TSC

TS431/431A/431B
Adjustable Precision Shunt Regulator

TO-92   SOT-89   SOT-23   SOP-8

**Sink Current Capability up to 100mA**
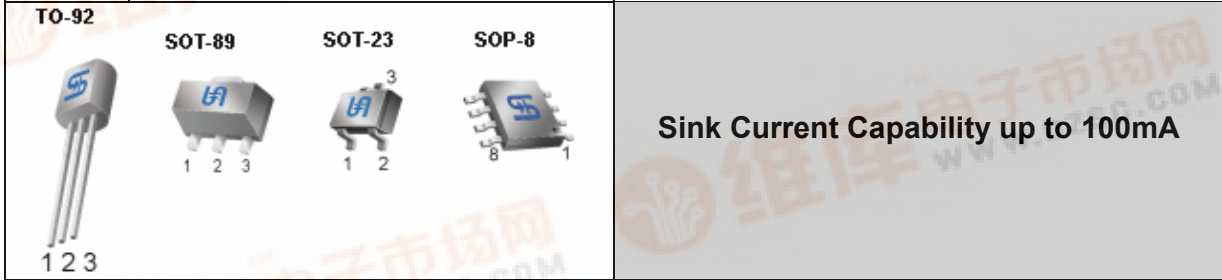
General Description

The TS431/431A/431B integrated circuits are three-terminal programmable shunt regulator diodes. These monolithic IC voltage references operate as a low temperature coefficient zener which is programmable from Vref to 36 volts with two external resistors. These devices exhibit a wide operating current range of 1.0 to 100mA with a typical dynamic impedance of 0.22Ω. The characteristics of these references make them excellent replacements for zener diodes in many applications such as digital voltmeters, power supplies, and op amp circuitry. The 2.5volt reference makes it convenient to obtain a stable reference from 5.0volt logic supplies, and since The TS431/431A/431B operates as a shunt regulator, it can be used as either a positive or negative stage reference.

This series is offered in 3-pin TO-92, SOT-89, SOT-23 and SOP-8 package.

Features

◇ Precision Reference Voltage
  TS431   2.495V±2%
  TS431A   2.495V±1%
  TS431B   2.495V±0.5%
◇ Equivalent Full Range Temp. Coefficient: 50ppm/^{o}C
◇ Programmable Output Voltage up to 36V
◇ Fast Turn-On Response
◇ Sink Current Capability of 1.0 to 100 mA
◇ Low Dynamic Output Impedance: 0.22Ω
◇ Low Output Noise

Standard Application

$$Vout = Vref * (1 + R1 / R2)$$

Block Diagram

Ref (R)   Vref   2.495V   Cathode (C)   Anode (A)
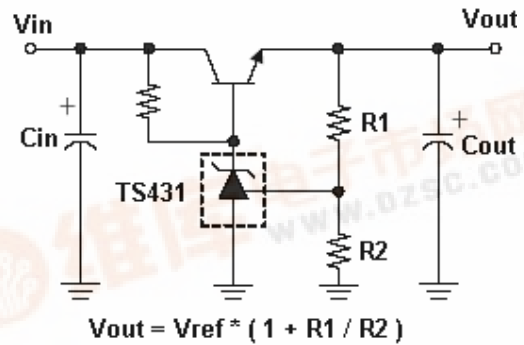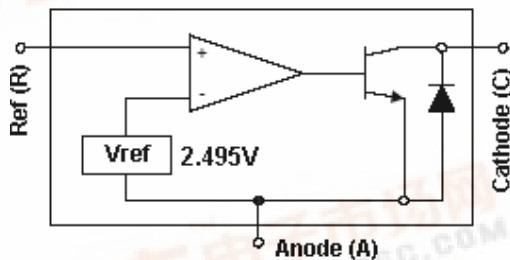
Ordering Information

Part No.	Operating Temp. (Ambient)	Package
TS431**x**CT		TO-92
TS431**x**CY	-20 ~ +85°C	SOT-89
TS431**x**CX		SOT-23
TS431**x**CS		SOP-8

