



# 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

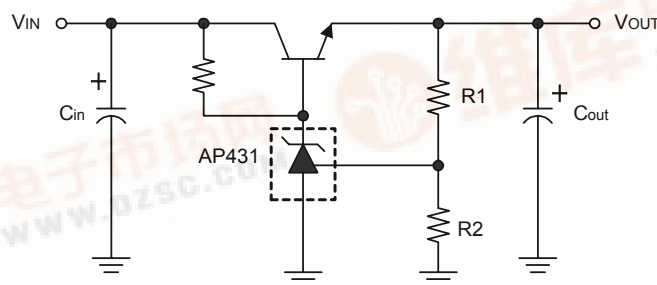
The AP431/AP431A are 3-terminal adjustable precision shunt regulators with guaranteed temperature stability over the applicable extended commercial temperature range. The output voltage may be set at any level greater than  $2.495V(V_{REF})$  up to 36V merely by selecting two external resistors that act as a voltage divider network. These devices have a typical output impedance of  $0.2\Omega$ . Active output circuitry provides 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 X                                                            |                                                    |                                                                                            |                                         |                                    |
|--------------------------------------------------------------------------------|----------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------|------------------------------------|
| Operating Temp. Range                                                          | Reference Voltage                                  | Package                                                                                    | Lead Free                               | Packing                            |
| Blank : $-20^{\circ}C \sim 85^{\circ}C$<br>I : $-40^{\circ}C \sim 85^{\circ}C$ | Tolerance:<br>Blank : $\pm 1\%$<br>A : $\pm 0.5\%$ | Blank : SOP-8L<br>Y : SOT89-3L<br>V : TO92-3L<br>W : SOT23-3L<br>R : SOT23-3L<br>Q : SOT25 | Blank : Normal<br>L : Lead Free Package | Blank : Tube or bulk<br>A : Taping |

### ■ Typical Application Circuit



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

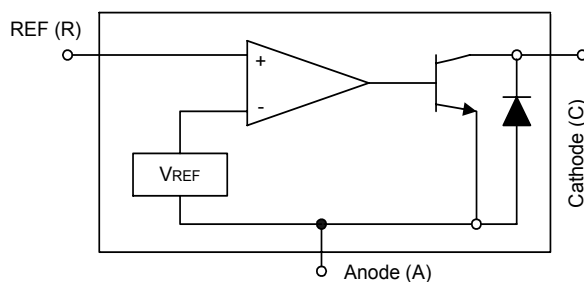
Precision Regulator



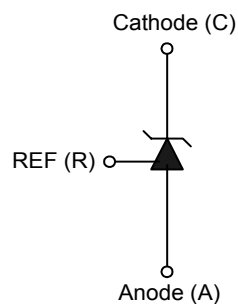
# AP431/AP431A

## Adjustable Precision Shunt Regulator

### ■ Block Diagram



### ■ Symbol



### ■ Pin Configuration

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



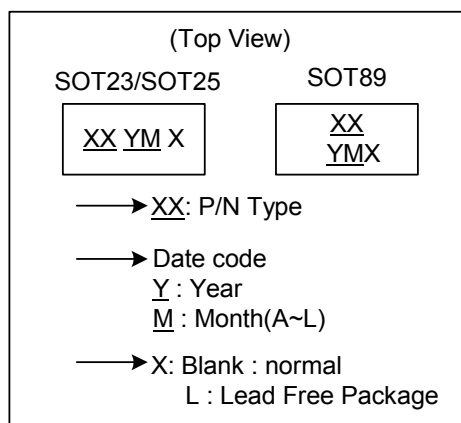
# AP431/AP431A

## Adjustable Precision Shunt Regulator

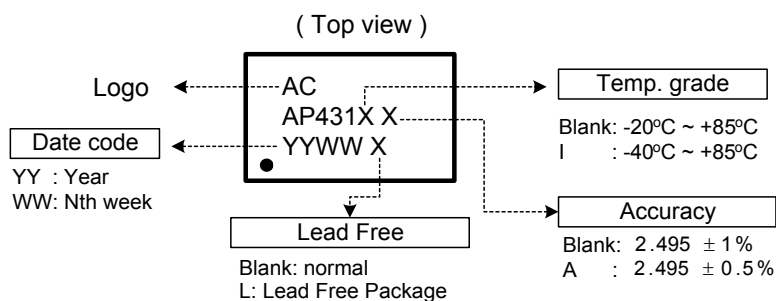
### ■ Marking Information

#### (1) SOT23 / SOT25 / SOT89

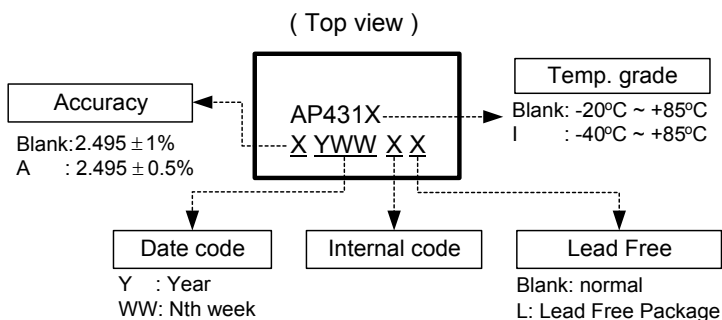
| P/N Type | X X |
|----------|-----|
| AP431Y   | A 4 |
| AP431AY  | A 5 |
| AP431IY  | A A |
| AP431IAY | A B |
| AP431W   | A 6 |
| AP431AW  | A 7 |
| AP431IW  | A C |
| AP431IAW | A D |
| AP431R   | A 8 |
| AP431AR  | A 9 |
| AP431IR  | A E |
| AP431IAR | A F |
| AP431Q   | A 2 |
| AP431AQ  | A 3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



