

This series is offered in 3-pin TO-92 and SOT-23 package.

- ✧ Precision Reference Voltage
 - TS1431 2.495V±2%
 - TS1431A 2.495V±1%
 - TS1431B 2.495V±0.5%
- ✧ Equivalent Full Range Temp. Coefficient: 50ppm/°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

The diagram shows an operational amplifier configured as a voltage follower. The non-inverting input (+) is connected to the input voltage V_{in} . The inverting input (-) is connected to a voltage divider consisting of two resistors, R_1 and R_2 , connected in series between the output V_{out} and ground. The output V_{out} is also connected directly to the inverting input (-), forming a voltage follower configuration. A capacitor C_{in} is connected between V_{in} and ground, and a capacitor C_{out} is connected between V_{out} and ground. The feedback network is highlighted with a dashed box around the op-amp and the resistors R_1 and R_2 .

$$V_{out} = V_{ref} * (1 + R_1 / R_2)$$

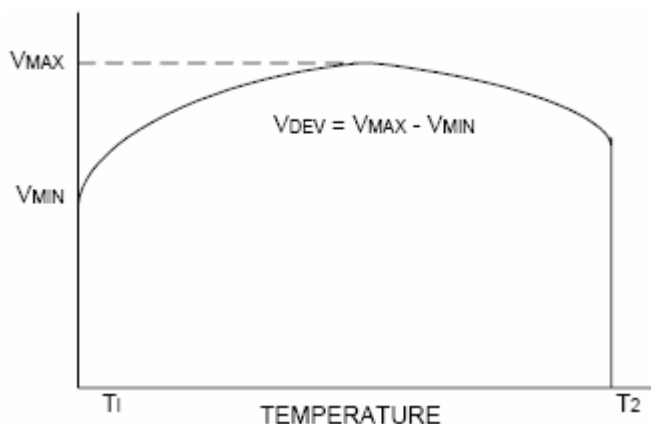
Part No.	Operating Temp. (Ambient)	Package
TS1431xCT	-20 ~ +85 °C	TO-92
TS1431xCX		SOT-23

Blank: $\pm 2\%$
A: $\pm 1\%$
B: $\pm 0.5\%$



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)		Pd	0.625		W			
			0.3					
Operating Junction Temperature Range		Tj	-25 ~ +125		°C			
Storage Temperature Range		TSTG	-65 ~ +150		°C			
Note 1: Voltage values are with respect to the anode terminal unless otherwise noted.								
Note 2: Tj Max = 125°C								
Note 3: Rating apply to ambient temperature at 25 °C								
Recommend Operating Condition								
Cathode Voltage Range		Vka	Ref ~ 36		V			
Cathode Current Range (for regulation)		Ik	1 ~ 100		mA			
Electrical Characteristics								
(Ta=25 °C, unless otherwise specified.)								
Parameter		Symbo	Test Conditions		Min	Typ	Max	Unit
Reference voltage	TS1431	Vref	Vka =Vref, Ik=10mA (Figure 1)		2.446	2.495	2.545	V
	TS1431A				2.470		2.520	
	TS1431B				2.483		2.507	
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 αV_{ref} is defined as:

$$|\alpha V_{ref}| = [V_{DEV} / V_{ref}(25^{\circ}\text{C})] * 10^6 / T2 - T1 \dots\dots\dots (\text{PPM}/^{\circ}\text{C})$$

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

αV_{ref} can be positive or negative depending on whether the slope is positive or negative.

Example: Maximum V_{ref} =2.496V at 30°C, minimum V_{ref} =2.492V at 0°C, V_{ref} =2.495V at 25°C, ΔT =70 °C

$$|\alpha V_{ref}| = [4\text{mV} / 2495\text{mV}] * 10^6 / 70^{\circ}\text{C} \approx 23\text{ppm}/^{\circ}\text{C}$$

