ADJUSTABLE PRECISION SHUNT REGULATOR

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: 30 ppm/°C
- Fast turn-on response
- Low dynamic output impedance: 0.2Ω
- Programmable output voltage to 36V
- Low output noise
- Packages: SOT-23 and SC-59. SOT-25, PowerDI™5, SOP-8L, and DFN under development

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.

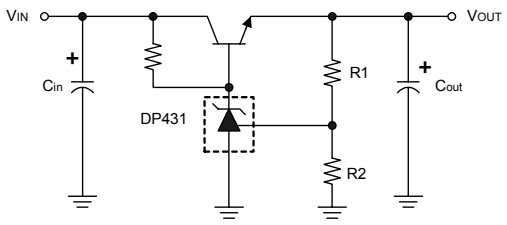
Ordering Information

A P 4 3 1 A X X X

- Reference Voltage — Tolerance: Blank : +/- 1%; A : +/- 0.5%
- Package — SA : SOT23; SB : SOT25; SN : SC-59; PB : PowerDI™5; SM : SOP-8L; FB : DFN
- Lead-Free — F : Lead-Free; G : Green
- Packing — Blank : Tube or bulk; -7/-13 : Taping

Device (Note 1)	Package Code	Packaging (Note 2)	7" Tape and Reel		13" Tape and Reel	
			Quantity	Part Number Suffix	Quantity	Part Number Suffix
AP431(A)SA	SA	SOT-23	3000/Tape & Reel	-7	10,000/Tape & Reel	-13
AP431(A)SB	SB	SOT-25	3000/Tape & Reel	-7	10,000/Tape & Reel	-13
AP431(A)SN	SN	SC-59	3000/Tape & Reel	-7	10,000/Tape & Reel	-13
AP431(A)PB	PB	PowerDI™5	NA	NA	5000/Tape & Reel	-13
AP431(A)SM	SM	SOP-8L	3000/Tape & Reel	-7	10,000/Tape & Reel	-13
AP431(A)FB	FB	DFN	3000/Tape & Reel	-7	10,000/Tape & Reel	-13

Typical Application Circuit

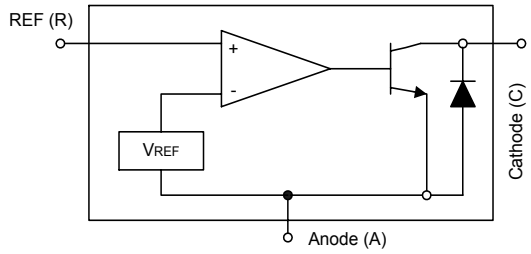


$V_{OUT} = (1+R1/R2)V_{REF}$

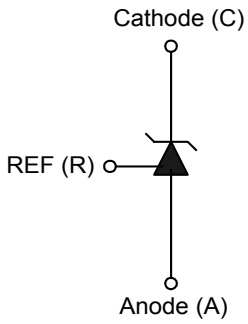
Precision Regulator

Notes: 1. Suffix "A" denotes AP431A device.
2. 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.

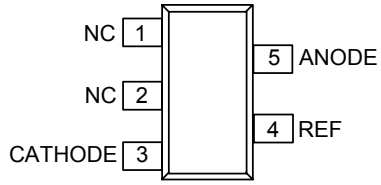
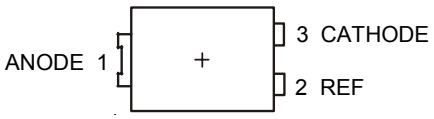
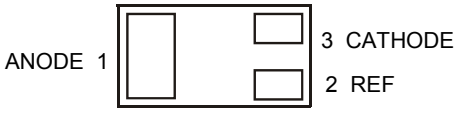
Block Diagram

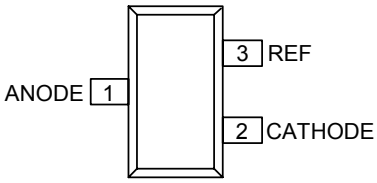
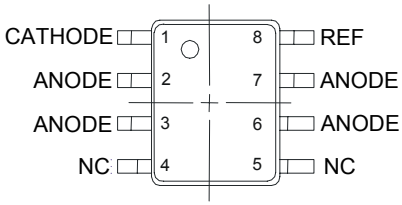
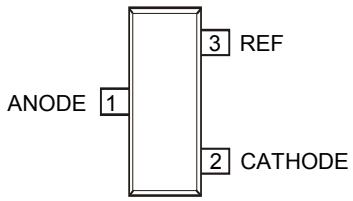


