

LM431A

Adjustable Precision Zener Shunt Regulator

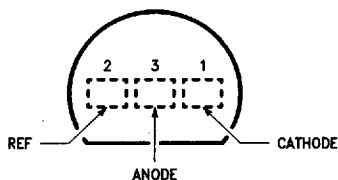
General Description

The LM431A is a 3-terminal adjustable shunt regulator with guaranteed temperature stability over the entire temperature range of operation. The output voltage may be set at any level greater than 2.5V (V_{REF}) up to 36V merely by selecting two external resistors that act as a voltage divided network. Due to the sharp turn-on characteristics this device is an excellent replacement for many zener diode applications.

Features

- Average temperature coefficient 50 ppm/°C
- Temperature compensated for operation over the full temperature range
- Programmable output voltage
- Fast turn-on response
- Low output noise

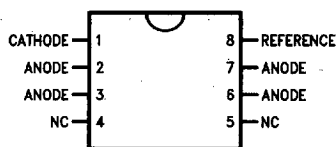
Connection Diagrams



Top View

Order Number LM431ACZ or LM431AIZ
See NS Package Number Z03A

TL/H/10055-1



Top View

Order Number LM431ACM or LM431AIM
See NS Package Number M08A

TL/H/10055-2

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	
Industrial (LM431AI)	−40°C to +85°C
Commercial (LM431AC)	0°C to +70°C

Lead Temperature	
TO-92 Package/SO-8 Package	
(Soldering, 10 sec.)	265°C

Internal Power Dissipation (Notes 1, 2)	
TO-92 Package	0.78W
SO-8 Package	0.81W

Cathode Voltage		37V
Continuous Cathode Current	−10 mA to +150 mA	
Reference Voltage	−0.5V	
Reference Input Current	10 mA	
Operating Conditions	Min	Max
Cathode Voltage	V _{REF}	37V
Cathode Current	1.0 mA	100 mA

Note 1: T_J Max = 150°C.

Note 2: Ratings apply to ambient temperature at 25°C. Above this temperature, derate the TO-92 at 6.2 mW/°C, and the SO-8 at 6.5 mW/°C.

LM431A

Electrical Characteristics T_A = 25°C unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V _{REF}	Reference Voltage	V _Z = V _{REF} , I _I = 10 mA (Figure 1)	2.440	2.495	2.550	V
V _{DEV}	Deviation of Reference Input Voltage Over Temperature (Note 3)	V _Z = V _{REF} , I _I = 10 mA, T _A = Full Range (Figure 1)		8.0	17	mV
$\frac{\Delta V_{REF}}{\Delta V_Z}$	Ratio of the Change in Reference Voltage to the Change in Cathode Voltage	I _Z = 10 mA (Figure 2)	V _Z from V _{REF} to 10V		−1.4	−2.7
			V _Z from 10V to 36V		−1.0	−2.0
I _{REF}	Reference Input Current	R ₁ = 10 kΩ, R ₂ = ∞, I _I = 10 mA (Figure 2)		2.0	4.0	μA
∞ I _{REF}	Deviation of Reference Input Current over Temperature	R ₁ = 10 kΩ, R ₂ = ∞, I _I = 10 mA, T _A = Full Range (Figure 2)		0.4	1.2	μA
I _{Z(MIN)}	Minimum Cathode Current for Regulation	V _Z = V _{REF} (Figure 1)		0.4	1.0	mA
I _{Z(OFF)}	Off-State Current	V _Z = 36V, V _{REF} = 0V (Figure 3)		0.3	1.0	μA
r _Z	Dynamic Output Impedance (Note 4)	V _Z = V _{REF} , Frequency = 0 Hz (Figure 1)			0.75	Ω

Note 3: Deviation of reference input voltage, V_{DEV}, is defined as the maximum variation of the reference input voltage over the full temperature range.

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

$$\infty V_{REF} \frac{\text{ppm}}{^{\circ}\text{C}} = \frac{\pm \left[\frac{V_{\text{Max}} - V_{\text{Min}}}{V_{REF}(\text{at } 25^{\circ}\text{C})} \right] 10^6}{T_2 - T_1} = \pm \left[\frac{V_{DEV}}{V_{REF}(\text{at } 25^{\circ}\text{C})} \right] 10^6 \frac{1}{T_2 - T_1}$$

Where:

T₂ − T₁ = full temperature change.

