

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

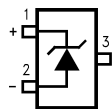
- **Portable, Battery-Powered Equipment**
- **Data Acquisition Systems**
- **Instrumentation**
- **Process Control**
- **Energy Management**
- **Product Testing**
- **Power Supplies**

KEY SPECIFICATIONS

- **Output Voltage Tolerance: 25°C: $\pm 2.0\%$ (Max)**
- **Low Output Noise (10 Hz to 10 kHz): $35 \mu\text{V}_{\text{rms}}$ (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

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.



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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, $T_{Jmax} = 125^\circ\text{C}$, 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 k Ω resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

Operating Ratings⁽¹⁾⁽²⁾

Temperature Range ($T_{min} \leq T_A \leq T_{max}$)		$0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$
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, $T_{Jmax} = 125^\circ\text{C}$, 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 $T_A = T_J = 25^\circ\text{C}$.

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

(1) Typicals are at $T_J = 25^\circ\text{C}$ 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

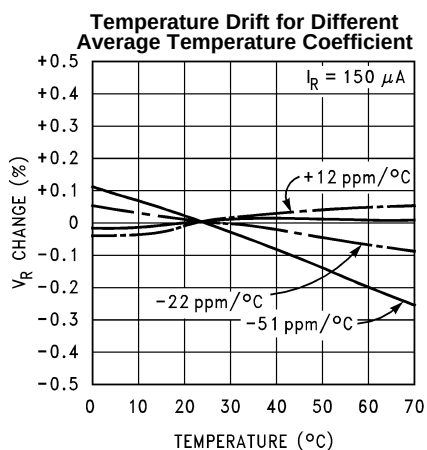


Figure 2.

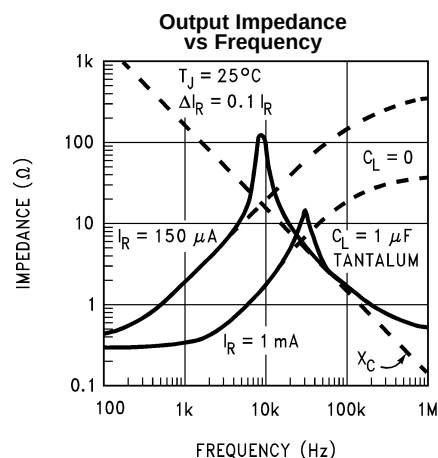


Figure 3.

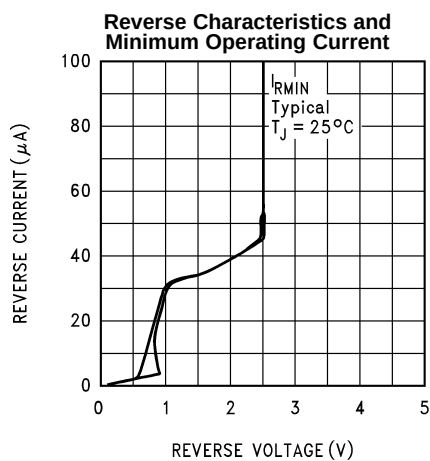


Figure 4.

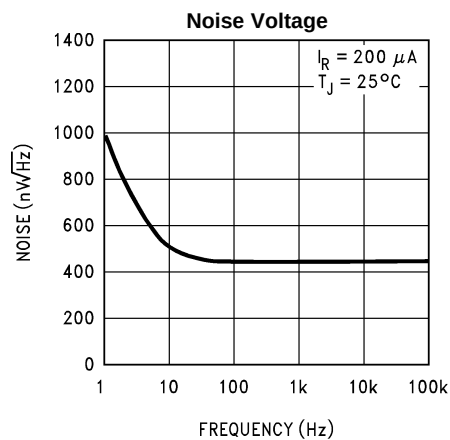


Figure 5.

Start-Up Characteristics

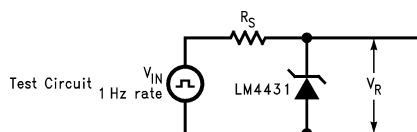
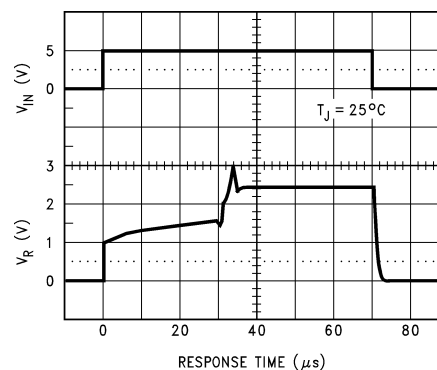
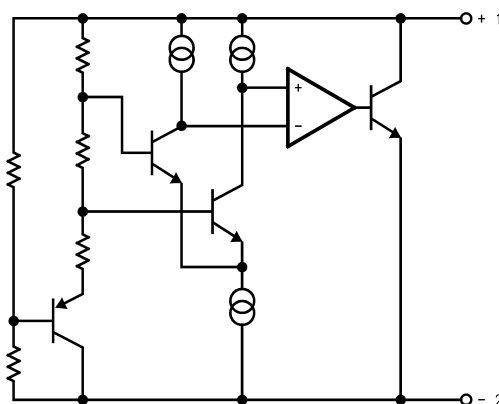


Figure 6. Test Circuit

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 μ A 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 .

$$R_S = \frac{V_S - V_R}{I_L + I_Q} \quad (1)$$

Typical Applications

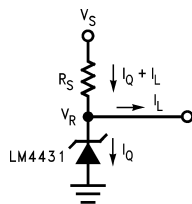


Figure 8. Shunt Regulator

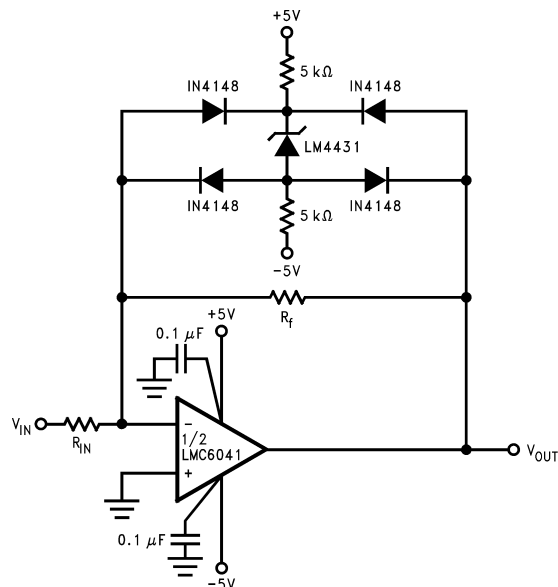


Figure 9. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage.
Nominal clamping voltage is $\pm 3.9\text{V}$ (LM4431's reverse breakdown voltage + 2 diode V_F).

