AP431/AP431A

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: 300 μA
- Equivalent full-range temp. coefficient: 30 ppm/°C
- Fast turn-on response
- Low dynamic output impedance: 0.2 Ω
- 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 Ω. 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

A P 4 3 1 X X X X

Operating Temperature Range	Reference Voltage	Package	Packing
Blank : -20°C~85°C I : -40°C~85°C	Tolerance: Blank : +/- 1% A : +/- 0.5%	Blank : SOP-8L Y : SOT89-3L V : TO92-3L W : SOT23-3L R : SOT23-3L Q : SOT25	Blank : Tube or bulk A : Taping

■ Typical Application Circuit

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

Precision Regulator

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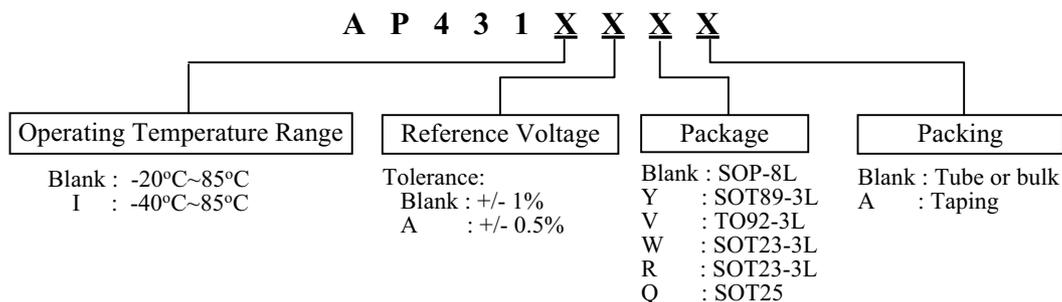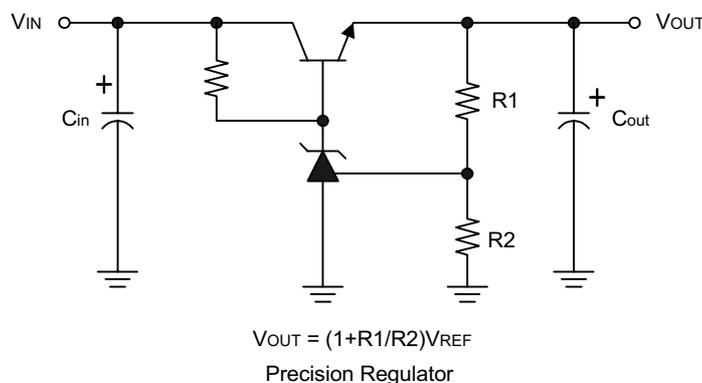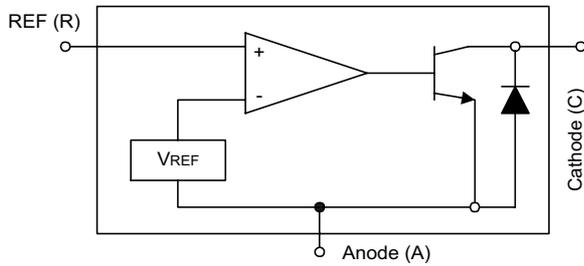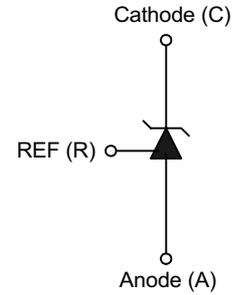
AP431/AP431A

Adjustable Precision Shunt Regulator

■ Block Diagram

■ Symbol

■ Pin Configuration

Order Number	Pin Configuration (Top View)
AP431Y AP431AY AP431IY AP431IAY (SOT89)	3 Cathode 2 Anode 1 REF
AP431V AP431AV AP431IV AP431IAV (TO92)	3 Cathode 2 Anode 1 REF
AP431 AP431A AP431I AP431IA (SOP)	Cathode 1 — 8 REF Anode 2 — 7 Anode Anode 3 — 6 Anode NC 4 — 5 NC

Order Number	Pin Configuration (Top View)
AP431R AP431AR AP431IR AP431IAR (SOT23)	Anode 1 — 3 Cathode 2 REF
AP431W AP431AW AP431IW AP431IAW (SOT23)	Anode 1 — 3 REF 2 Cathode
AP431Q AP431AQ AP431IQ AP431IAQ (SOT25)	NC 1 — 5 Anode NC 2 — Cathode 3 — 4 REF

AP431/AP431A
Adjustable Precision Shunt Regulator

ATC

■ Marking Information

(1) SOT23 / SOT25 / SOT89

P/N Type	:	X X
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

(Top View)

SOT23/SOT25   SOT89

XX YM   XX
                   YM

⟶ XX: P/N Type

⟶ Date code
   Y : Year
   M : Month

(2) SOP

(Top view)

