

LM431

Adjustable Precision Zener Shunt Regulator

General Description

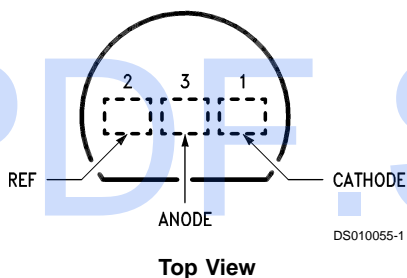
The LM431 is a 3-terminal adjustable shunt regulator with guaranteed temperature stability over the entire temperature range of operation. It is now available in a chip sized package (4-Bump micro SMD) using National's micro SMD package technology. The output voltage may be set at any level greater than 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

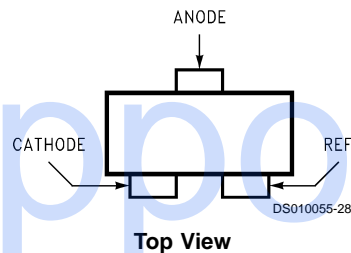
- Average temperature coefficient 50 ppm/°C
- Temperature compensated for operation over the full temperature range
- Programmable output voltage
- Fast turn-on response
- Low output noise
- LM431 in micro SMD package

Connection Diagrams

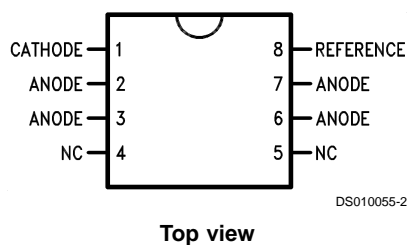
TO-92: Plastic Package



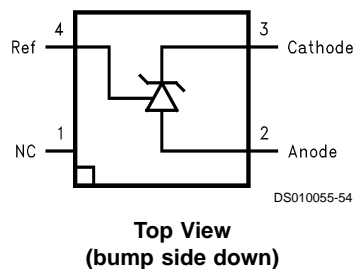
SOT-23: 3-Lead Small Outline



SO-8: 8-Pin Surface Mount



4-Bump micro SMD



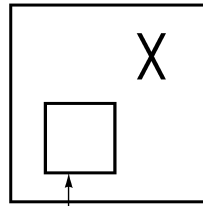
Ordering Information

Package	Typical Accuracy Order Number/Package Marking			Temperature Range	Transport Media	NSC Drawing
	0.5%	1%	2%			
TO-92	LM431CCZ/ LM431CCZ	LM431BCZ/ LM431BCZ	LM431ACZ/ LM431ACZ	0°C to +70°C	Rails	Z03A
	LM431CIZ/ LM431CIZ	LM431BIZ/ LM431BIZ	LM431AIZ/ LM431AIZ	-40°C to +85°C		
SO-8	LM431CCM/ 431CCM	LM431BCM/ 431BCM	LM431ACM/ LM431ACM	0°C to +70°C	Rails and Tape & Reel	M08A
	LM431CIM/ 431CIM	LM431BIM/ 431BIM	LM431AIM/ LM431AIM	-40°C to +85°C		
SOT-23	LM431CCM3/ N1B	LM431BCM3/ N1D	LM431ACM3/ N1F	0°C to +70°C	Rails and Tape & Reel	MF03A
	LM431CIM3 N1A	LM431BIM3 N1C	LM431AIM3 N1E	-40°C to +85°C		
micro SMD	-	-	LM431AIBP LM431AIBPX(Note 1)	-40°C to +85°C	250 Units Tape and Reel 3k Units Tape and Reel	BPA04AFA

Note 1: The micro SMD package marking is a 1 digit manufacturing Date Code only

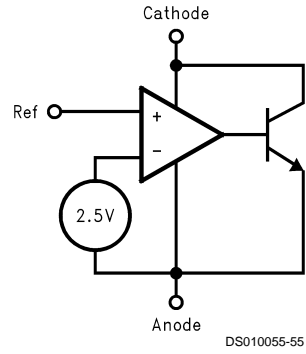
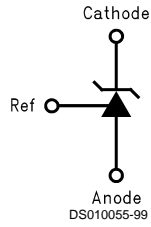
micro SMD Top View Marking Example

X = Date Code



Pin 1 Identifier
DS010055-56

Symbol and Functional Diagrams



DC Test Circuits

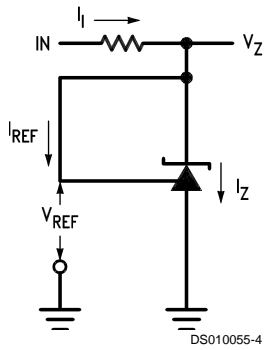
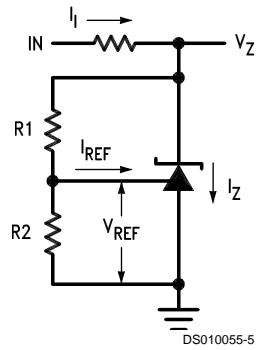


