

## Description

The ZXRE250 and ZXRE252 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 36 volts by selection of two external divider resistors.

ZXRE250 has the same electrical specifications as the industry standard '431 except that it features a very low minimum cathode current for regulation. The typical value of 40 $\mu$ A makes the parts ideal for very low-power applications.

The devices can be used as a replacement for zener diodes in many applications requiring an improvement in zener performance. The ZXRE250/2 is available in two grades with initial tolerances of 1% and 0.5% for the A and B grades respectively.

## Features

- Minimum Cathode Current for Regulation: 40 $\mu$ A (typ)
- Temperature Range: -40°C to +125°C
- Reference Voltage Tolerance at +25°C
  - ZXRE250A: 2.495V  $\pm$  1.0%
  - ZXRE250B: 2.495V  $\pm$  0.5%
- Low Output Noise
- 0.2 $\Omega$  Typical Output Impedance
- Sink Current Capability: 0.065mA to 100mA
- Adjustable Output Voltage: V<sub>REF</sub> to 36V
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- Halogen and Antimony Free. "Green" Device (Note 3)

## Applications

- Opto-Coupler Linearisers
- Shunt Regulators
- Improved Zener
- Variable Reference

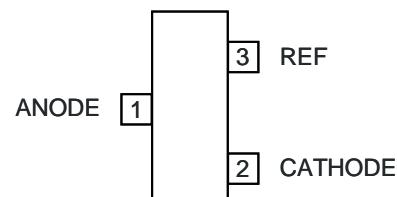
Notes:

1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

## Pin Assignments

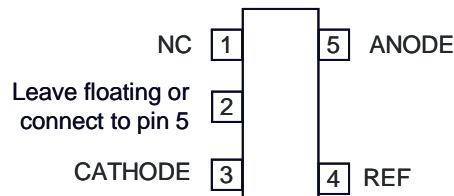
### ZXRE250

#### (Top View)



### SOT23

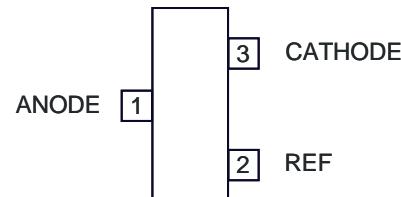
#### (Top View)



### SOT25

### ZXRE252

#### (Top View)



### SOT23

**Absolute Maximum Ratings** (Note 4) (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

| Symbol    | Parameter                       | Rating        | Unit             |    |
|-----------|---------------------------------|---------------|------------------|----|
| $V_{KA}$  | Cathode Voltage                 | 40            | V                |    |
| $I_{KA}$  | Continuous Cathode Current      | 150           | mA               |    |
| $I_{REF}$ | Reference Input Current         | -0.050 to +10 | mA               |    |
| $T_J$     | Operating Junction Temperature  | +150          | $^\circ\text{C}$ |    |
| $T_{ST}$  | Storage Temperature             | -55 to +150   | $^\circ\text{C}$ |    |
| $P_D$     | Power Dissipation (Notes 5 & 6) | SOT23         | 330              | mW |
|           |                                 | SOT25         | 500              | mW |

Notes:

- 4. Operation above the absolute maximum rating may cause device failure. Operation at the absolute maximum ratings, for extended periods, may reduce device reliability. Unless otherwise stated voltages specified are relative to the ANODE pin.
- 5.  $T_J$ , max =  $+150^\circ\text{C}$
- 6. Ratings apply to ambient temperature at  $+25^\circ\text{C}$ .

**Recommended Operating Conditions** (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

| Symbol   | Parameter                     | Min       | Max  | Unit             |
|----------|-------------------------------|-----------|------|------------------|
| $V_{KA}$ | Cathode Voltage               | $V_{REF}$ | 36   | V                |
| $I_{KA}$ | Cathode Current               | 0.065     | 100  | mA               |
| $T_A$    | Operating Ambient Temperature | -40       | +125 | $^\circ\text{C}$ |