Note: Where **x** denotes voltage tolerance.
     Blank: ±2%
      A: ±1%
      B: ±0.5%

Pin Assignment

Pin No.				Pin Description
TS431/A/BCT	TS431/A/BCY	TS431/A/BCX	TS431/A/BCS	
1	1	1	8	Reference
2	2	3	2,3,6,7	Anode
3	3	2	1	Cathode
			4,5	Non connect

TSC

Absolute Maximum Rating

Cathode Voltage (Note 1)	Vka	37	V
Continuous Cathode Current Range	Ik	-100 ~ +150	mA
Reference Input Current Range	Iref	-0.05 ~ +10	mA
Power Dissipation (Note 2, 3) TO-92		0.625	
SOT-89 / SOP-8	Pd	0.5	W
SOT-23		0.3	
Operating Junction Temperature Range	Tj	+125	^{o}C
Storage Temperature Range	T$_{STG}$	-65 ~ +150	^{o}C

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

Note 2: Tj Max = 150 ^{o}C

Note 3: Rating apply to ambient temperature at 25 ^{o}C

Recommend Operating Condition

Cathode Voltage Range	Vka	Ref ~ 36	V
Cathode Current Range (for regulation)	Ik	1 ~ 100	mA

Electrical Characteristics

(Ta=25 ^{o}C, unless otherwise specified.)

Parameter		Symbo	Test Conditions		Min	Typ	Max	Unit
Reference voltage	TS431	Vref	Vka =Vref, Ik=10mA (Figure 1)		2.450	2.495	2.550	V
	TS431A				2.475		2.525	
	TS431B				2.487		2.513	
Deviation of reference input voltage, over temp. (Note 4)		ΔVref	Ta = full range Vka =Vref, Ik=10mA (Figure 1)		--	3	17	mV
Reference Input current		Iref	R1=10KΩ, R2=∞ , Ika=10mA (Figure 2)		--	0.7	4.0	uA
Radio of change in Vref to change in cathode Voltage		ΔVref / ΔVka	Ika=10mA, Vka = 10V to Vref, Vka = 36V to 10V (Figure 2)		-- --	-1.4 - 1.0	-2.7 - 2.0	mV/V
Deviation of reference input current, over temp.		Iref(DEV)	Ta= full range R1=10KΩ, R2=∞ , Ika=10mA (Figure 2)		--	0.4	1.2	uA
Minimum operating cathode current		Ika(min)	Vka=Vref (Figure 1)		--	0.4	0.6	mA
Off-state Cathode Current		Ioff	Vref=0V (Figure 3)	Vka=36V	--	--	1.0	uA
Dynamic Output Impedance		|Zka|	f<1KHz, Vka=Vref Ika=1mA to 100mA (Figure 1)		--	0.22	0.5	Ω

Electrical Characteristics (continued) (Ta=25 °C, unless otherwise specified.)
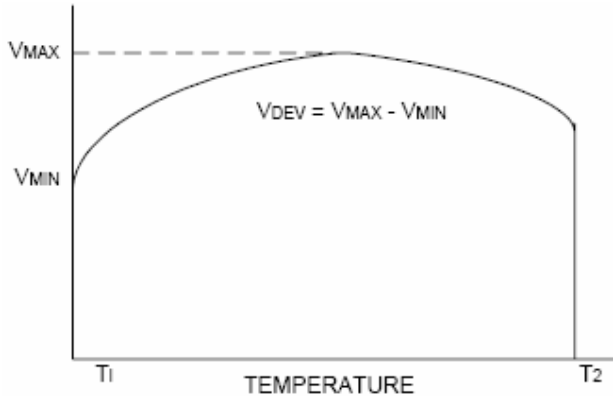
Note 4. Deviation of reference input voltage, VDEV, is defined as the maximum deviation of the reference over the full temperature range.

