

## EMC Compliant RS-485 Transceiver Protection Circuits

### EVALUATION AND DESIGN SUPPORT

#### Circuit Evaluation Boards

[CN-0313 Circuit Evaluation Board \(EVAL-CN0313-SDPZ\)](#)

#### Design and Integration Files

[Schematics, Layout Files, Bill of Materials](#)

### CIRCUIT FUNCTION AND BENEFITS

The circuits shown in Figure 1 demonstrate proven and tested electromagnetic compatibility (EMC) compliant solutions for three protection levels for popular RS-485 communication ports

using the [ADM3485E](#) transceiver. Each solution was tested and characterized to ensure that the dynamic interaction between the transceiver and the protection circuit components functions correctly together to protect against the electrostatic discharge (ESD), electrical fast transients (EFT), and surge immunity specified in IEC 61000-4-2, IEC 61000-4-4, and IEC 61000-4-5, respectively. The circuits offer proven protection for RS-485 interfaces using the [ADM3485E](#) to the ESD, EFT, and surge levels often encountered in harsh environments.

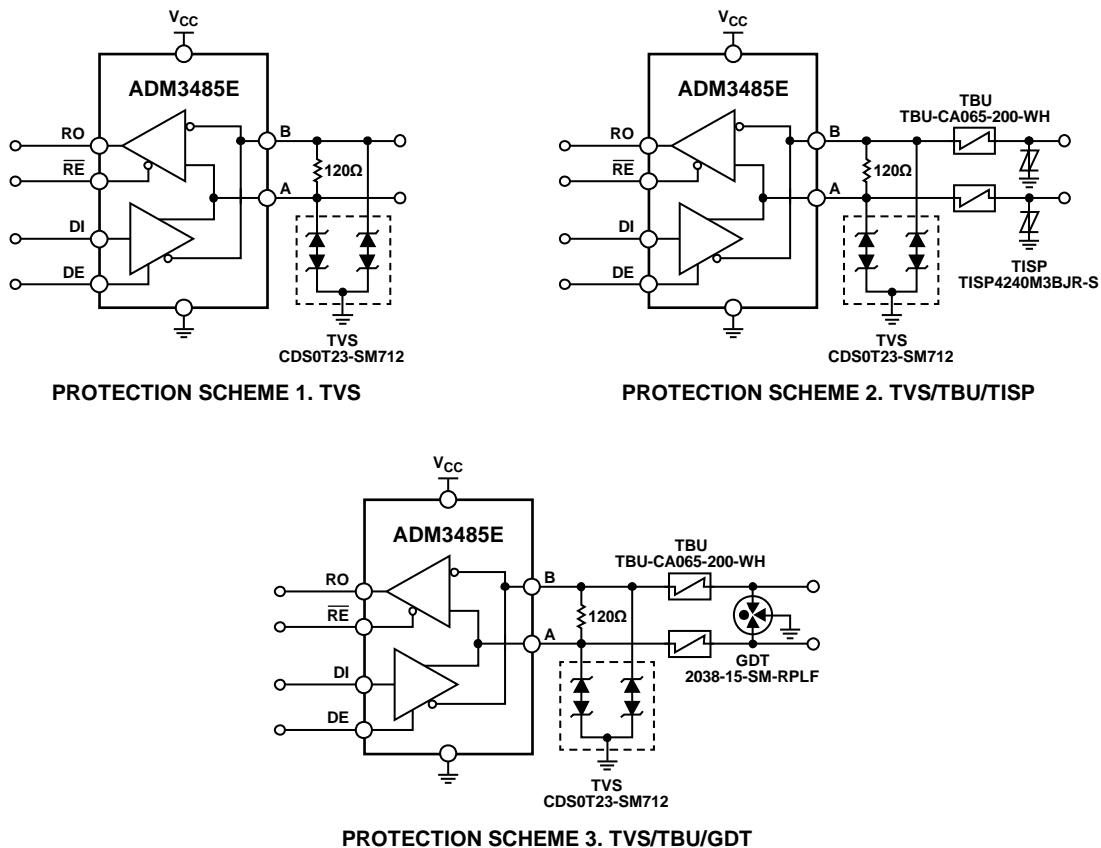


Figure 1. Three EMC Compliant [ADM3485E](#) Protection Circuits (Simplified Schematic, All Connections Not Shown)

