

**SOT-23**

**Pin Definition:**

1. Reference
2. Cathode
3. Anode

### General Description

The TS432AI/TS432BI is a three-terminal adjustable shunt regulator with specified thermal stability. The output voltage may be set to any value between  $V_{REF}$  (approximately 1.24V) and 18V with two external resistors. The TS432AI/TS432BI has a typical output impedance of  $0.05\Omega$ . Active output circuitry provides a very sharp turn-on characteristic, making the TS432AI/TS432BI excellent replacement for zener diode in many applications.

### Features

- Precision Reference Voltage  
TS432AI –  $1.24V \pm 1\%$   
TS432BI –  $1.24V \pm 0.5\%$
- Minimum Cathode Current for Regulation:  $20\mu A$  (typ.)
- Equivalent Full Range Temp. Coefficient:  $50\text{ppm}/^\circ\text{C}$
- Programmable Output Voltage up to 18V
- Fast Turn-On Response
- Sink Current Capability of  $80\mu A$  to  $100\text{mA}$
- Low Dynamic Output Impedance:  $0.2\Omega$
- Low Output Noise

### Application

- Voltage Monitor
- Delay Timmer
- Constant –Current Source/Sink
- High-Current Shunt Regulator
- Crow Bar
- Over-Voltage / Under-Voltage Protection

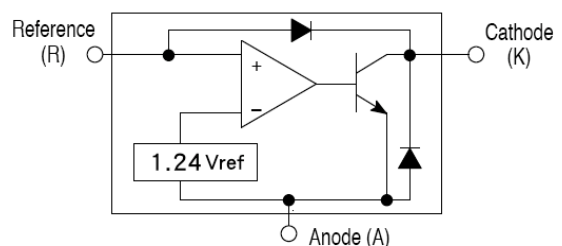
### Ordering Information

| Part No.     | Package | Packing           |
|--------------|---------|-------------------|
| TS432xIX RF  | SOT-23  | 3kpcs / 7" Reel   |
| TS432xIX RFG | SOT-23  | 3kpcs / 7" Reel   |
| TS432xIX RK  | SOT-23  | 10kpcs / 13" Reel |
| TS432xIX RKG | SOT-23  | 10kpcs / 13" Reel |

**Note:** "G" denote for Halogen Free Product

**Note:** Where **xx** denotes voltage tolerance  
**A:**  $\pm 1\%$ , **B:**  $\pm 0.5\%$

### Block Diagram



### Absolute Maximum Ratings ( $T_A = 25^\circ\text{C}$ unless otherwise noted)

| Parameter                        | Symbol     | Limit      | Unit             |
|----------------------------------|------------|------------|------------------|
| Cathode Voltage (Note 1)         | $V_{KA}$   | 18         | V                |
| Continuous Cathode Current Range | $I_K$      | 100        | mA               |
| Reference Input Current Range    | $I_{REF}$  | 3          | mA               |
| Power Dissipation                | TO-92      | 0.625      | W                |
|                                  | SOT-23     | 0.35       |                  |
| Junction Temperature             | $T_J$      | +150       | $^\circ\text{C}$ |
| Operation Temperature Range      | $T_{OPER}$ | -40 ~ +105 | $^\circ\text{C}$ |
| Storage Temperature Range        | $T_{STG}$  | -65 ~ +150 | $^\circ\text{C}$ |

Note 1: Voltage values are with respect to the anode terminal unless otherwise noted.

Note 2: Rating apply to ambient temperature at  $25^\circ\text{C}$

### Recommend Operating Condition

| Parameter                        | Symbol   | Limit | Unit |
|----------------------------------|----------|-------|------|
| Cathode Voltage (Note 1)         | $V_{KA}$ | 18    | V    |
| Continuous Cathode Current Range | $I_K$    | 100   | mA   |

