

# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

## FEATURES

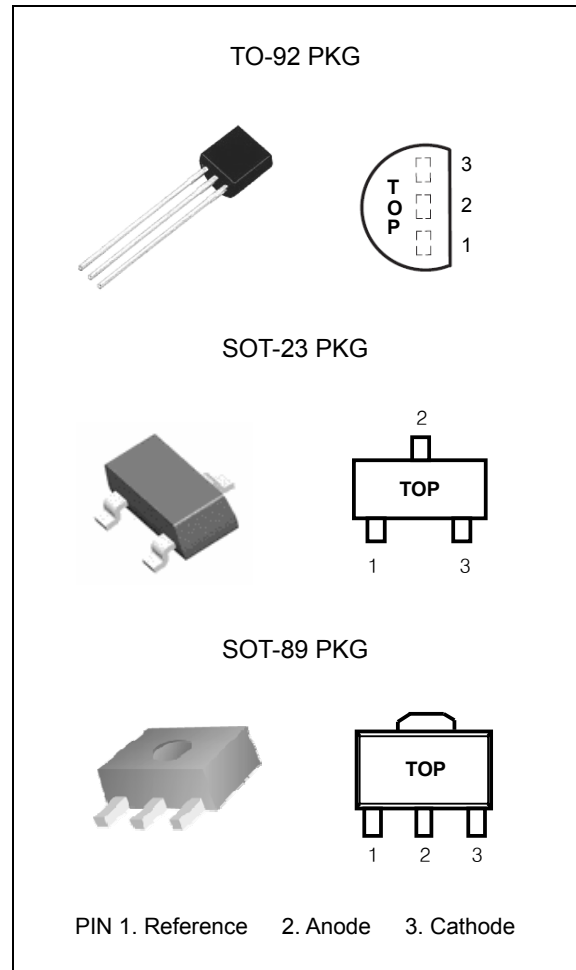
- Programmable Output Voltage to 40V
- Guaranteed 0.5% Reference Voltage Tolerance
- Low (0.2Ω Typ.) Dynamic Output Impedance
- Cathode Current Range(Continuous) – 100 ~ 150 mA
- Equivalent Full Range Temperature Coefficient of 50PPM/°C
- Temperature Compensated For Operation Over Full Rate Operating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

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## RECOMMENDED OPERATING CONDITIONS

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

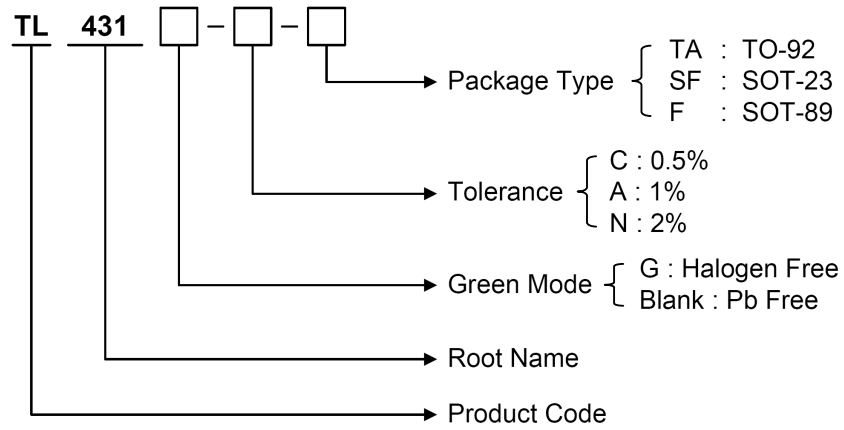
## Ordering Information

$V_{REF}$	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

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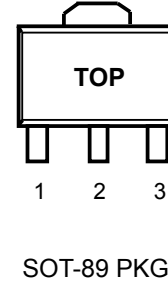
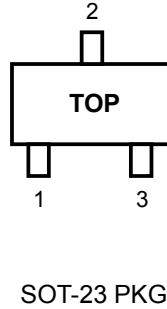
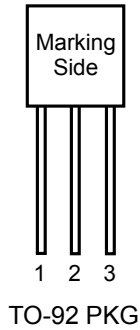
## Ordering Information

(continued)



# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

## 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

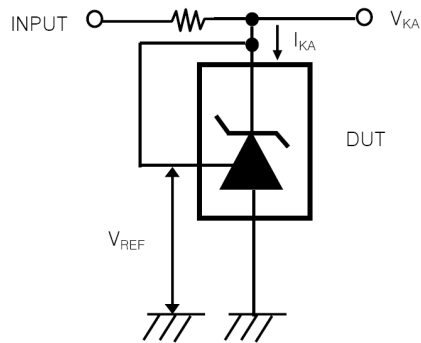
## TL431 ELECTRICAL CHARACTERISTICS

( $T_A=25^\circ\text{C}$ , unless otherwise specified)

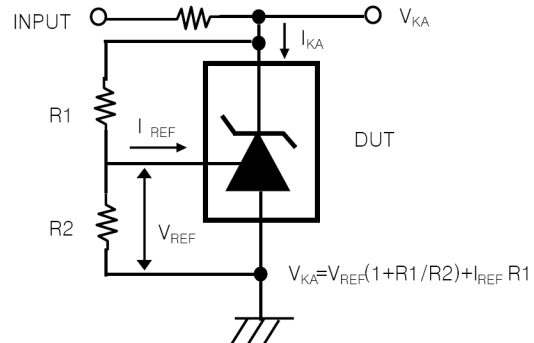
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT	
Reference Input Voltage	$V_{REF}$	$V_{KA}=V_{REF}$ , $I_K=10\text{mA}$	TL431C	2.483	2.495	2.507	V
			TL431A	2.470	2.495	2.520	
			TL431	2.440	2.495	2.550	
Deviation of Reference Input Voltage	$\Delta V_{REF}/\Delta T$	$V_{KA}=V_{REF}$ , $I_K=10\text{mA}$ $T_A=\text{Full Range}$		8	20	mV	
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	$I_K=10\text{mA}$	$\Delta V_{KA}=10\text{V}-V_{REF}$		-1.4	-2.7	mV/V
			$\Delta V_{KA}=36\text{V}-10\text{V}$		-1.0	-2.0	
Reference Input Current	$I_{REF}$	$I_{KA}=10\text{mA}$ , $R_1=10\text{k}\Omega$ , $R_2=\infty$		1.8	4.0	$\mu\text{A}$	
Deviation of Reference Input Current	$\Delta I_{REF}/\Delta T$	$I_K=10\text{mA}$ , $R_1=10\text{k}\Omega$ , $R_2=\infty$ $T_A=\text{Full Range}$		0.4	1.2	$\mu\text{A}$	
Minimum Cathode Current for Regulation	$I_{K(MIN)}$	$V_{KA}=V_{REF}$			0.5	mA	
Off-State Cathode Current	$I_{K(OFF)}$	$V_{KA}=36\text{V}$ , $V_{REF}=0$		0.17	0.90	$\mu\text{A}$	
Dynamic Impedance	$Z_{KA}$	$V_{KA}=V_{REF}$ , $I_K=1\text{mA}\sim 100\text{mA}$ $f \leq 1\text{kHz}$		0.27	0.50	$\Omega$	

# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

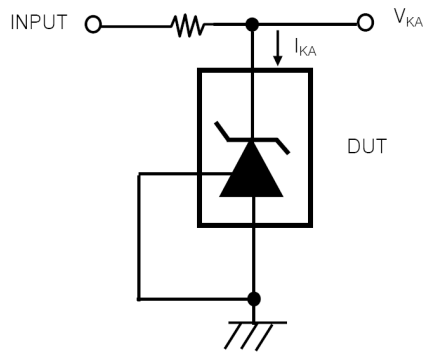
## TEST CIRCUITS



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



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

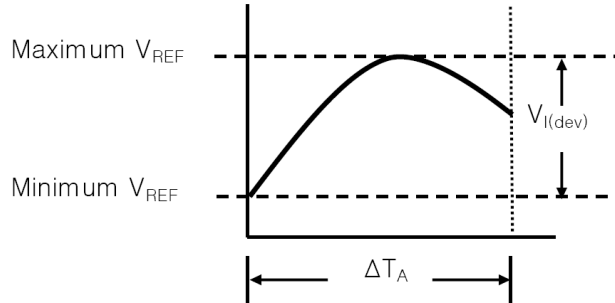


[ Fig 3. Test circuit for  $I_{KA(OFF)}$  ]

# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

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 :

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



Where :

$\Delta T_A$  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 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

