

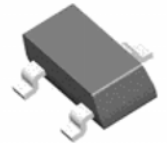
Shunt Regulator

General Description

- The LM431 Series ICs are 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 36V with two external resistors. These devices exhibit a wide operating current range of 1.0 to 100mA with a typical dynamic impedance of 0.15 to 0.22 Ω . 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 2.5V reference makes it convenient to obtain a stable reference from 5.0V logic supplies, and since the LM431 series operates as a shunt regulator, it can be used as either a positive or negative voltage reference.
- The output voltage of both types can be set to any value between V_{REF} (2.5V) and the corresponding maximum cathode voltage.



TO-92



SOT-23



SOT-23-5



SOP-8



SOT-89



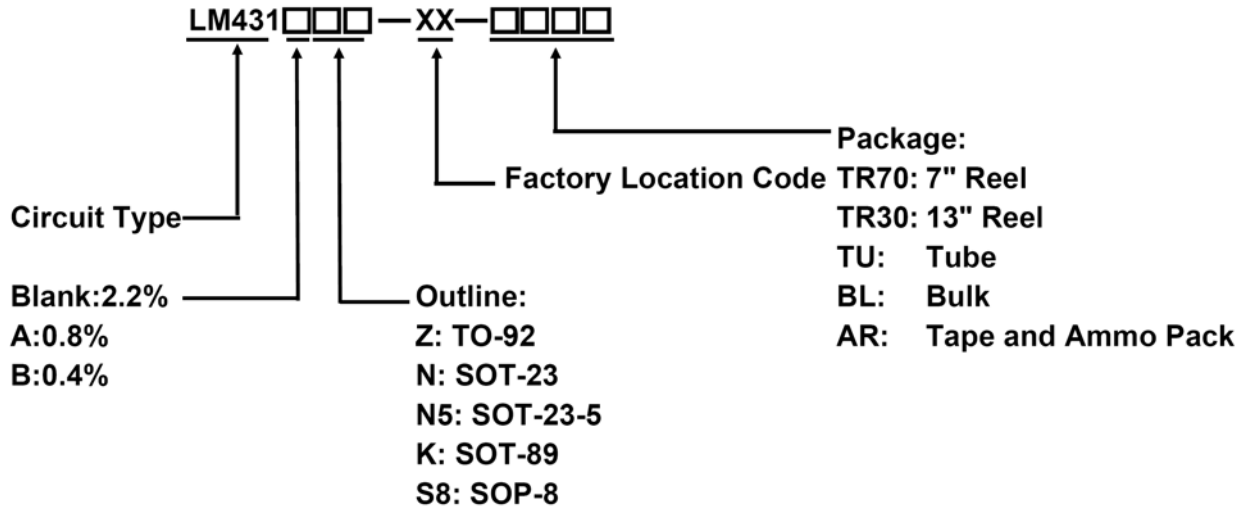
Features

- Programmable Precise Output Voltage from 2.5V to 36V
- High Stability under Capacitive Load
- Low Temperature Deviation
- Can be used in either positive or negative Voltage reference
- Low Dynamic Output Impedance: 0.15 to 0.22 Ω Typical
- Operating Current from 1.0mA to 100mA
- Low Output Noise Voltage
- RoHS Compliance

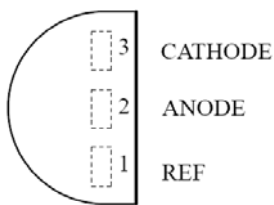
Applications

- Charger
- Voltage Adapter
- Switching Power Supply
- Graphic Card
- Precision Voltage Reference

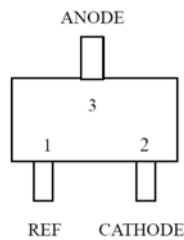
Ordering Information



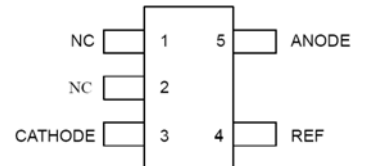
Pin Configuration



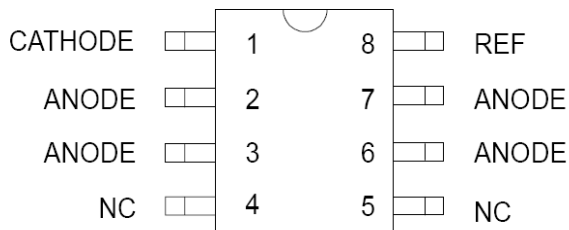
Outline: Z
TO-92



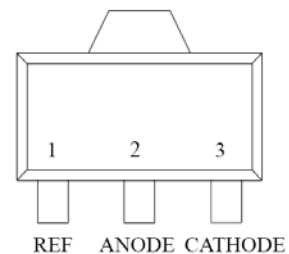
Outline: N
SOT-23



Outline: N5
SOT-23-5



Outline: S8
SOP-8

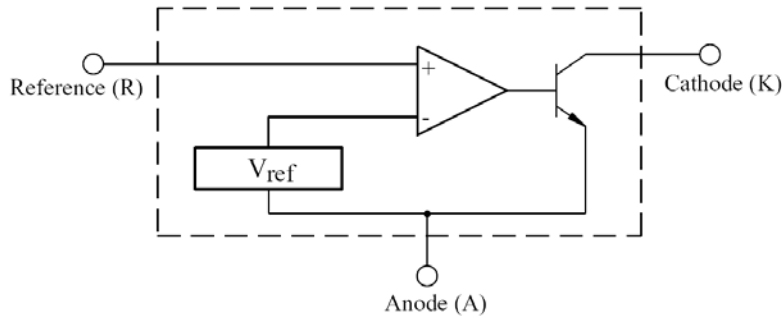


Outline: K
SOT-89

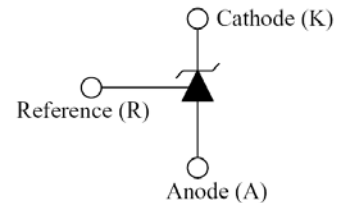
Shunt Regulator

LM431

Block Diagram



Symbols



Absolute Maximum Ratings (Ta=25° C)

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

| Symbol | Description | LM431 | LM431A | LM431B | Unit |
|-------------------|--|-------------|-----------|--------|-------|
| V _{KA} | Cathode Voltage | 36 | | | V |
| I _{KA} | Cathode Current Range (Continuous) | -100 ~ 150 | | | mA |
| I _{REF} | Reference Input Current Range (Continuous) | -0.05 ~ 10 | | | mA |
| T _J | Operating Junction Temperature | 150 | | | ° C |
| T _{OPR} | Operating Temperature Range | -40 ~ 85 | -40 ~ 125 | | ° C |
| T _{STG} | Storage Temperature Range | -65 ~ 150 | | | ° C |
| P _D | Power Dissipation | Z:TO-92 | 700 | 770 | mW |
| | | N:SOT-23 | - | 370 | |
| | | N5:SOT-23-5 | - | 370 | |
| | | K: SOT-89 | 800 | 770 | |
| | | S8: SOP-8 | - | 770 | |
| R _{thJA} | Package Thermal Impedance | Z:TO-92 | 180 | 150 | ° C/W |
| | | N:SOT-23 | - | 330 | |
| | | N5:SOT-23-5 | - | 250 | |
| | | K: SOT-89 | 160 | 50 | |
| | | S8: SOP-8 | - | 150 | |

Shunt Regulator

LM431

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

| Symbol | Description | | LM431 | | | LM431A | | | LM431B | | | Unit | Test Circuit | Conditions | |
|--------------------------------|--|------------------------|-------|-------|-------|--------|-------|-------|--------|-------|-------|---------------|---------------|---|--|
| | | | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | | | | |
| V_{REF} | Reference Input Voltage | | 2.440 | 2.495 | 2.550 | 2.480 | 2.500 | 2.520 | 2.490 | 2.500 | 2.510 | V | Fig.1 | $V_{KA}=V_{REF}, I_{KA}=10\text{mA}$ | |
| ΔV_{REF} | Reference Input Voltage Deviation | 0-70° C | - | - | - | - | 4.8 | 8 | - | 4.5 | 8 | mV | Fig.1 (Note1) | $V_{KA}=V_{REF}, I_{KA}=10\text{mA}$ | |
| | | -40-85° C | - | 7.0 | 30 | - | 4.5 | 10 | - | 4.5 | 10 | | | | |
| $\Delta V_{REF}/\Delta V_{KA}$ | Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage | | - | -1.4 | -2.7 | - | -1.0 | -2.7 | - | -1.0 | -2.7 | mV/V | Fig.2 | $I_{KA}=10\text{mA}$ | $\Delta V_{KA}=10\text{V} \sim V_{REF}$ |
| | | | - | -1.0 | -2.0 | - | -0.5 | -2.0 | - | -0.5 | -2.0 | | | | $\Delta V_{KA}=36\text{V} \sim 10\text{V}$ |
| I_{REF} | Reference Input Current | $T_A=25^\circ\text{C}$ | - | 1.8 | 4.0 | - | 0.7 | 4.0 | - | 0.7 | 4.0 | μA | Fig.2 | $I_{KA}=10\text{mA}, R_1=10\text{K}\Omega, R_2=\infty$ | |
| | | $T_A=T_{opr}$ | - | - | 6.5 | - | - | - | - | - | - | | | | |
| ΔI_{REF} | Reference Input Current Deviation | | - | 0.8 | 2.5 | - | 0.4 | 1.2 | - | 0.4 | 1.2 | μA | Fig.2 | $I_{KA}=10\text{mA}, R_1=10\text{K}\Omega, R_2=\infty, -40 \sim 85^\circ\text{C}$ | |
| I_{MIN} | Min. Cathode Current For Regulation | | - | 0.5 | 1.0 | - | 0.4 | 1.0 | - | 0.4 | 1.0 | mA | Fig.1 | $V_{KA}=V_{REF}$ | |
| I_{OFF} | Off-State Cathode Current | | - | 2.6 | 1000 | - | 50 | 1000 | - | 50 | 1000 | nA | Fig.3 | $V_{KA}=36\text{V}, V_{REF}=0\text{V}$ | |
| Z_{KA} | Dynamic Impedance | | - | 0.22 | - | - | 0.15 | 0.5 | - | 0.15 | 0.5 | Ω | Fig.1 (Note2) | $V_{KA}=V_{REF}, I_{KA}=1.0 \sim 100\text{mA}, f \leq 1.0\text{KHz}$ | |

