National Semiconductor

June 1999

LMV431/LMV431A
Low-Voltage (1.24V) Adjustable Precision Shunt Regulators

General Description

The LMV431and LMV431A are precision 1.24V shunt regulators capable of adjustment to 30V. 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 1.24V band-gap reference. Shorting the cathode to the adjust pin (voltage follower) provides a cathode voltage of a 1.24V.

The LMV431 and LMV431A have respective initial tolerances of 1.5% and 1%. Both grades are available in commercial and Industrial temperature ranges.

The LMV431 and LMV431A functionally lends themselves to several applications that require zener diode type performance at low voltages. Applications include a 3V to 2.7V low drop-out regulator, an error amplifier in a 3V off-line switching regulator and even as a voltage detector. The part is typically stable with capacitive loads greater than 10nF and less than 50 pF.

The LMV431 and LMV431A provide performance at a competitive price.

Features

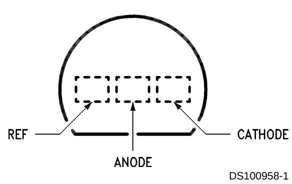
- Low Voltage Operation/Wide Adjust Range (1.24V/30V)
- 1% Initial Tolerance (LMV431A)
- Temperature Compensated for Industrial Temperature Range (39 PPM/°C for the LMV431AI)
- Low Operation Current (55µA)
- Low Output Impedance (0.25Ω)
- Fast Turn-On Response
- Low Cost

Applications

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

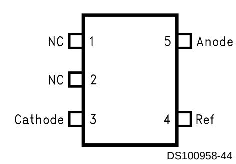
Connection Diagrams

TO92: Plastic Package



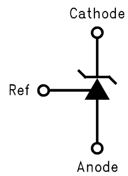
Top View
Order Number LMV431AIZ, LMV431IZ, LMV431ACZ, LMV431CZ

SOT23-5



Top View
Order Number LMV431AIM5, LMV431IM5, LMV431ACM5, LMV431CM5

Symbol and Functional Diagrams



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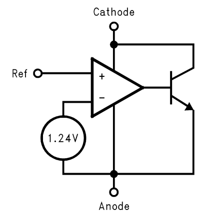

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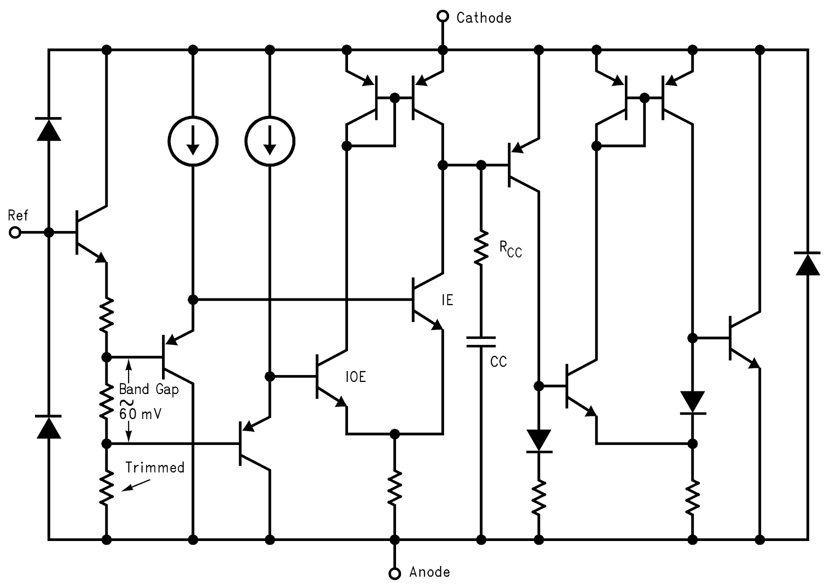
Simplified Schematic



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Ordering Information

Package	Temperature Range	Voltage Tolerance	Part Number	Package Marking	Drawing Number
TO92	Industrial Range −40˚C to +85˚C	1%	LMV431AIZ	LMV431AIZ	Z03A
		1.5%	LMV431IZ	LMV431IZ	
	Commerial Range 0˚C to + 70˚C	1%	LMV431ACZ	LMV431ACZ	
		1.5%	LMV431CZ	LMV431CZ	
SOT23-5	Industrial Range −40˚C to +80˚C	1%	LMV431AIM5	N08A	MA05A
		1%	LMV431AIM5X	N08A	
		1.5%	LMV431IM5	N08B	
		1.5%	LMV431IM5X	N08B	
	Commercial Range 0˚C to + 70˚C	1%	LMV431ACM5	N09A	
		1%	LMV431ACM5X	N09A	
		1.5%	LMV431CM5	N09B	
		1.5%	LMV431CM5X	N09B	

