

# AP431/AP431A

## Adjustable Precision Shunt Regulator

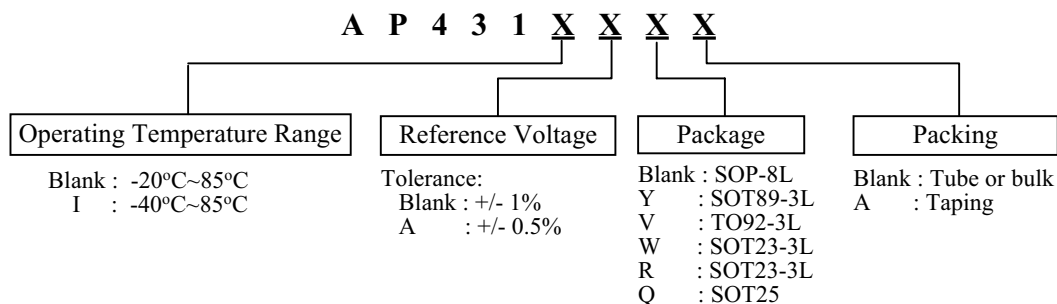
### ■ Features

- 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:  $30 \text{ ppm}/^\circ C$
- Fast turn-on response
- Low dynamic output impedance:  $0.2 \Omega$
- Programmable output voltage to 36v
- Low output noise.
- Packages: TO92, SOT89, SOT23, SOT25 and SOP

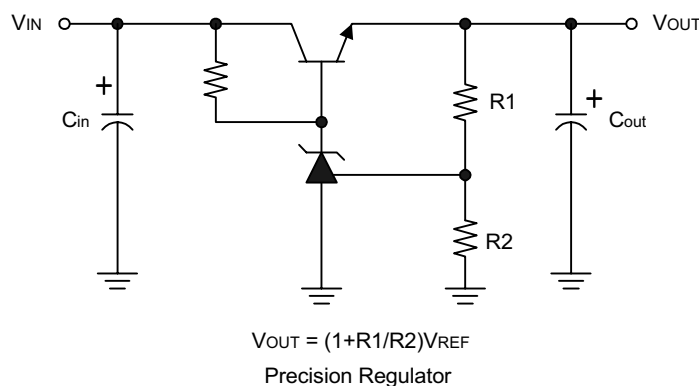
### ■ Description

The AP431/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 a 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 AP431/431A 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



### ■ Typical Application Circuit



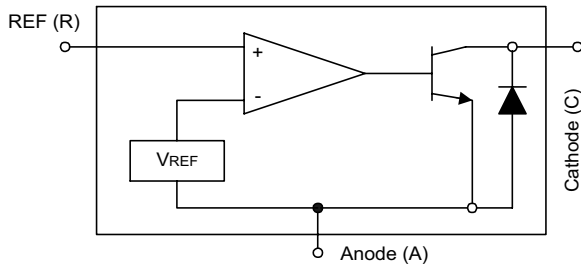
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# AP431/AP431A

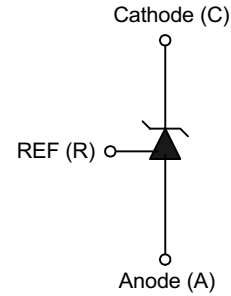
## Adjustable Precision Shunt Regulator



### ■ Block Diagram



### ■ Symbol



### ■ Pin Configuration

Order Number	Pin Configuration (Top View)	Order Number	Pin Configuration (Top View)
AP431Y AP431AY AP431IY AP431IAY (SOT89)		AP431R AP431AR AP431IR AP431IAR (SOT23)	
AP431V AP431AV AP431IV AP431IAV (TO92)		AP431W AP431AW AP431IW AP431IAW (SOT23)	
AP431 AP431A AP431I AP431IA (SOP)		AP431Q AP431AQ AP431IQ AP431IAQ (SOT25)	

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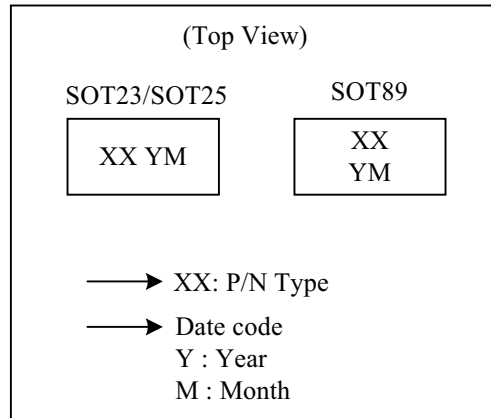
## Adjustable Precision Shunt Regulator