Symbol



Pin Configuration

Package	Pin Configuration (Top View)
SOT25	
PowerDI™5	
DFN	

Package	Pin Configuration (Top View)
SC-59	
SOP-8L	
SOT23	

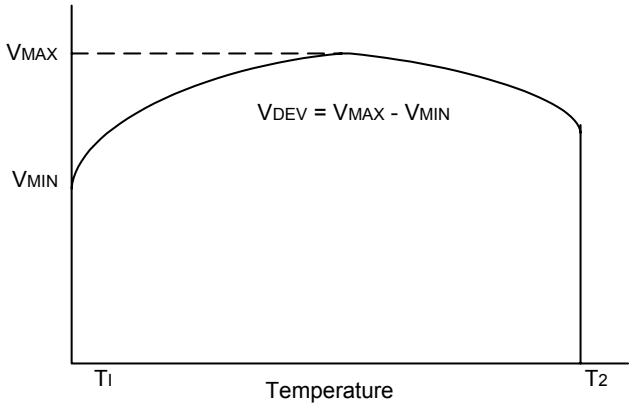
Absolute Maximum Ratings

Cathode Voltage 36V
Continuous Cathode Current ..... -10mA ~ 250mA
Reference Input Current Range 10mA
Operating Temperature Range (AP431) ..... -20°C ~ 85°C
Lead Temperature ..... 260°C
Storage Temperature ..... -65°C ~ 150°C
Power Dissipation (Notes 3, 4)
- SOT-25 Package 250mW
- PowerDI™5 Package 900mW
- SC-59 Package 400mW
- SOP-8L Package 600mW
- DFN Package 250mW

Note 3. T_J, max =150°C
Note 4. Ratings apply to ambient temperature at 25°C

Electrical Characteristics (T_A=25°C, V^+=+5.0V, unless otherwise stated)

PARAMETER	TEST CONDITIONS		SYMBOL	MIN.	TYP.	MAX.	UNIT
Reference voltage	V_{KA} = V_{REF}, I_{KA} = 10mA (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 3)	V_{KA} = V_{REF}, I_{KA} = 10mA, Ta = 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} = 10mA (Fig.2)	V_{KA} = 10V ~V_{REF}	ΔV_{REF}	—	-1.4	-2.0	mV/V
		V_{KA}= 36V ~10V	ΔV_{KA}	—	-1	-2	mV/V
Reference input current	R1 = 10KΩ,R2 = ∞ I_{KA}= 10mA (Fig.2)		I_{REF}	—	1.4	3.5	μA
Deviation of Reference input current over temperature	R1 = 10KΩ,R2 = ∞ I_{KA} = 10mA Ta = Full range (Fig.2)		αI_{REF}	—	0.4	1.2	μA
Minimum Cathode current for regulation	V_{KA} = V_{REF} (Fig.1)		$I_{KA(MIN)}$	—	0.19	0.5	mA
Off-state current	V_{KA} = 36V, V_{REF} = 0V (Fig.3)		$I_{KA(OFF)}$	—	0.1	1.0	μA
Dynamic output impedance (Note 4)	V_{KA} = V_{REF} V_{KA} = V_{REF} ΔI_{KA} = 0.1mA ~ 15Ma Frequency ≤ 1KHz (Fig.1)		$\|Z_{KA}\|$	—	0.2	0.5	Ω



Electrical Characteristics (Continued) (T_A=25°C, V^+=+5.0V, unless otherwise stated)
(Note 5)

Note 5. 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:

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

Where:
T2 – T1 = full temperature change.
αV_{REF} can be positive or negative depending on whether the slope is positive or negative.
Note 4. 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 Circuits

