

## 1.24V Programmable Shunt Voltage Reference

### DESCRIPTION

The TS432AIX and TS432BIX 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 TS432AIX and TS432BIX has a typical output impedance of 0.05Ω. Active output circuitry provides a very sharp turn-on characteristic, making the TS432AIX and TS432BIX excellent replacement for zener diode in many applications.

### FEATURES

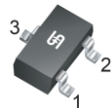
- Precision Reference Voltage  
TS432AI – 1.24V±1%  
TS432BI – 1.24V±0.5%
- Minimum cathode current: 20μA(typ.)
- Equivalent full range Temp. coefficient: 50ppm/°C
- Programmable output voltage up to 18V
- Fast turn-on response
- Sink current capability of 80μA to 100mA
- Low dynamic output impedance: 0.2Ω
- Low output noise
- Compliant to RoHS Directive 2011/65/EU and in accordance to WEEE 2002/96/EC
- Halogen-free according to IEC 61249-2-21

### APPLICATION

- SMPS
- Lighting
- Telecommunication
- Home appliance



### SOT-23

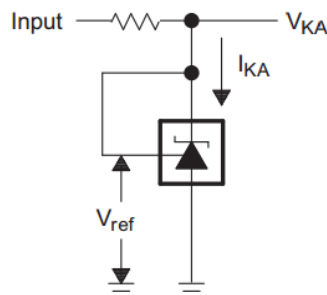


### Pin Definition:

1. Reference
2. Cathode
3. Anode

**Notes:** MSL 1 (Moisture Sensitivity Level) per J-STD-020

### SIMPLIFIED SCHEMATIC



<b>ABSOLUTE MAXIMUM RATINGS</b> ( $T_A = 25^\circ\text{C}$ unless otherwise noted)			
PARAMETER	SYMBOL	LIMIT	UNIT
Cathode Voltage	$V_{KA}$	18	V
Continuous Cathode Current	$I_K$	100	mA
Reference Input Current	$I_{REF}$	3	mA
Power Dissipation	$P_D$	0.35	W
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.
- 2: Rating apply to ambient temperature at  $25^\circ\text{C}$

<b>RECOMMEND OPERATING CONDITION</b>			
PARAMETER	SYMBOL	LIMIT	UNIT
Cathode Voltage (Note 1)	$V_{KA}$	18	V
Continuous Cathode Current Range	$I_K$	100	mA

<b>ELECTRICAL SPECIFICATIONS</b> ( $T_A = +25^\circ\text{C}$ , unless otherwise specified)							
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	
Reference voltage	$V_{REF}$	$V_{KA} = V_{REF}$ , $I_K = 10\text{mA}$ (Figure 1)	TS432AI	1.227	1.24	1.252	V
			TS432BI	1.233		1.246	
Deviation of reference input voltage	$\Delta V_{REF}$	$V_{KA} = V_{REF}$ , $I_K = 10\text{mA}$ (Figure 1) $T_A = \text{full range}$	--	10	25	mV	
Ratio of change in Vref to change in cathode Voltage	$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	$I_{KA} = 10\text{mA}$ , $V_{KA} = 18\text{V}$ to $V_{REF}$ (Figure 2)	--	-1.0	-2.7	mV/V	
Reference Input current	$I_{REF}$	$R1 = 10\text{k}\Omega$ , $R2 = \infty$ $I_{KA} = 10\text{mA}$ (Figure 2)	--	0.25	0.5	$\mu\text{A}$	
Deviation of reference input current, over temp.	$\Delta I_{REF}$	$R1 = 10\text{k}\Omega$ , $R2 = \infty$ , $I_{KA} = 10\text{mA}$ $T_A = \text{full range}$ (Figure 2)	--	0.04	0.08	$\mu\text{A}$	
Off-state Cathode Current	$I_{KA(off)}$	$V_{REF} = 0\text{V}$ (Figure 3), $V_{KA} = 18\text{V}$	--	0.125	0.5	$\mu\text{A}$	
Dynamic Output Impedance	$ Z_{KA} $	$f < 1\text{kHz}$ , $V_{KA} = V_{REF}$ (Figure 1) $I_{KA} = 1\text{mA}$ to $100\text{mA}$	--	0.2	0.4	$\Omega$	
Minimum operating cathode current	$I_{KA}(\text{min})$	$V_{KA} = V_{REF}$ (Figure 1)	--	60	80	$\mu\text{A}$	

