Application Note

How to Properly Set Up THVD1505 and SN65HVD888 in Applications

ABSTRACT

This application note discusses polarity free RS-485 set up in applications. The measurement data shows the devices' behavior in different system configurations.

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1 Introduction

The RS-485 interface works using differential signaling which is effective in rejecting common-mode noise making it a robust choice for long-distance communication. To make the system work properly, the transmitter and receiver have to be connected correctly - pin A to pin A and pin B to pin B. In some RS-485 applications, however, the bus polarity might not be known. For example, with long cable length the two ports might be wrongly detected in installation. TI's polarity free RS-485 transceivers like THVD1505 and SN65HVD888 are designed to work in these situations. These two devices can detect the bus polarity automatically, resulting in a RS-485 system independent from the bus wire connection. This feature makes the system more reliable and the installation or debug more efficient. THVD1505 meets the requirements of part 11 Serial Communication Protocol RS-485 standard in the Q/GDW 11179.11-2015 standard, published by the State Grid Corporation of China (SGCC). The certificate can be found on this website.

Talking about polarity-free RS-485 transceivers, it is worth mentioning that THVD8000 and THVD8010 also have the polarity-free feature and have been widely used in power line communications. These two devices are able to modulate RS-485 signals through On-off keying (OOK) modulation to transmit RS-485 signals over either an AC or DC power line. This feature can reduce the number of wires from four to two to greatly reduce the system cost. More information about the parts can be found in this article.

Back to the topic of this article, THVD1505 and SN65HVD888 are easy to use in systems. The A and B pins can be connected to the bus freely. However, for the devices to work in a system correctly, some conditions must be met. In a simplified summary, the devices need to be put in receiver mode to detect the existing polarity of the bus. The bus bias can be established by a common non-polarity-free RS-485 transceiver like THVD1550 or external biasing network using pull-up and pull-down resistors. Please be aware that the devices constantly drive the bus with power on and driver enabled.

To help better understand the device's behavior in applications, several different test cases are presented.

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2 Test Cases

Test Case 1: A-A and B-B correct connection

Two half-duplex RS-485 EVMs are used in this test. The 5-V supply is individually supplied to each board. THVD1550 (regular non-polarity free RS-485 transceiver) is populated with a 120-Ω termination on board 1 as shown in Figure 2-1. This board is set as the leading node in the test, where the DE and D pins (pin 2 and pin 3) are high and the REB pin (pin 1) is low. On board 2, THVD1505 (polarity free RS-485 transceiver) is populated with a 120-Ω termination. This board is configured with the D pin high and the DE and REB pin low to make it function as the follower in the test. The receiver output R pin is biased with a 10k-Ω pull-down resistor. The wires between these two boards are connected normally, meaning *A* (pin 7) is wired to *A* and *B* (pin 6) is wired to *B* between the two boards.

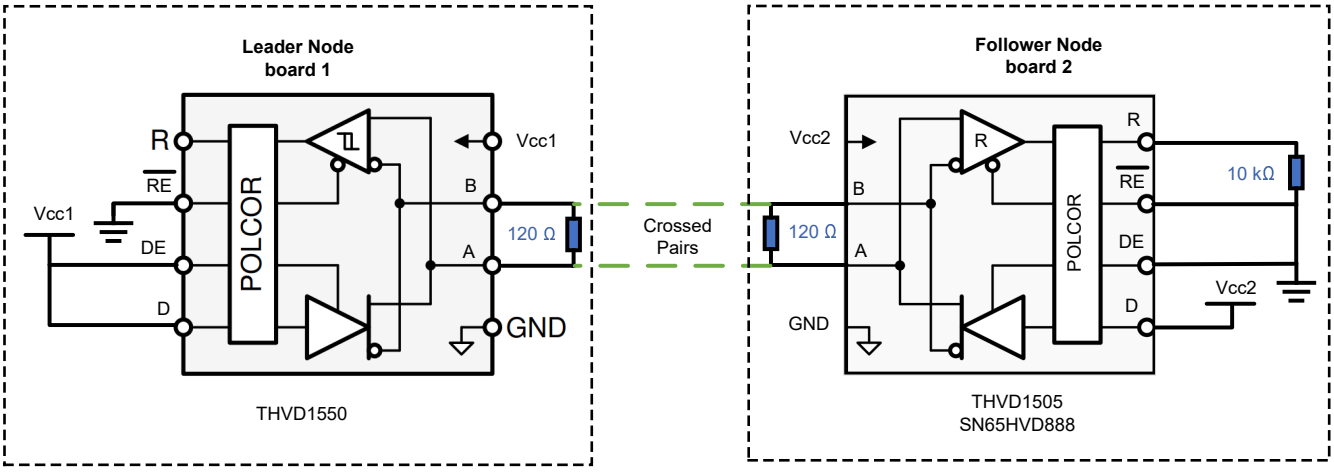

Figure 2-1. Test Case 1 Setup

In this test, THVD1550 is used to set the bus polarity. After board 1 is powered on, board 2 is turned on a few seconds later. The bus waveforms (A: purple curve; B: green curve) and R (blue curve) of THVD1505 in Figure 2-2 show that THVD1505 detects the bus polarity correctly after being powered up. Since the bus bias is positive, the correct output at R is generated to be a logic high. Similar results are obtained with SN65HVD888 deployed on Board 2, as shown in Figure 2-3.

