

TSM36A SOT-23 パッケージのサージ保護デバイス

1 特長

- 産業用信号ライン向け 1.7kV、42Ω の IEC 61000-4-5 サージ・テストに耐える単方向のサージ保護機能
- 強力なサージ保護:
 - IEC61000-4-5 (8/20μs): 41A
- 25A でクランプ電圧が 50V と低く、8/20μs のサージ電流で下流の部品を保護
- 動作電圧が 36V で、24V システムの信号を保護
- 小さいリーク電流: 1μA
- 低い動的抵抗: 0.5Ω
- レベル 4 IEC 61000-4-2 に準拠した ESD 保護機能を内蔵
- 30kV の ESD 保護 (IEC 61000-4-2)
- SOT-23 (DBZ): 小型、標準、共通フットプリント
- 自動光学検査 (AOI) に適したリード付きパッケージ

2 アプリケーション

- 産業機器用センサ
- IO-Link
- PLC I/O モジュール
- 24V の電源ライン、またはデジタル入出力ライン
- 4/20mA ループ
- 家電製品
- 医療用機器
- モーター・ドライバ

3 概要

TSM36A はテキサス・インスツルメンツのサージ保護デバイス・ファミリーの一部です。TSM36A は、最大 41A の IEC 61000-4-5 フォルト電流を確実に分流して、システムを大電力の過渡や落雷から保護します。本デバイスは、一般的な産業用信号ラインの EMC 要件向けのソリューションとして、42Ω のインピーダンスにより結合される、最大 1.7kV の IEC 61000-4-5 開路電圧に耐えられます。サージ・イベントでは TSM36A がクランプされるため、 $I_{pp} = 25A$ でシステムがさらされる電圧を 50V 未満にします。

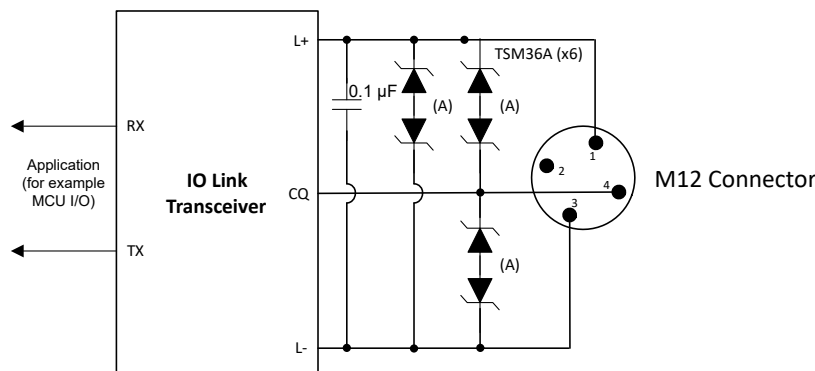
また、TSM36A は、業界標準の SMA パッケージに比べて約 50% 小型化された小型のリード付き SOT-23 (DBZ) パッケージで供給されています。リーク電流と容量が極めて小さいため、保護するラインへの影響も最小限に抑えられます。

サージ・ファミリーに属する他のデバイスの詳細については、この[リンク](#)に掲載されている製品をご覧ください。

パッケージ情報 (1)

| 部品番号 | パッケージ | 本体サイズ (公称) |
|--------|-----------------|-----------------|
| TSM36A | DBZ (SOT-23, 3) | 2.92mm × 1.30mm |

- (1) 利用可能なパッケージについては、このデータシートの末尾にある注文情報を参照してください。



- A. この図は、2 つの TSM36A 単方向デバイスを直列に接続し、各信号間を保護するため陽極を双方向で結合した状態を示しています。

産業用センサの IO-Link アプリケーション



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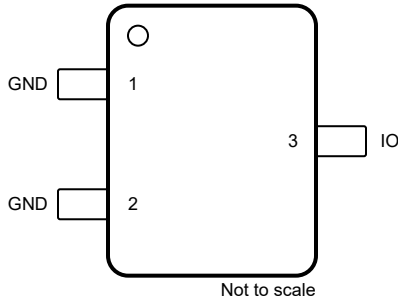
| | | | |
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4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

| Changes from Revision * (June 2022) to Revision A (October 2022) | Page |
|--|------|
| • データシートのステータスを「事前情報」から「量産データ」に変更 | 1 |

