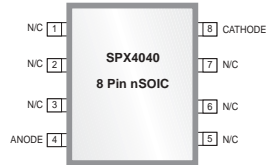


## Precision Micropower 2.5V Shunt Voltage Reference

### FEATURES

- Trimmed Bandgap to 0.5% and 1%
- Wide Operating Current 160 $\mu$ A to 15mA
- Extended Temperature Range: -40 $^{\circ}$ C to 85 $^{\circ}$ C
- Low Temperature Coefficient 100 ppm/ $^{\circ}$ C
- Replacement in for LM4040



*Now Available in Lead Free Packaging*

### APPLICATIONS

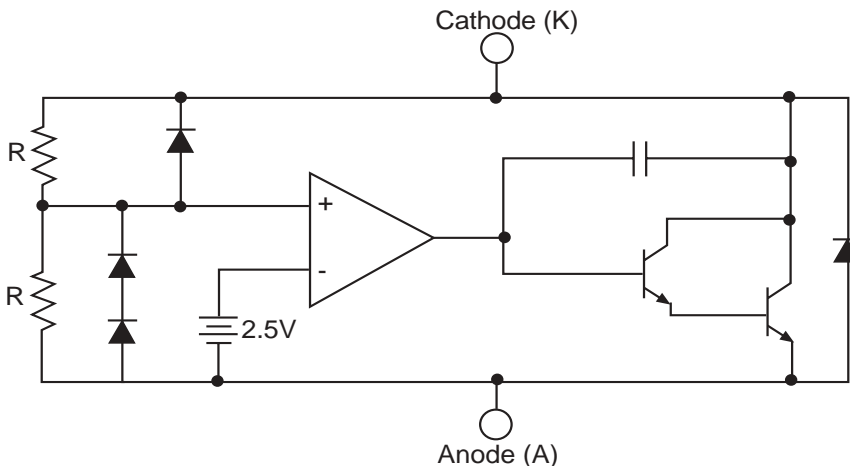
- Battery Operating Equipment
- Adjustable Supplies
- Switching Power Supplies
- Error Amplifiers
- Single Supply Amplifier
- Monitors / VCRs / TVs
- Personal Computers

### DESCRIPTION

The SPX4040 is a 2-terminal, temperature compensated, bandgap voltage reference that provides a fixed 2.5V output for input currents between 160 $\mu$ A and 15mA. The bandgap voltage (2.5V) is independently trimmed from the output voltage to achieve a very low temperature coefficient. This trimming technique gives a stable device over the full temperature range (100ppm/ $^{\circ}$ C).

The SPX4040 is available in 3 pin TO-92, 3 SOT-23 and 8 pin NSOIC packages. The operating temperature range is -40 $^{\circ}$ C to 85 $^{\circ}$ C. The SPX4040 advanced design eliminates the need for an external stabilizing capacitor while ensuring stability with any capacitive load, making it easy to use.

### TYPICAL APPLICATIONS CIRCUIT



## ABSOLUTE MAXIMUM RATINGS

|   |               |
|---|---------------|
| Anode-Cathode Forward Current, (<10ms) $I_{AK}$ ..... | 10mA          |
| Anode-Cathode Reverse Current $I_{KA}$ .....          | 20mA          |
| Continuous Power Dissipation at 25°C $P_D$            |               |
| TO-92 .....   | 550mW         |
| SOT-23 .....  | 300 mW        |
| SOIC-8 .....  | 525mW         |
| Junction Temperature $T_J$ .....                      | 150 °C        |
| Storage Temperature $T_{STG}$ .....                   | -65 to 150 °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.

