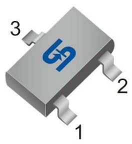
TAIWAN SEMICONDUCTOR

RoHS COMPLIANCE

TS432I

Adjustable Precision Shunt Regulator

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

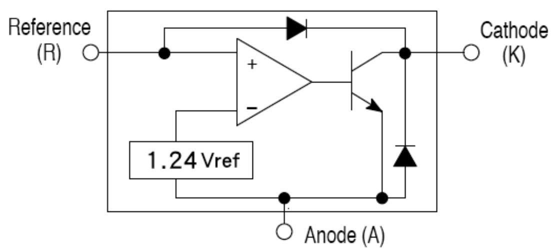
- Precision Reference Voltage
  TS432AI – 1.24V±1%
  TS432BI – 1.24V±0.5%
- Minimum Cathode Current for Regulation: 20µA(typ.)
- Equivalent Full Range Temp. Coefficient: 50ppm/ ºC
- Programmable Output Voltage up to 18V
- Fast Turn-On Response
- Sink Current Capability of 80µA to 100mA
- Low Dynamic 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: ±1%, **B:** ±0.5%

Block Diagram



Application

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

Absolute Maximum Ratings (T_A = 25°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	P_D	0.625	W
	SOT-23		0.35	
Junction Temperature		T_J	+150	^oC
Operation Temperature Range		T_{OPER}	-40 ~ +105	^oC
Storage Temperature Range		T_{STG}	-65 ~ +150	^oC

Note 1: Voltage values are with respect to the anode terminal unless otherwise noted.
Note 2: Rating apply to ambient temperature at 25^{o}C

Recommend Operating Condition

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

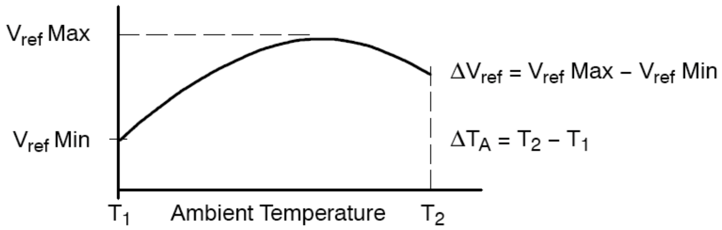
Recommend Operating Condition

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Reference voltage	TS432AI	V_{REF}	V_{KA} =V_{REF}, I_K=10mA (Figure 1) Ta=25°C	1.227	1.240	1.252	V
	TS432BI			1.233		1.246	
Deviation of reference input voltage		ΔV_{REF}	V_{KA} =V_{REF}, I_K=10mA Ta= 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=10KΩ, R2=∞, I_{KA}=10mA Ta= full range (Figure 2)	--	0.25	0.5	µA
Deviation of reference input current, over temp.		ΔI_{REF}	R1=10KΩ, R2=∞, I_{KA}=10mA Ta= 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:

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



Where: **T2-T1** = 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: ΔV_{REF}=7.2mV and the slope is positive, V_{REF}=1.241V at 25°C, ΔT=125°C

$$\alpha V_{ref}\left(\frac{ppm}{^\circ C}\right) = \frac{\frac{0.0072}{1.241} \times 10^6}{125} = 46\ ppm/^\circ C$$

* 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

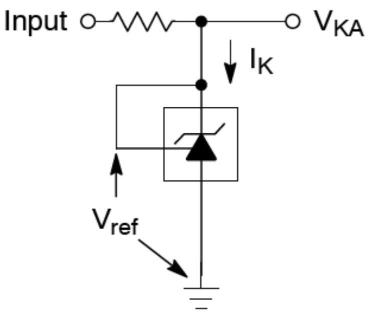
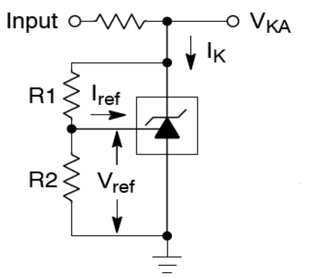