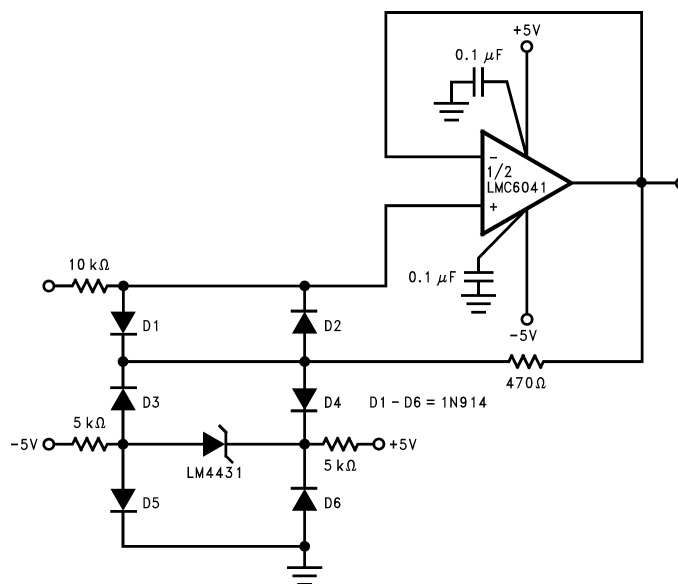
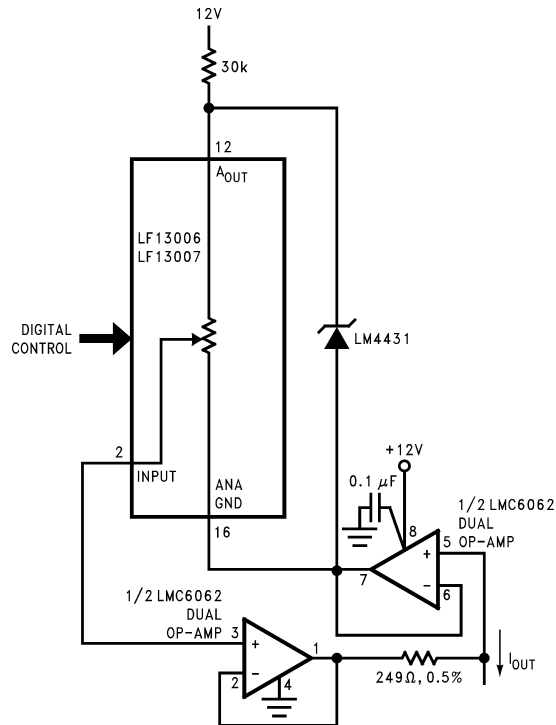
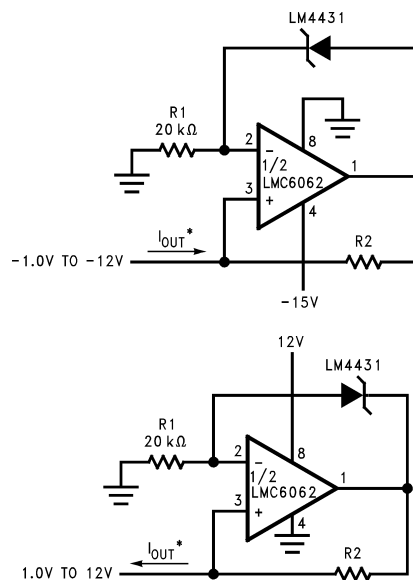


Figure 10. Protecting Op Amp input.
The bounding voltage is $\pm 4\text{V}$ with the LM4431 (LM4431's reverse breakdown voltage + 3 diode V_F).



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

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	3000 SMALL T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3-2.5/NOPB.A	Active	Production	SOT-23 (DBZ) 3	3000 SMALL T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	S2E
LM4431M3-2.5/NOPB.B	Active	Production	SOT-23 (DBZ) 3	3000 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.

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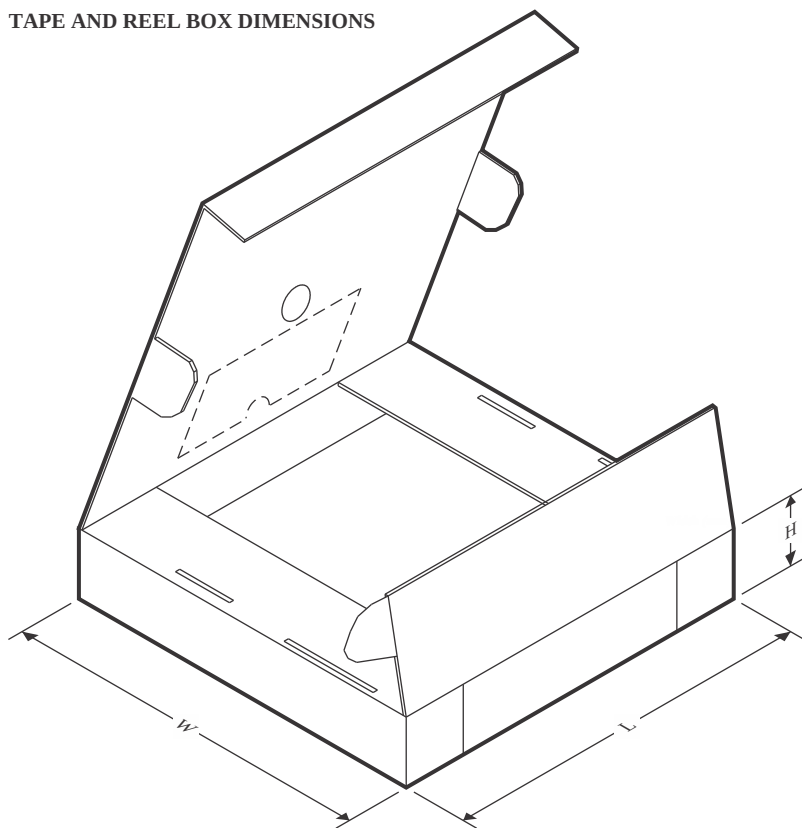
TAPE AND REEL INFORMATION



