Transient Protection for the Standard RS-485 Transceiver: ISL3152E

Standard compliant RS-485 transceivers, such as the ISL3152E, have asymmetric stand-off voltages of -9V and +14V. This requires a bidirectional TVS with asymmetric breakdown voltages. The only device satisfying this requirement is the 400W TVS, SM712 from Semtech. This application note provides the schematic, bill of materials, and layout guidelines for a transient protection circuit for the ISL3152E transceiver.

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Related Literature

For more detailed information on transient protection for RS-485 transceivers, refer to the following application notes on our website ISL3152E.

- AN1976: Important Transient Immunity Tests for RS-485 Networks
- AN1977: Transient Voltage Suppressors: Operation and Features
- AN1978: Surge Protection for Renesas' Standard RS-485 Transceivers
- AN1979: Surge Protection simplified with Renesas' Overvoltage Protected (OVP) Transceivers

1. Asymmetric Transient Voltage Suppressor SM712

The SM712 transient voltage suppressor (TVS) is designed for asymmetrical (+12 to -7V) protection in standard RS-485 applications. The device is used to protect transceivers against transient voltages resulting from Electrostatic Discharge (ESD), Electrical Fast Transients (EFT), and lightning. The SM712 integrates two 12V and two 7V TVS diodes in a single SOT23 package. It is rated for 400W peak-pulse power (t_p = 8/20µs) and protects to:

- IEC61000-4-2 (ESD) +15kV (air), +8kV (contact)
- IEC61000-4-4 (EFT) 40A (%/50ns)
- IEC61000-4-5 (Lightning) 12A (8/20µs)

Figure 1 shows the SM712 inner structure and Table 1 lists its key parameters.

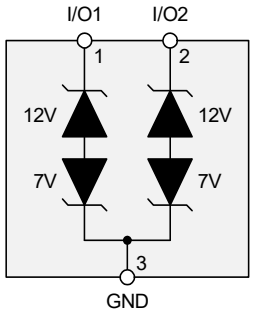


Figure 1. SM712

Table 1. Key Parameters of SM712

Parameter	Symbol	12 TVS	7V TVS	Unit
Stand-Off Voltage	V_{WM}	12	7	V
Breakdown Voltage	V_{BR}	13.3	7.5	V
Clamping Voltage at I_{P-P}	V_C	26	12	V
Peak-Pulse Current	I_{P-P}	17		A
Derating Factor at +85°C	DF	average	0.5	-
		pulse	0.8	
Junction Capacitance	C_J	45		pF

2. TVS Design Cautions

Many application examples of transient protected RS-485 nodes have the TVS diodes directly connected to the transceiver bus terminals. Because standard RS-485 transceivers have internal ESD structures whose trigger levels are close to the external SM712 breakdown voltage (V_{BR}), the transceiver ESD cells might interact with the external TVS.

The ESD structures within the ISL3152E have a Zener switching characteristic, similar to the one of the SM712, and therefore will share the high transient current with the external TVS. Because a surge transient has about eight million times the energy of an ESD transient of the same peak-pulse voltage, the transceiver ESD cells are at risk of damage by high surge currents.

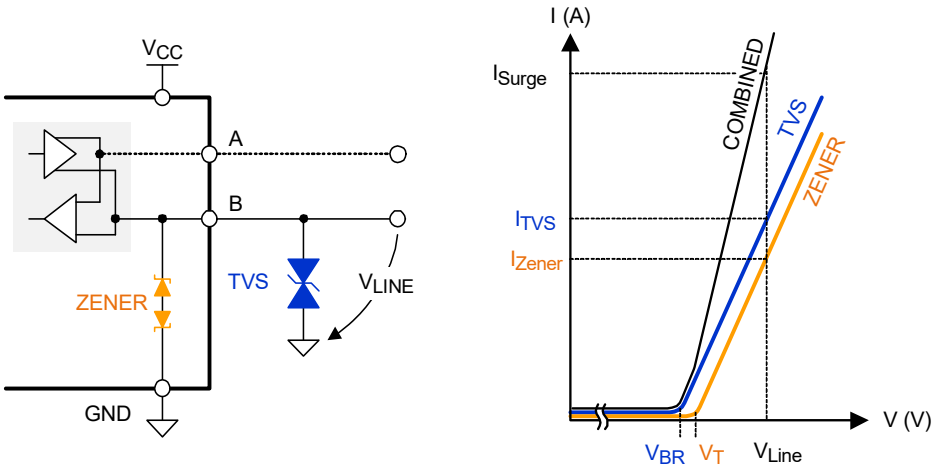
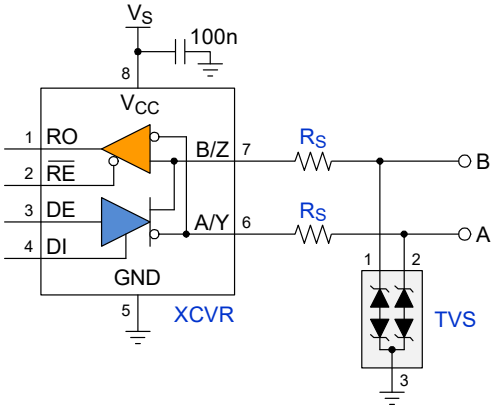


