

## Shunt Regulator

### General Description

- The LM431 Series ICs are low voltage three-terminal programmable shunt regulators with guaranteed thermal stability over a full operation range. These monolithic ICs voltage reference operate as a low temperature coefficient Zener which is programmable from  $V_{ref}$  to 18V with two external resistors. These devices exhibit a wide operating current range of 80 $\mu$ A to 50/100mA with a typical dynamic impedance of 0.05 to 0.22 $\Omega$ . The characteristics of these references make them excellent replacements for Zener diodes in many applications such as digital voltmeters, power supplies and op amp circuitry
- The LM431L precision reference is offered in three voltage tolerance for  $V_{REF}=1.240V$ : 1.5%, 1.0% and 0.5%.
- These ICs are available in 4 packages: TO-92, SOT-23, SOT-23-5 and SOT-89.



TO-92



SOT-23



SOT-23-5



SOT-89



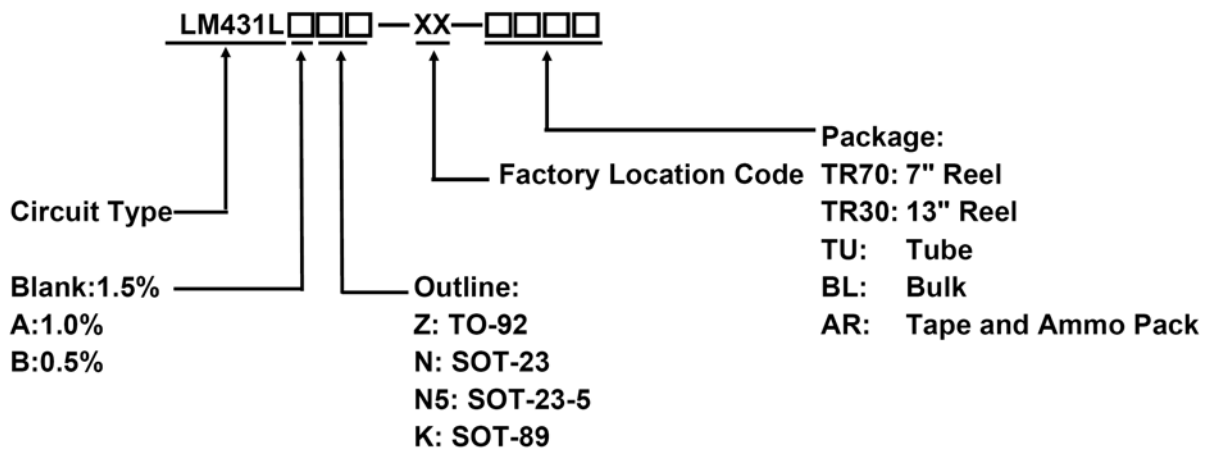
### Features

- Programmable Precise Output Voltage from 1.24V to 16/18V
- High Stability under Capacitive Load
- Low Temperature Deviation
- Low Dynamic Output Impedance: 0.05 to 0.22 $\Omega$  Typical
- Operating Current from 80 $\mu$ A to 50/100mA.
- Low Output Noise Voltage
- RoHS Compliance

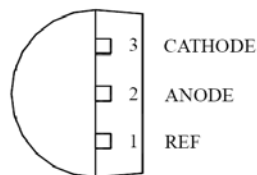
### Applications

- Graphic Card
- PC Motherboard
- Voltage Adapter
- Switching Power Supply
- Charger

