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)**

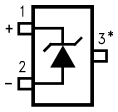
DESCRIPTION

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	$I_{RMIN} \le I_R \le$ 1 mA	0.4		mV
				1.0	mV (max)
				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, 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

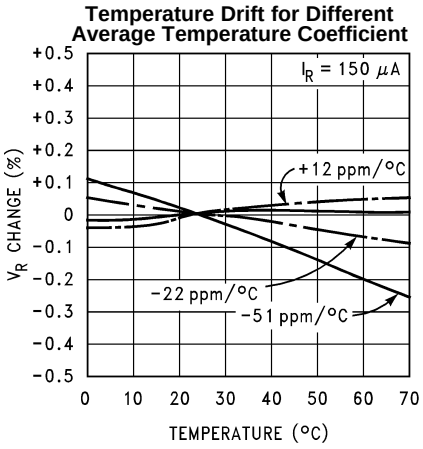


Figure 2.

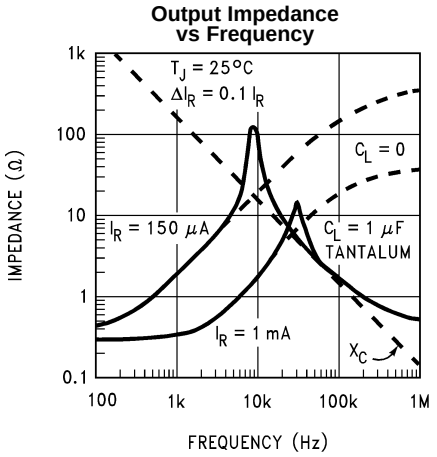


Figure 3.

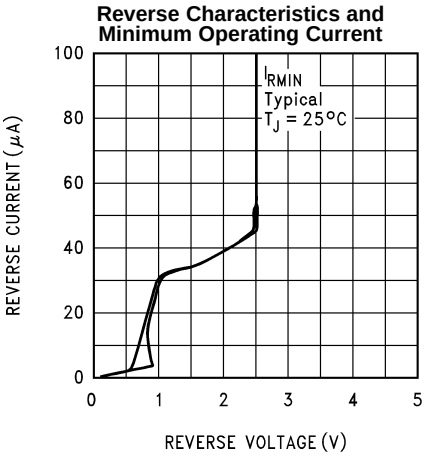


Figure 4.

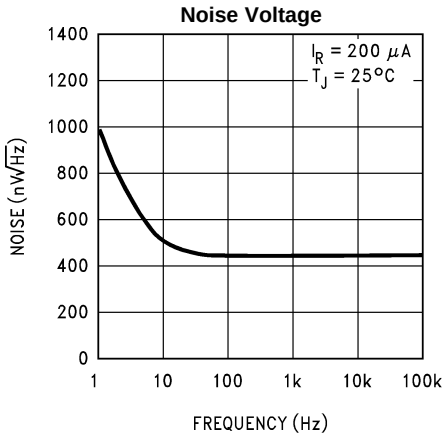


Figure 5.

Start-Up Characteristics

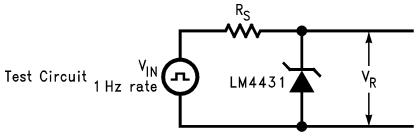


Figure 6. Test Circuit

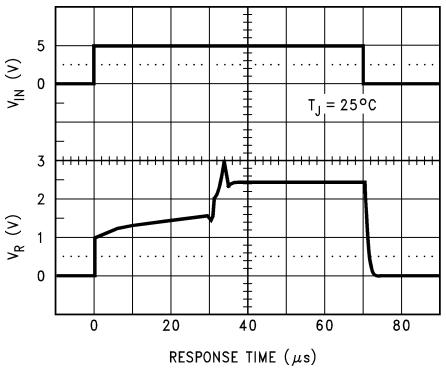
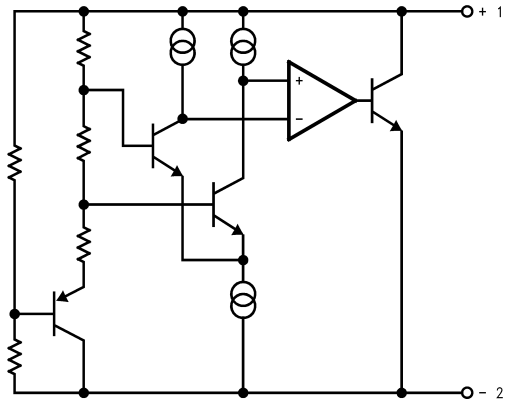