Logo ← ATC
AP431X X
● YYWW

→ Temp. grade

Blank: $-20^0 C \sim +85^0 C$
I   : $-40^0 C \sim +85^0 C$

Date code ←

YY : Year
WW: Nth week

→ Accuracy

Blank: $2.495 \pm 1\%$
A : $2.495 \pm 0.5\%$

(2) TO92

(Top view)

Logo ← ATC
AP431X
X YWW X X

→ Temp. grade

X = Blank: $-20^0 C \sim +85^0 C$
X = I   : $-40^0 C \sim +85^0 C$

Accuracy	Date code	Internal code
Blank: $2.495 \pm 1\%$	Y : Year	XX: $2.495 \pm 1\%$
A : $2.495 \pm 0.5\%$	WW: Nth week	X : $2.495 \pm 0.5\%$
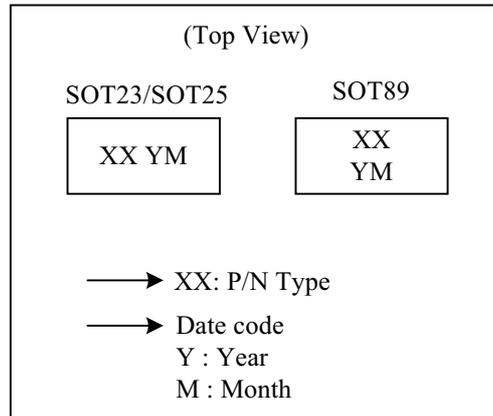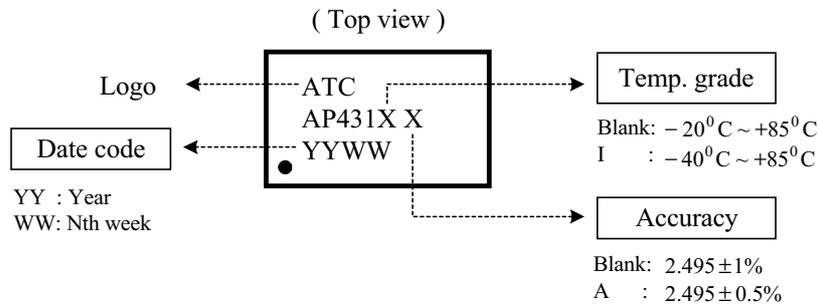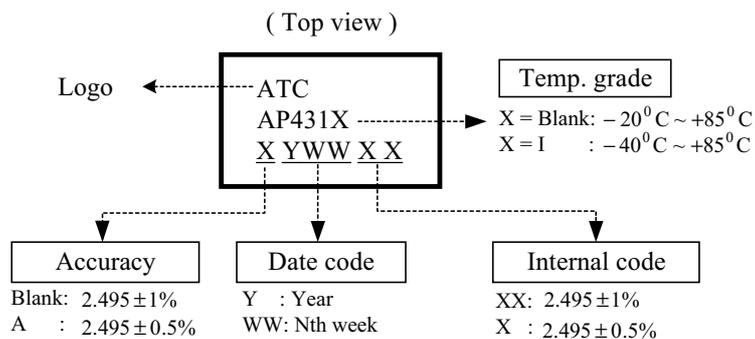
AP431/AP431A

Adjustable Precision Shunt Regulator

■ 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: TJ, 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_{KA} = VRef, I_{KA} = 10mA (Fig.1)	AP431	V_{REF}	2.470	2.495	2.520	V
		AP431A		2.482		2.507	
Deviation of Reference input voltage over temperature (Note 3)	V_{KA} = V_{REF} , I_{KA} = 10mA , Ta = 0°C ~ + 70°C (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} =1mA ~ 100mA Frequency$\leq$ 1KHz (Fig.1)		$|Z_{KA}|$		0.2	0.5	Ω
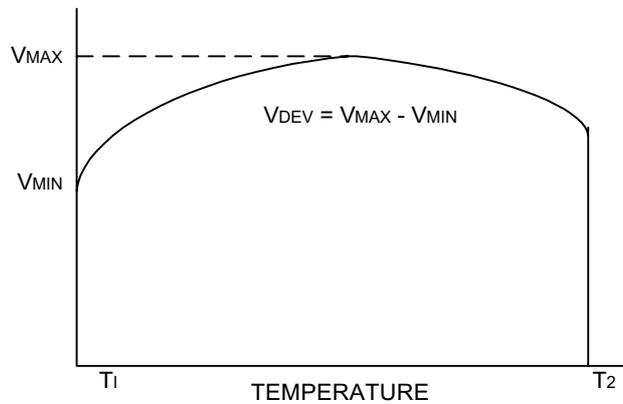
Note 3. Deviation of reference input voltage, V_{DEV}, is defined as the maximum variation of the reference over the full temperature range.

