

## Adjustable Precision Shunt Regulator

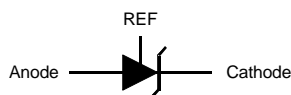
### Features

- Precise Reference Voltage to 2.500V
- Guaranteed 0.5% or 1% Reference Voltage Tolerance
- Sink Current Capability , 1mA to 100mA
- Quick Turn-on
- Adjustable Output Voltage ,  $V_O = V_{REF}$  to 20V
- Low Operational Cathode Current , 250 $\mu$ A Typical
- 0.1 $\Omega$  Typical Output Impedance
- SOT-23 , SOT-89 and TO-92 Packages
- Lead Free and Green Devices Available (RoHS Compliant)

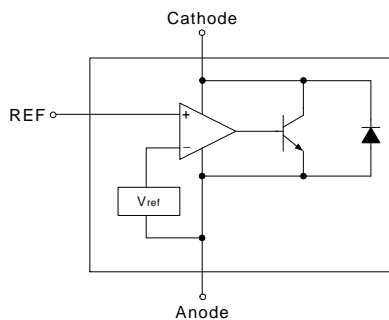
### Applications

- Linear Regulators
- Adjustable Power Supply
- Switching Power Supply

### Symbol



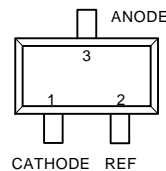
### Functional Diagram



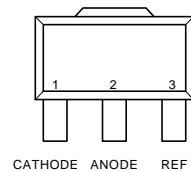
### General Description

The APL1431 is a 3-terminal adjustable voltage reference with specified thermal stability over applicable commercial temperature ranges. Output voltage may be set to any value between  $V_{REF}$  (2.5 V) and 20 V with two external resistors (see Figure 2). When used with an photocoupler, the APL1431 is an ideal voltage reference in isolated feedback circuits for 2.5V to 12V switching-mode power supplies. This device has a typical output impedance of 0.1 $\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making the APL1431 excellent replacements for zener diodes in many applications, including on-board regulation and adjustable power supplies.

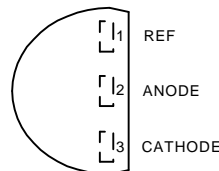
### Pin Configuration



SOT-23 (Top View)



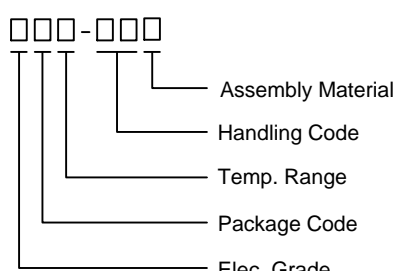
SOT-89 (Top View)



TO-92 (Top View)

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

## Ordering and Marking Information

|   |  |
|---|--|
| <p>APL1431    □□□-□□□</p>  <p>Assembly Material<br/>Handling Code<br/>Temp. Range<br/>Package Code<br/>Elec. Grade</p> | <p>Elec. Grade<br/>A : 0.5% Reference Voltage Tolerance<br/>B : 1% Reference Voltage Tolerance</p> <p>Package Code<br/>A : SOT-23                    D : SOT-89    E : TO-92<br/>Y : Chip Form</p> <p>Temp. Range<br/>C : 0 to 70 °C                    I : -40 to 85 °C</p> <p>Handling Code<br/>TB : Tape &amp; Box    TR : Tape &amp; Reel</p> <p>Assembly Material<br/>L : Lead Free Device<br/>G : Halogen and Lead Free Device</p> |
| <p>APL1431 A :    □1431</p>   | <p>APL1431 E :    □APL<br/>                      □1431<br/>                      □XXXXX      XXXXX - Date Code</p>   |
| <p>APL1431 D :    □APL1431<br/>                      □XXXXX      XXXXX - Date Code</p>  |  |

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020C for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

## Absolute Maximum Ratings

| Symbol        | Parameter   | Rating                   | Unit                   |    |
|---------------|---|--------------------------|------------------------|----|
| $V_{KA}$      | Cathode Voltage   | 21                       | V                      |    |
| $I_K$         | Continuous Cathode Current Range                        | 120                      | mA                     |    |
| $I_{REF}$     | Reference Current Range                                 | 3                        | mA                     |    |
| $\theta_{JA}$ | Thermal Resistance from Junction to Ambient in Free Air |                          | °C/W                   |    |
|               | SOT-23  | 416                      |                        |    |
|               | SOT-89  | 250                      |                        |    |
|               | TO-92   | 250                      |                        |    |
| $T_A$         | Ambient Temperature Range                               | APL1431XXC<br>APL1431XXI | 0 to 70<br>-40 to 85   | °C |
| $T_j$         | Junction Temperature Range                              | APL1431XXC<br>APL1431XXI | 0 to 150<br>-40 to 150 | °C |
| $T_{STG}$     | Storage Temperature Range                               |                          | -65 to 150             | °C |
| $T_{SDR}$     | Maximum Lead Soldering Temperature, 10 Seconds          |                          | 260                    | °C |

## Electrical Characteristics $T_A = 25^\circ\text{C}$ ( unless otherwise noted)

| Symbol                           | Parameter                                | Test Conditions   | APL1431        |              |                | Unit |
|----------------------------------|--|---|----------------|--------------|----------------|------|
|                                  |  |   | Min.           | Typ.         | Max.           |      |
| $V_{REF}$                        | Reference Voltage                        | $V_{KA}=V_{REF}, I_K=10\text{mA}$<br>APL431A<br>APL431B   | 2.487<br>2.475 | 2.500        | 2.513<br>2.525 | V    |
| $\Delta V_{REF}/T$               | Reference Voltage Drift Over Temp. Range | $V_{KA}=V_{REF}, I_K=10\text{mA}$<br>$T_A = 0 \text{ to } 70^\circ\text{C}^{*1}$<br>$T_A = -40 \text{ to } 85^\circ\text{C}^{*1}$ |                |              | 20<br>30       | mV   |
| $\Delta V_{REF} / \Delta V_{KA}$ | Voltage Ratio (open loop gain)           | $I_K=10\text{mA}, V_{KA}=V_{REF} \text{ to } 10V^{*2}$<br>$I_K=10\text{mA}, V_{KA}=V_{REF} \text{ to } 20V^{*2}$                  |                | -1.5<br>-1.2 | -3<br>-2.5     | mV/V |

