



**ADJUSTABLE PRECISION SHUNT REGULATOR**

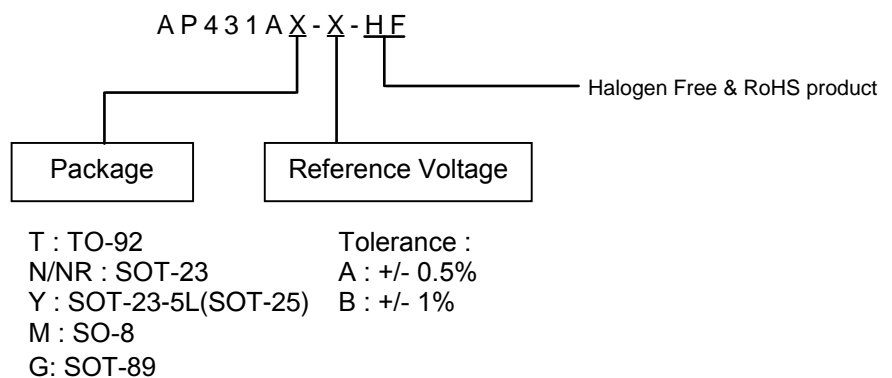
**■ Features**

- Precision reference voltage  
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: 0.2Ω
- Programmable output voltage to 36V
- Low output noise.
- Packages: TO-92, SOT-23, SOT-23-5L(SOT-25)  
and SO-8 SOT-89
- Halogen Free & RoHS Compliant Product

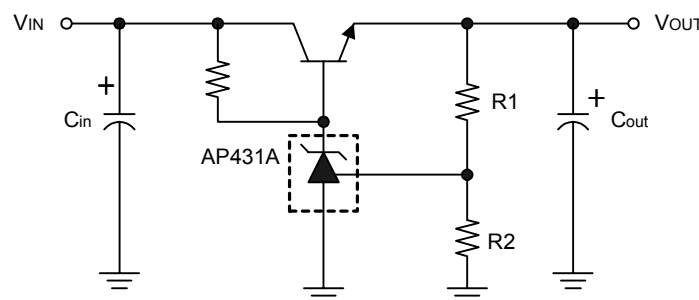
**■ Description**

The 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<sub>REF</sub>) 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 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**



**■ Typical Application Circuit**

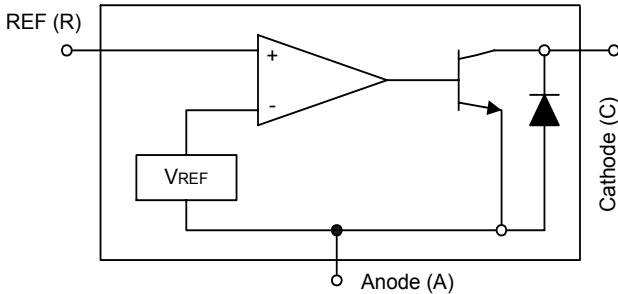


$$V_{OUT} = (1 + R1/R2)V_{REF}$$

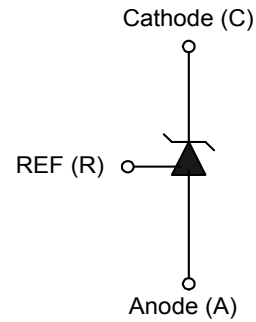
Precision Regulator



■ **Block Diagram**



■ **Symbol**



■ **Pin Configuration**

Order Number	Pin Configuration ( Top View )	Order Number	Pin Configuration ( Top View )
<p><b>AP431AT</b> ( TO-92 )</p> <p>Rthja=160°C/W Rthjl=60°C/W</p>	<p>3 Cathode 2 Anode 1 REF</p>	<p><b>AP431AN</b> ( SOT-23 )</p> <p>Rthja=500°C/W Rthjc=180°C/W</p>	<p>Anode 3 2 Cathode 1 REF</p>
<p><b>AP431AM</b> ( SO-8 )</p> <p>Rthja=208°C/W Rthjc=50°C/W</p>	<p>Cathode 1 Anode 2 Anode 3 NC 4 8 REF 7 Anode 6 Anode 5 NC</p>	<p><b>AP431AY</b> ( SOT-23-5L )</p> <p>Rthja=500°C/W Rthjc=180°C/W</p>	<p>NC 1 NC 2 Cathode 3 5 Anode 4 REF</p>
<p><b>AP431AG</b> ( SOT-89 )</p> <p>Rthja=250°C/W Rthjc=110°C/W</p>	<p>3 Cathode Anode 1 REF 2</p>	<p><b>AP431AY5</b> ( SOT-23-5L )</p> <p>Rthja=500°C/W Rthjc=180°C/W</p>	<p>REF 1 Anode 2 Cathode 3 5 NC 4 NC</p>
<p><b>AP431ANR</b> ( SOT-23 )</p> <p>Rthja=500°C/W Rthjc=180°C/W</p>	<p>Anode 3 2 REF 1 Cathode</p>		

