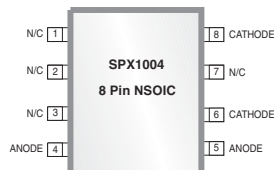


## 1.2V / 2.5V Micropower Voltage Reference

### FEATURES

- Initial Voltage Tolerance:  
SPX1004-1.2 =  $\pm 10\text{mV}$   
SPX1004-2.5 =  $\pm 20\text{mV}$
- Low Dynamic Impedance  
0.6  $\Omega$  Max.
- Low Operating Current:  
SPX1004-1.2 =  $\pm 10\mu\text{A}$   
SPX1004-2.5  $\pm 20\mu\text{A}$
- Wide Operating Current Range  
0.6  $\Omega$  Max.
- Direct Replacement for LT1004,  
LM1004 and AS1004
- Lead Free, RoHS Compliant  
Packages



### APPLICATIONS

- A/D and D/A Reference
- Reference for 5V Systems
- Digital Voltmeter
- Power Supply Monitor

### DESCRIPTION

The SPX1004 is a 2-terminal bandgap precision voltage reference that provides a stable fixed output voltage of 1.2V and 2.5V with a tolerance of  $\pm 10\text{mV}$  for SPX1004-1.2 and  $\pm 20\text{mV}$  for SPX1004-2.5. Design, process and precision on chip trimming yield a very low temperature coefficient of 25 ppm/ $^{\circ}\text{C}$ .

The SPX1004 can be used as a pin-to-pin replacement for the LT1004, LM1004 or AS1004. The SPX1004 is available in SOT-89, NSOIC-8 and TO-92 packages over the operating temperature range of  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ .

### BLOCK DIAGRAMS

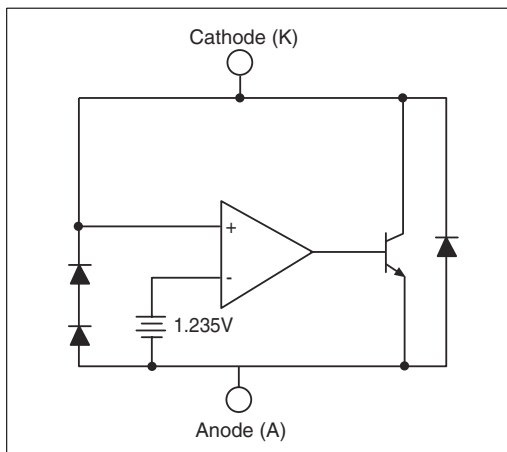


Figure 1a. SPX1004-1.2 Block Diagram

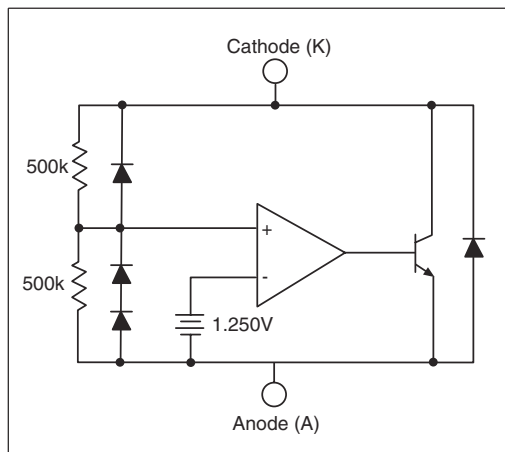


Figure 1b. SPX1004-2.5 Block Diagram

## ABSOLUTE MAXIMUM RATINGS

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.

Forward Current ( $I_{AK}$ ).....10mA  
 Reverse Current ( $I_{KA}$ ).....30mA  
 Lead Temperature (soldering, 10 seconds).....300°C  
 Storage Temperature Range.....-65°C to +150°C  
 Junction Temperature.....150°C

Continuous Power Dissipation ( $P_D$ )

TO-92.....775mW  
 NSOIC-8.....750mW  
 SOT-89.....1000mW

## TYPICAL THERMAL RESISTANCES

| PACKAGE | $\theta_{JA}$ | $\theta_{JA}$ | TYPICAL DERATING |
|---------|---------------|---------------|------------------|
| TO-92   | 160°C/W       | 80°C/W        | 6.3 mW/°C        |
| NSOIC-8 | 175°C/W       | 45°C/W        | 5.7mW/°C         |
| SOT-89  | 110°C/W       | 8°C/W         | 9.1mW/°C         |

## ELECTRICAL CHARACTERISTICS

Electrical characteristics are guaranteed over full junction temperature range (0°C to 70°C). Ambient temperature must be derated based on power dissipation and package thermal characteristics.

