ESD652 18V Bi-Directional ESD Protection in SOT-23

1 Features

- IEC 61000-4-5 surge protection:
  - 5.5A (8/20µs)
- IEC 61000-4-2 ESD protection:
  - ±30kV contact discharge
  - ±30kV air gap discharge
- 18V working voltage
- I/O Capacitance:
  - 4pF (typical)
- Bidirectional polarity to support positive and negative voltage swings
- 2 channel device provides complete ESD protection with single component
- Small, leaded SOT-23 allows low cost automatic optical inspection (AOI)

2 Applications

- End equipment:
  - Factory automation and control
  - Building automation
  - Grid infrastructure
  - HVAC systems
  - Energy storage systems

3 Description

The ESD652 is a bidirectional ESD protection diode for battery management system and other communication line protection. The ESD652 is rated to dissipate ESD strikes beyond the maximum level specified in the IEC 61000-4-2 international standard (±30kV Contact, ±30kV Air-gap). The device can clamp 8/20µs surges with peak pulse currents up to 5.5A in accordance with the IEC 61000-4-5 standard.

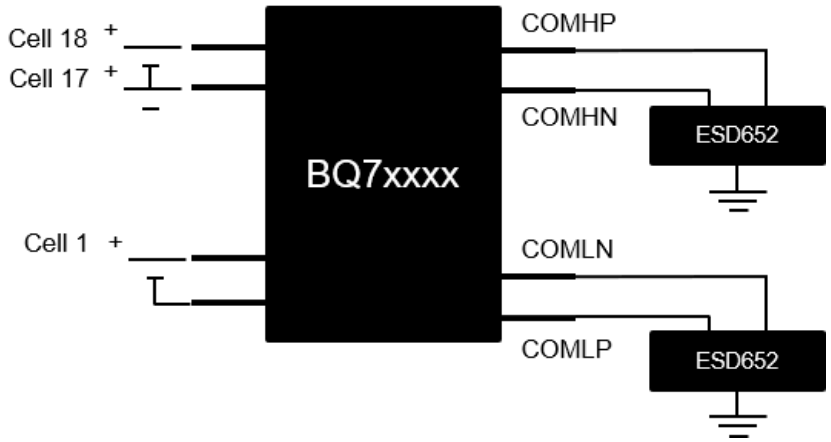
This device features a 4pF (typical) IO capacitance enabling high-speed interface protection. The low clamping voltage in the positive and negative direction help protect systems against transient events. This protection is key in industrial systems which require a high level of robustness and reliability.

The ESD652 is available in a small leaded SOT-23 (DBZ) package.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
ESD652	DBZ (SOT-23, 3)	2.92mm × 2.37mm

(1) For more information, see Section 9.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Typical Application Schematic

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4 Pin Configuration and Functions

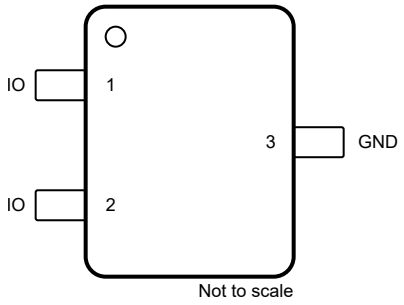

Figure 4-1. ESD652 DBZ Package, 3-Pin SOT-23 (Top View)

Table 4-1. Pin Functions for ESD652

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
IO	1, 2	I/O	Surge and ESD protected IO
GND	3	GND	Ground. Connect to ground

(1) I = Input, O = Output, I/O = Input or Output, GND = ground

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

Parameter		MIN	MAX	UNIT
P_{PPM}	IEC 61000-4-5 Surge (t_p = 8/20µs) Peak Pulse Power at 25°C (2)		176	W
I_{PPM}	IEC 61000-4-5 Surge (t_p = 8/20µs) Peak Pulse Current at 25°C (2)		5.5	A
T_A	Operating free-air temperature	–40	125	°C
T_{stg}	Storage temperature	–65	155	°C

(1) Operation outside the *Absolute Maximum Rating* may cause permanent device damage. *Absolute Maximum Rating* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Condition*. If used outside the *Recommended Operating Condition* but within the *Absolute Maximum Rating*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
(2) Voltages are with respect to GND unless otherwise noted.