Figure 1: $V_{KA} = V_{REF}$



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

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

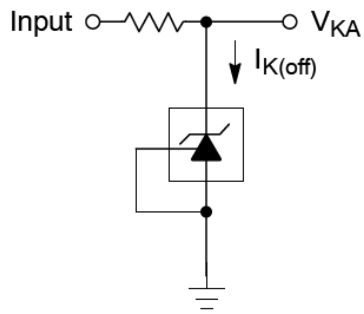


Figure 3: Off-State Current

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:

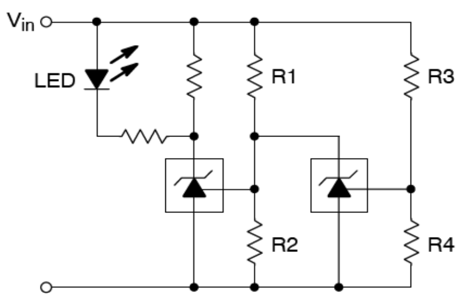
A) No load capacitance across the device, decouple at the load.

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 ≤1nF or ≥10µF.

Applications Examples

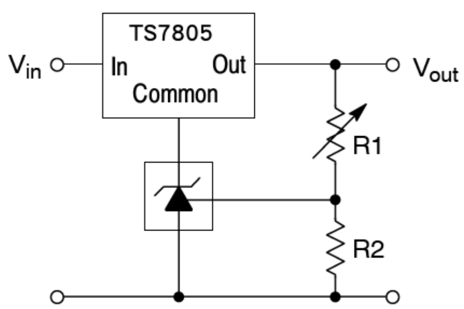


L.E.D. indicator is 'ON' when V_{in} is between the upper and lower limits,

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

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

Figure 4: Voltage Monitor

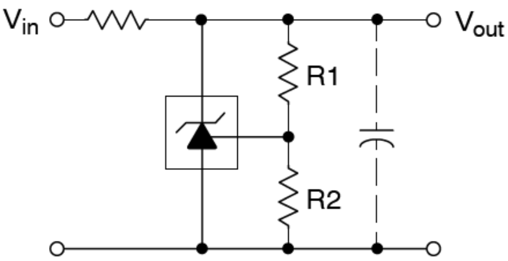


$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

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

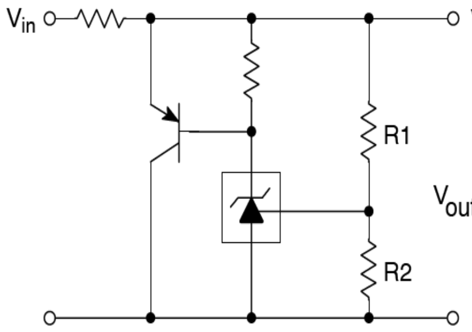
Figure 5: Output Control for Three Terminal Fixed Regulator

Applications Examples (Continue)



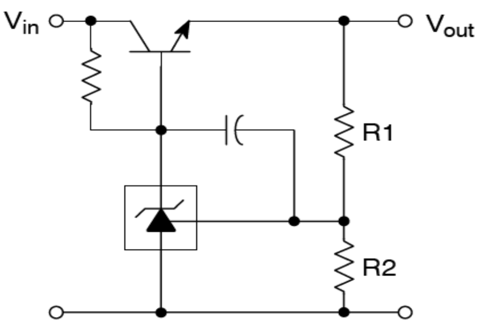
$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

Figure 6: Shunt Regulator



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

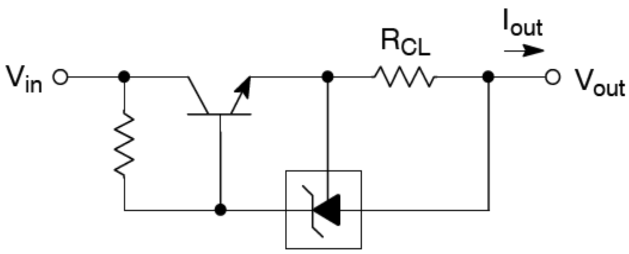
Figure 7: High Current Shunt Regulator



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

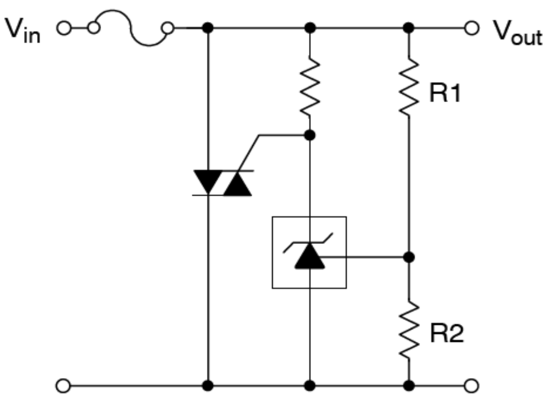
$$V_{out(min)} = V_{ref} + V_{be} \approx 2.0\ V$$

