Using Isolated RS-485 Repeaters

Expand Your RS-485 & Shrink Your Problems

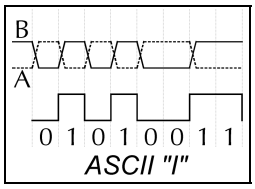
RobustDC Application Note #11

Quick Index:

• Brief Overview of EIA/RS-485

RS-485 is the most common, open standard for multi-drop industrial data communications today. Isolated RS-485 repeaters can be used to: 1) extend the over-all distance, 2) increase the RS-485 device count, 3) increase the robustness, and 4) convert to a star or tree topology (wiring layout). Robust DataComm Pte Ltd has developed the world's most effective isolated RS-485 repeaters which gives you all this and greatly reduces your system down-time.

EIA/RS-485 is called a "balanced differential" signal. It uses twisted wire pairs to transmit data by a differential voltage signal. ***The two wires in a pair are not a loop*** -- both are '+' signals sourcing current to a third "virtual" ground conductor. For example, here is the differential signal for an ASCII character 'I'. EIA labels the signals A and B, while many vendors label them '+' and '--'. Data is represented by the relative voltage of A to B. When $V_A < V_B$, then the data is a binary 1 (or Mark or Off). When $V_A > V_B$, then the data is a binary 0 (or Space or On). An idle asynchronous line without data will be in the binary 1 state.



RS-485 gains it's noise immunity from the nature of electrical noise on a wire pair. A noise spike picked up by one wire will induce an equal noise on the other wire. Since an RS-485 receiver is just comparing the relative voltage polarity (ie: which is more positive) even during the noise spike the transmitted relationship will hold true. For example, if A is 2vdc and B is 4vdc, then a common noise spike of 3 volts will make them 5 and 7vdc respectively - but the relationship A < B still holds true.

• Issues in selecting / locating your isolated RS-485 repeater.

- ***Duplex (direction) control.*** This is the most important question. While a 2-wire RS-485 bus works magically well with both sending and receiving of data on the same wire, a repeater is not so magic. It must explicitly change from receiving data on one side and transmitting on the other, to the opposite. There are three main ways to do this:

1) Directly under software control. A second wire pair (often called RTS+/-) is used to turn repeaters around or some other proprietary "signal" is used. Beware of these repeaters - or repeaters not in-

tended for the general data communications markets. Many vendors have come up with imaginative ways to control their repeaters as part of their own total PLC or controller product line, but you may have difficulty using them with other products.

2) Indirectly on a byte-oriented, timed method. The repeater uses network bias resisters and receives on both sides. Whenever it detects data on either side, it starts a timer and echos a byte's worth of data to the other side - plus a small amount of "idle" space to compensate for timer error. These repeaters require some jumper setting for "baud rate", plus cause problems if the slave devices start replying too fast after a master poll. Since the timer has a margin of error, the repeater may still be in "transmit" mode and miss the beginning of the slave response.

3) Indirectly on a bit-oriented, untimed method. Robust DataComm used this method. The repeater uses network bias resisters and receives on both sides. Whenever it detects a data bit on either side, it echos that bit directly to the other side. These repeaters do not require jumper setting for "baud rate" or speed. Plus the repeater will never miss the beginning of the slave response no matter how fast it is.

- ***RS-485 2 or 4 wire.*** the second most important question. Robust DataComm has both models available - the rdc485ir3 for 2-wire and rdc485ir5 for 4-wire systems.

- ***Physical design and installation.*** How large is it? How is it mounted? What type of power supply is required? Robust DataComm uses small, DIN-rail mounting units with direct DC supplies for use in industrial panels. Other vendors make units from small to huge (selling by the pound I guess!) with AC supplies and some do not even offer any means to mount securely. You can easily waste several hundred dollars in engineering time if you select an inappropriate unit.

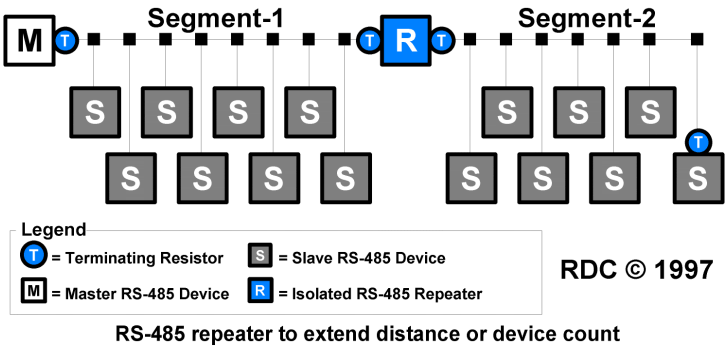
- ***Galvanic Isolation.*** This is a critical feature. Because a repeater is used only to "increase" the complexity of the overall system function, it is truly crazy not to insist on full optical/galvanic isolation at each repeater to help "decrease" the complexity of your power and grounding system. Robust DataComm does not even sell non-isolated RS-485 repeaters as they cannot be warranted to work for long.

