

### Features

- Precision reference voltage  
AP431 : 2.495V  $\pm$  1%  
AP431A : 2.495V  $\pm$  0.5%
- Sink current capability: 200mA
- Minimum cathode current for regulation: 300 $\mu$ A
- Equivalent full-range temp coefficient: 30 ppm/ $^{\circ}$ C
- Fast turn-on response
- Low dynamic output impedance: 0.2 $\Omega$
- Programmable output voltage to 36V
- Low output noise
- Packages: SOT23, SOT23R, SOT25, SC59 (W package code), SC59 (R package code), SOP-8L and TO92-3L
- SOT23, SOT23R, SOP-8L and SC59: Available in "Green" Molding Compound (No Br, Sb) (Note 1)
- Lead Free Finish/RoHS Compliant for Lead Free and "Green" Products (Note 2)

### General Description

The AP431 and AP431A are 3-terminal adjustable precision shunt regulators with guaranteed temperature stability over the applicable extended commercial temperature range. The output voltage may be set at any level greater than 2.495V ( $V_{REF}$ ) up to 36V merely by selecting two external resistors that act as a voltage divider network. These devices have a typical output impedance of 0.2 $\Omega$ . Active output circuitry provides very sharp turn-on characteristics, making these devices excellent improved replacements for Zener diodes in many applications.

The precise (+/-) 1% Reference voltage tolerance of the AP431/AP431A make it possible in many applications to avoid the use of a variable resistor, consequently saving cost and eliminating drift and reliability problems associated with it.

### Ordering Information



Note: 1. SOT23, SOT23R are "Green" products only.  
2. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see *EU Directive Annex Notes 5 and 7*.

Device (Note 4)	Package Code	Packaging (Note 5)	7" Tape and Reel		13" Tape and Reel		Ammo Box	
			Quantity	Part Number Suffix	Quantity	Part Number Suffix	Quantity	Part Number Suffix
AP431(A)SA	SA	SOT23	3000/Tape & Reel	-7	NA	NA	NA	NA
AP431(A)SR	SR	SOT23R	3000/Tape & Reel	-7	NA	NA	NA	NA
AP431(A)Q	Q	SOT25	3000/Tape & Reel	-7	NA	NA	NA	NA
AP431(A)W	W	SC59	3000/Tape & Reel	-7	NA	NA	NA	NA
AP431(A)R	R	SC59	3000/Tape & Reel	-7	NA	NA	NA	NA
AP431(A)		SOP-8L	NA	NA	2500/Tape & Reel	-13	NA	NA
AP431(A)V	V	TO92-3L	NA	NA	NA	NA	2000/Box	-A

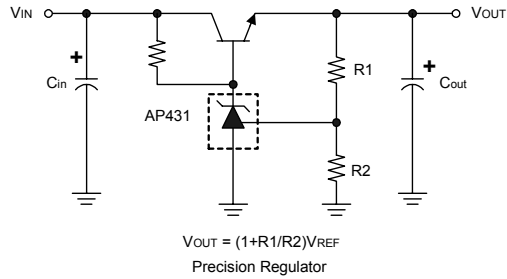
Notes: 3. Ammo Box is for TO92-3 Spread Lead.  
4. Suffix "A" denotes AP431A device.  
5. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

**Pin Assignment**

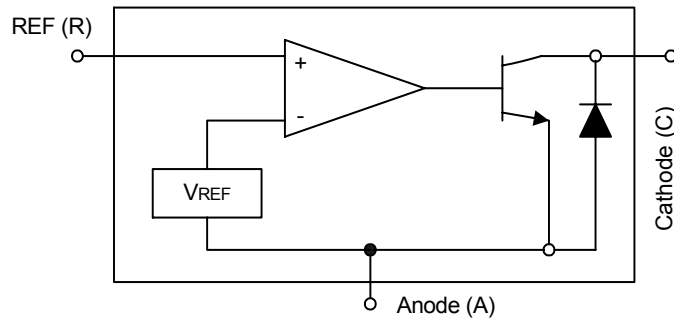
Package	Pin Configuration (Top View)
SOT25	<p>NC 1 NC 2 CATHODE 3 REF 4 ANODE 5</p>
SC-59 (Package Code-W)	<p>ANODE 1 CATHODE 2 REF 3</p>
SC-59 (Package Code-R)	<p>ANODE 1 REF 2 CATHODE 3</p>
TO92-3L	<p>3 Cathode 2 Anode 1 REF</p>