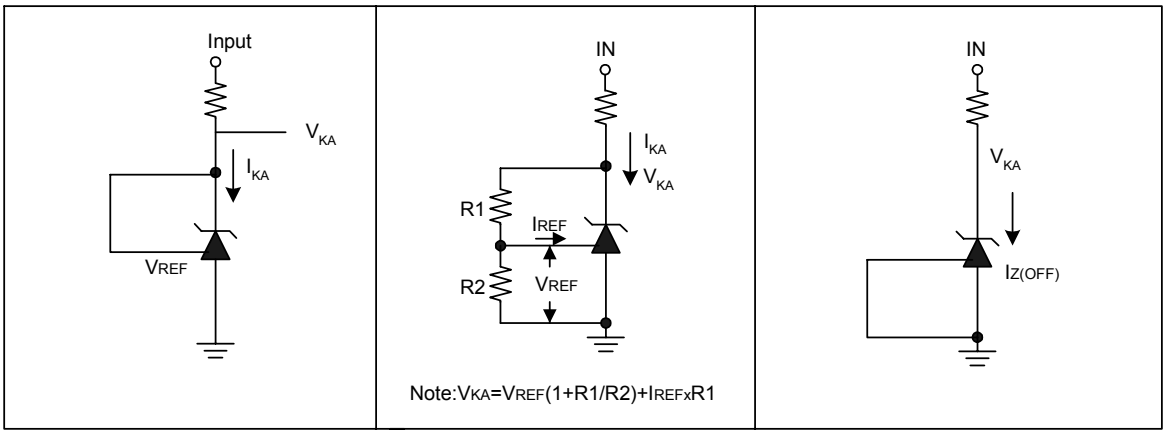
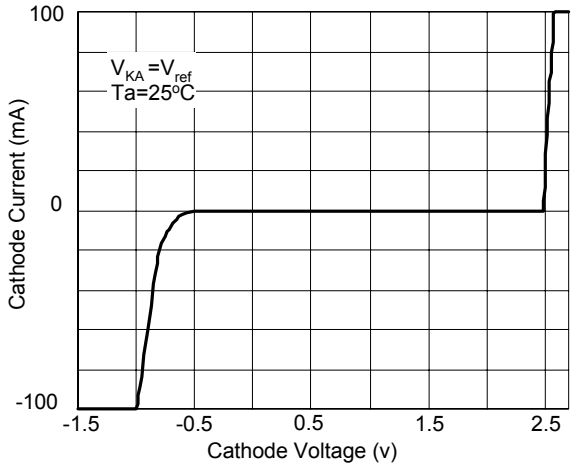


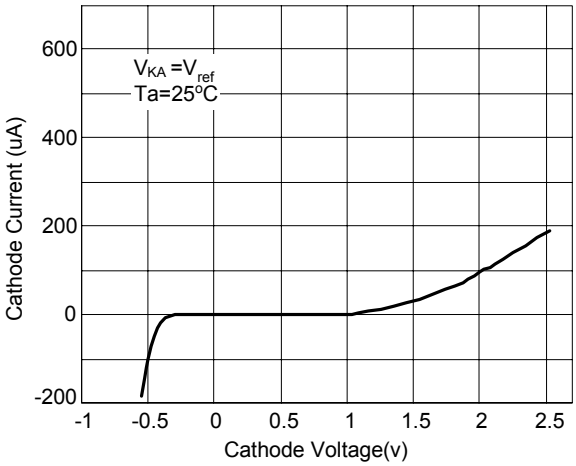
Fig 1. Test Circuit for V_{KA}= V_{REF} Fig 2. Test Circuit for $V_{KA>}V_{REF}$ Fig 3. Test Circuit for Off-State Current

