

**ZTL431/ZTL432**  
**COST EFFECTIVE ADJUSTABLE PRECISION SHUNT REGULATOR**

**Description**

The ZTL431 and ZTL432 are three terminal adjustable shunt regulators offering excellent temperature stability and output current handling capability up to 100mA. The output voltage may be set to any chosen voltage between 2.5 and 20 volts by selection of two external divider resistors.

The devices can be used as a replacement for zener diodes in many applications requiring an improvement in zener performance.

The ZTL432 has the same electrical specifications as the ZTL431 but has a different pin out in SOT23 (F-suffix) and SOT23F (FF-suffix).

Both variants are available in 2 grades with initial tolerances of 1% and 0.5% for the A and B grades respectively.

These are functionally equivalent to the TL431/ TL432 except for maximum operation voltage, and have an ambient temperature range of -40 to 125°C as standard.

**Features**

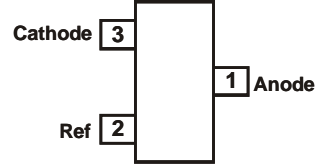
- Temperature range ..... -40 to 125°C
- Reference voltage tolerance at 25°C
  - 0.5%.....B grade
  - 1% .....A grade
- 0.2Ω typical output impedance
- Sink current capability..... 1mA to 100mA
- Adjustable output voltage.....V<sub>REF</sub> to 20V

**Applications**

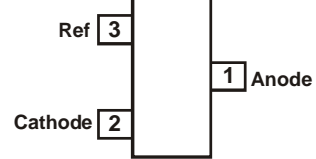
- Opto-coupler linearization
- Linear regulators
- Improved zener
- Variable reference

**Pin Assignments**

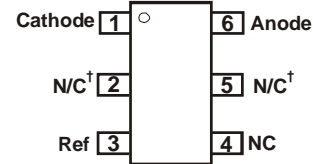
**ZTL431\_F SOT23, ZTL431\_FF SOT23F**  
(Top View)



**ZTL432\_F SOT23, ZTL432\_FF SOT23F**  
(Top View)

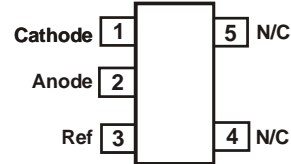


**ZTL431\_H6, SC70-6**  
(Top View)

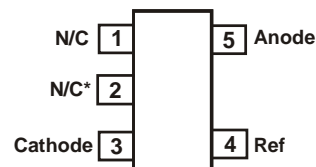


†Connected internally to substrate; should be left floating or connected to Anode

**ZTL431ASE5 SOT235**  
(Top View)



**ZTL431\_E5 SOT235**  
(Top View)



\*must be left floating or connected to pin 5

**Absolute Maximum Ratings** (Voltages specified are relative to the ANODE pin unless otherwise stated)

| Parameter                                   | Rating              | Unit         |
|---|---------------------|--------------|
| Cathode Voltage ( $V_{KA}$ )                | 20                  | V            |
| Continuous Cathode Current ( $I_{KA}$ )     | 150                 | mA           |
| Reference Input Current Range ( $I_{REF}$ ) | -50 $\mu$ A to 10mA |              |
| Operating Junction Temperature              | -40 to 150          | $^{\circ}$ C |
| Storage Temperature                         | -55 to 150          | $^{\circ}$ C |

Operation above the absolute maximum rating may cause device failure.  
Operation at the absolute maximum ratings, for extended periods, may reduce device reliability.

**Package Thermal Data**

| Package | $\theta_{JA}$      | $P_{DIS}$<br>$T_A = 25^{\circ}$ C, $T_J = 150^{\circ}$ C |
|---------|--------------------|--|
| SOT23   | 380 $^{\circ}$ C/W | 330 mW   |
| SOT23F  | 138 $^{\circ}$ C/W | 900 mW   |
| SOT23-5 | 250 $^{\circ}$ C/W | 500 mW   |
| SOT70-6 | 380 $^{\circ}$ C/W | 330mW  |