**Electrical Characteristics** (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

| Symbol                                 | Parameter   | Test Conditions  |                                       | Min   | Typ   | Max   | Unit               |
|--|---|--|---------------------------------------|-------|-------|-------|--------------------|
| $V_{REF}$                              | Reference Voltage   | $V_{KA} = V_{REF}$ ,<br>$I_{KA} = 10\text{mA}$                   | ZXRE250A                              | 2.470 | 2.495 | 2.520 | V                  |
|  |   |  | ZXRE250B                              | 2.482 | 2.495 | 2.507 | V                  |
| $V_{DEV}$                              | Deviation of Reference Voltage Over Full Temperature Range (Note 7)       | $V_{KA} = V_{REF}$ ,<br>$I_{KA} = 10\text{mA}$                   | $T_A = 0$ to $+70^\circ\text{C}$      | -     | 6     | 16    | mV                 |
|  |   |  | $T_A = -40$ to $+85^\circ\text{C}$    | -     | 14    | 34    | mV                 |
|  |   |  | $T_A = -40$ to $+125^\circ\text{C}$   | -     | 14    | 34    | mV                 |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ | Ratio of the Change in Reference Voltage to the Change in Cathode Voltage | $I_{KA} = 10\text{mA}$   | $V_{KA} = 10\text{V}$ to $V_{REF}$    | -     | -1.4  | -2.7  | mV/V               |
|  |   |  | $V_{KA} = 36\text{V}$ to $10\text{V}$ | -     | -1    | -2    | mV/V               |
| $I_{REF}$                              | Reference Input Current   | $I_{KA} = 10\text{mA}$ , $R1 = 10\text{K}\Omega$ , $R2 = \infty$ |                                       | -     | 1     | 4     | $\mu\text{A}$      |
| $\Delta I_{REF}$                       | $I_{REF}$ Deviation Over Full Temperature Range (Note 7)                  | $I_{KA} = 10\text{mA}$ , $R1 = 10\text{K}\Omega$ , $R2 = \infty$ | $T_A = 0$ to $+70^\circ\text{C}$      | -     | 0.8   | 1.2   | $\mu\text{A}$      |
|  |   |  | $T_A = -40$ to $+85^\circ\text{C}$    | -     | 0.8   | 2.5   | $\mu\text{A}$      |
|  |   |  | $T_A = -40$ to $+125^\circ\text{C}$   | -     | 0.8   | 2.5   | $\mu\text{A}$      |
| $I_{KA(MIN)}$                          | Minimum Cathode Current for Regulation                                    | $V_{KA} = V_{REF}$   |                                       | -     | 40    | 65    | $\mu\text{A}$      |
| $I_{KA(OFF)}$                          | Off-State Current   | $V_{KA} = 36\text{V}$ , $V_{REF} = 0\text{V}$                    |                                       | -     | 0.05  | 0.5   | $\mu\text{A}$      |
| $ Z_{KA} $                             | Dynamic Output Impedance (Note 8)   | $V_{KA} = V_{REF}$ , $f = 0\text{Hz}$                            |                                       | -     | 0.2   | 0.5   | $\Omega$           |
| $\theta_{JA}$                          | Thermal Resistance Junction to Ambient                                    | SOT23  |                                       | -     | 380   | -     | $^\circ\text{C/W}$ |
|  |   | SOT25  |                                       | -     | 250   | -     | $^\circ\text{C/W}$ |

Notes:

- 7. Deviation of  $V_{DEV}$ , and  $\Delta I_{REF}$  are defined as the maximum variation of the values over the full temperature range.
- 8. Derivation of  $Z_{KA}$  on following page.

## Electrical Characteristics (cont.) (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

The average temperature coefficient of the reference input voltage  $\alpha V_{\text{REF}}$  is defined as:

$$|\alpha V_{\text{REF}}| = \left( \frac{V_{\text{DEV}}}{V_{\text{REF}} @ 25^\circ\text{C}} \right) \times 10^6 \text{ ppm/}^\circ\text{C}$$

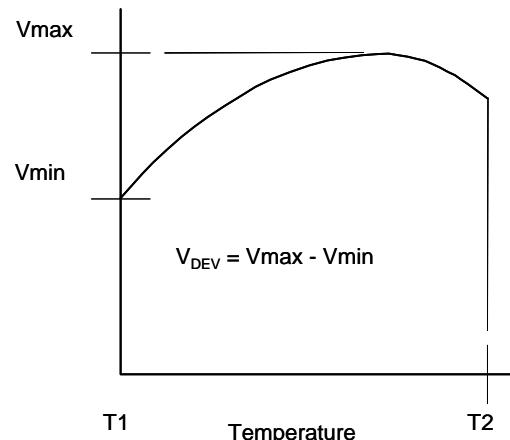
Where:

$T_2 - T_1$  = full temperature change.

$\alpha V_{\text{REF}}$  can be positive or negative depending on whether the slope is positive or negative.

Note: 8. The dynamic output impedance,  $Z_K$ , is defined as:

$$|Z_K| = \frac{\Delta V_K}{\Delta I_K}$$



When the device is programmed with two external resistors  $R_1$  and  $R_2$ , the dynamic output impedance of the overall circuit, is defined as:

$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_K| \left( 1 + \frac{R_1}{R_2} \right)$$

