DESIGN NOTE

RS-485 Port Protection Using Bourns® Model TBU-RS Series

INTRODUCTION

The evaluation boards covered in this design note aid in assessing the viability of circuit protection solutions for RS-485 serial ports using the Bourns® TBU-RS Series High-Speed Protector (HSP). The RS-485 Evaluation Boards 6, 7, 8, and 9 deliver a coordinated solution to meet the required industry standards for RS-485 port interfaces by combining Bourns® Model TBU-RS Series HSPs and TISP® Thyristor Surge Protectors (thyristors) or a Gas Discharge Tube (GDT) Surge Arrestor.

The recommended Bourns® Model TBU-RS Series HSP solutions offer enhanced performance features that allow engineers to heighten the transient surge protection level on RS-485 ports. The solutions presented also provide the advantage of placing the entire circuit protection solution onto a smaller printed circuit board (PCB) area as compared to alternative solutions such as series resistors and discrete circuit protection components.

The four Bourns® RS-485 Evaluation Boards covered in this design note measure 35 mm x 25 mm x 0.85 mm and are manufactured using FR-4 PCB material with nickel and gold plating on the mounting pads.

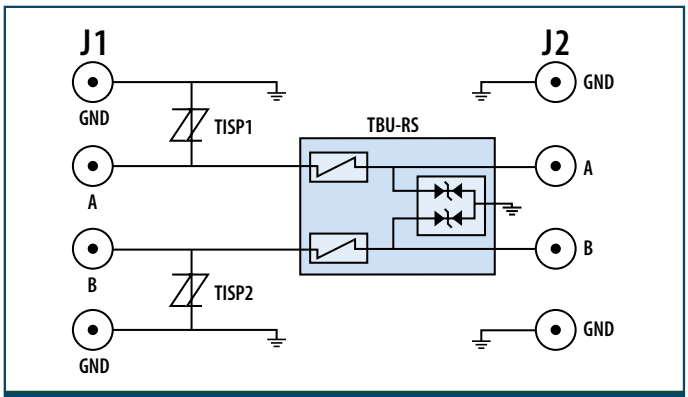

Figure 1 | *Schematic for RS-485 Evaluation Boards 6, 7, 8*

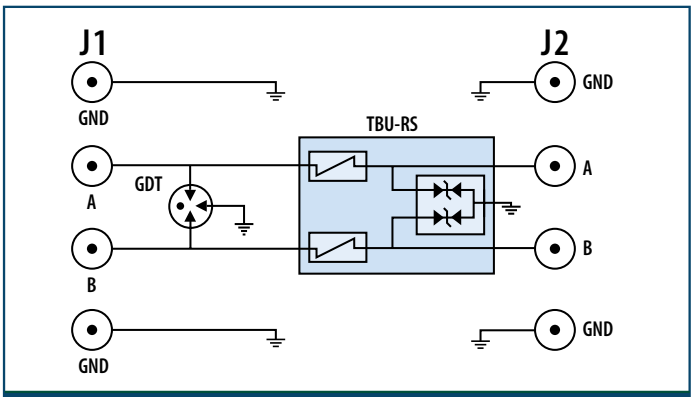

Figure 2 | *Schematic for RS-485 Evaluation Board 9*

Previous versions of the Bourns® RS-485 Evaluation Boards were based on the Bourns® Model TBU-CA Series (a single-channel device) or the Bourns® Model TBU-DF Series (a dual-channel device), combined with the Bourns® Model CDSOT23-SM712 Transient Voltage Suppressor (TVS) diode.

These four new Evaluation Boards achieve PCB area reduction by combining the enhanced dual-channel Model TBU-DF Series TBU® HSP and the TVS to clamp the voltages going to the RS-485 receiver and driver into a single package.

This combination both reduces the maximum surge voltages impressed on the RS-485 communication components and helps designers save valuable PCB real estate by facilitating protection designs using some of the smallest RS-485 protection solutions available in the industry.

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RS-485 EVALUATION BOARD CONFIGURATIONS

The central component on these Evaluation Boards is the Bourns® Model TBU-RS Series TBU® HSP. The surge protection components on the line side are selected to meet the class of protection for the application, which specifies the expected surge level to be encountered. Each of the four evaluation boards are populated with components rated for the surge levels specified for each class and maximum surge current.

Each Evaluation Board's performance is rated for the simulated lightning waveform of 8/20 µs at the peak currents shown. Please refer to the Bourns® TBU-RS Series data sheet for additional information on the capabilities of each Evaluation Board at other current levels.

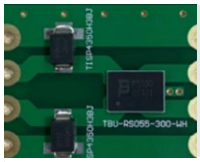
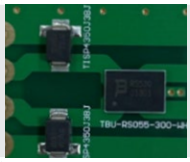
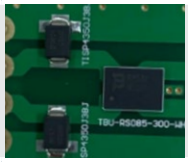
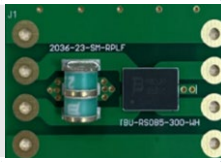
		RS-485EVALBOARD Model			
		6	7	8	9
					
Part Number	**Description**	**Bill of Materials (Quantity)**			
TBU-RS055-300-WH	550 V TBU® HSP	1	1		
TBU-RS085-300-WH	850 V TBU® HSP			1	1
TISP4350H3BJR-S	275 V, 300 A Thyristor	2			
TISP4350J3BJR-S	275 V, 800 A Thyristor		2	2	
2036-23-SM-RPLF	100 V/s, 230 V GDT				1
8/20 µs waveform with 2 Ω surge generator impedance (IEC 61000-4-5)					
Class 1		250 A			
Class 2			500 A	500 A	
Class 3					1 kA
Class 4					2 kA

Figure 3 | *RS-485EVALBOARD bill of materials and corresponding IEC 61000-4-5 surge impedance class*

Protection of RS-485 ports is typically required in three different application scenarios.

The first is for exposed and harsh environments, such as outdoor installations where induced lightning surges are a threat. Designers for these types of applications are familiar with the ITU-T K.20/21/44 recommendations (specifying the 10/700 µs voltage surge) or with the Telcordia GR-1089-CORE and IEC 61000-4-5 standard (specifying the combination wave generator with 8/20 µs current and 1.2/50 µs voltage surges).

The second scenario is for applications that need to accommodate long cable runs where multiple lines (data and AC power) are used in the same trunking or cabling. During a fault, during a fault incident, the AC power lines may come into contact with the signal lines. These applications require the 230 VAC tests specified in ITU-T K.20/.21/.44, or 120 V_{AC} tests specified in Telcordia GR-1089-CORE.

There are instances in lower voltage applications or for various installation threats where the standardized 120 V_{AC} or 230 V_{AC} tests are still used to test the robustness of the protection solution.

The third scenario is for applications to ensure protection against installation errors and faults. For example, 12 V_{DC} or 24 V_{DC} lines are frequently run together with the signal lines. The cable runs may include other exposed lines that can induce lightning surges onto RS-485 cables. In addition, there is the risk of deliberate and malicious attacks on RS-485 ports by unauthorized users.

This evaluation board design note highlights options for many levels of lightning surges that use a TISP® Thyristor Surge Protector for the lower surge levels or a GDT for the higher surge levels. By varying the chosen test voltage, the information stated here also demonstrates that an AC power cross of up to 120 V_{AC} or 230 V_{AC} can be accommodated by the Bourns® Model TBU-RS Series based RS-485 protection solution.

RS-485 Port Protection Using Bourns® Model TBU-RS Series

OVERVOLTAGE PROTECTOR (OVP) SELECTION

The TBU® RS-485 HSP requires a primary protector on the line side to protect it from potential high voltages that are expected to exceed its maximum withstanding voltage. Breakover voltage (V_{BO}) or impulse breakdown voltage of the overvoltage protector (OVP) should be below the maximum peak impulse voltage (V_{PK}) of the Model TBU-RS Series TBU® HSP, either at 550 or 850 volts. V_{BO} or V_{IMP} of the OVP should be above the maximum voltage of AC power cross (peak of V_{AC}):

- 120 V_{AC} has a peak of 170 V
- 230 V_{AC} has a peak of 325 V

RS-485 SURGE TEST SETUP

- Connect J1A and J1B to the exposed lines.
- Connect J2A and J2B to the RS-485 IC device.
- Connect GND to the communication system ground.