Figure 8: Series Pass Regulator



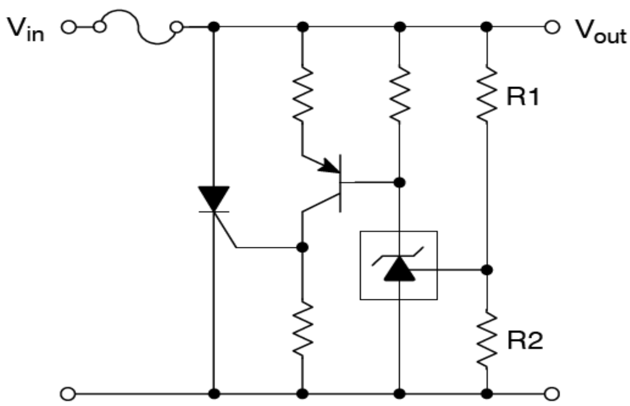
$$I_{out} = \frac{V_{ref}}{R_{CL}}$$

Figure 9: Constant Current Source



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

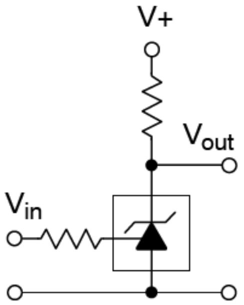
Figure 10: TRIAC Crowbar



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

Figure 11: SCR Crowbar

Applications Examples (Continue)



V_{IN}	V_{OUT}
$<V_{REF}$	V+
$>V_{REF}$	≈0.74V

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

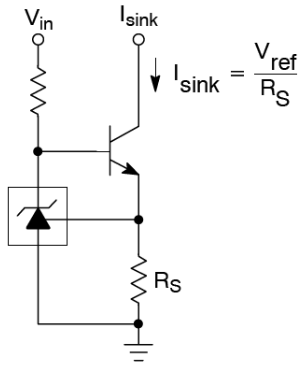
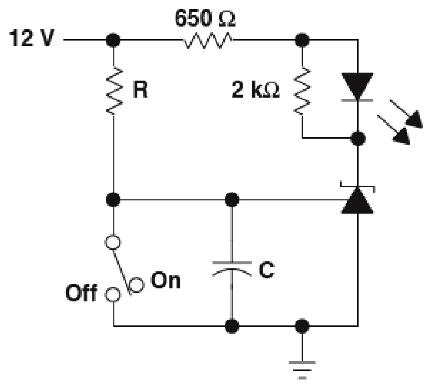


