

## 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 40µA 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: 40µA (typ)
- Temperature Range: -40°C to +125°C
- Reference Voltage Tolerance at +25°C
  - ZXRE250A: 2.495V ± 1.0%
  - ZXRE250B: 2.495V ± 0.5%
- Low Output Noise
- 0.2Ω 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

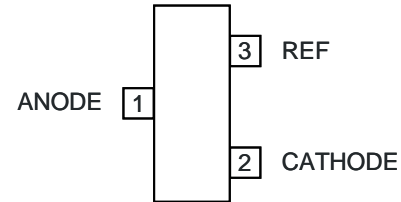
- Opto-Coupler Linearisers
- Shunt Regulators
- Improved Zener
- Variable Reference

- 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

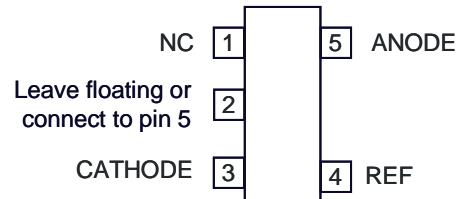
### ZXRE250

(Top View)



SOT23

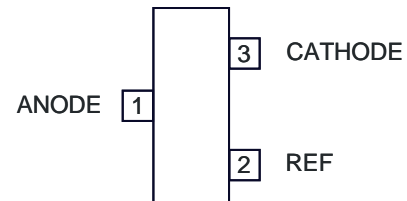
(Top View)



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	$V_{KA} = V_{REF}$ , $I_{KA} = 10\text{mA}$	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)	$V_{KA} = V_{REF}$ , $I_{KA} = 10\text{mA}$	$T_A = 0$ 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 10V	-	-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<sub>A</sub> = +25°C, unless otherwise specified.)

The average temperature coefficient of the reference input voltage αV<sub>REF</sub> is defined as:

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

Where:

T<sub>2</sub> – T<sub>1</sub> = full temperature change.

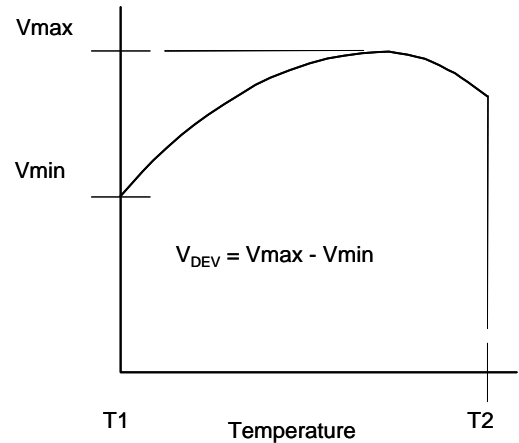
αV<sub>REF</sub> can be positive or negative depending on whether the slope is positive or negative.

Note: 8. The dynamic output impedance, R<sub>z</sub>, is defined as:

$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$$

When the device is programmed with two external resistors R1 and R2, the dynamic output impedance of the overall circuit, is defined as:

$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}| \left( 1 + \frac{R1}{R2} \right)$$



