

## 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

## Description

The GM432's are low-voltage three-terminal adjustable precision shunt regulators with specified thermal stability over their full temperature range. Output voltage can be set to any value from  $V_{ref}$  (1.24V) to 16V by using two external resistors. Their active output circuitry provides a very unique turn-on characteristic, making them excellent replacements for zener diodes in many applications such as onboard regulation and adjustable power supplies. In a wide range of home applications, these versatile darlings are ideal voltage references for 3.0V to 3.3V switching power supplies. With operational cathode current as low as 80 $\mu$ A, batteries keep on going. Whatever your application is, the GM432's offer the optimum combination of performance, reliability, and economy.

## Features

- ◆ Low-voltage operation, down to 1.24V
- ◆ 0.5%, 1% or 2% reference voltage tolerance
- ◆ Adjustable output voltage,  $V_O = V_{ref}$  to 16V
- ◆ Sink Current Capability 80 $\mu$ A to 100mA
- ◆ Low dynamic output impedance, 0.05  $\Omega$  typical
- ◆ Wide temperature range, 0° to +70°C
- ◆ Pin-to-pin replacement for TLV431, SC431L
- ◆ Available in SOT-23, SOT-25, SOT-89, TO-92 and SOP-8

## Application

Switching power supplies

Linear regulators

Adjustable supplies

Instrumentation

Battery-operated computers,

PDA's portable devices

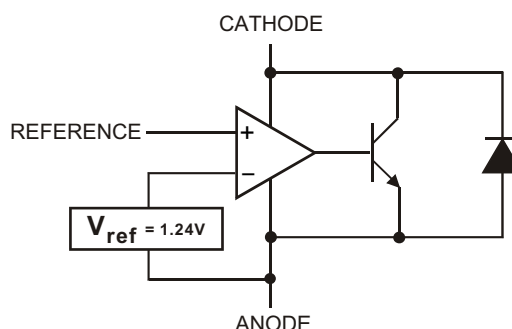
Monitors, TV's, camcorders

Computer disk drives

## LOGIC SYMBOL



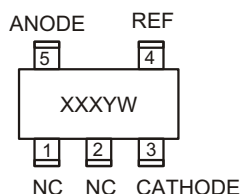
## BLOCK DIAGRAM (POSITIVE LOGIC)



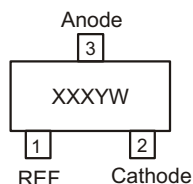
### 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

#### ◆ MARKING INFORMATION & PIN CONFIGURATIONS (TOP VIEW)

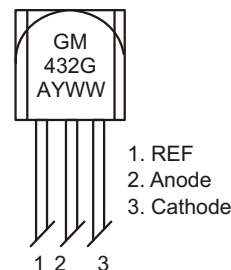
**SOT-25(SOT-23-5)**



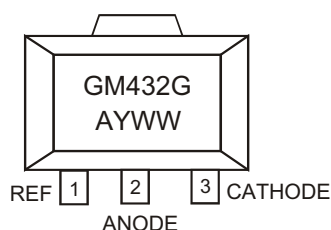
**SOT-23**



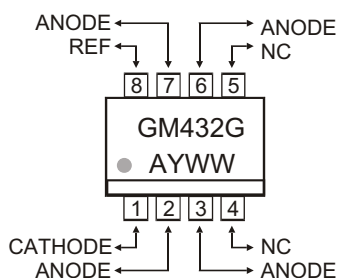
**TO-92**



**SOT-89**



**SOP-8**



XXX = Marking Code  
G\*\* = Grade  
A = Assembly Location  
Y = Year  
WW, W= Weekly

#### ◆ ORDERING INFORMATION

| Ordering Number | Precision | Device code | Grade | Package | Shipping                     |
|-----------------|-----------|-------------|-------|---------|------------------------------|
| GM432AT92B      | 0.5%      | MAA         | A     | TO-92   | 1,000 Units/ ESD Bag         |
| GM432AT92RL     | 0.5%      | MAA         | A     | TO-92   | 2,000 Units/ Ammo Pack(Tape) |
| GM432AST23R     | 0.5%      | MAA         |       | SOT-23  | 3,000 Units/Tape &Reel       |
| GM432AST25R     | 0.5%      | MAA         |       | SOT-25  | 3,000 Units/Tape &Reel       |
| GM432AS8R       | 0.5%      | MAA         |       | SOP-8   | 2,500 Units/Tape & Reel      |
| GM432AST89R     | 0.5%      | MAA         |       | SOT-89  | 1,000 Units/ Tape & Reel     |
| GM432BT92B      | 1%        | MAB         | B     | TO-92   | 1,000 Units/ ESD Bag         |
| GM432BT92RL     | 1%        | MAB         | B     | TO-92   | 2,000 Units/ Ammo Pack(Tape) |
| GM432BST23R     | 1%        | MAB         |       | SOT-23  | 3,000 Units/Tape &Reel       |
| GM432BST25R     | 1%        | MAB         |       | SOT-25  | 3,000 Units/Tape &Reel       |
| GM432BS8R       | 1%        | MAB         |       | SOP-8   | 2,500 Units/Tape & Reel      |
| GM432BST89R     | 1%        | MAB         |       | SOT-89  | 1,000 Units/ Tape & Reel     |
| GM432CT92B      | 2%        | MAC         | C     | TO-92   | 1,000 Units/ ESD Bag         |
| GM432CT92RL     | 2%        | MAC         | C     | TO-92   | 2,000 Units/ Ammo Pack(Tape) |
| GM432CST23R     | 2%        | MAC         |       | SOT-23  | 3,000 Units/Tape &Reel       |
| GM432CST25R     | 2%        | MAC         |       | SOT-25  | 3,000 Units/Tape &Reel       |
| GM432CS8R       | 2%        | MAC         |       | SOP-8   | 2,500 Units/Tape & Reel      |
| GM432CST89R     | 2%        | MAC         |       | SOT-89  | 1,000 Units/ Tape & Reel     |

\* For detail Ordering Number identification, please see last page.

