

## Description

The AP431S 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 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 50 $\mu$ A makes the parts ideal for very low power dissipation applications.

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

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

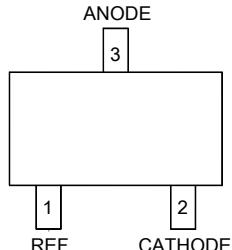
This IC is available in 3 packages: TO92 (ammo packing), SOT23 and SOT89.

## Features

- Low Minimum Cathode Current for Regulation: 50 $\mu$ A (Typ.), 100 $\mu$ A (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 100 $\mu$ A to 100mA
- Low Dynamic Impedance: 0.1 $\Omega$  (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)**

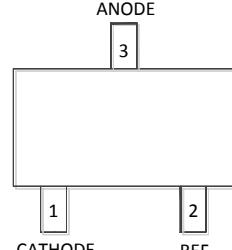
## Pin Assignments

(Top View)



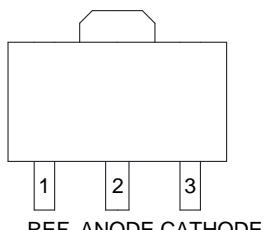
SOT23 (Package Code: N)

(Top View)



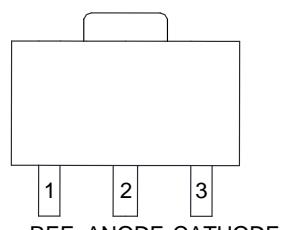
SOT23 (Package Code: N1)

(Top View)



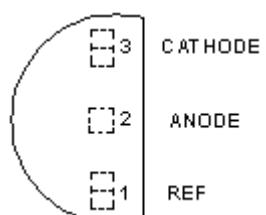
SOT89 (Option 1)

(Top View)



SOT89 (Option 2)

(Top View)



TO92 (Ammo Packing)

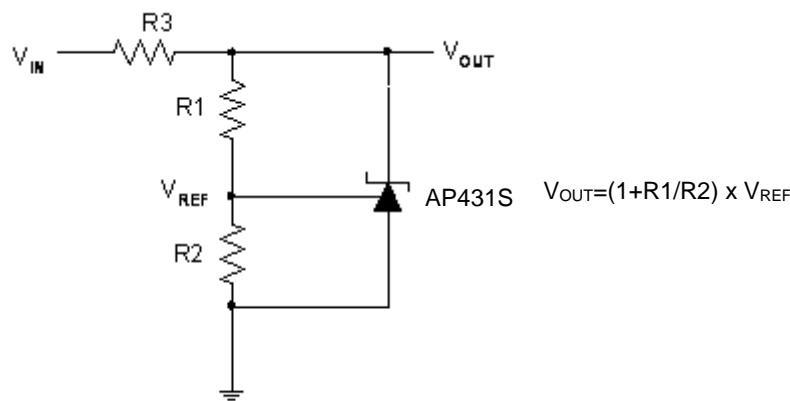
## Applications

- Charger
- Voltage Adapter
- Switching Power Supply
- Graphic Card
- Precision Voltage Reference

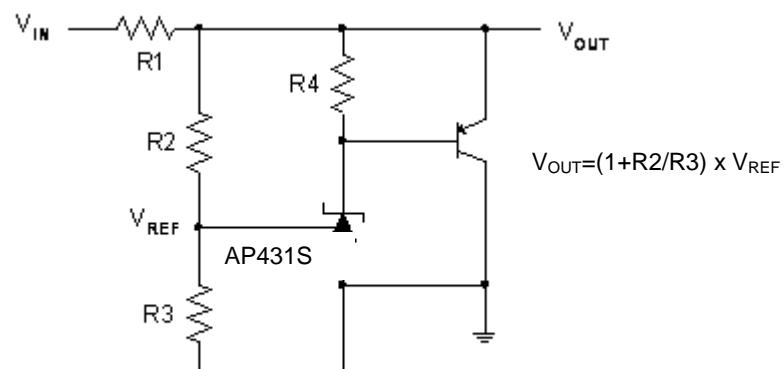
Notes:

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.