| PARAMETER                                     | CONDITIONS                                                                                      | SPX1004-1.2V |       |       | SPX1004-2.5V |       |       | UNITS       |
|-----------------------------------------------|-------------------------------------------------------------------------------------------------|--------------|-------|-------|--------------|-------|-------|-------------|
|                                               |                                                                                                 | MIN          | TYP   | MAX   | MIN          | TYP   | MAX   |             |
| Reverse breakdown                             | $I_Z=100\mu A$ , $T_J=25^\circ C$<br>$0^\circ C \leq T_A \leq 70^\circ C$                       | 1.225        | 1.235 | 1.245 | 2.480        | 2.500 | 2.520 | V           |
| Ave Temp. Coeff.                              | $I_{min} \leq I_Z \leq 20mA$                                                                    | 20           |       |       | 60           |       |       | ppm/<br>°C  |
| Min Operating Current                         |                                                                                                 | 4            |       |       | 12           |       |       | μA          |
| Reverse Breakdown Voltage Change with Current | $I_{min} \leq I_Z \leq 1mA$<br>over temperature<br>$1mA \leq I_Z \leq 20mA$<br>over temperature | 0.5          |       |       | 0.5          |       |       | mV          |
|                                               |                                                                                                 | 0.5          |       |       | 0.5          |       |       |             |
|                                               |                                                                                                 | 6.5          |       |       | 6.5          |       |       |             |
|                                               |                                                                                                 | 6.5          |       |       | 6.5          |       |       |             |
| Reverse Dynamic Impedance                     | $I_Z=100\mu A$ , $f=25Hz$<br>over temperature                                                   | 0.2          |       |       | 0.8          |       |       | Ω           |
|                                               |                                                                                                 | 1            |       |       | 1.5          |       |       |             |
| Wide Band Noise                               | $I_Z=100\mu A$ , $10Hz \leq f \leq 10kHz$                                                       | 60           |       |       | 120          |       |       | μV          |
| Long Term Stability                           | $I_Z=100\mu A$ , $T_A=25^\circ C \pm 0.1^\circ C$                                               | 20           |       |       | 60           |       |       | ppm/<br>kHr |
| Operating Temp Range                          |                                                                                                 | 0            |       |       | 0            |       |       | °C          |

