

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

## 1 Features

- Robust surge protection:
  - IEC61000-4-5 (8/20  $\mu$ s): 60 A
- Low clamping voltage of 38 V (typical) at 60 A for 8/20  $\mu$ s 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
  - $\pm$ 30-kV contact discharge
  - $\pm$ 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  $\Omega$  impedance. The TSM24A-Q1 clamps during a surge event, keeping system exposure below 38 V (typical) at  $I_{PP} = 60$  A.

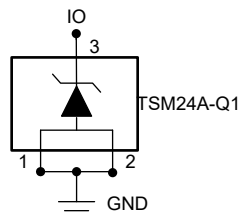
Additionally, the TSM24A-Q1 is available in a small leaded SOT-23 (DBZ) package which is reduced in size by approximately 50 percent compared to the industry standard SMA package. The device is designed to have a minimal effect on the protected line due to extremely low device leakage.

For the bidirectional version of this device, please see [TSM24CA-Q1](#).

### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
TSM24A-Q1	DBZ (SOT-23, 3)	2.92 mm $\times$ 2.37 mm

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



**Functional Block Diagram**



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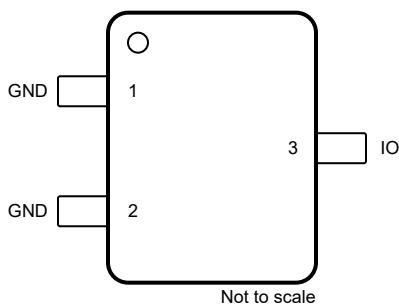
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## 4 Revision History

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

<b>Changes from Revision A (September 2023) to Revision B (October 2023)</b>	<b>Page</b>
• Changed the status from: <i>Advanced Information</i> to: <i>Production Data</i> .....	<b>1</b>

## 5 Pin Configuration and Functions



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

**Table 5-1. Pin Functions**

PIN		TYPE <sup>(1)</sup>	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)<sup>(1)</sup>

Parameter		MIN	MAX	UNIT
P <sub>PPM</sub>	IEC 61000-4-5 Surge (t <sub>p</sub> = 8/20 μs) Peak Pulse Power at 25 °C <sup>(2)</sup>		2800	W
I <sub>PPM</sub>	IEC 61000-4-5 Surge (t <sub>p</sub> = 8/20 μs) Peak Pulse Current at 25 °C <sup>(2)</sup>		60	A
T <sub>A</sub>	Operating free-air temperature	–55	150	°C
T <sub>stg</sub>	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 <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per AEC Q101-001 <sup>(1)</sup>	±2500	V
		Charged device model (CDM), per AEC Q101-005 <sup>(2)</sup>	±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 <sub>(ESD)</sub>	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 <sub>(ESD)</sub>	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 <sub>IN</sub>	Input voltage	0		24	V
T <sub>A</sub>	Operating Free Air Temperature	–55		150	°C

## 6.6 Thermal Information

THERMAL METRIC <sup>(1)</sup>		TSM24A	UNIT
		DBZ (SOT-23)	
		3 PINS	
$R_{\theta JA}$	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
$\Psi_{JT}$	Junction-to-top characterization parameter	8.7	°C/W
$\Psi_{JB}$	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  $T_A = 25^\circ\text{C}$  unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{RWM}$	Reverse stand-off voltage	$I_{IO} < 100\text{ nA}$			24	V
$I_{LEAK}$	Leakage current at $V_{RWM}$	$V_{IO} = 24\text{ V}$ , I/O to GND		25	75	nA
$V_{BR}$	Breakdown voltage, I/O to GND <sup>(1)</sup>	$I_{IO} = 10\text{ mA}$	26	29		V
$V_{FWD}$	Forward Voltage, GND to I/O <sup>(1)</sup>	$I_{IO} = 10\text{ mA}$		0.7		V
$V_{CLAMP}$	Surge clamping voltage, $t_p = 8/20\text{ }\mu\text{s}$ <sup>(2)</sup>	$I_{PP} = 60\text{ A}$ , I/O to GND		38		V
$V_{CLAMP}$	Surge clamping voltage, $t_p = 8/20\text{ }\mu\text{s}$ <sup>(2)</sup>	$I_{PP} = 60\text{ A}$ , GND to I/O		7		V
$C_{LINE}$	Line capacitance, IO to GND	$V_{IO} = 0\text{ V}$ , $f = 1\text{ MHz}$		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  $\mu\text{s}$  exponential decay waveform according to IEC 61000-4-5