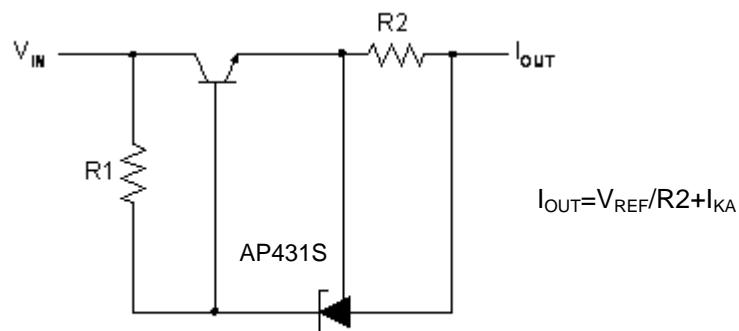
## Typical Applications Circuit



Shunt Regulator

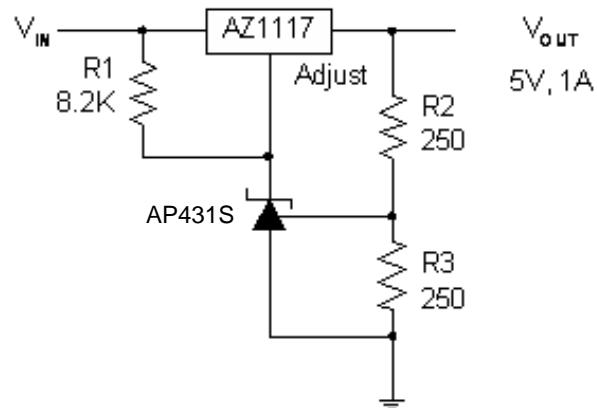


High Current Shunt Regulator

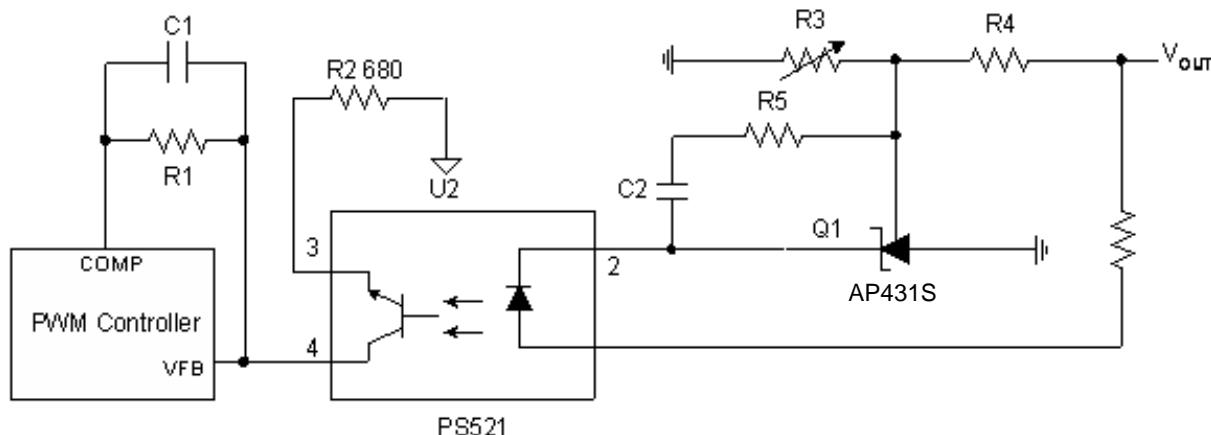


Current Source or Current Limit

Typical Applications Circuit (Cont.)

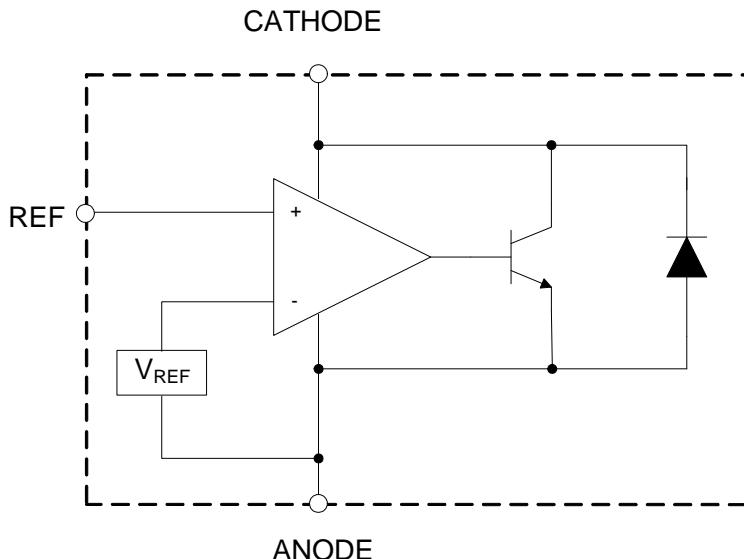


Precision 5V 1A Regulator



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	TO92	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" may 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 may affect device reliability.