\*\*Grade A: indicates Precision of 0.5%, B: indicates Precision of 1%, C: indicates Precision of 2%

### 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

#### ◆ ABSOLUTE MAXIMUM RATINGS (over free-air temperature range except as noted)

| PARAMETER                                                                         | SYMBOL     | VALUE                   | UNIT               |
|-----------------------------------------------------------------------------------|------------|-------------------------|--------------------|
| Cathode Voltage <sup>(1)</sup>                                                    | $V_{KA}$   | 20                      | V                  |
| Continuous cathode current                                                        | $I_K$      | 100                     | mA                 |
| Reference input current range                                                     | $I_{ref}$  | 3                       | mA                 |
| Power dissipation at $T_A = 25^\circ\text{C}$<br>SOT-23<br>SOP-8<br>TO-92         | $P_D$      | 0.37<br>0.49<br>0.95    | W                  |
| Package thermal impedance <sup>(2, 3)</sup><br>SOT-23<br>SOT-25<br>TO-92<br>SOP-8 | $J_A$      | 336<br>256<br>132<br>97 | $^\circ\text{C/W}$ |
| Operating ambient temperature range                                               | $T_A$      | 0 to + 70               | $^\circ\text{C}$   |
| Lead temperature (soldering) 10 seconds                                           | $T_{LEAD}$ | 260                     | $^\circ\text{C}$   |

These are stress ratings only. Functional operation of the device at these or any conditions beyond the "recommended operating conditions" is not implied. Exposure to absolute maximum rated conditions may affect device reliability.

#### NOTES:

- Voltage values are with respect to the anode except as noted.
- Maximum power dissipation is a function of  $T_{J(max)}$ ,  $J_A$  and  $T_A$ . Maximum allowable power dissipation at any allowable ambient temperature is  

$$P_D = (T_{J(max)} - T_A) / J_A$$
- Package thermal impedance is calculated per JESD 51.

#### ◆ RECOMMENDED OPERATING CONDITIONS

| PARAMETER       | SYMBOL   | MINIMUM          | MAXIMUM | UNIT |
|-----------------|----------|------------------|---------|------|
| Cathode Voltage | $V_{KA}$ | $V_{ref}$        | 16      | V    |
| Cathode Current | $I_K$    | 80 $\mu\text{A}$ | 100     | mA   |

## 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

◆ ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

## GM432A (0.5%)

| PARAMETER                                                        |                                 | CONDITION                                                                                                                                                                   | MIN            | TYP            | MAX            | UNIT |
|------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|------|
| Reference input Voltage                                          | $V_{\text{ref}}$                | $V_{KA} = V_{\text{ref}}, I_K = 10 \text{ mA}, T_A = 25^\circ\text{C}^{(1)}$<br>$V_{KA} = V_{\text{ref}}, I_K = 10 \text{ mA}, T_A = 0 \text{ to } +70^\circ\text{C}^{(1)}$ | 1.234<br>1.222 | 1.240          | 1.246<br>1.258 | V    |
| $V_{\text{ref}}$ temp deviation                                  | $V_{\text{dev}}$                | $V_{KA} = V_{\text{ref}}, I_K = 10 \text{ mA}^{(1)}$                                                                                                                        |                | 10             | 25             | mV   |
| Ratio of change in $V_{\text{ref}}$ to change in $V_{KA}$        | $\frac{V_{\text{ref}}}{V_{KA}}$ | $I_K = 10 \text{ mA}, V_{KA} = 16 \text{V to } V_{\text{ref}}$                                                                                                              | - 2.7          | -1.0           |                | mV/V |
| Reference input current                                          | $I_{\text{ref}}$                | $I_K = 10 \text{ mA}, R1 = 10 \text{K}, R2 = \infty^{(2)}$                                                                                                                  |                | 0.15           | 0.5            | A    |
| Deviation of reference input voltage over full temperature range | $I_{\text{ref(dev)}}$           | $I_K = 10 \text{ mA}, R1 = 10 \text{K}, R2 = \infty^{(2)}$<br><b><math>T_A = \text{full range}</math></b>                                                                   |                | 0.1            | 0.4            | A    |
| Minimum operating current                                        | $I_{K(\text{min})}$             | $V_{KA} = V_{\text{ref}}^{(1)}$                                                                                                                                             |                | 20             | 80             | A    |
| Off-state cathode current                                        | $I_{K(\text{off})}$             | $V_{KA} = 6 \text{V}, V_{\text{ref}} = 0 \text{V}^{(3)}$<br>$V_{KA} = 16 \text{V}, V_{\text{ref}} = 0 \text{V}^{(3)}$                                                       |                | 0.125<br>0.135 | 0.150<br>0.150 | A    |
| Dynamic impedance                                                | $ Z_{KA} $                      | $f \leq 1 \text{ kHz}, V_{KA} = V_{\text{ref}}, I_K = 100 \text{ A to } 100 \text{ mA}^{(1)}$                                                                               |                | 0.05           | 0.15           |      |

