

**FEATURES**

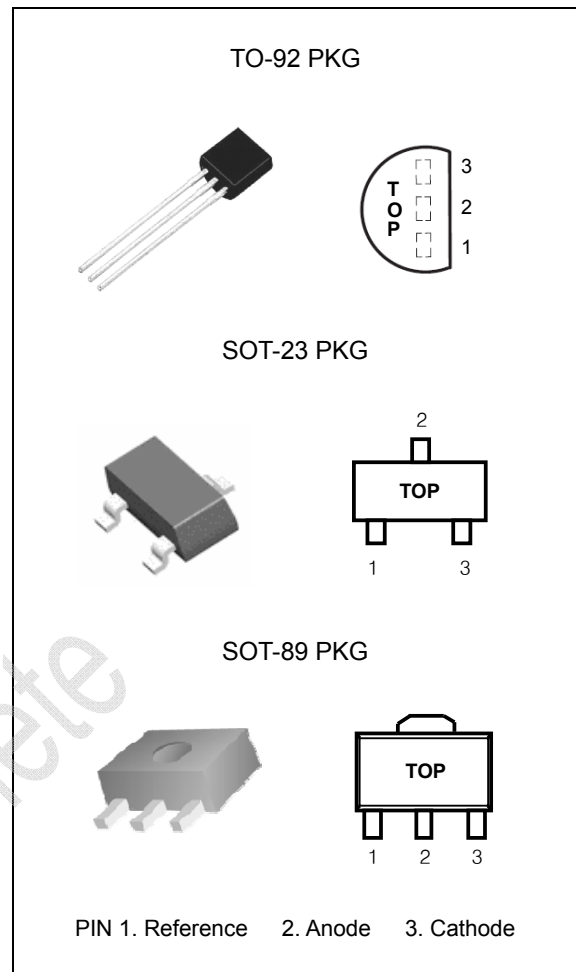
- Programmable Output Voltage to 40V
- Guaranteed 0.5% Reference Voltage Tolerance
- Low (0.2Ω Typ.) Dynamic Output Impedance
- Cathode Current Range(Continuous) – 100 ~ 150 mA
- Equivalent Full Range Temperature Coefficient of 50PPM/°C
- Temperature Compensated For Operation Over Full Rate Operating 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 TL431Z 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 TL431Z is characterized for operation from -40°C to +125°C.



**ORDERING INFORMATION**

Device (Marking)	Package
TL431Z	TO-92
TL431-AZ	
TL431-CZ	
431Z	SOT-23 3L
431Z	SOT-89 3L

**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	$T_J$	0	150	°C
Storage Temperature Range	$T_{STG}$	-60	150	°C
Operating Temperature Range	$T_{OPR}$	-40	125	°C

