TEXAS INSTRUMENTS
TSM24A-Q1
SLVSH76B – JUNE 2023 – REVISED OCTOBER 2023

TSM24A-Q1 24 V Unidirectional Surge Diode for Automotive Networks in SOT-23 Package

1 Features

- Robust surge protection:
  - IEC61000-4-5 (8/20 µs): 60 A
- Low clamping voltage of 38 V (typical) at 60 A for 8/20 µs surge current protects downstream components
- Unidirectional polarity for optimized clamping performance on single-ended data lines and power rails
- 24 V working voltage for protecting signals on 12-V systems
- Low leakage current of 75 nA (maximum)
- Low I/O capacitance of 54 pF (typical)
- Integrated IEC 61000-4-2 ESD protection
  - ±30-kV contact discharge
  - ±30-kV air-gap discharge
- Small SOT-23 leaded package to minimize board space and allow for automatic optical inspection (AOI)

2 Applications

- Industrial sensors
- USB Type-C™ V_{BUS}
- PLC I/O modules
- 24-V power lines, digital input, or output lines
- Automotive hybrid, electric, and power train systems
- HEV/EV on-board charger

3 Description

The TSM24A-Q1 is a part of TI's surge protection device family. The TSM24A-Q1 robustly shunts up to 60 A of IEC 61000-4-5 fault current to protect systems from high power transients or lightning strikes. The device offers a solution to the common industrial signal line EMC requirement to survive up to 2.5 kV IEC 61000-4-5 open circuit voltage coupled through a 42 Ω impedance. The TSM24A-Q1 clamps during a surge event, keeping system exposure below 38 V (typical) at I_{PP} = 60 A.

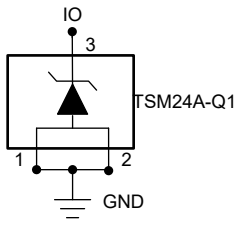
Additionally, the TSM24A-Q1 is available in a small leaded SOT-23 (DBZ) package which is reduced in size by approximately 50 percent compared to the industry standard SMA package. The device is designed to have a minimal effect on the protected line due to extremely low device leakage.

For the bidirectional version of this device, please see TSM24CA-Q1.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
TSM24A-Q1	DBZ (SOT-23, 3)	2.92 mm × 2.37 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Functional Block Diagram

Table of Contents

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (September 2023) to Revision B (October 2023)	Page
• Changed the status from: *Advanced Information* to: *Production Data*	1

5 Pin Configuration and Functions

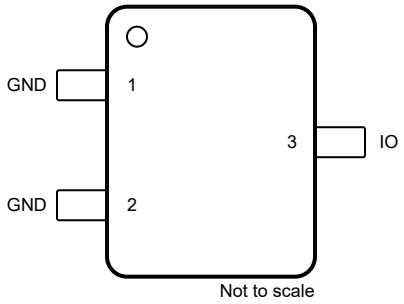


Figure 5-1. DBZ Package, 3-Pin SOT-23 (Top View)

Table 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

6 Specifications

6.1 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 = 8/20 µs) Peak Pulse Power at 25 °C (2)		2800	W
I_{PPM}	IEC 61000-4-5 Surge (t_p = 8/20 µs) Peak Pulse Current at 25 °C (2)		60	A
T_A	Operating free-air temperature	–55	150	°C
T_{stg}	Storage temperature	–65	155	°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 briefly operating outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.
(2) Voltages are with respect to GND unless otherwise noted.

6.2 ESD Ratings - AEC Specifications

Parameter		Test Conditions	VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q101-001(1)	±2500	V
		Charged device model (CDM), per AEC Q101-005(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.