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

$$|Z_{ka}| = \Delta V_{ka} / \Delta I_{ka}$$

When the device is programmed with two external resistors R1 and R2 (see Figure 2). The dynamic output impedance of the overall circuit, is defined as :

$$|Z_{ka}| = \Delta v / \Delta i \approx Z_{ka} * (1 + R1 / R2)$$

Test Circuits

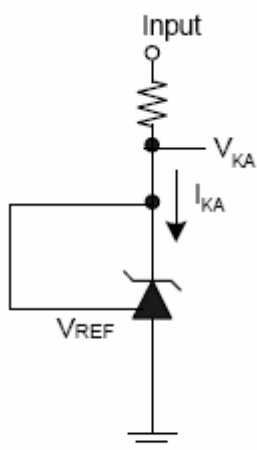
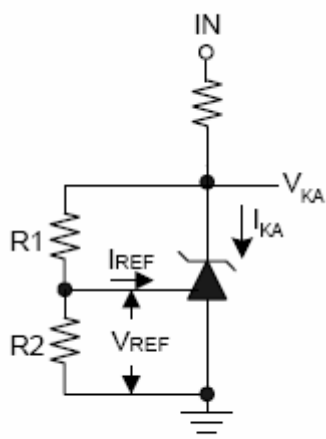


Figure 1. $V_{ka} = V_{ref}$



$$V_{ka} = V_{ref}(1 + R1/R2) + I_{ref} * R1$$

Figure 2. $V_{ka} > V_{ref}$

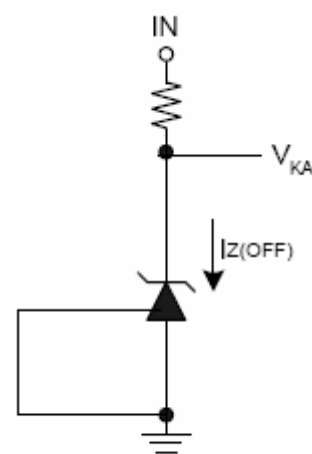
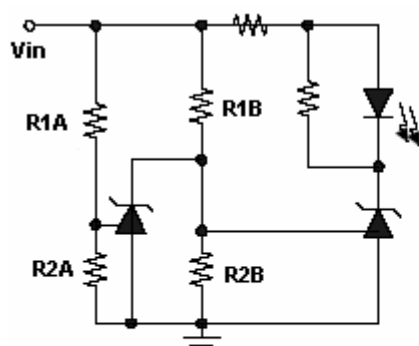


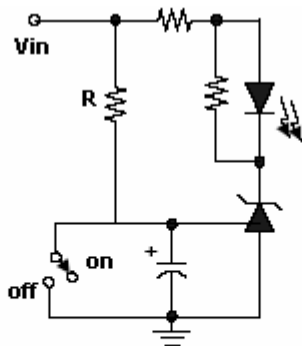
Figure 3. Off-state Current

Application Examples



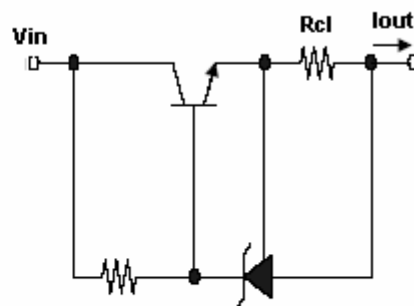
LED on when low limit < Vin < high limit
 low limit = $V_{ref} (1 + R1B / R2B)$
 high limit = $V_{ref} (1 + R1A / R2A)$

Figure 4. Voltage Monitor



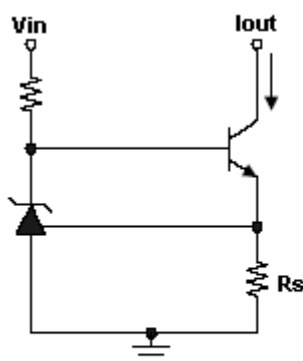
Delay = $RC \ln (V_{in} / (V_{in} - V_{ref}))$

