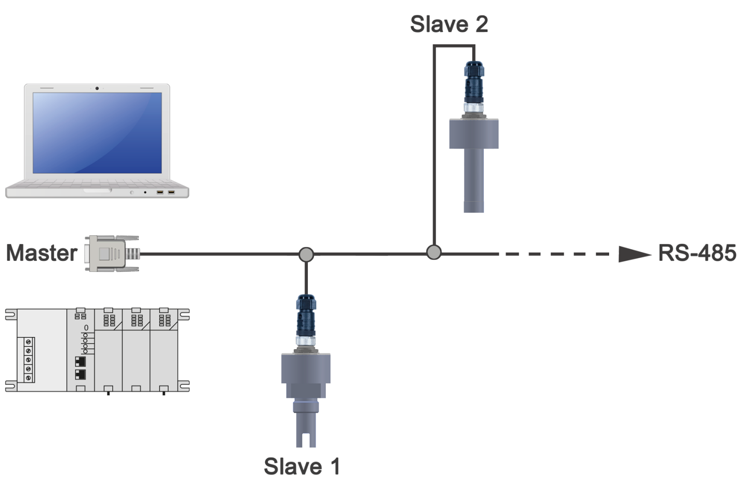
Martens
Member of GHM GROUP

EN

MODBUS RTU

Digital sensors



Members of GHM GROUP:
GREISINGER
HONSBERG
Martens
IMTRON
Delta OHM
VAL.CO

Table of contents

List of figures

List of tables

1 About this documentation

1.1 Foreword

Read this document carefully and familiarise yourself with the operation of the product before you use it. Keep this document ready to hand and in the immediate vicinity of the product so that it is available to the personnel/user for reference at all times in case of doubt.

The product was developed according to the state of the art and fulfils the requirements of the applicable European and national Directives. All corresponding documents are available from the manufacturer.

Only technically qualified persons are permitted to carry out commissioning, operation, maintenance and decommissioning. The qualified personnel must have carefully read and understood the operating manual before beginning any work.

1.2 Purpose of the document

This document describes the MODBUS protocol for use with digital sensors. This is a communications protocol based on a master/slave or client/server architecture.

1.3 Legal notices

This document is entrusted to the recipient for personal use only. Any impermissible transfer, duplication, translation into other languages or excerpts from this operating manual are prohibited.

The manufacturer assumes no liability for print errors.

1.4 Correctness of content

The contents of this document were checked for corrected and are subject to a continuous correction and updating process. This does not rule out potential errors. In the event that errors are discovered or in case of suggestions for improvement, please inform us immediately via the indicated contact information in order to help us make this document even more user-friendly.

2 Bases for measurement

2.1 Explanation

The MODBUS protocol is a communications protocol based on a master/slave or client/server architecture. The protocol should primarily enable simple, reliable and fast communication between automation and field devices. It is a proven field bus that is resistant to interference and can be implemented affordable with these requirements. With the manufacturer-independent data structure, the communications exchange between devices from different manufacturers does not pose any problems.

If multiple measurements are detected by a measuring transducer, the wiring installation work increased for each measurement with analogue transmission technology. An alternative is the use of digital bus systems that makes it possible to implement measurement recording and parameterisation centrally via an interface.

3 RS485

3.1 Description

The MODBUS devices are connected to each other via an RS485 interface (EIA-485). This is an interface standard for wired, differential data transmission, wherein multiple senders / receivers can be connected to a wire pair. A half-duplex-capable 2-wire bus is used for the present products. Because only one transmission path is available, only one participant can send data. The RS485 2-wire bus consists of the actual bus cable with a maximum length of 1200m according to the drawing. The third line, which is also identified as C / C' is used as a reference conductor.

A master, PLC / operating panel / PC and a maximum of 32 slaves are provided for the present bus system. The maximum number of slaves can be increased by segment coupler. The individual slaves are arranged in line and/or bus topologies. This means that line A, which is frequently identified as A/A' is routed from the first product to the second, from the second to the third, etc. The same applies for line B, which is identified as B/B'. The linear arrangement of the bus is optimal. Short branch lines of 1 to 5m are frequently used in practice. Then the transmission speed should be moderate.