#### Rev. 0

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**CIRCUIT DESCRIPTION**

The RS-485 bus standard is one of the most widely used physical layer bus designs in industrial and instrumentation applications. RS-485 offers differential data transmission between multiple systems often over very long distances. Applications for RS-485 include process control networks; industrial automation; remote terminals; building automation, such as heating, ventilation, air conditioning (HVAC) and security systems; motor control; and motion control.

In these real systems, lightning strikes, power source fluctuations, inductive switching, and electrostatic discharge can cause damage to communications ports by generating large transient voltages. Designers must ensure that equipment does not just work in ideal conditions, but it must also work in real-world conditions. To ensure that these designs can work in electrically harsh environments, EMC regulations must be met.

Many EMC problems are not simple or obvious and must be considered at the start of the product development cycle. Proper solutions and protection circuits must be part of the total design effort and not left to the last minute. The protection circuits must incorporate the input and output structure of the specific transceiver manufacturer as part of the design.

The IEC 61000 specifications define the set of EMC immunity requirements. Within this set of specifications, designers must be concerned with the following three types of high voltage transients for data communication lines:

- IEC 61000-4-2 electrostatic discharge (ESD)
- IEC 61000-4-4 electrical fast transients (EFT)
- IEC 61000-4-5 surge immunity

ESD and EFT have similar rise times, pulse widths, and energy levels. The surge transient has longer rise times and pulse widths; as a result, the surge transient energy can be three to four orders of magnitude larger than the energy in an ESD or EFT transient. Due to the similarities between ESD and EFT transients, the design of the circuit protection can be similar. However, due to the high energy associated with surge transients, they must be dealt with differently.

Each solution protects data ports to ESD voltages of 8 kV contact and 15 kV air discharge, and EFT voltages of 2 kV. The different solutions provide an increased level of surge protection up to 6 kV. Protection levels for the circuits are summarized in Table 1.

**Table 1. Protection Levels Offered by Each of the Three Protection Circuits in Figure 1**

| Protection Scheme | ESD                               | EFT (kV) | Surge (kV) |
|-------------------|-----------------------------------|----------|------------|
| 1. TVS            | 8 kV contact, 15 kV air discharge | 2        | 1          |
| 2. TVS/TBU/TISP   | 8 kV contact, 15 kV air discharge | 2        | 4          |
| 3. TVS/TBU/GDT    | 8 kV contact, 15 kV air discharge | 2        | 6          |

Figure 2 shows a photo of the EVAL-CN0313-SDPZ board. There are three ADM3485E devices on the board, one for each protection scheme. Each protection scheme provides ESD and EFT protection as described and increasing levels of surge protection.

A complete design support package for the EVAL-CN0313-SDPZ board including schematics, layout files, and bill of materials can be found at [www.analog.com/CN0313-DesignSupport](http://www.analog.com/CN0313-DesignSupport).