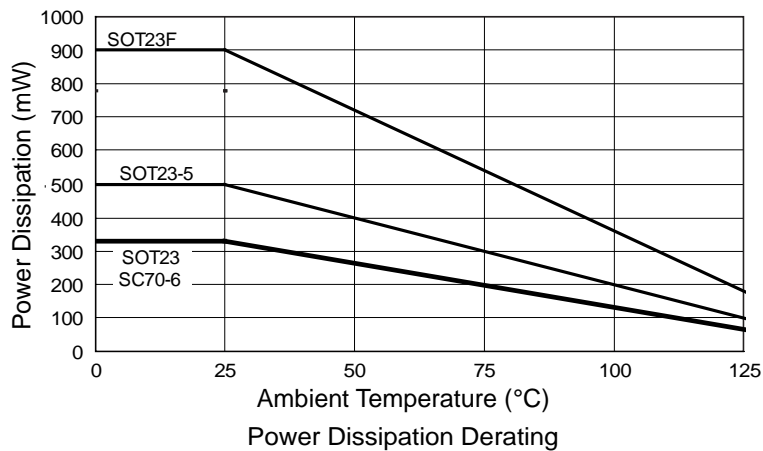
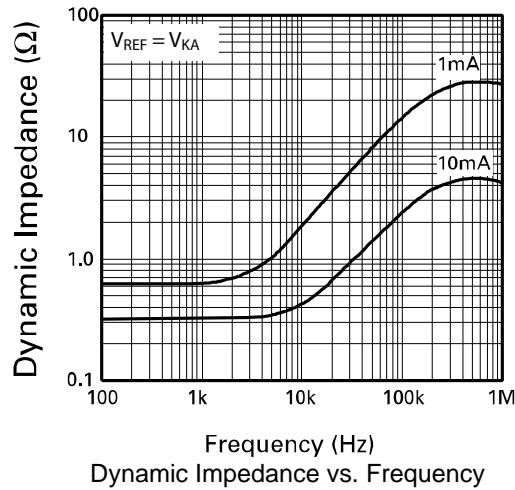
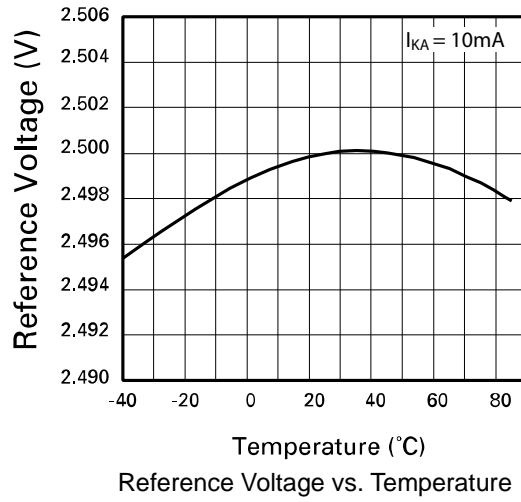
**Recommended Operating Conditions**

|   | Min       | Max | Units        |
|---|-----------|-----|--------------|
| $V_{KA}$ Cathode Voltage                  | $V_{REF}$ | 20  | V            |
| $I_{KA}$ Cathode Current                  | 1         | 100 | mA           |
| $T_A$ Operating Ambient Temperature Range | -40       | 125 | $^{\circ}$ C |

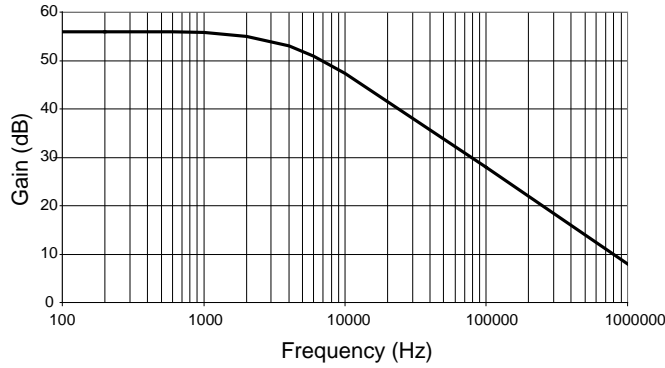
**Electrical Characteristics** (Test conditions unless otherwise specified:  $T_A = 25^{\circ}$ C)

