

### Description

The TL431 and TL432 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.

The devices can be used as a replacement for zener diodes in many applications requiring an improvement in zener performance. Diodes' TL431 has the same electrical specifications as the industry standard '431 and is available in 2 grades with initial tolerances of 1% and 0.5% for the A and B grades respectively.

### Features

- Temperature range -40 to +125°C
- Reference Voltage Tolerance at 25°C
  - TL431A: 2.495V ± 1.0%
  - TL431B: 2.495V ± 0.5%
- Low Output Noise
- 0.2Ω Typical Output Impedance
- Sink Current Capability: 1mA to 100mA
- Adjustable Output Voltage: V<sub>REF</sub> to 36V
- All devices are:
  - Totally Lead-Free & Fully RoHS compliant (Notes 1 & 2)
  - Halogen and Antimony Free. "Green" Device (Note 3)

### Applications

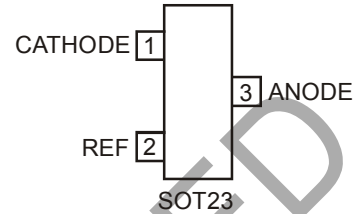
- Opto-Coupler Linearisers
- Shunt Regulators
- Improved Zener
- Variable Reference

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.

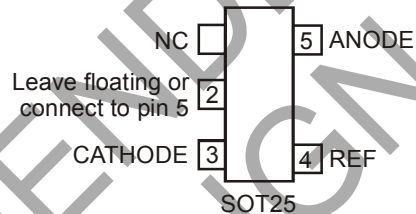
### Pin Assignments

#### TL431

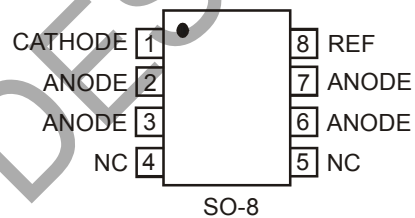
(Top View)



(Top View)

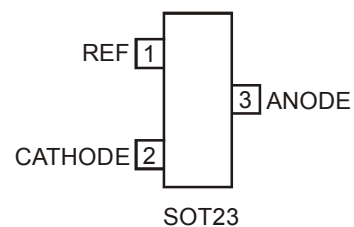


(Top View)



#### TL432

(Top View)



### Absolute Maximum Ratings (Note 4)

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	°C
$T_{ST}$	Storage Temperature		-55 to +150	°C
$P_D$	Power Dissipation (Notes 5, 6)	SOT23	330	mW
		SOT25	500	
		SO-8*	700	

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.  $T_J, MAX = 150^\circ C$ .

6. Ratings apply to ambient temperature at 25°C.

### Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
$V_{KA}$	Cathode Voltage	$V_{REF}$	36	V
$I_{KA}$	Cathode Current	1	100	mA
$T_A$	Operating Ambient Temperature	-40	+125	°C

NOT RECOMMENDED FOR NEW DESIGN

### Electrical Characteristics (T<sub>A</sub> = +25°C, unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
V <sub>REF</sub>	Reference voltage	V <sub>K</sub> A = V <sub>REF</sub> , I <sub>K</sub> A = 10mA	TL431A 2.470	2.495	2.520	V
			TL431B 2.482	2.495	2.507	
V <sub>DEV</sub>	Deviation of reference voltage over full temperature range (Note 5)	V <sub>K</sub> A = V <sub>REF</sub> , I <sub>K</sub> A = 10mA	T <sub>A</sub> = 0 to 70°C	6	16	mV
			T <sub>A</sub> = -40 to +85°C	14	34	
			T <sub>A</sub> = -40 to +125°C	14	34	
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of the change in reference voltage to the change in cathode voltage	I <sub>K</sub> A = 10mA	V <sub>K</sub> A = 10V to V <sub>REF</sub>	-1.4	-2.7	mV/V
			V <sub>K</sub> A = 36V to 10V	-1	-2	
I <sub>REF</sub>	Reference input current	I <sub>K</sub> A = 10mA, R1 = 10KΩ, R2 = ∞		1	4	μA
ΔI <sub>REF</sub>	I <sub>REF</sub> deviation over full temperature range (Note 7)	I <sub>K</sub> A = 10mA, R1 = 10KΩ, R2 = ∞	T <sub>A</sub> = 0 to 70°C	0.8	1.2	μA
			T <sub>A</sub> = -40 to +85°C	0.8	2.5	
			T <sub>A</sub> = -40 to +125°C	0.8	2.5	
I <sub>K</sub> (MIN)	Minimum cathode current for regulation	V <sub>K</sub> A = V <sub>REF</sub>		0.4	0.7	mA
I <sub>K</sub> (OFF)	Off-state current	V <sub>K</sub> A = 36V, V <sub>REF</sub> = 0V		0.05	0.5	μA
Z <sub>KA</sub>	Dynamic output impedance (Note 8)	V <sub>K</sub> A = V <sub>REF</sub> , f = 0Hz		0.2	0.5	Ω
θ <sub>JA</sub>	Thermal Resistance Junction to Ambient	SOT23		380		°C/W
		SOT25		250		
		SO-8*		70		

Notes: 7. Deviation of V<sub>DEV</sub>, and ΔI<sub>REF</sub> are defined as the maximum variation of the values over the full temperature range.

