

FEATURES

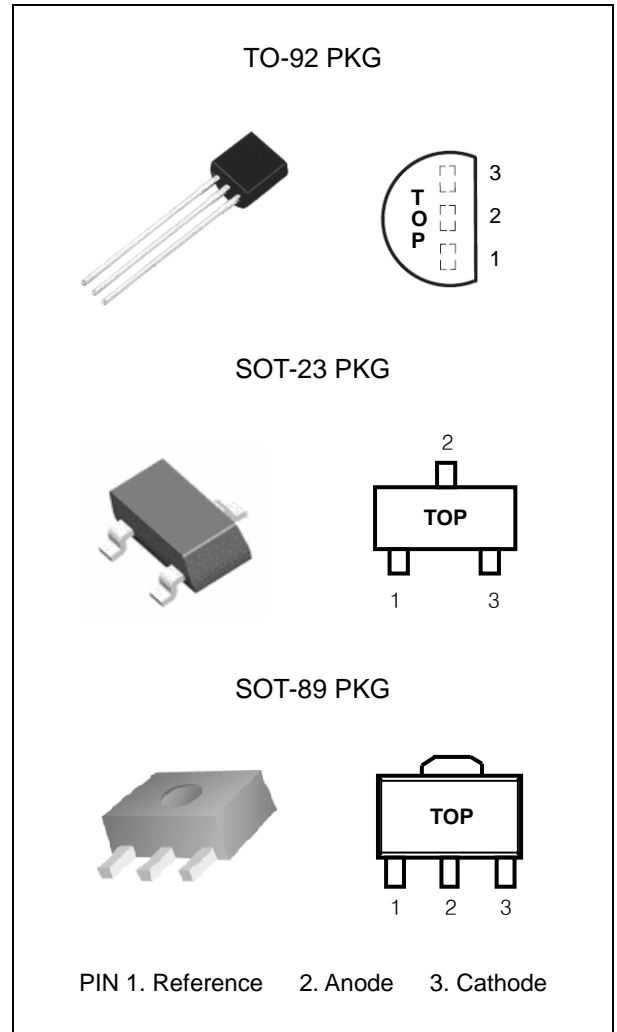
- Programmable Output Voltage to 40V
- Guaranteed 0.5% Reference Voltage Tolerance
- Low (0.2Ω Typ.) Dynamic Output Impedance
- Cathode Current Range(Continuous) – 100 ~ 150 mA
- Equivalent Full Range Temperature Coefficient of 50PPM/°C
- Temperature Compensated For Operation Over Full Rate Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response
- TO-92, SOT-89 or SOT-23 3L Package

APPLICATION

- Shunt Regulator
- Precision High-Current Series Regulator
- High-Current Shunt Regulator
- Crowbar Circuit
- PWM Converter With Reference
- Voltage Monitor
- Precision Current Limiter

DESCRIPTION

The TL431 is a three-terminal adjustable shunt regulator with specified thermal stability over applicable temperature V_{REF} (Approx. 2.5V) and 40V with two external resistors. This device has a typical dynamic output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making this device excellent replacement for zener diodes in many applications. The TL431 is characterized for operation from -40°C to +125°C.


ORDERING INFORMATION

Device	Package
TL431	TO-92(Bulk)
TL431TA	TO-92(Taping)
TL431SF	SOT-23 3L
TL431F	SOT-89 3L

* Refer to the page 2 for detailed ordering Information,

Absolute Maximum Ratings

(Operating temperature range applies unless otherwise specified)

CHARACTERISTIC	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	42	V
Cathode Current Range(Continuous)	I_K	-100	150	mA
Reference Input Current Range	I_{REF}	-0.05	10	mA
Junction Temperature Range	T_J	-40	150	°C
Operating Temperature Range	T_{OPR}	-40	125	°C
Storage Temperature Range	T_{STG}	-65	150	°C