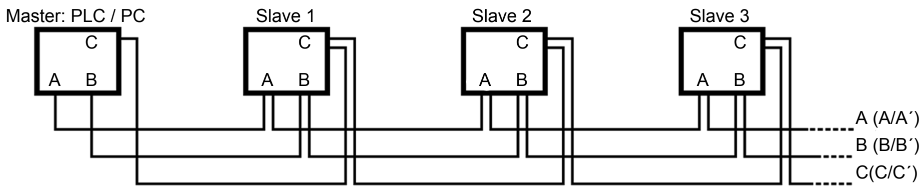


Fig. 1: **RS485 communications diagram without terminating resistor Rf**

3.2 Terminating resistors

Line reflections always occur at the first and last participants in a bus system as a result of the open cable ends. They are intensified as the selected baud rate increases. In order to minimise the reflections, a terminating resistor is used. A defined resting potential is achieved with the pull-up/down resistors.

In practice, 150 Ω for the terminating resistors and 390 Ω for the pull-up/down resistors have been beneficial. However, a general statement cannot be made, because this depends on many parameters, such as the master/slaves that are used, the number, cable lengths, cable type or transmission speed. Consequently, the user must simply test different values.

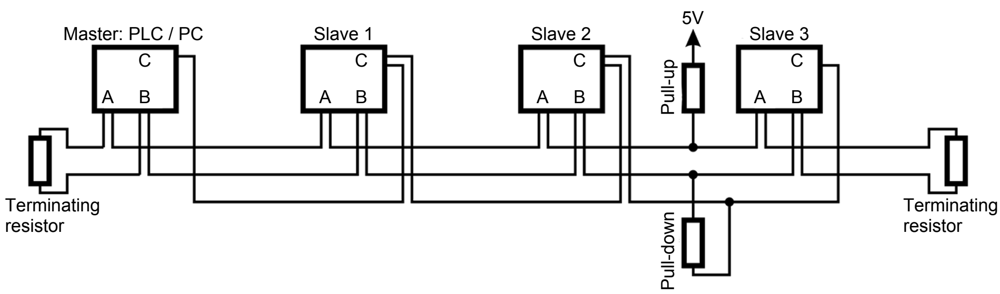


Fig. 2: **RS485 communications diagram with terminating resistor Rf**

3.3 Reference conductor

Many products from third-party providers, including RS485 interface converters for PCs do not lead outward line C, which is also referred to as common or reference conductor, outwards. This does not correspond to the recommendations of the MODBUS *over serial line specification and implementation guide*. Because the differential signal between A/A' and B/B' is evaluated, the communication still functions if the reference conductor is left.

3.4 RS485 connection to a master

Many PLCs have an RS485 interface. If the appropriate driver for MODBUS RTU or ASCII is also present, a simple connection is possible. The same applies for various operating panels that frequently support MODBUS RTU / ASCII via RS485 by default. See RTU transmission modes [▸ p. 9].

However, a standard PC can be used as a master. RS485 interface cards of third-party providers are also available for this purpose. There are also several external interface converters, such as RS232 to RS485 or USB to RS485. We recommend choosing solutions that galvanically isolate the BUS system and the actual PC interface. Refer to the documentation of the relevant devices for the connection assignments of the master interfaces.

3.5 Connection of a digital measuring transducer

The products have an 8-pin round plug connector with the following pin assignment:

Pin assignment

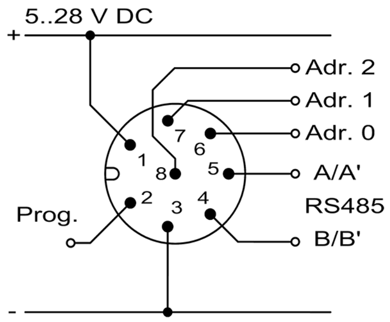


Fig. 3: **RS485 connection**

PIN	Signal
1	+ Supply voltage
2	Prog. connection
3	- Supply voltage, C/C dimension
4	Bus line B/B'
5	Bus line A/A'
6	Addr. 0
7	Addr. 1
8	Addr. 2

Tab. 1: Cable colour assignment

4 MODBUS

4.1 Master-slave process

The data is transmitted via MODBUS protocol. Communication takes place according to the master-slave process. Communication is always begun by the master, PC, PLC, etc. with a query. Each slave has a uniquely assigned address. The value range of the address is 1 to 247. If a slave recognises that its address was contacted by the master, it reacts accordingly. Then the salve always sends an answer. The slaves never communicate with each other. They are also incapable of starting a communication with the master.

4.2 Timeout

After a query, the master awaits an answer of a slave. A timeout function is implemented in the process. This prevents the master from waiting perpetually if a slave has been removed from the bus, has not operating voltage or another error has occurred.

