

**Circuits
from the Lab®**
Reference Designs

Circuits from the Lab® reference designs are engineered and tested for quick and easy system integration to help solve today's analog, mixed-signal, and RF design challenges. For more information and/or support, visit www.analog.com/CN0373.

Devices Connected/Referenced

| | |
|--------------------------|---|
| ADM3252E | 2.5 kV, Signal and Power Isolated, Dual Channel, RS-232 Line Driver/Receiver |
| ADM2587E | 2.5 kV, Signal and Power Isolated, ±15 kV ESD Protected, Full/Half-Duplex, RS-485 Transceiver |
| ADuM3160 | Full/Low Speed, 2.5 kV, USB Digital Isolator |
| ADuM3070 | 2.5 kV, Isolated Switch Regulator With Integrated Feedback |
| ADP190 | Logic Controlled, High-Side Power Switch |
| ADP7102 | 20 V, 300 mA, Low Noise, CMOS LDO |

Isolated USB to Isolated RS-485/Isolated RS-232 Interface

EVALUATION AND DESIGN SUPPORT

Circuit Evaluation Boards

[CN-0373 Circuit Evaluation Board \(EVAL-CN0373-EB1Z\)](#)

Design and Integration Files

[Schematics](#), [Layout Files](#), [Bill of Materials](#)

CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 provides a completely isolated connection between the popular USB bus and an RS-485 or RS-232 bus. Both signal and power isolation ensures a safe USB device interface to an industrial bus or debug port, allowing TIA/EIA-485/232 bus traffic monitoring and the convenience of sending and receiving commands to and from a PC that is not equipped with an RS-485 or RS-232 port.

Isolation in this circuit increases system safety and robustness by providing protection against electrical line surges and breaks

the ground connection between bus and digital pins, thereby removing possible ground loops within the system.

The TIA/EIA RS-485 bus standard is one of the most widely used physical layer bus designs in industrial and instrumentation applications. RS-485 offers differential data transmission between multiple systems, often over very long distances. RS-485 communication offers additional robustness through differential communication when compared to the RS-232 standard.

TIA/EIA RS-232 devices are widely used in industrial machines, networking equipment, and scientific instruments. In modern personal computers, which are often used for debugging network problems, USB has displaced RS-232 from most of its peripheral interface roles, and many computers do not come equipped with RS-232 ports. The circuit in Figure 1 offers a robust and compact solution for both RS-232 and RS-485 interfaces.

