DESIGN NOTE

# RS-485 Port Protection Evaluation Board 4

## INTRODUCTION

This evaluation board serves as an aid in evaluating circuit protection solutions for RS-485 serial ports. It uses a Bourns® TBU® High-Speed Protector (HSP), a Gas Discharge Tube (GDT) Surge Arrestor and a Transient Voltage Suppressor (TVS) that are designed to meet the required industry standards on RS-485 port interfaces. The recommended Bourns® TBU® HSP solution offers enhanced performance features over competing technologies. These performance features can help engineers improve the surge and transient protection level on RS-485 ports, while allowing them to place the entire circuit protection solution into a smaller PCB area as compared to alternative solutions. The Bourns® RS-485 Evaluation Board 4 measures 35 mm x 25 mm x 0.85 mm, and is manufactured using an FR-4 PCB with nickel-gold pad plating on the top and bottom sides.

Bourns' three previous versions of the RS-485 Evaluation Boards (EVB1, 2 and 3) used the Bourns® Model TBU-CA, which is a single-channel device. Because the RS-485 interface has two lines, this new evaluation board provides further PCB area reduction by utilizing the new Bourns® Model TBU-DF HSP, which is a dual-channel device. This latest evaluation board is the smallest RS-485 evaluation board offering a more compact solution helping designers save valuable PCB real estate.

## HOW TO CONNECT THE EVALUATION BOARD FOR TEST SET-UP

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

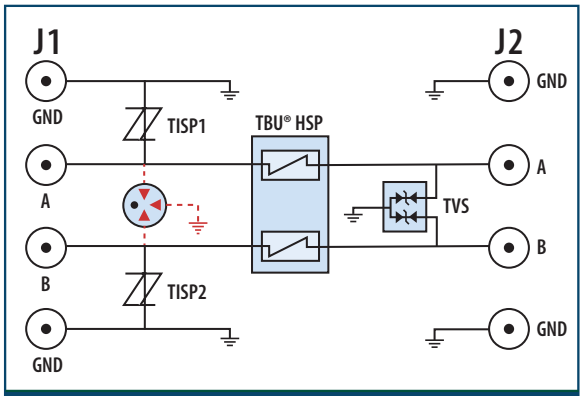



*Figure 1* | *RS-485 Evaluation Board 4 Schematic*

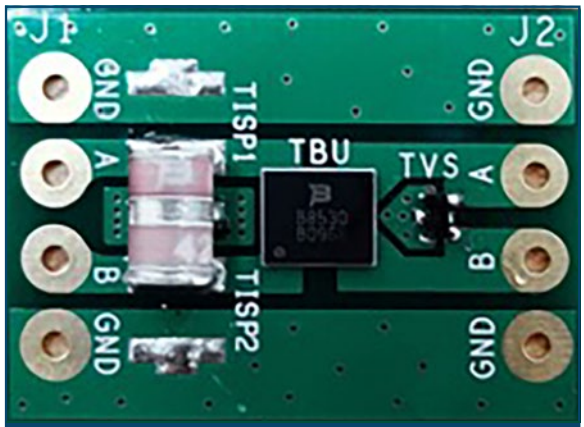



*Figure 2* | *RS-485 Evaluation Board 4 Top Side Layout*

*Table 1* | *RS-485 Evaluation Board 4 Bill of Materials*

| No. | Part Number | Qty. | Description | Product |
|---|---|---|---|---|
| 1 | TBU-DF085-300-WH | 1 | 850 V 300 mA Dual Channel Bidirectional TBU® HSP | TBU® HSP |
| 2 | 2030-42T-SM-RPLF | 1 | Fast Acting, 3-Electrode 420 V Gas Discharge Tube | GDT |
| 3 | CDSOT23-SM712 | 1 | SOT23 12 V Dual Bidirectional TVS Diode | TVS Diode |

The default configuration of this board uses a TBU® HSP, a GDT and a TVS diode.
The board allows different configurations:

- One Model 2030-42T-SM-RPLF could be replaced by two Model TISP4350J3BJR-S
- One Model 2030-42T-SM-RPLF could be replaced by two Model TISP4500H3BJR-S
- One Model 2030-42T-SM-RPLF could be replaced by one Model 2036-07-SM-RPLF

# RS-485 Port Protection Evaluation Board 4

## RS-485 EVALBOARD 4 CONFIGURATION

Protection of RS-485 ports are typically required in three scenarios. The first scenario is for exposed and harsh environments, such as outdoor installations where induced lightning surges are a threat. Customers 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 or IEC 61000-4-5 standard (specifying the CWG 8/20 µs current, 1.2/50 µs voltage surges).

The second scenario accommodates long cable runs where multiple lines (data and AC power) are used in the same trucking or cabling. During a fault incidence, the AC power lines may come in contact with the signal lines. These applications require 230 $V_{AC}$ tests specified in ITU-T K.20/21/44, or 120 $V_{AC}$ tests specified in Telcordia GR-1089-CORE. There are applications with lower voltage application/installation threats, but 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 protects 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 ports. In addition, there is the risk of deliberate and malicious attacks on RS-485 ports by unauthorized users. All of these can typically be taken care of with a protection solution that meets the higher protection levels offered in scenarios one and two.

This evaluation board brief will highlight options for two levels of lightning surges that use a TISP® Thyristor Surge Protector for the lower surge level and a GDT for the higher surge level. By varying the chosen voltage, this brief will also demonstrate that AC power cross up to 120 $V_{AC}$ or 230 $V_{AC}$ can be accommodated by a Bourns® Model TBU-DF based RS-485 protection solution.

*Table 2 | Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination*

| OVP Part Number | OVP Surge Rating | $V_{DRM}$ (V) | $V_{BO}$ (V) (1000 V/µs) | TBU® HSP Part Number | Surge Capability | AC Power Cross Capability |
|---|---|---|---|---|---|---|
| TISP4350J3BJR-S | 800 A, 8/20 µs<br>350 A, 5/310 µs | 275 | 350 | TBU-DF055-300-WH | IEC61000-4-5, Level 4, 4 kV 1.2/50 µs, 42 Ohm | 120 $V_{AC}$ |
| 2030-42T-SM | 500 A, 8/20 µs<br>150 A, 5/310 µs | 360 | 850 | TBU-DF085-300-WH | | 230 $V_{AC}$ |
| TISP4500H3BJR-S | 200 A, 5/310 µs | 350 | 500 | TBU-DF055-300-WH | ITU K.20/21/45 Enhanced Lighting, 6 kV 10/700 µs, 40 Ohm | 230 $V_{AC}$ |
| 2036-07-SM | 10,000 A, 8/20 µs<br>2,000 A, 5/310 µs | 75 | 750 | TBU-DF085-300-WH | | – |

Overvoltage Protector (OVP) Selection:

- Breakover voltage ($V_{BO}$) or impulse breakdown voltage ($V_{imp}$) of the overvoltage protector (OVP) should be below the maximum Peak Impulse Voltage ($V_{imp}$) of the TBU® HSP.
- $V_{BO}$ or $V_{imp}$ of the OVP should be above the maximum voltage of AC power cross (peak of $V_{AC}$).

