Description of the Modbus interface

for APM-1 / ACM-1

K02/0922

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1.1 Preface

These instructions are intended for equipment manufacturers with technical expertise and PC knowledge.

Read these instructions before you begin working on the device. Keep the instructions in a place which is accessible to all users at all times. Your comments can help us to improve these instructions.

Warranty

All necessary settings are described in these instructions. If any difficulties should arise during startup we ask that you do not conduct unauthorized manipulations to the unit, i.e. manipulations that are not described in the instructions. Doing so could void your warranty rights! For further information please contact the nearest subsidiary or the head office.

Electrostatic discharge

When accessing the inside of the device or when returning device plug-in units, modules, or components then the regulations according to DIN EN 61340-5-1 and DIN EN 61340-5-2 "Protection of electronic devices from electrostatic phenomena" must be observed. Use only **ESD** packaging for transport.

Please note that we cannot accept any liability for damage caused by ESD (electrostatic discharge).

ESD = **E**lectro**s**tatic **D**ischarge

1.2 Typographical conventions

1.2.1 Warning signs

The signs for Danger and Warning are used in this operating manual under the following conditions:

Danger This symbol is used when **danger to personnel** may occur if the instructions are ignored or not followed correctly!

Caution This symbol is used when **damage to equipment or data** may occur if the instructions are ignored or not followed correctly!

Caution This symbol is used where special care is required when handling components liable to damage through electrostatic discharge.

1.2.2 Note signs

Note This symbol is used to draw your **particular attention** to a remark.

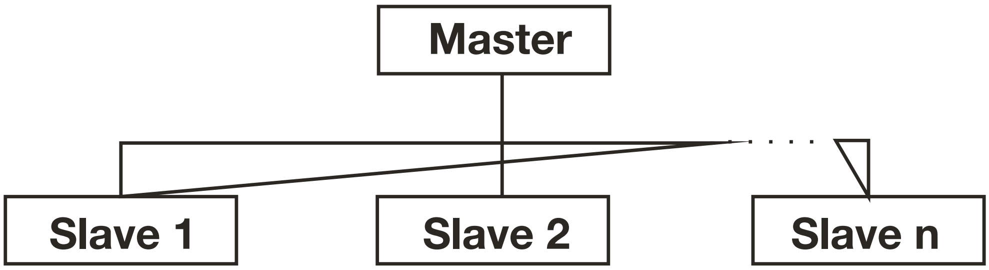
Reference This symbol refers to further information in other manuals, chapters, or sections.

1.2.3 Notation

0x0010 **Hexadecimal number** A hexadecimal number is identified by a "0x" prefix (in this case 16 decimal).

2.1 Master/slave principle

Communication between a PC (master) and a device (slave) via the Modbus protocol takes place according to the master/slave principle in the form of data request/instruction - response.



The master controls data exchange, while the slaves have only a response function. They are identified by their device address.

2.2 Transfer mode

RTU mode (Remote Terminal Unit) is used as the transfer mode. Data transfer is in binary format with 8-bit. The LSB (Least Significant Bit) is transferred first. ASCII transfer mode is not supported.

Data format The data format describes the structure of the characters that are transferred. The following options are provided for the data format:

Start bit	Data word	Parity bit	Stop bit	Number of bit
1	8-bit	-	1	10
1	8-bit	Even	1	11
1	8-bit	Odd	1	11
1	8-bit	-	2	11
1	8-bit	Even	2	12
1	8-bit	Odd	2	12

2.3 Device address

The device address of the slave can be set between 0 and 254. Device address 0 is reserved.

☞ A maximum of 31 slaves can be addressed via the RS422/485 interface.

Two different options are available for data exchange:

Query Data request/instruction from the master to a slave via the corresponding device address.
The addressed slave responds.

Broadcast Instruction from the master to all slaves via device address 0. The connected slaves do not respond. This makes it possible to transfer a specific setpoint value to all slaves, for example. In this case the setpoint value should be read afterwards to ensure that the value was correctly transferred to the slaves.
A data request with device address 0 does not make sense.

2.4 Temporal sequence of communication

The beginning and end of a data block are marked by pauses in the transfer. A maximum of three times the amount of time required to transfer one character may elapse between two successive characters.

The character transfer time (time to transfer one character) depends on the baud rate and the data format that is used (stop bit and parity bit).

With a data format of 8 data bits, one start bit, no parity bit, and one stop bit the result is:

Character transfer time [ms]
= 1000 × 10 bit/baud rate

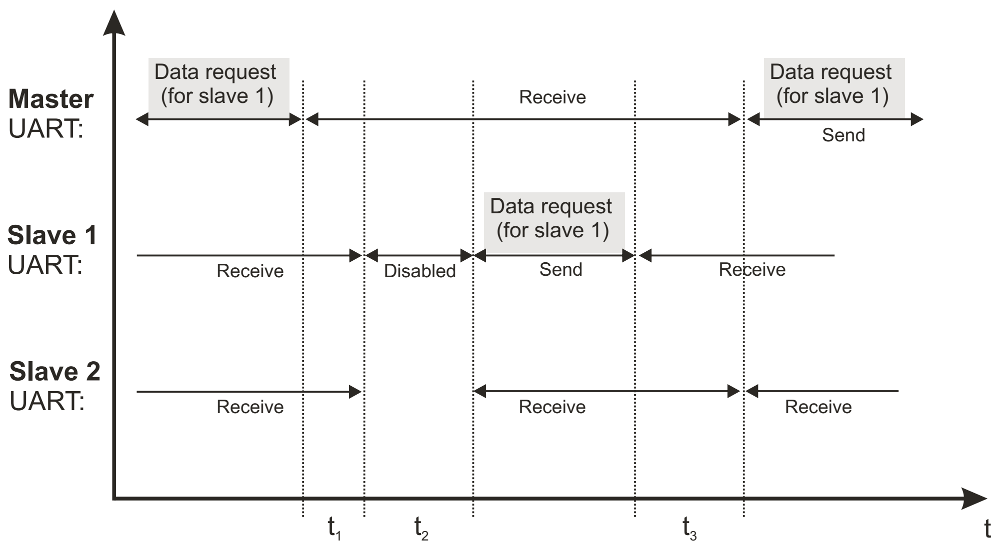
The result with other data formats is:

