TAIWAN SEMICONDUCTOR

RoHS COMPLIANCE

TS432

Adjustable Precision Shunt Regulator

TO-92

Pin Definition:
1. Reference
2. Anode
3. Cathode

SOT-23

Pin Definition:
1. Reference
2. Cathode
3. Anode

SOT-25

Pin Definition:
1. N/C
2. N/C *
3. Cathode
4. Reference
5. Anode

* (pin 2 is connect to substrate and must be connected to Anode or left open)

General Description

TS432 series is a three-terminal adjustable shunt regulator with specified thermal stability. The output voltage may be set to any value between Vref (approximately 1.24V) and 18V with two external resistors. TS432 series has a typical output impedance of 0.05Ω. Active output circuitry provides a very sharp turn-on characteristic, making TS432 series excellent replacement for zener diode in many applications.

Features

- Precision Reference Voltage
  TS432 – 1.24V±2%
  TS432A – 1.24V±1%
  TS432B – 1.24V±0.5%
- Minimum Cathode Current for Regulation: 20uA(typ.)
- Equivalent Full Range Temp. Coefficient: 50ppm/ °C
- Programmable Output Voltage up to 18V
- Fast Turn-On Response
- Sink Current Capability of 80uA to 100mA
- Low Dynamic Output Impedance: 0.05Ω
- Low Output Noise
- Halogen Free Available

Ordering Information

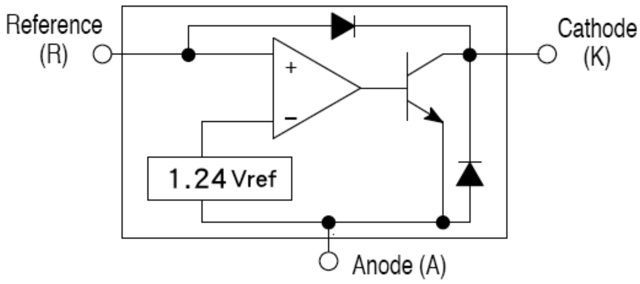
Part No.	Package	Packing
TS432**x**CT B0	TO-92	1Kpcs / Bulk
TS432**x**CT B0G	TO-92	1Kpcs / Bulk
TS432**x**CT A3	TO-92	2Kpcs / Ammo
TS432**x**CT A3G	TO-92	2Kpcs / Ammo
TS432**x**CX RF	SOT-23	3Kpcs / 7" Reel
TS432**x**CX RFG	SOT-23	3Kpcs / 7" Reel
TS432**x**CX5 RF	SOT-25	3Kpcs / 7" Reel
TS432**x**CX5 RFG	SOT-25	3Kpcs / 7" Reel

Note: Where **x** denotes voltage tolerance
Blank: ±2%, **A**: ±1%, **B**: ±0.5%
"G" denotes for Halogen free products

Application

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

Block Diagram



Absolute Maximum Rating (Ta = 25°C unless otherwise noted)

Parameter		Symbol	Limit	Unit
Cathode Voltage (Note 1)		Vka	18	V
Continuous Cathode Current Range		Ik	100	mA
Reference Input Current Range		Iref	3	mA
Power Dissipation	TO-92	Pd	0.625	W
	SOT-23		0.35	
	SOT-25		0.35	
Junction Temperature		T_J	+150	°C
Operation Temperature Range		T_{OPER}	0 ~ +70	°C
Storage Temperature Range		T_{STG}	-65 ~ +150	°C

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

TS432

Adjustable Precision Shunt Regulator

Recommend Operating Condition

Parameter	Symbol	Limit	Unit
Cathode Voltage (Note 1)	Vka	16	V
Continuous Cathode Current Range	Ik	100	mA