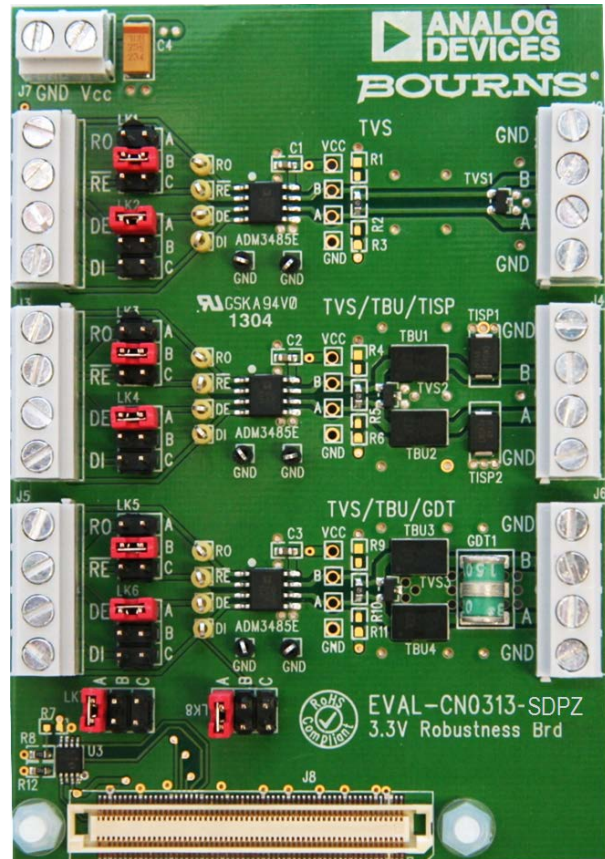


Figure 2. EVAL-CN0313-SDPZ Board

The [ADM3485E](#) is a 3.3 V, low power data transceiver suitable for half-duplex communication on multipoint transmission lines. It has a data rate up to 12 Mbps with a common-mode range on the bus pins (A and B) of  $-7\text{ V}$  to  $+12\text{ V}$ . Data transmits on the DI pin, and it is received on the RO pin. Both the driver and receiver outputs can be enabled or disabled, that is, put into a high impedance state, by changing the logic levels on the DE and RE pins, respectively.

Power and ground are connected via a screw-wire connector ( $V_{CC}$  and GND). This connector supplies all three [ADM3485E](#) devices.

Logic inputs DE and  $\overline{\text{RE}}$  are set using LK1 to LK6. For each [ADM3485E](#), LK2, LK4, and LK6 relate to DE and LK1, LK3, and LK5 relate to  $\overline{\text{RE}}$ . For each link, Position A connects the logic pin to  $V_{CC}$ , Position B connects the logic pin to GND, and Position C connects the logic pin to the four terminal, side screw-wire connector. The input DI and output RO pins are connected directly to the four terminal screw connector.

The [EVAL-CN0313-SDPZ](#) is also compatible with the Analog Devices, Inc., ezLINX™ board ([EZLINX-IIIDE-EBZ](#)) and the system development platform ([EVAL-SDP-CB1Z](#)). Connector J8 links the UART and GPIO interfaces on the SDP or the ezLINX board to the logic I/O of the [ADM3485E](#) devices. The I/O connections and jumper configurations are shown in Table 2.

**Table 2. ezLINX and SDP I/O Connections and Jumper Configurations**

| <a href="#">ADM3485E</a> | I/O Pin                | SDP/ezLINX Connector | Selection |
|--------------------------|------------------------|----------------------|-----------|
| TVS                      | RO                     | UART_RX              | LK7 (A)   |
|                          | $\overline{\text{RE}}$ | GPIO_0               | LK1 (C)   |
|                          | DE                     | GPIO_3               | LK2 (C)   |
|                          | DI                     | UART_TX              | LK8 (A)   |
| TVS/TBU/TISP             | RO                     | UART_RX              | LK7 (B)   |
|                          | $\overline{\text{RE}}$ | GPIO_1               | LK3 (C)   |
|                          | DE                     | GPIO_4               | LK4 (C)   |
|                          | DI                     | UART_TX              | LK8 (B)   |
| TVS/TBU/GDT              | RO                     | UART_RX              | LK7 (C)   |
|                          | $\overline{\text{RE}}$ | GPIO_2               | LK5 (C)   |
|                          | DE                     | GPIO_5               | LK6 (C)   |
|                          | DI                     | UART_TX              | LK8 (C)   |

The [ADM3485E](#) transmitter and receiver share the same differential bus pins (A and B). The protection circuitry is used to protect these bus pins.

In the first protection circuit, shown in Figure 1 as **TVS**, it uses one component, the Bourns CDSOT23-SM712. This is the transient voltage suppressor (TVS) array shown on the [EVAL-CN0313-SDPZ](#). It consists of two bidirectional TVS diodes optimized to protect RS-485 systems with minimal overstress while allowing the full range of the RS-485 signal and common-mode excursions. The TVS has high impedance to ground in normal operating conditions. When an overvoltage occurs, the TVS enters into avalanche breakdown mode and clamps the pin voltage to a safe predetermined level. It then diverts the transient current away from the [ADM3485E](#) to ground.