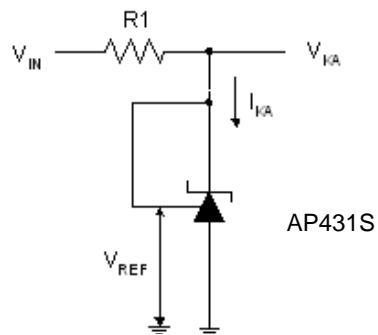
## Recommended Operating Conditions

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

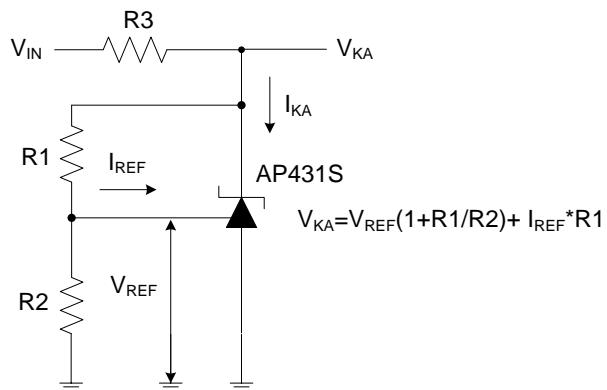
**Electrical Characteristics** ( $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Parameter		Test Circuit	Conditions		Min	Typ	Max	Unit		
$V_{\text{REF}}$	Reference Voltage	0.5%	4	$V_{\text{KA}} = V_{\text{REF}}, I_{\text{KA}} = 1\text{mA}$ (AP431SA)		2.487	2.500	2.512	V		
		1.0%		$V_{\text{KA}} = V_{\text{REF}}, I_{\text{KA}} = 1\text{mA}$ (AP431SHA)		2.483	2.495	2.507			
		$V_{\text{KA}} = V_{\text{REF}}, I_{\text{KA}} = 1\text{mA}$ (AP431SB)		2.475		2.500	2.525	2.525			
		$V_{\text{KA}} = V_{\text{REF}}, I_{\text{KA}} = 1\text{mA}$ (AP431SHB)		2.470		2.495	2.520	2.520			
$\Delta V_{\text{REF}}$	Deviation of Reference Voltage Over Full Temperature Range		4	$V_{\text{KA}} = V_{\text{REF}}$ $I_{\text{KA}} = 1\text{mA}$	0 to $+70^\circ\text{C}$	—	3	6	mV		
					-40 to $+85^\circ\text{C}$	—	6	10			
					-40 to $+125^\circ\text{C}$	—	11	18			
$\frac{\Delta V_{\text{REF}}}{\Delta V_{\text{KA}}}$	Ratio of Change in Reference Voltage to the Change in Cathode Voltage		5	$I_{\text{KA}} = 1\text{mA}$	$\Delta V_{\text{KA}} = 10\text{V}$ to $V_{\text{REF}}$	—	-1.0	-2.7	mV/V		
					$\Delta V_{\text{KA}} = 36\text{V}$ to 10V	—	-0.5	-2.0			
$I_{\text{REF}}$	Reference Current		5	$I_{\text{KA}} = 1\text{mA}, R1 = 10\text{k}\Omega, R2 = \infty$		—	0.2	0.5	$\mu\text{A}$		
$\Delta I_{\text{REF}}$	Deviation of Reference Current Over Full Temperature Range		5	$I_{\text{KA}} = 1\text{mA}, R1 = 10\text{k}\Omega$ $R2 = \infty, T_A = -40$ to $+125^\circ\text{C}$		—	0.1	0.3	$\mu\text{A}$		
$I_{\text{KA}}$ (Min)	Minimum Cathode Current for Regulation		4	$V_{\text{KA}} = V_{\text{REF}}$		—	50	100	$\mu\text{A}$		
$I_{\text{KA}}$ (Off)	Off-state Cathode Current		6	$V_{\text{KA}} = 36\text{V}, V_{\text{REF}} = 0$		—	0.05	1.0	$\mu\text{A}$		
$Z_{\text{KA}}$	Dynamic Impedance		4	$V_{\text{KA}} = V_{\text{REF}},$ $I_{\text{KA}} = 1$ to $100\text{mA}, f \leq 1.0\text{kHz}$		—	0.1	0.3	$\Omega$		
$\theta_{\text{JC}}$	Thermal Resistance		—	TO92		—	80	—	$^\circ\text{C/W}$		
				SOT89		—	80	—			
				SOT23		—	140	—			

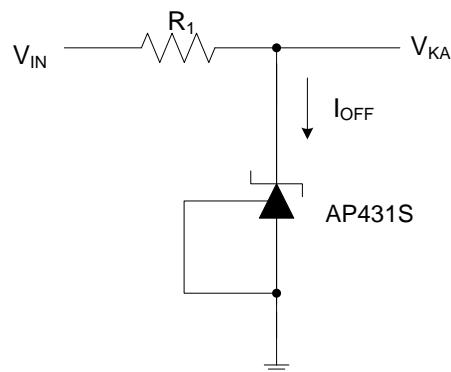
**Electrical Characteristics (Cont.)**



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



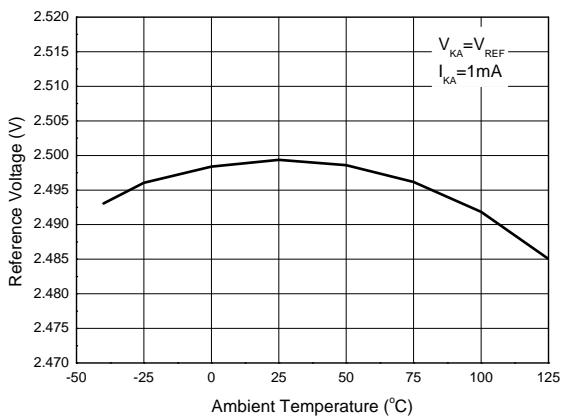
Test Circuit 5 for  $V_{KA} > V_{REF}$



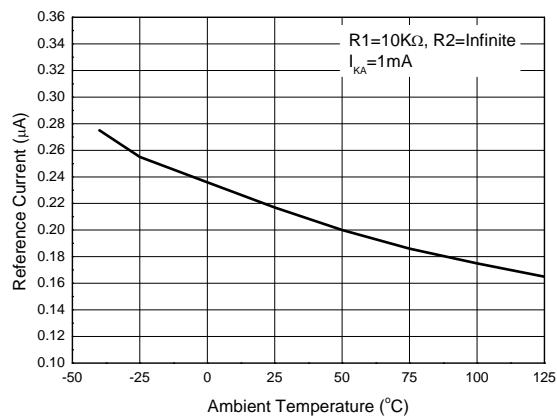
Test Circuit 6 for  $I_{OFF}$

## Performance Characteristics

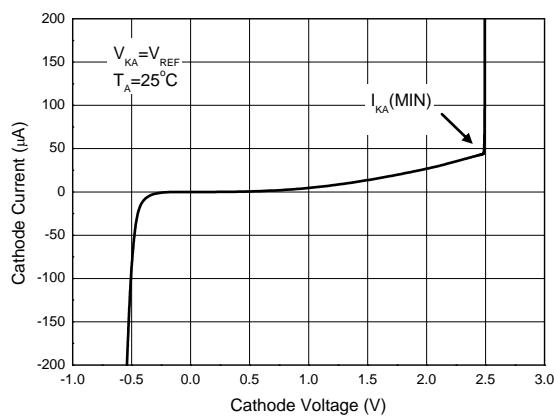
### Reference Voltage vs. Ambient Temperature