Figure 7. LM4431-2.5, R_S = 30k

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

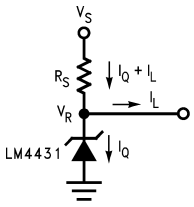


Figure 8. Shunt Regulator

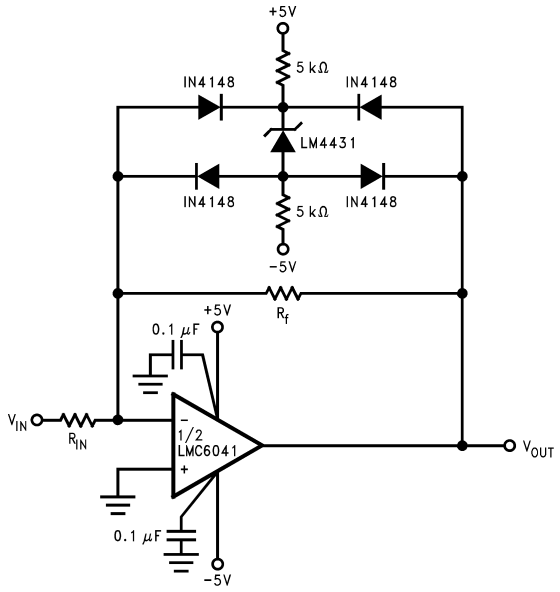


Figure 9. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage. Nominal clamping voltage is ±3.9V (LM4431's reverse breakdown voltage +2 diode V_F).

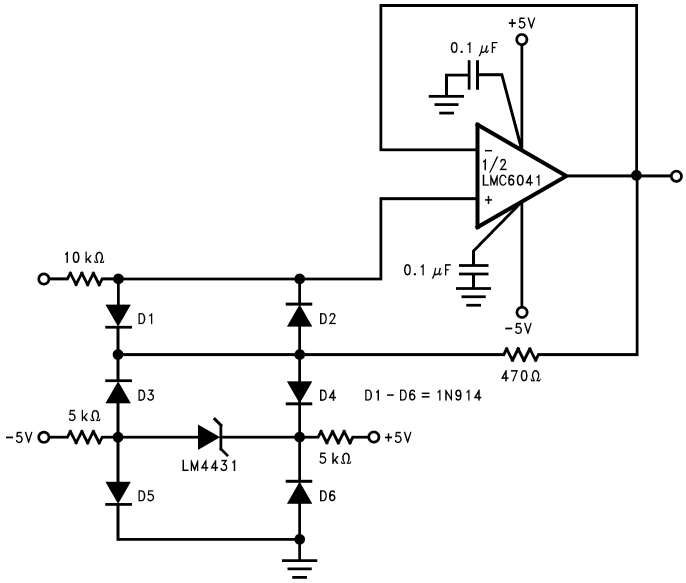
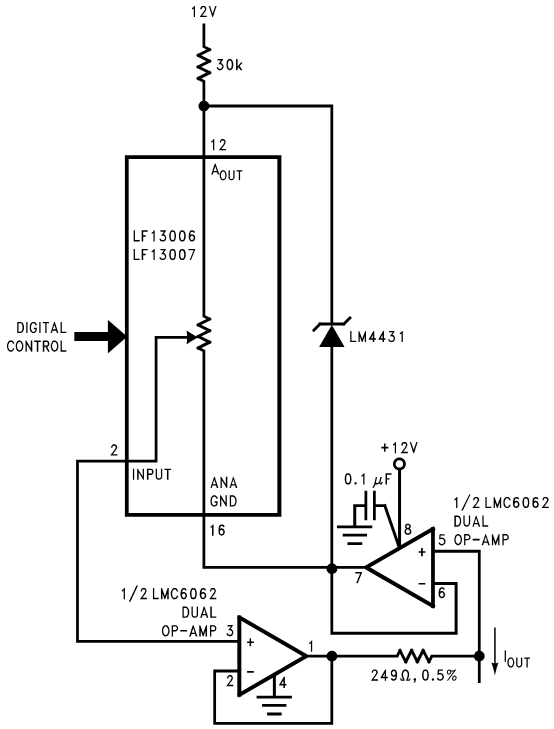
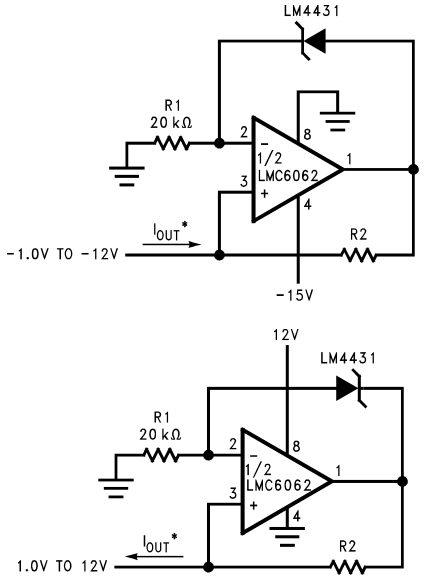