*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	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	3000	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
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	3.2	2.85	1.3	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS

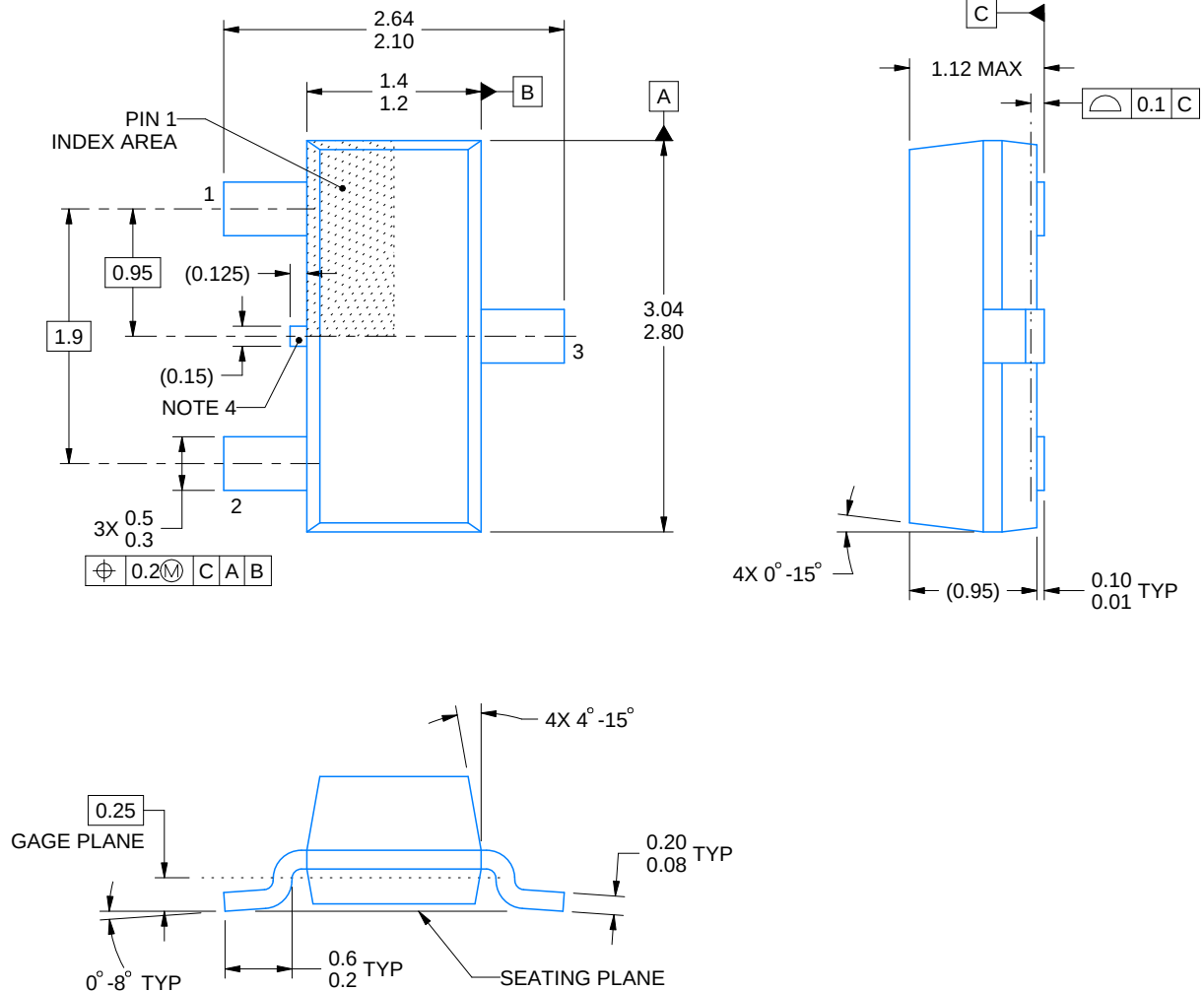


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4431M3-2.5/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4431M3X-2.5/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0

DBZ0003A**PACKAGE OUTLINE****SOT-23 - 1.12 mm max height**

SMALL OUTLINE TRANSISTOR



