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**

KEY SPECIFICATIONS

- **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)**

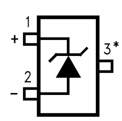
DESCRIPTION

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.

Connection Diagram

Top View



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

Figure 1. SOT-23 Package
See Package Number DBZ0003A

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][2]

Reverse Current			20 mA
Forward Current			10 mA
Power Dissipation (T_A = 25°C)[3]		DBZ0003A Package	306 mW
Storage Temperature			−65°C to +150°C
Lead Temperature	DBZ0003A Package	Vapor phase (60 seconds)	+215°C
		Infrared (15 seconds)	+220°C
ESD Susceptibility		Human Body Model[4]	2 kV
		Machine Model[4]	200V

(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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The specified 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) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) 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.
(4) 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 ≤ T_A ≤ +70°C
Reverse Current	LM4431-2.5	100 µA to 15 mA

(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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The specified 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.

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

(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 ensured through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.

Typical Performance Characteristics

Temperature Drift for Different Average Temperature Coefficient

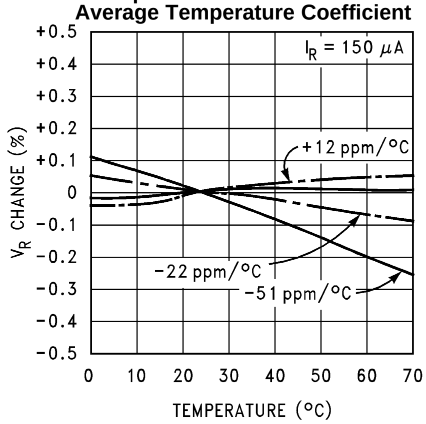


Figure 2.

Output Impedance vs Frequency

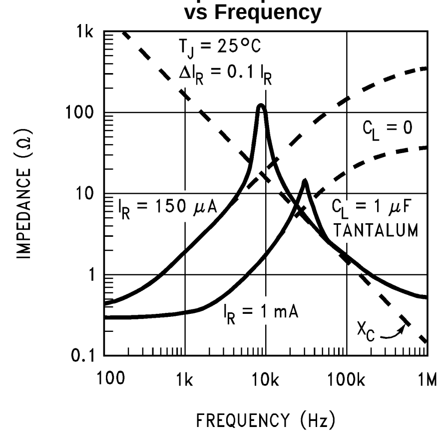


Figure 3.

Reverse Characteristics and Minimum Operating Current

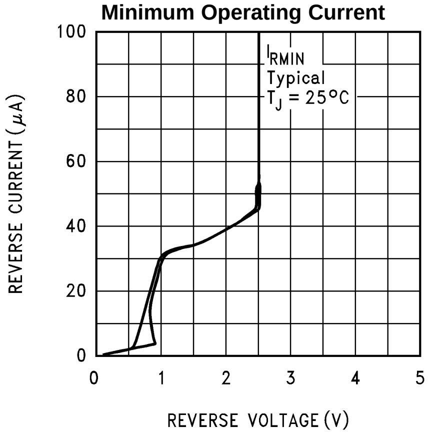


Figure 4.

Noise Voltage

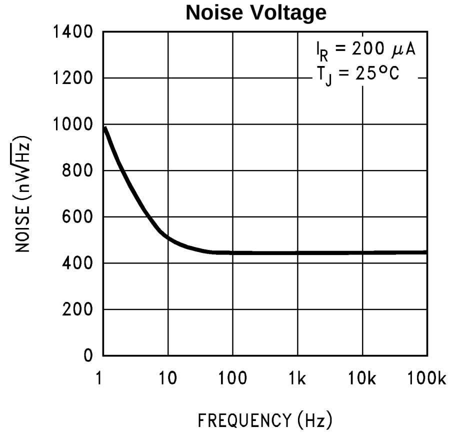


Figure 5.