**Electrical Characteristics (Cont.)**  $T_A = 25^\circ\text{C}$  ( unless otherwise noted)

| Symbol              | Parameter                 | Test Conditions  | APL1431 |      |      | Unit          |
|---------------------|---------------------------|--|---------|------|------|---------------|
|                     |                           |  | Min.    | Typ. | Max. |               |
| $I_{REF}$           | Reference Current         | $I_K=10\text{mA}$ ,<br>$R_1=10\text{k}\Omega$ , $R_2=\text{open}^{*2}$                                     |         | 1.0  | 3    | $\mu\text{A}$ |
| $\Delta I_{REF}/T$  | Reference Current Drift   | $I_K=10\text{mA}$ , $R_1=10\text{k}\Omega$ ,<br>$R_2=\text{open}$ , $T_A = -40$ to $85^\circ\text{C}^{*2}$ |         | 0.3  | 1    | $\mu\text{A}$ |
| $I_{K(\text{min})}$ | Min. Cathode Current      | $V_{KA}=V_{REF}^{*1}$  |         | 0.25 | 0.5  | $\text{mA}$   |
| $I_{K(\text{off})}$ | Off-state Cathode Current | $V_{KA}= 20\text{V}$ , $V_{REF}= 0\text{V}^{*3}$   |         | 0.1  | 1    | $\mu\text{A}$ |
| $ Z_{KA} $          | Dynamic Impedance         | $V_{KA}=V_{REF}$<br>$I_K=1\text{mA}$ to $100\text{mA}$ , $f \leq 1\text{kHz}^{*1}$                         |         | 0.1  | 0.4  | $\Omega$      |
| $I_K$               | Cathode Current           |  |         |      | 100  | $\text{mA}$   |

Notes : \*1 : use Figure 1  
 \*2 : use Figure 2  
 \*3 : use Figure 3

**Test figures**

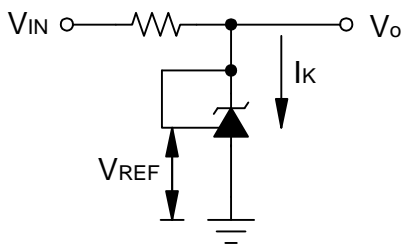


Figure 1. Test Circuit for  $V_{KA}=V_{REF}$ ,  $V_O=V_{KA}=V_{REF}$

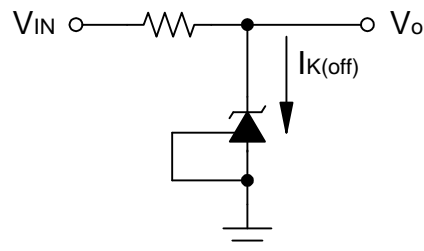


Figure 3. Test Circuit for  $I_{K(\text{off})}$

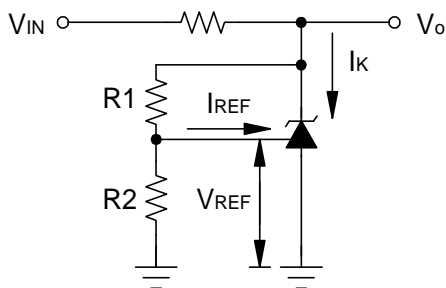
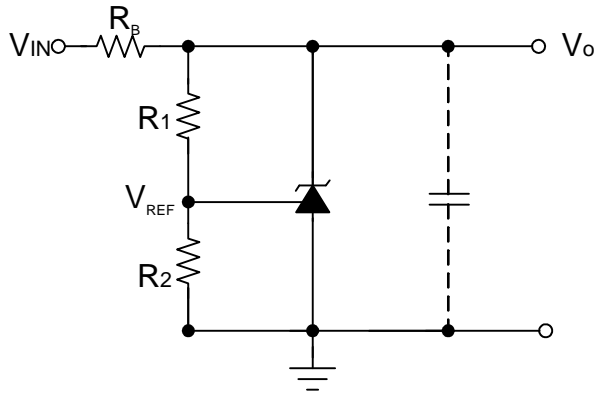
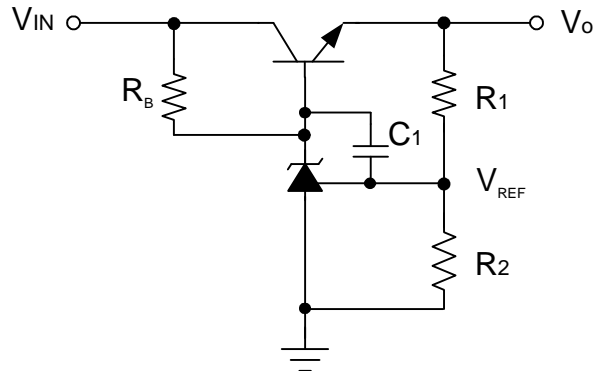


Figure 2. Test Circuit for  $V_{KA}>V_{REF}$   
 $V_O = V_{KA} = V_{REF} \times (1+R_1/R_2) + I_{REF} \times R_1$

