

INTEGRATED *iCoupler* DIGITAL ISOLATION WITH *isoPower* BRIDGES THE GAP BETWEEN USB AND TRADITIONAL INDUSTRIAL INTERFACES

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Introduction

As a standard for serial communication to peripheral devices, USB is ubiquitous today. However, industrial devices still rely, in many cases, on the older standard of RS-232 for debug or master slave connections. In order to add robustness through differential communication, RS-422 or RS-485 are also widely used, and RS-485 remains the physical layer standard used by various wired multinode industrial network or fieldbus protocols. As a result, there can be a mismatch between the available interfaces on tools used for debugging or monitoring, such as laptop computers that only have USB for serial communications, and industrial equipment that may only expose RS-232, RS-422, or RS-485 interfaces.

In addition to the hardware interfaces required for any USB to UART translation, galvanic isolation is a functional and potential safety requirement for any interface circuit between test or monitoring equipment, as well as industrial equipment that is potentially in active use in an electrically harsh environment. Combinations of interface *iCoupler*® and *isoPower*® isolation technology from Analog Devices, integrated together in a variety of ICs, allow easy solutions for bridging the gap between USB and traditional industrial interfaces.

Why Use Galvanic Isolation?

When interfacing with industrial equipment, it is of paramount importance to avoid interfering with the operation of those systems. Galvanic isolation prevents any flow of current while allowing data transfer, protecting both the unit under test and the debug unit. When connecting debug consoles, such as laptop computers, several hazards are apparent, as shown in Figure 1.

- ▶ If the debug equipment is grounded, differences in ground potentials can result in loop currents
- ▶ If the debug equipment is not grounded, static can discharge into the units under test
- ▶ Hazardous voltages can occur on fieldbus networks due to switching noise from motors and relays
- ▶ Some basic diagnostic equipment, such as a laptop, may not have the same rigorous levels of interface protection as industrial equipment

In a USB to UART interface, there are two possibilities: either the USB interface can be isolated or the UART interfaces (RS-232, RS-485, and RS-422) can be isolated. In theory, both can be isolated in order to protect the interface module itself from either equipment, or to provide safety isolation from two basic isolation interfaces in series.

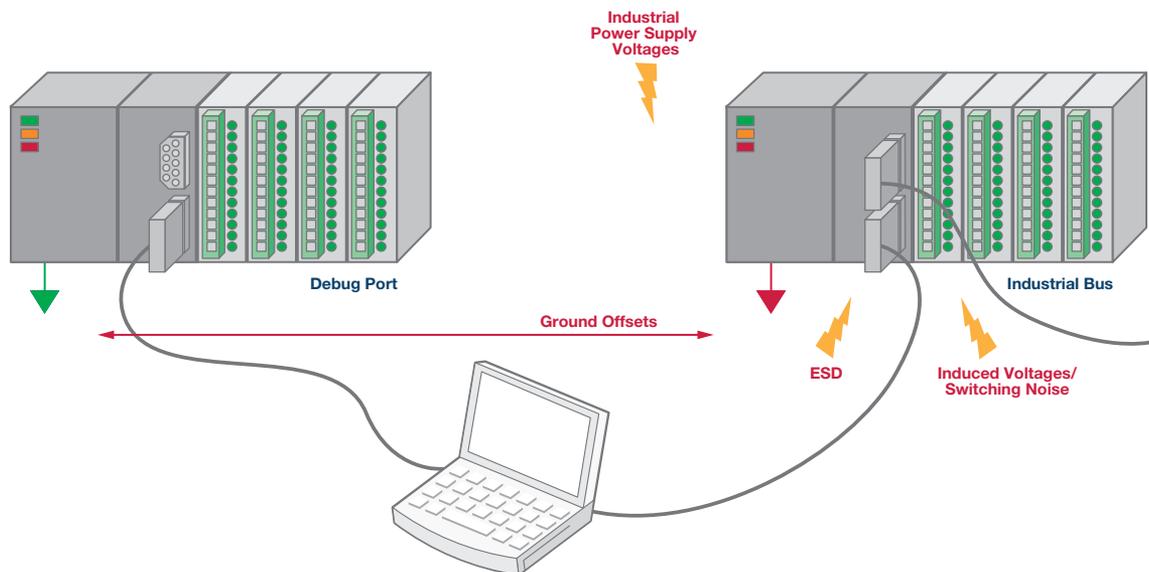


Figure 1. Potential electrical hazards.