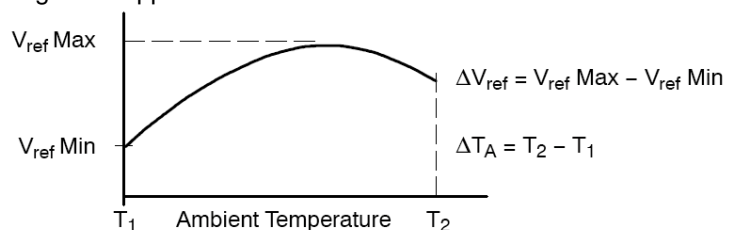
### Recommend Operating Condition

| Parameter  | Symbol                         | Test Conditions  | Min   | Typ   | Max   | Unit          |
|--|--------------------------------|--|-------|-------|-------|---------------|
| Reference voltage                                    | $V_{REF}$                      | $V_{KA} = V_{REF}$ , $I_K = 10\text{mA}$ (Figure 1)<br>$T_a = 25^\circ\text{C}$                          | 1.227 | 1.240 | 1.252 | V             |
|  |                                |  | 1.233 |       | 1.246 |               |
| Deviation of reference input voltage                 | $\Delta V_{REF}$               | $V_{KA} = V_{REF}$ , $I_K = 10\text{mA}$<br>$T_a = \text{full range}$ (Figure 1)                         | --    | 10    | 25    | mV            |
| Radio of change in Vref to change in cathode Voltage | $\Delta V_{REF}/\Delta V_{KA}$ | $I_{KA} = 10\text{mA}$ , $V_{KA} = 18\text{V to } V_{REF}$<br>(Figure 2)                                 | --    | -1.0  | -2.7  | mV/V          |
| Reference Input current                              | $I_{REF}$                      | $R1 = 10\text{K}\Omega$ , $R2 = \infty$ , $I_{KA} = 10\text{mA}$<br>$T_a = \text{full range}$ (Figure 2) | --    | 0.25  | 0.5   | $\mu\text{A}$ |
| Deviation of reference input current, over temp.     | $\Delta I_{REF}$               | $R1 = 10\text{K}\Omega$ , $R2 = \infty$ , $I_{KA} = 10\text{mA}$<br>$T_a = \text{full range}$ (Figure 2) | --    | 0.04  | 0.08  | $\mu\text{A}$ |
| Off-state Cathode Current                            | $I_{KA(off)}$                  | $V_{REF} = 0\text{V}$ (Figure 3),<br>$V_{KA} = 18\text{V}$   | --    | 0.125 | 0.5   | $\mu\text{A}$ |
| Dynamic Output Impedance                             | $ Z_{KA} $                     | $f < 1\text{KHz}$ , $V_{KA} = V_{REF}$<br>$I_{KA} = 1\text{mA to } 100\text{mA}$ (Figure 1)              | --    | 0.2   | 0.4   | $\Omega$      |
| Minimum operating cathode current                    | $I_{KA(min)}$                  | $V_{KA} = V_{REF}$ (Figure 1)  | --    | 60    | 80    | $\mu\text{A}$ |

\* The deviation parameters  $\Delta V_{REF}$  and  $\Delta I_{REF}$  are defined as difference between the maximum value and minimum value obtained over the full operating ambient temperature range that applied.

\* The average temperature coefficient of the reference input voltage,  $\alpha V_{REF}$  is defined as:

$$\alpha V_{ref} \left( \frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{\left( \frac{\Delta V_{ref}}{V_{ref}} \right) \times 10^6}{\Delta T_A}$$



Where: **T2-T1** = full temperature change.

$\alpha V_{REF}$  can be positive or negative depending on whether  $V_{REF}$  Min. or  $V_{REF}$  Max occurs at the lower ambient temperature. Example:  $\Delta V_{REF} = 7.2\text{mV}$  and the slope is positive,  $V_{REF} = 1.241\text{V}$  at  $25^\circ\text{C}$ ,  $\Delta T = 125^\circ\text{C}$

$$\alpha V_{ref} \left( \frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{0.0072 \times 10^6}{1.241} = 46 \text{ ppm}/^\circ\text{C}$$

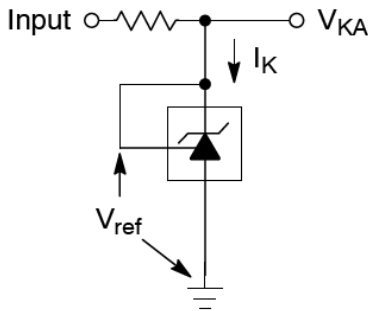
\* The dynamic impedance  $Z_{KA}$  is defined as:

$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

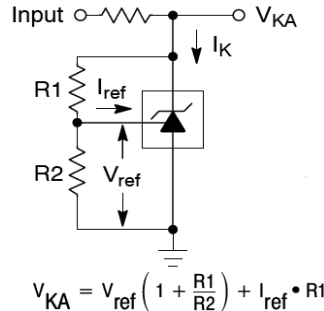
\* When the device operating with two external resistors,  $R1$  and  $R2$ , (refer to Figure 2) the total dynamic impedance of the circuit is given by:

$$|Z_{KA}'| = |Z_{KA}| \times \left( 1 + \frac{R1}{R2} \right)$$

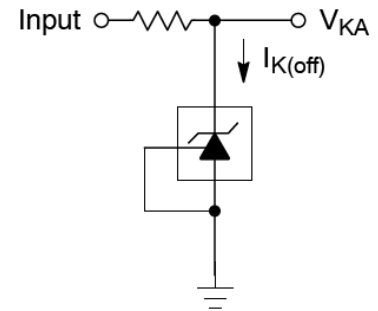
**Test Circuits**



**Figure 1:  $V_{KA} = V_{REF}$**



**Figure 2:  $V_{KA} > V_{REF}$**



**Figure 3: Off-State Current**

**Additional Information – Stability**

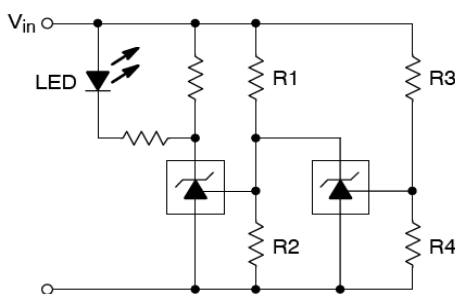
When The TS432AI/432BI is used as a shunt regulator, there are two options for selection of  $C_L$ , are recommended for optional stability:

- A) No load capacitance across the device, decouple at the load.
- B) Large capacitance across the device, optional decoupling at the load.

The reason for this is that TS432AI/432BI exhibits instability with capacitances in the range of 10nF to 1μF (approx.) at light cathode current up to 3mA(typ). The device is less stable the lower the cathode voltage has been set for. Therefore while the device will be perfectly stable operating at a cathode current of 10mA (approx.) with a 0.1μF capacitor across it, it will oscillate transiently during start up as the cathode current passes through the instability region. Select a very low capacitance, or alternatively a high capacitance (10μF) will avoid this issue altogether. Since the user will probably wish to have local decoupling at the load anyway, the most cost effective method is to use no capacitance at all directly across the device. PCB trace/via resistance and inductance prevent the local load decoupling from causing the oscillation during the transient start up phase.

Note: if the TS432AI/432BI is located right at the load, so the load decoupling capacitor is directly across it, then this capacitor will have to be  $\leq 1nF$  or  $\geq 10\mu F$ .

**Applications Examples**

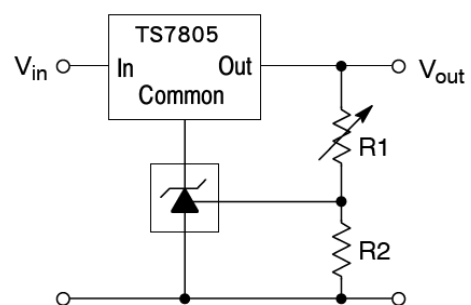


L.E.D. indicator is 'ON' when  $V_{in}$  is between the upper and lower limits,

$$\text{Lower limit} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$$\text{Upper limit} = \left(1 + \frac{R3}{R4}\right) V_{ref}$$

