 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<br>10V to 20V                | -2.7            | -1.01 | 0.3   | -2.7           | -1.01 | 0.3   | mV/V  |
|   |                                     |        |   | -2.0            | -0.4  |       | -2.0           | -0.4  |       |       |
| 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      | $V_{REF} = 0V,$<br>$V_{KA} = 20V$             |                 | 0.04  |       |                | 0.04  | 500   | nA    |
| Dynamic Output Impedance                        | $Z_{KA}$                            | 2      | $f_z \leq 1\text{kHz}$<br>$I_K = 1$ to 100mA  |                 | 0.15  | 0.5   |                | 0.15  | 0.5   | Ω     |

## CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)

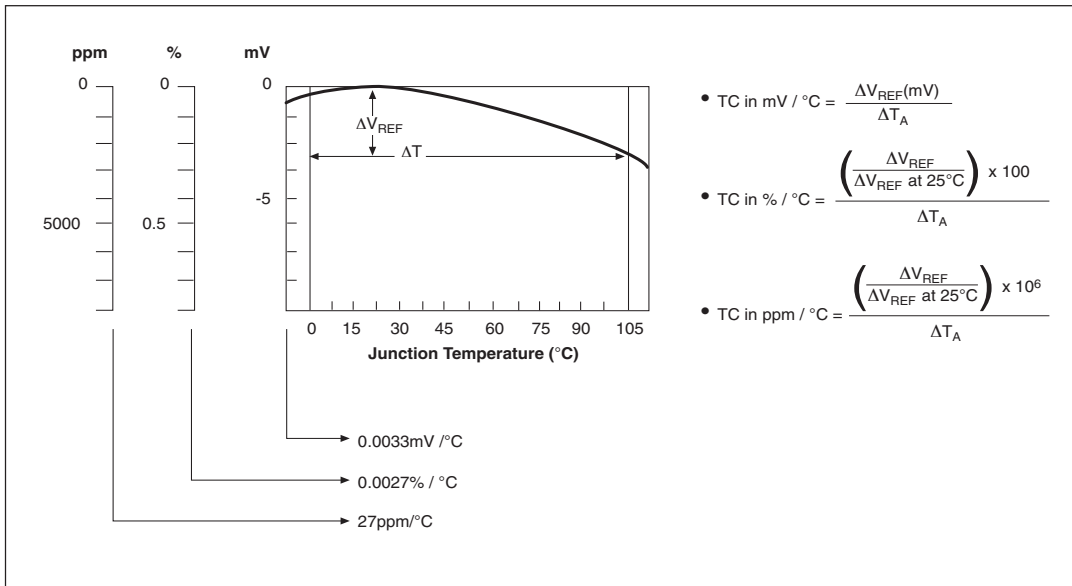


Figure 1.  $V_{REF}$  VS Temperature