4.3 Frame

The data to be transmitted is always within a specified frame and is defined as follows:

Field 1	**Field 2**	**Field 3**	**Field 4**
Address	Function code	Data	CRC

Tab. 2: MODBUS frame

Field 1	Address	Address of the slave, valid range of 1 to 247_{Dec}
Field 2	Function code	Specification of reading or writing of the parameter
Field 3	Data	Master -> Which parameters are queried Slave -> Content of the queried parameters
Field 4	CRC	Cyclical redundancy check. Check value for data in order to recognise errors in the data transmission

4.4 Function codes

Several function codes are defined in MODBUS. They are as follows:

Function code		**Name**	**Description**
03_{Dec}	03_{Hex}	Read Hold Register	Read product parameters, integer / float
04_{Dec}	04_{Hex}	Read Input Register	Read actual value, integer / float
06_{Dec}	06_{Hex}	Write Single Register	Write product parameters by word
16_{Dec}	10_{Hex}	Write Multiple Register	Write multiple product parameters by word

Tab. 3: MODBUS function codes

4.5 RTU transmission modes

The individual bytes are coded to 8 bit binary in RTU mode. A byte consist of 11 bits, because, for example, start / stop bits are used. The parity is used for recognition of an incorrectly transmitted sequence of bits. Parity identifies the number of the bits assigned with 1 in the information word and means even, if the number of these bits is even; otherwise, odd. If parity is not used, a byte still consists of 11 bits, but an additional stop bit is attached.

Example with parity recognition

Start bit	BIT 1	BIT 2	BIT 3	BIT 4	BIT 5	BIT 6	BIT 7	BIT 8	Parity	Stop bit

Example without parity recognition

Start bit	BIT 1	BIT 2	BIT 3	BIT 4	BIT 5	BIT 6	BIT 7	BIT 8	Stop bit	Stop bit

Then a frame appears as follows in RTU mode:

Field 1	Field 2	Field 3	Field 4
Address	Function codes	Data	CRC
1 byte	1 byte	0 to 252 bytes	2 bytes, low / high

Tab. 4: MODBUS RTU transmission modes

A minimum pause of 3.5 characters must be provided between the frames so that the end of a message is recognised; RTU always uses CRC, field 4.

4.6 Register

MODBUS specifies that the data is stored in different registers. Registers store 2 bytes each. The following different types of register are used:

Register number/ address	Type	Name	Description
30001 – 34999	Read	Input registers	Input registers, measurements of the measuring transducer
35001 – 39999	Write	Commands	Commands trigger specific actions to the product
40001 – 49999	Read and write	Output holding registers	Holding register for parameters, product configuration, etc.

Tab. 5: MODBUS register

4.7 Parameters table

Each slave has a parameters table and an actual value table. These tables can be used to determine the addresses under which the parameters are found.

The data type column indicates the format in which a parameter / actual value can be written or read. The authorisation column indicates whether a parameter / actual value can only be read (R) or can be read and written (R/W).

Excerpt from a parameters table:

Address register	Parameter name	Value range	Meaning	Date type	Authorisation
40001	Language	0 ... 1	0: English 1: English	UNIT16	R/W
40002	Contrast	0 ... 100	[%]	UNIT16	R/W
40003	Decimal places	0 ... 3	0: 0000 1: 000.0 2: 00.00 3: 0.000	UNIT16	R/W

Tab. 6: MODBUS parameters table

Excerpt from an actual table:

Address register	Parameter name	Value range	Meaning	Date type	Authorisation
30001	Actual value 1	-9999 ... 9999	Float	R	30001
30003	Actual value 2	-9999 ... 9999	Float	R	30003
30005	Minimum actual value buffer	-9999 ... 9999	Float	R	30005
30007	Maximum actual value buffer	-9999 ... 9999	Float	R	30007

Tab. 7: MODBUS actual value table

4.8 Addresses of parameters

The register addresses are found in the tables above. A PLC or operating panel normally works with the register addresses.

4.9 Date type

The relevant data type can be found in the parameters table and the actual value table.

Date type	Description
INIT16	16 bit integer value with arithmetic symbol. The INT16 value occupies 1 Value range from -32768 to 32767
UNIT16	16 bit integer value without arithmetic symbol. The UNIT16 value occupies 1 Value range from 0 to 65535
FLOAT	32 bit floating comma number; representation takes place according to IEEE 754 / IEC-60559 The float value occupies 2 register

Tab. 8: MODBUS data type

4.10 Error messages

The slave answers with error messages if, for example, the master accesses parameter addresses that are not defined. This also applies if the master sends values to the slave that are outside of the defined value range, e.g. the master requests 4 decimal places, but only a maximum of 3 is possible.

