Application Report

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TVS3300 Configurations Characterization

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ABSTRACT

This application report shows the electrical characteristics and test data of using two TVS3300 Unidirectional TVS diodes to make a bidirectional solution. The application note gives typical data and graphs showing all of the different specifications that are found in the TVS3300 datasheet, but with two of them back to back to protect in a bidirectional application.

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1 Introduction

The TVS3300 is a precision clamp that keeps ultra-low and flat clamping voltage during transient overvoltage events like surge. With TI’s precision surge technology, the TVS3300s clamping voltage varies little across the surge current it is rated for. The TVS3300 also responds fast to the surge to limit overshoot voltage during clamping. Used in the system, the TVS3300's flat low clamping ensures a lower voltage for downstream devices than traditional TVS diodes. This application report helps understand the electrical characteristics of the different configurations the TVS3300 can be used in. Figure 1 shows the functional block diagram of the TVS3300.

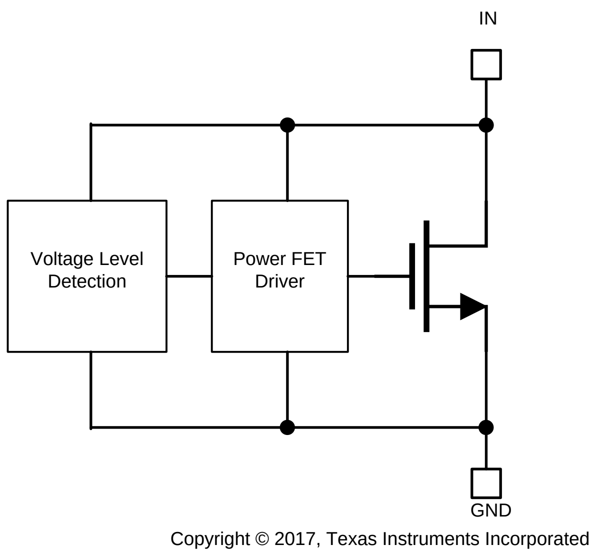

Figure 1. TVS3300 Functional Block Diagram

2 Detailed Description

The TVS3300 is a precision clamp that keeps ultra-low and flat clamping voltage during transient overvoltage events like surge. The TVS3300 can handle 35-A of 8/20-µs surge pulse. The flat clamping feature helps keep the clamping voltage very low to keep the downstream circuits from being stressed. The flat clamping feature can also help end-equipment designers save cost by opening up the possibility to use lower-cost lower voltage tolerant downstream ICs. The TVS3300 has minimal leakage, even in bi-directional configuration, under the standoff voltage of 33 V, making it an ideal candidate, but not limited to for majority of factory and process automation applications. IEC61000-4-2 and IEC61000-4-4 ratings make it a robust protection solution for ESD and EFT events. Wide ambient temperature range of –40°C to 125°C make it a good candidate for most applications. Compact packages enable it to be used in small devices and save board area.

2.1 *Bidirectional Configuration*

The TVS3300 can be modeled as a power FET with control circuitry. However, the main power FET has an internal body diode from source to drain pictured in Figure 2.

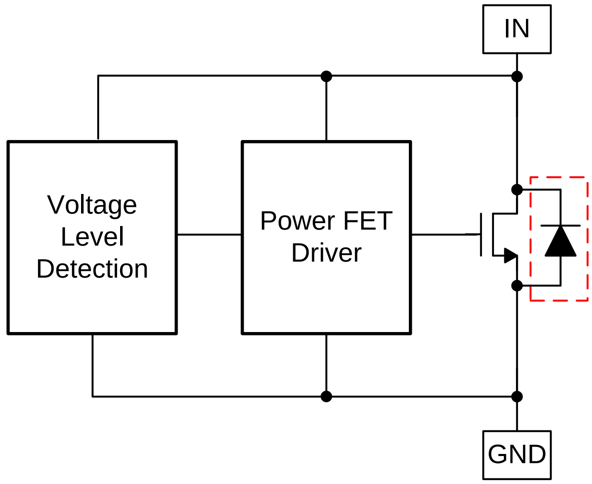

Figure 2. Body Diode of TVS3300

Therefore if the device is connected backwards in an application, current would easily flow from the "GND" pin to the "IN" pin. Miswiring configurations are troublesome for applications that require bidirectional configuration for their TVS diodes. In order to compensate for this, two TVS3300's placed with their ground pins connected together are used. See Figure 3.