## SURGE CAPABILITY

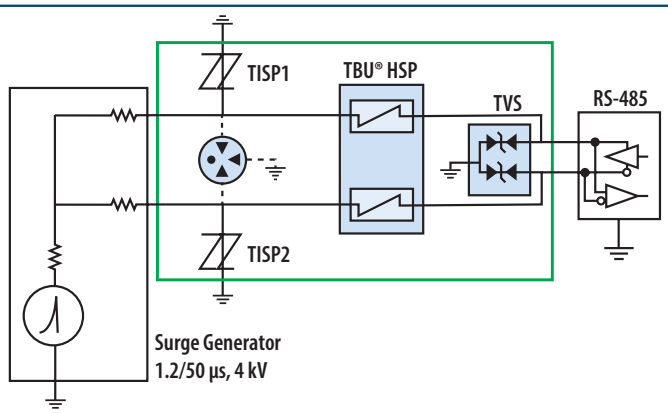


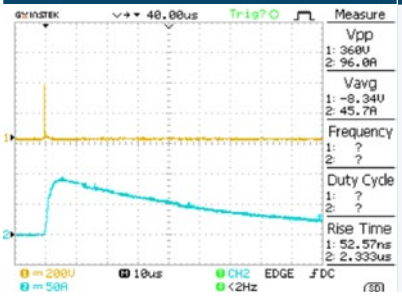

*Figure 3 | RS-485 Port Protection Evaluation Board Surge Test Setup*

# RS-485 Port Protection Evaluation Board 4

Below are graphs of different surge tests performed on Bourns' RS-485 Evaluation Board 4 based on the various standards requirements.

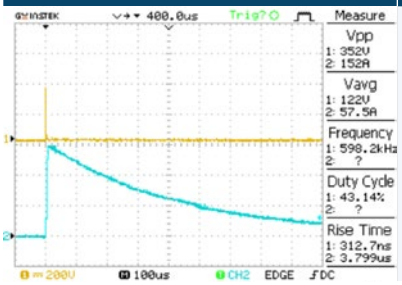
*Table 3 | Test Results for Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination*

| TBU® HSP & OVP Combination Products | | |
|---|---|---|
| 1 Bourns® Model TBU-DF055-300-WH | 2 Bourns® Model TISP4350J3BJR-S | 1 Bourns® Model CDSOT23-SM712 |

| 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 TBU-DF055-300-WH increases to trigger TBU-DF055-300-WH quickly (<1 µs).<br>• When the TBU-DF055-300-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.<br>• When the line voltage increases to the $V_{BO}$ of TISP4350J3BJR-S (350V), TISP4350J3BJR-S will trigger shunt the line to GND.<br>• 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: TISP4350J3BJR-S Voltage CH2: Surge Generator Output Current

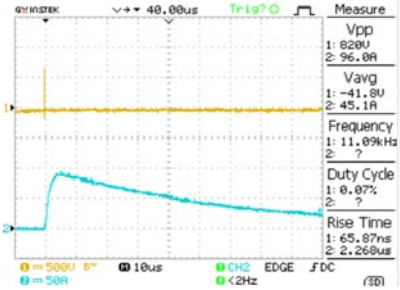
| Test Results | Surge Capability: IEC61000-4-5 Level 4, 6 kV 10/700 µs |
|---|---|
|  | • Upon application of the 6 kV (150 A) surge (Channel 2), the transient current flowing through TBU-DF055-300-WH increases to trigger TBU-DF055-300-WH quickly (<1 µs).<br>• When the TBU-DF055-300-WH is in the blocking state, the line voltage (Channel 1) increases with the surge, as there is no current flow into the protected interface.<br>• When the line voltage increases to the $V_{BO}$ of TISP4350J3BJR-S (350 V), TISP4350J3BJR-S will trigger shunt the line to GND.<br>• 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: TISP4350J3BJR-S Voltage CH2: Surge Generator Output Current

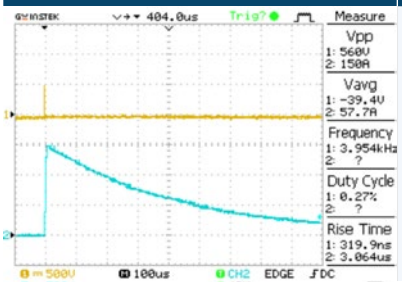
*Table 4 | Test Results for Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination*

| TBU® HSP & OVP Combination Products | | |
|---|---|---|
| 1 Bourns® Model TBU-DF085-300-WH | 1 Bourns® Model 2030-42T-SM-RPLF | 1 Bourns® Model CDSOT23-SM712 |

| 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 TBU-DF085-300-WH increases to trigger TBU-DF085-300-WH quickly (<1 µs).<br>• When the TBU-DF085-300-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.<br>• When the line voltage increases to the $V_{BO}$ of 2030-42T-SM (850 V), 2030-42T-SM will trigger shunt the line to GND.<br>• 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 820 V momentarily. |



