

FEATURES

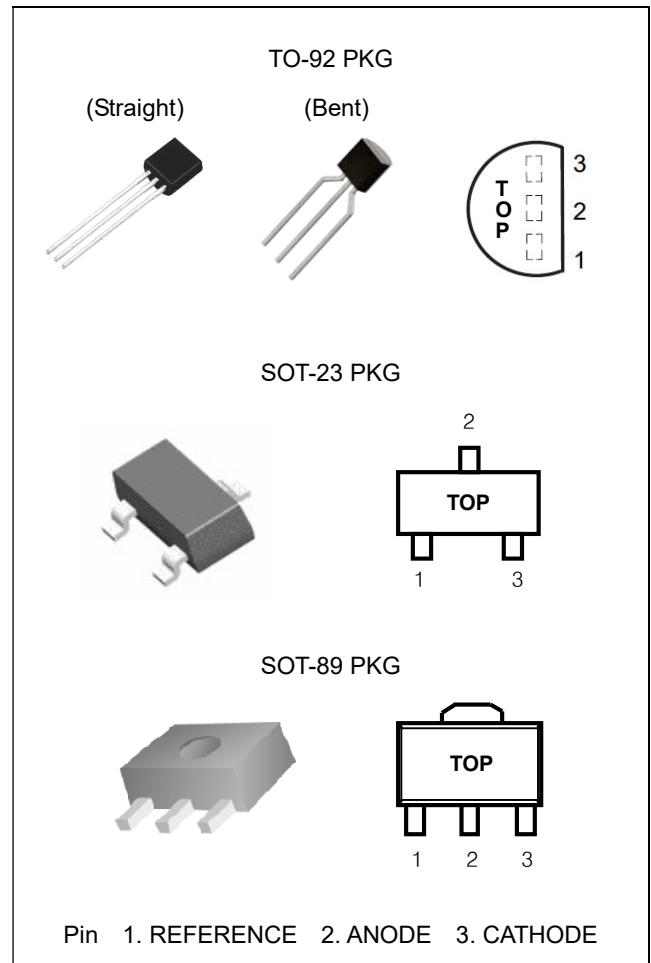
- Programmable Output Voltage to 40V
- Guaranteed 0.5% Reference Voltage Tolerance
- Low (0.2Ω Typ.) Dynamic Output Impedance
- Cathode Current Range (Continuous) – 100 ~ 150 mA
- Equivalent Full Range Temperature Coefficient of 50PPM/°C
- Temperature Compensated For Operation Over Full Rate Operating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

APPLICATIONS

- 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} (2.495V) 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
TL431x	TO-92 (Bulk, Straight)
TL431xTA	TO-92 (Tape, Bent)
TL431xSF	SOT-23-3L
TL431xF	SOT-89-3L

* Refer to the ordering information for the details.

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies unless otherwise noted.)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	42	V
Cathode Current Range	I_{KA}	-100	150	mA
Reference Input Current Range	I_{REF}	-0.05	10	mA
Junction Temperature Range	T_J	-40	150	°C
Storage Temperature Range	T_{STG}	-65	150	°C

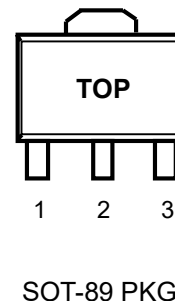
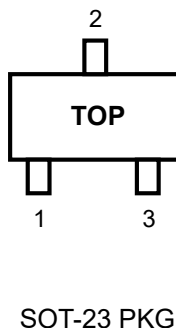
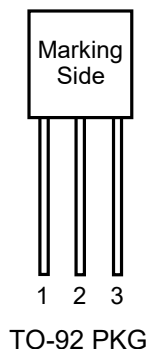
RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	40	V
Cathode Current	I_{KA}	0.5	100	mA
Operating Temperature Range	T_{OPR}	-40	125	°C