**Note:** 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.

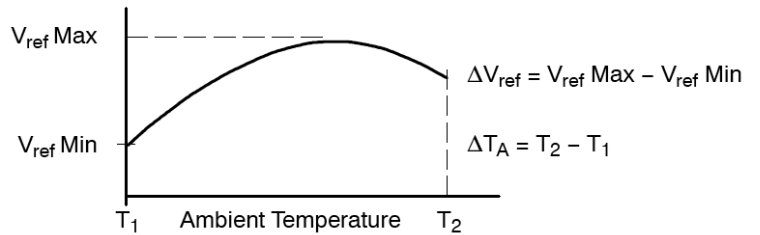
**ORDERING INFORMATION**

ORDERING CODE	PACKAGE	PACKING
TS432AIX RFG	SOT-23	3,000pcs / 7" Reel
TS432BIX RFG	SOT-23	3,000pcs / 7" Reel

**DEVIATION PARAMETERS**

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

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



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  $25^{\circ}\text{C}$ ,  $\Delta T=125^{\circ}\text{C}$

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

**Dynamic Impedance**

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

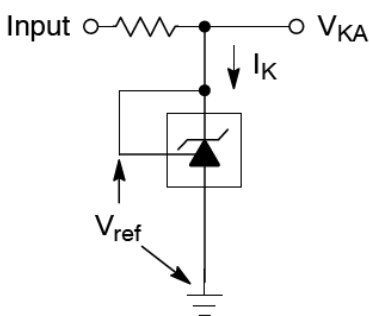
$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

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:

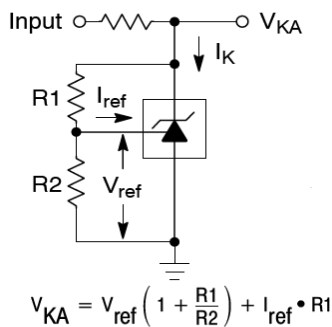
$$|Z_{KA}'| = |Z_{KA}| \times \left( 1 + \frac{R1}{R2} \right)$$

**Calculating Deviation Parameters and Dynamic Impedance**

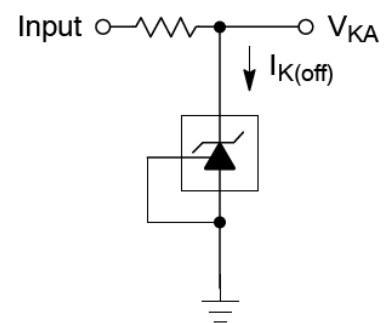
**TEST CIRCUIT**



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



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



**Figure 3:** Off-State Current

**APPLICATION INFORMATION**

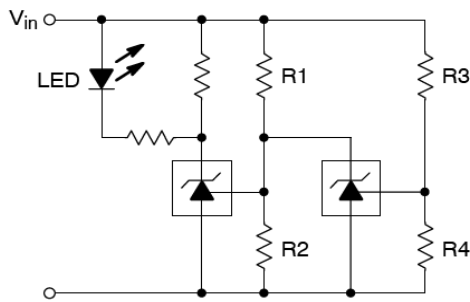
When The TS432AI/432BI is used as a shunt regulator, there are two options for selection of  $C_L$ , are recommended for optional stability:

- 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  $\geq 10\mu\text{F}$ .