DC/AC Test Circuits for Table and Curves

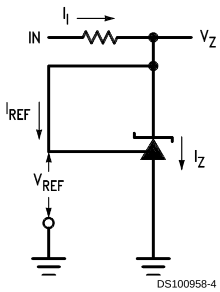
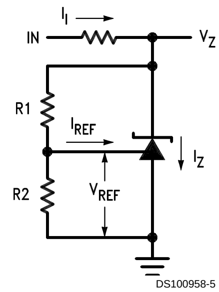


FIGURE 1. Test Circuit for $V_Z = V_{REF}$



Note: $V_Z = V_{REF}(1 + R1/R2) + I_{REF} \cdot R1$

FIGURE 2. Test Circuit for $V_Z > V_{REF}$

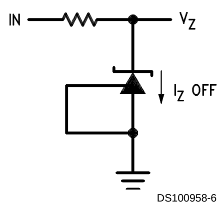


FIGURE 3. Test Circuit for Off-State Current

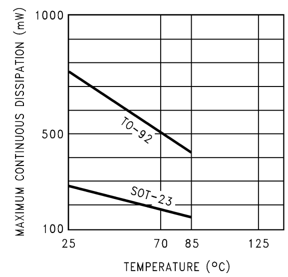
Absolute Maximum Ratings (Note 1)

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 (LMV431AI, LMV431I)	−40˚C to +85˚C
Commercial (LMV431AC, LMV431C)	0˚C to +70˚C
Lead Temperature	
TO92 Package/SOT23 -5Package	
(Soldering, 10 sec.)	265˚C
Internal Power Dissipation (Note 2) TO92	0.78W
SOT23-5 Package	0.28W
Cathode Voltage	35V
Continuous Cathode Current	−30 mA to +30 mA
Reference Input Current range	−.05mA to 3 mA

Operating Conditions

Cathode Voltage	V_{REF} to 30V
Cathode Current	0.1 mA to 15mA
Temperature range	
LMV431AI	$-40˚C \leq T_A \leq 85˚C$
Thermal Resistance (θ_{JA})(Note 3)	
SOT23-5 Package	455 ˚C/W
TO-92 Package	161 ˚C/W
Derating Curve (Slope = $-1/\theta_{JA}$)	



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LMV431C 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_Z=10 mA *(See Figure 1)*	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 (Note 4)	$V_Z= V_{REF}$, I_Z=10mA, T_A=Full Range *(See Figure 1)*			4	12	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 *(see Figure 2)* V_Z from V_{REF} to 6V R_1 = 10k, $R_2 = \infty$ and 2.6K			−1.5	−2.7	mV/V
I_{REF}	Reference Input Current	R_1 = 10 kΩ, $R_2 = \infty$ I_I = 10 mA *(see Figure 2)*			0.15	0.5	µA
$\propto I_{REF}$	Deviation of Reference Input Current over Temperature	R_1 = 10 kΩ, $R_2 = \infty$, I_I = 10 mA, T_A = Full Range *(see Figure 2)*			0.05	0.3	µA
$I_{Z(MIN)}$	Minimum Cathode Current for Regulation	$V_Z = V_{REF}$ *(see Figure 1)*			55	80	µA
$I_{Z(OFF)}$	Off-State Current	V_Z=6V, V_{REF} = 0V *(see Figure 3)*			0.001	0.1	µA
r_Z	Dynamic Output Impedance (Note 5)	$V_Z = V_{REF}$, I_Z = 0.1mA to 15mA Frequency = 0 Hz *(see Figure 1)*			0.25	0.4	Ω