# PROGRAMMABLE PRECISION SHUNT REGULATOR

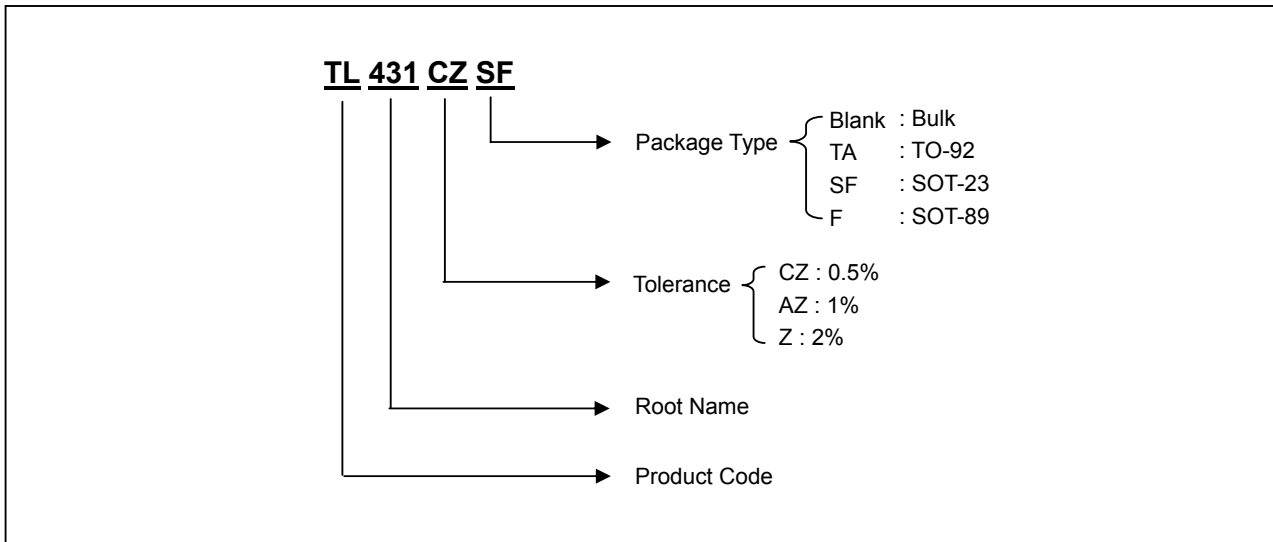
# TL431Z/AZ/CZ

## RECOMMENDED OPERATING CONDITIONS

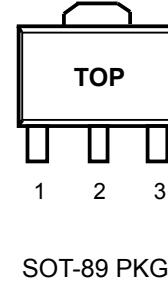
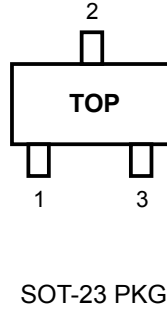
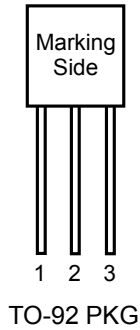
CHARACTERISTIC	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	$V_{KA}$	$V_{REF}$	40	V
Cathode Current	$I_K$	0.5	100	mA

## Ordering Information

$V_{REF}$	Package	Tolerance	Order No.	Package Marking	Status
2.495V	TO-92	0.5%	TL431CZ	TL431-CZ	Obsolete
			TL431CZTA		Obsolete
		1%	TL431AZ	TL431-AZ	Obsolete
			TL431AZTA		Obsolete
		2%	TL431Z	TL431Z	Obsolete
			TL431ZTA		Obsolete
	SOT-23	0.5%	TL431CZSF	431Z	Obsolete
			TL431AZSF		Obsolete
			TL431ZSF		Obsolete
	SOT-89	0.5%	TL431CZF	431Z	Obsolete
			TL431AZF		Obsolete
			TL431ZF		Obsolete



PIN CONFIGURATION



PIN DESCRIPTION

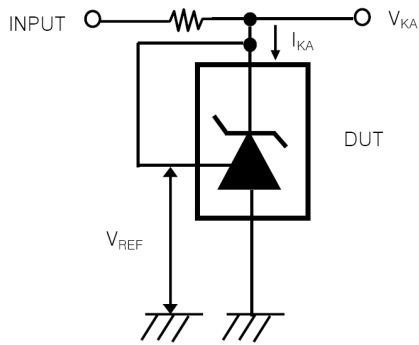
Pin No.	TO-92 / SOT-23 / SOT-89	
	Name	Function
1	Reference	Reference Voltage
2	Anode	Ground
3	Cathode	Input Supply Voltage

TL431Z ELECTRICAL CHARACTERISTICS

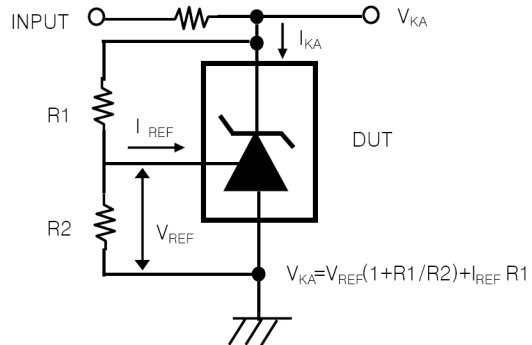
(T<sub>A</sub>=25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT	
Reference Input Voltage	V <sub>REF</sub>	V <sub>KA</sub> =V <sub>REF</sub> , I <sub>K</sub> =10mA	TL431CZ	2.483	2.495	2.507	V
			TL431AZ	2.47	2.495	2.52	
			TL431Z	2.44	2.495	2.55	
Deviation of Reference Input Voltage	ΔV <sub>REF</sub> /ΔT	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>K</sub> = 10mA T <sub>A</sub> = Full Range		3	17	mV	
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	ΔV <sub>REF</sub> /ΔV <sub>KA</sub>	I <sub>K</sub> = 10mA	ΔV <sub>KA</sub> = 10V - V <sub>REF</sub>	-1.4	-2.7	mV/V	
			ΔV <sub>KA</sub> = 36V - 10V	-1.0	-2.0		
Reference Input Current	I <sub>REF</sub>	I <sub>KA</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = ∞		1.8	4.0	μA	
Deviation of Reference Input Current	ΔI <sub>REF</sub> /ΔT	I <sub>K</sub> = 10mA, R <sub>1</sub> = 10kΩ, R <sub>2</sub> = ∞ T <sub>A</sub> = Full Range		0.4	1.2	μA	
Minimum Cathode Current for Regulation	I <sub>K(MIN)</sub>	V <sub>KA</sub> = V <sub>REF</sub>			0.5	mA	
Off-State Cathode Current	I <sub>KOFF</sub>	V <sub>KA</sub> = 42V, V <sub>REF</sub> = 0		0.17	0.9	μA	
Dynamic Impedance	Z <sub>KA</sub>	V <sub>KA</sub> = V <sub>REF</sub> , I <sub>K</sub> = 1mA ~ 100mA f ≤ 1kHz		0.27	0.5	Ω	