## Test Circuits

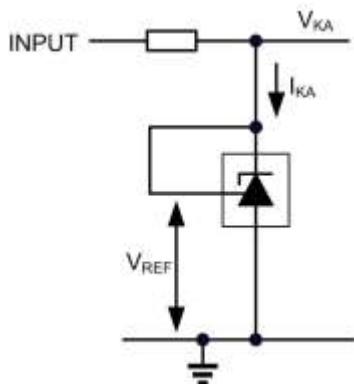


Figure 1 Test Circuit for  $V_{\text{KA}} = V_{\text{REF}}$

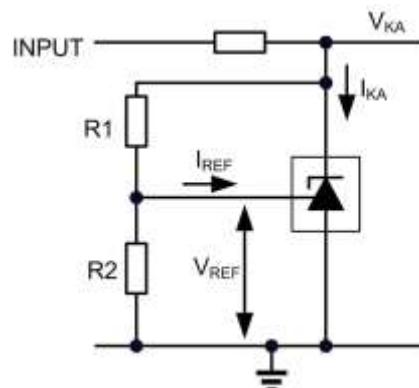


Figure 2 Test Circuit for  $V_{\text{KA}} > V_{\text{REF}}$

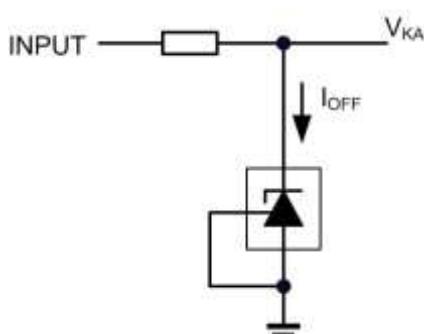