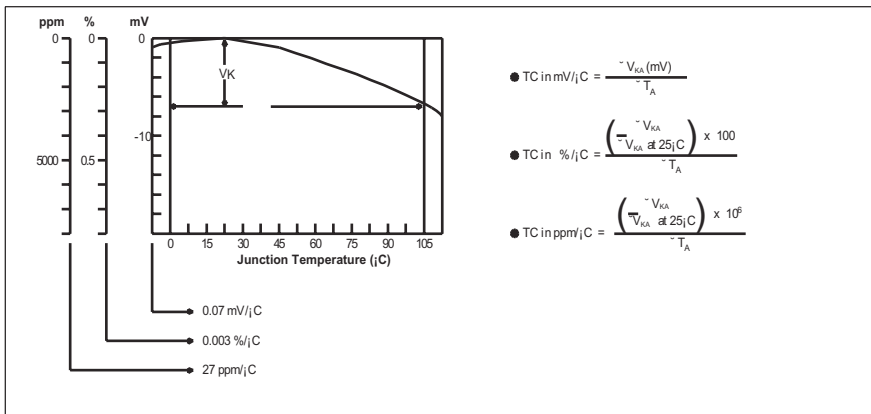


Figure 2.  $V_{REF}$  vs Temperature for 2.5V Version

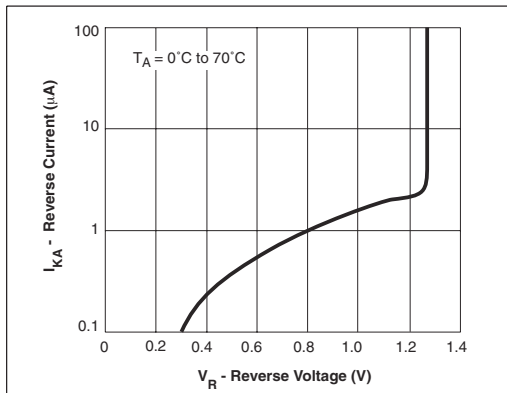


Figure 3. SPX1004-1.2V Reverse Operating Characteristic

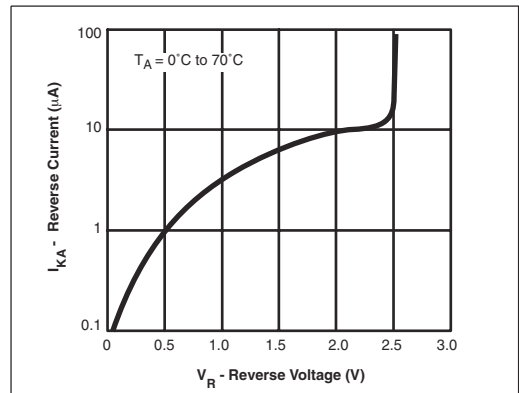


Figure 4. SPX1004-2.5V Reverse Operating Characteristic

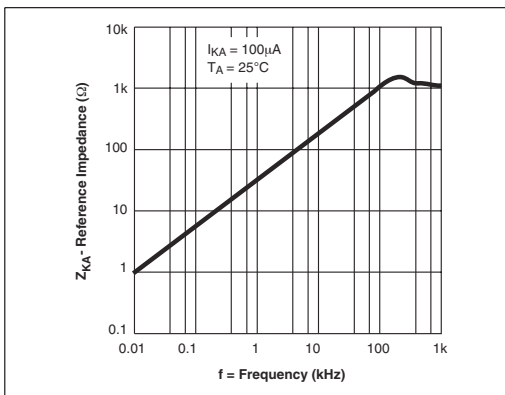


Figure 5. SPX1004-1.2V Reverse Dynamic Impedance

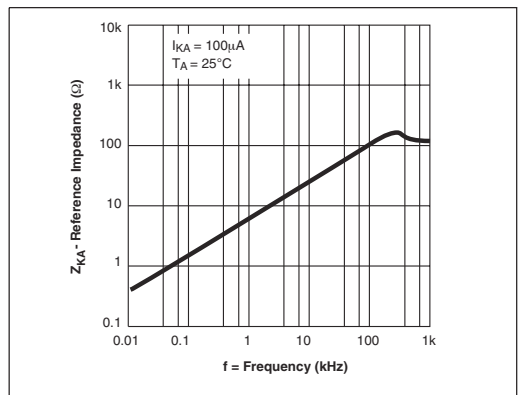


Figure 6. SPX1004-2.5V Reverse Dynamic Impedance

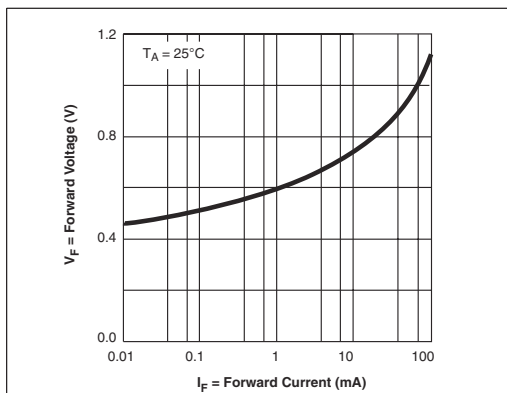


Figure 7. Forward Characteristics for SPX1004-1.2 and SPX1004-2.5