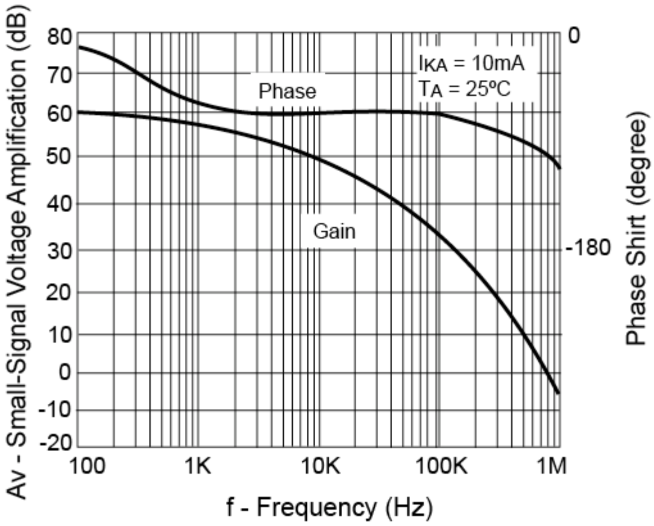
Figure 13: Constant Current Sink

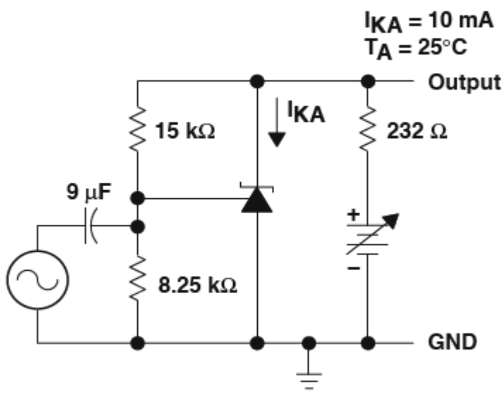


$$\text{Delay} = R \times C \times \ln\left(\frac{12\ V}{12\ V - V_{ref}}\right)$$