**Test Circuits**

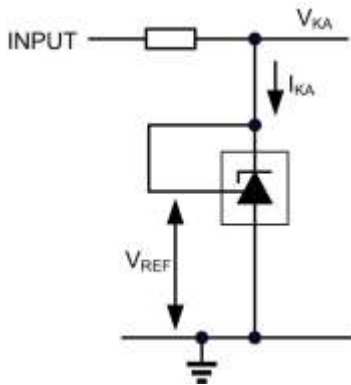


Figure 1 Test Circuit for V<sub>KA</sub> = V<sub>REF</sub>

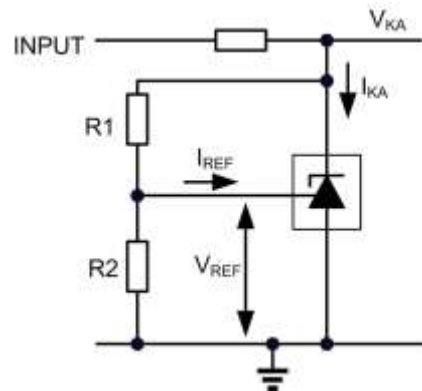


Figure 2 Test Circuit for V<sub>KA</sub> > V<sub>REF</sub>

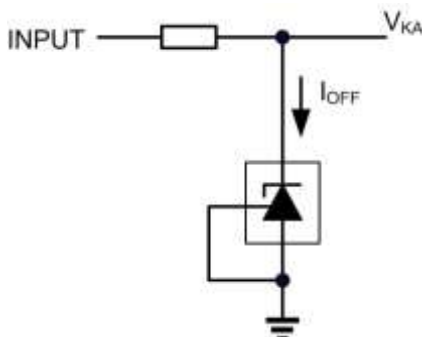
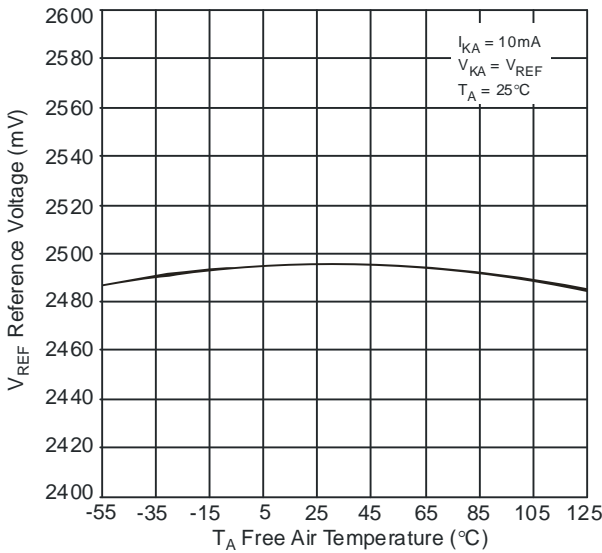
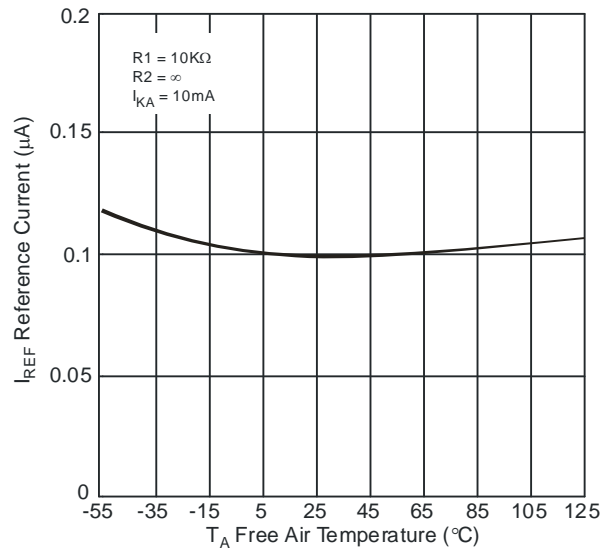


