

**LOW CATHODE CURRENT ADJUSTABLE PRECISION SHUNT REGULATOR**

## Description

The AP431S/AP431SH is a 3-terminal adjustable shunt regulator with guaranteed thermal stability over a full operation range. It features sharp turn-on characteristics, low-temperature coefficient and low output impedance, which makes it ideal substitute for Zener diode in applications such as switching power supply, charger and other adjustable regulators.

The AP431S/AP431SH has the same electrical specifications as the industry standard 431 except that it features a low minimum cathode current for regulation. The typical value of 50µA makes the parts ideal for very low power dissipation applications.

The output voltage of the AP431S/AP431SH can be set to any value between  $V_{REF}$  (2.5V/2.495V) and the corresponding maximum cathode voltage (36V).

The AP431S/AP431SH is offered in two grade initial voltage tolerance at +25°C, 0.5% and 1%.

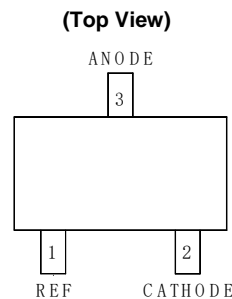
This IC is available in 3 packages: TO-92 (Ammo Packing), SOT23 and SOT89.

## Features

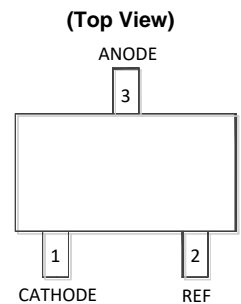
- Low Minimum Cathode Current for Regulation: 50µA (typ.), 100µA (max.)
- Programmable Precise Output Voltage from 2.5V/2.495V to 36V
- High Stability Under Capacitive Load
- Low Deviation of Reference Voltage Over Full Temperature Range: 11mV typical (-40°C to +125°C)
- Sink Current Capacity from 100µA to 100mA
- Low Dynamic Impedance: 0.1Ω (typ.)
- Wide Operating Temperature Range: -40°C to +125°C
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please [contact us](https://www.diodes.com/quality/product-definitions/) or your local Diodes representative.**  
<https://www.diodes.com/quality/product-definitions/>

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.  
 2. See <https://www.diodes.com/quality/lead-free/> 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.

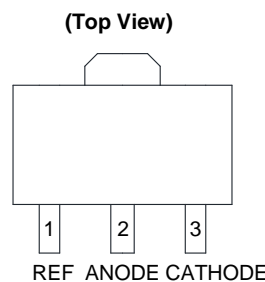
## Pin Assignments



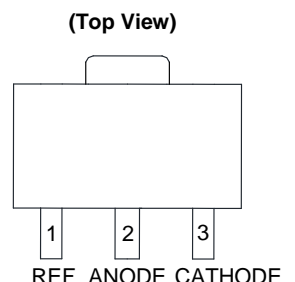
**SOT23 (Package Code: N)**



**SOT23 (Package Code: N1)**



**SOT89 (Option 1)**



**SOT89 (Option 2)**

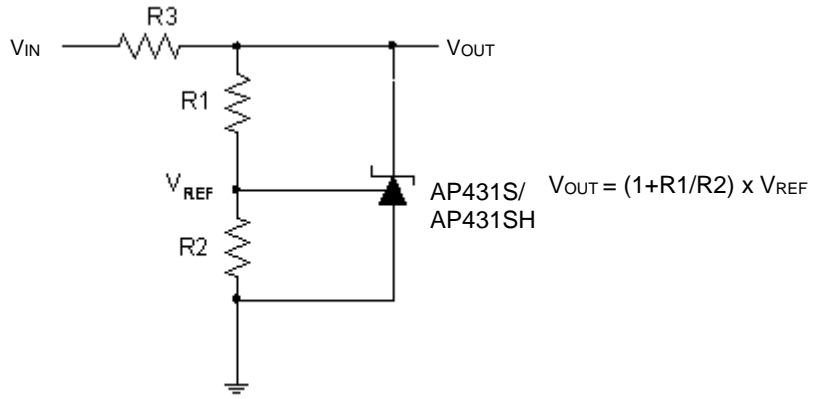


**TO-92 (Ammo Packing)**

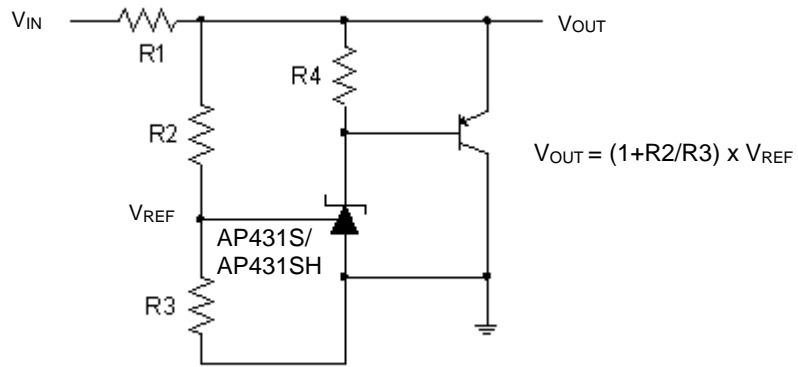
## Applications

- Chargers
- Voltage adapters
- Switching power supplies
- Graphic cards
- Precision voltage references

