

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 0.05Ω . 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 100mA
- Low Dynamic Output Impedance: 0.2Ω
- Low Output Noise

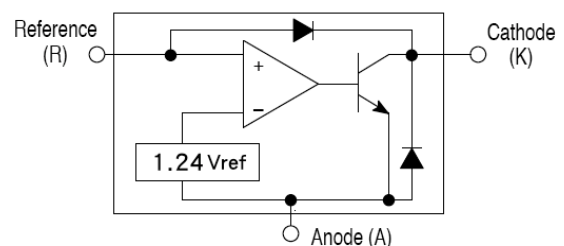
Ordering Information

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°C

Recommend Operating Condition

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

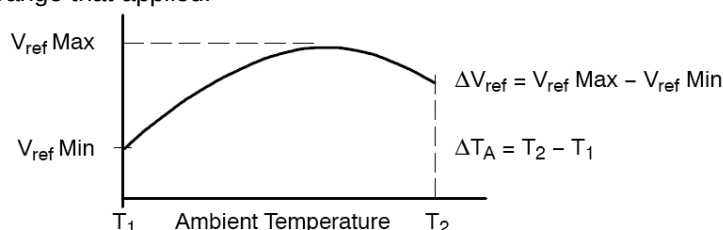
Recommend Operating Condition

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

* The deviation parameters ΔV_{REF} and ΔI_{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, αV_{REF} is defined as:

$$\alpha V_{ref} \left(\frac{ppm}{^{\circ}C} \right) = \frac{\left(\frac{\Delta V_{ref}}{V_{ref}} \right) (T_A = 25^{\circ}C) \times 10^6}{\Delta T_A}$$



Where: T_2-T_1 = full temperature change.

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

$$\alpha V_{ref} \left(\frac{ppm}{^{\circ}C} \right) = \frac{0.0072 \times 10^6}{125} = 46 \text{ ppm}/^{\circ}C$$

* 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

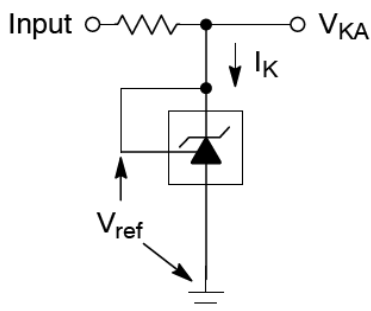


Figure 1: $V_{KA} = V_{REF}$

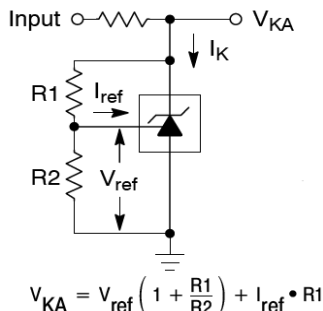


Figure 2: $V_{KA} > V_{REF}$

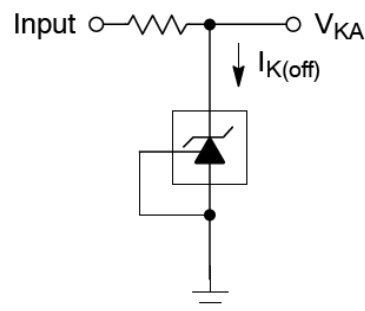


Figure 3: Off-State Current

Additional Information – Stability

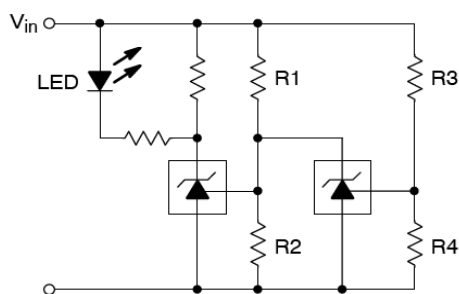
When The TS432AI/432BI is used as a shunt regulator, there are two options for selection of C_L , are recommended for optional stability:

- 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 $\leq 1\text{nF}$ or $\geq 10\mu\text{F}$.

