

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**

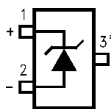
APPLICATIONS

- **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)**

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 ($T_A = 25^\circ\text{C}$) ⁽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 $326^\circ\text{C}/\text{W}$ 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.
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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 $T_A = T_J = 25^\circ\text{C}$.

| 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) Typical values 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

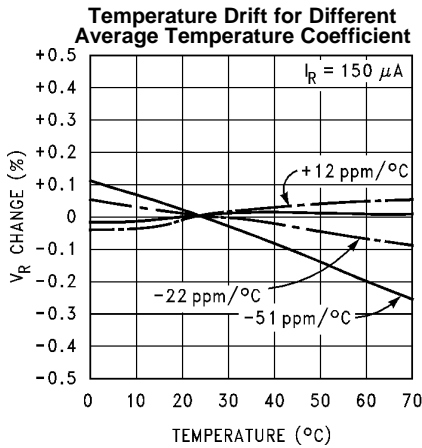


Figure 2.

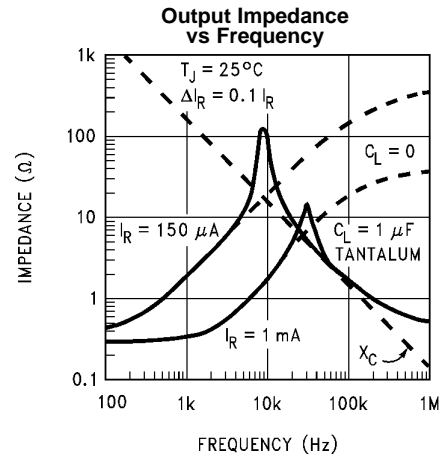


Figure 3.

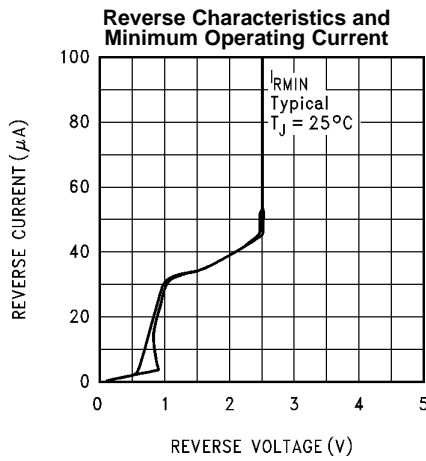


Figure 4.

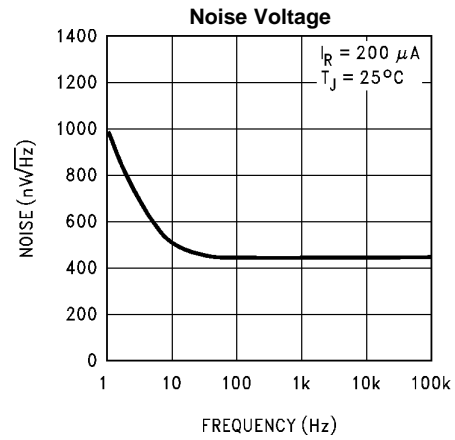


Figure 5.

Start-Up Characteristics

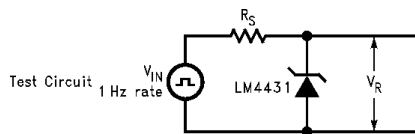


Figure 6. Test Circuit

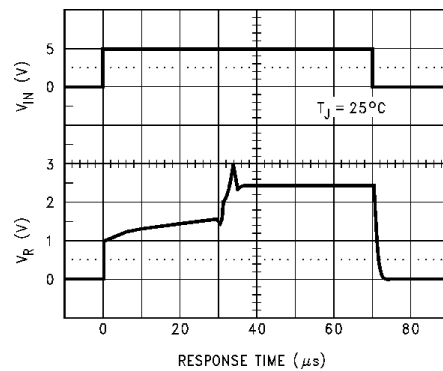
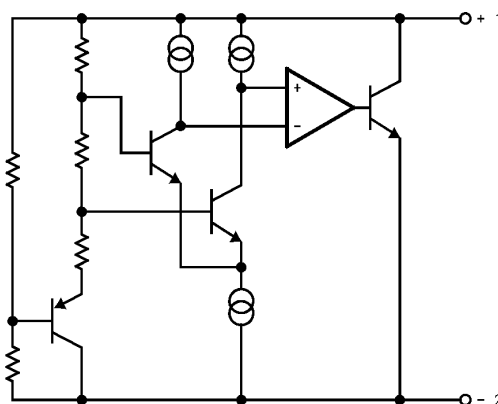


Figure 7. LM4431-2.5, R_S = 30k

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 .