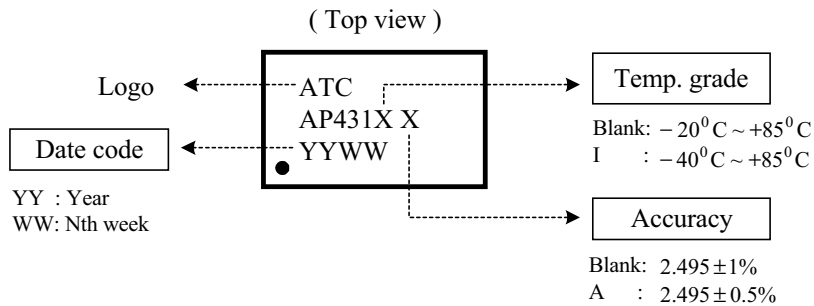
### ■ Marking Information

(1) SOT23 / SOT25 / SOT89

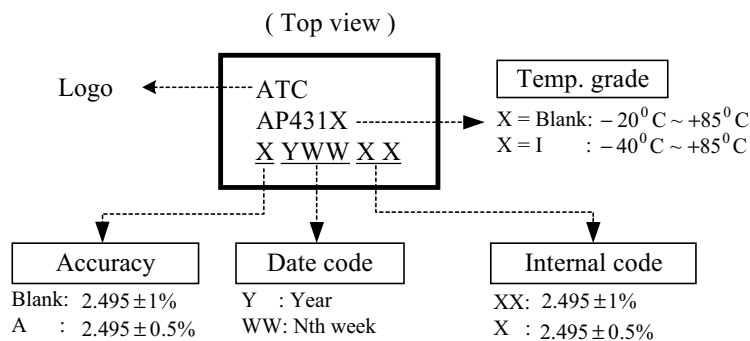
P/N Type	:	XX
AP431Y	:	A 4
AP431AY	:	A 5
AP431IY	:	A A
AP431IAY	:	A B
AP431W	:	A 6
AP431AW	:	A 7
AP431IW	:	A C
AP431IAW	:	A D
AP431R	:	A 8
AP431AR	:	A 9
AP431IR	:	A E
AP431IAR	:	A F
AP431Q	:	A 2
AP431AQ	:	A 3
AP431IQ	:	A G
AP431IAQ	:	A H



(2) SOP



(2) TO92



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### ■ Absolute Maximum Ratings

Cathode Voltage .....	36V
Continuous Cathode Current .....	-10mA ~ 250mA
Reference Input Current Range .....	10mA
Operating Temperature Range (AP431).....	-20°C ~ 85°C
(AP431I).....	-40°C ~ 85°C
Lead Temperature.....	260°C
Storage Temperature .....	-65°C ~ 150°C
Power Dissipation (Notes 1, 2)	
SOT89 Package .....	0.80W
TO92 Package .....	0.78W
SOT23 package .....	0.23W
SOT25 Package.....	0.23W
SOP Package.....	0.6W

Note 1: T<sub>J</sub>, max =150°C

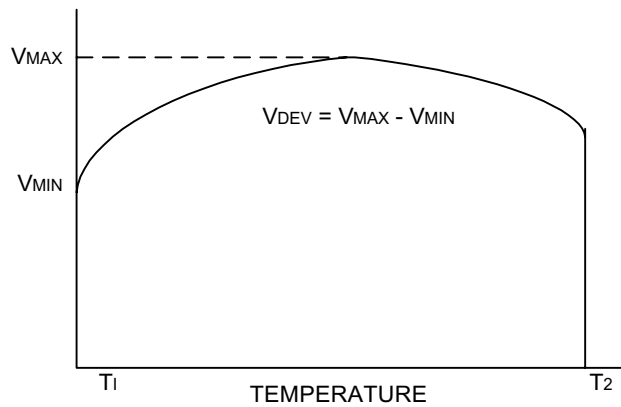
Note 2: Ratings apply to ambient temperature at 25°C

### ■ Electrical Characteristics (Ta=25°C , unless otherwise specified.)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Reference voltage	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA (Fig.1)	AP431 AP431A	2.470 2.482	2.495	2.520 2.507	V
	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA , Ta = 0°C ~ + 70°C (Fig.1)	V <sub>REF</sub>		8.0	20	mV
Ratio of the change in Reference voltage to the change in Cathode voltage	I <sub>KA</sub> = 10mA (Fig.2)	V <sub>KA</sub> = 10V ~ V <sub>REF</sub>	$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	-1.4	-2.0	mV/V
		V <sub>KA</sub> = 36V ~ 10V	$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	-1	-2	mV/V
Reference input current	R1 = 10KΩ, R2 = ∞ I <sub>KA</sub> = 10mA (Fig.2)	I <sub>REF</sub>		1.4	3.5	μA
Deviation of Reference input current over temperature	R1 = 10KΩ, R2 = ∞ I <sub>KA</sub> = 10mA Ta = Full range (Fig.2)	α I <sub>REF</sub>		0.4	1.2	μA
Minimum Cathode current for regulation	V <sub>KA</sub> = V <sub>REF</sub> (Fig.1)	I <sub>KA(MIN)</sub>		0.19	0.5	mA
Off-state current	V <sub>KA</sub> = 36V, V <sub>REF</sub> = 0V (Fig.3)	I <sub>KA(OFF)</sub>		0.1	1.0	μA
Dynamic output impedance (Note 4)	V <sub>KA</sub> = V <sub>REF</sub> V <sub>KA</sub> = V <sub>REF</sub> ΔI <sub>KA</sub> = 1mA ~ 100mA Frequency ≤ 1KHz (Fig.1)	Z <sub>KA</sub>		0.2	0.5	Ω

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Note 3. 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 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  $R_1$  and  $R_2$  (see Figure 2.), the dynamic output impedance of the overall circuit, is defined as:

$$|Z'_{KA}| = \frac{\Delta v}{\Delta i} \approx |Z_{KA}| \cdot \left(1 + \frac{R_1}{R_2}\right)$$