In case of an error, the slave sends the following telegram:

Field 1	Field 2	Field 3	Field 4
Address	Function code + 80 HEX	Error code	CRC

80_{HEX} were added to the function code used in the query from the master. Then the master can immediately recognise that there is an error and then evaluate Field 3 with the error code.

NOTE

If there is an error, the BUS LED blinks on the front of the product blinks.

Error code	MODBUS designation	Description
01_{HEX}	Illegal function	Unsupported function code
02_{HEX}	Illegal data address	Product parameter not present
03_{HEX}	Illegal data value	Write access outside of the weather report or parameter is write-protected

4.11 Telegram example

The master should read the maximum actual value buffer of a slave with the address 1_{Dec}, which corresponds to 01_{Hex}. Code no. 04_{Hex} is used here. The maximum value in the slave is under the address 06_{Hex}. Because the actual value buffer is a FLOAT, 2 registers must be read.

Master query

The following applies for the frame:

Field 1	Field 2	Field 3	Field 4
Address	Function code	Data	CRC

As a result, the master generates the following query:

Field 1	Field 2	Field 3	Field 4
01_{Hex}	04_{Hex}	00_{Hex} 06_{Hex} 00_{Hex} 02_{Hex}	91_{Hex} CA_{Hex}

Interpretation of the data in field 3:

00_{Hex} 06_{Hex}	$(00\ 06)_{Hex}$	Start address 6
00_{Hex} 02_{Hex}	$(00\ 02)_{Hex}$	Reading register 2

Slave answer

The slave with the address 1 answers as follows:

Field 1	Field 2	Field 3	Field 4
01_{Hex}	04_{Hex}	04_{Hex} 00_{Hex} 00_{Hex} 41_{Hex} 10_{Hex}	CA_{Hex} 18_{Hex}

Interpretation of the data in field 3:

00_{Hex} 00_{Hex} 41_{Hex} 10_{Hex}	$(00\ 00\ 41\ 10)_{Hex}$	Float actual value 2

The 32 bit hexadecimal number $(00\ 00\ 41\ 10)_{Hex}$ results in Modbus byte sequence 9.000.

4.12 Word sequence

Floating comma numbers are represented in IEEE-754 format as usual. It consists of 4 bytes that are described as the byte sequence ABCD. Modbus uses the IEEE-754 format with the difference that the low word and the high word are interposed. The Modbus format is also described with CDAB.

The field for the addresses and function codes remains unaffected by this, because this only affects the LONG and FLOAT numbers.

Example

	Field 1	**Field 2**	**Field 3**		**Field 4**
Format	Address	Function code	Data		CRC
			Number of bytes	FLOAT number	
Modbus	01_{Hex}	04_{Hex}	04_{Hex}	$D4_{Hex}$ 96_{Hex} *$C1_{Hex}$* *$8B_{Hex}$*	33_{Hex} AF_{Hex}

Tab. 9: MODBUS word sequence

The 32 bit FLOAT number –17.4788017 is represented in IEEE-754 format as 0x*C18B* D496 (*AB* CD).

In Modbus format, the sequence changes to 0xD496 *C18B* (CD *AB*).

4.13 Baud rate

The baud rate specifies the step speed of a data transmission. This must be the same for all participants in the bus system for both the master and the slaves. Baud rates with 1200, 2400, 4800, 9600 and 19200 baud are supported.

4.14 Additional information

Additional information about the MODBUS protocol can be found only in the freely accessible specifications of the Modbus user organisation at http://www.modbus.org.

- MODBUS application protocol specification
- MODBUS over serial line specification and implementation guide

These documents also explain how, for example, the CRC calculation is carried out.

5 Bus configuration

5.1 Configuration of the master

Simple access is possible with the appropriate PLC / panel configuration and programming software tools. Only the configuration of the bus system (which baud rate, which type of parity is used, etc.) must be created. Configuration of which parameters must now be read / written and in which format they are provided must also take place. Telegram structure, or CRC calculations, are no longer relevant for the user in this case.