## TEST CIRCUITS

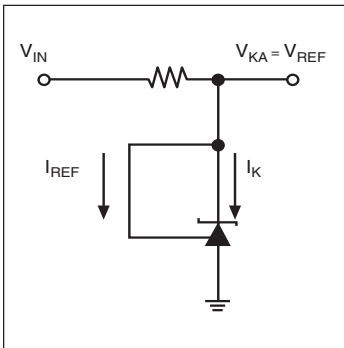


Figure 2. Test Circuit for  $V_{KA} = V_{REF}$

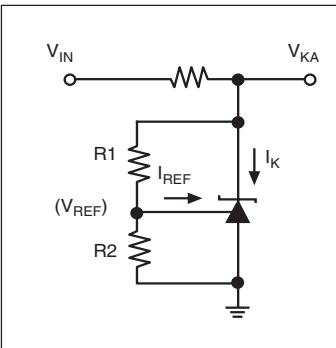


Figure 3. Test Circuit for  $V_{KA} > V_{REF}$

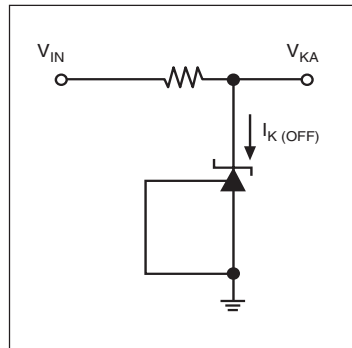


Figure 4. Test Circuit for  $I_{KOFF}$

# TYPICAL PERFORMANCE CHARACTERISTICS

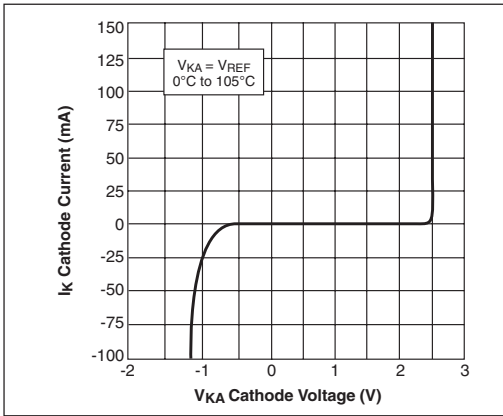


Figure 5. High Current Operating Characteristics

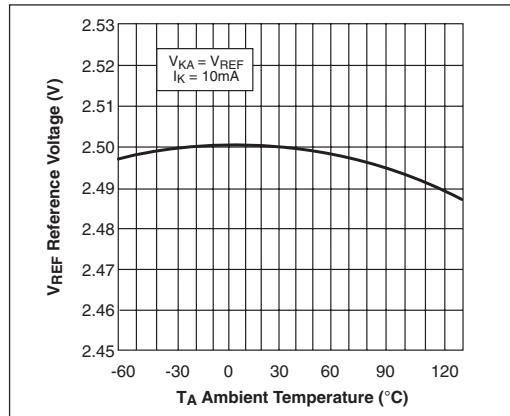


Figure 6. Reference Voltage VS Ambient Temperature

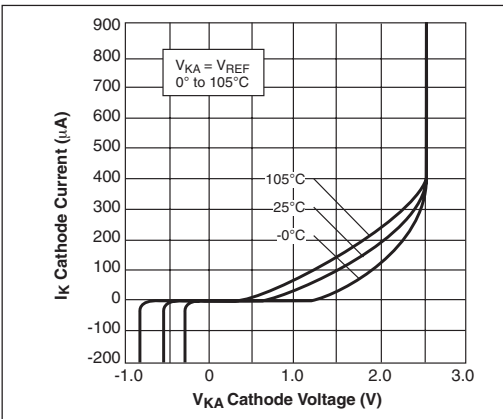


Figure 7. Low Current Operating Characteristics

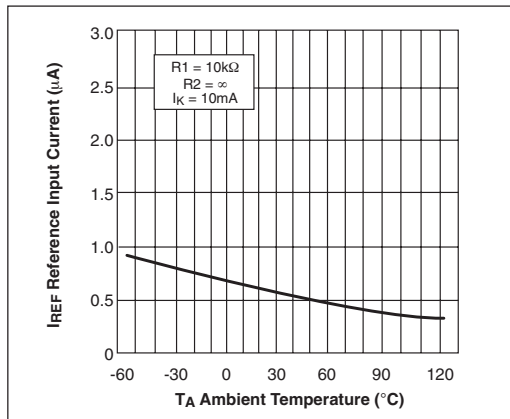


Figure 8. Reference Input Current VS Ambient Temperature

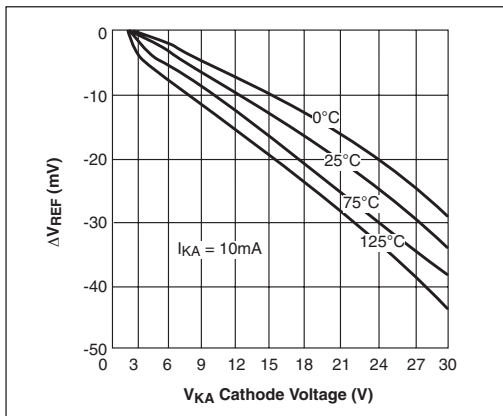


Figure 9. Reference Voltage Line Regulation VS Cathode Voltage and  $T_{AMBIENT}$