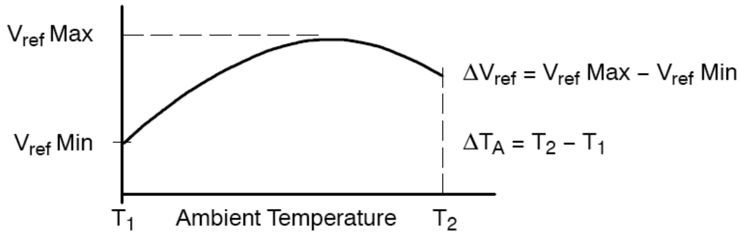
Recommend Operating Condition

Parameter		Symbo	Test Conditions	Min	Typ	Max	Unit
Reference voltage	TS432	Vref	Vka =Vref, Ik=10mA (Figure 1) Ta=25°C	1.215	1.240	1.264	V
	TS432A			1.227		1.252	
	TS432B			1.233		1.246	
Deviation of reference input voltage		∆Vref	Vka =Vref, Ik=10mA Ta= full range (Figure 1)	--	10	25	mV
Radio of change in Vref to change in cathode Voltage		∆Vref/∆Vka	Ika=10mA, Vka = 18V to Vref (Figure 2)	--	-1.0	-2.7	mV/V
Reference Input current		Iref	R1=10KΩ, R2=∞, Ika=10mA Ta= full range (Figure 2)	--	0.25	0.5	uA
Deviation of reference input current, over temp.		∆Iref	R1=10KΩ, R2=∞, Ika=10mA Ta= full range (Figure 2)	--	0.04	0.8	uA
Off-state Cathode Current		Ika(off)	Vref=0V (Figure 3), Vka=18V	--	0.125	0.5	uA
Dynamic Output Impedance		|Zka|	f<1KHz, Vka=Vref Ika=1mA to 100mA (Figure 1)	--	0.2	0.4	Ω
Minimum operating cathode current		Ika(min)	Vka=Vref (Figure 1)	--	20	80	uA

* The deviation parameters ∆Vref and ∆Iref 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, αVref is defined as:

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



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

αVref can be positive or negative depending on whether Vref Min. or Vref Max occurs at the lower ambient temperature. Example: ∆Vref=7.2mV and the slope is postive, Vref=1.241V at 25°C, ∆T=125°C

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

* The dynamic impedance ZKA is defined as:

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

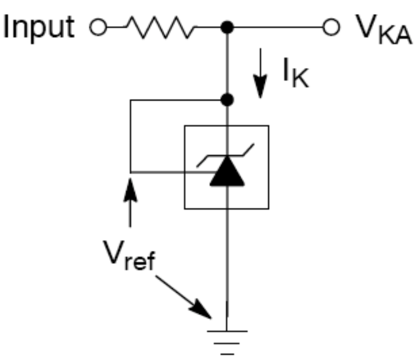
* When the device operating with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is given by:

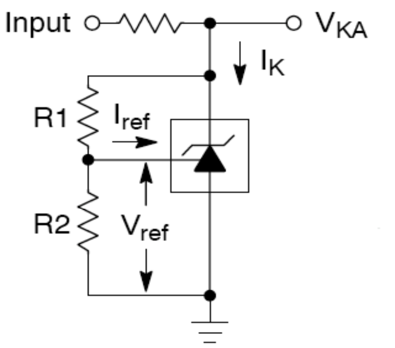
$$|Z_{KA}'| = |Z_{KA}| \times \left(1 + \frac{R1}{R2}\right)$$

TS432

Adjustable Precision Shunt Regulator

Test Circuits





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

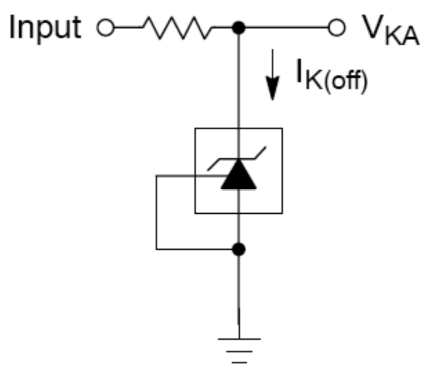


Figure 1: Vka = Vref **Figure 2: Vka > Vref** **Figure 3: Off-State Current**

Additional Information – Stability

When TS432 series is used as a shunt regulator, there are two options for selection of C_L, are recommended for optional stability:

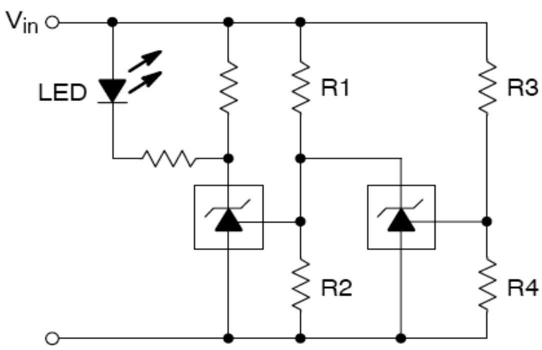
A) No load capacitance across the device, decouple at the load.

B) Large capacitance across the device, optional decoupling at the load.

The reason for this is that TS432 series exhibits instability with capacitances in the range of 10nF to 1uF (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 0.1uF 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 (10uF) 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 TS432 series is located right at the load, so the load decoupling capacitor is directly across it, then this capacitor will have to be ≤1nF or ≥10uF.