## 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        |

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

## ELECTRICAL CHARACTERISTICS

Electrical characteristics at  $I_N = 1000\mu A$  and  $T_A = +25^\circ C$  unless otherwise specified.

| PARAMETERS                  | CONDITIONS   | SPX4040A-2.5 |       |                      | SPX4040-2.5 |       |                      | UNITS       |
|-----------------------------|--|--------------|-------|----------------------|-------------|-------|----------------------|-------------|
|                             |  | MIN          | TYP   | MAX                  | MIN         | TYP   | MAX                  |             |
| Reverse Breakdown Voltage   | $I_R = 500 \mu A$                                    | 2.4875       | 2.500 | 2.5125               | 2.475       | 2.500 | 2.525                | V           |
| Reverse Breakdown Tolerance | $I_R = 500\mu A$<br>$-40^\circ C < T_A < 85^\circ C$ |              |       | $\pm 12$<br>$\pm 29$ |             |       | $\pm 25$<br>$\pm 49$ | mV<br>mV    |
| Output Impedance            |  |              | 0.60  | 0.8                  |             | 0.60  | 0.8                  | $\Omega$    |
| Noise Voltage               | $0.1KHz \leq f \leq 10Hz$                            |              | 15    |                      |             | 15    |                      | $\mu V$ p-p |
| Tempco                      | Note 1   |              |       | 100                  |             |       | 100                  | ppm/°C      |
| Turn-on Setting             | 1.0% of $V_{OUT}$                                    |              | 30    |                      |             | 30    |                      | $\mu Sec$   |
| Operating Current Range     | Note 2   | 0.16         |       | 15                   | 0.16        |       | 15                   | mA          |
| Temp. Range (ambient)       |  | -40          |       | 85                   | -40         |       | 85                   | °C          |

Notes:

1. Three-point measurement guarantees the error band over the specified temperature range.
2. Optimum performance is obtained at current below 1000 $\mu A$ .

## CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)

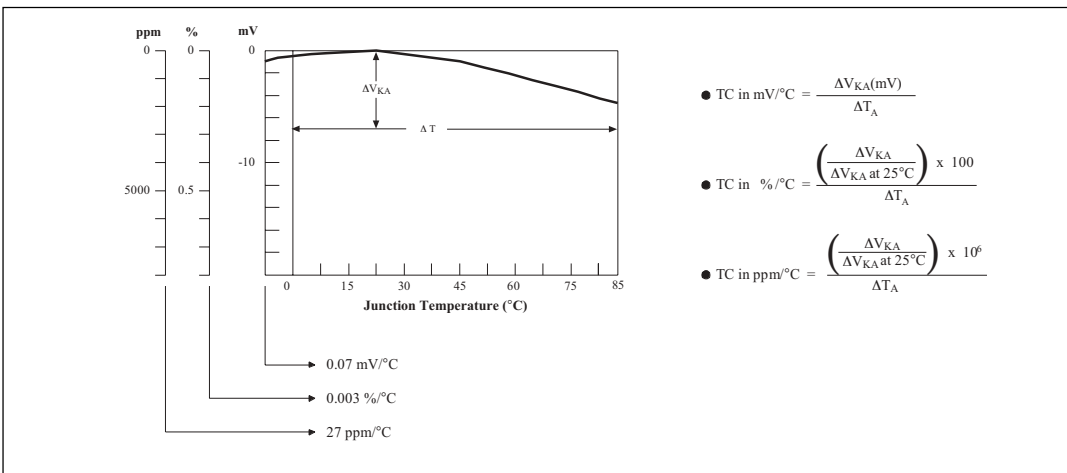


Figure 1.  $V_{KA}$  VS Temperature.

