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RS-485 Transceivers in Fieldbus Networks

Application Note

Revision History

Document No.	Release Date	Change Description
300ANR00	September 30, 2024	Initial release.

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Introduction

The RS-485 and RS-232 are two types of communication methods used to send data between devices. Before fieldbus networks came along, industrial control systems rely on a setup where each device has its own connection for communication. This setup not only wastes communication lines but also makes it costly and difficult to manage, limiting how much the system can grow or adapt. On top of that, different vendors had their own unique communication rules, making it hard for devices from different brands to work together.

Fieldbus takes those old communication methods and makes them smarter, turning them into systems that can do more than sending data. By setting standards for how devices communicates to each other, fieldbus becomes control systems more interconnected, spreading out across networks instead of staying isolated. This means that control and monitoring can happen from anywhere, not only locally. Once everything is connected, systems become more efficient, reliable, and easier to expand, all while costing less to maintain and manage.

Even with all those advancements in industrial automation, RS-485 and RS-232 still use communication ports that offer the expected balance of cost, reliability, flexibility, and compatibility, making them solid choices for fieldbus networks.

What exactly is a fieldbus over RS-485.This application note describes the fundamentals of fieldbus networks and the impact that they have across industrial sectors.

What is Fieldbus?

Fieldbus is an industrial data bus that originated in the 1980s with the goal of replacing conventional central parallel wiring and analog signal transmission methods. Fieldbus acts as a communication network that defines communication protocols and network structures. Its primary function is to enable digital communication among field devices, such as intelligent instruments, controllers, and actuators in industrial settings. Furthermore, fieldbus addresses issues related to communication between these field devices, advanced controls, and information transfer within systems. To cater to industry-specific requirements and accommodate the preferred proprietary solutions of major manufacturers, multiple bus systems with distinct properties are established in the market.

Fieldbus is used in factory automation because it offers notable advantages including simplicity, reliability, cost-effectiveness, and practicality. For instance, in traditional factories, electric motor drive systems often consume a significant portion of industrial power, sometimes up to 70%. However, by implementing fieldbus and transmitting data, PLCs can issue instructions and control the speed of electric motors. This enables synchronized data collection processes, machine-to-machine communication, network data transmission, and centralized management, leading to cost savings and improved work efficiency.

Fieldbus Advantages

Enhanced Efficiency Fieldbus systems improve device communication, making wiring simpler and reducing installation time. This speeds up setup and minimizes downtime during maintenance.	**Flexibility and Scalability** Fieldbus networks link various devices, improving communication and management in industrial processes. They offer flexibility, efficiency, and easy monitoring and management of a wide range of field devices. This adaptability supports dynamic manufacturing and seamless integration of new equipment.
Cost Savings Fieldbus networks streamline communication and management in industrial applications by connecting diverse devices. They boost flexibility, efficiency, and simplify oversight and control of field devices. This results in cost savings across installation, maintenance, and operation.	**Improved Accuracy and Troubleshooting** Fieldbus devices often include microprocessors for local control, enhancing measurement accuracy. Some devices support control schemes such as a proportional–integral–derivative (PID) controller directly, further enhancing accuracy. Fieldbus protocols also feature diagnostic tools for detailed monitoring and troubleshooting of networked devices. This enables quick issue identification and resolution, reducing production downtime and enhancing system reliability.

In summary, the adoption of fieldbus systems in industrial automation offers benefits, including enhanced efficiency, flexibility, cost savings, and improved system reliability and performance.

Common Fieldbus Network Topologies

A fieldbus topology is the arrangement of devices and communication paths within an industrial network. The following figures show some common fieldbus topologies.

Daisy-Chain Topology

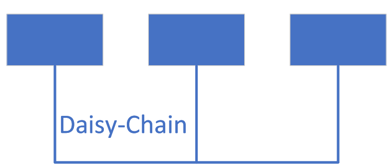

Figure 1: Daisy-Chain Topology

In a daisy-chain topology, devices are connected in a linear chain, where each device communicates with adjacent devices.

A daisy-chain topology is simple and easy to implement. However, if one device fails it disrupts communication for the entire chain.