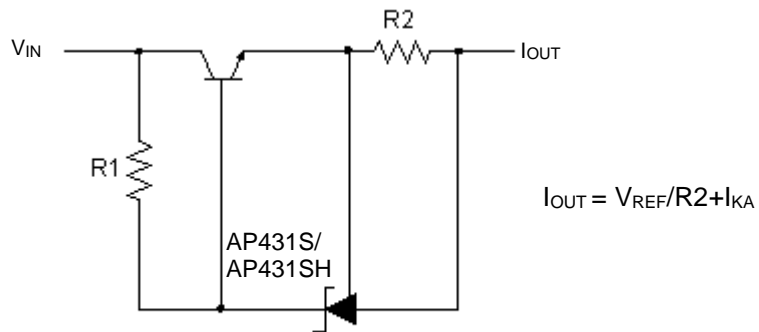
**Typical Applications Circuit**



Shunt Regulator

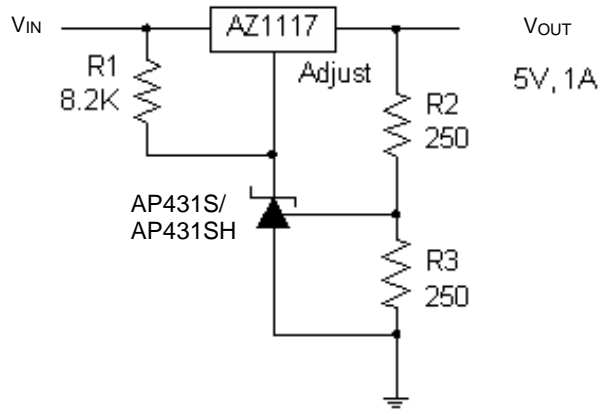


High Current Shunt Regulator

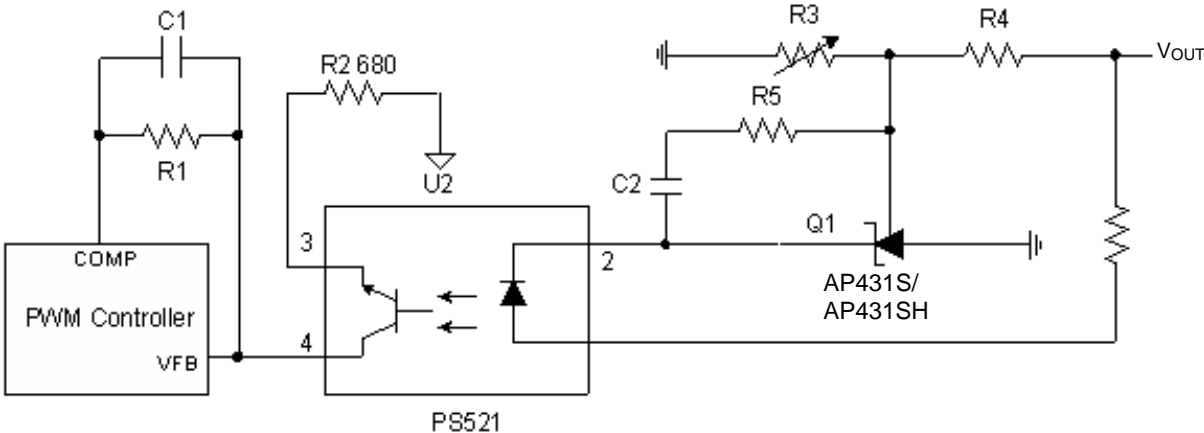


Current Source or Current Limit

**Typical Applications Circuit** (continued)

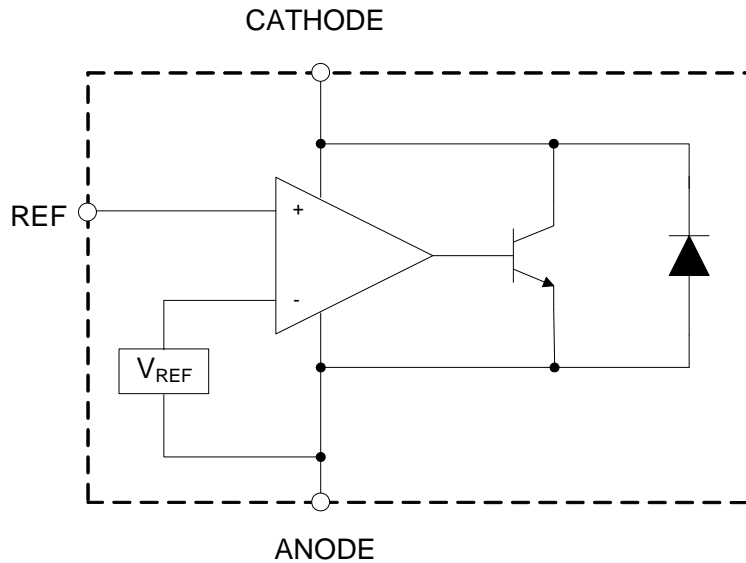


Precision 5V 1A Regulator



PWM Converter with Reference

**Functional Block Diagram**



**Absolute Maximum Ratings** (Note 4)

Symbol	Parameter	Rating		Unit
$V_{KA}$	Cathode Voltage	40		V
$I_{KA}$	Cathode Current Range (Continuous)	-100 to 150		mA
$I_{REF}$	Reference Input Current Range	10		mA
$P_D$	Power Dissipation	TO-92 (Ammo Packing)	750	mW
		SOT89	750	
		SOT23	350	
$T_J$	Junction Temperature	+150		°C
$T_{STG}$	Storage Temperature Range	-65 to +150		°C
ESD	ESD (Human Body Model)	5,500		V
ESD	ESD (Machine Model)	300		V

Note 4: Stresses greater than those listed under “Absolute Maximum Ratings” can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods can affect device reliability.