**Figure 4: Voltage Monitor**

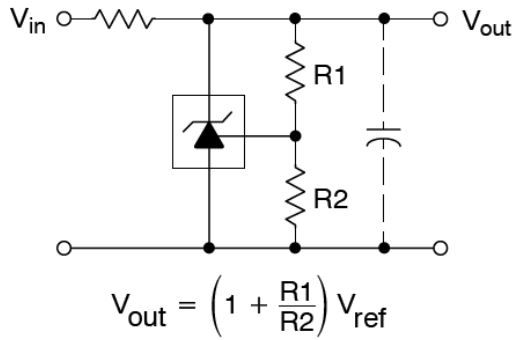


$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

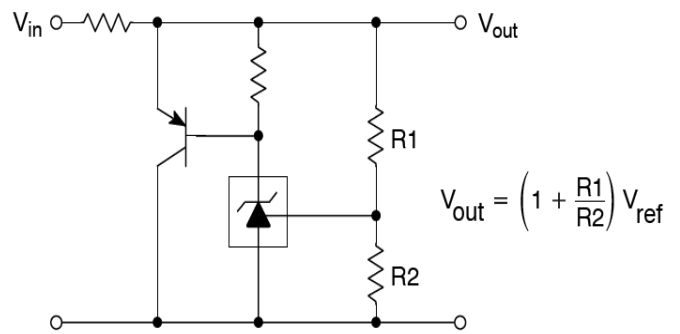
$$V_{out(min)} = V_{ref} + 5.0 V$$

**Figure 5: Output Control for Three Terminal Fixed Regulator**

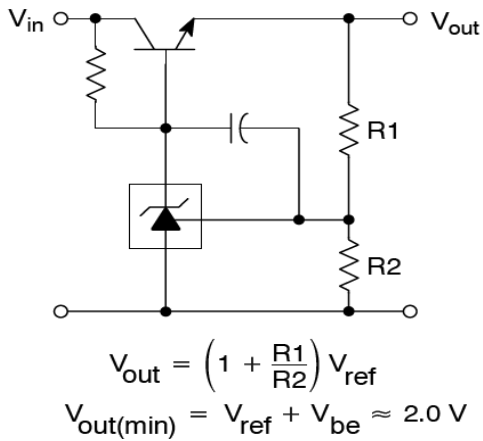
**Applications Examples (Continue)**



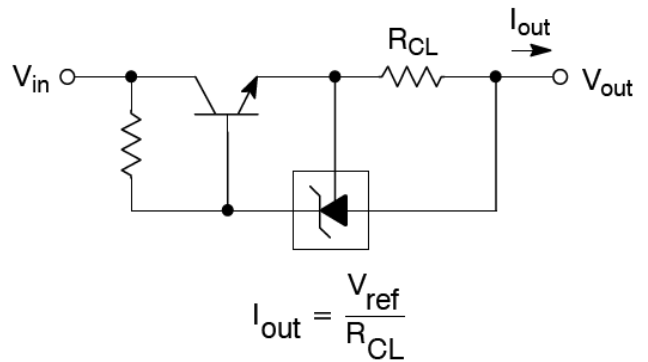
**Figure 6: Shunt Regulator**



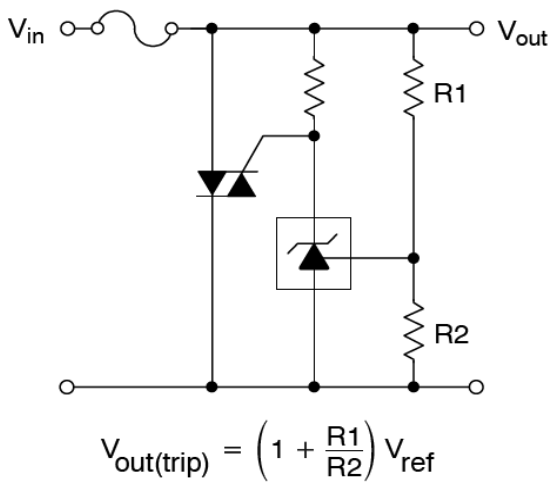
**Figure 7: High Current Shunt Regulator**