Connect the test generator to the line inputs of the RS-485 port protection board with low value (or zero ohm) resistors.

SURGE CAPABILITY

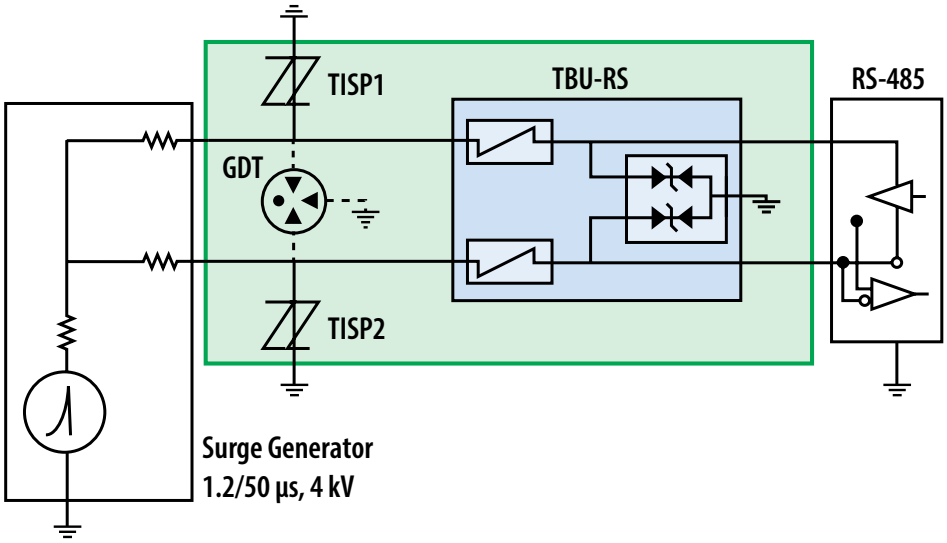


Figure 4 | *Diagram illustrating how the RS-485 port protection board surge test is setup, including both the thyristor (TISP® device) and GDT primary protector options in a single schematic*

RS-485 Port Protection Using Bourns® Model TBU-RS Series

Below are graphs of different surge tests performed on Bourns® RS-485 Evaluation Boards 8 and 9 based on the various standards requirements.