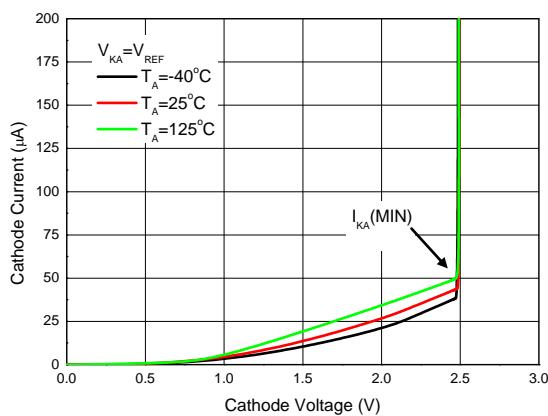
### Reference Current vs. Ambient Temperature



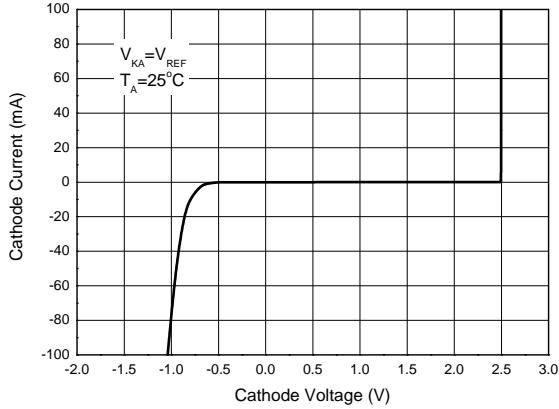
### Minimal Cathode Current for Regulation



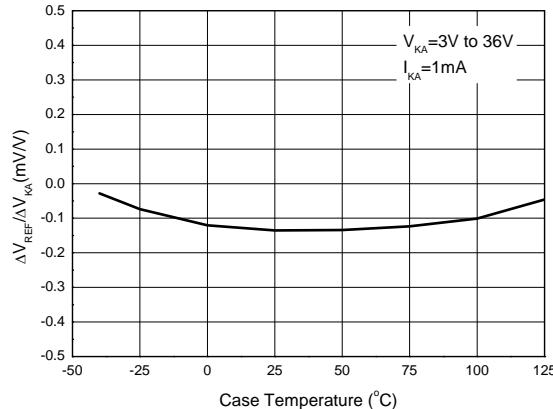
### Minimal Cathode Current for Regulation at Different Ambient Temperature



### Cathode Current vs. Cathode Voltage

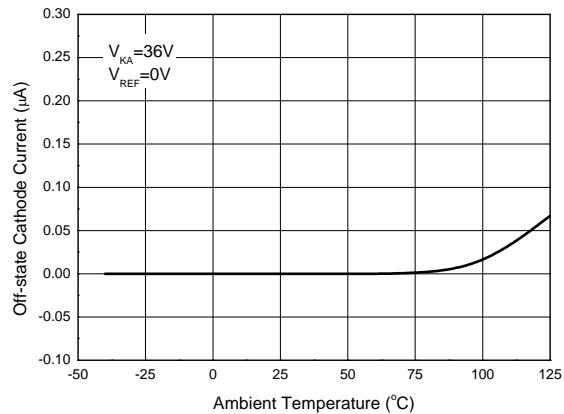


### Ratio of Delta Reference Voltage to Delta Cathode Voltage vs. Case Temperature

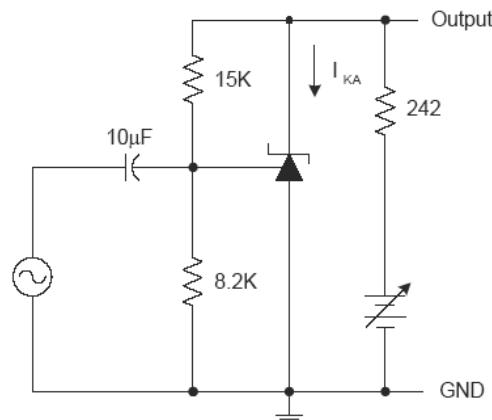
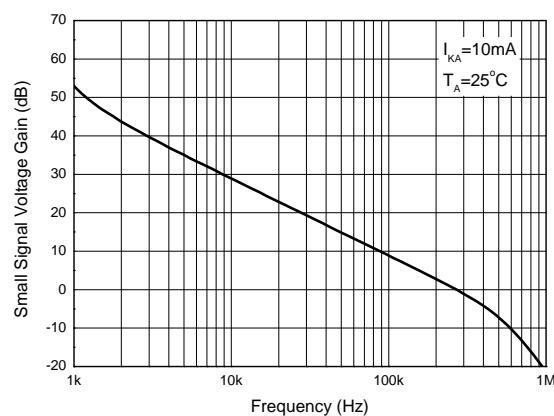