5.2 ESD Ratings - JEDEC Specifications

Parameter		Test Conditions	VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001, all pins(1)	±2500	V
		Charged device model (CDM), per JEDEC specification JS-002, all pins(2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

5.3 ESD Ratings - IEC Specifications

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

5.4 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage between any 2 pins	–18		18	V
T_A	Operating Free Air Temperature	–40		125	°C

5.5 Thermal Information

THERMAL METRIC[1]		ESD652(Q1) DBZ (SOT-23) 3 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	249.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	129.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	83.1	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	24.2	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	82.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	NA	°C/W

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

5.6 Electrical Characteristics

At TA = 25°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{RWM}	Reverse stand-off voltage	I_{IO} < 50nA	-18		18	V
I_{LEAK}	Leakage current at V_{RWM}	VIO = ±18V, I/O to GND		1	50	nA
V_{BR}	Breakdown voltage, I/O to GND (1)	I_{IO} = ±10mA	19		25	V
V_{CLAMP}	Surge clamping voltage, t_p = 8/20µs (2)	I_{PP} = ±1A, I/O to GND		22	25	V
		I_{PP} = ±5.5A, I/O to GND		25	32	V
V_{CLAMP}	TLP clamping voltage, t_p = 100ns (3)	I_{PP} = ±16A TLP, I/O to GND		28		V
R_{DYN}	Dynamic resistance (4)	I/O to GND		0.32		Ω
		GND to I/O		0.32		
C_{LINE}	Line capacitance, IO to GND	V_{IO} = 0V, f = 1MHz		4		pF

(1) V_{BR} is defined as the voltage obtained at 10mA when sweeping the voltage up, before the device latches into the snapback state
(2) Device stressed with 8/20µs exponential decay waveform according to IEC 61000-4-5
(3) Non-repetitive square wave current pulse, Transmission Line Pulse (TLP); ANSI / ESD STM5.5.1-2008
(4) Extraction of R_{DYN} using least squares fit of TLP characteristics between I = 10A and I = 20A