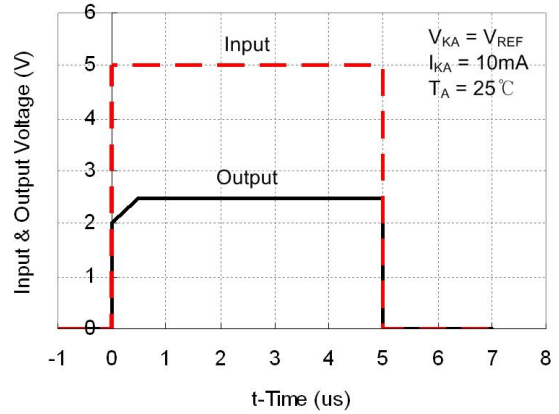
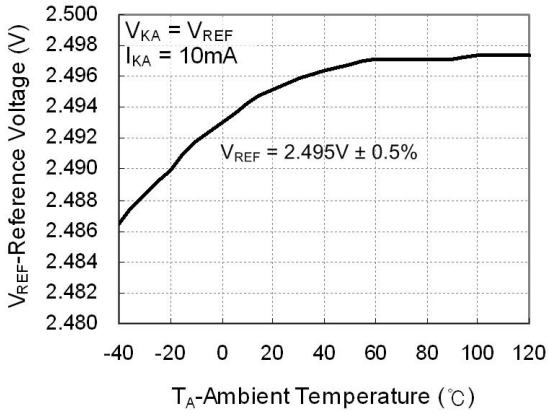
The dynamic impedance is defined as :  $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

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

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

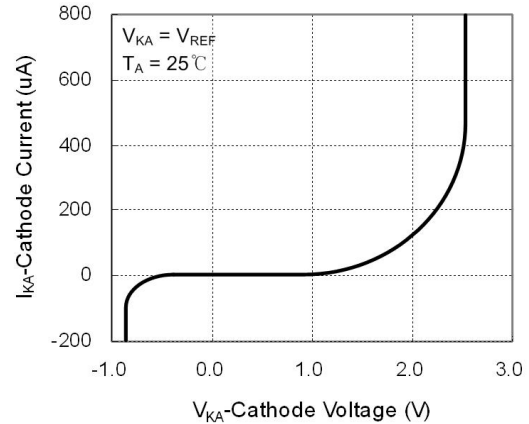
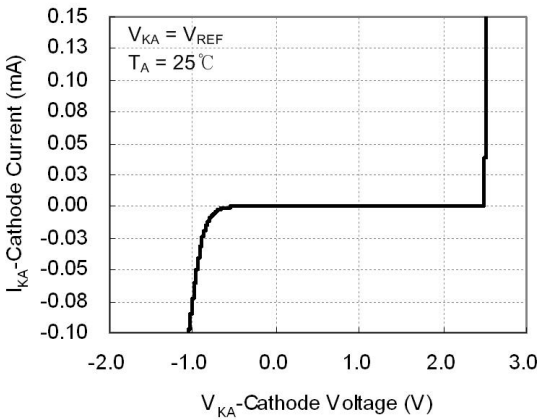
# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