Figure 10. Protecting Op Amp input. The bounding voltage is ±4V with the LM4431 (LM4431's reverse breakdown voltage + 3 diode V_F).



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

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 part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM4431M3-2.5/NOPB	Active	Production	SOT-23 (DBZ) | 3	1000 | SMALL T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3-2.5/NOPB.A	Active	Production	SOT-23 (DBZ) | 3	1000 | SMALL T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3-2.5/NOPB.B	Active	Production	SOT-23 (DBZ) | 3	1000 | SMALL T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3X-2.5/NOPB	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3X-2.5/NOPB.A	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3X-2.5/NOPB.B	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

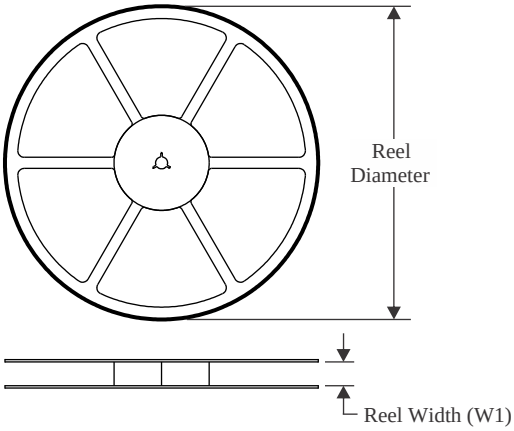
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

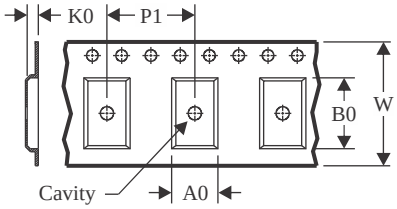
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