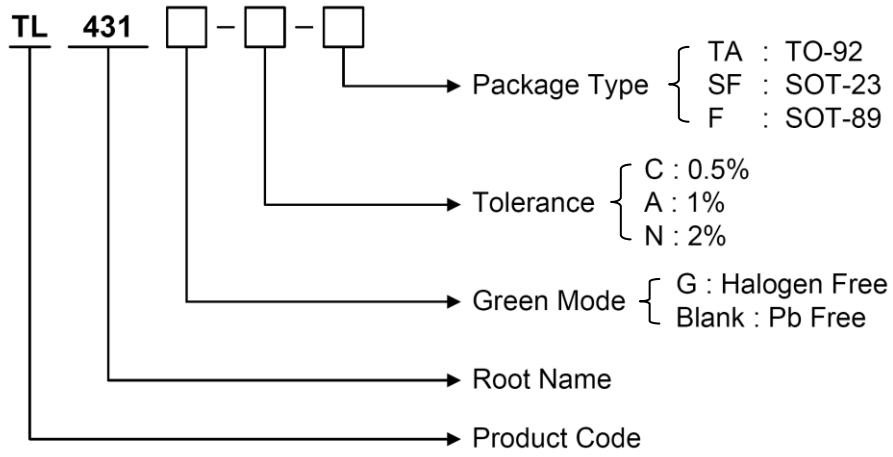
RECOMMENDED OPERATING CONDITIONS

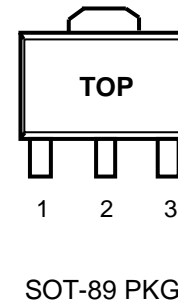
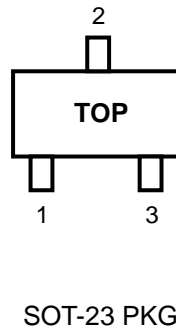
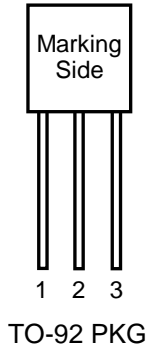
CHARACTERISTIC	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	40	V
Cathode Current	I_K	0.5	100	mA

Ordering Information

V_{REF}	Package	Tolerance	Order No.	Package Marking	Supplied As
2.495V	TO-92	0.5%	TL431C	TL431-C	Bulk
			TL431GC	TL431GC	
			TL431CTA	TL431-C	Tape
			TL431GCTA	TL431GC	
		1%	TL431A	TL431-A	Bulk
			TL431GA	TL431GA	
			TL431ATA	TL431-A	Tape
			TL431GATA	TL431GA	
	2%	TL431	TL431	Bulk	
		TL431G	TL431G		
		TL431TA	TL431	Tape	
		TL431GTA	TL431G		
	SOT-23	0.5%	TL431CSF	431	Reel
			TL431GCSF	431	
		1%	TL431ASF	431	Reel
			TL431GASF	431	
		2%	TL431SF	431	Reel
			TL431GSF	431	
	SOT-89	0.5%	TL431CF	431	Reel
		1%	TL431AF	431	Reel
2%		TL431F	431	Reel	

Ordering Information (continued)



PIN CONFIGURATION

PIN DESCRIPTION

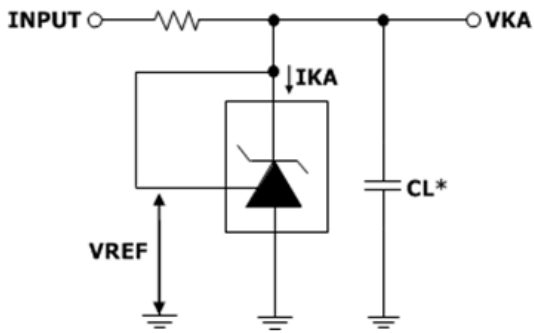
Pin No.	TO-92 / SOT-23 / SOT-89	
	Name	Function
1	Reference	Reference Voltage
2	Anode	Ground
3	Cathode	Input Supply Voltage

