

## Adjustable Precision Shunt Regulator

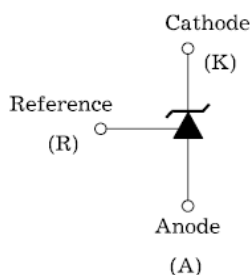
### ◆ Description

The TL431 is a three-terminal adjustable regulator series with a guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between  $V_{ref}$  and 36 volts with two external resistors. These device have a typical dynamic output impedance of  $0.27\Omega$ , Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.

### ◆ Features

- Programmable Output Voltage to 36V. ➤
- Low Dynamic Output Impedance :  
TL431xx:  $0.27\ \Omega$  (Typical).
- Sink Current Capability of 0.1mA to 100mA.
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C
- Temperature Compensated for Operation over Full Rated Operating Temperature Range.
- Low Output Noise Voltage.
- Fast Turn on Responds.
- SOT-23, TO-92, SOT-89, SOP-8, TO-92L packages

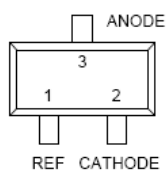
### ◆ Symbol



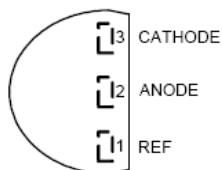
### ◆ Applications

- Precision Voltage Reference
- Linear Regulator
- Adjustable Power Supply
- Switching Power Supply
- Graphic Card
- Adapter

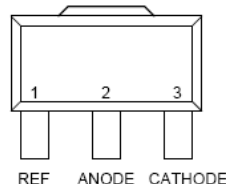
### ◆ Pin Description



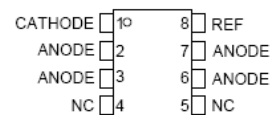
SOT-23 (Top View)



TO-92 (Top View)



SOT-89 (Top View)



SOP-8 (Top View)

◆ **Absolute Maximum Ratings**

| Symbol      | Parameter                         |        | Value    | Unit |
|-------------|-----------------------------------|--------|----------|------|
| $V_{KA}$    | Cathode Voltage                   | TL431x | 40       | V    |
| $I_K$       | Cathode Current Range(Continuous) |        | -100~150 | mA   |
| $I_{REF}$   | Reference Input Current Range     |        | 0.05~10  | mA   |
| $T_{oper.}$ | Operating Temperature Range       | TL431x | -40~85   | °C   |
| $T_J$       | Junction Temperature Range        |        | 150      | °C   |
| $T_{stg}$   | Storage Temperature Range         |        | -65~+150 | °C   |

◆ **Thermal Characteristics**

| Symbol        | Parameter   | Package | Typical Value | Unit |
|---------------|---|---------|---------------|------|
| $\theta_{JA}$ | Thermal Resistance From Junction to Ambient in Free Air. (Measured with the component mounted on a high effective thermal conductivity test board in free air.) | SOT-23  | 400           | °C/W |
|               |   | TO-92   | 400           |      |
|               |   | SOT-89  | 400           |      |
|               |   | SOP-8   | 450           |      |

◆ **Recommended Operating Conditions**

| Symbol   | Characteristic  |        | Min.      | Typ. | Max. | Unit |
|----------|-----------------|--------|-----------|------|------|------|
| $V_{KA}$ | Cathode Voltage | TL431x | $V_{REF}$ | -    | 36   | V    |
| $I_K$    | Cathode Current | TL431x | 0.5       | -    | 100  | mA   |

### ◆ Electrical Characteristics

( $T_a=25\text{ }^\circ\text{C}$ ,  $V_{KA}=V_{REF}$ ,  $I_K=10\text{mA}$  unless otherwise noted .)

| Symbol                                 | Parameter   |         | Test Condition   | Min.  | Typ.  | Max.  | Unit          |
|--|---|---------|--|-------|-------|-------|---------------|
| $V_{REF}$                              | Reference input Voltage   |         | $V_{KA}=V_{REF}$ ,<br>$I_K=10\text{mA}$   0.5%               | 2.483 | 2.495 | 2.508 | V             |
| $V_{REF(dev)}$                         | Deviation of Reference Input Voltage Over Full Temperature Range            |         | $T_{min} \leq T_a \leq T_{max}$                              | -     | 3     | 17    | mV            |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ | Ratio of change in Reference input Voltage to the Change in Cathode Voltage |         | $\Delta V_{KA}=10\text{V}-V_{REF}$                           | -0.4  | -     | 2.7   | mV/<br>V      |
|  |   |         | $\Delta V_{KA}=36\text{V}-10\text{V}$                        | -0.4  | -     | 2.0   |               |
| $I_{REF}$                              | Reference Input Current   |         | $R_1=10\text{K}\Omega$ , $R_2=\infty$                        | -     | 1.8   | 4     | $\mu\text{A}$ |
| $I_{REF(dev)}$                         | Deviation of Reference Input Current Over Full Temperature Range            |         | $R_1=10\text{K}\Omega$ , $R_2=\infty$                        | -     | 0.4   | 1.2   | $\mu\text{A}$ |
| $I_{K(min)}$                           | Minimum Cathode Current for Regulation                                      |         |  | -     | 0.25  | 0.5   | mA            |
| $I_{K(off)}$                           | Off-State Cathode Current   |         | $V_{KA}=40\text{V}$ , $V_{REF}=0$                            | -     | 0.17  | 0.9   | $\mu\text{A}$ |
| $Z_{KA}$                               | Dynamic Impedance   | TL431xx | $I_K=1\text{mA}$ to $100\text{mA}$<br>$f \leq 1.0\text{KHz}$ | -     | 0.27  | 0.5   | $\Omega$      |

