How to Isolate Signal and Power for an RS-485 System

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Introduction:

The Telecommunications Industry Association (TIA) and Electronic Industries Alliance (EIA) standard for RS-485 communication was established two decades ago and has been widely adopted for a variety of applications. RS-485 is the ideal standard for reliable communication over long distances of 1000 meters because of the twisted pair structure used to send a differential signal.

For motor control, factory automation, grid infrastructure, and other systems where high voltages can be present, communication between high voltage and low voltage domains create a need to isolate nodes of the RS-485 system. Isolating an RS-485 node protects circuitry, and in some cases human operators, from high voltages and any unwanted transients. Isolation used to protect human operators from high voltages is referred to as reinforced isolation and is the equivalent of having two functional isolation barriers in series. Galvanic isolation is also used in RS-485 systems to prevent ground loops that can cause noise, which interferes with the RS-485 bus communication.

There are a variety of methods that can be implemented to isolate signal and power to achieve these system-level benefits. This article addresses the different solutions available for isolating an RS-485 node and explains the trade-offs between them.

Signal Isolation:

There are two common methods for isolating the signal for an RS-485 system. The first method is a discrete solution of a digital isolator and RS-485 transceiver. In this solution, the enables (RE, DE), transmit (D), and receive (R) signals are isolated using a digital isolator such as the ISO7741 between the MCU and the RS-485 transceiver. Figure 1 shows an example of this solution with ISO7741 and an RS-485 transceiver such as the THVD1410. One key advantage of the discrete solution is the flexibility to choose the best transceiver for the specific application. However, the discrete solution comes with the drawback of requiring additional board space because of the multi-chip solution.

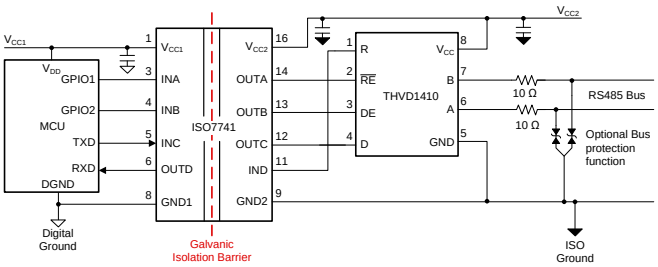

Figure 1. Discrete implementation of isolated RS-485 using ISO7741 and THVD1410

The second method is to use an integrated solution that combines the digital isolator and RS-485 transceiver in one package. The ISO1410 integrates the core isolation technology from ISO7741 and the THVD1410 transceiver in single package. The core isolation technology leads to the capability to achieve 1500 Vpk continuous working voltage, reinforced 5 kVrms isolation rating, and 100 kV/us typical common mode transient immunity (CMTI). The integrated transceiver provides high noise immunity on the bus with Profibus compliance, 16 kV IEC electrostatic discharge (ESD), and 4 kV IEC electrical fast transients (EFT) to ensure reliable communication even in noisy environments like a factory floor. The ISO1410 has the added benefit over the discrete solution of a wider logic side supply with support for 1.71 V to 5.5 V to enable lower logic level MCU's and 3 V to 5.5 V for the bus side supply.

By combining the isolator and transceiver into one package, this solution provides system-level board space reduction compared to the discrete solution. Figure 2 shows how the discrete solution from Figure 1 can be replaced with the ISO1410.

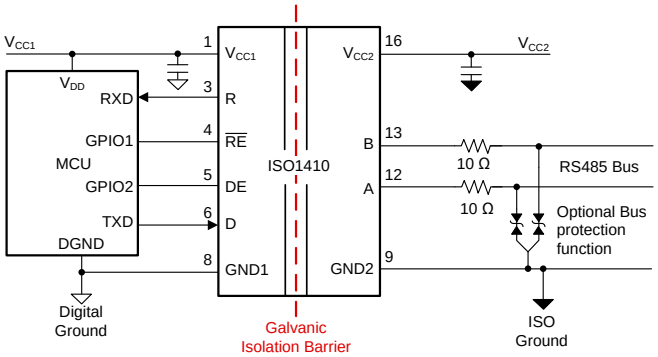

Figure 2. Integrated solution for isolated RS-485 using ISO1410

Power Isolation:

Regardless of the method used to isolate the RS-485 signals, an isolated power supply is required to power the secondary side of the digital isolator and the RS-485 transceiver or isolated RS-485 device. The first solution for providing isolated power is shown in Figure 3, where the transformer driver, SN6501 in combination with an external transformer and LDO provides isolated power for the ISO1410. This solution can also be used with the discrete approach for signal isolation.