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.

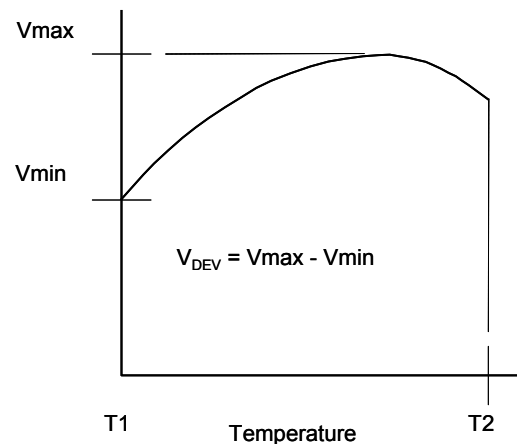
αV<sub>REF</sub> can be positive or negative depending on whether the slope is positive or negative.

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

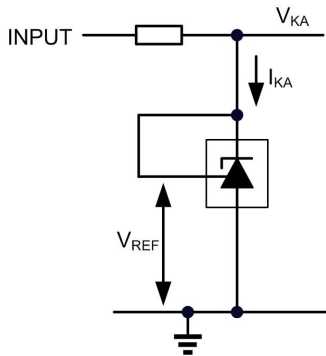
$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$$

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

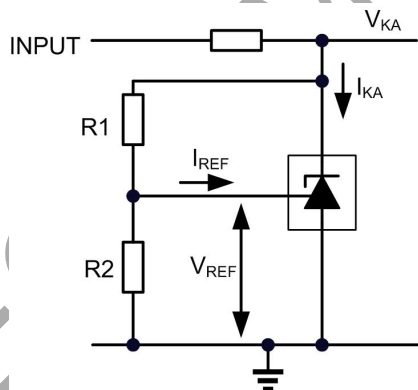
$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}| \left( 1 + \frac{R1}{R2} \right)$$



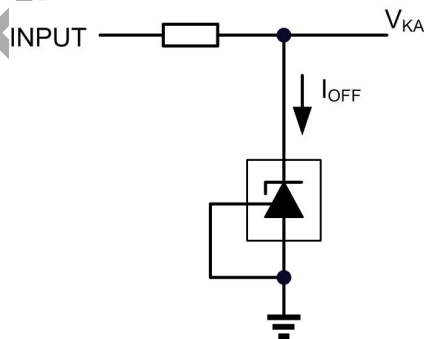
**Test Circuits**



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

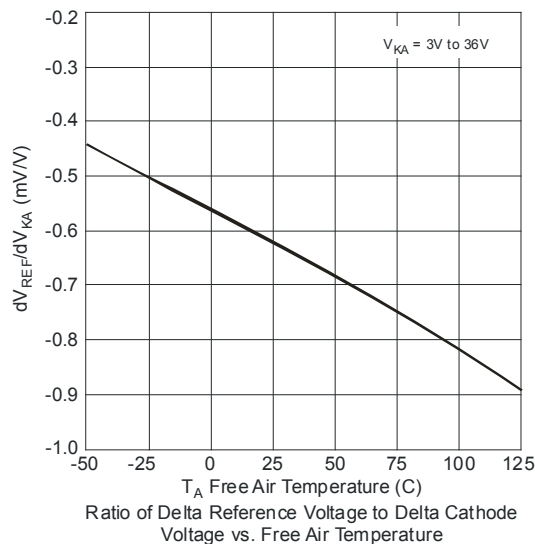
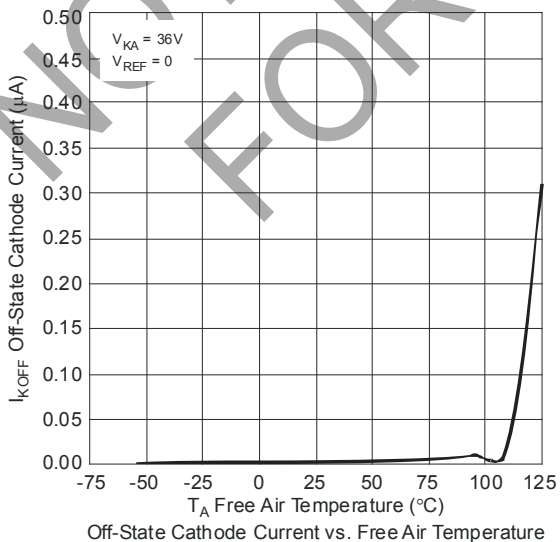
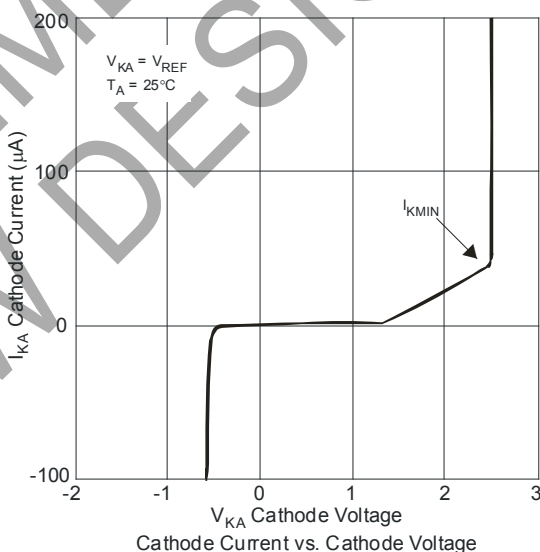
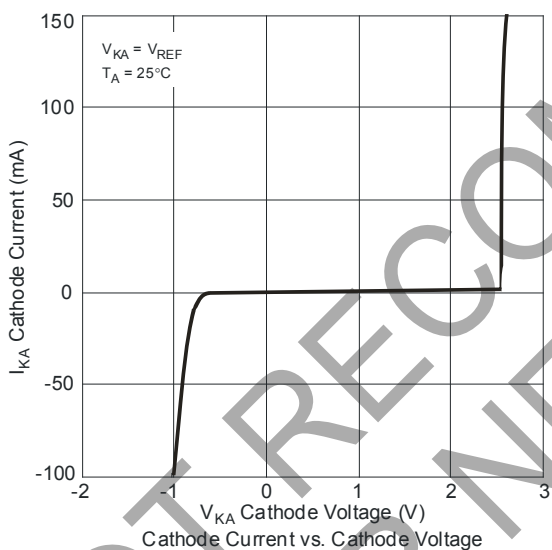
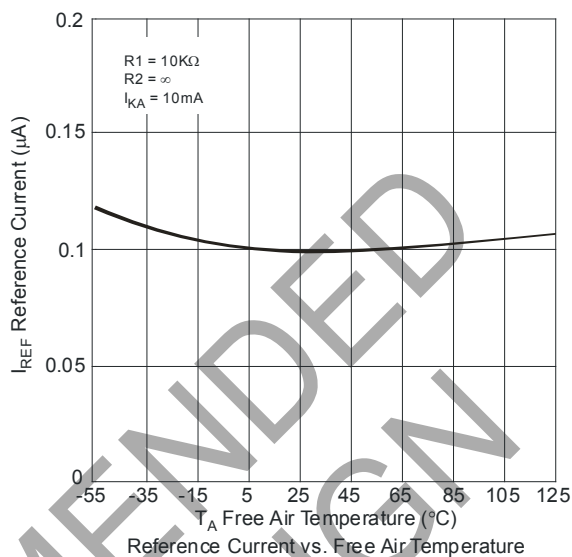
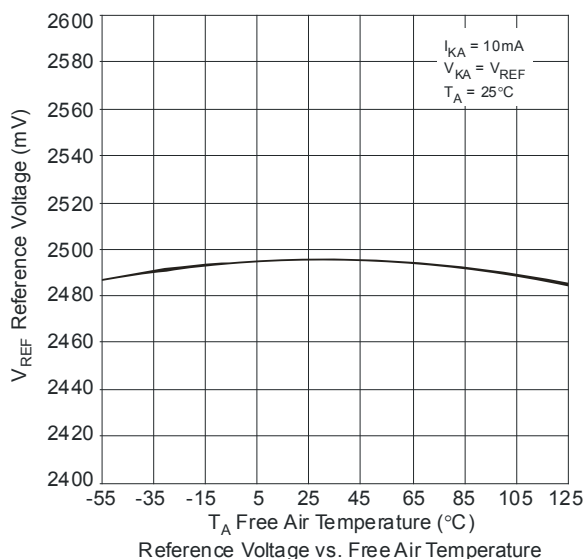


**Figure 2. Test circuit for  $V_{KA} > V_{REF}$**

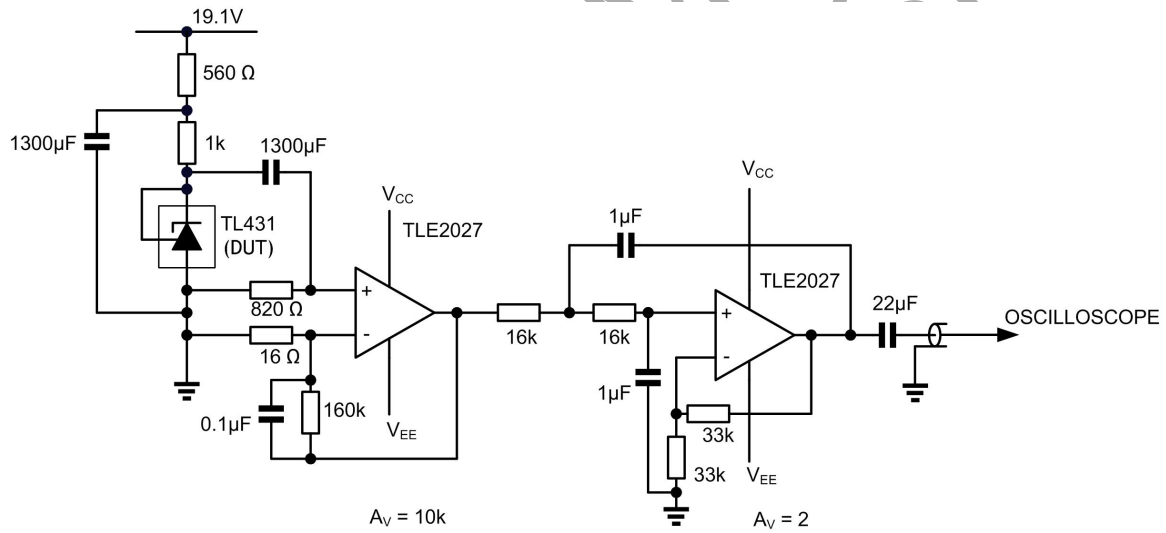
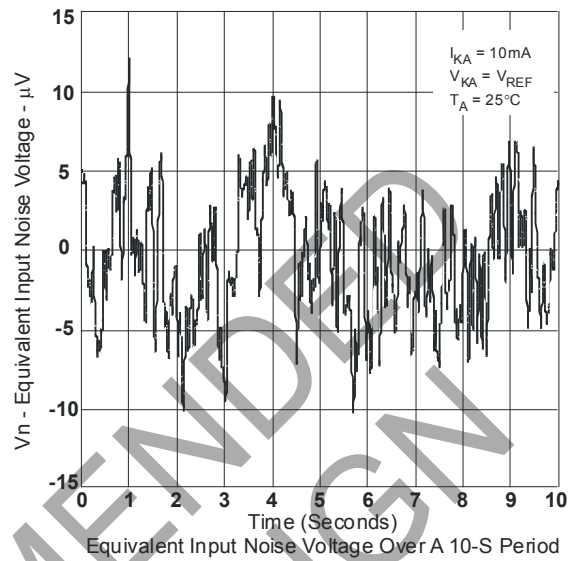
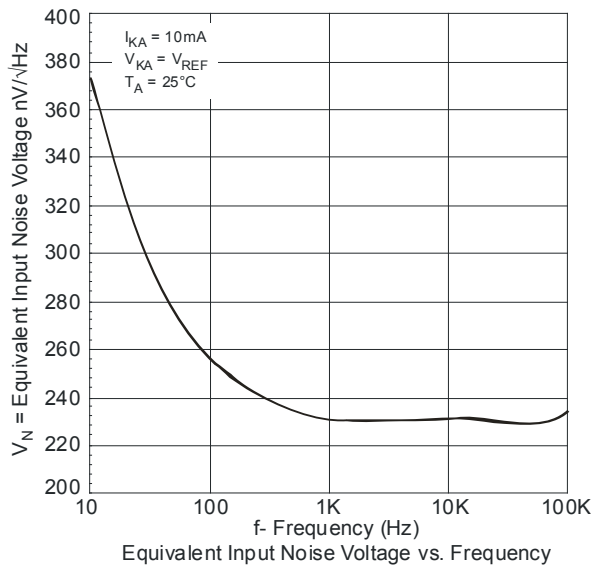


**Figure 3. Test circuit for  $I_{OFF}$**

**Typical Performance Characteristics**

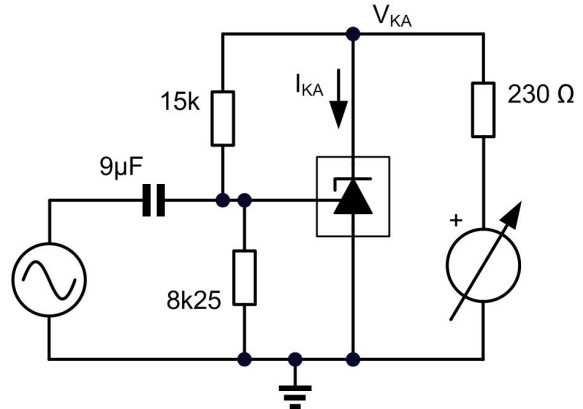
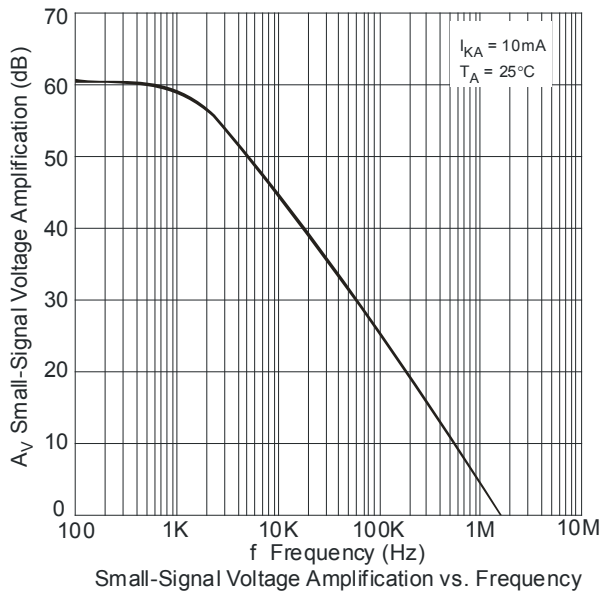


**Typical Performance Characteristics (cont.)**

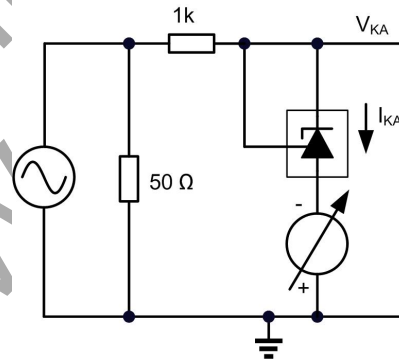
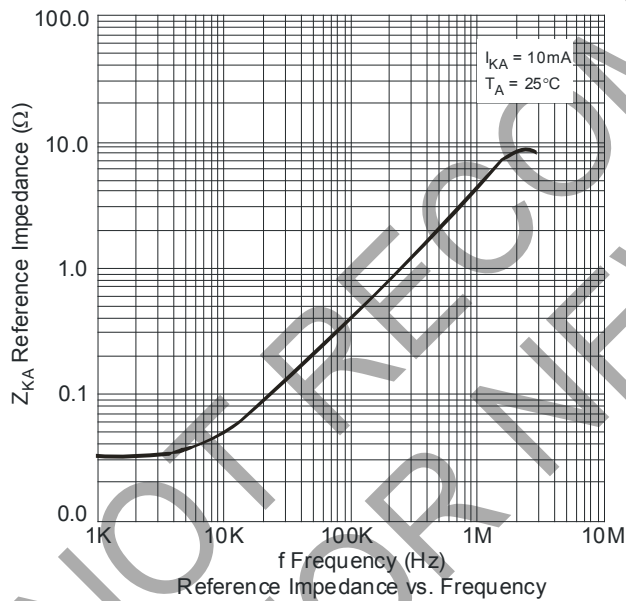


**Figure 4. Test circuit for noise input voltage**

**Typical Performance Characteristics (cont.)**

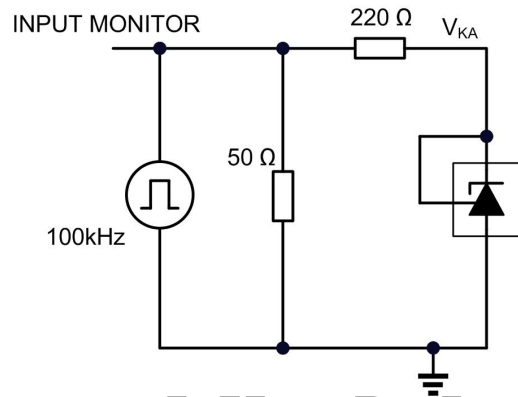
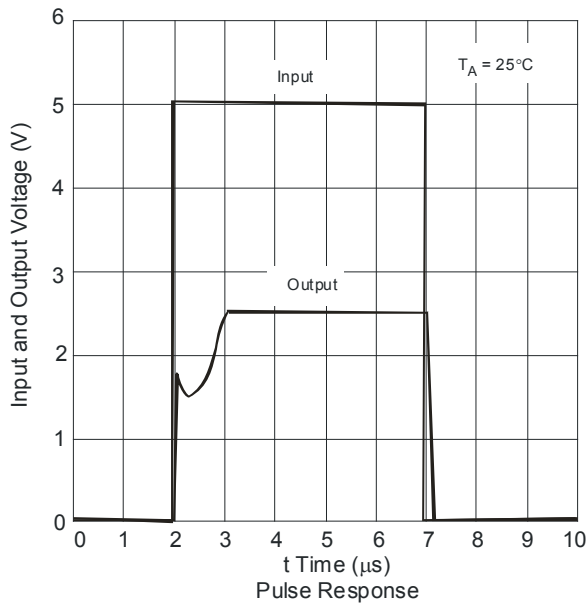


**Test circuit for voltage amplification**

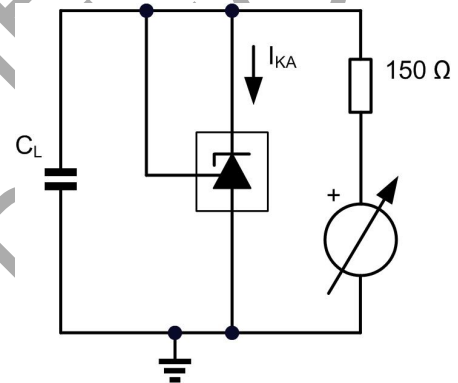
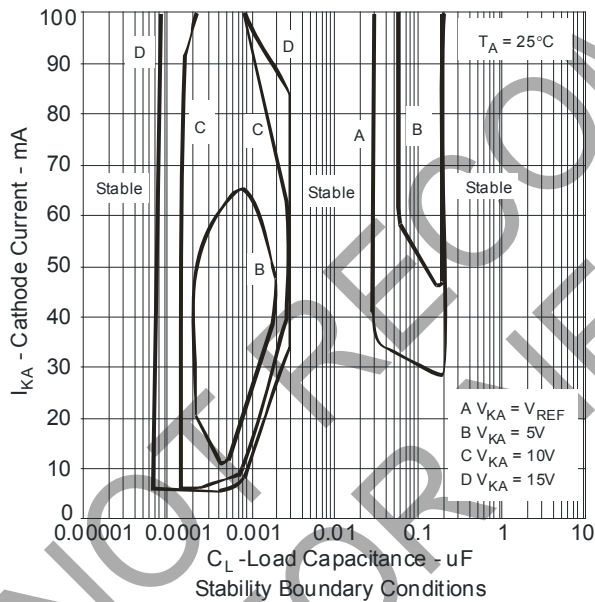


**Test circuit for reference impedance**

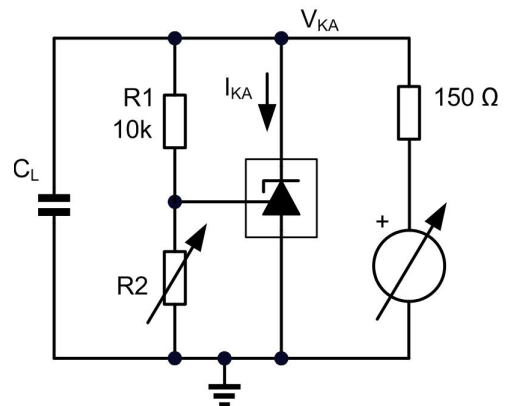
**Typical Performance Characteristics (cont.)**



**Test Circuit for Pulse Response**



**Test Circuit for Curve A**

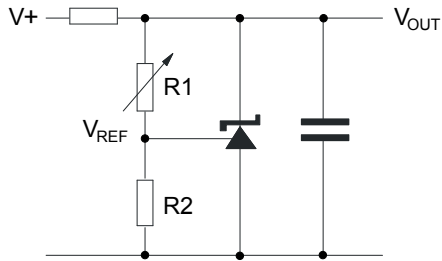


**Test Circuit for Curves B, C, D**

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.

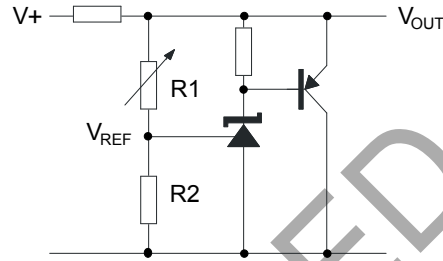


**Applications Information**



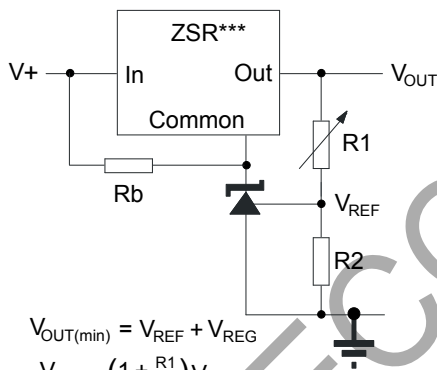
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

**Shunt Regulator**



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

**Higher Current Shunt Regulator**

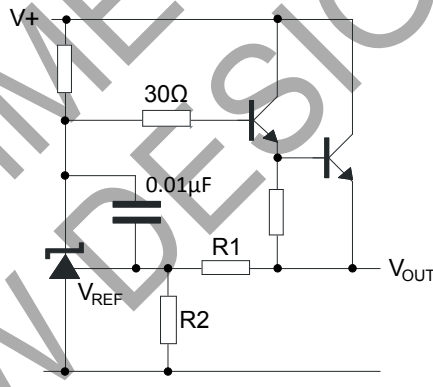


$$V_{OUT(min)} = V_{REF} + V_{REG}$$

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

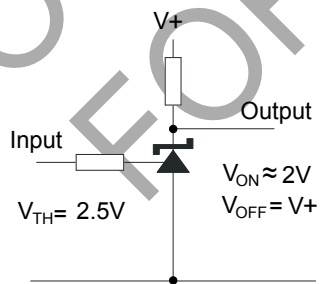
Rb - Optional to provide minimum cathode current

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

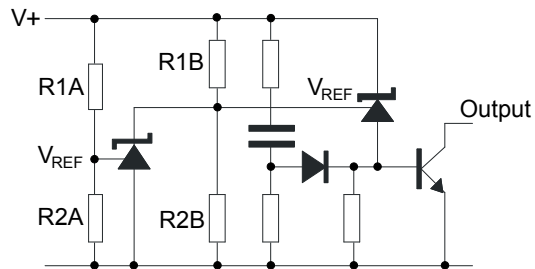


$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

**Series Regulator**



**Single Supply Comparator with Temperature Compensated Threshold**

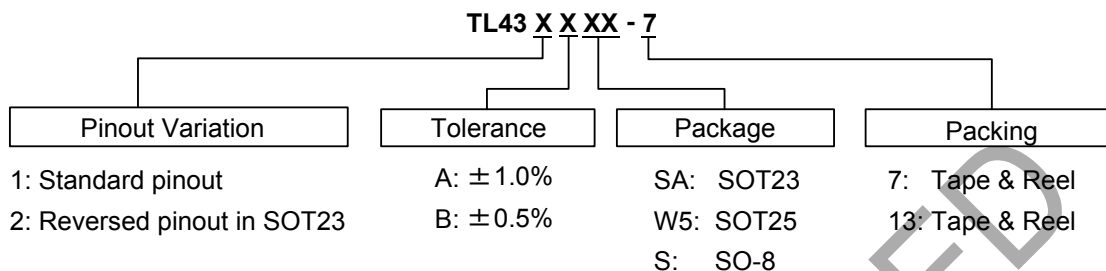






$$\text{Low Limit} = \left(1 + \frac{R1B}{R2B}\right) V_{REF}$$

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

**Over Voltage / Under Voltage Protection Circuit**

### Ordering Information



Device	Package Code	Packaging (Note 9)	7" Tape and Reel		Ammo Box	
			Quantity	Part Number Suffix	Quantity	Part Number Suffix
 TL431A(B)SA-7	SA	SOT23	3000/Tape & Reel	-7	NA	NA
 TL431A(B)W5-7	W5	SOT25	3000/Tape & Reel	-7	NA	NA
 TL431A(B)S-13*	S	SO-8*	2500/Tape & Reel	-13	NA	NA
 TL432A(B)SA-7	SA	SOT23	3000/Tape & Reel	-7	NA	NA

\* Suffix "B" denotes TL431B device.