ORDERING INFORMATION

VREF	Package	Tolerance	Order No.	Marking	Supplied As	
2.495V	TO-92	0.5%	TL431C	TL431-C	Bulk (Straight Lead)	
			TL431CTA	TL431-C	Tape & Ammo Pack	
		1%	TL431A	TL431-A	Bulk (Straight Lead)	
			TL431ATA	TL431-A	Tape & Ammo Pack	
		2%	TL431	TL431	Bulk (Straight Lead)	
			TL431TA	TL431	Tape & Ammo Pack	
	SOT-23	0.5%	TL431CSF	431	Tape & Reel	
			1%	TL431ASF	431	Tape & Reel
			2%	TL431SF	431	Tape & Reel
	SOT-89	0.5%	TL431CF	431	Tape & Reel	
			1%	TL431AF	431	Tape & Reel
			2%	TL431F	431	Tape & Reel

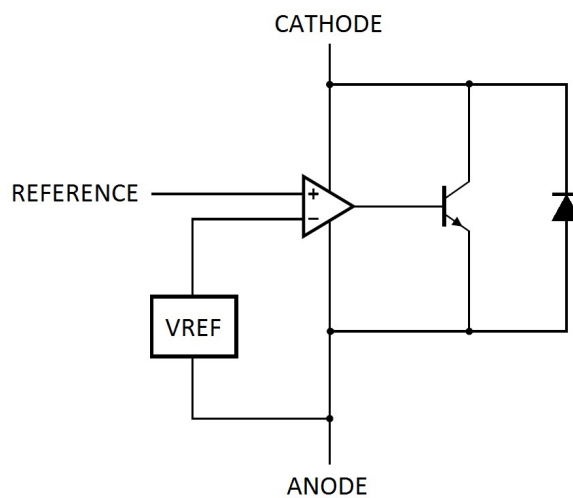
PIN CONFIGURATION



PIN DESCRIPTION

Pin No.	TO-92 / SOT-23 / SOT-89	
	Pin Name	Pin Description
1	REFERENCE	Reference Voltage
2	ANODE	Ground
3	CATHODE	Input Supply Voltage

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	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 (Note 1)	ΔV _{REF} /ΔT	V _{KA} = V _{REF} , I _K = 10mA T _A = Full Range		15	30	mV	
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	ΔV _{REF} /ΔV _{KA}	I _K = 10mA	ΔV _{KA} = 10V to V _{REF}		-1.4	-2.7	mV/V
			ΔV _{KA} = 36V to 10V		-1.0	-2.0	
Reference Input Current	I _{REF}	I _{KA} = 10mA, R ₁ = 10kΩ, R ₂ = ∞		1.8	4.0	μA	
Deviation of Reference Input Current (Note 1)	ΔI _{REF} /ΔT	I _K = 10mA, R ₁ = 10kΩ, R ₂ = ∞ T _A = Full Range		0.4	1.2	μA	
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	μA	
Dynamic Impedance (Note 2)	Z _{KA}	V _{KA} = V _{REF} , I _K = 1mA~100mA f ≤ 1kHz		0.27	0.50	Ω	

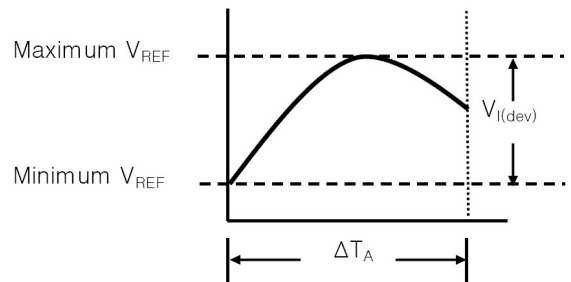
(Note 1) The deviation parameters ΔV_{REF}/ΔT_A and ΔI_{REF}/ΔT_A are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF}, is defined as:

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

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}=2496mV at 30°C, minimum V_{REF}=2492mV at 0°C, V_{REF}=2495mV at 25°C, ΔT_A=70°C for TL431C.