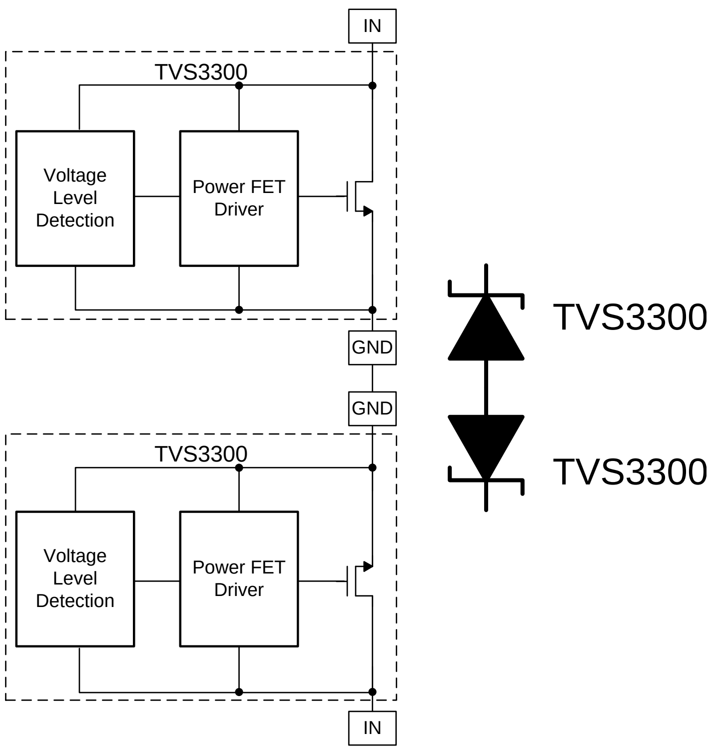

Figure 3. TVS3300 Bidirectional Configuration

It is important to note that if desired the TVS3300 can be placed in the direction where their body diodes are facing each other (shorting the "IN" pins together). However in that scenario the bottom TVS3300 body diode will be blocking the path to ground until the bottom FET turn on. While this is not an issue it is more intuitive to have the bottom TVS3300 diode facing ground so that any stored up charge in between the two devices will have an easier path to dissipate to ground. Therefore it is recommended to connect the "GND" pins together but is acceptable to reverse both TVS3300s.

3 Electrical Characteristics

over operating free-air temperature, –40°C to 125°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IN}	IN pin voltage			33		V
T_A	Ambient operating temperature		–40		125	°C
V_{RWM}	Reverse standoff voltage	Measured I_N = 1 µA		33		V
$-V_{RWM}$	Negative reverse standoff voltage	Measured I_N = –1 µA		-33		V
I_{LEAK}	Leakage current	Measured at V_{IN} = 33 V T_A = 27ºC		19		nA
V_{BR}	Breakdown voltage	I_{IN} = 1 mA		36.2		V
$-V_{BR}$	Negative breakdown voltage	I_{IN} = –1 mA		–36.2		V
V_{CLAMP}	Clamping voltage	I_{PP} = 35 A, IEC 61000-4-5 surge (8/20 µs), V_{IN} = 0 V before surge		38		V
R_{DYN}	8/20-µs surge dynamic resistance	Calculated from V_{CLAMP} at 15 A and 30 A surge current levels, T_A = 27°C		87		mΩ
C_{IN}	Input pin capacitance	V_{IN} = 12 V		89		pF

4 ESD Ratings - JEDEC Specification

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001	±2000	V
		Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002	±500	

5 ESD Ratings - IEC Specification

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	IEC 61000-4-2 contact discharge - WCSP package	±14000	V
		IEC 61000-4-2 contact discharge - DRV package	±11000	
		IEC 61000-4-2 air gap discharge	±30000	
		IEC 61000-4-4 EFT protection (5/50 ns)	80	A
Peak pulse	Clamping direction	IEC 61000-4-5 current (8/20 µs)	35	A
		IEC 61000-4-5 power (8/20 µs)	1330	W

6 Typical Characteristic Graphs

All graphs taken with two TVS3300's in bidirectional configuration.