Figure 3 Test Circuit for I<sub>OFF</sub>

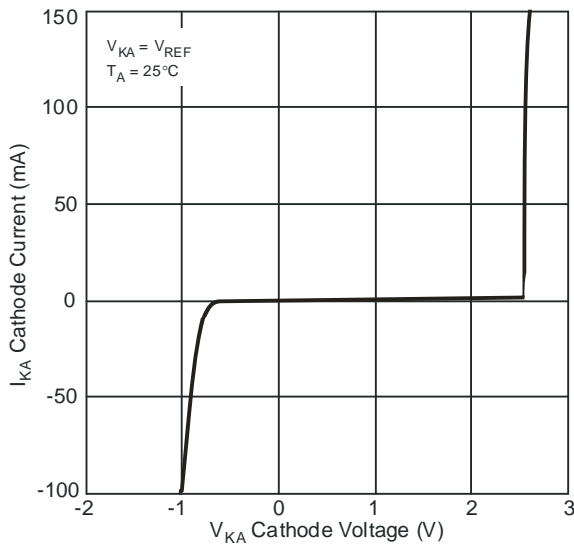
**Typical Performance Characteristics**



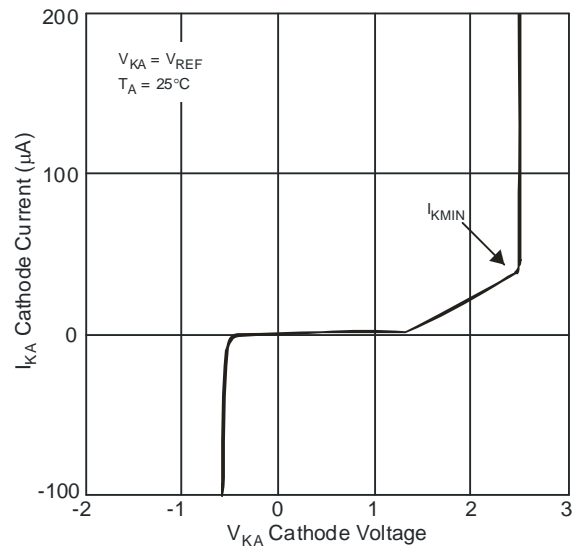
Reference Voltage vs. Free Air Temperature



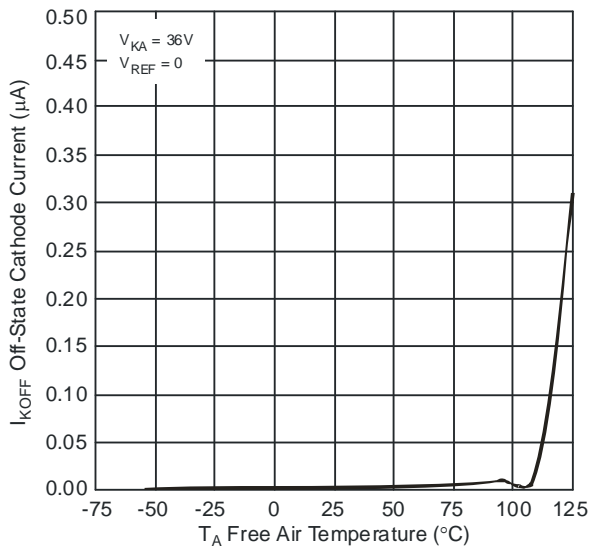
Reference Current vs. Free Air Temperature



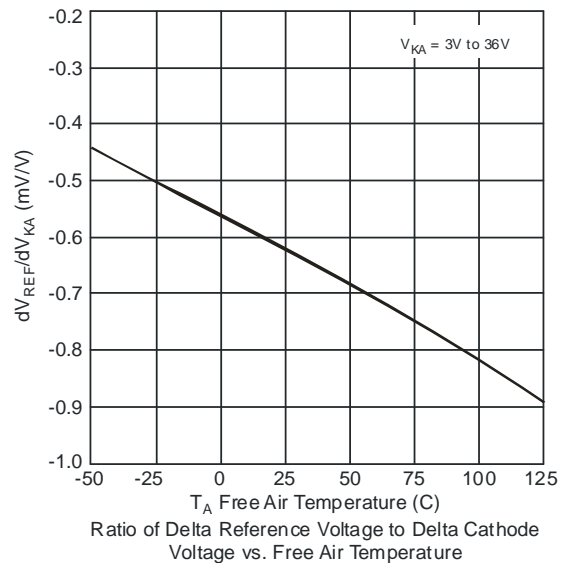
Cathode Current vs. Cathode Voltage



Cathode Current vs. Cathode Voltage



Off-State Cathode Current vs. Free Air Temperature



Ratio of Delta Reference Voltage to Delta Cathode Voltage vs. Free Air Temperature