LMV431I 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_Z=10 mA *(See Figure 1)*	T_A = 25˚C	1.222	1.24	1.258	V
			T_A = Full Range	1.202		1.278	
V_{DEV}	Deviation of Reference Input Voltage Over Temperature (Note 4)	V_Z= V_{REF}, I_Z=10mA, T_A=Full Range *(See Figure 1)*			6	20	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 *(see Figure 2)* V_Z from V_{REF} to 6V R_1 = 10k, R_2 = ∞ and 2.6K			−1.5	−2.7	mV/V
I_{REF}	Reference Input Current	R_1 = 10 kΩ, R_2 = ∞ I_I = 10 mA *(see Figure 2)*			0.15	0.5	µA
$\propto I_{REF}$	Deviation of Reference Input Current over Temperature	R_1 = 10 kΩ, R_2 = ∞, I_I = 10 mA, T_A = Full Range *(see Figure 2)*			0.1	0.4	µA
$I_{Z(MIN)}$	Minimum Cathode Current for Regulation	V_Z = V_{REF} *(see Figure 1)*			55	80	µA
$I_{Z(OFF)}$	Off-State Current	V_Z=6V, V_{REF} = 0V *(see Figure 3)*			0.001	0.1	µA
r_Z	Dynamic Output Impedance (Note 5)	V_Z = V_{REF}, I_Z = 0.1mA to 15mA Frequency = 0 Hz *(see Figure 1)*			0.25	0.4	Ω

LMV431AC 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_Z=10 mA *(See Figure 1)*	T_A = 25˚C	1.228	1.24	1.252	V
			T_A = Full Range	1.221		1.259	
V_{DEV}	Deviation of Reference Input Voltage Over Temperature (Note 4)	V_Z= V_{REF}, I_Z=10mA, T_A=Full Range *(See Figure 1)*			4	12	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 *(see Figure 2)* V_Z from V_{REF} to 6V R_1 = 10k, R_2 = ∞ and 2.6K			−1.5	−2.7	mV/V
I_{REF}	Reference Input Current	R_1 = 10 kΩ, R_2 = ∞ I_I = 10 mA *(see Figure 2)*			0.15	0.50	µA
$\propto I_{REF}$	Deviation of Reference Input Current over Temperature	R_1 = 10 kΩ, R_2 = ∞, I_I = 10 mA, T_A = Full Range *(see Figure 2)*			0.05	0.3	µA
$I_{Z(MIN)}$	Minimum Cathode Current for Regulation	V_Z = V_{REF} *(see Figure 1)*			55	80	µA
$I_{Z(OFF)}$	Off-State Current	V_Z=6V, V_{REF} = 0V *(see Figure 3)*			0.001	0.1	µA
r_Z	Dynamic Output Impedance (Note 5)	V_Z = V_{REF}, I_Z = 0.1mA to 15mA Frequency = 0 Hz *(see Figure 1)*			0.25	0.4	Ω

LMV431AI Electrical Characteristics

$T_A = 25^{\circ}C$ unless otherwise specified

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{REF}	Reference Voltage	$V_Z=V_{REF}$, I_Z=10 mA *(See Figure 1)*	$T_A = 25^{\circ}C$	1.228	1.24	1.252	V
			T_A = Full Range	1.215		1.265	
V_{DEV}	Deviation of Reference Input Voltage Over Temperature (Note 4)	$V_Z= V_{REF}$, I_Z=10mA, T_A=Full Range *(See Figure 1)*			6	20	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 *(see Figure 2)* V_Z from V_{REF} to 6V R_1 = 10k, $R_2 = \infty$ and 2.6K			−1.5	−2.7	mV/V
I_{REF}	Reference Input Current	R_1 = 10 kΩ, $R_2 = \infty$ I_I = 10 mA *(see Figure 2)*			0.15	0.5	µA
$\propto I_{REF}$	Deviation of Reference Input Current over Temperature	R_1 = 10 kΩ, $R_2 = \infty$, I_I = 10 mA, T_A = Full Range *(see Figure 2)*			0.1	0.4	µA
$I_{Z(MIN)}$	Minimum Cathode Current for Regulation	$V_Z = V_{REF}$ *(see Figure 1)*			55	80	µA
$I_{Z(OFF)}$	Off-State Current	V_Z=6V, V_{REF} = 0V *(see Figure 3)*			0.001	0.1	µA
r_Z	Dynamic Output Impedance (Note 5)	$V_Z = V_{REF}$, I_Z = 0.1mA to 15mA Frequency = 0 Hz *(see Figure 1)*			0.25	0.4	Ω

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.