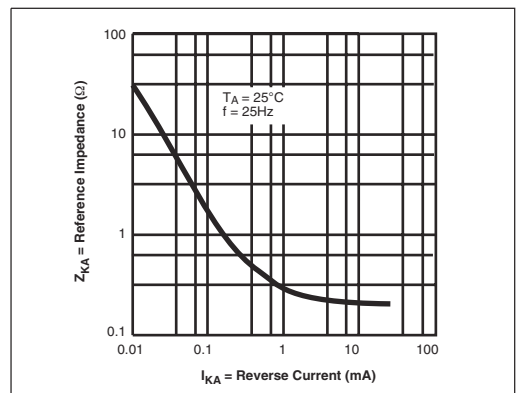


Figure 8. Low Frequency Reverse Dynamic Impedance for SPX1004-1.2

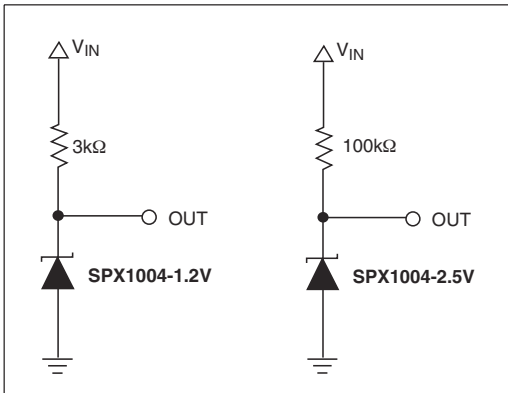


Figure 9a. 1.2V Reference, Figure 9b. 2.5V Reference

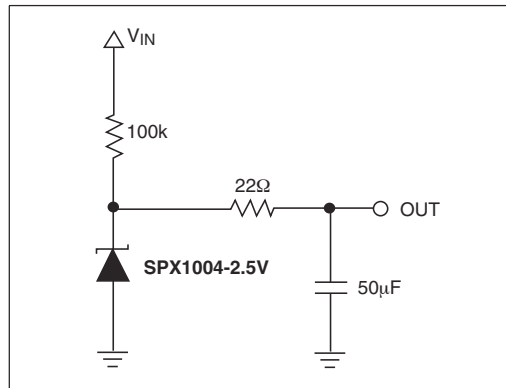


Figure 10. Low Noise Reference

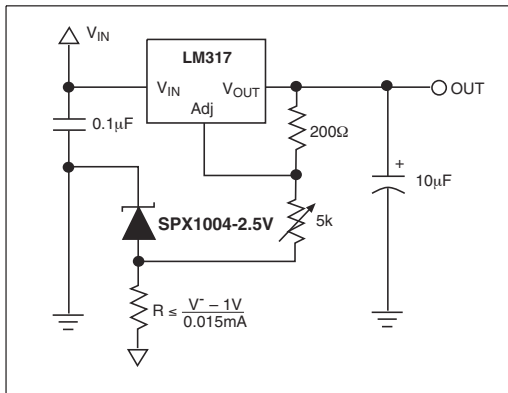


Figure 11. Variable Output Regulator

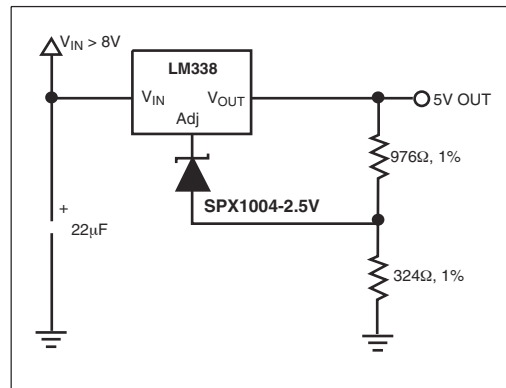


Figure 12. High Stability 5V Regulator

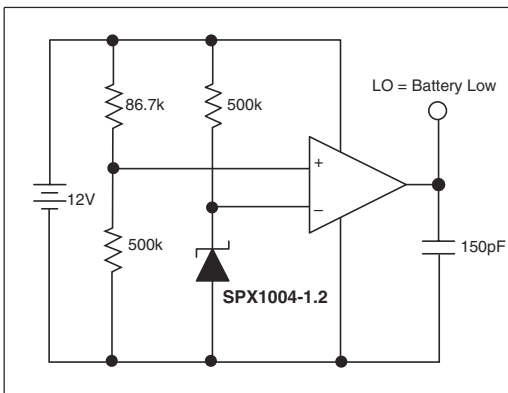


Figure 13. Low Battery Detector

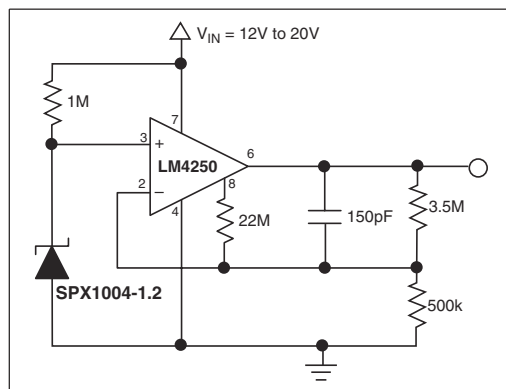