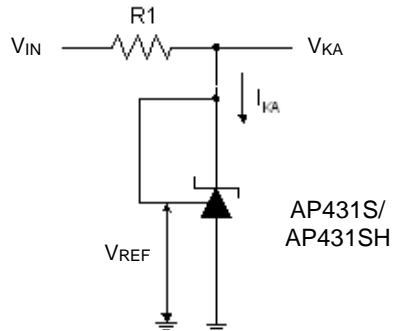
**Recommended Operating Conditions**

Symbol	Parameter	Min	Max	Unit
$V_{KA}$	Cathode Voltage	$V_{REF}$	36	V
$I_{KA}$	Cathode Current	0.1	100	mA
$T_A$	Operating Ambient Temperature Range	-40	+125	°C

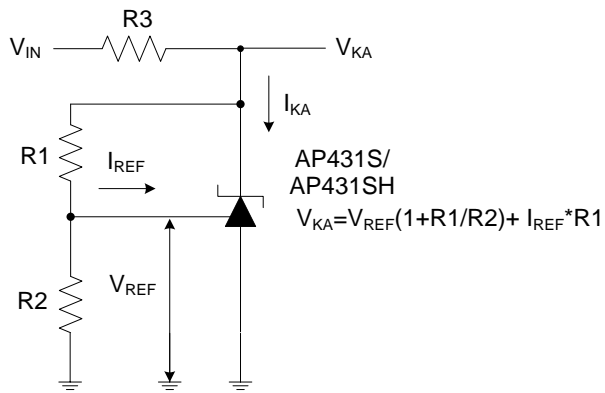
**Electrical Characteristics** ( $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Parameter		Test Circuit	Conditions	Min	Typ	Max	Unit	
$V_{REF}$	Reference Voltage	0.5%	4	$V_{KA} = V_{REF}, I_{KA} = 1\text{mA}$ (AP431SA)	2.487	2.500	2.512	V	
				$V_{KA} = V_{REF}, I_{KA} = 1\text{mA}$ (AP431SHA)	2.483	2.495	2.507		
		1.0%		$V_{KA} = V_{REF}, I_{KA} = 1\text{mA}$ (AP431SB)	2.475	2.500	2.525		
				$V_{KA} = V_{REF}, I_{KA} = 1\text{mA}$ (AP431SHB)	2.470	2.495	2.520		
$\Delta V_{REF}$	Deviation of Reference Voltage Over Full Temperature Range		4	$V_{KA} = V_{REF}$ $I_{KA} = 1\text{mA}$	0°C to +70°C	—	3	6	mV
					-40°C to +85°C	—	6	10	
					-40°C to +125°C	—	11	18	
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of Change in Reference Voltage to the Change in Cathode Voltage		5	$I_{KA} = 1\text{mA}$	$\Delta V_{KA} = 10\text{V}$ to $V_{REF}$	—	-1.0	-2.7	mV/V
					$\Delta V_{KA} = 36\text{V}$ to $10\text{V}$	—	-0.5	-2.0	
$I_{REF}$	Reference Current		5	$I_{KA} = 1\text{mA}, R_1 = 10\text{k}\Omega, R_2 = \infty$	—	0.2	0.5	$\mu\text{A}$	
$\Delta I_{REF}$	Deviation of Reference Current Over Full Temperature Range		5	$I_{KA} = 1\text{mA}, R_1 = 10\text{k}\Omega$ $R_2 = \infty, T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	—	0.1	0.3	$\mu\text{A}$	
$I_{KA}$ (Min)	Minimum Cathode Current for Regulation		4	$V_{KA} = V_{REF}$	—	50	100	$\mu\text{A}$	
$I_{KA}$ (Off)	Off-state Cathode Current		6	$V_{KA} = 36\text{V}, V_{REF} = 0$	—	0.05	1.0	$\mu\text{A}$	
$Z_{KA}$	Dynamic Impedance		4	$V_{KA} = V_{REF},$ $I_{KA} = 1\text{mA}$ to $100\text{mA}, f \leq 1.0\text{kHz}$	—	0.1	0.3	$\Omega$	
$\theta_{JC}$	Thermal Resistance		—	TO-92 (Ammo Packing)	—	80	—	$^\circ\text{C/W}$	
				SOT89	—	80	—		
				SOT23	—	140	—		

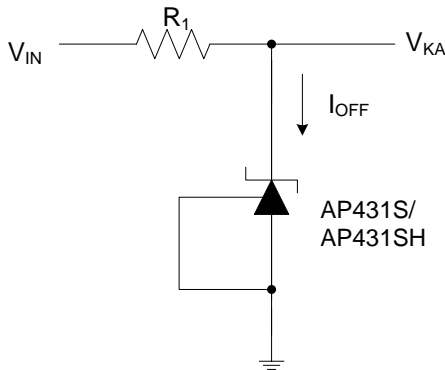
**Electrical Characteristics** (continued)