### Application Circuits



Precision Voltage Reference



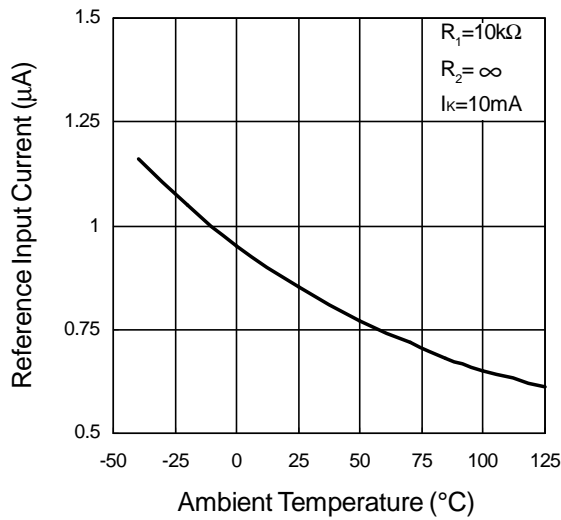
Precision High-Current Series Regulator

Notes for Application Circuits:

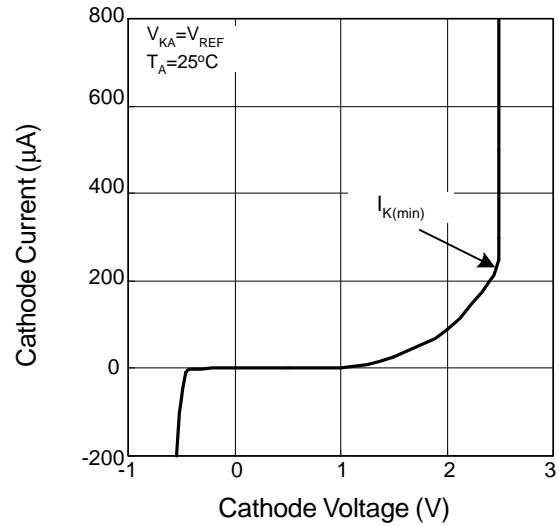
- 1) For the series regulator applications, add a compensation capacitor C1 between CATHODE and REF is strongly recommended to improve the stability of output voltage .
- 2) Set  $V_o$  according to the following equation:  $V_o = V_{REF}(1+R1/R2)+I_{REF} \times R1$
- 3) Choose the value for  $R_B$  as follows:
  - A) The maximum limit for  $R_B$  should be such that the cathode current ( $I_k$ ) is greater than the minimum operating current (0.5mA) at  $V_{IN(MIN)}$ .
  - B) The minimum limit for  $R_B$  should be such that the cathode current ( $I_k$ ) does not exceed 100mA under all load conditions, and the instantaneous turn-on value for  $I_k$  does not exceed 120mA.

## Typical Characteristics

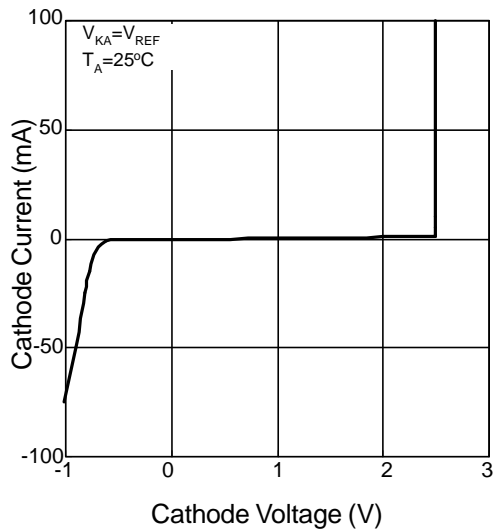
Reference Input Current vs. Ambient Temperature