The average temperature coefficient of the reference input voltage αV_{REF} is defined as:

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

Where:

T2 – T1 = full temperature change.

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

Note 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:

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

■ Test Circuits
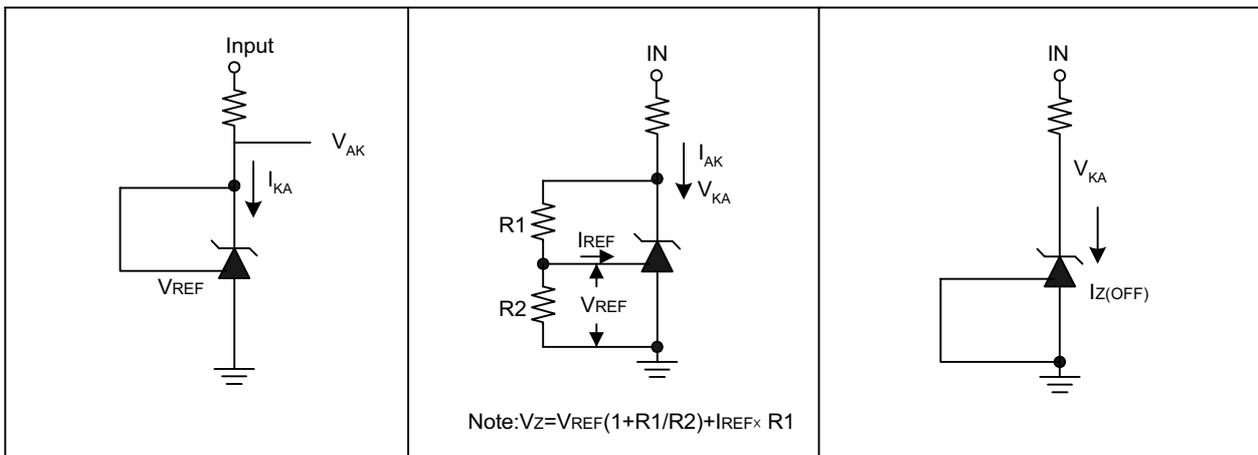
Fig1. Test Circuit for $V_{KA} = V_{REF}$ Fig2. Test circuit for $V_{KA} > V_{REF}$ Fig3. Test Circuit for off-state Current

■ Typical Performance Characteristics

Cathode current Vs Cahode Voltage

Cathode current (uA)