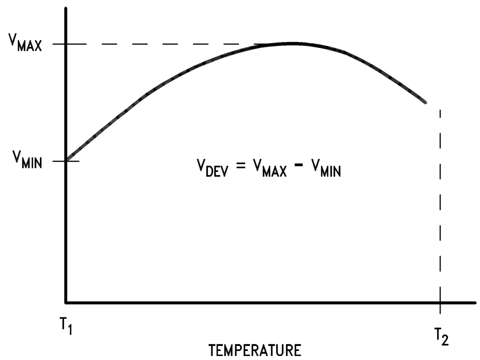
Note 2: Ratings apply to ambient temperature at 25˚C. Above this temperature, derate the TO92 at 6.2 mW/˚C, and the SOT23-5 at 2.2 mW/˚C. See derating curve in Operating Condition section..

Note 3: $T_{J\ Max} = 150^{\circ}C$, $T_J = T_A + (\theta_{JA} P_D)$, where P_D is the operating power of the device.

Note 4: Deviation of reference input voltage, V_{DEV}, is defined as the maximum variation of the reference input voltage over the full temperature range.

See following:

LMV431AI Electrical Characteristics (Continued)



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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} = 6.0mV, $_{REF}$ = 1240mV, $T_2 - T_1$ = 125˚C.

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

Note 5: The dynamic output impedance, r_Z, is defined as:

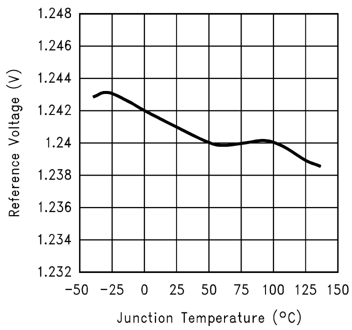
$$r_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

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:

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

Typical Performance Characteristics

Reference Voltage vs Junction Temperature



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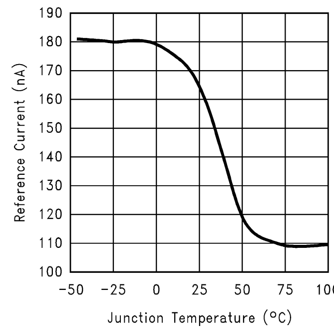
Reference Input Current vs Junction Temperature



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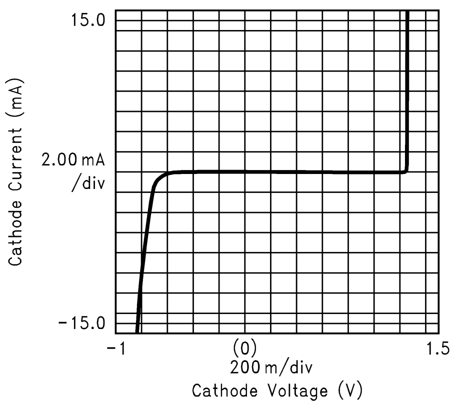
Cathode Current vs Cathode Voltage 1



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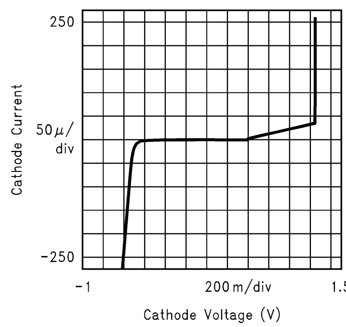
Cathode Current vs Cathode Voltage 2



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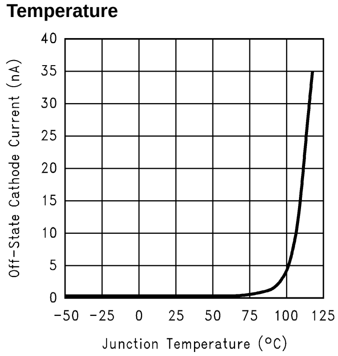
Off-State Cathode Current vs Junction Temperature



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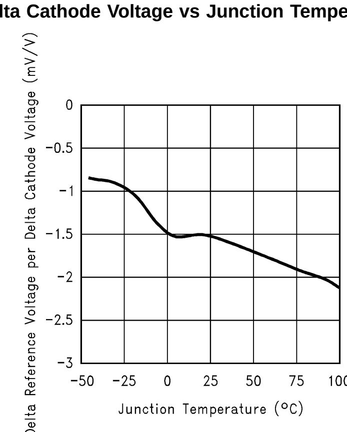
Delta Reference Voltage Per Delta Cathode Voltage vs Junction Temperature