Applications Examples

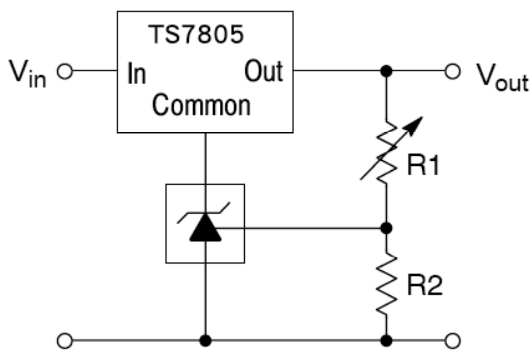


L.E.D. indicator is 'ON' when V_{in} is between the upper and lower limits,

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

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

Figure 4: Voltage Monitor

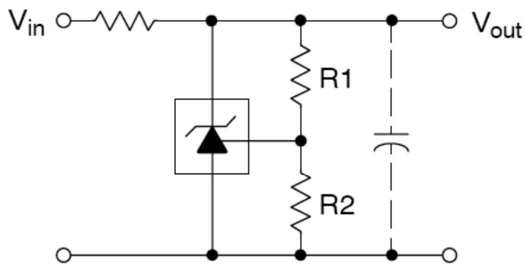


$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

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

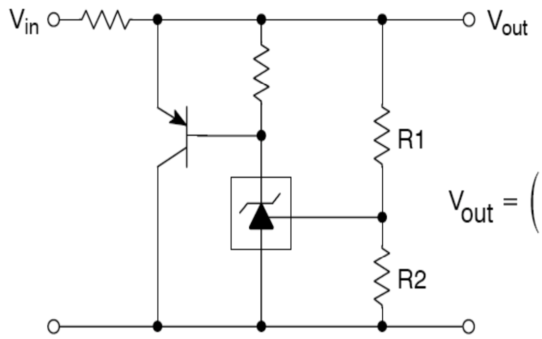
Figure 5: Output Control for Three Terminal Fixed Regulator

Applications Examples (Continue)



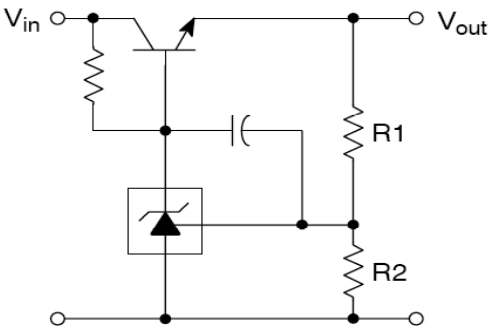
$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

Figure 6: Shunt Regulator



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

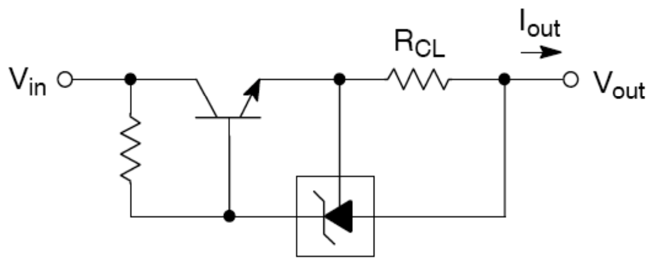
Figure 7: High Current Shunt Regulator



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

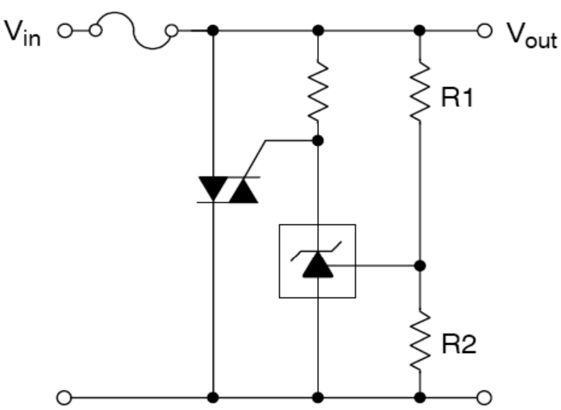
$$V_{out(min)} = V_{ref} + V_{be} \approx 2.0\ V$$

Figure 8: Series Pass Regulator



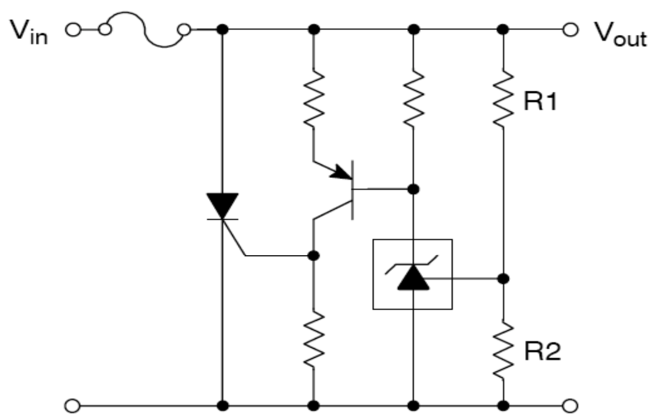
$$I_{out} = \frac{V_{ref}}{R_{CL}}$$

Figure 9: Constant Current Source



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

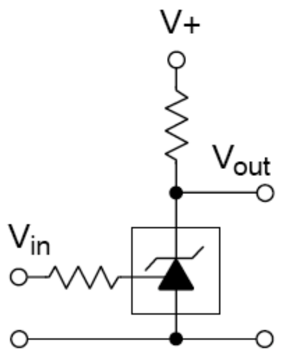
Figure 10: TRIAC Crowbar



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

Figure 11: SCR Crowbar

Applications Examples (Continue)