Typical Performance Characteristics

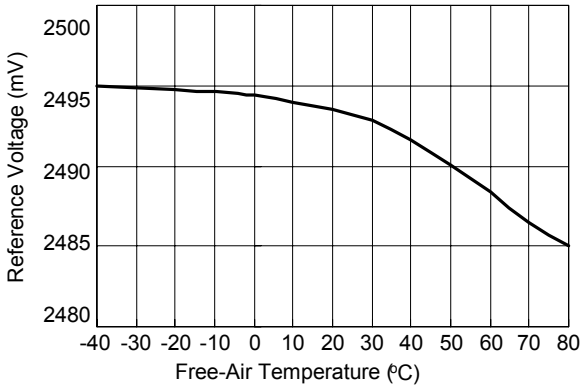
Cathode Current vs Cathode Voltage



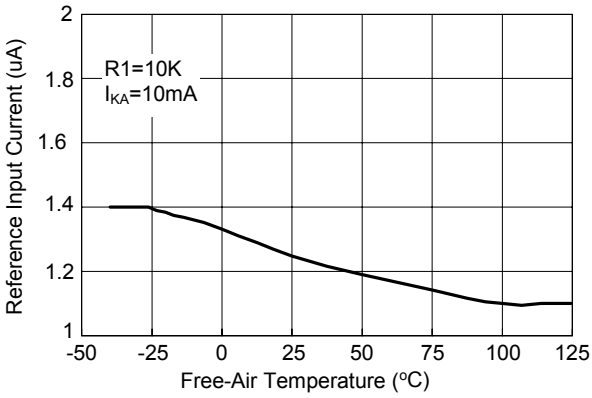
Cathode Current (uA) vs Cathode Voltage



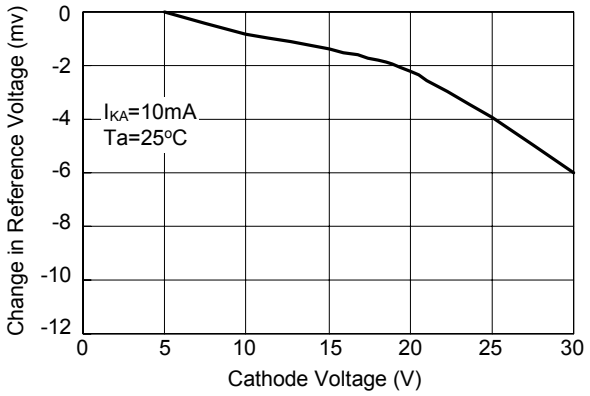
Reference Voltage vs Free-Air Temperature



Reference Input Current vs Free Temperature

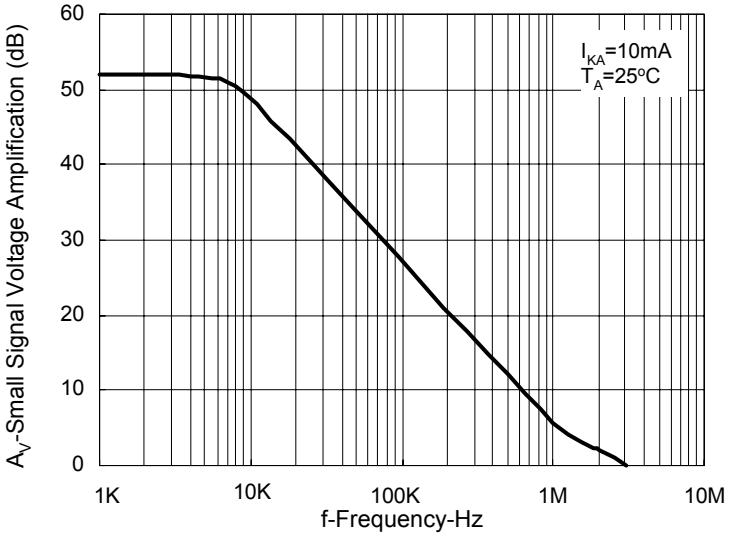


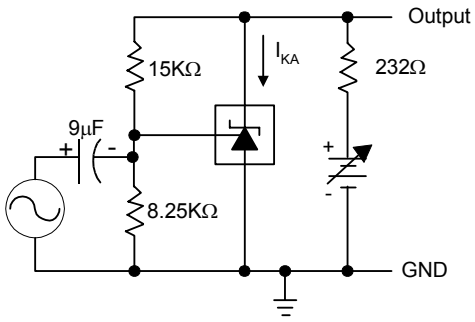
Change in Reference Voltage vs Cathode Voltage



Typical Performance Characteristics (Continued)

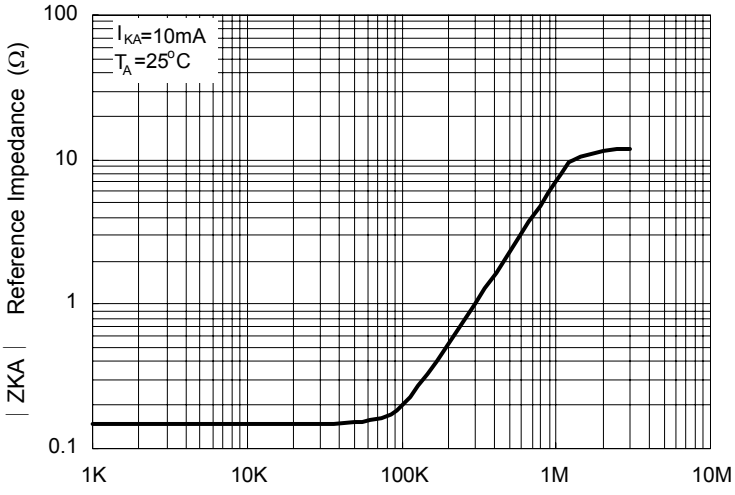
Small-Signal Voltage Amplification vs Frequency

