LM4431 Micropower Shunt Voltage Reference

Check for Samples: LM4431

FEATURES

- **Small package: SOT-23**
- **No output capacitor required**
- **Tolerates capacitive loads**
- **Fixed reverse breakdown voltage of 2.50V**

APPLICATIONS

- **Portable, Battery-Powered Equipment**
- **Data Acquisition Systems**
- **Instrumentation**
- **Process Control**
- **Energy Management**
- **Product Testing**
- **Power Supplies**

DESCRIPTION

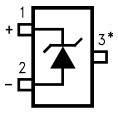
Ideal for space critical applications, the LM4431 voltage reference is available in the sub-miniature (3 mm x 1.3 mm) SOT-23 surface-mount package. The LM4431's advanced design eliminates the need for an external stabilizing capacitor while ensuring stability with any capacitive load, thus making the LM4431 easy to use. The operating current range is 100 µA to 15 mA.

The LM4431 utilizes fuse and zener-zap reverse breakdown voltage trim during wafer sort to ensure that the parts have an accuracy of better than ±2.0% at 25°C. Bandgap reference temperature drift curvature correction and low dynamic impedance ensure stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents.

Table 1. Key Specifications

	VALUE	UNIT
Output voltage tolerance	25°C: ±2.0% (max)	
Low output noise (10 Hz to 10 kHz)	35 µV	$_{rms}$ (typ)
Wide operating current range	100 µA to 15 mA	
Commercial temperature range	0 to +70	°C
Low temperature coefficient	30	ppm/°C (typ)

Connection Diagram



* This pin must be left floating or connected to pin 2.

Figure 1. SOT-23 (Top View)

SOT-23 Package Marking Information

Only three fields of marking are possible on the SOT-23's small surface. The following table gives the meaning of the three fields.

Part Marking	Field Definition
S2E	First Field:

Part Marking	Field Definition
	S = Reference
	Second Field:
	2 = 2.500V Voltage Option
	Third Field:
	E = Initial Reverse Breakdown Voltage Tolerance of ±2.0%

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings (1)

Reverse Current	20 mA
Forward Current	10 mA
Power Dissipation (T_A = 25°C) (2)	
M3 Package	306 mW
Storage Temperature	−65°C to +150°C
Lead Temperature	
M3 Package	
Vapor phase (60 seconds)	+215°C
Infrared (15 seconds)	+220°C
ESD Susceptibility	
Human Body Model (3)	2 kV
Machine Model (3)	200V
See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.	

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

(2) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $PD_{max} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4431, T_{Jmax} = 125°C, and the typical thermal resistance (θ_{JA}), when board mounted, is 326°C/W for the SOT-23 package.

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

Operating Ratings (1) (2)

Temperature Range	
($T_{min} \le T_A \le T_{max}$)	$0°C \le T_A \le +70°C$
Reverse Current	
LM4431-2.5	100 µA to 15 mA

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LM4431-2.5
Electrical Characteristics

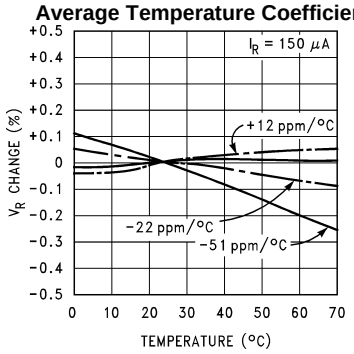
Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX}; all other limits $T_A = T_J = 25°C$.