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

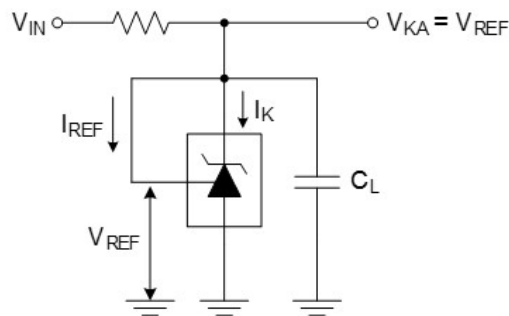
Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

(Note 2) 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:

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

TEST CIRCUITS



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

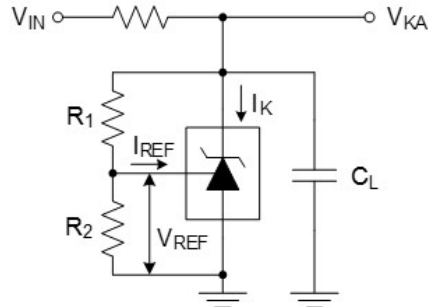
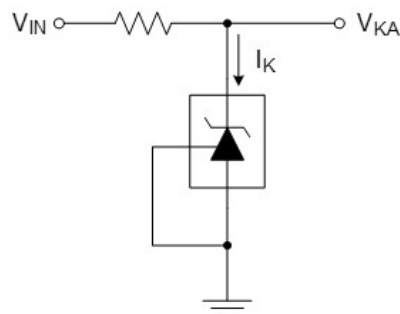


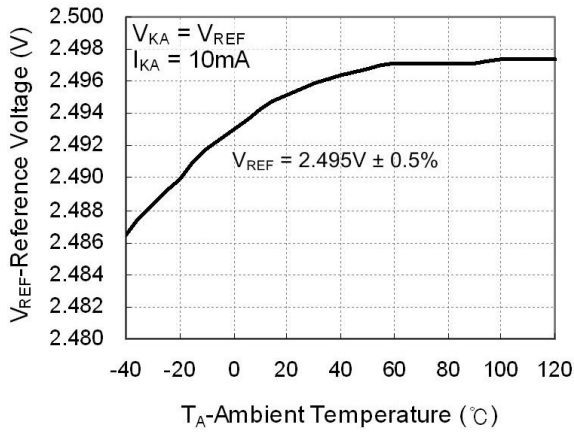
Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



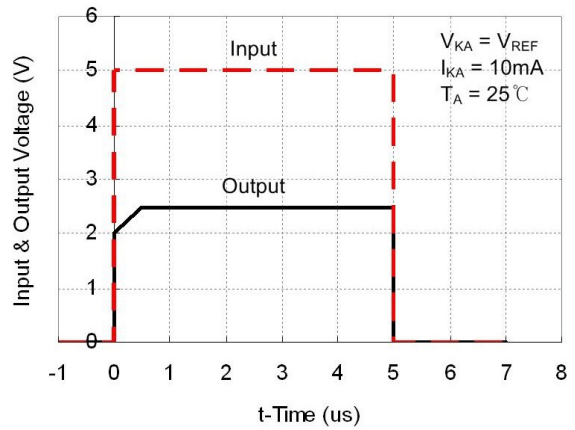
< Fig 3. Test circuit for $I_{KA(OFF)}$ >