∞ V_{REF} can be positive or negative depending on whether the slope is positive or negative.

Example: V_{DEV} = 8.0 mV, V_{REF} = 2495 mV, T₂ − T₁ = 70°C, slope is positive.

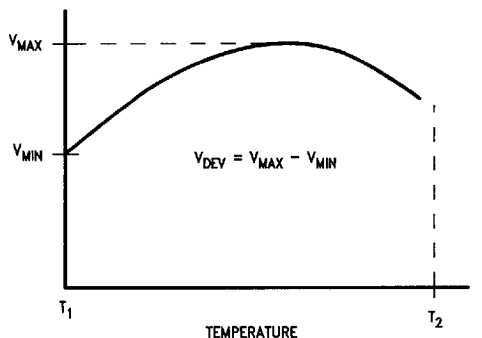
$$\infty V_{REF} = \frac{\left[\frac{8.0 \text{ mV}}{2495 \text{ mV}} \right] 10^6}{70^{\circ}\text{C}} = +46 \text{ ppm}/^{\circ}\text{C}$$

Note 4: The dynamic output impedance, r_Z, is defined as:

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

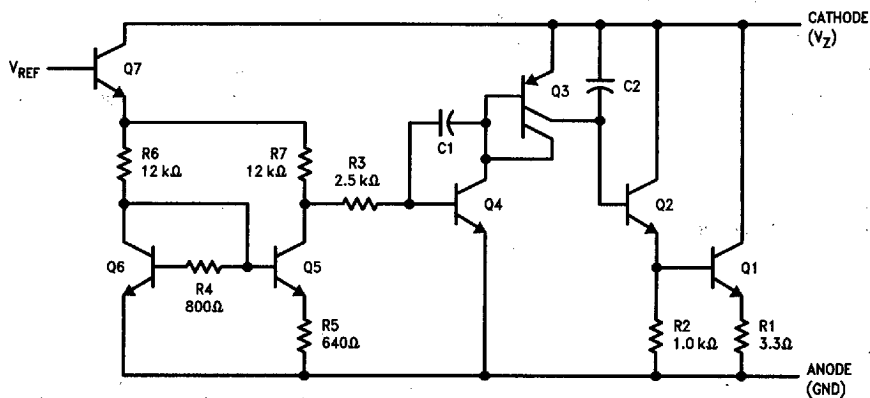
When the device is programmed with two external resistors, R₁ and R₂, (see Figure 2), the dynamic output impedance of the overall circuit, r_Z, is defined as:

$$r_Z = \frac{\Delta V_Z}{\Delta I_Z} \approx \left[r_Z 1 + \frac{R_1}{R_2} \right]$$



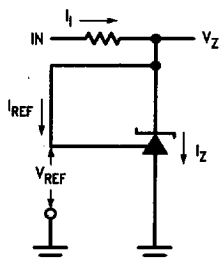
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Equivalent Circuit

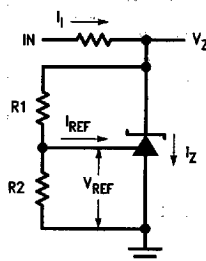


TL/H/10055-3

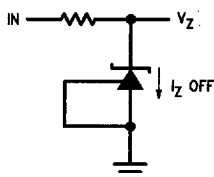
DC Test Circuits



TL/H/10055-4

FIGURE 1. Test Circuit for $V_Z = V_{REF}$ 

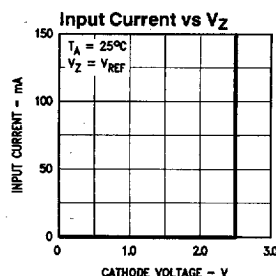
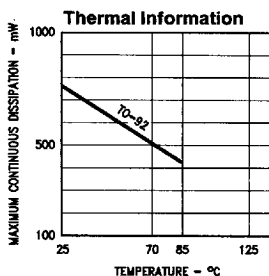
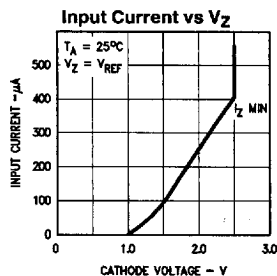
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Note: $V_Z = V_{REF} (1 + R1/R2) + I_{REF} \cdot R1$ FIGURE 2. Test Circuit for $V_Z > V_{REF}$ 