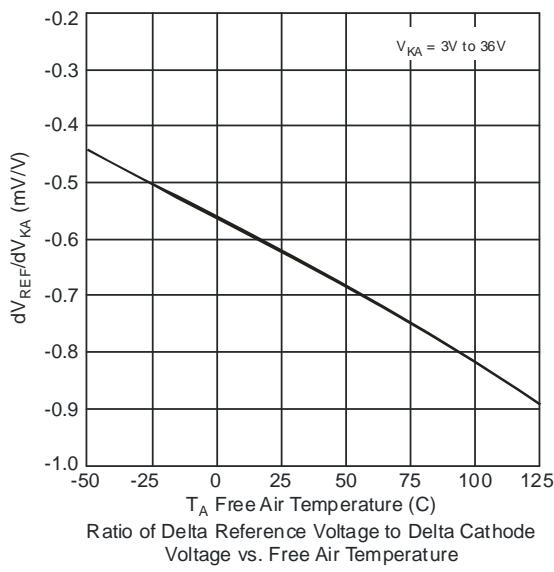
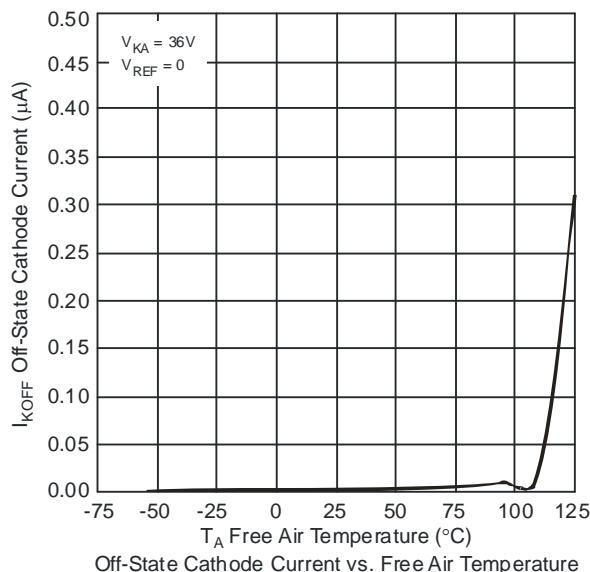
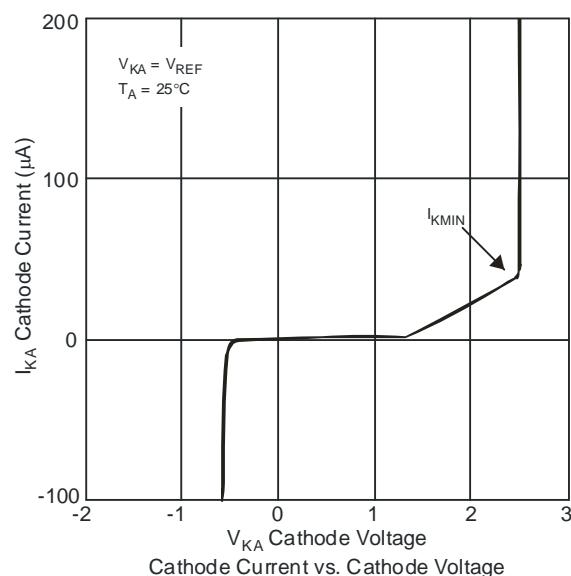
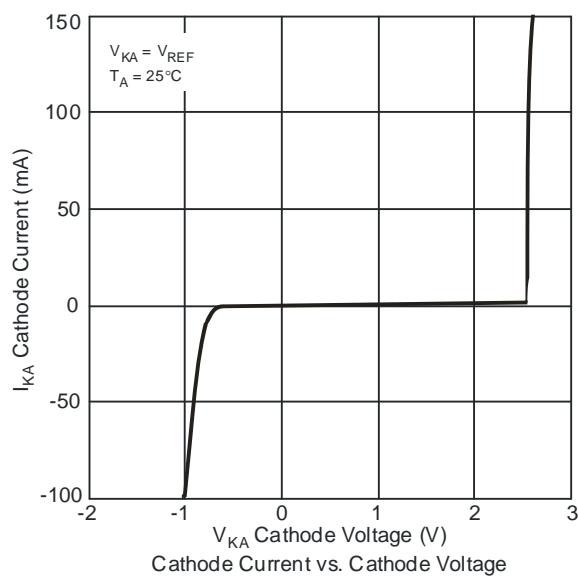
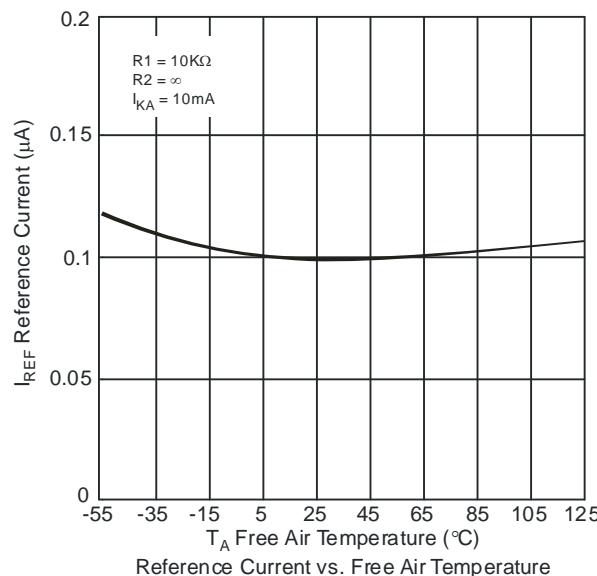
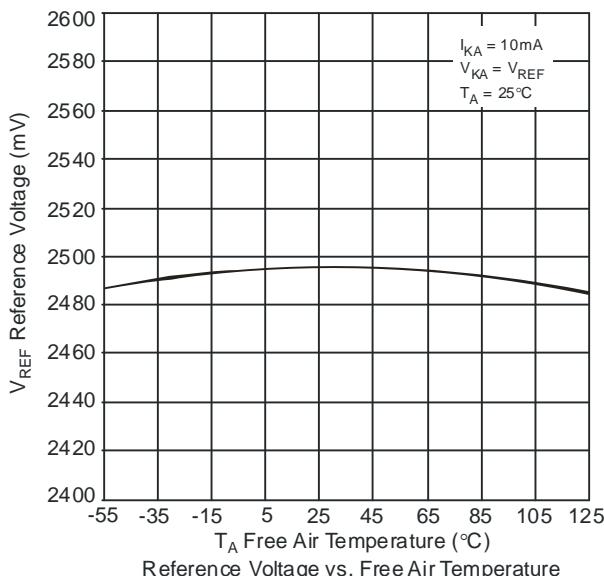
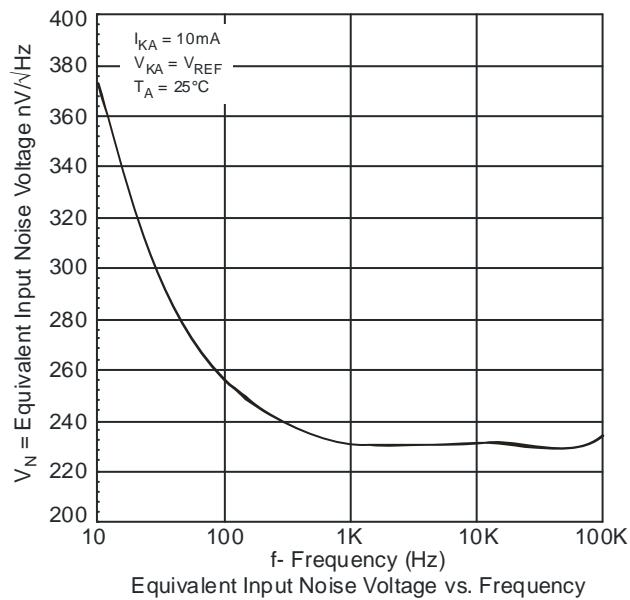