| Symbol                                 | Parameter   | Conditions  | Min.                           | Typ.  | Max. | Units    |         |
|--|---|---|--------------------------------|-------|------|----------|---------|
| $V_{REF}$                              | Reference voltage   | $V_{KA} = V_{REF}$<br>$I_{KA} = 10$ mA                  | ZTL43_A                        | 2.475 | 2.5  | 2.525    | V       |
|  |   |   | ZTL43_B                        | 2.487 | 2.5  | 2.513    |         |
| $V_{DEV}$                              | Deviation of reference voltage over full temperature range            | $V_{KA} = V_{REF}$<br>$I_{KA} = 10$ mA                  | $T_A = 0$ to $70^{\circ}$      |       | 6    | 16       | mV      |
|  |   |   | $T_A = -40$ to $85^{\circ}$ C  |       | 14   | 34       |         |
|  |   |   | $T_A = -40$ to $125^{\circ}$ C |       | 14   | 34       |         |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ | Ratio of change in reference voltage to the change in cathode voltage | $I_{KA} = 10$ mA  | $V_{KA} = V_{REF}$ to 10       |       | -1.4 | -2.7     | mV/V    |
|  |   |   | $V_{KA} = 10$ V to 20V         |       | -1.0 | -2.0     |         |
| $I_{REF}$                              | Reference input current   | $I_{KA} = 10$ mA, $R_1 = 10$ k $\Omega$<br>$R_2 = OC$   |                                | 2     | 4    | $\mu$ A  |         |
| $\Delta I_{REF}$                       | $I_{REF}$ deviation over full temperature range                       | $I_{KA} = 10$ mA<br>$R_1 = 10$ k $\Omega$<br>$R_2 = OC$ | $T_A = 0$ to $70^{\circ}$ C    |       | 0.8  | 1.2      | $\mu$ A |
|  |   |   | $T_A = -40$ to $85^{\circ}$ C  |       | 0.8  | 2.5      |         |
|  |   |   | $T_A = -40$ to $125^{\circ}$ C |       | 0.8  | 2.5      |         |
| $I_{KA(MIN)}$                          | Minimum cathode current for regulation                                | $V_{KA} = V_{REF}$                                      |                                | 0.4   | 0.6  | mA       |         |
| $I_{KA(OFF)}$                          | Off state current   | $V_{KA} = 20$ V, $V_{REF} = 0$ V                        |                                | 0.1   | 0.5  | $\mu$ A  |         |
| $R_Z$                                  | Dynamic output impedance  | $V_{KA} = V_{REF}$ , $f = 0$ Hz                         |                                | 0.2   | 0.5  | $\Omega$ |         |