Start-Up Characteristics

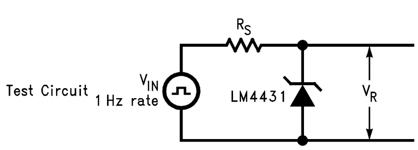


Figure 6. Test Circuit

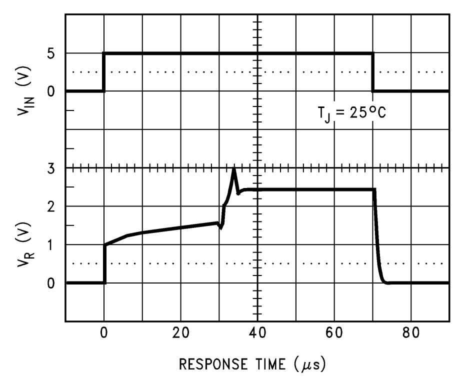
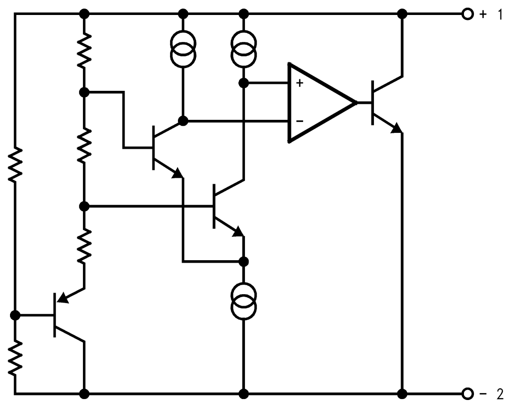


Figure 7. LM4431-2.5, R_S = 30k

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 8), 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

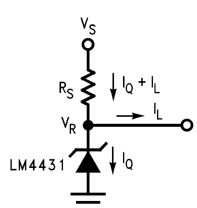


Figure 8. Shunt Regulator

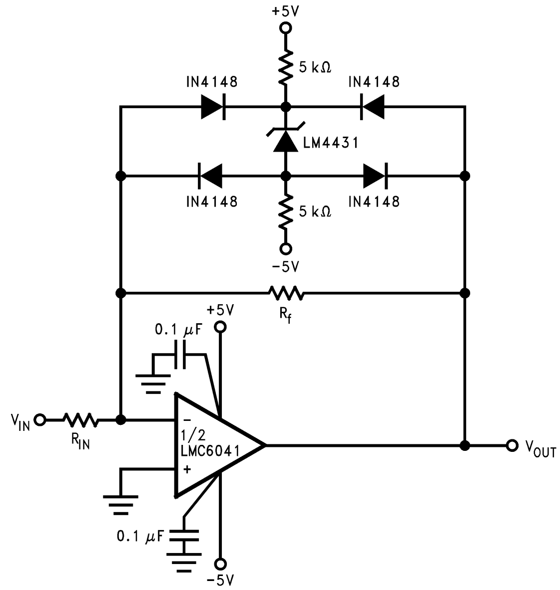


Figure 9. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage. Nominal clamping voltage is ±3.9V (LM4431's reverse breakdown voltage +2 diode V_F).

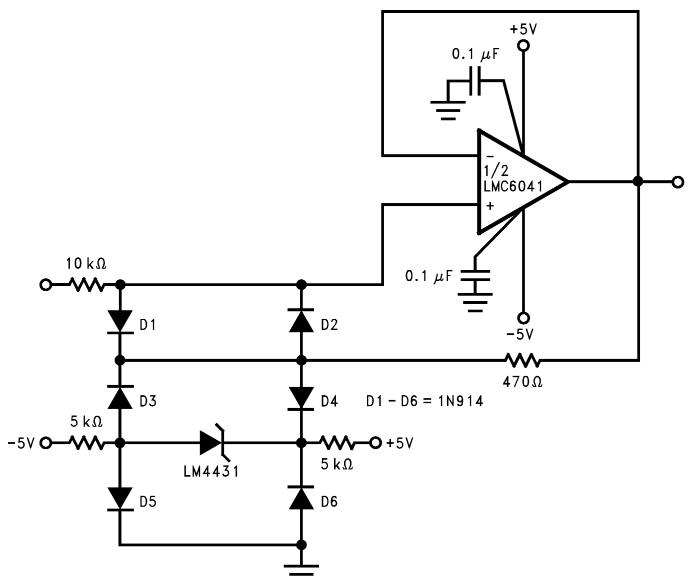
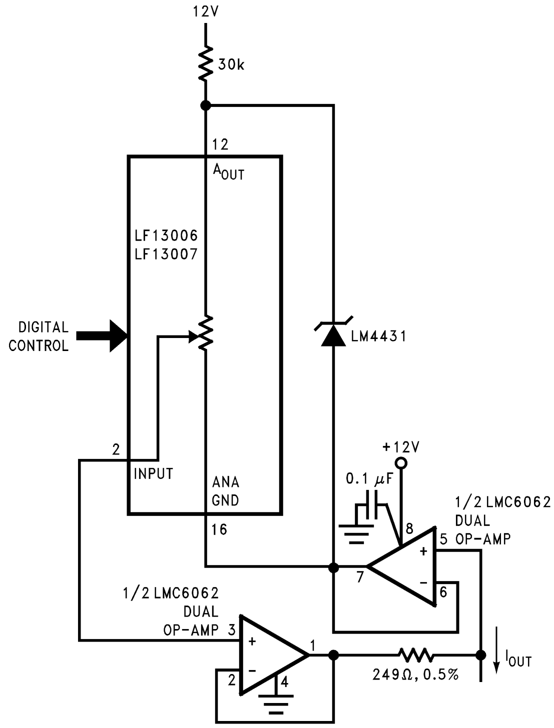
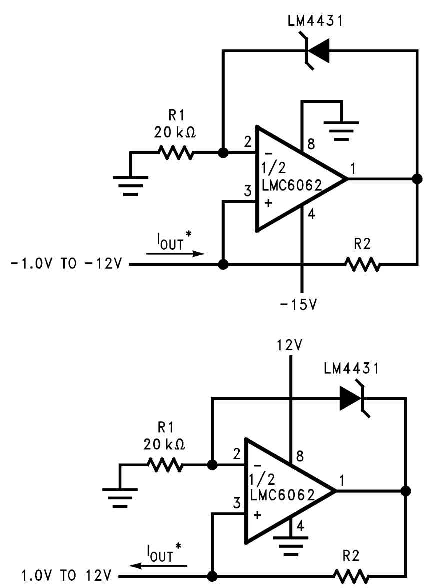


