

Lightning Proof RS-485

RobustDC Application Note #31

Quick Index:

- Overview 1
- Installation with Single RS-485 Device 1
- Installation with Multiple RS-485 Devices 2
- Frequently Asked Questions (FAQ) 2
- Putting it together - Example Application: 4

See Also:

- RobustDC Application Note AN005 *Grounding and RS-422/485*
- RobustDC Application Note AN018 *Surge Management 101 - A Simple Primer*
- RobustDC rdcLPU User Manual

• Overview

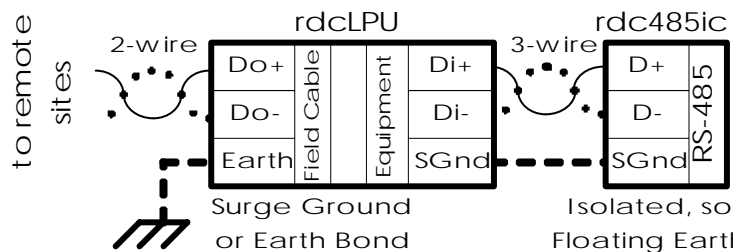
One of the great frustrations of installing industrial RS-485 data communications is designing a system to just install and forget. Surge, grounding problems, and device failure too often become a reoccurring source of indigestion and site trips. Fortunately, RobustDC has combined experience with hundreds of actual field sites to design a 2-part RS-485 system which is as close to permanent and maintenance-free as possible with wire-based data communications.

WARNING!
THE SUCCESS OF ALL LIGHTNING PROTECTION DESIGNS DEPEND PRIMARILY ON PROPER INSTALLATION & GROUNDING!

The difficulty when combining RS-485, lightning surge management, and proper grounding is that it requires a careful balance of conflicting design rules. For example, while ground design principles require a distributed RS-485 system to be grounded at only 1 point, effective surge management requires every device in that RS-485 system to be directly earth bonded locally (ie: grounded at multiple points). RobustDC has balanced these conflicts by designing a special 2-part system for robust RS-485 systems. It combines effective 2500v optical/galvanic isolation to prevent ground problems with 6kV 20kA lightning protection units optimized for isolated data communications lines.

• Installation with Single RS-485 Device

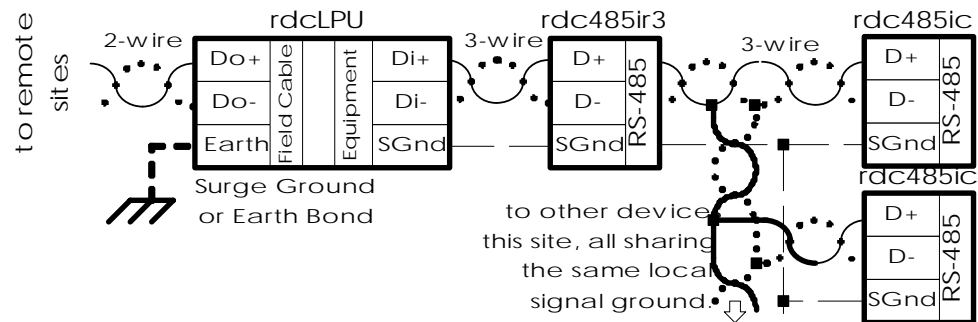
The drawing at right shows install of the rdcLPU with a single isolated RS-485 device. Notice how your field cable can be a traditional single pair (2-wire) cable. Between the isolated RS-485 device and the rdcLPU you still require a 3-wire (or 2-



to the Earth Bond point as possible. The rdc485ic must be installed at least 25 cm (or 1 foot) away from the rdcLPU.

• **Installation with Multiple RS-485 Devices**

With multiple isolated RS-485 devices at one site, the most robust design includes an isolated repeater to isolate and segment the RS-485 into 2 sub-



networks. Why? The nature of RS-485 is that "less is more" - fewer devices & shorter distances means greater robustness. Splitting a single RS-485 network into 2 or more segments with repeaters can increase the robustness of the overall RS-485 system by an order of magnitude. Every RS-485 device sharing the wire pair adds load to the network - dampening (attenuating) the RS-485 signal slightly. So fewer devices sharing a wire pair means a stronger, cleaner RS-485 signal. Yes, RS-485 is defined to support 32 "unit loads", but it is an inevitable law of physics that an RS-485 system with only 6 devices is more robust than 1 with 32.