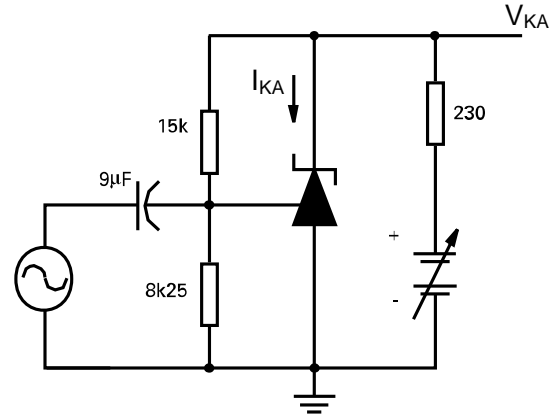
**Typical Characteristics**



**Typical Characteristics (Cont.)**

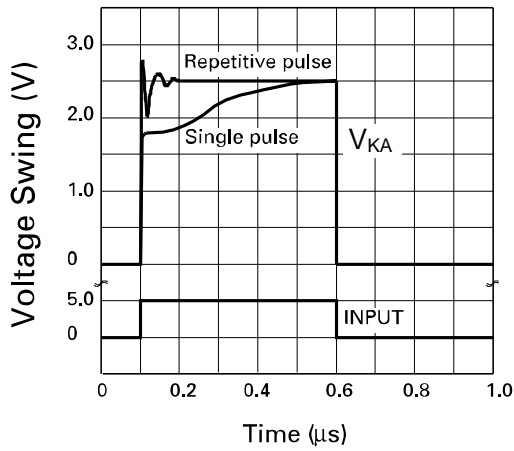


Gain vs. Frequency

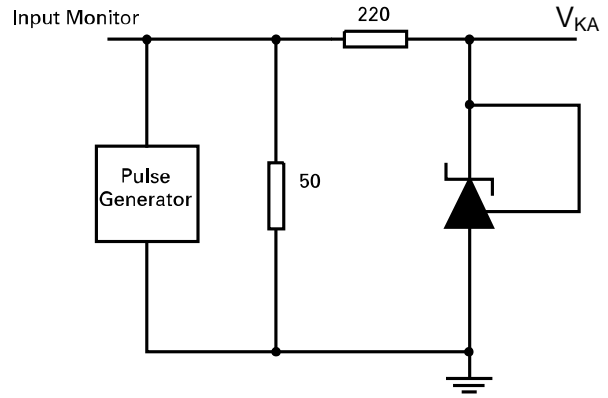


$I_{KA} = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

Test Circuit for Open Loop Voltage Gain

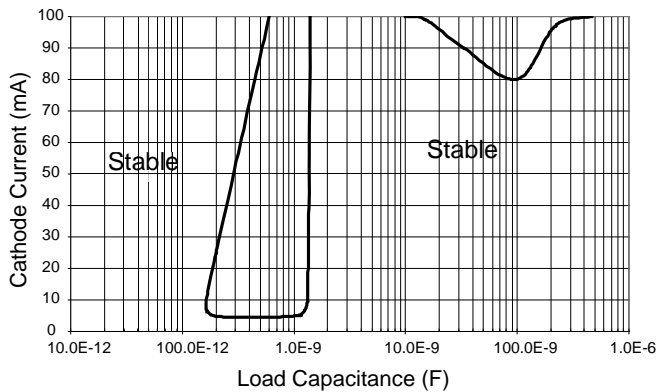


Pulse Response

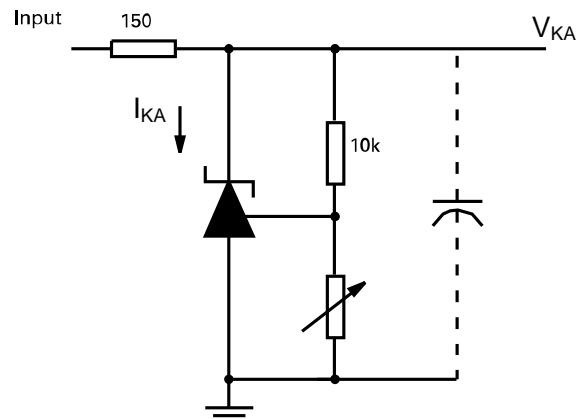


$T_A = 25^\circ\text{C}$

Test Circuit for Pulse Response



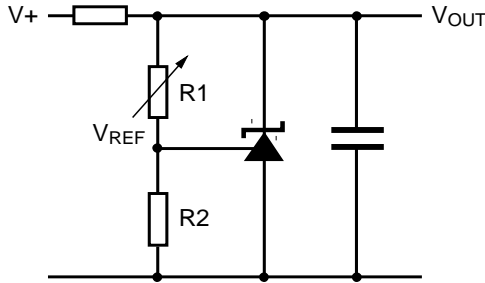
Stability Boundary Condition



$V_{REF} < V_{KA} < 20$ ,  $I_{KA} = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

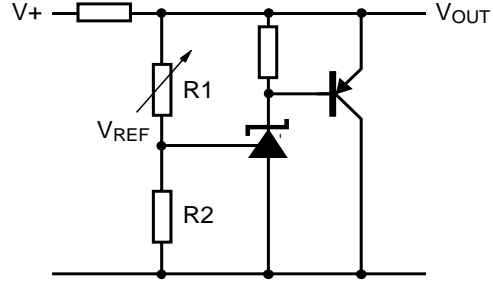
Test Circuit for Stability Boundary Conditions

**Application Circuits**



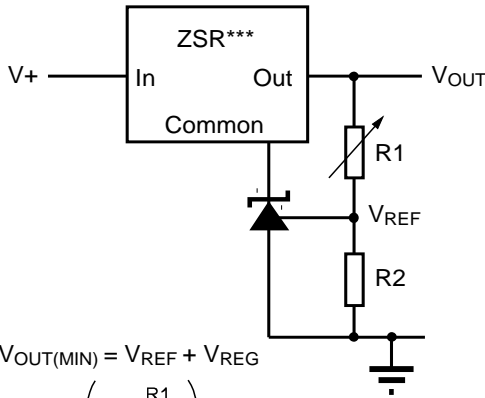
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Shunt regulator



$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

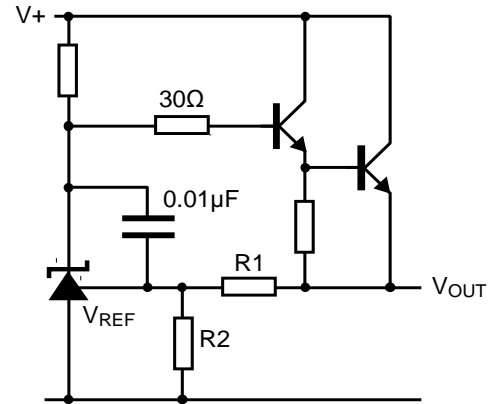
Higher current shunt regulator



$$V_{OUT(MIN)} = V_{REF} + V_{REG}$$

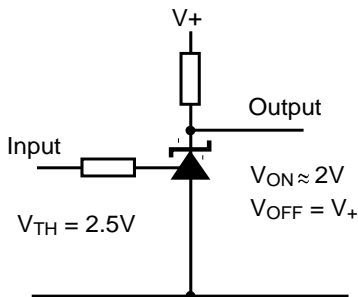
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Output control of a three terminal fixed regulator