◆ Test Circuit

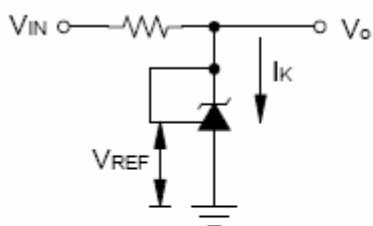


Figure 1. Test Circuit for  $V_{KA} = V_{REF}$ ,  $V_O = V_{KA} = V_{REF}$

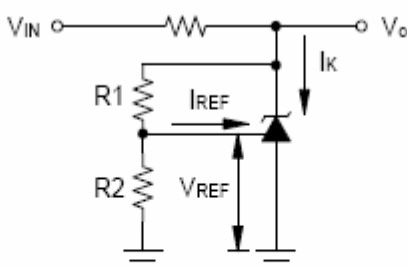


Figure 2. Test Circuit for  $V_{KA} > V_{REF}$ ,  $V_O = V_{KA} = V_{REF} \times (1 + R_1/R_2) + I_{REF} \times R_1$

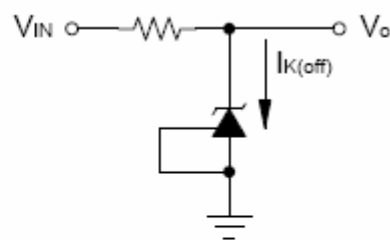
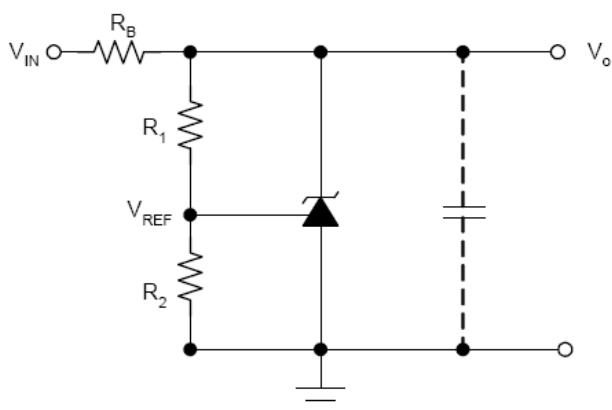
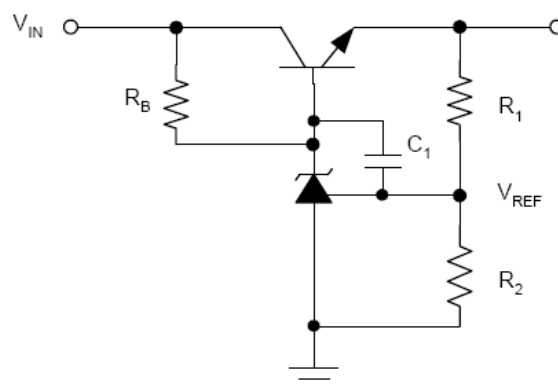