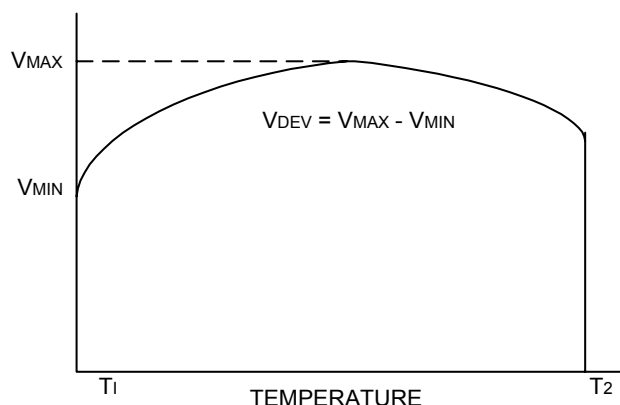


■ **Absolute Maximum Ratings**

Cathode Voltage .....	36V
Continuous Cathode Current .....	-10mA ~ 250mA
Reference Input Current Range .....	10mA
Operating Temperature Range .....	-40°C ~ 85°C
Lead Temperature.....	260°C
Storage Temperature .....	-65°C ~ 150°C
Power Dissipation (Notes 1, 2)	
TO-92 Package .....	0.78W
SOT-23 Package .....	0.25W
SOT-23-5L Package.....	0.25W
SO-8 Package.....	0.6W
SOT-89 Package.....	0.5W
Note 1: T <sub>J</sub> , max = 150°C	
Note 2: Ratings apply to ambient temperature at 25°C	

■ **Electrical Characteristics** (T<sub>a</sub>=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)	-B -A V <sub>REF</sub>	2.470 2.482	2.495	2.520 2.507	V
Deviation of Reference input voltage over temperature (Note 3)	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>KA</sub> = 10mA, T <sub>a</sub> = Full range (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>		-1.4	-2.0	mV/V
		V <sub>KA</sub> = 36V ~10V	ΔV <sub>KA</sub>		-1	-2
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 T <sub>a</sub> = Full range (Fig.2)	αI <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> Frequency ≤ 1KHz (Fig.1)	Z <sub>KA</sub>		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  $\alpha V_{REF}$  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:

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

**■ Test Circuits**

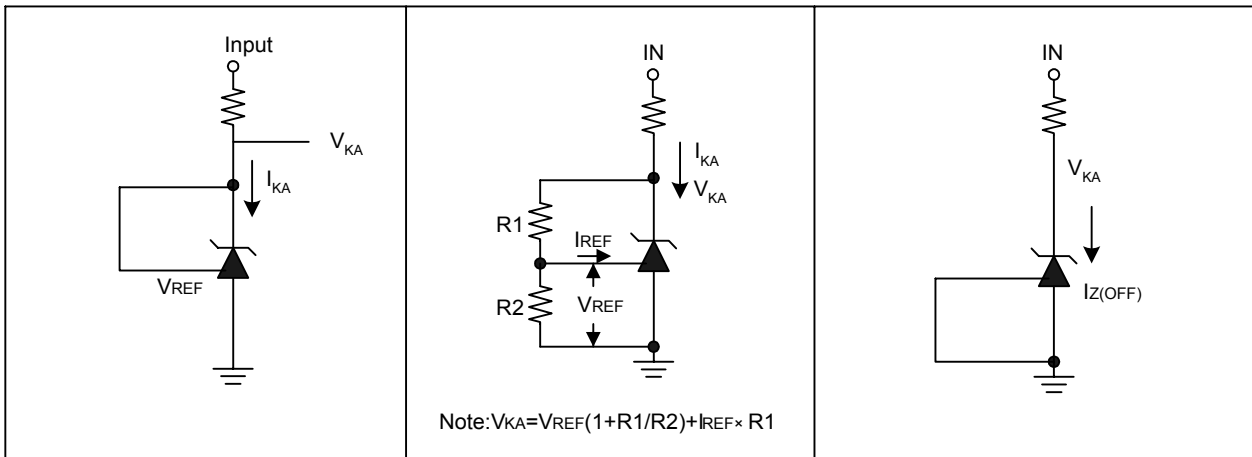


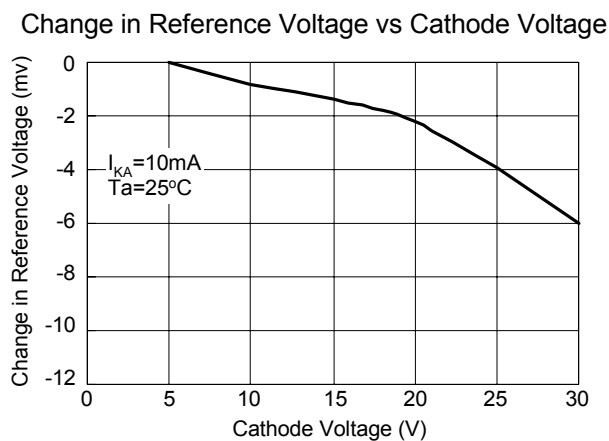
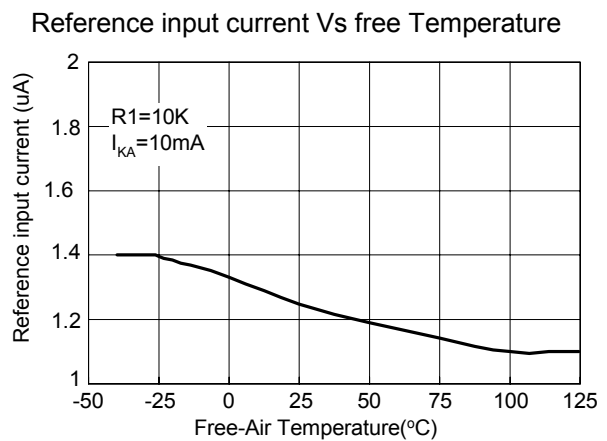
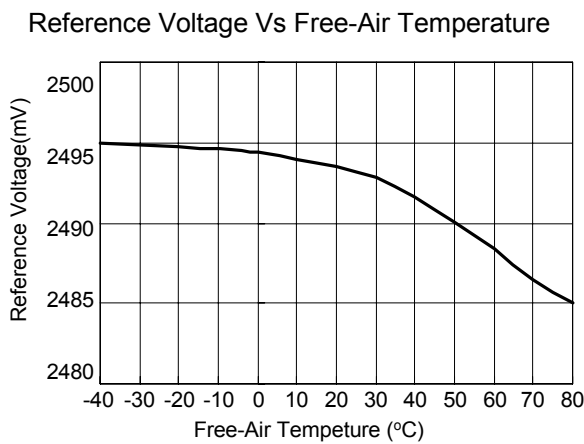
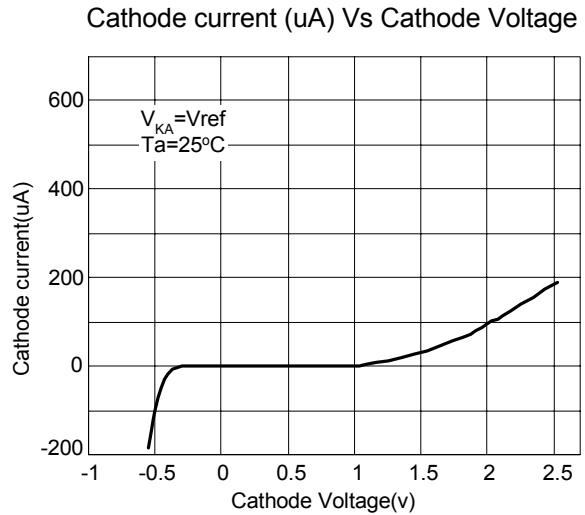
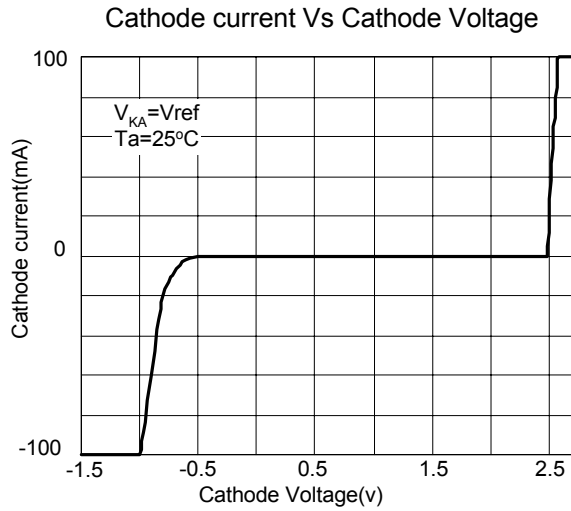
Fig1. Test Circuit for  $V_{KA} = V_{REF}$