### ■ Test Circuits

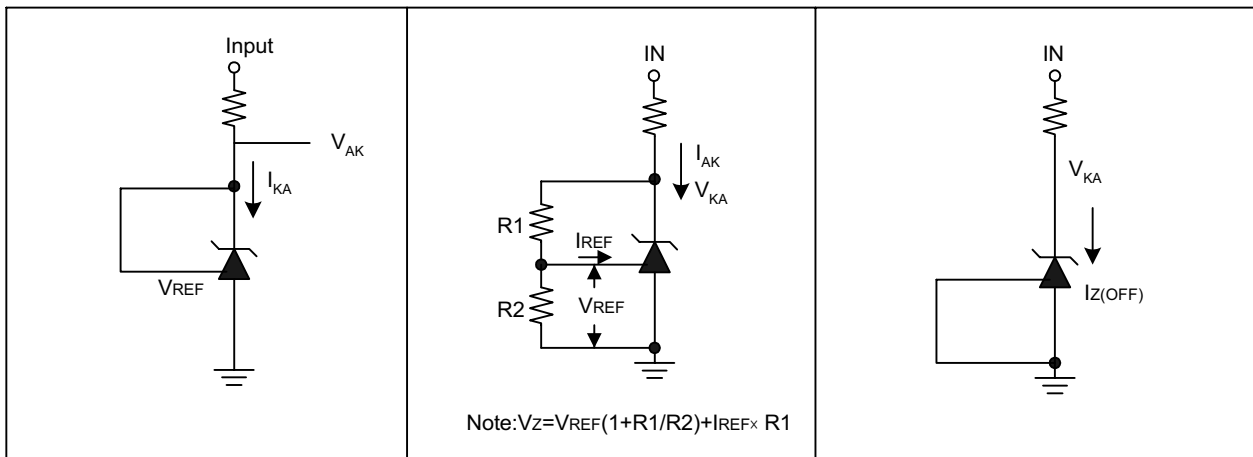


Fig1. Test Circuit for  $V_{KA} = V_{REF}$

Fig2. Test circuit for  $V_{KA} > V_{REF}$

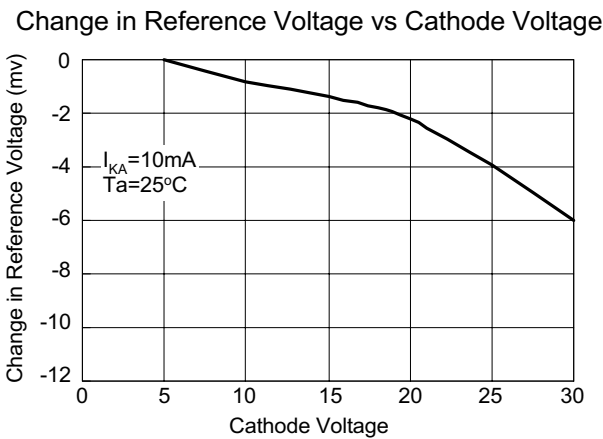
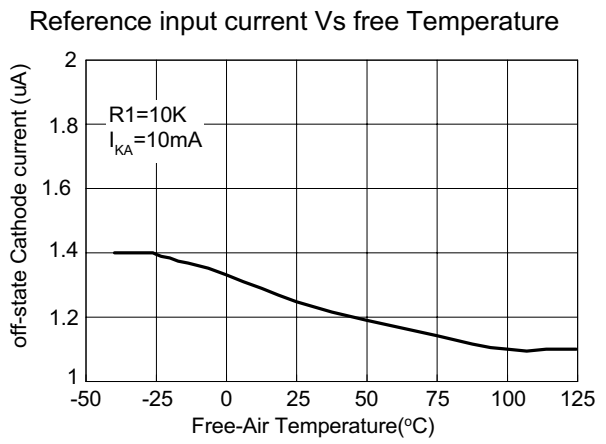
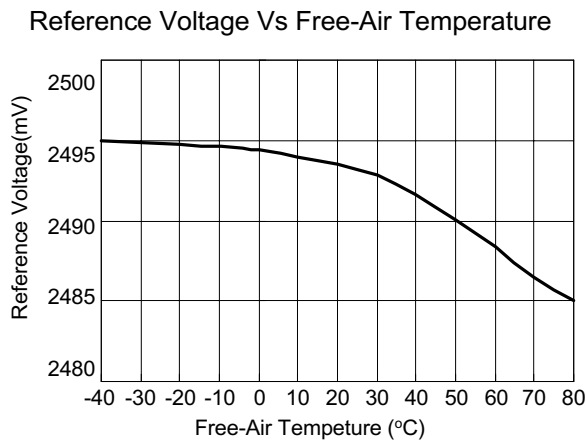
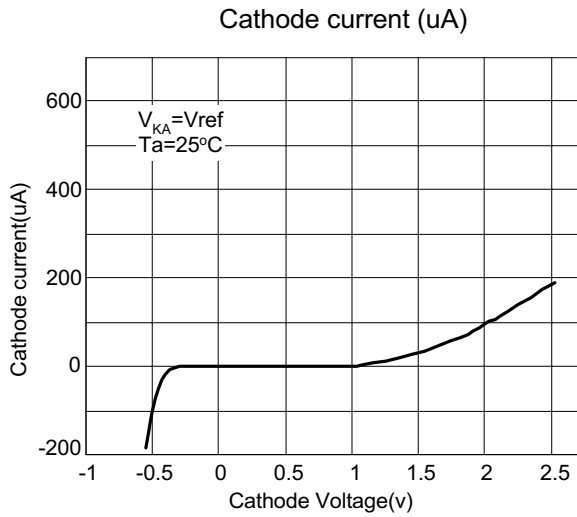
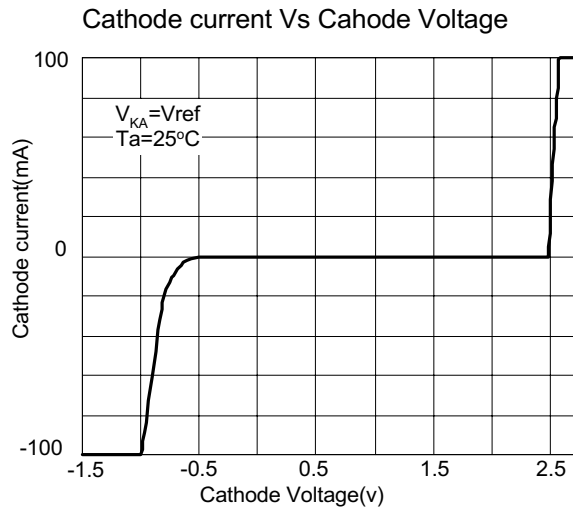
Fig3. Test Circuit for off-state Current

