ADJUSTABLE PRECISION SHUNT REGULATOR

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 0.2Ω. Active output circuitry provides very sharp turn-on characteristics, making these devices excellent improved replacements for Zener diodes in many applications.

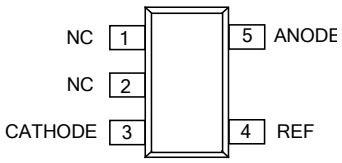
The precise (+/-) 1% reference voltage tolerance of the AP431/AP431A make it possible in many applications to avoid the use of a variable resistor, consequently saving cost and eliminating drift and reliability problems associated with it.

Features

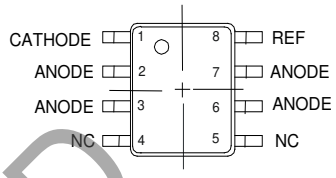
- Precision Reference Voltage
- AP431: 2.495V ± 1%
- AP431A: 2.495V ± 0.5%
- Sink Current Capability: 200mA
- Minimum Cathode Current for Regulation: 300µA
- Equivalent Full-Range Temp Coefficient: 30ppm/°C
- Fast Turn-On Response
- Low Dynamic Output Impedance: 0.2Ω
- Programmable Output Voltage to 36V
- Low Output Noise
- Lead Free Packages: SOT25, SC59, SC59R, SOT89 and SO-8
  - **Totally Lead-Free; RoHS Compliant (Notes 1 & 2)**
- SOT23, SOT23R, SOT25, SC59, SC59R, SO-8, SOT89: Available in "Green" Molding Compound (No Br, Sb). See "Ordering Information"
  - **Halogen and Antimony Free. "Green" Device (Note 3)**

Pin Assignments

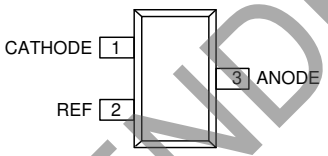
(1) SOT25
(Top View)



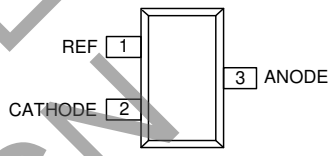
(2) SO-8
(Top View)



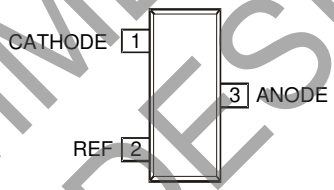
(3) SC59
(Top View)



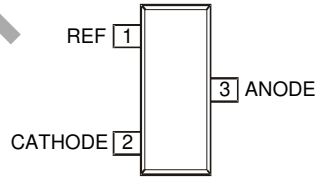
(4) SC59R
(Top View)



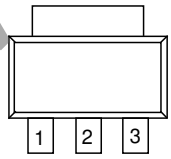
(5) SOT23
(Top View)



(6) SOT23R
(Top View)



(7) SOT89
(Top View)



NOT RECOMMENDED FOR NEW DESIGN

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 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.

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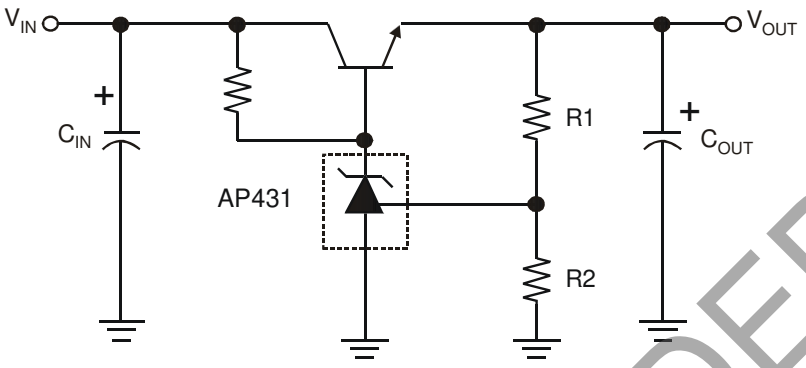
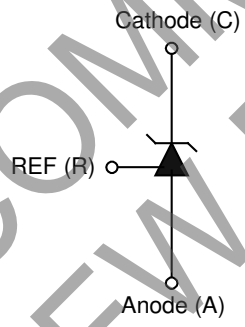
Typical Applications Circuit



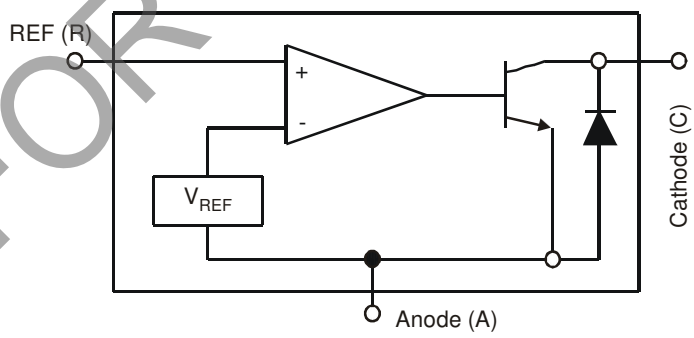
$V_{OUT} = (1 + R1/ R2)\ V_{REF}$

Precision Regulator

Symbol



Functional Block Diagram



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Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Parameter		Rating	Unit
Cathode Voltage		+36	V
Continuous Cathode Current		-10 to +250	mA
Reference Input Current		10	mA
Operating Temperature		-20 to +85	°C
Storage Temperature		-65 to +150	°C
Power Dissipation (Notes 4, 5)	SOT23(R)	400	mW
	SOT25	550	mW
	SC59(R)	400	mW
	SO-8	600	mW
	SOT89	800	mW

Notes: 4. T_J, max = +150°C.
5. Ratings apply to ambient temperature at +25°C.