#### (2) SOP



#### (3) TO92





# AP431/AP431A

## Adjustable Precision Shunt Regulator

### ■ Absolute Maximum Ratings

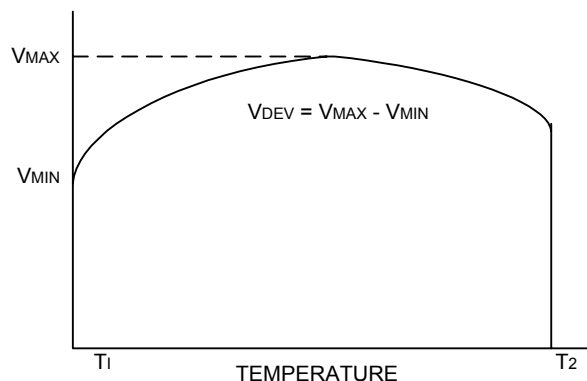
|                                          |               |
|------------------------------------------|---------------|
| Cathode Voltage .....                    | 36V           |
| Continuous Cathode Current .....         | -10mA ~ 250mA |
| Reference Input Current Range .....      | 10mA          |
| 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 .....                      | 0.25W         |
| SOT25 Package.....                       | 0.25W         |
| 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                                                         | $V_{KA} = V_{REF}$ ,<br>$I_{KA} = 10\text{mA}$ (Fig.1)                                                                           | AP431<br>AP431A<br>$V_{REF}$            | 2.470<br>2.482 | 2.495 | 2.520<br>2.507 | V             |
| Deviation of Reference input voltage over temperature (Note 3)            | $V_{KA} = V_{REF}$ , $I_{KA} = 10\text{mA}$ ,<br>$T_a = \text{Full range}$ (Fig.1)                                               | $V_{REF}$                               |                | 8.0   | 20             | mV            |
| Ratio of the change in Reference voltage to the change in Cathode voltage | $I_{KA} = 10\text{mA}$ (Fig.2)                                                                                                   | $V_{KA} = 10\text{V}$<br>$\sim V_{REF}$ |                | -1.4  | -2.0           | mV/V          |
|                                                                           |                                                                                                                                  | $V_{KA} = 36\text{V} \sim 10\text{V}$   |                | -1    | -2             | mV/V          |
| Reference input current                                                   | $R1 = 10\text{K}\Omega$ , $R2 = \infty$ $I_{KA} = 10\text{mA}$<br>(Fig.2)                                                        | $I_{REF}$                               |                | 1.4   | 3.5            | $\mu\text{A}$ |
| Deviation of Reference input current over temperature                     | $R1 = 10\text{K}\Omega$ , $R2 = \infty$ $I_{KA} = 10\text{mA}$<br>$T_a = \text{Full range}$ (Fig.2)                              | $\alpha I_{REF}$                        |                | 0.4   | 1.2            | $\mu\text{A}$ |
| Minimum Cathode current for regulation                                    | $V_{KA} = V_{REF}$ (Fig.1)                                                                                                       | $I_{KA(MIN)}$                           |                | 0.19  | 0.5            | mA            |
| Off-state current                                                         | $V_{KA} = 36\text{V}$ , $V_{REF} = 0\text{V}$ (Fig.3)                                                                            | $I_{KA(OFF)}$                           |                | 0.1   | 1.0            | $\mu\text{A}$ |
| Dynamic output impedance (Note 4)                                         | $V_{KA} = V_{REF}$ $V_{KA} = V_{REF}$<br>$\Delta I_{KA} = 0.1\text{mA} \sim 15\text{mA}$<br>Frequency $\leq 1\text{KHz}$ (Fig.1) | $ Z_{KA} $                              |                | 0.2   | 0.5            | $\Omega$      |



## Adjustable Precision Shunt Regulator

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 R1 and R2 (see Figure 2.), the dynamic output impedance of the overall circuit, is defined as:

$$|Z_{KA}'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}| \left( 1 + \frac{R1}{R2} \right)$$