Test Circuit 4 for  $V_{KA} = V_{REF}$



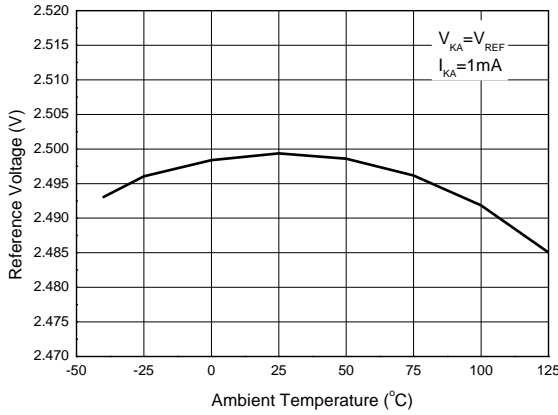
Test Circuit 5 for  $V_{KA} > V_{REF}$



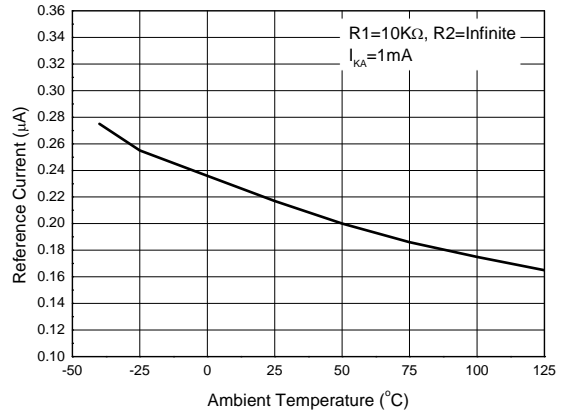
Test Circuit 6 for  $I_{OFF}$

**Performance Characteristics**

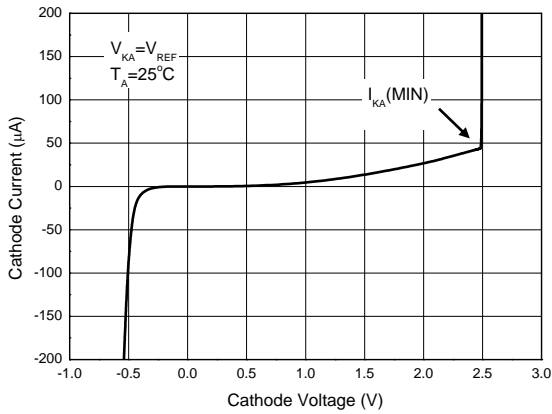
**Reference Voltage vs. Ambient Temperature**



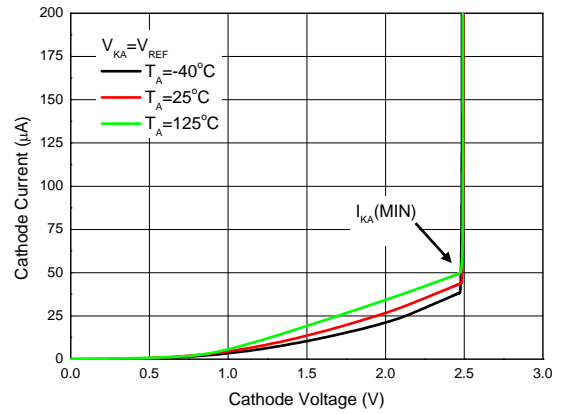
**Reference Current vs. Ambient Temperature**



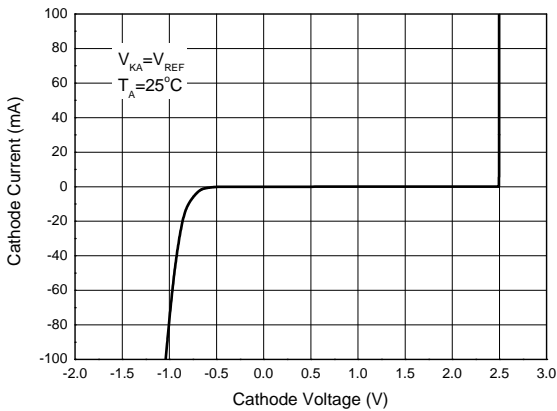
**Minimal Cathode Current for Regulation**



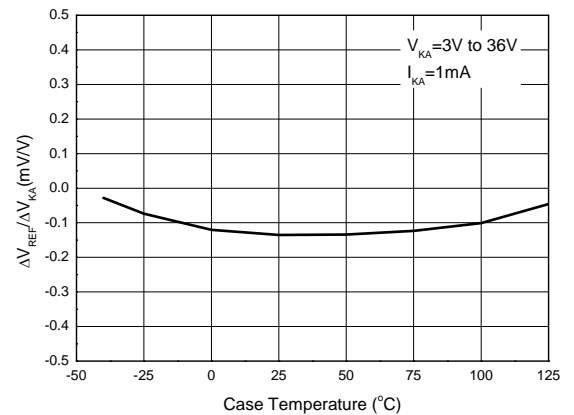
**Minimal Cathode Current for Regulation at Different Ambient Temperature**