Figure 3 Test Circuit for  $I_{\text{OFF}}$

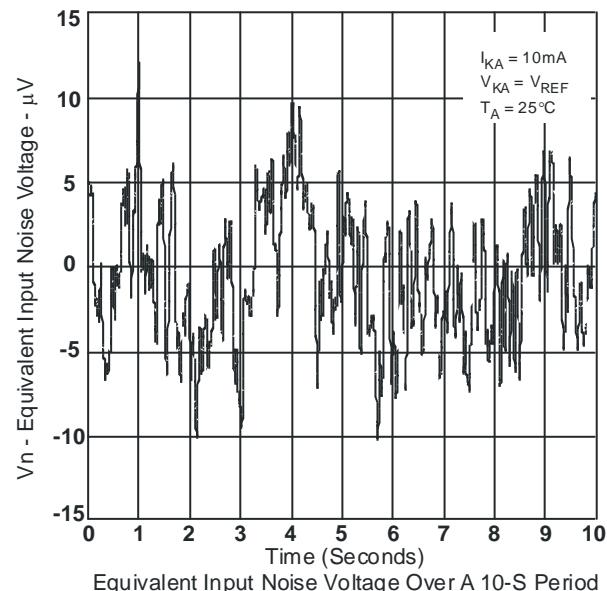
## Typical Performance Characteristics



**Typical Performance Characteristics (Continued)**



Equivalent Input Noise Voltage vs. Frequency



Equivalent Input Noise Voltage Over A 10-S Period

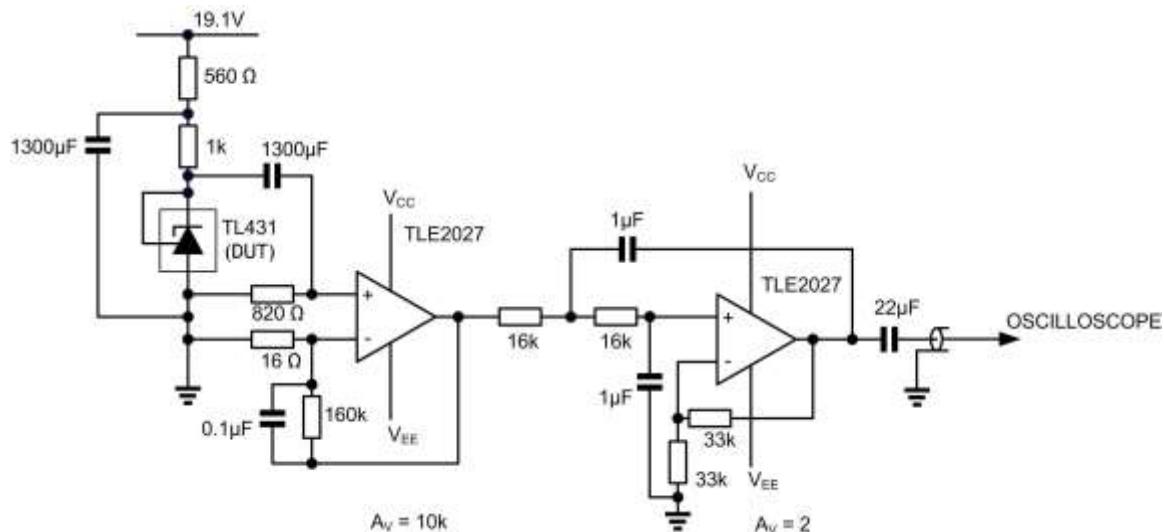
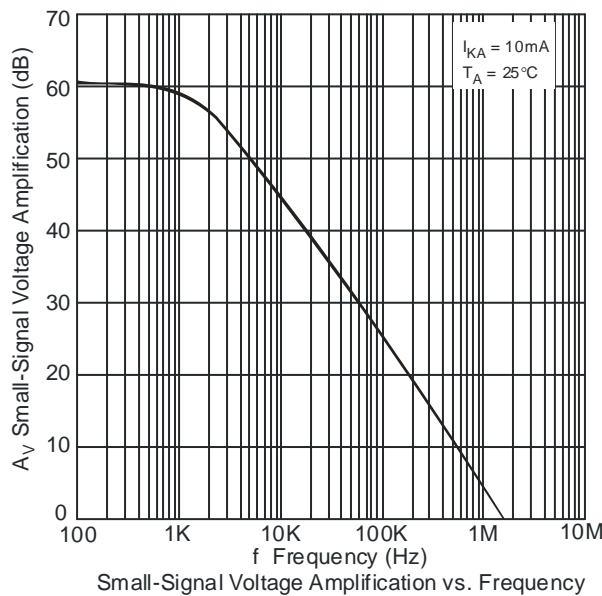
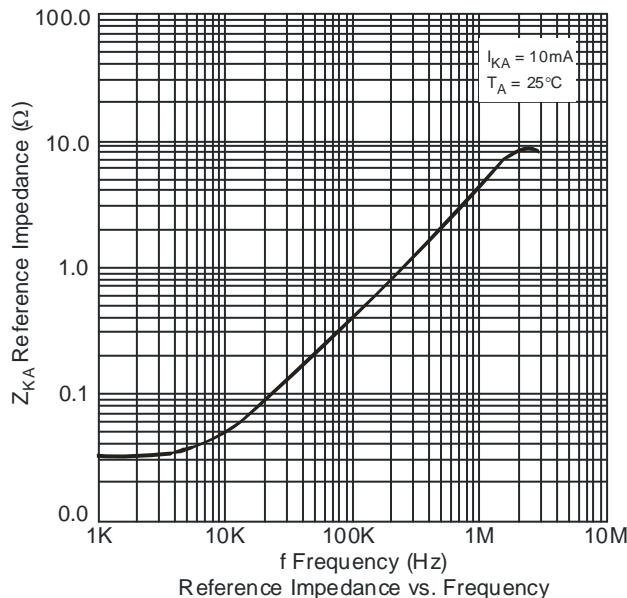


Figure 4 Test Circuit for Noise Input Voltage

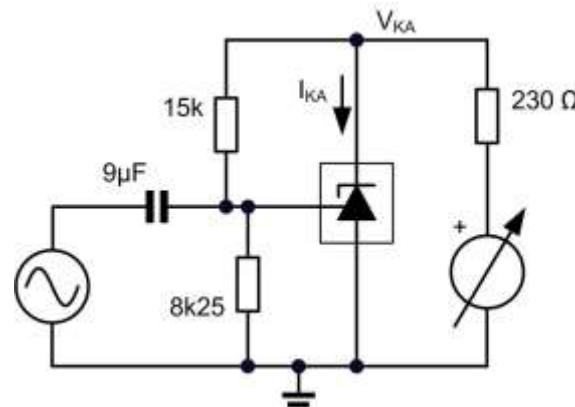
**Typical Performance Characteristics (Cont.)**



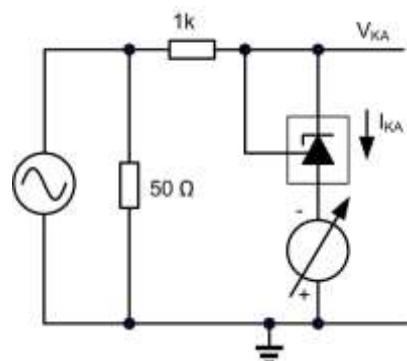
Small-Signal Voltage Amplification vs. Frequency