FIGURE 1. Test Circuit for $V_Z = V_{REF}$



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

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

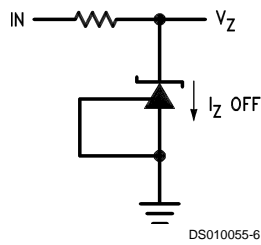


FIGURE 3. Test Circuit for Off-State Current

Absolute Maximum Ratings (Note 2)

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 (LM431xI)	-40°C to +85°C
Commercial (LM431xC)	0°C to +70°C
Soldering Information	
Infrared or Convection (20 sec.)	235°C
Wave Soldering (10 sec.)	260°C (lead temp.)
Cathode Voltage	37V
Continuous Cathode Current	-10 mA to +150 mA

Reference Voltage	-0.5V
Reference Input Current	10 mA
Internal Power Dissipation (Notes 3, 4)	
TO-92 Package	0.78W
SO-8 Package	0.81W
SOT-23 Package	0.28W
micro SMD Package	0.30W

Operating Conditions

	Min	Max
Cathode Voltage	V_{REF}	37V
Cathode Current	1.0 mA	100 mA

LM431
Electrical Characteristics

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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{REF}	Reference Voltage	$V_Z = V_{REF}$, $I_I = 10\text{ mA}$ LM431A (Figure 1)	2.440	2.495	2.550	V
		$V_Z = V_{REF}$, $I_I = 10\text{ mA}$ LM431B (Figure 1)	2.470	2.495	2.520	V
		$V_Z = V_{REF}$, $I_I = 10\text{ mA}$ LM431C (Figure 1)	2.485	2.500	2.510	V
V_{DEV}	Deviation of Reference Input Voltage Over Temperature (Note 5)	$V_Z = V_{REF}$, $I_I = 10\text{ mA}$, $T_A = \text{Full Range}$ (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	$I_Z = 10\text{ mA}$, V_Z from V_{REF} to 10V (Figure 2)		-1.4	-2.7	mV/V
		V_Z from 10V to 36V		-1.0	-2.0	
I_{REF}	Reference Input Current	$R_1 = 10\text{ k}\Omega$, $R_2 = \infty$, $I_I = 10\text{ mA}$ (Figure 2)		2.0	4.0	μA
∞I_{REF}	Deviation of Reference Input Current over Temperature	$R_1 = 10\text{ k}\Omega$, $R_2 = \infty$, $I_I = 10\text{ mA}$, $T_A = \text{Full Range}$ (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	$V_Z = 36\text{V}$, $V_{REF} = 0\text{V}$ (Figure 3)		0.3	1.0	μA
r_Z	Dynamic Output Impedance (Note 6)	$V_Z = V_{REF}$, LM431A, Frequency = 0 Hz (Figure 1)			0.75	Ω
		$V_Z = V_{REF}$, LM431B, LM431C Frequency = 0 Hz (Figure 1)			0.50	Ω

Note 2: 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.

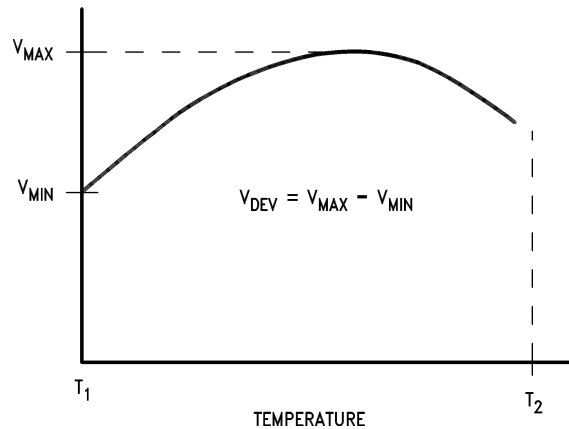
Note 3: $T_{J\text{ Max}} = 150^\circ\text{C}$.

Note 4: Ratings apply to ambient temperature at 25°C. Above this temperature, derate the TO-92 at 6.2 mW/°C, the SO-8 at 6.5 mW/°C, the SOT-23 at 2.2 mW/°C and the micro SMD at 3mW/°C.

Note 5: Deviation of reference input voltage, V_{DEV} , is defined as the maximum variation of the reference input voltage over the full temperature range.

LM431

Electrical Characteristics (Continued)



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

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

Where:

$T_2 - T_1$ = full temperature change (0-70°C).

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

Example: $V_{DEV} = 8.0 \text{ mV}$, $V_{REF} = 2495 \text{ mV}$, $T_2 - T_1 = 70^{\circ}\text{C}$, slope is positive.

