Application Example

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.

This guidance is intended for users who have not worked with Modbus and need a step-by-step instruction on how to connect the HCD-S-MOD (RMS-HCD-S & E2-05XX-MOD) to a computer and getting started with read out data through RS-485 with Modbus RTU protocol:

Delivery Package

- RMS-HCD-S
- E2-05XX-MOD

List of used materials

- RMS-HCD-S
- E2-05XX-MOD
- AC3001
- Luster terminal (3 pol)
- USB-RS485-WE-1800-BT
- Modbus Master software
- RMS-CONFIG
- Hex Converter

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.

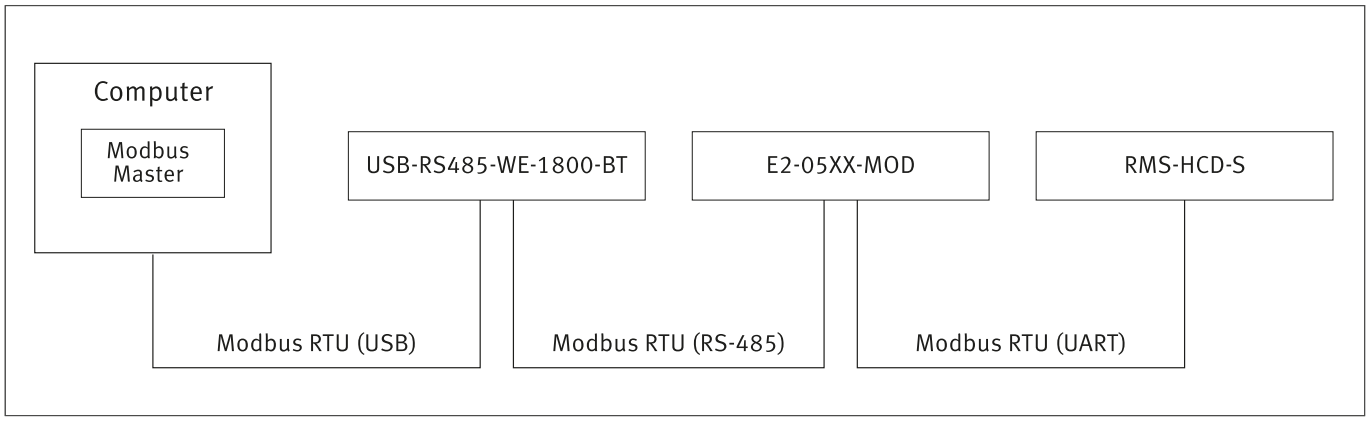
Interface

Per default the RMS-HCD-S has an UART service interface which is converted by the E2-05XX-MODBUS into RS-485. The third-party device US-RS485-WE-1800-BT so then convert the RS-485 signal to USB:

Device	Interface				Communication		Parameter	Cost
	Analog	Digital	+AC3001	+E2-05XX-MOD[1]	Modbus		Hum/Temp	Budget
RMS-HCD-S	No	UART	USB	RS-485	Yes	RTU	%rh & °C	$$