Star Topology

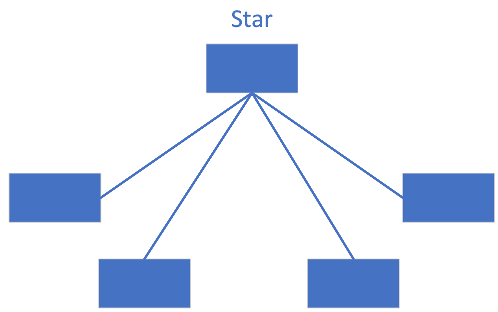

Figure 2: Star Topology

In a star topology, all devices connect to a central hub (like a star). The hub manages communication between devices.

Star topologies are robust and fault-tolerant, if a single device fails other devices are not affected. However, this topology requires more cabling.

Ring Topology

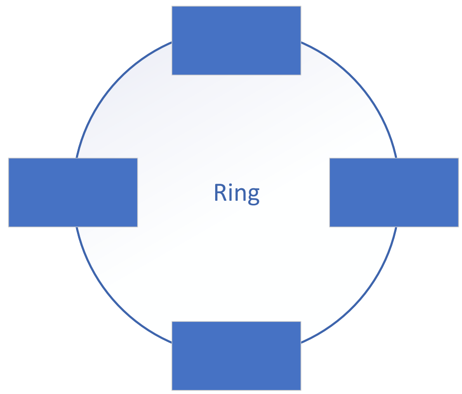

Figure 3: Ring Topology

In a ring topology, devices form a closed loop, with each device connected to its neighbors. Data travels in one direction around the ring. If one device fails, the ring is broken, affecting communication.

Branch Topology

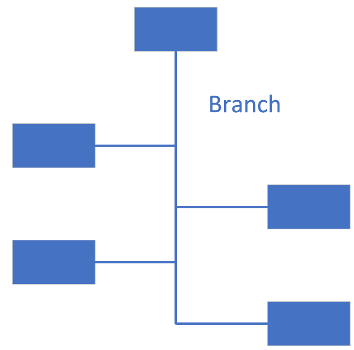

Figure 4: Branch Topology

A branch topology is a combination of daisy-chain and star topologies. Devices are connected in branches off a main trunk. Branch topologies offer flexibility and redundancy.

Tree Topology

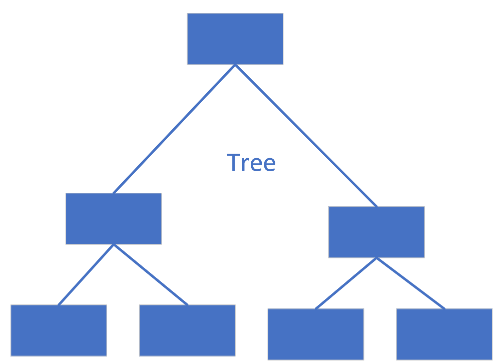

Figure 5: Tree Topology

In a tree topology, devices are connected in a hierarchical structure resembling a tree. The main trunk connects to branches, which further split into sub-branches. Tree topologies provide scalability and organization.

Choice of topology depends on factors such as system requirements, reliability, scalability, and cost. Each topology has its trade-offs and users select the most suitable one based on the specific application.

Fieldbus and Physical Interface

Fieldbus applications operate in a single communication point at the controller level and can connect multiple nodes simultaneously as LAN-type connections.

The RS-485 standard serves as a common physical layer for fieldbus systems, defining the electrical characteristics of communication. It is used in industrial control systems and building automation due to its robustness and versatility.

RS-485 supports multiple devices on the same communication line and can transmit data over distances exceeding 4000 feet (approximately 1200 meters). Its differential transmission method enhances noise immunity and reliability, simplifying cable layouts and reducing overall complexity in fieldbus installations.

Many fieldbus protocols specify RS-485 communication ports because of the ease of implementing the physical layer using RS-485 transceivers. This standardization contributes to the widespread adoption of RS-485 in various industrial applications.

Fieldbus Configurations and Protocols

Fieldbus Configurations

Fieldbus systems streamline connectivity by using a single gateway to link all network devices to a central controller. This setup drastically reduces wiring needs while enhancing system efficiency. Through software addressing, every device can link to the master controller, simplifying the connection process. The system automatically detects connected devices and initiates necessary communication actions.

