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.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>RS-485 Evaluation Board 4 Bill of Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Part Number</td>
</tr>
<tr>
<td>1</td>
<td>TBU-DF085-300-WH</td>
</tr>
<tr>
<td>2</td>
<td>2030-42T-SM-RPLF</td>
</tr>
<tr>
<td>3</td>
<td>CDSOT23-SM712</td>
</tr>
</tbody>
</table>

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 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 VAC tests specified in ITU-T K.20/21/44, or 120 VAC tests specified in Telcordia GR-1089-CORE. There are applications with lower voltage application/installation threats, but where the standardized 120 VAC or 230 VAC tests are still used to test the robustness of the protection solution.

The third scenario protects against installation errors and faults. For example, 12 VDC or 24 VDC 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 VAC or 230 VAC 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

<table>
<thead>
<tr>
<th>OVP Part Number</th>
<th>OVP Surge Rating</th>
<th>VDRM (V)</th>
<th>VBO (V) (1000 V/µs)</th>
<th>TBU® HSP Part Number</th>
<th>Surge Capability</th>
<th>AC Power Cross Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>TISP4350J3BJR-S</td>
<td>800 A, 8/20 µs</td>
<td>275</td>
<td>350</td>
<td>TBU-DF055-300-WH</td>
<td>IEC61000-4-5, Level 4, 4 kV 1.2/50 µs, 42 Ohm</td>
<td>120 VAC</td>
</tr>
<tr>
<td>TISP4500H3BJR-S</td>
<td>200 A, 5/310 µs</td>
<td>350</td>
<td>500</td>
<td>TBU-DF055-300-WH</td>
<td>230 VAC</td>
<td>230 VAC</td>
</tr>
<tr>
<td>2036-07-SM</td>
<td>10,000 A, 8/20 µs</td>
<td>75</td>
<td>750</td>
<td>TBU-DF085-300-WH</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Overvoltage Protector (OVP) Selection:

- Breakover voltage (VBO) or impulse breakdown voltage (Vimp) of the overvoltage protector (OVP) should be below the maximum Peak Impulse Voltage (Vimp) of the TBU® HSP.
- VBO or Vimp of the OVP should be above the maximum voltage of AC power cross (peak of VAC).

SURGE CAPABILITY

![RS-485 Port Protection Evaluation Board Surge Test Setup Diagram](image-url)
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**

<table>
<thead>
<tr>
<th>TBU® HSP &amp; OVP Combination Products</th>
<th>Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Bourns® Model TBU-DF055-300-WH</td>
<td></td>
</tr>
<tr>
<td>2 Bourns® Model TISP4350J3BJR-S</td>
<td></td>
</tr>
<tr>
<td>1 Bourns® Model CDSOT23-SM712</td>
<td></td>
</tr>
</tbody>
</table>

- 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 TISP4350J3BJR-S (350 V), TISP4350J3BJR-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 360 V momentarily.

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

<table>
<thead>
<tr>
<th>TBU® HSP &amp; OVP Combination Products</th>
<th>Surge Capability: IEC61000-4-5 Level 4, 6 kV 10/700 µs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Bourns® Model TBU-DF085-300-WH</td>
<td></td>
</tr>
<tr>
<td>1 Bourns® Model 2030-42T-SM-RPLF</td>
<td></td>
</tr>
<tr>
<td>1 Bourns® Model CDSOT23-SM712</td>
<td></td>
</tr>
</tbody>
</table>

- 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-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 TISP4350J3BJR-S (350 V), TISP4350J3BJR-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 352 V momentarily.
TBU® HSP & OVP Combination Products

1 Bourns® Model TBU-DF055-300-WH

Test Results

- 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.

Test Results Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs

CH1: TISP4500H3BJR-S Voltage

CH2: Surge Generator Output Current

1 Bourns® Model TBU-DF055-300-WH

Test Results

- 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.

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

CH1: TISP4500H3BJR-S Voltage

CH2: Surge Generator Output Current

1 Bourns® Model TBU-DF085-300-WH

Test Results

- 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.

Test Results Surge Capability: IEC61000-4-5 Level 4, 4 kV 1.2/50 µs

CH1: 2036-07-SM-RPLF Voltage

CH2: Surge Generator Output Current

1 Bourns® Model TBU-DF085-300-WH

Test Results

- 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.

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

CH1: 2036-07-SM-RPLF Voltage

CH2: Surge Generator Output Current
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

<table>
<thead>
<tr>
<th>TBU® HSP &amp; OVP Combination Products</th>
<th>Surge Capability: AC Power Cross 120 V&lt;sub&gt;AC&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Bourns® Model TBU-DF055-300-WH</td>
<td><img src="image" alt="Test Results for Bourns® TBU® High-Speed Protector (HSP) and Overvoltage Protector (OVP) Combination" /></td>
</tr>
<tr>
<td>2 Bourns® Model TISP4350J3BJR-S</td>
<td></td>
</tr>
<tr>
<td>1 Bourns® Model CDSOT23-SM712</td>
<td></td>
</tr>
</tbody>
</table>

- Bourns® Model TISP4350J3BJR-S will not be triggered since the peak voltage of 120 V<sub>AC</sub> is less than the V<sub>BO</sub> of Bourns® Model TISP4350J3BJR-S. As a result, Bourns® Model TISP4350J3BJR-S (350 V) will maintain high impedance.
- 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<sub>TRIGGER</sub> (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.
- Once the AC voltage ramps down below V<sub>reset</sub>, Bourns® Model TBU-DF055-300-WH will reset to the conductive state and allow current flow again.