Reference Voltage Vs Free-Air Temperature

Reference input current Vs free Temperature

Change in Reference Voltage vs Cathode Voltage
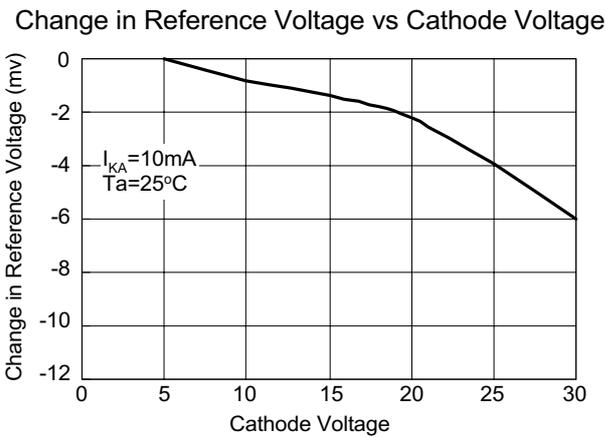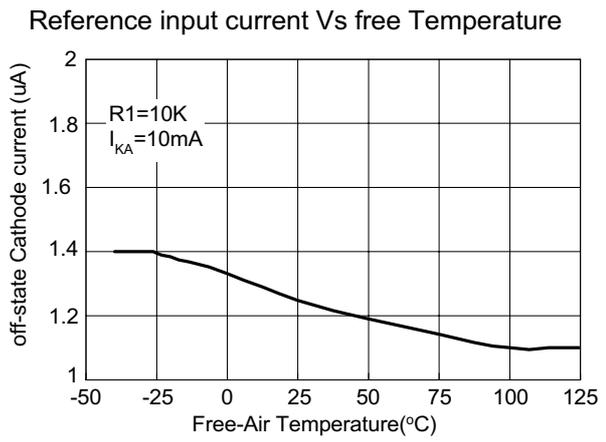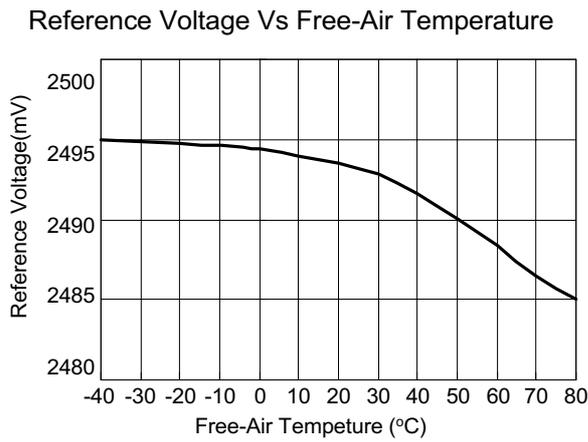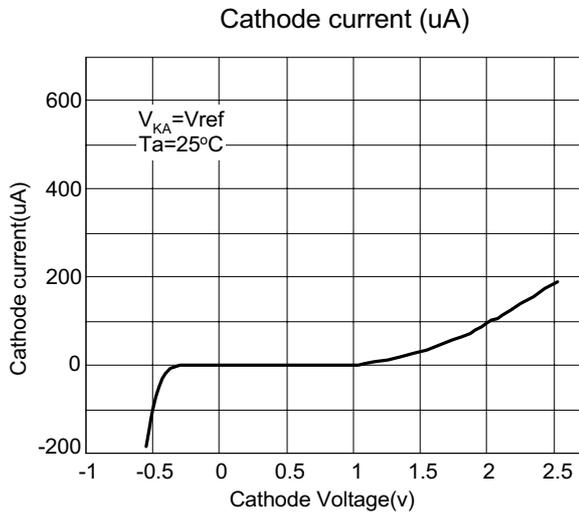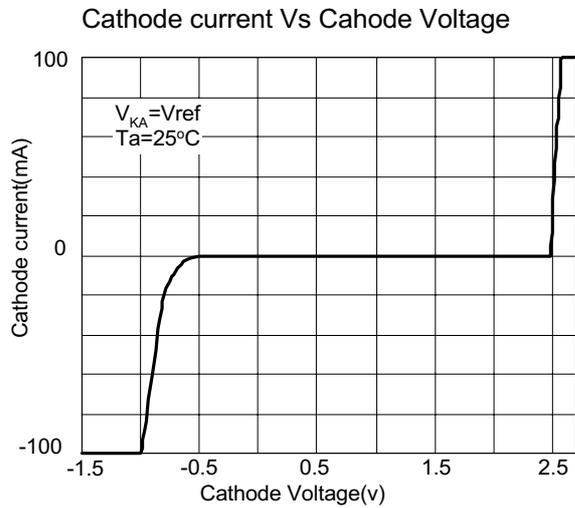
■ Typical Performance Characteristics (Continued)

SMALL-SIGNAL VOLTAGE AMPLIFICATION vs. FREQUENCY

I_{KA}=10mA
T_A=25°C
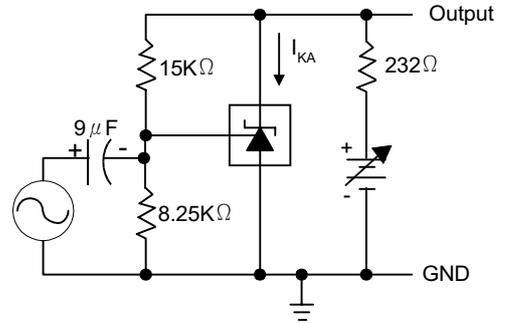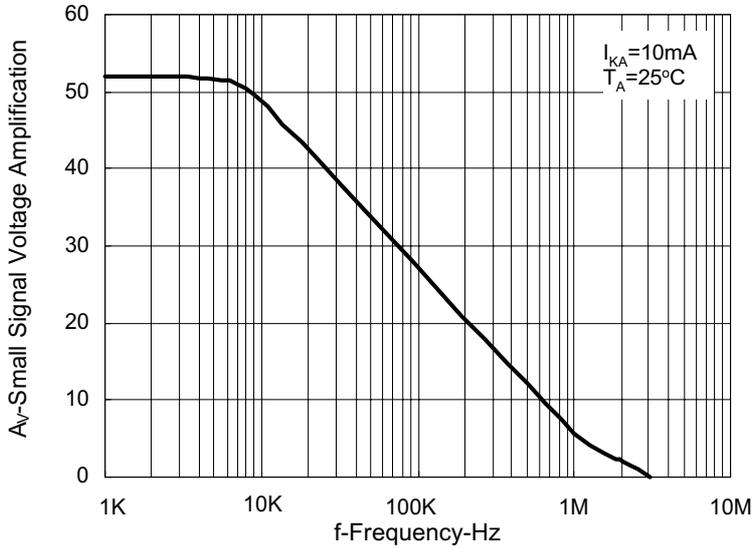
TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