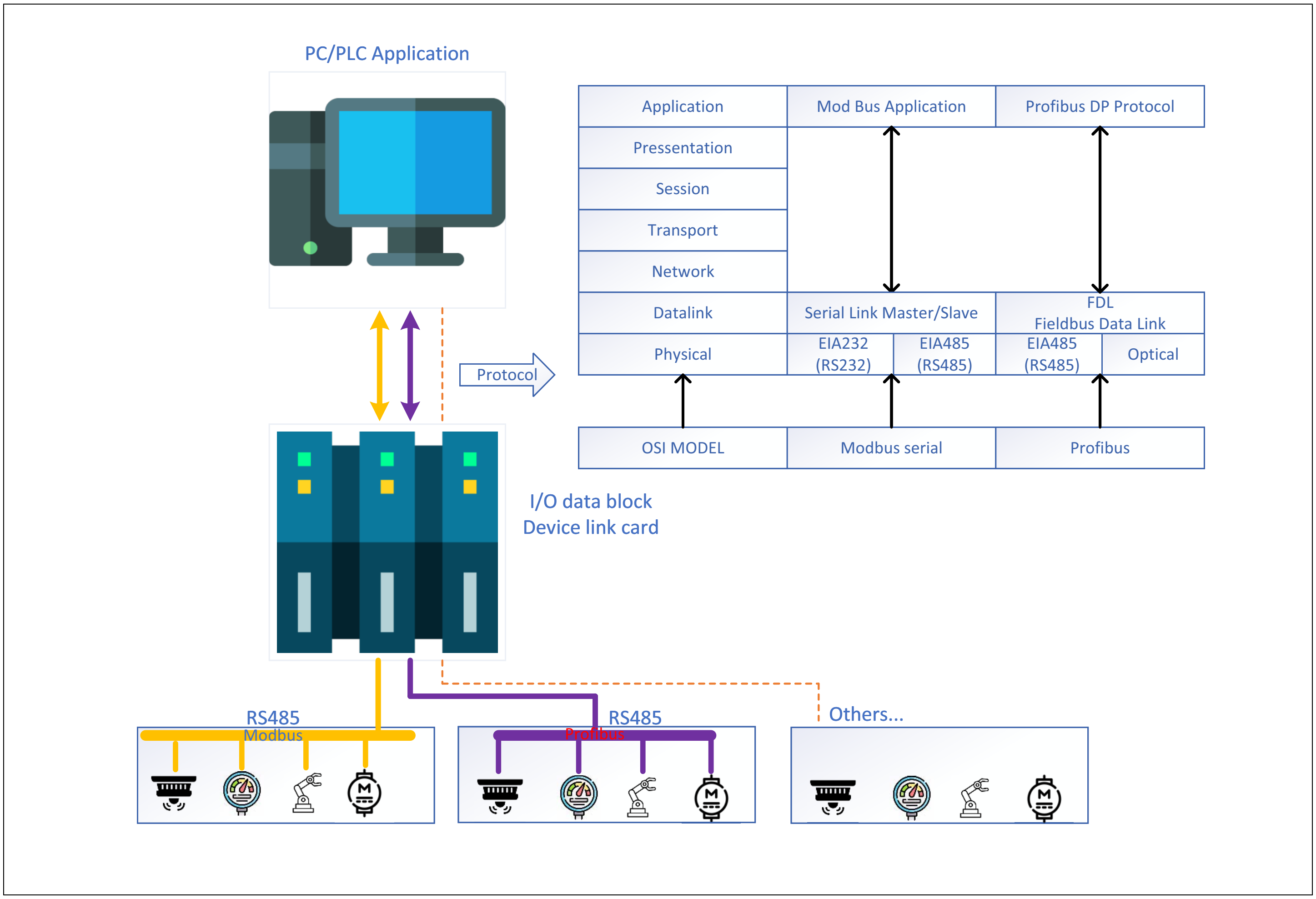

Figure 6: Common Fieldbus System Configuration

Fieldbus Protocols

Common fieldbus protocols that use a RS-485 as physical layer include PROFIBUS Process Fieldbus–Distributed Peripherals (DP) and MODBUS Remote Terminal Unit (RTU).