Figure 2. Transceiver Damage Due to Zener Sharing High Transient Current with External TVS

To limit the bus currents into the transceiver during a surge event, carbon composite or pulse-proof thick-film resistors should be inserted between the TVSs and the transceiver. Due to their voltage divider action with the bus termination resistors, their value should be less than 20Ω to minimize bus voltage attenuation during normal operation. Figure 3 shows the schematic of a Level 2 surge protection example for the ISL3152E and its bill of materials.



Name	Function	Order No.	Vendor
XCVR	5V, 115kbps transceiver	ISL3152EIBZ	Renesas
TVS	400W (8,20µs), bidirectional TVS	SM712.TCT	Semtech
R_S	10Ω, 0.2W, pulse-proof thick-film resistor	CRCW0603-HP e3 series	Vishay

Figure 3. IEC61000-4-5 Level 2 (1kV) Surge Protection and Associated Bill of Materials

Note: The design does not use a TVS for differential transients, as these mainly occur when TVS switching does not happen simultaneously (as with some older, high-capacitance TVS diodes), or when non-twisted pair cables, such as lamp wires or flat band cables are used. When using twisted pair cable in combination with modern TVS devices, the possibility for differential voltage transients is eliminated.

3. Layout Suggestions

While it is possible to use smaller size 0402 resistors for R_S, manufacturer Vishay does not recommend them for wave soldering but reflow soldering only. To enable the application of either technique, 0603 resistors are recommended.

Figure 4 shows a recommended PCB layout for the TVS section. Because electrical transients span a wide frequency range, the application of low-inductance reference planes for V_{CC} and ground layers is strongly advised. This will typically require a minimum 4-layer board.

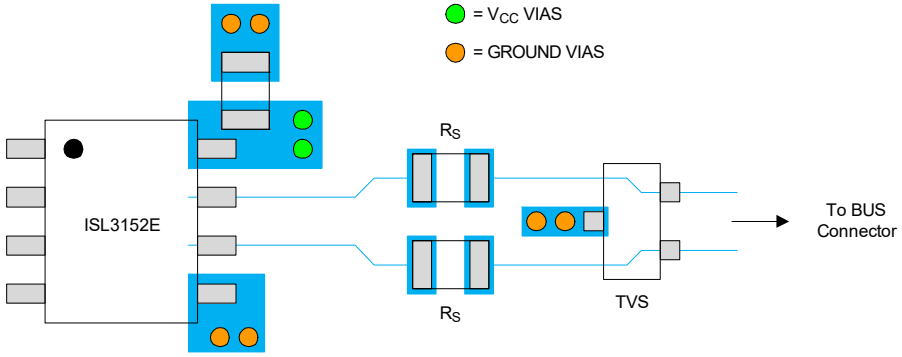


Figure 4. Suggested PCB Layout with Ground and V_{CC} Layers

- Place the components in the direction of the current flow.
- Use 45° bends for PCB traces.
- Place decoupling capacitors close to all active components, such as transceiver, voltage regulator, and MCU.
- Use at least two vias for each connection to the VCC or ground planes to reduce via inductance.

4. Revision History

Revision	Date	Description
1.00	Aug 19, 2022	Applied new template. Updated titles in the related literature section. Added Revision History section.
0.00	Jul 17, 2017	Initial release

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