Electrical Characteristics (@T_A = +25°C, V_{DD} = 3V; unless otherwise specified.)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{REF}	Reference voltage	$V_{KA} = V_{REF}$, I_{KA} = 10mA (Figure 1)	AP431 AP431A	2.470 2.482	2.495	2.520 2.507	V
V_{DEV}	Deviation of reference input voltage over temperature (Note 5)	$V_{KA} = V_{REF}$, I_{KA} = 10mA T_A = Full Range (Figure 1)		—	8.0	20.0	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of the change in reference voltage to the change in cathode voltage	I_{KA} = 10mA (Figure 2)	$V_{KA} = V_{REF}$ to 10V	—	-1.4	-2.0	mV/V
			V_{KA} = 10V to 36V	—	-1	-2	mV/V
I_{REF}	Refernce input current	R1 = 10KΩ, R2 = ∞ I_{KA} = 10mA (Figure 2)		—	1.4	3.5	µA
αI_{REF}	Deviation of reference input current over temperature	R1 = 10KΩ, R2 = ∞ I_{KA} = 10mA T_A = Full range (Figure 2)		—	0.4	1.2	µA
$I_{KA(MIN)}$	Minimum cathode current for regulation	$V_{KA} = V_{REF}$ (Figure 1)		—	0.19	0.50	mA
$I_{KA(OFF)}$	Off-state current	V_{KA} = 36V, V_{REF} = 0V (Figure 3)		—	0.1	1.0	µA
$\|Z_{KA}\|$	Dynamic output impedance (Note 7)	$V_{KA} = V_{REF}$ $V_{KA} = V_{REF}$ ΔI_{KA} = 0.1mA to 15mA Frequency ≤ 1KHz (Figure 1)		—	0.2	0.5	Ω

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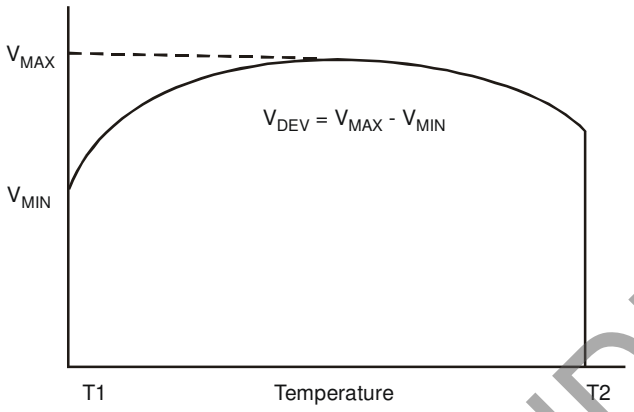
Electrical Characteristics (cont.) (@T_A = +25°C, V_{DD} = 3V; unless otherwise specified.)



Note: 6. 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 αV_{REF} is defined as:

$$|\alpha V_{REF}| = \frac{(\frac{V_{DEV}}{V_{REF}(25°C)}) \cdot 10^6}{T_2 - T_1} \quad \text{..... } (\frac{ppm}{°C})$$

Where:

T2 – T1 = full temperature change.

αV_{REF} can be positive or negative depending on whether the slope is positive or negative.

Note: 7. 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:

$$|Z_{KA}'| = \frac{\Delta v}{\Delta i} \approx |Z_{KA}| \quad (1 + \frac{R1}{R2})$$

Test Conditions

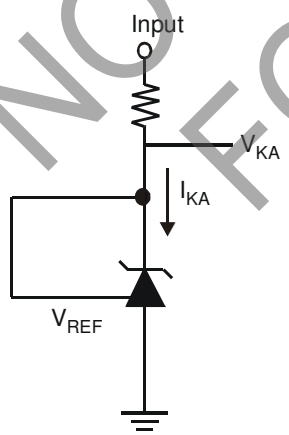
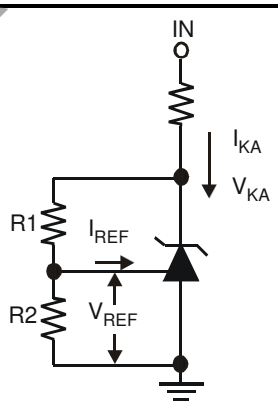