Applications Examples

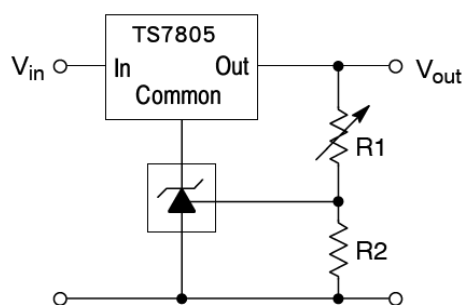


L.E.D. indicator is 'ON' when V_{in} is between the upper and lower limits,

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

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

Figure 4: Voltage Monitor



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

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

Figure 5: Output Control for Three Terminal Fixed Regulator

Applications Examples (Continue)

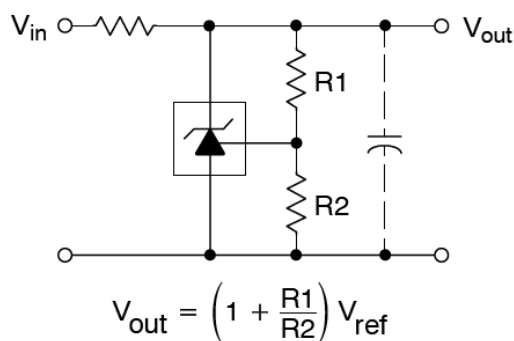


Figure 6: Shunt Regulator

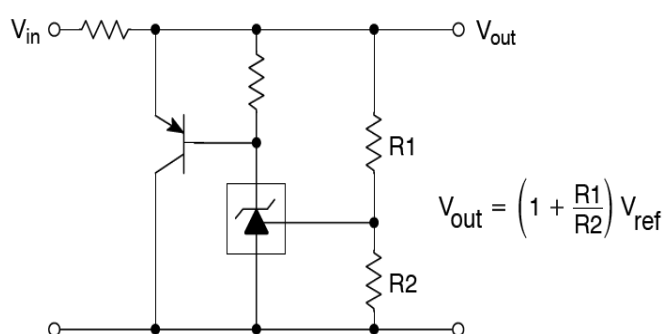


Figure 7: High Current Shunt Regulator

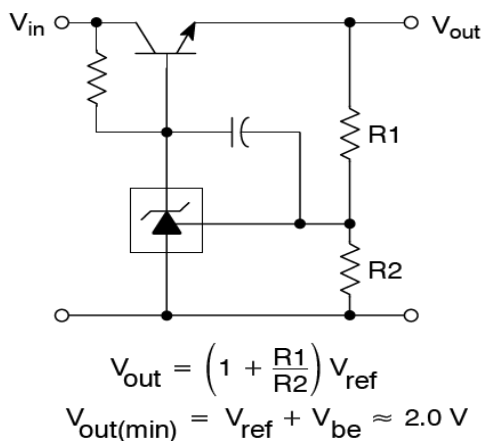


Figure 8: Series Pass Regulator

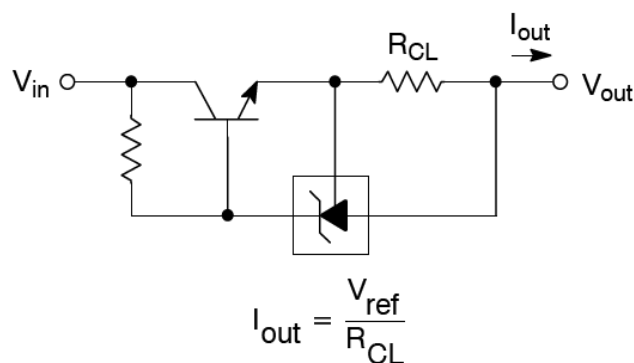


Figure 9: Constant Current Source

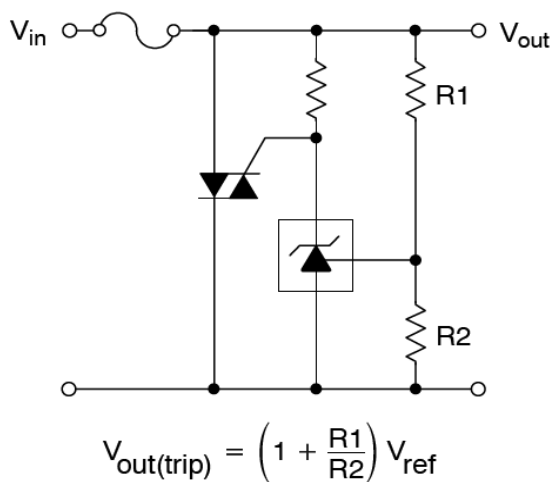


Figure 10: TRIAC Crowbar

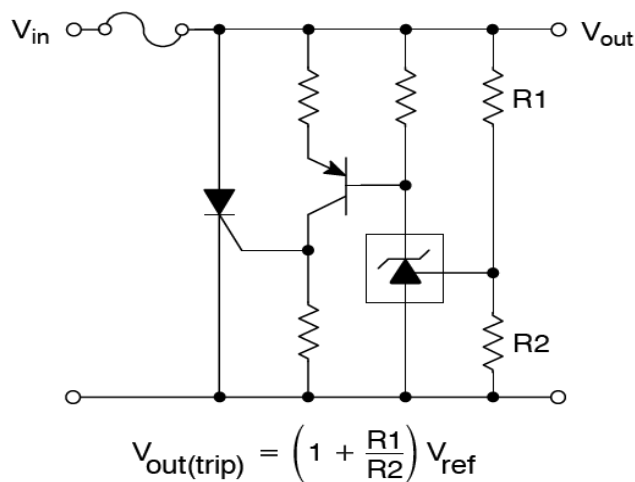


Figure 11: SCR Crowbar

Applications Examples (Continue)