Reference Impedance vs. Frequency

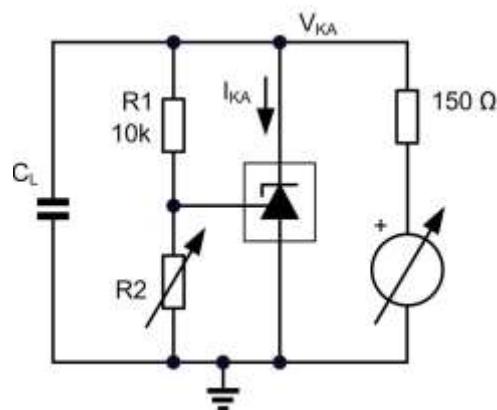
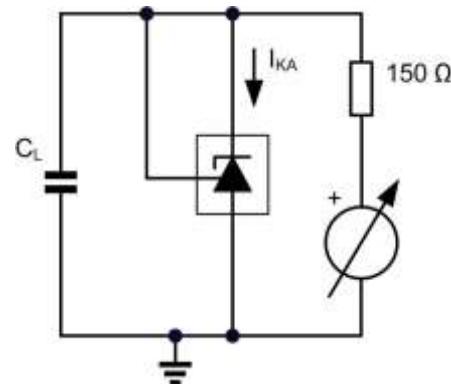
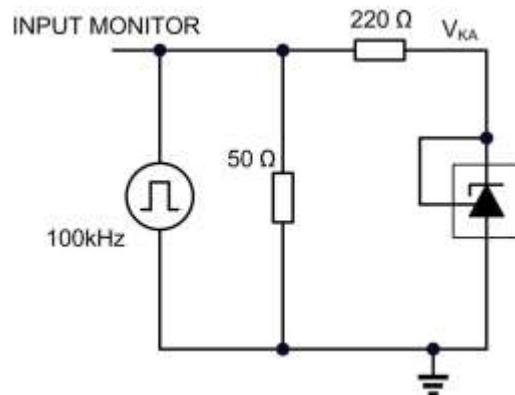
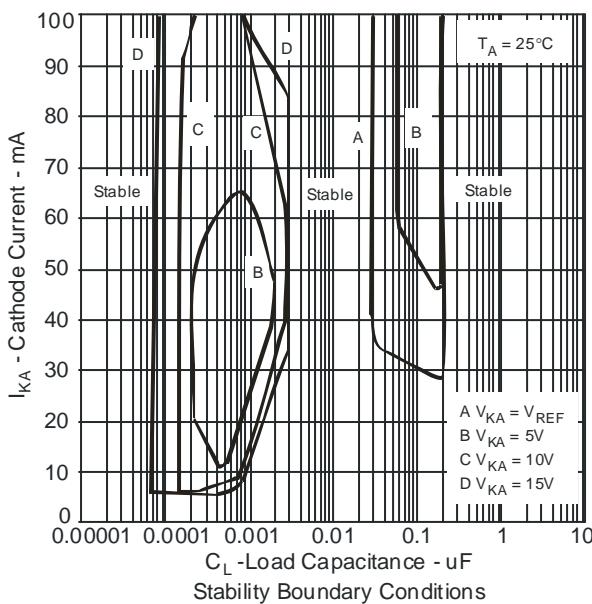
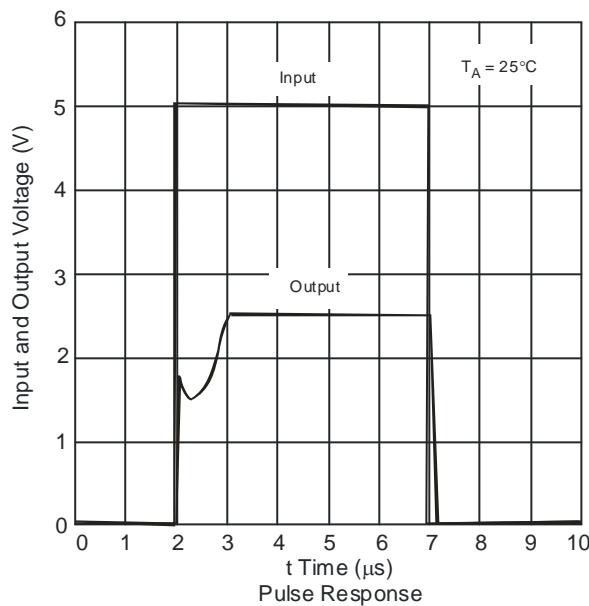


Test Circuit for Voltage Amplification



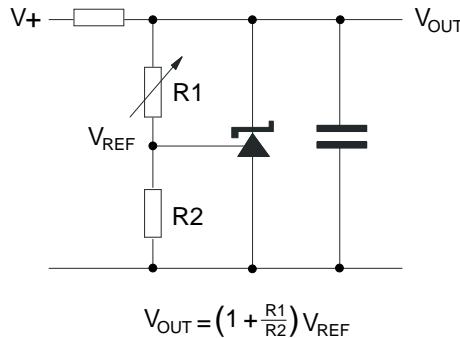
Test Circuit for Reference Impedance

**Typical Performance Characteristics (Cont.)**

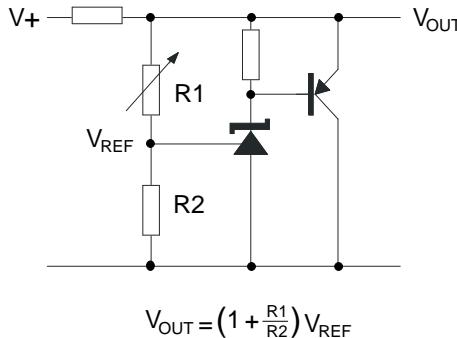


The device is stable under all conditions with a load capacitance not exceeding 50pF. The device is stable under all conditions with a load capacitance between 5nF and 20nF. The device is stable under all conditions with a load capacitance exceeding 300nF. With a cathode current not exceeding 5mA, the device is stable with any load capacitance.

