PST
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TECHNOLOGIES

Rotronic Modbus – Digital Communication

Modbus is a popular communication protocol used in industrial automation to exchange data between devices such as PLCs, sensors, and actuators. Modbus can be over Ethernet (known as Modbus TCP) using standard patch leads or over RS-485 and RS-232 (known as Modbus RTU) using twisted pair cables.

Rotronic Modbus application wall

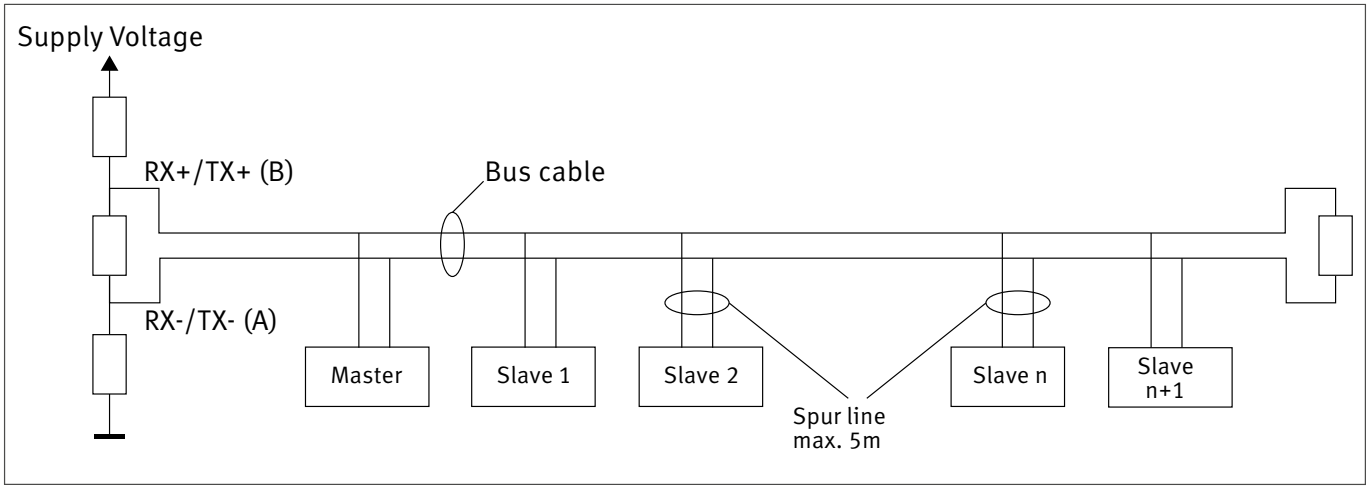
Why use Modbus over RS-485?

Modbus RTU networks are predominantly used due to the ease and reduced cost of adding many devices via a single “bus cable” (unlike analogue or ethernet that requires a direct cable to every device). With Modbus RTU networks you can also easily add additional devices at any point along the bus cable. Only a single PLC device is required to communicate with potentially up to 247 devices presenting a huge cost saving compared to analog signals. Finally, by using digital vs analog there is no signal degradation or error and you are also able to receive additional information such as device and probe serial numbers, units & error codes.

For Modbus RTU applications proper wiring is essential to ensure reliable and error-free communication between Modbus devices. In this application report, we introduce a guidance for our recommended installation of a RS-485 network:

Basic structure of an RS-485 network

Modbus has specific wiring standards that must be followed to ensure proper communications, the most commonly-used is RS-485. RS-485 specifies the electrical characteristics of the signaling, such as voltage levels, current levels, and impedance, that are required for a proper communication.



