

# RS-485 Full-Duplex Evaluation Module

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This user's guide describes the RS-485 full-duplex evaluation module (EVM). This EVM helps designers evaluate device performance, supporting the fast development and analysis of data transmission systems using any of the TI RS-485 full-duplex devices in a 14-pin SOIC package.

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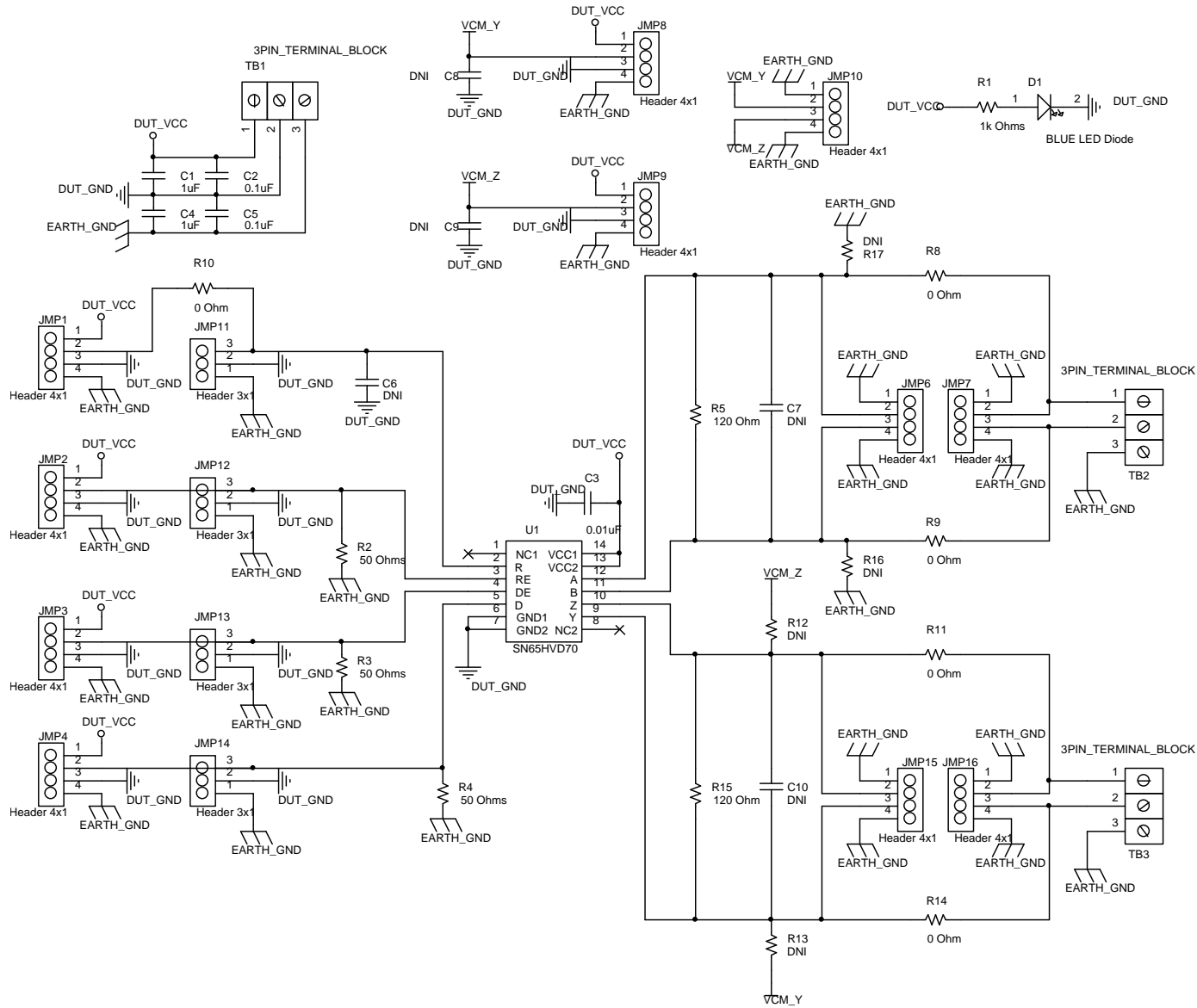
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## 1 Overview

TI RS-485 full-duplex devices in the 14-pin SOIC package have robust drivers and receivers in a small package for demanding industrial applications. The bus pins are robust to ESD events, with high levels of protection to human-body model (HBM) and IEC contact discharge specifications. These devices each combine a differential driver and a differential receiver, which operate from a single power supply. The driver differential outputs and receiver differential inputs are not connected internally, making the devices suitable for full-duplex (four-wire bus) communication. TI's RS-485 full-duplex transceivers feature a wide common-mode voltage ( $V_{(CM)}$ ) range, making the devices suitable for multi-point applications over long cable runs.