Symbol	Parameter	Conditions	Typical	LM4431M3	Units
			(1)	Limits	(Limit)
				(2)	
V_R	Reverse Breakdown Voltage	I_R = 100 µA	2.500		V
	Reverse Breakdown VoltageTolerance	I_R = 100 µA		±50	mV (max)
I_{RMIN}	Minimum Operating Current		45		µA
				100	µA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown	I_R = 10 mA	±30		ppm/°C
	Voltage Temperature	I_R = 1 mA	±30		ppm/°C
	Coefficient	I_R = 100 µA	±30		ppm/°C
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage	$I_{RMIN} \le I_R \le$ 1 mA	0.4		mV
	Change with Operating			1.0	mV (max)
	Current Change			**1.2**	mV (max)
		1 mA $\le I_R \le$ 15 mA	2.5		mV
				8.0	mV (max)
				25	mV (max)
Z_R	Reverse Dynamic Impedance	I_R = 1 mA, f = 120 Hz	1.0		Ω
		$I_{AC} = 0.1\ I_R$			
e_N	Wideband Noise	I_R = 100 µA	35		μV_{rms}
		10 Hz ≤ f ≤ 10 kHz			
ΔV_R	Reverse Breakdown Voltage	t = 1000 hrs			
	Long Term Stability	T = 25°C ±0.1°C	120		ppm
		I_R = 100 µA			

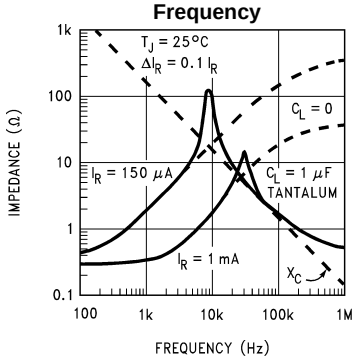
(1) Typicals are at T_J = 25°C and represent most likely parametric norm.
(2) Limits are 100% production tested at 25°C. Limits over temperature are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's AOQL.

Typical Performance Characteristics

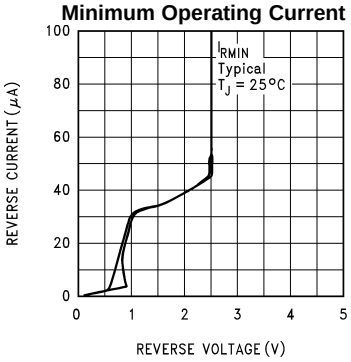
Temperature Drift for Different Average Temperature Coefficient



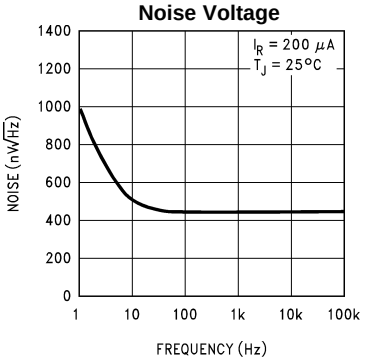
Output Impedance vs Frequency



Reverse Characteristics and Minimum Operating Current



Noise Voltage



Start-Up Characteristics

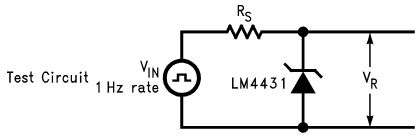


Figure 2. Test Circuit

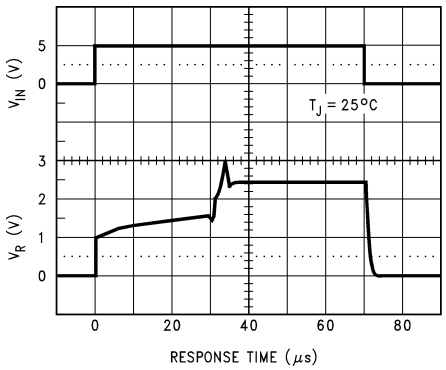
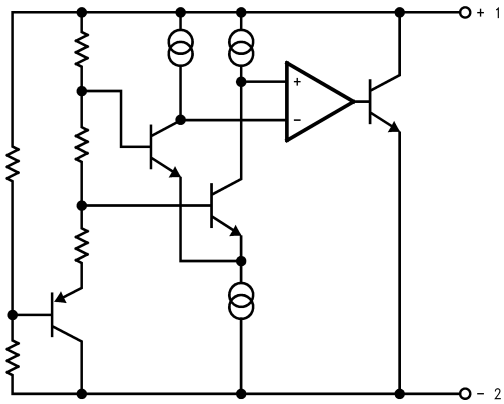