Figure. 1 Test Circuit for $V_{KA} = V_{REF}$



Note: $V_{KA} = V_{REF} (1 + R1/R2) + I_{REF} \times R1$

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

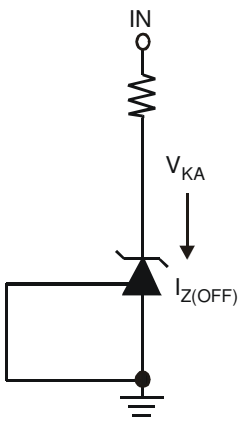


Figure. 3 Test Circuit for Off-State Current

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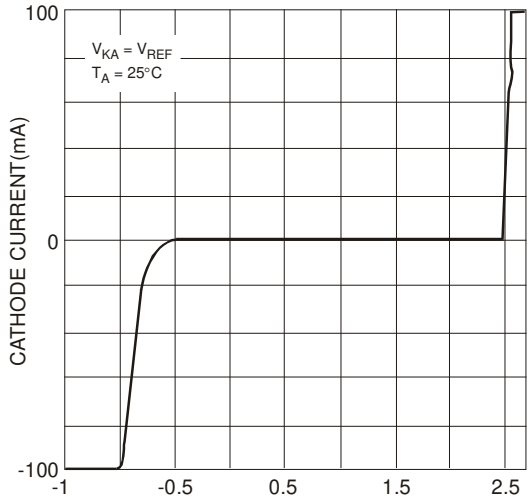
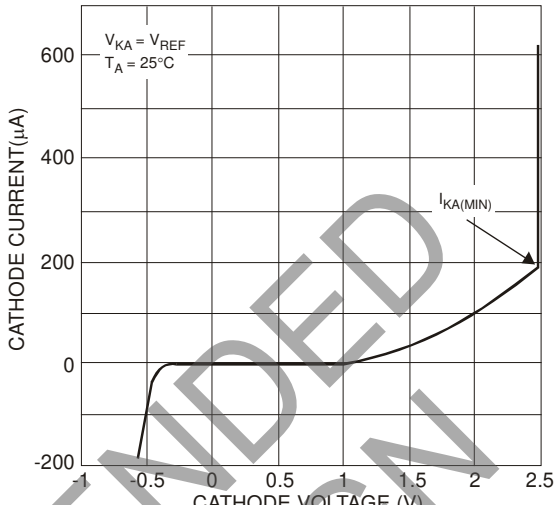
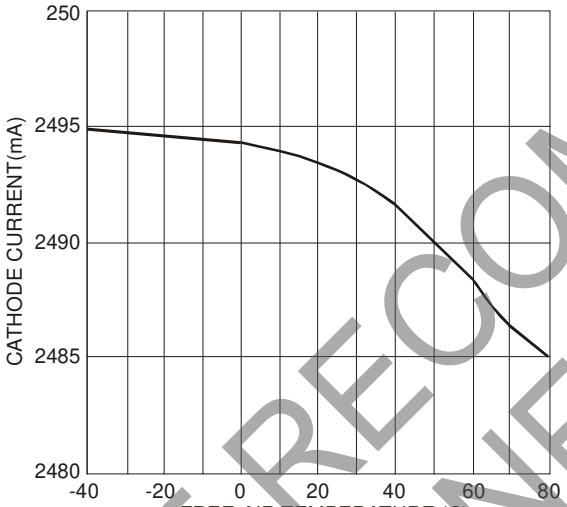
Typical Performace Characteristics



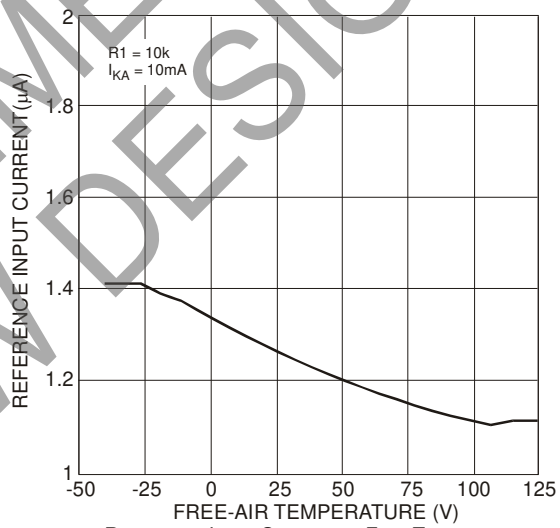
Cathode Current vs. Cathode Voltage



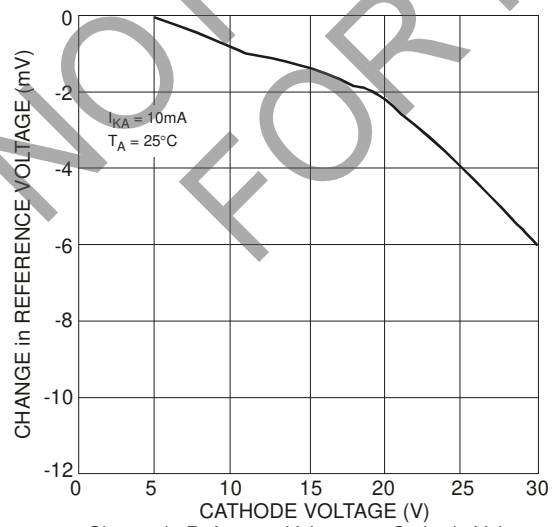
Cathode Current (μA) vs. Cathode Voltage