1 Note: Rotronic can only support the RMS-HCD-S in combination with the cable E2-05XX-MOD in use.

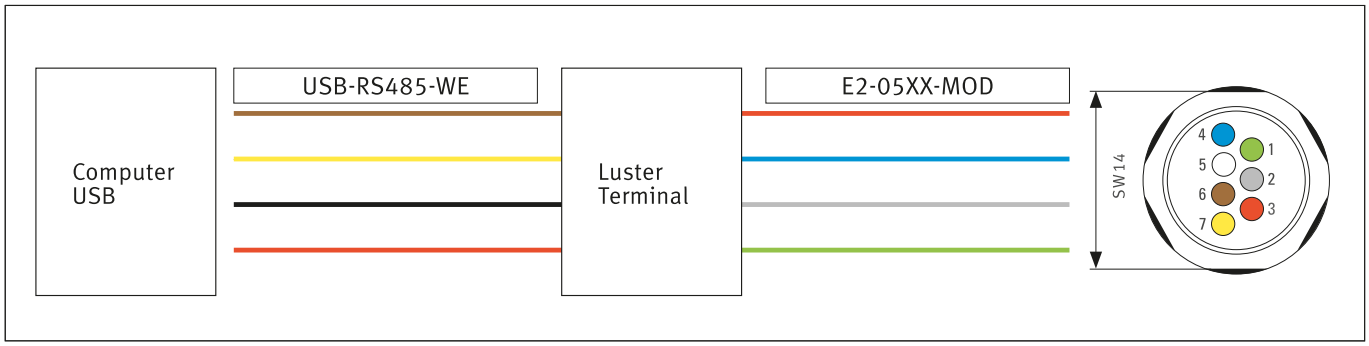
Schematic structure



Wiring

Wiring of the setup

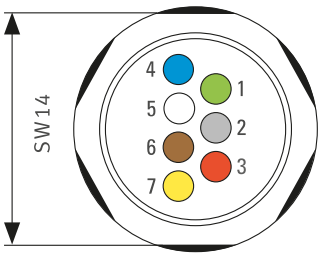
1. Connect the RMS-HCD-S with the E2-05XX-MOD
2. Connect the E2-05XX-MOD with the luster terminal
3. Connect the USB-RS485-WE-1800-BT with the luster terminal
4. Connect the USB-RS485-WE-1800-BT with the USB to computer



Specification

1. RMS-HCD-S

Connection diagram (7-pin connector, male – view: probe side)