Figure 3. LM4431-2.5 R_S = 30k

Functional Block Diagram



Applications Information

The LM4431 is a micro-power curvature-corrected 2.5V bandgap shunt voltage reference. For space critical applications, the LM4431 is available in the sub-miniature SOT-23 surface-mount package. The LM4431 has been designed for stable operation without the need of an external capacitor connected between the "+" pin and the "−" pin. If, however, a bypass capacitor is used, the LM4431 remains stable. The operating current range is 100 µA to 15 mA.

The LM4431's SOT-23 package has a parasitic Schottky diode between pin 2 (−) and pin 3 (Die attach interface contact). Therefore, pin 3 of the SOT-23 package must be left floating or connected to pin 2.

In a conventional shunt regulator application (Figure 4) , an external series resistor (R_S) is connected between the supply voltage and the LM4431. R_S determines the current that flows through the load (I_L) and the LM4431 (I_Q). Since load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable I_Q to the LM4431 even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and I_L is at its minimum, R_S should be large enough so that the current flowing through the LM4431 is less than 15 mA.

R_S is determined by the supply voltage, (V_S), the load and operating current, (I_L and I_Q), and the LM4431's reverse breakdown voltage, V_R.

$$R_S = \frac{V_S - V_R}{I_L + I_Q} \tag{1}$$

Typical Applications

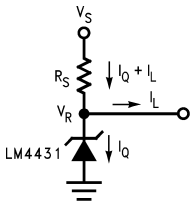


Figure 4. Shunt Regulator

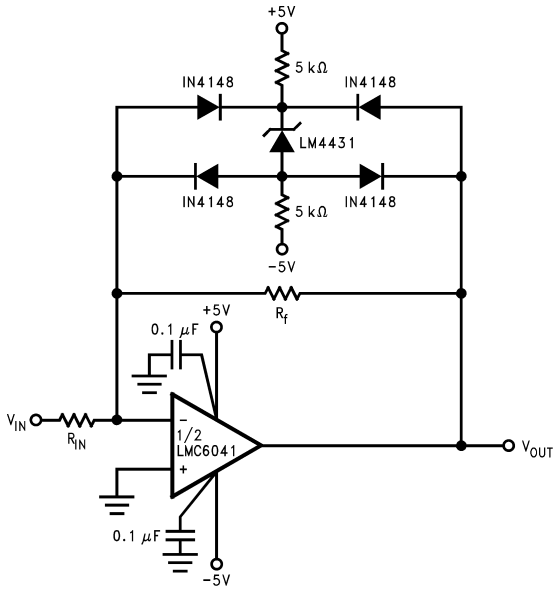


Figure 5. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage.
Nominal clamping voltage is ±3.9V (LM4431's reverse breakdown voltage +2 diode V_F).

