MICROVA
electronics & automation

RS-485 Network Wiring

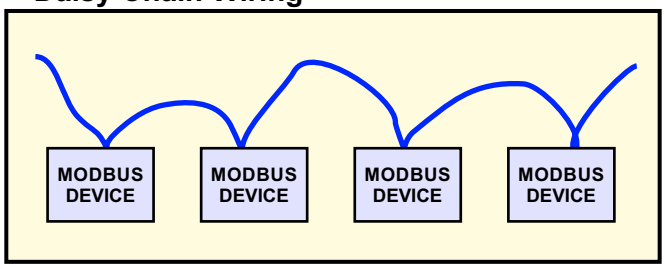
Introduction

RS-485 networks are widely used for communication in industrial settings due to their reliability, low cost and ease of installation. One of the most common industrial network standards is Modbus RTU which uses the RS-485 physical layer. See Microva application notes *"AN130 What is Modbus?"* and *"AN132 Microva Modbus RTU Implementation"* for more information on Modbus. This document explains the proper procedures for RS-485 network installation.

Network Topology

Generic RS-485 can support up to 256 "nodes" on the network, however, Modbus RTU limits the number of nodes to 247. Each node on the network is a controller or I/O device. Nodes should be connected in a daisy chain as shown in the diagram below. Standard "half duplex" RS-485, which is used for Modbus RTU, requires three connection wires per node: DATA A, DATA B and GROUND. DATA A and DATA B are the same data except they are inverted which provides noise immunity. The A connection is defined as the non-inverting data line and B is the inverting data line. In the half duplex configuration only one node on the network can transmit at a time. All the other nodes are listening. Modbus RTU is a master/slave type network with one master node on the network which sends and requests data to/from all the other nodes on the network. Besides DATA A, DATA B, and GROUND, often POWER is also connected on the network bus. Microva devices label the POWER wire V+ and the GROUND wire V- and DATA A is labeled A and DATA B is labeled B. The table below shows some other common names used by RS-485 device manufacturers.

Daisy Chain Wiring



Network Termination

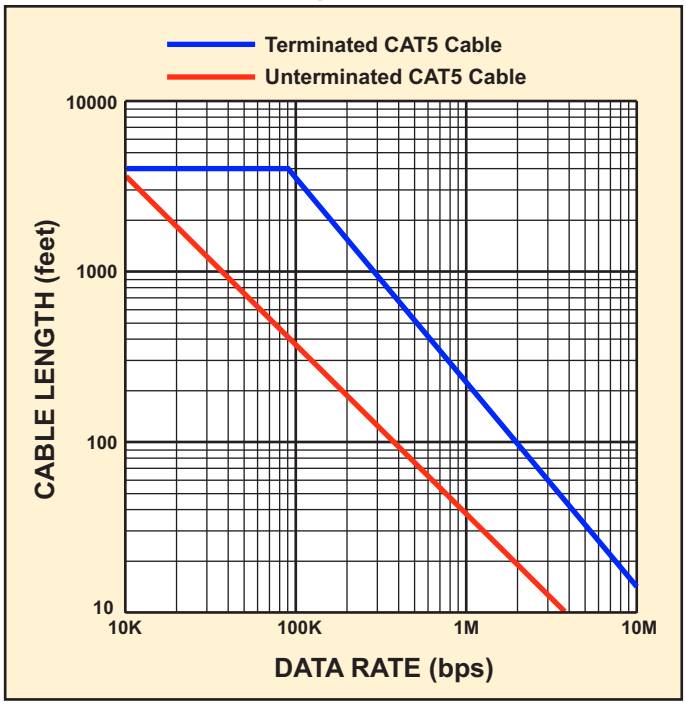
RS-485 networks can operate at slow speeds down to 1200 bits/second (baud) or slower or at high speeds of 20 Megabits/second or more. The time required for a signal to propagate down the wire to a receiver determines if the network is considered a transmission line. Long wires have longer propagation times. Shorter wires have shorter propagation times. Longer wires running at higher speeds require the network (the transmission line) to be properly terminated.

Modbus RTU Signal Names

Name	Description	Other Names
A	non-inverting	DATA+, D+, D0, COM+, DATA_A
B	inverting	DATA-, D-, D1, COM-, DATA_B
V+	power plus	POWER, SUPPLY, DC, VCC
V-	power minus	GROUND, COMMON, GND, C

Terminating the network just means connecting a 120 ohm resistor from the A terminal to the B terminal at both ends of the network, i.e. at the two furthest nodes on the network. Shorter networks or networks running at slower speeds are not considered transmission lines and do not need to be terminated. Typically, if the time required for data to propagate from one end of the network and back is less than about 10% of the bit time then the network does not need to be terminated. Signals in a copper wire travel at about 7.4e+08 feet/second. Therefore, the time for data to traverse a 1000 foot cable is 2 x 1000 / 7.4e+08 = 2.7uS. If the cable is not terminated then the bit time should be at least ten times longer than the two way propagation time. Therefore, for this example a 1000 foot cable would require the bit time to be 27uS or longer if the cable is not terminated. So the maximum baud rate is 1/27uS = 37K. So a baud rate of 19,200 would probably be okay for a 1,000 foot unterminated cable but a baud rate of 100,000 would not. The graph below shows the approximate maximum network cable length for terminated transmission line networks and for unterminated networks which are not considered transmission lines.

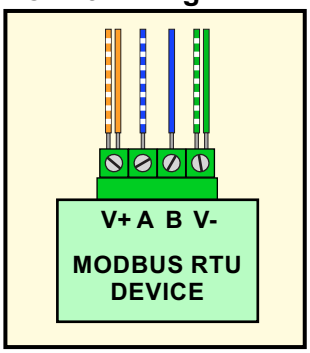
Maximum Cable Length vs Data Rate



Network Wiring

Typically, category 5 (CAT 5) or category 6 (CAT 6) computer network cable (Ethernet cable) is used for RS-485 wiring. This type of cable consists of four twisted pairs of wires- 8 wires total. The wire pair colors are: blue/blue_white, green/green_white, orange/orange_white and brown/brown_white. There is no standard for the wire color connections to the RS-485 connector. Microva recommends that the blue wire pair be used for data communication with data terminal B connected to the blue wire (B for blue) and data terminal A connected to blue_white. Use the green pair (both wires) for V- and the orange pair (both wires) for V+. This is shown in the drawing right.

CAT5 Wiring



Network Power

Modbus nodes on the network can be powered over the network or can be self powered using a separate power supply. Nodes which require more than a few Watts of power, like motor drivers, should be powered with their own dedicated power supply. Power supplies on the network must be isolated from one another with no ground connection to other nodes on the network except for the V- connection on the RS-485 I/O connector. That is critical to prevent "ground loops" which cause communication errors. The diagram below shows how power is connected. The network USB-to-RS485 interface "dongle" shown in the diagram is powered from the computer USB port (for example Microva model number MB100).

Power Over the Network