## ■ Test Circuits

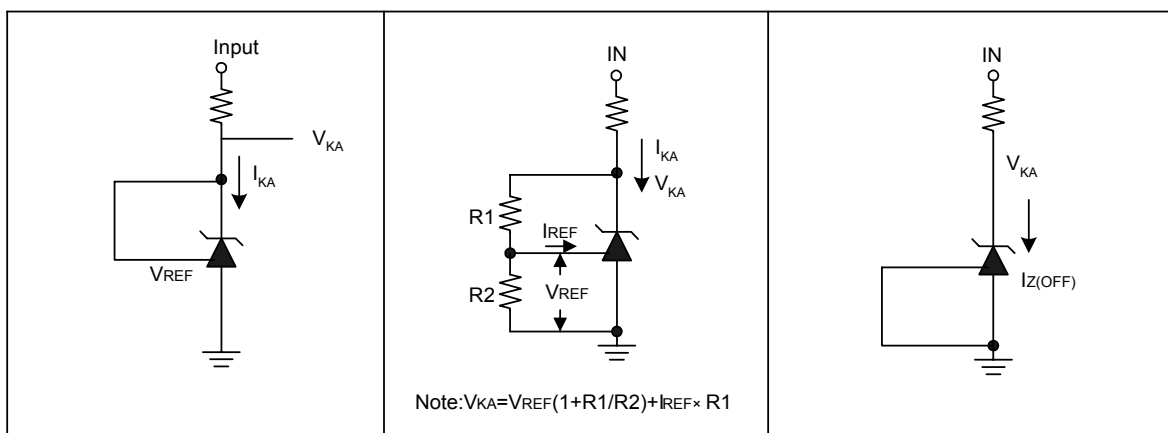


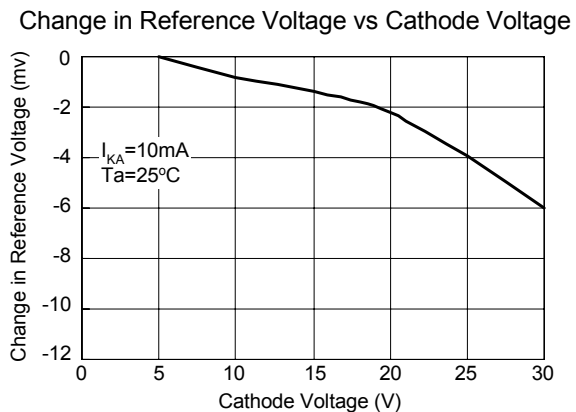
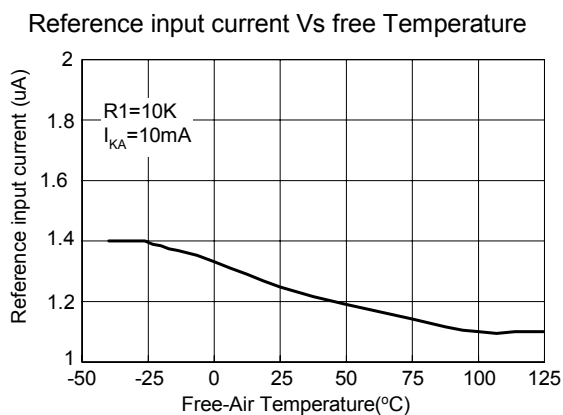
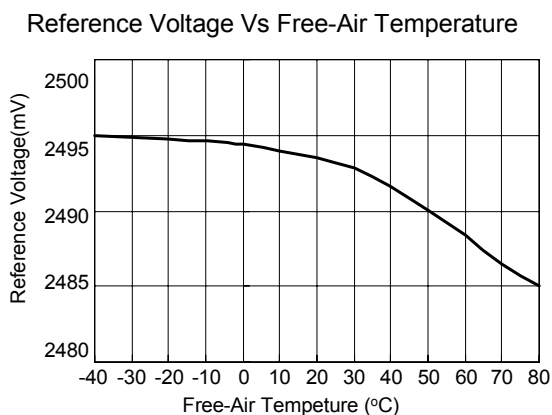
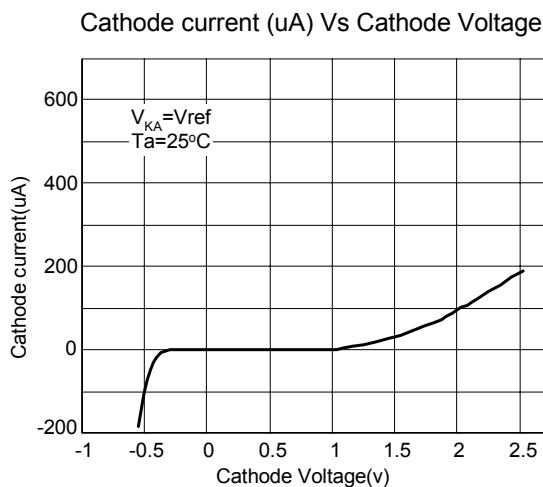
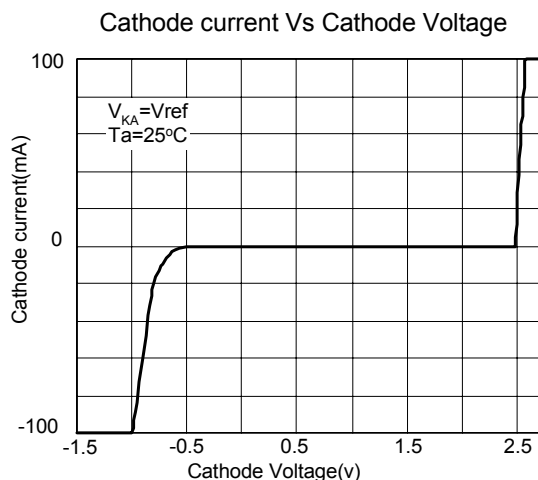
Fig1. Test Circuit for  $V_{KA} = V_{REF}$

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

Fig3. Test Circuit for off-state Current



### ■ Typical Performance Characteristics



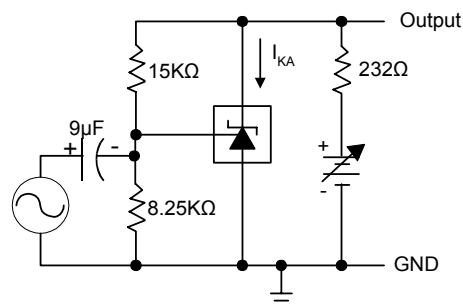
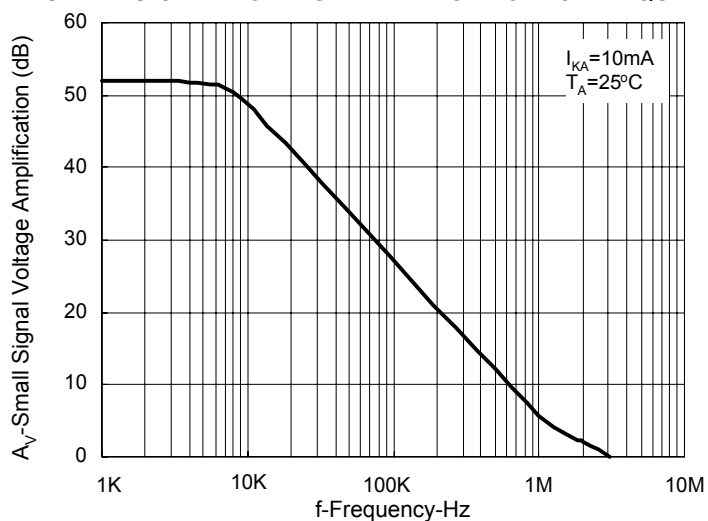