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

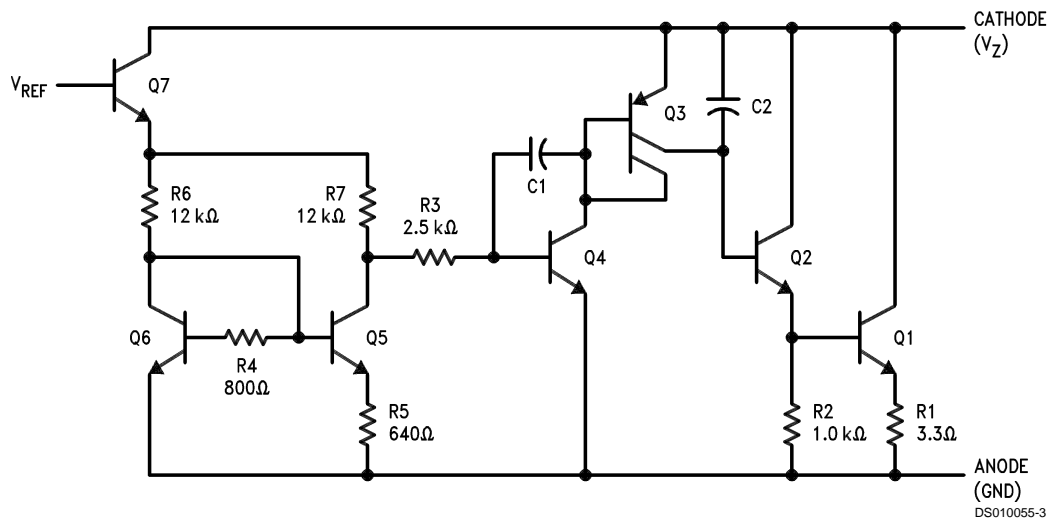
Note 6: The dynamic output impedance, r_z , is defined as:

$$r_z = \frac{\Delta V_z}{\Delta I_z}$$

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:

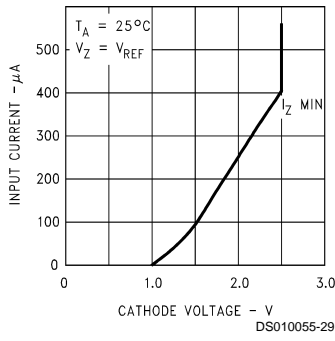
$$r_z = \frac{\Delta V_z}{\Delta I_z} \approx \left[r_z \left(1 + \frac{R1}{R2} \right) \right]$$

Equivalent Circuit

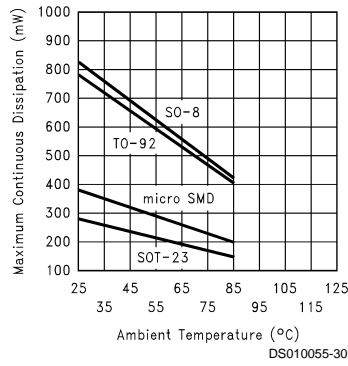


Typical Performance Characteristics

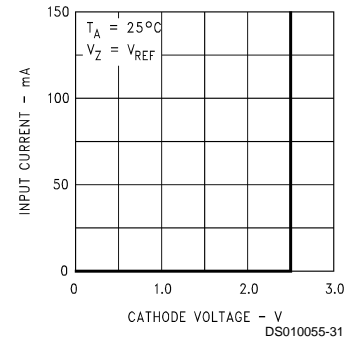
Input Current vs V_Z



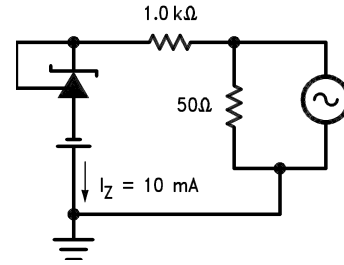
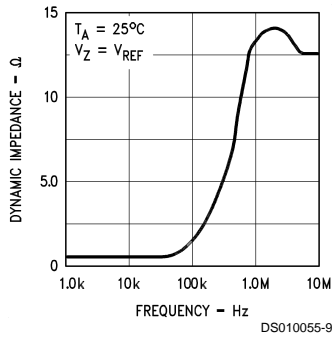
Thermal Information



Input Current vs V_Z

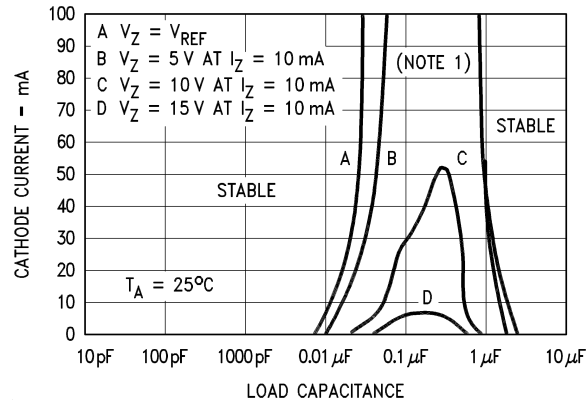


Dynamic Impedance vs Frequency



DS010055-10

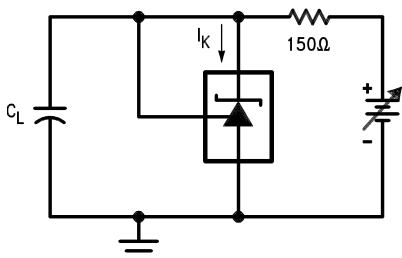
Stability Boundary Conditions



DS010055-11

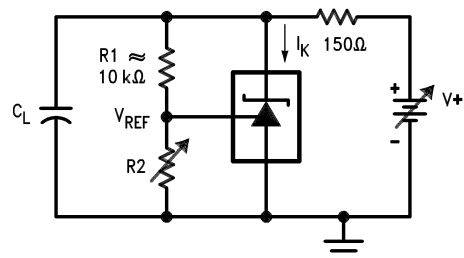
Note: The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R_2 and V^+ were adjusted to establish the initial V_Z and I_Z conditions with $C_L = 0$. V^+ and C_L were then adjusted to determine the ranges of stability.

