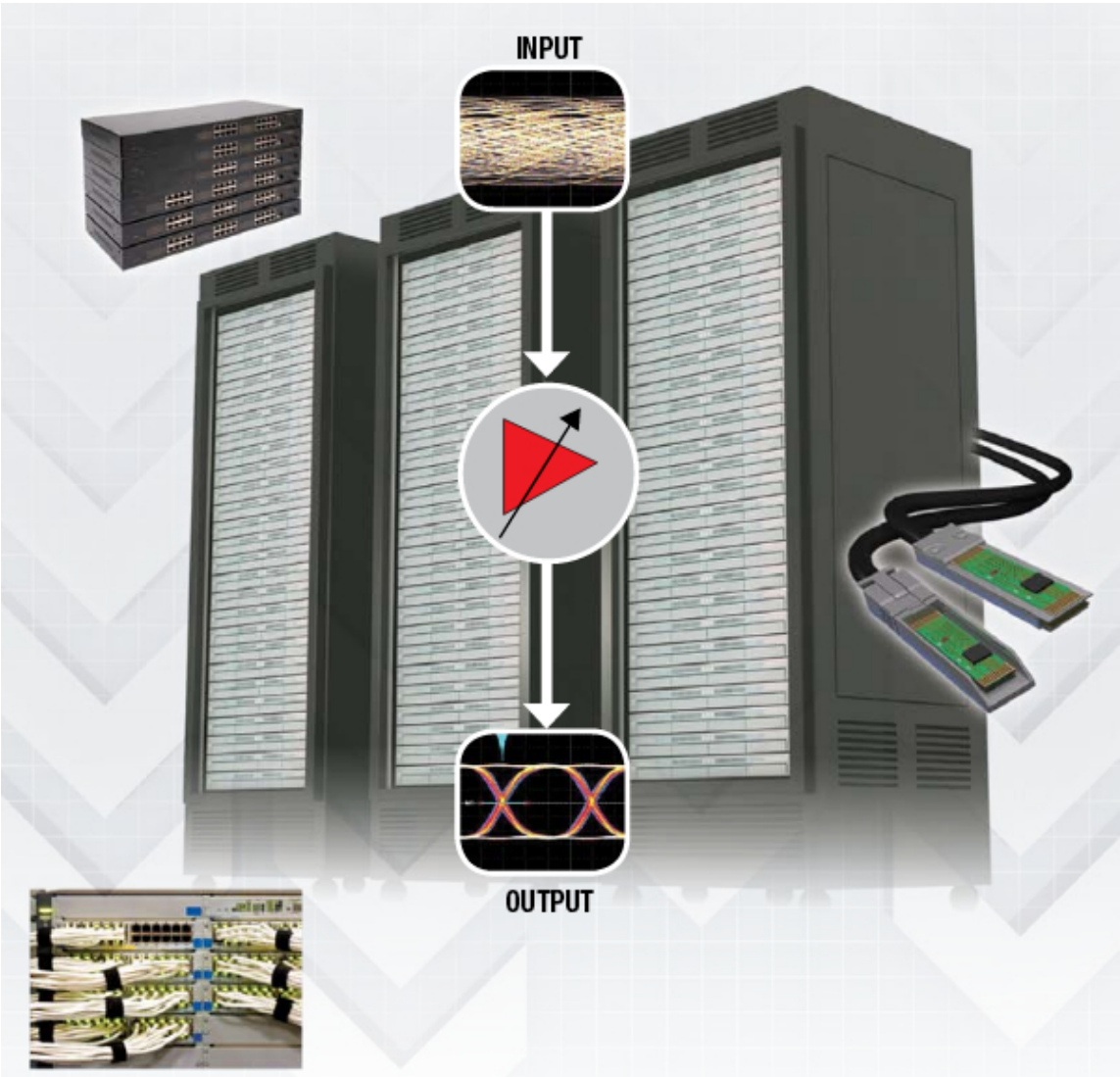
Technical Article

Get Connected: the Basics of Protecting RS-485 against ESD

Michael Peffers

Welcome back to the Get Connected blog series on Analog Wire. In my last post, I discussed fail-safe biasing of differential buses and how to implement fail-safe biasing in your designs. In this post, I'll look at protecting your differential bus against system-level transients using a transient voltage suppressor (TVS) diode and pulse-proof resistors.



Industrial networks such as RS-485 are expected to withstand harsh system-level transients in their end applications without being damaged. Damage can occur from electrostatic discharge (ESD) during handling, interruption of inductive loads, relay contact bounce and/or lightning strikes. You can protect your industrial design against these transient events through the addition of external components on the differential bus.