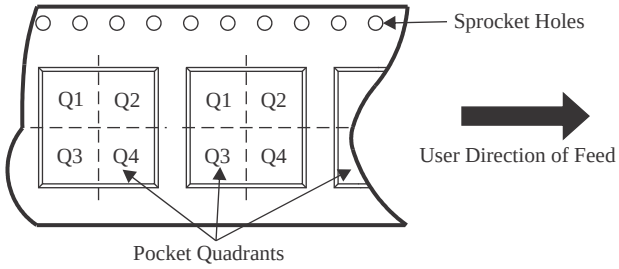


TAPE DIMENSIONS



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

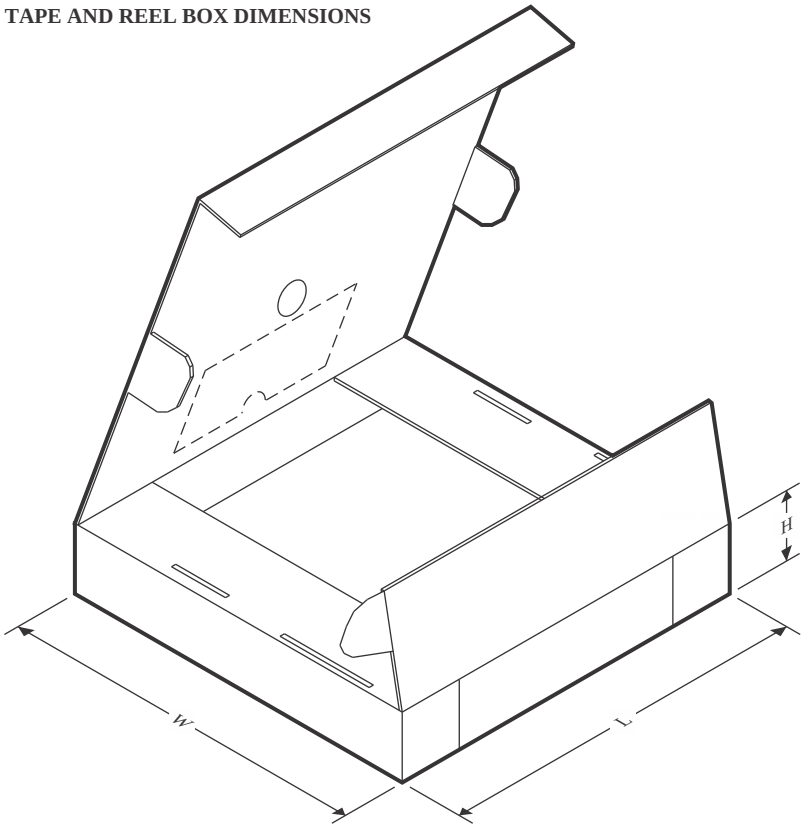
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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/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

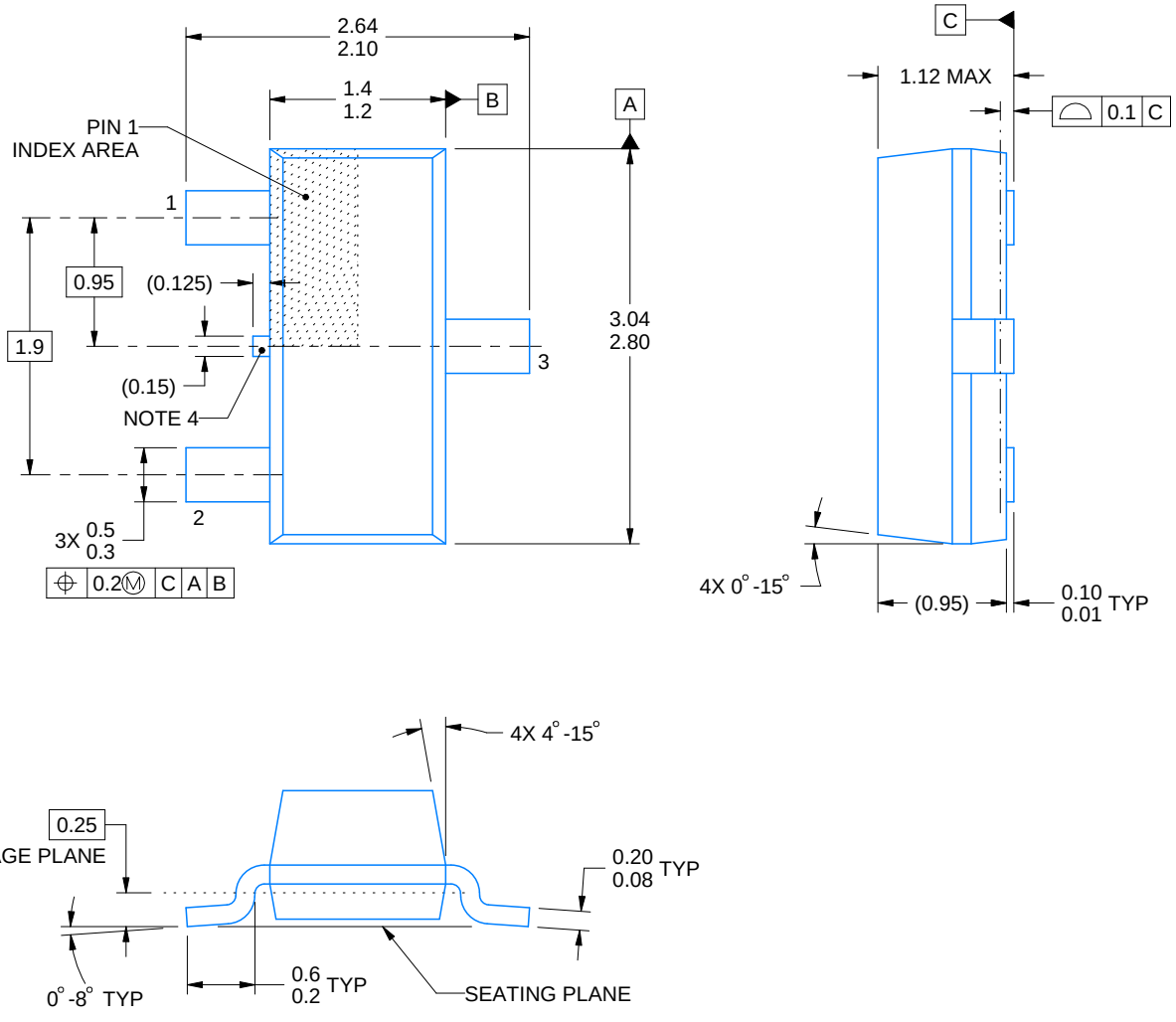
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	1000	208.0	191.0	35.0
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0

