

RS-485 Cabling Requirements for Modbus RTU and BACnet MSTP

Revision R19B

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1 SCOPE

1.1 IDENTIFICATION

This document describes the RS-485 cabling requirements for Modbus RTU and BACnet MSTP.

1.2 INTRODUCTION

The signal lines of RS-485 networks are differential twisted pairs. This allows for fast, long length networks up to 4000ft, but conditions have to near ideal for successful networking at these extremes. There are many factors that can reduce the effective maximum length of a RS-485 network.

- Very high speeds.
- Electrically noisy environments.
- Less than ideal cable characteristics.
- Improperly terminated networks.

RS-485 was designed for a maximum of 32 unit load devices on the bus. Although it is possible to have more than 32 devices on the bus using modern sub-unit load transceiver chips, this is not recommended because the network becomes increasingly difficult to manage and troubleshoot.

2 RS-485 CABLING

The RS-485 Cabling Requirements for Modbus RTU and BACnet MSTP are as follows:

2.1 CABLING AND TOPOLOGY REQUIREMENTS

For long network and high baud rates, cabling requirements become more stringent.

- **Number of conductors:** RS-485 is a three wire bus. One twisted pair is required for the two data signal wires, plus an additional wire for a common reference, which does not need to be twisted. Although the shield can be used for the common reference, it is preferable to use a separate wire for the common. A cable with two twisted pairs may also be used, where one or both conductors of the second pair is/are used for the common.
- **Shield:** A shield may not be need for short networks, but is recommended and required for long networks, or for network in an electrically noisy environment. The shield must be connected to a ground point at ONE side only.
- **Wire Gauge:** 22-24 AWG is recommended. Thicker conductors may also be used but the mutual capacitance increases, making it more difficult to achieve this requirement.
- **Characteristic Impedance (Z_0):** 100 to 120 ohms.
- **Mutual capacitance:** <30 pF/ft (<12.5 pF/ft is preferable)
- **Capacitance to Shield:** <60 pF/ft (<22 pF/ft is preferable)
- **Termination:** A terminating resistor of 120 ohms must be fitted to each physical end of the network.
- **Biasing:** All Measurlogic meters are equipped with "fail-safe" RS-485 transceivers. This make biasing of the bus unnecessary. If devices from other manufacturers are on the bus it is possible that those devices may require biasing. Biasing will not affect the operation of Measurlogic devices, so can also be added in increase the noise immunity of the bus. If biasing is used, we recommend a 720/130/720 combination in place of the terminating resistor at one end of the bus only.
- **Bus Topology:** A RS-485 bus must be a linear bus. Devices must be connected as close to the bus as possible – Stubs are not allowed.
- **Voltage Rating:** We do not recommend running the communication cable in the same conduits as high voltage or high current cables. Run the communications cable in its own conduit. This also has the advantage that high voltage rated communications cable is not needed, so normal 300V cable is sufficient.

2.2 CABLING SPECIFICATIONS

- One twisted-pair for the two data signal wires, plus an additional wire for a common reference, which does not need to be twisted.
- Shield: Braid or Foil with drain wire.
- Wire Size: 22-24 AWG.
- Cable Type: Twisted-pair, copper wire, tinned.
- Characteristic Impedance (Z_0): 100 to 120 ohms
- Mutual capacitance <30 pF/ft (<12.5 pF/ft is preferable)
- Capacitance to Shield <60 pF/ft (<22 pF/ft is preferable)
- Propagation velocity $\geq 78\%$ (Higher is better)

2.3 CABLE RECOMMENDATIONS

For strict cable compliance, the following cables are recommended for RS-485 Modbus RTU and BACnet MSTP networks:

Manufacturer	Part Number	Voltage Rating	AWG	Pairs	Operating Temp °C	Impedance Ohms	Capacitance pF/ft	Cable Diameter
Alpha Wire	6454	300V PLTC, CM	22	1.5	-20 to +60	120	11	0.32"
Belden	3106A	300V PLTC, CM	22	1.5	-20 to +60	120	11	0.30"

2.4 CAT-5 ETHERNET CABLE

Inexpensive Ethernet cables (Cat 5, Cat 5e, and Cat 6) can, and are often, used for many short RS-485 networks. The typical capacitance of 15 pF/ft and a characteristic impedance of 100 ohms meet the electrical requirements for RS-485 cables, although impedances closer to 120 ohm are preferable for better matching.

However, the inexpensive Ethernet cable is generally unshielded twisted pair, which may be fine for shorter networks in low electrical noise environments. Be sure to use one of the twisted pairs for the signal conductors, one or both conductors of another pair for the common. Also be aware the conductors of this type of cable are solid core, so break easily at the point where they are screwed into a plug terminal.

Do not used Ethernet cable for long length networks, or networks in electrically noisy environments.

3 REFERENCES

Additional information regarding RS-485 for Modbus and BACnet.

Understanding EIA-485 Networks:

<https://www.ccontrols.com/pdf/ExtV1N1.pdf>

Examining the BACnet MS/TP Physical Layer

<https://www.ccontrols.com/pdf/Extv9n2.pdf>

Number of devices on a BACnet MSTP chain

<https://www.cimetrics.com/blogs/news/number-of-devices-on-a-bacnet-mstp-chain>

Contemporary Controls BASrouter

<https://www.ccontrols.com/basautomation/basrouter.php>

Contemporary Controls Portable BASrouter

<https://www.ccontrols.com/basautomation/basportable.php>