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## Adjustable Precision Shunt Regulator



### ■ Typical Performance Characteristics



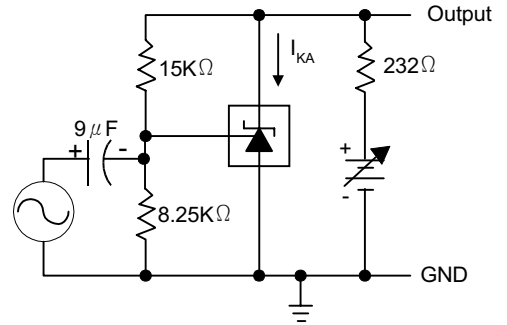
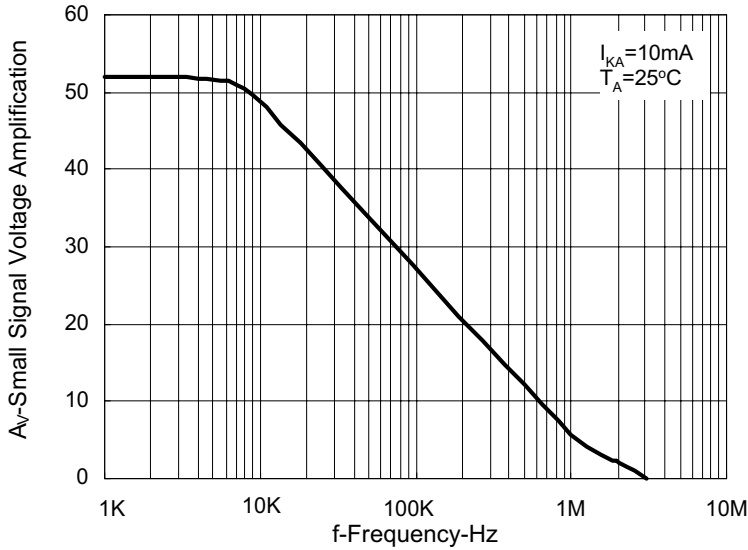
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Adjustable Precision Shunt Regulator



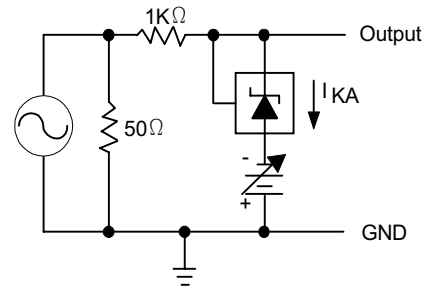
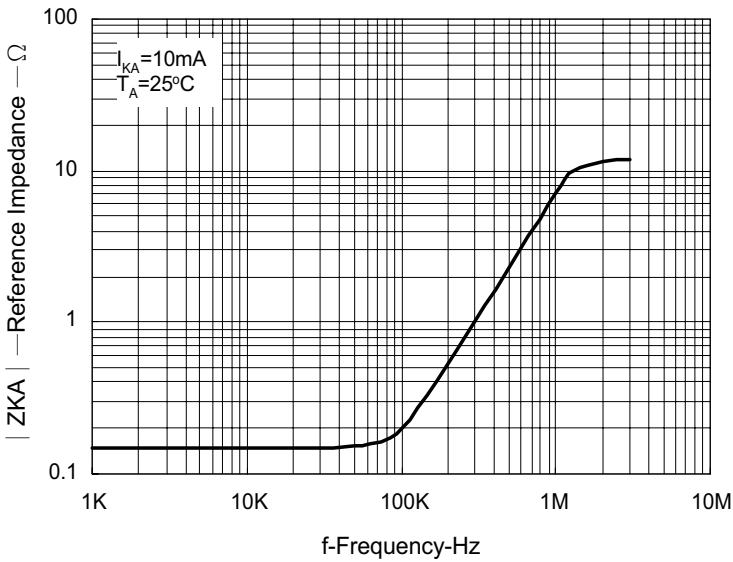
## ■ Typical Performance Characteristics (Continued)