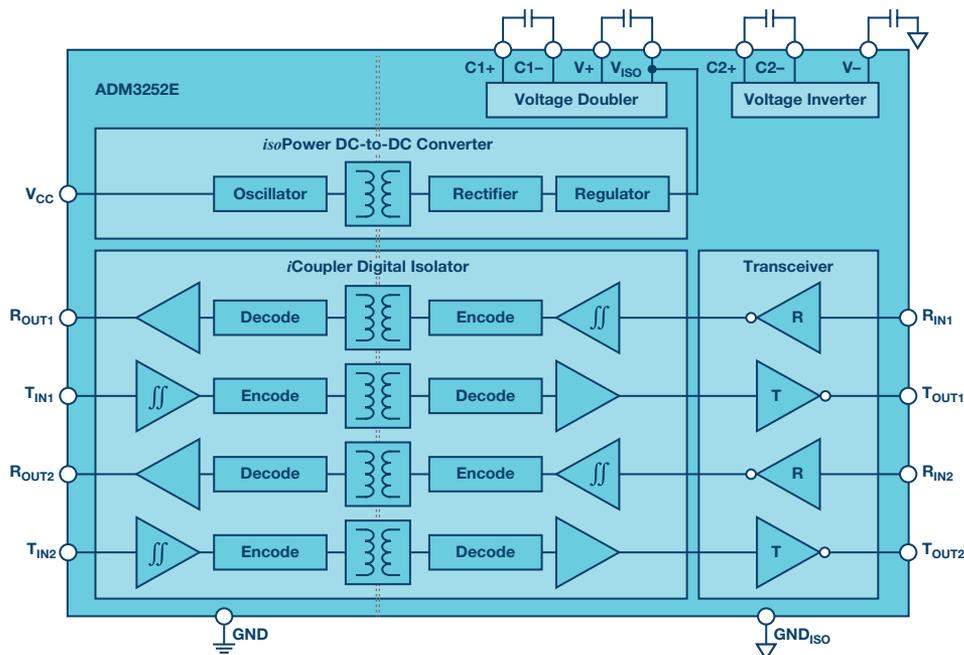


Figure 2. ADM3252E block diagram.

Isolating Using *iCoupler* Digital Isolators

Digital isolators using *iCoupler* technology offer high levels of robustness for galvanic isolation with enhanced reliability and lower power requirements than optocouplers. Other IC functionality, such as transceivers, can be integrated into single chip solutions requiring a little extra PCB area compared to nonisolated solutions. This is particularly advantageous for isolating RS-232 or RS-485 interfaces where an IC is already required to transmit and receive at the appropriate voltages.

For USB, two signals, D+ and D–, need to be isolated transparently or have custom software drivers in order to not interfere with the USB handshaking protocol. Using a digital isolator for USB, such as [ADuM3160](#), achieves this in a wide body SOIC footprint. Power is available on one side of the isolator across the USB cable, so a similar power supply should be provided on the isolated side as well. The [ADuM5000](#) provides an isolated supply in a single wide-body SOIC, using integrated *isoPower* chip scale transformers for isolated power. If additional levels of power are required, an external transformer and rectifier can be used, requiring a transformer driver and a secondary regulator, which are combined in the [ADuM3070](#).

In order to isolate RS-232, a transmit (Tx) and a receive (Rx) signal require isolation, as well as some control signals (RTS and CTS). However, in addition to a TTL interface to the UART, an RS-232 transceiver is required to convert these signals to/from the RS-232 voltage levels. An isolated power supply is also required to power the transceiver and the transceiver side of the isolator. All three components (signal isolation, transceiver, and isolated power) are combined in the [ADM3252E](#), as shown in Figure 2, resulting in a single BGA footprint to provide a complete isolated RS-232 interface.

RS-485 also requires a transceiver to interface with either a 2-wire bus (A and B) or 4-wire bus (A, B, Y, and Z). The signals to be isolated are transmit (TxD), receive (RxD), driver enable (DE), and receiver enable (RE).

Similar to the RS-232 solution, the [ADM2587E](#) provides a fully isolated RS-485 interface, as shown in Figure 3, including the integrated *isoPower* dc-to-dc converter required to power the transceiver side of the device. The transceiver can also be used for RS-422 communication.

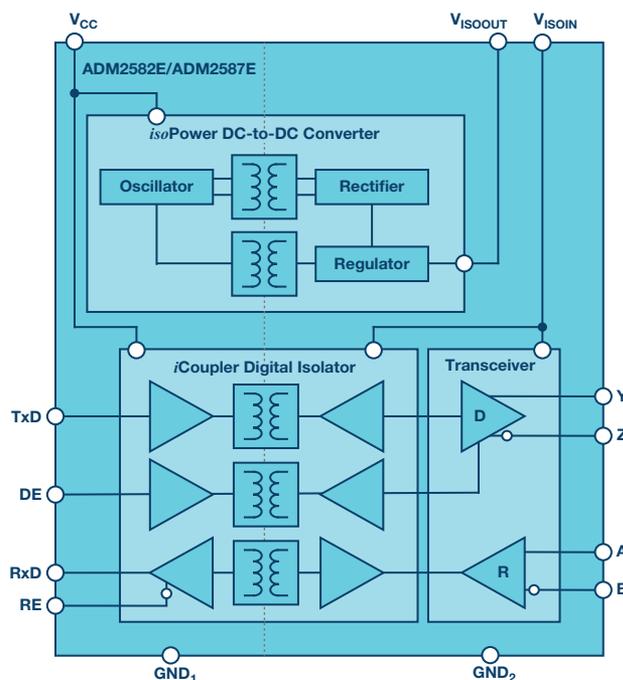


Figure 3. ADM2587E block diagram.