The average temperature coefficient of the reference input voltage αVref is defined as:

$$| \alpha Vref | = [\ V_{DEV} \ / \ Vref(25\,°C) \ ] * 10^6 \ / \ T2 - T1 .... (PPM/°C)$$

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

αVref can be positive or negative depending on whether the slope is positive or negative.

Example: Maximum Vref=2.496V at 30°C, minimum Vref=2.492V at 0°C, Vref=2.495V at 25°C, ΔT=70°C

$$| \alpha Vref | = [\ 4mV \ / \ 2495mV \ ] * 10^6 \ / \ 70°C \approx 23ppm/°C$$

Note 5. The dynamic output impedance, Rz, is defined as:

$$| Zka | = \Delta Vka \ / \ \Delta Ika$$

When the device is programmed with two external resistors R1and R2 (see Figure 2). The dynamic output impedance of the overall circuit, is defined as :

$$| Zka | = \Delta v \ / \ \Delta i \ | \approx Zka \ | * (1 + R1 \ / \ R2)$$

Test Circuits
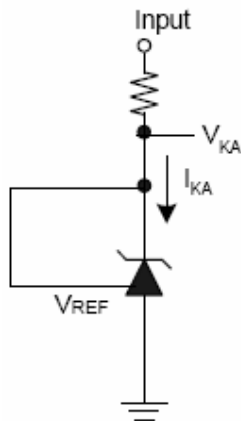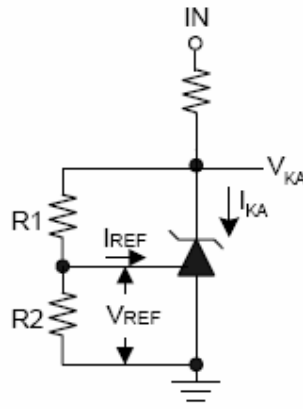
Vka = Vref(1+R1/R2)+Iref * R1
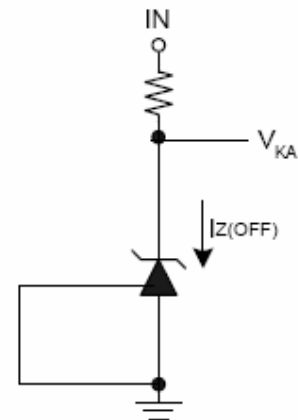
Figure 1. Vka = Vref   Figure 2. Vka > Vref   Figure 3. Off-state Current
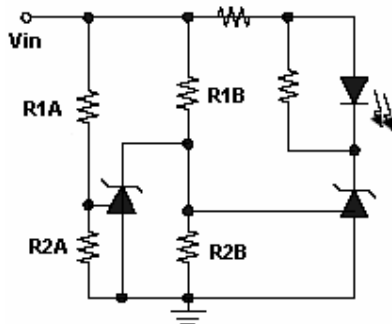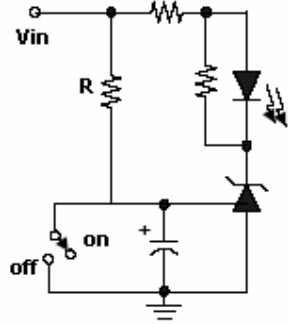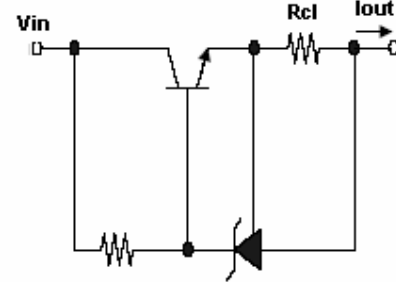
Application Examples

LED on when low limit<Vin<high limit
low limit= Vref (1 + R1B / R2B)
high limit= Vref (1 + R1A / R2A)

Figure 4. Voltage Monitor

Delay= RC * ln (Vin / Vin - Vref)