## TYPICAL OPERATING CHARACTERISTICS



Reference Voltage vs. Ambient Temperature

Pulse Response



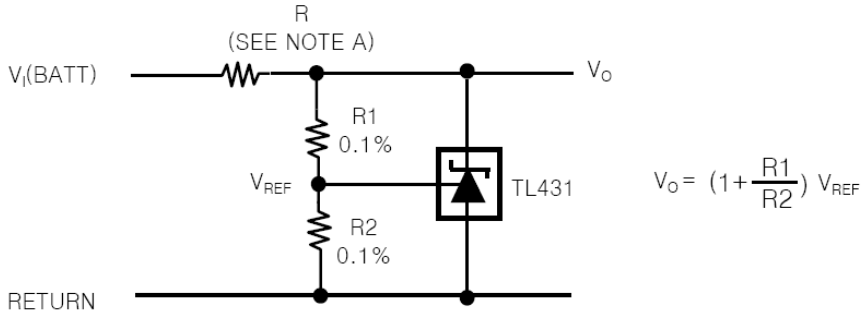
Cathode Current vs. Cathode Voltage

Cathode Current vs. Cathode Voltage

# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

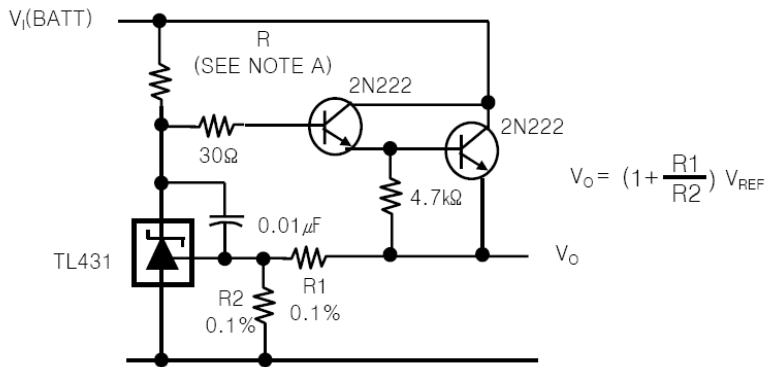
## APPLICATION INFORMATION

### 1. Shunt Regulator



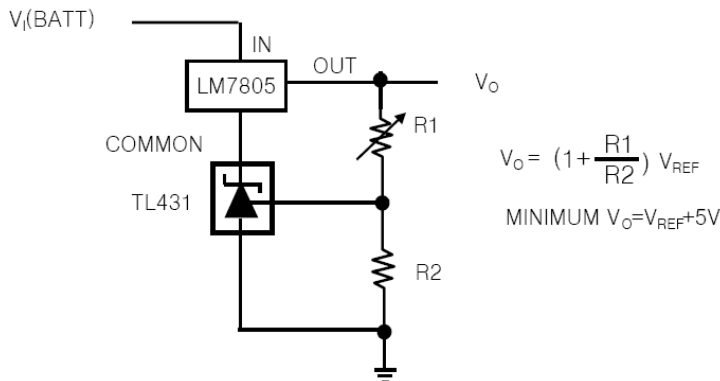
Note A : R Should provide cathode current 1mA to the TL431 at minimum  $V_{i(BATT)}$

### 2. Precision High-Current Series Regulator



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

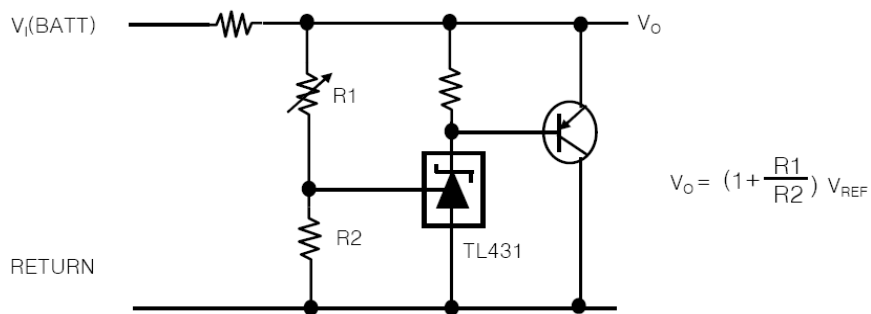
### 3. Output Control of a Three-Terminal Fixed Regulator