# AP431/AP431A

## Adjustable Precision Shunt Regulator

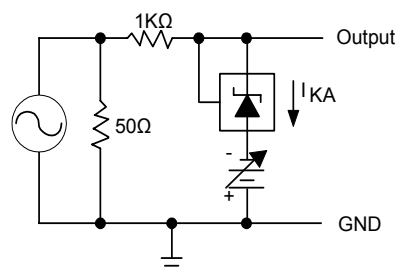
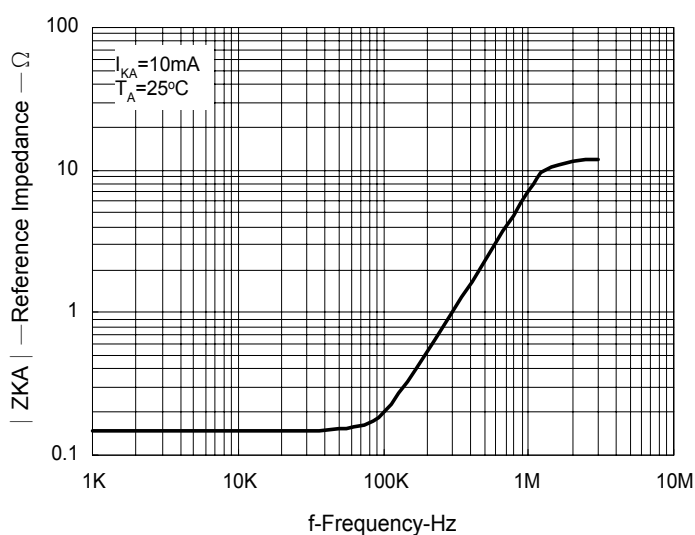
### ■ Typical Performance Characteristics(Continued)

SMALL-SIGNAL VOLTAGE AMPLIFICATION vs. FREQUENCY



TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

REFERENCE IMPEDANCE vs. FREQUENCY

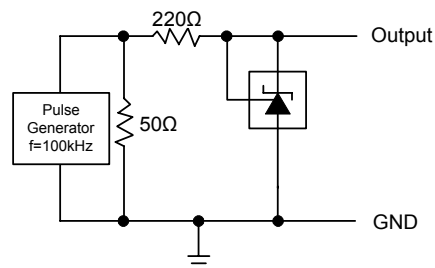
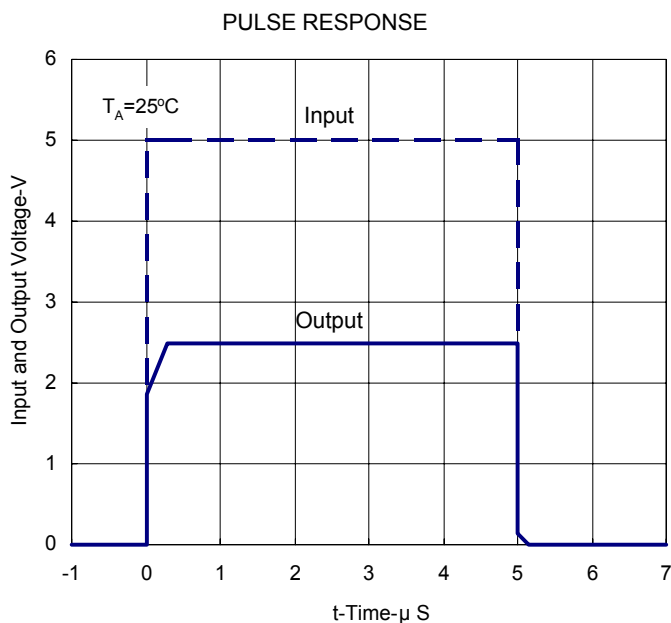


TEST CIRCUIT FOR REFERENCE IMPEDANCE

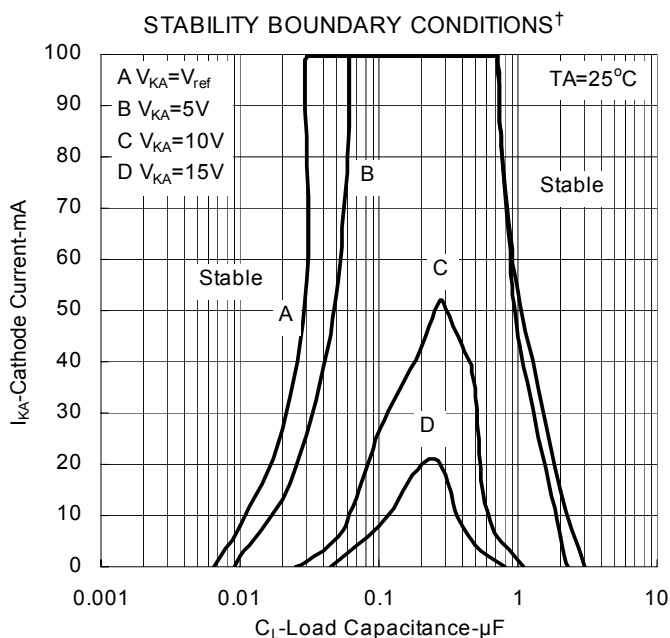


# AP431/AP431A

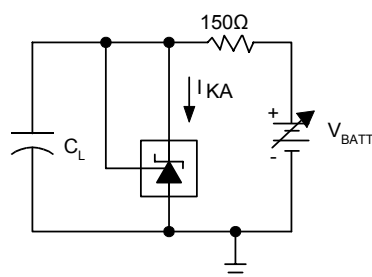
## Adjustable Precision Shunt Regulator



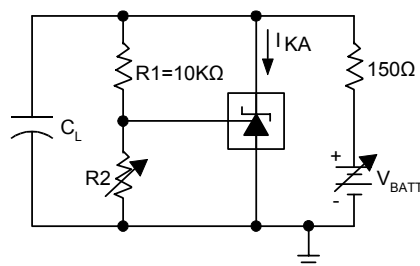
TEST CIRCUIT FOR PULSE RESPONSE



<sup>†</sup>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.