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

Typical Applications

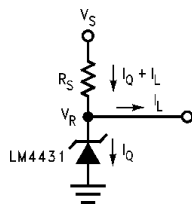


Figure 8. Shunt Regulator

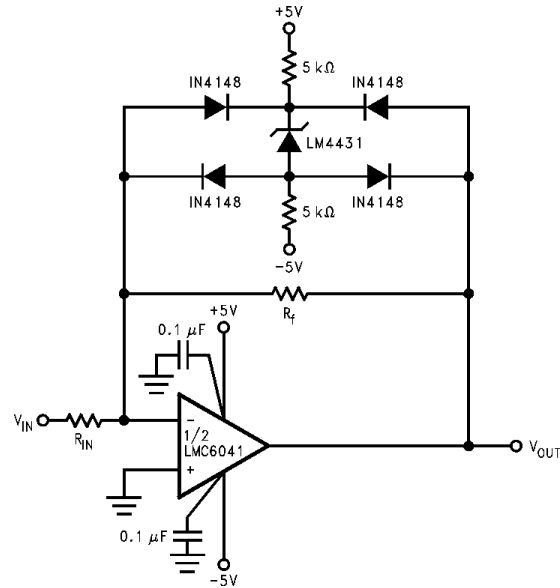


Figure 9. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage.
Nominal clamping voltage is $\pm 3.9\text{V}$ (LM4431's reverse breakdown voltage + 2 diode V_F).

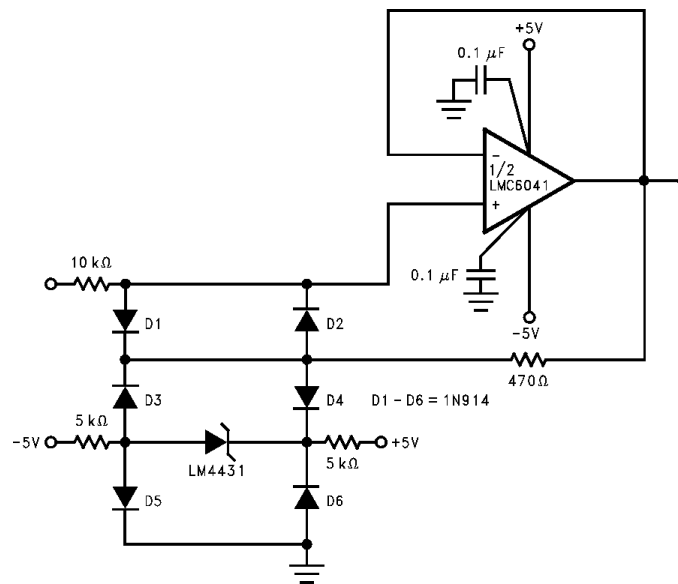
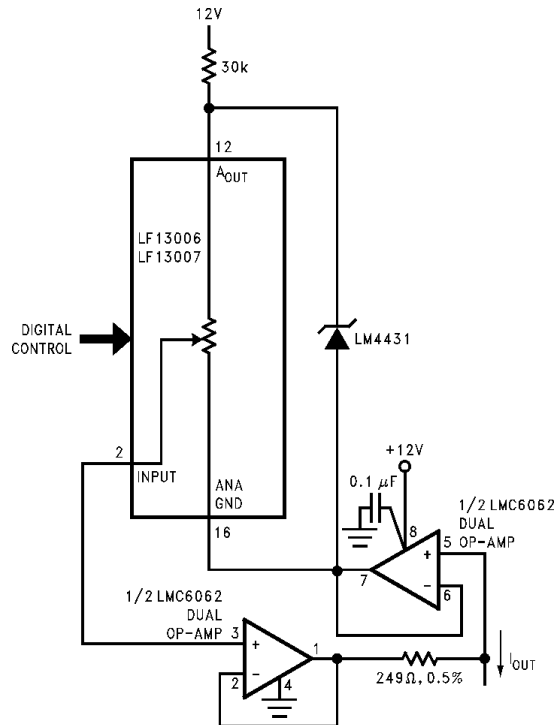
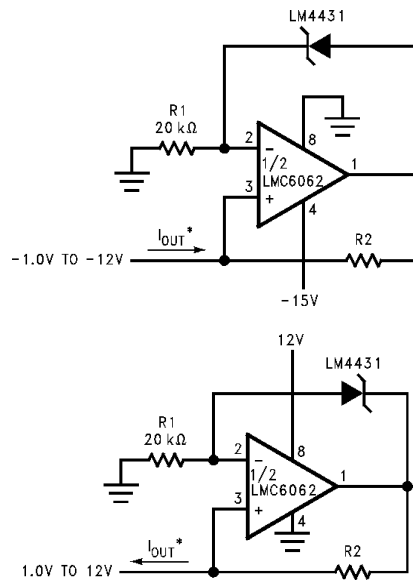