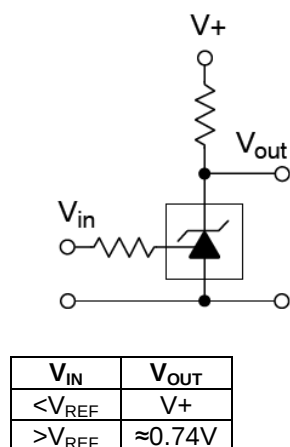


Figure 12: Single-Supply Comparator with Temperature-Compensated Threshold

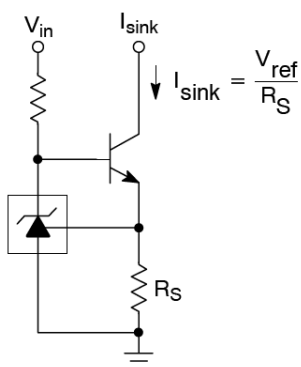


Figure 13: Constant Current Sink

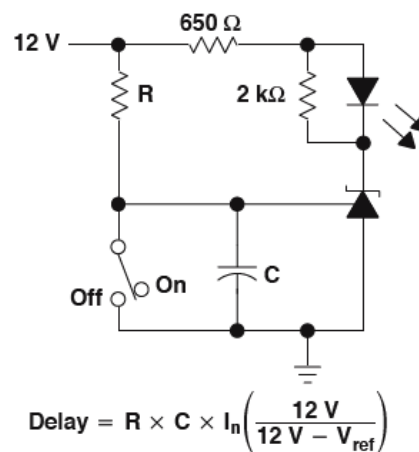


Figure 14: Delay Timer

Typical Performance Characteristics

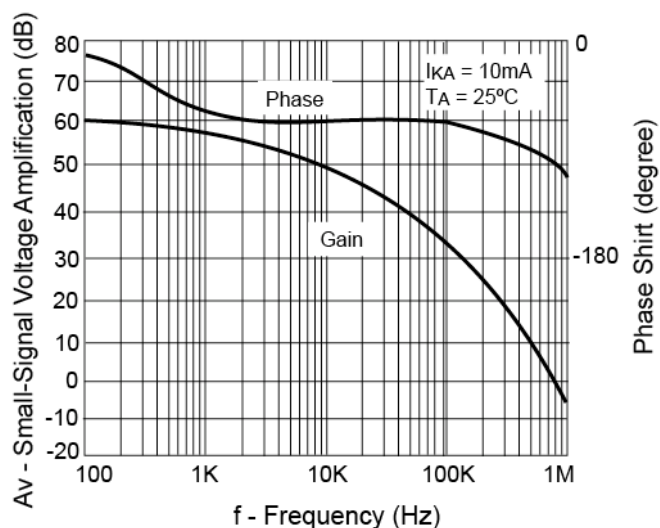


Figure 15: Small-Signal Voltage Gain and Phase Shift vs. Frequency

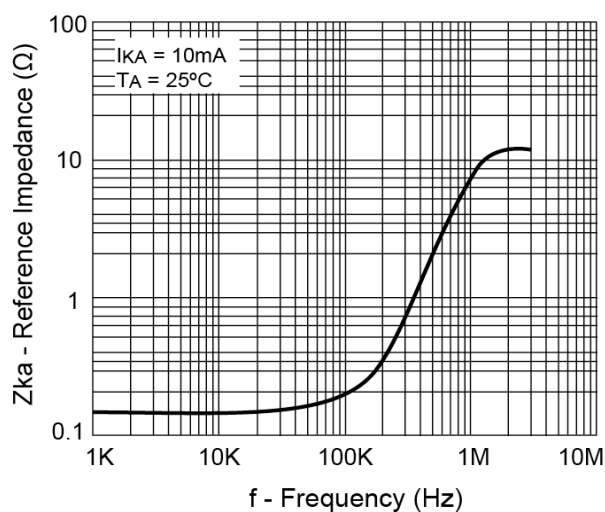
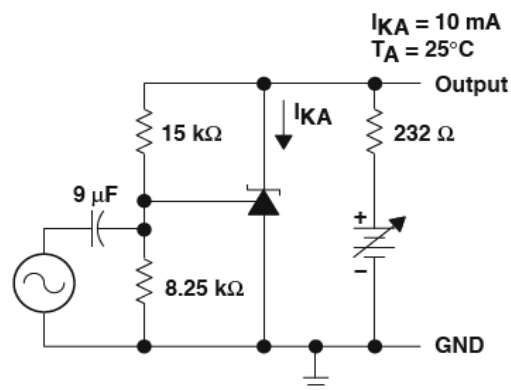
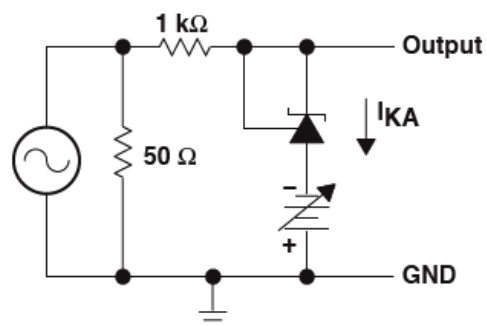