## GM432B (1.0%)

| PARAMETER                                                        |                                 | CONDITION                                                                                                                                                                   | MIN            | TYP            | MAX            | UNIT |
|------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|------|
| Reference input Voltage                                          | $V_{\text{ref}}$                | $V_{KA} = V_{\text{ref}}, I_K = 10 \text{ mA}, T_A = 25^\circ\text{C}^{(1)}$<br>$V_{KA} = V_{\text{ref}}, I_K = 10 \text{ mA}, T_A = 0 \text{ to } +70^\circ\text{C}^{(1)}$ | 1.228<br>1.215 | 1.240          | 1.252<br>1.258 | V    |
| $V_{\text{ref}}$ temp deviation                                  | $V_{\text{dev}}$                | $V_{KA} = V_{\text{ref}}, I_K = 10 \text{ mA}^{(1)}$                                                                                                                        |                | 10             | 25             | mV   |
| Ratio of change in $V_{\text{ref}}$ to change in $V_{KA}$        | $\frac{V_{\text{ref}}}{V_{KA}}$ | $I_K = 10 \text{ mA}, V_{KA} = 16 \text{V to } V_{\text{ref}}$                                                                                                              | - 2.7          | -1.0           |                | mV/V |
| Reference input current                                          | $I_{\text{ref}}$                | $I_K = 10 \text{ mA}, R1 = 10 \text{K}, R2 = \infty^{(2)}$                                                                                                                  |                | 0.15           | 0.5            | A    |
| Deviation of reference input voltage over full temperature range | $I_{\text{ref(dev)}}$           | $I_K = 10 \text{ mA}, R1 = 10 \text{K}, R2 = \infty^{(2)}$<br><b><math>T_A = \text{full range}</math></b>                                                                   |                | 0.1            | 0.4            | A    |
| Minimum operating current                                        | $I_{K(\text{min})}$             | $V_{KA} = V_{\text{ref}}^{(1)}$                                                                                                                                             |                | 20             | 80             | A    |
| Off-state cathode current                                        | $I_{K(\text{off})}$             | $V_{KA} = 6 \text{V}, V_{\text{ref}} = 0 \text{V}^{(3)}$<br>$V_{KA} = 16 \text{V}, V_{\text{ref}} = 0 \text{V}^{(3)}$                                                       |                | 0.125<br>0.135 | 0.150<br>0.150 | A    |
| Dynamic impedance                                                | $ Z_{KA} $                      | $f \leq 1 \text{ kHz}, V_{KA} = V_{\text{ref}}, I_K = 100 \text{ A to } 100 \text{ mA}^{(1)}$                                                                               |                | 0.05           | 0.15           |      |

## NOTES:

(1) See test circuit 1 on page 4.

(2) See test circuit 2 on page 4.

(3) See test circuit 3 on page 4.

## 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

◆ ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

## GM432C (2.0%)

| PARAMETER                                                        | CONDITION                                                                                                                                                             | MIN            | TYP            | MAX            | UNIT |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|------|
| Reference input Voltage                                          | $V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}$ , $T_A = 25^\circ\text{C}^{(1)}$<br>$V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}$ , $T_A = 0\text{ to }+70^\circ\text{C}^{(1)}$ | 1.215<br>1.200 | 1.240          | 1.265<br>1.280 | V    |
| $V_{ref}$ temp deviation                                         | $V_{KA} = V_{ref}$ , $I_K = 10\text{ mA}^{(1)}$                                                                                                                       |                | 10             | 35             | mV   |
| Ratio of change in $V_{ref}$ to change in $V_{KA}$               | $I_K = 10\text{ mA}$ , $V_{KA} = 16\text{V to }V_{ref}$                                                                                                               | -2.7           | -1.0           |                | mV/V |
| Reference input current                                          | $I_K = 10\text{ mA}$ , $R1 = 10\text{ K}$ , $R2 = \infty^{(2)}$                                                                                                       |                | 0.15           | 0.5            | A    |
| Deviation of reference input voltage over full temperature range | $I_K = 10\text{ mA}$ , $R1 = 10\text{ K}$ , $R2 = \infty^{(2)}$<br><b><math>T_A = \text{full range}</math></b>                                                        |                | 0.1            | 0.4            | A    |
| Minimum operating current                                        | $V_{KA} = V_{ref}^{(1)}$                                                                                                                                              |                | 20             | 80             | A    |
| Off-state cathode current                                        | $V_{KA} = 6\text{V}$ , $V_{ref} = 0\text{V}^{(3)}$<br>$V_{KA} = 16\text{V}$ , $V_{ref} = 0\text{V}^{(3)}$                                                             |                | 0.125<br>0.135 | 0.150<br>0.150 | A    |
| Dynamic impedance                                                | $f \leq 1\text{ kHz}$ , $V_{KA} = V_{ref}$ , $I_K = 100\text{ A to }100\text{ mA}^{(1)}$                                                                              |                | 0.05           | 0.15           |      |

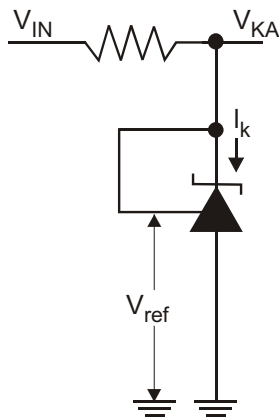
## NOTES:

(1) See test circuit 1.

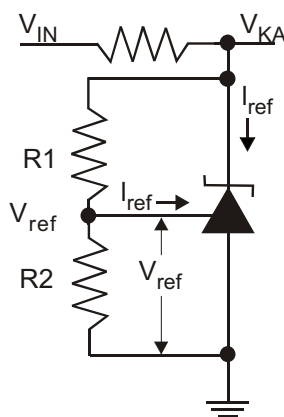
(2) See test circuit 2.

(3) See test circuit 3.