5 Pin Configuration and Functions



**图 5-1. DBZ Package,
3-Pin SOT-23
(Top View)**

表 5-1. Pin Functions

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|------|------|---------------------|--|
| NAME | NO. | | |
| IO | 3 | I/O | Surge and ESD protected IO |
| GND | 1, 2 | G | Connect to ground. To achieve the rated performance, it is required to connect pin 1 and 2 together on the PCB as close to the device as possible. |

(1) I = Input, O = Output, I/O = Input or Output, G = Ground, P = Power

6 Specifications

6.1 Absolute Maximum Ratings

$T_A = 25^\circ\text{C}$ (unless otherwise noted) ⁽¹⁾

| Parameter | | Device | MIN | MAX | UNIT |
|-----------------|--|--------|-----|------|------------------|
| $P_{pk_8_20}$ | IEC 61000-4-5 Power ($t_p - 8/20 \mu\text{s}$) | TSM36A | | 2000 | W |
| $I_{pp_8_20}$ | IEC 61000-4-5 Current ($t_p - 8/20 \mu\text{s}$) | TSM36A | | 41 | A |
| T_A | Operating free-air temperature | | -55 | 150 | $^\circ\text{C}$ |
| T_J | Junction temperature | | -55 | 150 | $^\circ\text{C}$ |
| T_{stg} | Storage temperature | | -65 | 155 | $^\circ\text{C}$ |

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings—JEDEC Specification

| Parameter | | | VALUE | UNIT |
|-------------|-------------------------|--|------------|------|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001 | ± 2500 | V |
| | | Charged device model (CDM), per JEDEC specification JS-002 | ± 1000 | |

6.3 ESD Ratings—IEC Specification

$T_A = 25^\circ\text{C}$ (unless otherwise noted)

| Parameter | | | VALUE | UNIT |
|-------------|-------------------------|---|-------------|------|
| $V_{(ESD)}$ | Electrostatic discharge | IEC 61000-4-2 Contact Discharge, all pins | ± 30000 | V |
| | | IEC 61000-4-2 Air-gap Discharge, all pins | ± 30000 | |

6.4 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| Parameter | | MIN | NOM | MAX | UNIT |
|-----------|--------------------------------|-----|-----|-----|------------------|
| V_{IN} | Input voltage | 0 | | 36 | V |
| T_A | Operating free-air temperature | -55 | | 150 | $^\circ\text{C}$ |

6.5 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | TSM36A | UNIT |
|-------------------------------|--|--------------|---------------------------|
| | | DBZ (SOT-23) | |
| | | 3 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 204.4 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 96.9 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 39.9 | $^\circ\text{C}/\text{W}$ |
| Ψ_{JT} | Junction-to-top characterization parameter | 7.1 | $^\circ\text{C}/\text{W}$ |
| Ψ_{JB} | Junction-to-board characterization parameter | 39.5 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | N/A | $^\circ\text{C}/\text{W}$ |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

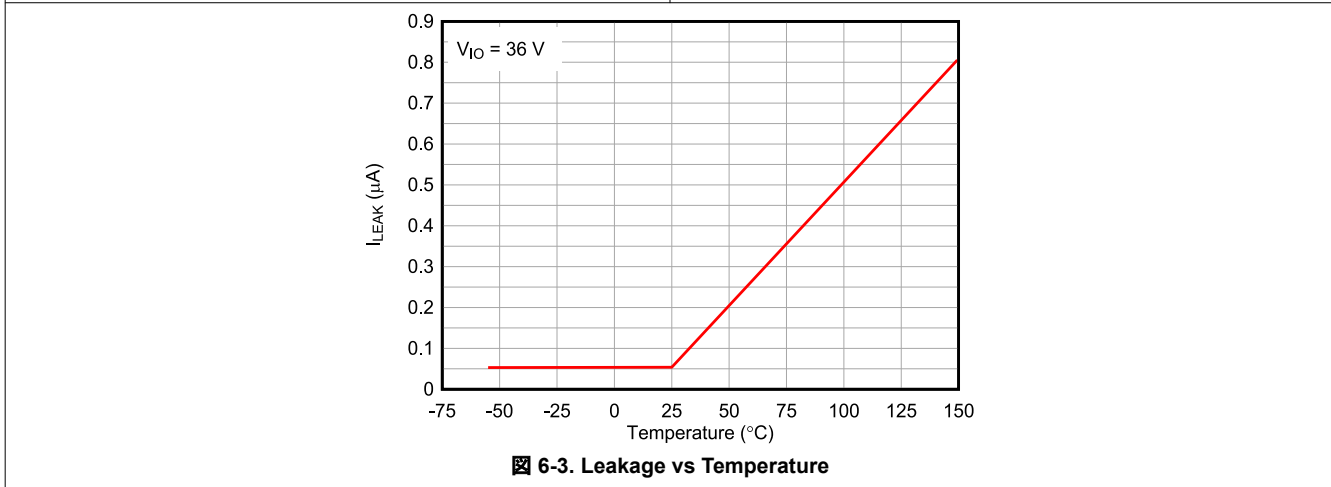
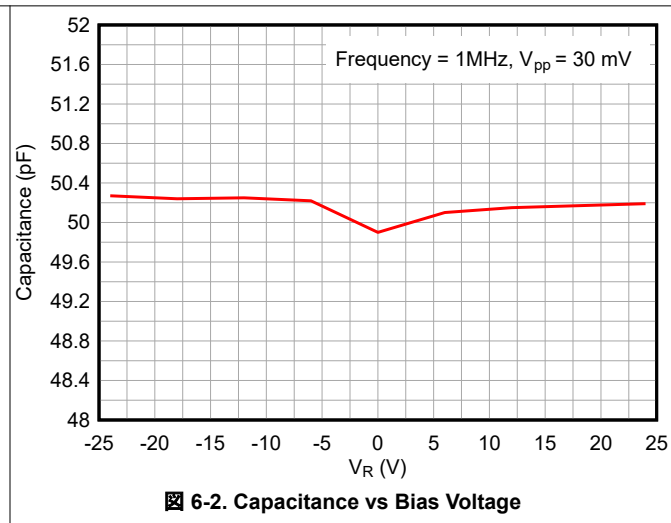
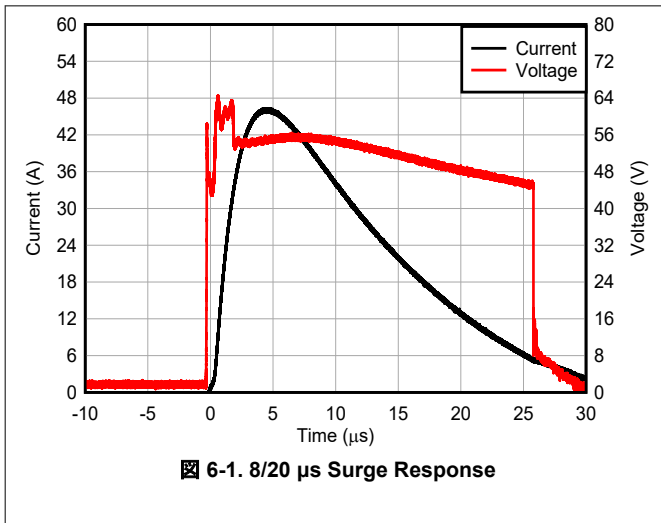
6.6 Electrical Characteristics

$T_A = 25^\circ\text{C}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | Device | MIN | TYP | MAX | UNIT |
|--------------|--|---|--------|------|-----|------|---------------|
| V_{RWM} | Reverse stand-off voltage | | TSM36A | 0 | | 36 | V |
| V_{BRF} | Forward breakdown voltage ⁽¹⁾ | $I_{IO} = -10\text{ mA}$ | TSM36A | | 0.8 | | V |
| V_{BRR} | Reverse breakdown voltage ⁽¹⁾ | $I_{IO} = 10\text{ mA}$ | TSM36A | 37.8 | | 44.2 | V |
| V_{CLAMP} | Clamping voltage ⁽²⁾ | $I_{PP} = 25\text{ A}$, $t_p = 8/20\ \mu\text{s}$, from IO to GND | TSM36A | | 50 | | V |
| | | $I_{PP} = 40\text{ A}$, $t_p = 8/20\ \mu\text{s}$, from IO to GND | TSM36A | | 57 | | |
| I_{LEAK} | Leakage current | $V_{IO} = +36\text{ V}$ | TSM36A | | | 1 | μA |
| R_{DYN} | Dynamic resistance | $t_p = 8/20\ \mu\text{s}$, from IO to GND | TSM36A | | 0.5 | | Ω |
| C_{IO-GND} | Line capacitance | $V_{IO} = 0\text{ V}$, $f = 1\text{ MHz}$, $V_{p-p} = 30\text{ mV}$ | TSM36A | | 50 | 80 | pF |