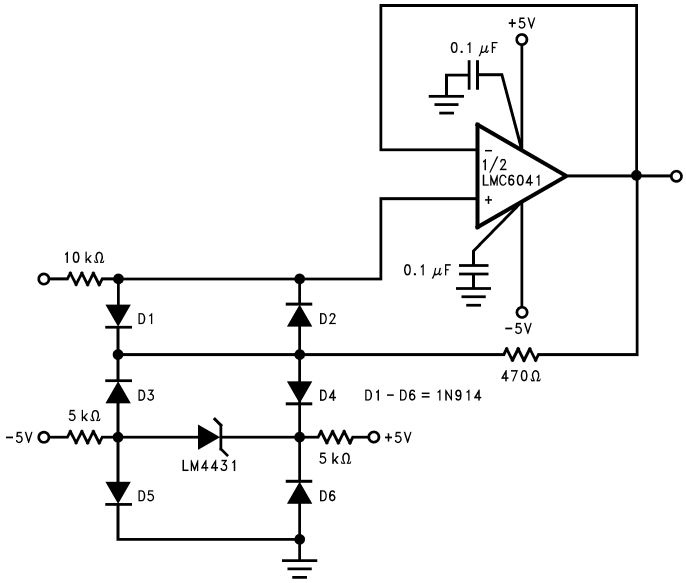
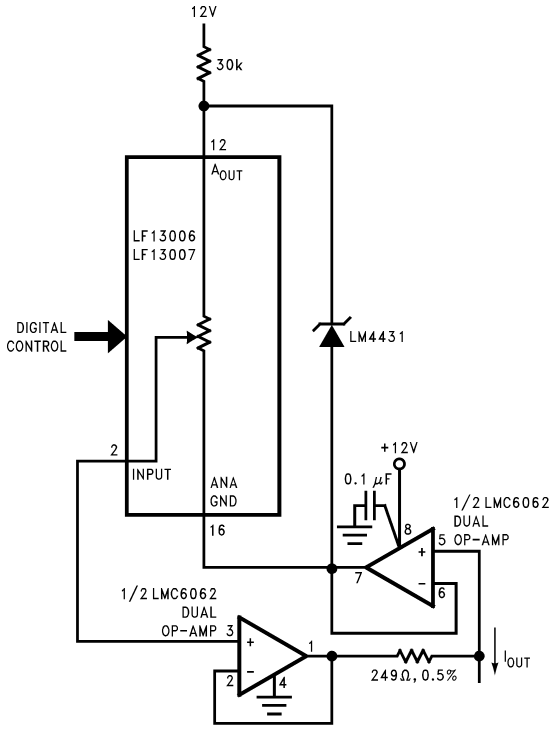
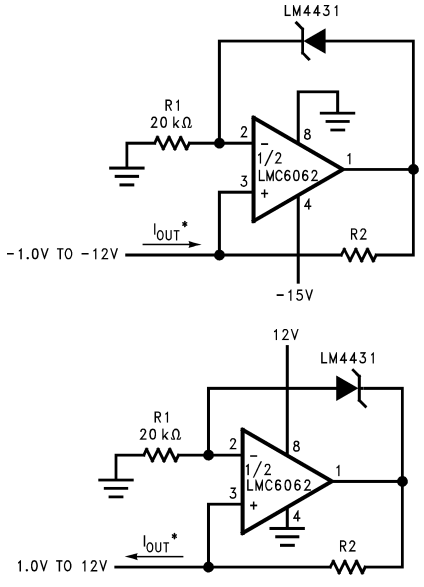


Figure 6. Protecting Op Amp input. The bounding voltage is ±4V with the LM4431 (LM4431's reverse breakdown voltage + 3 diode V_F).



$$I_{OUT} = \frac{2.5V}{249\Omega}\left[\frac{1}{\text{gain set \#}}\right]$$

Figure 7. Programmable Current Source



$$^{*}I_{OUT} = \frac{2.5V}{R2}$$

Figure 8. Precision 1 µA to 1 mA Current Sources

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LM4431M3-2.5	ACTIVE	SOT-23	DBZ	3	1000	TBD	Call TI	Call TI	0 to 70	S2E	Samples
LM4431M3-2.5/NOPB	ACTIVE	SOT-23	DBZ	3	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	S2E	Samples
LM4431M3X-2.5	ACTIVE	SOT-23	DBZ	3	3000	TBD	Call TI	Call TI	0 to 70	S2E	Samples
LM4431M3X-2.5/NOPB	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	S2E	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