Table 1 | *Test Results for Bourns® RS-485EVALBOARD8*

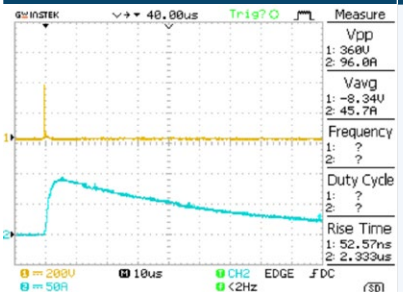
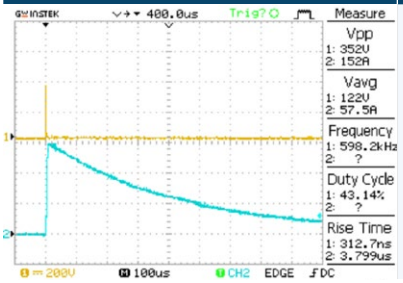
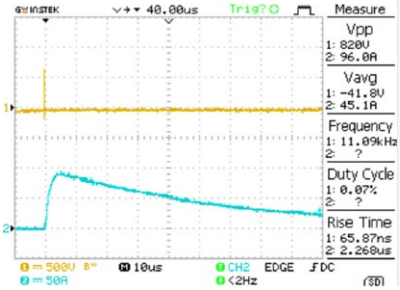
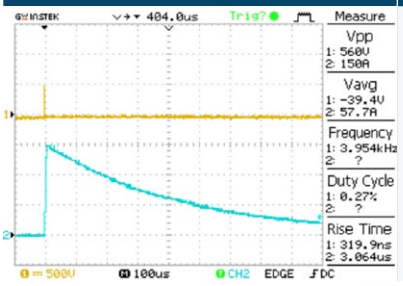
RS-485EVALBOARD8: TBU-RS Series & TISP® Device Combination Solution Example	
1 Bourns® Model TBU-RS085-300-WH	2 Bourns® Model TISP4350J3BJR-S
Test Results	**Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs**
	• Upon application of the 4 kV (95.2 A) surge (Channel 2), the transient current flowing through Model TBU-RS085-300-WH increases to trigger Model TBU-RS085-300-WH quickly (<1 µs). • When the Model TBU-RS085-300-WH is in the blocking state, the line voltage (Channel 1) increases with the surge, as there is no current flow into the protected interface. • When the line voltage increases to the V_{BO} of Model TISP4350J3BJR-S (350 V), Model TISP4350J3BJR-S will shunt the line to GND. • Hence, the protected interface is only subject to a very low (300 mA) transient current <1 µs and the interface exposed to a low line voltage of 360 V momentarily.
CH1: Voltage across TISP CH2: Surge Generator Output Current	
Test Results	**Surge Capability: IEC61000-4-5 Level 4, 6 kV 10/700 µs**
	• Upon application of the 6 kV (150 A) surge (Channel 2), the transient current flowing through Model TBU-RS085-300-WH increases to trigger Model TBU-RS085-300-WH quickly (<1 µs). • When the Model TBU-RS085-300-WH is in the blocking state, the line voltage (Channel 1) increases with the surge, as there is no current flow into the protected interface. • When the line voltage increases to the V_{BO} of Model TISP4350J3BJR-S (350 V), Model TISP4350J3BJR-S will shunt the line to GND. • Hence, the protected interface is only subject to a very low (300 mA) transient current <1 µs and the interface exposed to a low line voltage of 352 V momentarily.
CH1: Voltage across TISP CH2: Surge Generator Output Current	

Table 2 | *Test Results for Bourns® RS-485EVALBOARD9*

RS-485EVALBOARD9: TBU-RS & GDT Combination Solution Example	
1 Bourns® Model TBU-RS085-300-WH	1 Bourns® Model 2036-23-SM-RPLF
Test Results	**Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs**
	• Upon application of the 4 kV (95.2 A) surge (Channel 2), the transient current flowing through Model TBU-RS085-300-WH increases to trigger Model TBU-RS085-300-WH quickly (<1 µs). • When the Model TBU-RS085-300-WH is in the blocking state, the line voltage (Channel 1) increases with the surge, as there is no current flow into the protected interface. • When the line voltage increases to the V_{BO} of Model 2036-23-SM-RPLF (600 V), Model 2036-23-SM-RPLF will shunt the line to GND. • Hence, the protected interface is only subject to a very low (300 mA) transient current <1 µs and the interface exposed to a low line voltage of typically around 700 V momentarily.
CH1: Voltage across GDT CH2: Surge Generator Output Current	
Test Results	**Surge Capability: IEC61000-4-5 Level 4, 6 kV 10/700 µs**
	• Upon application of the 6 kV (150 A) surge (Channel 2), the transient current flowing through Model TBU-DF085-300-WH increases to trigger Model TBU-RS085-300-WH quickly (<1 µs). • When the Model TBU-RS085-300-WH is in the blocking state, the line voltage (Channel 1) increases with the surge, as there is no current flow into the protected interface. • When the line voltage increases to the V_{BO} of Model 2036-23-SM-RPLF (600 V), Model 2036-23-SM-RPLF will shunt the line to GND. • Hence, the protected interface is only subject to a very low (300 mA) transient current <1 µs and the interface exposed to a low line voltage of typically around 700 V momentarily.
CH1: Voltage across GDT CH2: Surge Generator Output Current	

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AC POWER-CROSS 120 V_{AC} SURGE CAPABILITY

A power cross condition exists when an AC power mains voltage comes into contact with RS-485 cables. Bourns® Model TISP4350J3BJR-S will not be triggered since the peak voltage of 120 V_{AC} is less than the V_{BO} of the thyristor. As a result, the Bourns® Model TISP4350J3BJR-S maintains high impedance.

