## 1. DESCRIPTION

The XB431 is precision 1.24 V shunt regulators capable of adjustment to 30 V. Negative feedback from the cathode to the adjust pin controls the cathode voltage, much like a non-inverting op amp configuration (Refer to Symbol and Functional Diagrams). A two-resistor voltage divider terminated at the adjust pin controls the gain of a 1.24 V band-gap reference. Shorting the cathode to the adjust pin (voltage follower) provides a cathode voltage of a 1.24 V.

The XB431 have respective initial tolerances of 1.5%, and functionally lend themselves to several applicationsthat require zener diode type performance at low voltages. Applications include a 3 V to 2.7 V low drop-out regulator, an error amplifier in a 3 V off-line switching regulator and even as a voltage detector. These parts are typically stable with capacitive loads greater than 10 nF and less than 50 pF.

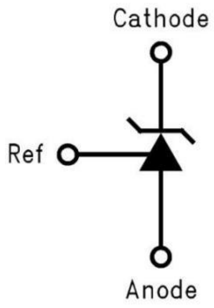
## 2. FEATURES

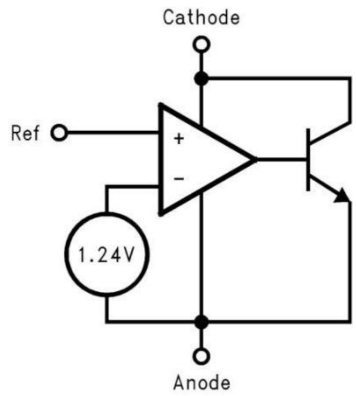
- Low-Voltage Operation/Wide Adjust Range (1.24 V/30 V)
- Temperature Compensated for Industrial
- Low Operation Current (55 µA)
- Low Output Impedance (0.25 Ω)
- Fast Turn-On Response

## 3. APPLICATIONS

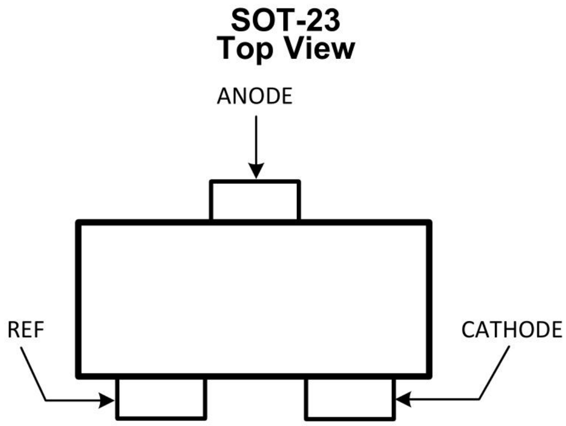
- Shunt Regulator
- Series Regulator
- Current Source or Sink
- Voltage Monitor
- Error Amplifier
- 3-V Off-Line Switching Regulator
- Low Dropout N-Channel Series Regulator

## 4. SYMBOL AND FUNCTIONAL DIAGRAMS




## 5. PIN CONFIGURATIONS AND FUNCTIONS



# 6. SPECIFICATIONS

## 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Operating temperature | Commercial (XB431) | 0 | 70 | °C |
| Lead temperature | SOT-23 -5,-3 Package (Soldering, 10 sec.) | | 265 | |
| Internal power dissipation(2) | SOT-23-5, -3 Package | | 0.28 | W |
| Cathode voltage | | | 35 | V |
| Continuous cathode current | | −30 | 30 | mA |
| Reference input current | | −.05 | 3 | |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Ratings apply to ambient temperature at 25°C. Above this temperature, derate the SOT-23-3at 2.2 mW/°C. See derating curve in Operating Condition section.

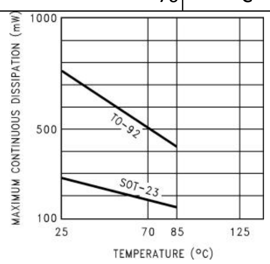
## 6.2 Handling Ratings

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $T_{stg}$ | Storage temperature range | | −65 | 150 | °C |
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1) | | 2000 | V |

(1) The human body model is a 100 pF capacitor discharged through a 1.5kΩ resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

## 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| Cathode voltage | | $V_{REF}$ | | 30 | V |
| Cathode current | | 0.1 | | 15 | mA |
| Temperature | XB431 | 0 | | 70 | °C |
| Derating Curve (Slope = $-1/R_{\theta JA}$) | |  | | | |