Figure 5. Delay Timer



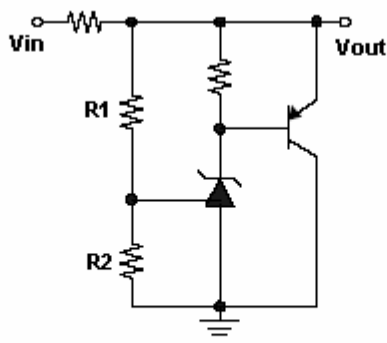
$I_{out} = V_{ref} / R_{cl}$

Figure 6. Current limiter or Current Source



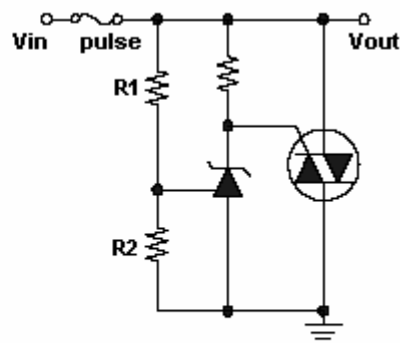
$I_{out} = V_{ref} / R_s$

Figure 7. Constant Current Sink



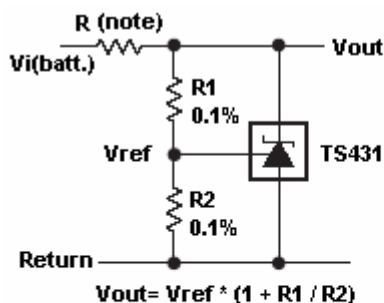
$V_{out} = V_{ref} * (1 + R1 / R2)$

Figure 8. Higher Current Shunt



Limit = $V_{ref} * (1 + R1 / R2)$

Figure 9. Crow Bar



$V_{out} = V_{ref} * (1 + R1 / R2)$

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

Figure 10. Shunt Regulator

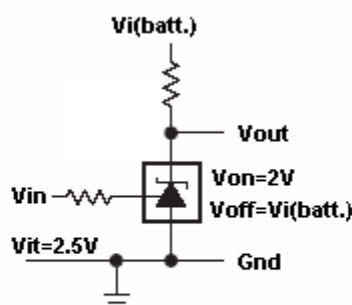
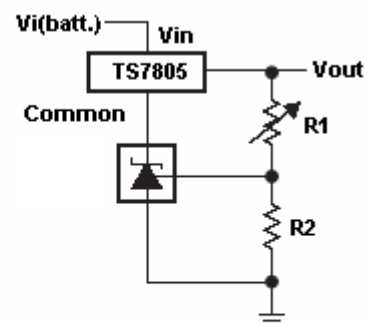


Figure 11. Single Supply Comparator v.s. Temp.-Compensated Threshold



$V_{out} = V_{ref} * (1 + R1 / R2)$
 minimum $V_{out} = V_{ref} + 5V$

Figure 12. Output Control of a Three-Terminal Fixed Regulator

Application Examples

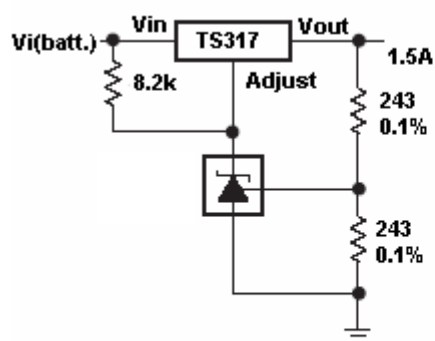


Figure 13. Precision 5V/1.5A regulator

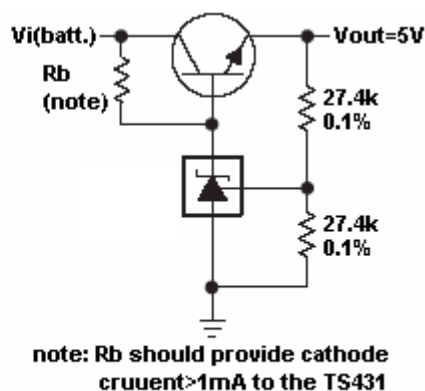
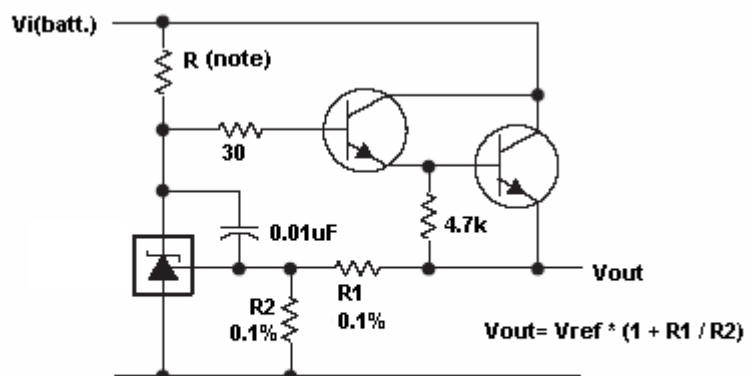