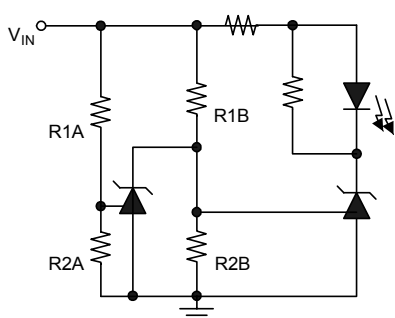
TEST CIRCUIT FOR CURVE A



TEST CIRCUIT FOR CURVE B, C, AND D

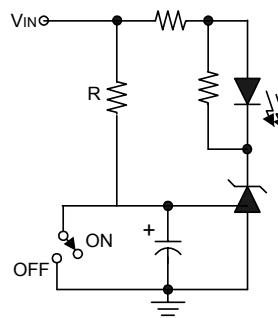
## Adjustable Precision Shunt Regulator

### Application Examples



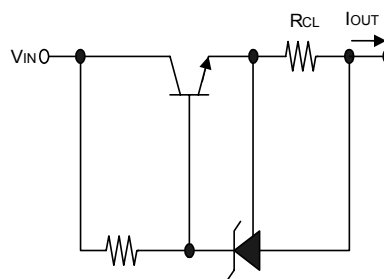
LED on when Low Limit <  $V_{IN}$  < High Limit  
 Low Limit  $\approx V_{REF} (1 + R1B/R2B)$   
 High Limit  $\approx V_{REF} (1 + R1A/R2A)$

Fig.4 Voltage Monitor



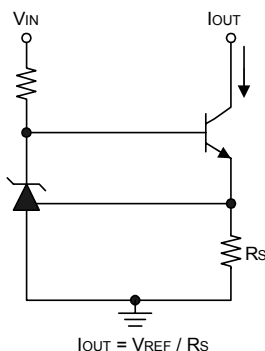
$$\text{Delay} = RC \times \ln\left(\frac{V_{IN}}{V_{IN} - V_{REF}}\right)$$

Fig.5 Delay Timer



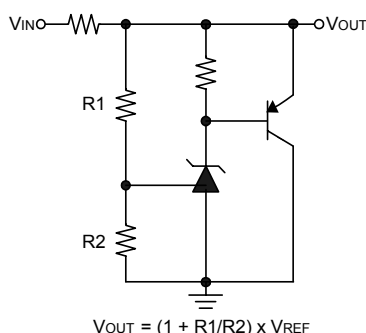
$$I_{OUT} = V_{REF} / R_{CL}$$

Fig.6 Current Limiter or Current Source



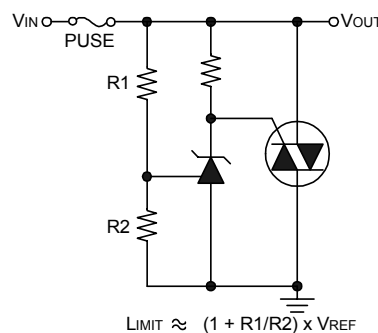
$$I_{OUT} = V_{REF} / R_s$$

Fig.7 Constant-Current Sink



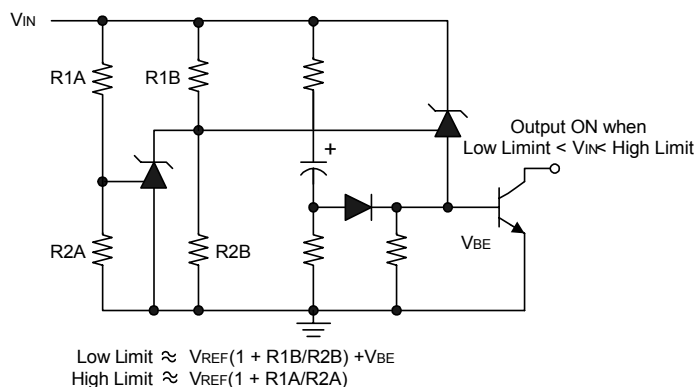
$$V_{OUT} = (1 + R1/R2) \times V_{REF}$$