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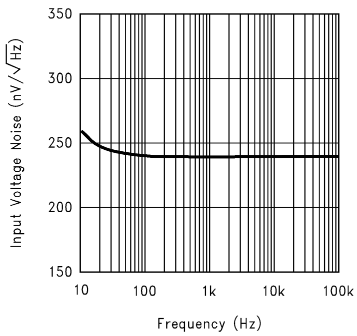
Typical Performance Characteristics (Continued)

Input Voltage Noise vs Frequency



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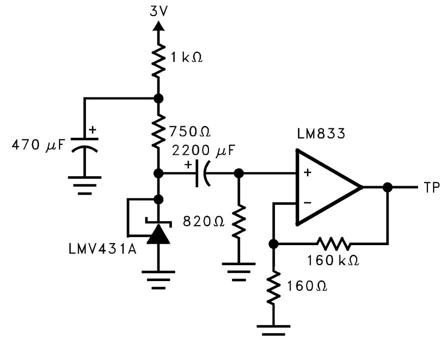

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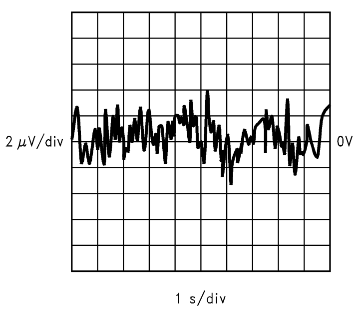
Test Circuit for Input Voltage Noise vs Frequency

Low Frequency Peak to Peak Noise



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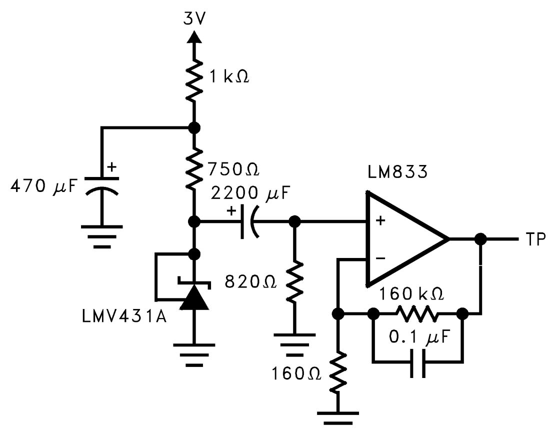

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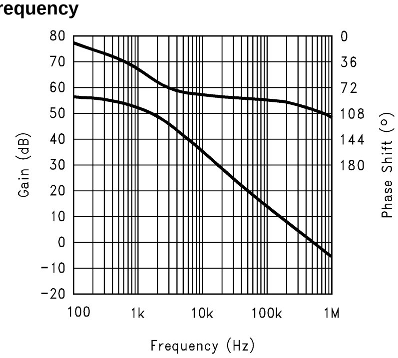
Test Circuit for Peak to Peak Noise (BW= 0.1Hz to 10Hz)

Small Signal Voltage Gain and Phase Shift vs Frequency



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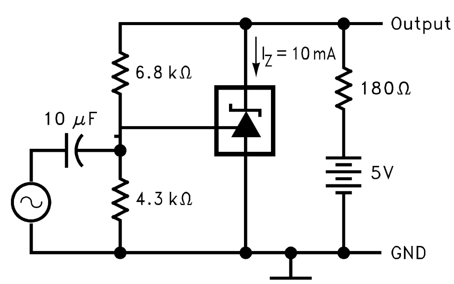

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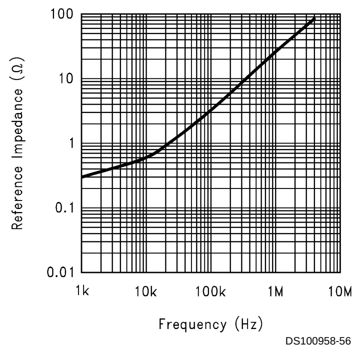
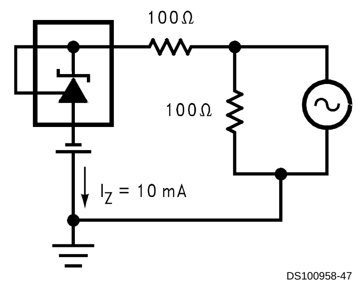
Test Circuit For Voltage Gain and Phase Shift vs Frequency