Vin	Vout
<Vref	V+
>Vref	≈0.74V

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

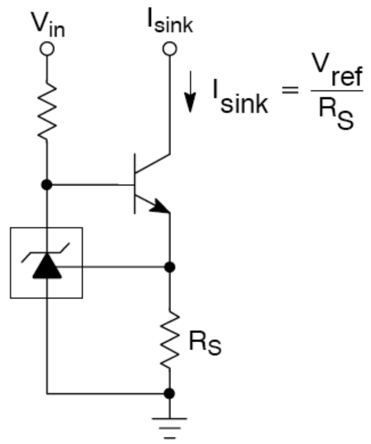
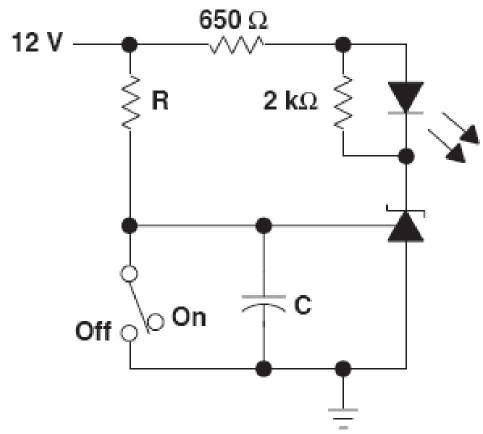


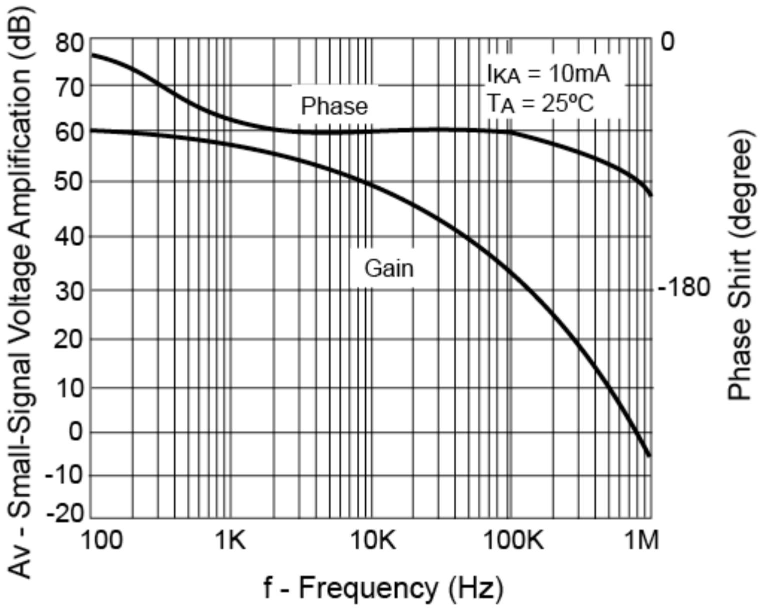
Figure 13: Constant Current Sink

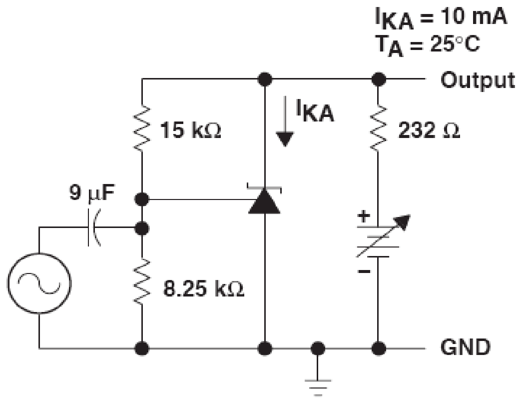


$$\text{Delay} = R \times C \times l_n\left(\frac{12\ V}{12\ V - V_{ref}}\right)$$