**Cathode Current vs. Cathode Voltage**

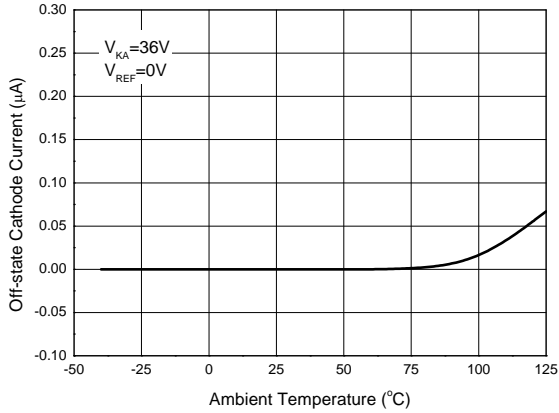


**Ratio of Delta Reference Voltage to Delta Cathode Voltage vs. Case Temperature**

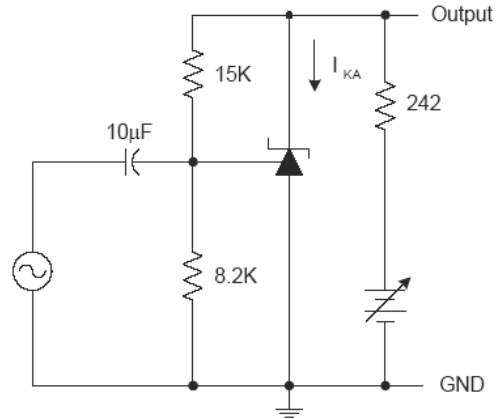
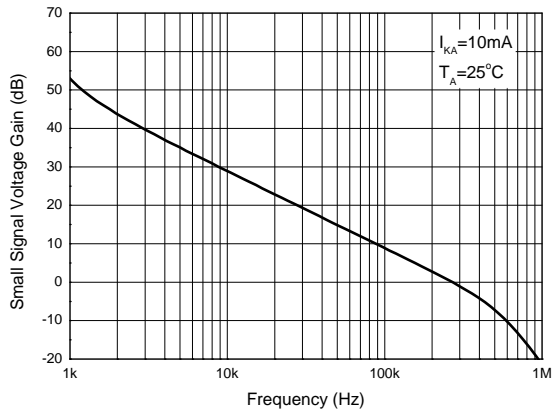


**Performance Characteristics** (continued)

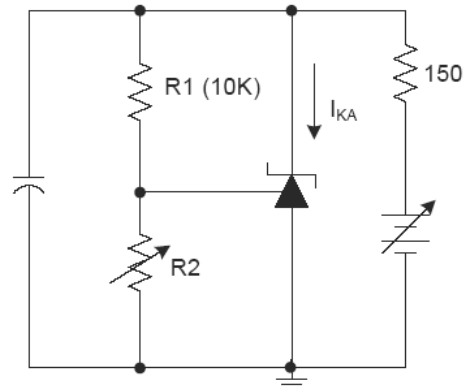
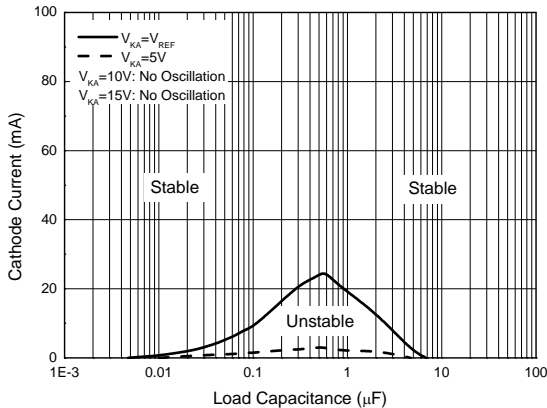
**Off-state Cathode Current vs. Ambient Temperature**



**Small Signal Voltage Gain vs. Frequency**



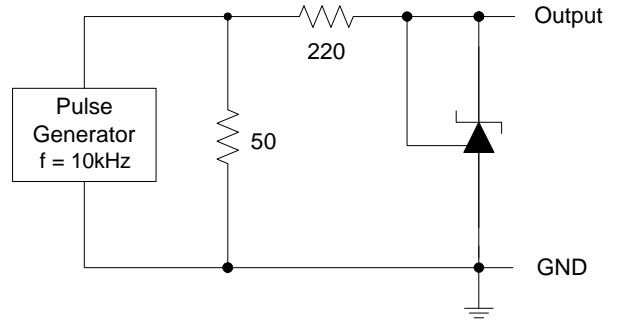
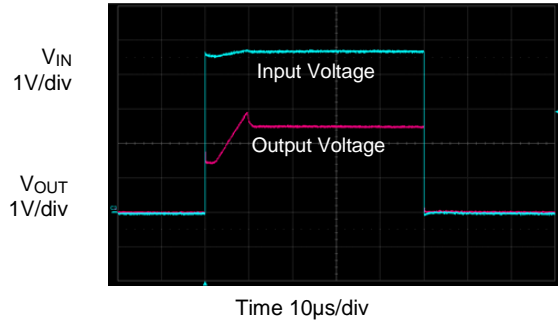
**Stability Boundary Conditions**