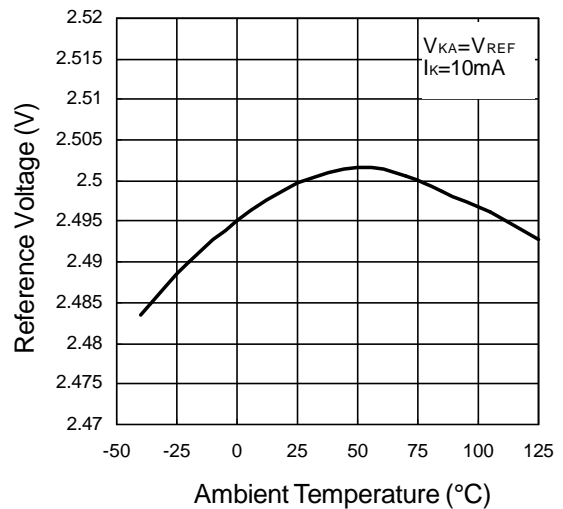
Cathode Current vs. Cathode Voltage



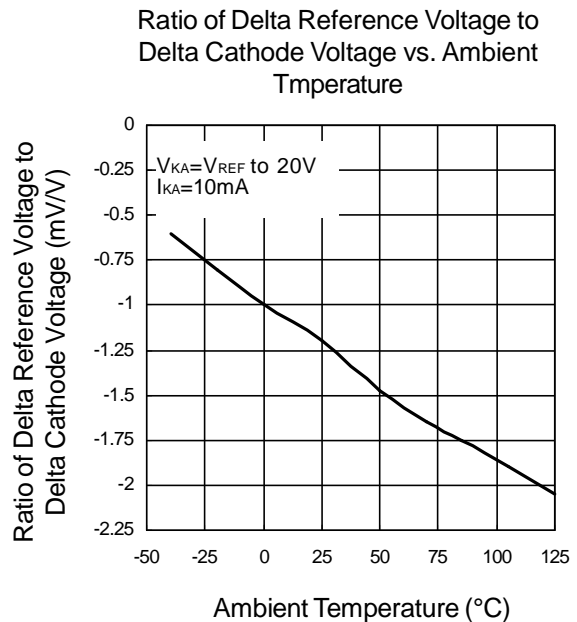
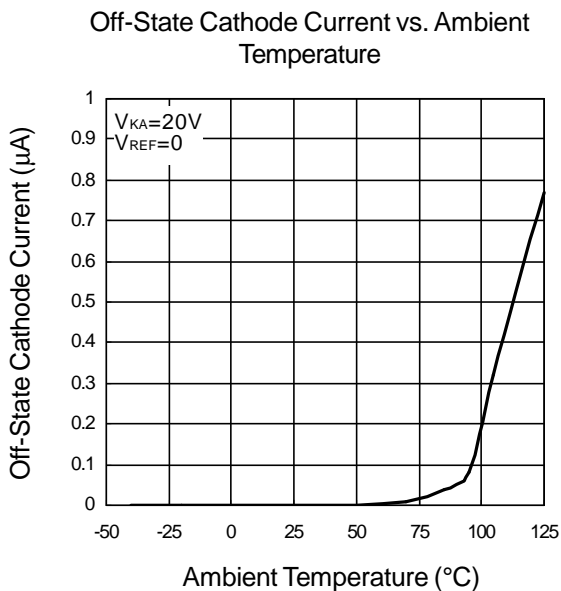
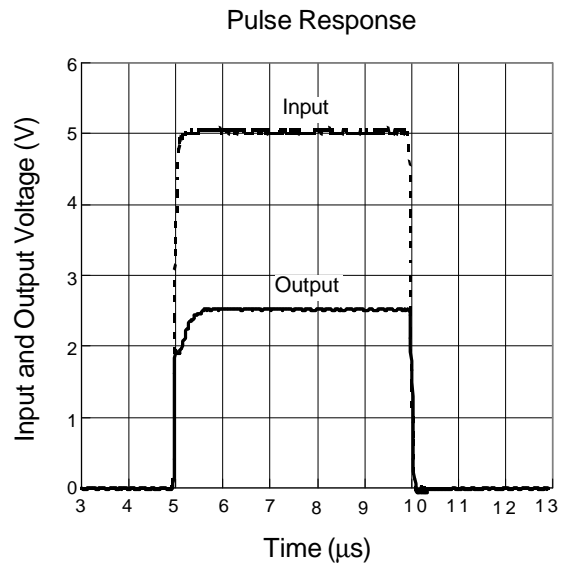
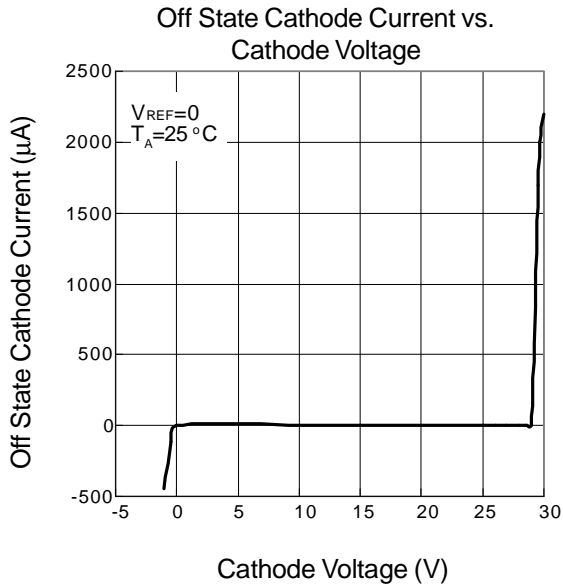
Cathode Current vs. Cathode Voltage