## 6.4 Thermal Information

| THERMAL METRIC(1) | | XB431 SOT-23 3 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance (2) | 455 | °C/W |

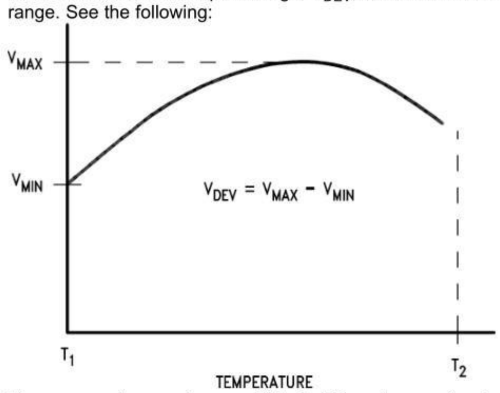
(1) $T_{J\,Max}$ = 150°C, $T_J = T_A + (R_{\theta JA}\, P_D)$, where $P_D$ is the operating power of the device.

## 6.5 XB431-LM Electrical Characteristics

$T_A$ = 25°C unless otherwise specified

| SYMBOL | PARAMETER | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $V_{REF}$ | Reference Voltage | $V_Z = V_{REF}$, $I_Z$ = 10 mA | $T_A$ = 25°C | 1.222 | 1.24 | 1.258 | V |
| | | | $T_A$ = Full Range | 1.21 | | 1.27 | |
| $V_{DEV}$ | Deviation of Reference Input Voltage Over Temperature(1) | $V_Z = V_{REF}$, $I_Z$ = 10 mA, $T_A$ = Full Range | | | 4 | 12 | mV |
| $\frac{V_{REF}}{V_Z}$ | Ratio of the Change in Reference Voltage to the Change in Cathode Voltage | $I_Z$ = 10 mA<br>$V_Z$ from $V_{REF}$ to 6 V<br>$R_1$ = 10 kΩ, $R_2$ = ∞ and 2.6 kΩ | | | −1.5 | −2.7 | mV/V |
| $I_{REF}$ | Reference Input Current | $R_1$ = 10 kΩ, $R_2$ = ∞<br>$I_I$ = 10 mA | | | 0.15 | 0.5 | μA |
| $\propto I_{REF}$ | Deviation of Reference Input Current over Temperature | $R_1$ = 10 kΩ, $R_2$ = ∞,<br>$I_I$ = 10 mA, $T_A$ = Full Range | | | 0.05 | 0.3 | μA |
| $I_{Z(MIN)}$ | Minimum Cathode Current for Regulation | $V_Z = V_{REF}$ | | | 55 | 80 | μA |
| $I_{Z(OFF)}$ | Off-State Current | $V_Z$= 6 V, $V_{REF}$ = 0 V | | | 0.001 | | μA |
| $r_Z$ | Dynamic Output Impedance(2) | $V_Z = V_{REF}$, $I_Z$ = 0.1 mA to 15 mA<br>Frequency = 0 Hz | | | 0.25 | 0.4 | Ω |

(1) Deviation of reference input voltage, $V_{DEV}$, is defined as the maximum variation of the reference input voltage over the full temperature range. See the following:




The average temperature coefficient of the reference input voltage, $\propto V_{REF}$, is defined as:

$$\propto V_{REF}\ \frac{ppm}{°C} = \frac{\pm\left(\frac{V_{Max}-V_{Min}}{V_{REF}(at\ 25°C)}\right)10^6}{T_2-T_1} = \frac{\pm\left(\frac{V_{DEV}}{V_{REF}(at\ 25°C)}\right)10^6}{T_2-T_1}$$

Where: $T_2 - T_1$ = full temperature change. $\propto V_{REF}$ can be positive or negative depending on whether the slope is positive or negative.
Example: $V_{DEV}$ = 6 mV, $V_{REF}$ = 1240 mV, $T_2 - T_1$ = 125°C.

$$\propto V_{REF} = \frac{\left(\frac{6.0\ mV}{1240\ mV}\right)10^6}{125°C} = +39\ ppm/°C$$

(2) The dynamic output impedance, $r_Z$, is defined as:

$$r_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

When the device is programmed with two external resistors, R1 and R2, see Figure 31 the dynamic output impedance of the overall circuit, $r_Z$, is defined as:

$$r_Z = \frac{\Delta V_Z}{\Delta I_Z} \cong \left[r_Z\left(1+\frac{R1}{R2}\right)\right]$$