**APPLICATION EXAMPLE**

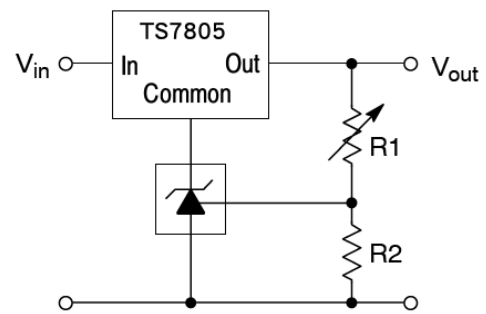


L.E.D. indicator is 'ON' when  $V_{in}$  is between the upper and lower limits,

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

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

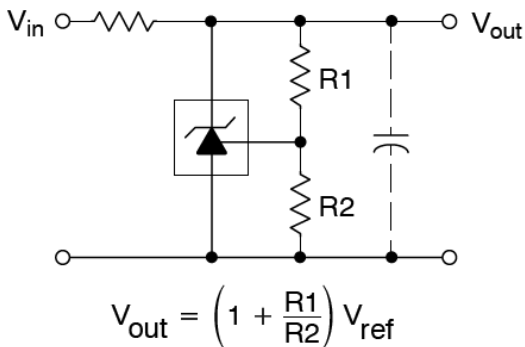
**Figure 4: Voltage Monitor**



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

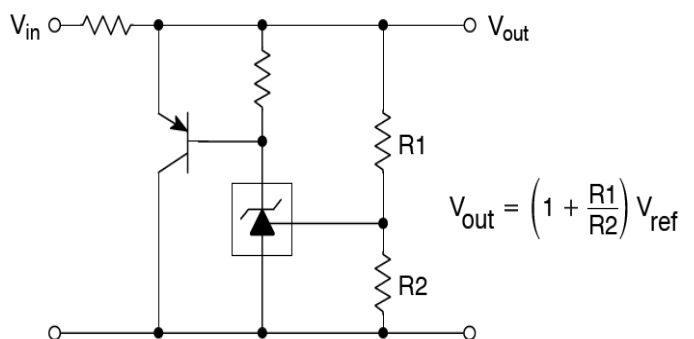
$$V_{out(min)} = V_{ref} + 5.0\text{ V}$$

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



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

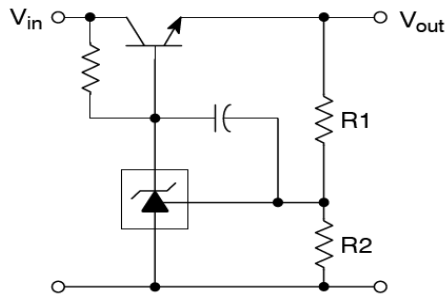
**Figure 6: Shunt Regulator**



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

**Figure 7: High Current Shunt Regulator**

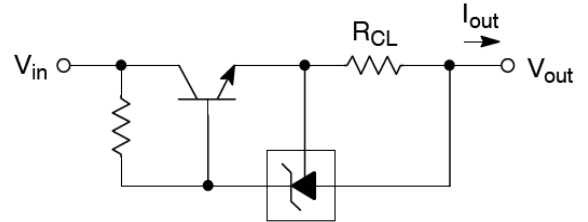
**APPLICATION EXAMPLE (CONTINUEO**



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

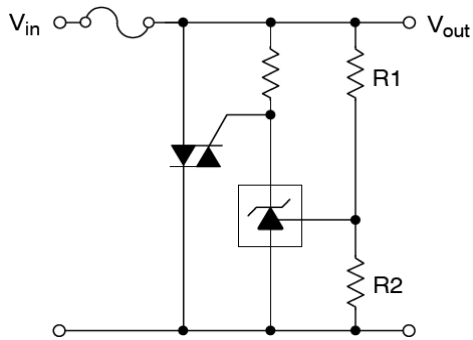
$$V_{out(min)} = V_{ref} + V_{be} \approx 2.0 V$$

**Figure 8: Series Pass Regulator**



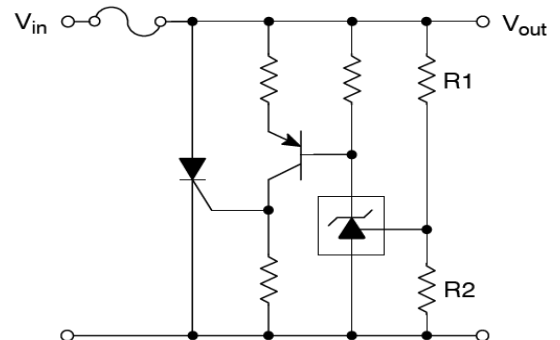
$$I_{out} = \frac{V_{ref}}{R_{CL}}$$

**Figure 9: Constant Current Source**



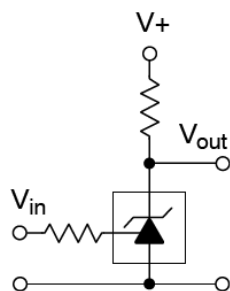
$$V_{out(trip)} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