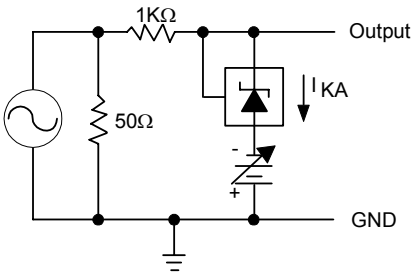




Test Circuit for Voltage Amplification

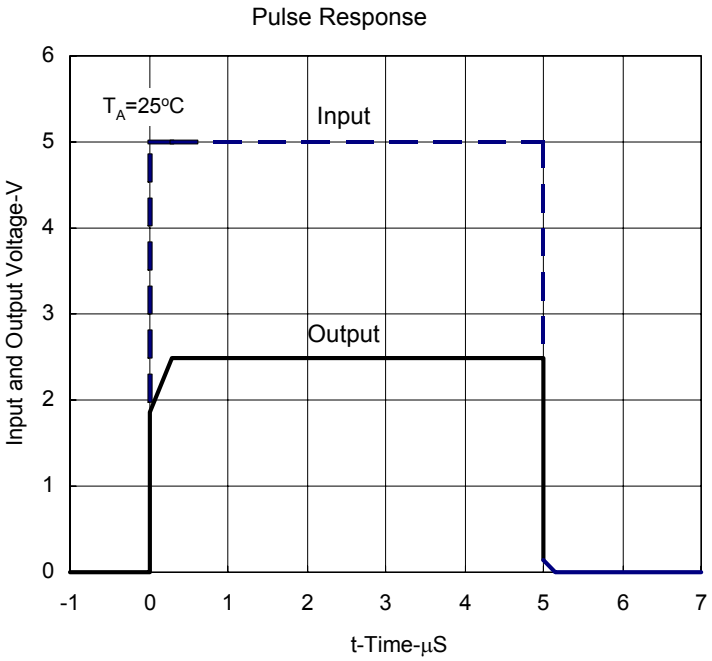
Reference Impedance vs Frequency

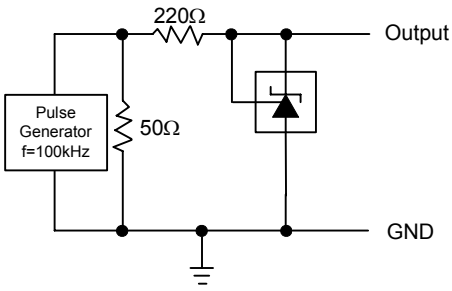




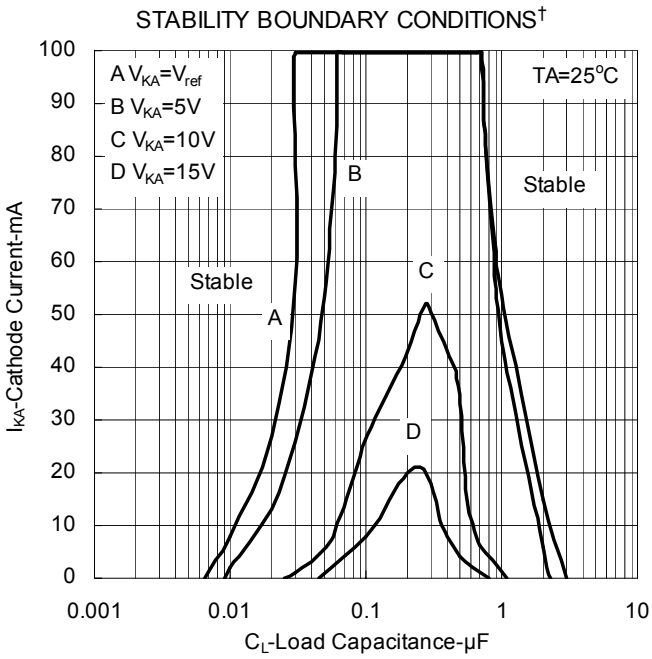
Test Circuit for Reference Impedance

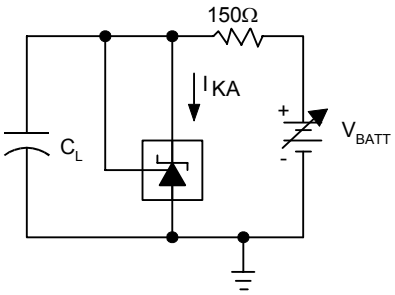
Typical Performance Characteristics (Continued)