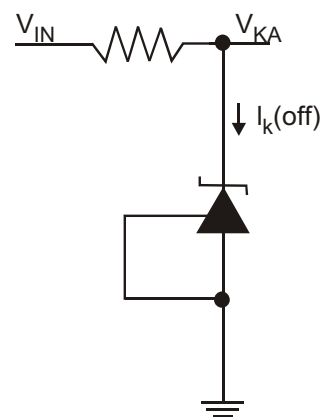
## ◆ TEST CIRCUITS



Test Circuit 1  
 $V_{KA} = V_{ref}$



Test Circuit 2  
 $V_{KA} > V_{ref}$



Test Circuit 3  
Off-State

### 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

#### ◆ TYPICAL APPLICATIONS

##### GM432A, GM432B

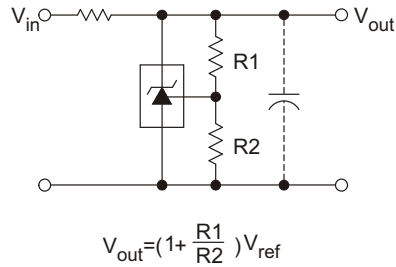


Figure 1. Shunt Regulator

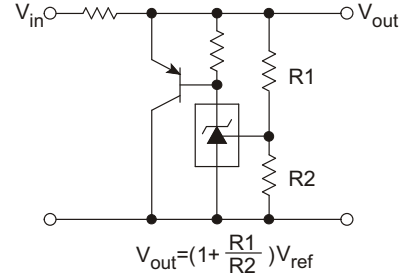


Figure 2. High Current Shunt Regulator

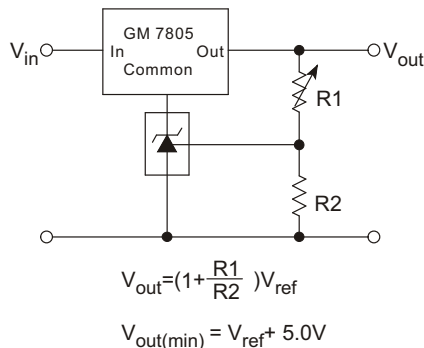


Figure 3. Output Control for a Three Terminal Fixed Regulator

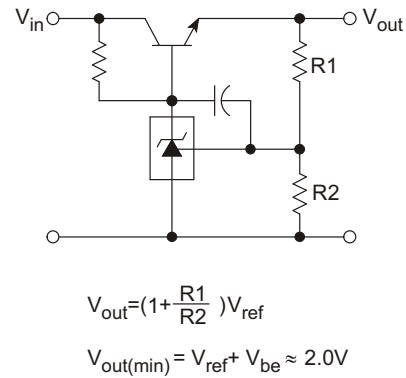


Figure 4. Series Pass Regulator

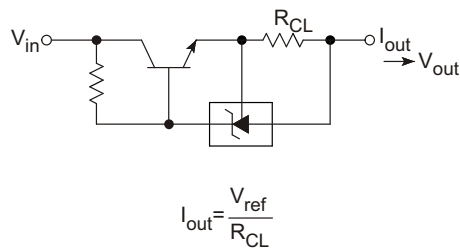


Figure 5. Constant Current Source

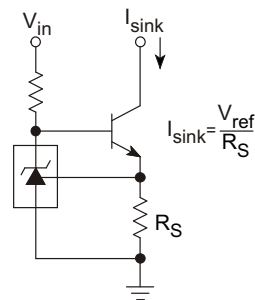


Figure 6. Constant Current Sink

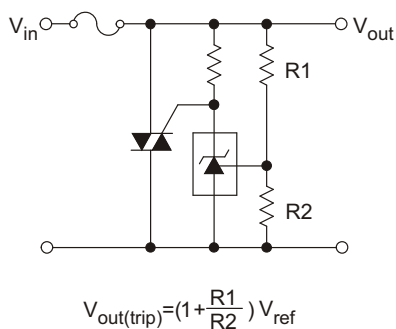


Figure 7. TRIAC Crowbar

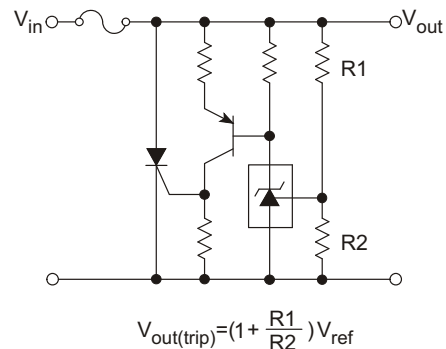
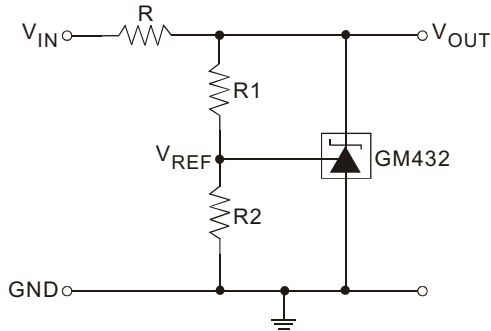


Figure 8. SRC Crowbar

### 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

#### ◆ TYPICAL APPLICATION CIRCUIT



##### Notes:

1. Set  $V_{OUT}$  according to the following equation:

$$V_{OUT} = V_{REF} \left( 1 + \frac{R1}{R2} \right) + I_{REF} R1$$

2. Choose the value for R as follows:

- ◆ The maximum limit for R should be such that the cathode current,  $I_K$ , is greater than the minimum operating current ( $80\mu A$ ) at  $V_{IN(MIN)}$ \*
- ◆ The minimum limit for R should be such that the cathode current,  $I_K$ , does not exceed  $100mA$  under all load conditions, and the instantaneous turn-on value for  $I_K$  does not exceed  $150mA$ . Both of the following conditions must be met:

$$R_{min} \geq \frac{V_{IN(max)}}{150mA} \quad (\text{to limit instantaneous turn-on } I_K)$$

$$R_{min} \geq \frac{V_{IN(max)} - V_{OUT}}{I_{OUT(min)} + 100mA} \quad (\text{to limit } I_K \text{ under normal operating conditions})$$