Character transfer time [ms]
= 1000 × (start bit + 8 data bits + parity bit+stop bit(s)) bit/baud rate

Sequence

Data request from the master Transfer time = n characters × 1000 × X bit/baud rate
Identifies the end of the data request 5 ms (regardless of the baud rate)
Processing of the data request by the slave (ℵ125 ms)
Response from the slave Transfer time = n characters × 1000 × X bit/baud rate
Identifies the end of the response 5 ms (regardless of the baud rate)

Time diagram A data request proceeds according to the following time diagram:



- t_1 identifies the end of the request:
  According to the Modbus specification it is at least 3.5 times as long as the transfer time for 1 character, depending on the baud rate. For the device it is 4 to 5 ms regardless of the baud rate.
- t_2 internal processing time:
  The time required by the device to process the request it has received and prepare the response. The required time in the device lasts up to 125 ms.
- t_{3i} identifies the end of the response:
  Same duration as t_1.

Temporal sequence
The master sends a data request for slave 1. After the last character is sent, all connected device slaves wait for a time of t_1. Then the instruction is evaluated. Slave 2 discards the instruction because the device

address does not match. On the other hand, slave 1 begins processing the request. This takes place within time t_2. Then slave 1 sends the response and switches back to reception again immediately after the last character. Slave 2, which is also "listening in" on the response in the case of an RS485 must still wait for time t_3 before it can evaluate the response that is received. Because the device address again does not match, it ignores the response and switches back to reception. The master cannot send a new instruction until all these times have elapsed!

No data requests may be made by the master within t_1, t_2, and t_3. Otherwise the device would ignore the instruction or the data on the bus would become invalid because of data collisions. Time t_3 is required by all other slaves on the bus to switch back to reception. The time after the response until the master is permitted to send the next request depends on the longest time t_3 of all the slaves involved. To be on the safe side a certain amount of additional time should also be added.

2.5 Layout of data blocks

All data blocks have the same structure:

Data structure

Slave address	Function code	Data field	CRC16 checksum
1 byte	1 byte	x bytes	2 bytes

Each data block contains four fields:

Slave address Device address of a specific slave

Function code Choice of function (read or write words)

Data field Contains the following items of information:

- Word address
- Number of words
- Word value

Checksum Detection of transfer errors

2.6 Error handling

Error codes

Five error codes exist:

1 Invalid function

2 Invalid parameter address or too many words to read or write

3 Impermissible value

4 Device not ready

8 Write access to parameters declined

Response in case of error

Slave address	Function XX OR 80h	Error code	CRC16 checksum
1 byte	1 byte	1 byte	2 bytes

The function code is ORed with 0x80 which means that the MSB (Most Significant Bit) is set to 1.

Example

Data request:

01	03	40	00	00	04	CRC16

Response:

01	83	02	CRC16

Special cases

If the slave does not respond then the following causes could be responsible:

- The baud rate and/or data format of the master and slave do not match
- The device address that is used does not match the slave address
- The checksum (CRC16) is not correct
- The instruction from the master is defined incompletely or excessively
- The number of words to read is zero

In these cases the data request should be sent again after the timeout time (2 s) has elapsed.

2.7 Checksum (CRC16)

The checksum (CRC16) is used to detect transfer errors. If an error is discovered during evaluation, the corresponding device does not respond.

Calculation diagram

<table>
<tr><td colspan="4">CRC = 0xFFFF</td></tr>
<tr><td rowspan="5"></td><td colspan="3">CRC = CRC XOR BytesOfMessage</td></tr>
<tr><td colspan="3">For (1 to 8)</td></tr>
<tr><td rowspan="3"></td><td colspan="2">CRC = SHR(CRC)</td></tr>
<tr><td colspan="2">if (shifted to the right flag = 1)</td></tr>
<tr><td>then
CRC = CRC XOR 0xA001</td><td>else</td></tr>
<tr><td colspan="4">while (not all BytesOfMessage processed);</td></tr>
</table>

The low byte of the checksum is transferred first, followed by the high byte.

Example

Data request: read two words starting at address 0x00CE
(CRC16 = 0x92A5)

07	03	00	CE	00	02	A5	92
						CRC16	

Response: (CRC16 = 0xF5AD)

07	03	04	00	00	41	C8	AD	F5
			Word 1		Word 2		CRC16	

2.8 Interface

2.8.1 Configuration

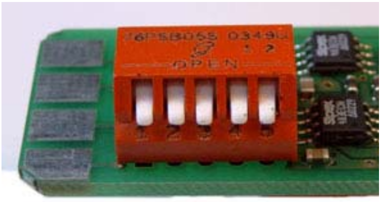
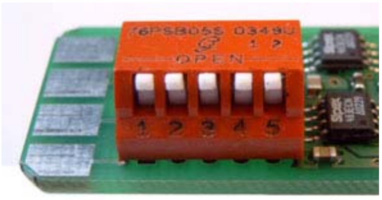
Parameter	Value/selection	Description
Modbus address	**1** to 254	Address in the data network
Baud rate	**9600** 19200 38400	
Parity	**None** Odd Even	
Stop bit	**1** 2	
Write EEPROM	**Off** On	Off: Data is written to RAM. This means data will be lost when the power supply is interrupted On: Data is written to EEPROM. CAUTION: The maximum number of write cycles (= 100 000) must be observed with this setting!

2.8.2 Terminating resistor of the RS422/485 serial interface

To ensure problem-free operation of several devices in a line structure, their internal terminating resistors must be activated at the beginning and end.

✱ Press on the ribbed surfaces and pull the device plug-in unit out towards the front

✱ Use a pen to push all the white switches in the same direction

Bus terminating resistor active:	✱ Press all 5 switches down 
No bus termination (factory setting)	✱ Push all 5 switches up 

✱ Insert the device plug-in unit in the case again

The following functions are available for the device:

Function number	Function	Limiting
0x03 or 0x04	Reading n words	Max. 125 words (250 bytes)
0x06	Writing a word	Max. 1 word (2 bytes)
0x10	Writing n words	Max. 125 words (250 bytes)

3.1 Reading n words

This function reads n (n ℵ125) words starting at a specific address.

Data request

Slave address	Function 0x03 or 0x04	Address First word	Number of words (max. 125)	CRC16 checksum
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Response

Slave address	Function 0x03 or 0x04	Number of bytes read	Word value(s)	CRC16 checksum
1 byte	1 byte	1 byte	x bytes	2 bytes

Example

Read the manually assigned temperature and the offset

Word address = 0x01E3

Data request:

01	03	01	E3	00	04	B403

Response:

01	03	08	0000	41C8	0000	0000	7B16
			Setpoint value 1 (25.0)		Setpoint value 2 (0.0)		

3.2 Writing a word

In the write word function, the data blocks for the instruction and response are identical.

Instruction

Slave address	Function 0x06	Word address	Word value	CRC16 checksum
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Response

Slave address	Function 0x06	Word address	Word value	CRC16 checksum
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Example

Write ON-delay for relay 1 = 2 seconds

Word address = 0x0345

Instruction: write the first part of the value

01	06	03	45	00	02	199A

Response (same as instruction):

01	06	03	45	00	02	199A

3.3 Writing n words

This function is used to write n (n ℵ125) words starting at a specific address.

Instruction

Slave address	Function 0x10	Address of first word	Number of words max. 127	Number of bytes	Word value(s)	CRC16 check-sum
1 byte	1 byte	2 bytes	2 bytes	1 byte	x bytes	2 bytes

Response

Slave address	Function 0x10	Address of first word	Number of words	CRC16 checksum
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Example

Write alarm 1 limit value = 25

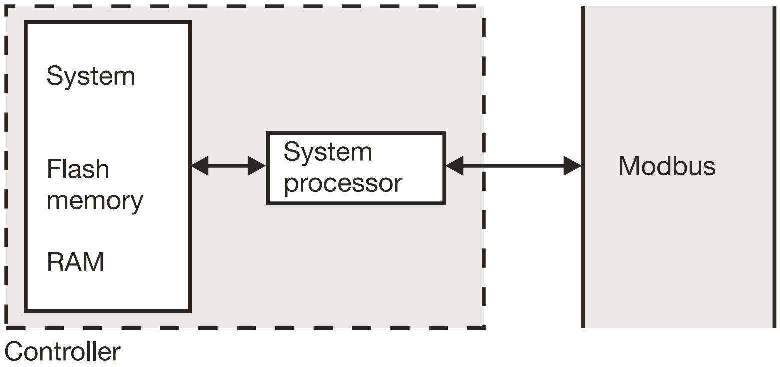
Word address = 0x02C2

Instruction:

01	10	02	C2	00	02	04	00	00	41	C8	5680

Response:

01	10	02	C2	00	02	E18C



The RS422/485 interface is inactive during communication via the setup interface.

All process values (variables) with their addresses, data type, and access type are described below.

Note the following abbreviations and conventions:

R/O	Read access only
R/W	Read and write access
Char, byte	Byte (8-bit)
Int	Integer (16-bit)
Bit x	Bit number x
Long	Long integer (4 bytes)
Float	Float value (4 bytes) according to IEEE 754

Order of bytes

Because the display of floating-point numbers and long values depends on the platform, the bytes must be moved into the appropriate order for the Modbus.

Please determine the order in which float values should be saved in your system (PC, PLC, etc.).

Single-float format (32-bit) according to standard IEEE 754

SEEEEEEE	EMMMMMMM	MMMMMMMM	MMMMMMMM

S - sign bit
E - exponent (two's complement)
M - 23-bit normalized mantissa

Modbus float format

Modbus address x		Modbus address x+1	
MMMMMMMM	MMMMMMMM	SEEEEEEE	EMMMMMMM

Example: Transferring floating-point number 3000

PC (master):	00	80	3B	45
Modbus:	80	00	45	3B
Byte	1	2	3	4

Long values

Example: Transferring number 66051

PC (master):	03	02	01	00
Modbus:	00	01	02	03
Byte	1	2	3	4

5.1 Process data

The configuration values written via Modbus are not checked for validity. Values outside of the permissible setting range or impermissible parameter combinations may lead to unexpected behavior of the device, incorrect measured values, or faulty control.

All temperature values are transferred in °C regardless of the setting on the device.

Address	Data type	Access	Parameter
0x50	Float	R/O	Main input measured value
0x52	Float	R/O	Uncompensated main input measured value
0x54	Float	R/O	Measured value for option input 1
0x56	Float	R/O	Uncompensated measured value for option input 1
0x58	Float	R/O	Measured value for option input 2
0x5A	Float	R/O	Uncompensated measured value for option input 2
0x5C	Float	R/O	Measured value for option input 3
0x5E	Float	R/O	Uncompensated measured value for option input 3
0x60	Float	R/O	Measured value for temperature input °C
0x62	Float	R/O	Measured value for temperature input °F
0x64	Float	R/O	Differential signal (main value – option input X)
0x66	Float	R/O	Input frequency of binary input
0x68	Float	R/O	Flow rate
0x6A	Float	R/O	Partial quantity counter
0x6C	Float	R/O	Total quantity counter
0x6E	Float	R/O	Current setpoint value 1 controller 1
0x70	Float	R/O	Current setpoint value 2 controller 1
0x72	Float	R/O	Current setpoint value 1 controller 2
0x74	Float	R/O	Current setpoint value 2 controller 2
0x76	Float	R/O	Math channel 1
0x78	Float	R/O	Math channel 2
0x7A	16-bit int.	R/O	Unit* of the main value
0x7B	16-bit int.	R/O	Unit* of the uncompensated main value
0x7C	16-bit int.	R/O	Unit* of option input 1
0x7D	16-bit int.	R/O	Unit* of uncompensated option input 1
0x7E	16-bit int.	R/O	Unit* of option input 2
0x7F	16-bit int.	R/O	Unit* of uncompensated option input 2
0x80	16-bit int.	R/O	Unit* of option input 3
0x81	16-bit int.	R/O	Unit* of uncompensated option input 3
0x82	16-bit int.	R/O	Unit* of setpoint value controller 1
0x83	16-bit int.	R/O	Unit* of setpoint value controller 2

Address	Data type	Access	Parameter
0x84	16-bit int.	R/O	Unit* of the flow rate
0x85	16-bit int.	R/O	Unit* of the quantity counter
0x9F	Float	R/O	Output level of controller 1
0xA1	Float	R/O	Output level of controller 2
0xA3	Float	R/O	Signal of analog output 1
0xA5	Float	R/O	Signal of analog output 2
0xA7	Float	R/O	Signal of analog output 3
0xA9	16-bit int.	R/O	States of the binary inputs Bit 0: Binary input 1 Bit 1: Binary input 2
0xAA	16-bit int.	R/O	States of the binary outputs Bit 0: Relay output 1 Bit 1: Relay output 2 Bit 2: Relay output 3 Bit 3: Relay output 4 Bit 4: Relay output 5 Bit 5: Relay output 6 Bit 6: Relay output 7 Bit 7: Relay output 8 Bit 8: Limit value switch 1 Bit 9: Limit value switch 2 Bit 10: Limit value switch 3 Bit 11: Limit value switch 4 Bit 12: Reserved Bit 13: Reserved Bit 14: Logic channel 1 Bit 15: Logic channel 2
0xAB	16-bit int.	R/O	Measuring range changeover for conductivity input 0: Measuring range 1 active 1: Measuring range 2 active
0xAE	16-bit int.	R/O	Error status Bit 0: Main value underrange Bit 1: Main value overrange Bit 2: Temperature underrange Bit 3: Temperature overrange Bit 4: Main value has left compensation range Bit 5: Reference electrode impedance too high Bit 6: Glass electrode impedance too high Bit 7: Glass electrode impedance too high Bit 8: Option input 1: out of range Bit 9: Option input 1: compensation range overflow/underflow

Address	Data type	Access	Parameter
			Bit 10: Option input 2: out of range Bit 11: Option input 2: compensation range overflow/underflow Bit 12: Option input 3: out of range Bit 13: Option input 3: compensation range overflow/underflow

*List of all units

0: °C
1: °F
2: seconds
3: mA
4: V
5: days
6: %/K
7: µS/cm
8: mS/cm
9: %
10: mV
11: seconds
12: minutes
13: hours
14: pH
15: ohm
16: kOhm
17: MOhm
18: ppm
19: l/min
20: l/s
21: l/min
22: l/h
23: m^3/min
24: m^3/h
25: gal/s
26: gal/min
27: gal/h
28: l
29: m^3
30: gal
31: Hz
32: mg/l
50: Customized unit
51: Unit for math 1
52: Unit for math 2

5.2 Configuration of pH input

Many parameters involved in the input configuration are dependent on each other and cannot be arbitrarily combined. If invalid configurations are made (configurations that the device or setup does not permit), the result may be unpredictable behavior of the device and errors in control as well as in calculating measured values.

Address	Data type	Parameter
0x100	32-bit int.	Calibration timer
0x102	16-bit int.	Calibration interval
0x103	16-bit int.	Supply frequency 0: 50 Hz 1: 60 Hz
0x104	16-bit int.	Difference determination 0: No calculation 1: Main value – option input 1 2: Main value – option input 2 3: Main value – option input 3 4: Option input 1 – main value 5: Option input 2 – main value 6: Option input 3 – main value

Address	Data type	Parameter
0x105	16-bit int.	Compensation source 0: Manual temperature entry 1: Temperature entry 2: Option input 1 3: Option input 2 4: Option input 3
0x160	Float	Electrode slope of alkaline range
0x162	Float	Electrode slope of acidic range
0x164	Float	Electrode zero point
0x166	16-bit int.	Electrode type 0: Standard pH electrode 1: Antimony electrode 2: Redox electrode 3: Ammonia electrode 4: IsFET pH electrode (via adapter)
0x167	16-bit int.	Unit for redox 0: mV 1: %
0x168	Float	Filter time constant
0x16A	16-bit int.	Reference electrode monitoring 0: Off 1: On
0x16B	16-bit int.	Glass electrode monitoring 0: Off 1: Min. glass impedance monitoring 2: Max. glass impedance monitoring 3: Min. and max. glass impedance monitoring
0x16C	16-bit int.	Max. reference electrode impedance

5.3 Configuration of CR input

Many parameters involved in the input configuration are dependent on each other and cannot be arbitrarily combined. If invalid configurations are made (configurations that the device or setup does not permit), the result may be unpredictable behavior of the device and errors in control as well as in calculating measured values.

Address	Data type	Parameter
0x100	32-bit int.	Calibration timer
0x102	16-bit int.	Calibration interval
0x103	16-bit int.	Supply frequency 0: 50 Hz 1: 60 Hz
0x104	16-bit int.	Difference determination 0: No calculation 1: Main value – option input 1 2: Main value – option input 2 3: Main value – option input 3 4: Option input 1 – main value 5: Option input 2 – main value 6: Option input 3 – main value
0x105	16-bit int.	Compensation source 0: Manual temperature entry 1: Temperature entry 2: Option input 1 3: Option input 2 4: Option input 3
0x180	Float	Relative cell constant for measuring range 1
0x182	Float	Relative cell constant for measuring range 2
0x184	Float	Temperature coefficient of measuring range 1
0x186	Float	Temperature coefficient of measuring range 2
0x1A0	16-bit int.	Operating mode 0: Conductivity measurement 1: TDS mode 2: Linear scaling 3: Table linearization

Address	Data type	Parameter
0x1A1	16-bit int.	Unit 0: μS/cm 1: mS/cm 2: kOhm/cm 3: MOhm/cm 4: Customized unit 5: ppm
0x1A2	16-bit int.	Display format (number of places after the decimal)
0x1A7	16-bit int.	2/4-wire modes 0: 2-wire connection 1: 4-wire connection
0x1A8	16-bit int.	Cell constant 0: 0.01 1: 0.10 2: 0.50 3: 1.00 4: 3.00 5: 10.0
0x1A9	Float	Offset for measuring range 1
0x1AB	Float	Offset for measuring range 2
0x1AD	16-bit int.	Compensation type for measuring range 1 0: No temperature compensation 1: Linear TC 2: Natural water 3: ASTM neutral impurity 4: ASTM acidic impurity 5: ASTM alkaline impurity
0x1AF	Float	Reference temperature (for linear temperature compensation)
0x1B1	Float	TDS factor
0x1B3	Float	Filter time constant
0x1B5	16-bit int.	Contamination detection 0: Off 1: On
0x1B6	16-bit int.	Cable break detection 0: Off 1: On

5.4 Configuration of Ci input

Many parameters involved in the input configuration are dependent on each other and cannot be arbitrarily combined. If invalid configurations are made (configurations that the device or setup does not permit), the result may be unpredictable behavior of the device and errors in control as well as in calculating measured values.

Address	Data type	Parameter
0x100	32-bit int.	Calibration timer
0x102	16-bit int.	Calibration interval
0x103	16-bit int.	Supply frequency 0: 50 Hz 1: 60 Hz
0x104	16-bit int.	Difference determination 0: No calculation 1: Main value – option input 1 2: Main value – option input 2 3: Main value – option input 3 4: Option input 1 – main value 5: Option input 2 – main value 6: Option input 3 – main value
0x105	16-bit int.	Compensation source 0: Manual temperature entry 1: Temperature entry 2: Option input 1 3: Option input 2 4: Option input 3
0x180	Float	Relative cell constant for measuring range 1
0x182	Float	Relative cell constant for measuring range 2
0x184	Float	Temperature coefficient of measuring range 1
0x186	Float	Temperature coefficient of measuring range 2

5.5 Configuration of AS input

Many parameters involved in the input configuration are dependent on each other and cannot be arbitrarily combined. If invalid configurations are made (configurations that the device or setup does not permit), the result may be unpredictable behavior of the device and errors in control as well as in calculating measured values.

Address	Data type	Parameter
0x100	32-bit int.	Calibration timer
0x102	16-bit int.	Calibration interval
0x103	16-bit int.	Supply frequency 0: 50 Hz 1: 60 Hz
0x104	16-bit int.	Difference determination 0: No calculation 1: Main value – option input 1 2: Main value – option input 2 3: Main value – option input 3 4: Option input 1 – main value 5: Option input 2 – main value 6: Option input 3 – main value
0x105	16-bit int.	Compensation source 0: Manual temperature entry 1: Temperature entry 2: Option input 1 3: Option input 2 4: Option input 3
0x200	Float	Relative cell constant
0x202	Float	Zero point
0x204	Float	Slope
0x206	Float	Temperature coefficient
0x208	Float	Chlorine reference temperature
0x20A	Float	Chlorine reference pH value

Address	Data type	Parameter
0x20C	16-bit int.	Operating mode 0: Off 1: Linear scaling 2: Temperature measurement 3: pH measurement 4: Conductivity measurement 5: Concentration measurement 6: Customer specific table 7: Output level feedback 8: pH-compensated chlorine measurement
0x20D	16-bit int.	Display format (number of places after the decimal)
0x20E	16-bit int.	Unit 0: µS/cm 1: mS/cm 2: kOhm × cm 3: MOhm × cm 4: No unit 5: Customized unit 6: mV 7: pH 8: % 9: ppm 10: mg/l
0x20F	Float	Input scaling start
0x211	Float	Input scaling end
0x213	16-bit int.	Signal type 0: No sensor 1: Pt100 2: Pt1000 3: Customized resistance sensor 4: 0 to 20 mA 5: 4 to 20 mA 6: 0 to 10 V 7: 2 to 10 V 8: 0 to 1 V 9: Resistance transmitter (potentiometer)
0x214	16-bit int.	Connection type (temperature sensing element 0: 2-wire 1: 3-wire 2: 4-wire

Address	Data type	Parameter
0x215	16-bit int.	Compensation type (conductivity) 0: No temperature compensation 1: Linear temperature compensation 2: TC curve 3: Natural water 4: ASTM neutral impurity 5: ASTM acidic impurity 6: ASTM alkaline impurity 7: Concentration of NaOH 0 to 12 % 8: Concentration of NaOH 25 to 50 % 9: Concentration of HNO_3 0 to 25 % 10: Concentration of HNO_3 36 to 82 % 11: Concentration of H_2SO_4 0 to 28 % 12: Concentration of H_2SO_4 36 to 85 % 13: Concentration of H_2SO_4 92 to 99 % 14: Concentration of HCl 0 to 18 % 15: Concentration of HCl 22 to 44 %
0x216	16-bit int.	Temperature compensation source 0: Manual temperature entry 1: Temperature entry 2: Option input 1 3: Option input 2 4: Option input 3
0x217	Float	Reference temperature
0x219	Float	Filter time constant
0x21B	16-bit int.	pH compensation source 2: Option input 1 3: Option input 2 4: Option input 3 5: Main input

5.6 Configuration of temperature input

Address	Data type	Parameter
0x1E0	16-bit int.	Temperature sensing element 0: No sensor 1: Pt100 2: Pt1000 3: Customized characteristic resistance line 4: 0 to 20 mA 5: 4 to 20 mA 6: 0 to 10 V 7: 2 to 10 V 8: 0 to 1 V 9: Resistance transmitter (potentiometer)
0x1E1	Float	Filter time constant
0x1E3	Float	Manual temperature
0x1E5	Float	Offset
0x1E7	Float	Scaling start
0x1E9	Float	Scaling end
0x1EB	16-bit int.	Unit (for standard signal) 0: °C / °F 1: % 2: No unit 3: Customized unit

5.7 Configuration of option inputs

Addr. of opt. in. 1	Addr. of opt. in. 2	Addr. of opt. in. 3	Data type	Parameter
0x220	0x240	0x260	Float	Relative cell constant
0x222	0x242	0x262	Float	Zero point
0x224	0x244	0x264	Float	Slope
0x226	0x246	0x266	Float	Temperature coefficient
0x228	0x248	0x268	Float	Chlorine reference temperature
0x22A	0x24A	0x26A	Float	Chlorine reference pH value
0x22C	0x24C	0x26C	16-bit int.	Operating mode 0: Off 1: Linear scaling 2: Temperature measurement 3: pH measurement 4: Conductivity measurement 5: Concentration measurement 6: Customer specific table 7: Output level feedback 8: pH-compensated chlorine measurement
0x22D	0x24D	0x26D	16-bit int.	Display format (number of places after the decimal)
0x22E	0x24E	0x26E	16-bit int.	Unit 0: µS/cm 1: mS/cm 2: kOhm*cm 3: MOhm*cm 4: No unit 5: Customized unit 6: mV 7: pH 8: % 9: ppm 10: mg/l
0x22F	0x24F	0x26F	Float	Input scaling start
0x231	0x251	0x271	Float	Input scaling end

Addr. of opt. in. 1	Addr. of opt. in. 2	Addr. of opt. in. 3	Data type	Parameter
0x233	0x253	0x273	16-bit int.	Signal type 0: No sensor 1: Pt100 2: Pt1000 3: Customized resistance sensor 4: 0 to 20 mA 5: 4 to 20 mA 6: 0 to 10 V 7: 2 to 10 V 8: 0 to 1 V 9: Resistance transmitter (potentiometer)
0x234	0x254	0x274	16-bit int.	Connection type (temperature sensing element) 0: 2-wire 1: 3-wire 2: 4-wire
0x235	0x255	0x275	16-bit int.	Compensation type (conductivity) 0: No temperature compensation 1: Linear temperature compensation 2: TC curve 3: Natural water 4: ASTM neutral impurity 5: ASTM acidic impurity 6: ASTM alkaline impurity 7: Concentration of NaOH 0 to 12 % 8: Concentration of NaOH 25 to 50 % 9: Concentration of HNO_3 0 to 25 % 10: Concentration of HNO_3 36 to 82 % 11: Concentration of H_2SO_4 0 to 28 % 12: Concentration of H_2SO_4 36 to 85 % 13: Concentration of H_2SO_4 92 to 99 % 14: Concentration of HCl 0 to 18 % 15: Concentration of HCl 22 to 44 %
0x236	0x256	0x276	16-bit int.	Temperature compensation source 0: Manual temperature entry 1: Temperature entry 2: Option input 1 3: Option input 2 4: Option input 3
0x237	0x257	0x277	Float	Reference temperature
0x239	0x259	0x279	Float	Filter time constant

Addr. of opt. in. 1	Addr. of opt. in. 2	Addr. of opt. in. 3	Data type	Parameter
0x23B	0x25B	0x27B	16-bit int.	pH compensation source 2: Option input 1 3: Option input 2 4: Option input 3 5: Main input

5.8 Configuration of binary inputs

Address of input 1	Address of input 2	Data type	Parameter
0x280	0x2A0	16-bit int.	Function 0: Measuring range changeover (conductivity) 1: No function 2: Manual mode 3: Hold mode 4: Hold mode (inverted) 5: Alarm suppression 6: Freeze measured values 7: Key lock 8: Level lock 9: Flow rate measurement 10: Reset partial quantity counter 11: Reset total quantity counter 12: Parameter block switching
0x281	0x2A1	Float	K factor
0x283	0x2A3	16-bit int.	Unit for flow rate 0: l/s 1: l/min 2: l/h 3: m^3/min 4: m^3/h 5: gal/s 6: gal/min 7: gal/h
0x284	0x2A4	16-bit int.	Decimal format for flow rate (number of places after the decimal)

Address of input 1	Address of input 2	Data type	Parameter
0x285	0x2A5	16-bit int.	Unit of quantity counter 0: XXXX l 1: XXX.x l 2: XX.xx l 3: XXX.x m³ 4: XX.xx m³ 5: X.xxx m³ 6: XXXX gal 7: XXX.x gal 8: XX.xx gal 9: X.xxx gal
0x286	0x2A6	Float	Filter time

If the units for the quantity counter are changed, the quantity counters must be reset. If this is not done, liters and gallons (for example) will be added together.

5.9 Configuration of alarm function

Address alarm 1	Address alarm 2	Address alarm 3	Address alarm 4	Data type	Parameters
0x2C0	0x2E0	0x300	0x320	16-bit int.	Choice of signal 0: No signal 1: Main value 2: Uncompensated main value 3: Temperature entry 4: Option input 1 5: Uncomp. option input 1 6: Option input 2 7: Uncomp. option input 2 8: Option input 3 9: Uncomp. option input 3 10: Math 1 11: Math 2 12: Differential signal 13: Flow rate 14: Partial quantity 15: Total quantity 16: Output level of controller 1 17: Output level of controller 2
0x2C1	0x2E1	0x301	0x321	16-bit int.	Switching function 0: Window function 1: Inverse window function

Address alarm 1	Address alarm 2	Address alarm 3	Address alarm 4	Data type	Parameters
					2: Min. limit value function 3: Min. limit value function 4: USP 5: USP warning alarm 6: Purified water 7: Purified water warning alarm
0x2C2	0x2E2	0x302	0x322	Float	Limit value of measuring range 1
0x2C4	0x2E4	0x304	0x324	Float	Hysteresis of measuring range 1
0x2C6	0x2E6	0x306	0x326	Float	Distance (1/2 window width) of measuring range 1
0x2C8	0x2E8	0x308	0x328	Float	Limit value of measuring range 2
0x2CA	0x2EA	0x30A	0x32A	Float	Hysteresis of measuring range 2
0x2CC	0x2EC	0x30C	0x32C	Float	Distance (1/2 window width) of measuring range 2
0x2CE	0x2EE	0x30E	0x32E	Float	Warning alarm

5.10 Configuration of binary outputs

Address relay 1	Address relay 2	Address relay 3	Address relay 4	Data type	Parameter
0x340	0x360	0x380	0x3A0	16-bit int.	Manual mode 0: Inactive 1: Active 2: No manual mode
0x341	0x361	0x381	0x3A1	16-bit int.	Choice of signal 0: No signal 1: Limit value switch 1 2: Limit value switch 2 3: Limit value switch 3 4: Limit value switch 4 5: Controller 1 output 1 6: Controller 1 output 2 7: Controller 2 output 1 8: Controller 2 output 2 9: Alarm for controller 1 10: Alarm for controller 2 11: Alarm for controller 1 or 2 12: Warning 13: Error signal
					14: Warning or error 15: Calibration timer 16: Wash timer

Address relay 1	Address relay 2	Address relay 3	Address relay 4	Data type	Parameter
					17: Logic 1 18: Logic 2 19: Autorange signal
0x342	0x362	0x382	0x3A2	16-bit int.	Response during calibration 0: Standard operation 1: Inactive 2: Active 3: Frozen
0x343	0x363	0x383	0x3A3	16-bit int.	Response to error 1: Inactive 2: Active 3: Frozen
0x344	0x364	0x384	0x3A4	16-bit int.	Response during hold 0: Standard operation 1: Inactive 2: Active 3: Frozen
0x345	0x365	0x385	0x3A5	16-bit int.	ON-delay
0x346	0x366	0x386	0x3A6	16-bit int.	OFF-delay
0x347	0x367	0x387	0x3A7	16-bit int.	Pulse time

Address relay 5	Address relay 6	Address relay 7	Address relay 8	Data type	Parameter
0x3C0	0x3E0	0x400	0x420	16-bit int.	Manual mode 0: Inactive 1: Active 2: No manual mode
0x3C1	0x3E1	0x401	0x421	16-bit int.	Choice of signal 0: No signal 1: Limit value switch 1 2: Limit value switch 2 3: Limit value switch 3 4: Limit value switch 4 5: Controller 1 output 1 6: Controller 1 output 2 7: Controller 2 output 1 8: Controller 2 output 2 9: Alarm for controller 1 10: Alarm for controller 2 11: Alarm for controller 1 or 2 12: Warning 13: Error signal

Address relay 5	Address relay 6	Address relay 7	Address relay 8	Data type	Parameter
					14: Warning or error 15: Calibration timer 16: Wash timer 17: Logic 1 18: Logic 2 19: Autorange signal
0x3C2	0x3E2	0x402	0x422	16-bit int.	Response during calibration 0: Standard operation 1: Inactive 2: Active 3: Frozen
0x3C3	0x3E3	0x403	0x423	16-bit int.	Response to error 1: Inactive 2: Active 3: Frozen
0x3C4	0x3E4	0x404	0x424	16-bit int.	Response during hold 0: Standard operation 1: Inactive 2: Active 3: Frozen
0x3C5	0x3E5	0x405	0x425	16-bit int.	ON-delay
0x3C6	0x3E6	0x406	0x426	16-bit int.	OFF-delay
0x3C7	0x3E7	0x407	0x427	16-bit int.	Pulse time

5.11 Configuration of analog outputs

Addr. of opt. in. 1	Addr. of opt. in. 2	Addr. of opt. in. 3	Data type	Parameter
0x440	0x460	0x480	16-bit int.	Simulation 0: Off 1: On
0x441	0x461	0x481	Float	Simulation value
0x443	0x463	0x483	16-bit int.	Choice of signal 0: Zero 1: Main value 2: Uncompensated main value 3: Temperature entry 4: Option input 1 5: Uncomp. option input 1
				6: Option input 2 7: Uncomp. option input 2 8: Option input 3

Addr. of opt. in. 1	Addr. of opt. in. 2	Addr. of opt. in. 3	Data type	Parameter
				9: Uncomp. option input 3 10: Math 1 11: Math 2 12: Differential signal 13: Flow rate 14: Partial quantity 15: Total quantity 16: Output level of controller 1 17: Output level of controller 2
0x444	0x464	0x484	16-bit int.	Signal type 0: 0 to 20 mA 1: 4 to 20 mA 2: 20 to 0 mA 3: 20 to 4 mA 4: 0 to 10 V 5: 10 to 0 V
0x445	0x465	0x485	Float	Scaling start of measuring range 1
0x447	0x467	0x487	Float	Scaling end of measuring range 1
0x449	0x469	0x489	Float	Scaling start of measuring range 2
0x44B	0x46B	0x48B	Float	Scaling end of measuring range 2
0x44D	0x46D	0x48D	16-bit int.	Response during calibration 0: Standard operation 1: Frozen 2: Substitute value
0x44E	0x46E	0x48E	16-bit int.	Response to error 0: Low (0 V / 0 mA / 4 mA) 1: High (10 V / 20 mA) 2: Frozen 3: Substitute value 4: NAMUR Low (0 V / 0 mA / 3.4 mA) 5: NAMUR High (10.7 V / 22 mA)
0x44F	0x46F	0x48F	16-bit int.	Response during hold 0: Low (0 V / 0 mA / 4 mA) 1: High (10 V / 20 mA) 2: Frozen 3: Substitute value 4: Standard operation
0x450	0x470	0x490	16-bit int.	Substitute value