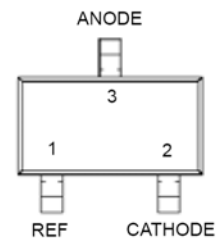
### Ordering Information



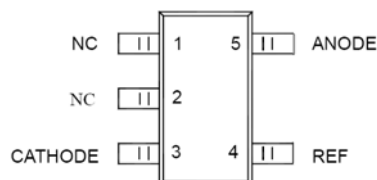
### Pin Configuration



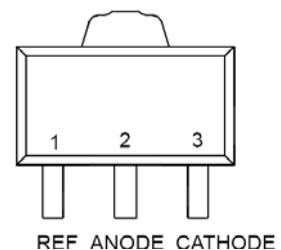
**Outline: Z**  
**TO-92**



**Outline: N**  
**SOT-23**



**Outline: N5**  
**SOT-23-5**

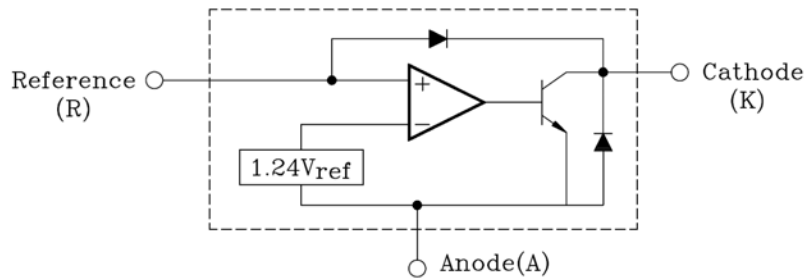


**Outline: K**  
**SOT-89**

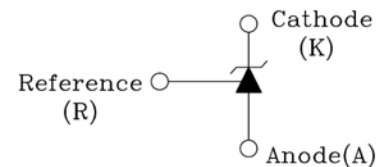
# Shunt Regulator

## LM431L

### Block Diagram



### Symbols



### Absolute Maximum Ratings (Ta=25° C)

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

Symbol	Description	LM431L	LM431LA	LM431LB	Unit
V <sub>KA</sub>	Cathode Voltage	16	18		V
I <sub>KA</sub>	Cathode Current Range (Continuous)	50	-100 ~ +100		mA
I <sub>REF</sub>	Reference Input Current Range (Continuous)	3	10		mA
T <sub>J</sub>	Operating Junction Temperature	150			° C
T <sub>OPR</sub>	Operating Temperature Range	-40 ~ 85	-40 ~ 125		° C
T <sub>STG</sub>	Storage Temperature Range	-65 ~ 150			° C
P <sub>D</sub>	Power Dissipation	Z:TO-92	700	770	mW
		N:SOT-23	350	370	
		N5:SOT-23-5	550	370	
		K: SOT-89	-	770	
R <sub>thJA</sub>	Package Thermal Impedance	Z:TO-92	180	150	° C/W
		N:SOT-23	360	330	
		N5:SOT-23-5	230	250	
		K: SOT-89	-	50	

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

Symbol	Description	LM431L			LM431LA			LM431LB			Unit	Test Circuit	Conditions	
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.				
$V_{REF}$	Reference Input Voltage	1.222	1.240	1.258	1.228	1.240	1.252	1.234	1.240	1.246	V	Fig.1	$V_{KA}=V_{REF}, I_{KA}=10\text{mA}$	
$\Delta V_{REF}$	Reference Input Voltage Deviation	0-70 °C	-	-	-	-	2	1-	-	2	10	mV	Fig.1 (Note1)	$V_{KA}=V_{REF}, I_{KA}=10\text{mA}$
		-40-85 °C	-	7.0	20	-	3	10	-	3	10			
		-40-125 °C	-	-	-	-	4	15	-	4	15			
$\Delta V_{REF}/\Delta V_{KA}$	Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage	-	-0.6	-1.5	-	-0.5	-1.5	-	-0.5	-1.5	mV/V	Fig.2	$I_{KA}=10\text{mA}$ $\Delta V_{KA}=V_{KA(max)}-V_{REF}$	
$I_{REF}$	Reference Input Current	$T_A=25^\circ\text{C}$	-	0.15	0.3	-	0.15	0.4	-	0.15	0.4	$\mu\text{A}$	Fig.2	$I_{KA}=10\text{mA}, R_1=10\text{K}\Omega, R_2=\infty$
$\Delta I_{REF}$	Reference Input Current Deviation Over Temperature Range	-	0.05	0.08	-	0.1	0.4	-	0.1	0.4	$\mu\text{A}$	Fig.2	$I_{KA}=10\text{mA}, R_1=10\text{K}\Omega, R_2=\infty$	
$I_{MIN}$	Min. Cathode Current For Regulation	-	55	80	-	55	80	-	55	80	$\mu\text{A}$	Fig.1	$V_{KA}=V_{REF}$	
$I_{OFF}$	Off-State Cathode Current	-	2.6	1000	-	40	100	-	40	100	nA	Fig.3	$V_{KA}=V_{KA(max)}, V_{REF}=0\text{V}$	
		-	-	-	-	10	50	-	10	50			$V_{KA}=6\text{V}, V_{REF}=0\text{V}$	
$Z_{KA}$	Dynamic Impedance	-	0.22	0.4	-	0.05	0.15	-	0.05	0.15	$\Omega$	Fig.1 (Note2)	$V_{KA}=V_{REF}, I_{KA}=1.0\text{mA} \sim I_{KA(max)}, f \leq 1.0\text{KHz}$	