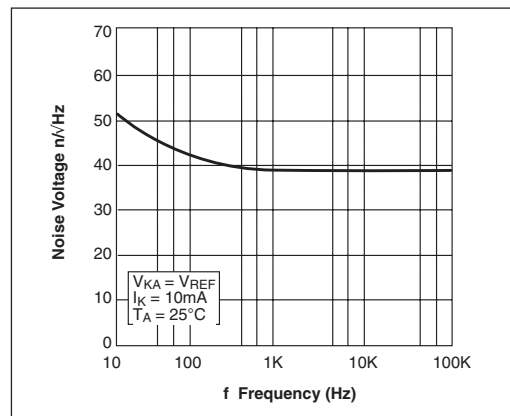


Figure 10. Noise Voltage VS Frequency

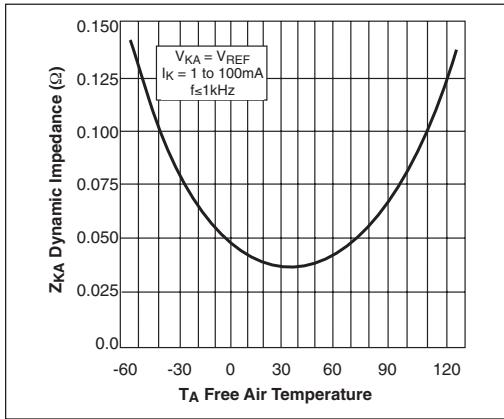


Figure 11. Low Frequency Dynamic Output Impedance VS  $T_{AMBIENT}$

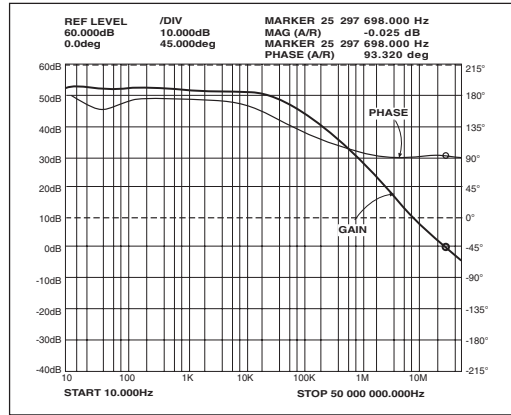


Figure 12. Small Signal Gain and Phase VS Frequency;  $I_K = 10mA$ ,  $T_A = 25^\circ C$