REFERENCE IMPEDANCE vs. FREQUENCY

I_{KA}=10mA
T_A=25°C
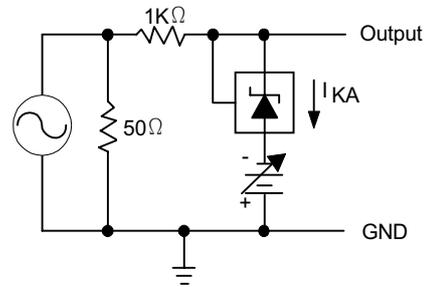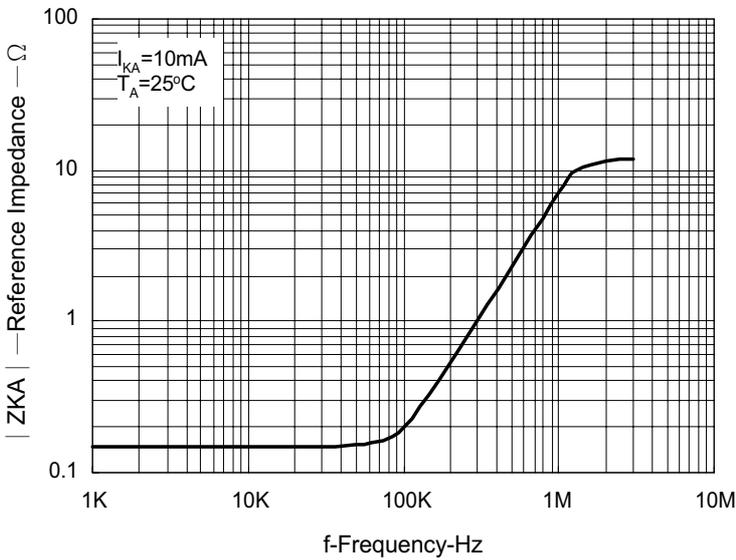
TEST CIRCUIT FOR REFERENCE IMPEDANCE

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PULSE RESPONSE

$T_A=25^oC$

Input

Output

Input and Output Voltage-V

t-Time-μS

220Ω

Pulse Generator f=100kHz

50Ω

Output

GND
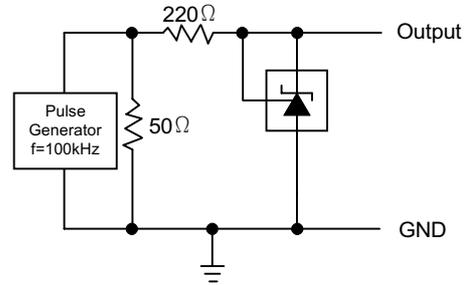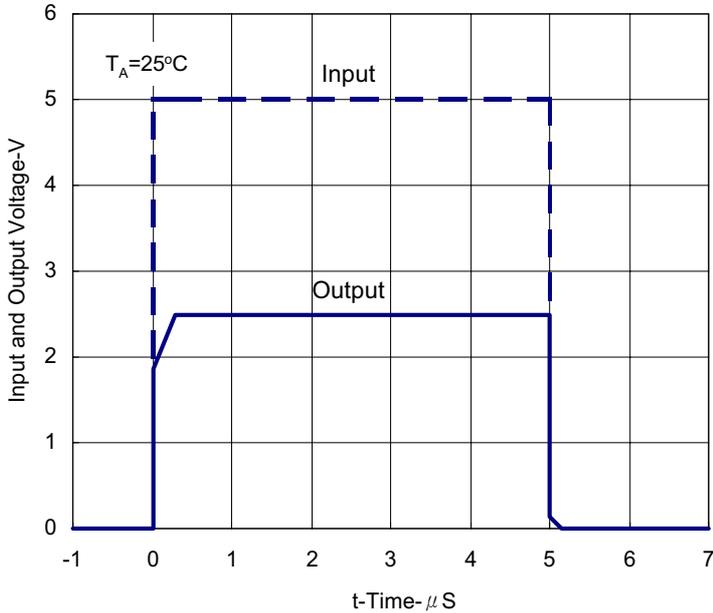
TEST CIRCUIT FOR PULSE RESPONSE