## Performance Characteristics (Cont.)

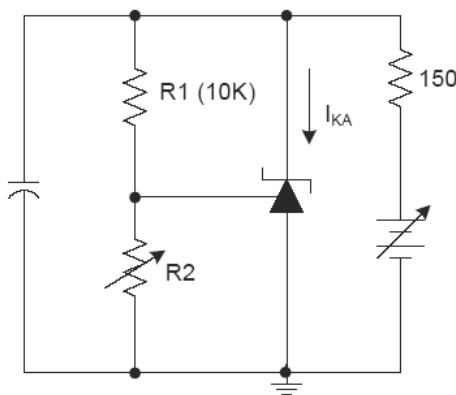
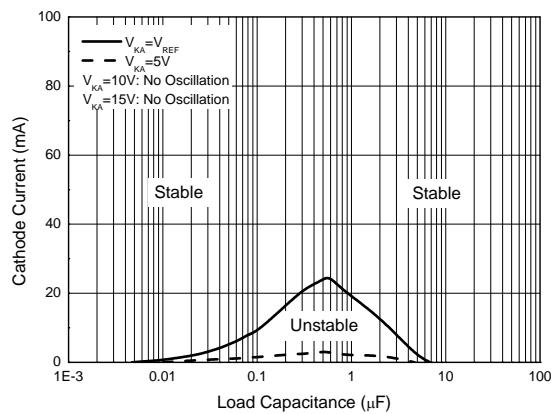
### Off-state Cathode Current vs. Ambient Temperature

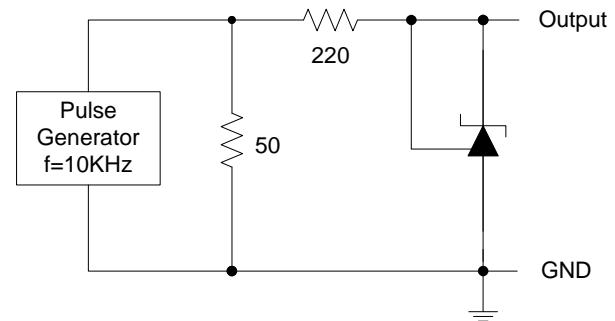
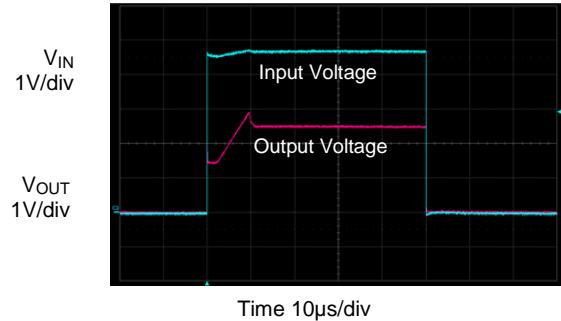


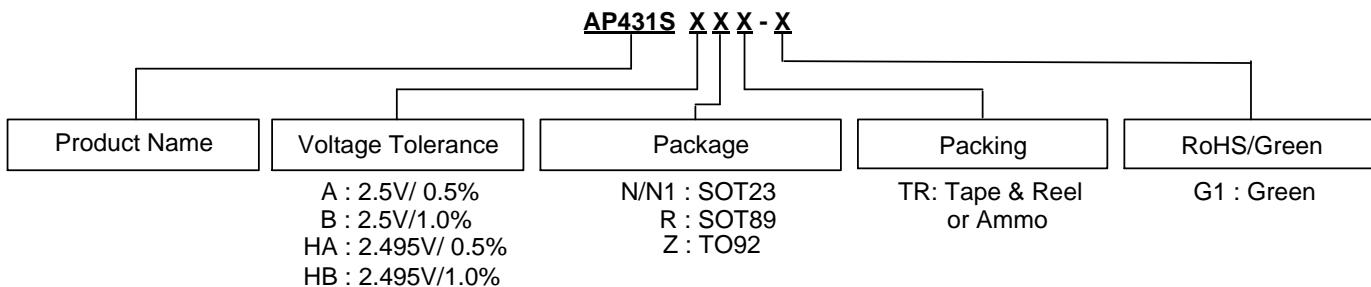
### Small Signal Voltage Gain vs. Frequency