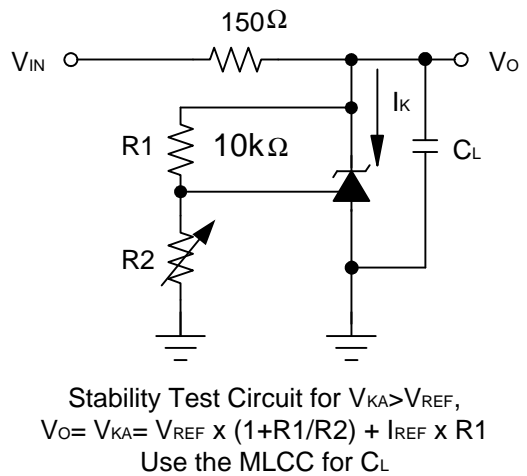
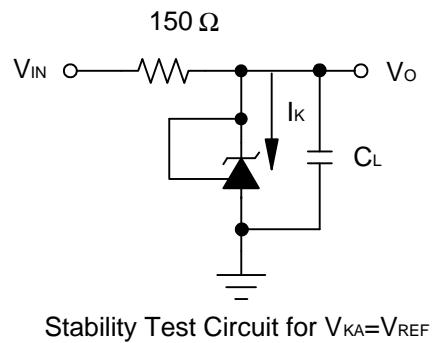
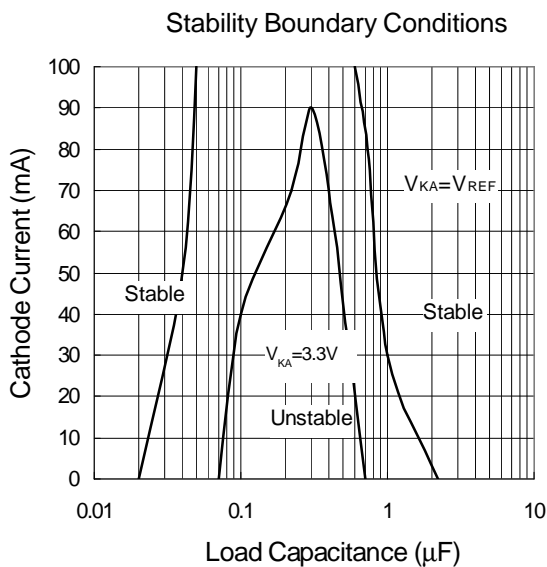
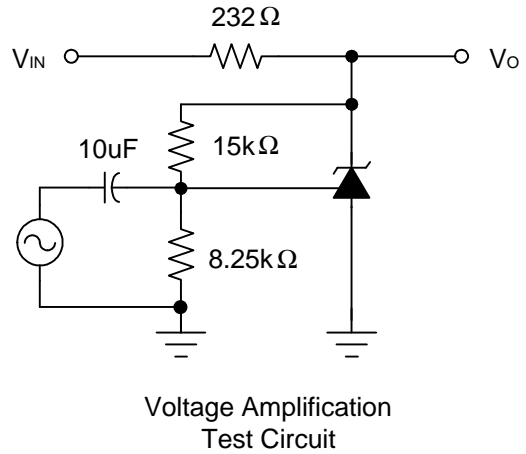
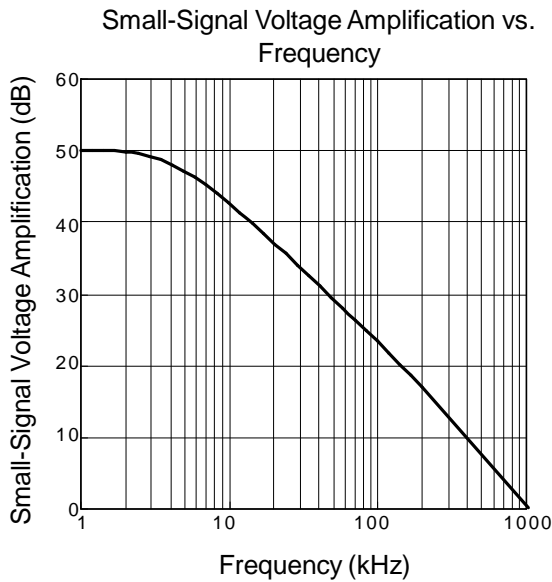
Reference Voltage vs. Ambient Temperature



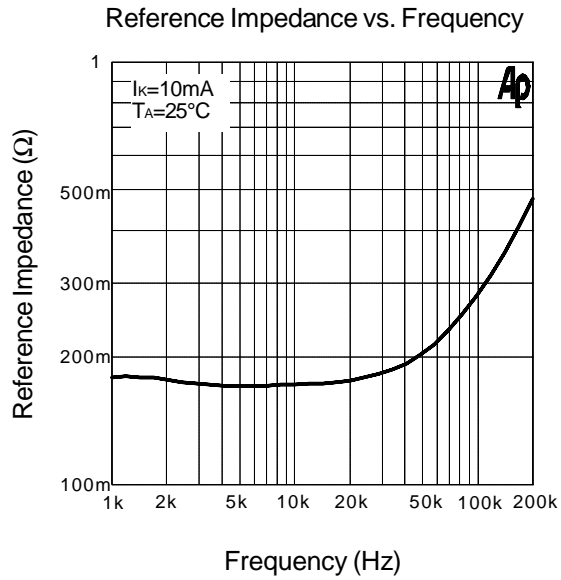
Typical Characteristics (Cont.)



Typical Characteristics (Cont.)



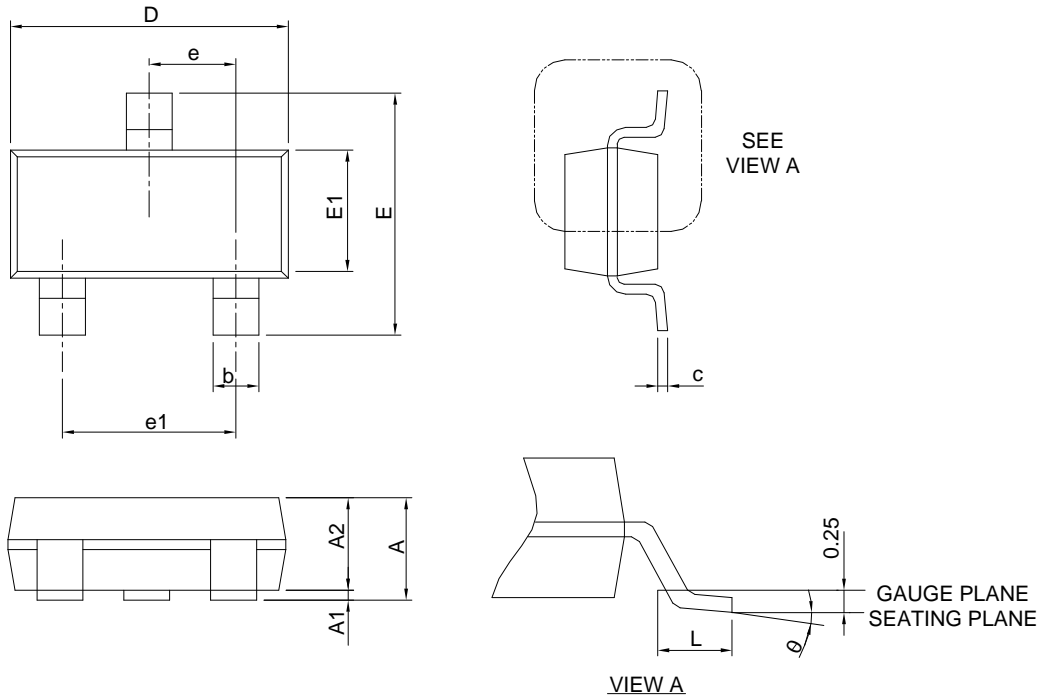
## Typical Characteristics (Cont.)