This protection scheme offers up to 8 kV contact and 15 kV air discharge ESD, 2 kV EFT, and 1 kV surge protection.

As described in the CDSOT23-SM712 data sheet, the part is designed specifically for RS-485 devices. The next two protection schemes add to the CDSOT23-SM712 to provide higher levels of circuit protection against surge.

In the second scheme, shown in Figure 1 as **TVS/TBU/TISP**, the CDSOT23-SM712 TVS provides secondary protection, and Bourns TISP4240M3BJR-S provides the primary protection. The TISP4240M3BJR-S is a totally integrated surge protector (TISP). The TISP is a solid-state thyristor. When its predetermined voltage is exceeded, the TISP provides a low impedance path to ground, diverting a majority of the transient energy away from the [ADM3485E](#).

Bourns TBU-CA065-200-WH transient blocking unit (TBU) is a nonlinear overcurrent protection device between the primary and secondary protection devices that ensures coordination occurs. The TBU is an overcurrent blocking device that becomes an open circuit at a predefined current. In blocking mode, TBU has very high impedance to block transient energy. This protection scheme offers up to 8 kV contact and 15 kV air discharge ESD, 2 kV EFT, and 4 kV surge protection.

The third protection scheme, shown in Figure 1 as **TVS/TBU/GDT**, operates in a similar fashion to Protection Scheme 2. In this scheme, a gas discharge tube (GDT) is used instead of the TISP. The GDT protects to higher overvoltages and overcurrents than the TISP described in the previous protection scheme. A GDT is a gas discharge plasma device that provides a low impedance path to ground to protect against over voltage transients. The selected GDT is the Bourns 2038-15-SM-RPLF.

This third protection scheme offers up to 8 kV contact and 15 kV air discharge ESD, 2 kV EFT, and 6 kV surge protection.

The [ADM3485E](#) has a 120  $\Omega$  termination attached to the bus pins.

## CIRCUIT EVALUATION AND TEST

Apply 3.3 V to  $V_{CC}$  to power the EVAL-CN0313-SDPZ board. The voltage can be checked on the  $V_{CC}$  test points near each ADM3485E. The transmit and receive paths can be tested by connecting one of the ADM3485E circuits as shown in Figure 3. A signal or pattern generator can be connected to DI. The outputs of the driver can be monitored on the A and B test points, and the output of the receiver can be monitored on the RO test point. Jumper configurations are also shown in Figure 3. This test setup can apply to any of the three circuits.

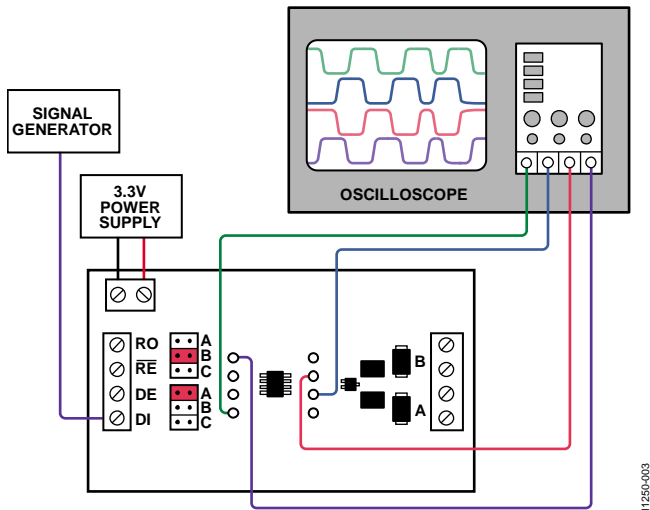


Figure 3. Transmit and Receive Test Setup

According to IEC 61000-4-2, ESD testing implies using two coupling methods, contact discharge and air gap discharge. Contact discharge implies the discharge gun is placed in direct connection with the port being tested. With air discharge, the charged electrode of the discharge gun is moved toward the port under test until a discharge occurs developing an arc across the air gap. Apply discharges to the screw terminal connector of each bus line.