**Figure 10: TRIAC Crowbar**



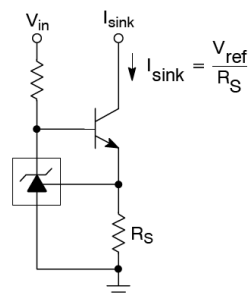
$$V_{out(trip)} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

**Figure 11: SCR Crowbar**



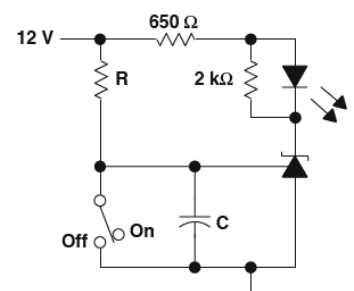
V <sub>IN</sub>	V <sub>OUT</sub>
<V <sub>REF</sub>	V <sub>+</sub>
>V <sub>REF</sub>	≈0.74V

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



$$I_{sink} = \frac{V_{ref}}{R_S}$$

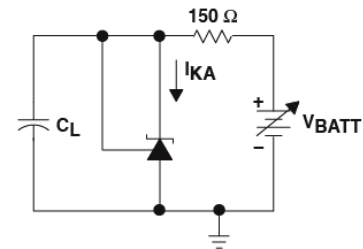
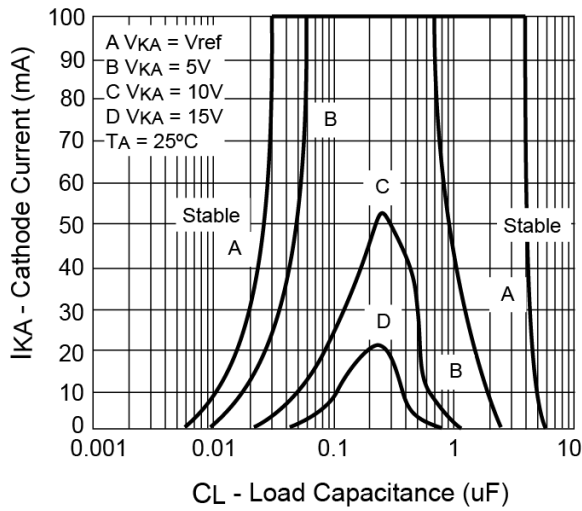
**Figure 13: Constant Current Sink**



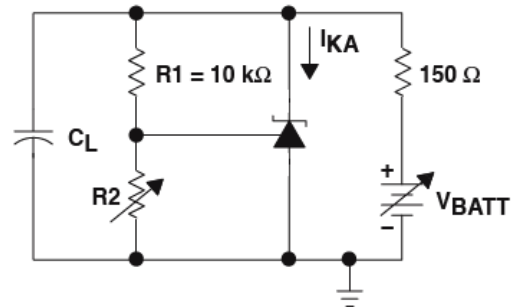
$$Delay = R \times C \times I_n \left( \frac{12 V}{12 V - V_{ref}} \right)$$

**Figure 14: Delay Timer**

**TYPICAL PERFORMANCE CHARACTERISTICS**



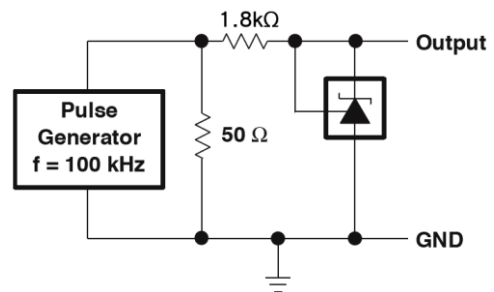
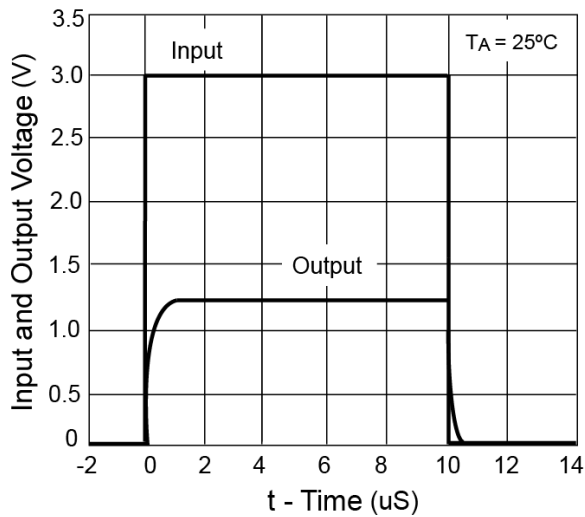
**Test Circuit for Curve A**