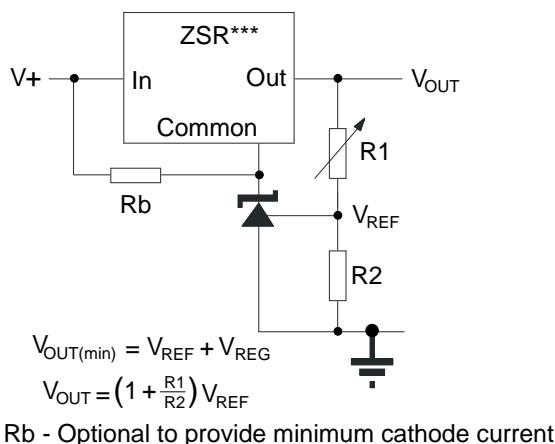
## Application Information



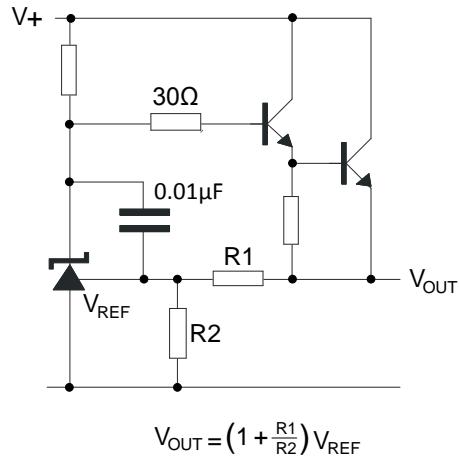
**Shunt Regulator**



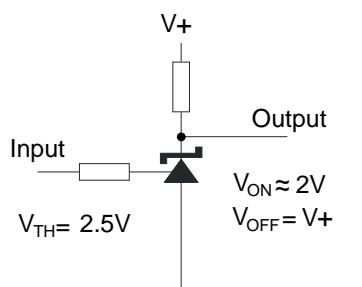
**Higher Current Shunt Regulator**



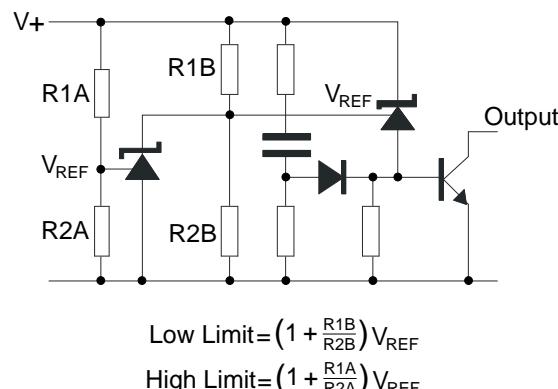
**Output Control of a Three Terminal Fixed Regulator**



**Series Regulator**

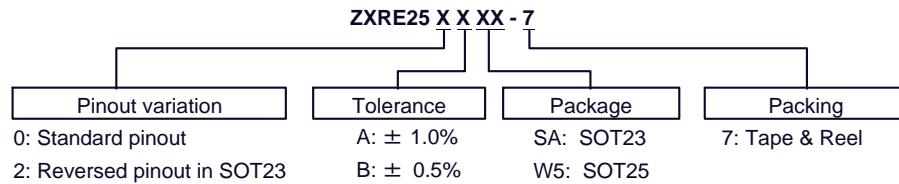


**Single Supply Comparator with Temperature Compensated Threshold**



**Over Voltage / Under Voltage Protection Circuit**

## Ordering Information



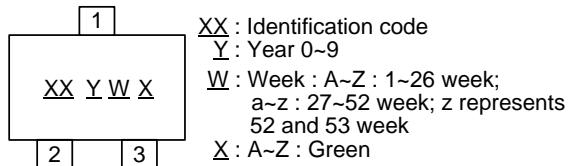
| Part Number<br>(Note 9) | Package<br>Code | Packaging | 7" Tape and Reel  |                    | Ammo Box |                    |
|-------------------------|-----------------|-----------|-------------------|--------------------|----------|--------------------|
|                         |                 |           | Quantity          | Part Number Suffix | Quantity | Part Number Suffix |
| ZXRE250A(B)SA-7         | SA              | SOT23     | 3,000/Tape & Reel | -7                 | NA       | NA                 |
| ZXRE250A(B)W5-7         | W5              | SOT25     | 3,000/Tape & Reel | -7                 | NA       | NA                 |
| ZXRE252A(B)SA-7         | SA              | SOT23     | 3,000/Tape & Reel | -7                 | NA       | NA                 |

Note: 9. Suffix (B) denotes ZXRE250B (0.5% tolerance) device.