## 6.6 Typical Performance Characteristics

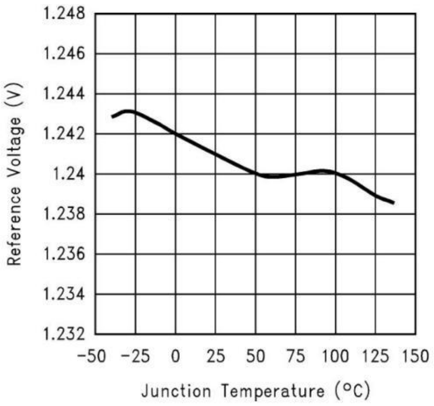



**Figure 1. Reference Voltage vs. Junction Temperature**

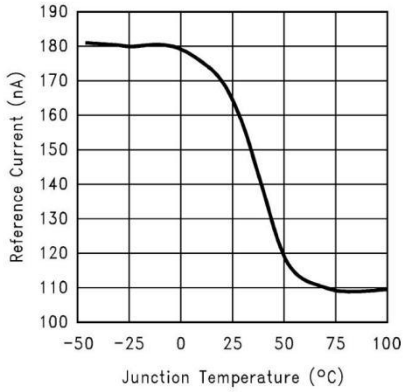



**Figure 2. Reference Input Current vs. Junction Temperature**

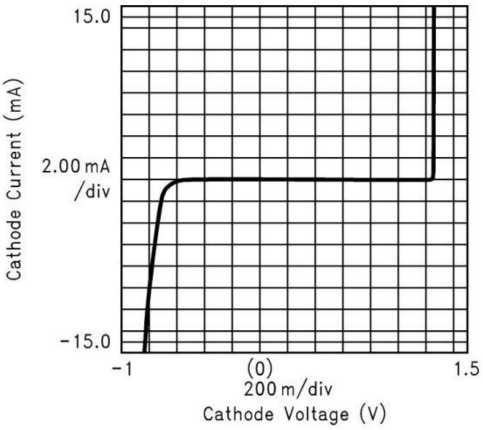



**Figure 3. Cathode Current vs. Cathode Voltage 1**

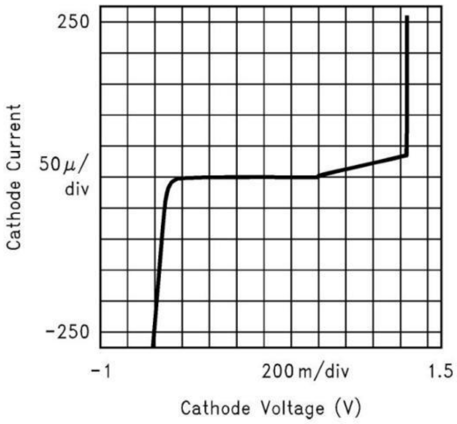



**Figure 4. Cathode Current vs. Cathode Voltage 2**

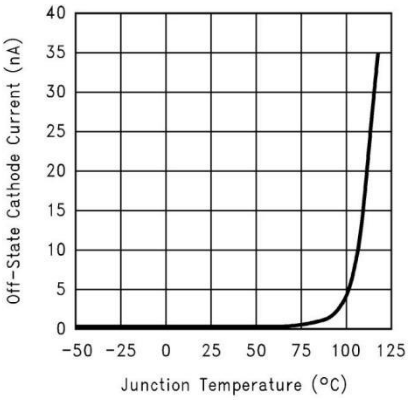