Figure 10. Protecting Op Amp input. The bounding voltage is ±4V with the LM4431 (LM4431's reverse breakdown voltage + 3 diode V_F).



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

Figure 11. Programmable Current Source



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

Figure 12. Precision 1 µA to 1 mA Current Sources

REVISION HISTORY

Changes from Revision B (April 2013) to Revision C	Page
• Changed layout of National Data Sheet to TI format	7

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM4431M3-2.5/NOPB	ACTIVE	SOT-23	DBZ	3	1000	RoHS & Green	SN	Level-1-260C-UNLIM	0 to 70	S2E	Samples
LM4431M3X-2.5/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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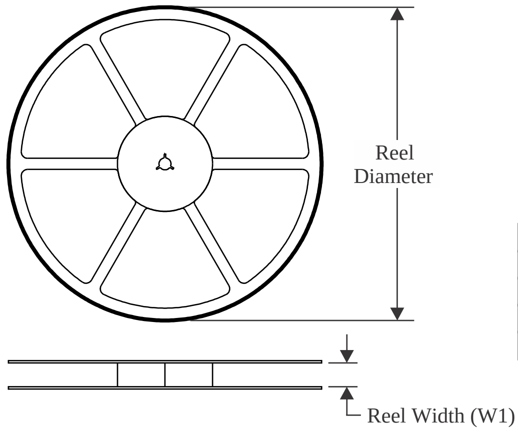
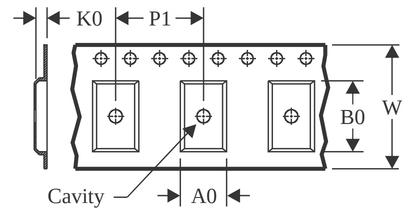
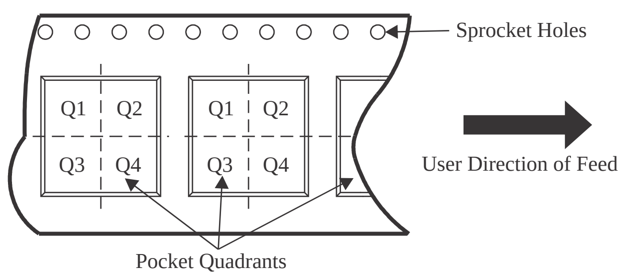
TAPE AND REEL INFORMATION