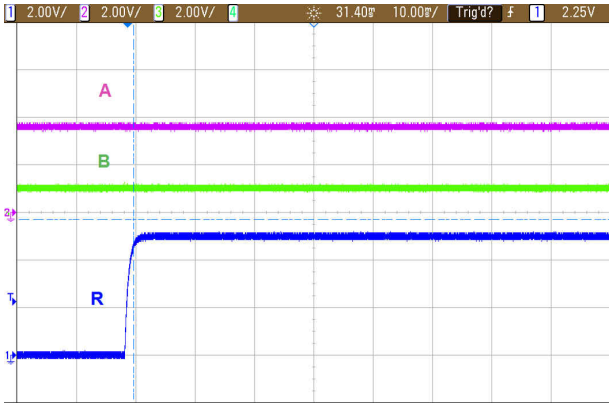

Figure 2-2. THVD1505 Powered Up with Correct Wiring

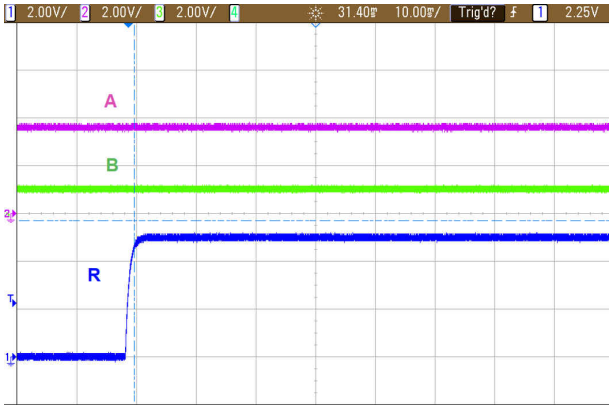

Figure 2-3. SN65HVD888 Powered Up with Correct Wiring

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Test Case 2: A-B and B-A Miswiring Connection

In this test, two boards are configured in a similar way as test case #1. However, the wire connections are mis-wired (Figure 2-4). To be more specific, the pin A of board 1 is wired to the pin B of board 2, while pin B of board 1 is wired to the pin A of board 2.