**Figure 5. Off-State Cathode Current vs. Junction Temperature**

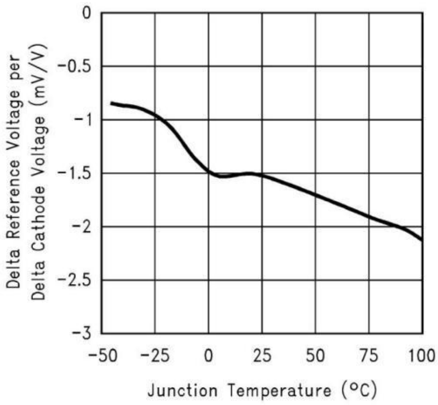



**Figure 6. Delta Reference Voltage Per Delta Cathode Voltage vs. Junction Temperature**

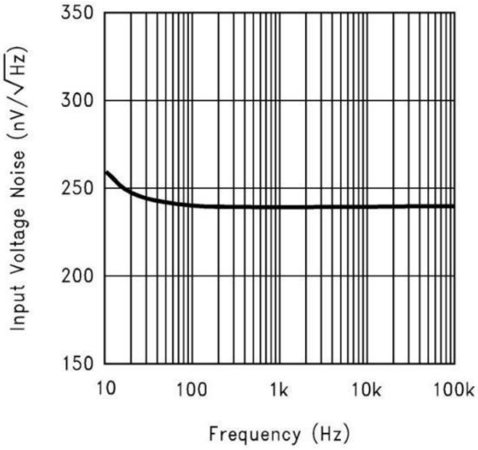



Figure 7. Input Voltage Noise vs. Frequency

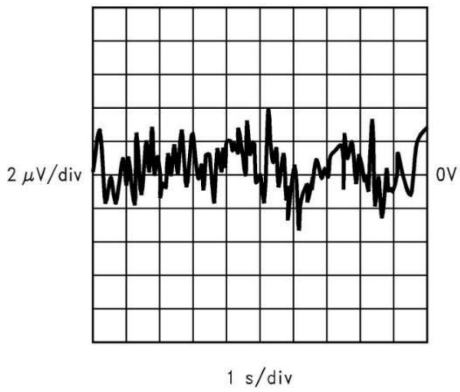



Figure 8. Low Frequency Peak To Peak Noise

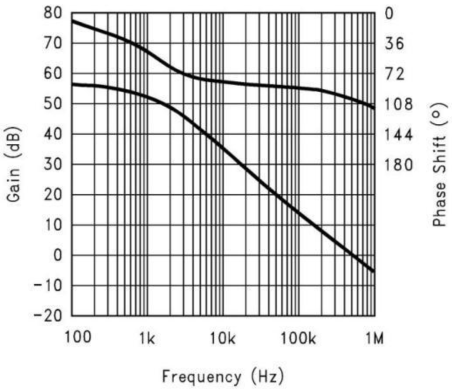



Figure 9. Small Signal Voltage Gain And Phase Shift vs. Frequency