Test Circuit for Curve A Above



DS010055-12

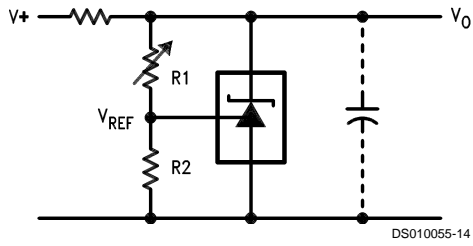
Test Circuit for Curves B, C and D Above



DS010055-13

Typical Applications

Shunt Regulator



DS010055-14

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

Single Supply Comparator with Temperature Compensated Threshold



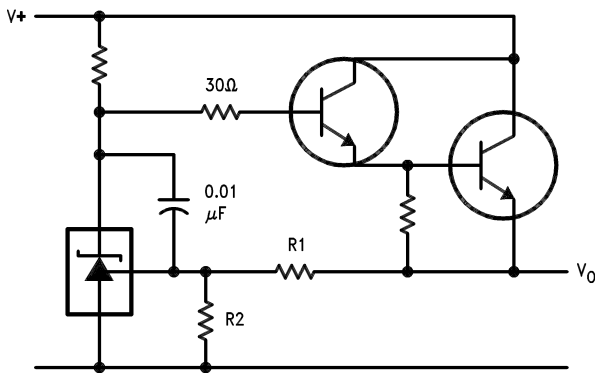
DS010055-15

$$V_{ON} \approx 2V$$

$$V_{OFF} = V+$$

$$V_{TH} \approx 2.5V$$

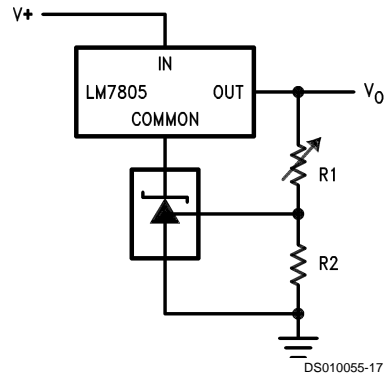
Series Regulator



DS010055-16

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

Output Control of a Three Terminal Fixed Regulator

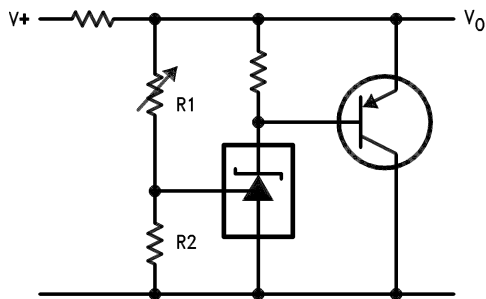


DS010055-17

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

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

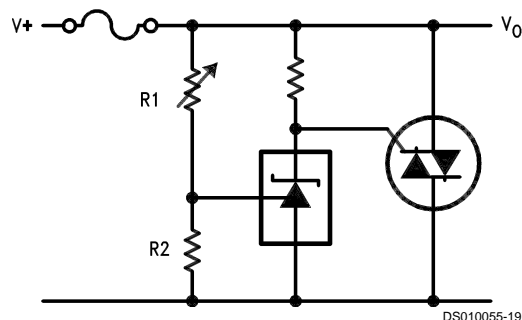
Higher Current Shunt Regulator



DS010055-18

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

Crow Bar

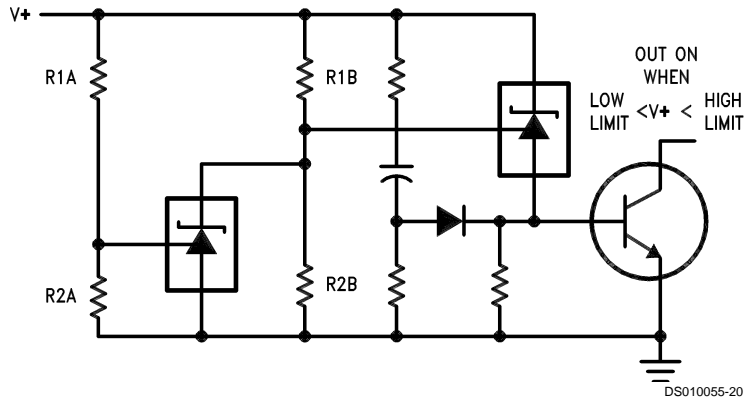


DS010055-19

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

Typical Applications (Continued)