- ***Fault Isolation.*** This is also a critical feature - for the same reason of helping to "decrease" the complexity of your hardware and increase system robustness. Robust DataComm has perhaps the only effective fault isolation in the industry. Any RS-485 line held in a non-standard condition (a "break" or grounded state or reversed wiring) will cause both a RED lamp on the rdc485ir3 and rdc485ir5 to light and force the repeater output to an idle state, containing the error. Don't be fooled that a "Fault" lamp on other vendors units mean much - I've seen such units at customer sites which neither light during common system faults nor prevent any faults from bring their whole system down.

• Application: RS-485 repeater to extend distance / device count.

Figure 11.1 shows a simple RS-485 multi-drop with an isolated RS-485 repeater. It doubles the permitted EIA/RS-485 distance from 1000m to 2000m. But don't forget the physical requirements - the repeater requires an enclosure and power supply and cannot usually just be located in "the middle". It also doubles

the EIA/RS-485 device count from 32 to 62 (the repeater is considered 2 devices!). However remember system timing - if the Master device can only talk to 5 slaves per second, then while a 10 device RS-485 network requires only 2 seconds to complete a polling cycle, a 60 device RS-485 network will require at least 12 seconds. With devices like card readers this means at least a 12 second wait for a system response after swiping a card - will it meet your requirements?



RS-485 repeater to extend distance or device count

This design actually creates 2 independent RS-485 networks bridged by the repeater. Each segment supports the EIA/RS-485 standard distance and load specs, plus each requires a terminating resister at each end. In this case at the Master device, both sides of the repeater, and the farthest Slave device (4 total for 2-wire, 8-total for 4-wire).

How will this design increase the robustness of your RS-485 multi-drop? First, by reducing the number of "loads" on each segment, the signal will be stronger and noise will have less impact. Second, with the special fault isolation circuitry built into every Robust DataComm isolated RS-485 repeater, wiring faults beyond the repeater (segment-2) will be "isolated", allowing the inner segment-1 to function as normal.

Configuration of your rdc485ir3 and rdc485ir5 isolated repeaters: your repeater is correctly configured from the factory. Jumpers for both bias resisters and terminating resisters must be installed on both sides.

- **Application: RS-485 repeaters for multiple sites.**

Figure 11.2 shows a very effective use of isolated repeaters for a widely distributed RS-485 multi-drop. While it still gives the same benefits - increased distance and device count - its most important benefit is increased robustness and simplified trouble shooting.

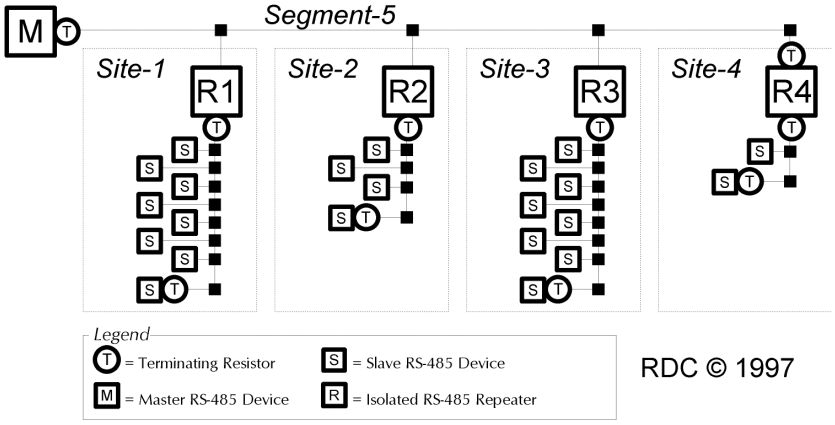


Figure 11.2 RS-485 repeaters for multiple sites

How will this design also increase the robustness of your RS-485 multi-drop? We now have 5 independent RS-485 segments. Each supports the EIA/RS-485 standard distance and load specs, plus each requires a terminating resister at each end (10 in total for 2-wire, 20 for 4-wire). It of course includes the benefit of stronger signals with less noise.

But the vast improvement in the robustness of this design can be easily appreciated. Remember our "rule" - longer segments with fewer devices are more robust. In Figure 11.2 we have a long segment-5 with only 5 devices - this *must* by definition be far more robust than if all 22 slave devices were on the main RS-485 multi-drop. Plus the smaller RS-485 segments at each site are the ones crowded with devices. One can easily envision a location where segment-5 is "stretched" to 1400m and the smaller segments at each site are only 50-100m each.

Now consider the special galvanic isolation and fault isolation circuitry built into every Robust Data-Comm isolated RS-485 repeater. Segment-5 now floats with respect to the ground at all 4 field sites - reducing noise and common mode surge potential. The local field ground at each site is never exposed to the ground at any other site, again reducing noise and common mode surge potential. Even if your slave devices are not galvanically isolated from their RS-485 port, if all installed within a single metal cabinet the likelihood of ground potential difference within a single field site is small. Finally, the special fault isolation circuitry will contain wiring faults at each site - say "Good-Bye" to the Christmas-Tree-Light syndrome where a single RS-485 fault brings down the whole system. For example, a faulty slave device or cable at site #2 will only affect site #2. Your trouble shooting job is already 75% complete since site #1, 3 & 4 still work. Image the cost and time savings - especially if your sites involve hazardous conditions and explosion-proof (flame-proof) housings.