CH1: 2030-42T-SM-RPLF Voltage 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 TBU-DF085-300-WH increases to trigger TBU-DF085-300-WH quickly (<1 µs).<br>• When the TBU-DF085-300-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.<br>• When the line voltage increases to the $V_{BO}$ of 2030-42T-SM (850 V), 2030-42T-SM will trigger shunt the line to GND.<br>• 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 560 V momentarily. |

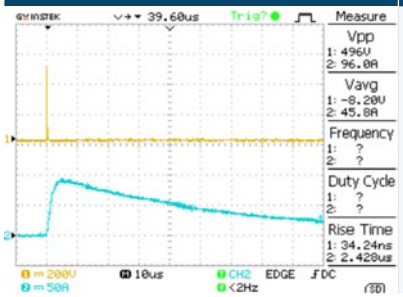


CH1: 2030-42T-SM-RPLF Voltage CH2: Surge Generator Output Current

# RS-485 Port Protection Evaluation Board 4

*Table 5* | *Test Results for Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination*

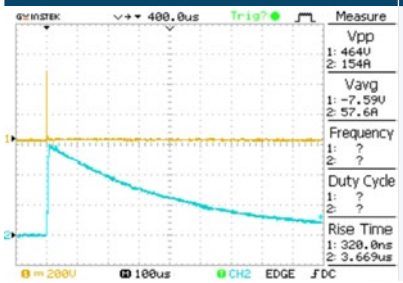
| TBU® HSP & OVP Combination Products | | |
|---|---|---|
| 1 Bourns® Model TBU-DF055-300-WH | 2 Bourns® Model TISP4500H3BJR-S | 1 Bourns® Model CDSOT23-SM712 |
| **Test Results** | **Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs** | |




- Upon application of the 4 kV (95.2 A) surge (Channel 2), the transient current flowing through TBU-DF055-300-WH increases to trigger TBU-DF055-300-WH quickly (<1 µs).
- When the TBU-DF055-300-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 TISP4500H3BJR-S (500 V), TISP4500H3BJR-S will trigger 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 496 V momentarily.

CH1: TISP4500H3BJR-S Voltage CH2: Surge Generator Output Current

| Test Results | Surge Capability: IEC61000-4-5 Level 4, 6 kV 10/700 µs |
|---|---|

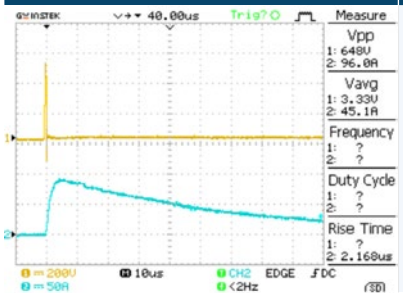



- Upon application of the 6 kV (150 A) surge (Channel 2), the transient current flowing through TBU-DF055-300-WH increases to trigger TBU-DF055-300-WH quickly (<1 µs).
- When the TBU-DF055-300-WH is in the blocking state, the line voltage (Channel 1) increases with the surge, as there is no current flow into the protected interface.
- When the line voltage increases to the $V_{BO}$ of TISP4500H3BJR-S (500 V), TISP4500H3BJR-S will trigger 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 464 V momentarily.