TL431 ELECTRICAL CHARACTERISTICS

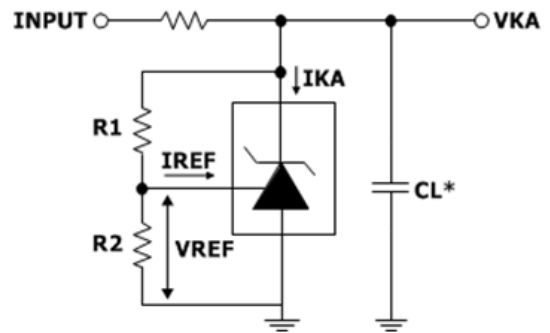
 (T_A=25 °C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT	
Reference Input Voltage	V _{REF}	V _{KA} =V _{REF} , I _K =10mA	TL431C	2.483	2.495	2.507	V
			TL431A	2.470	2.495	2.520	
			TL431	2.440	2.495	2.550	
Deviation of Reference Input Voltage	ΔV _{REF} /ΔT	V _{KA} = V _{REF} , I _K = 10mA T _A = Full Range		8	20	mV	
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	ΔV _{REF} /ΔV _{KA}	I _K = 10mA	ΔV _{KA} =10V -V _{REF}		-1.4	-2.7	mV/V
			ΔV _{KA} =36V-10V		-1.0	-2.0	
Reference Input Current	I _{REF}	I _{KA} =10mA, R ₁ =10kΩ, R ₂ =∞		1.8	4.0	uA	
Deviation of Reference Input Current	ΔI _{REF} /ΔT	I _K = 10mA, R ₁ =10kΩ, R ₂ =∞ T _A = Full Range		0.4	1.2	uA	
Minimum Cathode Current for Regulation	I _{K(MIN)}	V _{KA} = V _{REF}			0.5	mA	
Off-State Cathode Current	I _{K(OFF)}	V _{KA} =36V, V _{REF} =0		0.17	0.90	uA	
Dynamic Impedance	Z _{KA}	V _{KA} = V _{REF} , I _K =1mA~100mA f ≤ 1kHz		0.27	0.50	Ω	

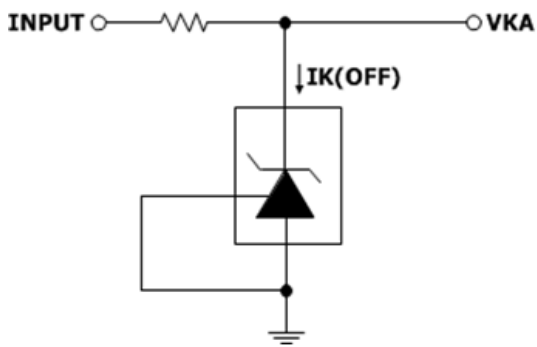
TEST CIRCUITS



< Fig 1. Test circuit for $V_{KA} = V_{REF}$ >



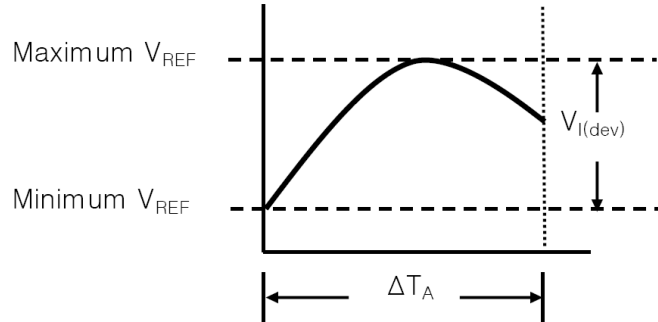
< Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



< Fig 3. Test circuit for $I_{KA(OFF)}$ >

The deviation parameters $\Delta V_{REF}/\Delta T$ and $\Delta I_{REF}/\Delta T$ are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF} , is defined as :

$$|\alpha V_{REF}|(\text{ppm}/^\circ\text{C}) = \frac{\left(\frac{V_{I(\text{dev})}}{V_{REF \text{ at } 25^\circ\text{C}}}\right) \times 10^6}{\Delta T_A}$$



Where :

ΔT_A is the recommended operating free-air temperature range of the device.

αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF} , respectively, occurs at the lower temperature.

Example : Maximum $V_{REF}=2496\text{mV}$ at 30°C , maximum $V_{REF}=2492\text{mV}$ at 0°C , $V_{REF}=2495\text{mV}$ at 25°C ,
 $\Delta T_A=70^\circ\text{C}$ for TL431C.

$$|\alpha V_{REF}| = \frac{\left(\frac{4\text{mV}}{2495\text{mV}}\right) \times 10^6}{70^\circ\text{C}} \approx 23\text{ppm}/^\circ\text{C}$$

Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

Calculating Dynamic Impedance

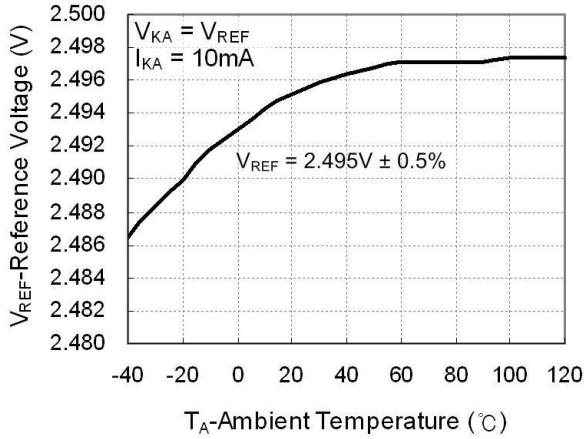
The dynamic impedance is defined as : $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors, the total dynamic impedance of the circuit is given by:

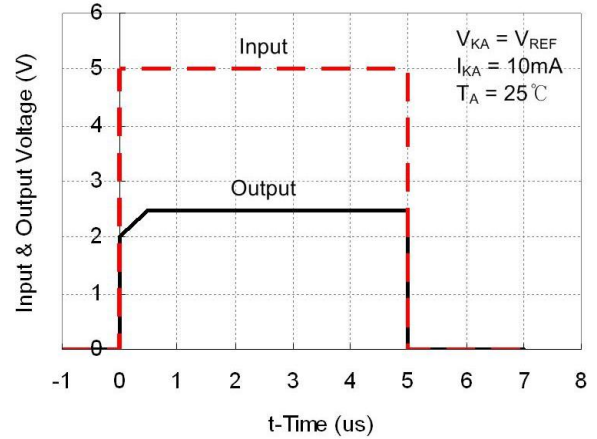
$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}| (1 + R1/R2)$$

TYPICAL OPERATING CHARACTERISTICS

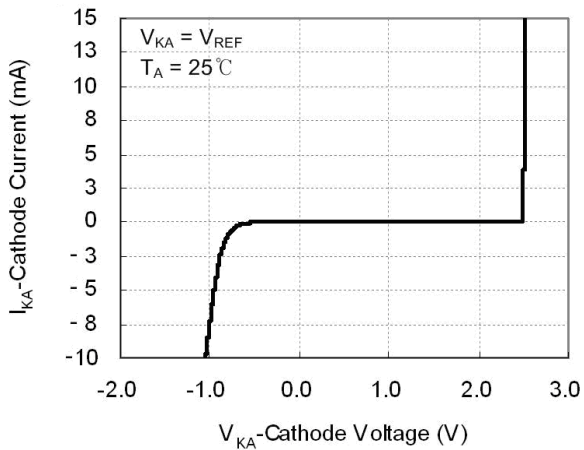
Reference Voltage vs. Ambient Temperature



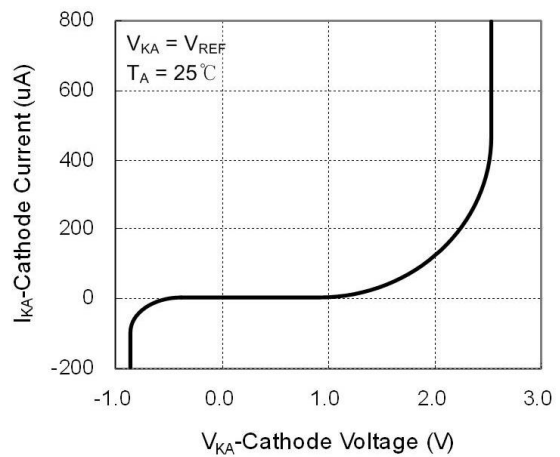
Pulse Response



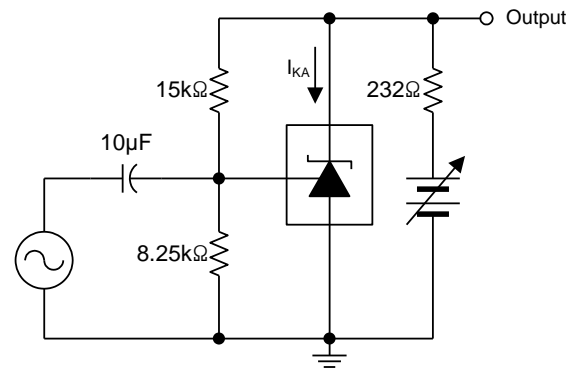
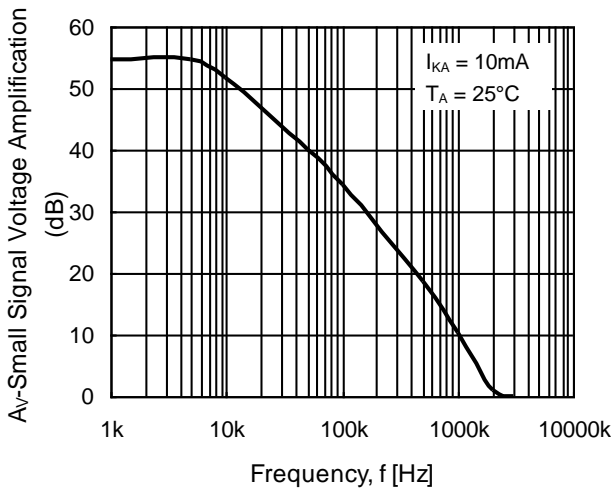
Cathode Current vs. Cathode Voltage