Supply voltage

Wiring

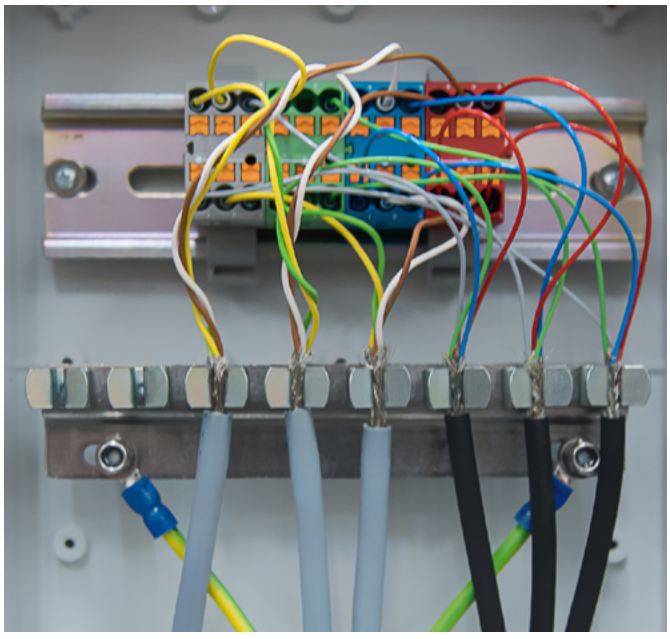
To realize an interference-free setup as far as possible, a shielded twisted pair cable must be used as bus cable. Shielded cables are designed with a metal foil or braided shield that wraps around the signal wires to block unwanted electrical noise. The twisted pair cable is designed with two wires twisted to ensure that any external noise picked up by one wire is canceled out by the other wire. The spur lines to the RS-485 devices must be kept as short as possible and should not exceed 5 meters.

Supply voltage

When setting up the power supply, it must be ensured that a galvanically isolated supply is used in which the power supply/bus ground is also carried. In general, the supply voltage for Modbus RTU devices can vary depending on the individual device requirements, but the most common is 12 VDC or 24 VDC. It's also worth noting that the supply voltage for Modbus RTU network is typically used to power the devices and not the communication line itself, which is usually powered by the data communication signals. However, some devices may require additional powering for communication.

Grounding

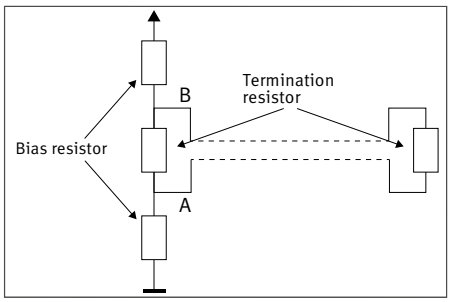
Proper grounding is essential to reduce electrical noise and ensure reliable communication. Therefore, all shields of the used cables must be connected to the ground. Possible potential differences must be avoided by means of short ground distances and using the same ground references. Connect the ground wire of the Modbus device to a common ground point and not with the metal casing of a device.



Common GND

Terminating resistors

Modbus requires terminating resistors at both ends of the network to prevent signal reflection that can cause communication errors. Terminating resistors match the impedance of the cable. Connect a terminating resistor across the B (RX+/TX+) and A (RX-/TX-) lines at both ends of the network.



Schematic structure of terminating resistors

The dimensioning of the resistors depends on the cable length, the used cable, and the Modbus master. Therefore, the manual of the respective Modbus master should be consulted.

Online tools are available to determine the correct resistance values: http://www.alciro.org/tools/RS-485/RS485-resistor-termination-calculator.jsp

Before powering on your Modbus devices, check the wiring continuity using a multimeter to ensure that all connections are correct.

Polling interval

The minimum polling speed is defined by the slowest device within the bus system. Transmission errors may occur during Modbus communication. This must be considered when evaluating the communication. In case of transmission errors consult the manual of the Modbus master.

Number of participants

The number of possible participants of a Modbus RTU network depends on the Modbus master. Typical Modbus masters in real world networks will support 32, 64, or 128 devices (theoretical max is 247).