- (1) V_{BRF} and V_{BRR} are defined as the voltage when $\pm 10\text{ mA}$ is applied in the positive-going direction.
 (2) Device stressed with 8/20 μs exponential decay waveform according to IEC 61000-4-5.

6.7 Typical Characteristics

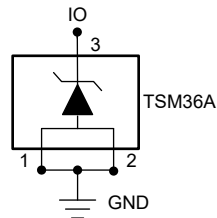


7 Detailed Description

7.1 Overview

The TSM36A is a surge protection diode that clamps the voltage during a fault and protects downstream components from overvoltage events.

7.2 Functional Block Diagram



7.3 Feature Description

The TSM36A is a surge protection diode that handles 41 A of IEC 61000-4-5 8/20 μ s surge current. The low clamping voltage protects downstream circuits from being stressed during a surge event. The TSM36A has minimal leakage current at the standoff voltage of 36 V, making it a good candidate for applications where low leakage is needed to reduce power dissipation. A 30-kV IEC 61000-4-2 rating makes it a robust protection solution for ESD events as well. The TSM36A has a wide ambient temperature range of -55°C to $+150^{\circ}\text{C}$ which enables it to work in applications requiring an extended temperature range. The small SOT-23 (DBZ) package enables it to save board area compared to other surge protection devices in a traditional SMA package. The leaded SOT-23 (DBZ) package enables automatic optical inspection during the assembly process.

7.4 Device Functional Modes

7.4.1 Protection Specifications

The TSM36A is specified according to both the IEC 61000-4-5 standard. The IEC 61000-4-5 standard requires protection against a pulse with a rise time of 8 μ s and a half length of 20 μ s.

Additionally, the TSM36A is tested according to IEC 61000-4-5 to pass a ± 1.7 kV surge test through a 42- Ω coupling resistor and a 0.5 μ F capacitor, which is a common test requirement for industrial signal I/O lines. The TSM36A will serve as a protection solution for applications with that requirement.

The TSM36A integrates 30-kV IEC 61000-4-2 rated ESD protection, which ensures that the device can protect against both surge and ESD transient events.

For more information on TI's test method for surge and ESD testing, reference [TI's IEC 61000-4-x Testing application note](#).

8 Application and Implementation

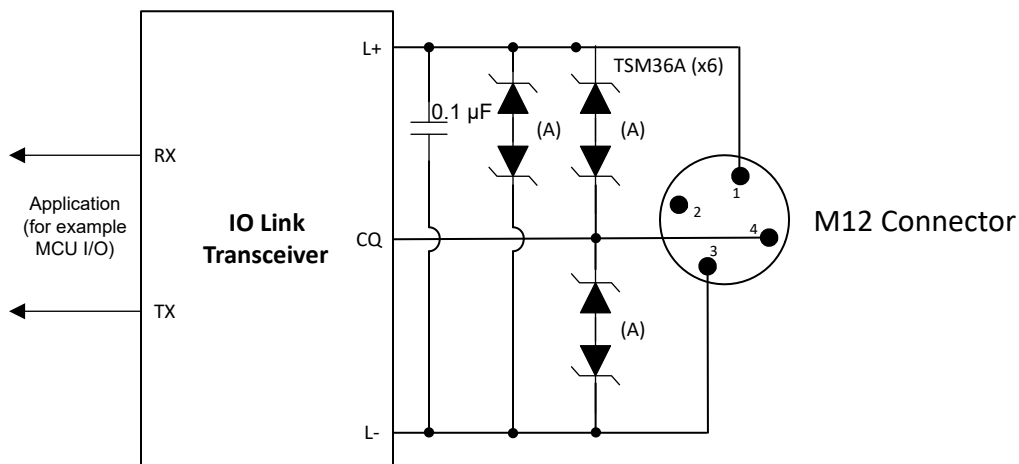
注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The TSM36A can be used to protect any power, analog, or digital signal from transient fault conditions caused by the environment or other electrical components.