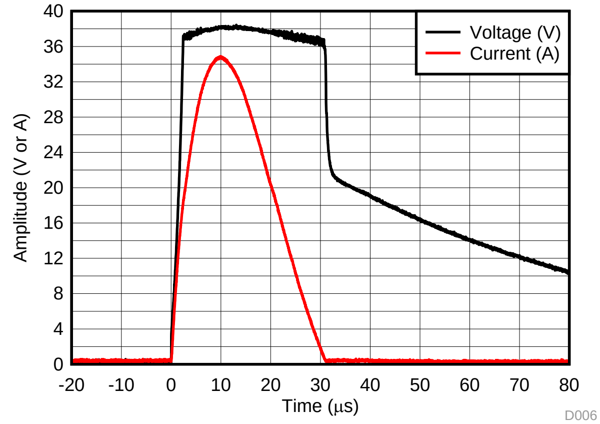

Figure 4. Surge Response at 35 A

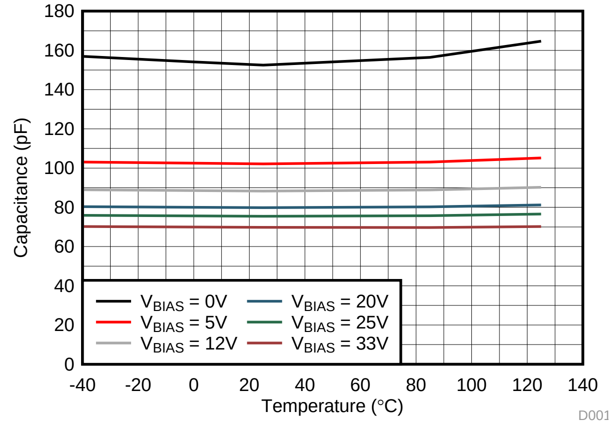

Figure 5. Capacitance vs Temperature Across Bias

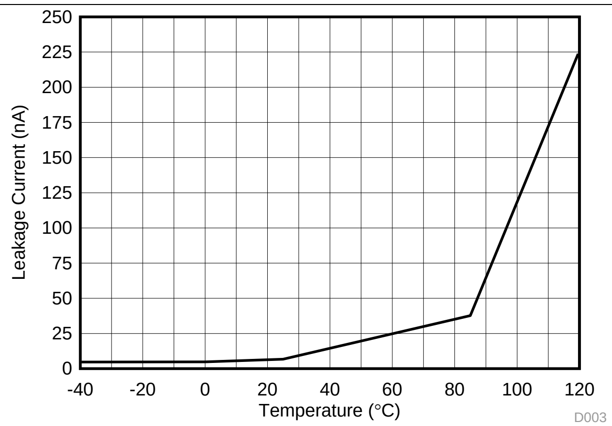

Figure 6. Leakage Current vs Temperature at 33 V

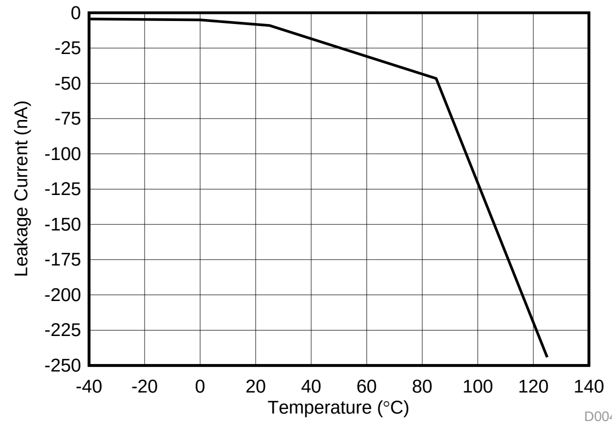

Figure 7. Leakage Current vs Temperature at –33 V

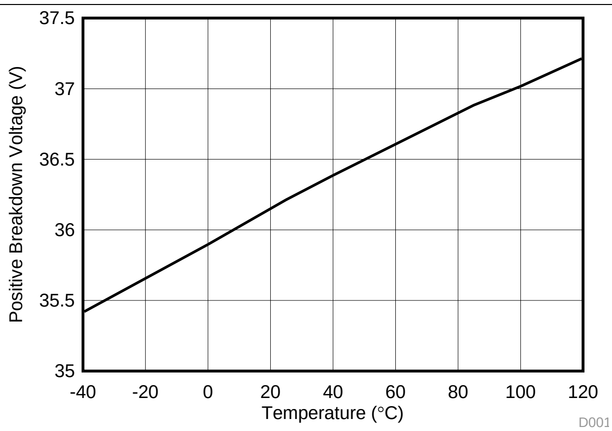

Figure 8. VBR+ Across Temperature

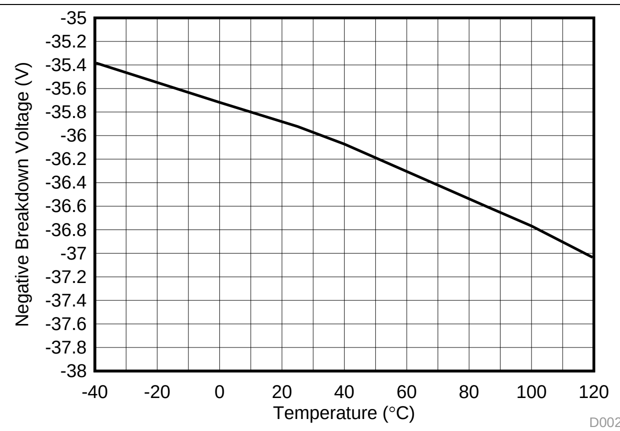

Figure 9. VBR- Across Temperature

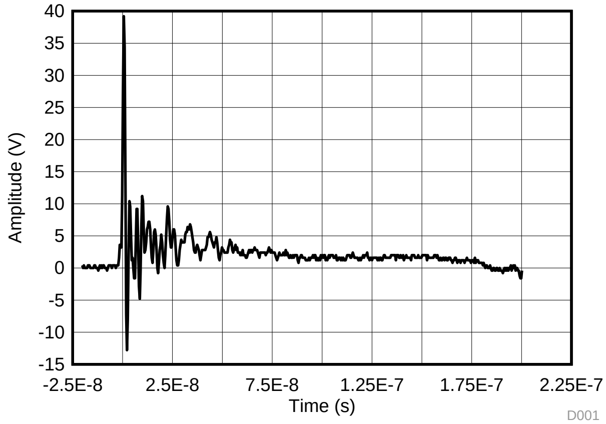

Figure 10. 8-kV IEC Response

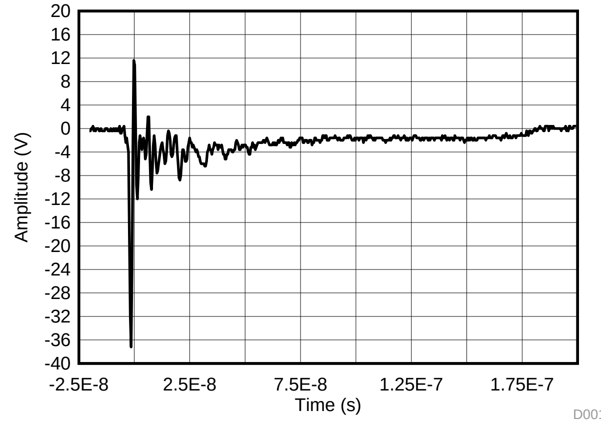

Figure 11. –8-kV IEC Response

7 Application and Information

The TVS3300 is a precision clamp that keeps ultra-low and flat clamping voltage during transient overvoltage events like surge. The TVS3300 also responds fast to surge so there is no overshoot voltage during clamping. When used for bidirectional applications, two TVS3300 device should be placed back to back. Key specifications that high light the differences between using two TVS3300s back to back and just one are, dynamic resistance and input capacitance. Obviously when two devices go in series their effective resistance is about doubled and their capacitance is half. Also because they are in series, they both take the same amount of current and therefore the total power capable of being used is the same as the single TVS3300 case.