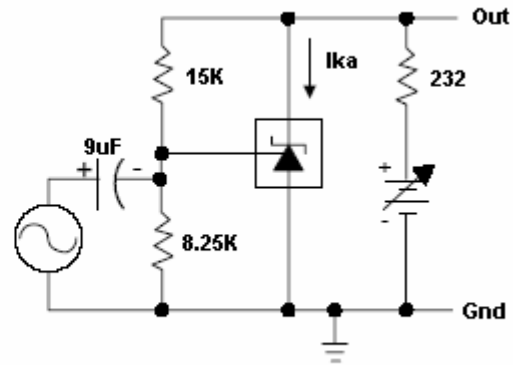
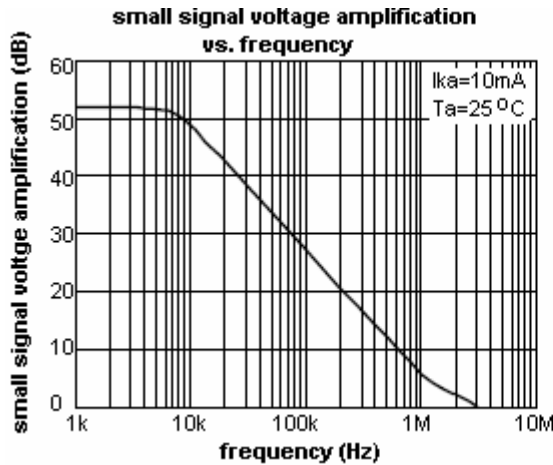
Figure 14. Efficient 5V Precision Regulator



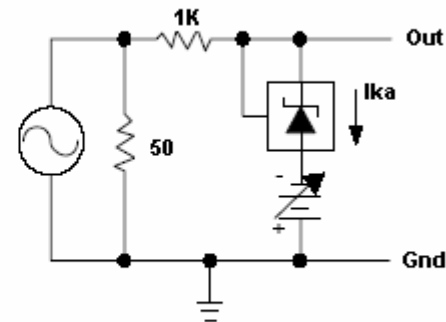
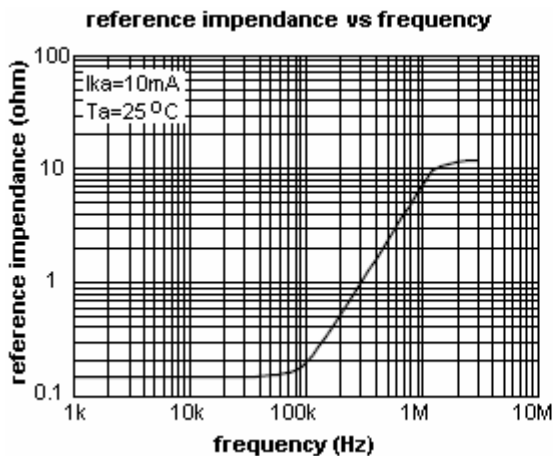
note: R should provide cathode current >1mA to the TS431 at minimum Vi(batt.)

Figure 15. Precision High Current Series Regulator

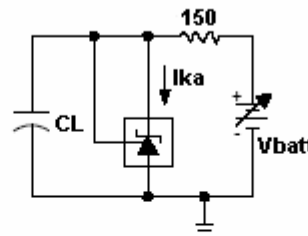
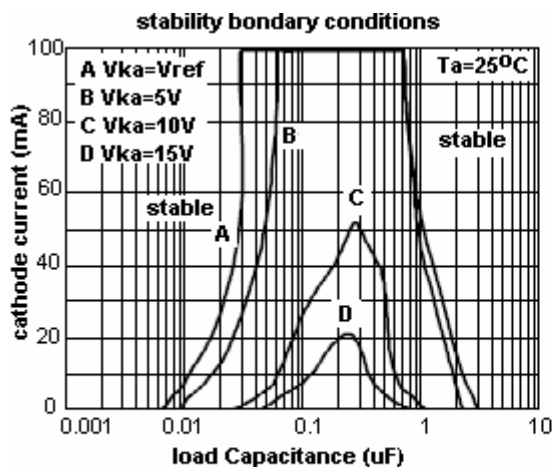
Typical Performance Characteristics



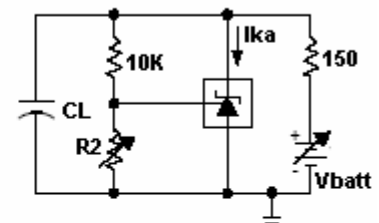
test circuit for voltage amplification



test circuit for reference impedance



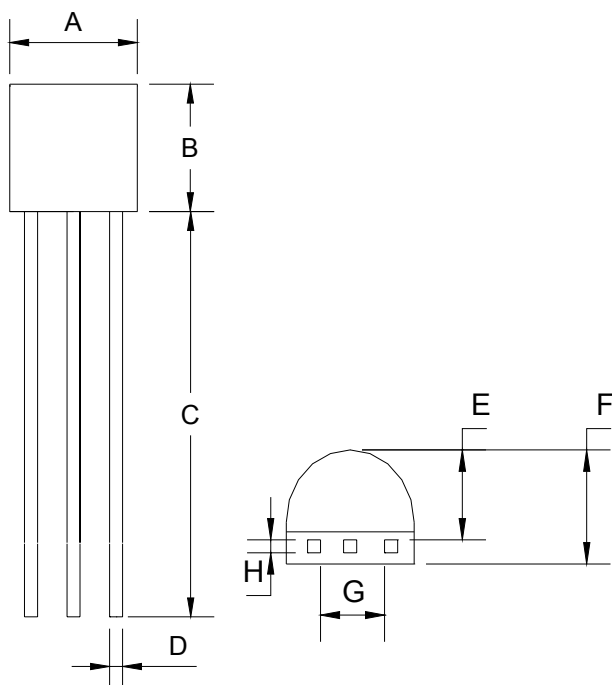
test circuit for curve A



test circuit for curve B, C, D

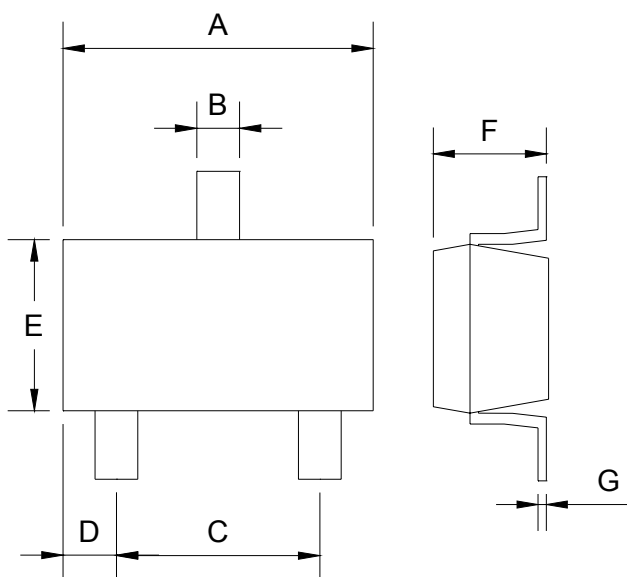
the area under the curves represent conditions that may cause the device to oscillate. for curves B, C and D, R_2 and V_+ were adjusted to establish the initial V_{ka} and I_{ka} conditions with $C_L=0$. V_{batt} and C_L were then adjusted to determine the ranges of stability.

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-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

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