5.7 Typical Characteristics

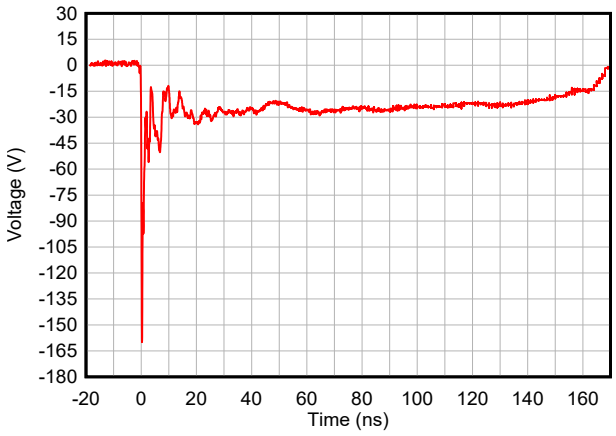

Figure 5-1. -8kV Clamped IEC Waveform

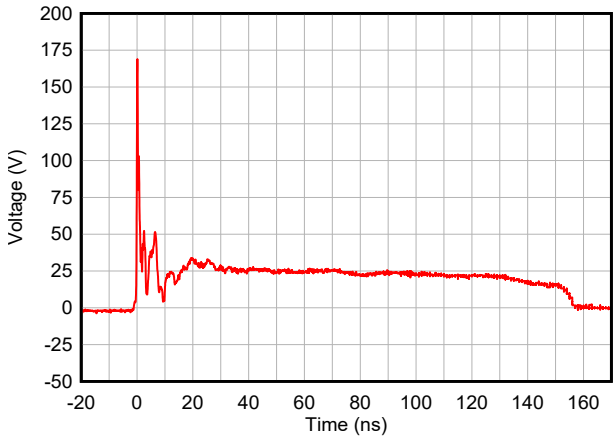

Figure 5-2. +8kV Clamped IEC Waveform

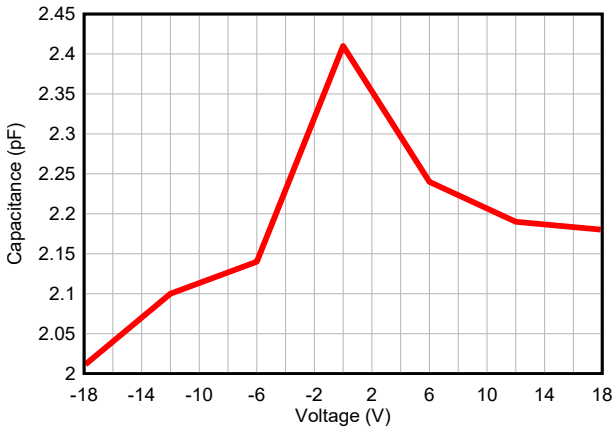

Figure 5-3. Capacitance vs. Bias Voltage

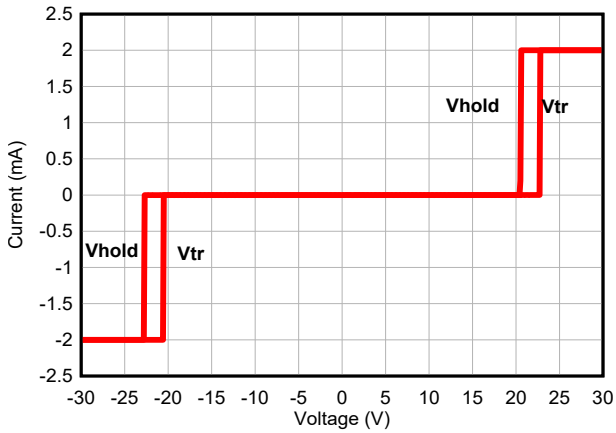

Figure 5-4. DC Voltage Sweep I-V Curve

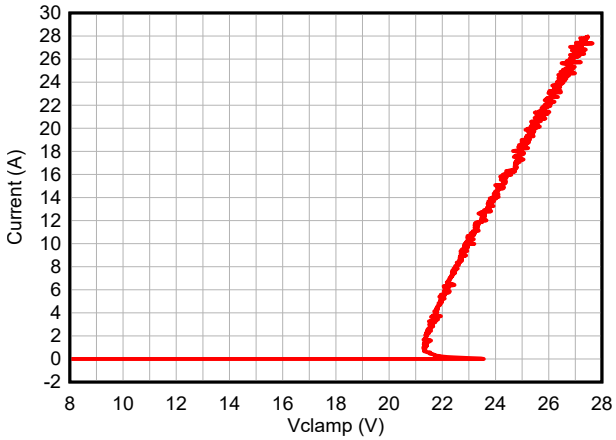

Figure 5-5. Negative TLP Curve

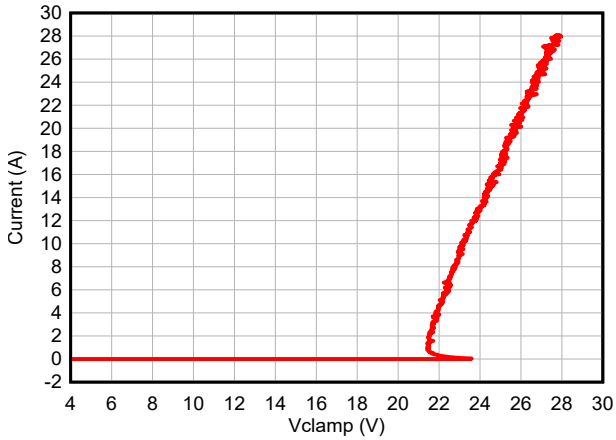

Figure 5-6. Positive TLP Curve

5.7 Typical Characteristics (continued)

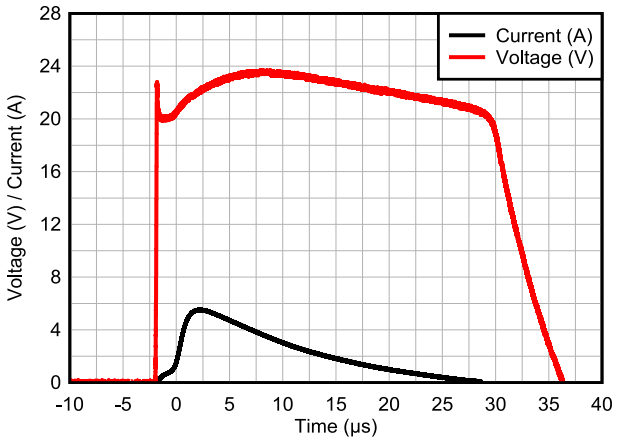

Figure 5-7. 8/20µs Surge Response

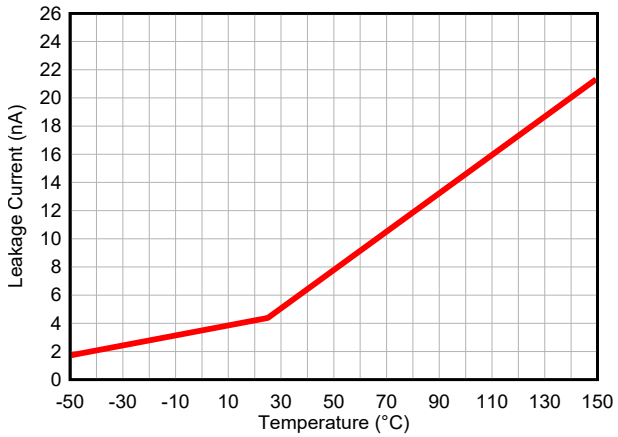

Figure 5-8. Leakage Current vs. Temperature

6 Application and Implementation

Note

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.

6.1 Application Information

The ESD652 is a diode type TVS that provides a path to ground for dissipating transient voltage spikes, such as ESD or surge, on signal lines and power lines. Connect the device in parallel to the down stream circuitry for protection. As the current from the transient passes through the device, only a small voltage drop is present across the diode. This is the voltage presented to the protected IC. The low R_{DYN} of the triggered TVS holds this voltage (V_{CLAMP}) to a safe level for the protected IC. For more information on how to properly use this device, refer to the *ESD Packaging and Layout Guide* for details.