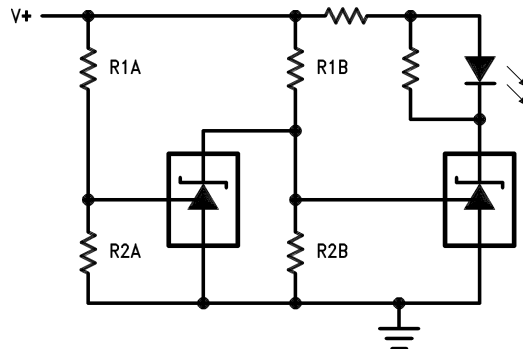
Over Voltage/Under Voltage Protection Circuit



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

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

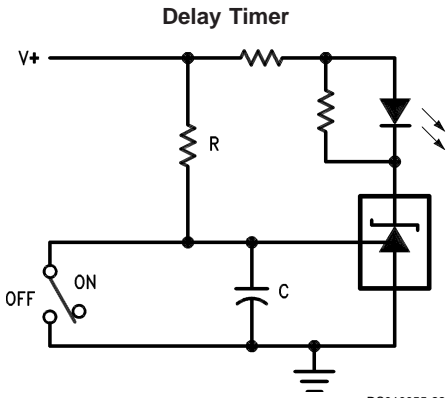
Voltage Monitor



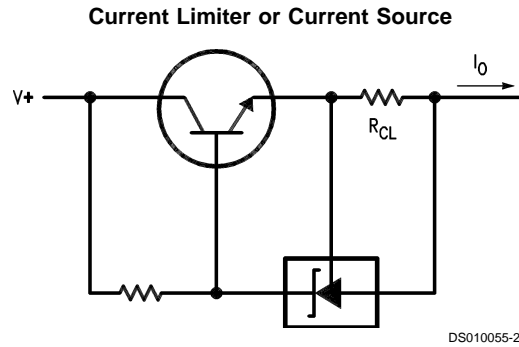
$$\text{LOW LIMIT} \approx V_{\text{REF}} \left(1 + \frac{R1B}{R2B} \right) \quad \text{LED ON WHEN LOW LIMIT} < V^+ < \text{HIGH LIMIT}$$

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

Typical Applications (Continued)

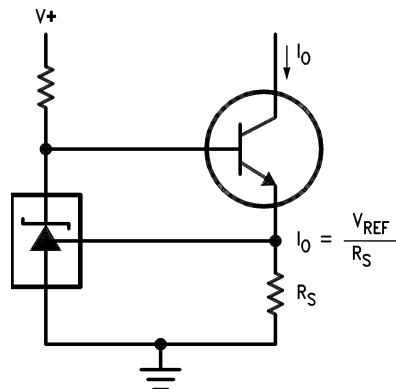


$$\text{DELAY} = R \cdot C \cdot \ln \frac{V^+}{(V^+) - V_{\text{REF}}}$$



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

Constant Current Sink



DS010055-24

Application Info

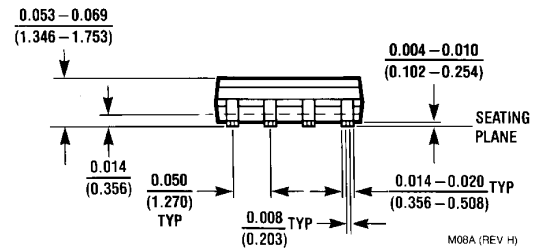
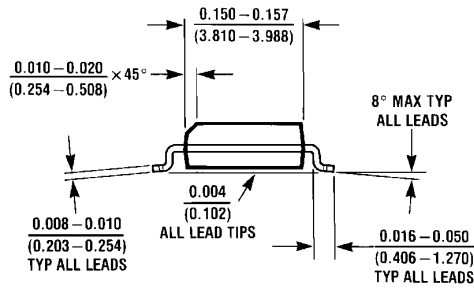
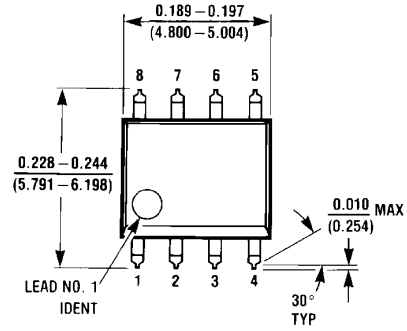
1.0 Mounting

To ensure that the geometry of the micro SMD package maintains good physical contact with the printed circuit board, pin 1 (NC) must be soldered to the pcb. Please see AN-1112 for more detailed information regarding board mounting techniques for the micro SMD package.