Fig.8 Higher-Current Shunt Regulator



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

Fig.9 Crow Bar



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

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

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

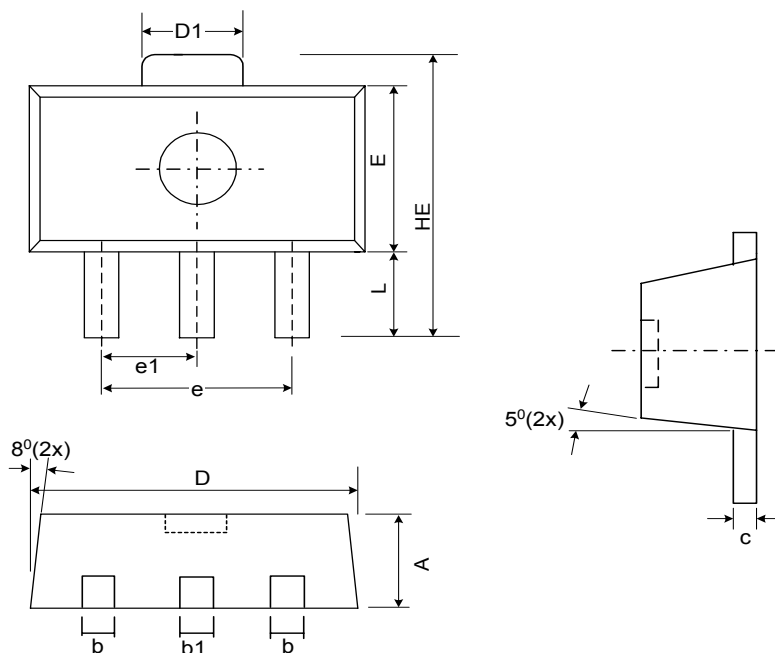


# AP431/AP431A

## Adjustable Precision Shunt Regulator

### ■ Package Diagrams

#### (1) SOT89-3L Package Outline Dimension



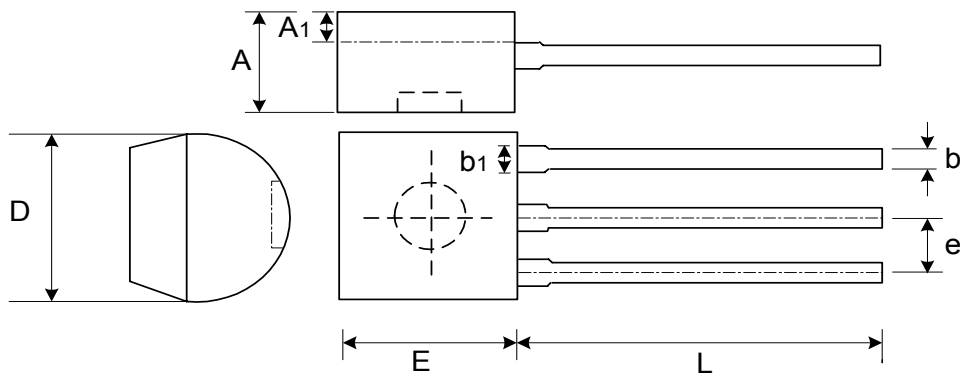
| Symbol | Dimensions In Millimeters |      |      | Dimensions In Inches |       |       |
|--------|---------------------------|------|------|----------------------|-------|-------|
|        | Min.                      | Nom. | Max. | Min.                 | Nom.  | Max.  |
| A      | 1.40                      | 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      | 0.35                      | 0.39 | 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



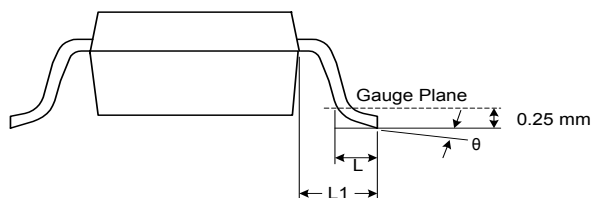
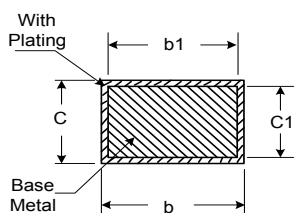
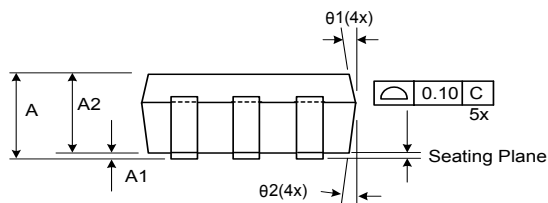
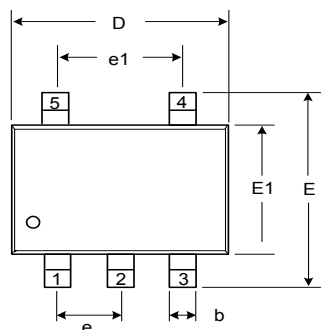
| Symbol | Dimensions In Millimeters |       |        | Dimensions In Inches |       |       |
|--------|---------------------------|-------|--------|----------------------|-------|-------|
|        | Min.                      | Nom.  | Max.   | Min.                 | Nom.  | Max.  |
| A      | 3.302                     | 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                     | -     | 15.500 | 0.512                | -     | 0.610 |
| e      | 1.150                     | 1.270 | 1.390  | 0.045                | 0.050 | 0.055 |



# AP431/AP431A

## Adjustable Precision Shunt Regulator

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



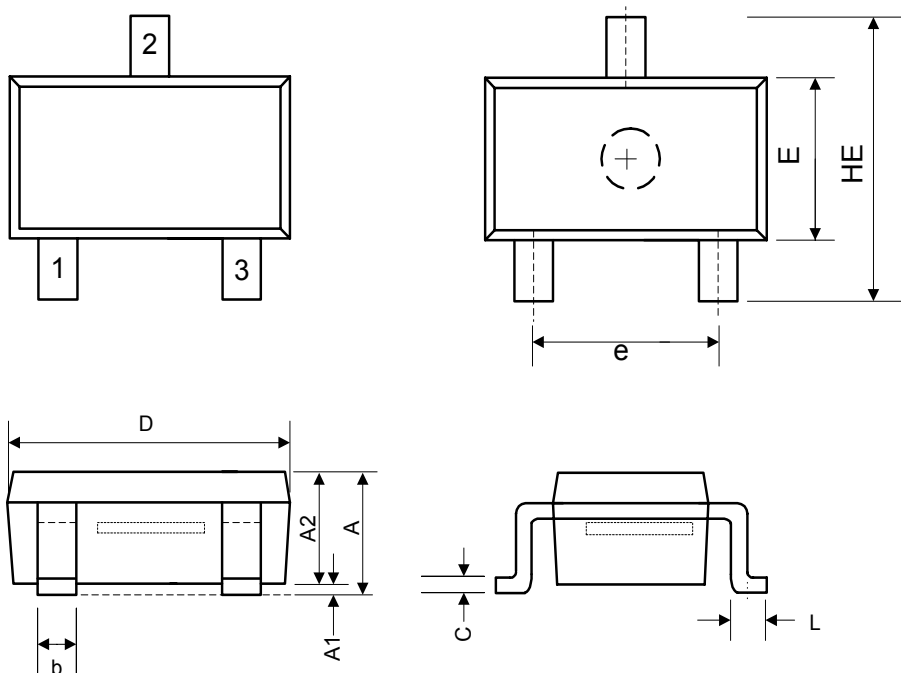
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|--------|---------------------------|------|------|----------------------|-------|-------|
|        | Min.                      | Nom. | Max. | Min.                 | Nom.  | Max.  |
| A      | 1.05                      | 1.20 | 1.35 | 0.041                | 0.047 | 0.053 |
| A1     | 0.05                      | 0.10 | 0.15 | 0.002                | 0.004 | 0.006 |
| A2     | 1.00                      | 1.10 | 1.20 | 0.039                | 0.043 | 0.047 |
| b      | 0.25                      | -    | 0.55 | 0.010                | -     | 0.022 |
| b1     | 0.25                      | 0.40 | 0.45 | 0.010                | 0.016 | 0.018 |
| c      | 0.08                      | -    | 0.20 | 0.003                | -     | 0.008 |
| c1     | 0.08                      | 0.11 | 0.15 | 0.003                | 0.004 | 0.006 |
| D      | 2.70                      | 2.85 | 3.00 | 0.106                | 0.112 | 0.118 |
| E      | 2.60                      | 2.80 | 3.00 | 0.102                | 0.110 | 0.118 |
| E1     | 1.50                      | 1.60 | 1.70 | 0.059                | 0.063 | 0.067 |
| L      | 0.35                      | 0.45 | 0.55 | 0.014                | 0.018 | 0.022 |
| L1     | 0.60 Ref.                 |      |      | 0.024 Ref.           |       |       |
| e      | 0.95 Bsc.                 |      |      | 0.037 Bsc.           |       |       |
| e1     | 1.90 Bsc.                 |      |      | 0.075 Bsc.           |       |       |
| θ      | 0°                        | 5°   | 10°  | 0°                   | 5°    | 10°   |
| θ1     | 3°                        | 5°   | 7°   | 3°                   | 5°    | 7°    |
| θ2     | 6°                        | 8°   | 10°  | 6°                   | 8°    | 10°   |