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

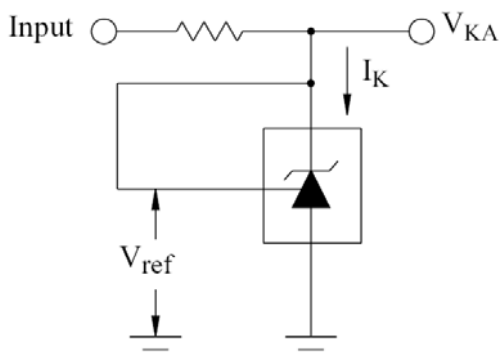
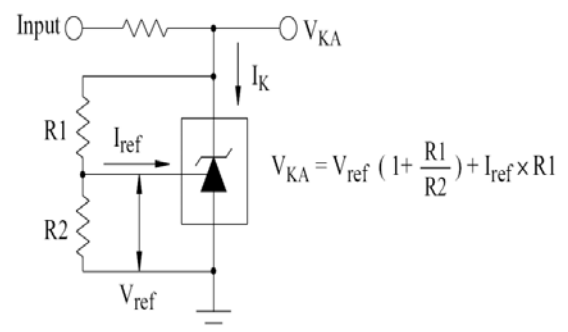
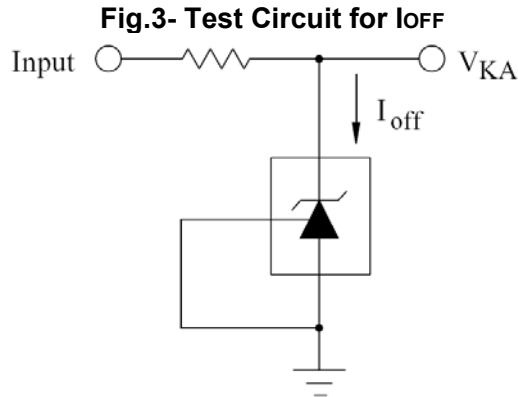


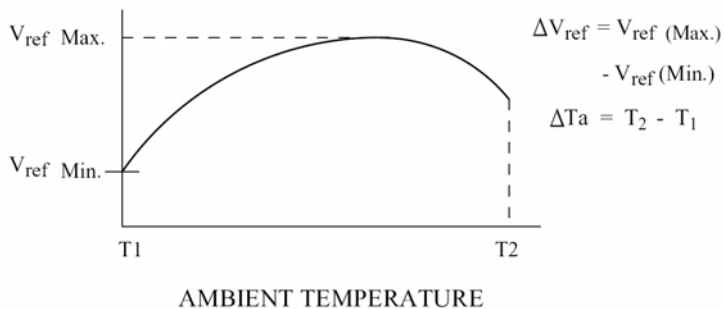
Fig.2- Test Circuit for $V_{KA}>V_{REF}$





Note1:

The deviation parameter ΔV_{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, αV_{ref} , is defined as:

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

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

αV_{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- $I_K - V_{KA}$

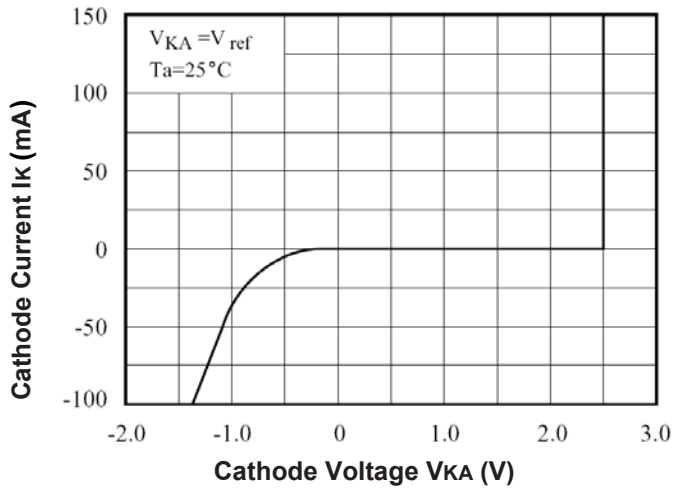


Fig.5- $I_K - V_{KA}$

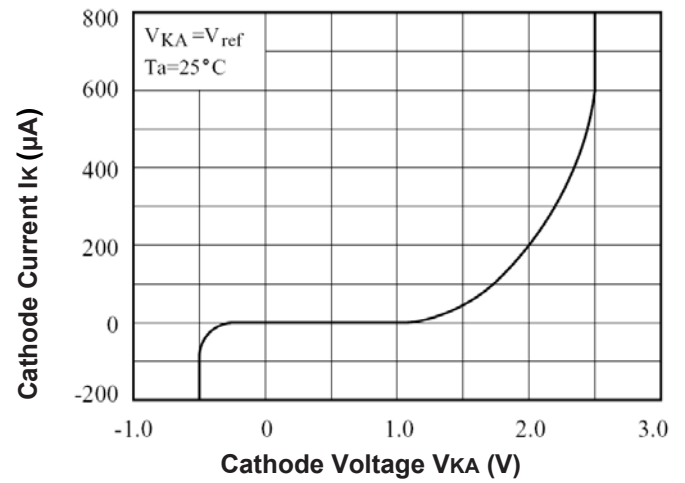


Fig.6- $\Delta V_{REF} - V_{KA}$

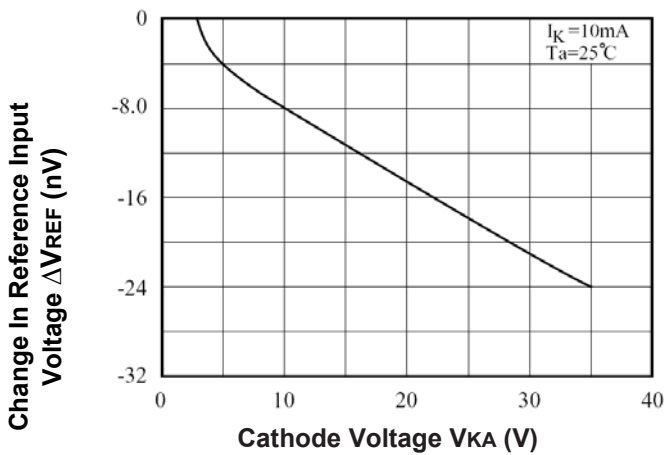


Fig.7- $|Z_{KA}| - f$

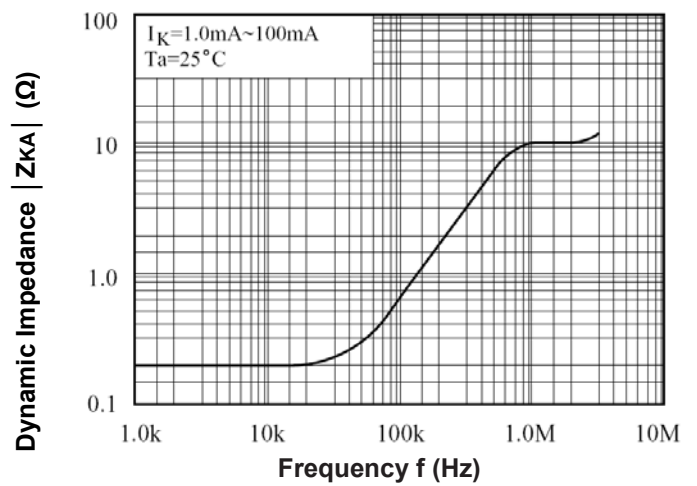


Fig.8- Gvo - f

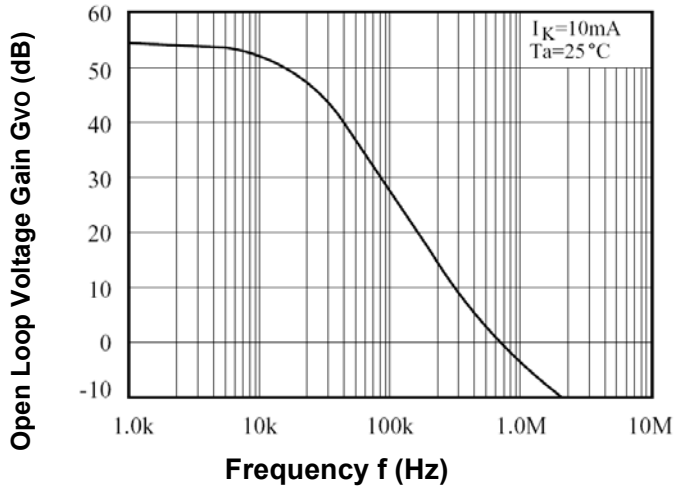


Fig.9- Pulse Response

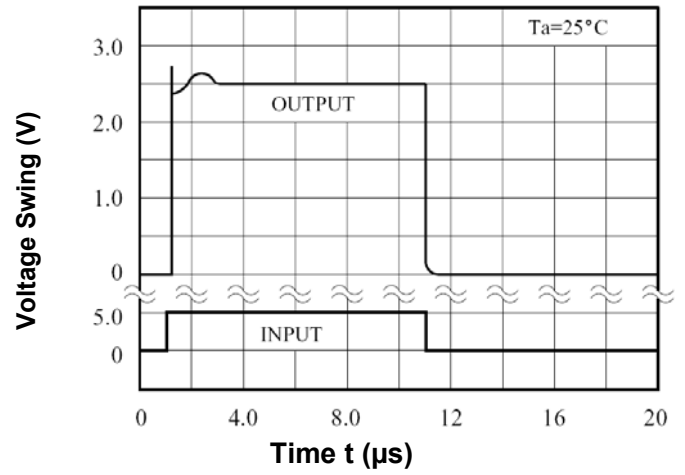
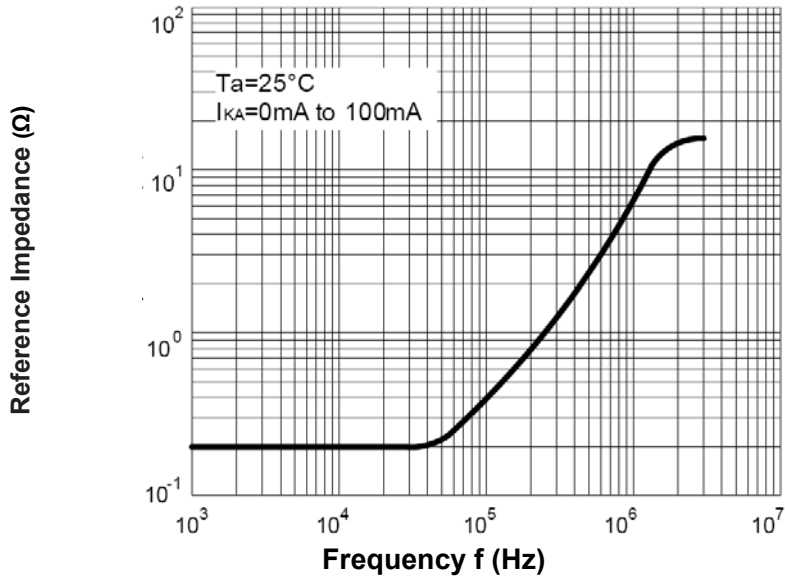


Fig.10- Dynamic Impedance vs. Frequency



Typical Application

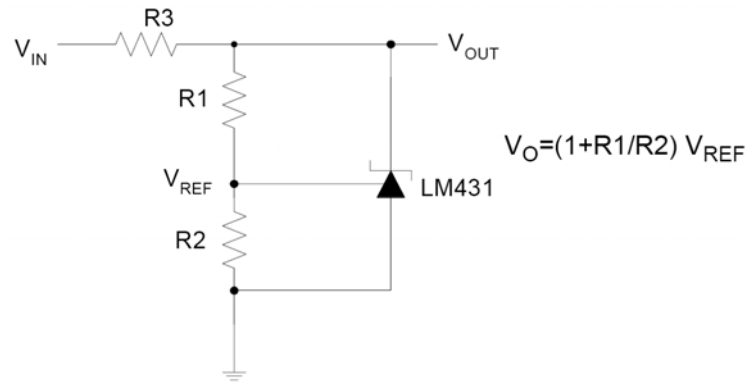


Fig.11-Shunt Regulator

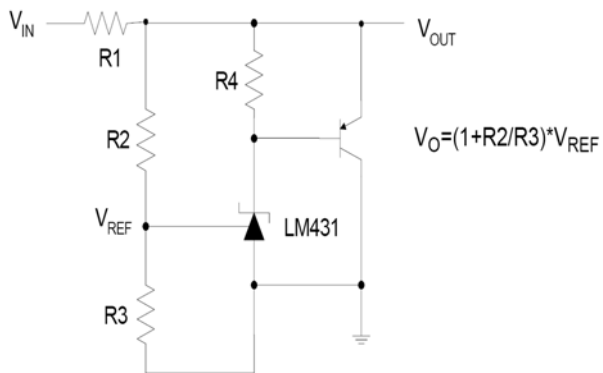


Fig.12- High Current Shunt Regulator

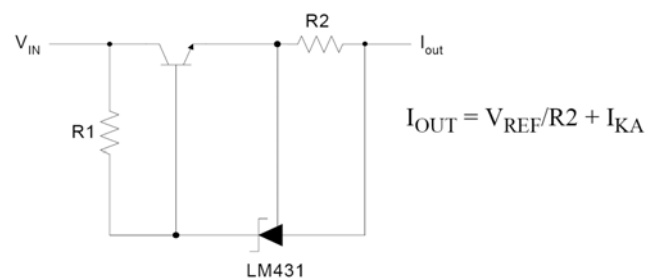


Fig.13- Current Source of Current Limit

Typical Application (Continued)

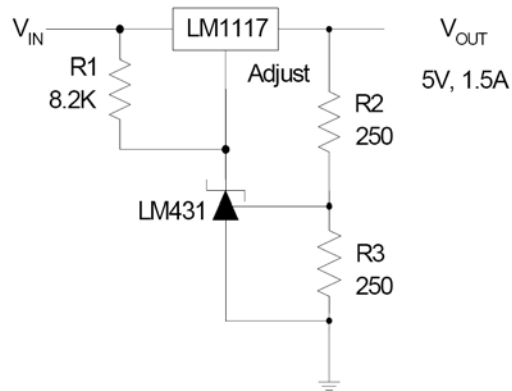


Fig.14- Precision 5V 1.5A Regulator

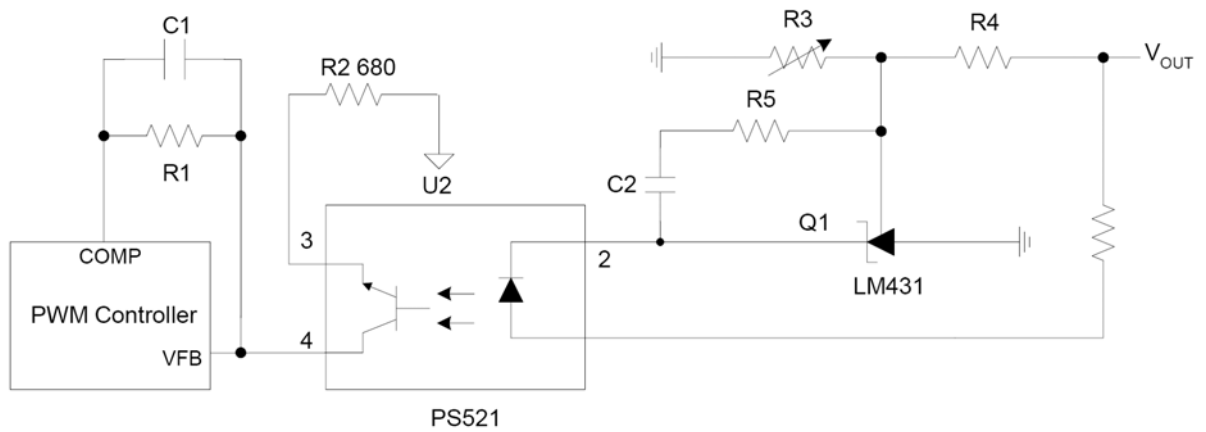
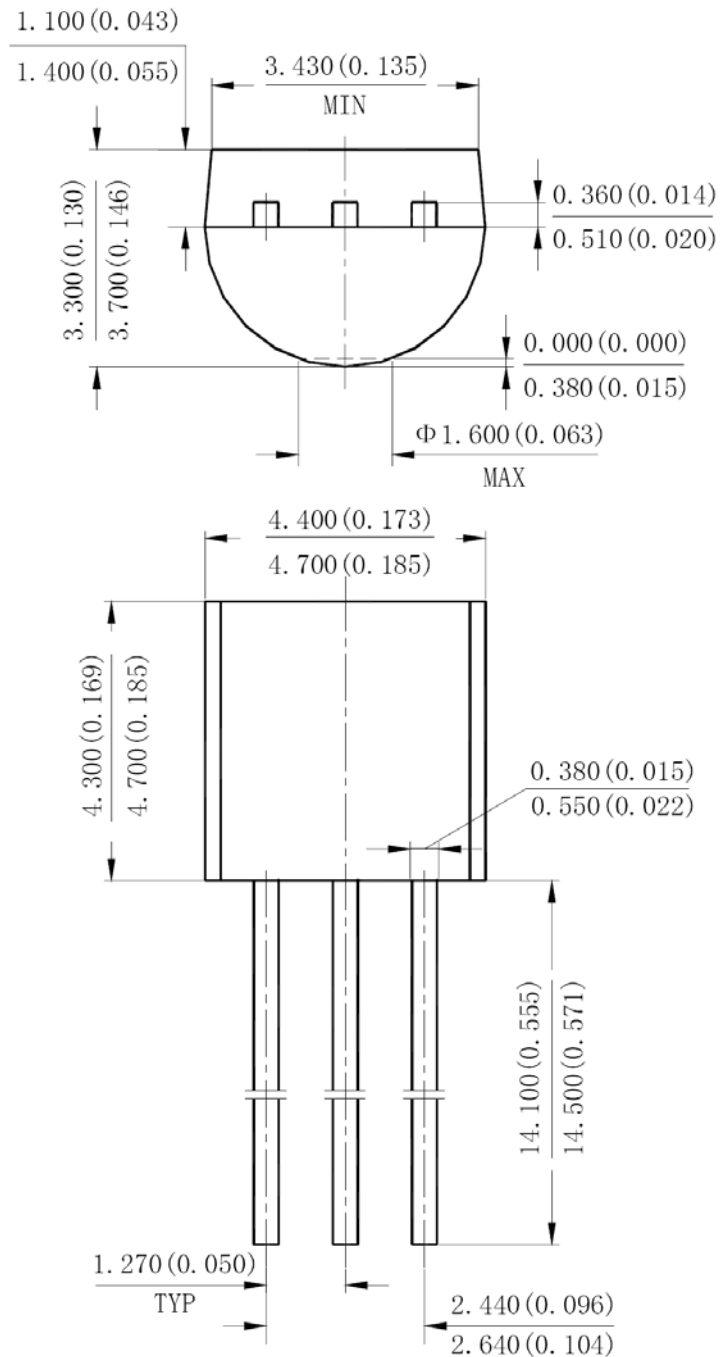


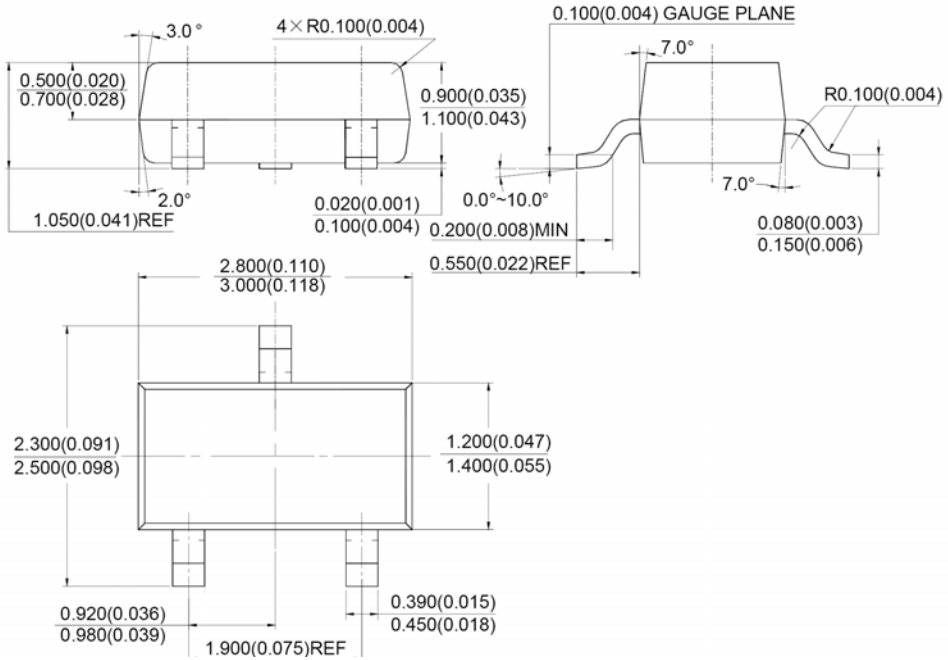
Fig.15- PWM Converter with Reference



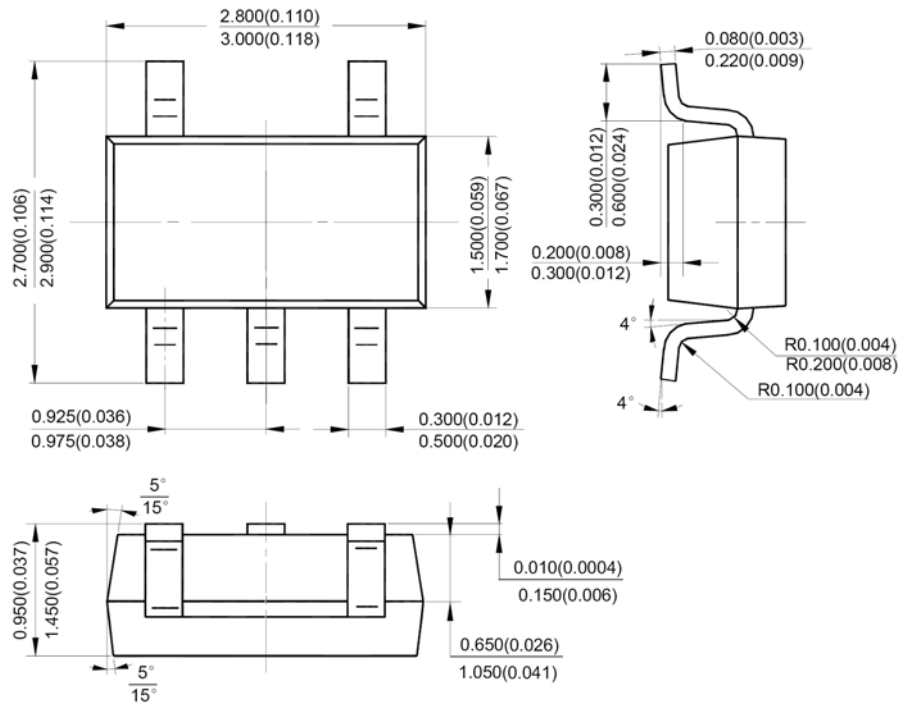
TO-92

Shunt Regulator