8.2 Typical Application



- A. Diagram shows two TSM36A unidirectional devices stacked in series with the anodes tied back-to-back to protect between the respective signals.

图 8-1. TSM36A Application Schematic

8.2.1 Design Requirements

In the previous example, the TSM36A is protecting an IO Link transceiver that has a nominal voltage of 24 V and a maximum input voltage of 30 V. Most industrial interfaces such as this require protection against ± 1 kV surge test through a 42- Ω coupling resistor and a 0.5 μ F capacitor, equaling approximately 24 A of surge current. If a surge event caused by lightning, coupling, ringing, or any other fault condition occurs without any input protection, then this input voltage will rise to hundreds of volts in microseconds, which violates the absolute maximum input voltage and will harm the device. An ideal surge protection diode will maximize the useable voltage range while still clamping at a safe level for the system.

8.2.2 Detailed Design Procedure

If the TSM36A is protecting the device, then during a surge event the voltage will rise to the breakdown of the diode at 37.8 V (minimum), the TSM36A will turn on and shunt the surge current to ground. With the low dynamic resistance of the TSM36A, large amounts of surge current will have some impact on the clamping voltage. The dynamic resistance of the TSM36A is around 0.5 Ω , which means 24 A of surge current will cause a voltage rise of $24 \text{ A} \times 0.5 \text{ } \Omega = 12 \text{ V}$. Because the device turns on at 37.8 V (minimum), the IO Link transceiver input will be exposed to $37.8 \text{ V} + 12 \text{ V} = 49.8 \text{ V}$ during surge pulses, which is well within the absolute maximum voltage of the IO Link transceiver input pins (L+, L-, and CQ) and will protect the circuit. The small size of the device also improves fault protection by lowering the effect of fault current coupling onto neighboring traces. The small form factor of the SOT-23 package allows the device to be placed extremely close to the input connector, lowering the length of the fault current path through the system compared to larger protection solutions. Finally, the low leakage of the TSM36A will have low input power losses. The device will receive a maximum of 1 μA leakage at 36 V for a constant power dissipation of 36 μW ; a small quantity that will minimally effect overall efficiency metrics and heating concerns.

8.2.3 Configuration Options

The TSM36A can either be used in an unidirectional or bidirectional configuration. For bidirectional operation, place two TSM36A devices in series with reverse orientation, which allows a working voltage of $\pm 36 \text{ V}$. TSM36A bidirectional operation is similar to its unidirectional operation, but with a minor increase in breakdown voltage and clamping voltage.

9 Power Supply Recommendations

This is a passive TVS diode-based surge protection device; therefore, there is no requirement to power it. Ensure that the maximum voltage specifications for each pin are not violated.

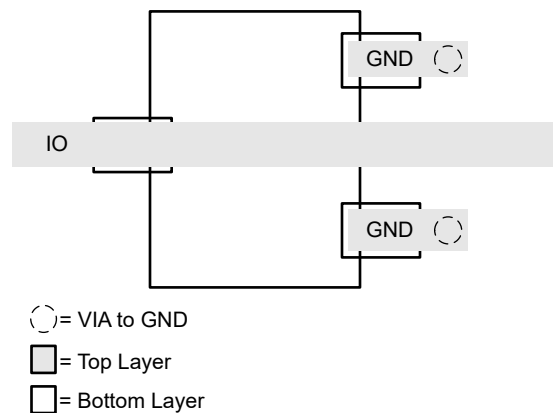
10 Layout

10.1 Layout Guidelines

- For optimal performance, place the device as close to the connector as possible.
 - EMI during an ESD event can couple from the trace being struck to other nearby unprotected traces, resulting in early system failures.
 - The PCB designer must minimize the possibility of EMI coupling by keeping any unprotected traces away from the protected traces which are between the TVS and the connector.
- Route the protected traces as straight as possible.
- Eliminate any sharp corners on the protected traces between the TVS and the connector by using rounded corners with the largest radii possible.
 - Electric fields tend to build up on corners, increasing EMI coupling.
- Pin 1 and 2 are not internally connected. To achieve the rated performance, it is required to connect Pin 1 and 2 together on the PCB as close to the device as possible and route the signal to ground. Also use a thick and short trace for this return path.