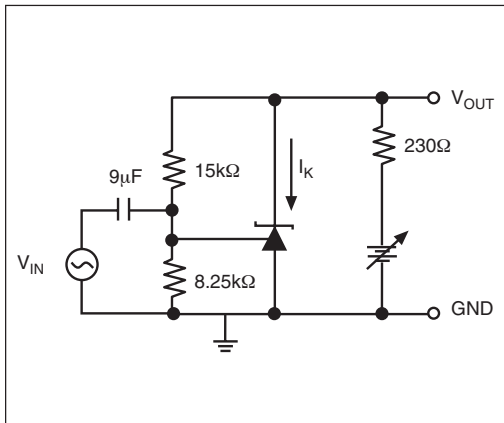


Figure 13. Test Circuit for Gain and Phase Frequency Response

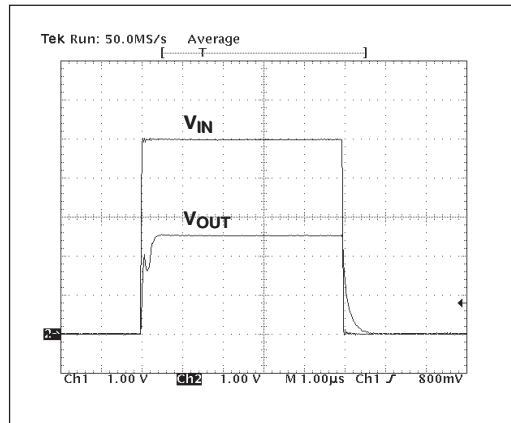


Figure 14. Frequency = 100kHz,  $I_K = 10mA$ ,  $T_A = 25^\circ C$

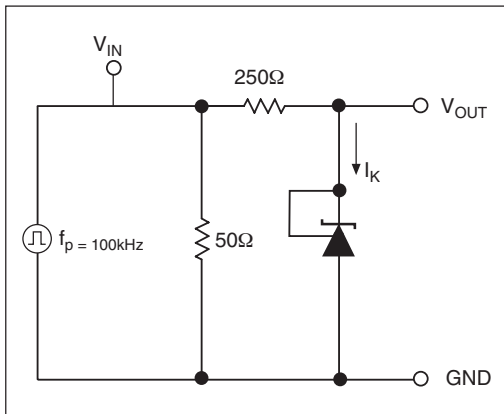


Figure 15. Test Circuit for Pulse Response

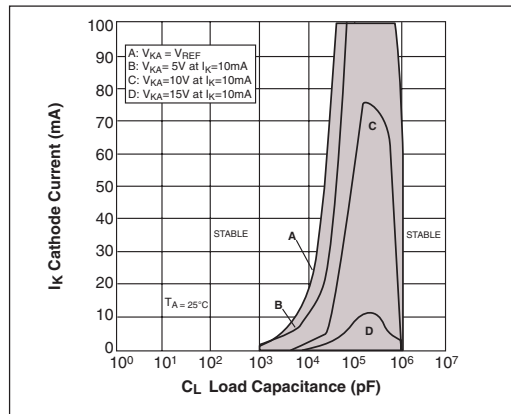


Figure 16. Stability Boundary Conditions

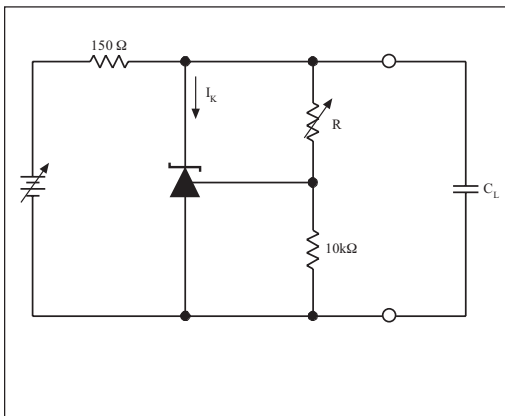


Figure 17. Test Circuit for Stability

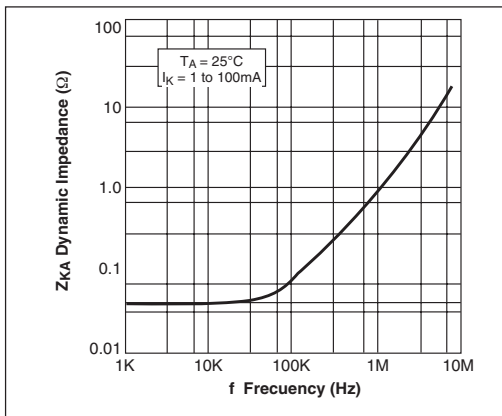


Figure 18. Dynamic Output Impedance  $T_A = 25^\circ\text{C}$ ,  $I_k = 1$  to  $100\text{mA}$