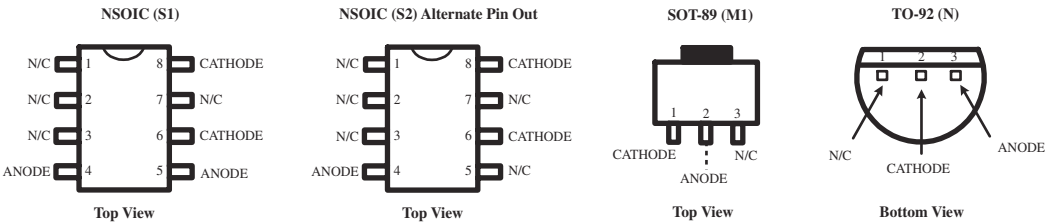
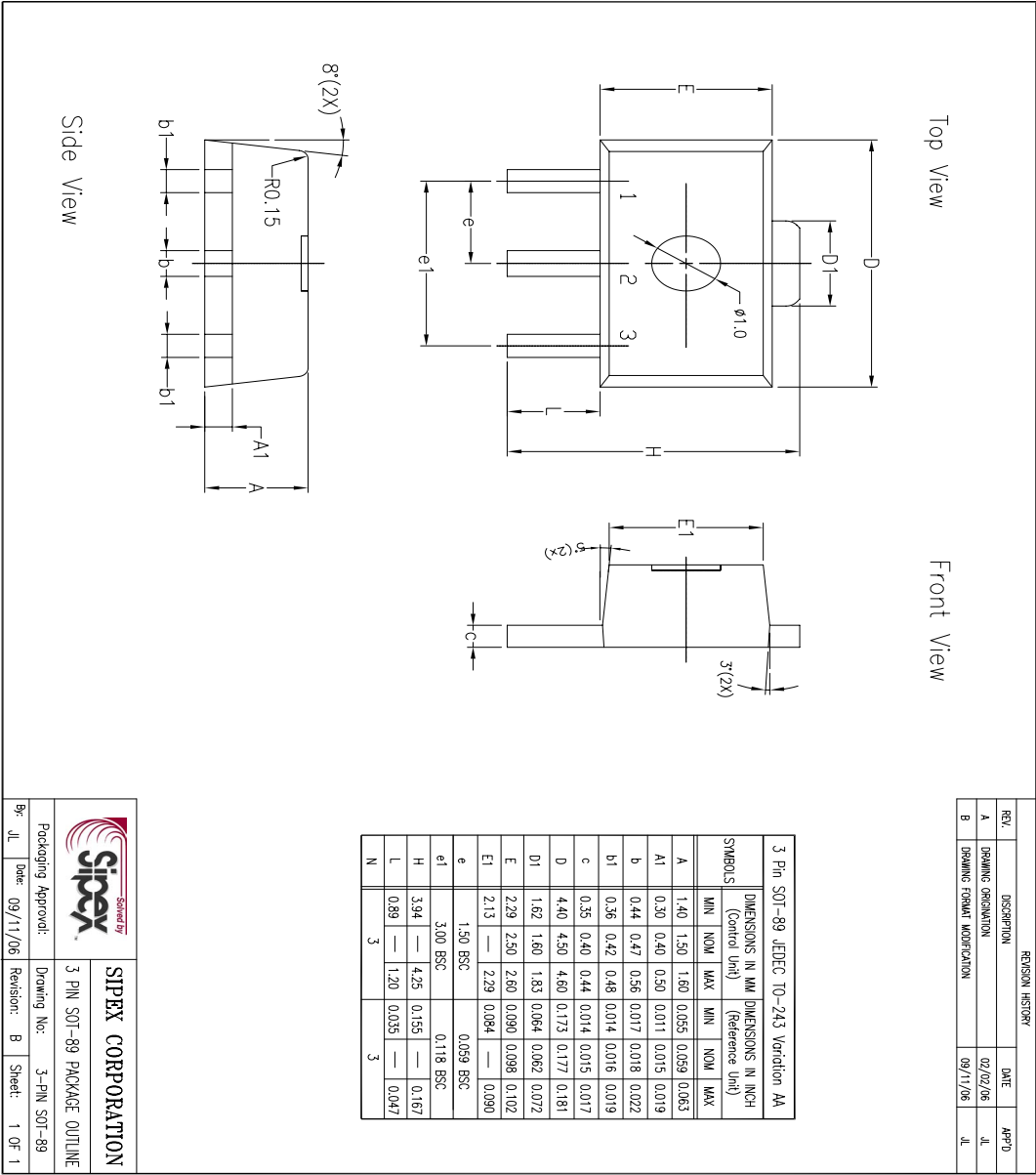


Figure 14. Micropower 10V Reference

PACKAGE: PINOUTS

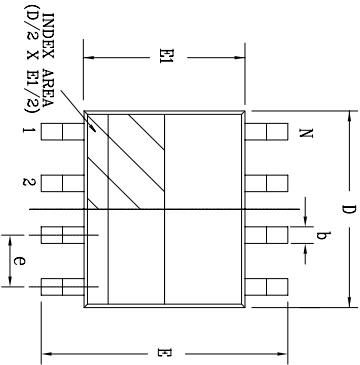


PACKAGE: 3 PIN SOT-89

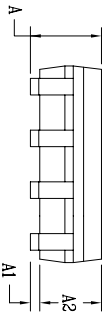


| REVISION HISTORY |                             |          |       |
|------------------|-----------------------------|----------|-------|
| REV.             | DISCRIPTION                 | DATE     | APP'D |
| A                | DRAWING ORIGINATION         | 08/16/05 | JL    |
| B                | DRAWING FORMAT MODIFICATION | 07/19/06 | JL    |