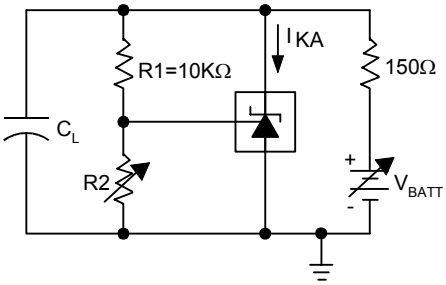


Test Circuit for Pulse Response





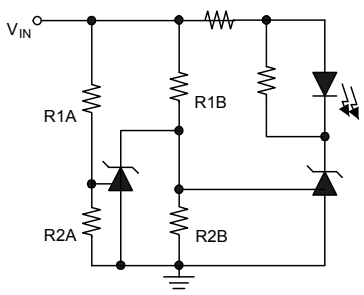
Test Circuit for Curve A



Test Circuit for Curve B, C, and D

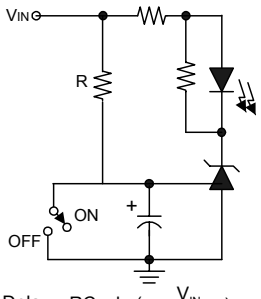
†The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 and V+ were adjusted to establish the initial V_{KA} and I_{KA} conditions with C_L=0.V_{BATT} and C_L were then adjusted to determine the ranges of stability.

Application Examples



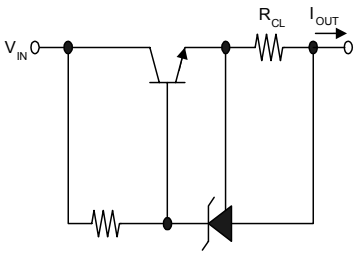
LED on when Low Limit< V_{IN} < High Limit
Low Limit ≈ V_{REF} (1+R1B/R2B)
High Limit ≈ V_{REF} (1+R1A/R2A)

Fig. 4 Voltage Monitor



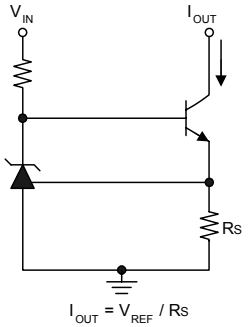
Delay = RC x ln ($\frac{V_{IN}}{V_{IN} - V_{REF}}$)

Fig. 5 Delay Timer



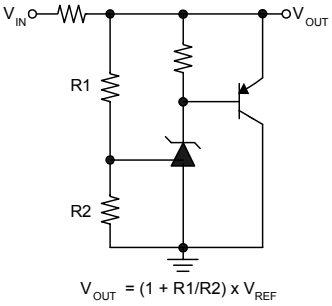
$I_{OUT} = V_{REF} / R_{CL}$

Fig. 6 Current Limiter or Current Source



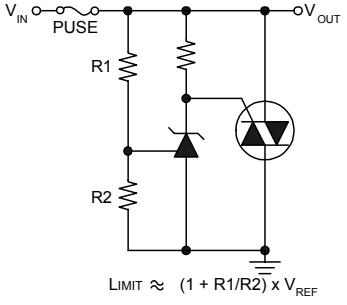
$I_{OUT} = V_{REF} / R_S$

Fig. 7 Constant-Current Sink



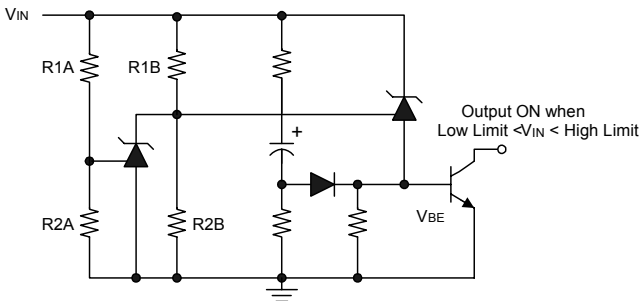
$V_{OUT} = (1 + R1/R2) \times V_{REF}$

Fig. 8 Higher-Current Shunt Regulator



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

Fig. 9 Crow Bar

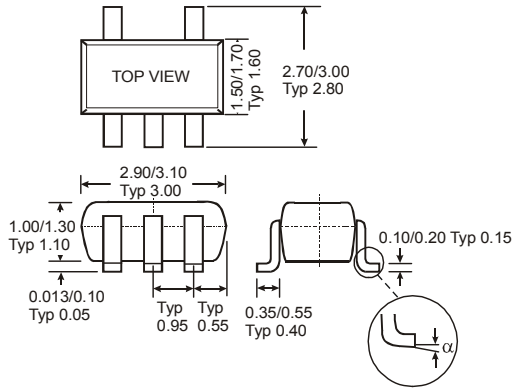


Low Limit ≈ V_{REF} (1 + R1B/R2B) +V_{BE}
High Limit ≈ V_{REF} (1 + R1A/R2A)