Typical Performance Characteristics (Continued)

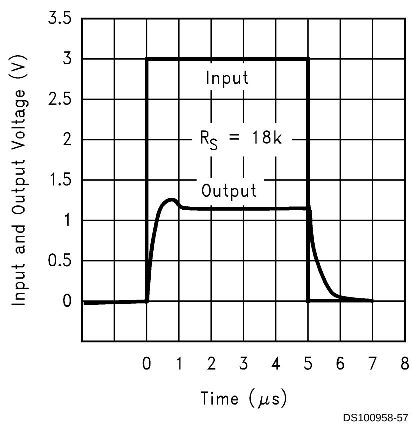
Reference Impedance vs Frequency

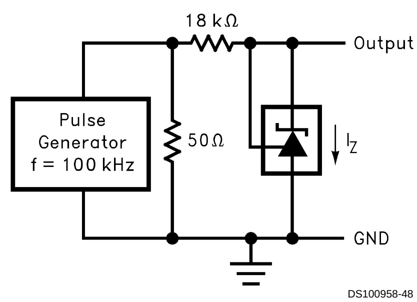




Test Circuit For Reference Impedance vs Frequency

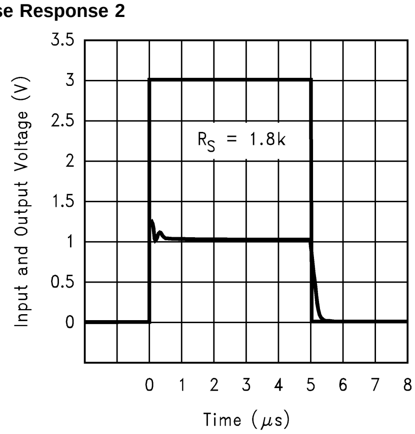
Pulse Response 1

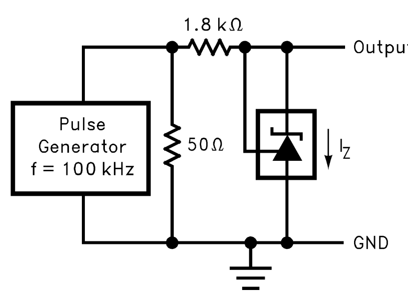




Test Circuit for Pulse Response 1

Pulse Response 2

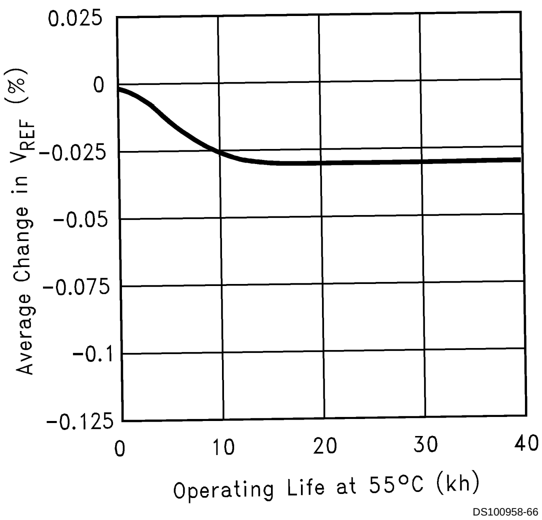




Test Circuit for Pulse Response 2

Typical Performance Characteristics (Continued)

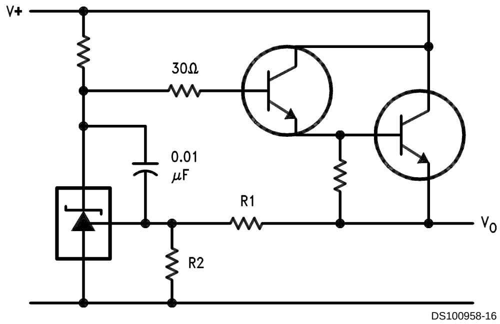
Percentage Change in V_{REF} vs Operating Life at 55˚C



Extrapolated from life-test data taken at 125˚C; the activation energy assumed is 0.7eV.