Package Information

SOT-23-3

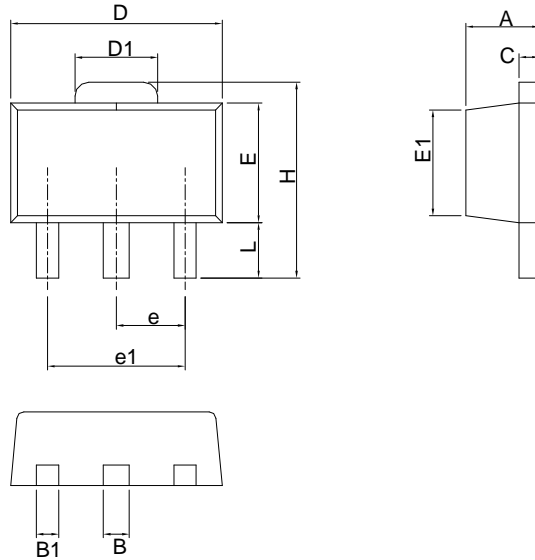


| SYMBOLS  | SOT-23      |      |           |       |
|----------|-------------|------|-----------|-------|
|          | MILLIMETERS |      | INCHES    |       |
|          | MIN.        | MAX. | MIN.      | MAX.  |
| A        |             | 1.45 |           | 0.057 |
| A1       | 0.00        | 0.15 | 0.000     | 0.006 |
| A2       | 0.90        | 1.30 | 0.035     | 0.051 |
| b        | 0.30        | 0.50 | 0.012     | 0.020 |
| c        | 0.08        | 0.22 | 0.003     | 0.009 |
| D        | 2.70        | 3.10 | 0.106     | 0.122 |
| E        | 2.60        | 3.00 | 0.102     | 0.118 |
| E1       | 1.40        | 1.80 | 0.055     | 0.071 |
| e        | 0.95 BSC    |      | 0.037 BSC |       |
| e1       | 1.90 BSC    |      | 0.075 BSC |       |
| L        | 0.30        | 0.60 | 0.012     | 0.024 |
| $\theta$ | 0°          | 8°   | 0°        | 8°    |

Note : Dimension D and E1 do not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.

Package Information

SOT-89

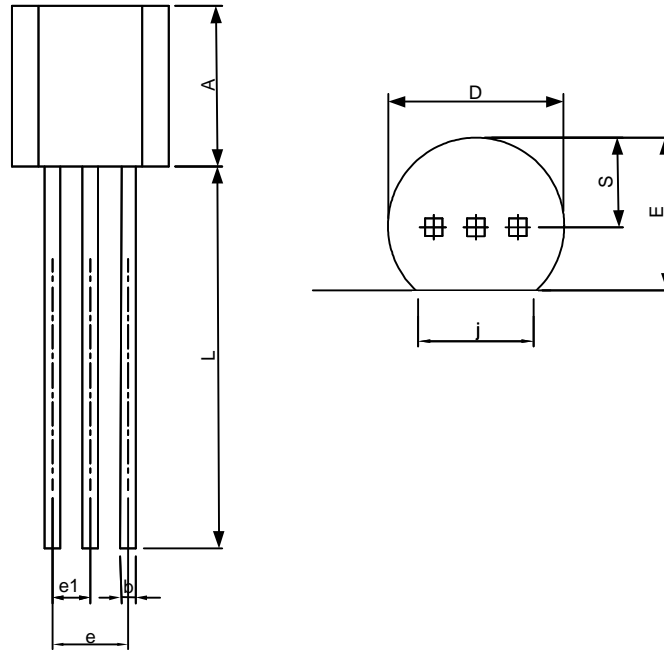


| SYMBOL | SOT-89      |      |           |       |
|--------|-------------|------|-----------|-------|
|        | MILLIMETERS |      | INCHES    |       |
|        | MIN.        | MAX. | MIN.      | MAX.  |
| A      | 1.40        | 1.60 | 0.055     | 0.063 |
| B      | 0.44        | 0.56 | 0.017     | 0.022 |
| B1     | 0.36        | 0.48 | 0.014     | 0.019 |
| C      | 0.35        | 0.44 | 0.014     | 0.017 |
| D      | 4.40        | 4.60 | 0.173     | 0.181 |
| D1     | 1.62        | 1.83 | 0.064     | 0.072 |
| E      | 2.29        | 2.60 | 0.090     | 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 |

Note : Follow JEDEC TO-243 AA.