Configuration of your rdc485ir3 and rdc485ir5 isolated repeaters: Repeaters R1, R2, and R3 must have both the bias resisters and the terminating resister jumpers removed from the side of segment-5. Repeater R4 will remain as configured at the factory. *Warning: the RS-485 repeaters of most other vendors cannot be used in this application without taking a wire cutter to their circuit board! Buy smart - buy RobustDC first!*

- **Application: RS-485 repeaters for a star topology.**

Figure 11.3 shows effective use of isolated repeaters to support a widely distributed RS-485 multi-drop where the cable must follow defined routes. Notice even the special case where repeater R1 supports a single slave device "too" far away. The previously mentioned benefits of galvanic and fault isolation still apply here, plus you can support a more realistic wire topology than a straight-line bus. Of course you could also place some isolated RS-485 repeaters in the field. For example, the repeater R1 could have been placed out where the cable run splits from that of R2. However, you must try to minimize the number of repeaters between the Master device and any slave device.

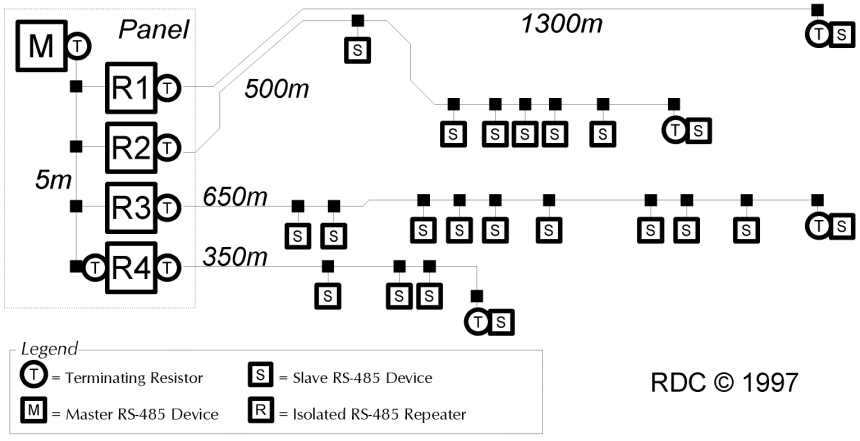


Figure 11.3 RS-485 repeaters for a "Star" topology

Configuration of your rdc485ir3 and rdc485ir5 isolated repeaters: Repeaters R1, R2, and R3 must have both the both bias resisters and the terminating resister jumpers removed from the side of segment-5. Repeater R4 will remain as configured at the factory. *Warning: RS-485 repeaters of most other vendors cannot be used in this application without taking a wire cutter to their circuit board! Buy smart - buy RobustDC first!*

• Application: RS-485 for distances longer than 2000m

We often have people asking about running RS-485 longer than 1000m - how about using 6 repeaters to go 6000m? Ignoring the lack of retiming and error introduced into an asynchronous signal by repeaters - are you willing to build 4 or 5 structures and provide power along your cable? In this situation RS-485 is probably not the single-best solution. There is also the issue of cable quality - 9 out of 10 RS-485 systems I've seen use standard instrumentation twisted pair cable without any specified impedance. We can easily debate if a 1500m RS-485 line on good cable will work - but who would bet on a 6000m line on unknown cable?

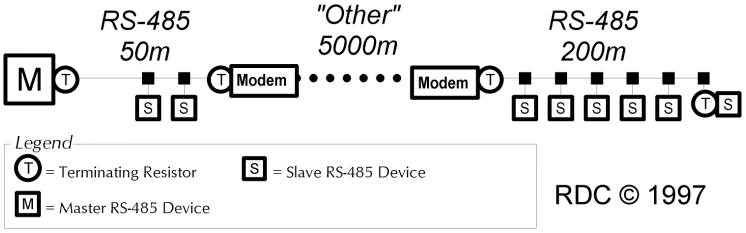


Figure 11.4 - Where's the Repeater?

Figure 11.4 shows an alternative "hybrid" solution which gets around both the distance and the cable quality problem. Two non-standard analog modems (also called short-haul modems, line-drivers, or private wire modems) use a frequency signal over 1 or 2 pairs of telephone grade cable. These modems can be purchased to go up to 15,000m or more. So what is the catch? Why use RS-485 at all? The answer is in the "standard". While it is easy to buy RS-485 device from many vendors and make them talk, these analog modems all do things their own way. If one fails, plan to replace them both. Even a newer version from the same vendor may not work well with the older model! You can use commercial modems (V.32 and so on), but these will pose mounting challenges, plus they require careful software configuration - configuration which can be lost during electrically noisy field conditions. So Figure 11.4 doesn't use any RS-485 repeater. If you cannot find modems which support RS-485 directly, you can include an RS-485 to RS-232 converter at each modem and use RS-232 modems.

• For More Information

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

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