7 Device and Documentation Support

7.1 Documentation Support

7.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *ESD Packaging and Layout Guide*
- 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 user's guide*

7.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* 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.

7.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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7.4 Trademarks

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7.5 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.

7.6 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

8 Revision History

DATE	REVISION	NOTES
February 2024	*	Initial Release

9 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 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)
ESD652DBZR	Active	Production	SOT-23 (DBZ) | 3	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 150	37K8

(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.

OTHER QUALIFIED VERSIONS OF ESD652 :

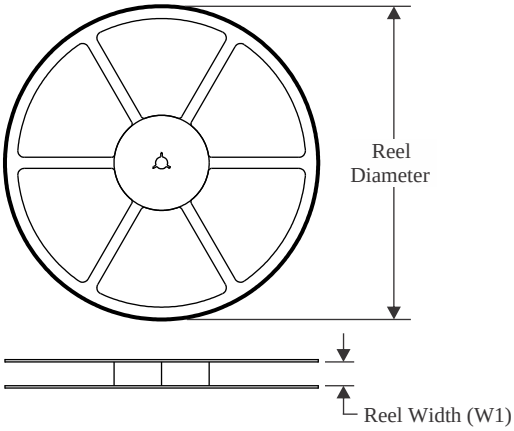
- Automotive : ESD652-Q1

NOTE: Qualified Version Definitions:

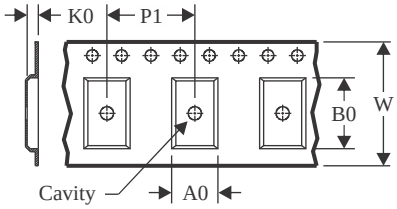
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