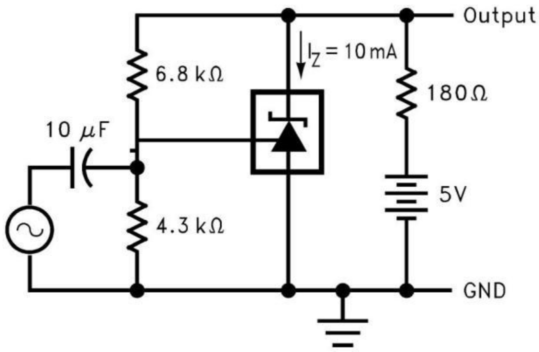



Figure 10. Test Circuit For Voltage Gain And Phase Shift vs. Frequency

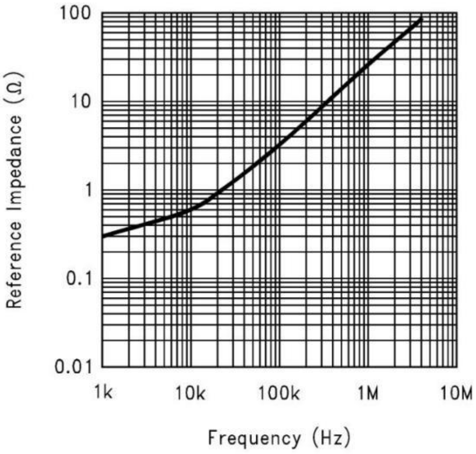



Figure 11. Reference Impedance vs. Frequency

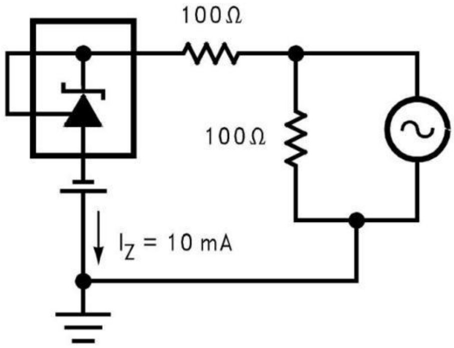



Figure 12. Test Circuit For Reference Impedance vs. Frequency

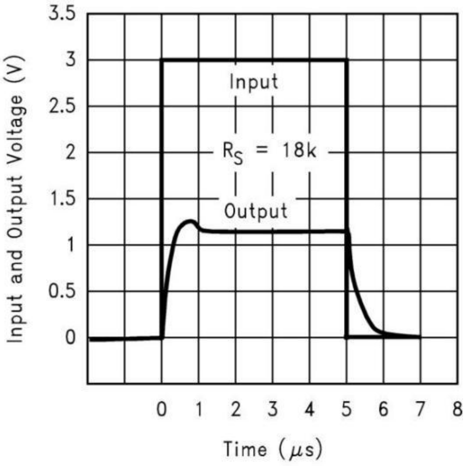



Figure 13. Pulse Response 1

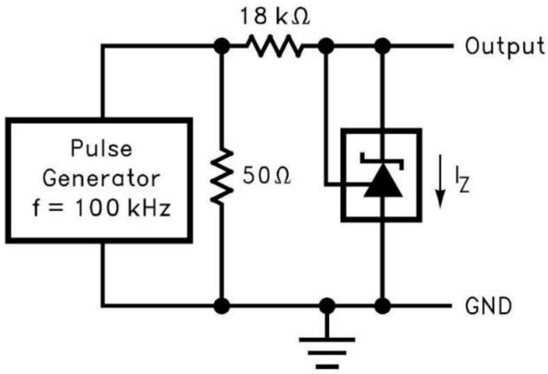



Figure 14. Test Circuit For Pulse Response 1

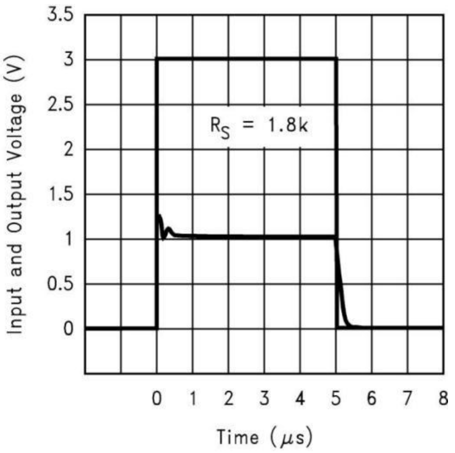