Figure 3. Test Circuit for  $I_{K(off)}$

◆ Typical Application Circuits



Precision Voltage Reference

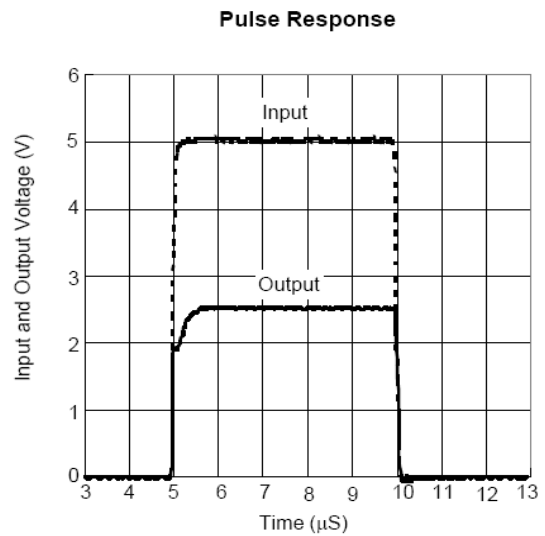
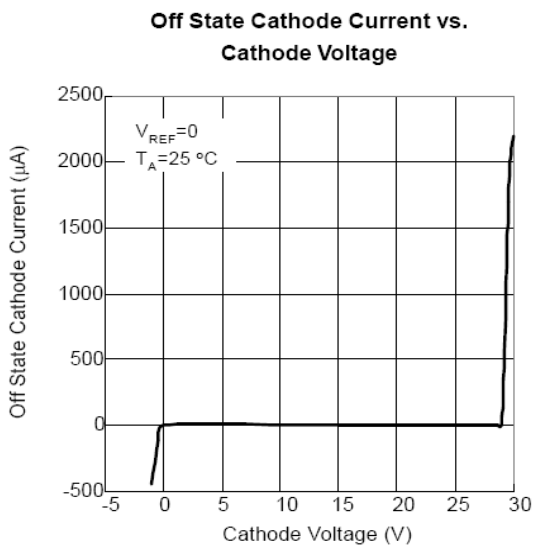
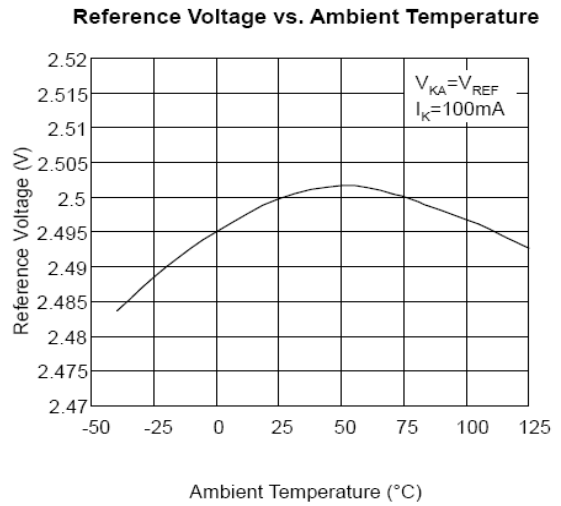
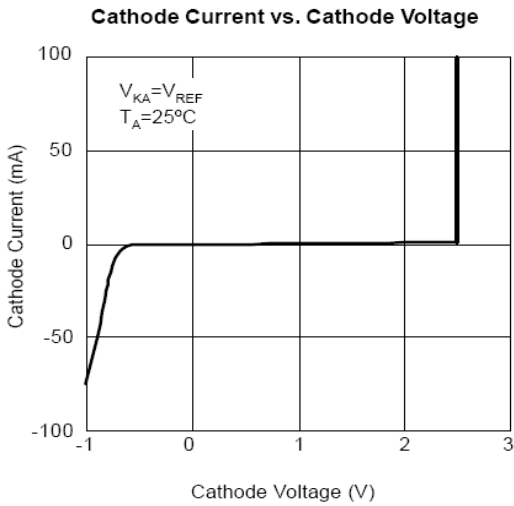
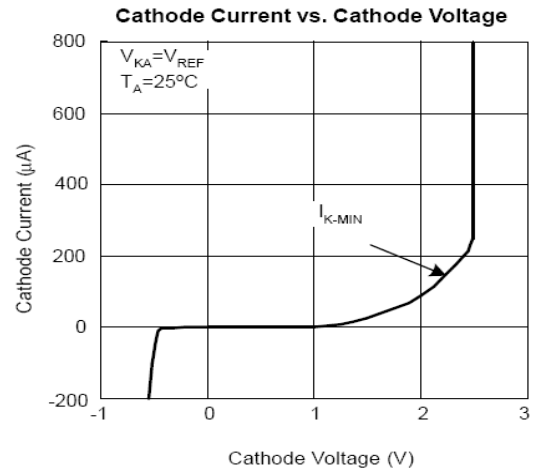
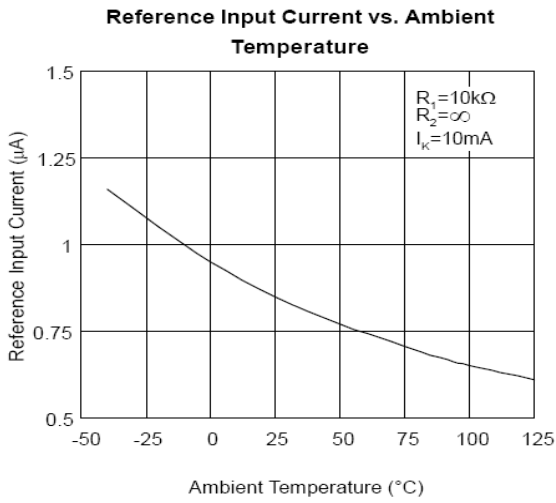