Figure 10. Protecting Op amp input.
The bounding voltage is $\pm 4\text{V}$ with the LM4431 (LM4431's reverse breakdown voltage + 3 diode V_F).



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

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 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 | LIFEBUY | SOT-23 | DBZ | 3 | 1000 | Non-RoHS & Green | Call TI | Level-1-260C-UNLIM | 0 to 70 | S2E | |
| 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

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

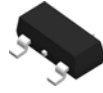
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| 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 | 208.0 | 191.0 | 35.0 |
| 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 |

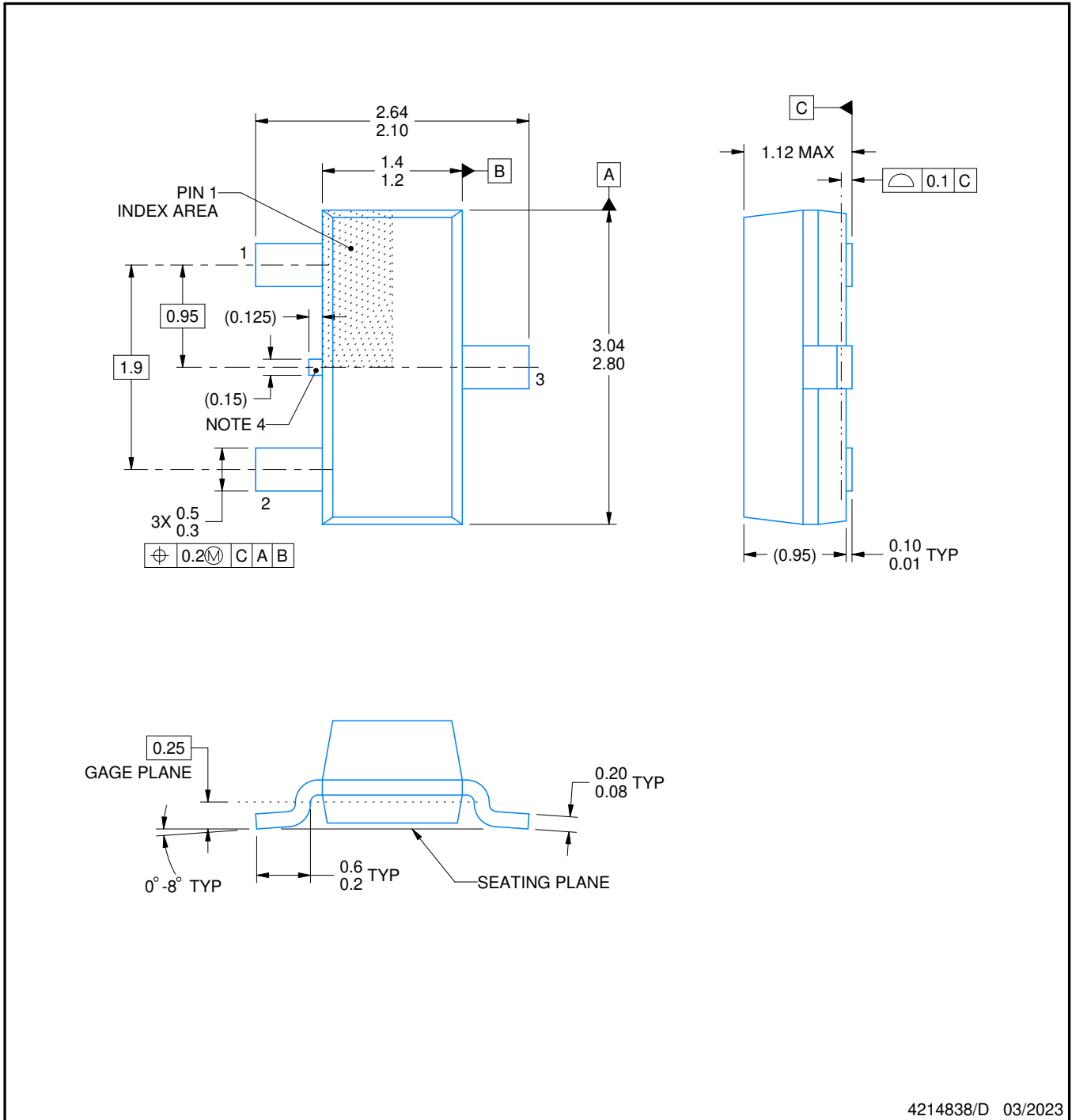
DBZ0003A



PACKAGE OUTLINE

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



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NOTES:

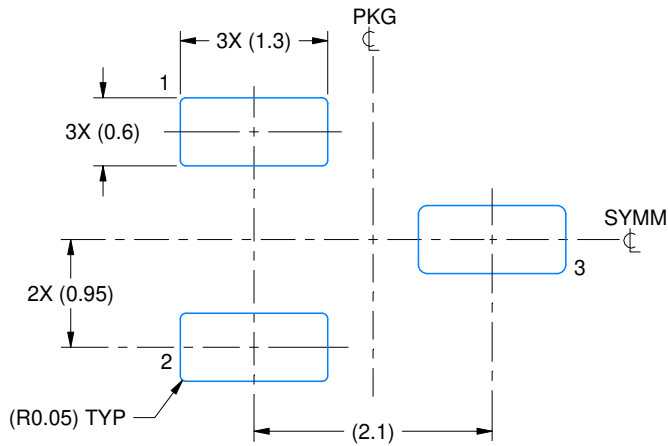
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not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

EXAMPLE BOARD LAYOUT

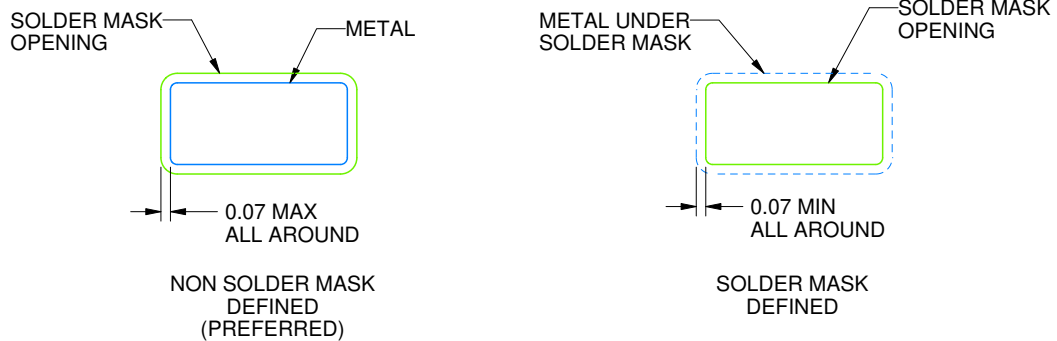
DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

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NOTES: (continued)

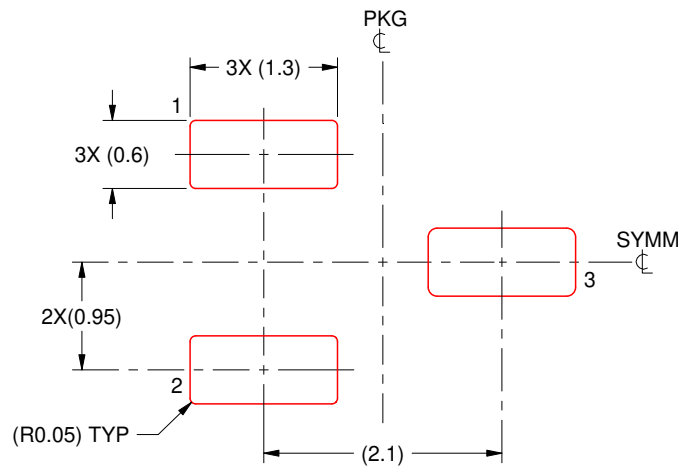
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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)

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

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