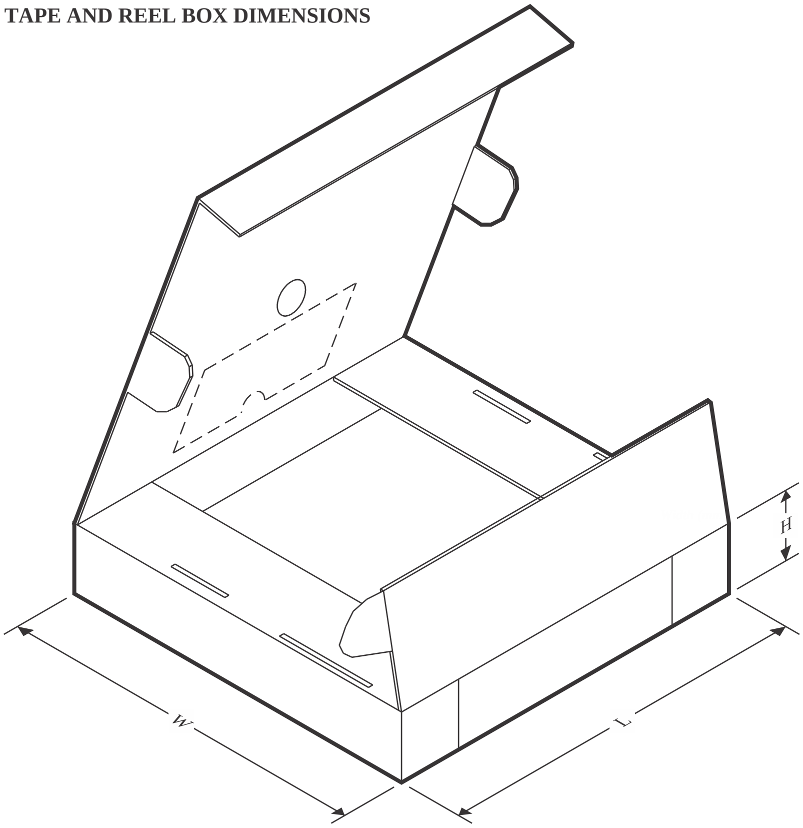
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*All dimensions are nominal

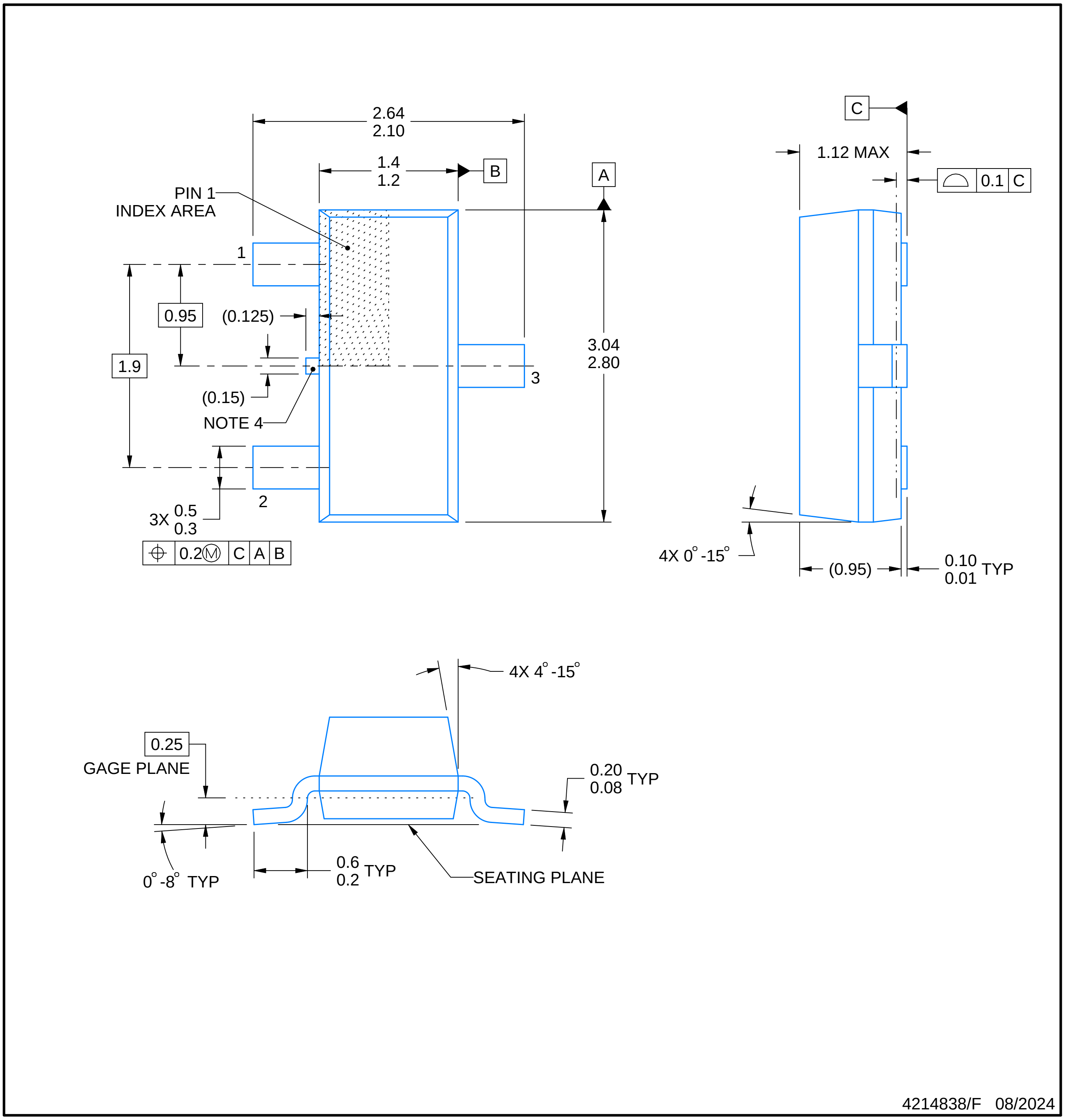
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	1000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