STABILITY BOUNDARY CONDITIONS†

A $V_{KA}=V_{ref}$
B $V_{KA}=5V$
C $V_{KA}=10V$
D $V_{KA}=15V$

TA=25°C

Stable

Stable

I_{KA}-Cathode Current-mA

A

B

C

D

C_L-Load Capacitance-μF

150Ω

I_{KA}

C_L

V_{BATT}

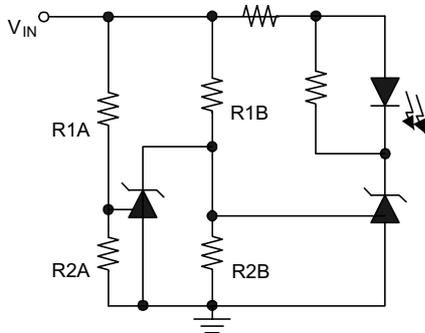TEST CIRCUIT FOR CURVE A

R1=10KΩ

I_{KA}

150Ω

C_L

R2

V_{BATT}
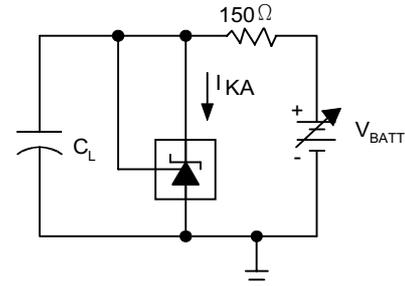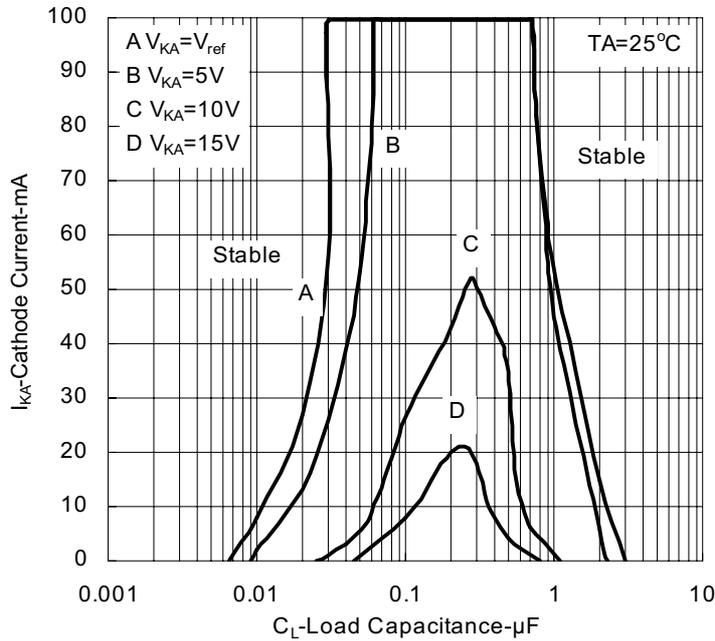
TEST CIRCUIT FOR CURVE B, C, AND D

†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.
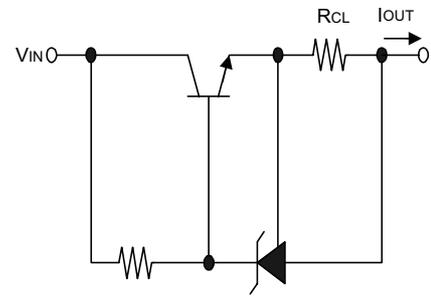
■ Application Examples

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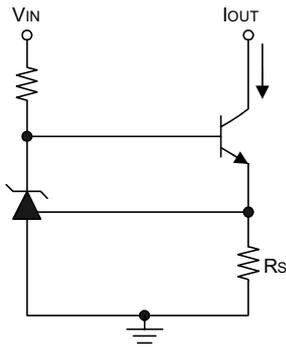High Limit $\approx$ V_{REF} (1+R1A/R2A)

Fig.4 Voltage Monitor
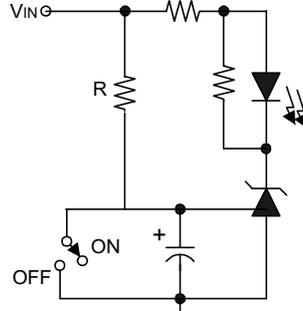
Delay = RC x ln($\frac{V_{IN}}{V_{IN} - V_{REF}}$)
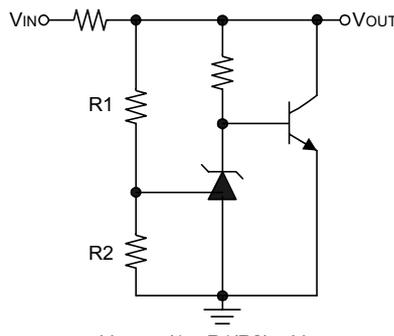
Fig.5 Delay Timer

I_{OUT} = V_{REF} / R_{CL}
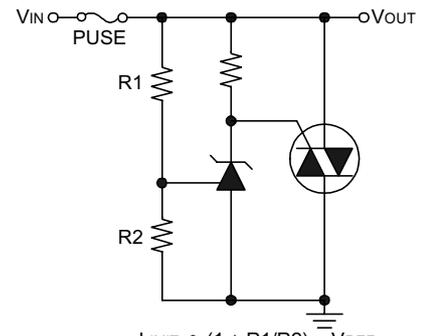
Fig.6 Current Limiter or Current Source