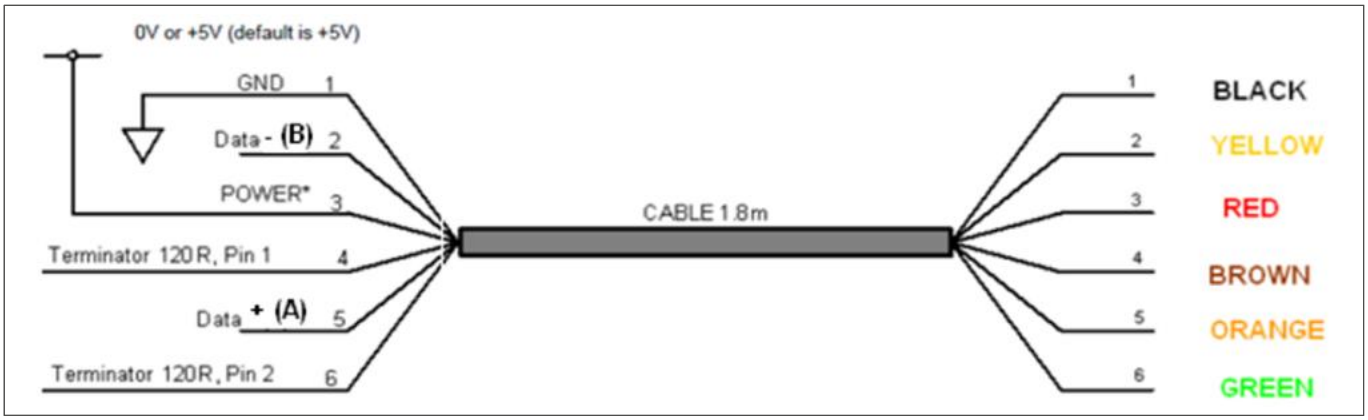


1 V+
2 GND
3 UART RxD
4 UART TxD
5 –
6 –
7 GND

2. E2-05XX-MOD

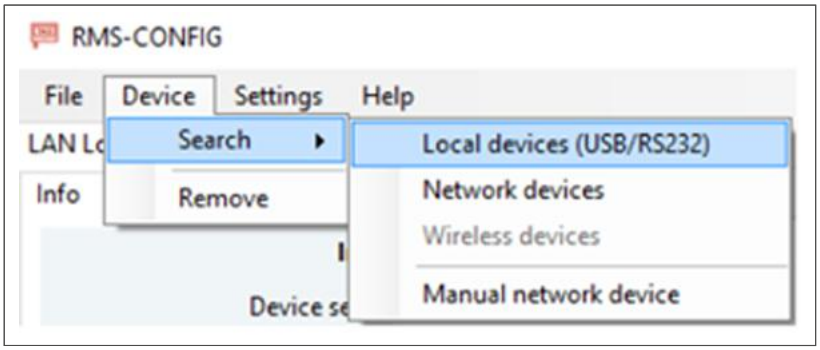
Specifications		
Supply voltage to adapter		5...28 VDC
Supply voltage to probe		3.3 VDC
Current consumption (includes HC2 probe)		10 mA typical
RS-485 specifications		Baud rate: 19'200 / Parity: none / Data bits: 8 / Stop bits: 1
Electrical installation		
Green	VDD (+)	Power supply +
Grey	GND	Power and digital signal
Red	RXD	RS-485 bi-directional TX+ / RX+
Blue	TXD	RS-485 bi-directional TX- / RX-

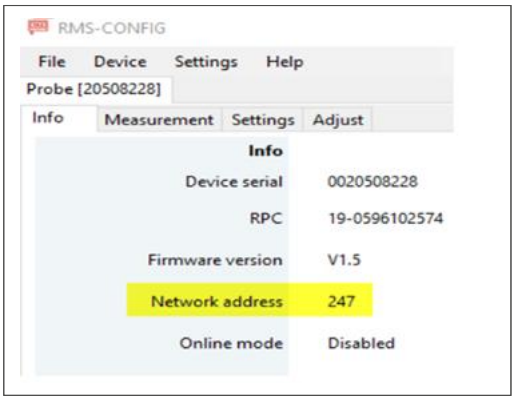
3. USB-RS485-WE-1800-BT



Setup the Modbus address

Review the RMS-HCD-S Modbus address of the RMS-HCD-S probe with the RMS-CONFIG software. Plug the RMS-HCD-S into the AC3001 cable and add a local device, per default the probe address is 247:



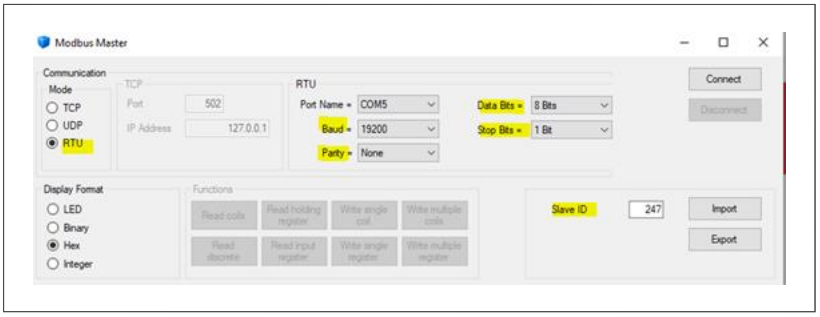


Modbus Master software

Modbus Tool-Master

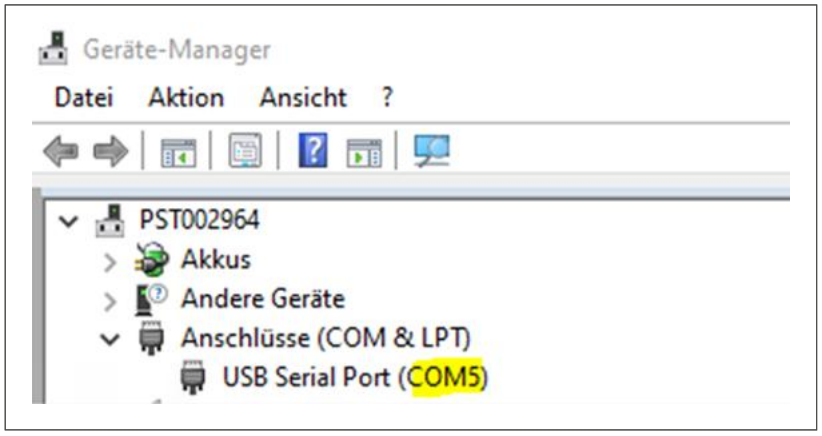
The Modbus Master software is a third-party software which we can use to start communication with the connected RMS-HCD-S. To communicate with the systems, the following information must be set up:

1. Modbus RTU
2. Baud rate 19’200
3. Parity: none
4. Data bits: 8
5. Stop bits: 1
6. Slave ID: 247

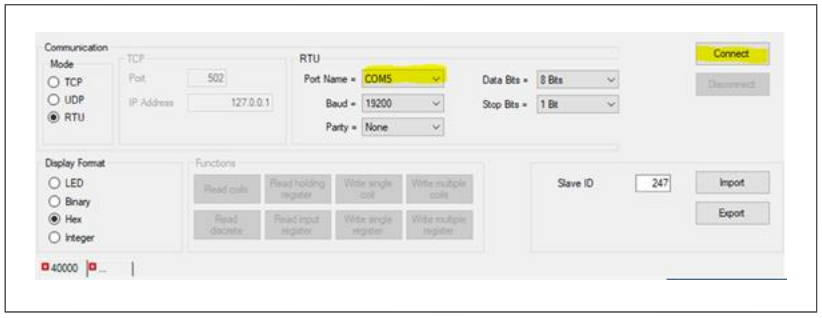


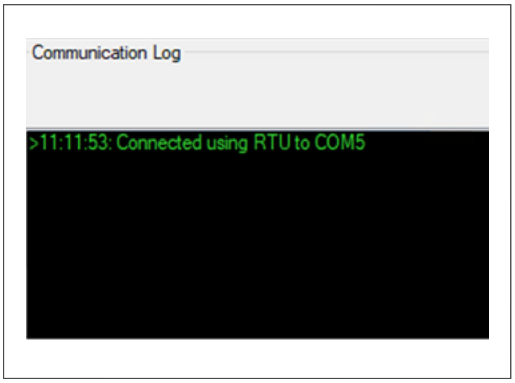
Port Name

Before the communication can be started, the port name must be determined. For this, you can check the ports within the Device-Manager on your local computer:



Connect the Modbus Master software





Read out data

The Modbus address overview can be reviewed here: **MODBUS**
The addresses 31000 and 31004 are the humidity & temperature values.

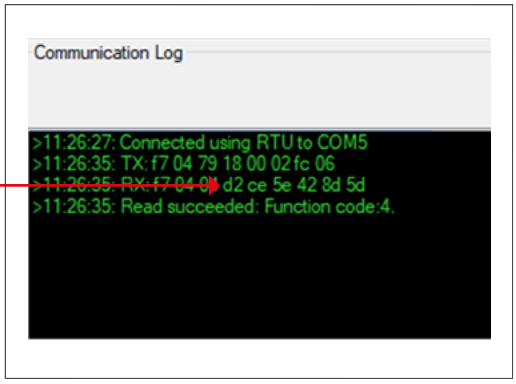
NOTE: RS485 address is the register address -1!

Add the start address 31000, Size 4, Display Format hex, press Apply and then Read Input register:

Register	Name	Description	Data type
31'001	Humidity	• Current humidity value (part 1)	Float 32 Bit
31'002		• Current humidity value (part 2)	
31'003	Temperature	• Current temperature value (part 1)	Float 32 Bit
31'004		• Current temperature value (part 2)	
31'005	Calculation	• Current calculation value (part 1)	Float 32 Bit
31'006		• Current calculation value (part 2)	
31'007	Measurement flags Humidity	• Current measurement flags humidity	Int. 16bit
31'008	Measurement flags Temperature	• Current measurement flags temperature	Int. 16bit

Read Current Float Value (Registers 31'001 to 31'008)

Data received from system:
31000: 0xd2ce
31001: 0x5e42



Data format received

The data format, or also called swap mode. The standard setting is 0x0001 with target bytes d c b a:

Value	Swap Mode	Source Bytes	Target Bytes
0x0000	Big endian - No Swap	[a b] [c d]	[a b c d]
0x0001	Little endian - byte and word swap	[a b] [c d]	[d c b a]
0x0002	Mid-big endian - byte swap	[a b] [c d]	[b a d c]
0x0003	Mid-little endian - word swap	[a b] [c d]	[c d a b]

Address	Source Bytes	Target Bytes
31000	[a b] d2ce	[d c b a] 0x425eced2
31001	[c d] 5e42	

Interpretation of received data

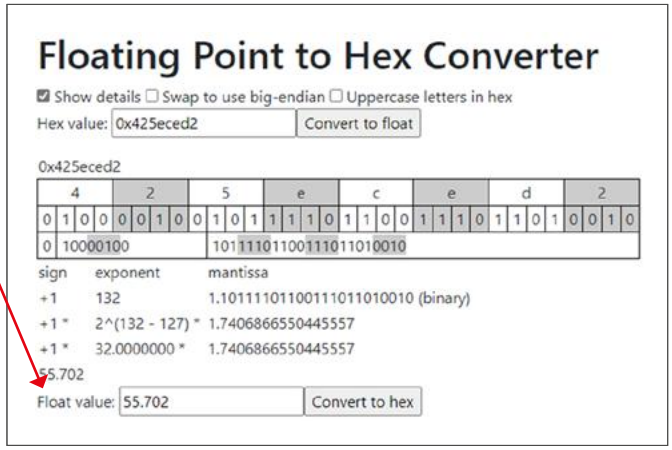
The received data in hex format must be converted into a float format with decimal values.
We use a third-party calculator which can be downloaded under Floating Point to Hex Converter (gregstoll.com):

Register	Name	Description	Data type
31001	Humidity	Current humidity value (part 1)	Float 32 Bit
31002		Current humidity value (part 2)	

The hex value 0x425eced2 is in decimal floating data format 55.7 %rh.

Target Bytes
0x425eced2

Target Bytes
55.7 %rh



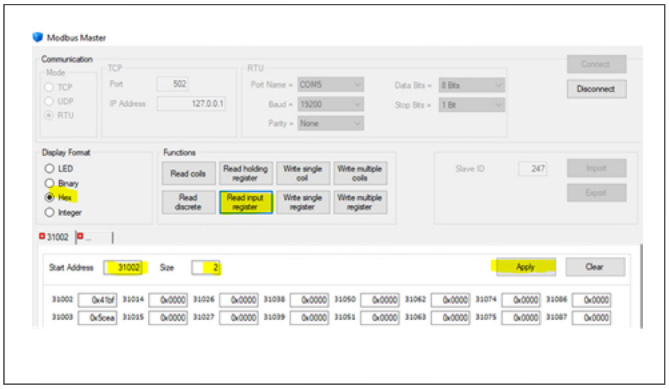
Read out temperature values

The addresses 31003 and 31004 are the humidity values.

NOTE: RS485 address is the register address -1!
Add the start address 31002, Size 2, Display Format hex, press Apply **and then** Read Input register:

Register	Name	Description	Data type
31'001	Humidity	• Current humidity value (part 1)	Float 32 Bit
31'002		• Current humidity value (part 2)	
31'003	Temperature	• Current temperature value (part 1)	Float 32 Bit
31'004		• Current temperature value (part 2)	
31'005	Calculation	• Current calculation value (part 1)	Float 32 Bit
31'006		• Current calculation value (part 2)	
31'007	Measurement flags Humidity	• Current measurement flags humidity	Int. 16bit
31'008	Measurement flags Temperature	• Current measurement flags temperature	Int. 16bit

Read Current Float Value (Registers 31'001 to 31'008)

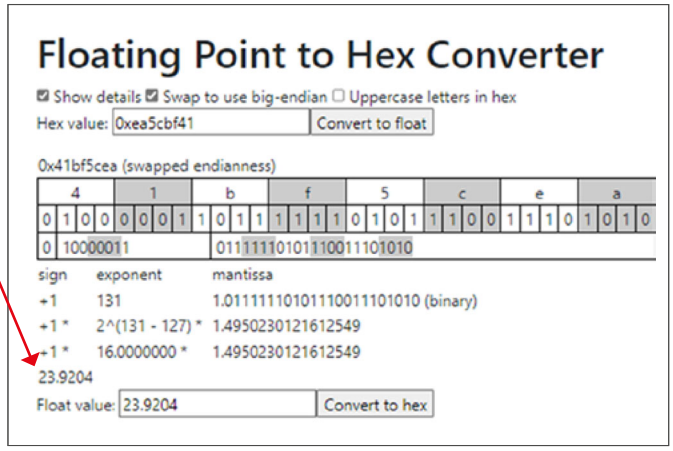


Address	Source Bytes	Target Bytes
31002	[a b] 41bf	[d c b a] 0xea5cbf41
31003	[c d] 5cea	