A standard PC can be used as a master. This is interesting, for example, if multiple devices should always be parameterised with the same configuration or a simple visualisation should be implemented. The data can also be used again with appropriate software in table calculations. This enables simple logging of the data and further processing at a later time. A host of software solutions form third-party providers are available for this purpose.

Based on the multitude of solution possibilities, the actual programming is not covered further in the scope of this documentation.

5.2 Configuration of the measuring transducer

If the bus is parameterised according to the standard setting of the sensor, only the device addresses have to be adapted with multiple equivalent sensors.

If this takes place via the address lines, the device can communicate without additional configuration with the system. Parameterisation of the further parameters can take place in the system.

Alternatively, the parameterisation can take place with the free software tool GHM-*ware* and the EYY220 programming adapter.

NOTE

Digital sensors have standard preconfigured factory settings. Therefore, they must be adapted to the specific application. Configuration and parameters tables are described in the relevant operating manual.

NOTE

Address assignment, standard bus configuration and the storage of parameters do not correspond to the general MODBUS specifications and are explained in the operating manual of the relevant digital sensor.

6 Service

6.1 Manufacturer

If you have any questions, please do not hesitate to contact us:

Contact

GHM Messtechnik GmbH
GHM GROUP - Martens
Kiebitzhörn 18
22885 Barsbüttel | GERMANY
Email: info@ghm-group.de

6.2 Sales offices

North Sales Office

Post code:	00000 – 25999 | 27000 – 34999
	37000 – 39999 | 98000 – 99999
Email:	vertrieb-nord@ghm-messtechnik.de
Tel:	+49 4067073-0
Fax:	+49 4067073-288

West Sales Office

Post code:	26000 – 26999 | 35000 – 36999
	40000 – 69999
Email:	vertrieb-west@ghm-messtechnik.de
Tel:	+49 2191 9672-0
Fax:	+49 2191 9672-40

South Sales Office

Post code:	70000 – 97999
Email:	vertrieb-sued@ghm-messtechnik.de
Tel:	+49 9402 9383-52
Fax:	+49 9402 9383-33

6.3 Sales subsidiaries

Austria
GHM Messtechnik GmbH
Office Austria
Breitenseer Str. 76/1/36
1140 Vienna | AUSTRIA
Phone +43 660 7335603
a.froestl@ghm-messtechnik.de

Brazil & Latin America
GHM Messtechnik do Brasil Ltda
Av. José de Souza Campos, 1073, cj 06
Campinas, SP
13025 320 | BRAZIL
Phone +55 19 3304 3408
Info@grupoghm.com.br

Czech Republic / Slovakia
GHM Greisinger s.r.o.
Ovci hajek 2 / 2153
158 00 Prague 5
Nove Butovice | CZECH REPUBLIC
Phone +420 251 613828
Fax +420 251 612607
info@greisinger.cz | www.greisinger.cz

Denmark
GHM Maaleteknik ApS
Maarslet Byvej 2
8320 Maarslet | DENMARK
Phone +45 646492- 00
Fax +45 646492- 01
info@ghm.dk | www.ghm.dk

France
GHM GROUP France SAS
Parc des Pivolles
9 Rue de Catalogne
69150 Décines-Charpieu (Lyon) | FRANCE
Phone +33 4 72 37 45 30
a.jouanilou@ghm-group.fr

India
GHM Messtechnik India Pvt Ltd.
209 | Udyog Bhavan | Sonowala Road
Gregaon (E) | Mumbai - 400 063
INDIA
Phone +91 22 40236235
info@ghmgroup.in | www.ghmgroup.in

Italy for Greisinger & Delta OHM
GHM GROUP – Delta OHM
Via Marconi 5
35030 Caselle di Selvazzano
Padova (PD) | ITALY
Phone +39 049 8977150
a.casati@ghm-messtechnik.de

Italy for Honsberg, Martens, Val.co
GHM GROUP – Val.co
Via Rovereto 9/11
20014 S. Ilario di Nerviano
Milano (MI) | ITALY
Phone +39 0331 53 59 20
alessandro.perego@valco.it

Netherlands
GHM Meettechniek BV
Zeeltweg 30
3755 KA Eemnes | NETHERLANDS
Phone +31 35 53805-40
Fax +31 35 53805-41
info@ghm-nl.com | www.ghm-nl.com

South Africa
GHM Messtechnik SA (Pty) Ltd
16 Olivier Street
Verwoerdpark, Alberton 1453
SOUTH AFRICA
Phone +27 74 4590040
j.grobler@ghm-sa.co.za