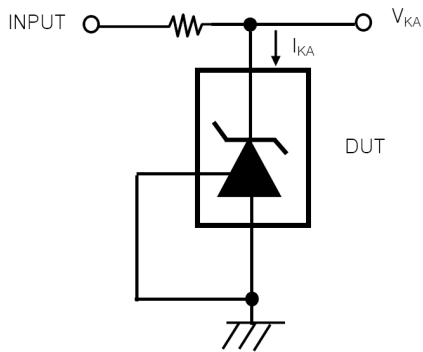
TEST CIRCUITS



[ Fig 1. Test circuit for  $V_{KA} = V_{REF}$  ]



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

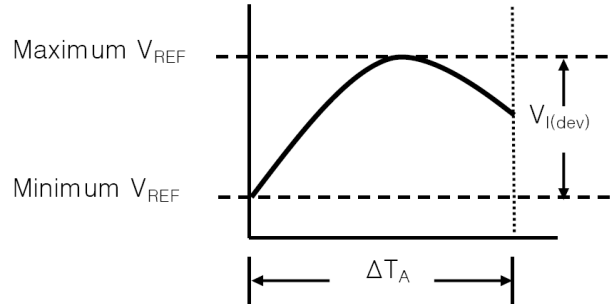


[ Fig 3. Test circuit for  $I_{KA(OFF)}$  ]

Obsolete

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,  $\alpha V_{REF}$ , is defined as :

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



Where :

$\Delta T_A$  is the recommended operating free-air temperature range of the device.

$\alpha V_{REF}$  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  $30^{\circ}\text{C}$ , maximum  $V_{REF}=2492\text{mV}$  at  $0^{\circ}\text{C}$ ,  $V_{REF}=2495\text{mV}$  at  $25^{\circ}\text{C}$ ,  $\Delta T_A=70^{\circ}\text{C}$  for TL431CZ.

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

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

**Calculating Dynamic Impedance**

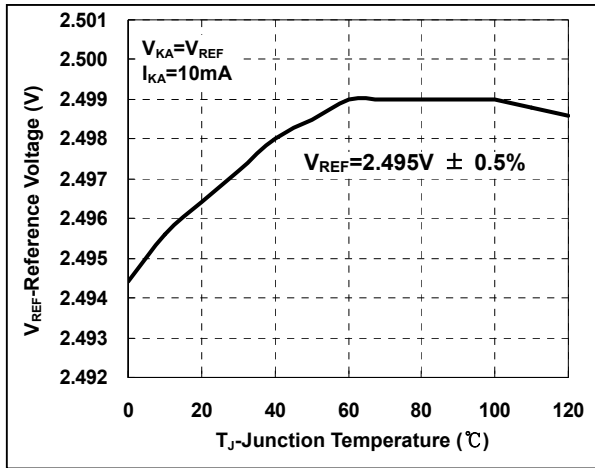
The dynamic impedance is defined as :  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