The hex value 0xea5cbf41 is in decimal floating data format 23.9 °C

Target Bytes
0xea5cbf41

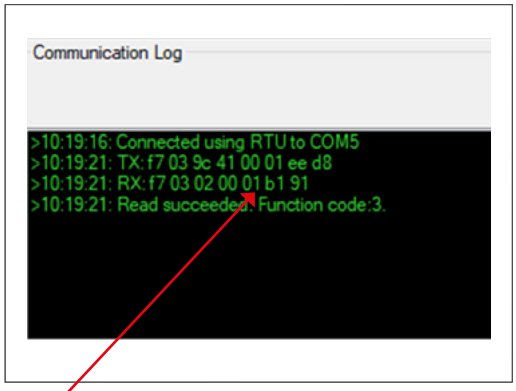
Target Bytes
23.9 °C



Change data format

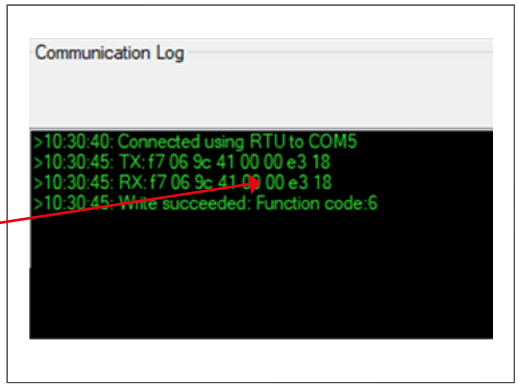
Before we can change the data format, we must read out the actual byte-swap format.
The addresses 40001 show the actual byte-swap format:

NOTE: RS485 address is the register address -1!

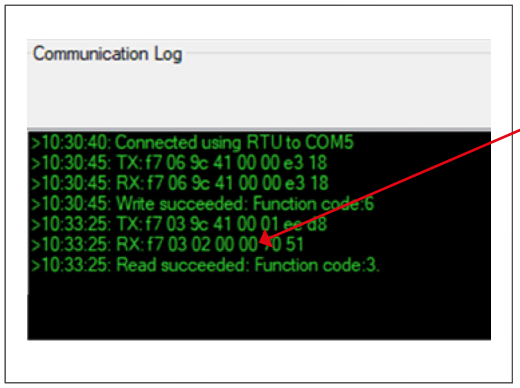


Value	Swap Mode	Source Bytes	Target Bytes
0x0000	Big endian - No Swap	[a b] [c d]	[a b c d]
0x0001	Little endian - byte and word swap	[a b] [c d]	[d c b a]
0x0002	Mid-big endian - byte swap	[a b] [c d]	[b a d c]
0x0003	Mid-little endian - word swap	[a b] [c d]	[c d a b]

Change to data format to 0x0000
Add the start address 40001, Size 1, Display Format hex, write into the address box a “0”, press Apply and then Write single register:



Read again the holding register of address 40001 and system has changed data format:



Value	Swap Mode	Source Bytes	Target Bytes
0x0000	Big endian - No Swap	[a b] [c d]	[a b c d]
0x0001	Little endian - byte and word swap	[a b] [c d]	[d c b a]
0x0002	Mid-big endian - byte swap	[a b] [c d]	[b a d c]
0x0003	Mid-little endian - word swap	[a b] [c d]	[c d a b]