SMALL-SIGNAL VOLTAGE AMPLIFICATION vs. FREQUENCY



TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

REFERENCE IMPEDANCE vs. FREQUENCY



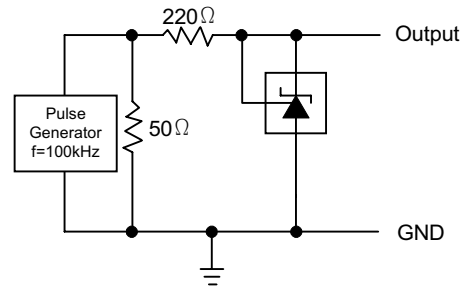
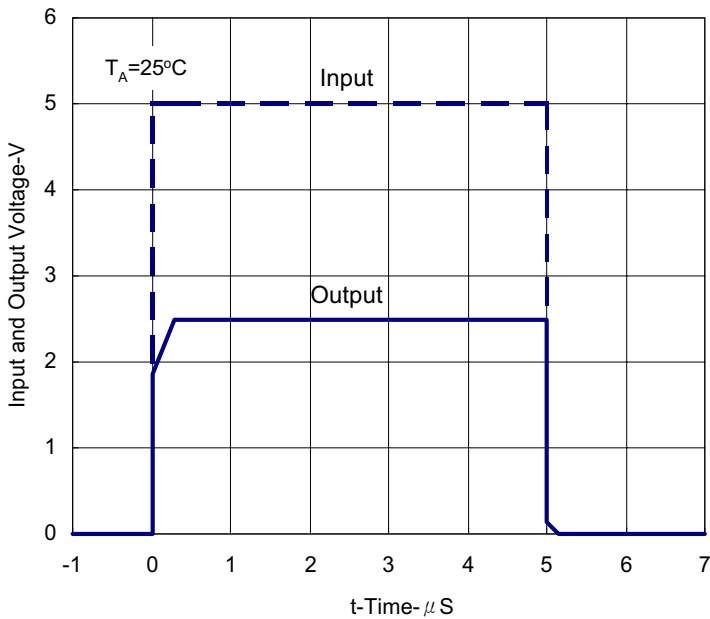
TEST CIRCUIT FOR REFERENCE IMPEDANCE

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## Adjustable Precision Shunt Regulator

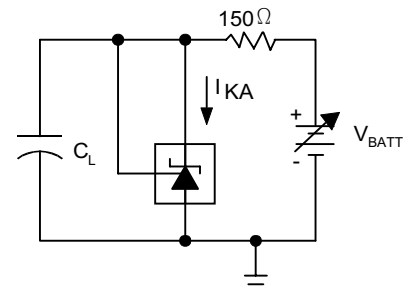
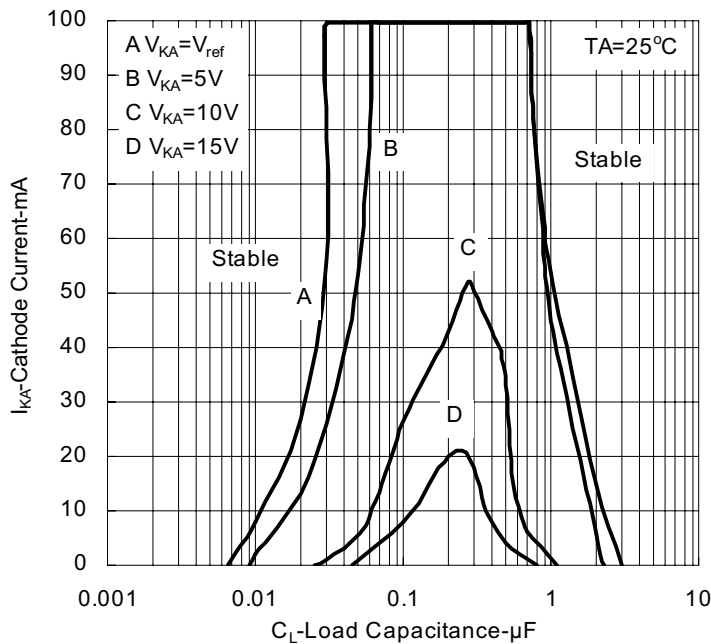


### PULSE RESPONSE

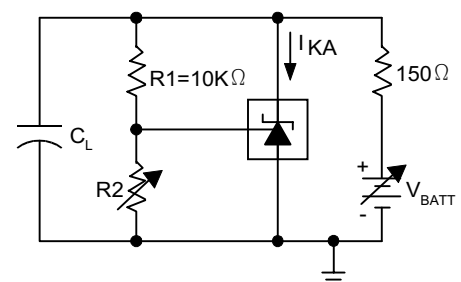


TEST CIRCUIT FOR PULSE RESPONSE

### STABILITY BOUNDARY CONDITIONS<sup>†</sup>



TEST CIRCUIT FOR CURVE A

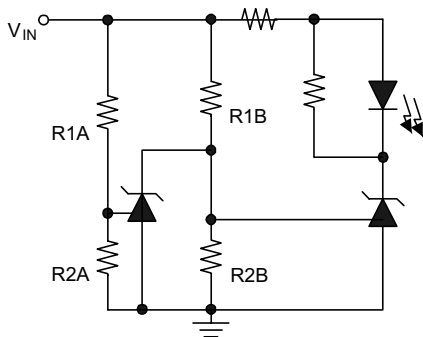


TEST CIRCUIT FOR CURVE B, C, AND D

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

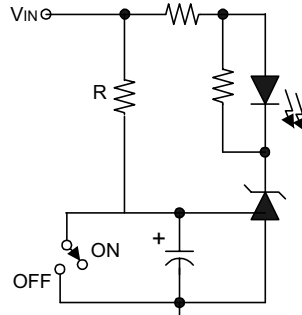


### Application Examples



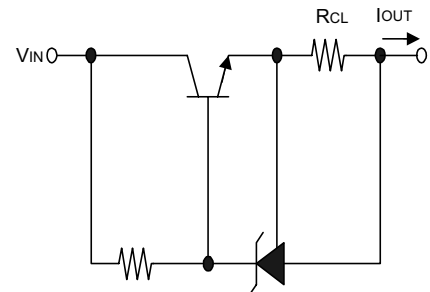
LED on when  $Low\ Limit < V_{IN} < High\ Limit$   
 $Low\ Limit \approx V_{REF} (1 + R1B/R2B)$   
 $High\ Limit \approx V_{REF} (1 + R1A/R2A)$