**Typical Performance Characteristics** (Continued)

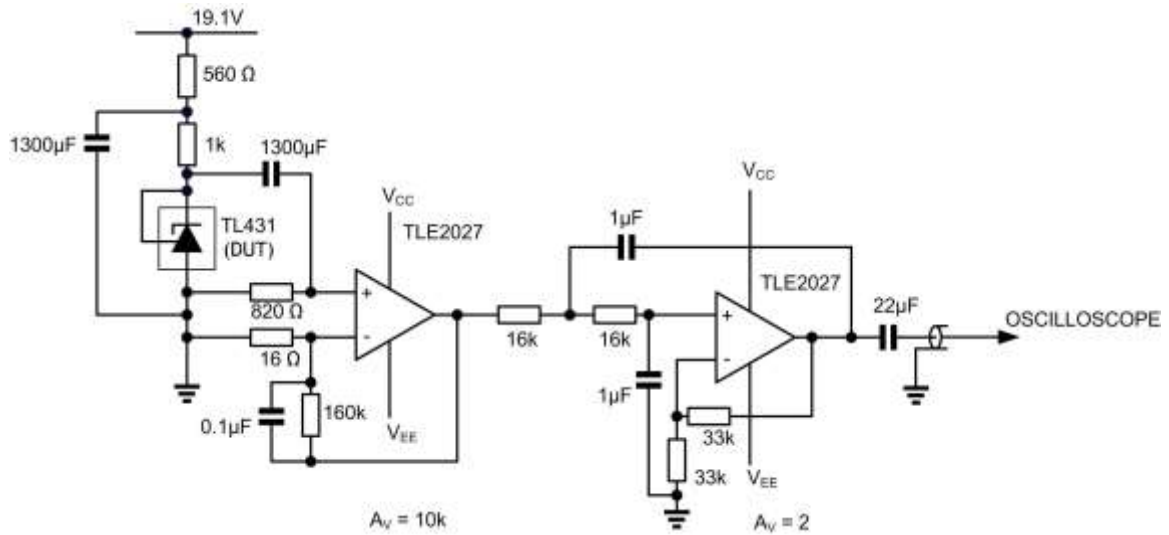
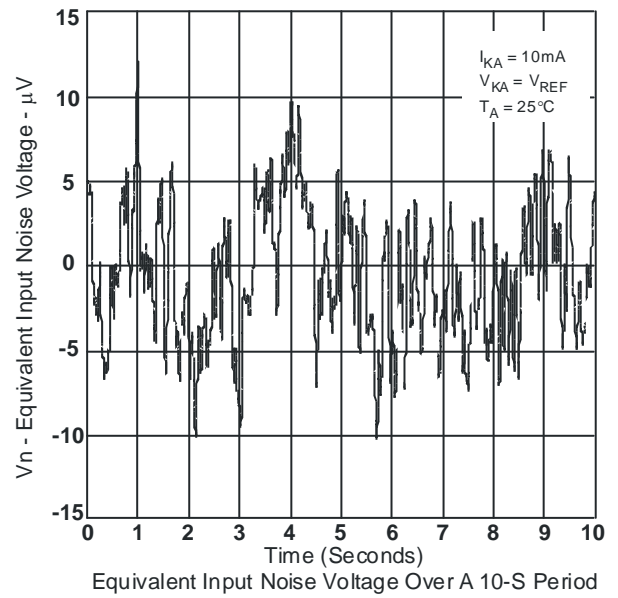
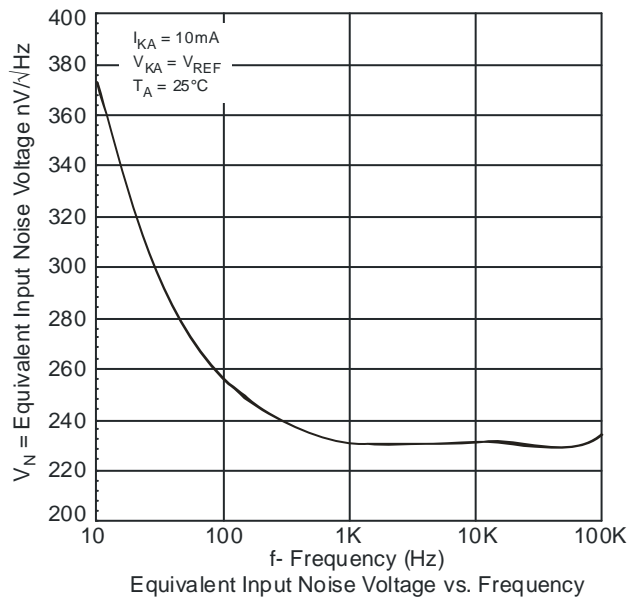