**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**

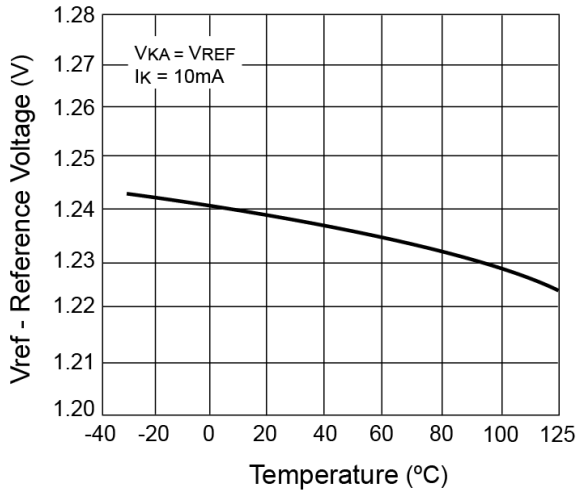


**Test Circuit for Pulse Response,  $I_k=1mA$**

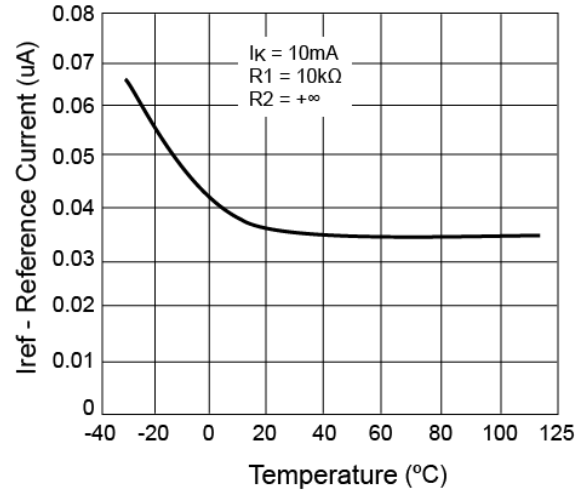
**Figure 18: Pulse Response**

**CHARACTERISTICS CURVES**

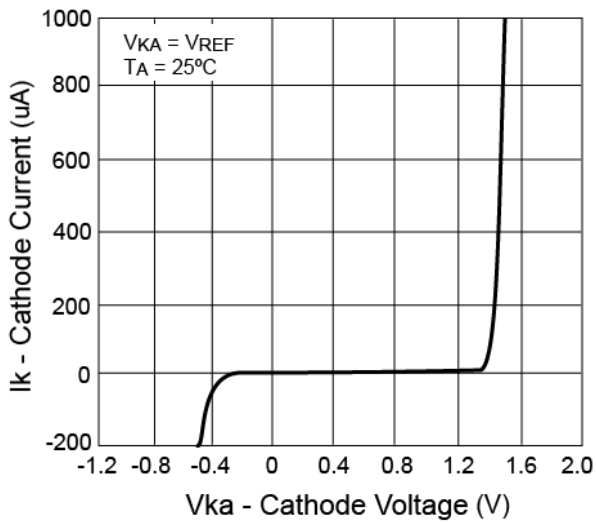
( $T_C = 25^\circ\text{C}$  unless otherwise noted)



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



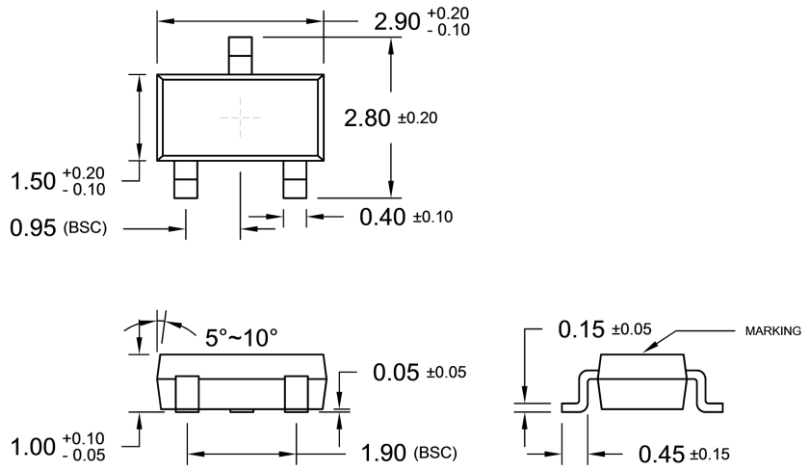
**Figure 20: Reference Current vs. Temperature**