When the AC power is applied and the line voltage (Channel 1) and line current (Channel 2) increase, Bourns® Model TBU-RS Series HSP quickly triggers into the blocking state when the line current reaches its $I_{TRIGGER}$ (300 mA), thereby preventing current flow into the protected port. This can be seen as the line current (Channel 2) drops to ~ 0 mA after the Bourns® Model TBU-RS Series HSP triggers. Once the AC voltage ramps down below V_{RESET}, the Bourns® Model TBU-RS Series HSP will reset to the conductive state and allow current flow again.

Notice in the scope picture in Figure 6 that the TBU® HSP resets every time the AC mains voltage crosses zero. As the voltage increases from zero, current flows into the TVS protecting the RS-485 communication circuits. The TBU® HSP will stop the current when the current reaches theTBU® device's trigger current. The TBU® HSP is in the high impedance mode and disconnects the mains voltage from the RS-485 interface so that it remains safe.

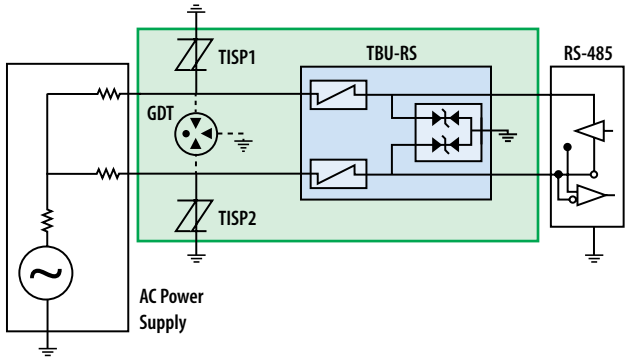
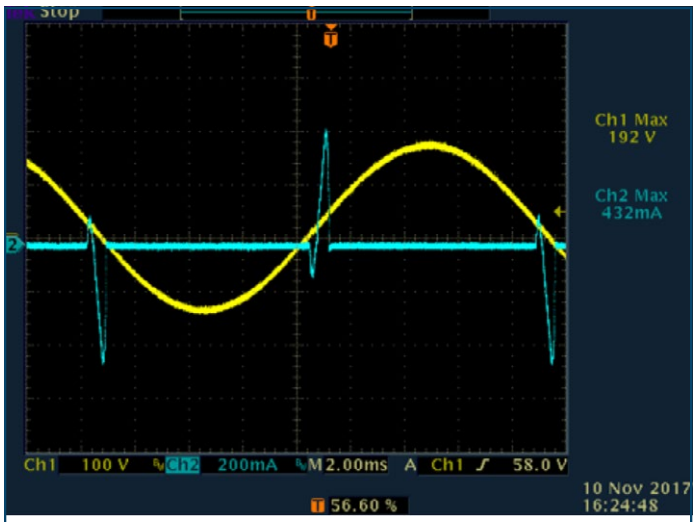


Figure 5 | *RS-485 Port Protection Evaluation Board AC Power-Cross Test Setup*



CH1: A TBU Voltage CH2: CH2: Line A TBU Current

Figure 6 | *TBU-RS Series HSP protecting RS-485 cable from AC Power-Cross*

ADDITIONAL RESOURCES

Visit www.Bourns.com for additional information on Bourns® circuit protection solutions.

- Bourns® TBU® High-Speed Protectors (HSPs)
- Bourns® TISP® Thyristor Surge Protectors
- Bourns® Gas Discharge Tubes (GDT)
- RS-485 Port Protection Evaluation Board 4
- Bourns® TBU® High-Speed Protector Technical Library
- Bourns® Parametric Search Product Selection Tool

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