### Stability Boundary Conditions



**Performance Characteristics (Cont.)****Pulse Response**

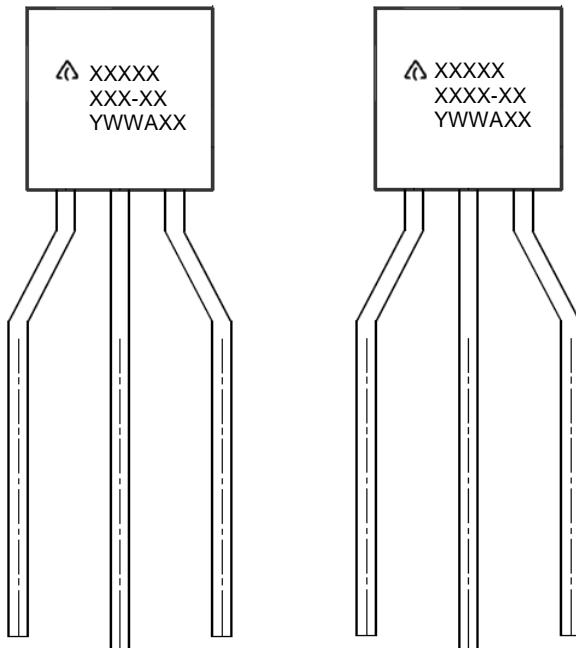
**Ordering Information**


Package	Package Code	Temperature Range	Voltage Tolerance	Part Number	Marking ID	Packing
SOT23	N	-40 to +125°C	0.5%	AP431SANTR-G1	GCA	3,000/Tape & Reel
	N1		0.5%	AP431SAN1TR-G1	GCC	
	N		0.5%	AP431SHANTR-G1	GCD	
	N1		0.5%	AP431SHAN1TR-G1	GCE	
	N		1.0%	AP431SBNTR-G1	GCB	
	N1		1.0%	AP431SBN1TR-G1	GCF	
	N		1.0%	AP431SHBNTR-G1	GCG	
	N1		1.0%	AP431SHBN1TR-G1	GCH	
	R		0.5%	AP431SARTR-G1	G33M	1,000/Tape & Reel
SOT89	R	-40 to +125°C	0.5%	AP431SHARTR-G1	G37M	
	R		1.0%	AP431SBRTR-G1	G33R	
	R		1.0%	AP431SHBRTR-G1	G33S	
	Z	-40 to +125°C	0.5%	AP431SAZTR-G1	AP431SAZ-G1	2,000/Ammo
TO92	Z		0.5%	AP431SHAZTR-G1	AP431SHAZ-G1	
	Z		1.0%	AP431SBZTR-G1	AP431SBZ-G1	
	Z		1.0%	AP431SHBZTR-G1	AP431SHBZ-G1	

## Marking Information

### (1) TO92 (Ammo Packing)

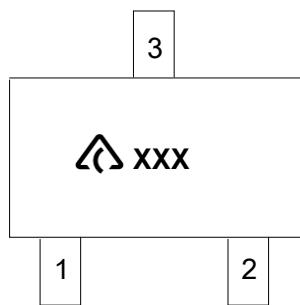
(Front View)



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

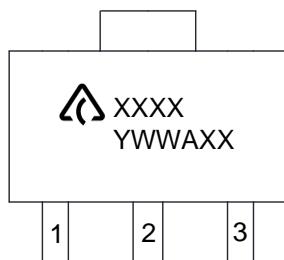
(Top View)



Logo : Logo  
XXX: Marking ID (See Ordering Information)

### (3) SOT89

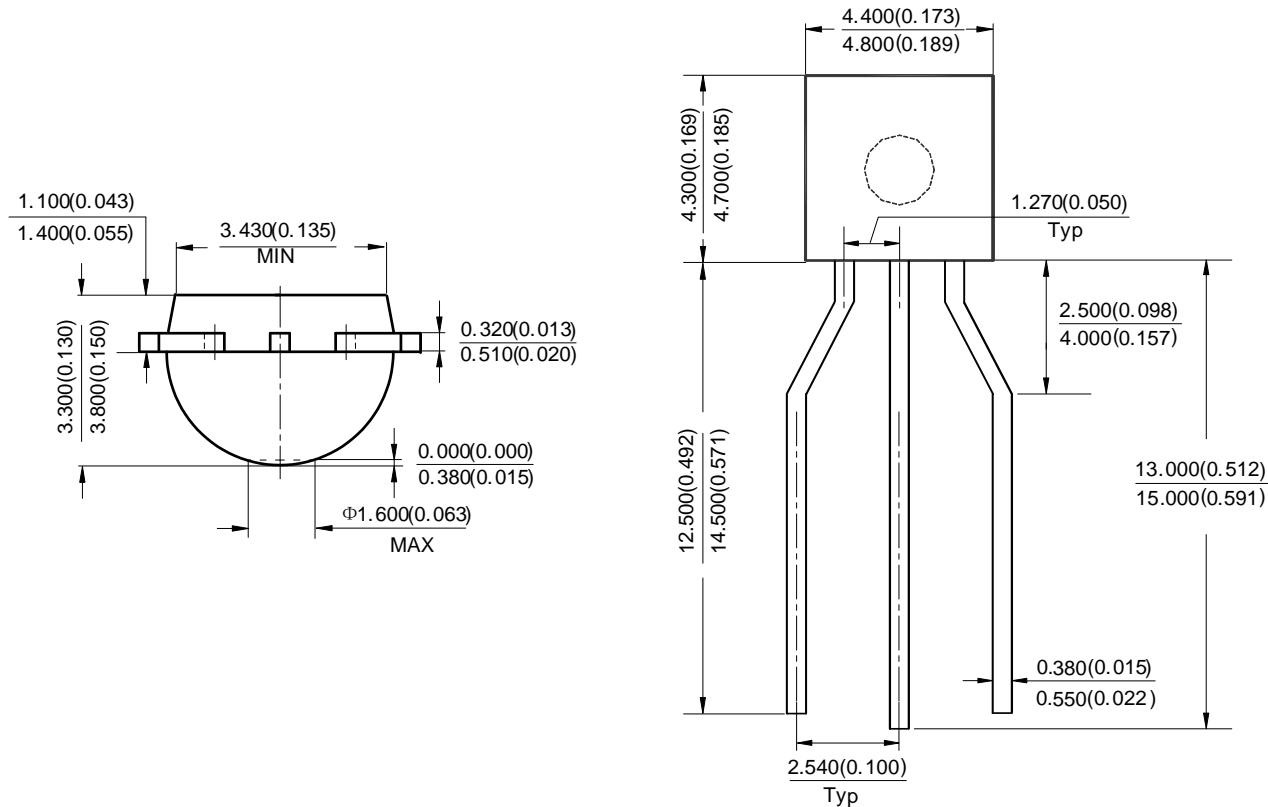
(Top View)