Fig.4 Voltage Monitor



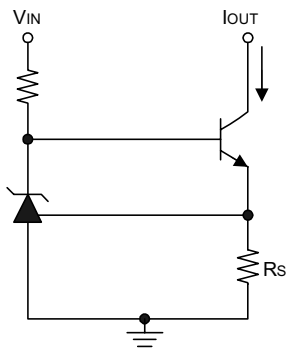
$$Delay = RC \times \ln\left(\frac{V_{IN}}{V_{IN} - V_{REF}}\right)$$

Fig.5 Delay Timer



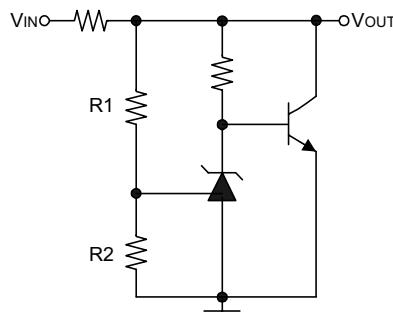
$$I_{OUT} = V_{REF} / R_{CL}$$

Fig.6 Current Limiter or Current Source



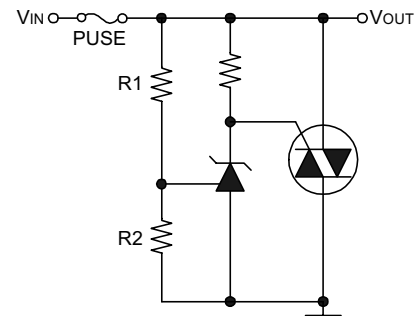
$$I_{OUT} = V_{REF} / R_s$$

Fig.7 Constant-Current Sink



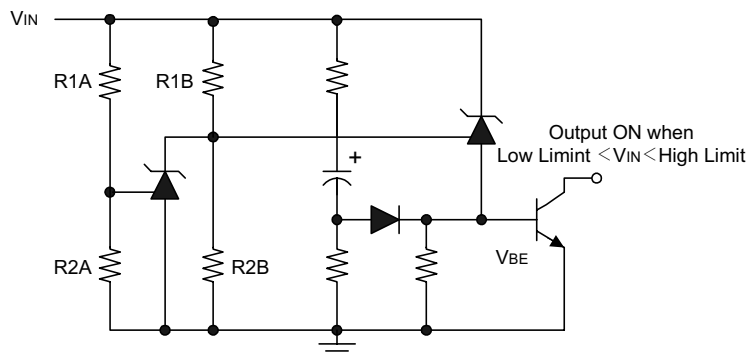
$$V_{OUT} = (1 + R1/R2) \times V_{REF}$$

Fig.8 Higher-Current Shunt Regulator



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

Fig.9 Crow Bar



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

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

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

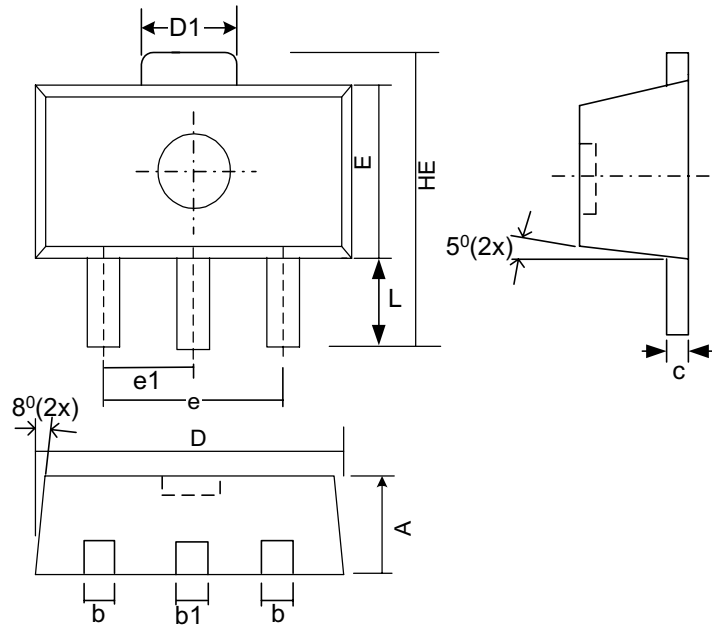
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## Adjustable Precision Shunt Regulator