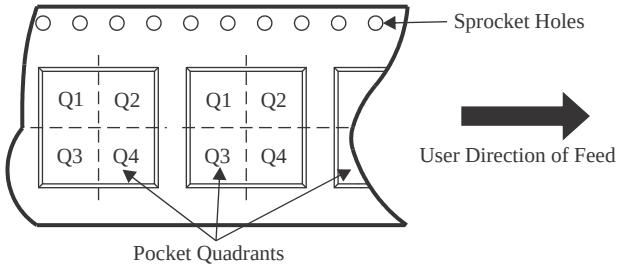


TAPE DIMENSIONS



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

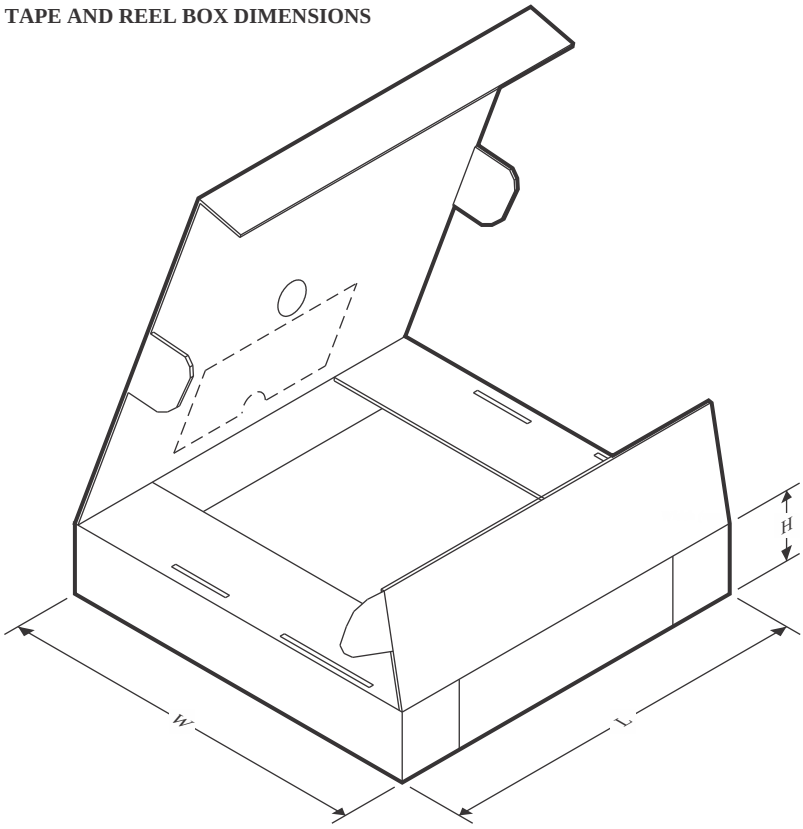
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
ESD652DBZR	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

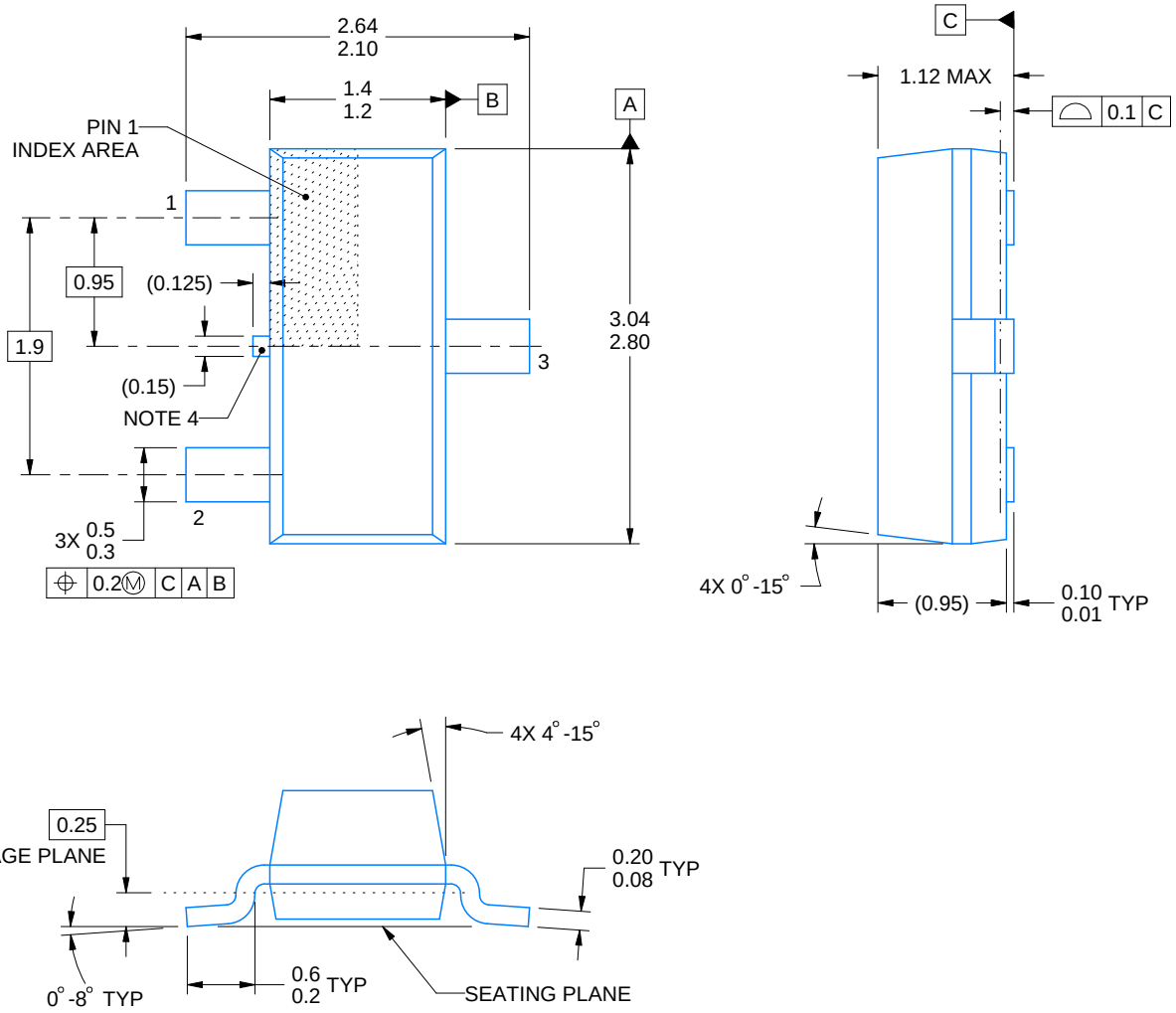
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ESD652DBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0