TYPICAL OPERATING CHARACTERISTICS

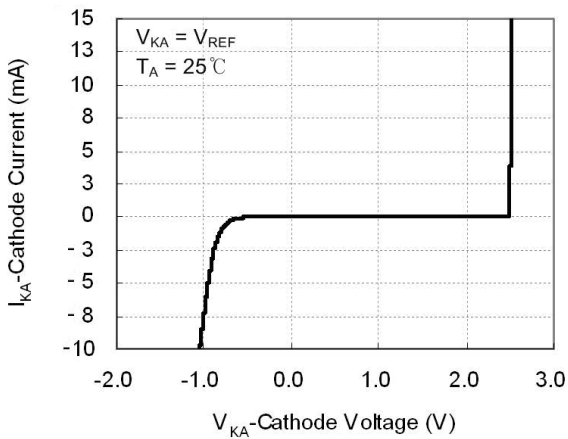
Reference Voltage vs. Ambient Temperature



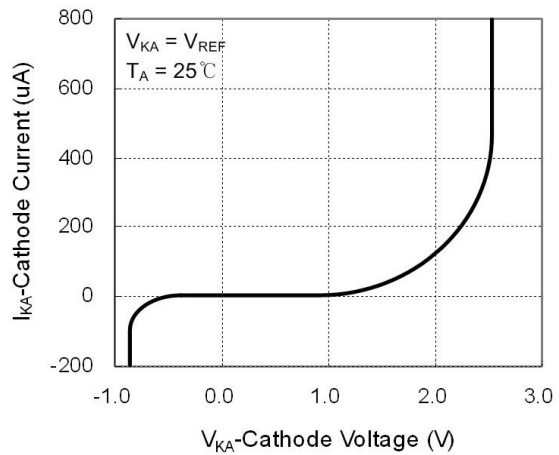
Pulse Response



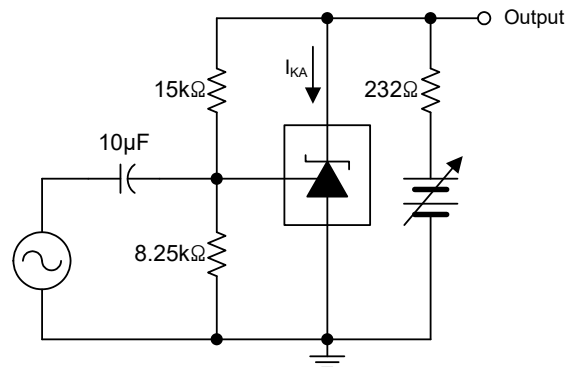
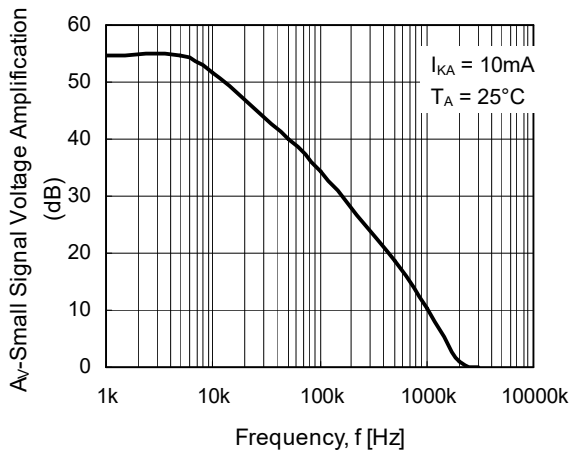
Cathode Current vs. Cathode Voltage



Cathode Current vs. Cathode Voltage



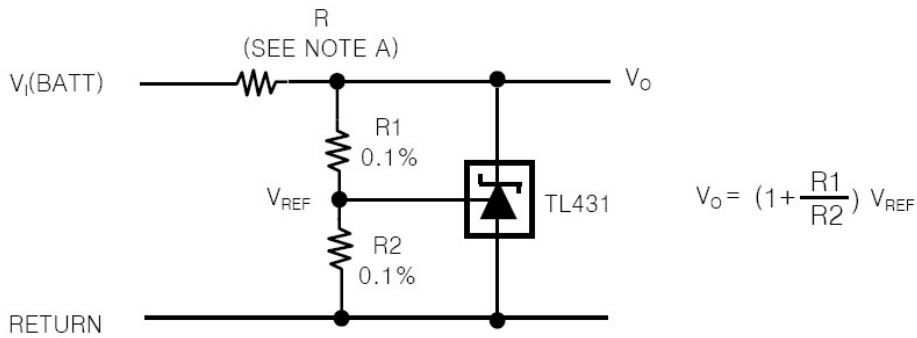
Small Signal Voltage Amplification vs. Frequency



