Abstract
This application note discusses the immunity of the RAA78815x family (RAA788150, RAA788152, RAA788153, RAA788155, RAA788156, RAA788158) of RS-485/RS-422 transceivers to repetitive Electrical Fast Transients (EFT) as defined in IEC61000-4-4. It describes the EFT test setup and the transceiver performance under the application of EFT pulses. Subsequent ATE tests confirm an EFT immunity of 5kV at 5kHz and 100kHz repetition rates for all RAA78815x transceivers, the highest possible test voltage of the AXOS-5 test system, which places this transceiver family into the highest special test level category of IEC61000-4-4.

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1. EFT Test according to IEC61000-4-4

The EFT test applies a burst of 75 fast transients that are coupled into the data lines of an RS-485 data link. Significant for the test pulses are the high amplitude, the short rise time, the high repetition rate, and the low energy of the transients. This test checks the immunity of RS-485/RS-422 transceivers when subjected to fast transients, such as those generated by the switching of inductive loads and relay contact bounce. The preferred test levels for the electrical fast transient test, applicable to data ports are listed in Table 1.

### Table 1. EFT Test Levels

<table>
<thead>
<tr>
<th>Test Level</th>
<th>Test Voltage (kV)</th>
<th>Repetition Frequency (kHz)[1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.25</td>
<td>5 or 100</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>5 or 100</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>5 or 100</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>5 or 100</td>
</tr>
<tr>
<td>X[2]</td>
<td>Special</td>
<td>Special</td>
</tr>
</tbody>
</table>

1. The use of 5kHz repetition rates is traditional, however, 100kHz is closer to reality.
2. X is an open level. The level has to be specified in the dedicated equipment specification.

An EFT transient has a rise time of 5ns and a pulse width (where \(V_{\text{Test,PK}}\) is > 50% \(V_{\text{Test}}\)) of 50ns (Figure 1). The burst period is 300ms and consists of 75 EFT pulses (t\(_{\text{Burst}}\)) followed by a break interval. Depending on the repetition frequency, t\(_{\text{Burst}}\) is 15ms at f\(_{\text{Rep}}\) = 5kHz, or 0.75ms at f\(_{\text{Rep}}\) = 100kHz. The total test time, comprising multiple burst periods, is not less than one minute (Figure 2).

Figure 3 depicts the principle test set-up for the application of the test voltage by a capacitive coupling clamp for laboratory test purposes.

In this setup, two Equipment Under Test (EUTs) are tested simultaneously. With both EUTs being equally distanced from the clamp by 0.5m, and a capacitive clamp length of 1m, the total test cable length is 2m (6ft). The entire setup is placed on top of a ground reference plane, with the EUTs and the clamp being isolated from the reference plane by an insulating support material of 0.1m height.
2. Actual Test Setup

Figure 4 shows the schematic of the test setup for testing the EFT immunity of RS-485 transceivers. A data signal in form of a square wave is applied to the data input (DI) of the left node. This node is configured as a driver whose output signal is looped back to the receiver output (RO1) and captured with the oscilloscope. The driver transmits data to the receiving node on the right, whose output (RO2) is also captured with the scope. For each EFT test, the test voltage is raised and applied while transmitting data, until one of the transceivers latches up.

A second measurement (dotted lines) is performed that captures the differential bus signal (M) and compares it with the data input (DI). M is the math-function of the scope that calculates the difference of the individually measured signals on the A and B bus lines.

Figure 5 shows a photograph of the actual test setup using the AXOS-5 test system.
3. Test Performance

Figure 6 depicts the receiver output signals during the EFT test with 5kHz repetition rate. Figure 7 shows the data input and the differential bus voltage during the same test. Both figures show that the driver and the receivers recover fast after an EFT event.

![Figure 6. RO1 and RO2 during EFT Test with low Repetition Rate](image)

![Figure 7. Data Input and differential Bus Voltage during EFT Test with low Repetition Rate](image)

Figure 8 depicts the receiver outputs during the EFT test with 100kHz repetition rate at a data rate of 10kbps. Therefore, each bit experiences five EFT transients. Figure 9 shows the data input and the differential bus voltage during the same test. It can be seen that even at a high repetition rate, the driver and both receivers recover fast after each EFT event.

![Figure 8. RO1 and RO2 during EFT Test with high Repetition Rate](image)

![Figure 9. Data Input and differential Bus Voltage during EFT Test with high Repetition Rate](image)
After each test run, both receiver outputs were observed for normal transceiver operation during data transmission, which is shown in Figure 10.

![Figure 10. Normal Transceiver Operation was confirmed after each Test Run](image)

In addition to the visual confirmation of normal transceiver operation, all transceivers were tested on an Automatic Test System (ATE) for parametric performance. The pass criterion required that a device did not show any parametric shift. The results of the EFT and ATE tests have been recorded in the EFT test datasheet, shown in Figure 11.

**Note:** To save space, only the highest EFT pass-levels are shown.

![Figure 11. EFT Test Data Sheet](image)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Parameter</th>
<th>Half-Duplex Transceivers</th>
<th>Full-Duplex Transceivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RAA788152</td>
<td>RAA788155</td>
</tr>
<tr>
<td>VCC = 5V</td>
<td>Rep. Freq. (kHz)</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Burst (ms)</td>
<td>15</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>EFT Voltage*</td>
<td>+5kV</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>TX</td>
<td>-5kV</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>RX</td>
<td>+5kV</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>RX/RX</td>
<td>-5kV</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td>ATE-Test</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

**Figure 11. EFT Test Data Sheet**
4. Conclusion

The RAA78815x family of 5V RS-485/RS-422 transceivers passed all EFT tests with 5kV test voltage, the highest possible test voltage of the AXOS-5 test system, which places this transceiver family into the highest special test level category (Table 2).

<table>
<thead>
<tr>
<th>Test Level</th>
<th>Test Voltage (kV)</th>
<th>Repetition Frequency (kHz)</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.25</td>
<td>5 or 100</td>
<td>RAA788150, RAA788152, RAA788153, RAA788155, RAA788156, RAA788158</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>5 or 100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>5 or 100</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>5 or 100</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>5</td>
<td>5 and 100</td>
<td></td>
</tr>
</tbody>
</table>

Although the RAA78815x transceivers possess high EFT immunity, the remaining components of a bus node, such as UART, MCU, and LDO voltage regulator, can have less immunity. To ensure the survivability of these components, and not only the transceiver, it is beneficial to protect an entire bus node circuit with external transient voltage suppressor (TVS) devices. Their design, functional principle, and application in combination with Renesas transceivers are explained in the application notes listed in the reference section.

5. References

The following references can be located on the RS-485/RS-422 Serial Interface family page.

- AN1976: Important Transient Immunity Tests for RS-485 Networks
- AN1977: Transient Voltage Suppressors: Operation and Features
- AN1978: Surge Protection for Renesas’ Standard RS-485 Transceivers
- AN1979: Surge Protection simplified with Renesas’ Overvoltage Protected (OVP) Transceivers
- R15AN0002: RS-485 Transient Protection in Industrial DC-Supply Buses

6. Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.0</td>
<td>Jun 8, 2021</td>
<td>Initial release</td>
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(Rev.1.0 Mar 2020)

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