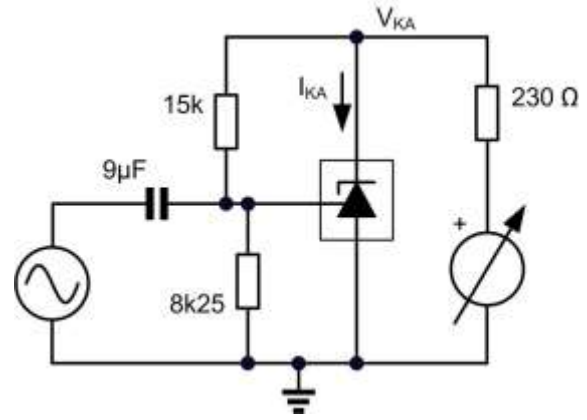
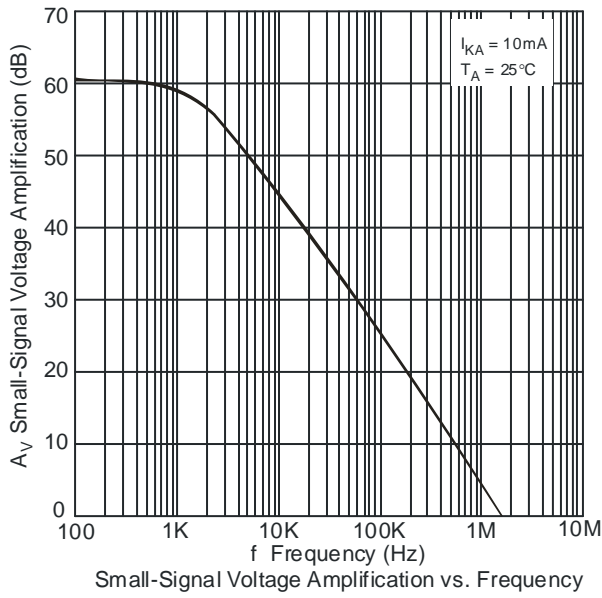
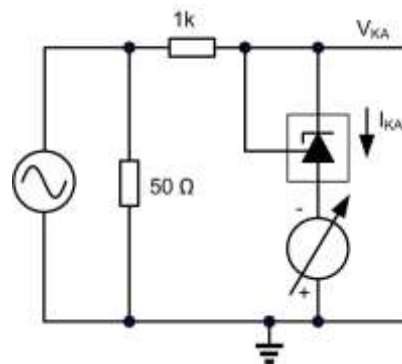
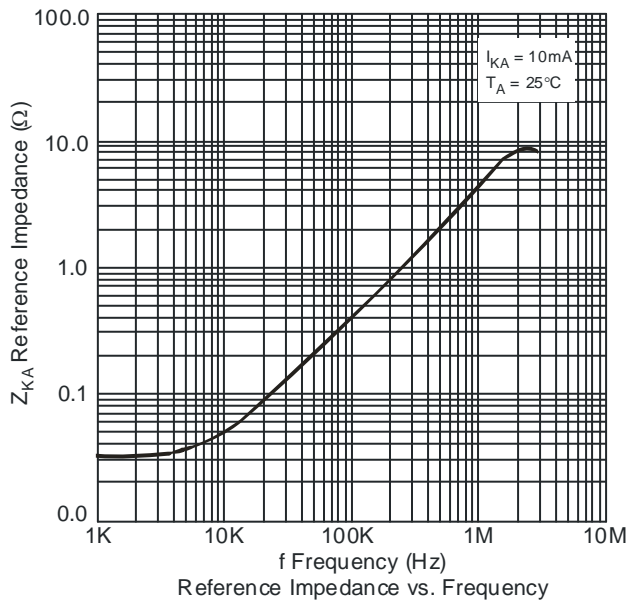