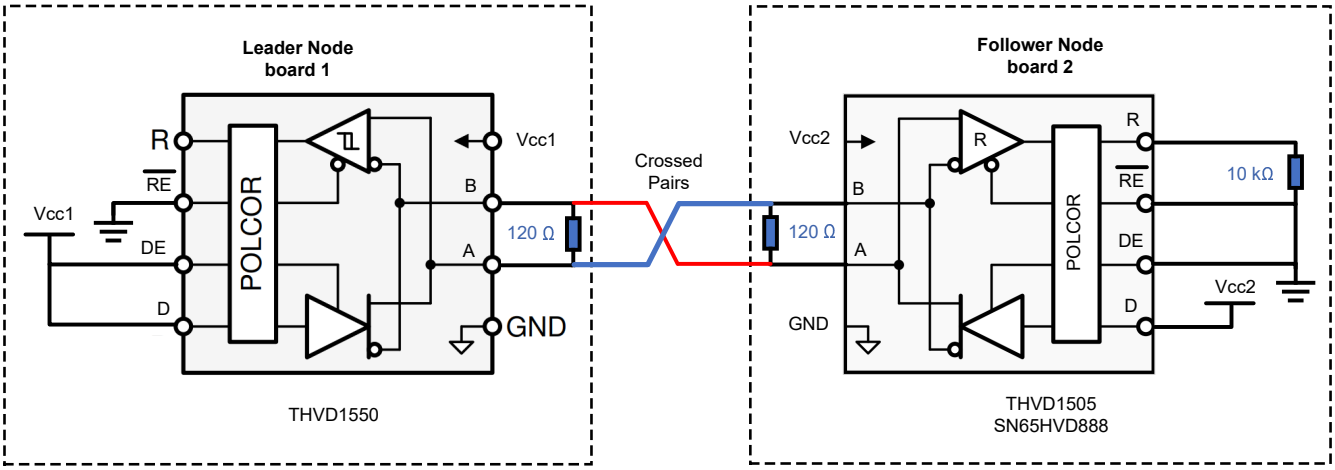

Figure 2-4. Test Case 2 Setup

Comparing to the results of Test case #1, Figure 2-5 shows that the voltage of the R pin (blue curve) of THVD1505 follows the rail during power ramping up. As the supply is high enough to fully turn on the device, the receiver output becomes low responding to the negative bus bias (the voltage of pin A of THVD1505 is lower than that of pin B). Nevertheless, the device keeps checking the bus polarity as it is powered up. After a certain time (fail-safe time t_{FS}), the receiver recognizes the bus polarity and corrects itself to match that. Therefore, the R pin voltage flips from low to high. Similar results are observed with SN65HVD888 on board 2, as shown in Figure 2-6. The longer timing difference shown in Figure 2-6 is due to the longer fail-safe time of SN65HVD888.

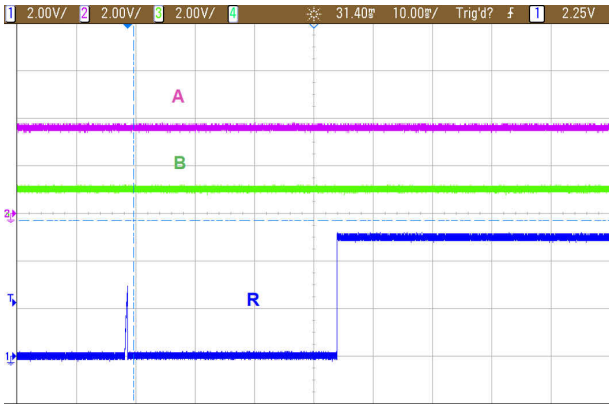

Figure 2-5. THVD1505 Powered Up with Mis-wiring

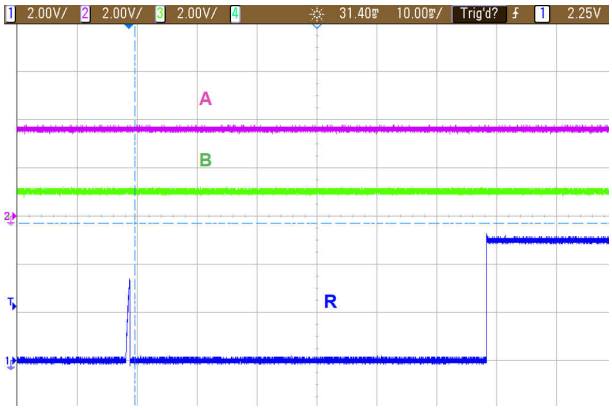

Figure 2-6. SN65HVD888 Powered Up with Mis-wiring

Test Case 3: A-B and B-A miswiring connection with drivers on

This break-the-part test shows what could happen if the driver of the polarity-free transceiver is turned on before the polarity information has been processed by the device.

In this test, board 1 is populated with THVD1550, while the enable pins are set as before (the DE pin and D pin are high, the REB pin low) (Figure 2-7). Please note that both boards are not terminated, for better demonstrating the devices' behavior in this problematic setup. Since it is supposed to drive the bus, the DE and D pins are high and the REB pin is low as board 1. Similarly, the wire connections are mis-wired (pin A of board 1 is wired to pin B of board 2, pin B of board 1 is wired to pin A of board 2).

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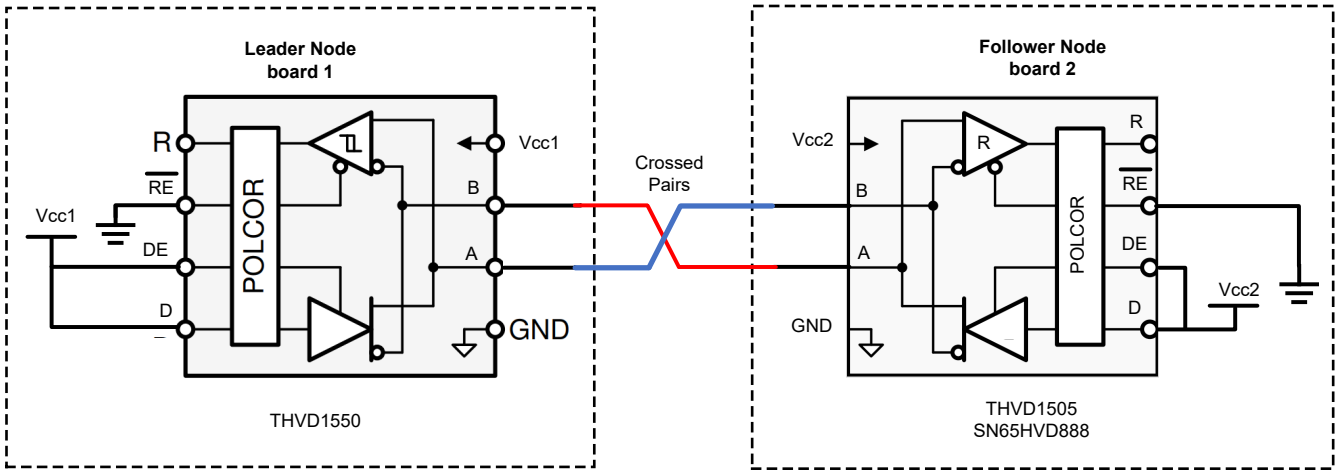