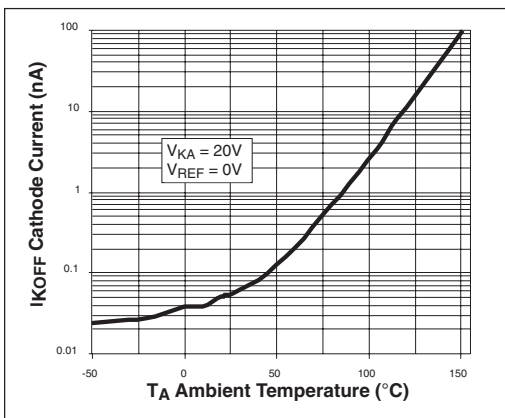


Figure 19. Off State Leakage

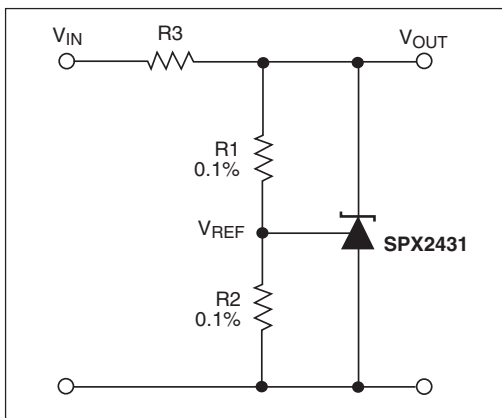


Figure 20. Shunt Regulator  $V_{OUT} = (1+R1/R2)V_{REF}$

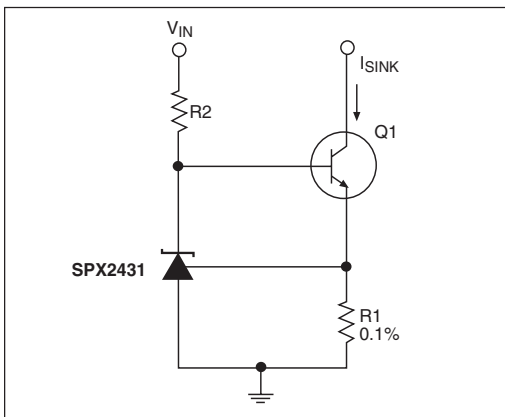


Figure 21. Constant Current, Sink,  $I_{SINK} = V_{REF}/R1$

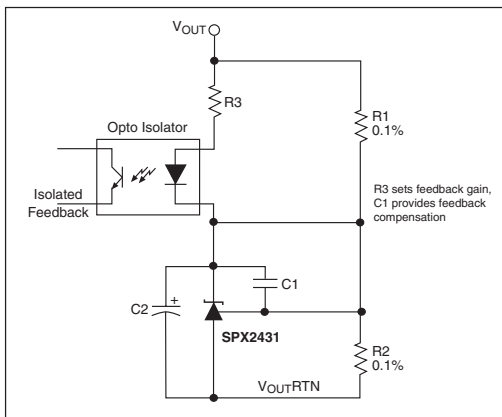


Figure 22. Reference Amplifier for Isolated Feedback in Off-Line DC-DC Converters

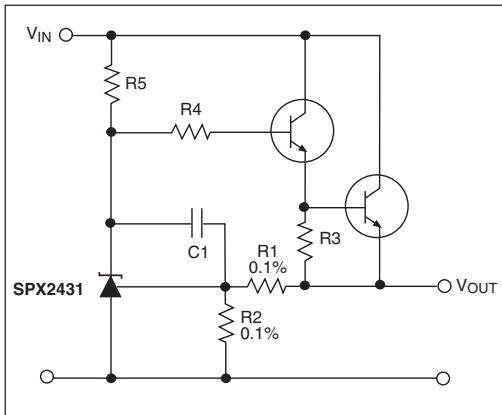


Figure 23. Precision High Current Series Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

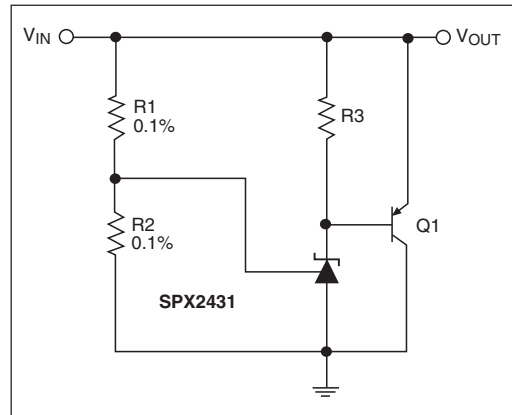


Figure 24. High Current Shunt Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