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

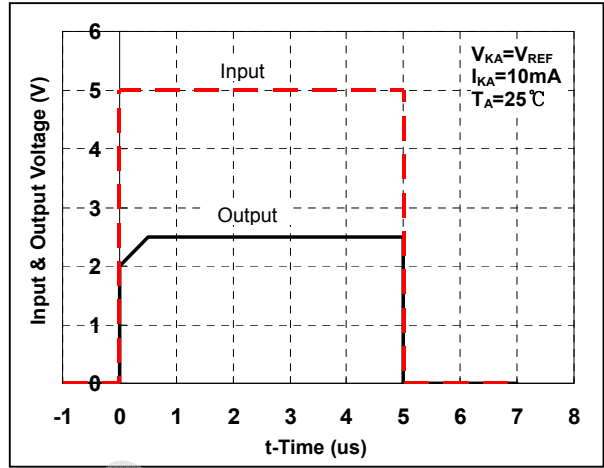
$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}| \left( 1 + \frac{R1}{R2} \right)$$

TYPICAL OPERATING CHARACTERISTICS

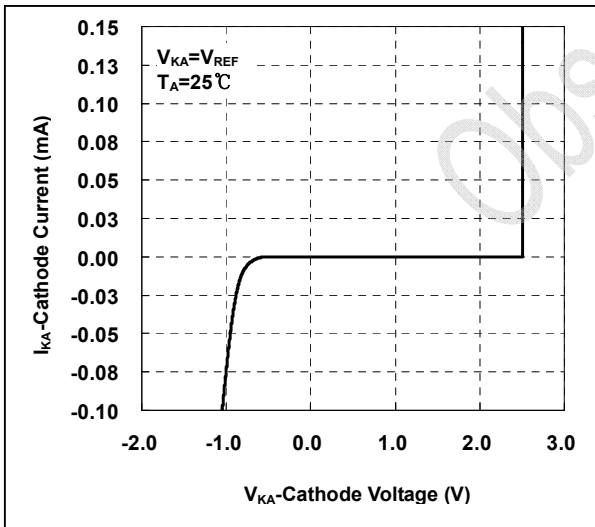
REFERENCE VOLTAGE vs JUNCTION TEMPERATURE