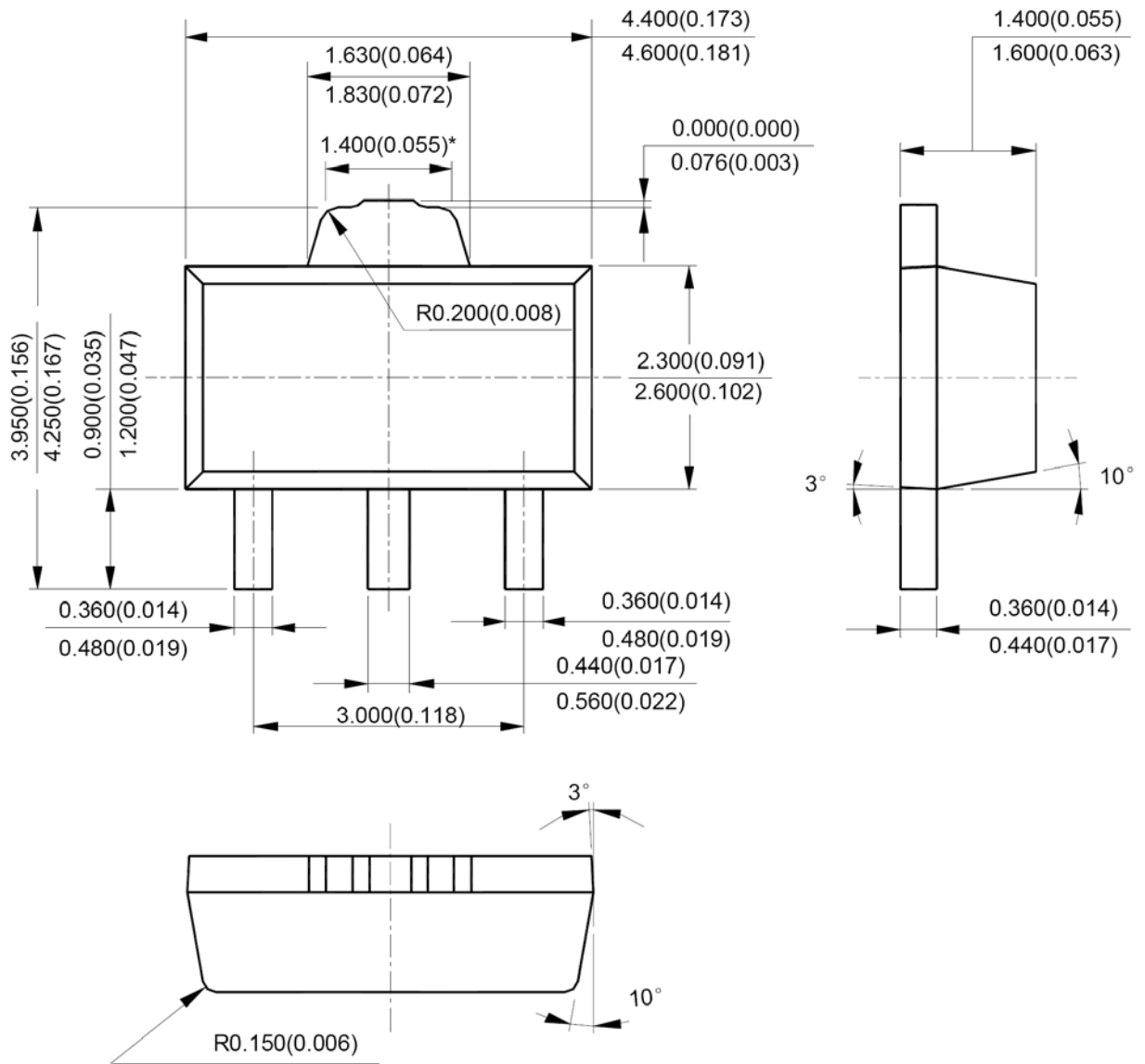
LM431



SOT-23



SOT-23-5



SOT-89

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