Modbus master

A Modbus master is a device that initiates communication on the network and sends requests to read or write data to one or more Modbus slaves. The master device is responsible for controlling the communication, defining the data to be exchanged and ensuring the integrity of the transmission. We have used the product from the manufacturer B&R as Modbus master:

PLC B&R X20CP1583

X20CP1583 | B&R Industrial Automation (br-automation.com)

RS-485 converter

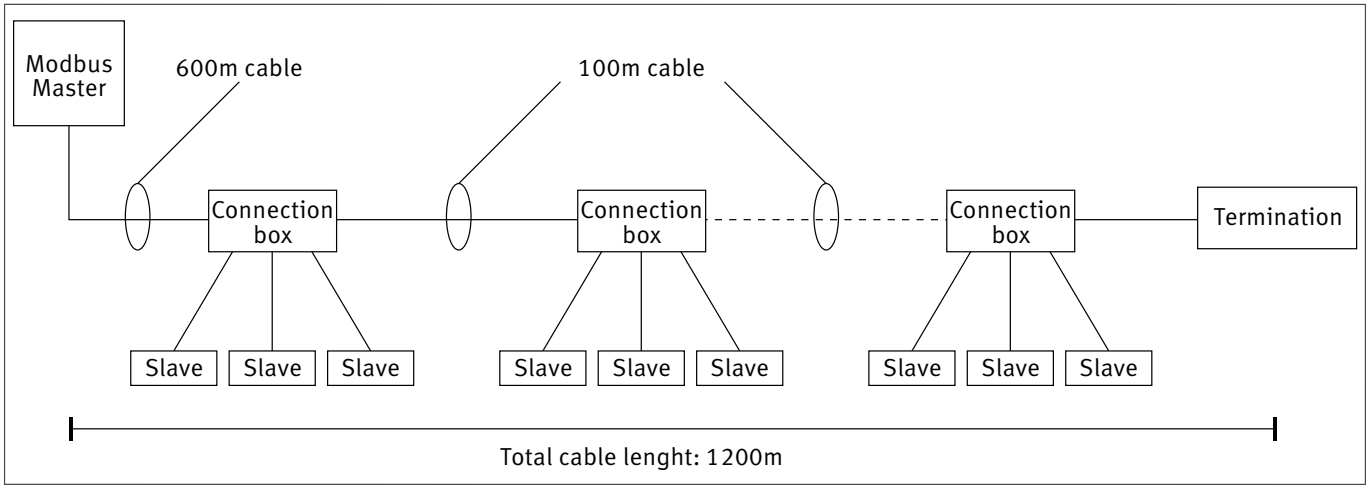
RS-485 is a differential signaling protocol that requires a specialized transceiver to convert the signal from the controller to the RS-485 standard. This is where the RS-485 converter comes in. The converter X20IF1030 acts as an interface between the XB20CP1583 controller and the RS-485 network, allowing the controller to communicate with other RS-485 devices. In other words, the RS-485 converter is required because the X20CP1583 does not have a built-in RS-485 transceiver. The converter provides the necessary signal conversion and allows the controller to communicate with other devices on the RS-485 network.

RS-485 converter B&R X20IF1030

X20IF1030 | B&R Industrial Automation (br-automation.com)