I_{OUT} = V_{REF} / R_S

Fig.7 Constant-Current Sink

V_{OUT} = (1 + R1/R2) × V_{REF}

Fig.8 Higher-Current Shunt Regulator

L_{IMIT} $\approx$ (1 + R1/R2) × V_{REF}

Fig.9 Crow Bar

Output ON when
Low Limint $<$ V_{IN} $<$ High Limit
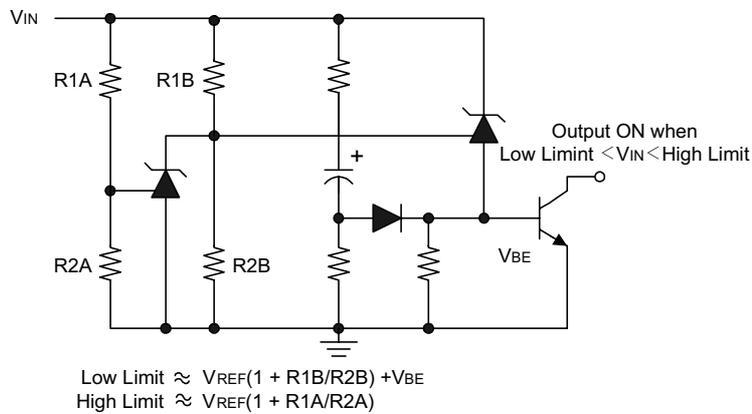
Low Limit $\approx$ V_{REF}(1 + R1B/R2B) +V_{BE}
High Limit $\approx$ V_{REF}(1 + R1A/R2A)

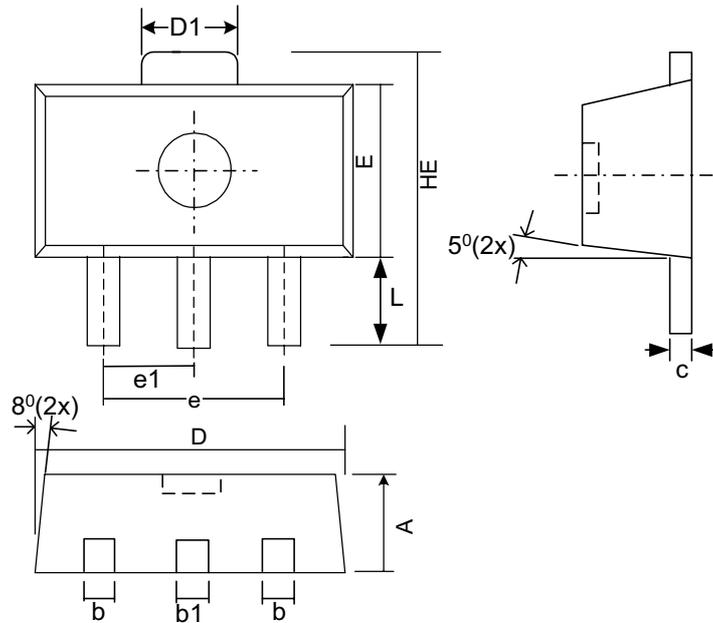Fig.10 Over-Voltage / Under-Voltage Protection Circuit