Fig.1- Test Circuit for  $V_{KA}=V_{REF}$

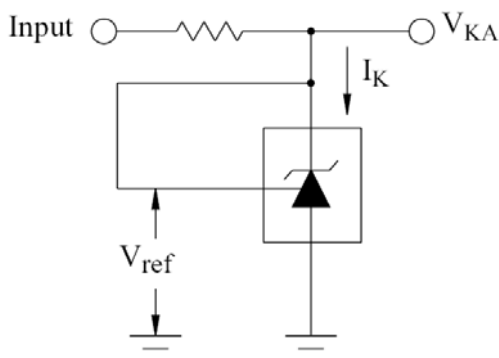
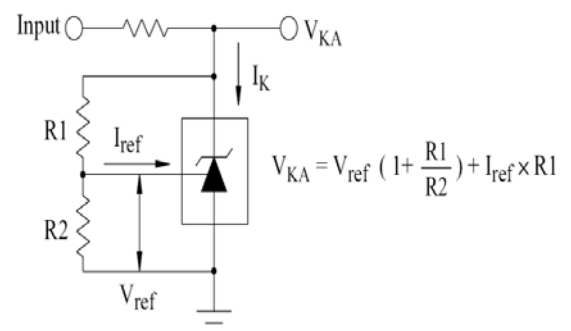
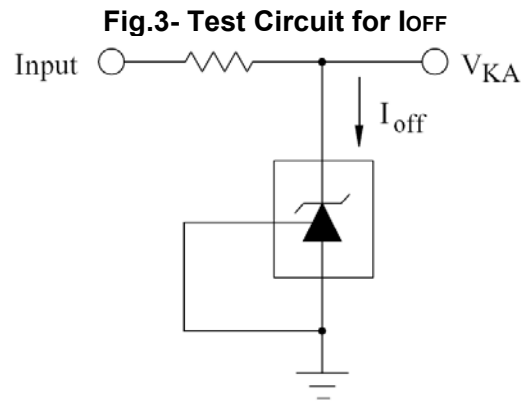


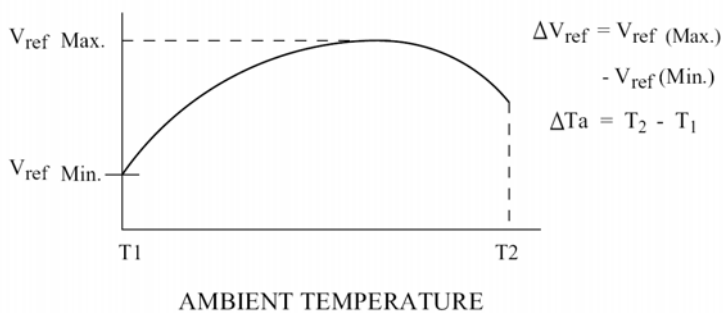
Fig.2- Test Circuit for  $V_{KA}>V_{REF}$





### Note1:

The deviation parameter  $\Delta V_{ref}$  is defined as the differences between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



The average temperature coefficient of the Reference input voltage,  $\alpha V_{ref}$ , is defined as:

$$\alpha V_{ref} \left( \frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left( \frac{\Delta V_{ref}}{V_{ref} \text{ at } 25^{\circ}\text{C}} \right) \times 10^6}{\Delta T_a}$$

$$= \frac{\Delta V_{ref} \times 10^6}{\Delta T_a (V_{ref} \text{ at } 25^{\circ}\text{C})}$$

$\alpha V_{ref}$  can be positive or negative depending on whether  $V_{ref} \text{ Min.}$  or  $V_{ref} \text{ Max.}$  occurs at the lower ambient temperature.

### Note2:

The dynamic impedance  $Z_{ka}$  is defined as:

$$|Z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_k}$$

When the device is programmed with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is defined as:

$$|Z_{ka'}| = |Z_{ka}| \left( 1 + \frac{R1}{R2} \right)$$

### Typical Characteristics Curves

Fig.4- VREF - TJ

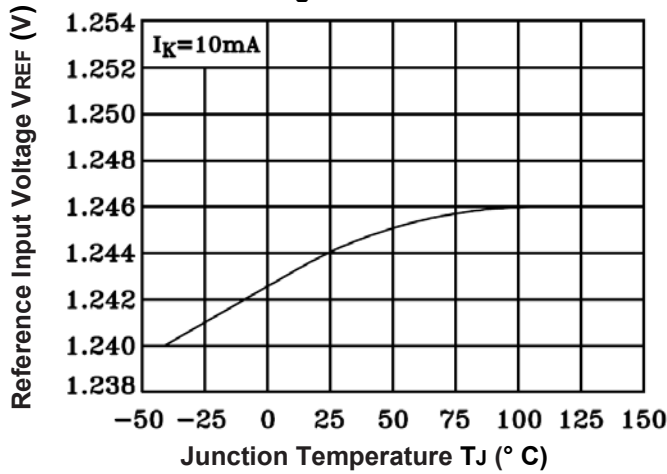


Fig.5- IREF - TJ

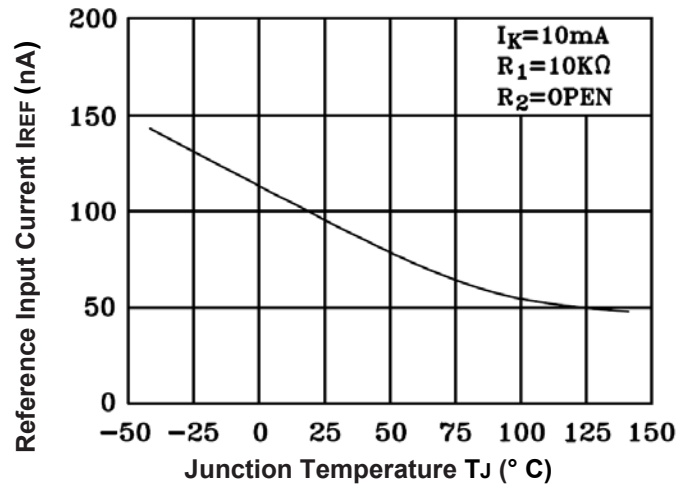


Fig.6-  $I_K - V_{KA}$  (1)

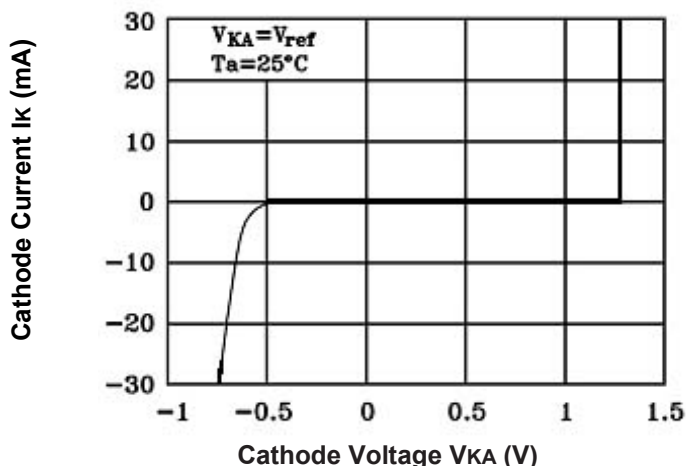
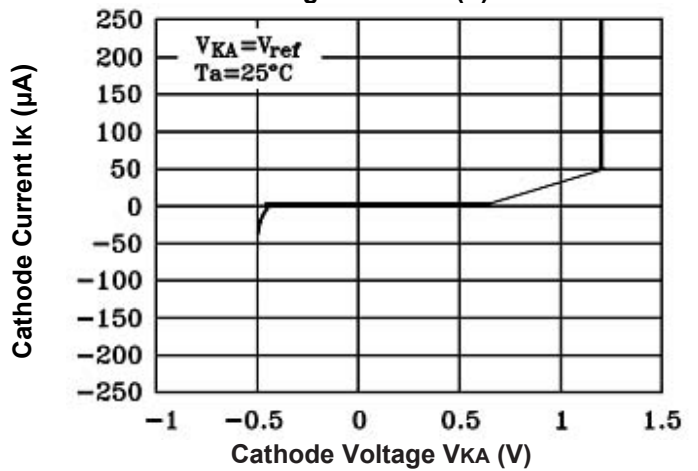


Fig.7-  $I_K - V_{KA}$  (2)