Reference Voltage vs. Free-Air Temperature



Reverence Input Current vs. Free Temperature



Change in Reference Voltage vs. Cathode Voltage

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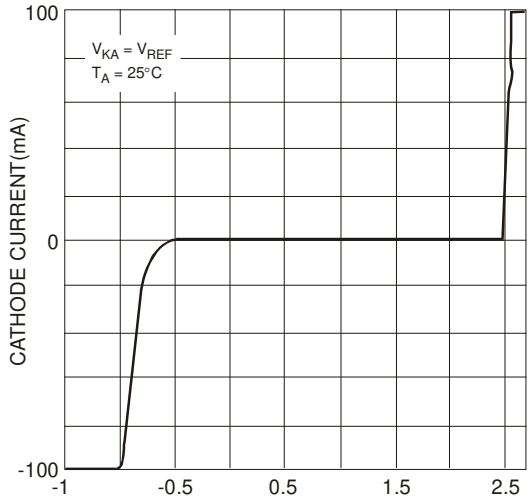
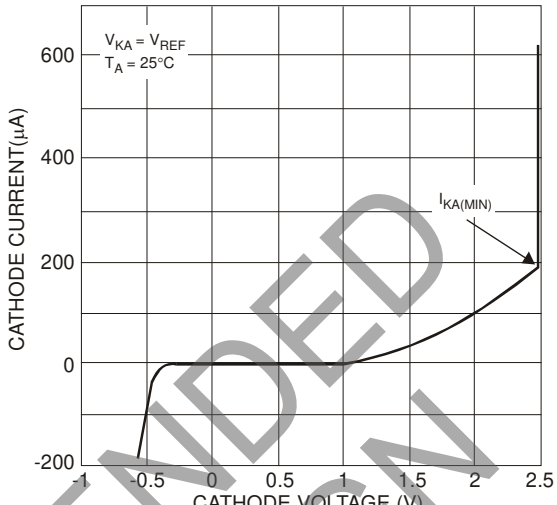
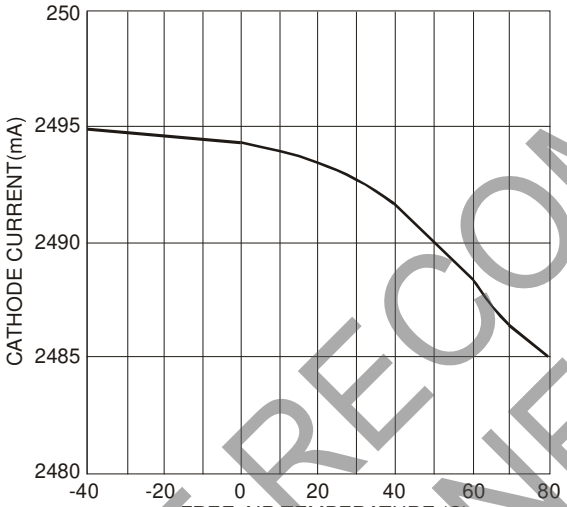
Typical Performance Characteristics (cont.)



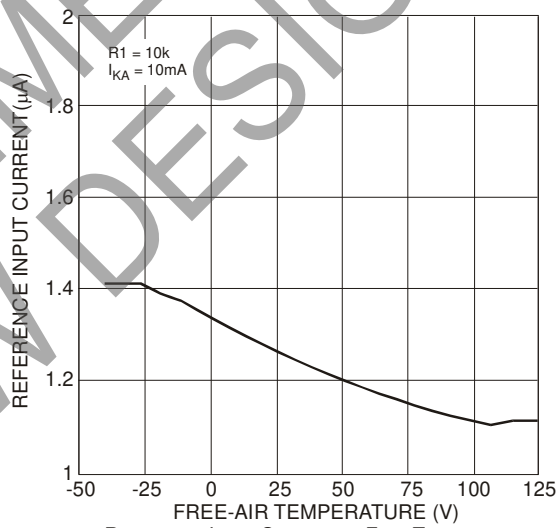
Cathode Current vs. Cathode Voltage



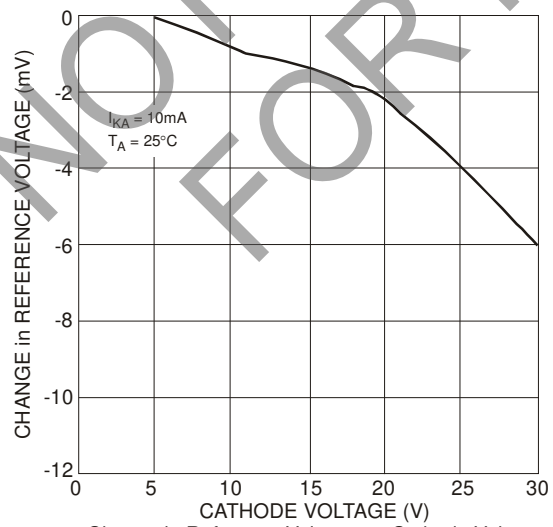
Cathode Current (µA) vs. Cathode Voltage