Package Information

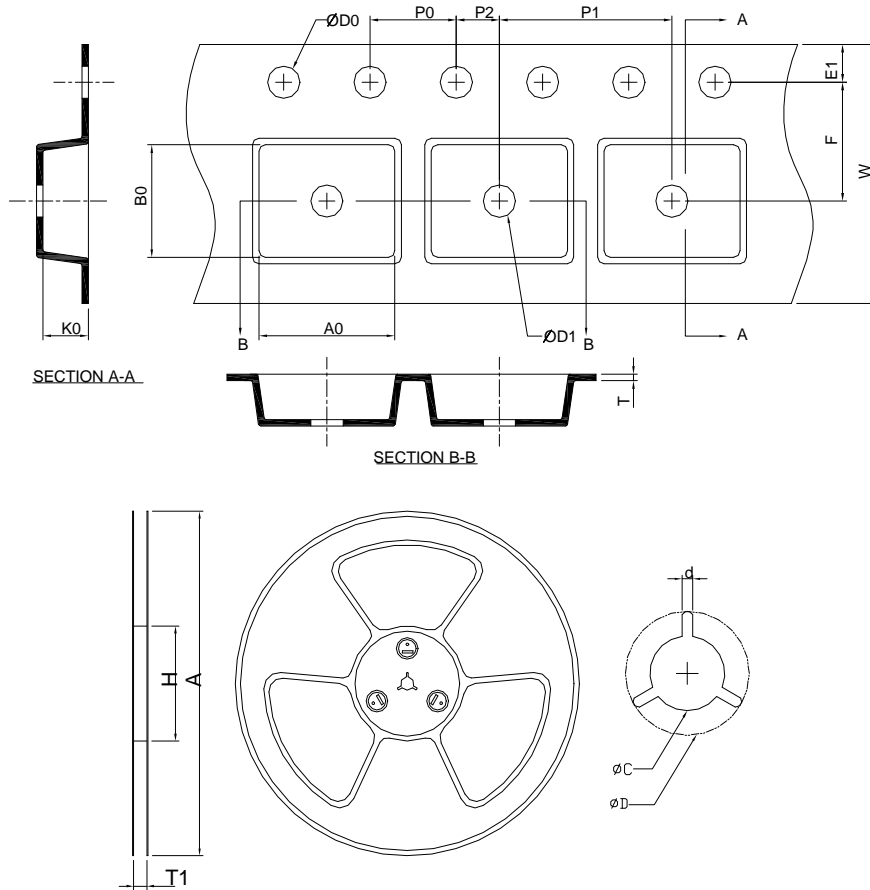
TO-92



| SYMBOL | TO-92       |       |        |       |
|--------|-------------|-------|--------|-------|
|        | MILLIMETERS |       | INCHES |       |
|        | MIN.        | MAX.  | MIN.   | MAX.  |
| A      | 4.32        | 5.33  | 0.170  | 0.210 |
| b      | 0.41        | 0.53  | 0.016  | 0.021 |
| D      | 4.45        | 5.20  | 0.175  | 0.205 |
| E      | 3.18        | 4.19  | 0.125  | 0.165 |
| e      | 2.42        | 2.66  | 0.095  | 0.105 |
| e1     | 1.15        | 1.39  | 0.045  | 0.055 |
| j      | 3.43        | 4.00  | 0.135  | 0.157 |
| L      | 12.70       | 15.00 | 0.500  | 0.591 |
| S      | 2.03        | 2.66  | 0.080  | 0.105 |

Note : Follow JEDEC TO-92.