# Shunt Regulator

## LM431L

Fig.8- Gvo - f

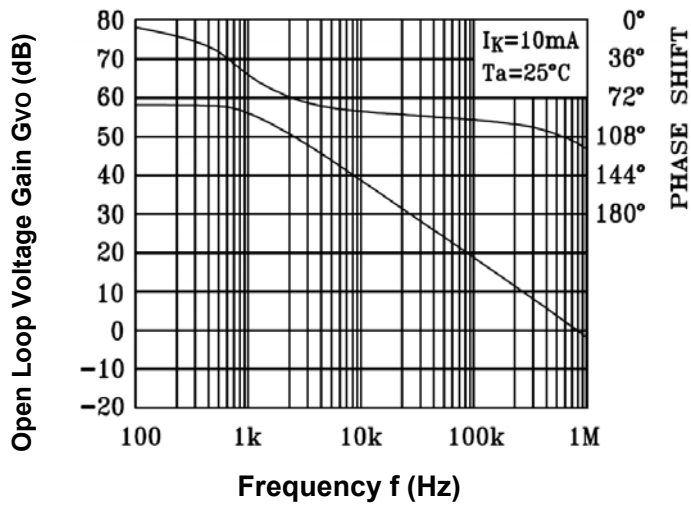


Fig.9- Pulse Response

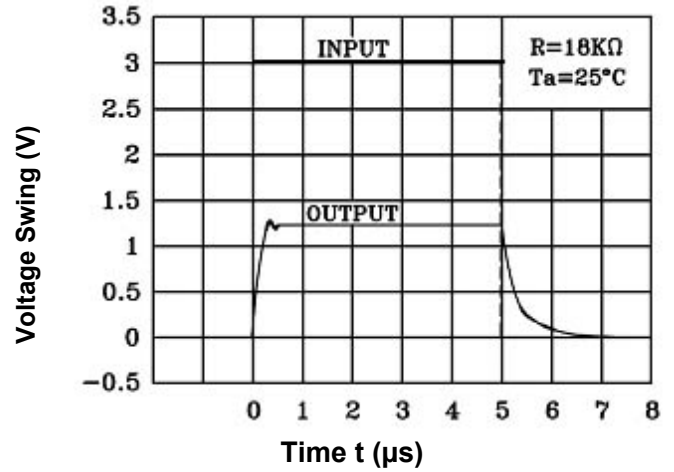


Fig.10-  $\Delta V_{REF} - T_J$

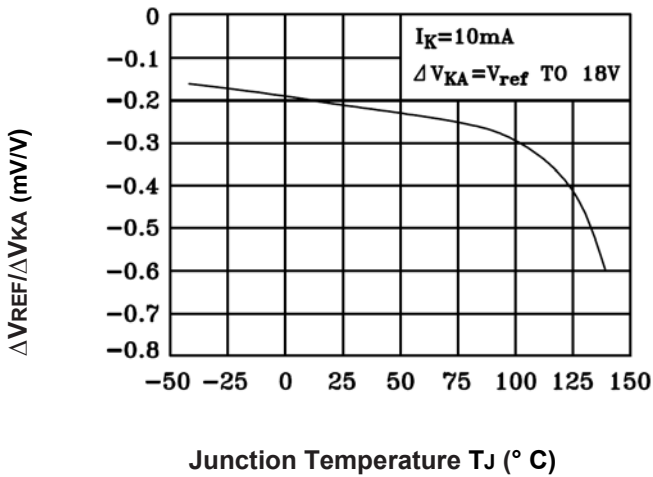
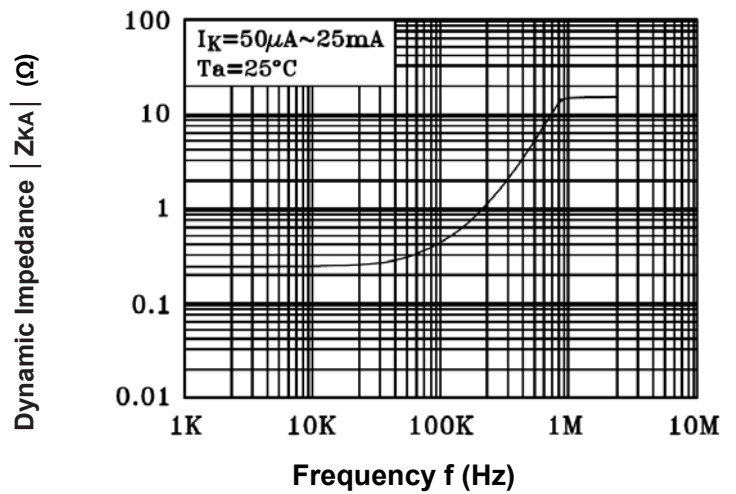
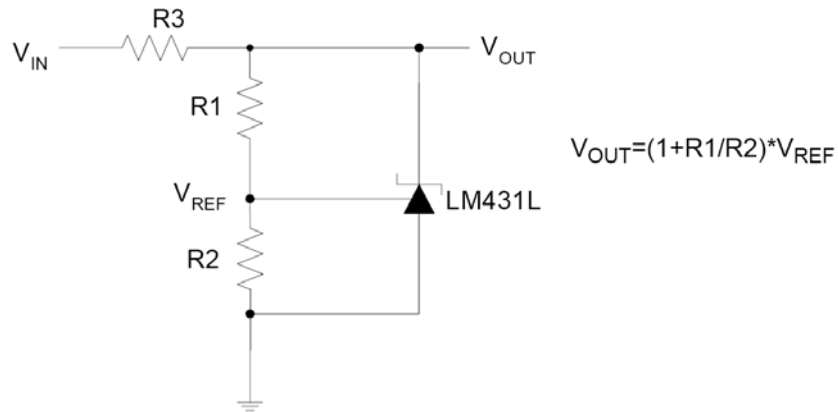