< Fig 4. TEST Circuit for Voltage Amplification >

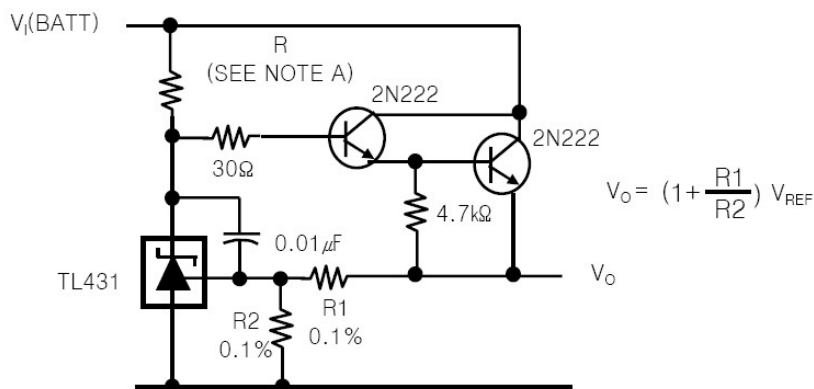
APPLICATION INFORMATION

1. Shunt Regulator



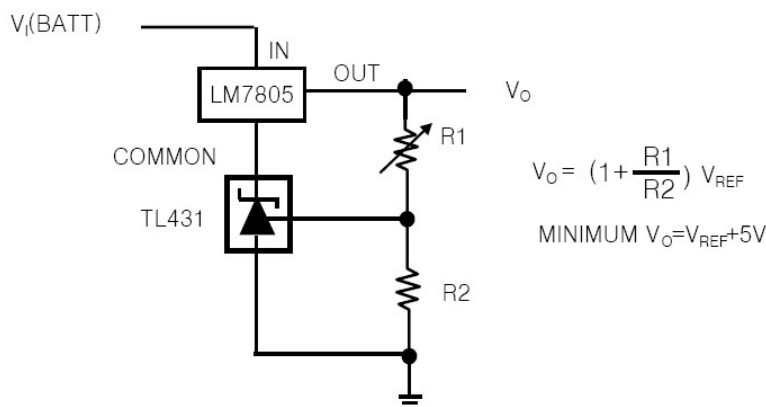
Note: R Should provide cathode current 1mA to the TL431 at minimum $V_{I(BATT)}$

2. Precision High-Current Series Regulator

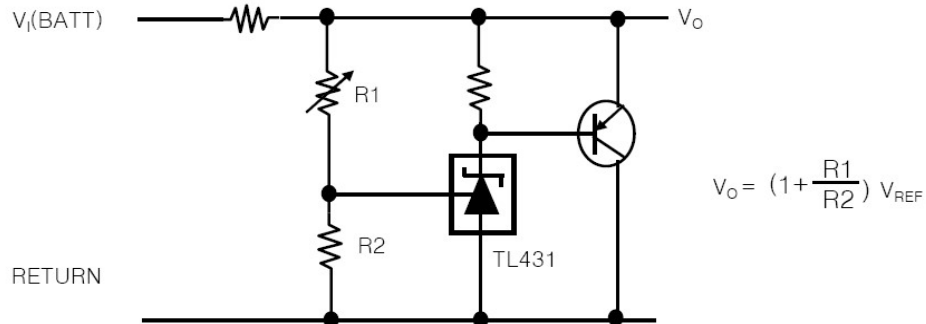


Note: R Should provide cathode current ≥ 1 mA to the TL431 at minimum $V_{I(BATT)}$