## 2 EVM Setup and Precautions

[Figure 1](#) shows the EVM schematic. The EVM board has header pins labeled from JMP1 to JMP14 (JMP5 is omitted) and three 3-pin terminal blocks labeled TB1, TB2, and TB3. These components support device evaluation for a wide range of system configurations.

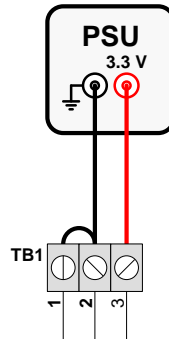


**Figure 1. RS-485 Full-Duplex EVM Schematic**

## 2.1 Power Supply Connections

- The  $V_{CC}$  pin is the positive supply voltage of the device-under-test (DUT) and is connected to the positive output of a regulated power-supply unit (PSU). The  $V_{CC}$  pin is available on various jumpers for convenient pullup connections for various signals.
- This pin is connected to the negative output or ground terminal of the PSU
- EARTH is a secondary ground net that allows for applying an external voltage between GND and EARTH to simulate common-mode voltage conditions.

For the first measurements, ignore the common-mode simulation and connect EARTH to GROUND through a wire-bridge between pin 1 and pin 2 of TB1. EARTH and GND can also be connected with a jumper on pins 3 and 4 on JMP9.

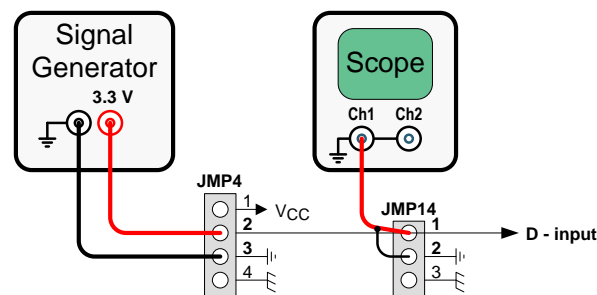


**Figure 2. Bridging GND With EARTH**

## 2.2 Signal Connections

The jumper points, JMP2, JMP3, and JMP4, are stimulation points for applying input signals to the  $\overline{RE}$ , DE, and D pins, respectively. JMP12, JMP13, and JMP14 are probe points at which the input signals can be monitored. Note that R2, R3, and R4 (located on the bottom layer of the EVM) are populated with 50- $\Omega$  resistors for convenient termination of standard 50- $\Omega$  test equipment.

If signals from external test equipment are not used for control of  $\overline{RE}$ , DE, or D, jumpers can be used to connect these pins directly to  $V_{CC}$  or GND on JMP2, JMP3, and JMP4. In this case, R2, R3, and R4 can be removed to avoid unnecessary current draw from the PSU.



**Figure 3. Example for Stimulus and Probe Points With JMP4 and JMP14**

Figure 3 shows an example for entering a data signal into the driver section of the transceiver. The signal output of the generator is adjusted to 3.3 V to match the device  $V_{CC}$  power-supply requirements, and is connected to pin 2 of JMP4. The ground terminal of the generator is connected to pin 3 of JMP4. The data signal is measured through an oscilloscope with the signal input connected to pin1 of JMP14 and the ground wire connected to pin 2 of JMP14.

The same setup can be applied to the DE and  $\overline{RE}$  inputs through the corresponding headers JMP2-JMP12 and JMP3-JMP13. Jumper points JMP1 and JMP11 represent the receiver output of the transceiver and must not receive an input signal.

Instead of using signal generators, the EVM can directly interface to micro controller I/O pins. In this case, R2, R3, and R4 should be removed. For proper operation, ensure that the high-level input voltage  $V_{IH} \geq 2$  V and the low-level input voltage  $V_{IL} \leq 0.8$  V.