# AP431/AP431A

## Adjustable Precision Shunt Regulator

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



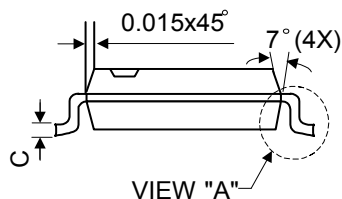
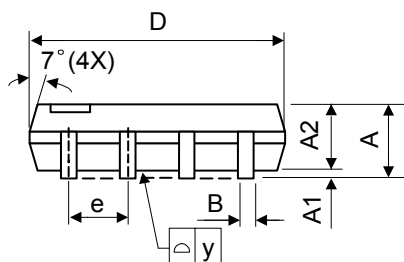
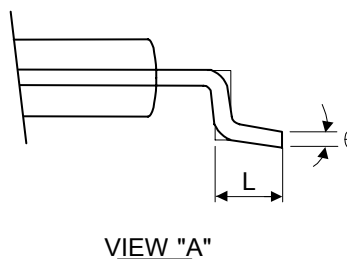
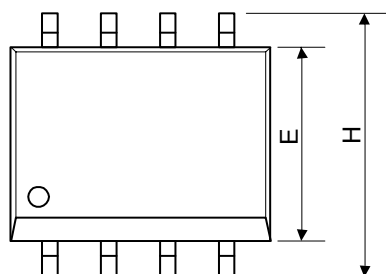
| Symbol | Dimensions In Millimeters |       |      | Dimensions In Inches |       |       |
|--------|---------------------------|-------|------|----------------------|-------|-------|
|        | Min.                      | Nom.  | Max. | Min.                 | Nom.  | Max.  |
| A      | 1.00                      | 1.20  | 1.40 | 0.039                | 0.047 | 0.055 |
| 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 |
| E      | 1.40                      | 1.60  | 1.80 | 0.055                | 0.063 | 0.071 |
| e      | 1.70                      | 2.00  | 2.30 | 0.067                | 0.079 | 0.091 |
| HE     | 2.40                      | 2.70  | 3.00 | 0.094                | 0.106 | 0.118 |
| L      | 0.30                      | -     | 0.55 | 0.012                | -     | 0.022 |



# AP431/AP431A

## Adjustable Precision Shunt Regulator

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



| Symbol | 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                      | 5.05 | 5.30 | 0.189                | 0.199 | 0.209 |
| E      | 3.70                      | 3.90 | 4.10 | 0.146                | 0.154 | 0.161 |
| 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°    |