Cathode Current vs. Cathode Voltage



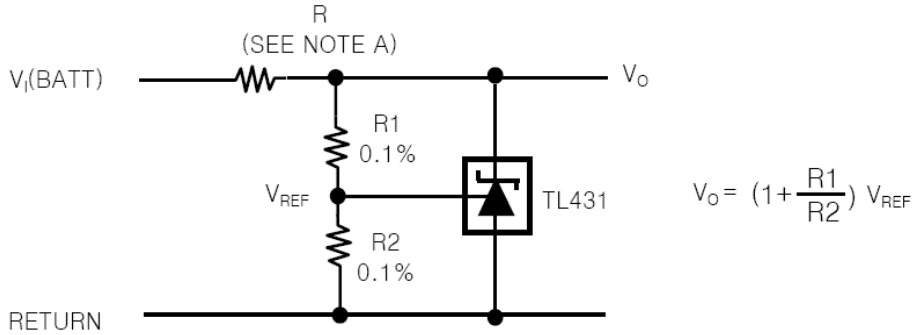
Small Signal Voltage Amplification vs. Frequency



< Fig 4. TEST Circuit for Voltage Amplification >

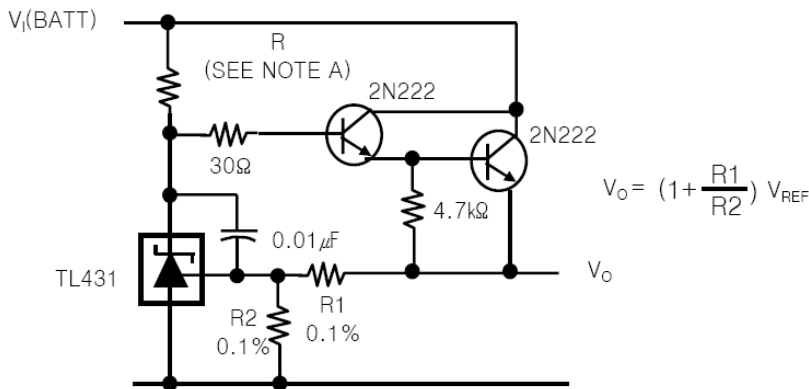
APPLICATION INFORMATION

1. Shunt Regulator



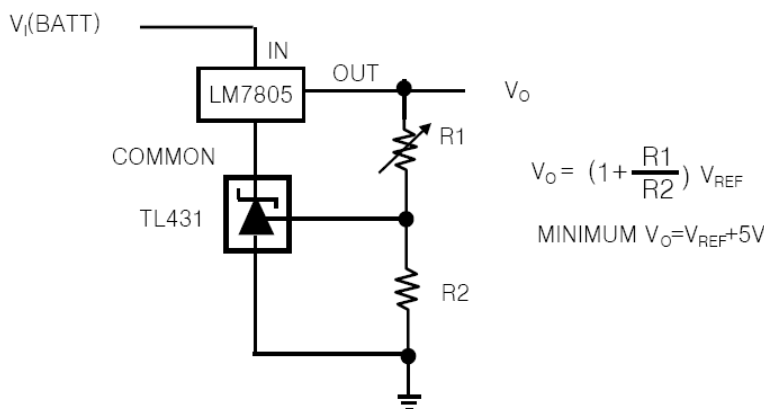
Note A : R Should provide cathode current 1mA to the TL431 at minimum $V_{I(BATT)}$