Figure 15. Pulse Response 2

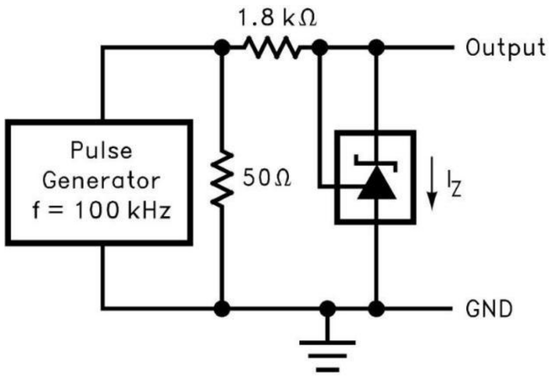



Figure 16. Test Circuit For Pulse Response 2

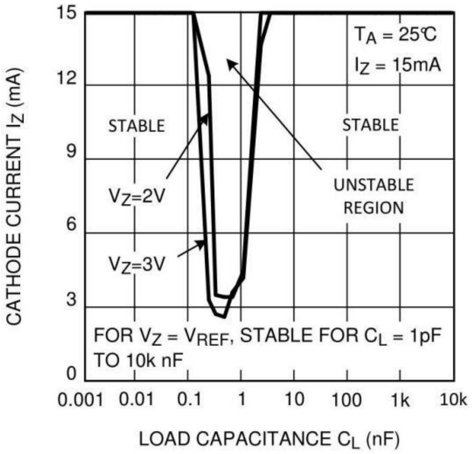



Figure 17. XB431 Stability Boundary Condition

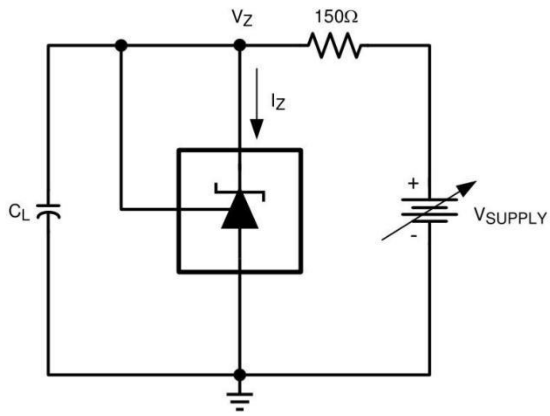



Figure 18. Test Circuit For $V_Z$ = $V_{REF}$

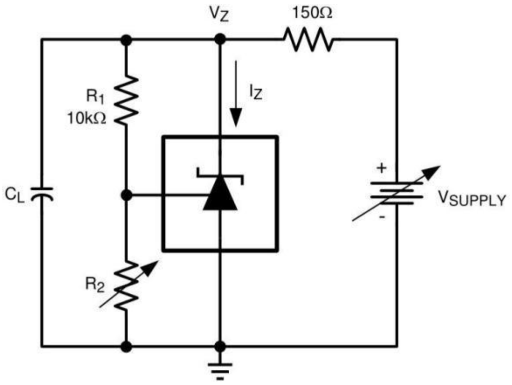



Figure 19.Test Circuit For $V_Z$ = 2V, 3V

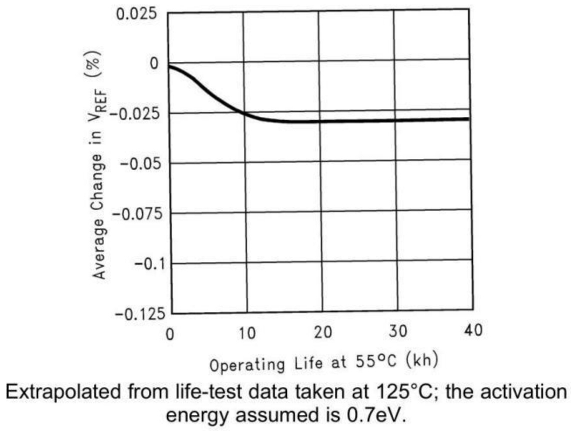
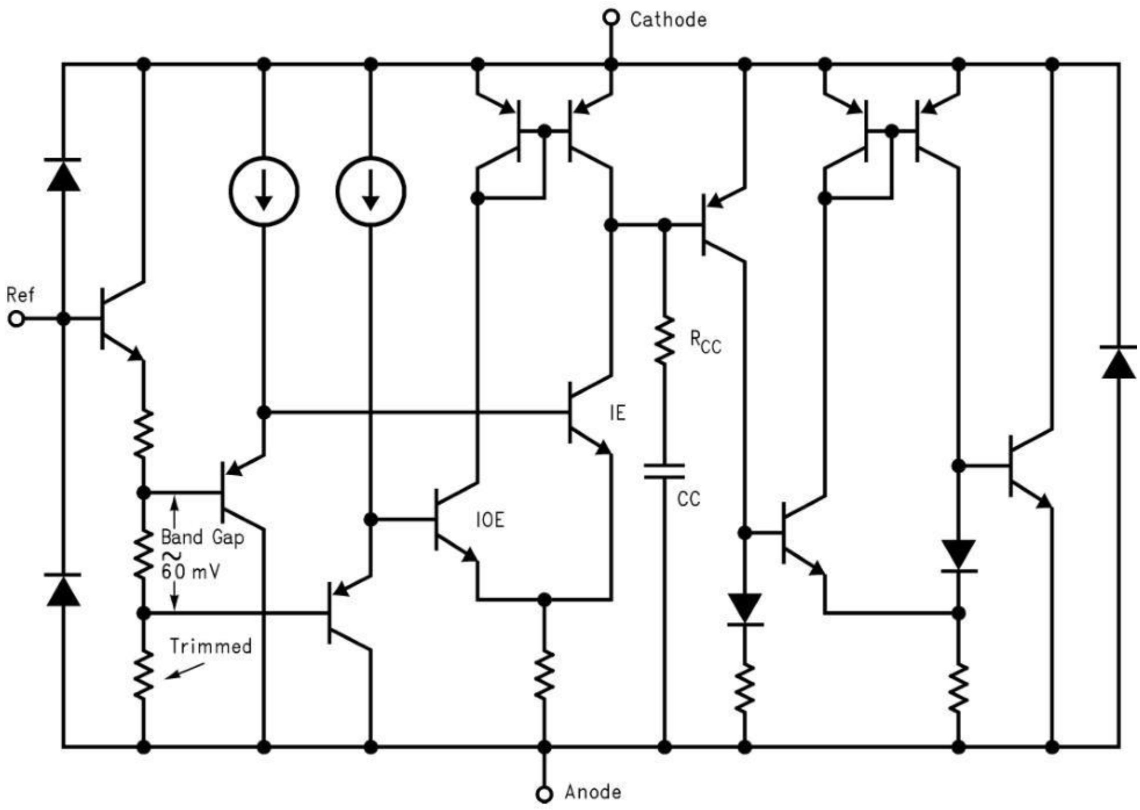