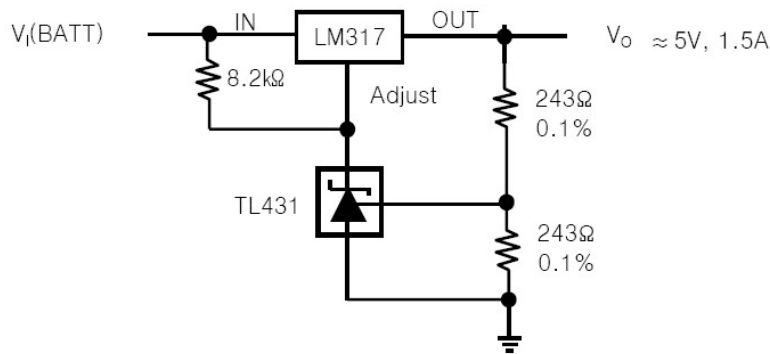
3. Output Control of a Three-Terminal Fixed Regulator



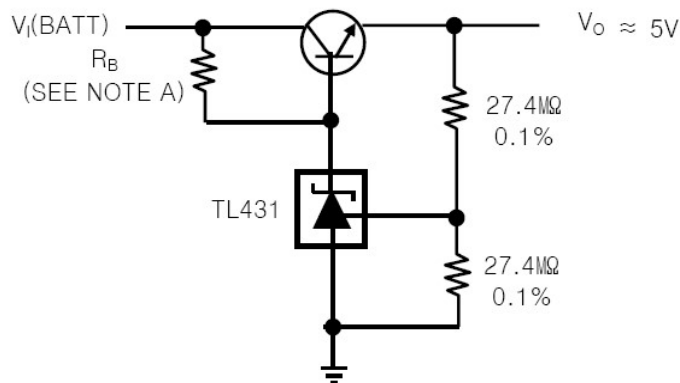
4. High-Current Shunt Regulator



5. Precision 5-V 1.5A Regulator

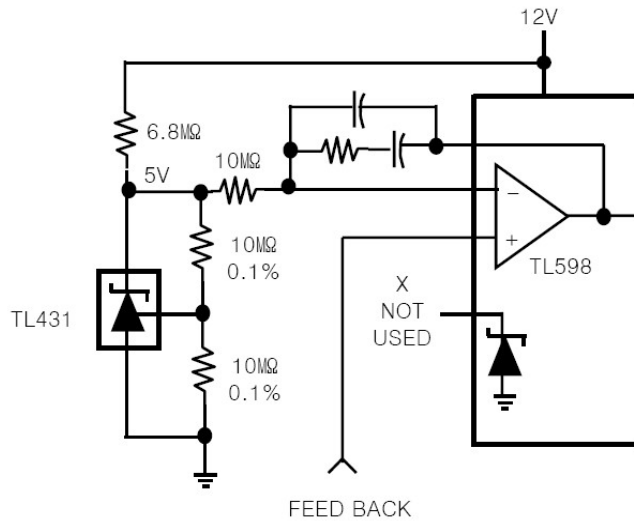


6. Efficient 5-V Precision Regulator

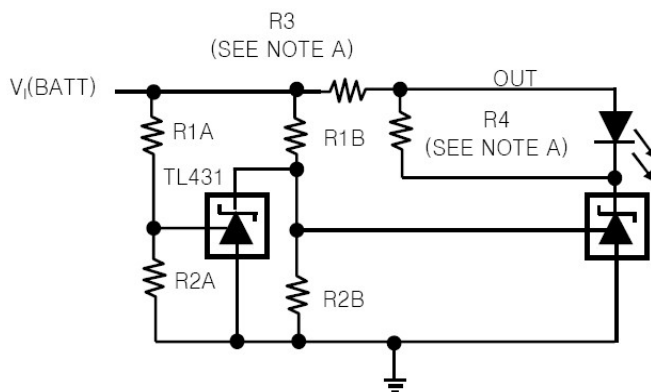


NOTE: R_B Should provide cathode current $\geq 1mA$ to the TL431.