Rotronic test application

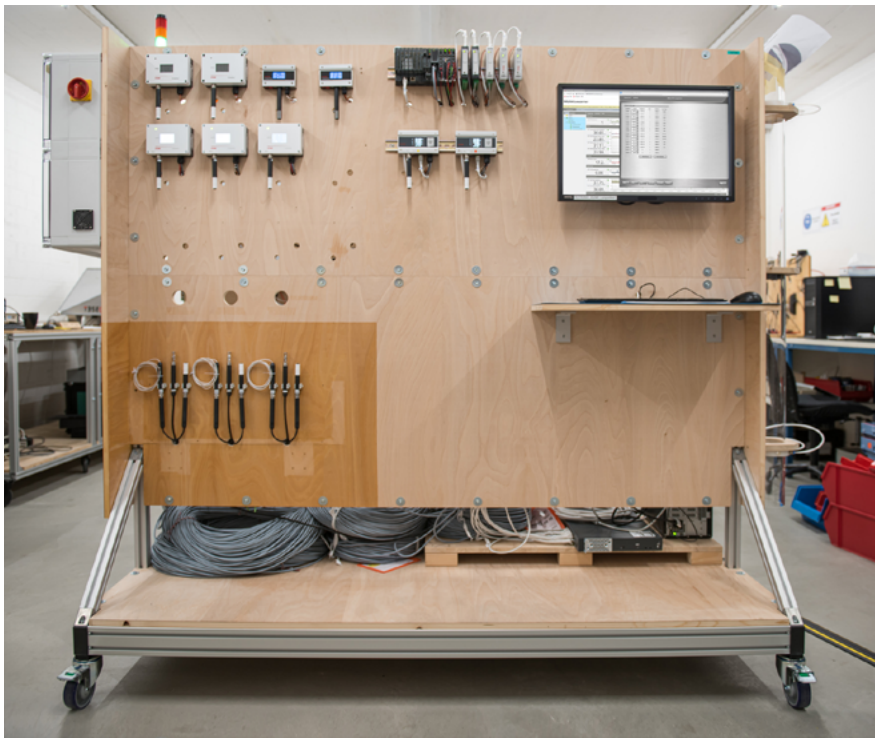
To test and monitor our Modbus-capable devices over the long term, Rotronic built up a testing wall with an applied RS-485 network with Modbus communication, over a total distance of 1200 meters:



Schematic structure of the Rotronic Wall application

Rotronic Modbus wall

The Rotronic test application includes all Rotronic devices that are Modbus RTU capable. The testing wall is designed in such a way, that the devices used are constantly evaluated. The transmission rate (error rate) can be tracked via the integrated monitor.



Rotronic Modbus application wall

Device list

- 2x PF4/PF5
- 3x HF5A-Digital
- 3x RMS-HCD-S
- 3x RMS-HCD-IC102
- 3x RMS-TCD-S-001

Modbus Master

- B&R X20CP1583 with RS-485 module X20IF1030

Bus cable

- VOLLTRON-Twist CY A 2X2X0,25

Modbus communication settings

To ensure smooth communication between Modbus devices on a network, it is crucial that they all have the same communication parameters and unique Modbus device addresses. During initial setup each Rotronic device was programmed individually with a unique address. Rotronic Modbus protocol:

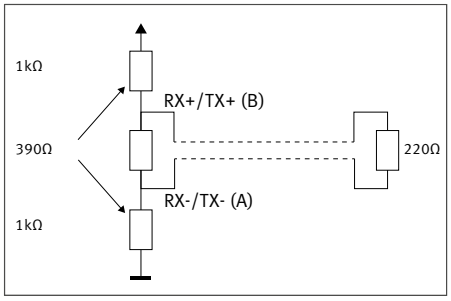
Hardware Overview > Sensors and Probes > HCD-Sx > MODBUS (rotronic.com)

The Modbus protocol utilizes function codes to exchange data between the master and slave devices and each vendor may have different register addresses for the same data due to the vendor-specific nature of Modbus registers. The Rotronic devices only support half-duplex operation, half-duplex is a communication mode which two devices can transmit and receive data, but not simultaneously. In other words, communication is bidirectional but can occur in one direction at a time. The SPS controller is the master and the Rotronic devices are the slaves. When the master requests, the first device can answer, then the second device, and so on.

Modbus cables can support different distances depending on the type of transmission and environment. The distance a Modbus cable can span without amplification depends on factors such as cable type, cable quality, transmission rate, voltage level, ambient temperature, and electromagnetic interference (EMI). For RS-485 Modbus communication using differential signal transmission, cable distances of up to 1200 meters can be achieved.

Up to 1200-meter cables

The dimensioning of terminating and bias resistors:



We have chosen 1 kΩ as bias resistors and 390 Ω respective 220 Ω AS terminating resistors.