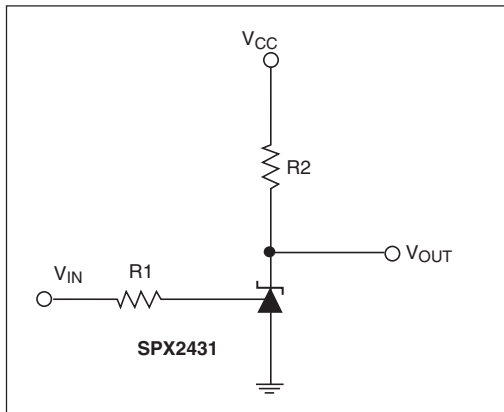
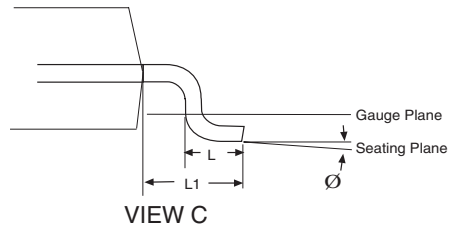
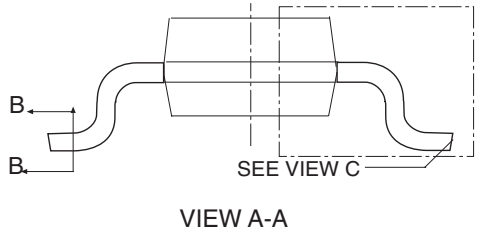
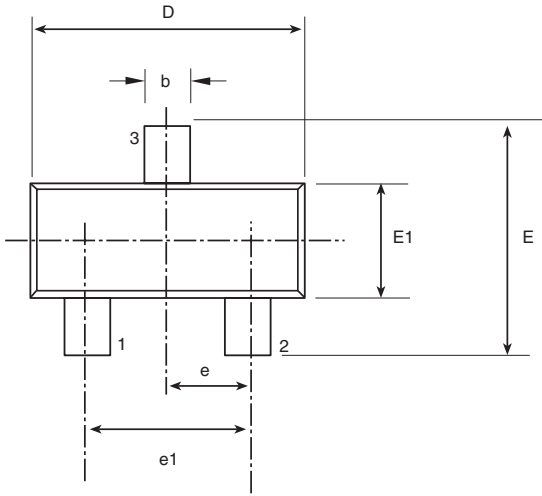
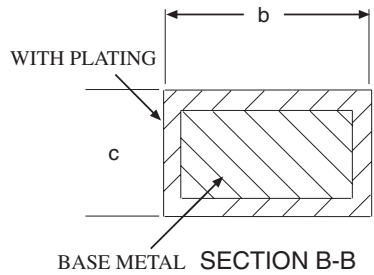
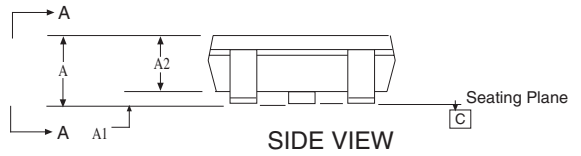


Figure 25. Single Supply Comparator with Temperature Compensated Threshold.  $V_{IN}$  Threshold = 2.5V

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



| 3 PIN SOT-23<br>JEDEC TO-236<br>(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**



| <b>PART NUMBER</b> | <b>ACC</b> | <b>OUTPUT VOLTAGE</b> | <b>PACKAGES</b> |
|--------------------|------------|-----------------------|-----------------|
| SPX2431AM .....    | 0.5% ..... | 2.5V .....            | 3 Pin SOT-23    |
| SPX2431AM/TR ..... | 0.5% ..... | 2.5V .....            | 3 Pin SOT-23    |
| SPX2431M .....     | 1.0% ..... | 2.5V .....            | 3 Pin SOT-23    |
| SPX2431M/TR .....  | 1.0% ..... | 2.5V .....            | 3 Pin SOT-23    |

/TR = Tape and Reel

Pack quantity is 2,500 for SOT-23.



ANALOG EXCELLENCE

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