10.2 Layout Example

The following is a typical example of the layout routing for the TSM36A unidirectional device.



10-1. Routing with DBZ Package

11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [TI's IEC 61000-4-x Testing application note](#)
- Texas Instruments, [ESD Layout Guide user's guide](#)
- Texas Instruments, [ESD Protection Diodes EVM user's guide](#)
- Texas Instruments, [Generic ESD Evaluation Module user's guide](#)
- Texas Instruments, [Reading and Understanding an ESD Protection data sheet](#)

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 サポート・リソース

TI E2E™ サポート・フォーラムは、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計に必要な支援を迅速に得ることができます。

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11.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

すべての商標は、それぞれの所有者に帰属します。

11.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|---------|
| TSM36ADBZR | ACTIVE | SOT-23 | DBZ | 3 | 3000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 150 | 2O98 | 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.

OBSELETE: 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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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

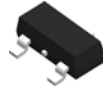
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TSM36ADBZR | SOT-23 | DBZ | 3 | 3000 | 180.0 | 8.4 | 2.9 | 3.35 | 1.35 | 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) |
|------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TSM36ADBZR | SOT-23 | DBZ | 3 | 3000 | 210.0 | 185.0 | 35.0 |

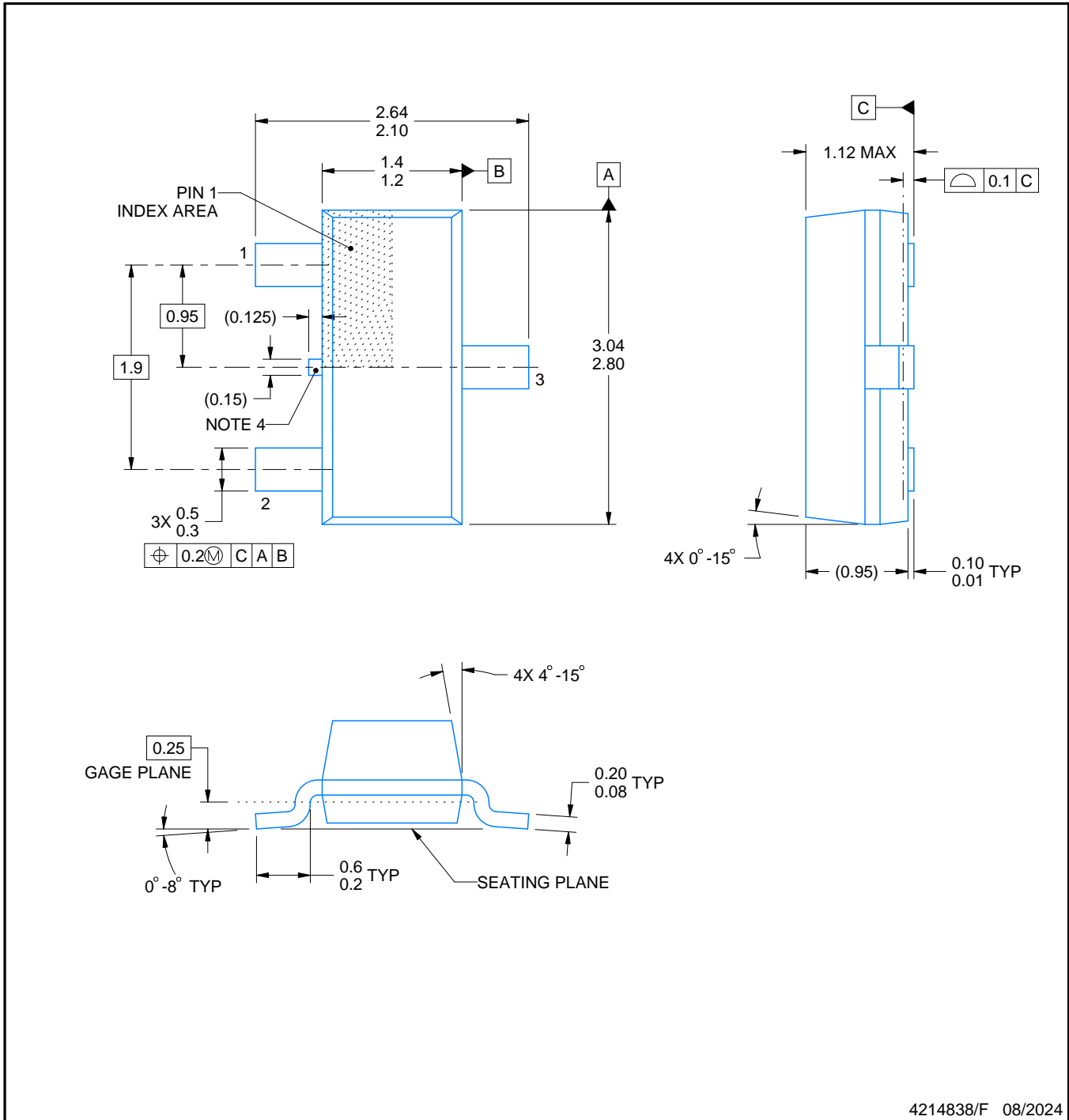
DBZ0003A



PACKAGE OUTLINE

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



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NOTES:

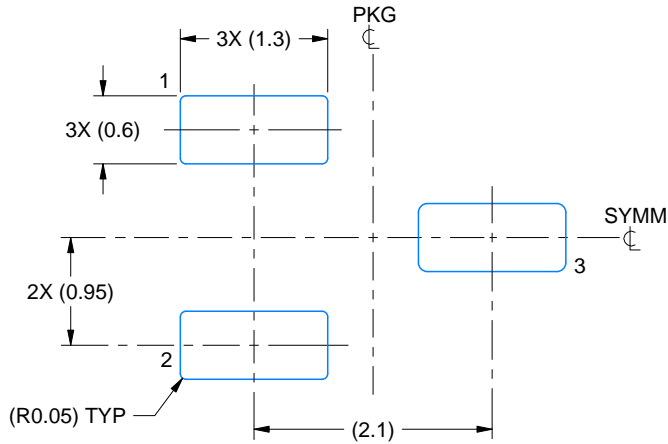
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not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

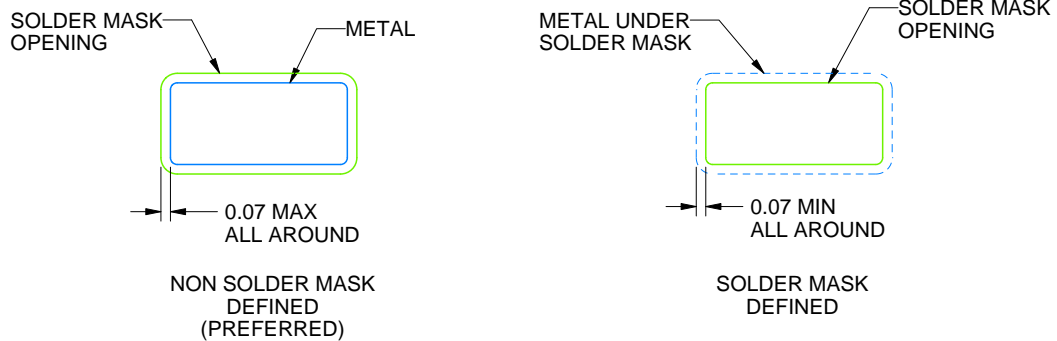
DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

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NOTES: (continued)

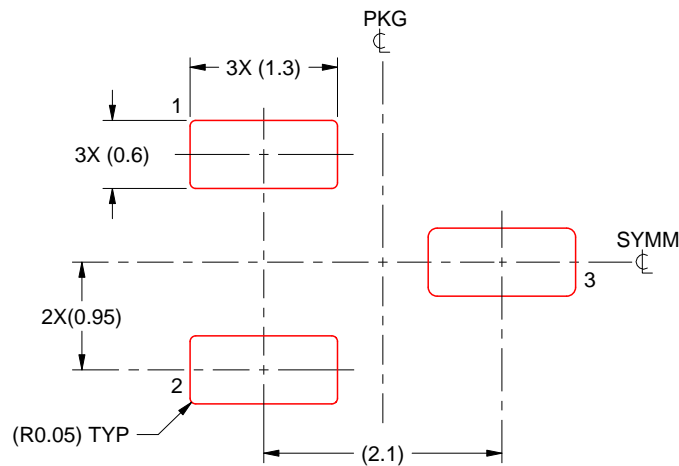
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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

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.

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