PACKAGE OUTLINE

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



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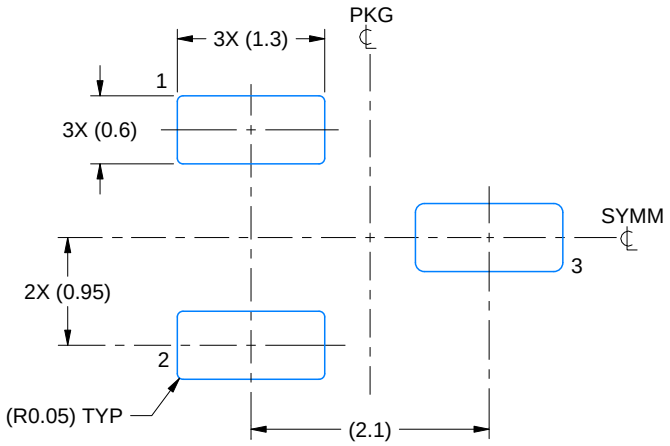
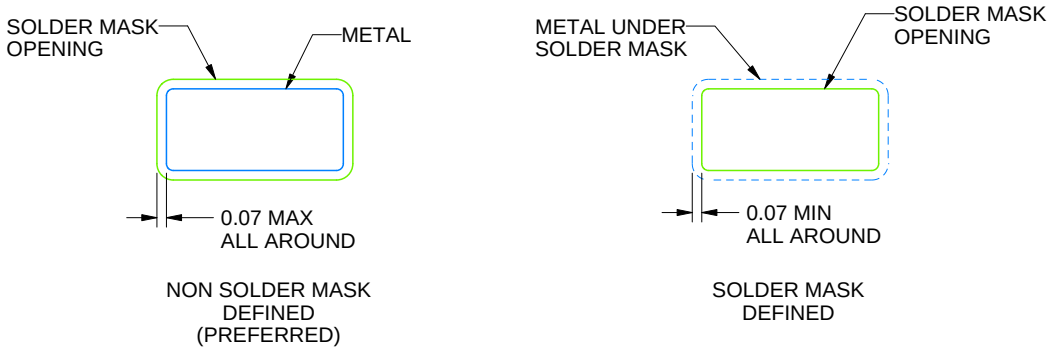
NOTES:

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



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

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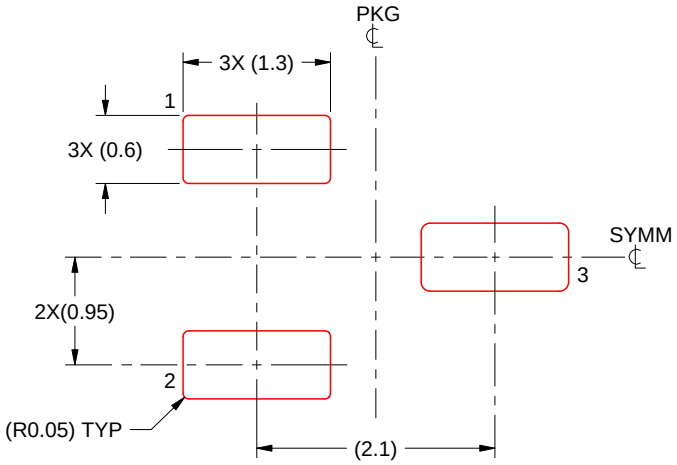
NOTES: (continued)

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



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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