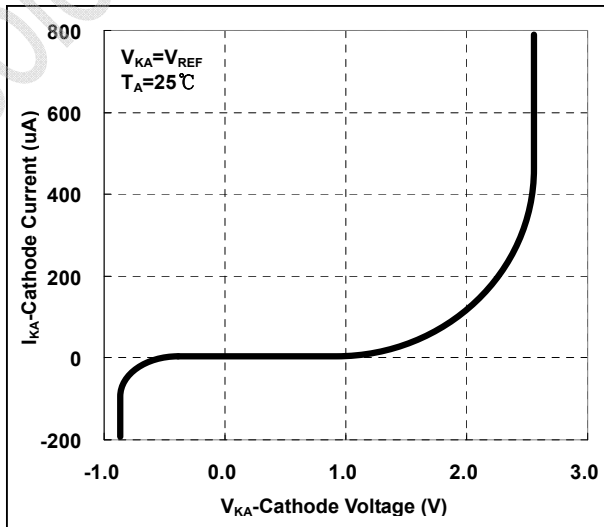
PULSE RESPONSE



CATHODE CURRENT vs CATHODE VOLTAGE



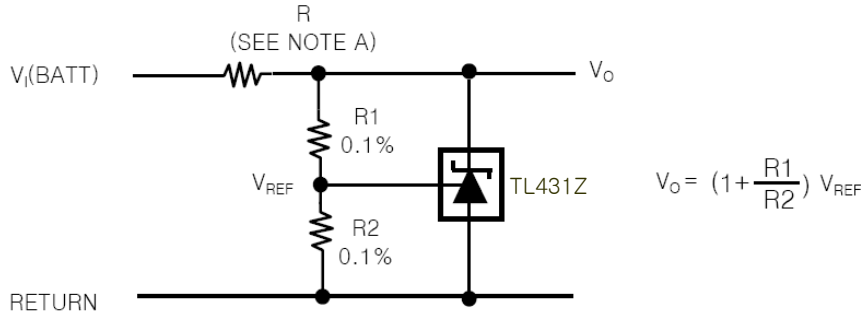
CATHODE CURRENT vs CATHODE VOLTAGE



T.B.D

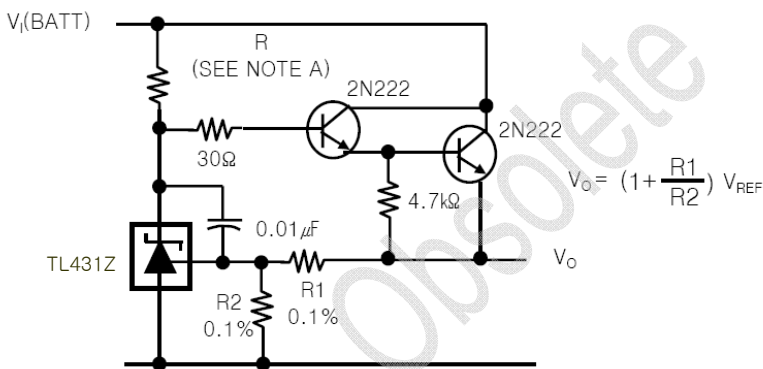
**APPLICATION INFORMATION**

**1. Shunt Regulator**



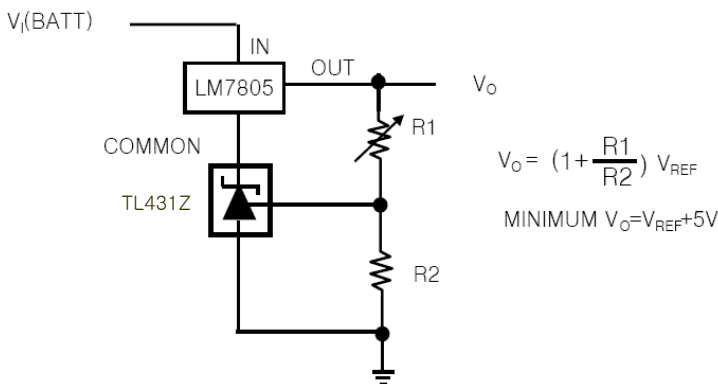
Note A : R Should provide cathode current 1mA to the TL431Z at minimum  $V_{i(BATT)}$

**2. Precision High-Current Series Regulator**

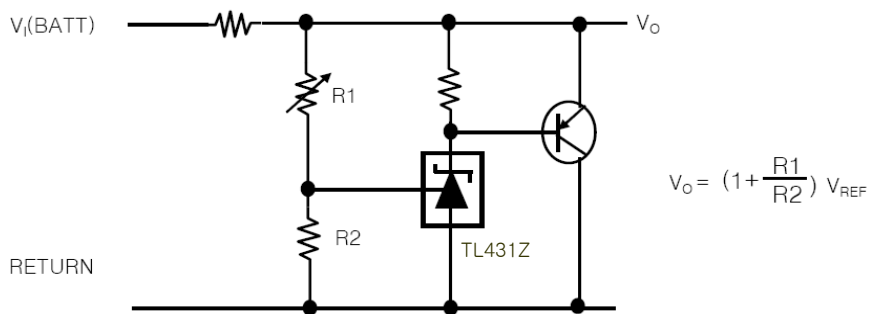


Note A : R Should provide cathode current  $\geq 1$ mA to the TL431Z at minimum  $V_{i(BATT)}$

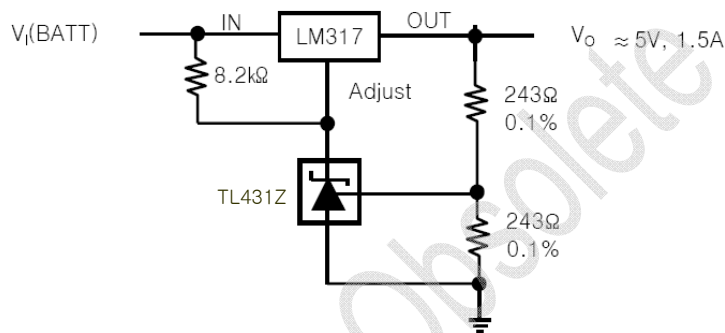
**3. Output Control of a Three-Terminal Fixed Regulator**