Figure 16: Reference Impedance vs. Frequency

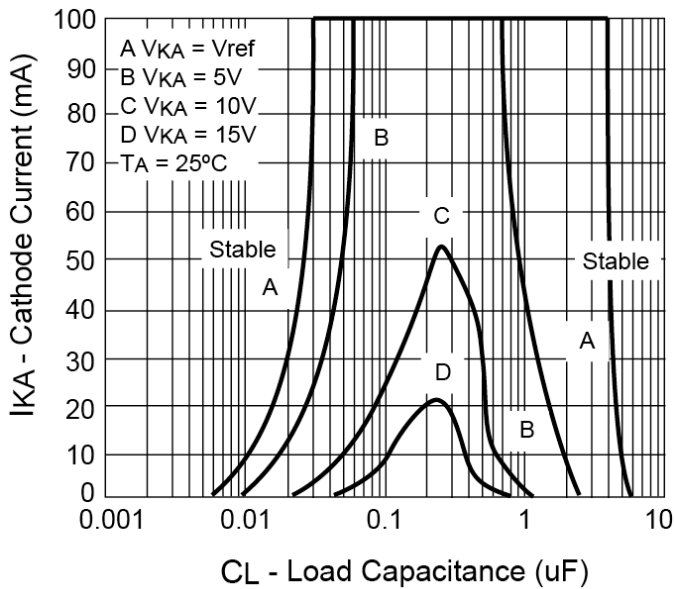


Test Circuit for Voltage Amplification

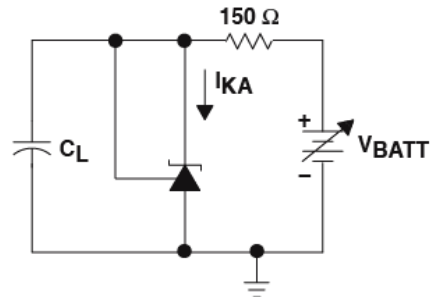


Test Circuit for Reference Impedance

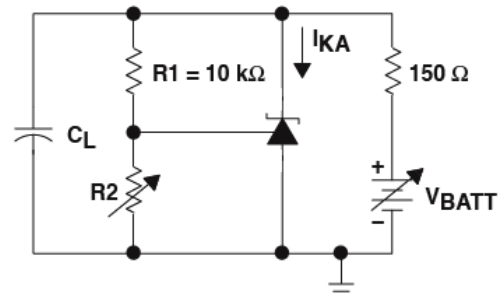
Typical Performance Characteristics



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.

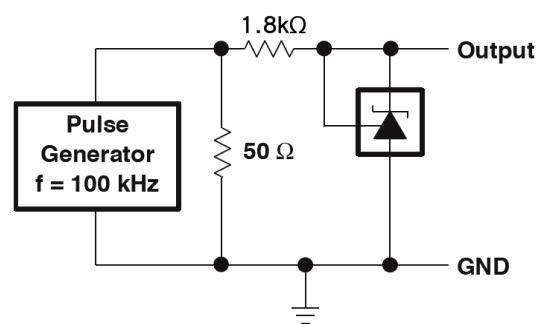
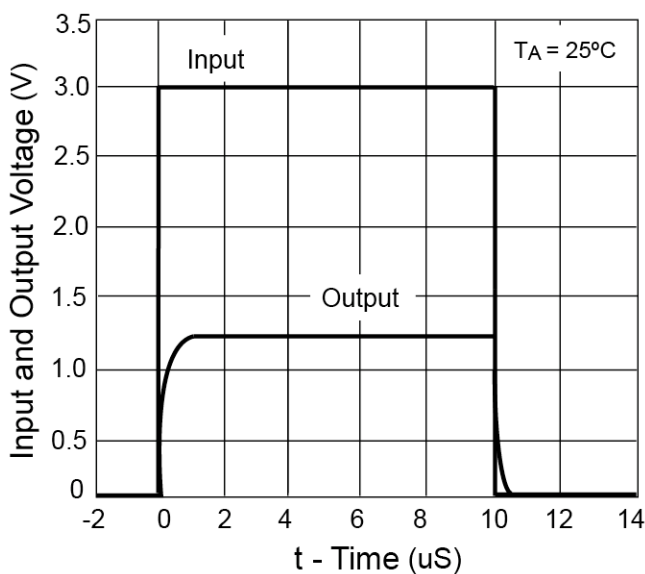