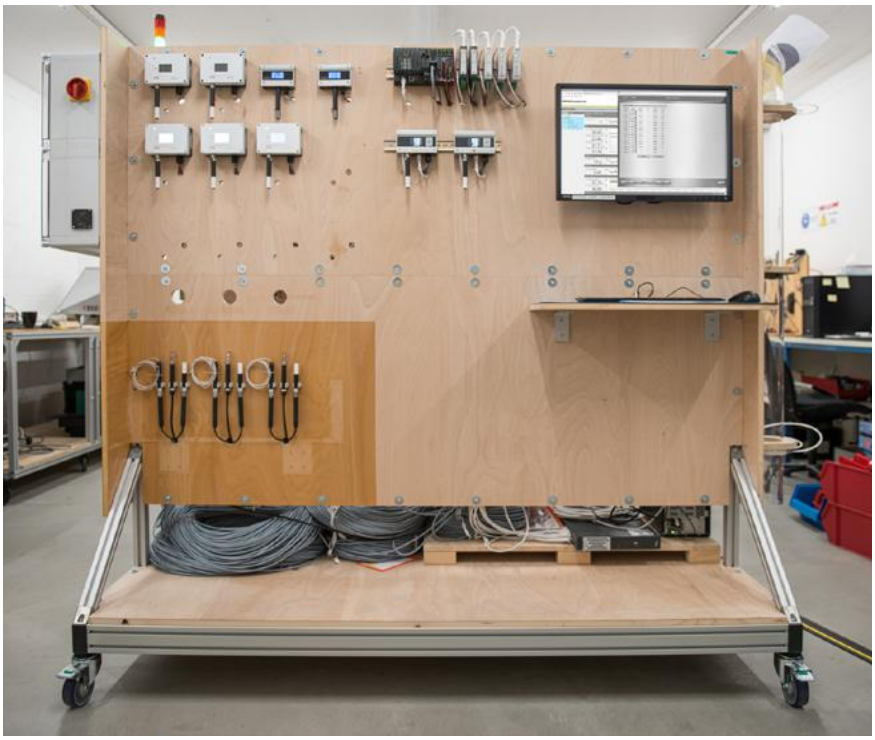
Read out humidity values again

Address	Source Bytes	Target Bytes
31002	[a b] c1f7	[d c b a] 0xc1f74c42
31003	[c d] 4c42	

Target Bytes
51.24 %rh

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

Rotronic Modbus wall

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:

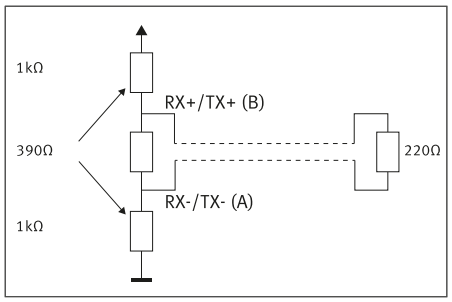
Hardware Overview > Sensors and Probes > HCD-Sx > MODBUS (rotronic.com)

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.

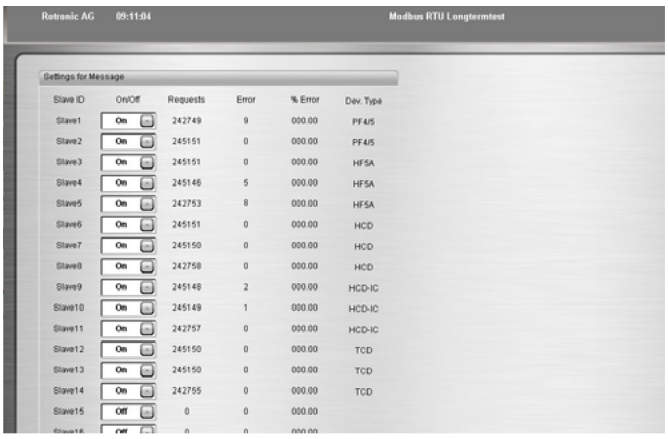
Polling cycle = Number of devices * Polling interval

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	$$$
PCMini52	0...1/5/10V	RS-485	No	No	Yes	RTU	%rh & °C	$
PC62 & PC62V	0...1/5/10V	RS-485	No	No	Yes	RTU	%rh & °C	$$

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.

53041E/2024-05