Figure 14: Delay Timer

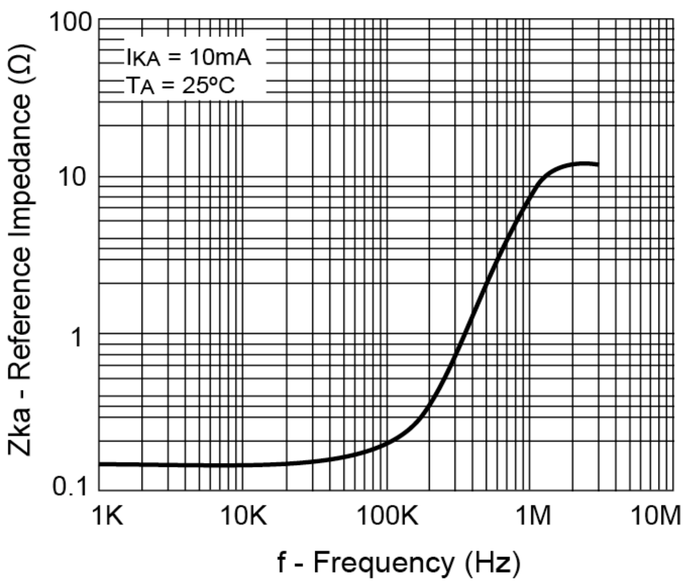
Typical Performance Characteristics

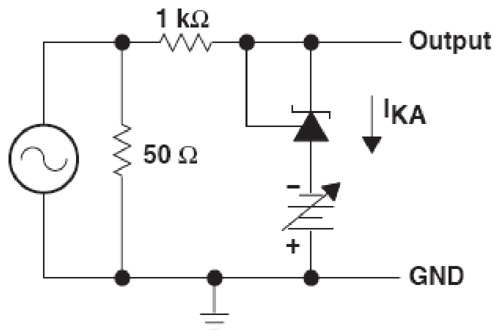




Test Circuit for Voltage Amplification

Figure 14: Small-Signal Voltage Gain and Phase Shift vs. Frequency

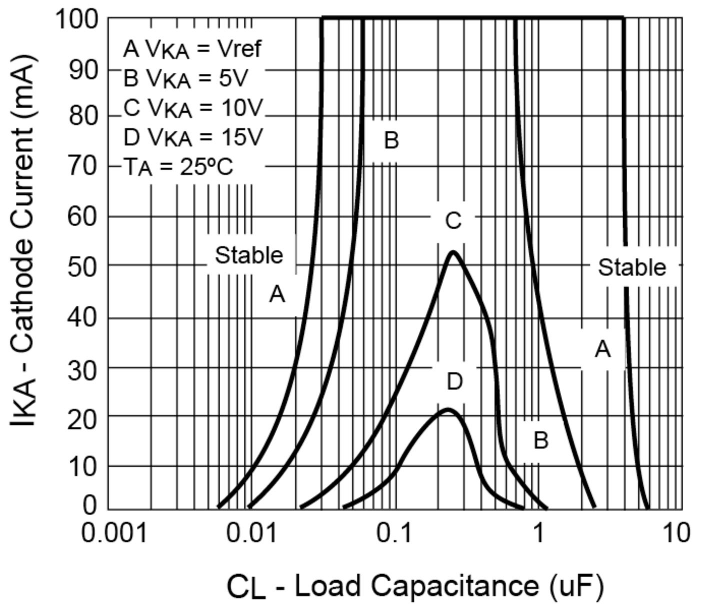


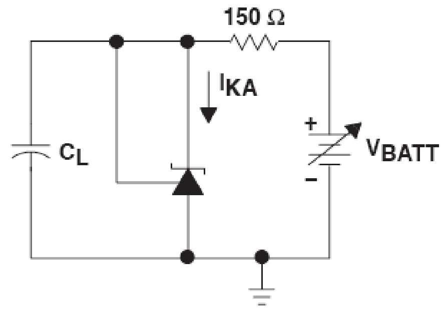


Test Circuit for Reference Impedance

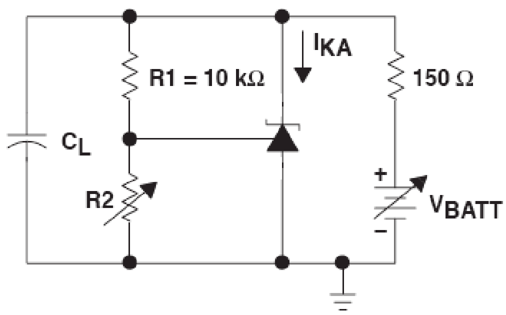
Figure 15: Reference Impedance vs. Frequency