AP431/AP431A

Adjustable Precision Shunt Regulator

■ Package Diagrams

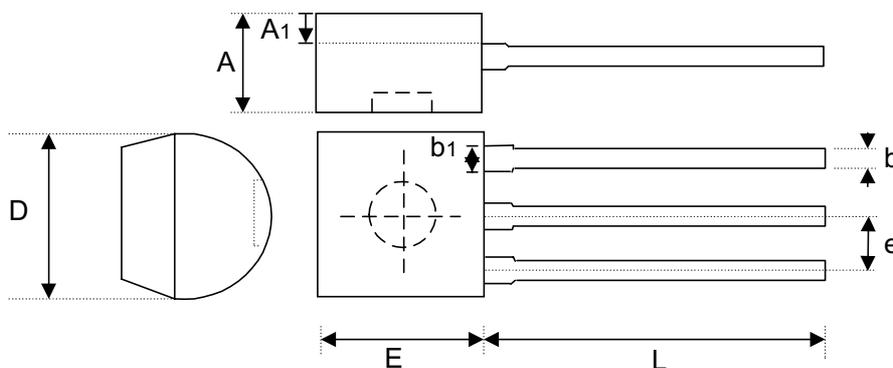(1) SOT89-3L   Package Outline Dimension

SYMBLOS	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

AP431/AP431A
Adjustable Precision Shunt Regulator

(2) TO92-3L Package Outline Dimension

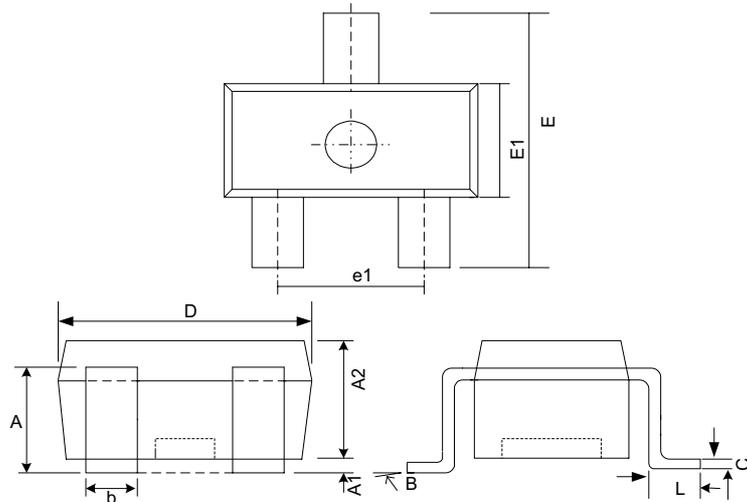| SYMBLOS	DIMENSIONS IN MILLMETER			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	3.302	3.556	3.810	0.130	0.140	0.150
A1	1.016	----------	----------	0.040	----------	----------
b	0.330	0.381	0.432	0.013	0.015	0.017
b1	0.406	0.457	0.506	0.016	0.018	0.020
D	4.445	4.572	4.699	0.175	0.180	0.185
E	4.445	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

Adjustable Precision Shunt Regulator

(3) SOT23-5L   Package Outline Dimension


(4) SOT23-3L   Package Outline Dimension

SYMBLOS	DIMENSIONS IN MILLMETER			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	0^0	5^0	9^0	0^0	5^0	9^0

(5) SOP-8L   Package Outline Dimension

VIEW "A"

0.015x45°

7° (4X)

VIEW "A"
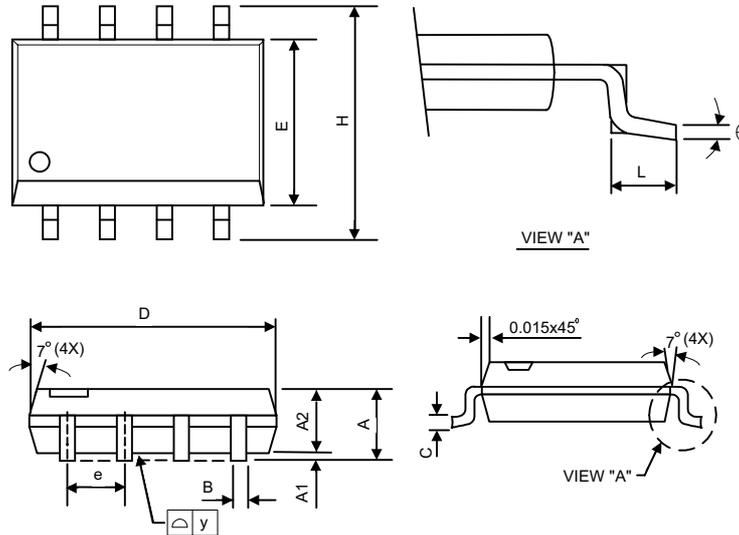
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.40	1.60	1.75	0.055	0.063	0.069
A1	0.10	–	0.25	0.040	–	0.100
A2	1.30	1.45	1.50	0.051	0.057	0.059
B	0.33	0.41	0.51	0.013	0.016	0.020
C	0.19	0.20	0.25	0.0075	0.008	0.010
D	4.80	4.85	5.05	0.189	0.191	0.199
E	3.80	3.91	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°

ATC

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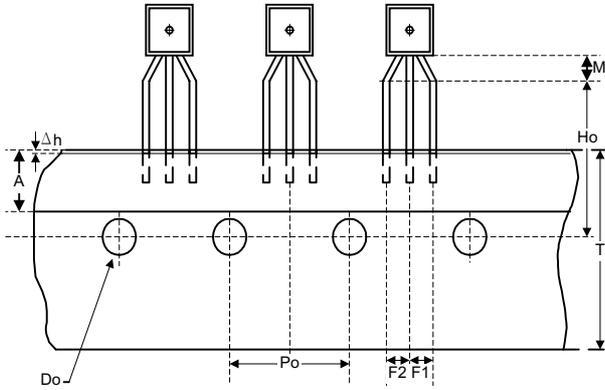
	MILLIMETERS		
	MIN	TYP	MAX
Po	12.4	12.7	13.0
M	2.0	2.5	3.0
Ho	15.5	16.0	16.5
D	-	4.0	-
A	-	6.0	-
△h	0.0	-	1.0
T	-	18.0	-
F1	2.4	2.5	2.9
F2	2.4	2.5	2.9