Package	Pin Configuration (Top View)
SOP-8L	<p>CATHODE 1 ANODE 2 ANODE 3 NC 4 REF 8 ANODE 7 ANODE 6 NC 5</p>
SOT23	<p>ANODE 1 CATHODE 2 REF 3</p>
SOT23R	<p>ANODE 1 REF 2 CATHODE 3</p>

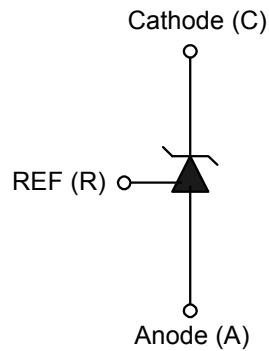
**Typical Application Circuit**



**Block Diagram**



**Symbol**



**Absolute Maximum Ratings**

Symbol	Parameter	Rating	Unit	
V <sub>CV</sub>	Cathode Voltage	+36	V	
I <sub>CC</sub>	Continuous Cathode Current	-10 to +250	mA	
I <sub>REF</sub>	Reference Input Current	10	mA	
T <sub>OP</sub>	Operating Temperature	-20 to +85	°C	
T <sub>ST</sub>	Storage Temperature	-65 to +150	°C	
P <sub>D</sub>	Power Dissipation (Notes 6, 7)	SOT23(R)	250	mW
		SOT25	250	mW
		SC59	400	mW
		SOP-8L	600	mW
		TO92-3L	780	mW

Note: 6. T<sub>J</sub>, max =150°C

7. Ratings apply to ambient temperature at 25°C

**Electrical Characteristics** (  $T_A = 25^{\circ}\text{C}$ ,  $V^+ = +5.0\text{V}$ , unless otherwise stated )

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT	
Reference voltage	$V_{KA} = V_{REF}$ , $I_{KA} = 10\text{mA}$ (Fig.1)	AP431 AP431A $V_{REF}$	2.470 2.482	2.495	2.520 2.507	V	
Deviation of Reference input voltage over temperature (Note 8)	$V_{KA} = V_{REF}$ , $I_{KA} = 10\text{mA}$ , $T_a = \text{Full range}$ (Fig.1)	$V_{REF}$	—	8.0	20	mV	
Ratio of the change in Reference voltage to the change in Cathode voltage	$I_{KA} = 10\text{mA}$ (Fig. 2)	$V_{KA} = 10\text{V} \sim V_{REF}$	$\Delta V_{REF}$	—	-1.4	-2.0	mV/V
		$V_{KA} = 36\text{V} \sim 10\text{V}$	$\Delta V_{KA}$	—	-1	-2	mV/V
Reference input current	$R1 = 10\text{K}\Omega$ , $R2 = \infty$ $I_{KA} = 10\text{mA}$ (Fig. 2)	$I_{REF}$	—	1.4	3.5	$\mu\text{A}$	
Deviation of Reference input current over temperature	$R1 = 10\text{K}\Omega$ , $R2 = \infty$ $I_{KA} = 10\text{mA}$ $T_a = \text{Full range}$ (Fig. 2)	$\alpha I_{REF}$	—	0.4	1.2	$\mu\text{A}$	
Minimum Cathode current for regulation	$V_{KA} = V_{REF}$ (Fig.1)	$I_{KA(MIN)}$	—	0.19	0.5	mA	
Off-state current	$V_{KA} = 36\text{V}$ , $V_{REF} = 0\text{V}$ (Fig. 3)	$I_{KA(OFF)}$	—	0.1	1.0	$\mu\text{A}$	
Dynamic output impedance (Note 9)	$V_{KA} = V_{REF}$ $V_{KA} = V_{REF}$ $\Delta I_{KA} = 0.1\text{mA} \sim 15\text{mA}$ Frequency $\leq 1\text{KHz}$ (Fig.1)	$ Z_{KA} $	—	0.2	0.5	$\Omega$	