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

Fig3. Test Circuit for off-state Current



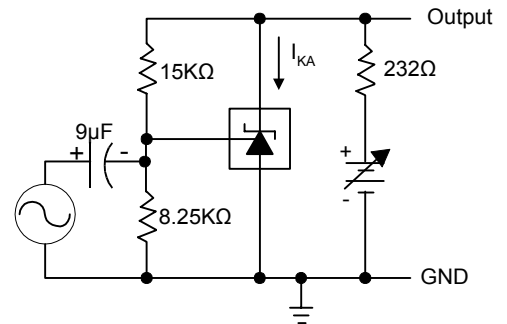
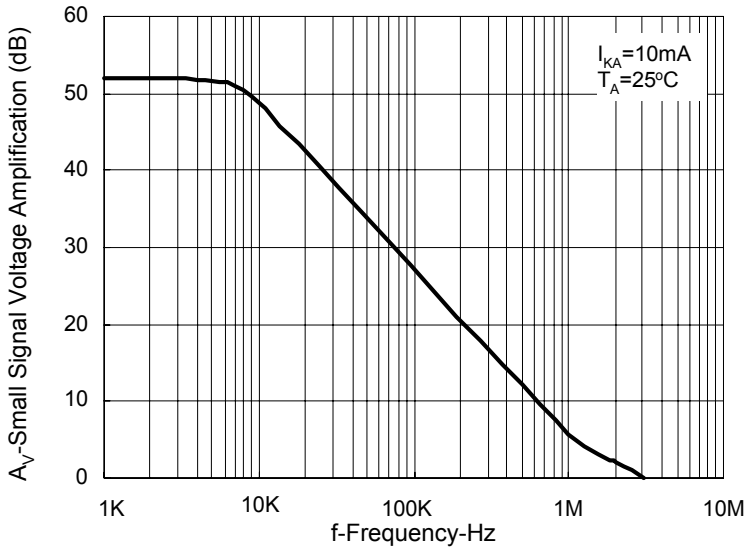
### ■ Typical Performance Characteristics





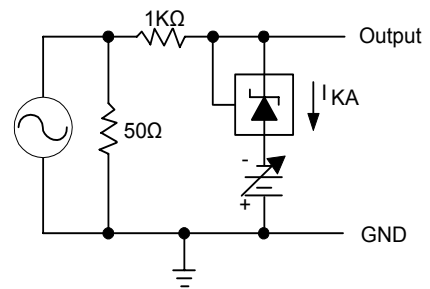
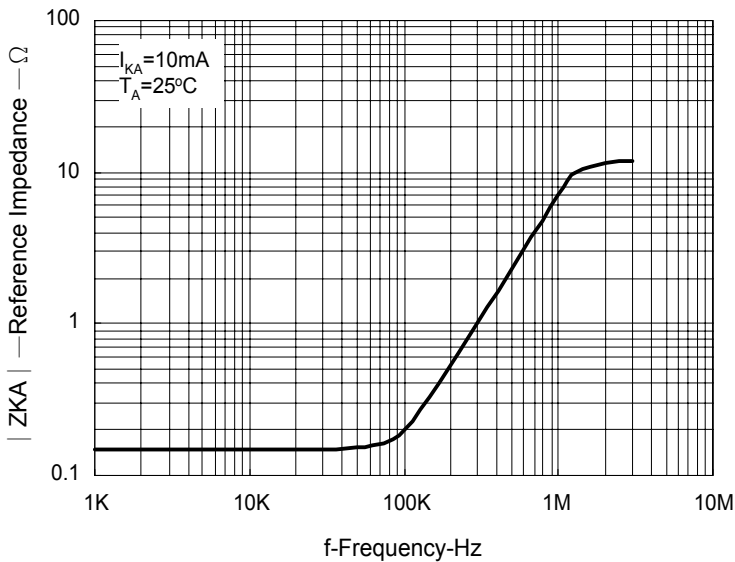
■ Typical Performance Characteristics(Continued)