Precision High-Current Series Regulator

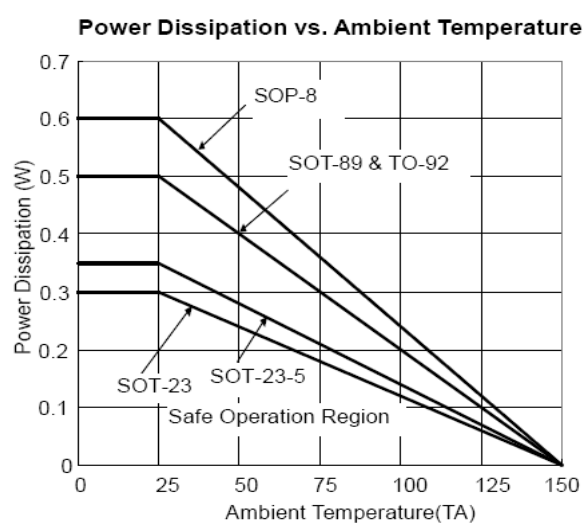
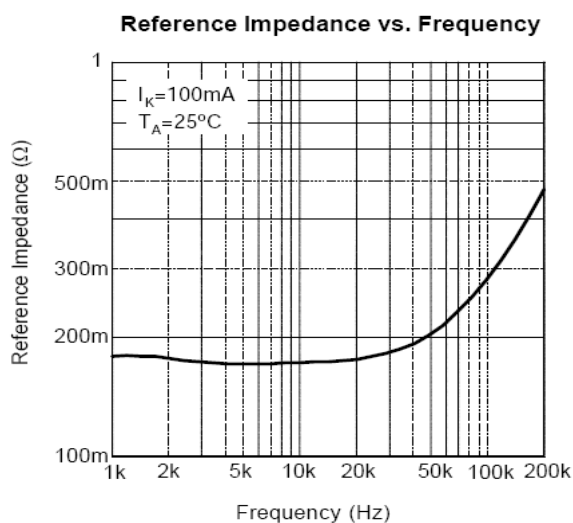
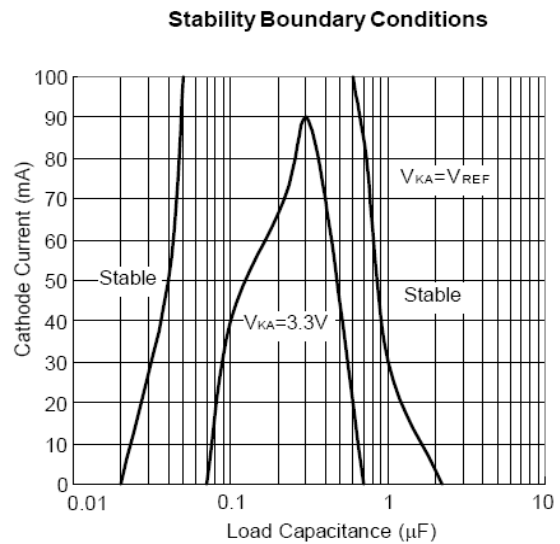
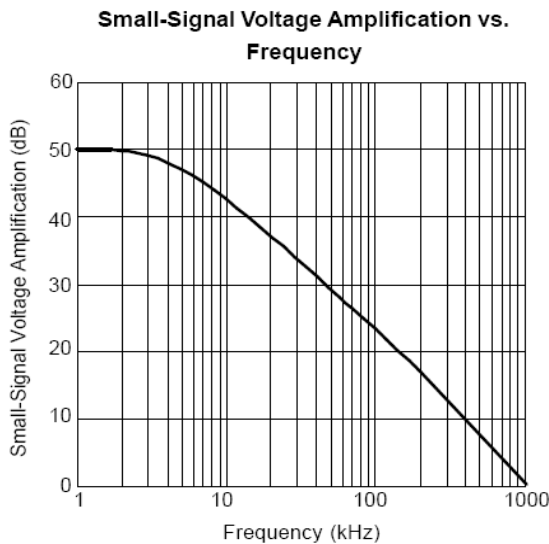
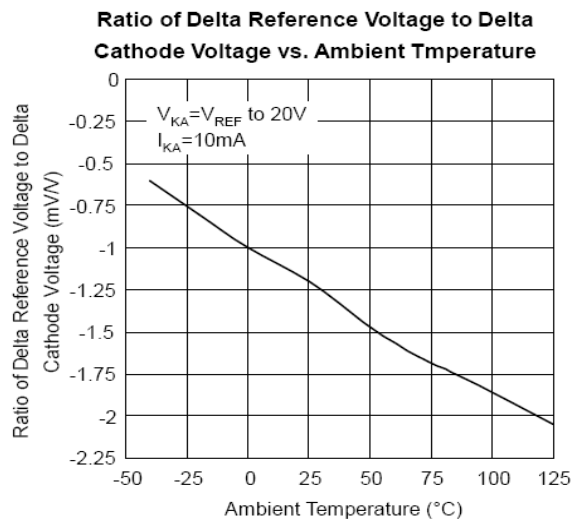
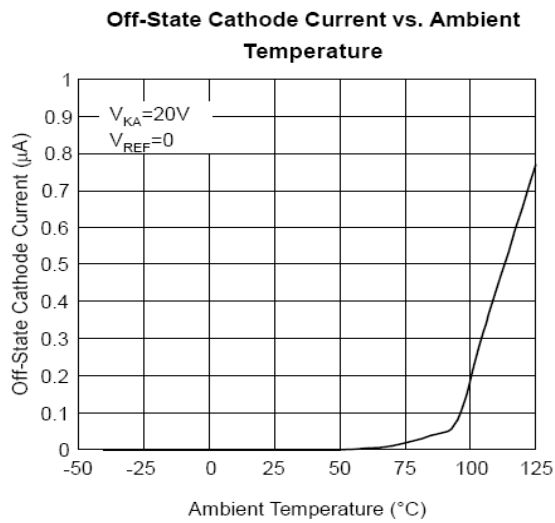
Notes for Typical Application Circuits:

1. For the series regulator applications, add a compensation capacitor  $C_1$  between CATHODE and REF is strongly recommended to improve the stability of output voltage.
2. Set  $V_o$  according to the following equation:  $V_o = V_{REF}(1 + R_1/R_2) + I_{REF} \times R_1$ .
3. Choose the Value for  $R_B$  as below:
  - (1). 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  $V_{IN(MIN)}$ .
  - (2). 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.