### ■ Package Diagrams

(1) SOT89-3L Package Outline Dimension



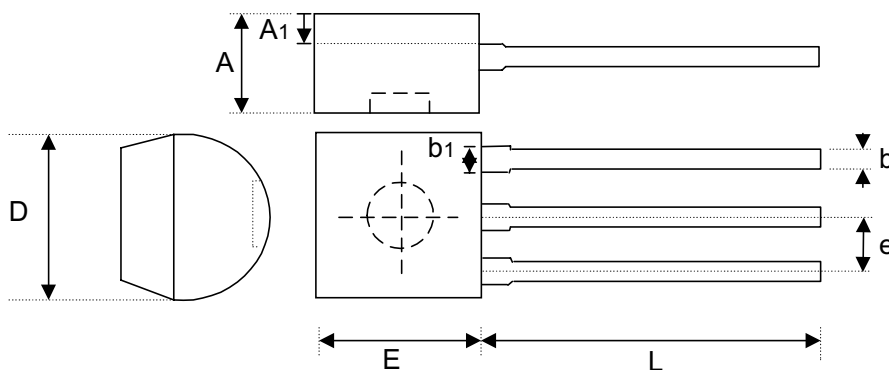
SYMBOLS	DIMENSIONS IN MILLMETER			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.40	1.50	1.60	0.055	0.059	0.063
B	0.36	0.42	0.48	0.014	0.016	0.018
b1	0.41	0.47	0.53	0.016	0.043	0.051
C	0.38	0.40	0.43	0.014	0.015	0.017
D	4.40	4.50	4.60	0.173	0.177	0.181
D1	1.40	1.60	1.75	0.055	0.062	0.069
E	2.90	3.00	3.10	0.114	0.118	0.122
e1	1.45	1.50	1.55	0.057	0.059	0.061
E	2.40	2.50	2.60	0.094	0.098	0.102
HE	3.94	-----	4.25	0.155	-----	0.167
L	0.80	-----	1.20	0.031	-----	0.047

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### (2) TO92-3L Package Outline Dimension



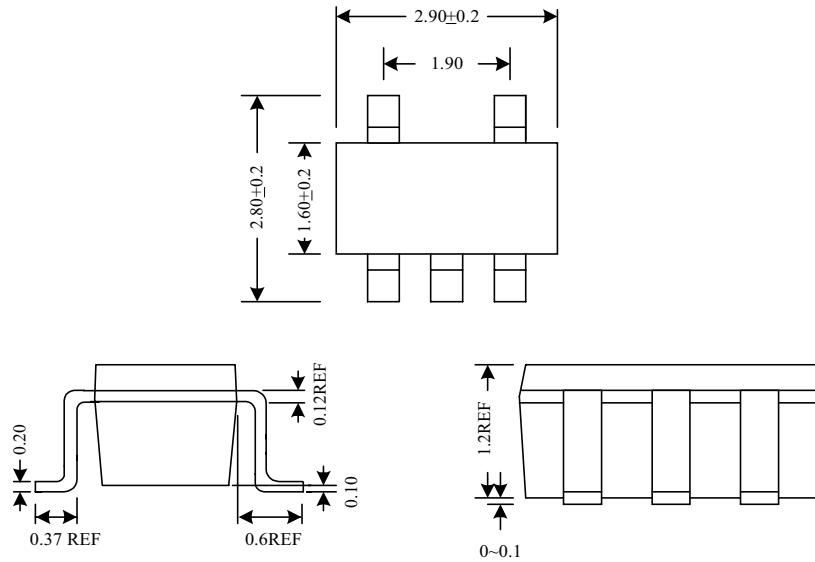
SYMBOLS	DIMENSIONS IN MILLMETER			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	3.302	3.556	3.810	0.130	0.140	0.150
A1	1.016	-----	-----	0.040	-----	-----
b	0.330	0.381	0.432	0.013	0.015	0.017
b1	0.406	0.457	0.506	0.016	0.018	0.020
D	4.445	4.572	4.699	0.175	0.180	0.185
E	4.445	4.572	4.699	0.175	0.180	0.185
L	13.00	-----	15.50	0.512	-----	0.610
e	1.150	-----	1.390	0.045	-----	0.055

# AP431/AP431A

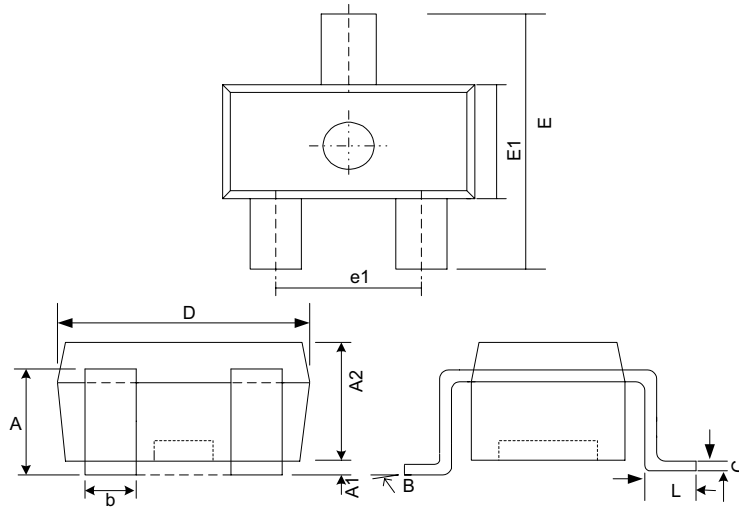
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### (3) SOT23-5L Package Outline Dimension