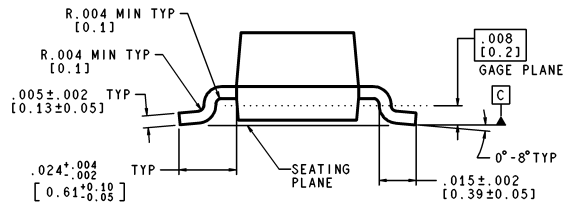
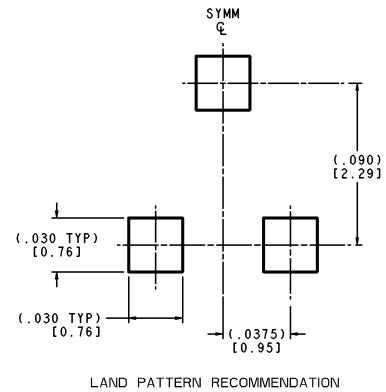
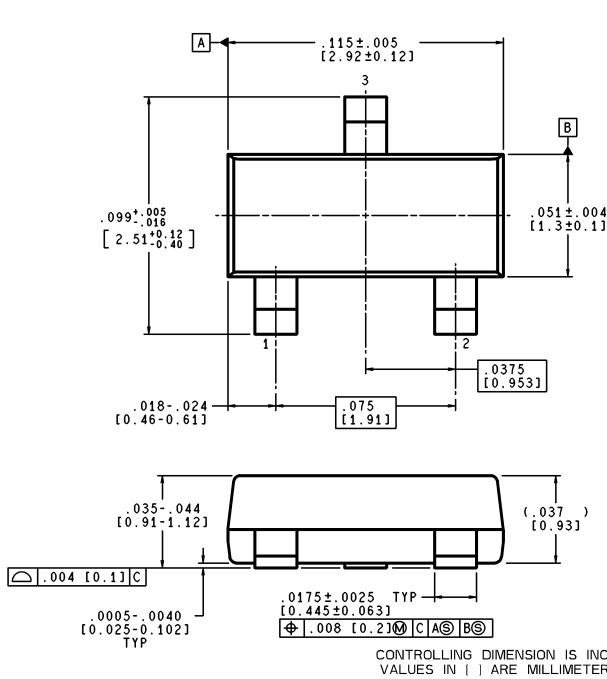
2.0 LM431 micro SMD Light Sensitivity

When the LM431 micro SMD package is exposed to bright sunlight, normal office fluorescent light, and other LED's and lasers, it operates within the guaranteed limits specified in the electrical characteristics table.

Physical Dimensions inches (millimeters) unless otherwise noted



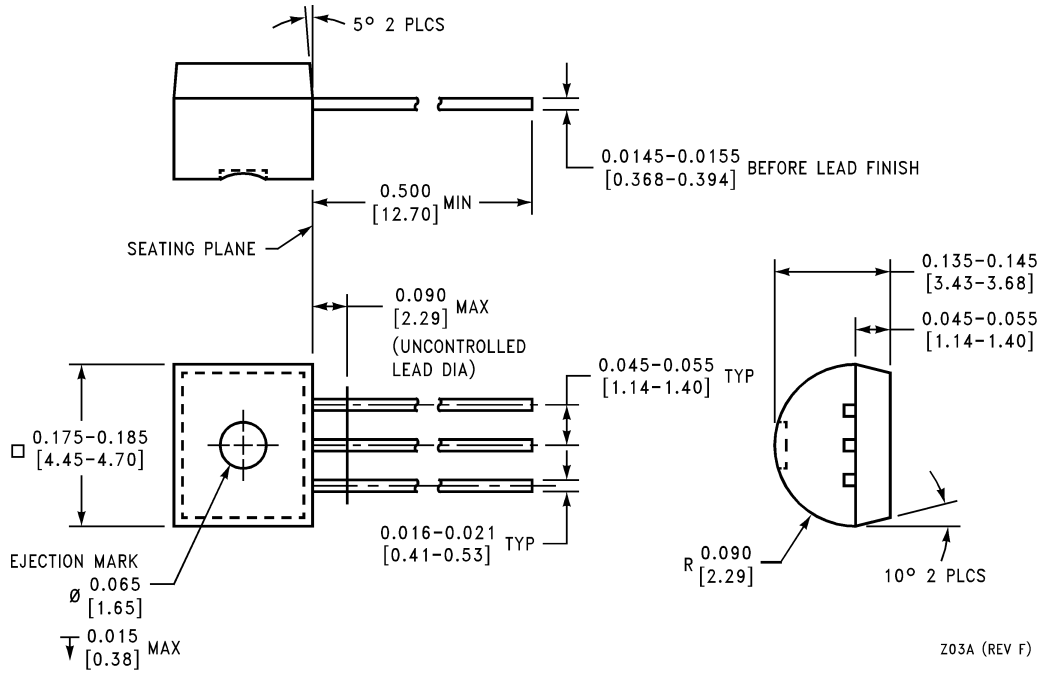
NS Package Number M08A



MF03A (Rev A)