CH1: TISP4500H3BJR-S Voltage CH2: Surge Generator Output Current

*Table 6* | *Test Results for Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination*

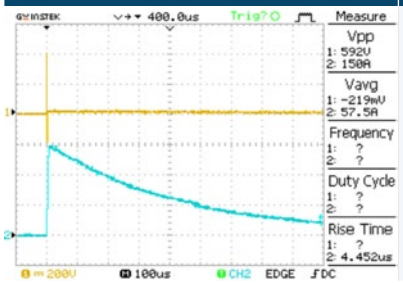
| TBU® HSP & OVP Combination Products | | |
|---|---|---|
| 1 Bourns® Model TBU-DF085-300-WH | 1 Bourns® Model 2036-07-SM-RPLF | 1 Bourns® Model CDSOT23-SM712 |
| **Test Results** | **Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs** | |




- Upon application of the 4 kV (95.2 A) surge (Channel 2), the transient current flowing through TBU-DF085-300-WH increases to trigger TBU-DF085-300-WH quickly (<1 µs).
- When the TBU-DF085-300-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 2036-07-SM (750 V), 2036-07-SM will trigger 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 648 V momentarily.

CH1: 2036-07-SM-RPLF Voltage 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 TBU-DF085-300-WH increases to trigger TBU-DF085-300-WH quickly (<1 µs).
- When the TBU-DF085-300-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 2036-07-SM (750 V), 2036-07-SM will trigger 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 592 V momentarily.

CH1: 2036-07-SM-RPLF Voltage CH2: Surge Generator Output Current

# RS-485 Port Protection Evaluation Board 4

## AC POWER CROSS CAPABILITY

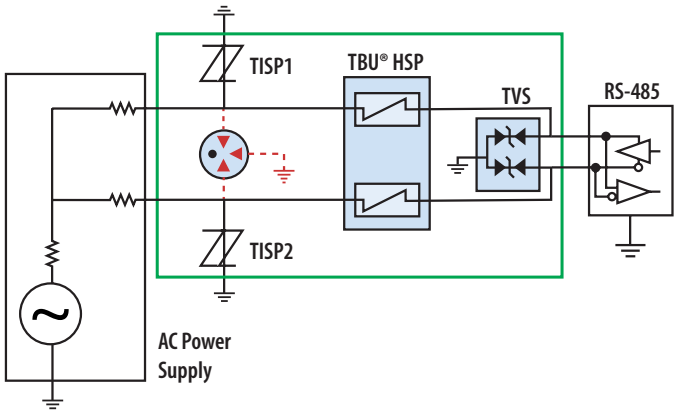
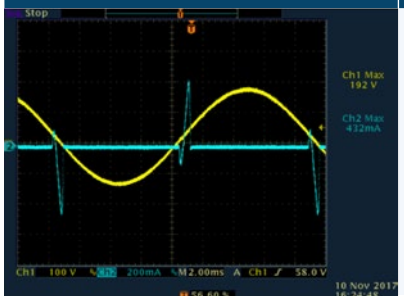



*Figure 3* | *RS-485 Port Protection Evaluation Board AC Power Cross Test Setup*

*Table 7* | *Test Results for Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination*

| TBU® HSP & OVP Combination Products | | |
|---|---|---|
| 1 Bourns® Model TBU-DF055-300-WH | 2 Bourns® Model TISP4350J3BJR-S | 1 Bourns® Model CDSOT23-SM712 |
| **Test Results** | **Surge Capability: AC Power Cross 120 $V_{AC}$** | |
|  | • Bourns® Model TISP4350J3BJR-S will not be triggered since the peak voltage of 120 $V_{AC}$ is less than the $V_{BO}$ of Bourns® Model TISP4350J3BJR-S. As a result, Bourns® Model TISP4350J3BJR-S (350 V) will maintain high impedance.<br>• When the AC power is applied and the line voltage (Channel 1) and line current (Channel 2) increases, Bourns® Model TBU-DF055-300-WH triggers quickly into the blocking state when the line current reaches its $I_{TRIGGER}$ (300 mA), 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-DF055-300-WH triggers.<br>• Once the AC voltage ramps down below $V_{reset}$, Bourns® Model TBU-DF055-300-WH will reset to the conductive state and allow current flow again. | |

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



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