For IEC 61000-4-4 EFT testing, a capacitive coupling clamp is used to couple the EFT bursts onto the cable connected to the bus lines. The coupling capacitance of the clamp depends on the cable diameter, material of the cables, and cable shielding.

IEC 61000-4-5 surge testing implies the use of a coupling/decoupling network (CDN) to couple the surge transient into the bus pins. According to the specification, this must be done using two  $80\ \Omega$  resistors for a two port test. Figure 4 shows the test setup for surge testing. Connect the CDN to the A and B terminals, and the common of the surge generator to the ground connection of the four terminal screw connector.

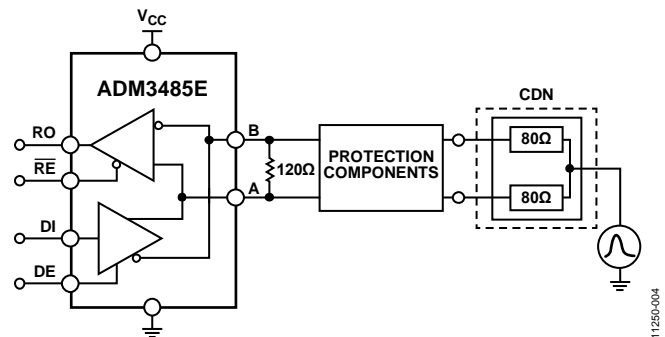


Figure 4. IEC 61000-4-5 Surge CDN to ADM3485E Setup

All protection circuits described were characterized in the lab with the ADM3485E and verified by an external independent EMC compliance test house.

For further information on the ezLINX iCoupler® isolated interface development environment, go to <http://wiki.analog.com/resources/eval/ezlinx>.

Information on other important EMC issues can be found at <http://www.analog.com/rs485emc>.

**LEARN MORE**

CN-0313 Design Support Package:

<http://www.analog.com/CN0313-DesignSupport>

[ezLINX™ iCoupler® Isolated Interface Development Environment, ezLINX Board Quick Start Guide](#)

[Certified EMC Compliant RS-485 Interface Design Tool](#)

[Marais, Hein. Application Note AN-960. RS-485/RS-422 Circuit Implementation Guide. Analog Devices, Inc.](#)

[Electromagnetic Compatibility \(EMC\) Part 4-2: Testing and Measurement Techniques—Electrostatic Discharge Immunity Test \(IEC 61000-4-2\)](#)

[Electromagnetic Compatibility \(EMC\) Part 4-4: Testing and Measurement Techniques—Electrical Fast Transient/Burst Immunity Test \(IEC 61000-4-4\)](#)

[Electromagnetic Compatibility \(EMC\) Part 4-5: Testing and Measurement Techniques—Surge Immunity Test \(IEC 61000-4-5\)](#)

**Data Sheets and Evaluation Boards**

[ADM3485E Data Sheet](#)

[System Development Platform \(EVAL-SDP-CB1Z\)](#)

[ezLINX™ iCoupler® Isolated Interface Development Environment \(EZLINX-IIIIDE-EBZ\)](#)

[UG-400 User Guide, ezLINX™ iCoupler® Isolated Interface Development Environment, Analog Devices.](#)

[CDSOT23-SM712—Surface Mount TVS Diode Data Sheet, Bourns](#)

[TISP4xxxM3BJ Overvoltage Protector Series \(TISP4240M3BJR-S\) Data Sheet, Bourns](#)

[TBU-CA Series—TBU® High Speed Protectors \(TBU-CA065-200-WH\) Data Sheet, Bourns](#)

[2038 Series Miniature Symmetrical Three Electrode Surface Mount Gas Discharge Tube \(2038-15-SM-RPLF\) Data Sheet, Bourns](#)

**REVISION HISTORY**

2/13—Revision 0: Initial Version

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