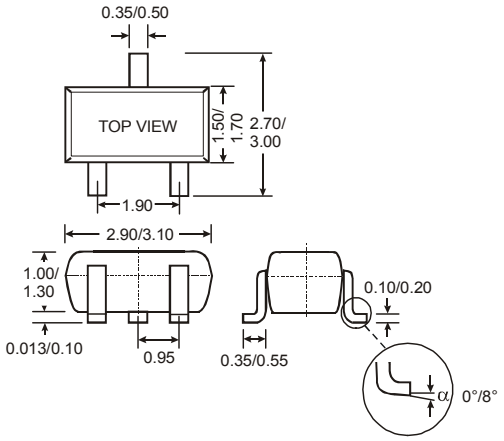
Fig.10 Over-Voltage / Under-Voltage Protection Circuit

Package Diagrams (All Dimensions in mm)

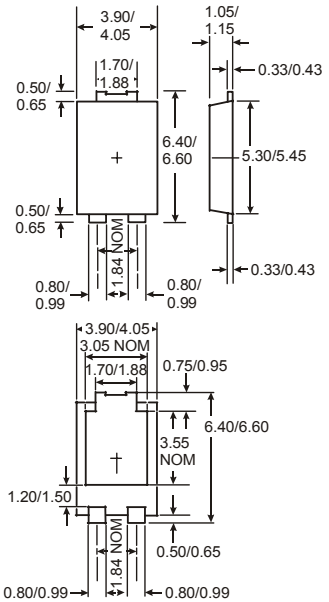
(1) SOT-25



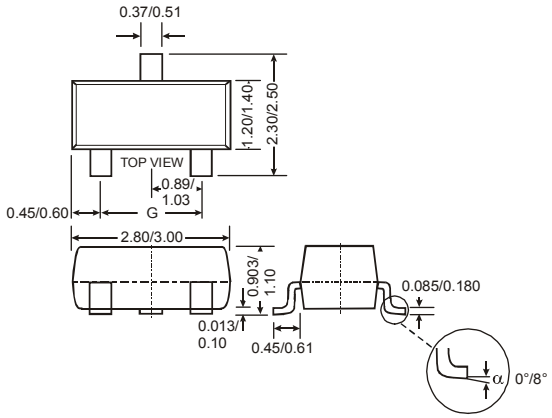
(2) SC-59



(3) PowerDI™5

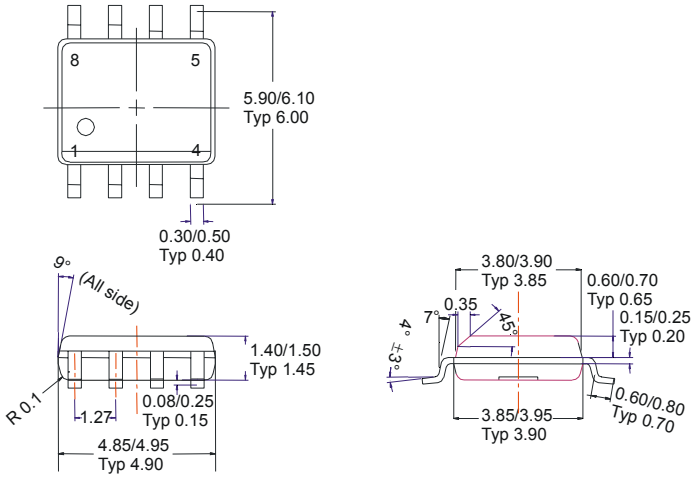


(4) SOT-23

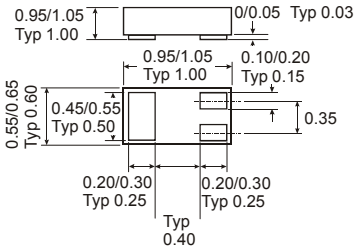


PowerDI is a trademark of Diodes Incorporated.