Test Circuit for Curve A



Test Circuit for Curve B, C and D

Figure 17: Stability Boundary Condition



Test Circuit for Pulse Response, $I_K = 1\ mA$

Figure 18: Pulse Response

Electrical Characteristics

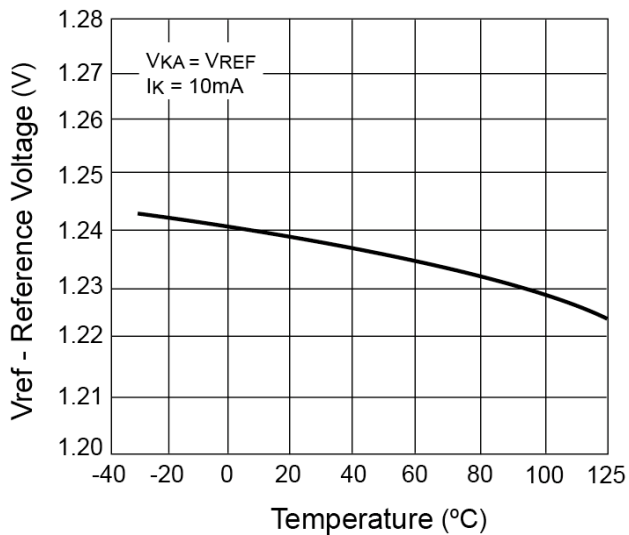


Figure 19: Reference Voltage vs. Temperature

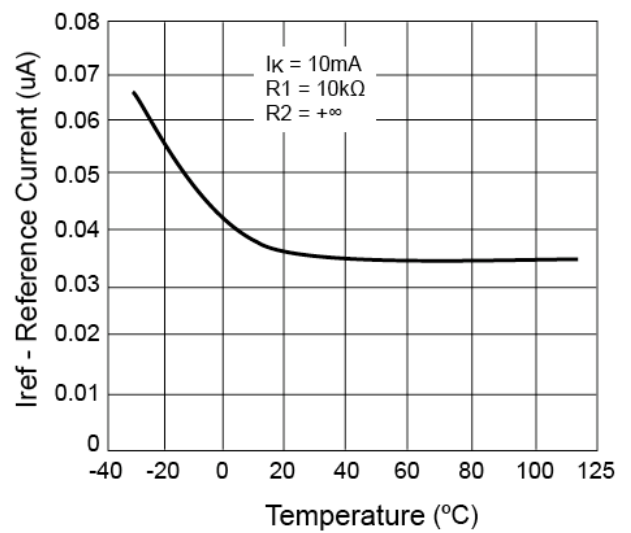


Figure 20: Reference Current vs. Temperature

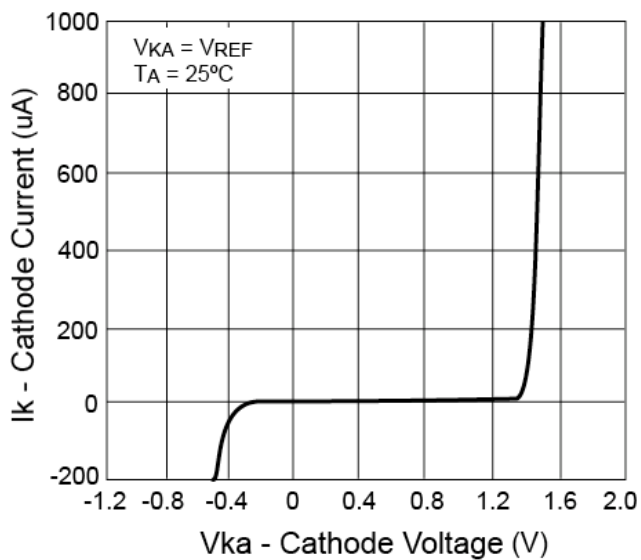
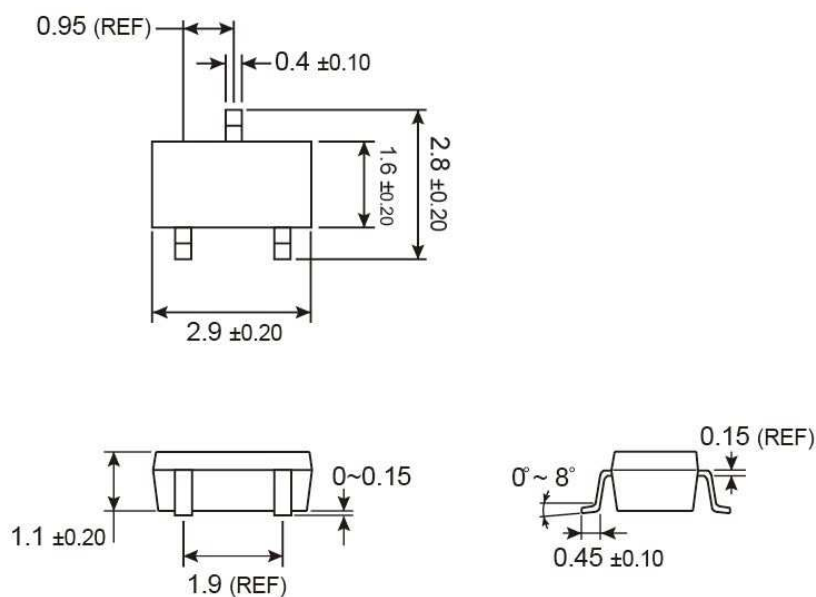


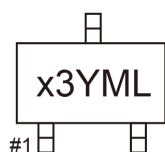
Figure 21: Cathode Current vs. Cathode Voltage

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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