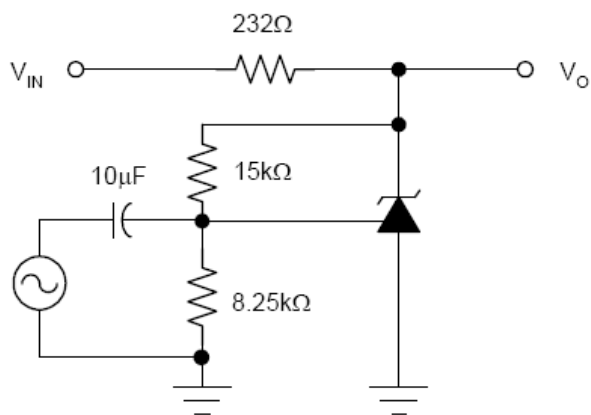
◆ Typical Characteristics



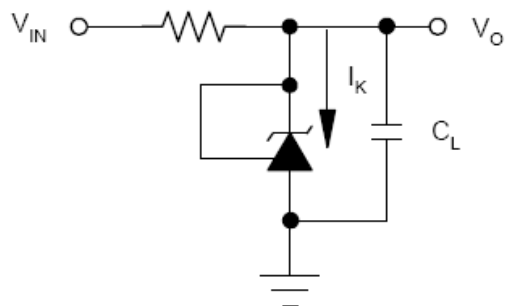
◆ Typical Characteristics (Continued)



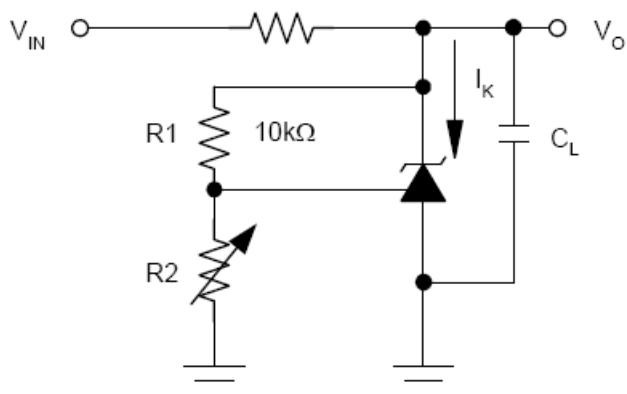
◆ Typical Characteristics (Continued)



Voltage Amplification Test Circuit



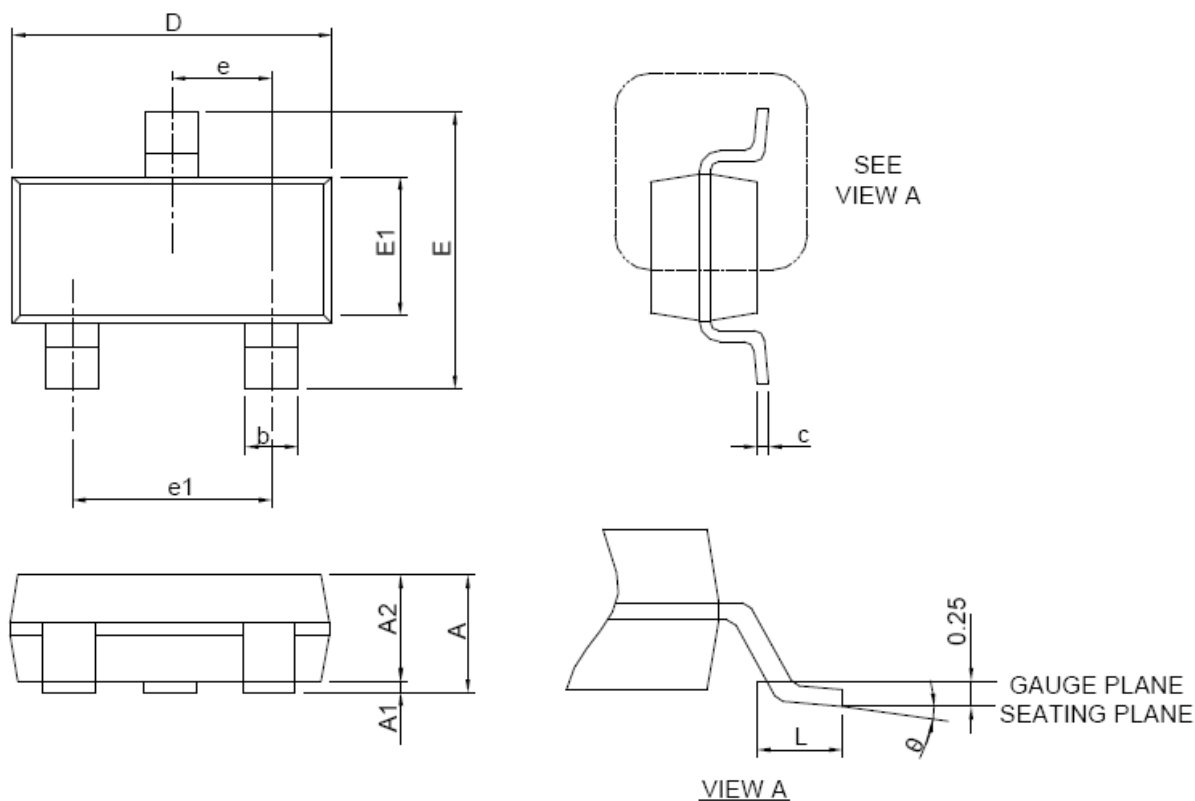
Stability Test Circuit for  $V_{KA}=V_{REF}$