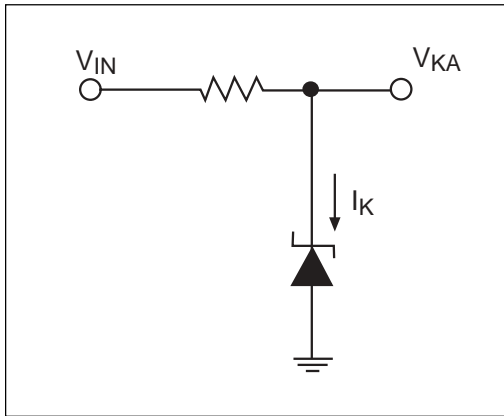


Figure 2. Test Circuit for  $I_{K REVERSE}$ ,  $V_{KA} = 2.5V$

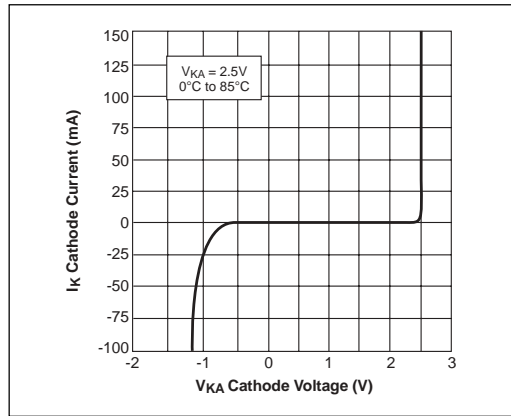


Figure 3. High Current Operating Characteristics

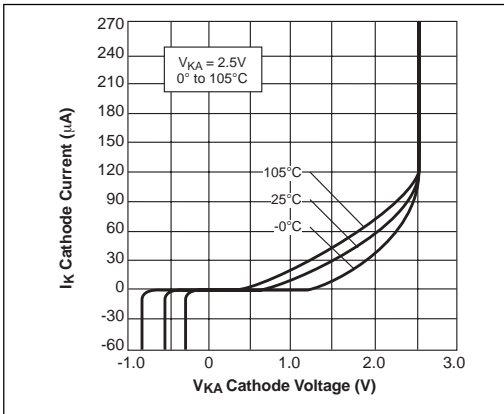


Figure 4. Low Current Operating Characteristics

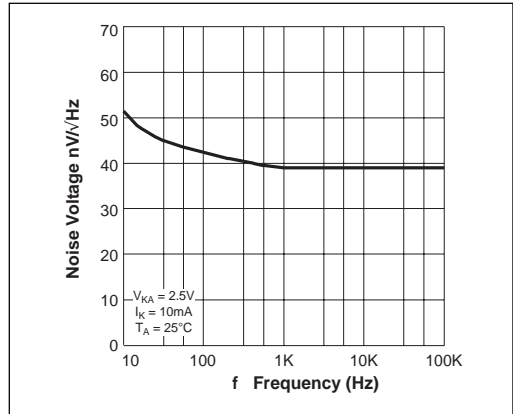


Figure 5. Noise Voltage VS Frequency

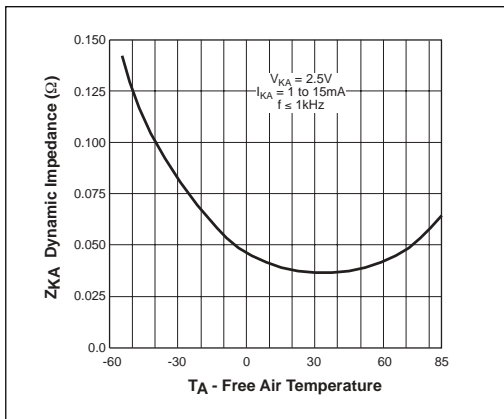


Figure 6. Low Frequency Dynamic Output Impedance VS.  $T_{AMBIENT}$

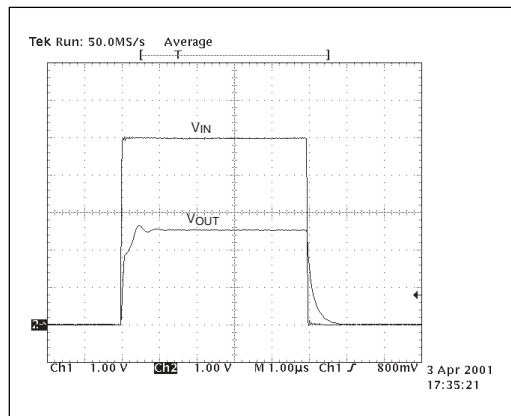


Figure 7. Frequency = 100kHz,  $I_K = 10mA$ ,  $T_A = 25°C$

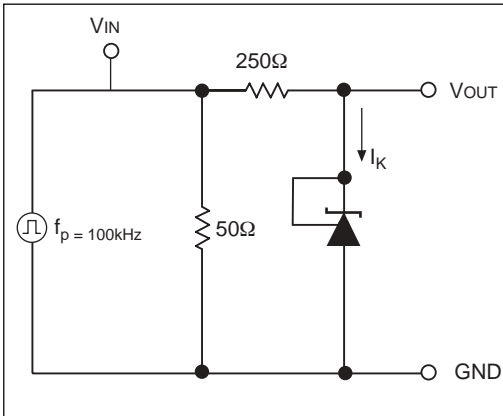


Figure 8. Test Circuit for Pulse Response

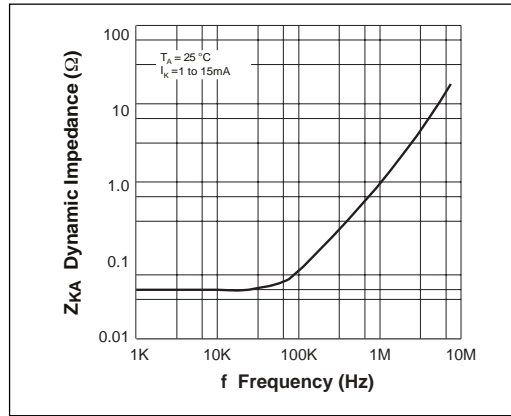


Figure 9. Dynamic Output Impedance  $T_A = 25^\circ\text{C}$ ,  $I_K = 1$  to  $15\text{mA}$

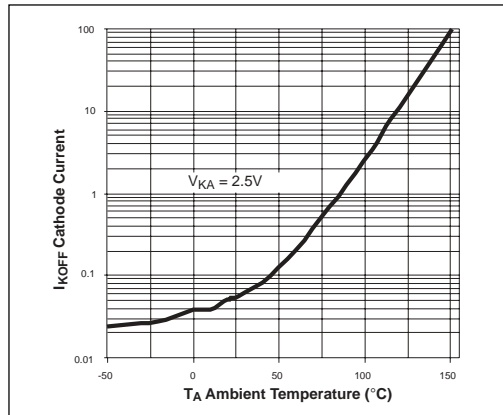


Figure 10. Off State Leakage

## APPLICATION INFORMATION

This device is designed for stable operation and has no need of an external capacitor between pins 4 and 8. The reference remains stable if a bypass capacitor is used.

### SOT-23

The SPX4040 in the SOT-23 package has a parasitic Schottky diode between pin 3 and pin 1. Pin 1 of SOT-23 must float or be connected to pin 3.

### Conventional Shunt Regulator

In a conventional shunt regulator application (see Figure 11), an external series resistor ( $R_S$ ) is connected between the supply voltage and the

SPX4040.  $R_S$  determines the current that flows through the load ( $I_L$ ) and the reference ( $I_Q$ ). Since load current and supply voltage may vary,  $R_S$  should be small enough to supply at least the minimum acceptable  $I_Q$  to the reference even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and  $I_L$  is at its minimum,  $R_S$  should be large enough so that the current flowing through the SPX4040 is less than 15mA.