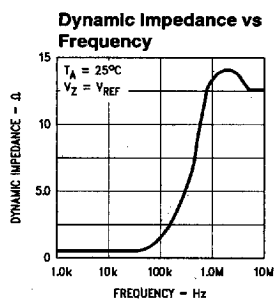
TL/H/10055-6

FIGURE 3. Test Circuit for Off-State Current

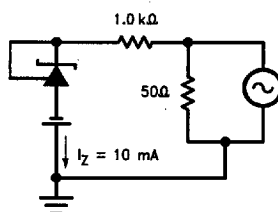
Typical Performance Characteristics



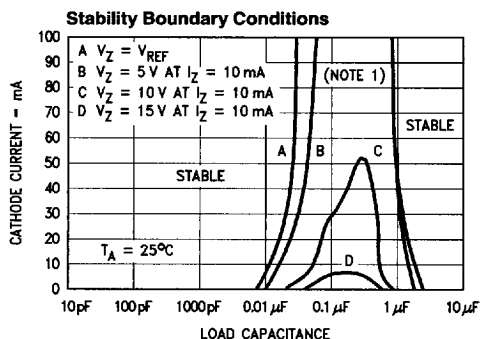
TL/H/10055-8



TL/H/10055-9

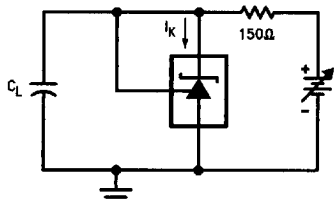


TL/H/10055-10



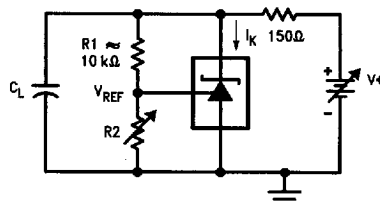
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Test Circuit for Curve A Above



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Test Circuit for Curves B, C and D Above

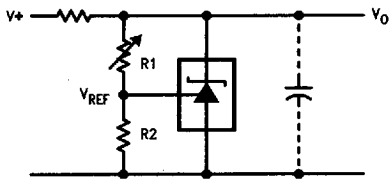


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Note 1: The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, $R2$ and V_+ were adjusted to establish the initial V_Z and I_Z conditions with $C_L = 0$. V_+ and C_L were then adjusted to determine the ranges of stability.

Typical Applications

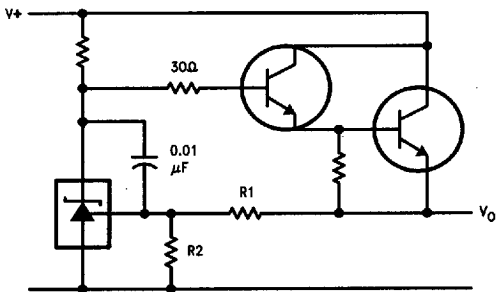
Shunt Regulator



TL/H/10055-14

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

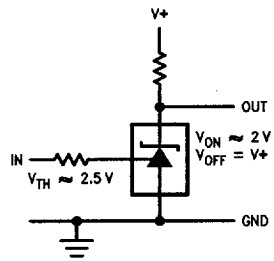
Series Regulator



TL/H/10055-16

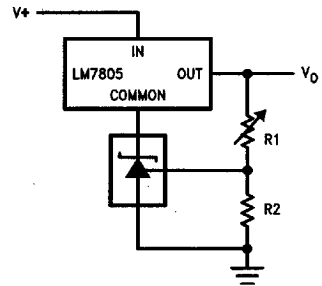
$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Single Supply Comparator with Temperature Compensated Threshold



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Output Control of a Three Terminal Fixed Regulator



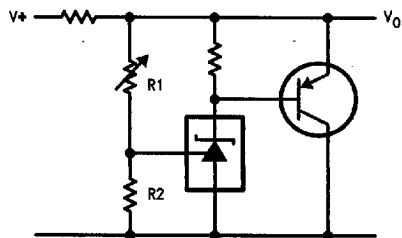
TL/H/10055-17

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

$$V_O \text{ MIN} = V_{REF} + 5V$$

Typical Applications (Continued)