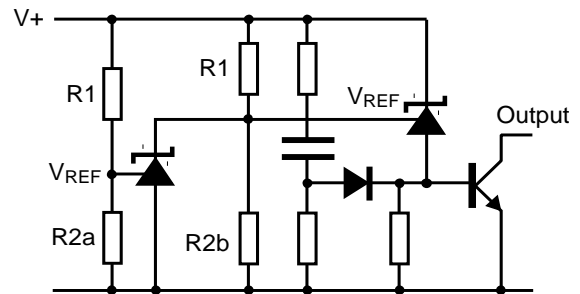


$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Series regulator



Single supply comparator with temperature compensated threshold



$$\text{Low limit} = \left(1 + \frac{R1B}{R2B}\right) V_{REF}$$

$$\text{High limit} = \left(1 + \frac{R1A}{R2A}\right) V_{REF}$$

Over voltage / under voltage protection circuit

**DC Test Circuits**

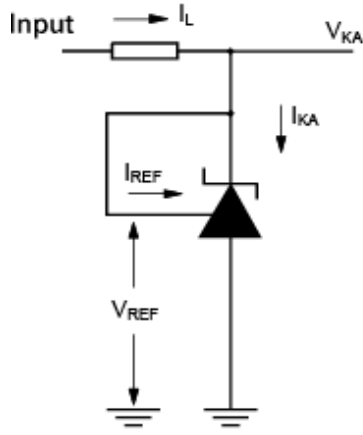


Figure 1. Test circuit for  $V_{KA} = V_{REF}$

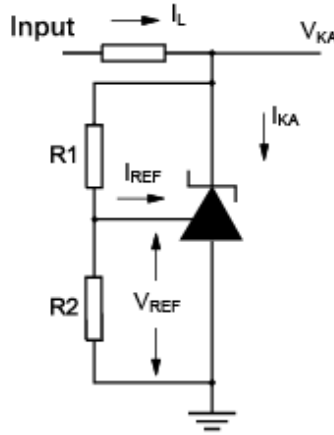


Figure 2. Test circuit for  $V_{KA} > V_{REF}$

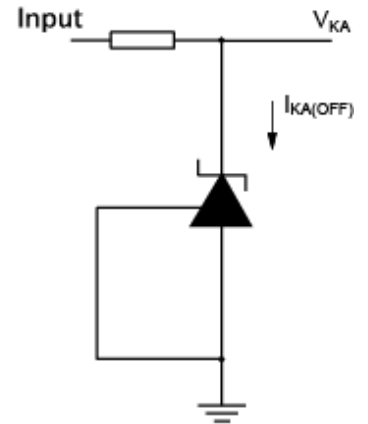


Figure 3. Test circuit for off state current

**Notes**

Deviation of reference input voltage,  $V_{dev}$ , is defined as the maximum variation of the reference input voltage over the full temperature range.

The average temperature coefficient of the reference input voltage,  $V_{ref}$  is defined as:

$$V_{REF}(ppm/^{\circ}C) = \frac{V_{DEV} \times 1,000,000}{V_{REF}(T1-T2)}$$

The dynamic output impedance,  $R_z$ , is defined as:

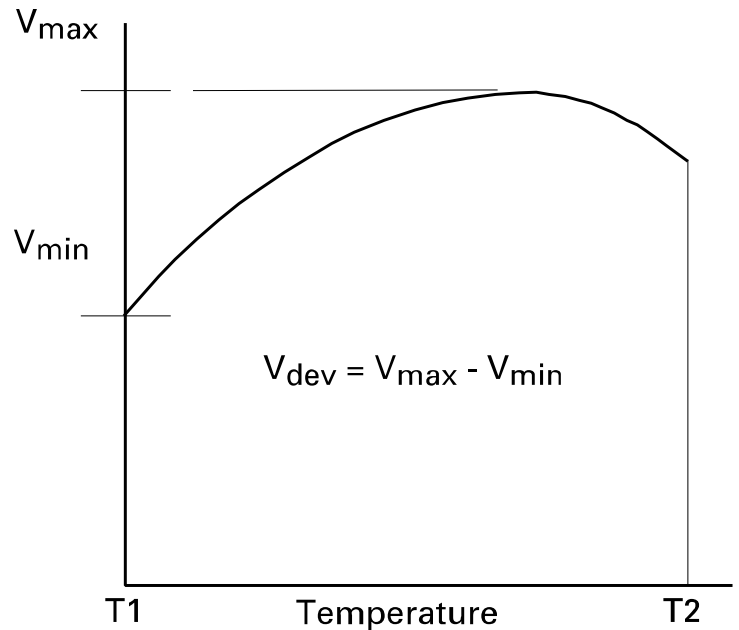
$$R_z = \frac{\Delta V_z}{\Delta I_z}$$

When the device is programmed with two external resistors, R1 and R2, (fig 2), the dynamic output impedance of the overall circuit,  $R'_z$ , is defined as:

$$R'_z = R_z \left( 1 + \frac{R1}{R2} \right)$$

**Stability Boundary**

The ZTL431 and ZTL432 are stable with a range of capacitive loads. A zone of instability exists as demonstrated in the typical characteristic graph on page 4. The graph shows typical conditions. To ensure reliable stability a capacitor of 4.7nF or greater is recommended between anode and cathode.

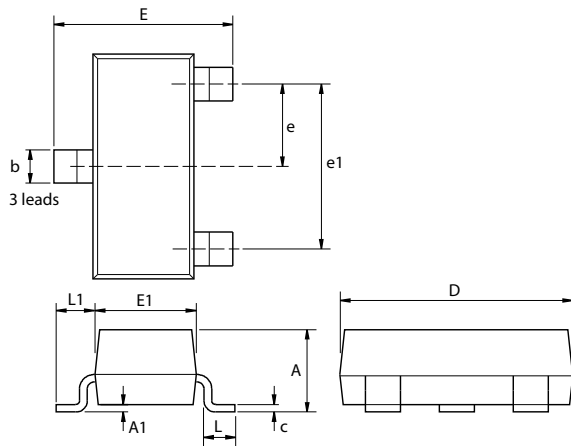


**Ordering Information**

| Tol.       | Ordering Code | Pack    | Part Mark | Status*   | Reel Size | Tape Width (mm) | Quantity per Reel |
|------------|---------------|---------|-----------|-----------|-----------|-----------------|-------------------|
| 1%         | ZTL431AE5TA   | SOT23-5 | 31A       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431AFFTA   | SOT23F  | 31A       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431AFTA    | SOT23   | 31A       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431AH6TA   | SC70-6  | 31A       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431ASE5TA  | SOT23-5 | S2A       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL432AFFTA   | SOT23F  | 32A       | Active    | 7", 180mm | 8               | 3000              |
| 0.5%       | ZTL432AFTA    | SOT23   | 32A       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431BE5TA   | SOT23-5 | 31B       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431BFFTA   | SOT23F  | 31B       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431BFTA    | SOT23   | 31B       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL431BH6TA   | SC70-6  | 31B       | Active    | 7", 180mm | 8               | 3000              |
|            | ZTL432BFFTA   | SOT23F  | 32B       | Active    | 7", 180mm | 8               | 3000              |
| ZTL432BFTA | SOT23         | 32B     | Active    | 7", 180mm | 8         | 3000            |                   |