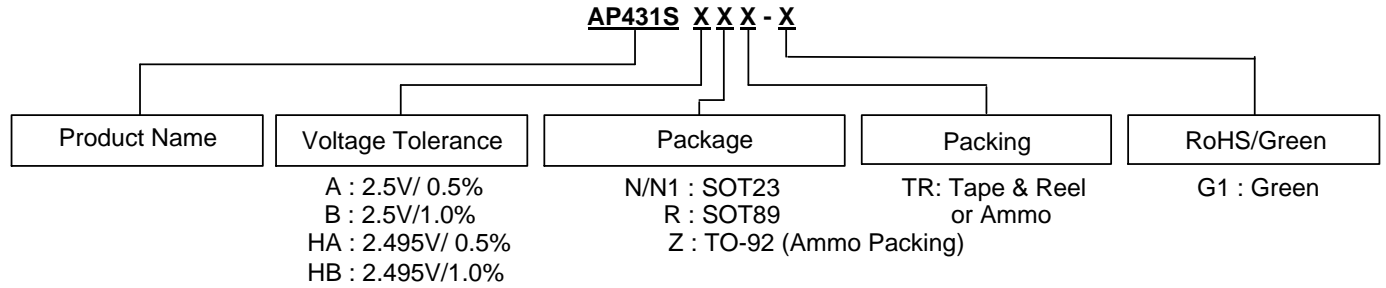


**Performance Characteristics** (continued)

**Pulse Response**



### Ordering Information

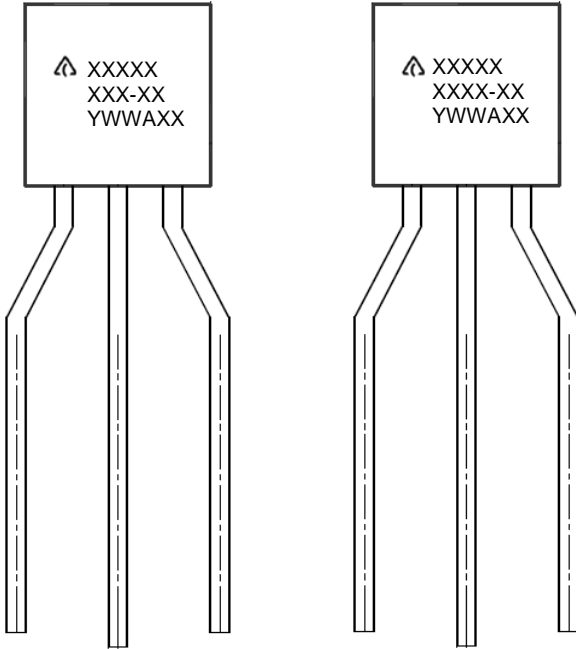


Part Number	Package	Package Code	Temperature Range	Voltage Tolerance	Marking ID	Packing	
						Qty.	Carrier
AP431SANTR-G1	SOT23	N	-40°C to +125°C	0.5%	GCA	3,000	Tape & Reel
AP431SAN1TR-G1		N1		0.5%	GCC		
AP431SHANTR-G1		N		0.5%	GCD		
AP431SHAN1TR-G1		N1		0.5%	GCE		
AP431SBNTR-G1		N		1.0%	GCB		
AP431SBN1TR-G1		N1		1.0%	GCF		
AP431SHBTR-G1		N		1.0%	GCG		
AP431SHBN1TR-G1		N1		1.0%	GCH		
AP431SARTR-G1	SOT89	R	-40°C to +125°C	0.5%	G33M	1,000	Tape & Reel
AP431SHARTR-G1		R		0.5%	G37M		
AP431SBRTR-G1		R		1.0%	G33R		
AP431SHBRTR-G1		R		1.0%	G33S		
AP431SAZTR-G1	TO-92 (Ammo Packing)	Z	-40°C to +125°C	0.5%	AP431SAZ-G1	2,000	Ammo
AP431SHAZTR-G1		Z		0.5%	AP431SHAZ-G1		
AP431SBZTR-G1		Z		1.0%	AP431SBZ-G1		
AP431SHBZTR-G1		Z		1.0%	AP431SHBZ-G1		

**Marking Information**

(1) TO-92 (Ammo Packing)

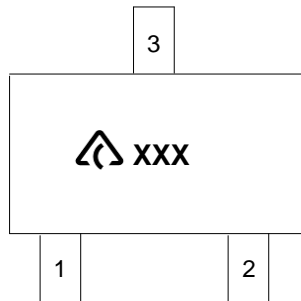
(Front View)




First and Second Lines: Logo and Marking ID  
(See Ordering Information)  
Third Line: Date Code  
Y: Year  
WW: Work Week of Molding  
A: Assembly House Code  
XX: Internal Code

(2) SOT23

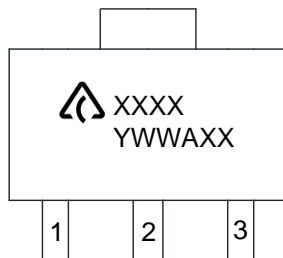
(Top View)



 : Logo  
XXX: Marking ID (See Ordering Information)

(3) SOT89

(Top View)