## Marking Information

### (1) SOT23

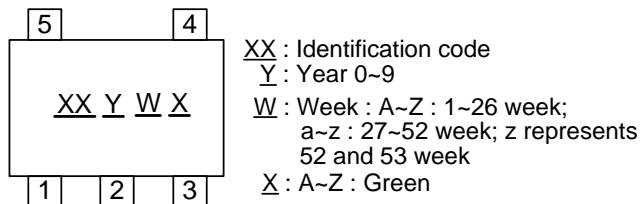
( Top View )



| Device     | Package | Identification Code |
|------------|---------|---------------------|
| ZXRE250ASA | SOT23   | DA                  |
| ZXRE250BSA | SOT23   | DB                  |
| ZXRE252ASA | SOT23   | FA                  |
| ZXRE252BSA | SOT23   | FB                  |

### (2) SOT25

( Top View )

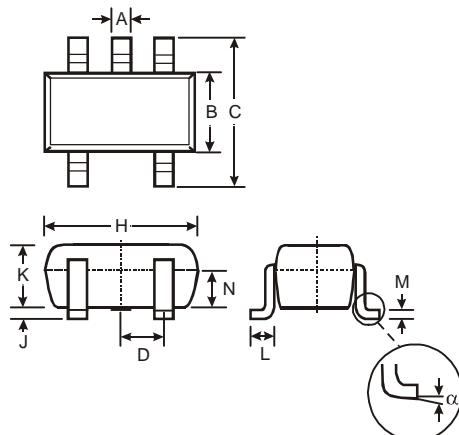


| Device     | Package | Identification Code |
|------------|---------|---------------------|
| ZXRE250AW5 | SOT25   | DA                  |
| ZXRE250BW5 | SOT25   | DB                  |

## Package Outline Dimensions

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

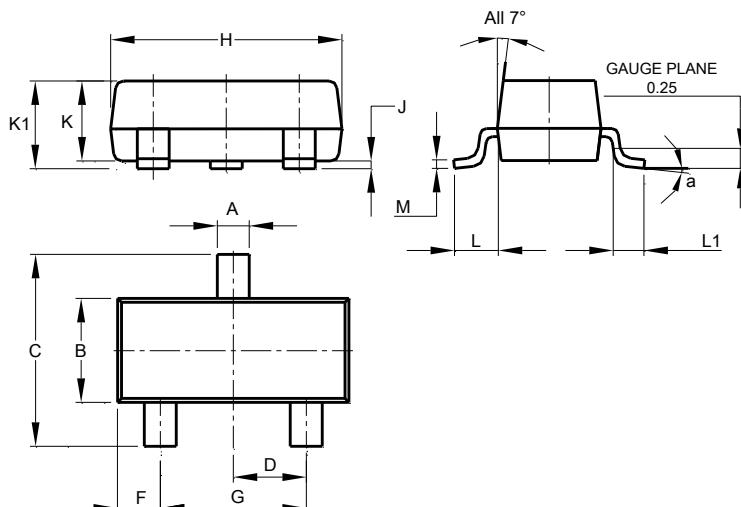
### (1) Package type: SOT25



| SOT25    |       |      |      |
|----------|-------|------|------|
| Dim      | Min   | Max  | Typ  |
| A        | 0.35  | 0.50 | 0.38 |
| B        | 1.50  | 1.70 | 1.60 |
| C        | 2.70  | 3.00 | 2.80 |
| D        | —     | —    | 0.95 |
| H        | 2.90  | 3.10 | 3.00 |
| J        | 0.013 | 0.10 | 0.05 |
| K        | 1.00  | 1.30 | 1.10 |
| L        | 0.35  | 0.55 | 0.40 |
| M        | 0.10  | 0.20 | 0.15 |
| N        | 0.70  | 0.80 | 0.75 |
| $\alpha$ | 0°    | 8°   | —    |

All Dimensions in mm

### (2) Package Types: SOT23



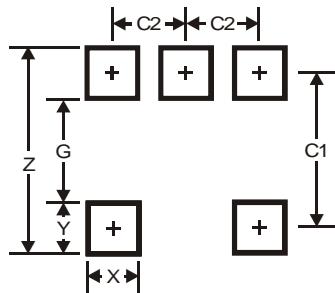
| SOT23 |       |       |       |
|-------|-------|-------|-------|
| Dim   | Min   | Max   | Typ   |
| A     | 0.37  | 0.51  | 0.40  |
| B     | 1.20  | 1.40  | 1.30  |
| C     | 2.30  | 2.50  | 2.40  |
| D     | 0.89  | 1.03  | 0.915 |
| F     | 0.45  | 0.60  | 0.535 |
| G     | 1.78  | 2.05  | 1.83  |
| H     | 2.80  | 3.00  | 2.90  |
| J     | 0.013 | 0.10  | 0.05  |
| K     | 0.890 | 1.00  | 0.975 |
| K1    | 0.903 | 1.10  | 1.025 |
| L     | 0.45  | 0.61  | 0.55  |
| L1    | 0.25  | 0.55  | 0.40  |
| M     | 0.085 | 0.150 | 0.110 |
| $a$   | 8°    |       |       |

All Dimensions in mm

## Suggested Pad Layout

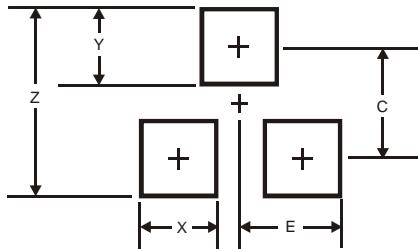
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**(1) Package type: SOT25**



| Dimensions | Value (in mm) |
|------------|---------------|
| Z          | 3.20          |
| G          | 1.60          |
| X          | 0.55          |
| Y          | 0.80          |
| C1         | 2.40          |
| C2         | 0.95          |

**(2) Package Types: SOT23**



| Dimensions | Value (in mm) |
|------------|---------------|
| Z          | 2.9           |
| X          | 0.8           |
| Y          | 0.9           |
| C          | 2.0           |
| E          | 1.35          |

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