WHITE PAPER

Intelligent RS-485

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MOXA®

Introduction

RS-485 is a top choice for engineers who need to create small, private device networks for automation applications, and is used widely for industrial field applications that require stable data transmission over relatively long distances. The RS-485 serial communications standard provides better noise immunity than RS-232, allows more devices to be connected to the same data line, and supports peer-to-peer communication at distances up to 4000 feet (1200 meters) at 9600 bps.

Although RS-485 technology has a number of benefits, it often takes a seasoned expert who has several years of experience to set up and fine-tune the RS-485 network. The biggest challenge is knowing how to configure the terminators and pull high/low resistors. The fact that a test network runs without error in the laboratory in no way guarantees that it won't fail in the field, particularly since field sites can contain any number of unexpected conditions that affect the fidelity of the network. A common scenario is that once the network is set up, an expert must be hired to go onsite to adjust the terminators and pull high/low resistors, resulting in an extra expenditure of both time and money.

In this white paper, we first review the problems that engineers face when setting up an RS-485 network, and then demonstrate how Moxa's new Intelligent RS-485 technology can help to eliminate the vast majority of these problems.

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Moxa is a leading manufacturer of industrial networking, computing, and automation solutions. With over 25 years of industry experience, Moxa has connected more than 30 million devices worldwide and has a distribution and service network that reaches customers in more than 70 countries. Moxa delivers lasting business value by empowering industry with reliable networks and sincere service for automation systems. Information about Moxa's solutions is available at www.moxa.com. You may also contact Moxa by email at info@moxa.com.

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The RS-485 Challenge

Setting up an RS-485 network is relatively straightforward. The challenge comes when the power is turned on and the devices connected to the network start transmitting and receiving data. In most cases, engineers will need to further tune the system by configuring pull high/low resistors and terminators at strategic points along the network. It may even be necessary to modify the environment, since electronic devices external to the network can disrupt data flow.

Three situations are commonly encountered:

- **The length of the network fits the RS-485 standard, and even though pull high/low resistors and terminators have been adjusted, communication still fails**

  RS-485 networks are commonly used for long distance wiring. However, the longer the transmission distance, the more likely it is that the signal will be corrupted by signal reflection caused by impedance mismatch. When this happens, communication failures are bound to occur. The first thing you should do to overcome this problem is enable termination on the network's two end devices, instead of on devices internal to the network.

- **The network works okay when only a few devices are connected, but cascading several RS-485 devices (10 or more, for example) causes communication failure**

  The devices on an RS-485 network form a parallel circuit, and consequently the internal impedances of the devices combine to alter the effective impedance of the network as a whole. In fact, the effective impedance could be such that the network's differential voltage no longer lies outside the -0.2 V to +0.2 V range, resulting in communication failure. One solution is to add a repeater to amplify the signal, but if successful communication still can't be achieved, then you'll need to check environmental conditions.

  Another solution is to change the pull high/low resistors to force the network's overall impedance to match an appropriate value. Since normally neither a 1 kΩ or 150 kΩ resistance meets the requirements, it may be necessary to use a tuning kit to determine the exact resistance values needed to get the correct impedance of the entire network.

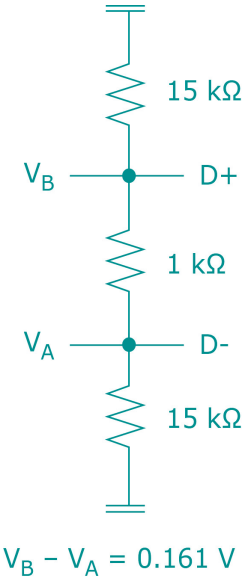

Figure 1: Impedance mismatch ($V_B - V_A = 0.161$ V, which no longer lies outside the -0.2 V to + 0.2 V range)

- **Changing the RS-485 baudrate from low to high decreases the maximum allowed cable length**

  Users will sometimes increase the baudrate setting of an RS-485 network to speed up data transmission. However, as indicated in Figure 2, as the baudrate on the network is

increased, the maximum allowed cable length will eventually decrease. Consequently, if the baudrate is increased arbitrarily, it is likely that at some point the actual cable length will exceed the maximum allowed length, resulting in communication failure. The solution is to turn on termination.