**Package Outline Dimensions**

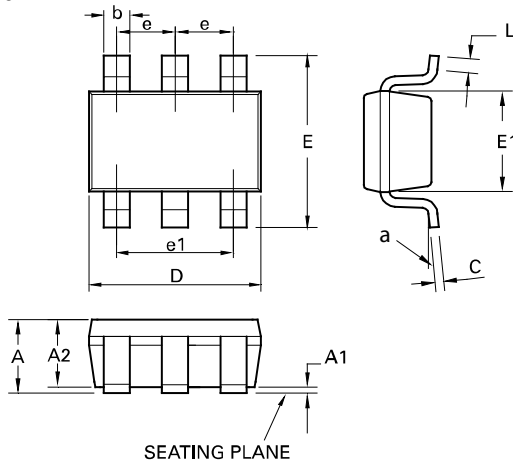
**SOT23**



| Dim. | Millimeters |       | Inches     |       | Dim. | Millimeters |           | Inches |       |
|------|-------------|-------|------------|-------|------|-------------|-----------|--------|-------|
|      | Min.        | Max.  | Min.       | Max.  |      | Min.        | Max.      | Max.   | Max.  |
| A    | -           | 1.12  | -          | 0.044 | e1   | 1.90 NOM    | 0.075 NOM |        |       |
| A1   | 0.01        | 0.10  | 0.0004     | 0.004 | E    | 2.10        | 2.64      | 0.083  | 0.104 |
| b    | 0.30        | 0.50  | 0.012      | 0.020 | E1   | 1.20        | 1.40      | 0.047  | 0.055 |
| C    | 0.085       | 0.120 | 0.003      | 0.008 | L    | 0.25        | 0.62      | 0.018  | 0.024 |
| D    | 2.80        | 3.04  | 0.110      | 0.120 | L1   | 0.45        | 0.62      | 0.018  | 0.024 |
| e    | 0.95 NOM    |       | 0.0375 NOM |       | -    | -           | -         | -      | -     |

**Note:** Controlling dimensions are in millimeters.  
Approximate dimensions are provided in inches

**SC70-6**

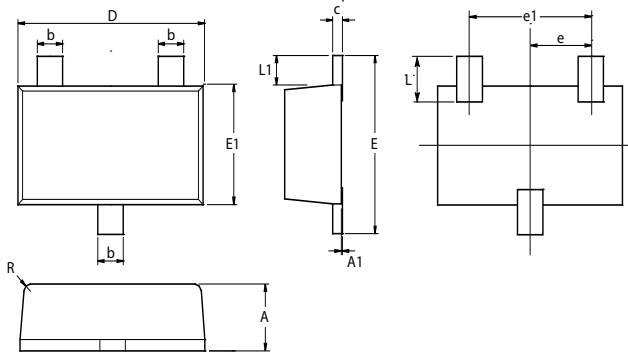


| Dim. | Millimeters |      | Inches     |        | Dim. | Millimeters |            | Inches |        |
|------|-------------|------|------------|--------|------|-------------|------------|--------|--------|
|      | Min.        | Max. | Min.       | Max.   |      | Min.        | Max.       | Max.   | Max.   |
| A    | 0.80        | 1.10 | 0.0315     | 0.0433 | E    | 2.10 BSC    | 0.0826 BSC |        |        |
| A1   | -           | 0.10 | -          | 0.0039 | E1   | 1.25        | 1.35       | 0.0492 | 0.0531 |
| A2   | 0.80        | 1.00 | 0.0315     | 0.0394 | e    | 0.65 BSC    | 0.0255 BSC |        |        |
| b    | 0.15        | 0.30 | 0.006      | 0.0118 | e1   | 1.30 BSC    | 0.0511 BSC |        |        |
| C    | 0.08        | 0.25 | 0.0031     | 0.0098 | L    | 0.26        | 0.46       | 0.0102 | 0.0181 |
| D    | 2.00 BSC    |      | 0.0787 BSC |        | a    | 0°          | 8°         | 0°     | 8°     |