### (4) SOT23-3L Package Outline Dimension



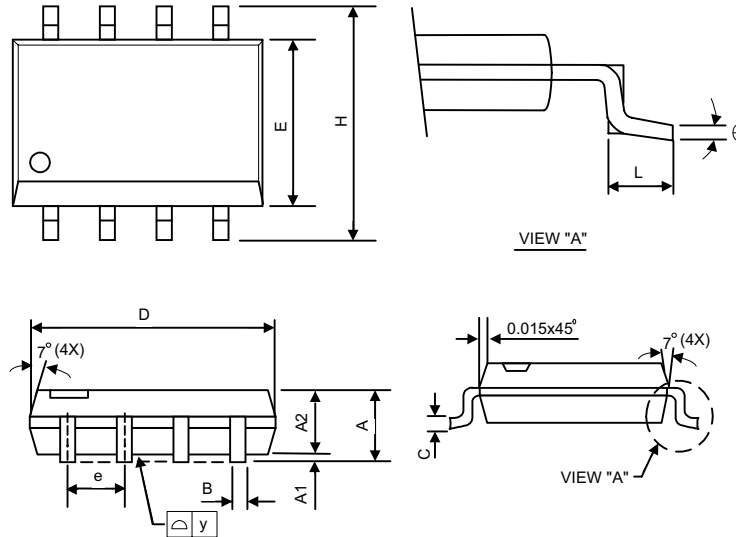
SYMBOLS	DIMENSIONS IN MILLIMETER			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.70	0.80	0.90	0.028	0.031	0.035
A1	0.00	-----	0.10	0.000	-----	0.004
A2	1.00	1.15	1.30	0.039	0.045	0.051
b	0.35	-----	0.50	0.014	-----	0.020
C	0.10	0.175	0.25	0.004	0.007	0.010
D	2.70	2.90	3.10	0.106	0.114	0.122
E1	1.40	1.60	1.80	0.055	0.063	0.071
e1	1.70	1.90	2.10	0.067	0.075	0.083
E	2.80	2.90	3.00	0.110	0.114	0.118
L	0.35	0.45	0.55	0.014	0.018	0.022
B	0°	5°	9°	0°	5°	9°

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## Adjustable Precision Shunt Regulator



### (5) SOP-8L Package Outline Dimension



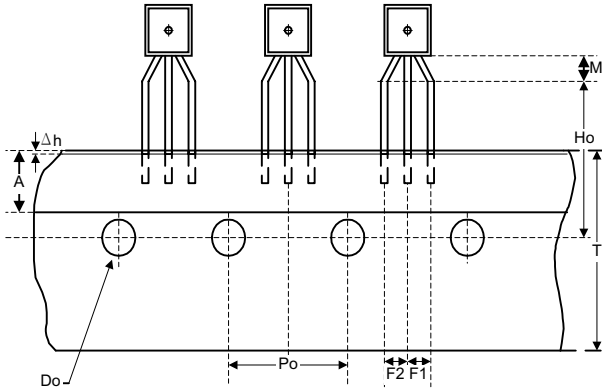
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.40	1.60	1.75	0.055	0.063	0.069
A1	0.10	—	0.25	0.040	—	0.100
A2	1.30	1.45	1.50	0.051	0.057	0.059
B	0.33	0.41	0.51	0.013	0.016	0.020
C	0.19	0.20	0.25	0.0075	0.008	0.010
D	4.80	4.85	5.05	0.189	0.191	0.199
E	3.80	3.91	4.00	0.150	0.154	0.157
e	—	1.27	—	—	0.050	—
H	5.79	5.99	6.20	0.228	0.236	0.244
L	0.38	0.71	1.27	0.015	0.028	0.050
y	—	—	0.10	—	—	0.004
θ	0°	—	8°	0°	—	8°

# AP431/AP431A

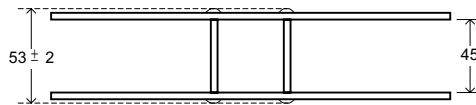
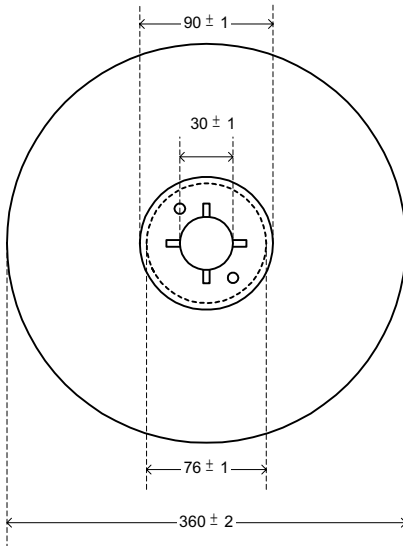
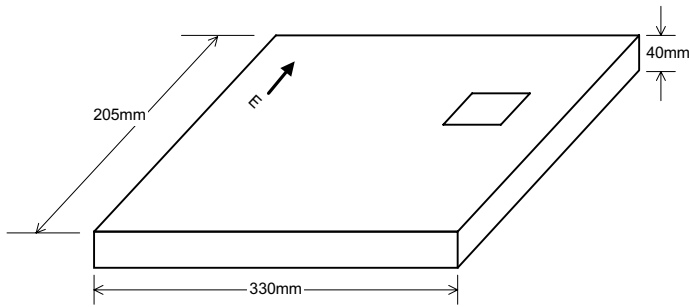
## Adjustable Precision Shunt Regulator



### ■ Taping Information



	MILLIMETERS		
	MIN	TYP	MAX
Po	12.4	12.7	13.0
M	2.0	2.5	3.0
Ho	15.5	16.0	16.5
D	-	4.0	-
A	-	6.0	-
$\Delta h$	0.0	-	1.0
T	-	18.0	-
F1	2.4	2.5	2.9
F2	2.4	2.5	2.9



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