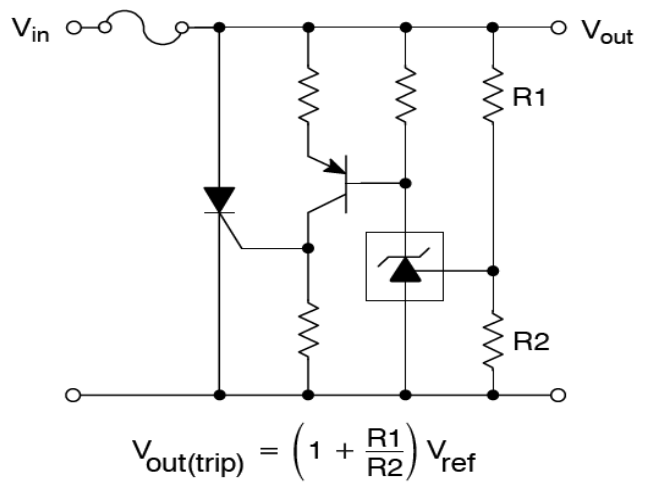
**Figure 8: Series Pass Regulator**



**Figure 9: Constant Current Source**

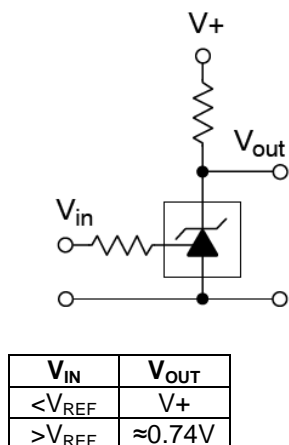


**Figure 10: TRIAC Crowbar**

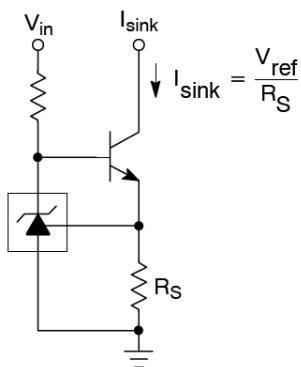


**Figure 11: SCR Crowbar**

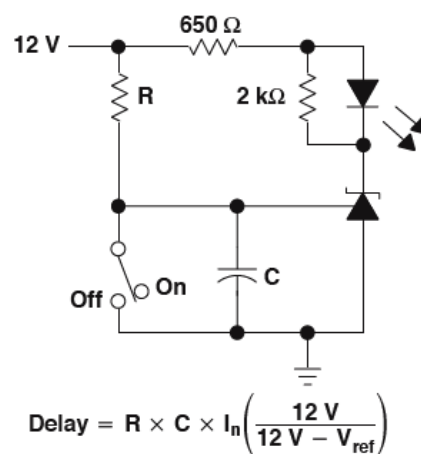
### Applications Examples (Continue)



**Figure 12: Single-Supply Comparator with Temperature-Compensated Threshold**

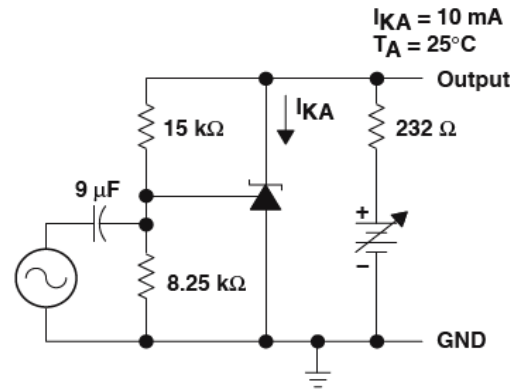
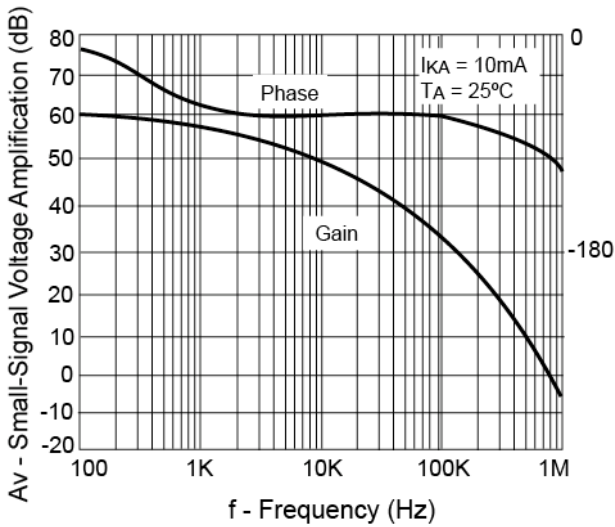