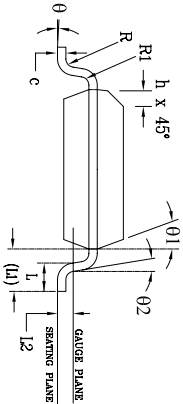
| 8 Pin SOICN |                                    | JEDEC MS-012 |      | Variation AA                           |     |       |
|-------------|------------------------------------|--------------|------|----------------------------------------|-----|-------|
| SYMBOLS     | DIMENSIONS IN MM<br>(Control Unit) |              |      | DIMENSIONS IN INCH<br>(Reference Unit) |     |       |
|             | MIN                                | NOM          | MAX  | MIN                                    | NOM | MAX   |
| A           | 1.35                               | —            | 1.75 | 0.053                                  | —   | 0.069 |
| A1          | 0.10                               | —            | 0.25 | 0.004                                  | —   | 0.010 |
| A2          | 1.25                               | —            | 1.65 | 0.049                                  | —   | 0.065 |
| b           | 0.31                               | —            | 0.51 | 0.012                                  | —   | 0.020 |
| c           | 0.17                               | —            | 0.25 | 0.007                                  | —   | 0.010 |
| E           | 6.00 BSC                           |              |      | 0.236 BSC                              |     |       |
| E1          | 3.90 BSC                           |              |      | 0.154 BSC                              |     |       |
| e           | 1.27 BSC                           |              |      | 0.050 BSC                              |     |       |
| h           | 0.25                               | —            | 0.50 | 0.010                                  | —   | 0.020 |
| L           | 0.40                               | —            | 1.27 | 0.016                                  | —   | 0.050 |
| L1          | 1.04 REF                           |              |      | 0.041 REF                              |     |       |
| L2          | 0.25 BSC                           |              |      | 0.010 BSC                              |     |       |
| R           | 0.07                               | —            | —    | 0.003                                  | —   | —     |
| R1          | 0.07                               | —            | —    | 0.003                                  | —   | —     |
| θ           | 0°                                 | —            | 8°   | 0°                                     | —   | 8°    |
| θ1          | 5°                                 | —            | 15°  | 5°                                     | —   | 15°   |
| θ2          | 0°                                 | —            | —    | 0°                                     | —   | —     |
| D           | 4.90 BSC                           |              |      | 0.193 BSC                              |     |       |
| N           | 8                                  |              |      | 8                                      |     |       |