Reference Voltage vs. Free-Air Temperature



Reverence Input Current vs. Free Temperature



Change in Reference Voltage vs. Cathode Voltage

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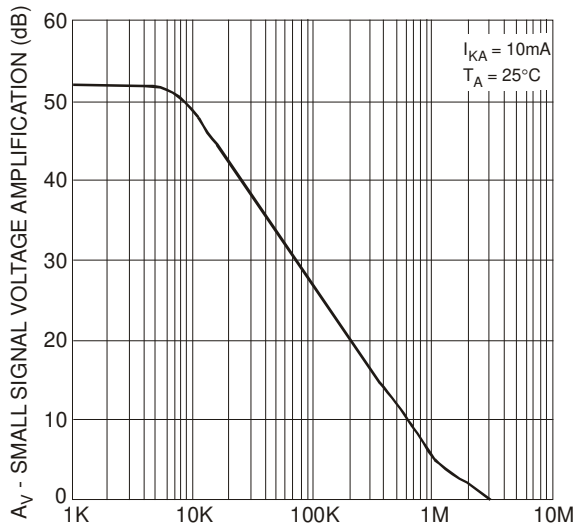
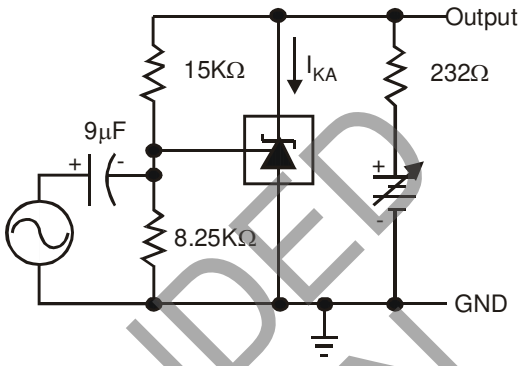
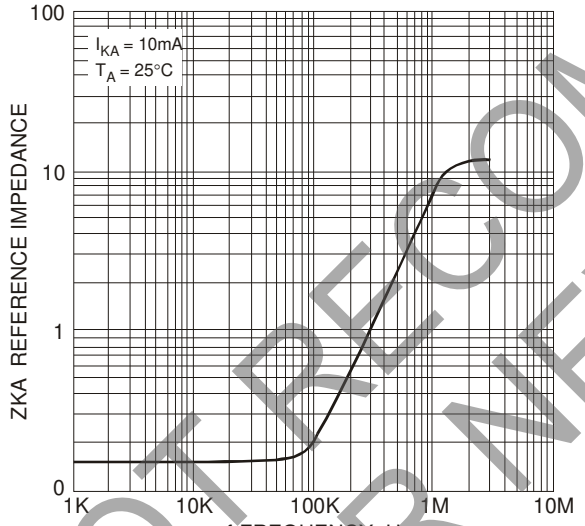
Typical Performance Characteristics (cont.)



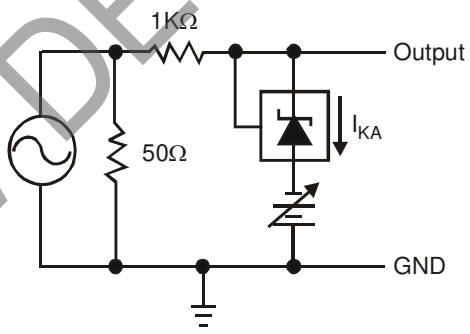
Small-Signal Voltage Amplification vs. Frequency



Test Circuit for Voltage Amplification



Reference Impedance vs. Frequency



Test Circuit for Reference Impedance

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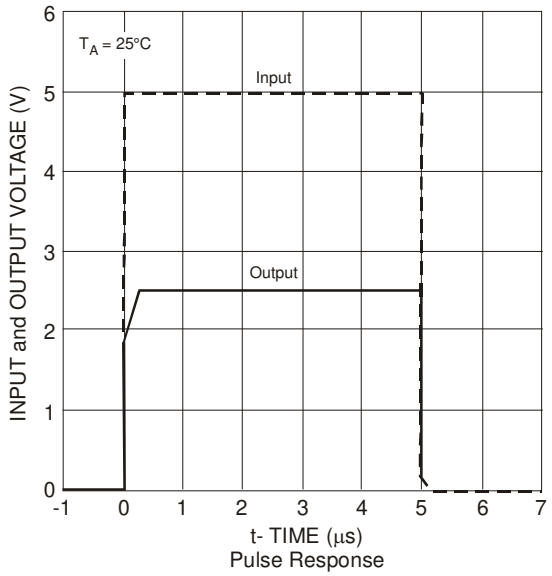
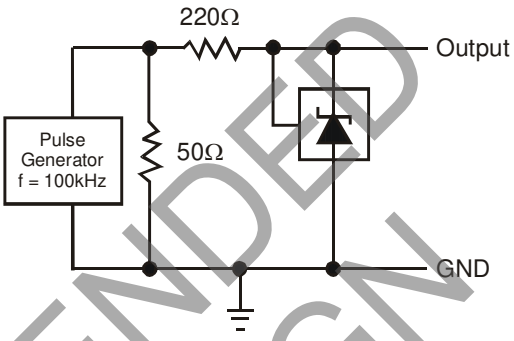
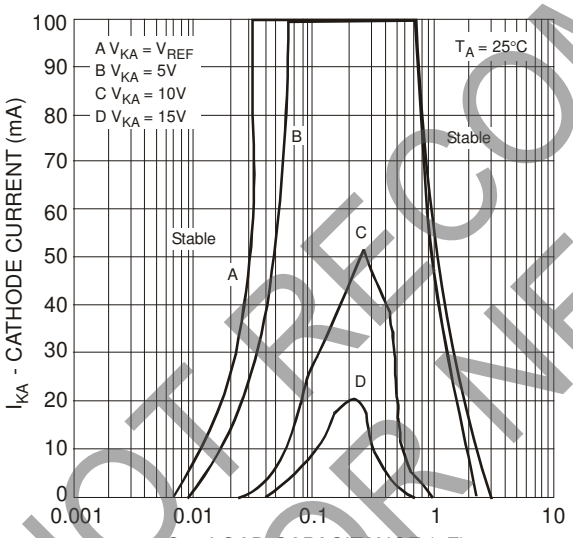
Typical Performance Characteristics (cont.)