PROFIBUS DP (EN50170 or DIN19245)

- PROFIBUS, originally developed in Europe, has gained global acceptance as an industrial fieldbus utilized in process automation and factory control systems. The most prevalent implementation is PROFIBUS-DP which employs RS-485 as its physical layer alongside a proprietary data link layer.
- The RS-485 standard specifies a minimum differential output voltage (VOD) of 1.5V across a fully loaded network and a 60Ω resistor, within a common-mode voltage range of –7V to +12V. However, PROFIBUS DP imposes stricter requirements on the differential output voltage, with RS-485 transceivers for PROFIBUS typically guaranteeing a voltage exceeding 2.1V with a 54Ω load.
- Electrical wire transmission for PROFIBUS-DP utilizes twisted wire pairs with an impedance of 150Ω, supporting bit rates ranging from 9.6kbit/s to 12Mbit/s. This transmission method is commonly paired with PROFIBUS-DP, with cable lengths between repeaters restricted from 100 to 1200 meters, depending on the bit rate.

MODBUS RTU

- MODBUS RTU has become an industry standard of communication protocol in the industrial field used as a connection method between industrial electronic equipment. MODBUS facilitates master-slave communication between intelligent devices and operates over various physical media such as RS-232, RS-485, and RS-422. While the original MODBUS interface uses RS-232 serial communication, most later implementations use RS-485 due to its capability for longer distances, higher speeds, and the ability to accommodate multiple devices on a single multi-drop network.

MaxLinear Fieldbus Solutions

A new family of MxL8321x, half-duplex RS-485 transceivers, meets the fieldbus requirements and offers several other advantages:

- Data rates up to 50Mbps
- Robust system protection
    - ±15kV ESD Human Body Model (HBM)
    - ±12kV ESD Contact Discharge (IEC 61000-4-2)
    - ±4kV Electrical Fast Transient (EFT) (IEC 61000-4-4)

MaxLinear offers a wide range of fieldbus solutions, including devices that can work with multiple fieldbus protocols. This versatility simplifies the selection process and circuit design for fieldbus applications.

All MaxLinear transceivers support MODBUS RTU since the MODBUS physical layer employs standard RS-232, RS-485, and RS-422 specifications. For suggested MaxLinear transceivers that support PROFIBUS DP, see the following table.

Table 1: MaxLinear Transceivers for PROFIBUS Applications

MaxLinear Part Number	Specification				
	Differential Output Voltage |VOD|	**Data Rate (Maximum)**	**EFT (±kV)**	**Propagation Skew**	**Driver Output Rise/ Fall Time**
MxL83211	2.1V (min)	0.25	4	15ns	700ns
MxL83212	2.1V (min)	0.5	4	15ns	250ns
MxL83214	2.1V (min)	50	4	0.8ns	4ns
MxL83101	2.1V (min)	0.25	2	20ns	950ns
MxL83102	2.1V (min)	0.5	2	20ns	400ns
MxL83111	2.1V (min)	0.25	2	15ns	700ns
MxL83112	2.1V (min)	0.5	2	15ns	250ns
SP1486E	2.1V (min)	20	Not specified	5ns	10ns
XR3072X	2.1V (min)	0.25	Not specified	20ns	350ns
XR3078X	2.1V (min)	20	Not specified	5ns	12ns
XR3082X	2.1V (min)	0.25	Not specified	20ns	400ns
XR3085X	2.1V (min)	1	Not specified	5ns	200ns
XR3087X	2.1V (min)	20	Not specified	5ns	15ns
XR3088X	2.1V (min)	20	Not specified	5ns	15ns

Conclusion

As technology progresses and the number of connected industrial devices grow, fieldbus applications are expanding and its operating conditions are becoming more stringent. These factors underscore the need for increasingly robust serial transceiver interfaces.

Maxlinear serial transceivers are designed to integrate into various industrial systems and support different fieldbus protocols. MaxLinear serial transceivers are capable of withstanding high levels of electromagnetic interference and electrostatic discharge, ensuring reliable and uninterrupted data communication. Moreover, they are equipped with wide common mode voltages and high input tolerances, enabling them to operate efficiently in demanding environments. Overall, MaxLinear serial transceivers are the ideal choice for industrial applications that require robust and dependable data communication capabilities.

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