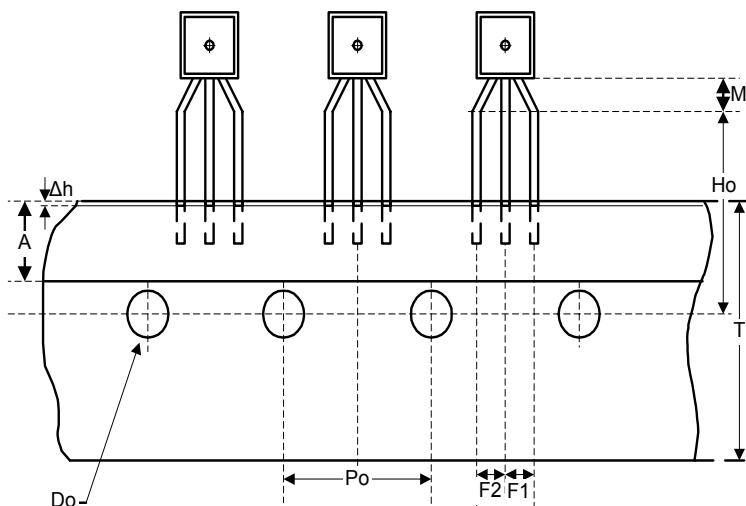


# AP431/AP431A

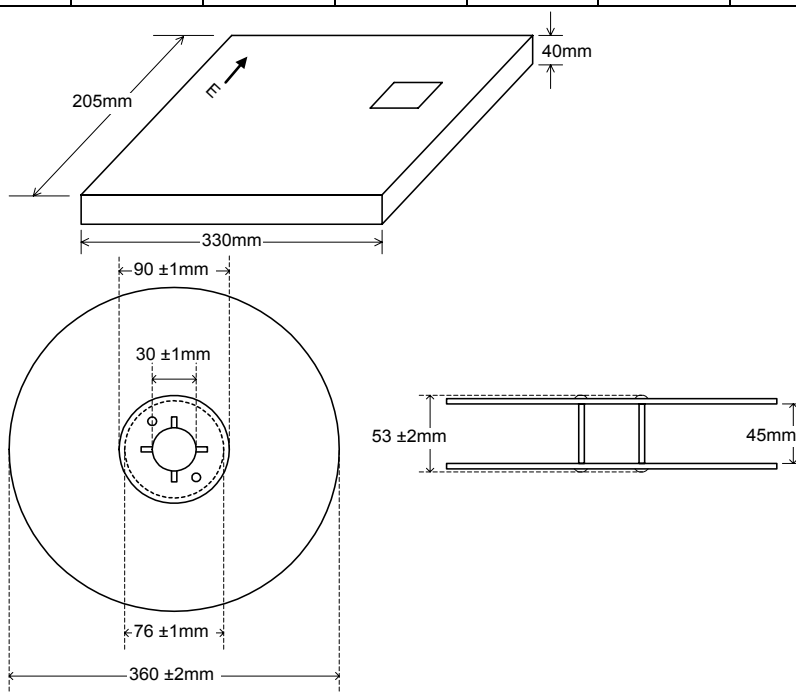
## Adjustable Precision Shunt Regulator

### ■ Taping Information

(1)TO92 TAPING



| Symbol | Millimeters |      |      | Inches |       |       |
|--------|-------------|------|------|--------|-------|-------|
|        | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| Po     | 12.4        | 12.7 | 13.0 | 0.488  | 0.500 | 0.512 |
| M      | 2.0         | 2.5  | 3.0  | 0.079  | 0.098 | 0.118 |
| Ho     | 15.5        | 16.0 | 16.5 | 0.610  | 0.630 | 0.650 |
| Do     | -           | 4.0  | -    | -      | 0.157 | -     |
| A      | -           | 6.0  | -    | -      | 0.236 | -     |
| Δh     | 0.0         | -    | 1.0  | 0.000  | -     | 0.039 |
| T      | -           | 18.0 | -    | -      | 0.709 | -     |
| F1     | 2.4         | 2.5  | 2.9  | 0.094  | 0.098 | 0.114 |
| F2     | 2.4         | 2.5  | 2.9  | 0.094  | 0.098 | 0.114 |

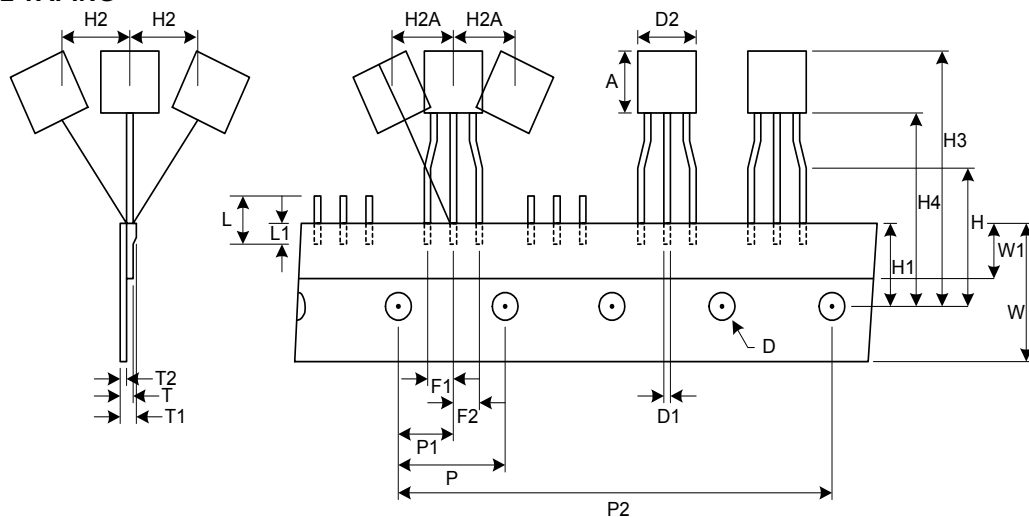




# AP431/AP431A

## Adjustable Precision Shunt Regulator

### (2)TO92 TAPING



| Symbol | Millimeters |       |      | Inches |        |        |
|--------|-------------|-------|------|--------|--------|--------|
|        | Min.        | Typ.  | Max. | Min.   | Typ.   | Max.   |
| A      | 3.18        | 7.59  | 12   | 0.125  | 0.299  | 0.472  |
| D      | 3.8         | 4     | 4.2  | 0.150  | 0.157  | 0.165  |
| D1     | 0.36        | 0.445 | 0.53 | 0.014  | 0.018  | 0.021  |
| D2     | -           | -     | 9.0  | -      | -      | 0.354  |
| F1,F2  | 2.4         | 2.5   | 2.7  | 0.094  | 0.098  | 0.106  |
| F1-F2  | -           | 0.30  | -    | -      | ±0.012 | -      |
| H      | 15.5        | 16    | 16.5 | 0.610  | 0.630  | 0.650  |
| H1     | 8.5         | 9     | 9.5  | 0.335  | 0.354  | 0.374  |
| H2     | -           | -     | 0.5  | -      | -      | 0.020  |
| H2A    | -           | -     | 0.5  | -      | -      | 0.020  |
| H3     | -           | -     | 27   | -      | -      | 1.063  |
| H4     | -           | -     | 20   | -      | -      | 0.787  |
| L      | -           | -     | 11   | -      | -      | 0.433  |
| L1     | 2.5         | -     | -    | 0.098  | -      | -      |
| P      | 12.5        | 12.7  | 12.9 | 0.492  | 0.500  | 0.508  |
| P1     | 5.95        | 6.35  | 6.75 | 0.234  | 0.250  | 0.266  |
| P2     | 50.3        | 50.8  | 51.3 | 1.980  | 2.000  | 2.020  |
| T      | -           | -     | 0.55 | -      | -      | 0.022  |
| T1     | -           | -     | 1.42 | -      | -      | 0.056  |
| T2     | 0.36        | 0.52  | 0.68 | 0.014  | 0.020  | 0.027  |
| W      | 17.5        | 18.25 | 19   | 0.689  | 0.719  | 0.748  |
| W1     | 5           | 6     | 7    | 0.197  | 0.236  | 0.276  |
| ----*  | 253         | 254   | 255  | 9.961  | 10.000 | 10.039 |

----\* = every 20 pcs distance.

### Adjustable Precision Shunt Regulator

## ■ BOX Dimension