The benefit of this solution is that it provides greater than 80% efficiency and the transformer and LDO can be selected to optimize for specific design considerations. The SN6501 provides up to 1.5 W of power and can be replaced with the SN6505 for up to 5 W if isolated power is needed for additional devices.

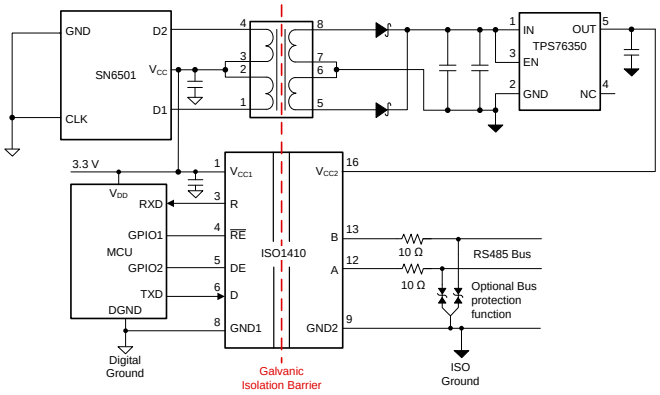

Figure 3. Isolated signal and power solution for RS-485 using ISO1410 and SN6501 transformer driver

The second solution for isolated power would be to replace the ISO7741 in Figure 1 with ISOW7841, which isolates signal and power in a 16-SOIC package. The Isolated RS-485 With Integrated Signal and Power Reference Design shows this solution using the SN65HVD1473 transceiver, but other RS-485 transceivers can also be used depending on the application needs. Figure 4 shows the complete solution for isolated signal and power using the ISOW7841 with the THVD1410.

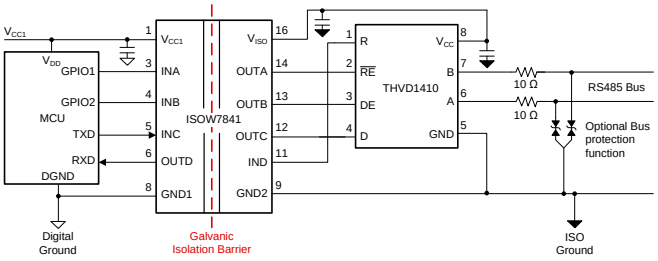

Figure 4. Isolated signal and power solution for RS-485 using ISOW7841 and THVD1410

The advantages of the ISOW7841 solution are that it eliminates the need for a transformer on the board, reduces board size, and makes certifications easy with all certifications available here. The small solution size comes with a trade off in efficiency as the transformer integrated into the chip provides a typical efficiency of around 50% and can provide up to 650 mW of isolated power. With the integrated power solution, since the transformers are smaller in size, switching frequencies are higher, leading to higher emissions as compared to the discrete solution. These emissions can be reduced by stitching capacitors as shown in the application note, Low-Emission Designs With ISOW7841 Integrated Signal and Power Isolator.

Conclusion:

There are many solutions for isolating signal and power in an RS-485 system depending on the specific application requirements. Using the ISO1410 integrated solution for signal isolation combines the advantages of a digital isolator and noise immune transceiver into one package to conserve board space while maintaining performance.

For power isolation, the trade-off is between the discrete solution using transformer drivers or an integrated solution. The ISOW7841 integrated solution makes design easy and reduces board space, but comes with the compromise of lower efficiency compared to the Figure 3 solution with SN6501.

Table 1. Relevant Technical Documents

Document Title
Enabling high voltage signal isolation quality and reliability
Robust Isolated RS-485 enables new industrial applications
How to isolate RS-485 for smallest size and highest reliability

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