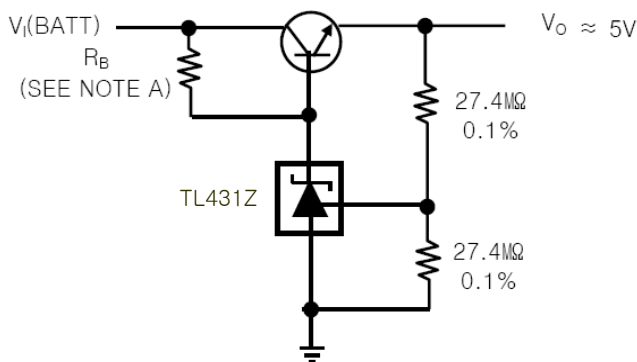
4. High-Current Shunt Regulator



5. Precision 5-V 1.5A Regulator



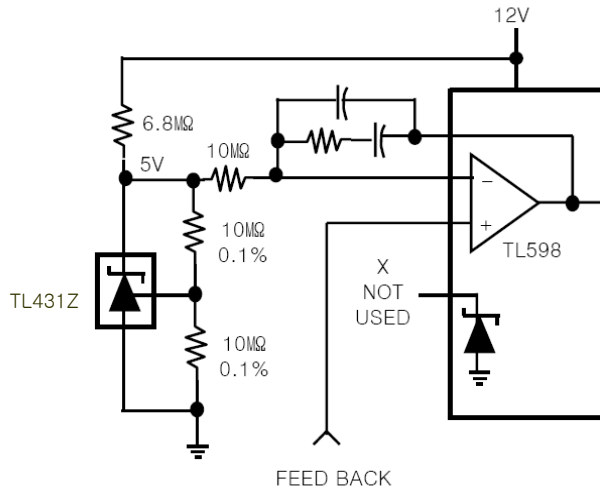
6. Efficient 5-V Precision Regulator



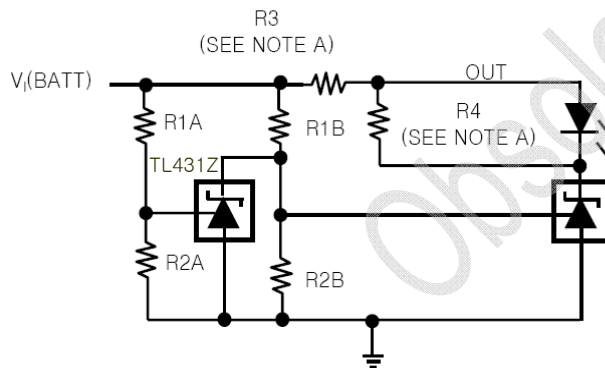
NOTE A : R<sub>B</sub> Should provide cathode current ≥ 1mA to the TL431Z.



7. PWM Converter With Reference



8. Voltage Monitor



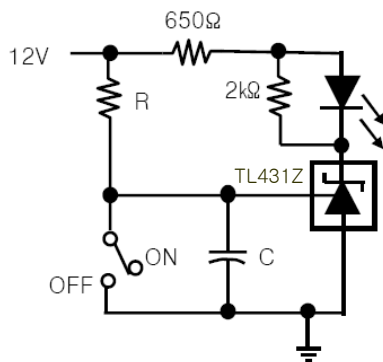
$$\text{LOW LIMIT} = \left(1 + \frac{R1B}{R2B}\right) V_{REF}$$

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

LED ON WHEN LOW LIMIT < V<sub>I</sub>(BATT) < HIGH LIMIT

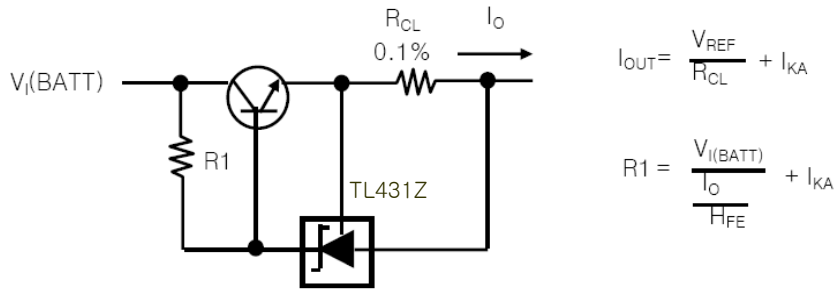
NOTE A : R3 and R4 are selected to provide the desired LED intensity and cathode current ≥1mA to the TL431Z at the available V<sub>I</sub>(BATT).

9. Delay Timer



$$\text{DELAY} = R \times C \times I_N \left( \frac{12V}{12V - V_{REF}} \right)$$

10. Precision Current Limiter



11. Precision Constant-Current Sink