Stability Test Circuit for  $V_{KA}>V_{REF}$   
 $V_O = V_{KA} = V_{REF} \times (1 + R1/R2) + I_{REF} \times R1$   
 Use the MLCC for  $C_L$

◆ Package Information

SOT-23

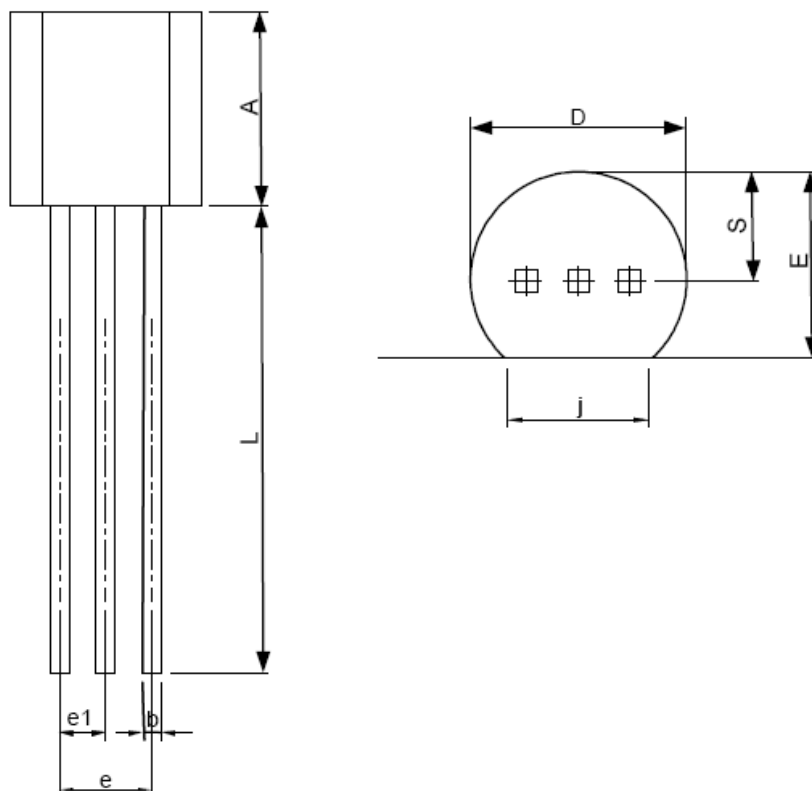


| SYMBOL | SOT-23      |      |           |       |
|--------|-------------|------|-----------|-------|
|        | MILLIMETERS |      | INCHES    |       |
|        | MIN.        | MAX. | MIN.      | MAX.  |
| A      |             | 1.15 |           | 0.045 |
| A1     | 0.00        | 0.10 | 0.000     | 0.004 |
| A2     | 0.90        | 1.05 | 0.035     | 0.041 |
| b      | 0.30        | 0.50 | 0.012     | 0.020 |
| c      | 0.08        | 0.15 | 0.003     | 0.006 |
| D      | 2.70        | 3.00 | 0.110     | 0.118 |
| E      | 2.25        | 2.55 | 0.089     | 0.100 |
| E1     | 1.20        | 1.40 | 0.047     | 0.055 |
| e      | 0.95 BSC    |      | 0.037 BSC |       |
| e1     | 1.90 BSC    |      | 0.075 BSC |       |
| L      | 0.30        | 0.60 | 0.012     | 0.024 |
| θ      | 0°          | 8°   | 0°        | 8°    |