So first, with an isolated rdc485ir3 repeater in place the local RS-485 devices are fully isolated and protected from remote ground and noise effects. With fewer RS-485 devices on the local segment, the signal within the site is stronger and cleaner. The rdc485ir3 also benefits the outside field segment of the RS-485 system. Instead of many local RS-485 devices and their cables, terminals, and taps to dampen the signal and add reflection noise, only the lone rdc485ir3 impacts it - the entire site is reduced to a single RS-485 "unit load". This segmentation of the RS-485 is especially helpful when heavy-duty lightning protection is installed. Unfortunately, the state of heavy-duty surge device technology requires that the rdcLPU have a minor (but measurable) impact on the RS-485 signal. It must dampen (attenuate) the RS-485 signal some. Any lightning protection vendor who claims their product has no impact on the RS-485 system (ie: claims that 32 RS-485 devices can communicate at full speed) is either 1) making partial lightning protection, or 2) ignorant of the true nature of their own products.

• **Frequently Asked Questions (FAQ)**

Q: What happened to the 3rd ground wire in the field cable? Not that I miss it, but RobustDC's AN005 makes a big fuss about how isolated RS-485 requires that 3rd ground wire to operate properly.

A very good question. To understand why we can eliminate the 3rd ground wire we need to understand the critical function of that 3rd ground wire in an isolated RS-485 interface.

First, it functions as the "signal return" to complete the electrical circuit (see RobustDC AN005). When an RS-485 interface is *transmitting*, both the "D+" and "D-" terminals *source* current - so a signal return path is

required to complete the circuit. When an RS-485 interface is *receiving*, both the "D+" and "D-" terminals *sink* current - again a signal return path is required to complete the circuit. By wiring the rdc485ic's floating signal ground through the rdclPU to the earth bond, we are in effect returning to the traditional RS-485 "bi-cycle electronics" design which uses the physical earth as the signal return. While this is not 100% desirable, it is a required compromise to achieve high-quality lightning protection. The rdc485ic's inherent 2500v galvanic isolation prevents ground loops and ground noise from interfering with your local equipment. Even if you do run the 3rd ground wire between sites, the instance you add good quality lightning protection you destroy the full ground isolation anyway. So this design just makes economical use of the necessary evil of the low-impedance surge ground path.

Second, it functions as the "signal reference" for the RS-485 receiver circuitry. While RS-485 uses a differential voltage signal, material physics requires it to still reference those voltages to its power supply earth. So while in theory an RS-485 receiver should see no difference between an input data signal of 1v and 4v (3v differential signal) and an input data signal of 1001v and 1004v, material physics (and common sense) says that the 1001v & 1004v data signal will not result in effective RS-485 data communications! So we need the 3rd ground wire to force our receiver circuit to reference the same ground as the transmitter used to generate the voltage. The EIA/RS-485 standard requires the voltage of the 2 receiver pins of the interface chip to be less than $\pm 25v$ with reference to the chip ground. The rdclPU design guarantees that the Di+ and Di- terminals remain within $\pm 15v$ with reference to the earth/surge ground. So running the 3rd ground wire from the SGnd terminal of the rdc485ic to the SGnd terminal of the rdclPU guarantees that the receiver pins of the RS-485 chip will remain within $\pm 15v$ with reference to the isolated circuit ground within the rdc485ic.

Q: Doesn't connecting the rdclPU to the earth bond and connecting the rdc485ic "isolated ground" to the rdclPU violate the principle of ground isolation?

Yes and No. This seeming contradiction is required for effective 6kV 20kA lightning protection (actually, surge "by-pass" of your equipment - see RobustDC AN018). Effective lightning protection requires a good, low-impedance path to the earth bond. Effective ground isolation (a floating earth) requires a high-impedance barrier to the earth bond. To link these two systems together requires a compromise. RobustDC's 2-part "Lightning Proof" RS-485 combines the strengths of both protection paradigms to overcome the weaknesses in the other.