Figure 2-7. Test Case 3 Setup

In Figure 2-8, the driver of THVD1505 is immediately turned on as the device is powered up. Same as the last two tests, the waveforms are A: purple curve; B: green curve and R: blue curve of THVD1505. However, by default the device's polarity is opposite to the bus or the polarity of THVD1550. Two drivers with the same input (logic high) drive the bus oppositely, causing the bus voltage to stay somewhere around half of Vcc. Please note that depending on the drive strength of the two drivers on two boards, the bus voltage could be anywhere from 0-V to Vcc. In this test report, THVD1550 driver is stronger and the differential bus voltage is above 0-V. Eventually THVD1505 gives up and acknowledges the bus polarity by correcting itself. Now both drivers are driving the same polarity. The bus voltage is back to normal as well as the receiver output.

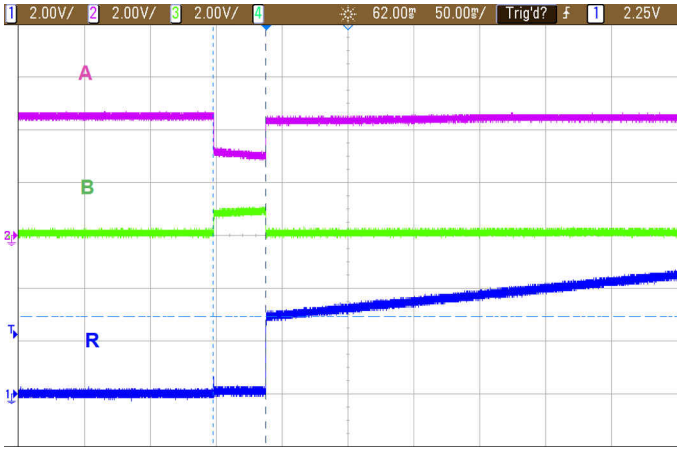

Figure 2-8. THVD1505 Powered Up with Mis-wiring and Driver On

As it is mentioned above, the bus voltage could be any value between 0-V and Vcc depending on the drive strength of the drivers at the two ends. In the test of SN65HVD888, the worst-case scenario happens – two drivers have similar drive capability and SN65HVD888 is stronger (Figure 2-9). The negative differential bus voltage does not force the SN65HVD888 to change its polarity. Therefore, the fight between two devices will never end: both drivers keep driving the bus in opposite polarities, the bus is locked, and system is stuck. Thus, the polarity-free device can never correct itself due to the wrong bus information.

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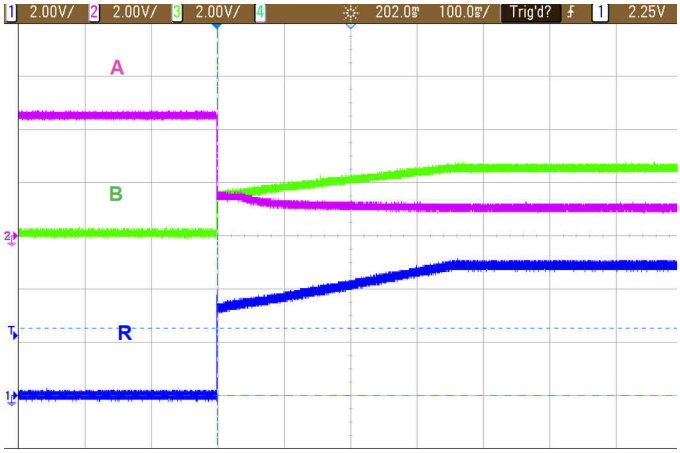

Figure 2-9. SN65HVD888 Powered Up with Mis-wiring and Driver On

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3 Summary

In summary, three scenarios are tested in this application note for two polarity free RS-485 transceivers – THVD1505 and SN65HVD888. After reviewing the test results, it is clear that the polarity-free devices should be put in the receiver mode as they are powered up in applications. After the biased bus makes the devices fix their polarities, the devices can work normally in the system. Again, if an existing RS-485 system is to be upgraded with this polarity free feature, some circuitry is needed to fix bus polarity. Like it is mentioned before, either pull-up and pull-down resistor network or a regular RS-485 transceiver (THVD1500, THVD1439, and so on) can do the job. With hardware upgrade, software update is not required.

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