For example, suppose you've cascaded 10 devices on an RS-485 network of total length 400 feet, the baudrate is set to 9,600 bps (≈ 10 kbps), and you've thoroughly tested the network and found that it works extremely well. Next, to improve performance, you decide to increase the baudrate to 921.6 kbps (≈ 1 Mbps). With reference to Fig. 2, the maximum allowed length of the network is still about 400 feet. However, the fact that the baudrate is now higher than before increases the amplitude of the reflective waveform and causes communication failure. The solution to this problem is to activate termination.

Figure 2: Max. allowed cable length vs. RS-485 baudrate

Understanding Moxa's Intelligent RS-485 Technology

When RS-485 communication fails it is common practice for engineers to use an oscilloscope to check the D+/D- signals, and then devise a solution based on the result of the test. Most engineers will need to spend at least one hour to check D+/D- signals. Another method that is sometimes used is to check D+/D- signals using a specially designed testing device on each RS-485 port. This method not only requires a significant amount of time, but the cost increases arithmetically with the number of RS-485 ports.

Based on our 25 years of experience designing serial communications products and networks, we are confident that Moxa's Intelligent RS-485 technology can help users resolve most of the RS-485 problems they encounter. In the event that the RS-485

network cannot be tuned automatically, the system will suggest what actions the engineer can take to remedy the situation.

Moxa's Intelligent RS-485 technology uses a CPLD (complex programmable logic device) chip placed between the UART controller and the RS-485 interface on the serial board. Instead of checking the D+/D- signals (as the engineer does), we've programmed the CPLD chip to check the RXD signal coming from the RS-485 network. To be precise, the CPLD chip sends out a test TXD signal and then receives what we call an "echo RXD" signal from the RS-485 interface. This echo RXD signal is the key, since it provides the CPLD chip with an accurate copy of the actual RXD signal being transmitted across the network. By analyzing the electrical characteristics of the echo RXD signal, we can determine the terminator and pull high/low resistor settings needed to tune the network.

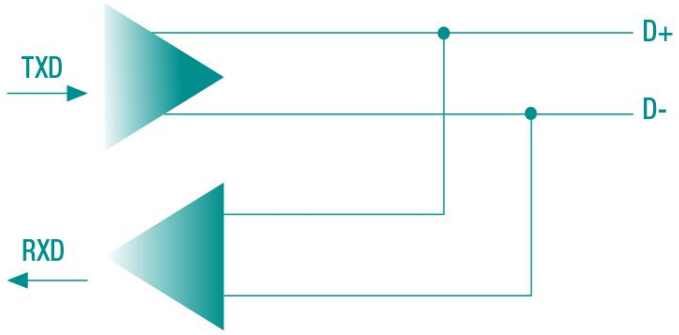

Figure 3: RS-485 bus monitor and hardware structure

Based on its analysis, the Intelligent RS-485 technology can deduce whether or not one of the following three conditions exists.

- **The width of the echo RXD signal is less than the width of the TXD signal**

Suppose the width of the test TXD signal is T; ideally, the width of the echo RXD signal will also be T. Our analysis has shown that if the width of the echo RXD signal is less than T, then a failure condition exists. This kind of problem can usually be fixed by configuring pull high/low resistors.

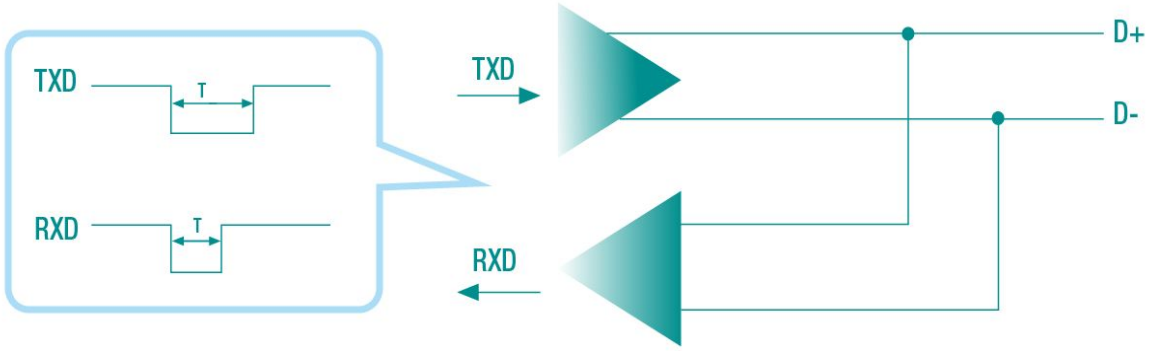

Figure 4: RXD signal width < TXD signal width

- **The width of the echo RXD signal is the same as the width of the TXD signal, but a reflective waveform was also detected**

If a reflective waveform is detected, then the RS-485 network is too long. This kind of problem can usually be fixed by making sure that termination is configured properly on the network's two end devices.