◆ Package Information

TO-92

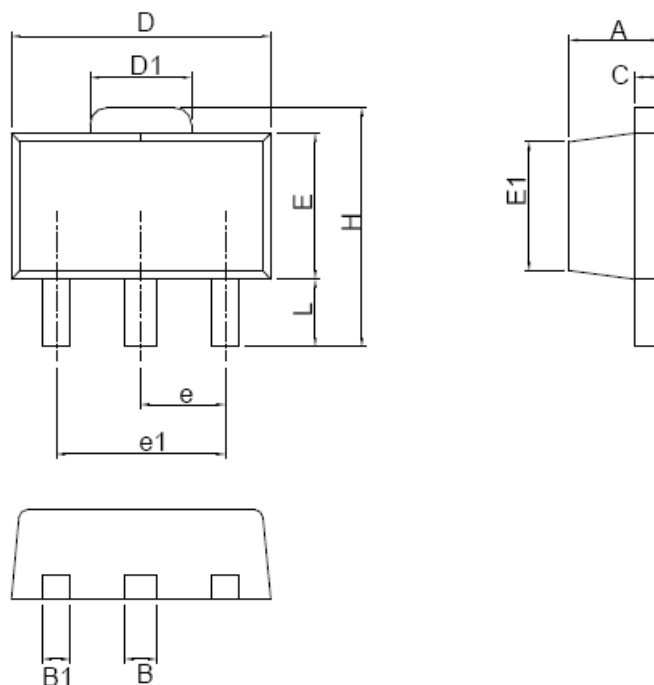


| SYMBOL | TO-92       |       |        |       |
|--------|-------------|-------|--------|-------|
|        | MILLIMETERS |       | INCHES |       |
|        | MIN.        | MAX.  | MIN.   | MAX.  |
| A      | 4.32        | 5.33  | 0.170  | 0.210 |
| b      | 0.41        | 0.53  | 0.016  | 0.021 |
| 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.

◆ Package Information

SOT-89

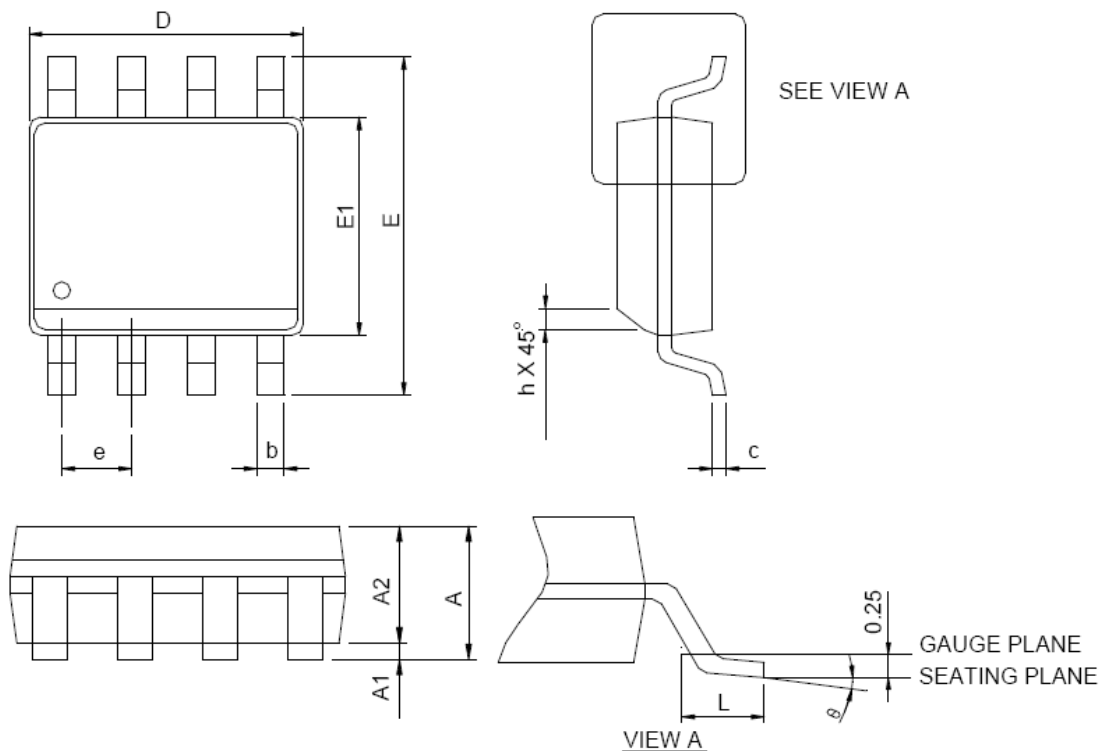


| SYMBOL | SOT-89      |      |           |       |
|--------|-------------|------|-----------|-------|
|        | MILLIMETERS |      | INCHES    |       |
|        | MIN.        | MAX. | MIN.      | MAX.  |
| A      | 1.40        | 1.60 | 0.055     | 0.063 |
| B      | 0.44        | 0.56 | 0.017     | 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