Figure 20.Percentage Change In $V_{REF}$ vs. Operating Life At 55°C

# 7. DETAILED DESCRIPTION

## 7.1 Functional Block Diagram

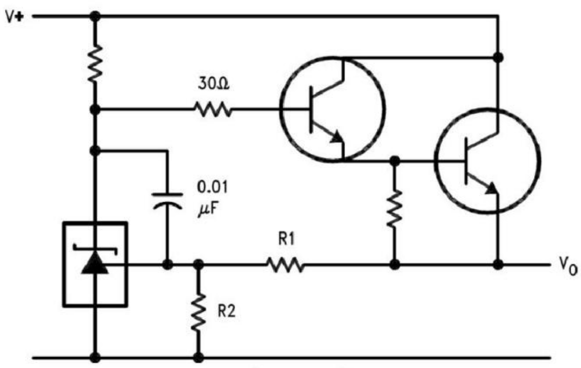


# 8. APPLICATION AND IMPLEMENTATION

**NOTE**

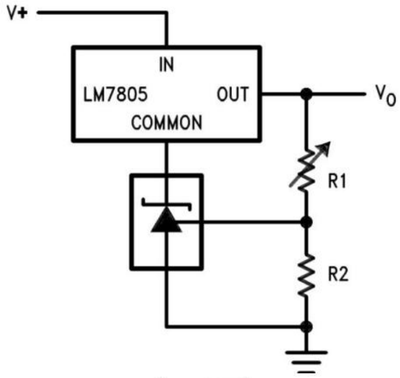
Information in the following applications sections is not part of the XINLUDA component specification, and XINLUDA does not warrant its accuracy or completeness. XINLUDA's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