7. PWM Converter With Reference



8. Voltage Monitor



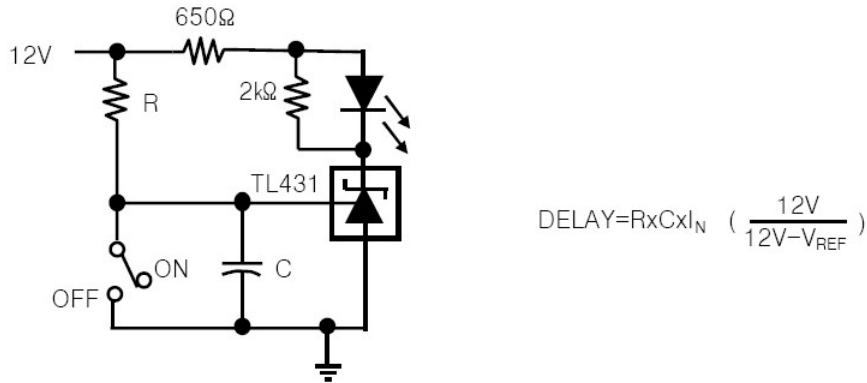
$$\text{LOW LIMIT} = \left(1 + \frac{R1B}{R2B}\right) V_{REF}$$

$$\text{HIGH LIMIT} = \left(1 + \frac{R1A}{R2A}\right) V_{REF}$$

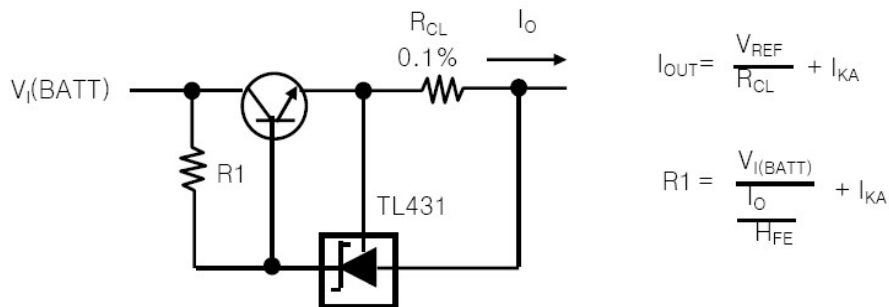
LED ON WHEN $\text{LOW LIMIT} < V_{I(BATT)} < \text{HIGH LIMIT}$

NOTE: R3 and R4 are selected to provide the desired LED intensity and cathode current $\geq 1\text{mA}$ to the TL431 at the available $V_{I(BATT)}$.

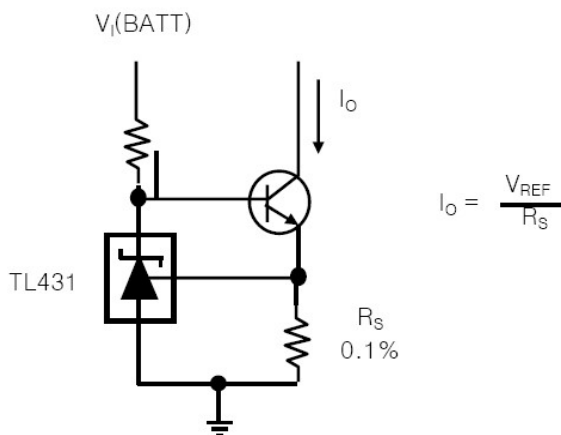
9. Delay Timer



10. Precision Current Limiter



11. Precision Constant-Current Sink



REVISION NOTICE

The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.