Note: 8. Deviation of reference input voltage,  $V_{DEV}$ , is defined as the maximum variation of the reference over the full temperature range. The average temperature coefficient of the reference input voltage  $\alpha V_{REF}$  is defined as:

$$|\alpha V_{REF}| = \frac{\left(\frac{V_{DEV}}{V_{REF}(25^{\circ}\text{C})}\right) \cdot 10^6}{T_2 - T_1} \dots\dots\dots (\text{ppm}/^{\circ}\text{C})$$

Where:

$T_2 - T_1 =$  full temperature change.

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

Note: 9. The dynamic output impedance,  $R_Z$ , is defined as:

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

When the device is programmed with two external resistors  $R1$  and  $R2$  (see Figure 2.), the dynamic output impedance of the overall circuit, is defined as:

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

**Test Circuits**

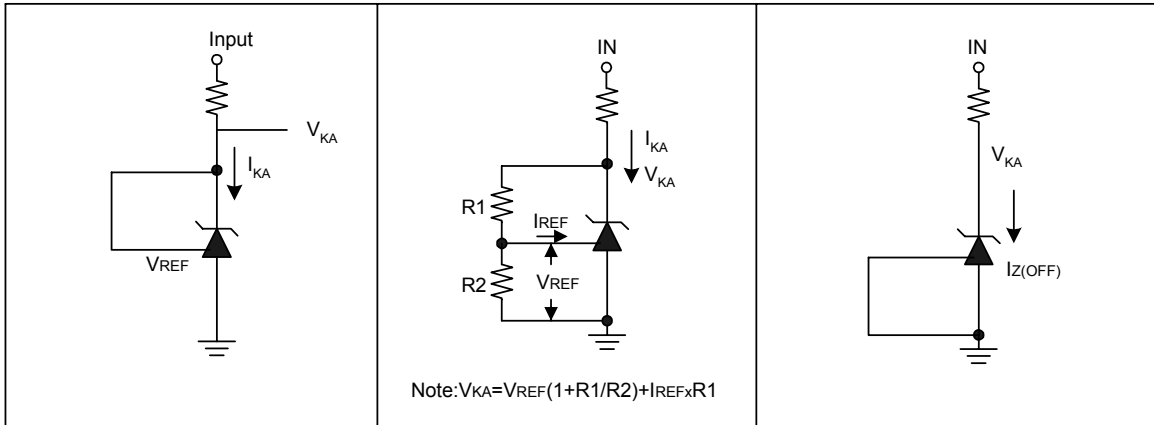
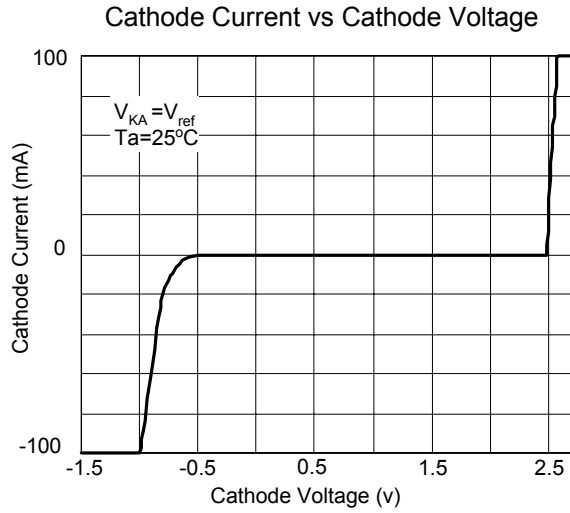