Copyright © 2023 Texas Instruments Incorporated

Let's look at the International Electrotechnical Commission (IEC) ESD 61000-4-2 system-level ESD test that manufacturers use to test for robustness. There are two types of testing methods involved with the IEC ESD test: contact discharge and air discharge. The contact ESD test discharges an ESD pulse from an IEC ESD gun directly onto the device under test (DUT). The air ESD discharge test involves moving the charged ESD gun toward the DUT until the air breaks down enough to allow conduction of the ESD strike between the ESD gun and the DUT. IEC ESD testing is performed with both positive and negative polarities, and a passing score is not possible until both polarities survive at a single level. Table 1 shows the IEC 61000-4-2 ESD test-voltage and peak-current levels.

Table 1. IEC 61000-4-2 ESD Test Voltage Levels

Contact discharge			**Air discharge**	
Level	Test voltage (kV)	Peak current (A)	Level	Test voltage (kV)
1	2	7.5	1	2
2	4	15	2	4
3	6	22.5	3	8
4	8	30	4	15
*	Special	Special	*	Special

*

Figure 1 depicts the basic shape of the IEC ESD pulse and shows the timing sequence of the test pulses.

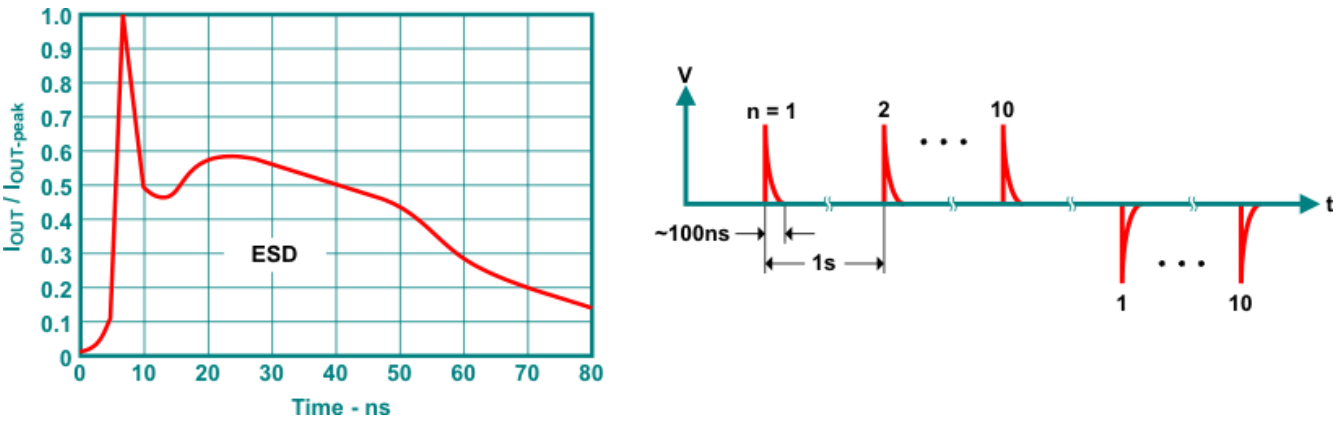


Figure 1. Current Waveform of IEC ESD Pulse and Timing Sequence of Test

To help protect your industrial design against the high levels of energy delivered during an ESD event, you can add a TVS diode and pulse-proof series resistor to the bus to help divert and consume the energy. Placing a TVS diode very close to the board connector where the bus lines enter the design ensures that any transient energy coupled onto the bus is minimized at the point of origin. The TVS acts as a clamping circuit to redirect any high-energy pulses to ground, away from the RS-485 transceiver.

Adding series pulse-proof resistors on the A and B bus lines limits the residual clamping current the transceiver sees if the TVS diode clamping voltage is higher than the specified maximum voltage of the transceiver bus pins. These resistors are typically very low in value (~10-20Ω). Select those resistors that can accommodate the appropriate power levels.

Figure 2 shows this concept using the SN65HVD82 RS-485 transceiver.

* This is an open level. The level has to be specified in the dedicated equipment speciation. If higher voltages than those shown are specified, you may need special test equipment.