6.3 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	

6.4 ESD Ratings - ISO Specifications

Parameter		Test Conditions		VALUE	UNIT
$V_{(ESD)}$	ISO 10605 Electrostatic Discharge	C = 150 pF; R = 330 Ω	Contact Discharge, all pins	±30000	V
			Air-gap Discharge, all pins	±30000	
		C = 330 pF; R = 330 Ω	Contact Discharge, all pins	±30000	
			Air-gap Discharge, all pins	±30000	

6.5 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage	0		24	V
T_A	Operating Free Air Temperature	–55		150	°C

6.6 Thermal Information

THERMAL METRIC[1]		TSM24A DBZ (SOT-23) 3 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	203.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	104.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	39.4	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	8.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	38.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

6.7 Electrical Characteristics

At T_A = 25°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{RWM}	Reverse stand-off voltage	I_{IO} < 100 nA			24	V
I_{LEAK}	Leakage current at V_{RWM}	VIO = 24 V, I/O to GND		25	75	nA
V_{BR}	Breakdown voltage, I/O to GND (1)	I_{IO} = 10 mA	26	29		V
V_{FWD}	Forward Voltage, GND to I/O (1)	I_{IO} = 10 mA		0.7		V
V_{CLAMP}	Surge clamping voltage, t_p = 8/20 µs (2)	I_{PP} = 60 A, I/O to GND		38		V
V_{CLAMP}	Surge clamping voltage, t_p = 8/20 µs (2)	I_{PP} = 60 A, GND to I/O		7		V
C_{LINE}	Line capacitance, IO to GND	V_{IO} = 0 V, f = 1 MHz		54		pF

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

6.8 Typical Characteristics

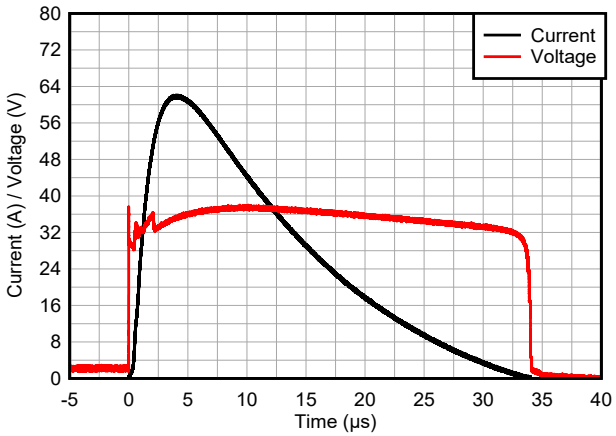


Figure 6-1. 8/20 µs Surge Response

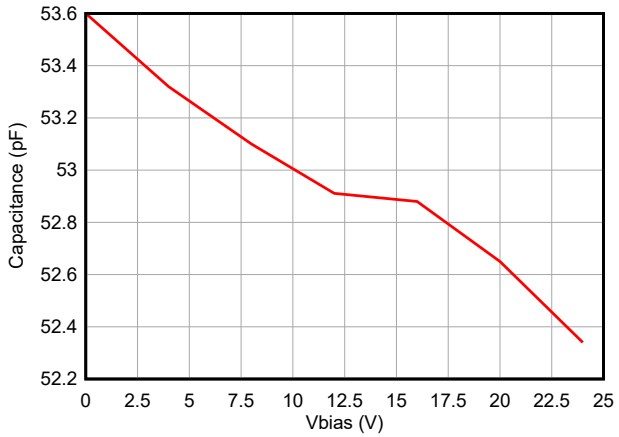


Figure 6-2. Capacitance vs Bias Voltage

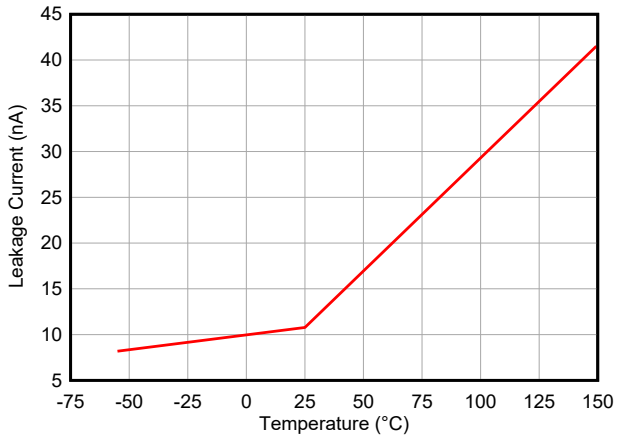


Figure 6-3. Leakage vs Temperature

7 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.

7.1 Application Information

The TSM24A-Q1 is a TVS diode 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 TVS, only a small voltage drop is present across the diode. The small voltage drop is 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*.