Top View

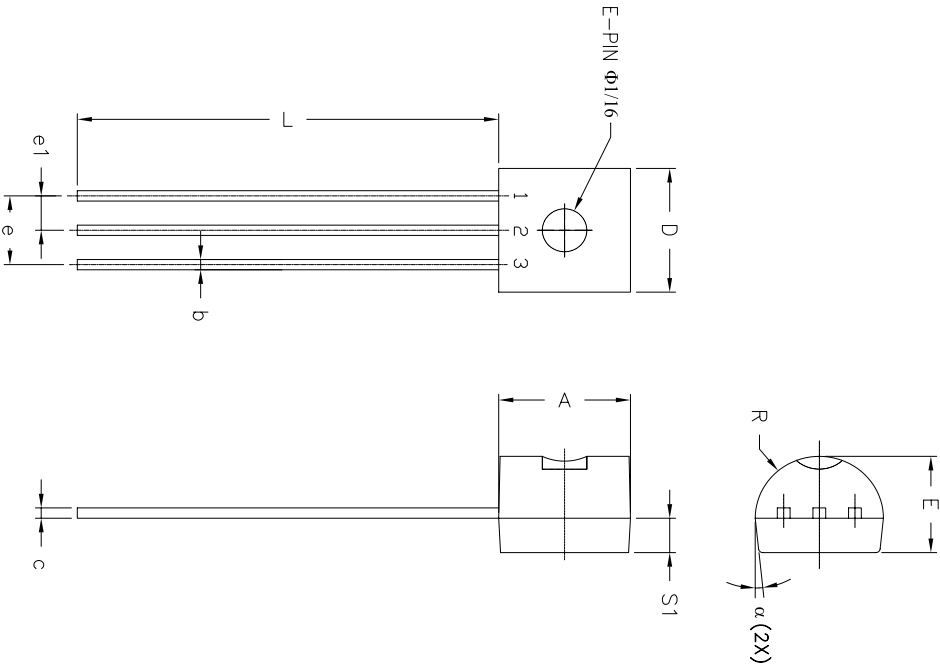


Side View



Front View

|                                                                                     |                |                             |             |
|-------------------------------------------------------------------------------------|----------------|-----------------------------|-------------|
|  |                | <b>SIPEX CORPORATION</b>    |             |
| Packaging Approval:                                                                 |                | 8 PIN SOICN PACKAGE OUTLINE |             |
| By: JL                                                                              | Date: 07/19/06 | Drawing No:                 | 8-PIN SOICN |
| Revision: B                                                                         |                | Sheet: 1                    | Of 1        |



| 3 Pin TO-92 JEDEC TO-226-AA |                                      |       |                                      |       |  |
|-----------------------------|--------------------------------------|-------|--------------------------------------|-------|--|
| SYMBOLS                     | DIMENSIONS IN INCH<br>(Control Unit) |       | DIMENSIONS IN MM<br>(Reference Unit) |       |  |
|                             | MIN                                  | MAX   | 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                                    |       |  |

| REVISION HISTORY |                             |          |       |
|------------------|-----------------------------|----------|-------|
| REV.             | DESCRIPTION                 | DATE     | APP'D |
| A                | DRAWING ORIGINATION         | 09/23/05 | JL    |
| B                | DRAWING FORMAT MODIFICATION | 08/15/06 | JL    |

|                                                                                     |                |                    |               |
|-------------------------------------------------------------------------------------|----------------|--------------------|---------------|
|  |                | SIPLEX CORPORATION |               |
| Packaging Approval:                                                                 |                | Drawing No:        | 3-PIN TO-92   |
| By: JL                                                                              | Date: 08/15/06 | Revision: B        | Sheet: 1 OF 1 |

| Part Number         | Accuracy | Output Voltage | MSL Level                     | RoHS | Package               | Pack Type   | Quantity |
|---------------------|----------|----------------|-------------------------------|------|-----------------------|-------------|----------|
| SPX1004AS1-L-1-2    | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8                | TUBE        | 98       |
| SPX1004AS1-L-1-2/TR | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8                | Tape & Reel | 2500     |
| SPX1004AS2-L-1-2    | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8<br>Alt. Pinout | TUBE        | 98       |
| SPX1004AS2-L-1-2/TR | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8                | Tape & Reel | 2500     |
| SPX1004S1-L-1-2     | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8                | TUBE        | 98       |
| SPX1004S1-L-1-2/TR  | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8                | Tape & Reel | 2500     |
| SPX1004S2-L-1-2     | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8<br>Alt. Pinout | TUBE        | 98       |
| SPX1004S2-L-1-2/TR  | 0.8%     | 1.235V         | L1 @ 260°C                    | Yes  | NSOIC8<br>Alt. Pinout | Tape & Reel | 2500     |
| SPX1004AM1-L-1-2    | 0.8%     | 1.235V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Canister    | Any      |
| SPX1004AM1-L-1-2/TR | 0.8%     | 1.235V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004M-L-1-2      | 0.8%     | 1.235V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Canister    | Any      |
| SPX1004M-L-1-2/TR   | 0.8%     | 1.235V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004AN-L-1-2     | 0.8%     | 1.235V         | No MSL for thru hole package. | Yes  | TO-92-3               | BOX         | Any      |
| SPX1004AN-L-1-2/TR  | 0.8%     | 1.235V         | No MSL for thru hole package. | Yes  | TO-92-3               | Tape & Reel | 2000     |
| SPX1004N-L-1-2      | 0.8%     | 1.235V         | No MSL for thru hole package. | Yes  | TO-92-3               | BOX         | Any      |
| SPX1004N-L-1-2/TR   | 0.8%     | 1.235V         | No MSL for thru hole package. | Yes  | TO-92-3               | Tape & Reel | 2000     |
| SPX1004AS1-1-2      | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8                | TUBE        | 98       |
| SPX1004AS1-1-2/TR   | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8                | Tape & Reel | 2500     |
| SPX1004AS2-1-2      | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8<br>Alt. Pinout | TUBE        | 98       |
| SPX1004AS2-1-2/TR   | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8<br>Alt. Pinout | Tape & Reel | 2500     |
| SPX1004S1-1-2       | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8                | TUBE        | 98       |
| SPX1004S1-1-2/TR    | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8                | Tape & Reel | 2500     |
| SPX1004S2-1-2       | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8<br>Alt. Pinout | TUBE        | 98       |
| SPX1004S2-1-2/TR    | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | NSOIC8<br>Alt. Pinout | Tape & Reel | 2500     |
| SPX1004AM1-1-2      | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | SOT-89-3              | Canister    | Any      |
| SPX1004AM1-1-2/TR   | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004M1-1-2       | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | SOT-89-3              | Canister    | Any      |
| SPX1004M1-1-2/TR    | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004M-1-2        | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | SOT-89-3              | Canister    | Any      |
| SPX1004M-1-2/TR     | 0.8%     | 1.235V         | L1 @ 240°C                    | No   | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004AN-1-2       | 0.8%     | 1.235V         | No MSL for thru hole package. | No   | TO-92-3               | BOX         | Any      |
| SPX1004AN-1-2/TR    | 0.8%     | 1.235V         | No MSL for thru hole package. | No   | TO-92-3               | Tape & Reel | 2000     |
| SPX1004N-1-2        | 0.8%     | 1.235V         | No MSL for thru hole package. | No   | TO-92-3               | BOX         | Any      |
| SPX1004N-1-2/TR     | 0.8%     | 1.235V         | No MSL for thru hole package. | No   | TO-92-3               | Tape & Reel | 2000     |