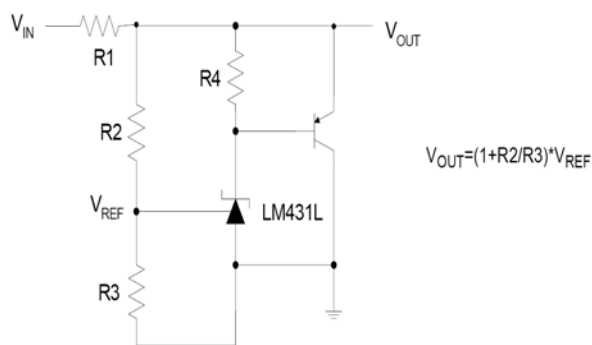
Fig.11-  $Z_{KA} - f$



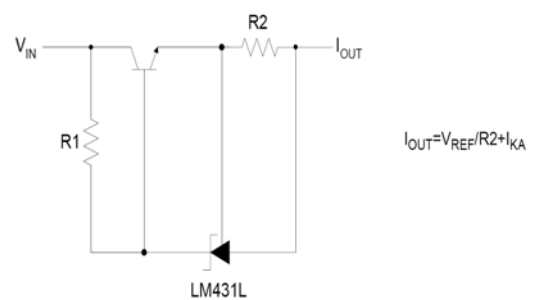
### Typical Application



**Fig.12-Shunt Regulator**



**Fig.13- High Current Shunt Regulator**



**Fig.14- Current Source of Current Limit**



### Typical Application (Continued)

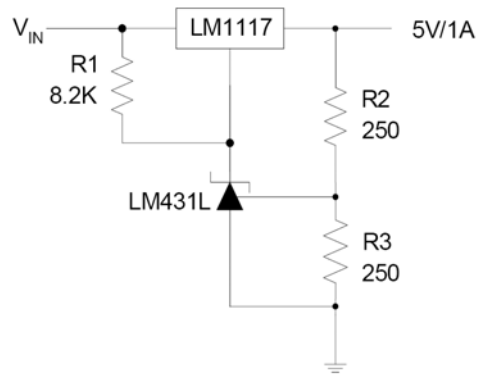


Fig.15- Precision 5V 1A Regulator

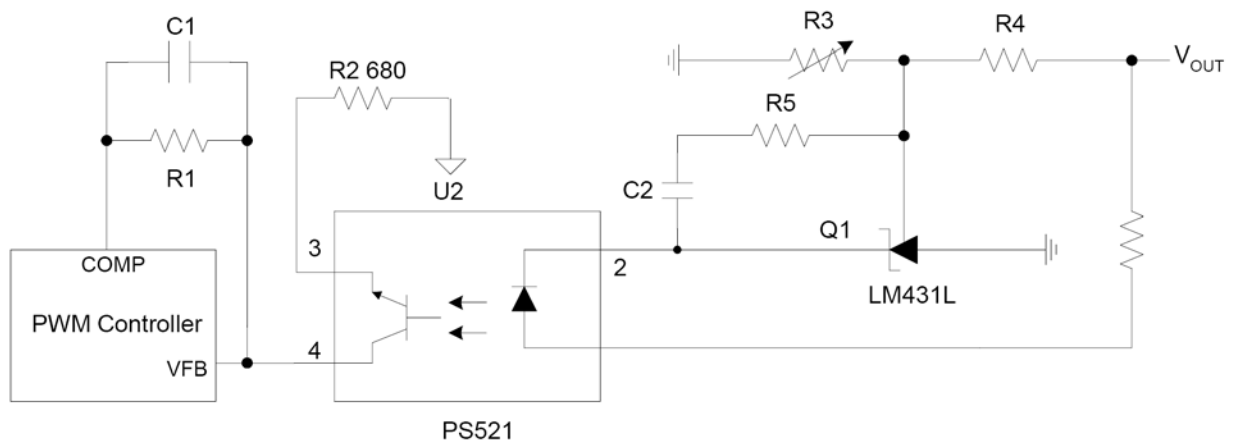
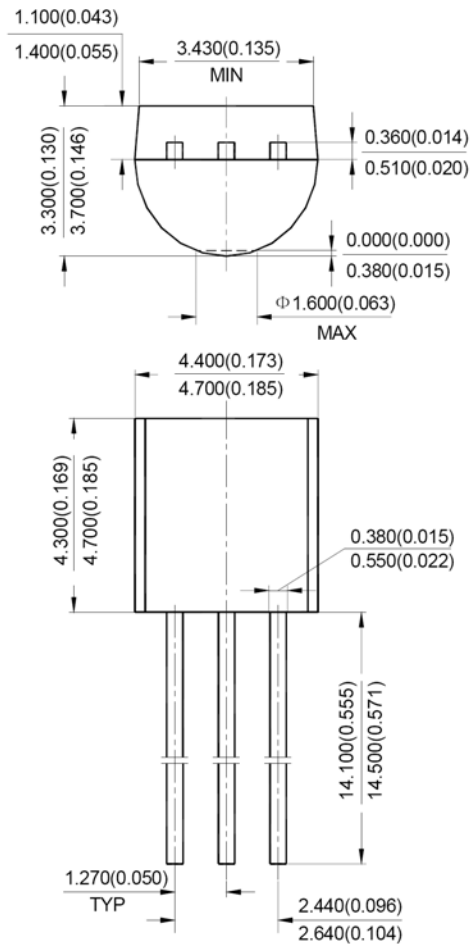