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 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* user's guide

8.2 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.

8.3 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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8.4 Trademarks

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8.5 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.

8.6 Glossary

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

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 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
TSM24ADBZRQ1	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-55 to 150	35L8	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.

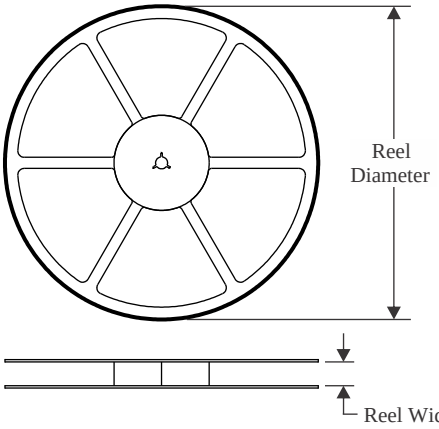
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

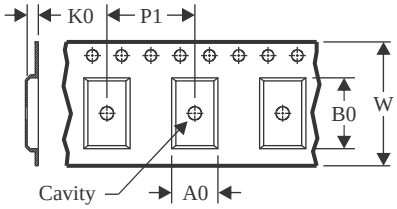
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

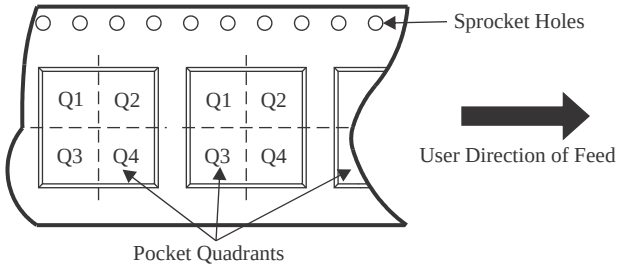


TAPE DIMENSIONS



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

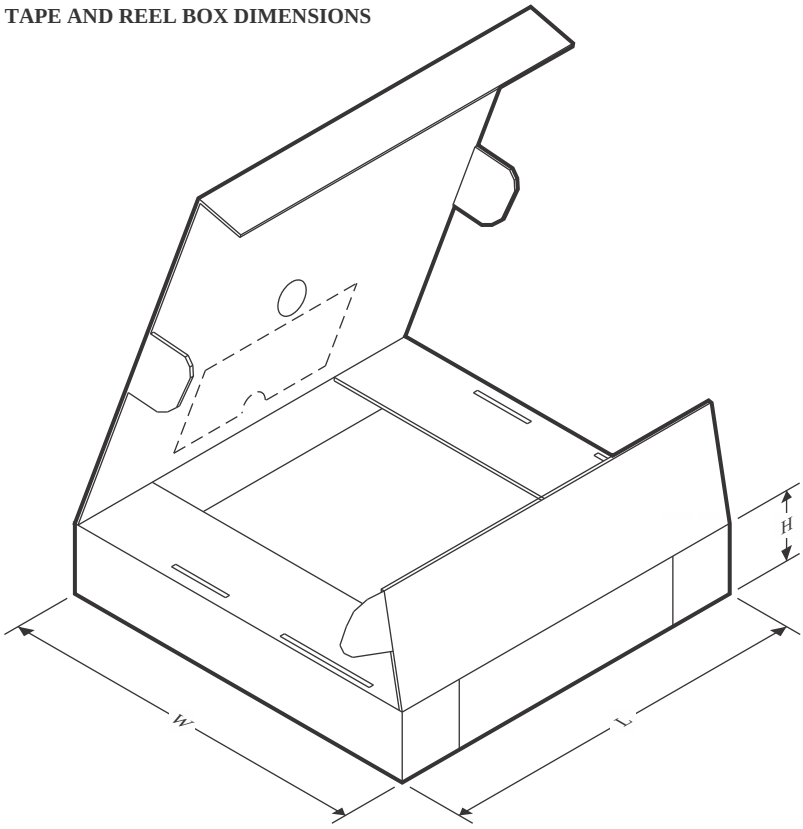
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TSM24ADBZRQ1	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)
TSM24ADBZRQ1	SOT-23	DBZ	3	3000	210.0	185.0	35.0

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