Figure 5. Delay Timer
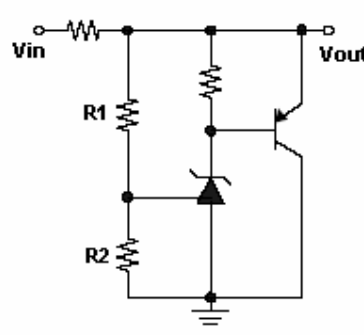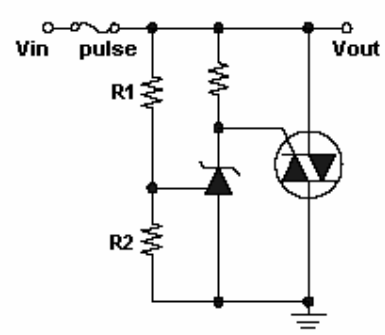
Iout= Vref / Rcl

Figure 6. Current limiter or Current Source
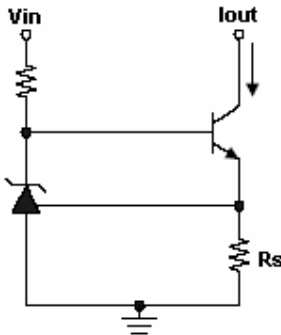
Iout= Vref / Rs

Figure 7. Constant Current Sink

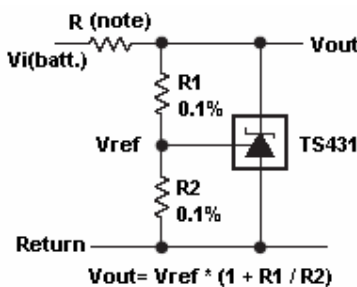Vout= Vref * (1 + R1 / R2)

Figure 8. Higher Current Shunt

Limit= Vref * (1 + R1 / R2)

Figure 9. Crow Bar

Vout= Vref * (1 + R1 / R2)

note: R should provide cathode
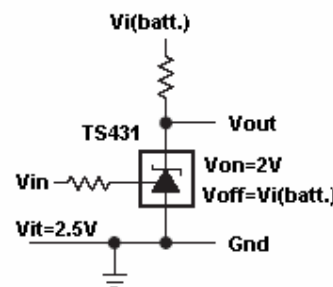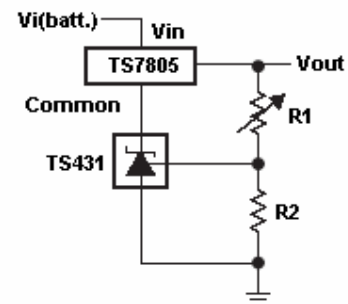current>1mA to the TS431 at
minimum Vi(batt.)

Figure 10. Shunt Regulator

**Figure 11. Single Supply Comparator
v.s. Temp.-Compensated Threshold**

Vout= Vref * (1 + R1 / R2)
minimum Vout=Vref+5V

**Figure 12. Output Control of a
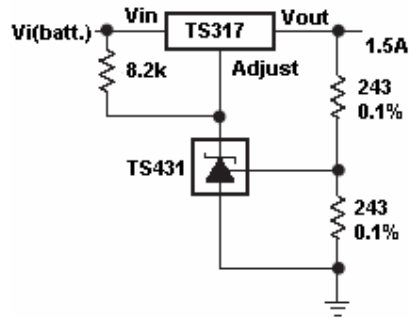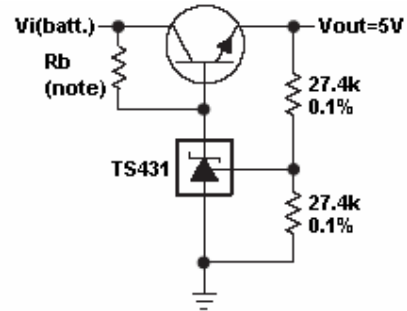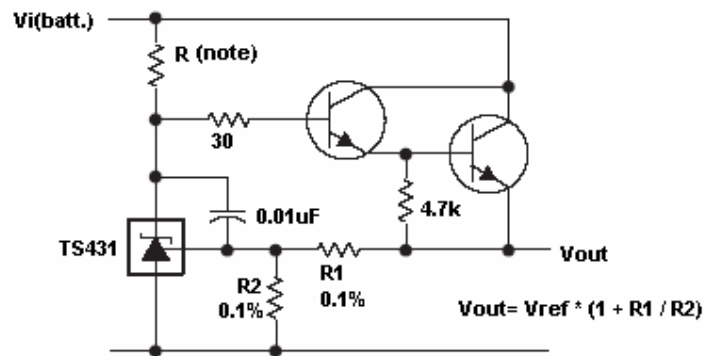Three-Therminal Fixed Regulator**