$R_S$  is determined by the supply voltage ( $V_S$ ), the load and operating current ( $I_L$  and  $I_Q$ ), reference's reverse breakdown voltage ( $V_R$ ).

$$R_S = (V_S - V_R) / (I_L + I_Q)$$

## TYPICAL PERFORMANCE CHARACTERISTICS

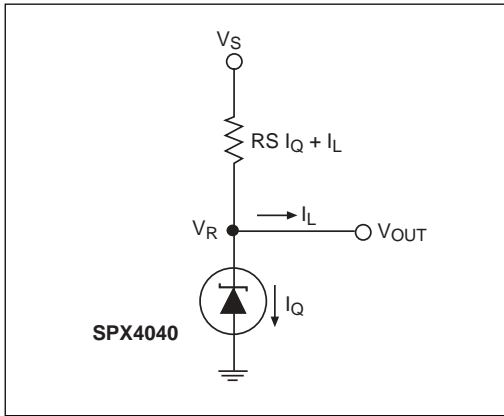


Figure 11. SPX4040 Fixed Shunt Regulator Application

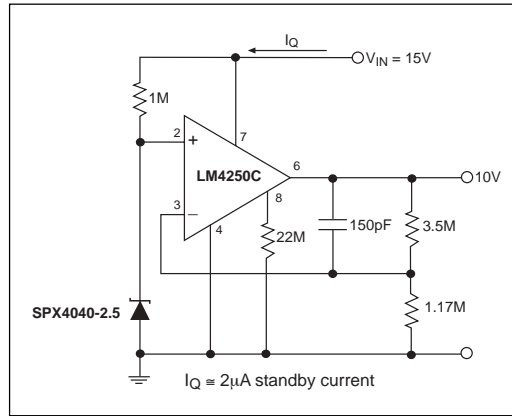


Figure 12. Micropower 10V Reference

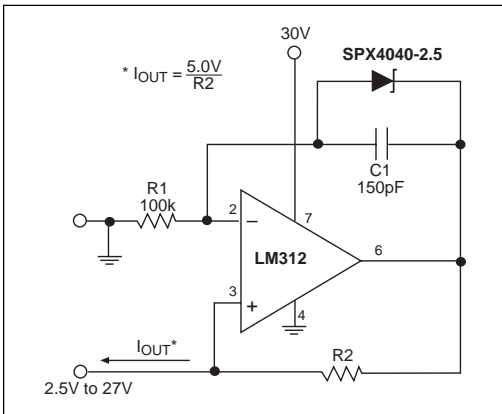


Figure 13. Precision 1µA to mA Current Source

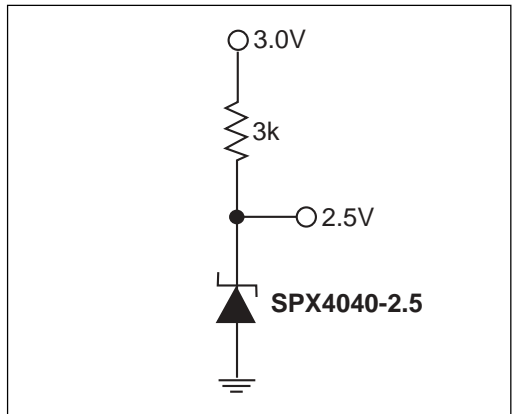


Figure 14. Reference from 3.0V Battery

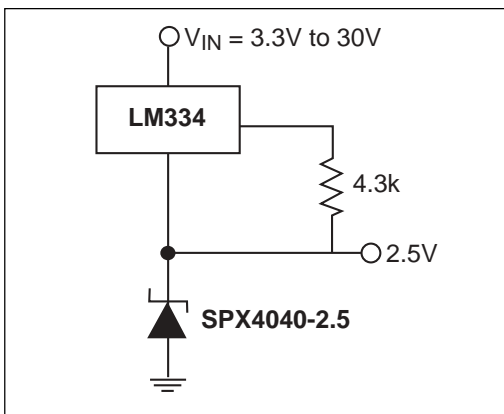
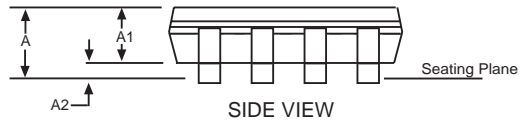
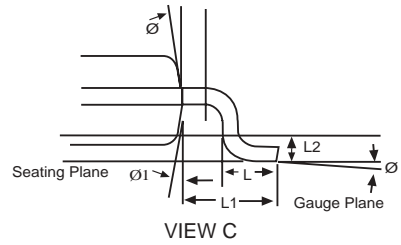
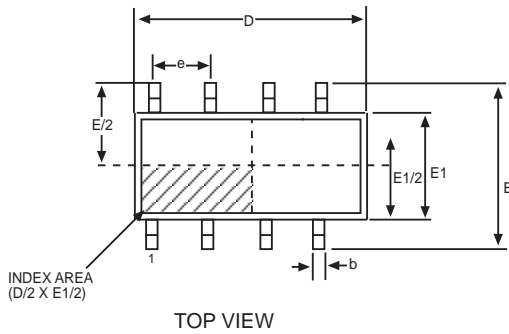
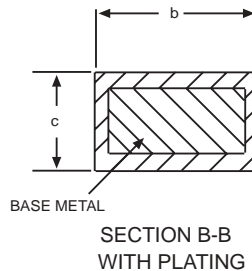
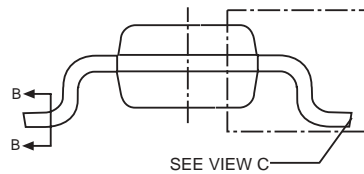


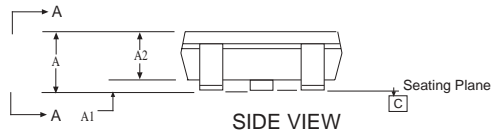
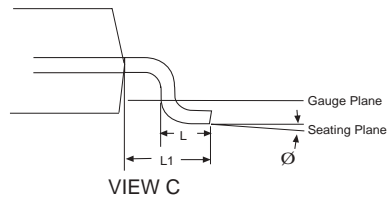
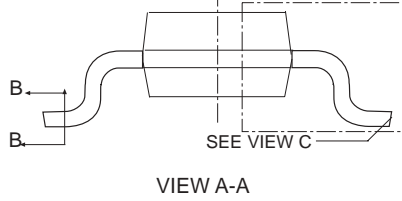
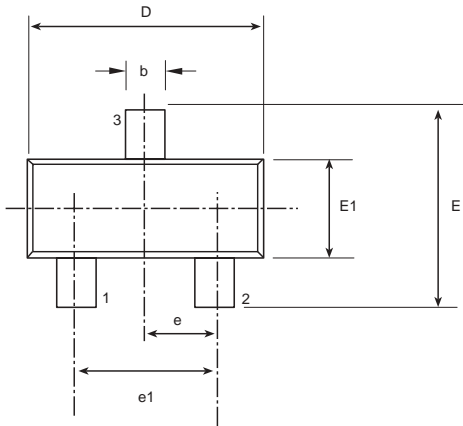
Figure 15. Wide Input Range Reference



| 8 Pin NSOIC JEDEC MO-012 (AA) Variation |          |     |      |
|---|----------|-----|------|
| SYMBOL                                  | MIN      | NOM | MAX  |
| A                                       | 1.35     | -   | 1.75 |
| A1                                      | 0.1      | -   | 0.25 |
| A2                                      | 1.25     | -   | 1.65 |
| b                                       | 0.31     | -   | 0.51 |
| c                                       | 0.17     | -   | 0.24 |
| D                                       | 4.90 BSC |     |      |
| E                                       | 6.00 BSC |     |      |
| E1                                      | 3.90 BSC |     |      |
| e                                       | 1.27 BSC |     |      |
| L                                       | 0.4      | -   | 1.27 |
| L1                                      | 1.04 REF |     |      |
| L2                                      | 0.25 BSC |     |      |
| ø                                       | 0°       | -   | 8°   |
| ø1                                      | 5°       | -   | 15°  |