Fig 1. Test Circuit for  $V_{KA} = V_{REF}$

Fig 2. Test Circuit for  $V_{KA} > V_{REF}$

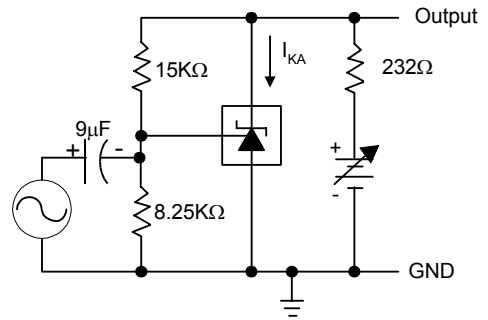
Fig 3. Test Circuit for Off-State Current

**Typical Performance Characteristics**



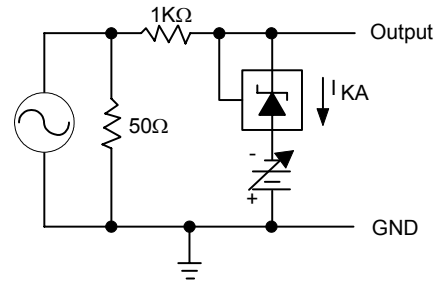
**Typical Performance Characteristics** ( Continued )

Small-Signal Voltage Amplification vs Frequency



Test Circuit for Voltage Amplification

Reference Impedance vs Frequency

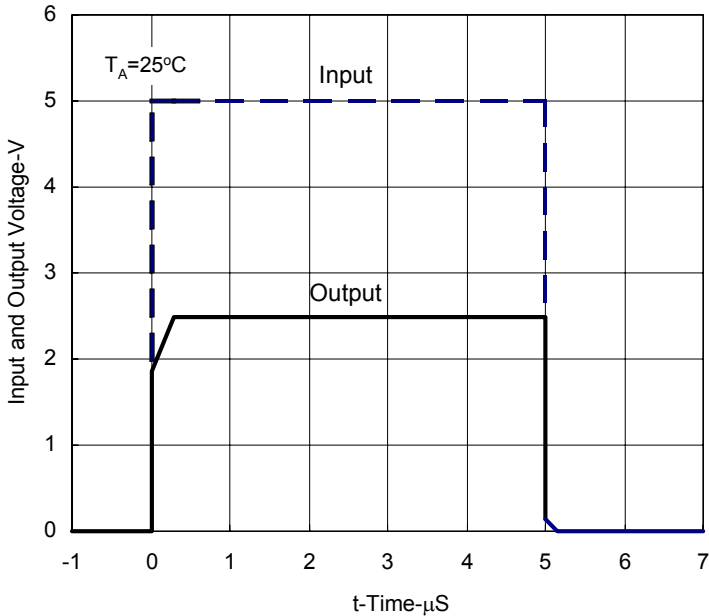


Test Circuit for Reference Impedance



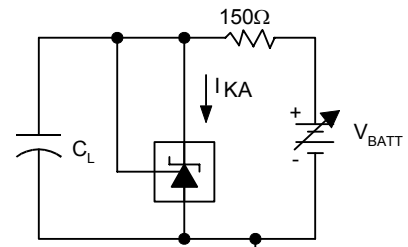
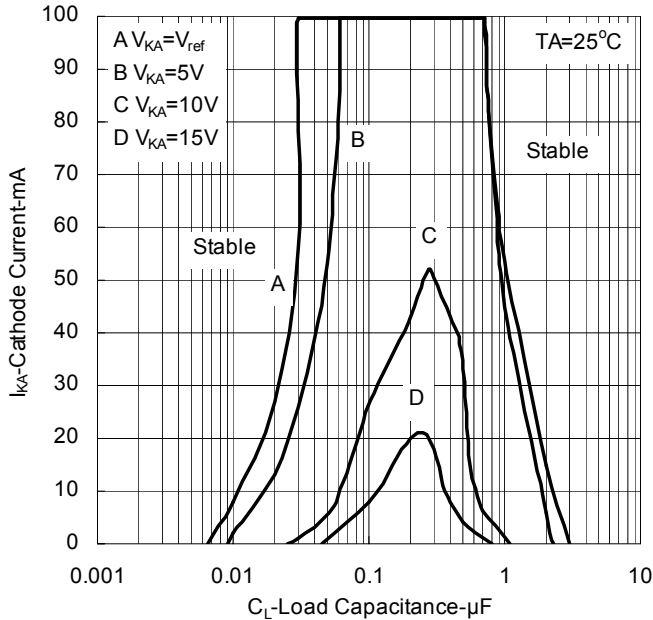
**Typical Performance Characteristics** (Continued)

Pulse Response

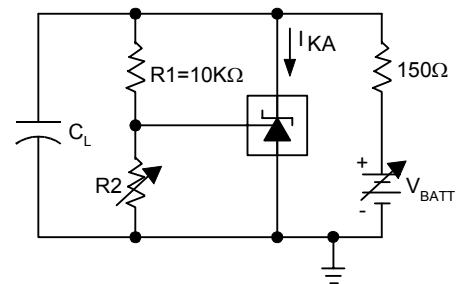


Test Circuit for Pulse Response

STABILITY BOUNDARY CONDITIONS<sup>†</sup>



Test Circuit for Curve A



Test Circuit for Curve B, C, and D

<sup>†</sup>The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D,  $R_2$  and  $V_+$  were adjusted to establish the initial  $V_{KA}$  and  $I_{KA}$  conditions with  $C_L=0$ .  $V_{BATT}$  and  $C_L$  were then adjusted to determine the ranges of stability.

**Application Examples**

LED on when  $Low\ Limit < V_{IN} < High\ Limit$   
 $Low\ Limit \approx V_{REF} (1 + R1B/R2B)$   
 $High\ Limit \approx V_{REF} (1 + R1A/R2A)$

**Fig. 4 Voltage Monitor**

$Delay = RC \times \ln \left( \frac{V_{IN}}{V_{IN} - V_{REF}} \right)$

**Fig. 5 Delay Timer**

$I_{OUT} = V_{REF} / R_{CL}$

**Fig. 6 Current Limiter or Current Source**

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$I_{OUT} = V_{REF} / R_s$

**Fig. 7 Constant-Current Sink**

$V_{OUT} = (1 + R1/R2) \times V_{REF}$

**Fig. 8 Higher-Current Shunt Regulator**

$LIMIT \approx (1 + R1/R2) \times V_{REF}$

**Fig. 9 Crow Bar**

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Output ON when  $Low\ Limit < V_{IN} < High\ Limit$

$Low\ Limit \approx V_{REF} (1 + R1B/R2B) + V_{BE}$   
 $High\ Limit \approx V_{REF} (1 + R1A/R2A)$

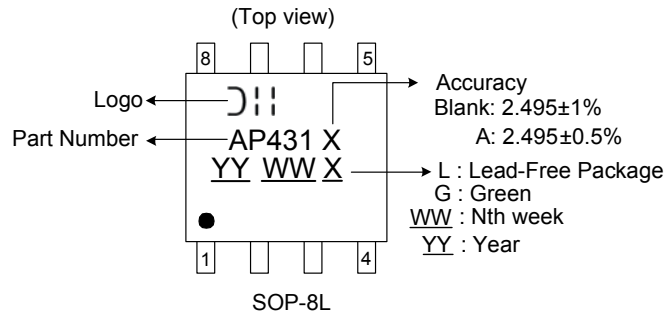
**Fig. 10 Over-Voltage / Under-Voltage Protection Circuit**