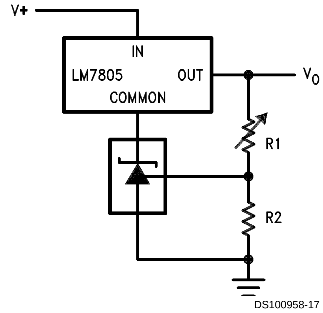
Typical Applications

Series Regulator



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

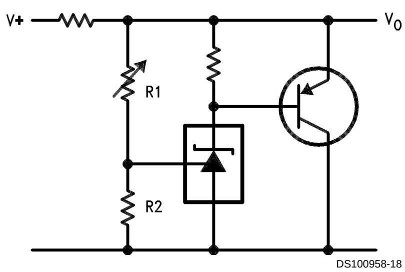
Output Control of a Three Terminal Fixed Regulator



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

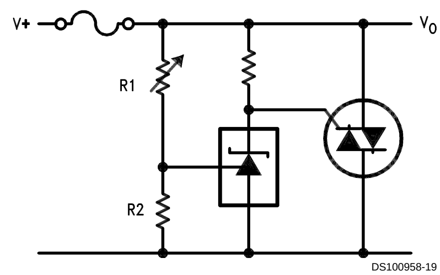
$$V_{O\ MIN} = V_{REF} + 5V$$

Higher Current Shunt Regulator



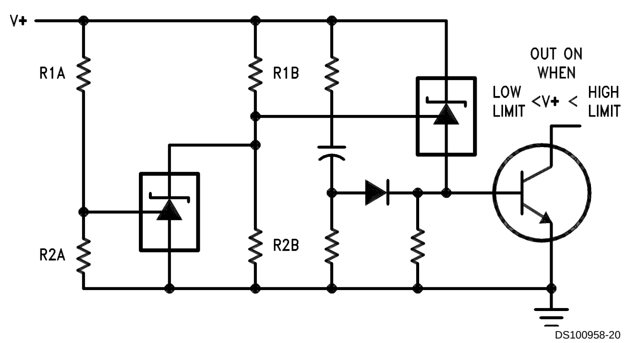
$$V_O \approx \left(1 + \frac{R1}{R2}\right) V_{REF}$$

Crow Bar



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

Over Voltage/Under Voltage Protection Circuit

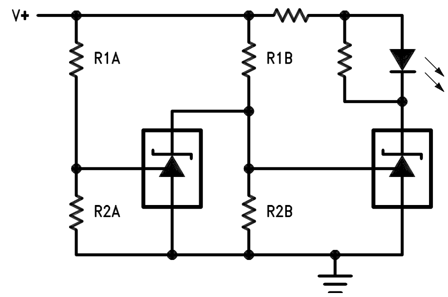


$$\text{LOW LIMIT} \approx V_{REF}\left(1 + \frac{R1B}{R2B}\right) + V_{BE}$$

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

Typical Applications (Continued)