Figure 4 Test Circuit for Noise Input Voltage

**Typical Performance Characteristics (Cont.)**

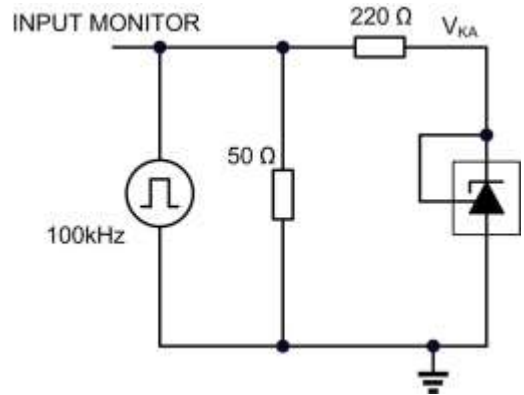
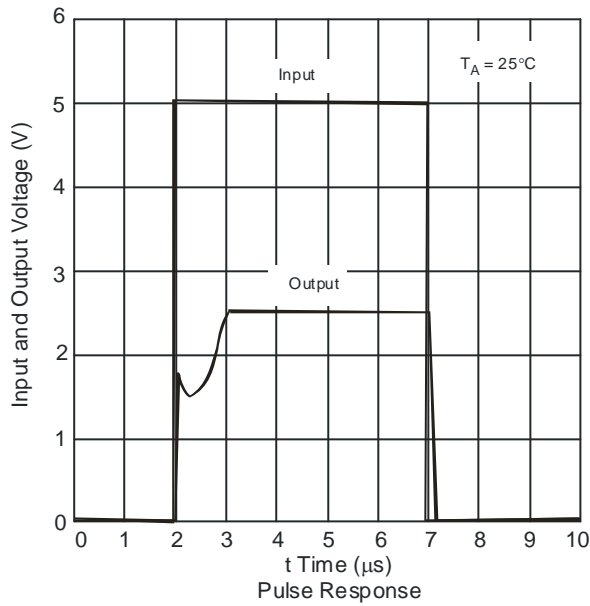


**Test Circuit for Voltage Amplification**

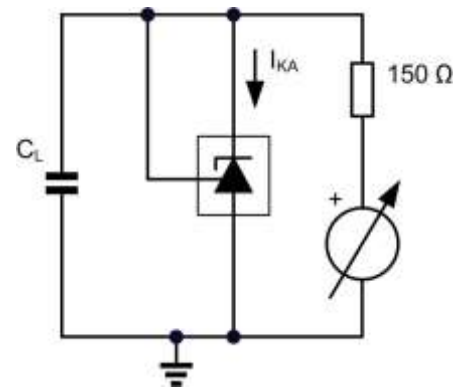
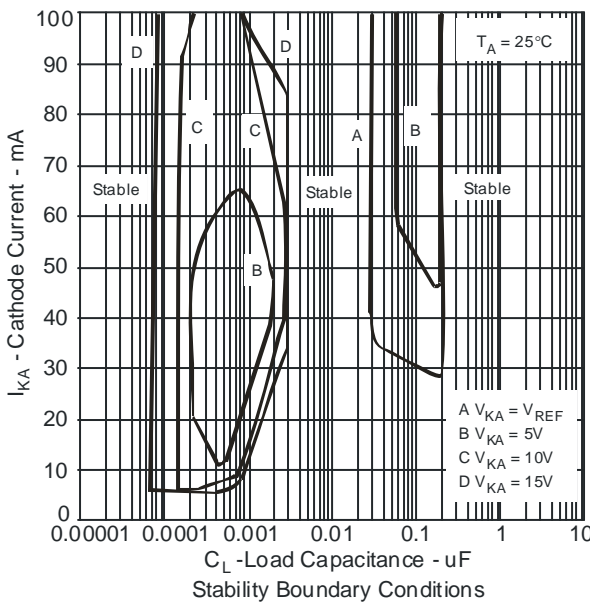


