Robust DataComm
Making Industrial Data Flow Like Water ... Safely, Silently, & Sanely

Extending RS-232 with RS-422, RS-485, and Fiber Optics

RobustDC Application Note #8

Quick Index:

• Short-Comings of EIA/RS-232

RS-232 is commonly used to connect devices in industrial applications. For example, RS-232 is often used to connect an MMI computer to a PLC or devices to a remote event printer. But RS-232 suffers from 3 common problems that limit its effectiveness (See RobustDC *AN007* on *Robust RS-232*).

- RS-232 is limited to about 15m or 45ft.
- RS-232 is easily affected by line noise.
- RS-232 requires multiple ground points - by definition creating ground loops.

This application note explains how to use standard RS-422 or RS-485 to overcome all three of these problems without resorting to non-standard, non-isolated, proprietary line drivers. RS-422 and RS-485 can extend the distance to 1000m or more; RS-422 and RS-485 are quite immune to noise; using isolated converters from RS-232 to RS-422 or RS-485 eliminates ground loops and common-mode surge damage due to ground potential shifts.

• Application #1: 2-wire RS-485 for Half-Duplex (or Simplex) Link

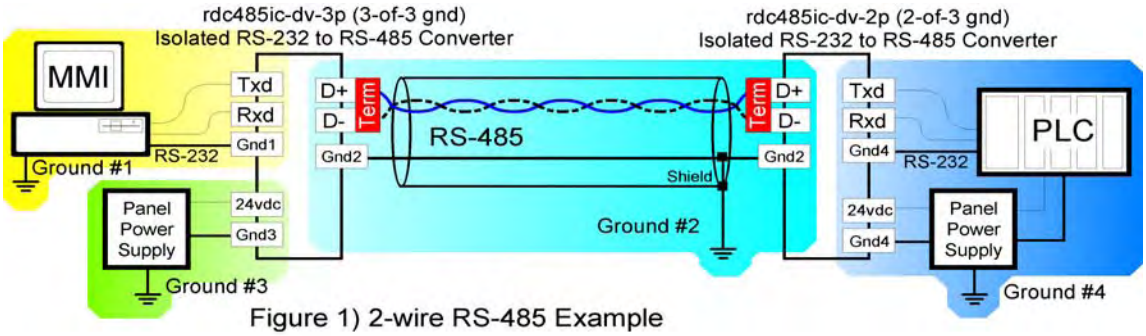

Figure 1) 2-wire RS-485 Example

This application example uses 2 units of rdc485ic to extend a half-duplex data communications link like Modbus or most other protocols suitable for "multi-drop" use. We require 1 twisted pair and 1 signal ground or 2 twisted pairs. The RS-485 (called 2-wire in this case) is bi-directional, so the rdc485ic units take turns sending/receiving data. They do this by automatically detecting when the MMI or PLC transmits data. (See RobustDC *AN003 RS-485 2-Wire Example* for more on how this "turn-around" works).

Notice the careful design of the ground systems. This example shows four isolated ground systems that greatly increase the robustness of the system. Of course ground #1 and #3 will be connected to a single

ground point outside our scope-of-supply. But since this *is outside* our scope-of-supply, we cannot directly control the quality of this external ground design. We cannot be sure that ground path #1 is not better than ground path #3, which would induce surge energy to possibly pass through our equipment from ground #3 to ground #1.

Starting on the left, we have a fully isolated (3-of-3 ground) rdc485ic RS-232 to RS-485 converter. The MMI computer ground #1 is fully protected from both the distributed RS-485 ground #2 and the equipment panel ground #3. This is a very safe design - especially since most computers directly short their RS-232 signal ground to both their chassis and the Physical Earth (PE) of the power system. *Without this isolation*, surge energy entering the industrial panel may partially dissipate through the rdc485ic and through the computer and by this second path to the external single-point ground. (See RobustDC *AN005 RS-422/RS-485 Grounding* and *AN007 Robust RS-232* for more details on grounding & surge issues).

The right hand side shows a partially isolated (2-of-3 ground) rdc485ic RS-232 to RS-485 converter. We can safely do this because the PLC is powered - and therefore grounded - by the same power supply that powers the rdc485ic. While in theory this creates a small ground loop through the rdc485ic, this is safe to do in this design because we have complete scope-of-supply and can confirm that a good ground design is used. *Note that virtually all isolated RS-232 to RS-485 converters on the market are partial 2-of-3 ground isolators. RobustDC is perhaps the only company in the world that markets fully isolated 3-of-3 ground converters and repeaters!*

- Application #2: 4-wire RS-422 for Full Duplex Link

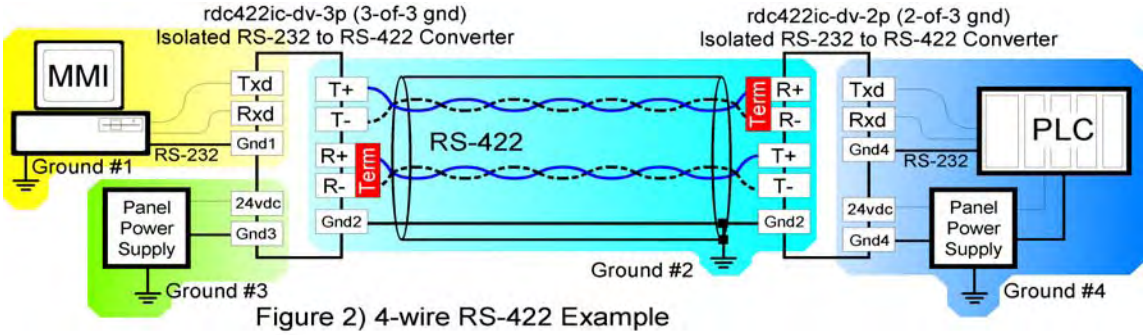

Figure 2) 4-wire RS-422 Example

This second application example uses 2 units of rdc422ic to extend a full-duplex (or unknown duplex) data communications link. The RS-422 (called 4-wire in this case) has 2 unidirectional or simplex links. Both devices can send and receive data at the same time. We require 2 twisted pair and 1 signal ground - or 3 twisted pair cable. While this design requires an extra wire pair, it is slightly more robust than a 2-wire design due to the nature of the unidirectional links. A 2-wire RS-485 device only activates it's transmitters when it has something to send. Therefore, guess what happens when neither device is talking. The answer is that the wire pair is either left to float or is only passively forced to an idle state. This unknown state can cause noise to be picked up and received by all devices on the 2-wire bus. In contrast, a full-duplex RS-422 link *always has its transmitters on*. Each transmitter forces its wire pair to be either binary 1 or binary 0 at all times - whether talking or not. So there is no unknown state as in RS-485.

Since the rdc485ic supports either 2 or 4-wire RS-485, you could also use 2 units of rdc485ic for a 4-wire link. This may be preferred if you need to mix 2 and 4-wire systems, since then you have only one model of hardware to stock and maintain. We have the same robust grounding design as in application #1.

- Application #3: 4-wire RS-422 for Printer with Hardware Hand-shaking

Printers generally work slower than the device sending data. For example, a printer that prints 150 characters per second can easily be receiving 1000 characters per second. While the printer does have an internal buffer, if filling at a rate of 850 characters per second this will eventually fill up no matter how large. So the printer must be able to signal the sending device to pause and wait until the printer can print the data it already has. This is called *handshaking*. The printer signals the sending device when it can and cannot accept more data.

Some systems use *software handshaking* like XON-XOFF. The printer sends a special character (XOFF) to signal the sending device to pause, and then sends another character (XON) when it can continue. Software handshaking can be supported with a 4-wire RS-422 solution - but not with a 2-wire RS-485 solution. Since the XON/XOFF data is send while data is being received by the printer, it requires a full-duplex solution. However, software handshaking can be unreliable - especially when long distance and industrial noise is involved. If either the XON or XOFF data gets lost due to noise then your printing may hang and require you to power-cycle the printer. Not good for an alarm printer! A second problem is that XON/XOFF requires the sending device to actively monitor the data comm port for data - and this takes CPU time.

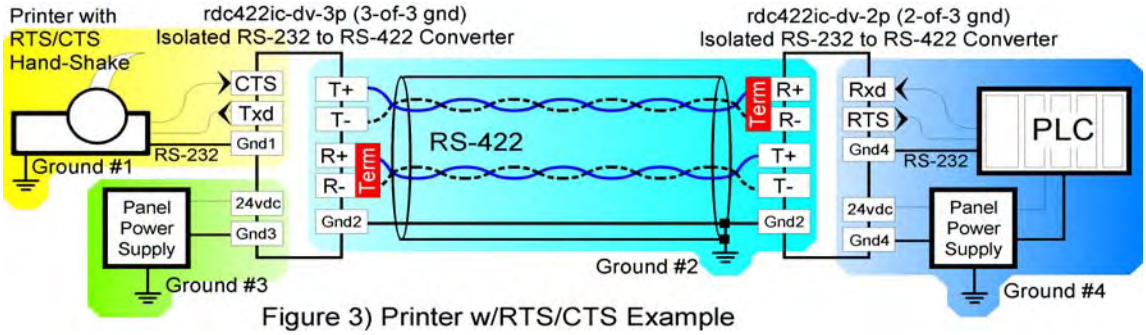

Figure 3) Printer w/RTS/CTS Example

A more robust alternative is *hardware handshaking* like RTS/CTS. The printer raises or drops its RTS output control to signal the sending device. However, 4-wire RS-422 is normally configured to support only the 2 data signals, Txd & Rxd. How to get the printer's RTS signal back to the sending device? An expensive solution is to add a 3rd and 4th RS-422 converter and another set of wires. to include the control pair RTS & CTS. But this may not be required. Most event printers work in simplex mode, meaning the device sends data to the printer, but the printer never sends data back. Therefore, the transmit wire *from* the printer *to* the device is *never used*! So we can instead use it to return the RTS output from the printer to the CTS input of the device. The printer can now signal the sending device when to start and when to stop sending data. The printer does not need to see the RTS output signal from the device. *But test this design first - some complex software expects configuration data to come from the printer.*

• Application #4: Fiber Optics for Robust Full-Duplex Link

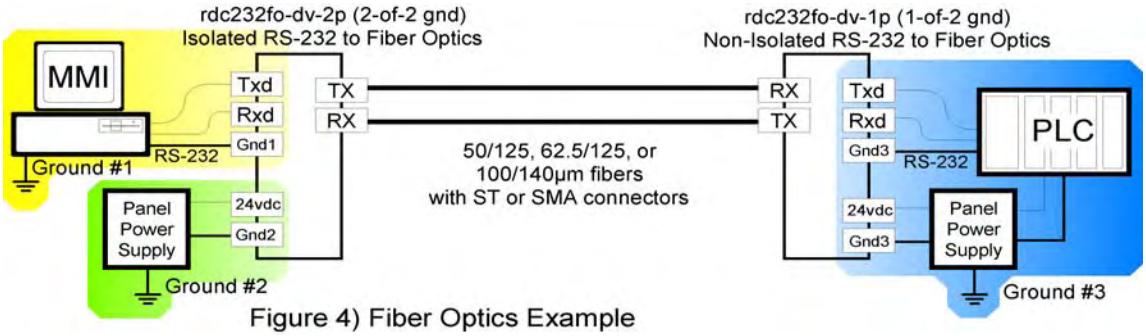

Figure 4) Fiber Optics Example

This last application example uses 2 units of rdc232fo to robustly extend a full-duplex (or unknown duplex) data communications link. The glass fiber provides complete galvanic isolation between sites, structures, and grounding systems. This eliminates the most common and damaging surge problem of ground potential shifts during system failures and lightning storms. The light signal is completely immune to electromagnetic interference. This eliminates the noise and induced surge problem from switching large electrical currents and radio communications. It also will not create such interference in other equipment. The commonly supported distance of 2 to 4km per fiber is long enough for most industrial sites. The use of single-mode fiber (9/125µm - more expensive, laser-type equipment) distances from 15 to 25km.

The left hand side shows a fully isolated (2-of-2 ground) rdc232fo RS-232 to Fiber Optic converter. This fully protects the computer from the 24vdc supply - and the equipment that it powers, plus protects the 24vdc supply from the computer's RS-232 port - which will "short" the 0v of the power supply to the frame ground & Physical Earth (PE). The right hand side shows a partially isolated (1-of-2 ground) rdc232fo RS-232 to Fiber Optic converter. We can safely do this because the PLC is powered - and therefore grounded - by the same power supply. While in theory this creates a small ground loop through the rdc232fo, this is safe to do because we have complete scope-of-supply and can confirm that a good ground design is used. *Note that virtually all RS-232 to Fiber Optic converters on the market are partial 1-of-2 ground isolators. RobustDC is perhaps the only company in the world that markets fully isolated ground DC-powered converters and repeaters!*

• For More Information

Robust DataComm can truly make your data flow like water - safely, sanely, and silently.

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