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

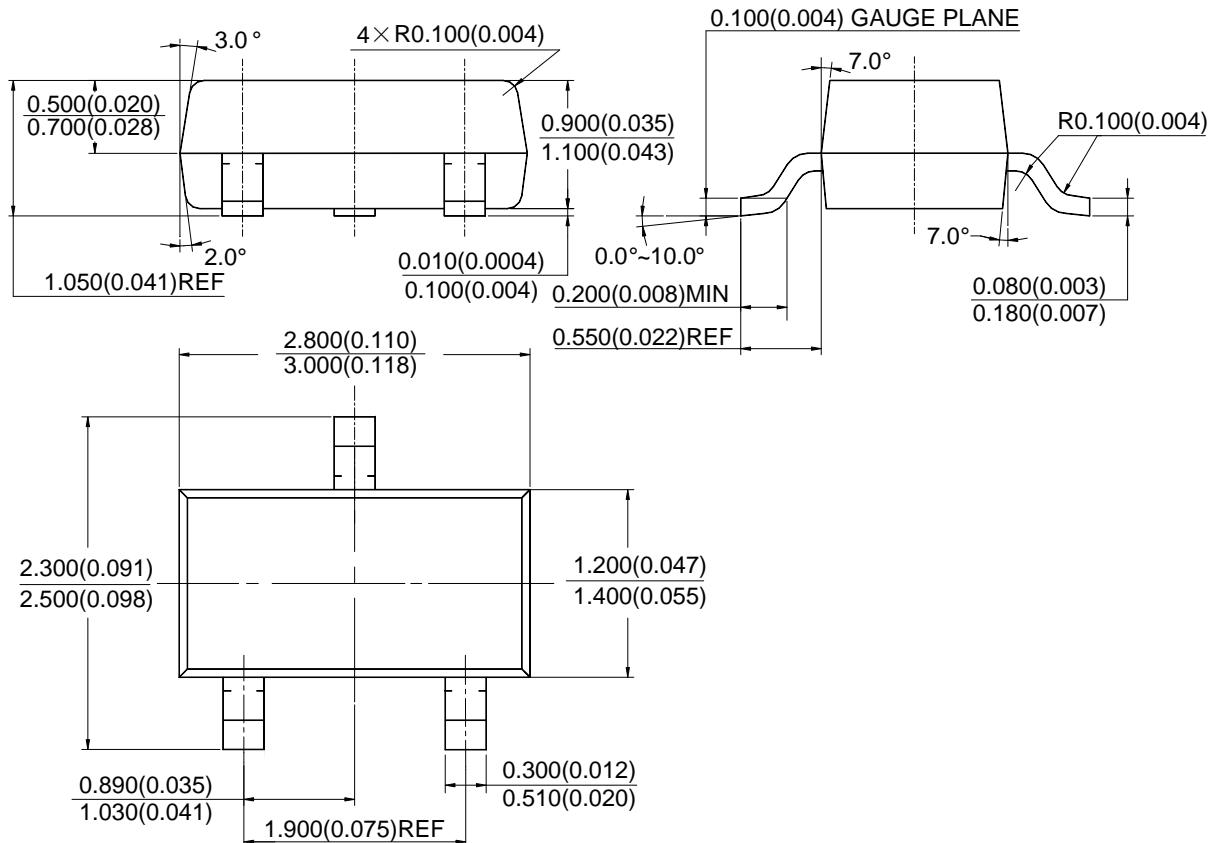
**Package Outline Dimensions** (All dimensions in mm (inch).)

**(1) Package Type: TO92 (Ammo Packing)**



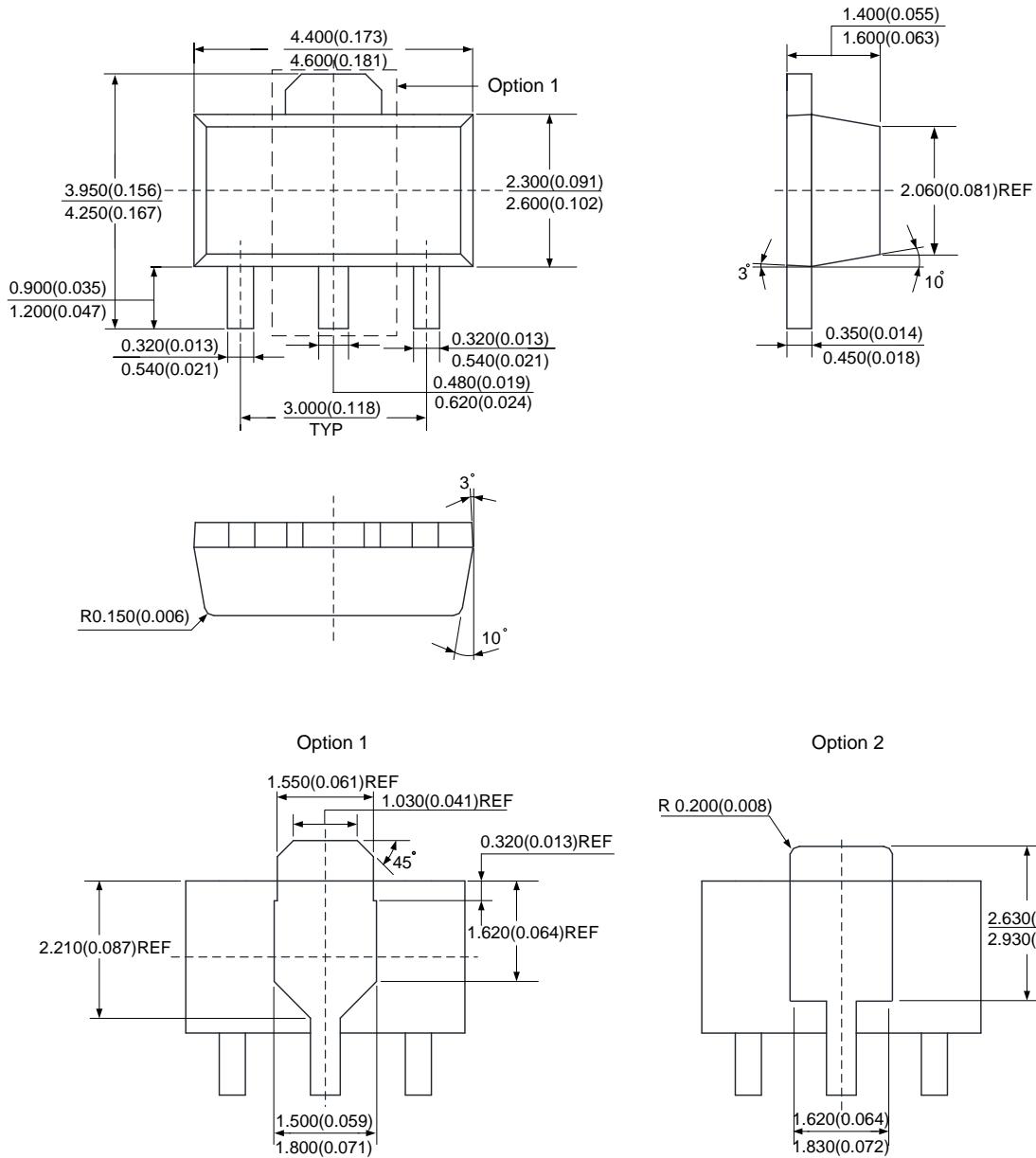
## Package Outline Dimensions (Cont.) ( All dimensions in mm(inch))