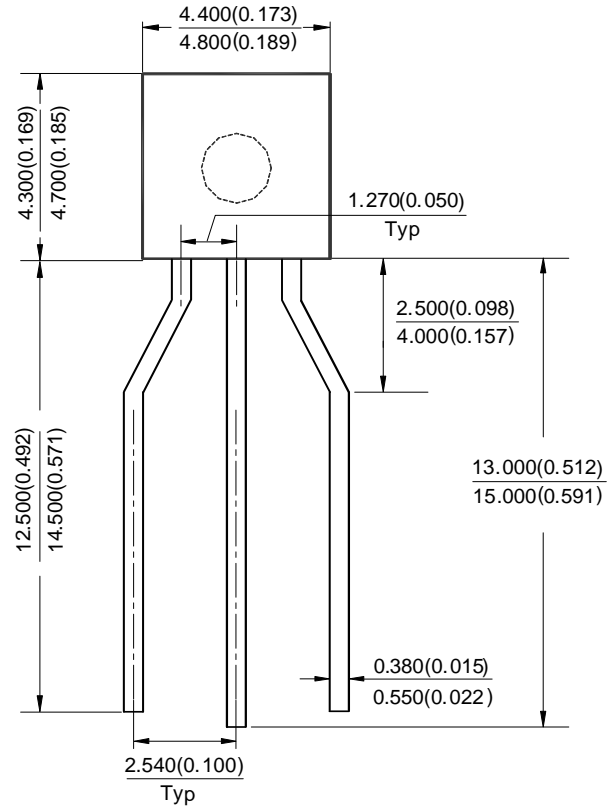
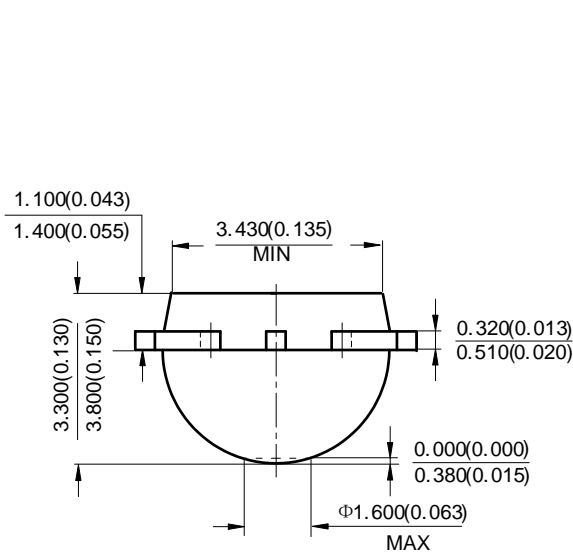


First Line: Logo and Marking ID  
(See Ordering Information)  
Second Line: Date Code  
Y: Year  
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XX: Internal Code

**Package Outline Dimensions** (All dimensions in mm (inch).)

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

(1) Package Type: TO-92 (Ammo Packing)