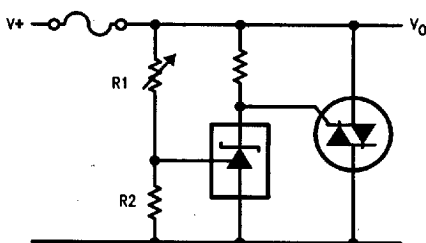
Higher Current Shunt Regulator



TL/H/10055-18

$$V_O = \left(1 + \frac{R_1}{R_2}\right) V_{REF}$$

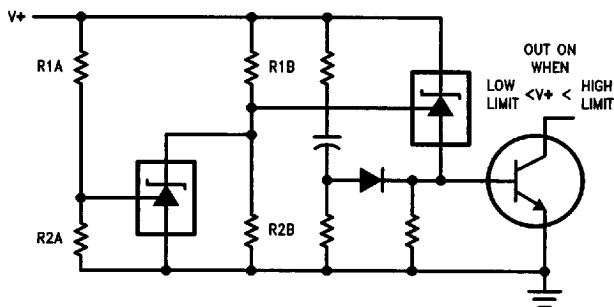
Crow Bar



TL/H/10055-19

$$V_{LIMIT} \approx \left(1 + \frac{R_1}{R_2}\right) V_{REF}$$

Over Voltage/Under Voltage Protection Circuit

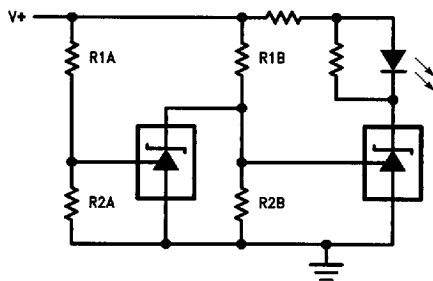


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$$\text{LOW LIMIT} \approx V_{REF} \left(1 + \frac{R_{1B}}{R_{2B}}\right) + V_{BE}$$

$$\text{HIGH LIMIT} \approx V_{REF} \left(1 + \frac{R_{1A}}{R_{2A}}\right)$$

Voltage Monitor

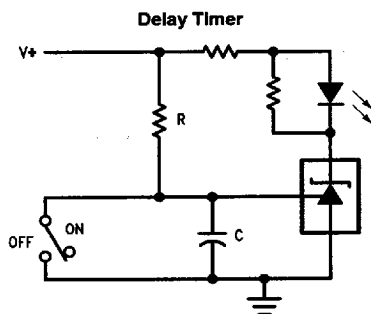


TL/H/10055-21

$$\text{LOW LIMIT} \approx V_{REF} \left(1 + \frac{R_{1B}}{R_{2B}}\right) \quad \text{LED ON WHEN LOW LIMIT} < V^+ < \text{HIGH LIMIT}$$

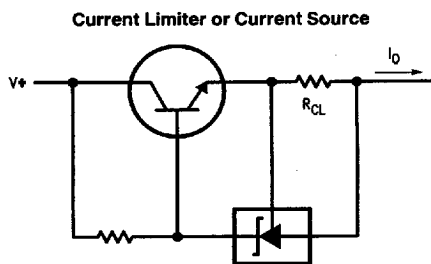
$$\text{HIGH LIMIT} \approx V_{REF} \left(1 + \frac{R_{1A}}{R_{2A}}\right)$$

Typical Applications (Continued)



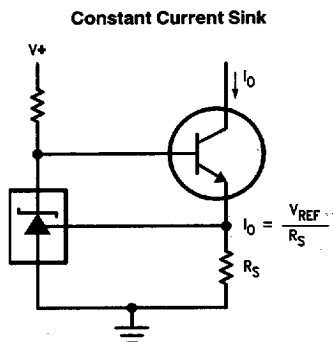
$$\text{DELAY} = R \cdot C \cdot \ln \frac{V^+}{(V^+) - V_{\text{REF}}}$$

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

TL/H/10055-23



$$I_O = \frac{V_{\text{REF}}}{R_S}$$

TL/H/10055-24