Rev. 0

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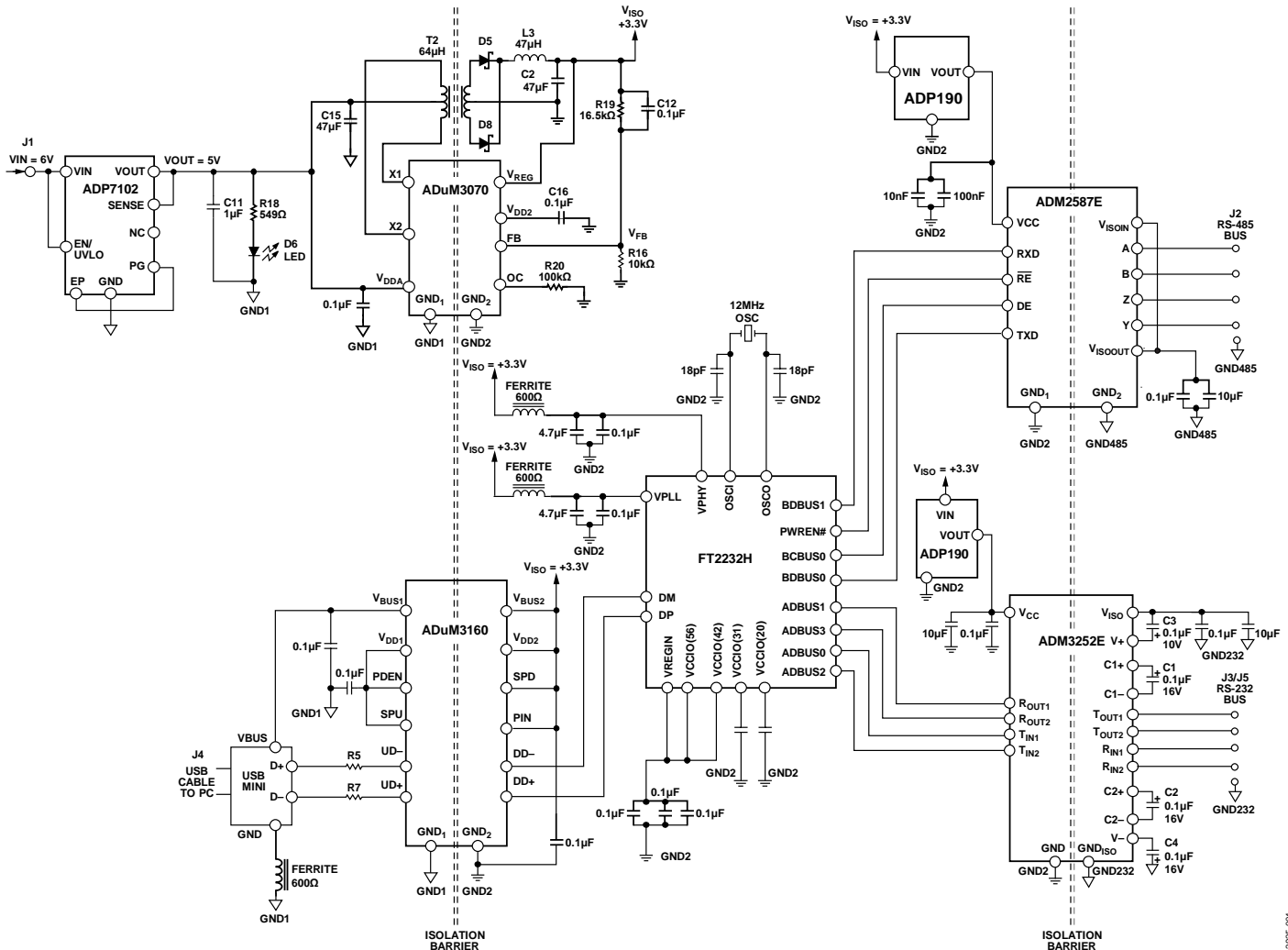


Figure 1. Isolated USB to FTDI Isolated RS-232/Isolated RS-485 Circuit (Simplified Schematic, All Connections Not Shown)

CIRCUIT DESCRIPTION

The circuit in Figure 1 provides highly integrated and robust isolation of fully TIA/EIA-485/232 compliant transceivers. The [ADM3252E](#) 2.5 kV rms isolated RS-232 and the [ADM2587E](#) 2.5 kV rms isolated RS-485 solutions are the smallest available in the industry. The [ADuM3160](#) provides market-leading USB port 2.5 kV rms isolation, and is easily integrated with low and full speed USB-compatible peripheral devices. The FTDI FT232RL (USB to UART converter) facilitates transmission via UART to RS-485 or RS-232 bus ports. TIA/EIA RS-232 devices are widely used in industrial machines, networking equipment,

and scientific instruments. Applications for RS-485 include process control networks; industrial automation; remote terminals; building automation, such as heating, ventilation, air conditioning (HVAC) and security systems; motor control; and motion control.

In these real-world systems, lightning strikes and power source fluctuations can cause damage to communications ports by generating large transient voltages. Isolation in the Figure 1 circuit increases system safety by providing protection against these electrical line surges.

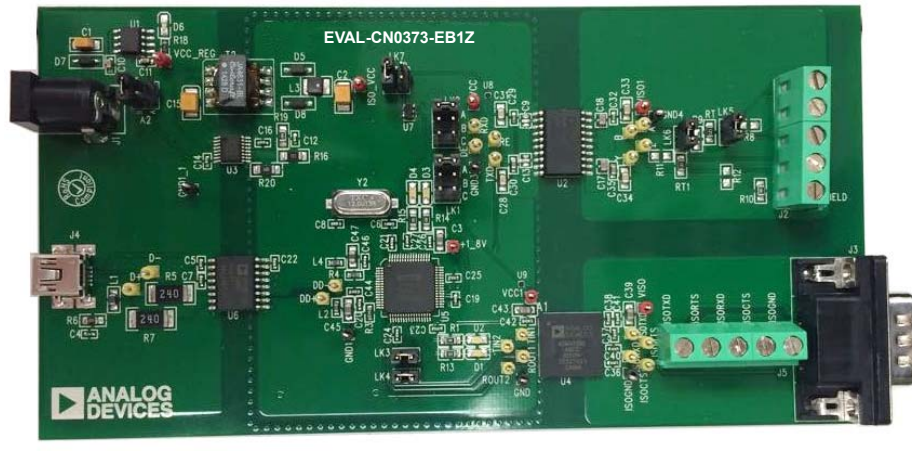


Figure 2. EVAL-CN0373-EB1Z Board

Figure 2 shows a photo of the isolated USB to FTDI isolated RS-232/isolated RS-485 circuit. It is possible to transmit from the USB port to both RS-485 and RS-232 ports simultaneously, if required, or to just one port.

The [ADuM3160](#) provides 2.5 kV rms digital isolation of the data signals on the D+ and D- USB bus input to the FTDI FT2232H (USB to UART converter). The isolated USB output DD- and DD+ signals are connected to the DM and DP pins of the FTDI, respectively. The FTDI FT2232H can transmit data via UART to RS-232/RS-485 depending on which PC virtual COM port (VCP) is chosen. The [ADuM3160](#) V_{BUS1} power is supplied via the USB cable connection. The [ADuM3070](#) provides a regulated isolated power source. Power (+6 V) and ground for the [ADuM3070](#) are connected via the J1 barrel socket connector. The [ADuM3160](#) V_{BUS2} pin is supplied with 3.3 V isolated power by the [ADuM3070](#). The [ADuM3070](#) 3.3 V output also supplies the primary power for the [ADM3252E](#) 2.5 kV rms isolated RS-232 and the [ADM2587E](#) 2.5 kV rms isolated RS-485 transceiver.

The [ADM2587E](#) 2.5 kV rms isolated RS-485 transceiver is the industry-leading signal and power isolated solution. This transceiver is capable of operating at 3.3 V or 5 V. Data transmits on the TxD pin, and it is received on the RxD pin. Both the driver and receiver outputs can be enabled or disabled, that is, put into a high impedance state, by changing the logic levels on the DE and RE pins, respectively.

The FTDI output pin BDBUS0 is connected to the TxD data input pin of the [ADM2587E](#). The FTDI output pins BCBUS0, PWREN#, and BDBUS1 are connected to the DE, RE, and RxD input pins of the [ADM2587E](#), respectively. The DE and RE pin state can also be configured via the LK1 and LK2 jumpers. For each link, Position A connects the logic pin to 3.3 V, Position B connects the logic pin to GND, and Position C connects the logic pin to the FTDI output pins.

The [ADM2587E](#) can transmit and receive bus data via the A, B, Y, and Z RS-485 inputs/outputs. An RS-485 bus cable can be connected via the J2 five-way connector. Disconnecting the LK5 and LK6 jumpers places the [ADM2587E](#) in a full duplex

configuration, where data can be transmitted via the Y and Z pins, and received via the A and B pins. Connecting the LK5 and LK6 jumpers places the [ADM2587E](#) inputs/outputs in a half duplex configuration, which is where bus data can only be transmitted or received, but not simultaneously.

The [ADM3252E](#) is a high speed, 2.5 kV, fully isolated, dual channel RS-232/V.28 transceiver device that is operational from a single 3.3 V or 5 V power supply. The RS-232 interface supports full-duplex communication and provides CTS and RTS for hardware handshaking via the J5 five-way connector or the J3 connector. J3 provides an RS-232 cable connector for connecting to industrial equipment.

The [ADM3252E](#) transmitter inputs (T_{INx}) accept TTL/CMOS input levels from the ADBUS0 and ADBUS2 output pins of the FTDI. The T_{INx} inputs are inverted and coupled across the isolation barrier, where they are transmitted as EIA/TIA-232E bus signals via the J3 or J5 connector. The [ADM3252E](#) receiver inputs (R_{INx}) accept EIA/TIA-232E signal levels from the J3 or J5 connector. The R_{INx} inputs are inverted and coupled across the isolation barrier to appear at the R_{OUTx} pins. The R_{OUTx} pins are connected to the ADBUS1 and ADBUS3 inputs to the FTDI.

Two separate [ADP190](#) circuits are used as soft start circuitry to power the [ADM2587E](#) and [ADM3252E](#) after the FTDI FT2232H has fully powered up. Jumper LK7 links the FTDI FT2232H PWREN# pin to the EN pin of the [ADP190](#) circuits via the 74AHC1G14W5-7 inverter. The [ADP190](#) EN pin must be high to turn on the power switch; drive EN low to turn off the power switch. Connecting LK7 in Position A (Position B disconnected) means that the [ADP190](#) EN pin is always high/enabled. Connecting LK7 in Position B (Position A disconnected) means that the [ADP190](#) EN pin is triggered via the inverted PWREN# signal.

The FTDI FT2232H data sheet provides a comprehensive listing of the pin functions for RS-232 communications. The LK3 and LK4 jumpers allow handshaking options for RS-232. When LK3 is connected, ADBUS4 (DTR#) is connected to ADBUS5 (DSR#). When LK4 is connected, ADBUS4 (DTR#) is connected to ADBUS6 (DCD#).

CIRCUIT EVALUATION AND TEST

Apply 6 V to the J1 barrel socket connector to power the [EVAL-CN0373-EB1Z](#) board. The voltage can be checked on the VCC_REG test point at the output of the [ADP7102](#) regulator. The [ADP7102](#) output voltage should measure 5 V. The 5 V is routed to the [ADuM3070](#) and T2 transformer, which supply the 3.3 V outputs to power the RS-485, RS-232, and FTDI circuits. Check that the ISO_VCC test point measures 3.3 V.

A complete transmit and receive path can be tested by connecting the RS-232 and RS-485 outputs to an Analog Devices [ezLINX™ iCoupler®](#) Isolated Interface Development Environment board. Alternatively, a USB to RS-232/RS-485 transmit test can be performed by using the Tera Term open source terminal emulator program. It is possible to transmit from the USB port to both RS-485/RS-232 ports simultaneously, if required, or to just one port.

Connect a USB cable from the laptop/PC to the J4 connector. Attach an oscilloscope probe to the ISOTxD test point next to the [ADM3252E](#) transceiver, as shown in Figure 3. Open the PC application software and select COM5, then click OK, as shown in Figure 4.

Load the RS-232 data to be transmitted by clicking **Send** under the **File** menu. Choose any large data size file for continuous test transmission and click **Send**, as shown in Figure 5.

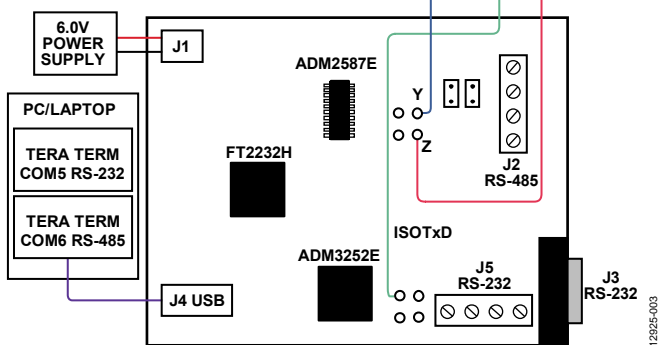
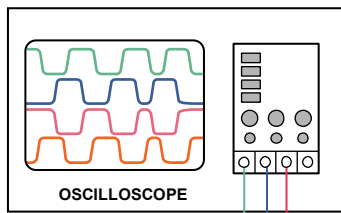


Figure 3. Test Setup for the [EVAL-CN0373-EB1Z](#) Board

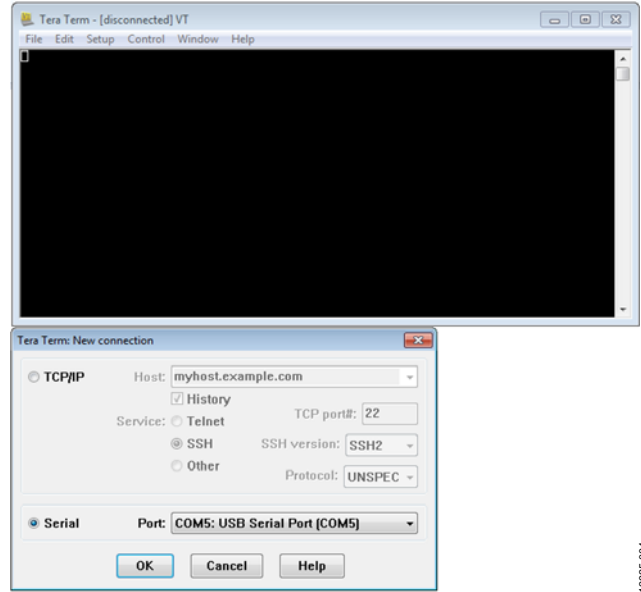


Figure 4. Tera Term COM5 for USB Transmission to the RS-232 Port on the [EVAL-CN0373-EB1Z](#) Board

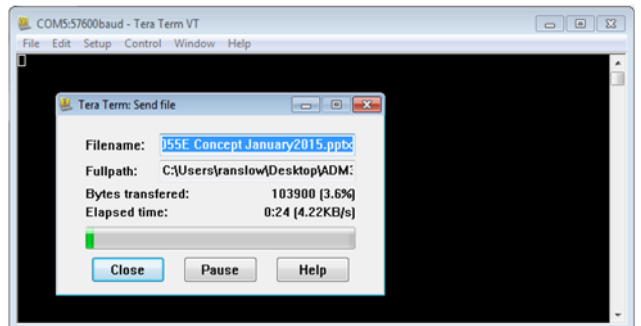


Figure 5. Tera Term COM5 Data for USB Transmission to the RS-232 Port on the [EVAL-CN0373-EB1Z](#) Board

Observe the isolated RS-232 signal on an oscilloscope by probing the ISOTxD test point on the [EVAL-CN0373-EB1Z](#) board (see Figure 6).

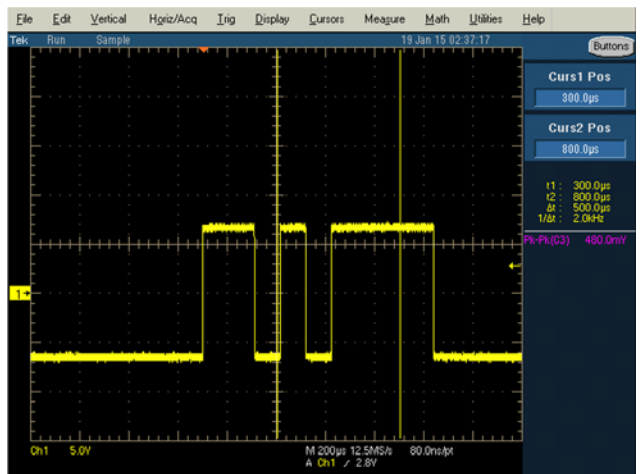


Figure 6. ISOTxD Signal for the RS-232 Port on the [EVAL-CN0373-EB1Z](#) Board

A similar test can be performed for the [ADM2587E](#) transceiver. Connect a USB cable from the laptop/PC to the J4 connector. Attach an oscilloscope probe to the Y and Z test points next to the [ADM2587E](#) transceiver as shown in Figure 3. Open a second Tera Term emulator window, and select **COM6** for RS-485 transmission, as shown in Figure 7.

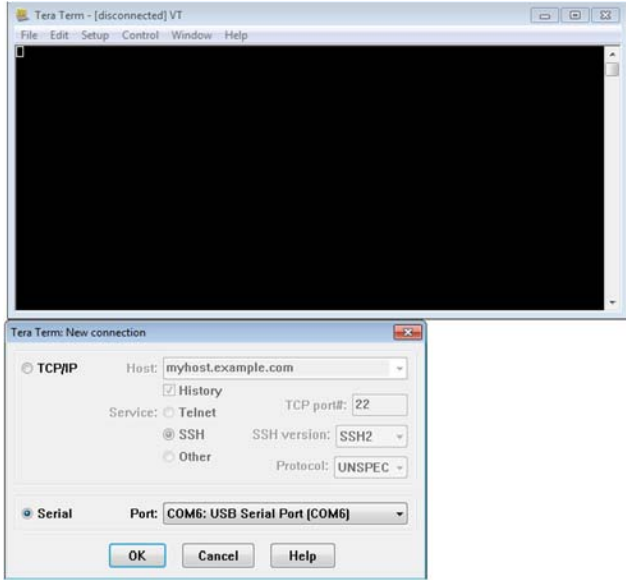


Figure 7. Tera Term COM6 for USB Transmission to the RS-485 Port on the [EVAL-CN0373-EB1Z](#) Board

Load the RS-485 data to be transmitted by clicking **Send** under the **File** menu. Choose any large data size file for continuous test transmission and click **Send**, as shown in Figure 8.

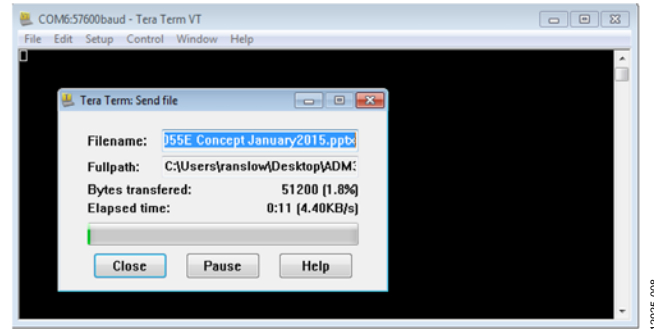


Figure 8. Tera Term COM6 Data for USB Transmission to the RS-485 Port on the [EVAL-CN0373-EB1Z](#) Board

Observe the isolated RS-485 signals on an oscilloscope by probing the Y and Z test points, or the differential bus signal by using the oscilloscope Y – Z Math function, as shown in Figure 9.



Figure 9. Math Y – Z Waveform for the RS-485 Port on the [EVAL-CN0373-EB1Z](#) Board

LEARN MORE

CN-0373 Design Support Package:

www.analog.com/CN0373-DesignSupport

ezLINX™ *iCoupler*® Isolated Interface Development Environment, ezLINX Board Quick Start Guide.

Marais, Hein. AN-960 Application Note. *RS-485/RS-422 Circuit Implementation Guide*. Analog Devices, Inc.

Clark, Sean and Ronn Kliger. AN-740 Application Note. *iCoupler*® *Isolation in RS-232 Applications*. Analog Devices, Inc.

UG-400 User Guide. *ezLINX™ iCoupler® Isolated Interface Development Environment*. Analog Devices, Inc.

Data Sheets and Evaluation Boards

[ADM2587E Data Sheet](#)

[ADM3252E Data Sheet](#)

[ADuM3160 Data Sheet](#)

[ADuM3070 Data Sheet](#)

[ADP190 Data Sheet](#)

[ADP7102 Data Sheet](#)

[ezLINX™ *iCoupler*® Isolated Interface Development Environment \(EZLINX-IIIDE-EBZ\)](#)

REVISION HISTORY

4/15—Revision 0: Initial Version

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