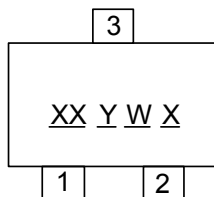
Notes: 9. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

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### Marking Information

#### (1) SOT23

(Top View)

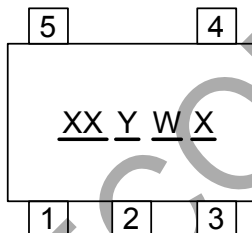


**XX** : Identification code  
**Y** : Year 0~9  
**W** : Week : A~Z : 1~26 week;  
           a~z : 27~52 week; z represents  
           52 and 53 week  
**X** : A~Z : Green

Device	Package	Identification Code
TL431ASA	SOT23	AA
TL431BSA	SOT23	AB
TL432ASA	SOT23	BA
TL432BSA	SOT23	BB

#### (2) SOT25

(Top View)

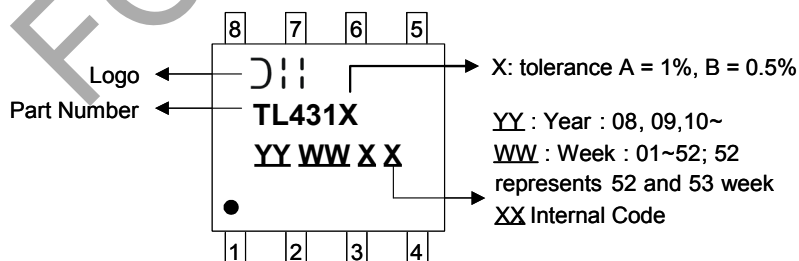


**XX** : Identification code  
**Y** : Year 0~9  
**W** : Week : A~Z : 1~26 week;  
           a~z : 27~52 week; z represents  
           52 and 53 week  
**X** : A~Z : Green

Device	Package	Identification Code
TL431AW5	SOT25	AA
TL431BW5	SOT25	AB

#### (3) SO-8\*

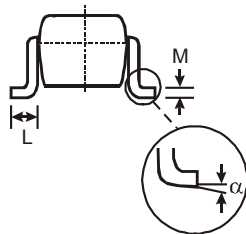
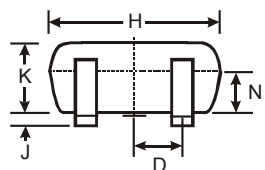
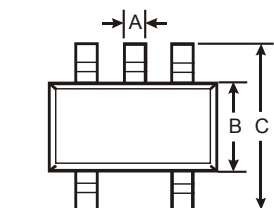
(Top View)



**X**: tolerance A = 1%, B = 0.5%  
**YY** : Year : 08, 09, 10~  
**WW** : Week : 01~52; 52  
           represents 52 and 53 week  
**XX** Internal Code

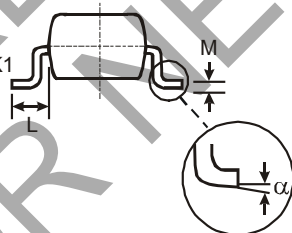
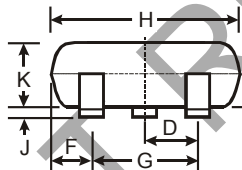
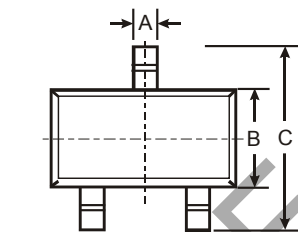
**Package Outline Dimensions (All Dimensions in mm)**

**(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			

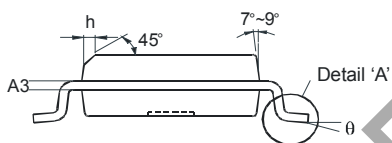
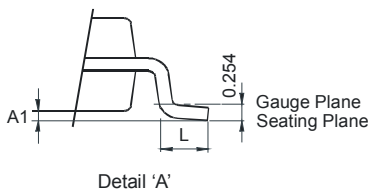
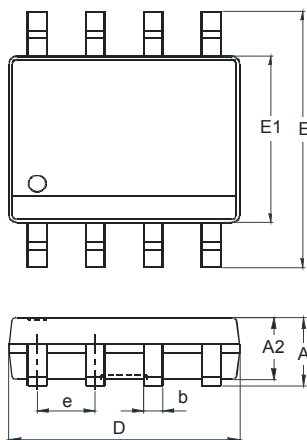
**(2) Package Types: SOT23**



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	0.903	1.10	1.00
K1	-	-	0.400
L	0.45	0.61	0.55
M	0.085	0.18	0.11
$\alpha$	0°	8°	-
All Dimensions in mm			

**Package Outline Dimensions (All Dimensions in mm)**

**(3) Package Types: SO-8\***



SO-8*		
Dim	Min	Max
A	-	1.75
A1	0.10	0.20
A2	1.30	1.50
A3	0.15	0.25
b	0.3	0.5
D	4.85	4.95
E	5.90	6.10
E1	3.85	3.95
e	1.27 Typ	
h	-	0.35
L	0.62	0.82
θ	0°	8°
All Dimensions in mm		

NOT RECOMMENDED FOR NEW DESIGN

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