2. Precision High-Current Series Regulator

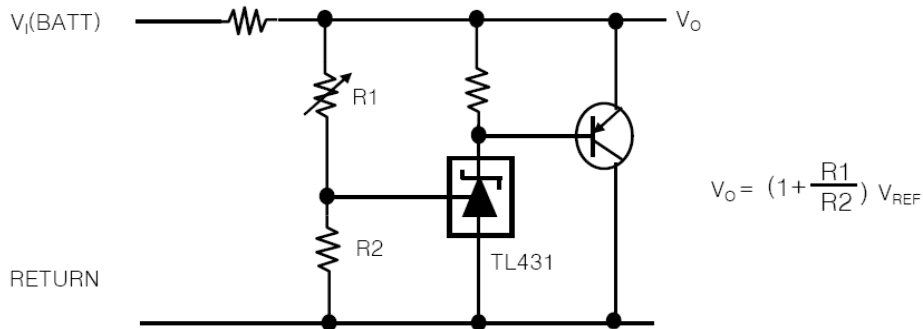


Note A : R Should provide cathode current $\geq 1\text{mA}$ to the TL431 at minimum $V_{I(BATT)}$

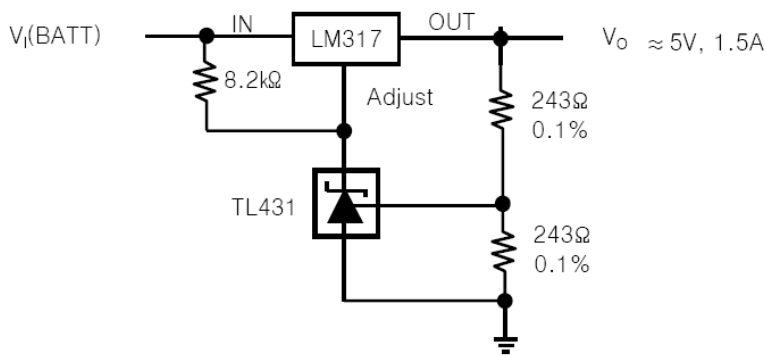
3. Output Control of a Three-Terminal Fixed Regulator



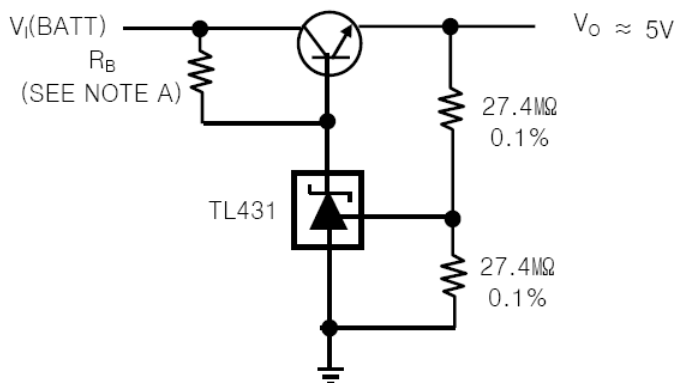
4. High-Current Shunt Regulator



5. Precision 5-V 1.5A Regulator

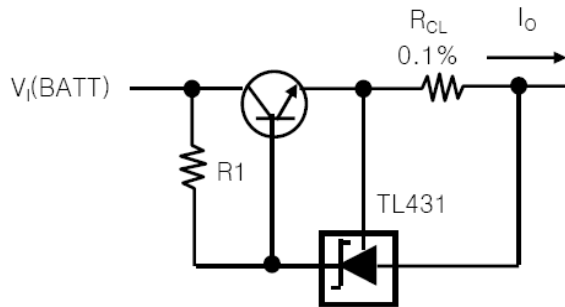


6. Efficient 5-V Precision Regulator



NOTE A : R_B Should provide cathode current ≥ 1mA to the TL431.

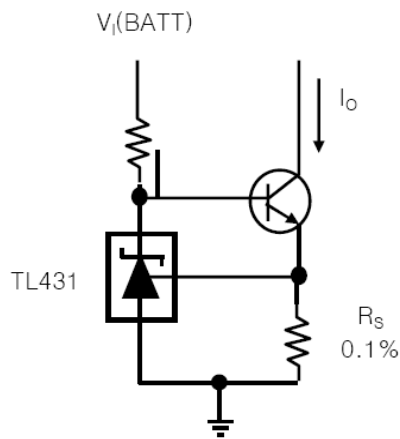
10. Precision Current Limiter



$$I_{OUT} = \frac{V_{REF}}{R_{CL}} + I_{KA}$$

$$R1 = \frac{V_{i(BATT)}}{I_o} + I_{KA}$$

11. Precision Constant-Current Sink



$$I_o = \frac{V_{REF}}{R_s}$$

REVISION NOTICE

The description in this data sheet can be revised without any notice to describe its electrical characteristics properly.