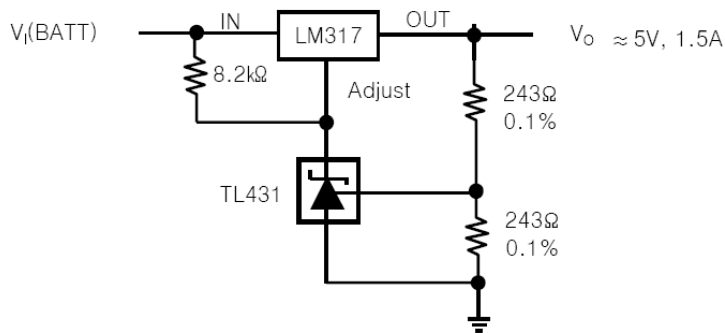


# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

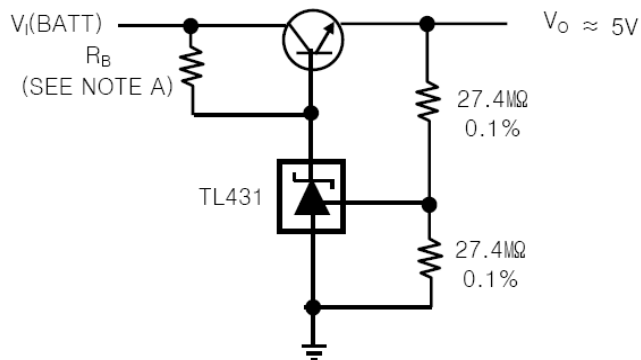
## 4. High-Current Shunt Regulator



## 5. Precision 5-V 1.5A Regulator



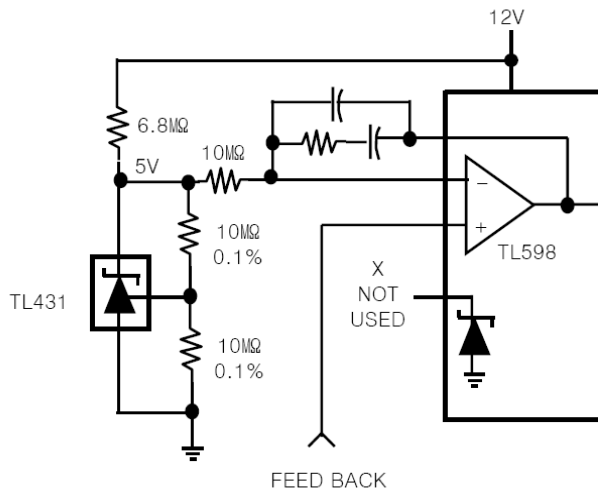
## 6. Efficient 5-V Precision Regulator



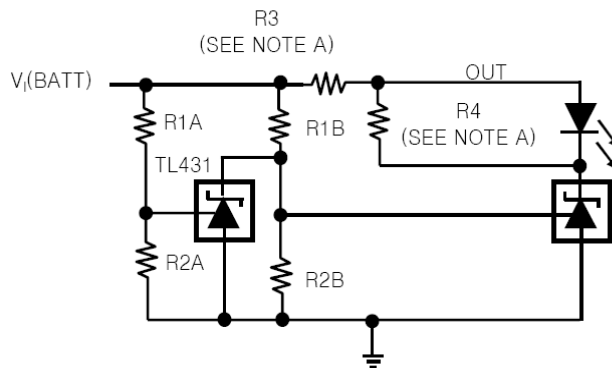
NOTE A :  $R_B$  Should provide cathode current  $\geq 1\text{mA}$  to the TL431.

# PROGRAMMABLE PRECISION SHUNT REGULATOR TL431/A/C

## 7. PWM Converter With Reference



## 8. Voltage Monitor



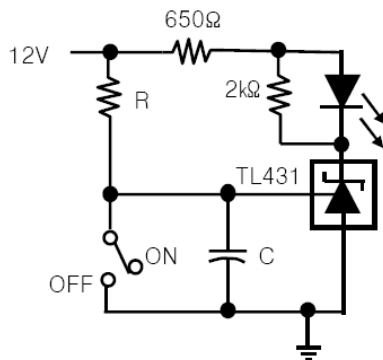
$$\text{LOW LIMIT} = \left(1 + \frac{R1B}{R2B}\right) V_{REF}$$

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

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

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

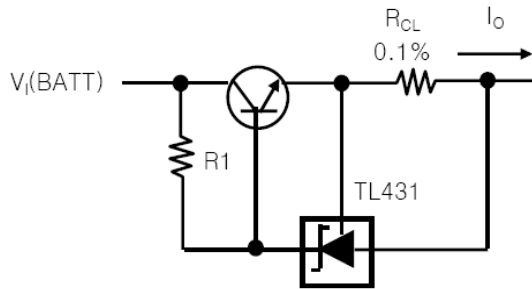
## 9. Delay Timer



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

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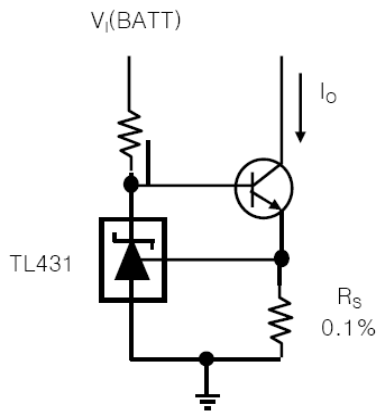
## 10. Precision Current Limiter



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

$$R_1 = \frac{V_I(\text{BATT})}{\frac{I_o}{H_{FE}} + I_{KA}}$$

## 11. Precision Constant-Current Sink



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