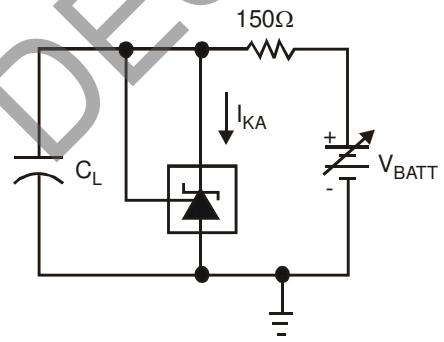
Pulse Response



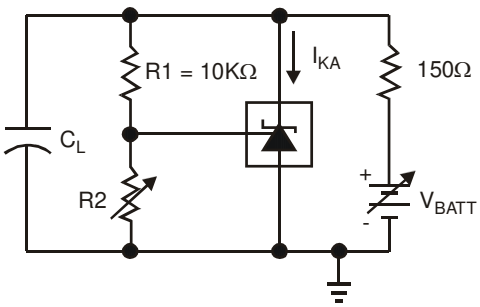
Test Circuit for Pulse Response



Stability Boundary Conditions†



Test Circuit for Curve A



Test Circuit for Curve B, C, and D

†The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 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.

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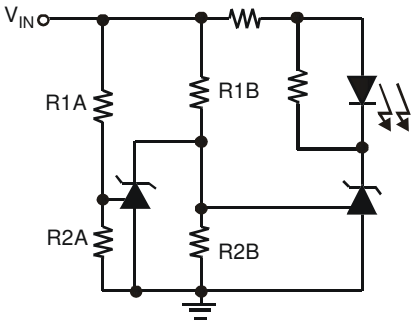
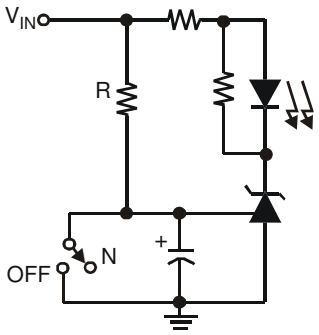
Application Examples



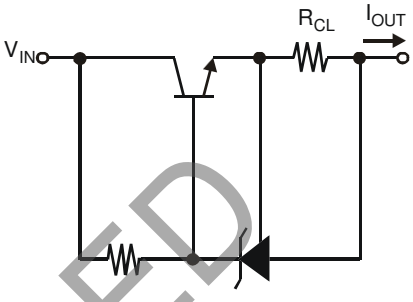
LED on when Low Limit < V_{IN} < High Limit
Low Limit ≈ V_{REF} (1 + R1B/R2B)
High Limit ≈ V_{REF} (1 + R1A/R2A)

Fig. 4 Voltage Monitor



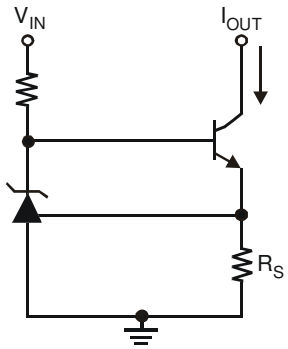
$$\text{Delay} = RC \times \ln\left(\frac{V_{IN}}{V_{IN} - V_{REF}}\right)$$

Fig 5. Delay Timer



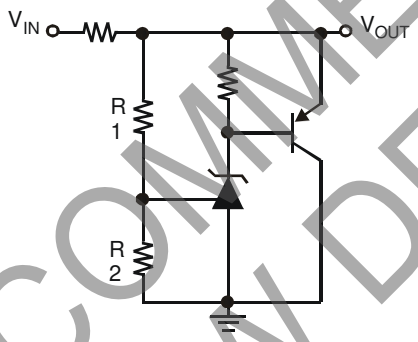
$I_{OUT} = V_{REF} / R_{CL}$

Fig 6. Current Limiter or Current Source



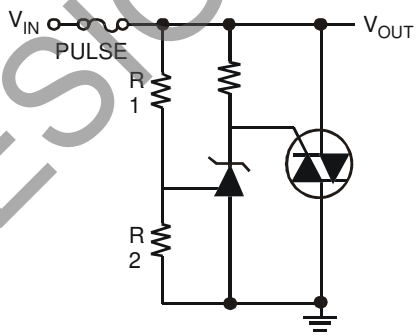
$I_{OUT} = V_{REF} / R_S$

Fig. 7 Constant-Current Sink



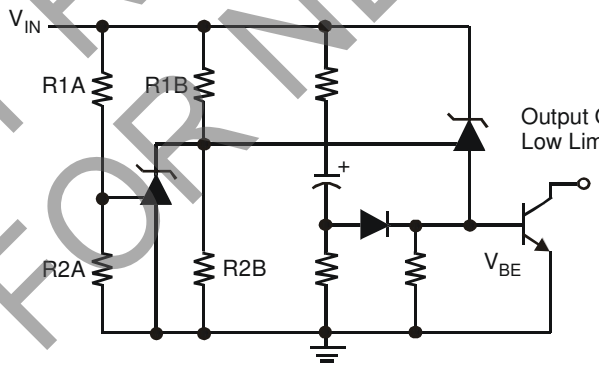
$V_{OUT} = (1 + R1/R2) \times V_{REF}$

Fig. 8 Higher-Current Shunt Regulator



Limit ≈ (1 + R1/R2) x V_{REF}

Fig. 9 Crow Bar



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

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

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Note: 12. Online application note, "Design Consideration with AP431 when used as a Comparator"
URL: http://www.diodes.com/_files/products_appnote_pdfs/AN78.pdf

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Ordering Information

AP431 X XX X - X

Reference Voltage Tolerance	Package	Lead-Free	Packing
Blank : ±1% A : ±0.5%	SA : SOT23 SR : SOT23R Q : SOT25 W : SC59 R : SC59R Blank : SO-8 Y : SOT89	L : Lead Free G : Green (Note 8)	7 : Tape & Reel (Note 11) 13 : Tape & Reel (Note 11) 13R : Tape & Reel (Note 11)