Fig.16- PWM Converter with Reference

### Device Marking Code

Circuit	Tolerance		SOT-23 (N)	SOT-23-5 (N5)	SOT-89 (K)
	LM431L	Blank	1.5%	24A	24A
A		1.0%	EA7	E6A	E41B
B		0.5%	EA6	E5A	E41A

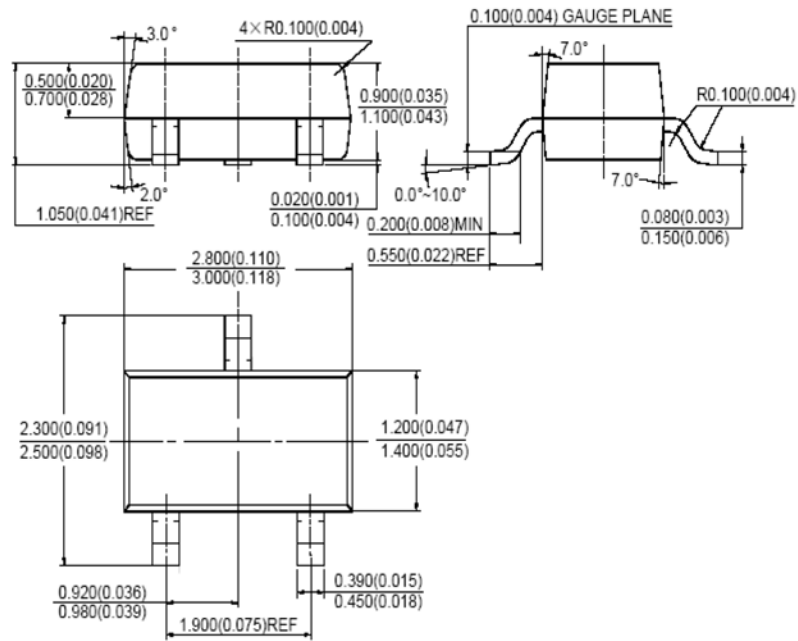
### Dimensions in inches (mm)