**Note:** Controlling dimensions are in millimeters.  
Approximate dimensions are provided in inches

**Package Outline Dimensions (continued)**

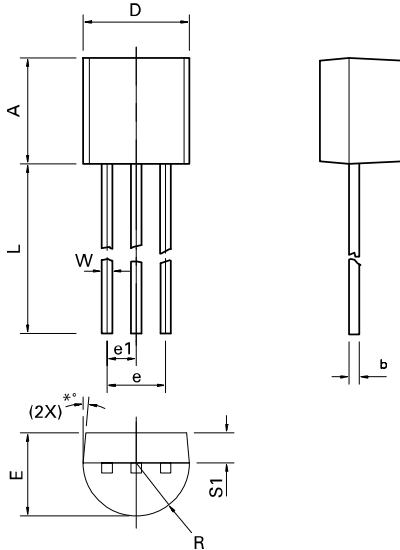
**SOT23F**



| Dim. | Millimeters |      | Inches     |        | Dim. | Millimeters |      | Inches |        |
|------|-------------|------|------------|--------|------|-------------|------|--------|--------|
|      | Min.        | Max. | Min.       | Max.   |      | Min.        | Max. | Max.   | Max.   |
| A    | 0.80        | 1.00 | 0.031      | 0.0394 | E    | 2.30        | 2.50 | 0.0906 | 0.0984 |
| A1   | -           | 0.10 | 0.00       | 0.0043 | E1   | 1.50        | 1.70 | 0.0590 | 0.0669 |
| A2   | 0.06        | 0.16 | 0.0024     | 0.0006 | E2   | 1.10        | 1.26 | 0.0433 | 0.0496 |
| b    | 0.39        | 0.41 | 0.0153     | 0.0161 | L    | 0.48        | 0.68 | 0.0189 | 0.0268 |
| c    | 0.11        | 0.20 | 0.0043     | 0.0079 | L1   | 0.39        | 0.41 | 0.0153 | 0.0161 |
| D    | 2.80        | 3.00 | 0.1102     | 0.1181 | R    | 0.05        | 0.15 | 0.0019 | 0.0059 |
| e    | 0.95 ref    |      | 0.0374 ref |        | O    | 0°          | 12°  | 0°     | 12°    |
| e1   | 1.90 ref    |      | 0.7480 ref |        | -    | -           | -    | -      | -      |

Note: Controlling dimensions are in millimeters.  
Approximate dimensions are provided in inches

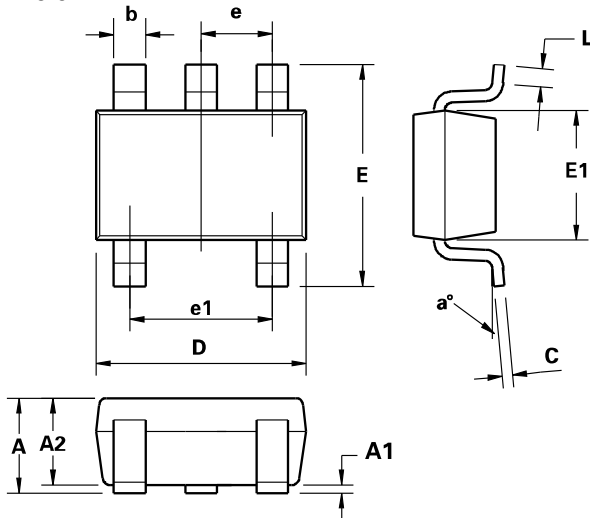
**TO92**



| Dim. | Millimeters |       | Inches |       |
|------|-------------|-------|--------|-------|
|      | Min.        | Max.  | Min.   | Max.  |
| A    | 4.32        | 4.95  | 0.170  | 0.195 |
| b    | 0.36        | 0.51  | 0.014  | 0.020 |
| C    | 2.50        | 3.50  | 0.099  | 0.138 |
| E    | 3.30        | 3.94  | 0.130  | 0.155 |
| e    | 4.88        | 5.88  | 0.192  | 0.232 |
| e1   | 2.44        | 2.94  | 0.096  | 0.116 |
| L    | 12.70       | 15.49 | 0.500  | 0.610 |
| R    | 2.16        | 2.41  | 0.085  | 0.095 |
| S1   | 1.14        | 1.52  | 0.045  | 0.060 |
| W    | 0.41        | 0.56  | 0.016  | 0.022 |
| D    | 4.45        | 4.95  | 0.175  | 0.195 |
| *°   | 4°          | 6°    | 4°     | 6°    |

Note: Controlling dimensions are in millimeters.  
Approximate dimensions are provided in inches

**SOT23-5**



| Dim. | Millimeters |      | Inches     |        |
|------|-------------|------|------------|--------|
|      | Min.        | Max. | Min.       | Max.   |
| A    | 0.90        | 1.45 | 0.0354     | 0.0570 |
| A1   | 0.00        | 0.15 | 0.00       | 0.0059 |
| A2   | 0.90        | 1.30 | 0.0354     | 0.0511 |
| b    | 0.20        | 0.50 | 0.0078     | 0.0196 |
| C    | 0.09        | 0.26 | 0.0035     | 0.0102 |
| D    | 2.70        | 3.10 | 0.1062     | 0.1220 |
| E    | 2.20        | 3.20 | 0.0866     | 0.1181 |
| E1   | 1.30        | 1.80 | 0.0511     | 0.0708 |
| e    | 0.95 REF    |      | 0.0374 REF |        |
| e1   | 1.90 REF    |      | 0.0748 REF |        |
| L    | 0.10        | 0.60 | 0.0039     | 0.0236 |
| a°   | 0°          | 30°  | 0°         | 30°    |

Note: Controlling dimensions are in millimeters.  
Approximate dimensions are provided in inches



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2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

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