Copyright © 2023 Texas Instruments Incorporated

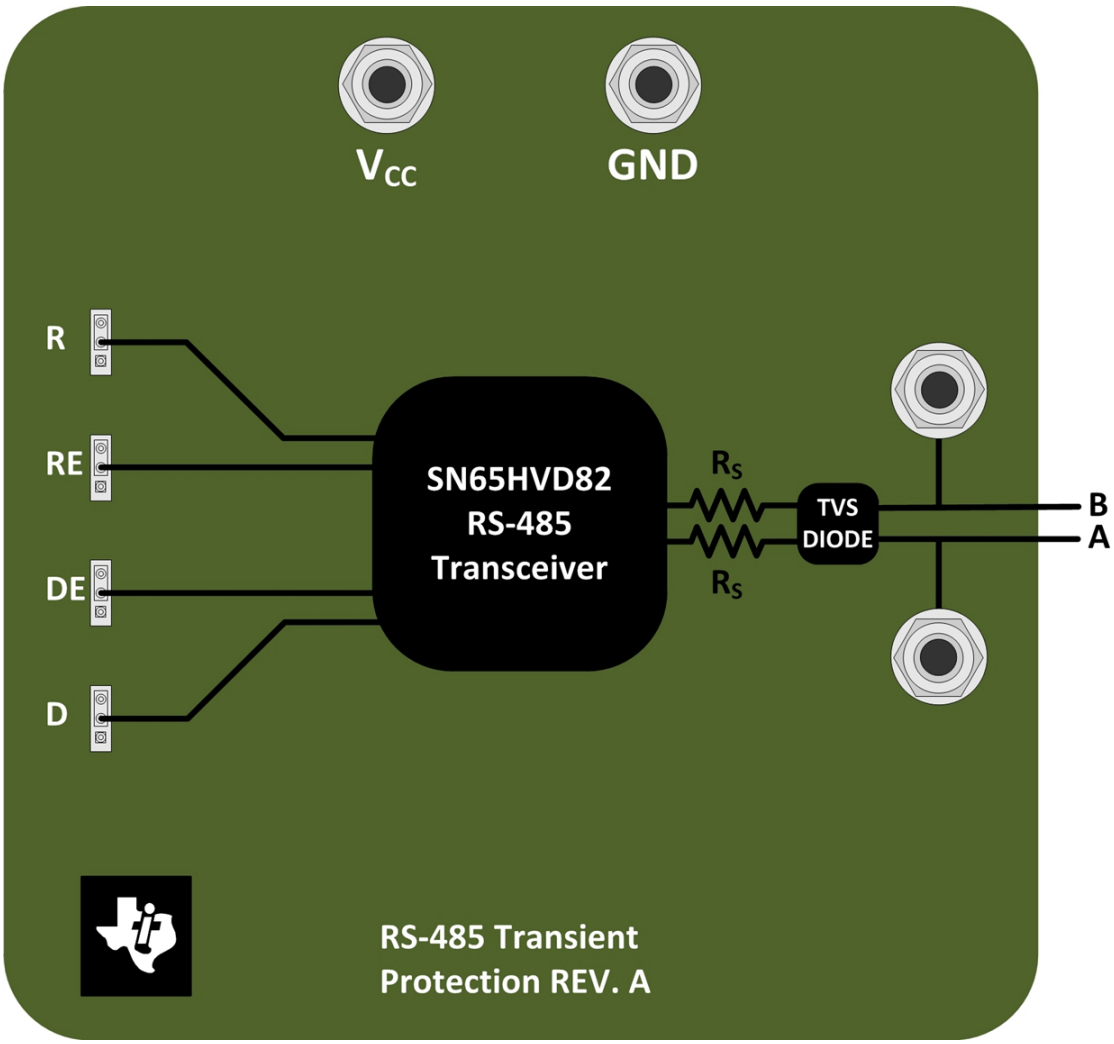


Figure 2. SN65HVD82 **RS-485 Transient Protection Overview**

Table 2 shows the achievable performance of the SN65HVD82 RS-485 transceiver with the added external components.

Table 2. Summary of Test Results

Protection scheme	IEC ESD (kV)	IEC EFT (kV)	IEC surge (kV)
SN65HVD82			
TVS	±30 contact ±30 air	±4	±1
SN65HVD3082E			
TVS	±14 contact ±30 air	±4	±1

For more information on IEC protection schemes, please see the RS-485 IEC ESD TI Designs reference design. Leave a comment if you'd like to hear more about anything discussed in this post or if there's an interface topic you'd like to see in the future.

Additional Resources

- Find out more about the SN65HVD82 RS-485 transceiver.
- Learn more about RS-485 in our RS-485 Design Guide.
- Read more posts in the Get Connected series.
- Learn more about IEC ESD and other electromagnetic compatibility testing in the Precision Hub blog series by Ian Williams: Get CerTIfied, not certi-FRIED! Electromagnetic compatibility testing explained.

Copyright © 2023 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated