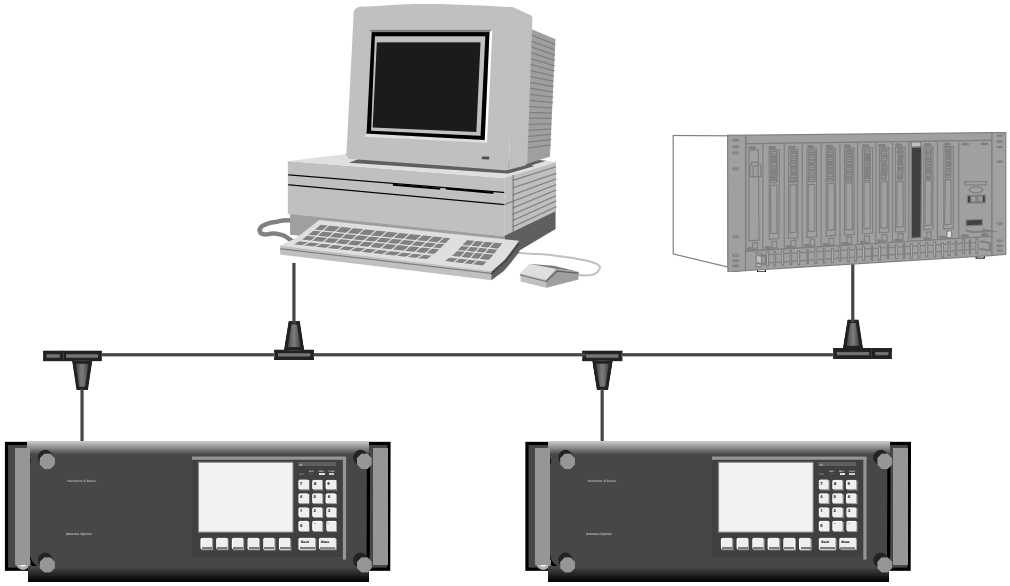
Advance Optima

Modbus

Functions and Components

Technical Information 30/24-310-1 EN



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Chapter 1 Overview

Introduction

Description

The Advance Optima Modbus is used to transfer information from the analyzer to a PLC, DCS or any other device that has an appropriate interface. Measurement values, status signals and also signals of analog and digital inputs and outputs are thus available for further usage.

In accordance with Optima M-DDE the signals can be integrated into standard software under Windows 95/NT (e.g. Excel, Visual Basic or LabView). You can obtain the Windows-driver Optima M-DDE for free at ABB Analytical.

RTU mode

This Technical Information is based on the Gould Modbus Protocol Reference Guide (January, 1985). The Advance Optima devices support the Modbus slave protocol with RTU (Remote Terminal Unit) mode.

Two interfaces

Two interfaces are available, where only one can be operated at a time.

- RS-485
- RS-232C (Advance Optima software version ≥ 1.2)

Both versions are explained in Chapter 2.

	Read	Write	Example
Measurement values	x	–	CO, NO, H_2, etc.
Digital Inputs	x	–	for indication of external status signals
Digital Outputs	x	–	for control of solenoid, pumps, etc.
Analog Inputs	x	–	for indication of mA-values of external analyzers
Analog Outputs	x	–	for indication of mA-values of measurement values or calculated values (function block application)
Modbus Digital Inputs	x	x	for control of Advance Optima functions as auto calibration, measuring range control, etc. after function block configuration
Modbus Digital Outputs	x	–	for indication of all functions such as alarm signaling etc. integrated by function block configuration
Status	x	–	indication of error, maintenance mode, maintenance request

Modbus-Frames and Functions

Data transfer

For data transfer a combination of frames is used, that consists of 1/0 information, united to one or more telegrams.

Frame

The transfer values are decomposed in bytes (= 8 bit). Each of these bytes is completed by one start-bit, possibly one parity-bit (even number of „1“) and one stop-bit. In the following description the term „byte“ will be used, even if ten or eleven bits will be transferred including the start-, stop- and parity-bits.

Telegrams

The Modbus-telegrams consist of the following frames:
address (1 byte), function (1 byte), data (n bytes) and check sum (2 bytes).

The telegrams also take on the „shake-hands-function“: each telegram from master to slave must be responded, before a new telegram is allowed to be transmitted. The computer has to have in a adequate supervision, for excluding non answering bus participants (time-out-supervision).

Admissible addresses

As addresses for the participants of the bus the numbers 1...255 are admitted.

The address 0 is the global address (broadcast-address). When this address will be used in a telegram, all participants accept this telegram without an acknowledgment to the master.

Functions

Code	Term	Function
01	Read coil status	Reading of binary values of type coil
02	Read input status	Reading of binary values of type status
03	Read holding registers	Reading of 16 bit holding-registers
04	Read input registers	Reading of 16 bit input-registers
05	Force single coil	Setting of a single binary value
06	Preset single register	Set of a single 16 bit-register; for DINT or REAL two telegrams are necessary
08	Loopback diagnostic test	Testing telegram for diagnostics of the communication capability of slave
15	Force multiple coils	Set of several successive binary values
16	Preset multiple registers	Set of several successive 16 bit-registers

Check sum

The check sum is calculated over all bytes of one telegram without the start-, stop- and parity-bits.

Transfer rules

The neutral position of the data line corresponds with the logical „1“.

A distance of more than 3.5 bytes, however at least 10 ms is defined as separation between two telegrams. For the beginning of the data transfer the neutral position of the data line must be observed.

IEEE 754-Format

Modbus-protocol and IEEE 754-Format

The Modbus-protocol allows only 16-bit-registers as transfer values. Some of the Advance Optima-data is stored in the IEEE 754-Format (32 bit). For this reason the data must be processed by the interrogating device..

Construction of IEEE-Format

Term	Number of bits	Meaning
S	1	Sign bit; explains the sign (0 = positive, 1 = negative)
E	8	Two's complement exponent. The true value is the exponent minus 127.
M	23	The „most significant bit" of the normalized mantissa before the decimal point is implicitly 1, but is not stored. The value range is also between 1.0 (included) and 2.0.

Example

The number –12.5 is stored as the hexadecimal value 0xC1480000. The following table shows the storage configuration:

Address	+0	+1	+2	+3
format	SEEEEEEE	EMMMMMMM	MMMMMMMM	MMMMMMMM
binary	11000001	01001000	00000000	00000000
hexadecimal	C1	48	00	00

Explanations

- The sign bit is 1, i.e. the value is negative.
- The exponent is 10000010 binary, which corresponds to the decimal value 130. Subtracting 127 from 130 leaves 3, which is the actual exponent.
- The stored mantissa value is 10010000000000000000000. Adding the non stored 1 before the decimal point gives the value 1.10010000000000000000000.
- After adjusting the mantissa to the exponent (moving it three places) the result is 1100.10000000000000000000. This binary number corresponds to the decimal value 12.5. Finally the sign bit needs to be taken into account. This makes the final value of –12.5.

Modbus Addresses and Data Format

Principle

The Advance Optima analyzer system is modular and very flexible. A system could consist of one or more analyzer modules which in itself could measure one or more components. It is also possible to connect different kinds of I/O-boards to a system. For this reason the Modbus addressing schema is not static.

Data format

There are five flexible groups and three fixed length groups of information defined in an Advance Optima system.

The grouped information can be read through „Single-Modbus-Request“.

Flexible groups

The flexible groups are:

- Measuring Values
- Analog Inputs (AI)
- Analog Outputs (AO)
- Digital Inputs (DI)
- Digital Output (DO)

Each flexible group has a fixed start address and a variable length of elements – depending on the system.

Fixed length groups

The fixed length groups are:

- Status (Error, Maintenance Request, Maintenance Mode)
- Modbus Digital Input (8x)
- Modbus Digital Output (8x)

Addressing example

The addressing example below is based on a system with three analyzer modules and two analog I/O-Boards. Analyzer 1 has three components, analyzer 2 has one component and analyzer 3 has two components.

Continued on next page

Measurement values

The measurement values are transmitted in the IEEE 32 bit standard floating point format. The floating point format is not a part of the Modbus specification. Advance Optima devices use two word registers to represent a floating point value (ordering: high word, low word).

Modicon Modbus-Address	Type	Register Number	Description/ Name
30001	Input register	0	Analyzer 1 - Component 1
30002		1	
30003	Input register	2	Analyzer 1 - Component 2
30004		3	
30005	Input register	4	Analyzer 1 - Component 3
30006		5	
30007	Input register	6	Analyzer 2 - Component 1
30008		7	
30009	Input register	8	Analyzer 3 - Component 1
30010		9	
30011	Input register	10	Analyzer 3 - Component 2
30012		11	
			etc.

Analog Inputs (AI)

Analog Inputs are also transmitted in the IEEE 32 bit standard floating point format. The floating point format is not a part of the Modbus specification. Advance Optima devices use two word registers to represent a floating point value (high word, low word).

Modicon Modbus-Address	Type	Register Number	Description/ Name
30100	Input register	99	Analog I/O-Board 1 V-in 1
30101		100	
30102	Input register	101	Analog I/O-Board 1 I-in 1
30103		102	
30104	Input register	103	Analog I/O-Board 1 V-in 2
30105		104	
30106	Input register	105	Analog I/O-Board 1 I-in 2
30107		106	
30108	Input register	107	Analog I/O-Board 2 V-in 1
30109		108	
30110	Input register	109	Analog I/O-Board 2 I-in 1
30111		110	
30112	Input register	111	Analog I/O-Board 2 V-in 2
30113		112	
30114	Input register	113	Analog I/O-Board 2 I-in 2
30115		114	
			etc.

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Analog Outputs (AO)

Analog Inputs are also transmitted in the IEEE 32 bit standard floating point format. The floating point format is not a part of the Modbus specification. Advance Optima devices use two word registers to represent a floating point value (high word, low word).

Modicon Modbus-Address	Type	Register Number	Description / Name
30300	Input register	299	Syscon AO 1
30301		300	
30302	Input register	301	Syscon AO 2
30303		302	
30304	Input register	303	Analog I/O-Board 1 AO 1
30305		304	
30306	Input register	305	Analog I/O-Board 1 AO 2
30307		306	
30308	Input register	307	Analog I/O-Board 2 AO 1
30309		308	
30310	Input register	309	Analog I/O-Board 2 AO 2
30311		310	
30312	Input register	311	Analog I/O-Board 3 AO 1
30313		312	
30314	Input register	313	Analog I/O-Board 3 AO 2
30315		314	
			etc.

Digital Inputs (DI)

The Modbus master has only read access to digital input values.

Modicon Modbus-Address	Type	Input Number	Description/ Name
10016	input status	15	Syscon DI 1
10017	input status	16	Syscon DI 2
10018	input status	17	Syscon DI 3
10019	input status	18	Syscon DI 4
10020	input status	19	Syscon DI purge
10021	input status	20	AI/O-Board 1 DI 1
10022	input status	21	AI/O-Board 1 DI 2
10023	input status	22	AI/O-Board 2 DI 1
10024	input status	23	AI/O-Board 2 DI 2
			etc.

Continued on next page

Digital Outputs (DO)

The Modbus master has only read access to digital output values.

Modicon Modbus-Address	Type	Input Number	Description/ Name
11036	input status	1035	Syscon DO 1
11037	input status	1036	Syscon DO 2
11038	input status	1037	Syscon DO 3
11039	input status	1038	Syscon DO 4
11040	input status	1039	AI/O-Board 1 DO 1
11041	input status	1040	AI/O-Board 1 DO 2
11042	input status	1041	AI/O-Board 2 DO 1
11043	input status	1042	AI/O-Board 2 DO 2
			etc.

Status

The Modbus master has read access to the three global status values.

Modicon Modbus-Address	Type	Input Number	Description/ Name
10001	input status	0	Error
10002	input status	1	Maintenance Mode
10003	input status	2	Maintenance Request

Modbus Digital Inputs (DI)

Modbus Digital Inputs are bit variables in the analyzer. The Modbus master has read and write access to these variables. The Modbus DI can be linked like a physical („real“) DI in a function block configuration. The master has access to eight variables and uses function code 1 to read and 5 or 15 to write the variables.

Modicon Modbus-Address	Type	Coil Number	Description/ Name
1	Coil status	0	Modbus-DI1
2	Coil status	1	Modbus-DI2
3	Coil status	2	Modbus-DI3
4	Coil status	3	Modbus-DI4
5	Coil status	4	Modbus-DI5
6	Coil status	5	Modbus-DI6
7	Coil status	6	Modbus-DI7
8	Coil status	7	Modbus-DI8

Continued on next page

Modbus Digital Outputs (DO)

Modbus Digital Outputs are bit variables in the analyzer which can only be read by the Modbus master. The Modbus DO can be linked like a physical DO in a function block configuration.

Modicon Modbus-Address	Type	Input Number	Description/ Name
12060	input status	2059	Modbus-DO1
12061	input status	2060	Modbus-DO2
12062	input status	2061	Modbus-DO3
12063	input status	2062	Modbus-DO4
12064	input status	2063	Modbus-DO5
12065	input status	2064	Modbus-DO6
12066	input status	2065	Modbus-DO7
12067	input status	2066	Modbus-DO8

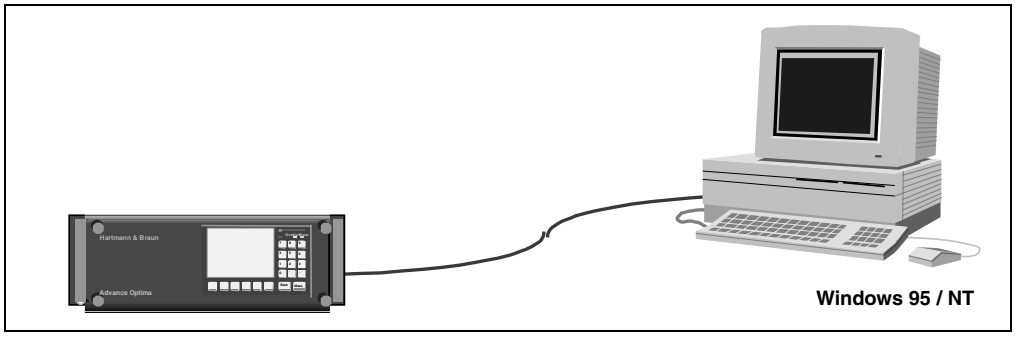
Modbus Connection via RS 232C

Connecting

You can connect the Modbus master to the RS-232C interface of the system controller (software version ≥ 1.2). The RS-232C connection only provides a point to point access (e.g. Advance Optima and a PC).

Figure 1

Connection via RS 232C



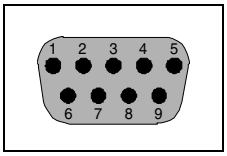
Which material is necessary?

Use cables with standard-RS-232C access for connecting.

The pin configuration is depicted below:

Figure 2

RS-232C interface



2 RxD
3 TxD
5 GND

type: 9 contacts Sub-D-connector

Interface settings

The settings for data transmission are

- 19200 baud
- no parity
- 1 stopbit

☞ These settings can be changed in software versions ≥ 1.4.

Modbus address settings

The standard Modbus address is 1. You can change this address in the menu `config. → system → network` on the display (range 1...255), depending on the configuration of the system.

Request interval

The response request of Advance Optima is < 500 ms. Therefore the times for the time-out-supervision in the master should be > 500 ms (recommendation: 1 s). Between two faultless requests a minimum waiting time of ≥ 100 ms need be to kept.

Modbus Connection via RS 485

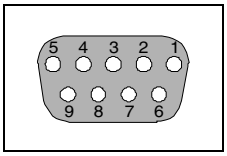
Connecting

You can connect the Modbus master to the RS-485 interface of the system controller. The following cables are made available to establish a Modbus network (color = purple):

- T-connection
- connections with user specified length
- connections with preconfigured length
- RC termination plugs

Figure 3

RS-485 interface



2 RTxD–
3 RTxD+
5 GND

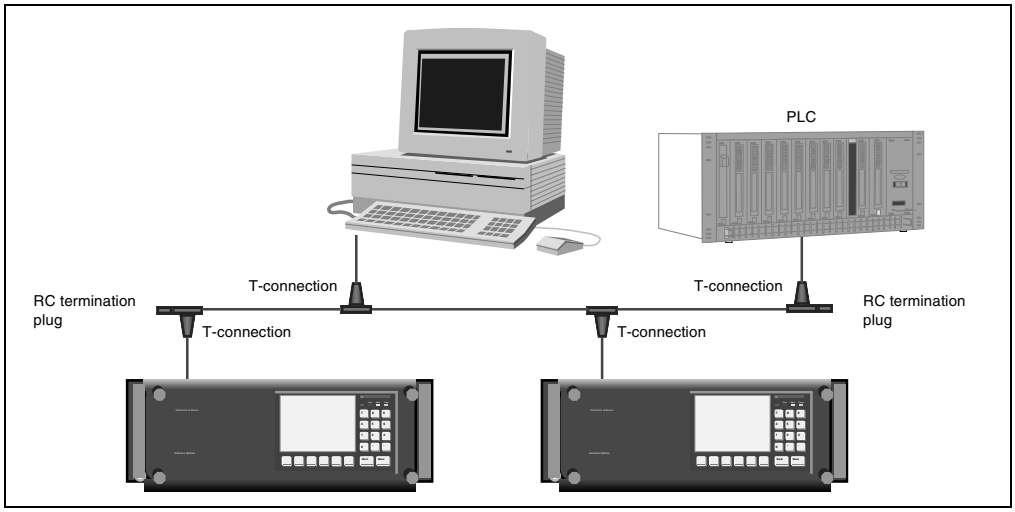
type: 9 contacts Sub-D-socket

Bus topology

The Modbus network uses a bus topology which needs to be terminated via a RC termination plug (see figure below). This is also true for a point to point connection.

Figure 4

Bus topology



Cable type

A three lines twisted pair cable e.g. Thomas & Betts Type LiYCY, 0.25 mm^2 is used for the Modbus connection. The max. cable length is limited to 1200 m. The max. number of nodes is 32.

Signal converter

If the PC has no RS-485 interface, an RS232C/RS485 signal converter must be linked between the PC and the Modbus network.

☞ Technical details are depicted in figure 5 on the next page. Note the input circuit of a Modbus slave.

Any internal termination need to be disconnected. AC termination is only allowed at the cable ends using the RC termination plugs.

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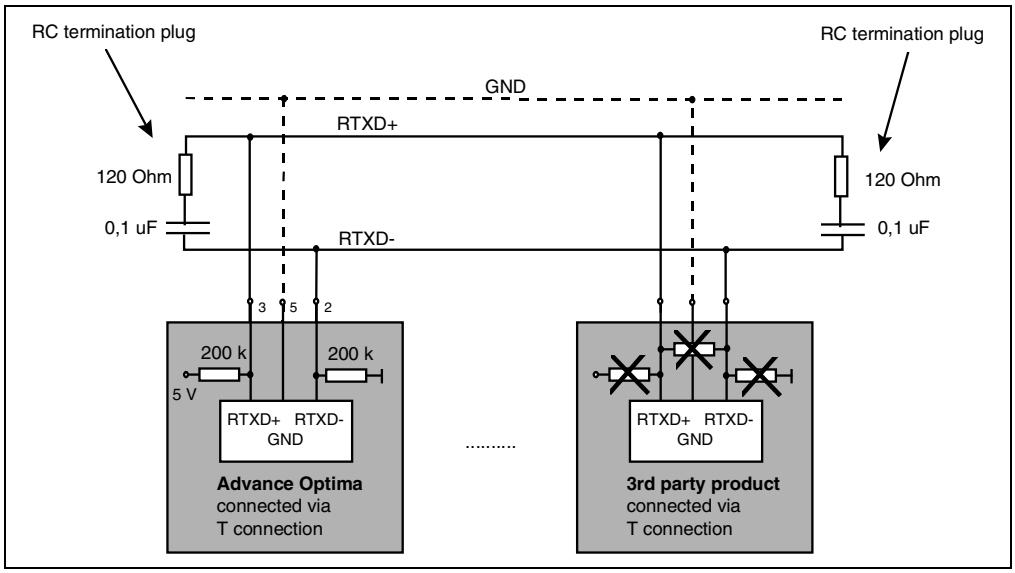
Figure 5

Cable ends with RC termination plugs



Other cables and connectors

You can also use other cables and connectors as long as they correspond to the specifications in figure 5.

Interface settings

The settings for data transmission are

- 19200 baud
- no parity
- 1 stopbit

☞ These settings can be changed in software versions ≥ 1.4.

Modbus address settings

The default Modbus address is 1 and can be changed in the menu `config.` → `system` → `network` on the display (range 1...255), depending on the configuration of the system.

Request interval

The response request of Advance Optima is < 500 ms. Therefore the times for the time-out-supervision in the master should be > 500 ms (recommendation: 1 s). Between two faultless requests a minimum waiting time of ≥ 100 ms need be to kept.

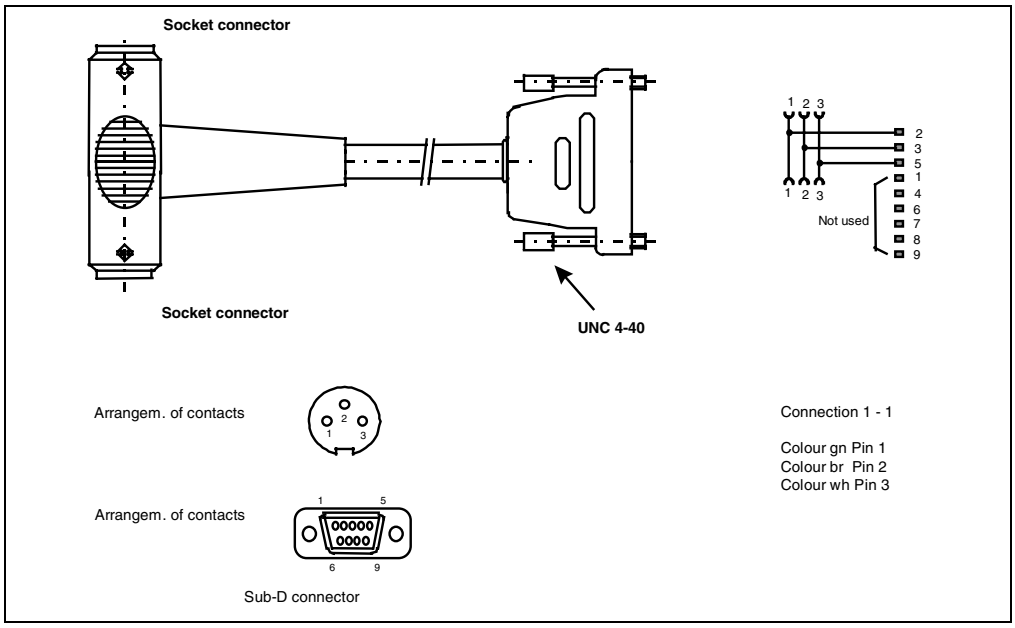
Components for RS-485 Interface

Components

The components that are used for setting up a Modbus network are listed below.

Figure 6

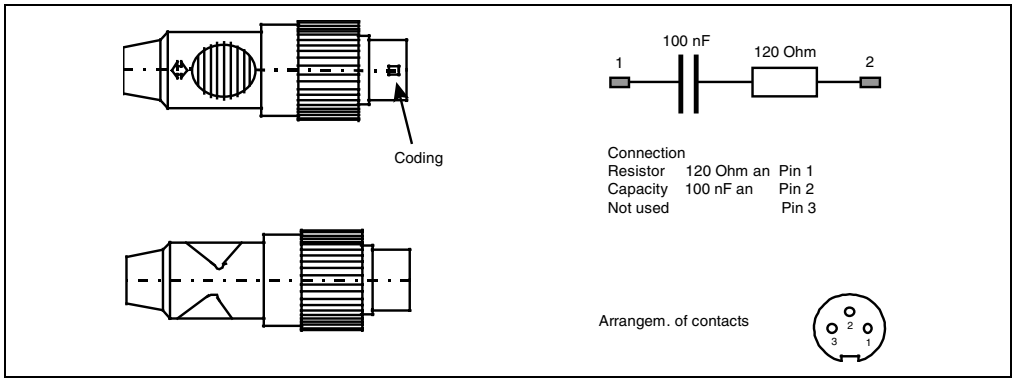
T-connection



Connector to cable	socket, 3 contacts
Connector to System Controller	D-Sub, pin, 9 contacts
Housing protection rating	IP 65 (DIN 40050)
Color	purple

Figure 7

RC termination plug



Connector type	pin, 3 contacts
Housing protection rating	IP 65 (DIN 40050)
Color	purple

Continued on next page

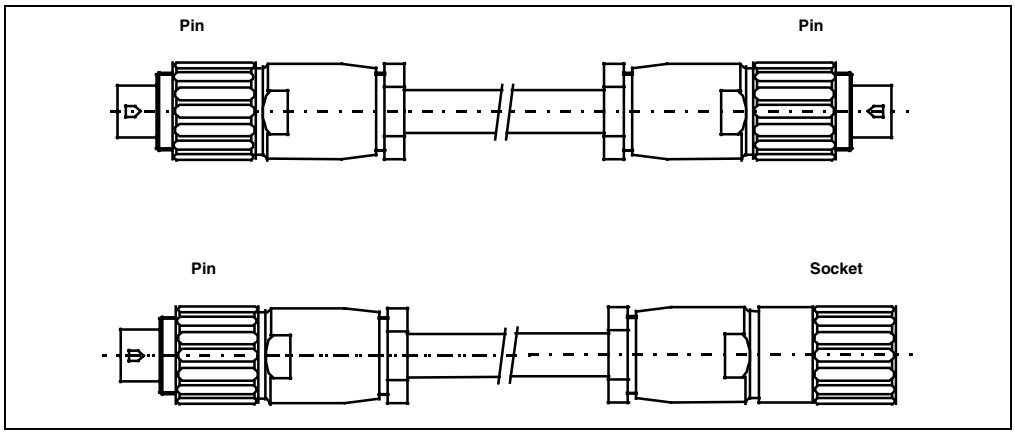
Modbus connections with user defined cable length

When using this type of cable one has to specify the desired length. Furthermore the connectors and the cable come as a set that need to be assembled. Two types of cables can be assembled.

- connection between two T-connections (pin connectors at each end)
- extension cord (pin and socket connector)

Figure 8

Variable connections



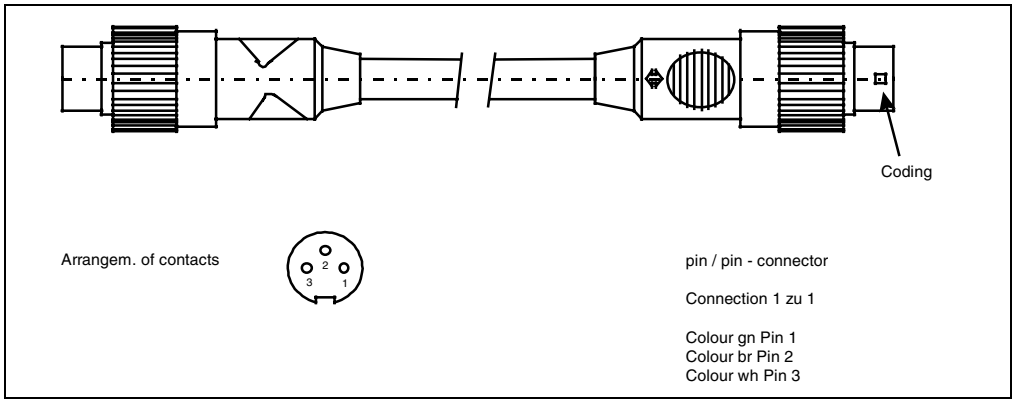
Connector type	pin / pin or pin / socket, 3 contacts, Color: silver
Length	like ordered
Color	purple

Cables with predefined length

This option allows ordering cables of three different lengths. The cable can be used to connect two T-connections.

Figure 9

Cables with predefined length



Connector type	pin / pin, 3 contacts, connection 1 - 1
Housing protection rating	IP 65 (DIN 40050)
Length	1.0 m, 2.0 m, 5.0 m
Color	purple

Continued on next page

Components for RS-485 Interface, Continued

☞ You can order the different components for networking the RS-485 interface at ABB Analytical.

Please use the below mentioned order numbers:

Order numbers

Modbus T-connection	24009-4-0746617
Modbus RC termination plug	24009-4-0746616
Modbus cable 1,0 m	24009-4-0746619
Modbus cable 2,0 m	24009-4-0746620
Modbus cable 5,0 m	24009-4-0746621
Modbus cable variable length	24009-4-0746622
plug for Modbus	24009-4-0746318
socket for Modbus	24009-4-0746471

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