**Marking Information**

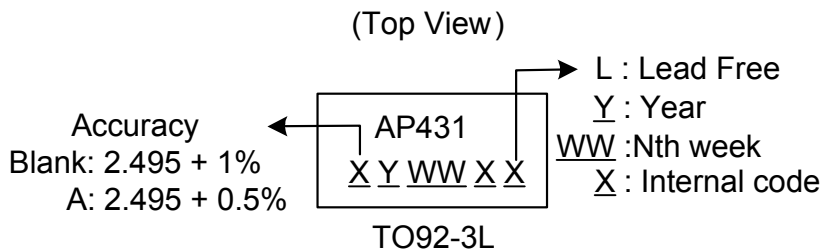
**(1) SOT23(R)/SOT25/SC59**



**(2) SOP-8L**



**(3) TO92-3L**



**Marking Code Table**

Device	Package (Note 10)	Marking Code	Date Code
AP431SA	SOT23	D1	YM
AP431ASA	SOT23	D2	YM
AP431SR	SOT23R	D5	YM
AP431ASR	SOT23R	D6	YM
AP431Q	SOT25	A2	YM
AP431AQ	SOT25	A3	YM
AP431W	SC59	A6	YM
AP431AW	SC59	A7	YM
AP431R	SC59	A8	YM
AP431AR	SC59	A9	YM

Note: 10. For Packaging Details, go to our website at <http://www.diodes.com/datasheets/ap02007.pdf>.

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

**(1) SOT25**



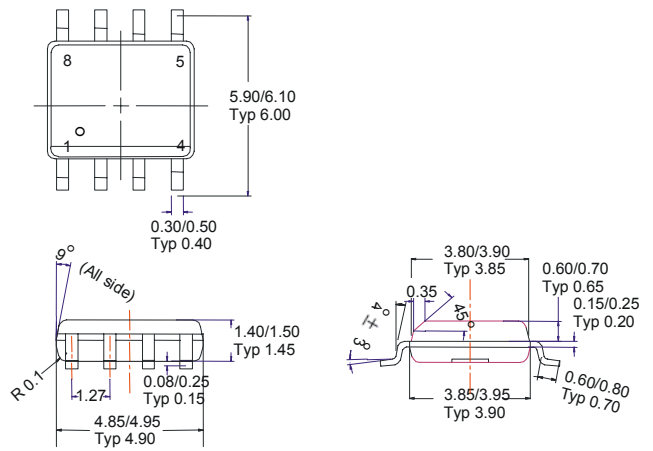
**(2) SC59**



**(3) SOT23(R)**

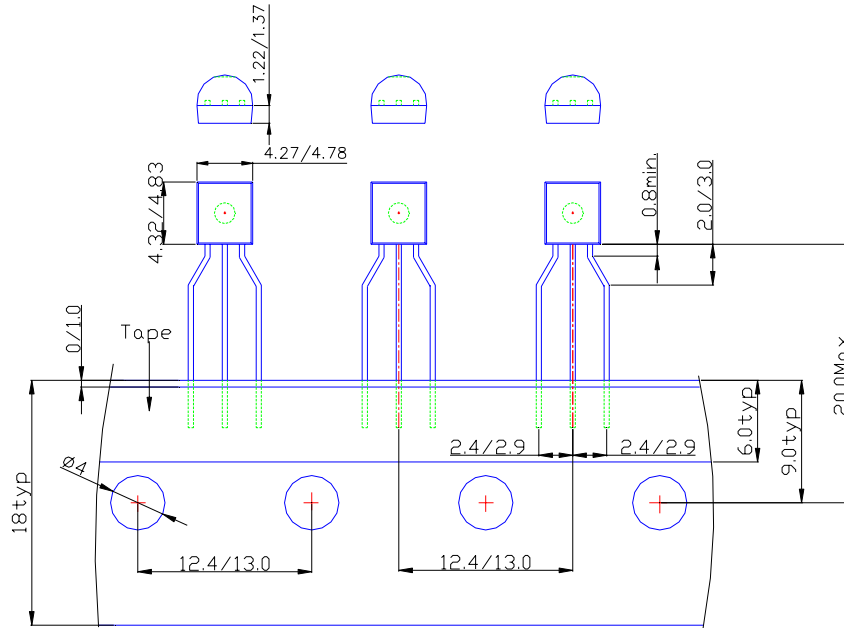


**(4) SOP-8L**



**Package Information** ( Continued ) ( All Dimensions in mm )

(5) TO92-3L for Ammo pack



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