A typical application where the bidirectional configuration of the TVS3300 is used is Figure 12. All current loop applications require a bidirectional TVS diode incase there is a negative voltage swing. Two TVS3300's work well in this application because of their low leakage current that is negligible compared to the signal and the flat clamping voltage that makes sure devices do not see big overvoltage events.

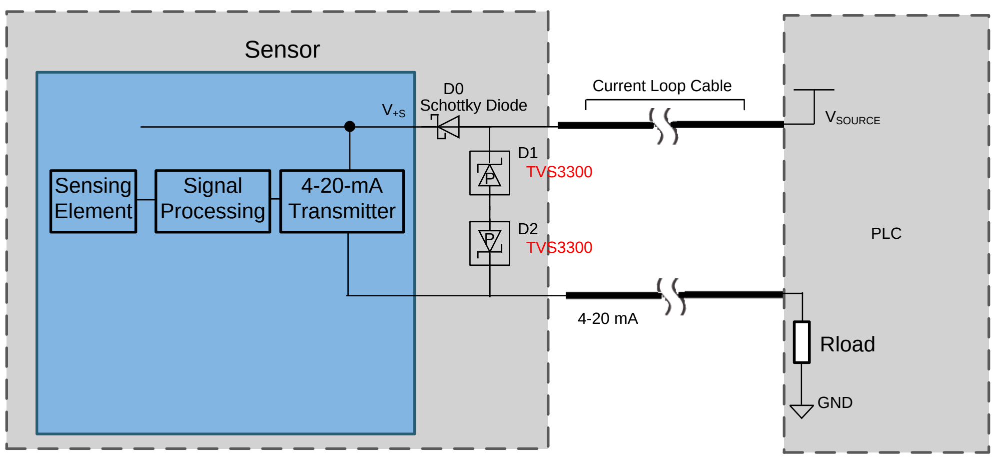

Figure 12. 4–20-mA Current Loop

8 Layout

8.1 Layout Guidelines

The optimum placement is 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 needs to minimize the possibility of EMI coupling by keeping any unprotected traces away from the protected traces which are between the two TVS3300s and the connector.

Route the protected traces as straight as possible

Eliminate any sharp corners on the protected traces between the TVS3300 and the connector by using rounded corners with the largest radii possible. Electric files tend to build up on corners, increasing EMI coupling.

8.2 Layout Example

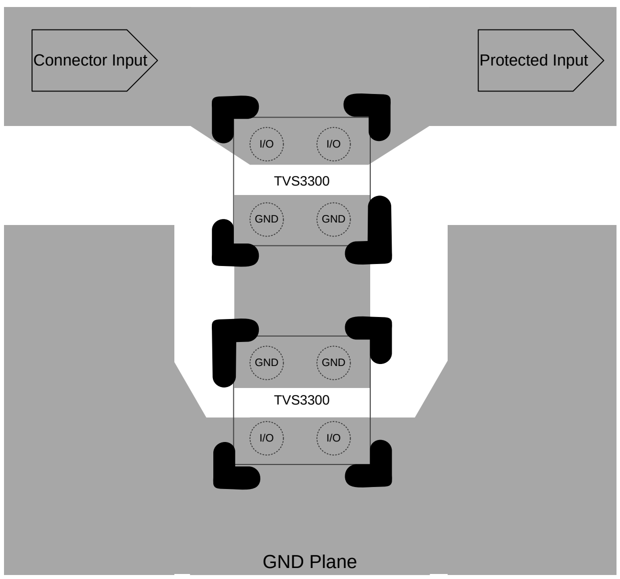

Figure 13. TVS3300 Bidirectional Layout