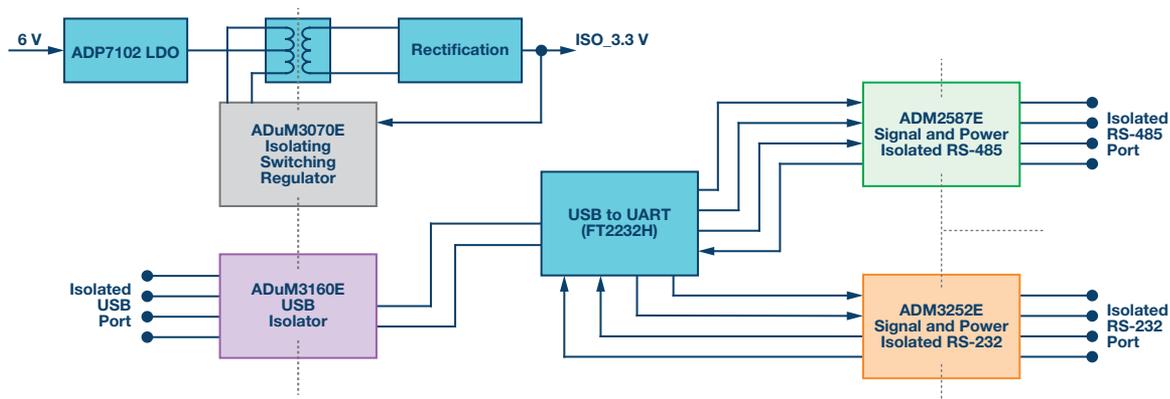


Figure 4. USB to UART.

Options for Isolated USB to Industrial Serial Interfaces

In order to interface with serial ports on industrial equipment, the RS-232, RS-422, or RS-485 transceivers must be combined with a USB to UART chip, such as the FTDI FT232H. Isolation can be provided separately at multiple serial interfaces—for example, an RS-232 port using [ADM3252E](#) and an RS-485 port using [ADM2587E](#), both hosted on the same USB connection. This has the advantage of isolating the two ports from each other, reducing potential hazards when connecting to two pieces of industrial equipment. In addition, no distinct isolated power supply is required, as the interface side power supplies are generated internally using *isoPower* technology in both the [ADM3252E](#) and [ADM2587E](#).

Alternatively, the isolation can be located easily at a single point using the [ADuM3160](#) or [ADuM4160](#) USB isolators. This means standard serial interface ICs can be used. However, the ports are not individually isolated, and an isolated power supply solution (such as the [ADuM3070](#)) is required to supply the USB to UART chip, the transceivers, and the downstream side of the USB isolator.

Both approaches are demonstrated on a single board in reference circuit CN-0373, shown in Figure 4. This combines [ADuM3160](#) to isolate the USB interface, [ADuM3070](#) to provide isolated power to the board including the USB to UART chip, and [ADM3252E](#)/[ADM2587E](#) to isolate RS-232, RS-422, and RS-485 interfaces, respectively.

Conclusions

Galvanic isolation is an essential component in interfacing to equipment in an industrial environment. Digital isolators using *iCoupler* technology allow this to be integrated with the ICs already needed to access industrial serial interfaces, as well as allowing transparent isolation of USB interfaces. This allows a complete isolated USB to serial implementation for industrial applications. In order to illustrate the possible isolation solutions for this application, ADI has provided a circuit note, CN-0373: Isolated USB to Isolated RS-485/Isolated RS-232 Interface. This fully isolates a USB to UART chip both at the USB interface and at the RS-232 and RS-485 ports, allowing full testing and demonstration of the robustness offered.

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About the Author

Dr. Conal Watterson is an applications engineer in the Interface and *iCoupler* Digital Isolator Group at Analog Devices in Limerick, Ireland. He is a Ph.D. and M.Eng. graduate of the University of Limerick since 2010. Conal has published a number of papers and articles on industrial fieldbus networks, diagnostics/reliability, and high speed signaling and isolation. His current focus topics are integrated isolated communication solutions and isolated power, high speed interfaces, and standards compliance for EMC and isolation.

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