### 3 Powering Up the EVM and Taking Measurements

The following lists the generally recommended procedure for setting up the EVM to take measurements.

1. Install the required ground connections.
2. Connect the oscilloscope with the probe points of interest.
3. Adjust the power-supply to match the  $V_{CC}$  requirements of the selected RS-485 device.
4. Adjust the signal generator outputs for a maximum output-signal level, based on the  $V_{CC}$  requirements of the selected RS-485 device, or check the logic switching levels of the controller I/O.
5. Connect the power-supply conductor with pin 3 of TB1 and observe the turnon of the blue LED (D1).
6. Connect signal conductors from the controller or signal generator with the corresponding EVM inputs at JMP2, JMP3 JMP4.

#### 3.1 Measurement Examples

Each of the following measurement examples shows the equivalent circuit diagram and the corresponding EVM setup. Only the measurement relevant headers and terminal blocks are shown, and not necessarily at the exact location on the EVM.

##### 3.1.1 Standard Transceiver Configuration

To evaluate the transceiver under normal operation using only one EVM, both the driver and receiver sections must be active. Therefore, the receiver enable pin,  $\overline{RE}$ , must be at logic-low potential, and the driver enable pin, DE, must be at logic high.

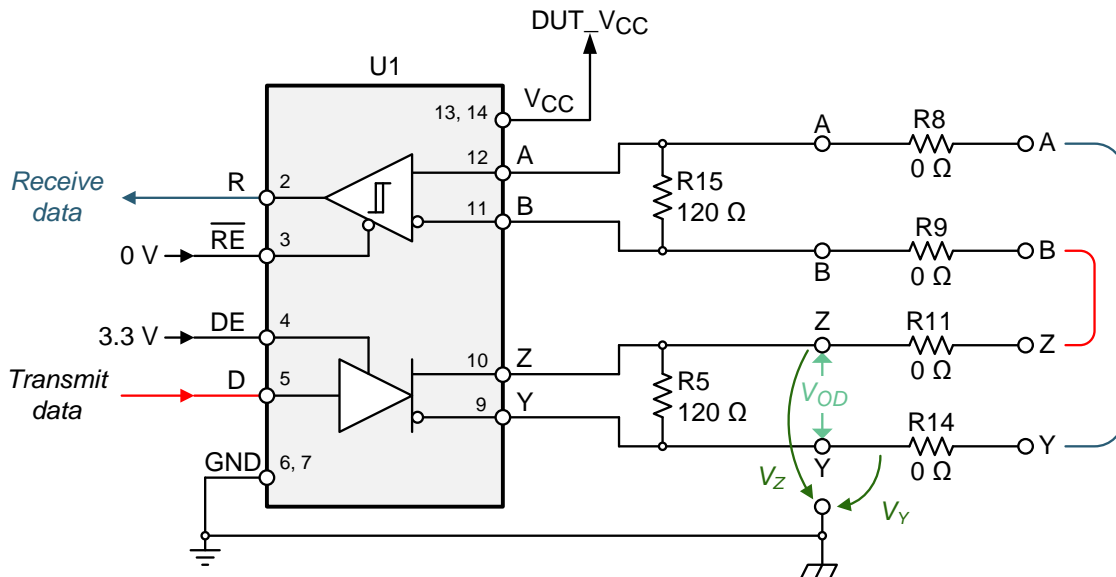
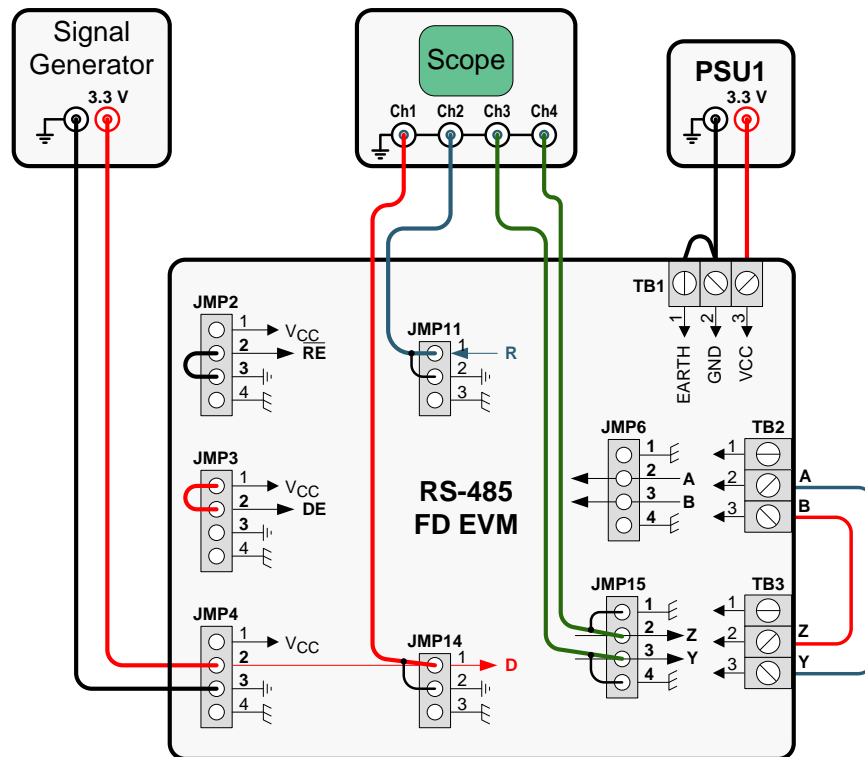


