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

• 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 (Read ECD-Info-01 Summary for RS-232, RS-422 and RS-485 Standard).

• 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

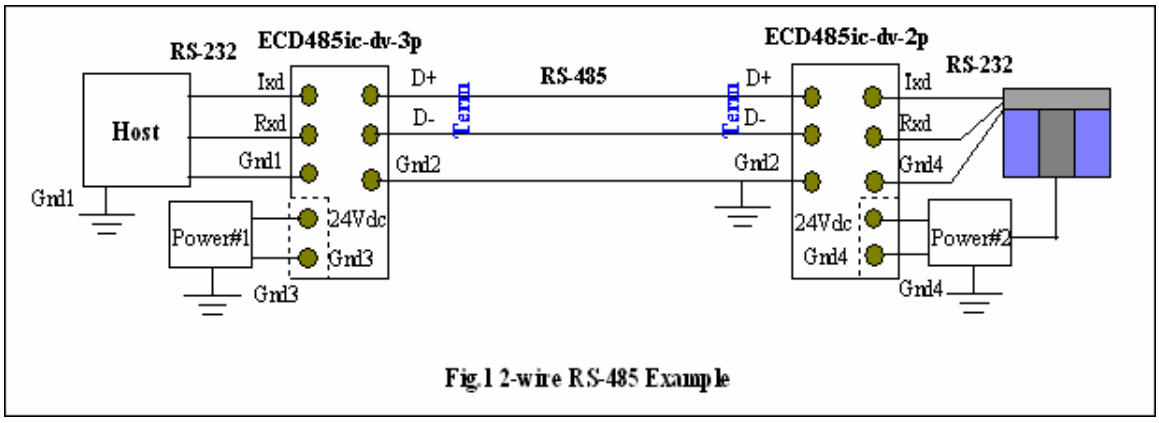

Fig.1 2-wire RS-485 Example

This application example uses 2 units of ECD485ic 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 ECD485ic units take turns sending/receiving data. They do this by automatically detecting when the MMI or PLC transmits data. (Read ECD-AN-02 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 ECD485ic 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 ECD485ic and through the computer and by this second path to the external single-point ground.

The right hand side shows a partially isolated (2-of-3 ground) ECD485ic 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 ECD485ic. While in theory this creates a small ground loop through the ECD485ic, 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. EC Data 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

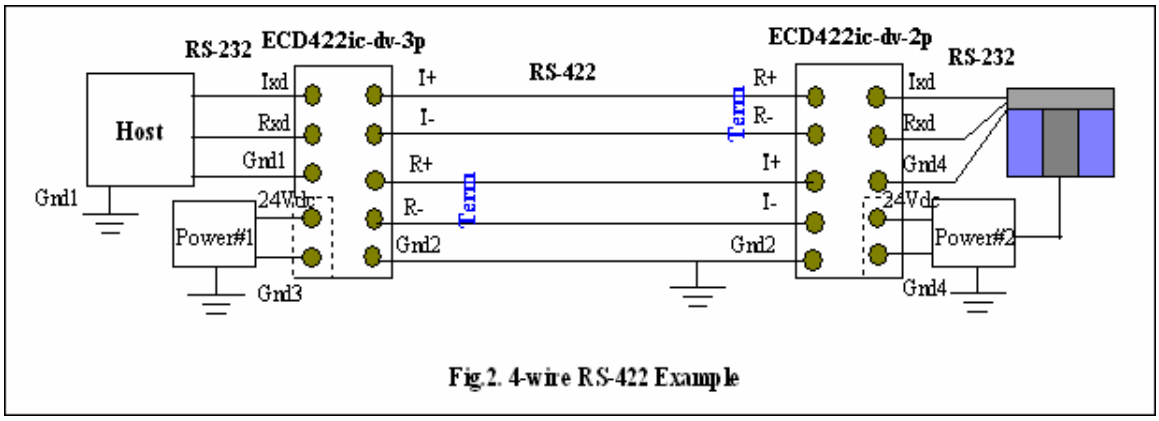

Fig.2. 4-wire RS-422 Example

This second application example uses 2 units of ECD422ic 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 de-vices 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 ECD485ic supports either 2 or 4-wire RS-485, you could also use 2 units of ECD485ic 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: Fiber Optics for Robust Full-Duplex Link

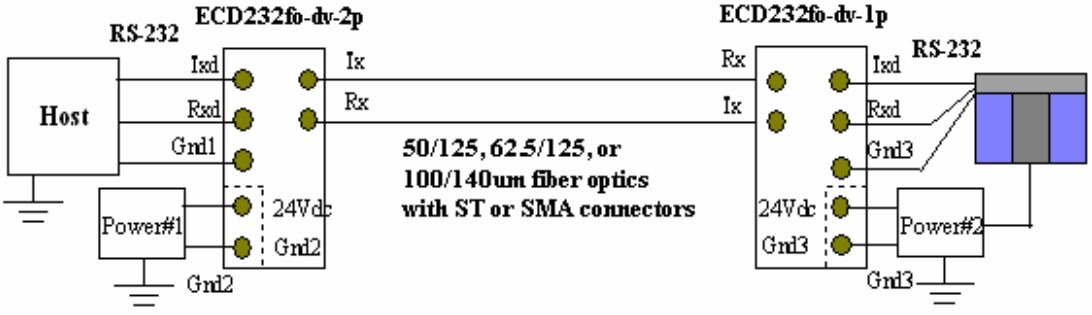

Fig.3. Fiber Optics Example

This last application example uses 2 units of ECD232fo 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 electro-magnetic 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,refer to ECD232fos) distances from 15 to 25km.

The left hand side shows a fully isolated (2-of-2 ground) ECD232fo 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) ECD232fo 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 ECD232fo, 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. EC Data is perhaps the only company in the world that markets fully isolated ground DC-powered converters and repeaters!*

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