Application Examples

Figure 13. Precision 5V/1.5A regulator

note: Rb should provide cathode
cruuent>1mA to the TS431

Figure 14. Efficient 5V Precision Regulator
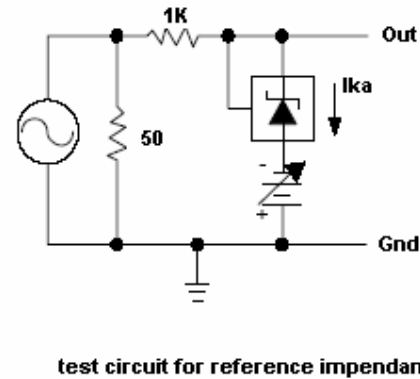

$$Vout = Vref * (1 + R1 / R2)$$

note: R should provide cathode current>1mA to the TS431 at minimum Vi(batt.)

Figure 15. Precision High Current Series Regulator

Typical Performance Characteristics

small signal voltage amplification vs. frequency

Ika=10mA
Ta=25 °C

small signal voltge amplification (dB) vs frequency (Hz)

test circuit for voltage amplification

15K, 232, 9uF, Ika, 8.25K, Out, Gnd

reference impendance vs frequency

Ika=10mA
Ta=25 °C

reference impendance (ohm) vs frequency (Hz)

test circuit for reference impendance

1K, 50, Ika, Out, Gnd

stability bondary conditions

A Vka=Vref
B Vka=5V
C Vka=10V
D Vka=15V

Ta=25 °C

stable

cathode current (mA) vs load Capacitance (uF)

test circuit for curve A

150, CL, Ika, Vbatt

test circuit for curve B, C, D

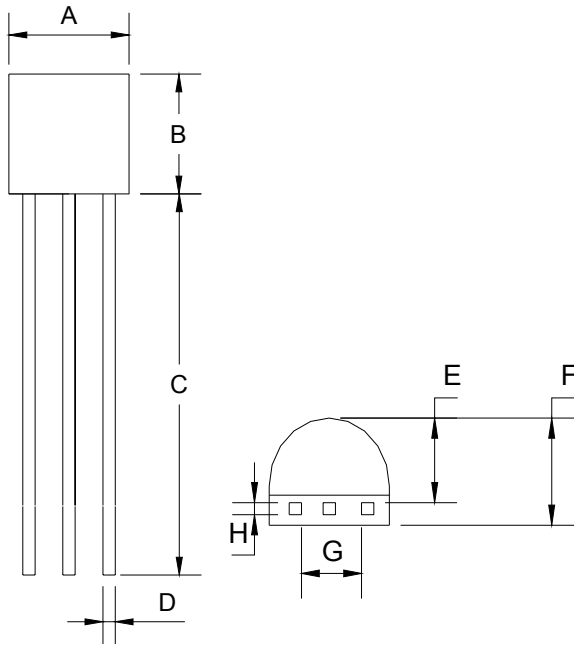10K, Ika, 150, CL, R2, Vbatt

the area 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 Vka and Ika conditions with CL=0. Vbatt and CL were then adjusted to determine the ranges of stability.