## 8.1 Typical Application




$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

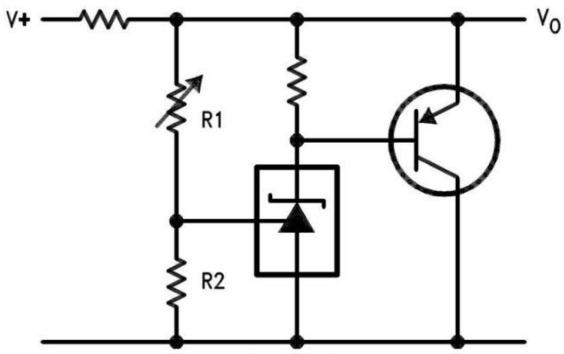
**Figure 21. Series Regulator**




$$V_O = \left(1 + \frac{R1}{R2}\right) V_{REF}$$

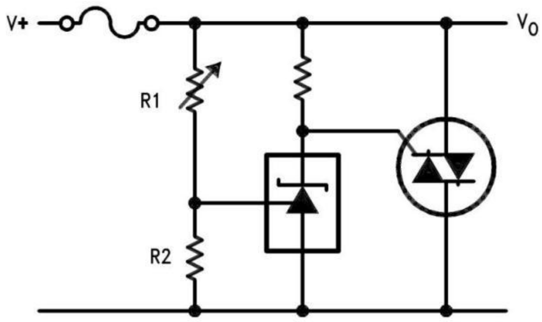
$$V_{O\,MIN} = V_{REF} + 5\ V$$

**Figure 22.Output Control of a Three-Terminal Fixed Regulator**



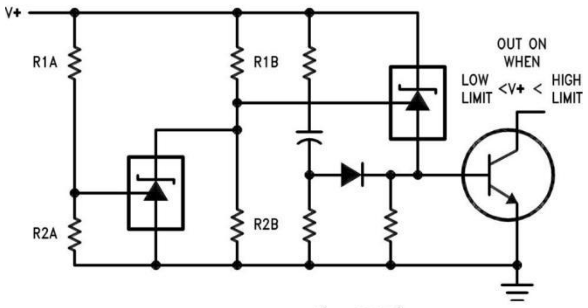

$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

**Figure 23.Higher Current Shunt Regulator**




$$V_{LIMIT} \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

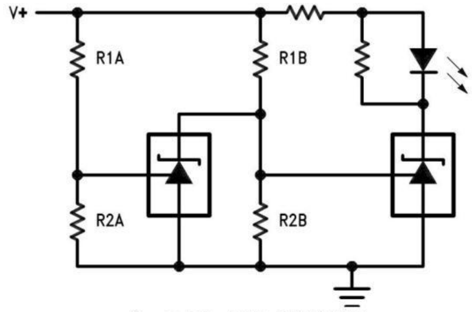
**Figure 24.Crow Bar**




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

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

**Figure 25.Overvoltage/Undervoltage Protection Circuit**



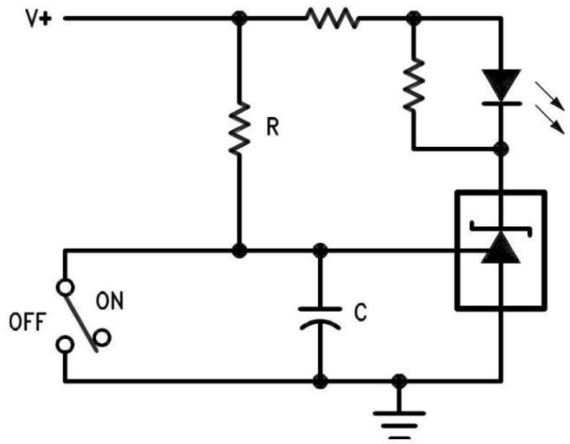

$$\text{LOW LIMIT} \approx V_{REF}\left(1+\frac{R1B}{R2B}\right)$$

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

LED ON WHEN

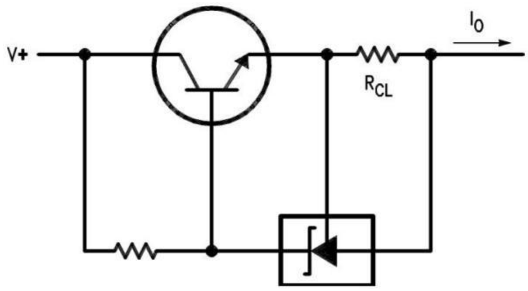
LOW LIMIT $<$ $V^+$ $<$ HIGH LIMIT

**Figure 26.Voltage Monitor**




$$\text{DELAY} = R \cdot C \cdot \ell n \frac{V+}{(V^+) - V_{REF}}$$

**Figure 27.Delay Timer**




$$I_O = \frac{V_{REF}}{R_{CL}}$$

**Figure 28.Current Limiter or Current Source**

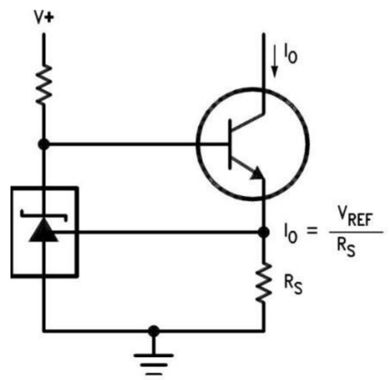



**Figure 29.Constant Current Sink**

## 8.2 DC/AC Test Circuit

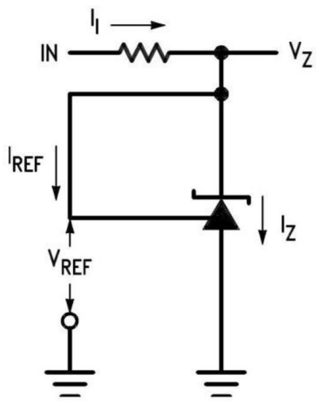



Figure 30.Test Circuit For $V_Z = V_{REF}$

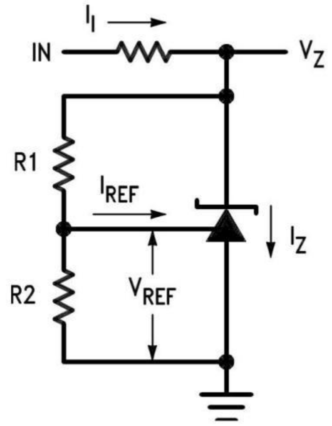



Figure 31.Test Circuit For $V_Z > V_{REF}$

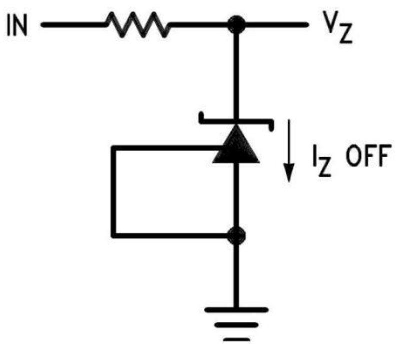



Figure 32.Test Circuit For Off-State Current

## 9. ORDERING INFORMATION

**Ordering Information**

| Part Number | Device Marking | Package Type | Body size (mm) | Temperature (℃) | MSL | Transport Media | Package Quantity |
|---|---|---|---|---|---|---|---|
| XB431-LM | RLA | SOT23-3 | 3.00 ∗ 1.40 | - 0 to +70 | MSL3 | T&R | 3000 |

## 10. DIMENSIONAL DRAWINGS