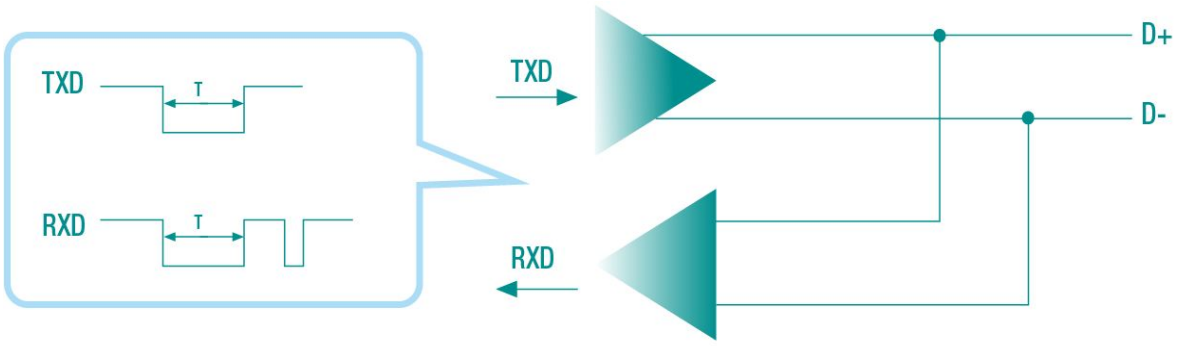

Figure 5: RXD signal with reflective waveform

- **The width of the echo RXD signal is greater than the width of the TXD signal**

If the width of the echo RXD signal is greater than the width of the TXD signal, then a failure condition exists. This kind of problem can usually be fixed by configuring pull high/low resistors.

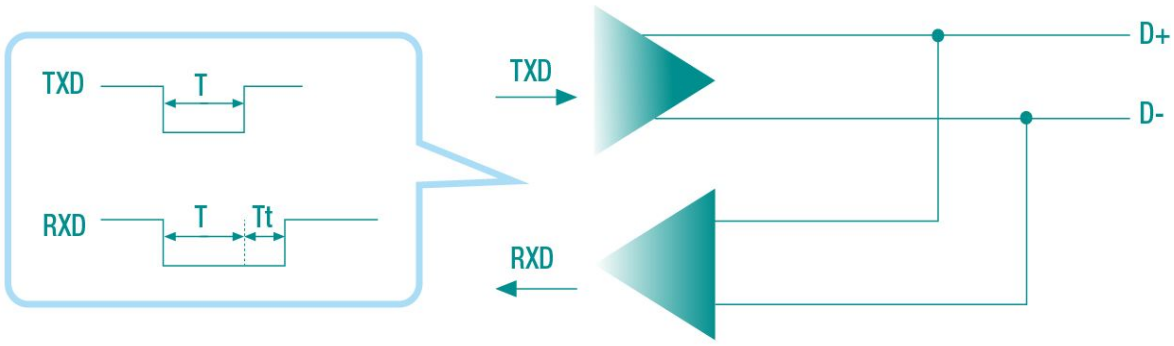

Figure 6: RXD signal width > TXD signal width

Using Moxa's Intelligent RS-485 Technology

Moxa's new Intelligent RS-485 technology provides a user-friendly interface that makes it easy to configure an RS-485 network. Intelligent RS-485 has two essential functions: (1) *One-Click Installation* automatically analyzes the network topology and then adjusts terminators and pull high/low resistors, and (2) *One-Click Troubleshooting* tells you what to change to make a deficient network viable.

1. One-Click Installation

Pressing the "Auto-Tuning" button tells the system to automatically detect the status of the RS-485 bus and then adjust terminators and pull high/low resistors in the appropriate way.