Figure 4. Transceiver Configuration for Normal Operation

Transmit data entering at the D input terminal appear as the differential output voltage ( $V_{OD} = V_{(Y)} - V_{(Z)}$ ) on the driver output pins, Y and Z. Sensing the data traffic in the transmit section is possible through the active receiver by connecting the driver Y output to the receiver A input, and connecting the driver Z output to the receiver B input.



**Figure 5. RS-485 Full-Duplex EVM Setup for Normal Transceiver Operation**

Figure 5 shows the corresponding EVM setup. EARTH and GND receive the same reference potential, PSU-ground, through the wire-bridge from pin 1 to pin 2 of terminal block TB1. Pin 3 of terminal block TB1 is connected to the positive supply of the PSU.

The low potential for  $\overline{RE}$  is provided through the wire-bridge from pin 2 to pin 3 of JMP2, and the high potential for DE is provided through the wire-bridge from pin 2 to pin 1 of JMP3. Data from the signal generator enter the board at pin 2 and pin 3 of JMP4. This data is measured with oscilloscope channel 1 (Ch1), which is connected to pin 1 and pin 2 of JMP14. Oscilloscope channel 2 (Ch2) measures the receive data at JMP11, and channel 3 (Ch3) and channel 4 (Ch4) measure the bus voltages, either  $V_{(Y)}$  and  $V_{(Z)}$  at JMP15, or  $V_{(A)}$  and  $V_{(B)}$  at JMP6.