**(2) Package Type: SOT23**



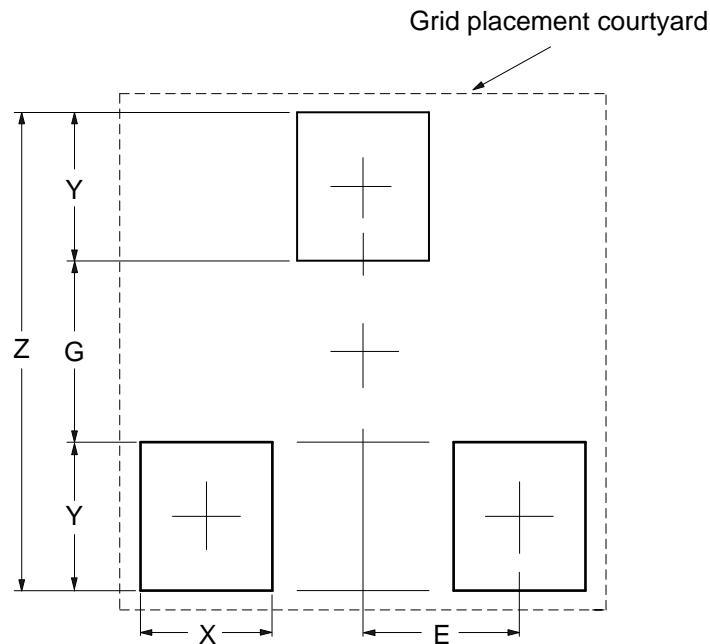
**Package Outline Dimensions (Cont.) (All dimensions in mm(inch).)**

**(3) Package Type: SOT89**



## Suggested Pad Layout

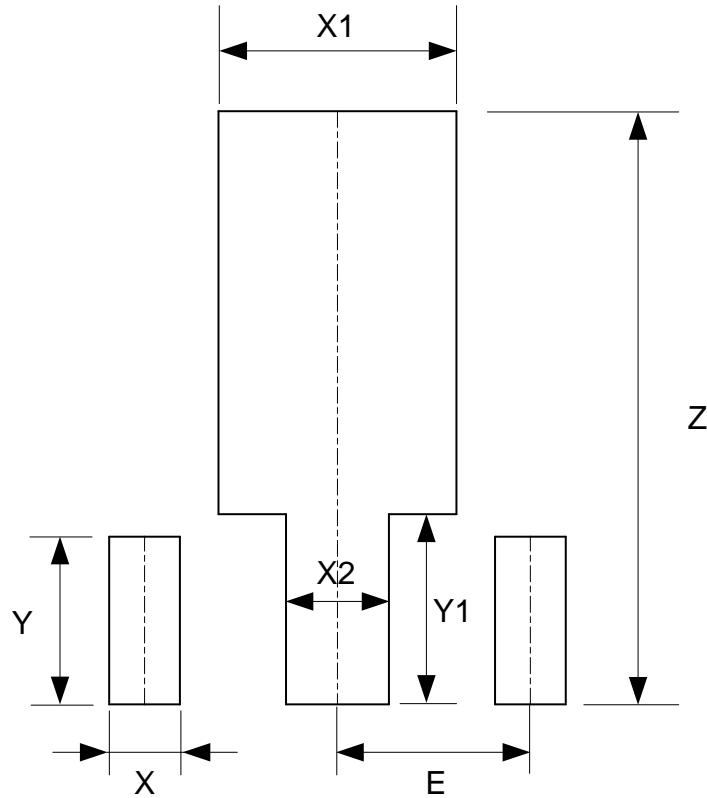
(1) Package Type: SOT23



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 (Cont.)**

(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

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