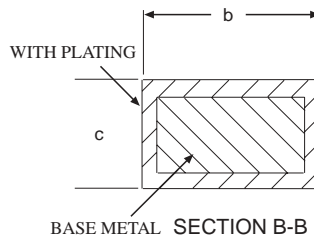
Note: Dimensions in (mm)

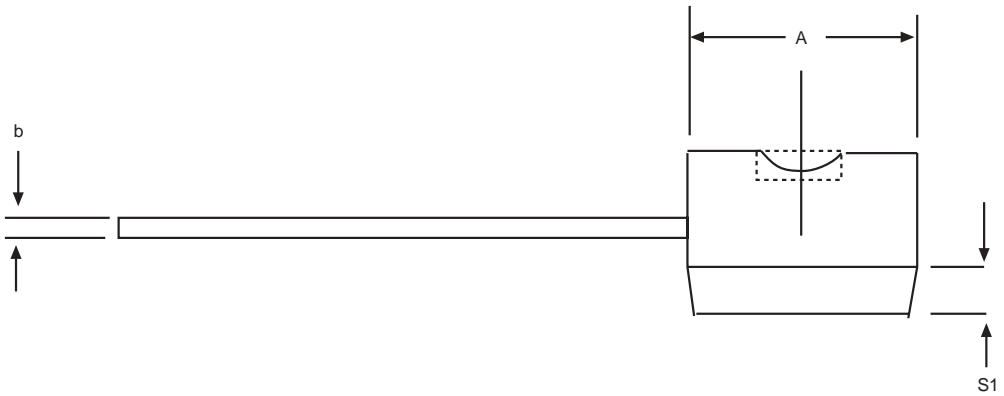
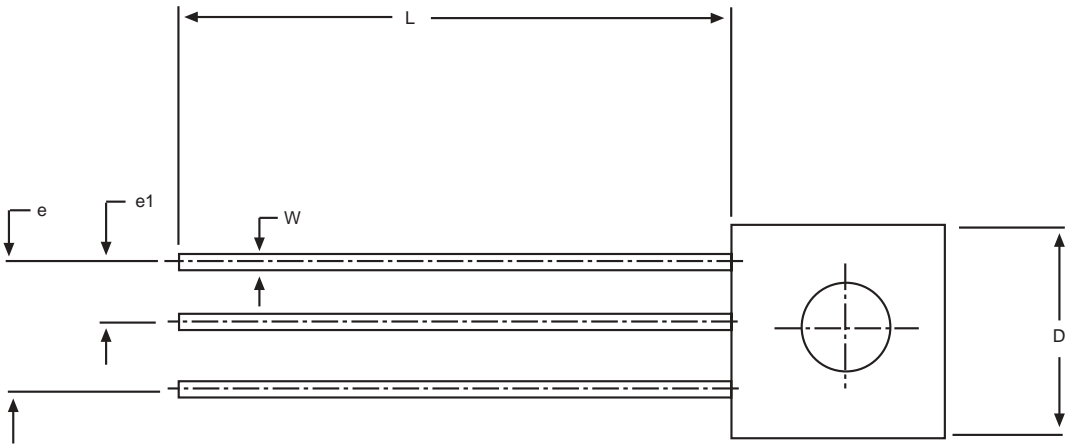




| 3 Pin SOT-23 JEDEC TO-236 (AB) Variation |          |      |      |
|--|----------|------|------|
| SYMBOL                                   | MIN      | NOM  | MAX  |
| A  | 0.89     | -    | 1.12 |
| A1                                       | 0.01     | -    | 0.1  |
| A2                                       | 0.88     | 0.95 | 1.02 |
| b  | 0.3      | -    | 0.5  |
| c  | 0.08     | -    | 0.2  |
| D  | 2.8      | 2.9  | 3.04 |
| e  | 0.95 BSC |      |      |
| e1                                       | 1.90 BSC |      |      |
| E  | 0.95     | -    | 2.64 |
| E1                                       | 1.2      | 1.3  | 1.4  |
| L  | 0.4      | 0.5  | 0.6  |
| L1                                       | 0.54 REF |      |      |
| Ø  | 0°       | -    | 8°   |