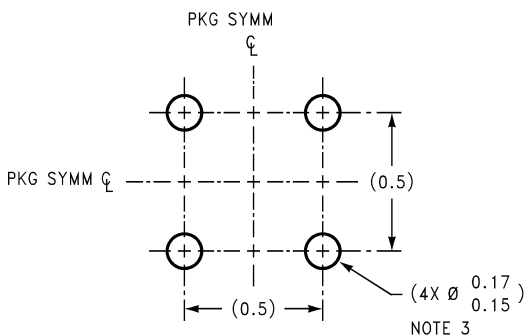
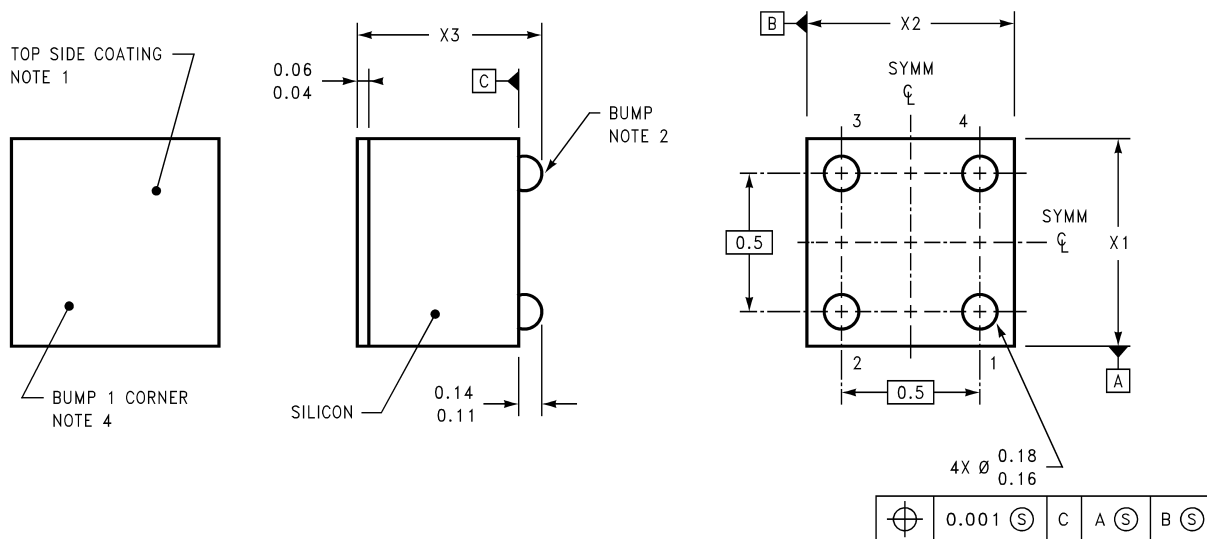
**SOT-23 Molded Small Outline Transistor Package (M3)
NS Package Number MF03A**

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



NS Package Number Z03A

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



DIMENSIONS ARE IN MILLIMETERS

LAND PATTERN RECOMMENDATION

BPA04XXX (REV A)

NOTES: UNLESS OTHERWISE SPECIFIED

1. EPOXY COATING
2. 63Sn/37Pb EUTECTIC BUMP
3. RECOMMEND NON-SOLDER MASK DEFINED LANDING PAD.
4. PIN 1 IS ESTABLISHED BY LOWER LEFT CORNER WITH RESPECT TO TEXT ORIENTATION. REMAINING PINS ARE NUMBERED.
5. XXX IN DRAWING NUMBER REPRESENTS PACKAGE SIZE VARIATION WHERE X1 IS PACKAGE WIDTH, X2 IS PACKAGE LENGTH AND X3 IS PACKAGE HEIGHT.
6. REFERENCE JEDEC REGISTRATION MO-211, VARIATION BA.

4-Bump micro SMD
X1 = 0.777 X2 = 0.904 X3 = 0.700
NS Package Number BPA04AFA

Notes

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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.

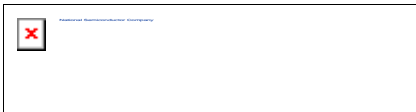


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Fax: 81-3-5639-7507



[See Micro SMD Package](#)

LM431 Adjustable Precision Zener Shunt Regulator

Generic P/N 431

Contents

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- [Design Tools](#)
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



General Description

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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
- LM431 in micro SMD package

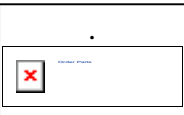
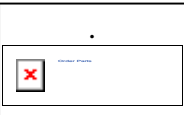


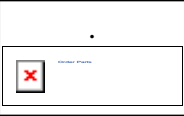






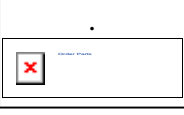
Datasheet

Title	Size (in Kbytes)	Date	 View Online	 Download	 Receive via Email
LM431 Adjustable Precision Zener Shunt Regulator	391 Kbytes	15-May-00	View Online	Download	Receive via Email
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Package Availability, Models, Samples & Pricing

Part Number	Package		Status	Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking
	Type	# pins		SPICE	IBIS		Quantity	\$US each		
LM431AIBP	MicroSMD	4	Full production	N/A	N/A	Samples 	1K+	\$0.1500	reel of 250	ø1
LM431AIBPX	MicroSMD	4	Full production	N/A	N/A		1K+	\$0.1500	reel of 3000	ø1
LM431ENG	SOIC NARROW	8	Preliminary	N/A	N/A	.			tube of N/A	-