(5) SOP-8L

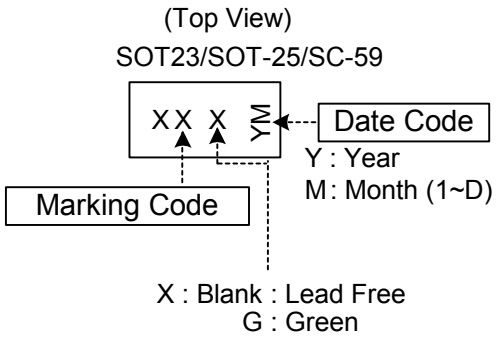


(6) DFN1006-3

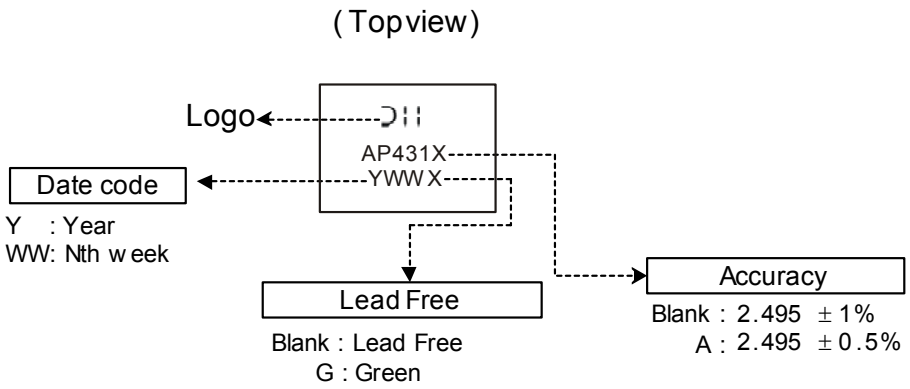


Marking Information

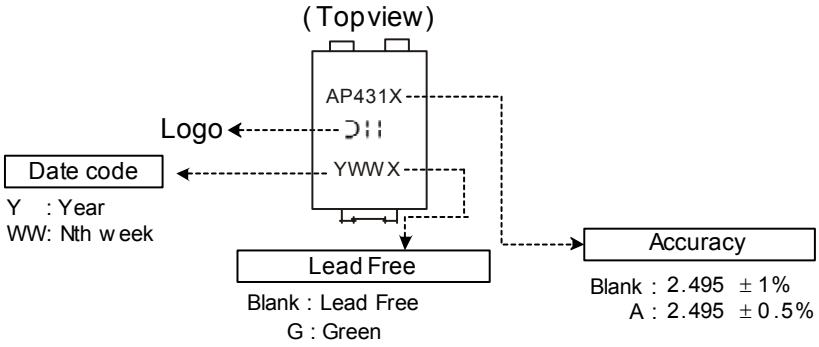
(1) SOT-23/SOT-25/SC-59



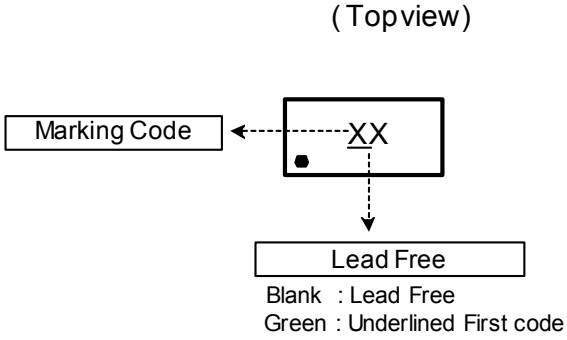
(2) SOP



(3) PowerDI™5



(4) DFN



Date Code Key

Year	2006	2007	2008	2009	2010
Code	**T**	**U**	**V**	**W**	**X**

Month	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**O**	**N**	**D**

Marking Code Table

Device	Package (Note 6)	Marking Code	Date Code
AP431SA	SOT-23	D1	YM
AP431ASA	SOT-23	D2	YM
AP431SB	SOT-25	D1	YM
AP431ASB	SOT-25	D2	YM
AP431SN	SC-59	D1	YM
AP431ASN	SC-59	D2	YM
AP431PB	PowerDI™5	AP431	YWW
AP431APB	PowerDI™5	AP431A	YWW
AP431SM	SOP-8L	AP431	YWW
AP431ASM	SOP-8L	AP431A	YWW
AP431FB	DFN	D1	—
AP431AFB	DFN	D2	—

Notes: 6. For Packaging Details, go to our website at http://www.diodes.com/datasheets/ap02007.pdf.