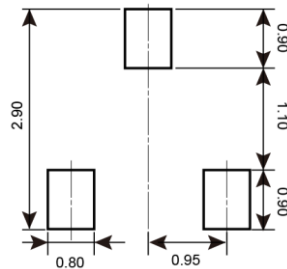
**Figure 21: Cathode Current vs. Cathode Voltage**

**PACKAGE OUTLINE DIMENSIONS** (Unit: Millimeters)

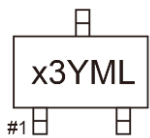
**SOT-23**



**SUGGESTED PAD LAYOUT** (Unit: Millimeters)



**MARKING DIAGRAM**



- x** = Device Code (**D** = TS432AI, **E** = TS432BI)
- 3** = SOT-23 package
- Y** = Year Code
- M** = 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 (1~9, A~Z)



## Notice

Specifications of the products displayed herein are subject to change without notice. TSC or anyone on its behalf, assumes no responsibility or liability for any errors or inaccuracies.

Information contained herein is intended to provide a product description only. No license, express or implied, to any intellectual property rights is granted by this document. Except as provided in TSC's terms and conditions of sale for such products, TSC assumes no liability whatsoever, and disclaims any express or implied warranty, relating to sale and/or use of TSC products including liability or warranties relating to fitness for a particular purpose, merchantability, or infringement of any patent, copyright, or other intellectual property right.

The products shown herein are not designed for use in medical, life-saving, or life-sustaining applications. Customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify TSC for any damages resulting from such improper use or sale.

## X-ON Electronics

Largest Supplier of Electrical and Electronic Components

*Click to view similar products for [Voltage References](#) category:*

*Click to view products by [Taiwan Semiconductor](#) manufacturer:*

Other Similar products are found below :

[REF01J/883](#) [5962-8686103XC](#) [NCV431BVDMR2G](#) [LT6654AMPS6-2.048#TRMPBF](#) [SCV431AIDMR2G](#) [LT1019AIS8-2.5](#)  
[LT6654AMPS6-3.3#TRM](#) [SC431ILPRAG](#) [AP432AQG-7](#) [NJM2823F-TE1](#) [TL431-A](#) [MCP1502T-18E/CHY](#) [MCP1502T-40E/CHY](#)  
[TL431ACZ](#) [KA431SLMF2TF](#) [KA431SMF2TF](#) [KA431SMFTF](#) [LM4040QCEM3-3.0/NOPB](#) [LM4041C12ILPR](#) [LM4120AIM5-2.5/NOP](#)  
[LM431SCCMFX](#) [TS3330AQPR](#) [REF5040MDREP](#) [REF3012AIDBZR](#) [LM285BXXMX-1.2/NOPB](#) [LM385BM-2.5/NOPB](#) [LM4040AIM3-10.0](#)  
[LM4040BIM3-4.1](#) [LM4040CIM3-10.0](#) [LM4040CIM3X-2.0/NOPB](#) [LM4041BSD-122GT3](#) [LM4041QDIM3-ADJ/NO](#)  
[LM4050QAEM3X4.1/NOPB](#) [LM4051BIM3-ADJ/NOPB](#) [LM4051CIM3X-1.2/NOPB](#) [LM4128CMF-1.8/NOPB](#) [LM4132DMF-1.8/NOPB](#)  
[LM4132EMF-1.8/NOPB](#) [LM4132EMF-2.0/NOPB](#) [LM4140CCMX-1.2/NOPB](#) [LM431CIM](#) [LM385BD-2.5R2G](#) [LM385M-2.5/NOPB](#)  
[LM4030AMF-4.096/NOPB](#) [LM4040D30ILPR](#) [LM4051CIM3X-ADJ/NOPB](#) [AP432YG-13](#) [AS431ANTR-G1](#) [AS431BZTR-E1](#) [AN431AN-  
ATRG1](#)