SOP-8

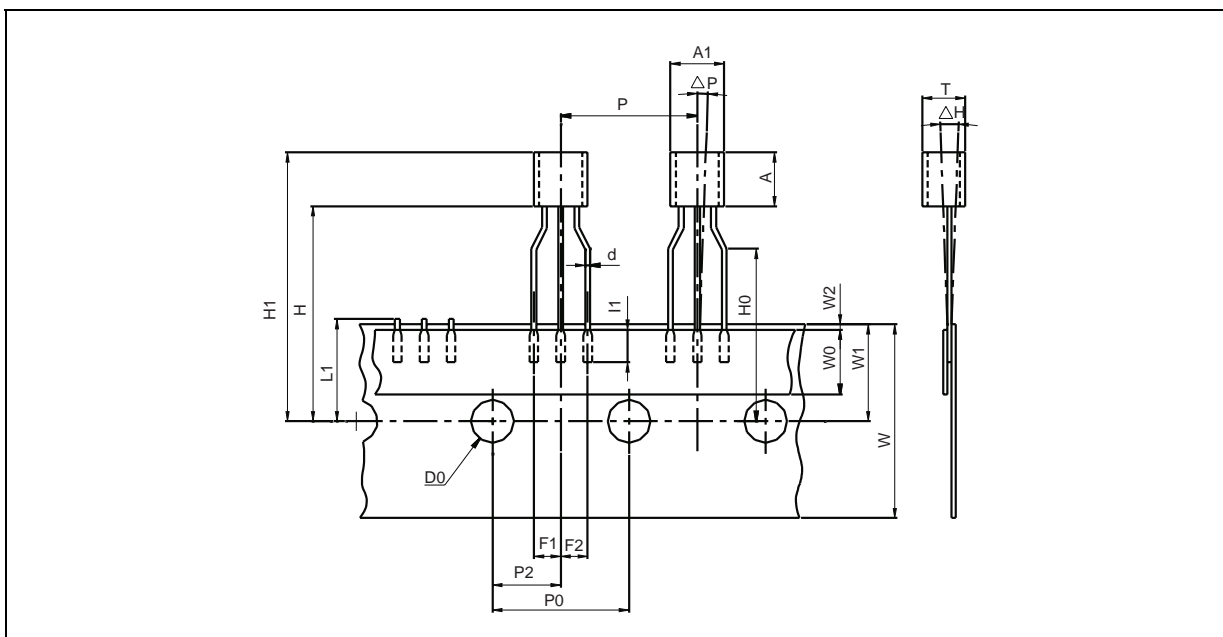


| SYMBOL   | SOP-8       |      |           |       |
|----------|-------------|------|-----------|-------|
|          | MILLIMETERS |      | INCHES    |       |
|          | MIN.        | MAX. | MIN.      | MAX.  |
| A        |             | 1.75 |           | 0.069 |
| A1       | 0.10        | 0.25 | 0.004     | 0.010 |
| A2       | 1.25        |      | 0.049     |       |
| b        | 0.31        | 0.51 | 0.012     | 0.020 |
| c        | 0.17        | 0.25 | 0.007     | 0.010 |
| D        | 4.80        | 5.00 | 0.189     | 0.197 |
| E        | 5.80        | 6.20 | 0.228     | 0.244 |
| E1       | 3.80        | 4.00 | 0.150     | 0.157 |
| 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 |
| $\theta$ | 0°          | 8°   | 0°        | 8°    |

- Note: 1. Follow JEDEC MS-012 AA.  
 2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.  
 3. Dimension "E" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

◆ Package Information

TO-92L



| Dim.  | Millimeters |      |      | Inches |       |       |
|-------|-------------|------|------|--------|-------|-------|
|       | Min         | Typ. | Max. | Min.   | Typ.  | Max.  |
| AL    |             |      | 5.0  |        |       | 0.197 |
| A     |             |      | 5.0  |        |       | 0.197 |
| T     |             |      | 4.0  |        |       | 0.157 |
| d     |             | 0.45 |      |        | 0.018 |       |
| I1    | 2.5         |      |      | 0.098  |       |       |
| P     | 11.7        | 12.7 | 13.7 | 0.461  | 0.500 | 0.539 |
| PO    | 12.4        | 12.7 | 13   | 0.488  | 0.500 | 0.512 |
| P2    | 5.95        | 6.35 | 6.75 | 0.234  | 0.250 | 0.266 |
| F1/F2 | 2.4         | 2.5  | 2.8  | 0.094  | 0.098 | 0.110 |
| Δh    | -1          | 0    | 1    | -0.039 | 0     | 0.039 |
| ΔP    | -1          | 0    | 1    | -0.039 | 0     | 0.039 |
| W     | 17.5        | 18.0 | 19.0 | 0.689  | 0.709 | 0.748 |
| W0    | 5.7         | 6    | 6.3  | 0.224  | 0.236 | 0.248 |
| W1    | 8.5         | 9    | 9.75 | 0.335  | 0.354 | 0.384 |
| W2    |             |      | 0.5  |        |       | 0.020 |
| H     |             |      | 20   |        |       | 0.787 |
| H0    | 15.5        | 16   | 16.5 | 0.610  | 0.630 | 0.650 |
| H1    |             |      | 25   |        |       | 0.984 |
| DO    | 3.8         | 4.0  | 4.2  | 0.150  | 0.157 | 0.165 |
| L1    |             |      | 11   |        |       | 0.433 |

◆ Ordering information

| Order Code  | Package | Baseqty | Deliverymode  | Accuracy |
|-------------|---------|---------|---------------|----------|
| UMW TL431AL | TO-92L  | 2000    | Ammo outfit   | 0.5%     |
| UMW TL431L  | TO-92   | 1000    | Bulk Bag      | 0.5%     |
| UMW TL431   | SOT-23  | 3000    | Tape and Reel | 0.5%     |
| UMW TL431S  | SOT-89  | 1000    | Tape and Reel | 0.5%     |
| UMW TL431D  | SOP-8   | 2500    | Tape and Reel | 0.5%     |