**Test Circuit for Reference Impedance**

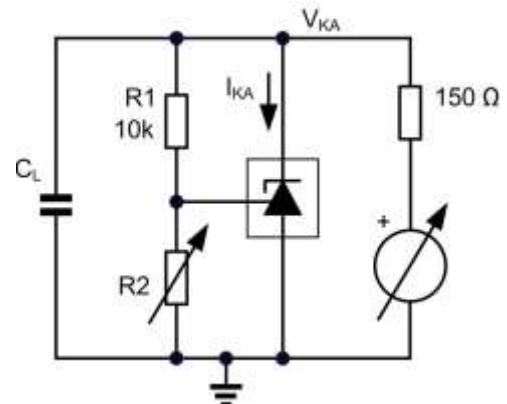
**Typical Performance Characteristics (Cont.)**



**Test Circuit for Pulse Response**



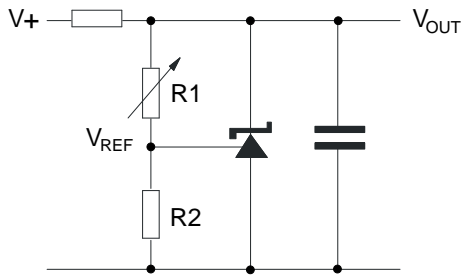
**Test Circuit for Curve A**



**Test Circuit for Curves B, C, D**

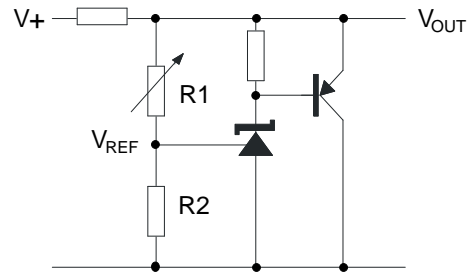
The device is stable under all conditions with a load capacitance not exceeding 50pF. The device is stable under all conditions with a load capacitance between 5nF and 20nF. The device is stable under all conditions with a load capacitance exceeding 300nF. With a cathode current not exceeding 5mA, the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

**Application Information**



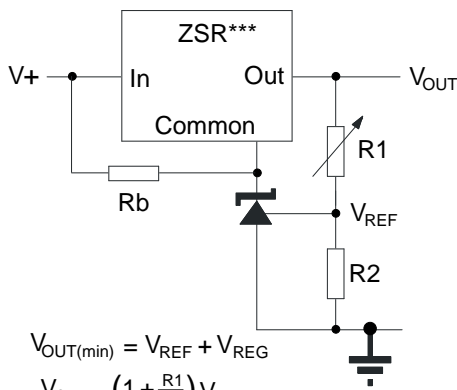
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

**Shunt Regulator**



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

**Higher Current Shunt Regulator**

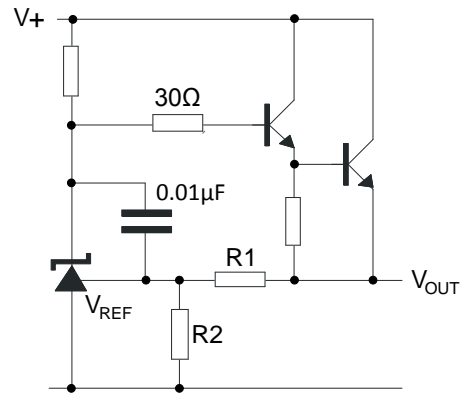


$$V_{OUT(min)} = V_{REF} + V_{REG}$$

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

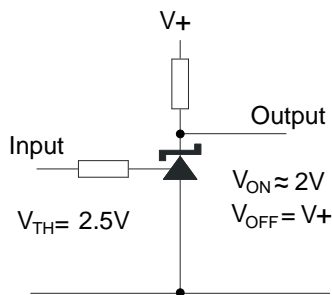
Rb - Optional to provide minimum cathode current