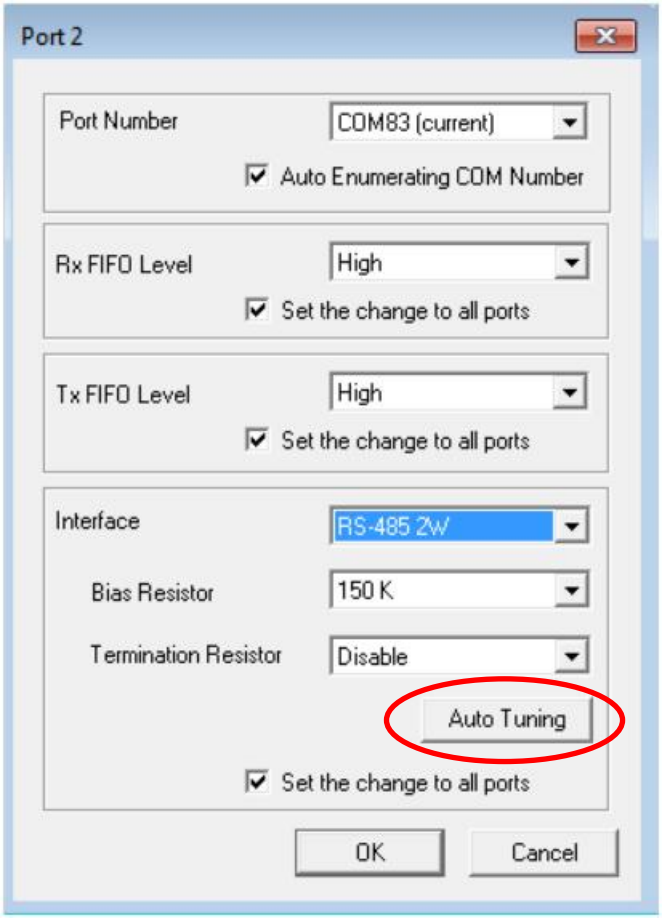

Figure 7: Atuo Tuning button

2. One-Click Troubleshooting

Pressing the "Start Diagnostic" button tells the system to display an error status table that indicates what adjustments need to be made to the network configuration.

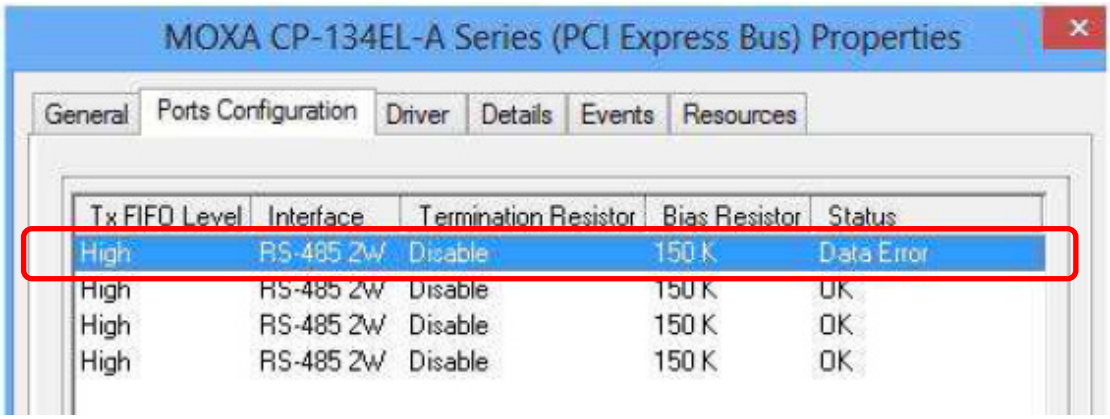

Figure 8: Diagnostic Error Status

Conclusion

Moxa's new Intelligent RS-485 technology (Patent Pending) was created to eliminate the hassle of setting up and tuning RS-485 networks. The technology is built into an exciting new series of advanced Moxa PCIe serial boards, giving engineers a powerful new tool that can be used to greatly simplify the task of setting up their networks.

The following new PCIe products all support Intelligent RS-485:

CP-134EL-A-I	4-port RS-422/485 PCIe card with isolation
CP-138E-A-I	8-port RS-422/485 PCIe card with isolation
CP-118E-A-I	8-port RS-232/422/485 PCIe card with isolation
CP-116E-A	16-port RS-232/422/485 PCIe card