**Figure 13: Constant Current Sink**



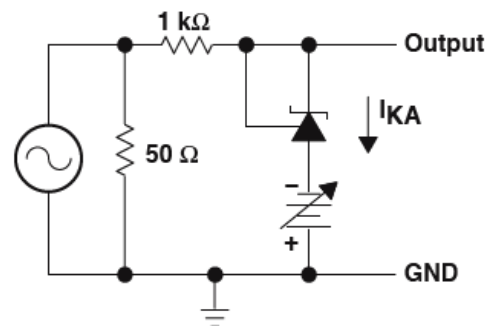
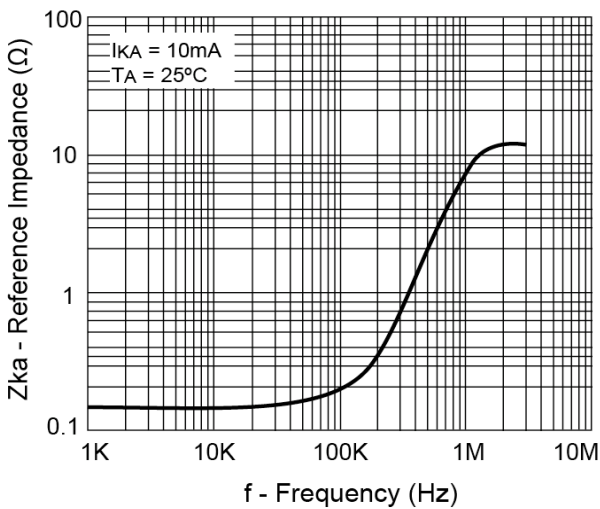
**Figure 14: Delay Timer**

**Typical Performance Characteristics**



**Test Circuit for Voltage Amplification**

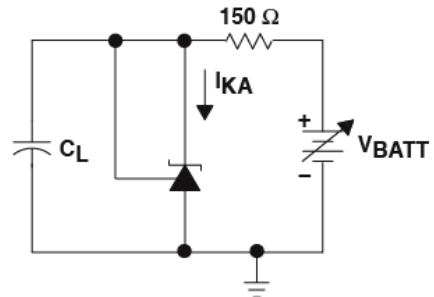
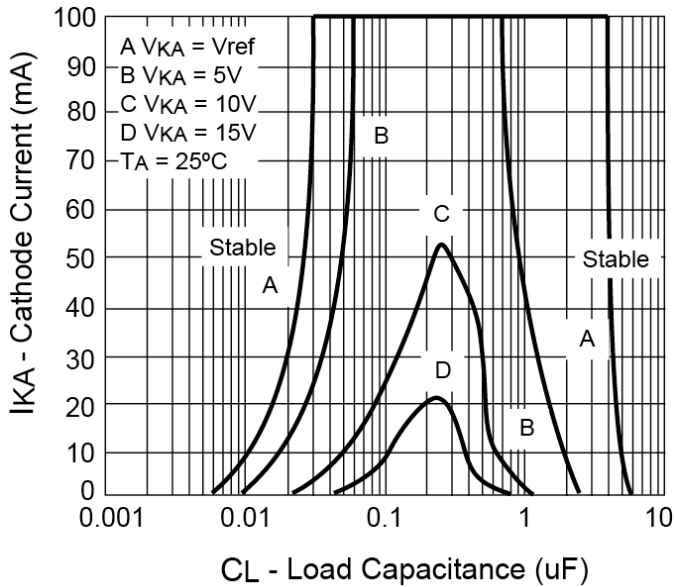
**Figure 15: Small-Signal Voltage Gain and Phase Shift vs. Frequency**



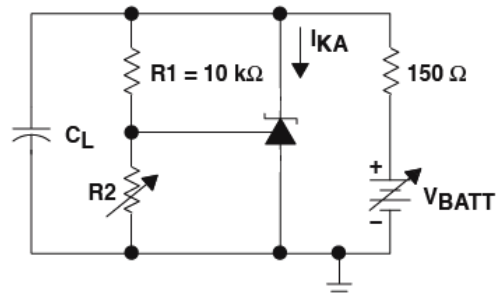
**Test Circuit for Reference Impedance**