#### ◆ Typical Performance Characteristics

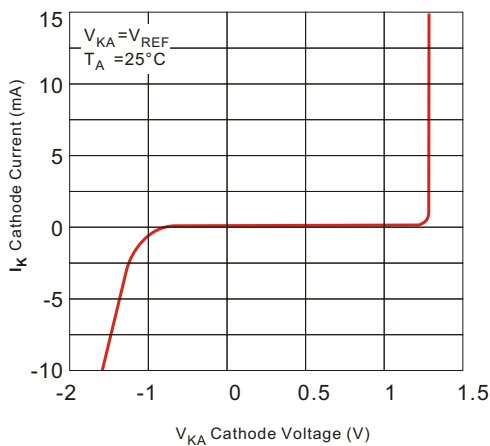


Figure 9. Cathode Current vs. Cathode Voltage

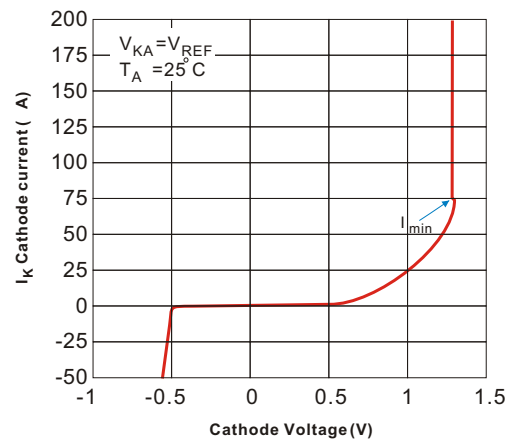


Figure 10. Cathode Current vs. Cathode Voltage

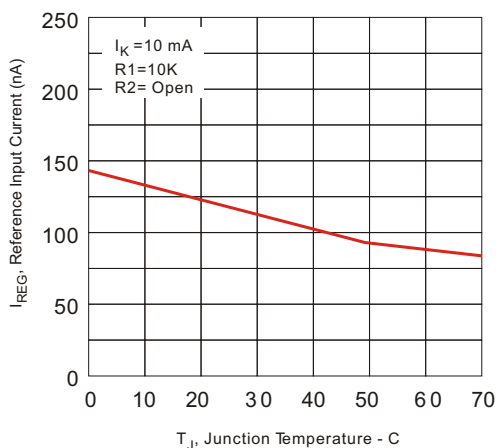


Figure 11. Ref. Voltage vs. Junction Temperature

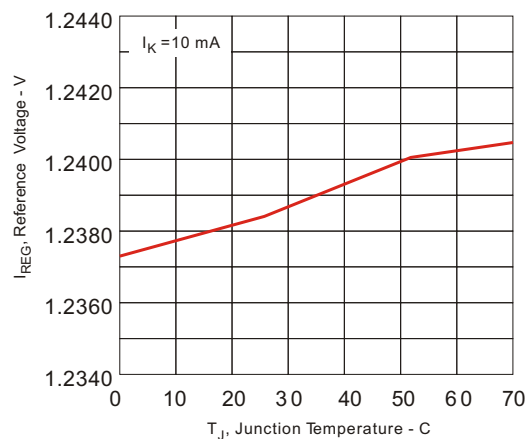
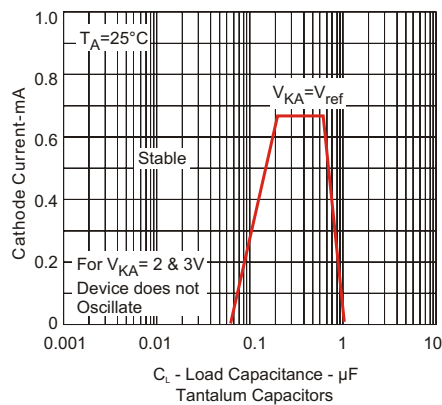
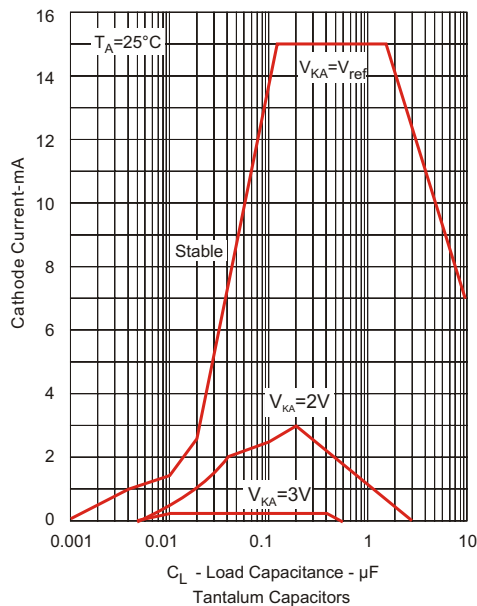


Figure 12. Ref. Input Current vs. Junction Temperature

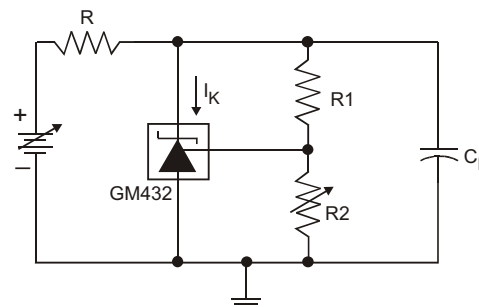
#### ◆ Stability Boundary Conditions



\* Stability boundary condition test shows that tantalum capacitors are recommended to minimize the conditions that may cause the device to oscillate.

#### A Note About Stability

When using the GM432 as a shunt regulator, you can optimize stability by setting  $C_L$  either (1) no load capacitance across the GM432, decouple at the load; or (2) large capacitance across the GM432, optional decoupling at the load. The GM432 can become unstable with capacitances of approximately 10nF to 1μF when cathode currents are less than 3mA or so, with instability increasing as cathode current is reduced. So, while the GM432 is happily stable at, for example, cathode current of 10mA with a 0.1μF capacitor across it, it can oscillate transiently as the cathode current rises through the region of instability. To avoid this problem completely, simply eliminate the capacitor or select a very low or very high (e.g. 10μF) capacitor  $C_L$ . Since you will probably want local decoupling at the load, the best idea is to use no capacitance across the device. Just the resistance and capacitance of the PCB traces and vias will prevent local load decoupling from causing transient oscillation during start-up. If you place the GM432 right next to the load, with the load decoupling capacitor directly across it, you must use a capacitor of  $\leq \text{nF}$  or  $\leq 10\mu\text{F}$ .