LM431ACM	SOIC NARROW	8	Full production	N/A	N/A		2500+	\$0.1480	tube of 95	[logo]ϵ2ϵT LM431 ACM
LM431AIM	SOIC NARROW	8	Full production	N/A	N/A		2500+	\$0.1920	tube of 95	[logo]ϵ2ϵT LM431 AIM
LM431BCM	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.2500	tube of 95	[logo]ϵ2ϵT 431 BCM
LM431BIM	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.3300	tube of 95	[logo]ϵ2ϵT 431 BIM
LM431CCM	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.7400	tube of 95	[logo]ϵ2ϵT 431 CCM
LM431CIM	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.8600	tube of 95	[logo]ϵ2ϵT 431 CIM
LM431ACMX	SOIC NARROW	8	Full production	N/A	N/A		2500+	\$0.1480	reel of 2500	[logo]ϵ2ϵT LM431 ACM
LM431AIMX	SOIC NARROW	8	Full production	N/A	N/A		2500+	\$0.1920	reel of 2500	[logo]ϵ2ϵT LM431 AIM
LM431BCMx	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.2800	reel of 2500	[logo]ϵ2ϵT 431 BCM
LM431BIMx	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.3600	reel of 2500	[logo]ϵ2ϵT 431 BIM
LM431CCMX	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.7700	reel of 2500	[logo]ϵ2ϵT 431 CCM
LM431CIMX	SOIC NARROW	8	Full production	N/A	N/A		1K+	\$0.8900	reel of 2500	[logo]ϵ2ϵT 431 CIM

LM431ACM3	SOT-23	3	Full production	N/A	N/A	Samples 	1K+	\$0.1800	reel of 1000	N1F ¢1¢T
LM431AIM3	SOT-23	3	Full production	N/A	N/A	Samples 	1K+	\$0.3000	reel of 1000	N1E ¢1¢T
LM431BCM3	SOT-23	3	Full production	N/A	N/A	Samples 	1K+	\$0.2500	reel of 1000	N1D ¢1¢T
LM431BIM3	SOT-23	3	Full production	N/A	N/A	Samples 	1K+	\$0.3300	reel of 1000	N1C ¢1¢T
LM431CCM3	SOT-23	3	Full production	N/A	N/A	Samples	1K+	\$0.7400	reel of 1000	N1B ¢1¢T
LM431CIM3	SOT-23	3	Full production	N/A	N/A	Samples 	1K+	\$0.8600	reel of 1000	N1A ¢1¢T
LM431ACM3X	SOT-23	3	Full production	N/A	N/A		1K+	\$0.1800	reel of 3000	N1F ¢1¢T
LM431AIM3X	SOT-23	3	Full production	N/A	N/A	.	1K+	\$0.3000	reel of 3000	N1E ¢1¢T
LM431BCM3X	SOT-23	3	Full production	N/A	N/A		1K+	\$0.2500	reel of 3000	N1D ¢1¢T
LM431BIM3X	SOT-23	3	Full production	N/A	N/A		1K+	\$0.3300	reel of 3000	N1C ¢1¢T
LM431CCM3X	SOT-23	3	Full production	N/A	N/A	.	1K+	\$0.7400	reel of 3000	N1B ¢1¢T
LM431CIM3X	SOT-23	3	Full production	N/A	N/A	.	1K+	\$0.8600	reel of 3000	N1A ¢1¢T








LM431ACZ	TO 92	3	Full production	N/A	N/A		2500+	\$0.1480	box of 1800	[logo]¢2¢T LM431 ACZ
LM431AIZ	TO 92	3	Full production	N/A	N/A		2500+	\$0.1920	box of 1800	[logo]¢2¢T LM431 AIZ
LM431BCZ	TO 92	3	Full production	N/A	N/A		1K+	\$0.2500	box of 1800	[logo]¢2¢T LM431 BCZ
LM431BIZ	TO 92	3	Full production	N/A	N/A		1K+	\$0.3300	box of 1800	[logo]¢2¢T LM431 BIZ
LM431CCZ	TO 92	3	Full production	N/A	N/A		1K+	\$0.7400	box of 1800	[logo]¢2¢T LM431 CCZ
LM431CIZ	TO 92	3	Full production	N/A	N/A		1K+	\$0.8600	box of 1800	[logo]¢2¢T LM431 CIZ
LM431J-MLS	Cerdip	8	Lifetime buy	N/A	N/A	.			tube of N/A	[logo]¢Z¢S¢4¢A\$E LM431J-MLS

Design Tools

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LM431AIBP Micro SMD Qualification Package	4172 Kbytes	17-Apr-2000	View Online	Download	Receive via Email

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Application Notes

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AN-1112: Application Note 1112 Micro SMD Wafer Level Chip Scale Package	4057 Kbytes	15-Aug-00	View Online	Download	Receive via Email
Application Note 1112 Micro SMD Wafer Level Chip Scale Package (JAPANESE) 	247 Kbytes				

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