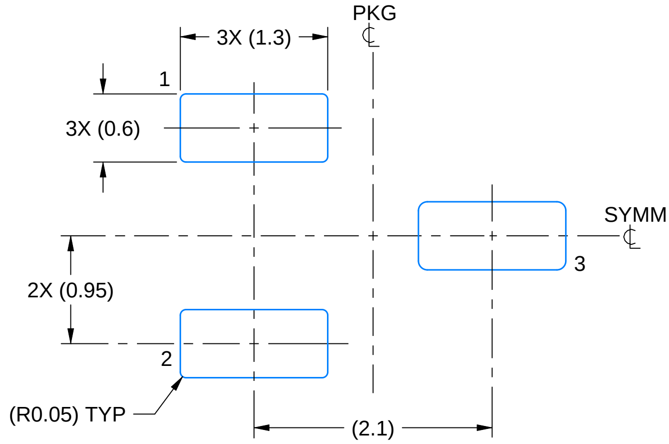
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	1000	208.0	191.0	35.0
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0

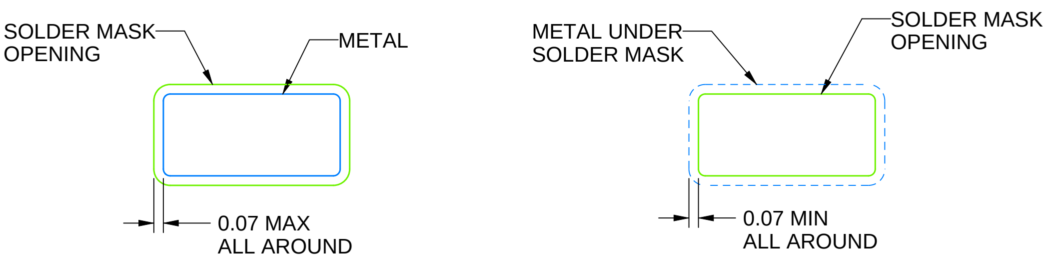


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not be present.
5. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



LAND PATTERN EXAMPLE
SCALE:15X



NON SOLDER MASK DEFINED (PREFERRED)

SOLDER MASK DEFINED

SOLDER MASK DETAILS

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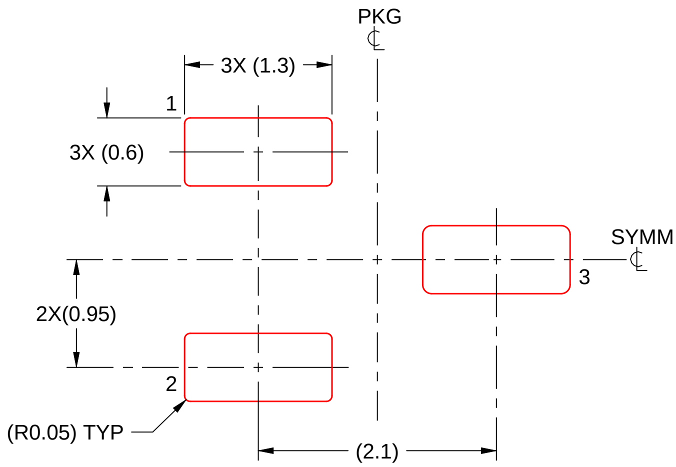
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:15X

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NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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