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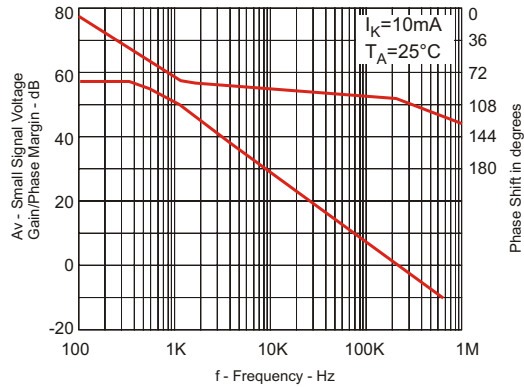


Figure 13. Small Signal Voltage Gain/ Phase Margin vs. Frequency

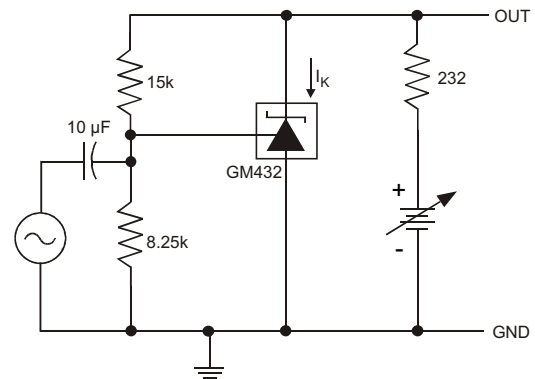
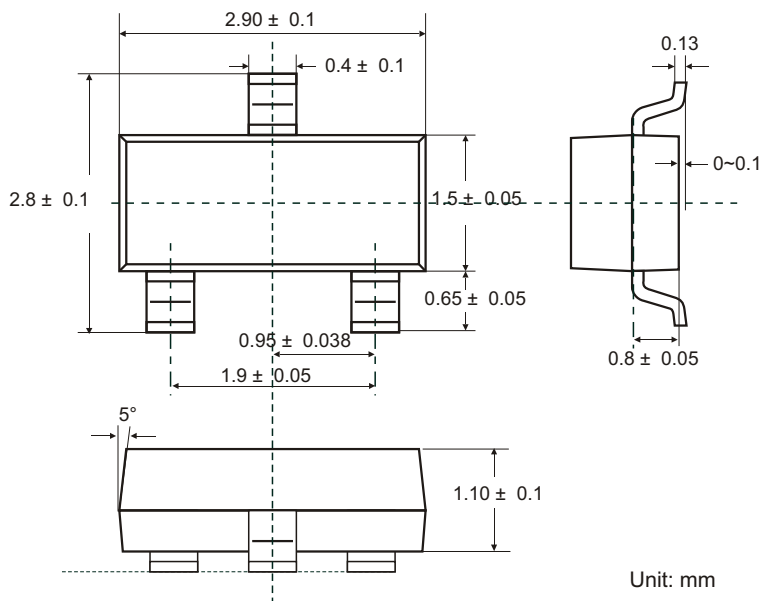
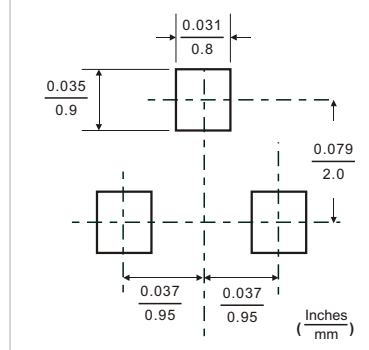