Part Number (Note 10)	Package Code	Packaging	7"/13 Tape and Reel		Ammo Box	
			Quantity	Part Number Suffix (Note 11)	Quantity	Part Number Suffix
AP431(A)SAG-7	SA	SOT23	3000/Tape & Reel	-7	NA	NA
AP431(A)SRG-7	SR	SOT23R	3000/Tape & Reel	-7	NA	NA
AP431(A)QL-7	Q	SOT25	3000/Tape & Reel	-7	NA	NA
AP431(A)QG-7	Q	SOT25	3000/Tape & Reel	-7	NA	NA
AP431AWL-7	W	SC59	3000/Tape & Reel	-7	NA	NA
AP431(A)WG-7	W	SC59	3000/Tape & Reel	-7	NA	NA
AP431(A)RL-7	R	SC59R	3000/Tape & Reel	-7	NA	NA
AP431(A)RG-7	R	SC59R	3000/Tape & Reel	-7	NA	NA
AP431(A)G-13		SO-8	2500/Tape & Reel	-13	NA	NA
AP431(A)YL-13	Y	SOT89	2500/Tape & Reel	-13	NA	NA
AP431(A)YG-13	Y	SOT89	2500/Tape & Reel	-13	NA	NA
AP431(A)YG-13R	Y	SOT89	4000/Tape & Reel	-13R	NA	NA

Notes: 8. SO-8, SOT23 and SOT23R are available in "Green" products only.
9. Suffix "A" denotes AP431A device.
10. Details of tape and reel options can be seen in document AP2007, which can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf

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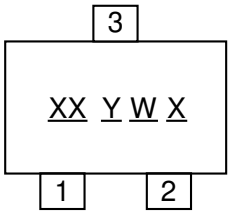
Marking Information

(1) SC59 and SC59R

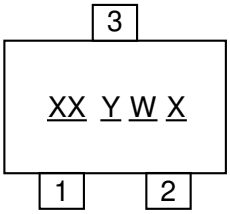
(Top View)



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
a~z : Lead Free

(2) SOT23 and SOT23R

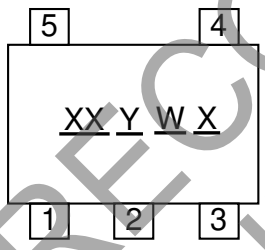
(Top View)



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

(3) SOT25

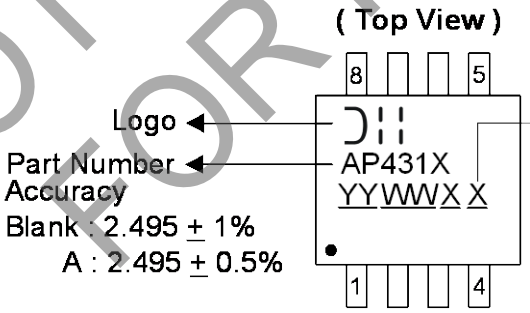
(Top View)



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
a~z : Lead Free

(4) SO-8

(Top View)



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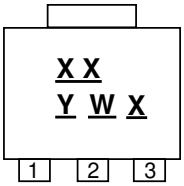
Marking Information (cont.)

(5) SOT89

(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 : Internal code
A~Z: Green
a~z : Lead Free

Identification Code Table

Device	Package (Note 11)	Identification 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
AP431Y	SOT89	A4	YM
AP431AY	SOT89	A5	YM

Note: 11. For Packaging Details, go to our website at http://www.diodes.com/datasheets/ap02007.pdf.

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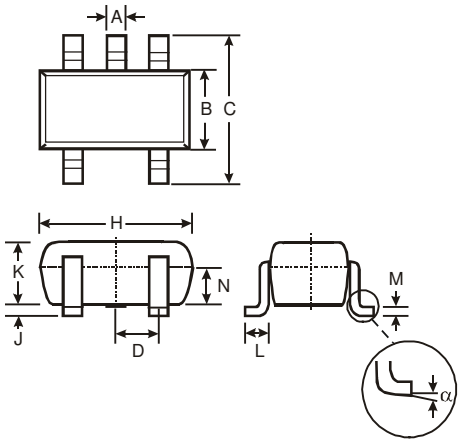
Package Outline Dimensions (All dimensions in mm.)

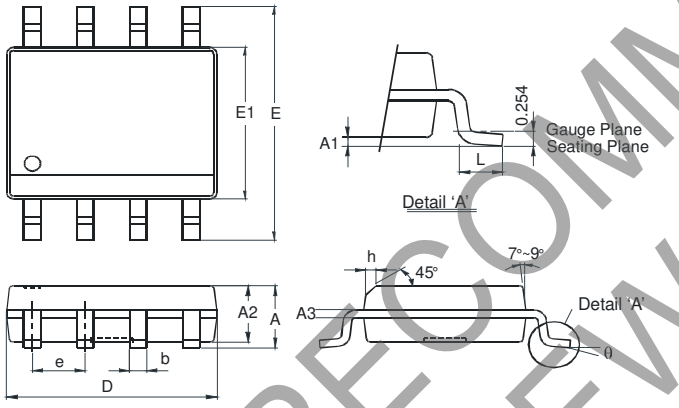
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(1) SOT25