## 6.8 Typical Characteristics

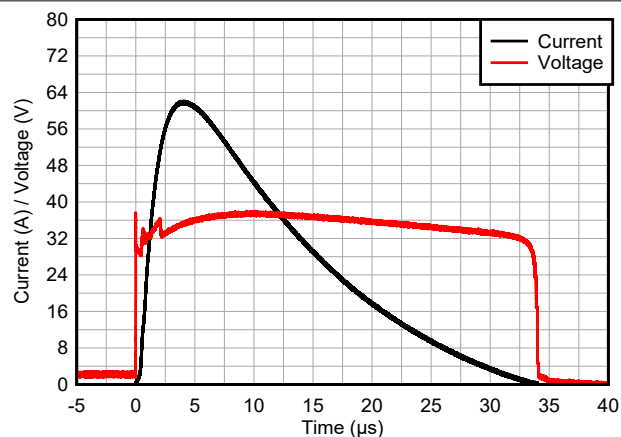
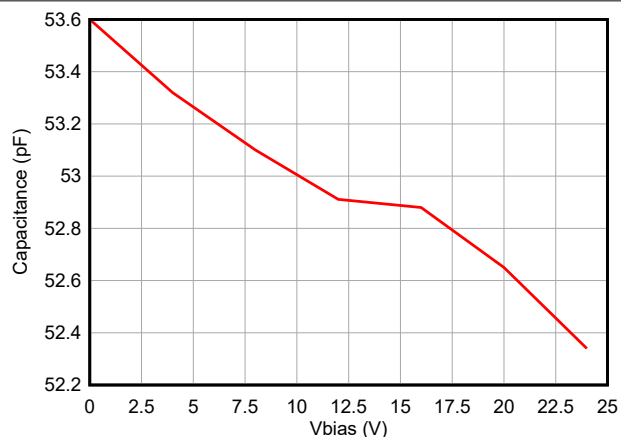
Figure 6-1. 8/20  $\mu$ s Surge Response

Figure 6-2. Capacitance vs Bias Voltage

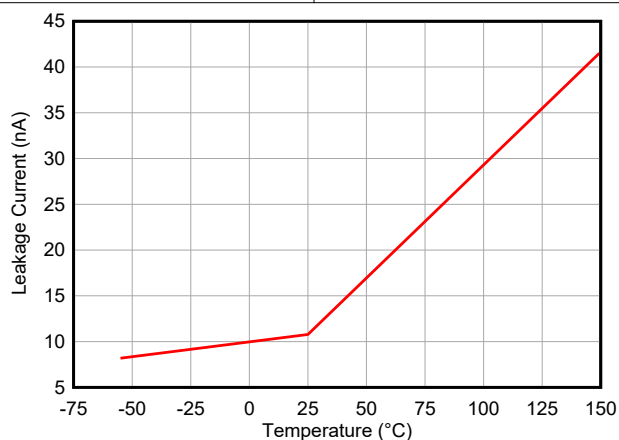


Figure 6-3. Leakage vs Temperature

## 7 Application and Implementation

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### 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.

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### 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](https://www.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 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)
<a href="#">TSM24ADBZRQ1</a>	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 150	35L8
TSM24ADBZRQ1.B	Active	Production	SOT-23 (DBZ)   3	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-55 to 150	35L8

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

<sup>(5)</sup> **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.

<sup>(6)</sup> **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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### OTHER QUALIFIED VERSIONS OF TSM24A-Q1 :

- Catalog : [TSM24A](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

## 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
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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