Polling interval

The polling interval is defined by the slowest device in this case the PF4/PF5 with 400 ms.
In this application we have 14 devices connected and one polling cycle takes approx. 5.6 seconds.

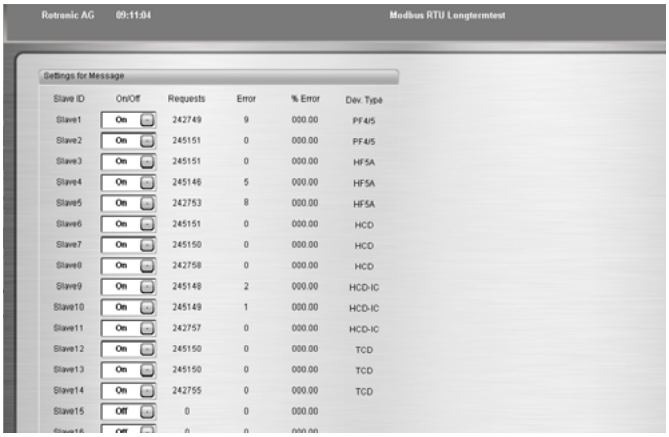
Polling cycle = Number of devices * Polling interval

Device	RMS-HCD-S	RMS-HCD-IC102	RMS-TCD-S-001	HF5A-D1D	PF4/PF5
Polling interval [ms]	250	250	250	250	400

Evaluation of the data

The Modbus wall is in continuous operation and is evaluated with an additional software. The wall simulates pressure changes several times a day, which is realized by a fan. Everyday some devices are switched off and turned on again. In addition, the Rotronic devices are continuously interrogated, and the response behavior is tracked and evaluated:

Out of more than 300'000 requests, only 8 responses were not received, which corresponds to an error rate of 0.002 %.



Monitoring of all devices and values and error counting

Rotronic Modbus device list

Rotronic devices are designed to monitor and control various parameters, such as humidity, temperatures, and differential pressure. The new generation of probes and transmitters are capable to measure these parameters and a Modbus interface for communication with other devices on the network

Device	Interface				Communication		Parameter	Cost
	Analog	Digital	+AC3001	+E2-05XX-MOD	Modbus		Hum/Temp/ Pressure	Budget
RMS-HCD-S	No	UART	USB	RS-485	Yes	RTU	%RH & °C	$$
RMS-HCD-IC	No	UART	USB	RS-485	Yes	RTU	%RH & °C	$$$
RMS-TCD-S	No	UART	USB	RS-485	Yes	RTU	°C	$
PCD-S	No	UART	USB	RS-485	Yes	RTU	Pa	$$
HC2A-S	0...1V	UART	USB	RS-485	Yes	RO-ASCII	%RH & °C	$$
HC2A IC	0...1V	UART	USB	RS-485	Yes	RO-ASCII	%RH & °C	$$$

Device	Probe Type	Interface screw-terminal		Interface LAN (RJ-45)	POE	Commu-nication	Parameter	Cost
		Analog	Digital	Digital		Modbus	Hum/Temp/ Pressure	Budget
HF3	Fixed	Yes	No	No	No	No	%RH & °C	$
HF5	Interchange	Yes	RS-485	Yes	No	RO-ASCII	%RH & °C	$$
PF4/PF5	Interchange	Yes	RS-485	Yes	Yes	RTU &TCP	%RH & °C & Pa	$$$

Additional Guidance

For customers who do not have experience with digital communication, the Rotronic RMS online manual has additional pages with instructions on how to integrate the Rotronic device and start communication. For more detailed discussion please contact the Rotronic PM team.
Help > Practical Topics > Understanding MODBUS > Guidance for MODBUS Communication with the RMS-HCD Digital Probe (rotronic.com)

Conclusion

Customers increasingly seek the most cost effective and efficient solution. Digital communications can present many benefits to our customers. Understanding the basics of Modbus network is vital to support customers and their products.

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