SMALL-SIGNAL VOLTAGE AMPLIFICATION vs. FREQUENCY



TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

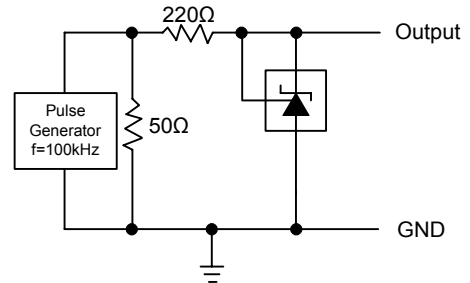
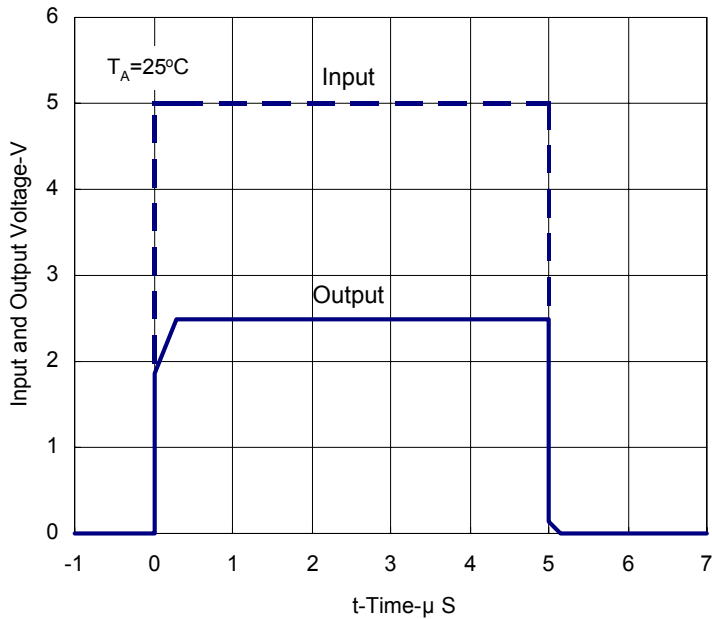
REFERENCE IMPEDANCE vs. FREQUENCY



TEST CIRCUIT FOR REFERENCE IMPEDANCE

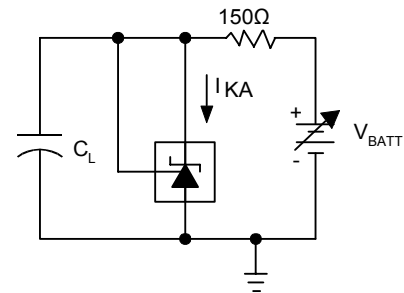
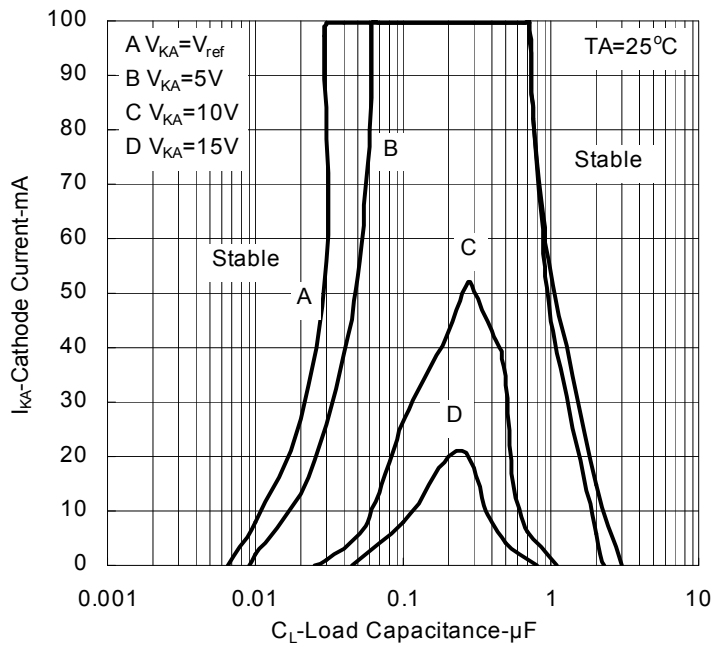


**PULSE RESPONSE**

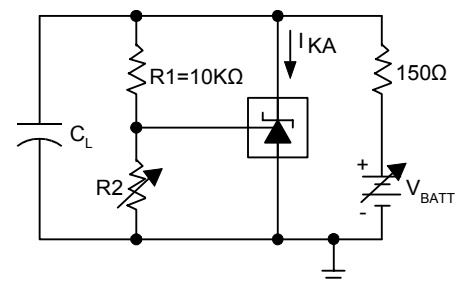


TEST CIRCUIT FOR PULSE RESPONSE

**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,  $R_2$  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 =  $RC \times \ln\left(\frac{V_{IN}}{V_{IN}-V_{REF}}\right)$

Fig.5 Delay Timer

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

Fig.6 Current Limiter or Current Source

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

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

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Output ON when Low Limit <  $V_{IN}$  < High Limit

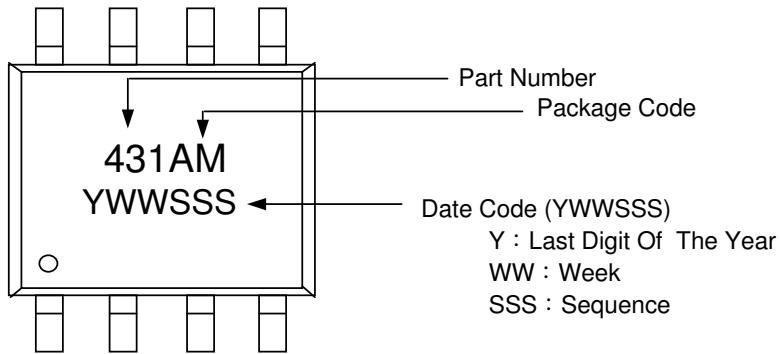
Low Limit  $\approx V_{REF}(1 + R1B/R2B) + V_{BE}$   
 High Limit  $\approx V_{REF}(1 + R1A/R2A)$

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

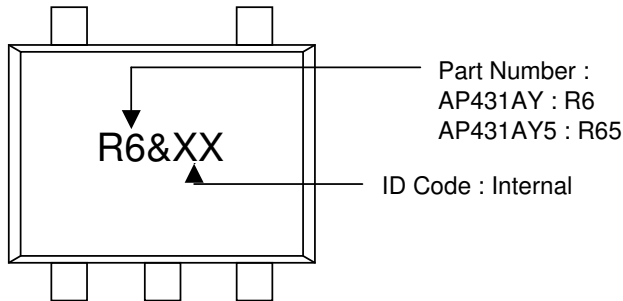


**MARKING INFORMATION**

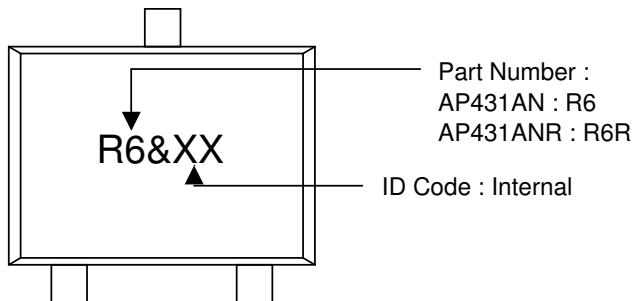
**SO-8**



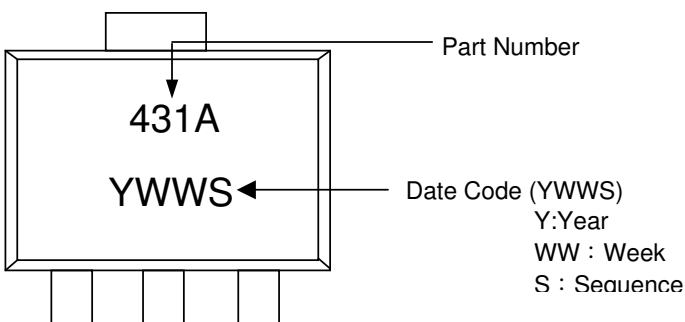
**SOT-23-5L**



**SOT-23**



**SOT-89**





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**MARKING INFORMATION**

TO-92