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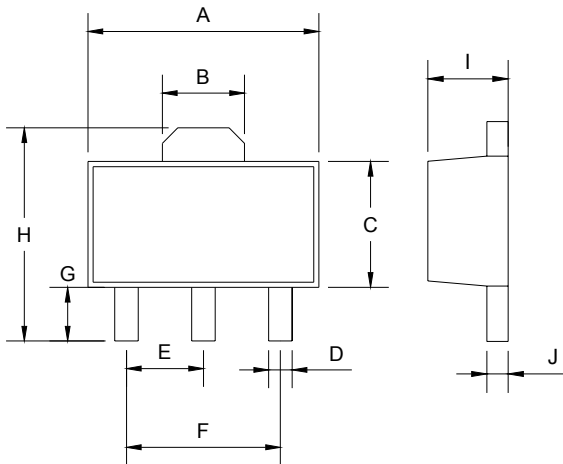
TO-92 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.70	0.169	0.185
B	4.30	4.70	0.169	0.185
C	14.30(typ)		0.563(typ)	
D	0.43	0.49	0.017	0.019
E	2.19	2.81	0.086	0.111
F	3.30	3.70	0.130	0.146
G	2.42	2.66	0.095	0.105
H	0.37	0.43	0.015	0.017

SOT-89 Mechanical Drawing

SOT-89 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.40	4.60	0.173	0.181
B	1.50	1.7	0.059	0.070
C	2.30	2.60	0.090	0.102
D	0.40	0.52	0.016	0.020
E	1.50	1.50	0.059	0.059
F	3.00	3.00	0.118	0.118
G	0.89	1.20	0.035	0.047
H	4.05	4.25	0.159	0.167
I	1.4	1.6	0.055	0.068
J	0.35	0.44	0.014	0.017

SOT-23 Mechanical Drawing
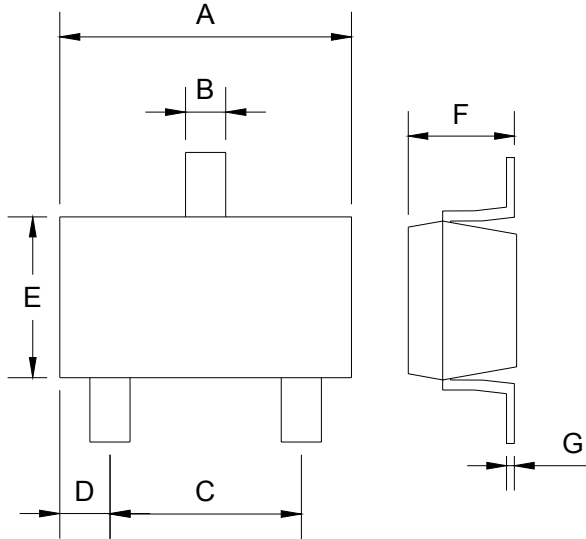
SOT-23 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.88	2.91	0.113	0.115
B	0.39	0.42	0.015	0.017
C	1.78	2.03	0.070	0.080
D	0.51	0.61	0.020	0.024
E	1.59	1.66	0.063	0.065
F	1.04	1.08	0.041	0.043
G	0.07	0.09	0.003	0.004

SOP-8 Mechanical Drawing
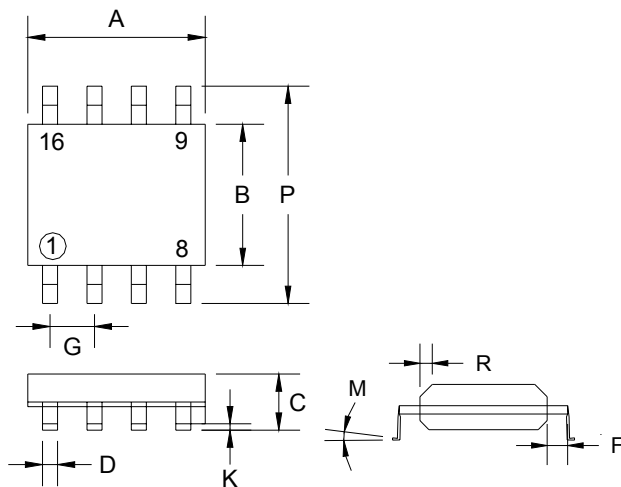
SOP-8 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 (typ)		0.05 (typ)	
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019