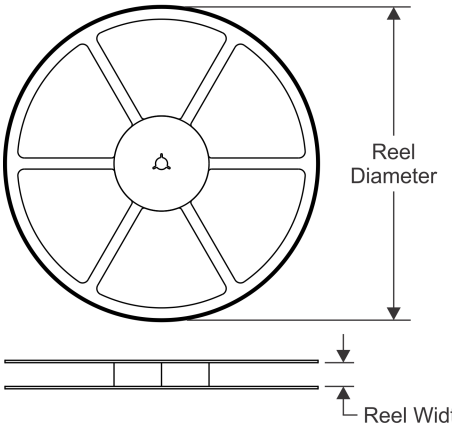
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

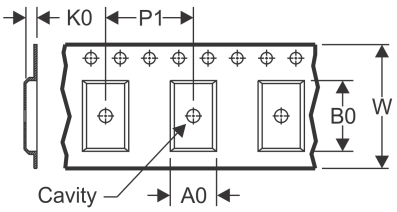
(4) Only one of markings shown within the brackets will appear on the physical device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

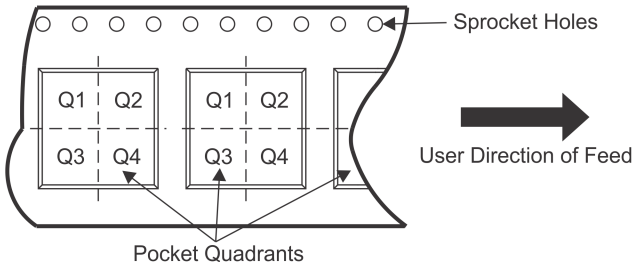


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

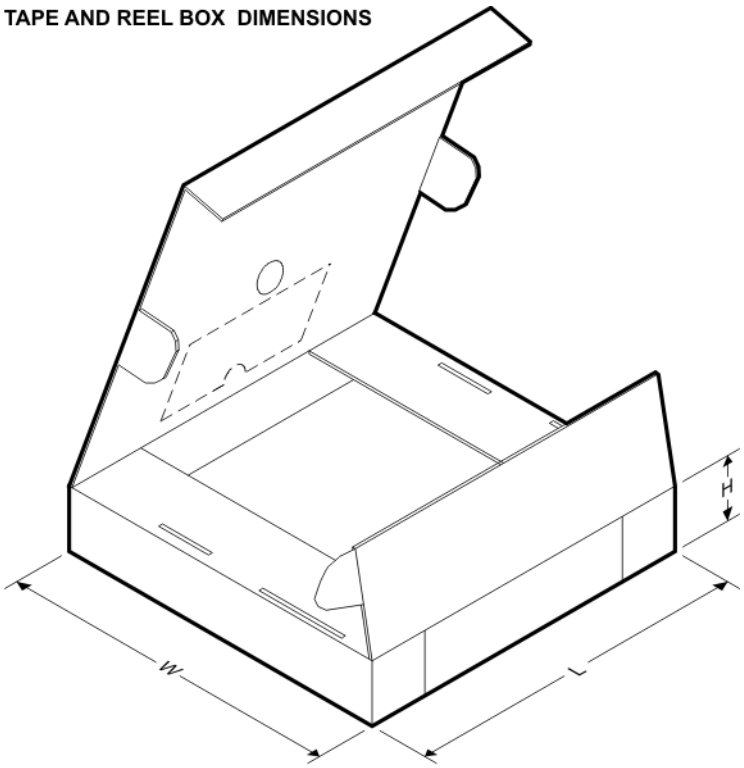
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM4431M3-2.5	SOT-23	DBZ	3	1000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	1000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3