Figure 14: Delay Timer

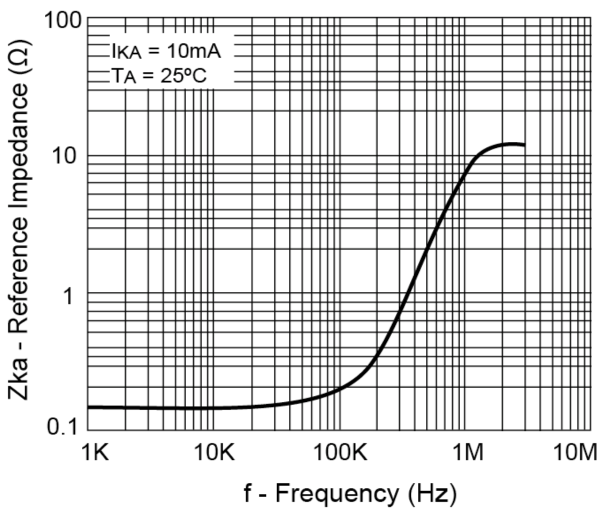
Typical Performance Characteristics

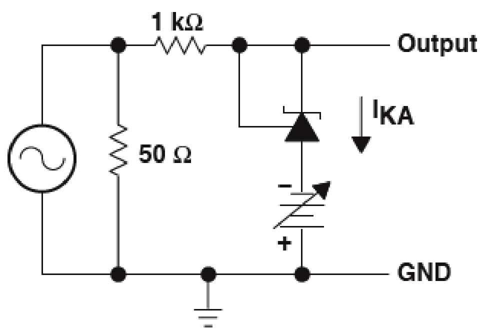




Test Circuit for Voltage Amplification

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

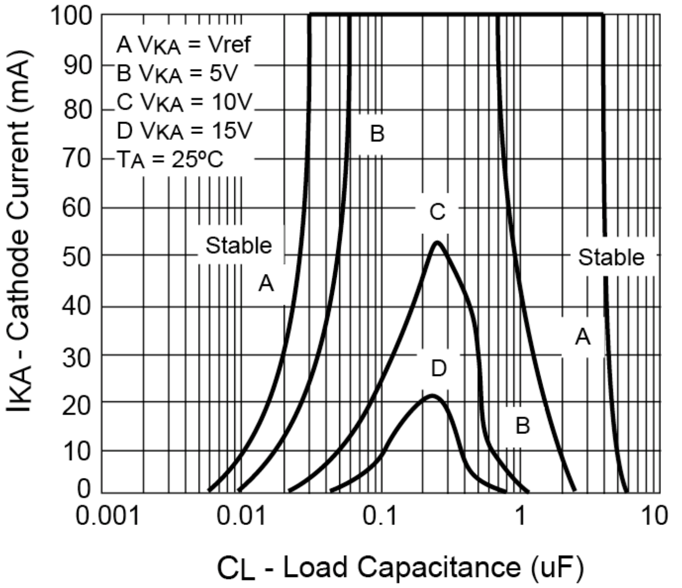




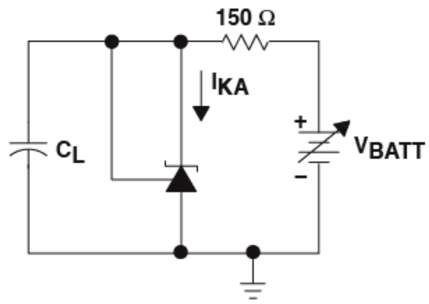
Test Circuit for Reference Impedance

Figure 16: Reference Impedance vs. Frequency

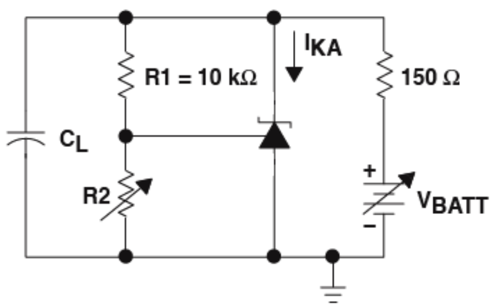
Typical Performance Characteristics



The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 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.