### 3.1.2 Operation Under Maximum Load

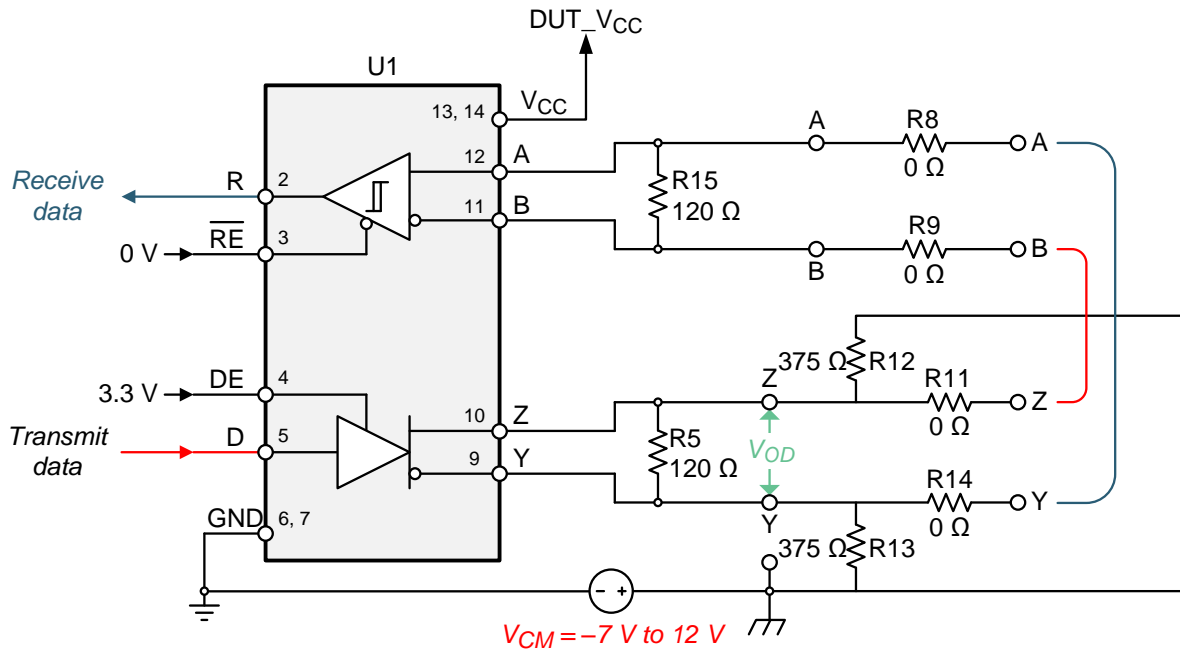


Figure 6. Transceiver Configuration for Maximum Loading

EIA-485 (RS-485) specifies three maximum load parameters: a maximum differential load of  $60\ \Omega$ , a maximum common-mode load of  $375\ \Omega$  for each bus wire, and a receiver common-mode voltage range from  $-7\ \text{V}$  to  $12\ \text{V}$ . Figure 6 shows the requirements through R5, R15, R12, R13, and  $V_{(CM)}$ . Note that under maximum load conditions the transceiver must be capable of sourcing and sinking bus currents of up to 70 mA. The purpose of this test is to show the robustness of  $V_{OD}$  over the entire common-mode voltage range at maximum load.

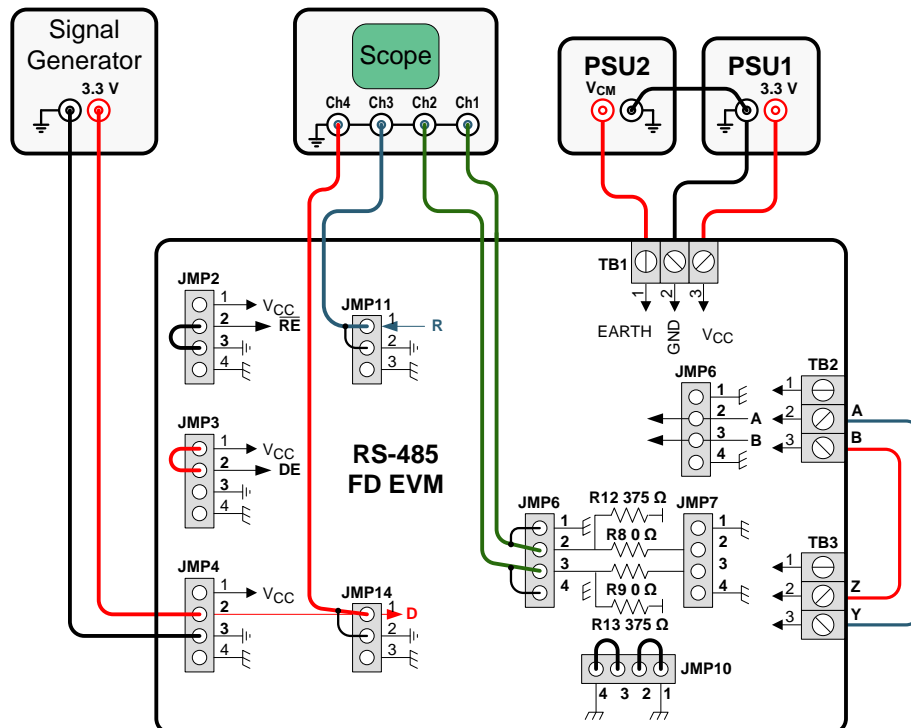


Figure 7. RS-485 Full-Duplex EVM Setup for Maximum Loading

While the cable connections of the signal generator and the oscilloscope remain the same as in the previous example, the following board changes must be implemented to reflect maximum load conditions:

- Place a 375- $\Omega$  resistor at R12
- Place a 375- $\Omega$  resistor at R13
- Connect pin 1 of JMP10 with pin 2 and pin 3 with pin 4
- Replace the previous wire-bridge at TB1 with a second power supply unit (PSU2) and connect the ground terminals of PSU1 and PSU2 with a wire-bridge, as show in Figure 7.