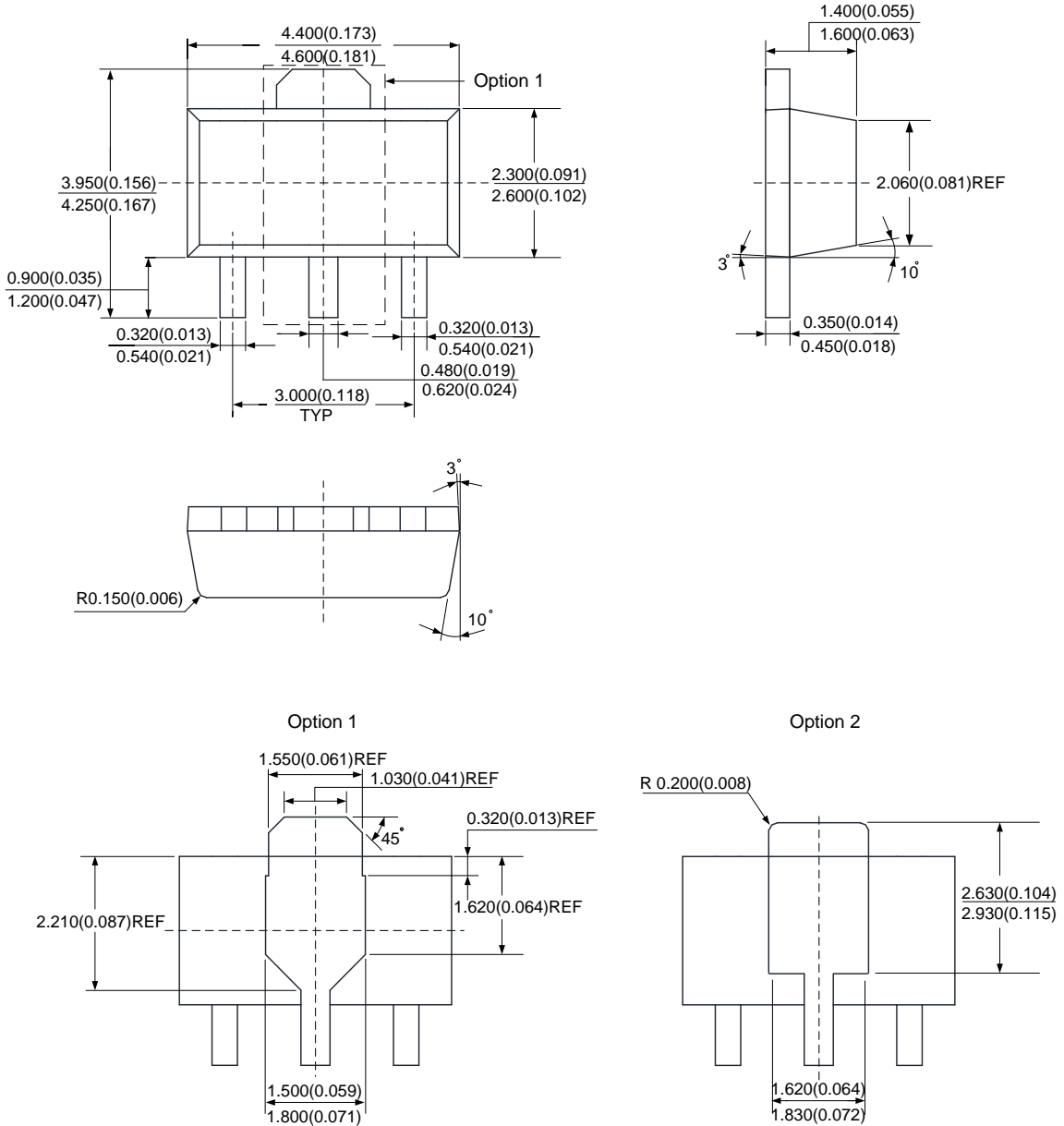




**Package Outline Dimensions** (continued) (All dimensions in mm (inch).)

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

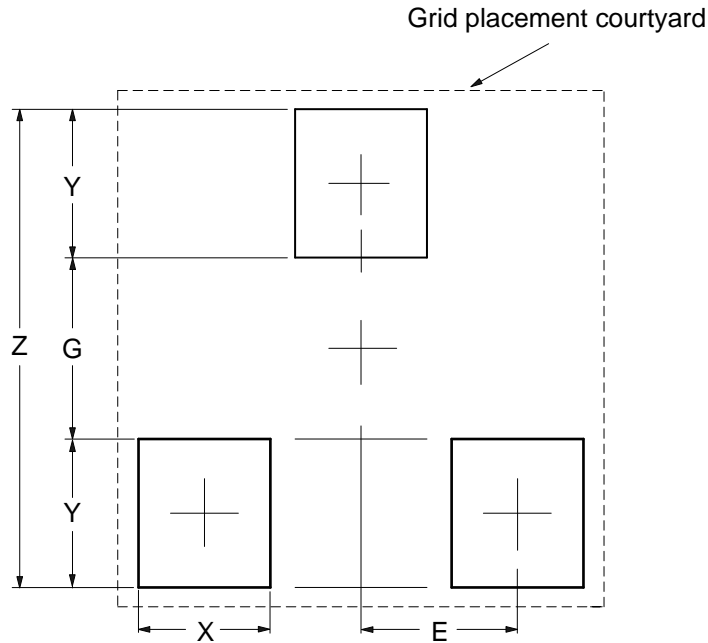
**(3) Package Type: SOT89**



**Suggested Pad Layout**

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

(1) Package Type: SOT23

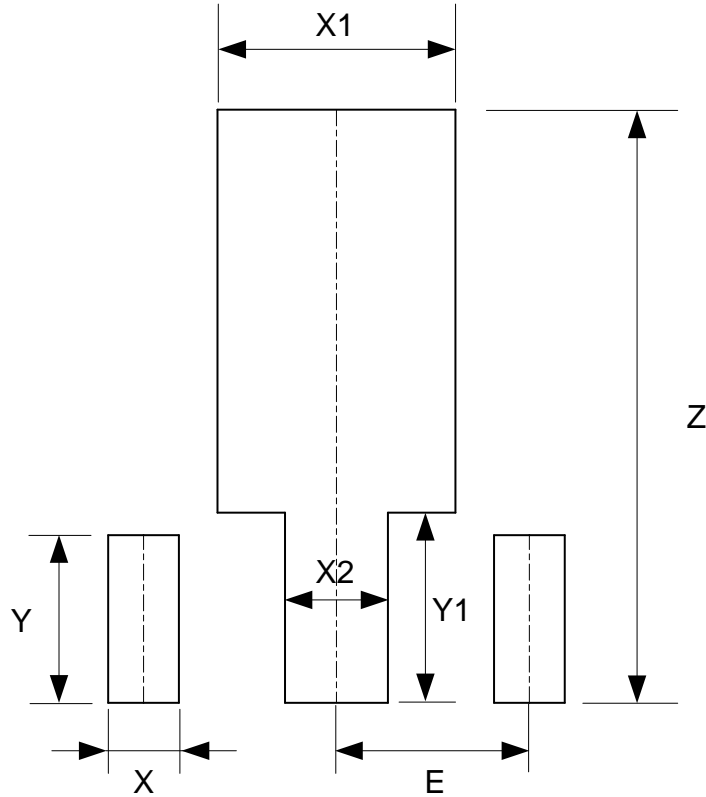


Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)
Value	2.900/0.114	1.100/0.043	0.800/0.031	0.900/0.035	0.950/0.037

**Suggested Pad Layout** (continued)

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

(2) Package Type: SOT89



Dimensions	Z (mm)/(inch)	X (mm)/(inch)	X1 (mm)/(inch)	X2 (mm)/(inch)	Y (mm)/(inch)	Y1 (mm)/(inch)	E (mm)/(inch)
Value	4.600/0.181	0.550/0.022	1.850/0.073	0.800/0.031	1.300/0.051	1.475/0.058	1.500/0.059

**Mechanical Data**

- Moisture Sensitivity: SOT23 Level 3 per J-STD-020  
SOT89 Level 3 per J-STD-020
- Terminals: Finish — Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208<sup>Ⓔ</sup>
- Weight: SOT23: 0.009 grams (Approximate)  
SOT89: 0.0561 grams (Approximate)  
TO-92 ( Ammo Packing): 0.157 grams (Approximate)



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