Figure 14. Test Circuit - Small - Signal Gain and Phase

◆ SOT-23 PACKAGE OUTLINE DIMENSIONS

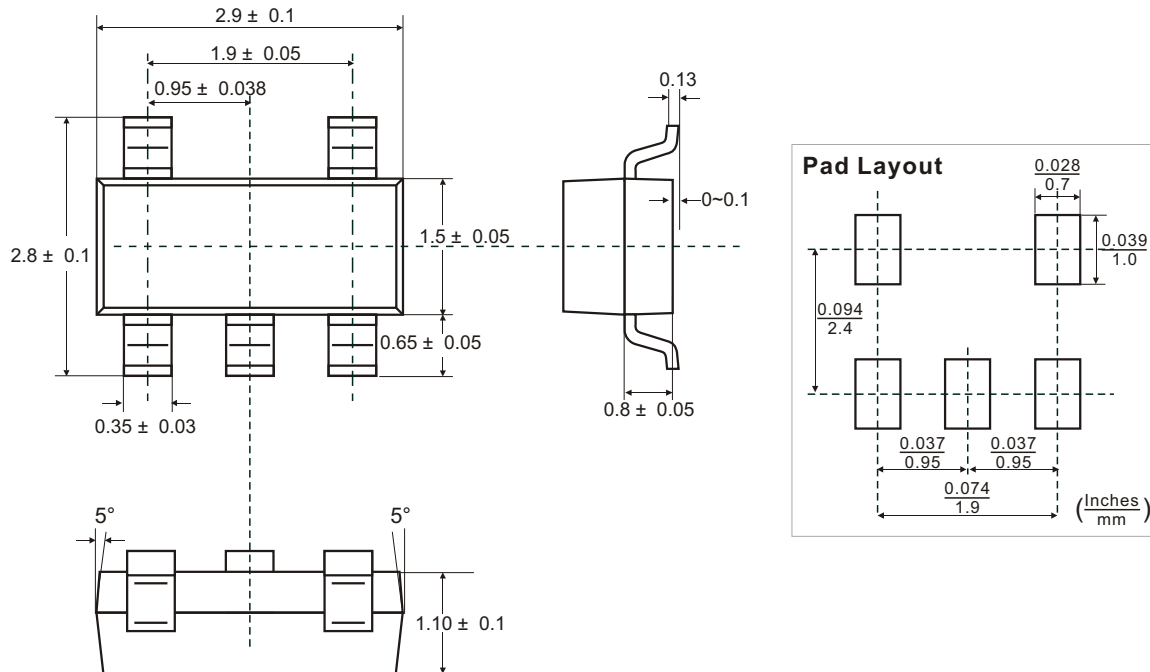


Pad Layout

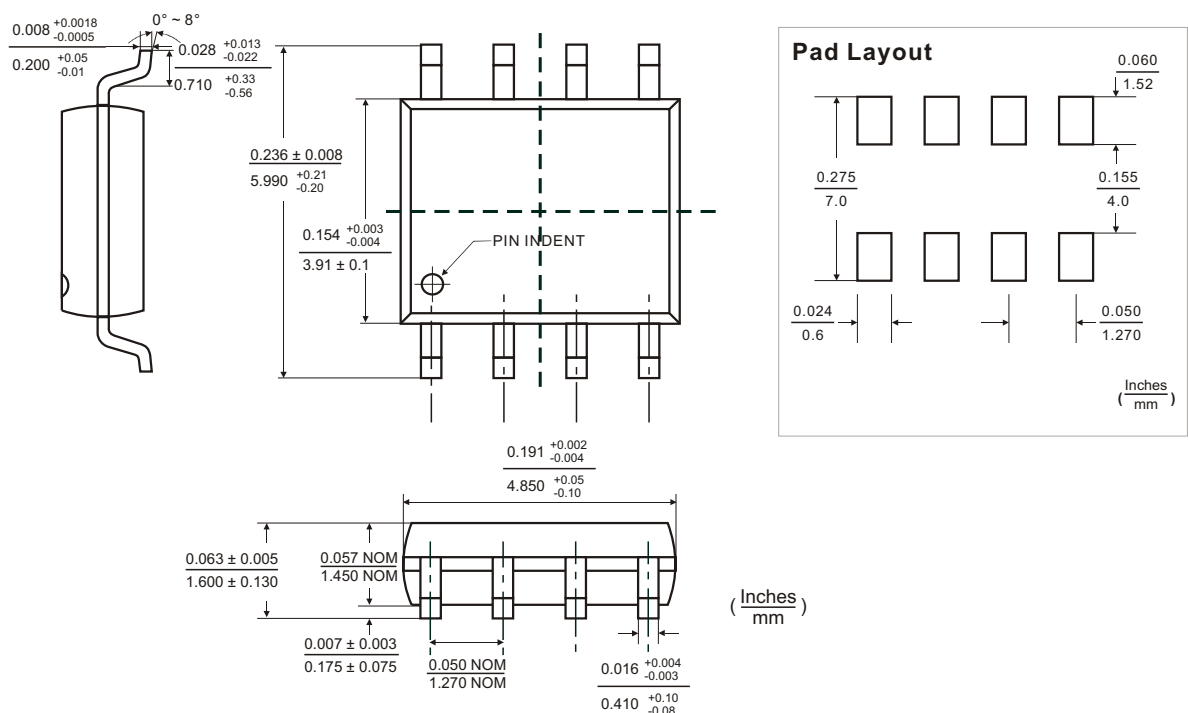


## 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

## ◆ SOT-25(SOT-23-5) PACKAGE OUTLINE DIMENSIONS

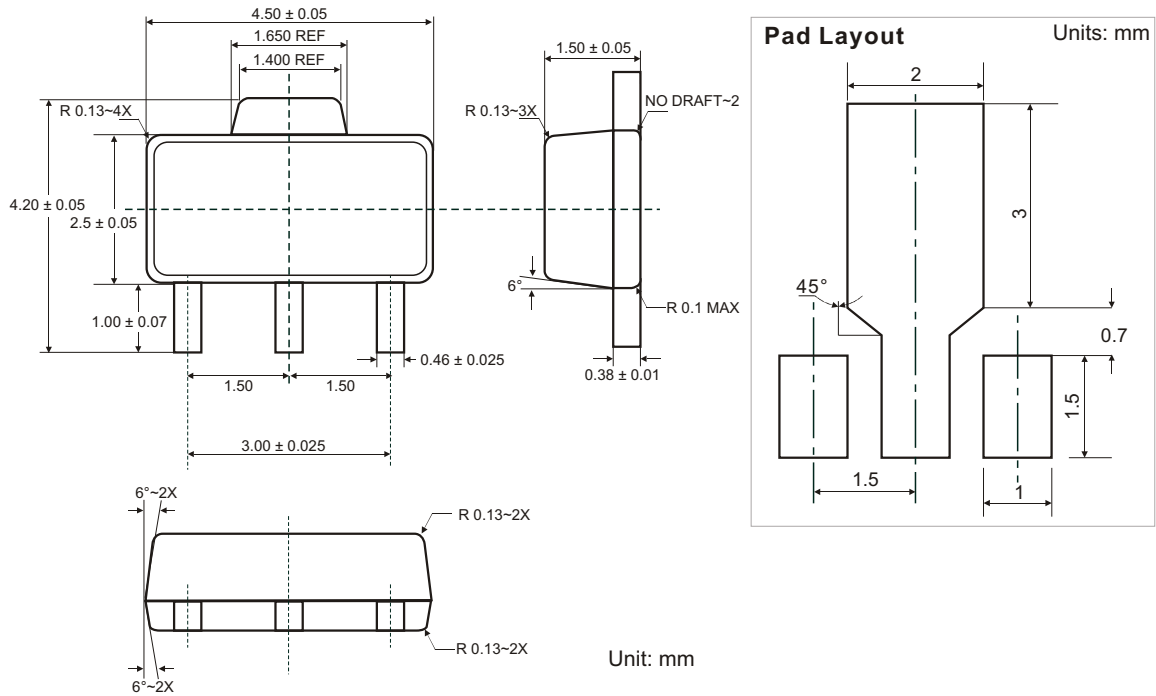