Note that Figure 7 only shows the wiring of PSU2 for positive common-mode voltages. For negative  $V_{(CM)}$ , connect the ground terminal of PSU2 with pin 1 of TB1 (EARTH), and the  $V_{(CM)}$ -output of PSU2 with the ground terminal of PSU1.

### 3.1.3 Full-Duplex Operation

To evaluate the transceiver during full-duplex (four-wire) operation, two transceivers may be connected together as shown in Figure 8. This allows both transceivers to transmit and receive data simultaneously in a forward and reverse channel. In this configuration, each driver and receiver can be enabled at all times. Each driver and receiver is terminated with a 120- $\Omega$  resistor, making the default EVM components suitable for evaluation with a 120- $\Omega$  cable.

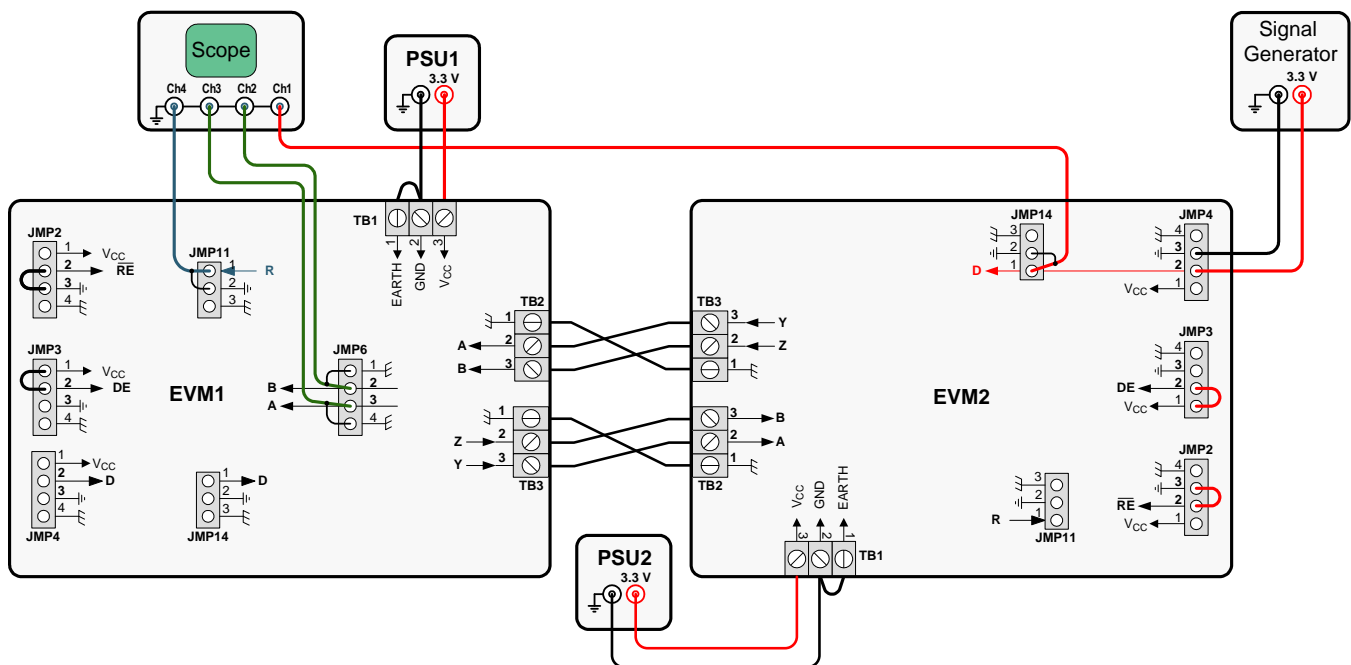


Figure 8. RS-485 Full-Duplex EVM Setup for Full-Duplex Operation



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- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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2. Use EVMs only after user obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after user obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless user gives the same notice above to the transferee. Please note that if user does not follow the instructions above, user will be subject to penalties of Radio Law of Japan.

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