## ORDERING INFORMATION (continued)

| Part Number        | Accuracy | Output Voltage | MSL Level                     | RoHS | Package               | Pack Type   | Quantity |
|--------------------|----------|----------------|-------------------------------|------|-----------------------|-------------|----------|
| SPX1004S1-L-2-5    | 0.8%     | 2.500V         | L1 @ 260°C                    | Yes  | NSOIC8                | TUBE        | 98       |
| SPX1004S1-L-2-5/TR | 0.8%     | 2.500V         | L1 @ 260°C                    | Yes  | NSOIC8                | Tape & Reel | 2500     |
| SPX1004S2-L-2-5    | 0.8%     | 2.500V         | L1 @ 260°C                    | Yes  | NSOIC8<br>Alt. Pinout | TUBE        | 98       |
| SPX1004S2-L-2-5/TR | 0.8%     | 2.500V         | L1 @ 260°C                    | Yes  | NSOIC8<br>Alt. Pinout | Tape & Reel | 2500     |
| SPX1004M1-L-2-5    | 0.8%     | 2.500V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Canister    | Any      |
| SPX1004M1-L-2-5/TR | 0.8%     | 2.500V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004M-L-2-5     | 0.8%     | 2.500V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Canister    | Any      |
| SPX1004M-L-2-5/TR  | 0.8%     | 2.500V         | L2 @ 260°C                    | Yes  | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004N-L-2-5     | 0.8%     | 2.500V         | No MSL for thru hole package. | Yes  | TO-92-3               | BOX         | Any      |
| SPX1004N-L-2-5/TR  | 0.8%     | 2.500V         | No MSL for thru hole package. | Yes  | TO-92-3               | Tape & Reel | 2000     |
| SPX1004S1-2-5      | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | NSOIC8                | TUBE        | 98       |
| SPX1004S1-2-5/TR   | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | NSOIC8                | Tape & Reel | 2500     |
| SPX1004S2-2-5      | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | NSOIC8<br>Alt. Pinout | TUBE        | 98       |
| SPX1004S2-2-5/TR   | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | NSOIC8<br>Alt. Pinout | Tape & Reel | 2500     |
| SPX1004M1-2-5      | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | SOT-89-3              | Canister    | Any      |
| SPX1004M1-2-5/TR   | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004M-2-5       | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | SOT-89-3              | Canister    | Any      |
| SPX1004M-2-5/TR    | 0.8%     | 2.500V         | L1 @ 240°C                    | No   | SOT-89-3              | Tape & Reel | 2500     |
| SPX1004N-2-5       | 0.8%     | 2.500V         | No MSL for thru hole package. | No   | TO-92-3               | BOX         | Any      |
| SPX1004N-2-5/TR    | 0.8%     | 2.500V         | No MSL for thru hole package. | No   | TO-92-3               | Tape & Reel | 2000     |

For latest information on ordering status, go to the Sipex Web Landing Page for this product  
<http://www.sipex.com/searchResults.aspx?keywordsval=spx1004>

For further assistance:

Email: [Sipexsupport@sipex.com](mailto:Sipexsupport@sipex.com)  
 WWW Support page: <http://www.sipex.com/content.aspx?p=support>  
 Sipex Application Notes: <http://www.sipex.com/applicationNotes.aspx>



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