Voltage Monitor



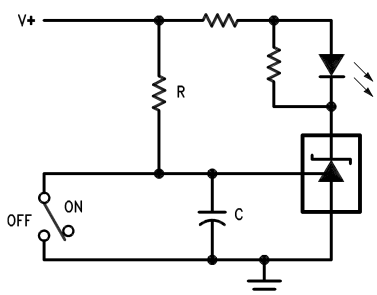
DS100958-21

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

LED ON WHEN
LOW LIMIT $< V^+ <$ HIGH LIMIT

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

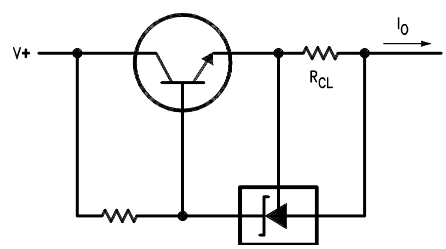
Delay Timer



DS100958-22

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

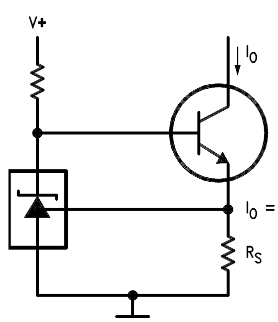
Current Limiter or Current Source



DS100958-23

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

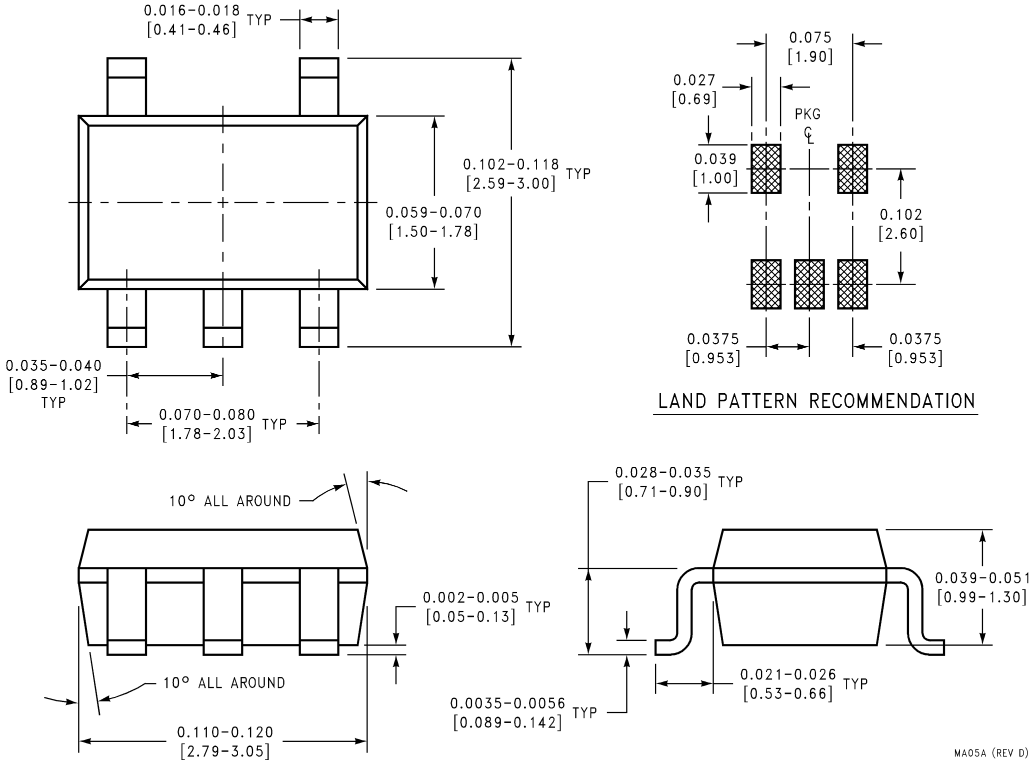
Constant Current Sink



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

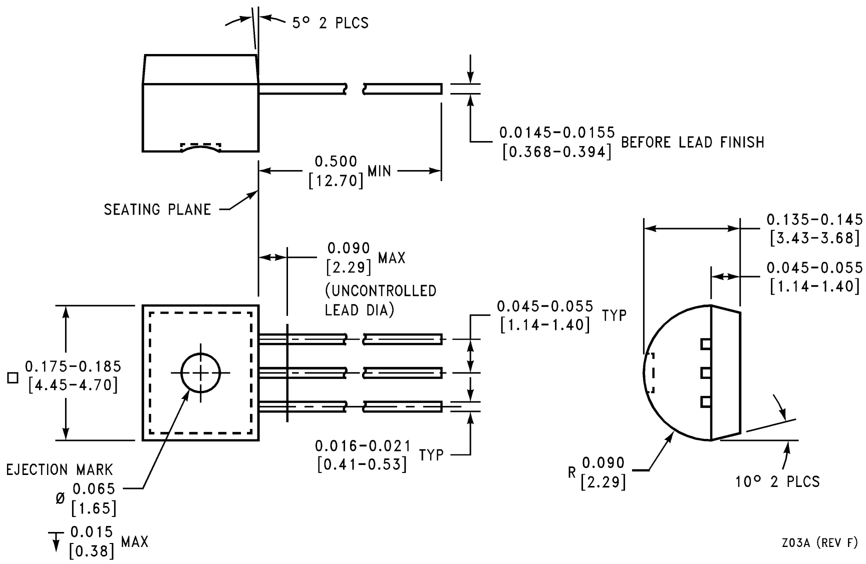
DS100958-24

Physical Dimensions inches (millimeters) unless otherwise noted



SOT23-5 Molded Small Outline Transistor Package (M5)
Order Number LMV431AIM5, LMV431AIM5X,
NS Package Number MA05A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Order Number LMV431AIZ, LMV431AIZX,
NS Package Number Z03A

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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