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NOTES:

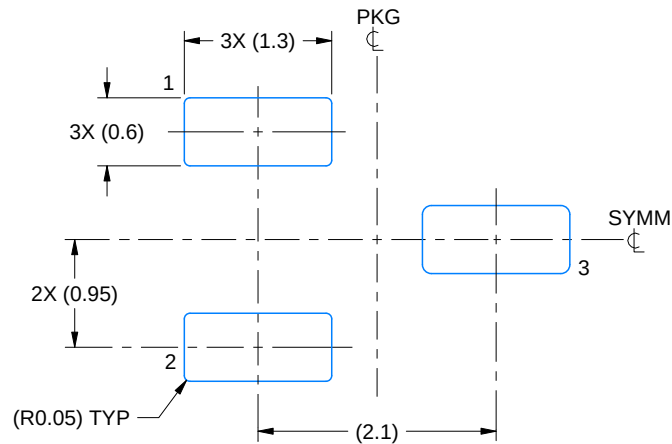
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not 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

EXAMPLE BOARD LAYOUT

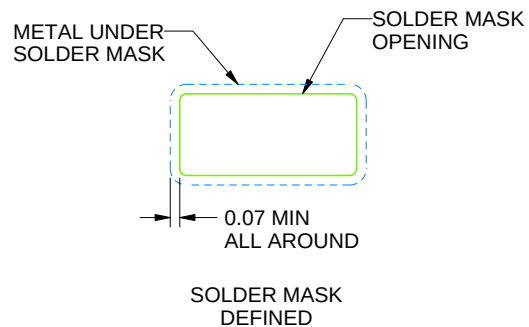
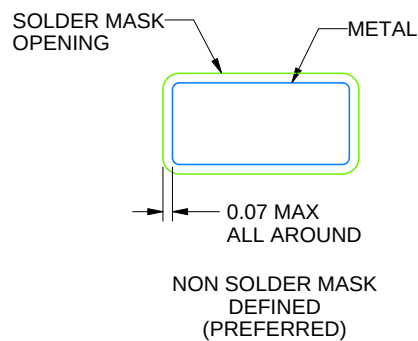
DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

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NOTES: (continued)

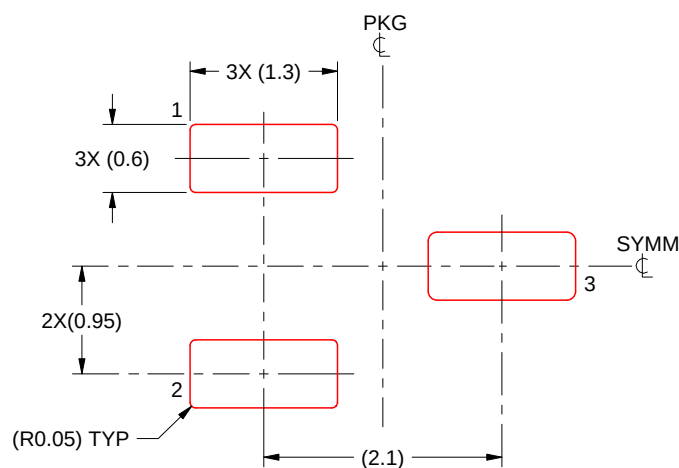
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



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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