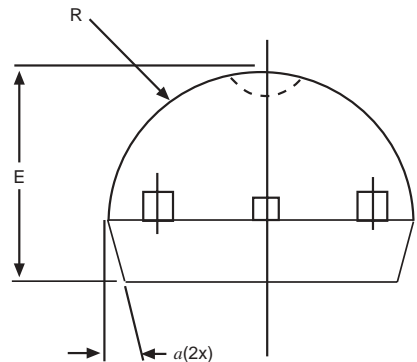
Note: Dimensions in (mm)



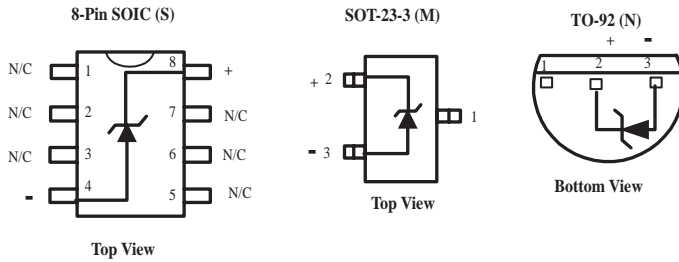


| 3 Pin TO-92 |       |     |       |
|-------------|-------|-----|-------|
| SYMBOL      | MIN   | NOM | MAX   |
| A           | 0.17  | -   | 0.195 |
| b           | 0.014 | -   | 0.02  |
| E           | 0.13  | -   | 0.155 |
| e           | 0.95  | -   | 0.105 |
| e1          | 0.045 | -   | 0.055 |
| L           | 0.5   | -   | 0.61  |
| R           | 0.085 | -   | 0.095 |
| S1          | 0.045 | -   | 0.06  |
| W           | 0.016 | -   | 0.022 |
| D           | 0.175 | -   | 0.195 |
| a           | 4°    | -   | 6°    |

Note: Dimensions in (inches)







**ORDERING INFORMATION**

| PART NUMBER      | ACC  | OUTPUT VOLTAGE | PACKAGES     |
|------------------|------|----------------|--------------|
| SPX4040AM-2.5    | 0.5% | 2.5V           | 3-Pin SOT-23 |
| SPX4040AM-2.5/TR | 0.5% | 2.5V           | 3-Pin SOT-23 |
| SPX4040AN-2.5    | 0.5% | 2.5V           | 3-Pin TO-92  |
| SPX4040AN-2.5/TR | 0.5% | 2.5V           | 3-Pin TO-92  |
| SPX4040AS-2.5    | 0.5% | 2.5V           | 8-Pin NSOIC  |
| SPX4040AS-2.5/TR | 0.5% | 2.5V           | 8-Pin NSOIC  |
| SPX4040M-2.5     | 1.0% | 2.5V           | 3-Pin SOT-23 |
| SPX4040M-2.5/TR  | 1.0% | 2.5V           | 3-Pin SOT-23 |
| SPX4040N-2.5     | 1.0% | 2.5V           | 3-Pin TO-92  |
| SPX4040N-2.5/TR  | 1.0% | 2.5V           | 3-Pin TO-92  |
| SPX4040S-2.5     | 1.0% | 2.5V           | 8-Pin NSOIC  |
| SPX4040S-2.5/TR  | 1.0% | 2.5V           | 8-Pin NSOIC  |

Available in lead free packaging. To order add "-L" suffix to part number.  
 Example: SPX4040S-2.5/TR = standard; SPX4040S-L-2.5/TR = lead free

/TR = Tape and Reel

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

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