Typical Performance Characteristics





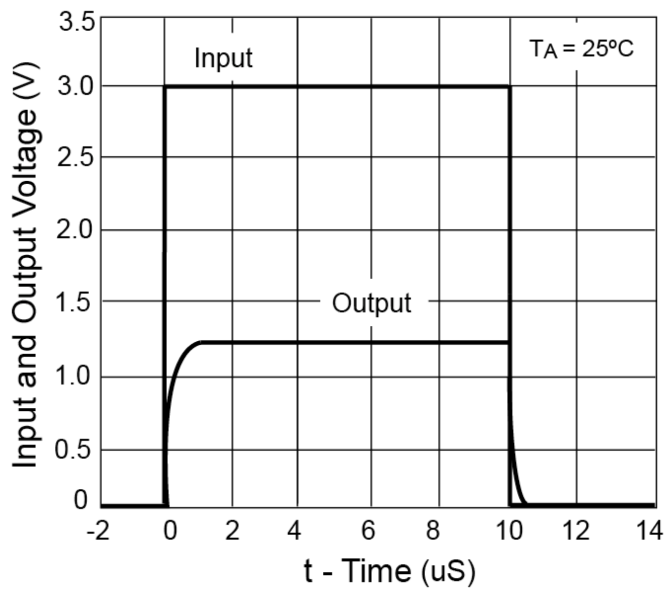
Test Circuit for Curve A

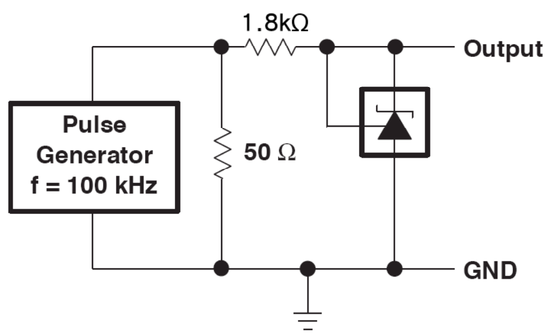


Test Circuit for Curve B, C and D

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

Figure 16: Stability Boundary Condition





Test Circuit for Pulse Response, Ik=1mA

Figure 17: Pulse Response

Electrical Characteristics

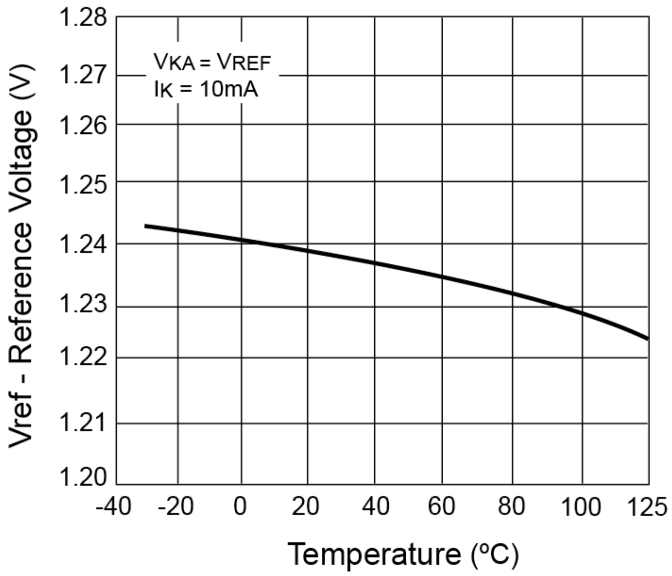


Figure 18: Reference Voltage vs. Temperature

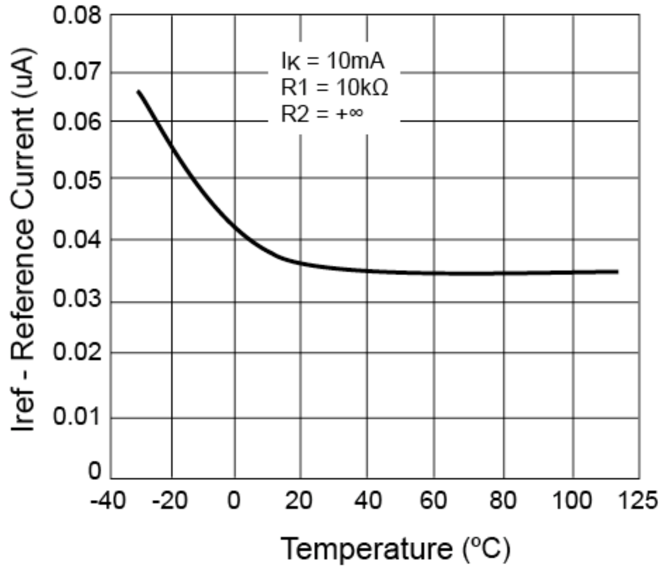