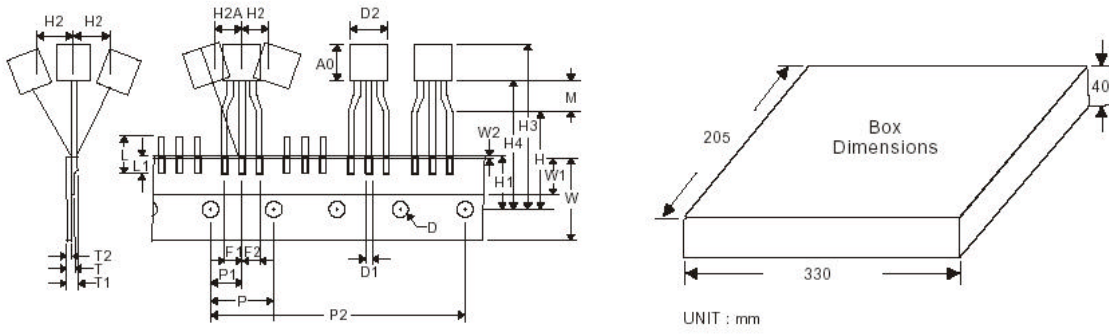
### Carrier Tape & Reel Dimensions



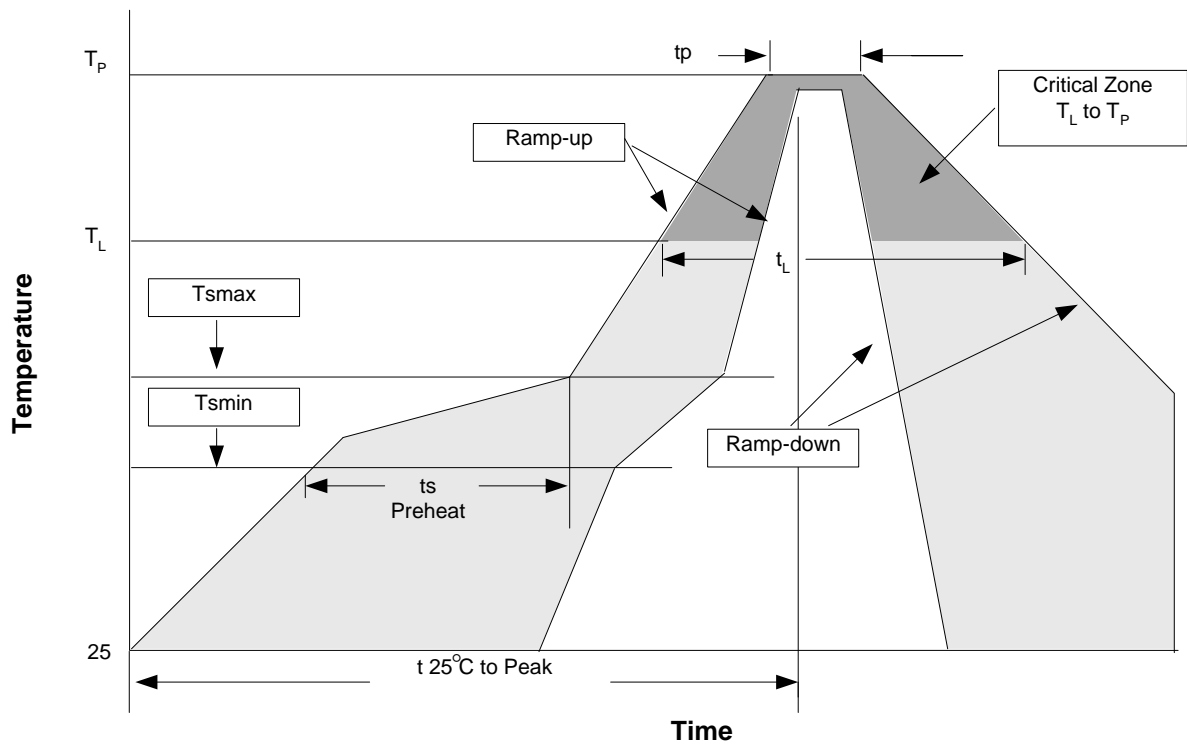
| Application     | A           | H         | T1                | C                  | d         | D                 | W          | E1         | F          |
|-----------------|-------------|-----------|-------------------|--------------------|-----------|-------------------|------------|------------|------------|
| <b>SOT-23-3</b> | 178.0 ±0.00 | 50 MIN.   | 8.4+2.00<br>-0.00 | 13.0+0.50<br>-0.20 | 1.5 MIN.  | 20.2 MIN.         | 8.0 ±0.30  | 1.75 ±0.10 | 3.5 ±0.05  |
|                 | <b>P0</b>   | <b>P1</b> | <b>P2</b>         | <b>D0</b>          | <b>D1</b> | <b>T</b>          | <b>A0</b>  | <b>B0</b>  | <b>K0</b>  |
|                 | 4.0 ±0.10   | 4.0 ±0.10 | 2.0 ±0.10         | 1.5+0.10<br>-0.00  | 1.5 MIN.  | 0.6+0.00<br>-0.40 | 3.20 ±0.20 | 3.10 ±0.20 | 1.50 ±0.20 |
| Application     | A           | H         | T1                | C                  | d         | D                 | W          | E1         | F          |
| <b>SOT-89</b>   | 178.0 ±0.00 | 50 MIN.   | 8.4+2.00<br>-0.00 | 13.0+0.50<br>-0.20 | 1.5 MIN.  | 20.2 MIN.         | 12.0 ±0.30 | 1.75 ±0.10 | 5.50 ±0.05 |
|                 | <b>P0</b>   | <b>P1</b> | <b>P2</b>         | <b>D0</b>          | <b>D1</b> | <b>T</b>          | <b>A0</b>  | <b>B0</b>  | <b>K0</b>  |
|                 | 4.0 ±0.10   | 8.0 ±0.10 | 2.0 ±0.10         | 1.5+0.10<br>-0.00  | 1.5 MIN.  | 0.6+0.00<br>-0.40 | 4.80 ±0.20 | 4.50 ±0.20 | 1.80 ±0.20 |

(mm)

### Carrier Tape & Box Dimensions



### Reflow Condition (IR/Convection or VPR Reflow)



## Devices Per Unit

| Package Type | Unit        | Quantity |
|--------------|-------------|----------|
| SOT-23-3     | Tape & Reel | 3000     |
| SOT-89       | Tape & Reel | 1000     |
| TO-92        | Tape & Box  | 2000     |

## Reliability Test Program

| Test item     | Method              | Description                   |
|---------------|---------------------|-------------------------------|
| SOLDERABILITY | MIL-STD-883D-2003   | 245°C, 5 sec                  |
| HOLT          | MIL-STD-883D-1005.7 | 1000 Hrs Bias @125°C          |
| PCT           | JESD-22-B, A102     | 168 Hrs, 100%RH, 121°C        |
| TST           | MIL-STD-883D-1011.9 | -65°C~150°C, 200 Cycles       |
| ESD           | MIL-STD-883D-3015.7 | VHBM > 2KV, VMM > 200V        |
| Latch-Up      | JESD 78             | 10ms, 1 <sub>tr</sub> > 100mA |

## Classification Reflow Profiles

| Profile Feature  | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|--|-------------------------|------------------|
| Average ramp-up rate (T <sub>L</sub> to T <sub>P</sub> )     | 3°C/second max.         | 3°C/second max.  |
| Preheat  |                         |                  |
| - Temperature Min (T <sub>smin</sub> )                       | 100°C                   | 150°C            |
| - Temperature Max (T <sub>smax</sub> )                       | 150°C                   | 200°C            |
| - Time (min to max) (t <sub>s</sub> )                        | 60-120 seconds          | 60-180 seconds   |
| Time maintained above:                                       |                         |                  |
| - Temperature (T <sub>L</sub> )                              | 183°C                   | 217°C            |
| - Time (t <sub>L</sub> )                                     | 60-150 seconds          | 60-150 seconds   |
| Peak/Classification Temperature (T <sub>p</sub> )            | See table 1             | See table 2      |
| Time within 5°C of actual Peak Temperature (t <sub>p</sub> ) | 10-30 seconds           | 20-40 seconds    |
| Ramp-down Rate   | 6°C/second max.         | 6°C/second max.  |
| Time 25°C to Peak Temperature                                | 6 minutes max.          | 8 minutes max.   |

Note: All temperatures refer to topside of the package. Measured on the body surface.

## Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm           | 240 +0/-5°C                    | 225 +0/-5°C                    |
| ≥2.5 mm           | 225 +0/-5°C                    | 225 +0/-5°C                    |

Table 2. Pb-free Process – Package Classification Reflow Temperatures

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>>2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm           | 260 +0°C*                      | 260 +0°C*                          | 260 +0°C*                       |
| 1.6 mm – 2.5 mm   | 260 +0°C*                      | 250 +0°C*                          | 245 +0°C*                       |
| ≥2.5 mm           | 250 +0°C*                      | 245 +0°C*                          | 245 +0°C*                       |

\* Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.

## Customer Service

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