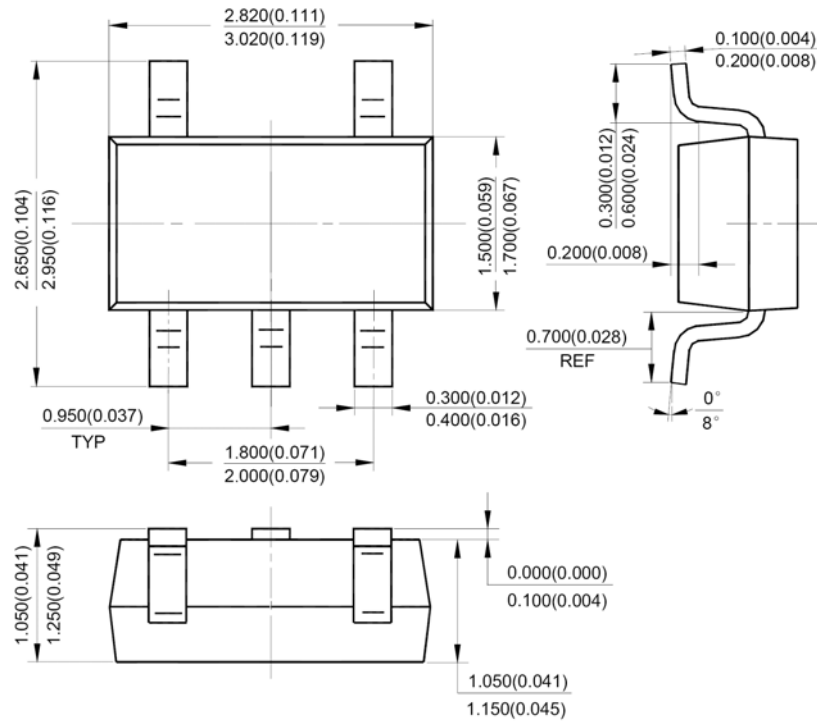
TO-92

# Shunt Regulator

## LM431L



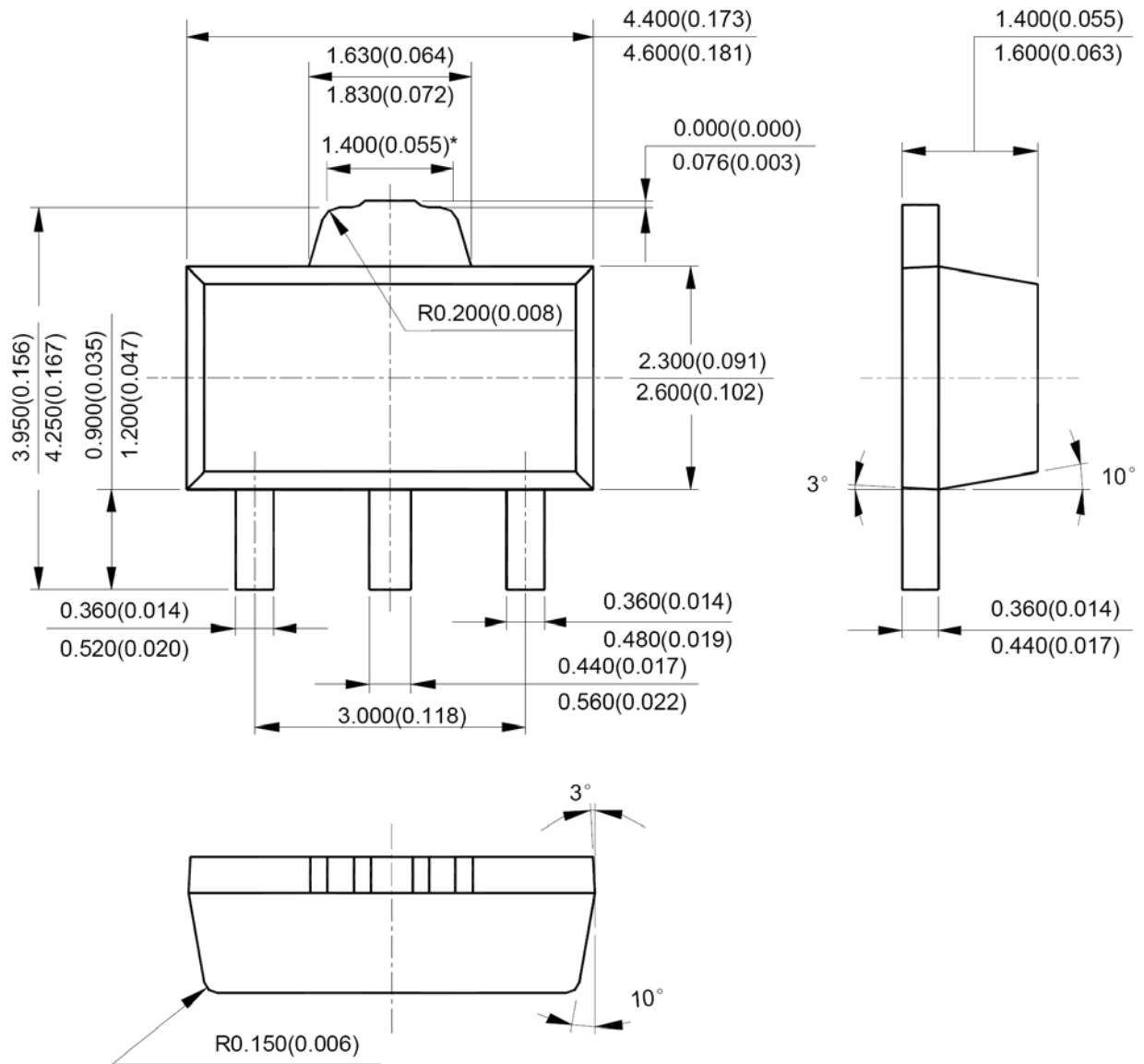
**SOT-23**



**SOT-23-5**

# Shunt Regulator

## LM431L



SOT-89

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