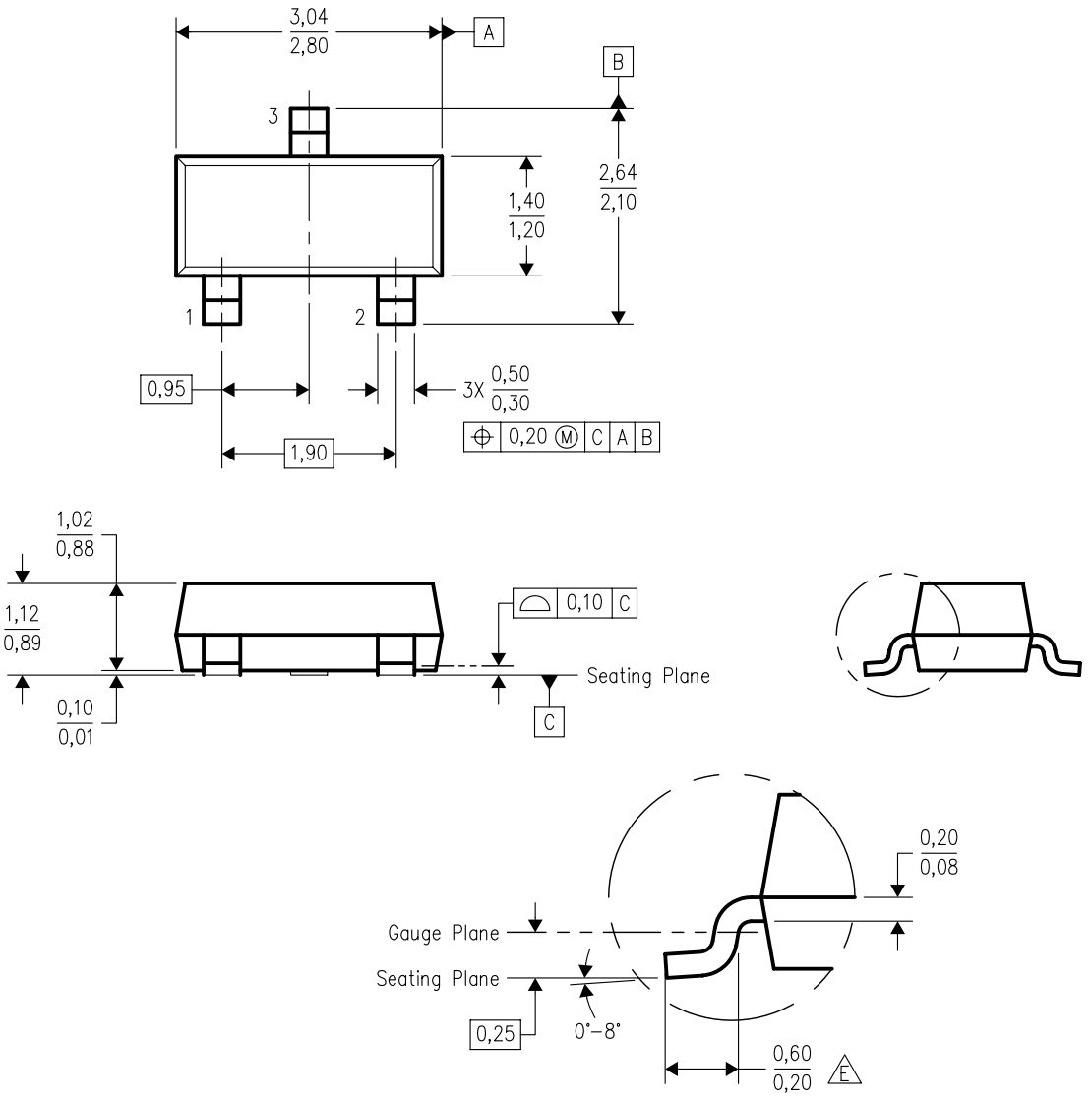
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4431M3-2.5	SOT-23	DBZ	3	1000	203.0	190.0	41.0
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	1000	203.0	190.0	41.0
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	206.0	191.0	90.0

DBZ (R–PDSO–G3) PLASTIC SMALL–OUTLINE



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Lead dimensions are inclusive of plating.
D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
E. Falls within JEDEC TO–236 variation AB, except minimum foot length.

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