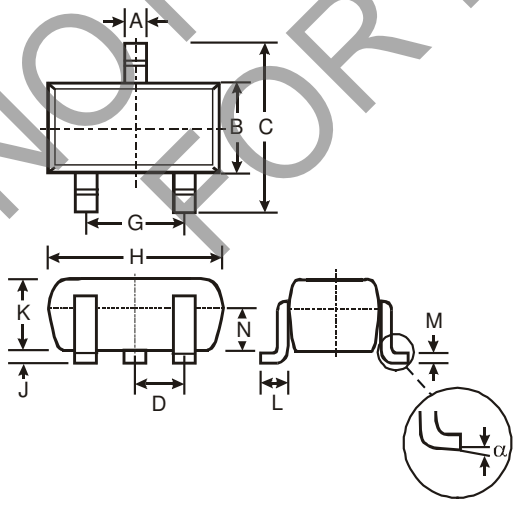
SOT25			
Dim	Min	Max	Typ
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	—	—	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	—
All Dimensions in mm			

(2) 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		

(3) SC59 and SC59R



SC59			
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
G	-	-	1.90
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			

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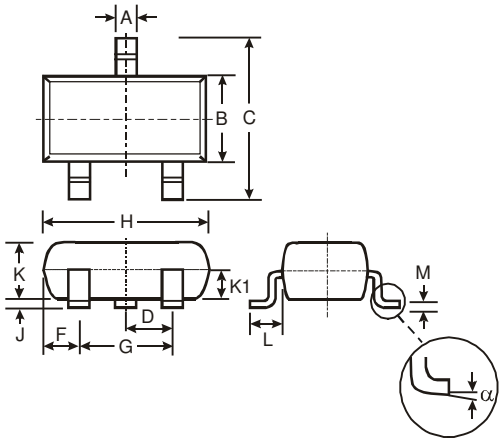
Package Outline Dimensions (cont.) (All dimensions in mm.)

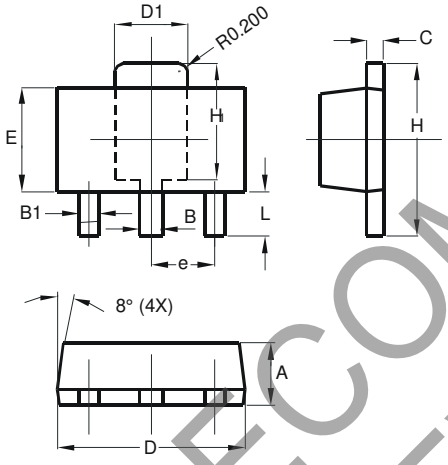
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(4) SOT23 and SOT23R



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
α	0°	8°	-
All Dimensions in mm			

(5) SOT89



SOT89		
Dim	Min	Max
A	1.40	1.60
B	0.44	0.62
B1	0.35	0.54
C	0.35	0.44
D	4.40	4.60
D1	1.62	1.83
E	2.29	2.60
e	1.50 Typ	
H	3.94	4.25
H1	2.63	2.93
L	0.89	1.20
All Dimensions in mm		

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Suggested Pad Layout

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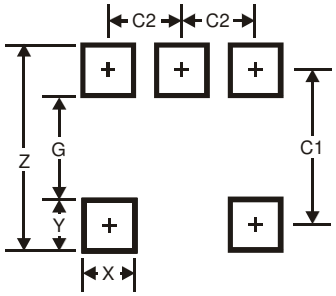
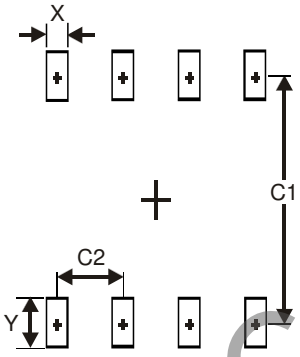
(1) SOT25



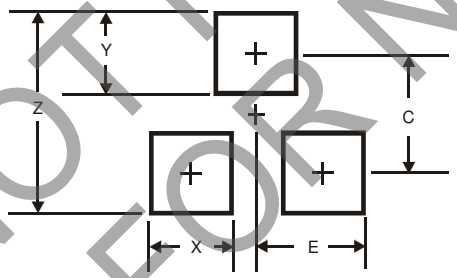
Dimensions	Value (in mm)
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

(2) SO-8



Dimensions	Value (in mm)
X	0.60
Y	1.55
C1	5.4
C2	1.27

(3) SC59 and SC59R



Dimensions	Value (in mm)
Z	3.4
X	0.8
Y	1.0
C	2.4
E	1.35

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Suggested Pad Layout (cont.)

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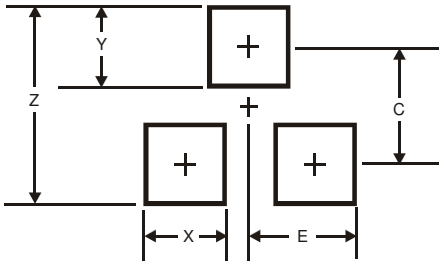
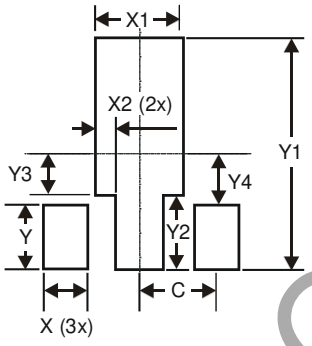
(4) SOT23 and SOT23R



Dimensions	Value (in mm)
Z	2.9
X	0.8
Y	0.9
C	2.0
E	1.35

(5) SOT89



Dimensions	Value (in mm)
X	0.900
X1	1.733
X2	0.416
Y	1.300
Y1	4.600
Y2	1.475
Y3	0.950
Y4	1.125
C	1.500

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