PACKAGE OUTLINE

DBZ0003A

SOT-23 - 1.12 mm max height

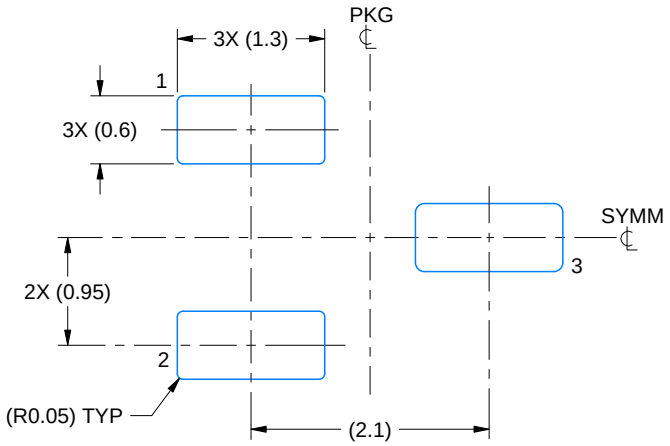
SMALL OUTLINE TRANSISTOR



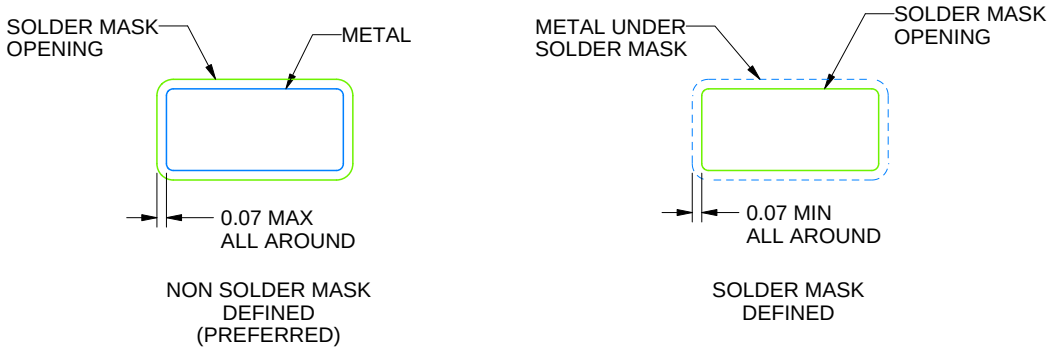
4214838/F 08/2024

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

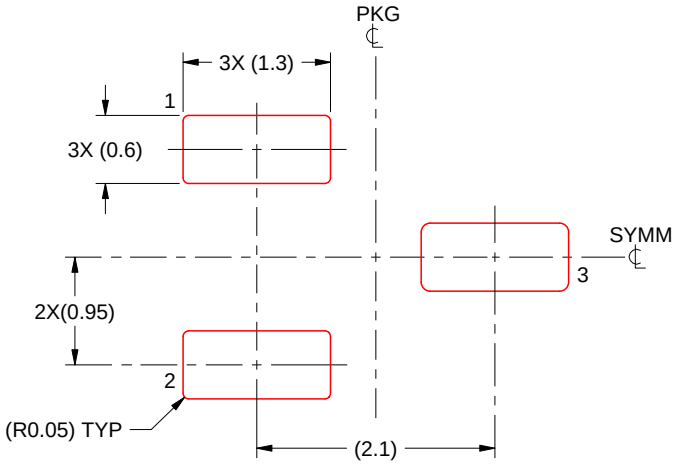


SOLDER MASK DETAILS

4214838/F 08/2024

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

4214838/F 08/2024

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.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265