Figure 19: Reference Current vs. Temperature

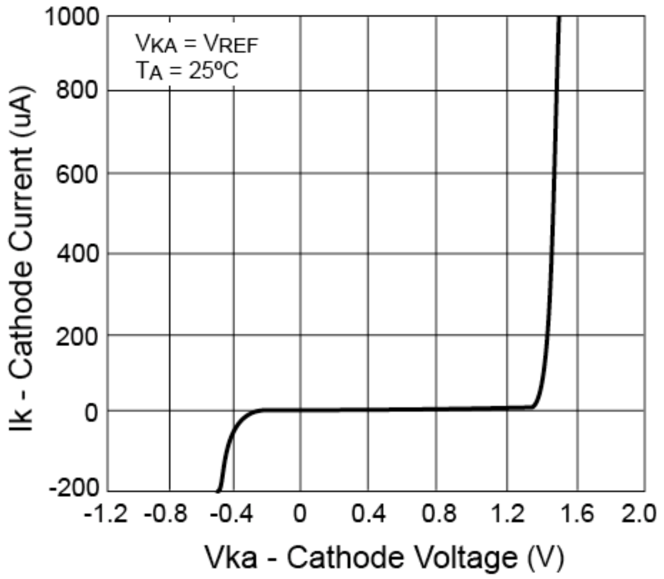
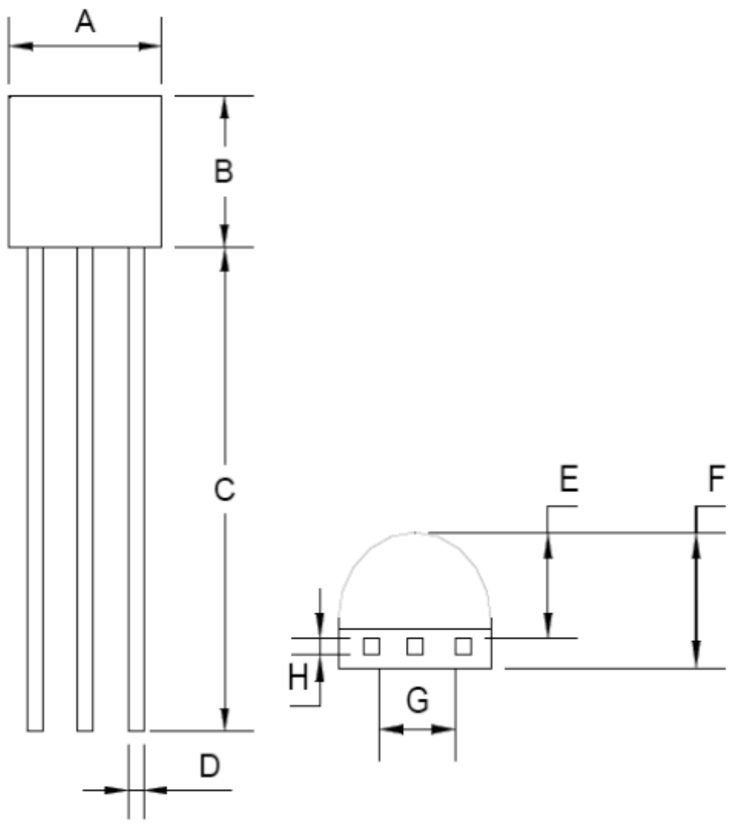


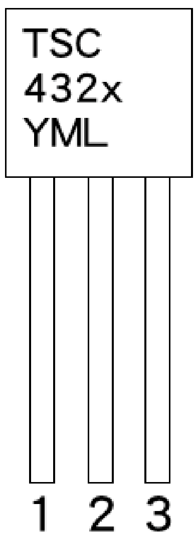
Figure 20: Cathode Current vs. Cathode Voltage

TO-92 Mechanical Drawing



TO-92 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.70	0.169	0.185
B	4.30	4.70	0.169	0.185
C	14.30(typ)		0.563(typ)	
D	0.43	0.49	0.017	0.019
E	2.19	2.81	0.086	0.111
F	3.30	3.70	0.130	0.146
G	2.42	2.66	0.095	0.105
H	0.37	0.43	0.015	0.017