## ◆ SOP-8 PACKAGE OUTLINE DIMENSIONS

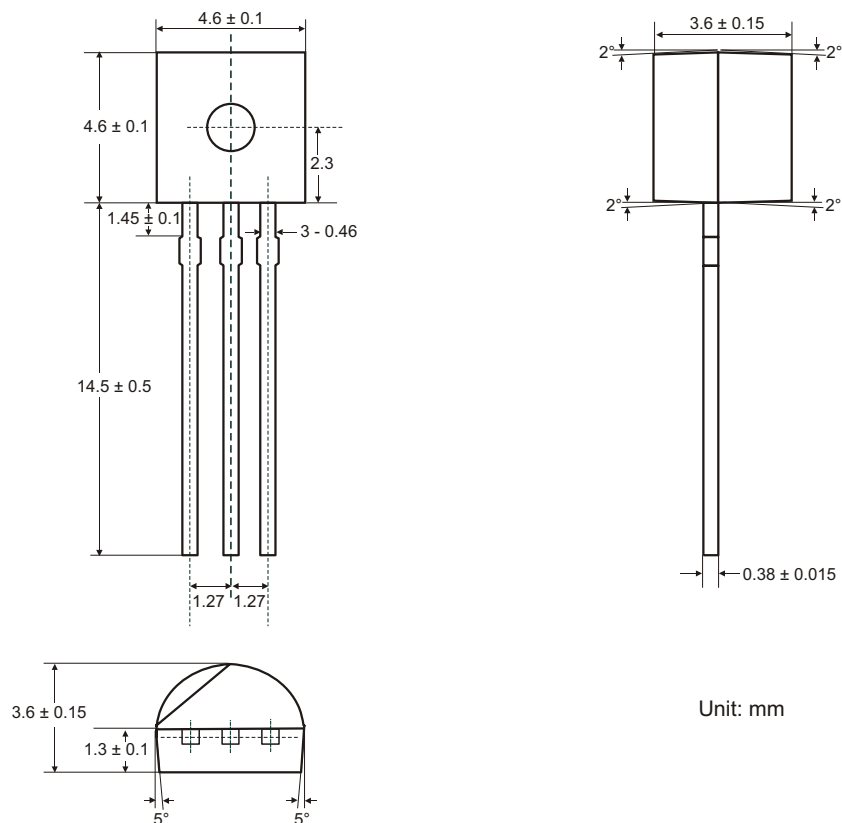


## 1.24V ADJUSTABLE PRECISION SHUNT REGULATORS

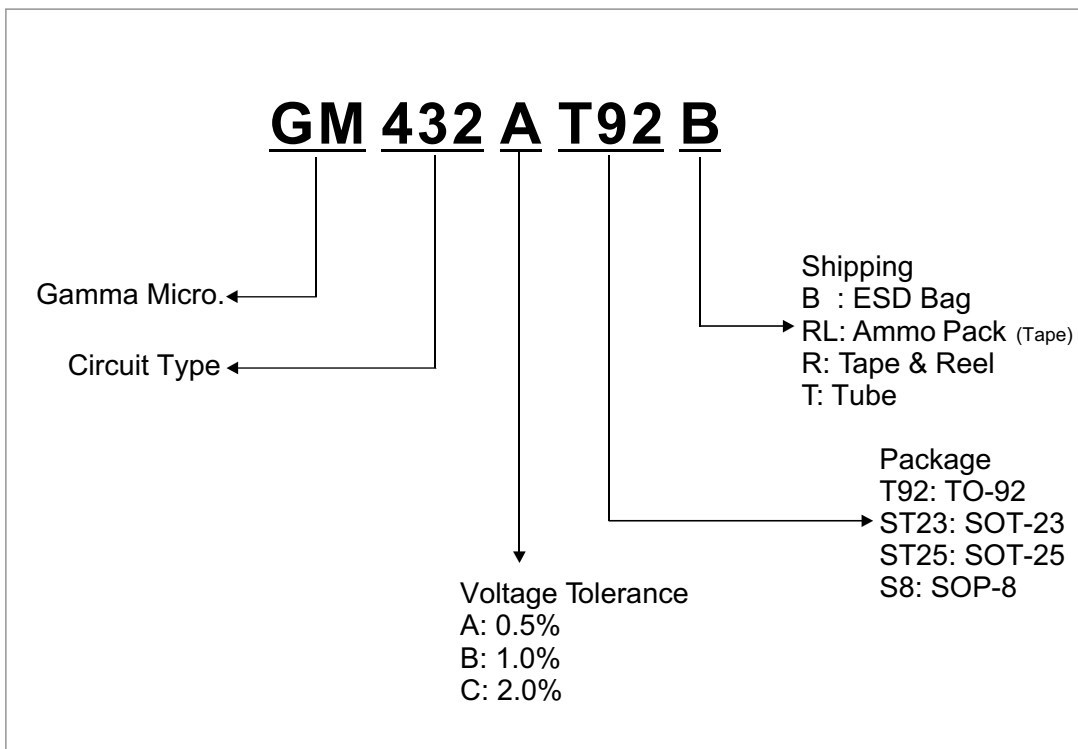
## ◆ SOT-89 PACKAGE OUTLINE DIMENSIONS



## ◆ TO-92 PACKAGE OUTLINE DIMENSIONS



#### ◆ ORDERING NUMBER



**1.24V ADJUSTABLE PRECISION SHUNT REGULATORS**

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