Q: Why don't you put the lightning protection components inside the rdc485ic?

Unfortunately, the issues of installation, cable routing, and air gaps make such "compact" solutions inherently unreliable. To be effective, you must separate your field cables from your device and your "safe" in panel cables by as much space as possible - definitely more than a few inches.

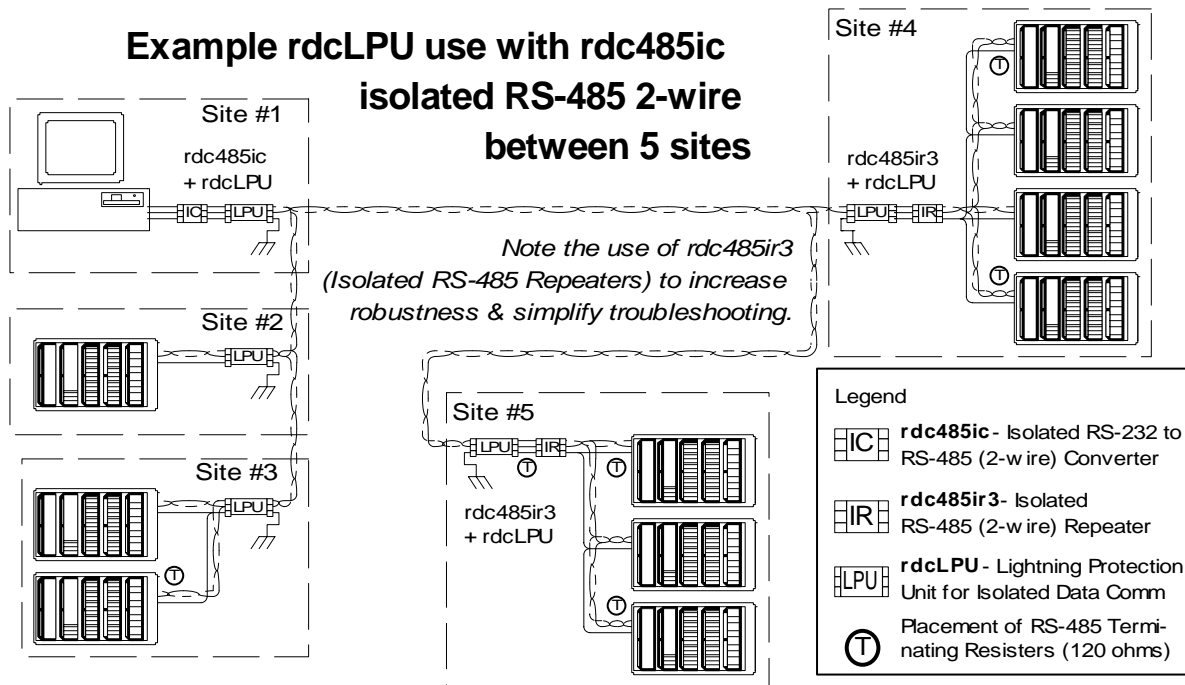
Q: Can I use the rdcLPU on any RS-485 network?

The rdcLPU should work on any RS-485 network. However it's design is optimized for use with fully isolated RS-485 interfaces such as offered by the rdc485ic and rdc485ir3. It should work on any system that permits the limits of 250mA current, ±15v signals and about 6 ohms of in-line resistance.

• Putting it together - Example Application:

Below is an example site layout with the following details:

- 5 x rdcLPU *Lightning Protection Unit* optimized for isolated data communications lines.
- 1 x Modbus Master device - such as a Windows NT workstation with MMI software.
- 10 x Modbus Slave devices - such as PLC or flow computer.
- 3 x independent isolated RS-485 two-wire network segments
- 1 x rdc485ic *Isolated RS-232 to RS-485 Converter*
- 2 x rdc485ir3 *Isolated RS-485 two-wire repeater* (creates the 2nd and 3rd segments)



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