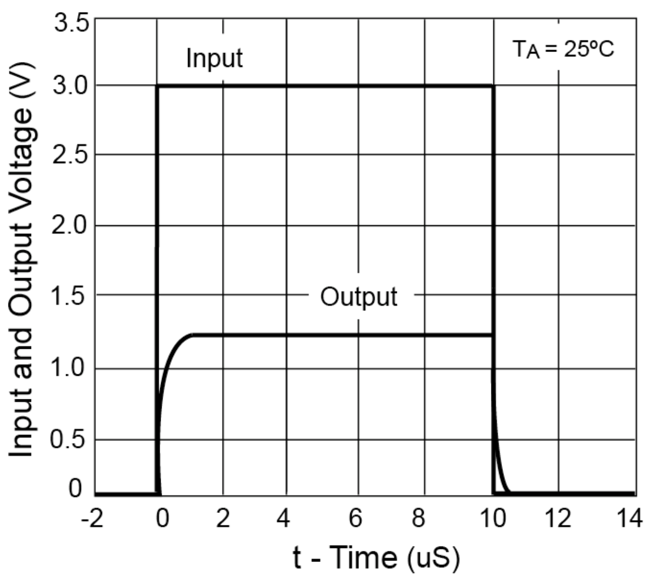


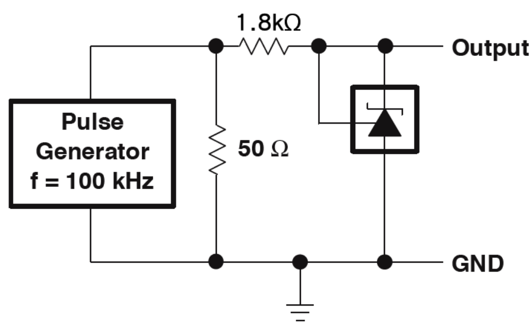
Test Circuit for Curve A



Test Circuit for Curve B, C and D

Figure 17: Stability Boundary Condition





Test Circuit for Pulse Response, Ik=1mA

Figure 18: Pulse Response

Electrical Characteristics

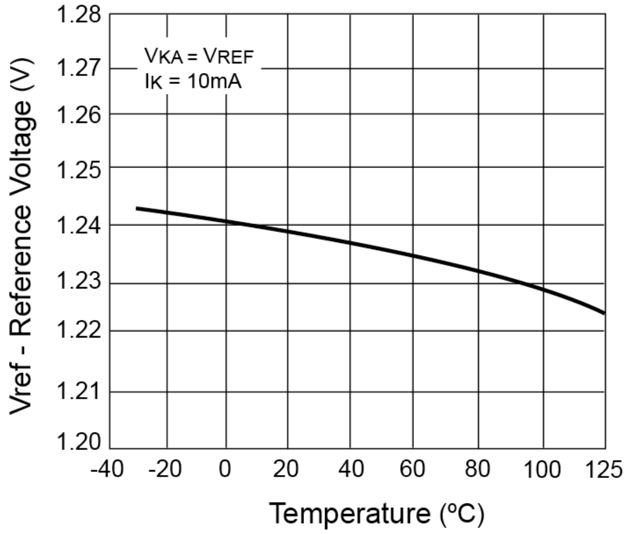


Figure 19: Reference Voltage vs. Temperature

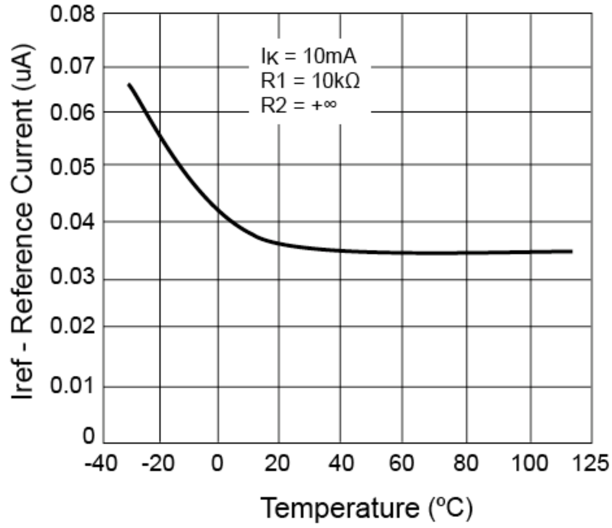


Figure 20: Reference Current vs. Temperature

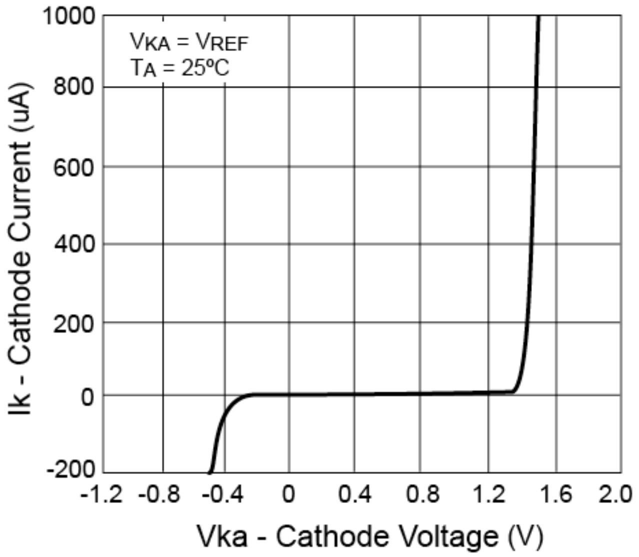
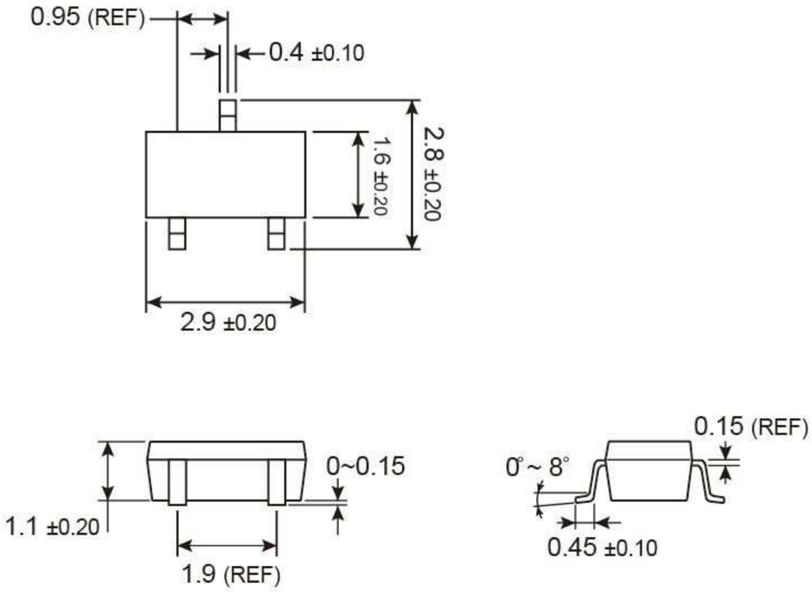


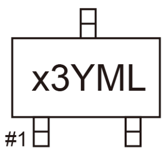
Figure 21: Cathode Current vs. Cathode Voltage

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**=Apl, **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**=Apl, **S**=May, **T**=Jun, **U**=Jul, **V**=Aug, **W**=Sep, **X**=Oct, **Y**=Nov, **Z**=Dec)
L = Lot Code

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