Marking Diagram



X = Tolerance Code
(**A** = ±1%, **B** = ±0.5%, **Blank** = ±2%,)
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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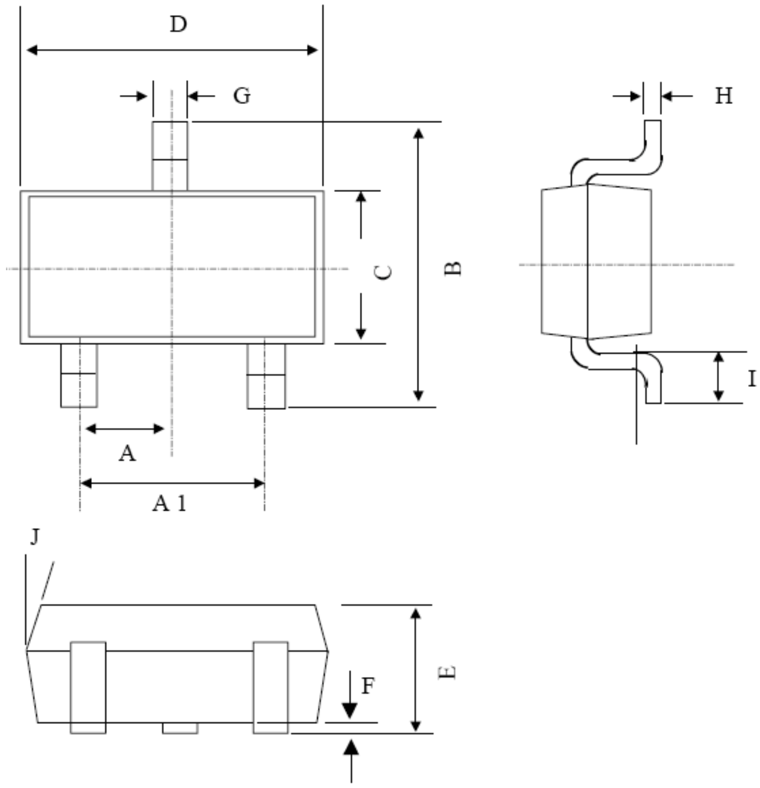
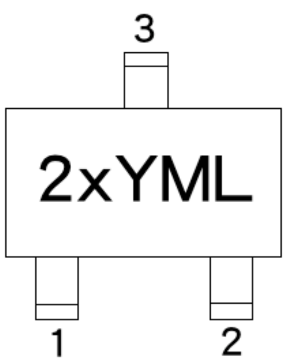
SOT-23 Mechanical Drawing



SOT-23 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX.
A	0.95 BSC		0.037 BSC	
A1	1.9 BSC		0.074 BSC	
B	2.60	3.00	0.102	0.118
C	1.40	1.70	0.055	0.067
D	2.80	3.10	0.110	0.122
E	1.00	1.30	0.039	0.051
F	0.00	0.10	0.000	0.004
G	0.35	0.50	0.014	0.020
H	0.10	0.20	0.004	0.008
I	0.30	0.60	0.012	0.024
J	5º	10º	5º	10º

Marking Diagram



2 = Device Code

X = Tolerance Code
(**A** = ±1%, **B** = ±0.5%, **C** = ±2%,)

Y = Year Code

M = Month Code
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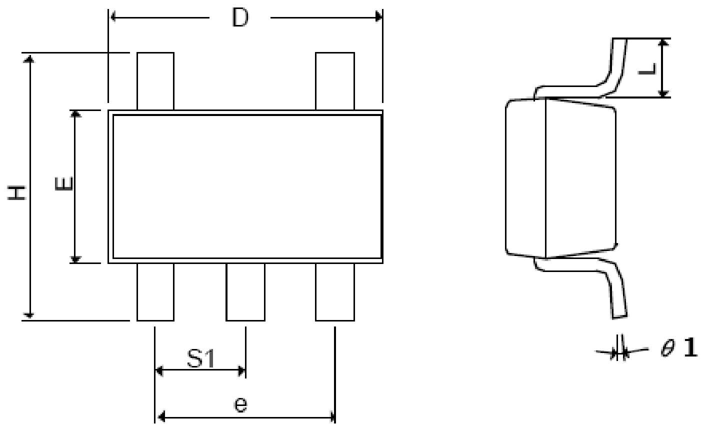
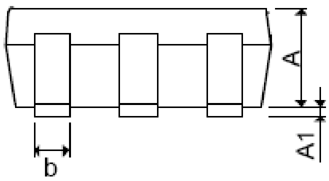
L = Lot Code

SOT-25 Mechanical Drawing

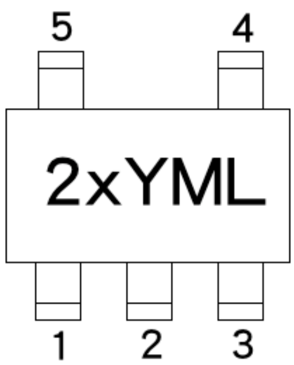


SOT-25 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX.
A+A1	0.09	1.25	0.0354	0.0492
B	0.30	0.50	0.0118	0.0197
C	0.09	0.25	0.0035	0.0098
D	2.70	3.10	0.1063	0.1220
E	1.40	1.80	0.0551	0.0709
E	1.90 BSC		0.0748 BSC	
H	2.40	3.00	0.09449	0.1181
L	0.35 BSC		0.0138 BSC	
Ɵ1	0º	10º	0º	10º
S1	0.95 BSC		0.0374 BSC	

Front View



Marking Diagram



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L = Lot Code

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