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

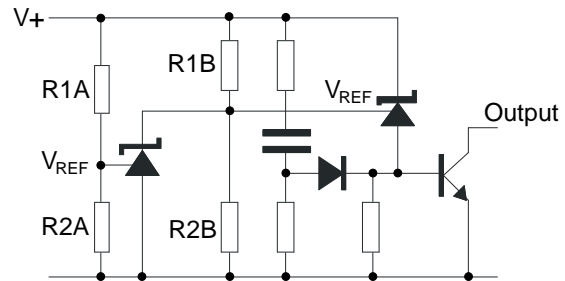


$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

**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**

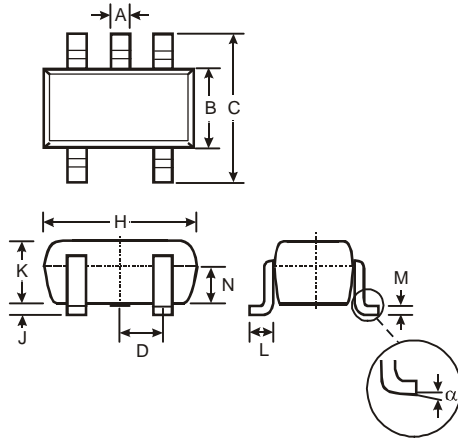




**Package Outline Dimensions**

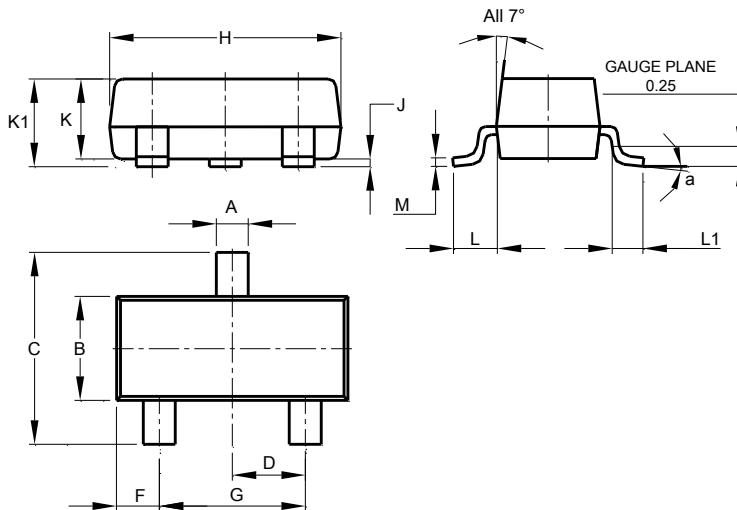
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**(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
α	0°	8°	—
All Dimensions in mm			

**(2) Package Types: SOT23**

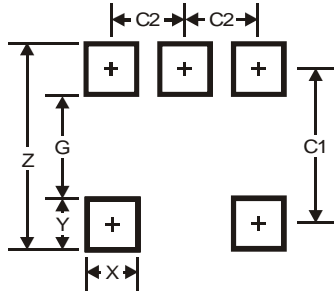


SOT23			
Dim	Min	Max	Typ
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.890	1.00	0.975
K1	0.903	1.10	1.025
L	0.45	0.61	0.55
L1	0.25	0.55	0.40
M	0.085	0.150	0.110
a	8°		
All Dimensions in mm			

## Suggested Pad Layout

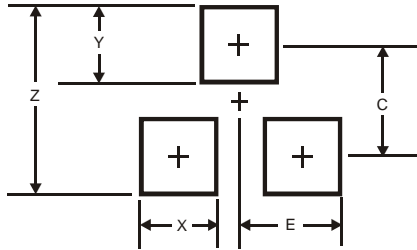
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**(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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