**Figure 16: Reference Impedance vs. Frequency**

**Typical Performance Characteristics**



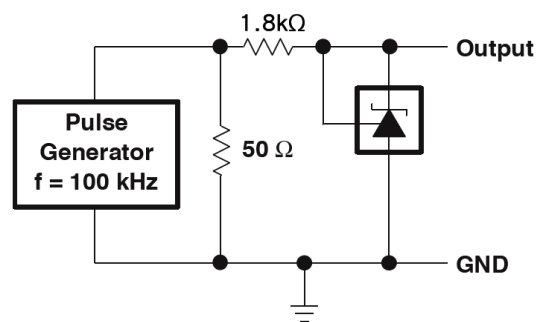
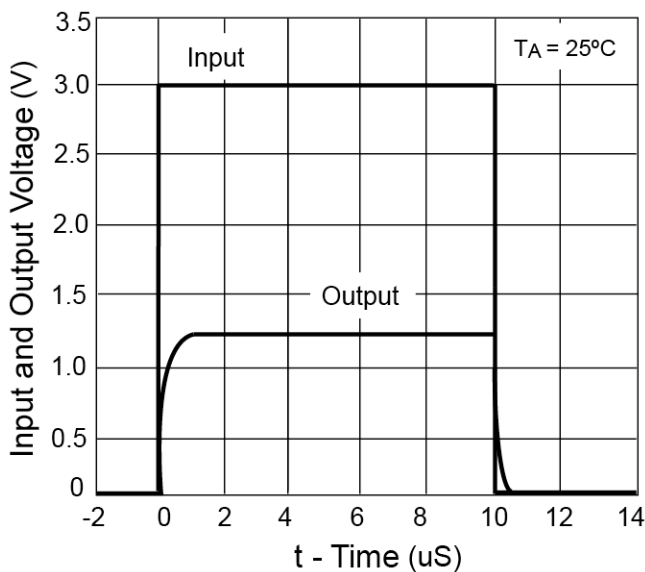
**Test Circuit for Curve A**



**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  $C_L$  then were adjusted to determine the ranges of stability.

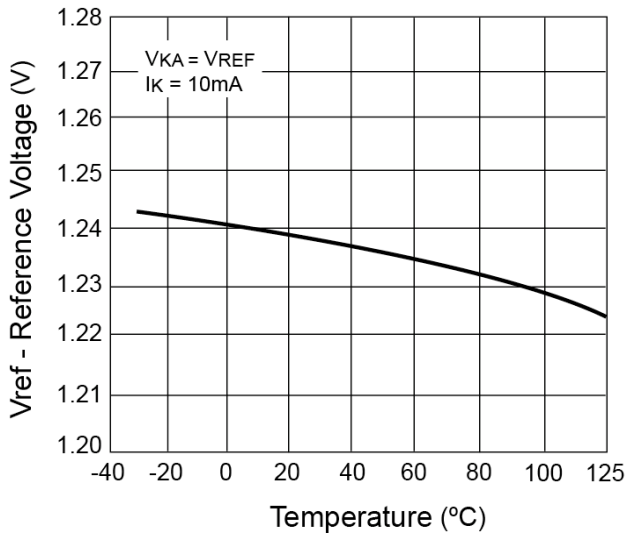
**Figure 17: Stability Boundary Condition**



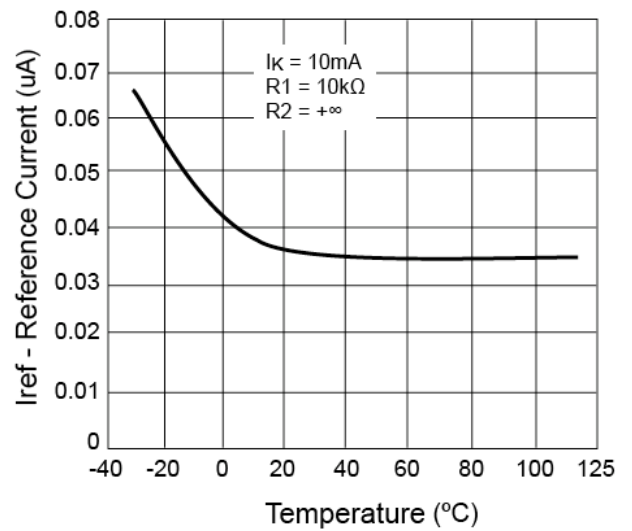
**Test Circuit for Pulse Response,  $I_{k}=1mA$**

**Figure 18: Pulse Response**

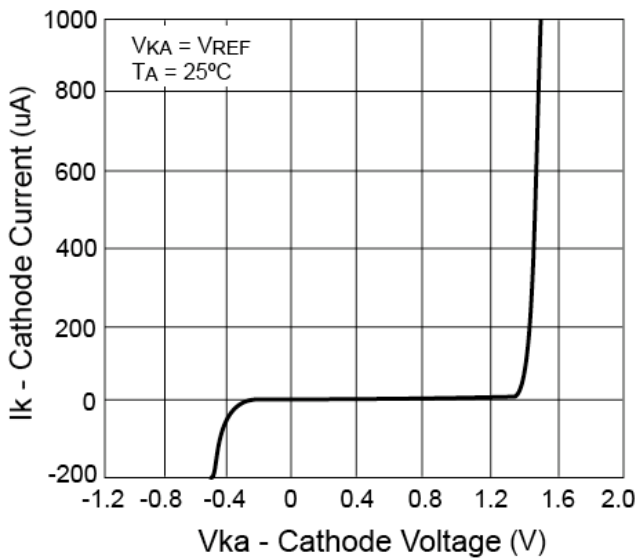
**Electrical Characteristics**



**Figure 19: Reference Voltage vs. Temperature**



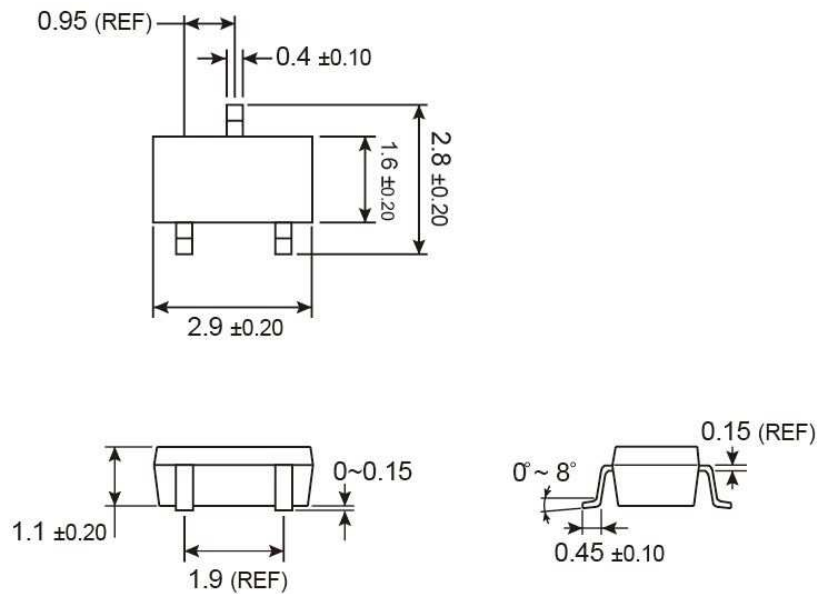
**Figure 20: Reference Current vs. Temperature**



**Figure 21: Cathode Current vs. Cathode Voltage**

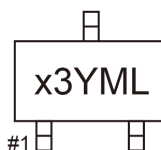


**SOT-23 Mechanical Drawing**



Unit: Millimeters

**Marking Diagram**



- X** = Device Code  
(**D** = TS432AI, **E** = TS432BI)
- 3** = SOT-23 package
- Y** = Year Code
- M** = Month Code  
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apr, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)  
= Month Code for Halogen Free Product  
(**O**=Jan, **P**=Feb, **Q**=Mar, **R**=Apr, **S**=May, **T**=Jun, **U**=Jul, **V**=Aug, **W**=Sep, **X**=Oct, **Y**=Nov, **Z**=Dec)
- L** = Lot Code



# TS432I

## Adjustable Precision Shunt Regulator

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