5.12 Controller parameters

Addr. of contr. 1 param. set 1	Addr. of contr. 1 param. set 2	Addr. of contr. 2 param. set 1	Addr. of contr. 2 param. set 2	Data type	Parameter
0x5C0	0x5E0	0x600	0x620	Float	Lower setpoint limit
0x5C2	0x5E2	0x602	0x622	Float	Upper setpoint limit
0x5C4	0x5E4	0x604	0x624	Float	Setpoint value 1
0x5C6	0x5E6	0x606	0x626	Float	Setpoint value 2
0x5C8	0x5E8	0x608	0x628	Float	Proportional band
0x5CA	0x5EA	0x60A	0x62A	Float	Reset time
0x5CC	0x5EC	0x60C	0x62C	Float	Derivative time
0x5CE	0x5EE	0x60E	0x62E	Float	Pulse period
0x5D0	0x5F0	0x610	0x630	Float	Hysteresis
0x5D2	0x5F2	0x612	0x632	Float	ON-delay
0x5D4	0x5F4	0x614	0x634	Float	OFF-delay
0x5D6	0x5F6	0x616	0x636	16-bit int.	Output level limit
0x5D7	0x5F7	0x617	0x637	Float	Min. switch-on time
0x5D9	0x5F9	0x619	0x639	16-bit int.	Actuator time
0x5DA	0x5FA	0x61A	0x63A	Float	Max. pulse frequency
0x5DC	0x5FC	0x61C	0x63C	Float	Alarm tolerance
0x5DE	0x5FE	0x61E	0x63E	16-bit int.	Alarm delay

5.13 Display configuration

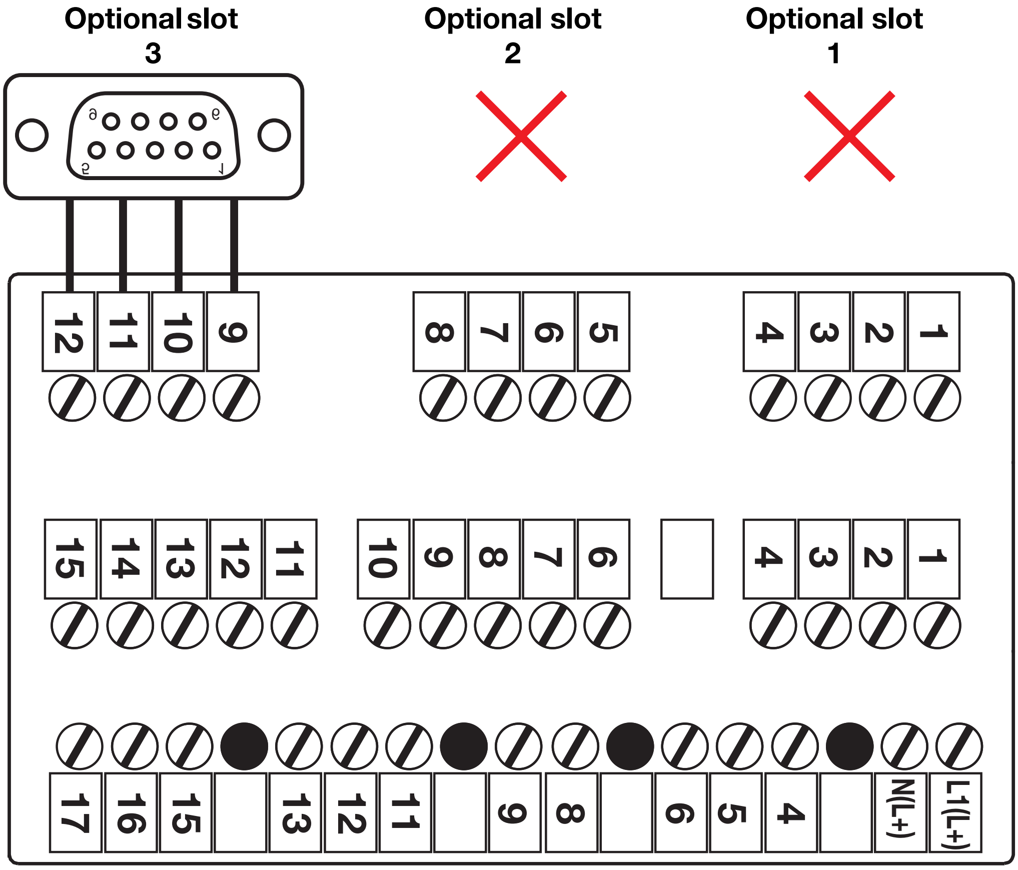
Address	Data type	Parameter
0x140	16-bit int.	Lighting 1: On 2: During operation
0x141	16-bit int.	Inversion 0: Normal 1: Inverted
0x142	16-bit int.	Type of measured value display 0: Standard display of 2 measured values 1: Trend display 2: Bar graph 3: Trend curve 4: Large display 5: 3 measured values 6: Time
0x143	16-bit int.	Display on bottom 0: No signal 1: Main value

Address	Data type	Parameter
		2: Uncompensated main value 3: Temperature entry 4: Option input 1 5: Uncomp. option input 1 6: Option input 2 7: Uncomp. option input 2 8: Option input 3 9: Uncomp. option input 3 10: Math 1 11: Math 2 12: Differential signal 13: Flow rate 14: Partial quantity 15: Total quantity 16: Output level of controller 1 17: Output level of controller 2 18: Controller 1 setpoint value 1 19: Controller 1 setpoint value 2 20: Controller 2 setpoint value 1 21: Controller 2 setpoint value 2
0x144	16-bit int.	Display in middle 0: No signal 1: Main value 2: Uncompensated main value 3: Temperature entry 4: Option input 1 5: Uncomp. option input 1 6: Option input 2 7: Uncomp. option input 2 8: Option input 3 9: Uncomp. option input 3 10: Math 1 11: Math 2 12: Differential signal 13: Flow rate 14: Partial quantity 15: Total quantity 16: Output level of controller 1 17: Output level of controller 2 18: Controller 1 setpoint value 1 19: Controller 1 setpoint value 2 20: Controller 2 setpoint value 1

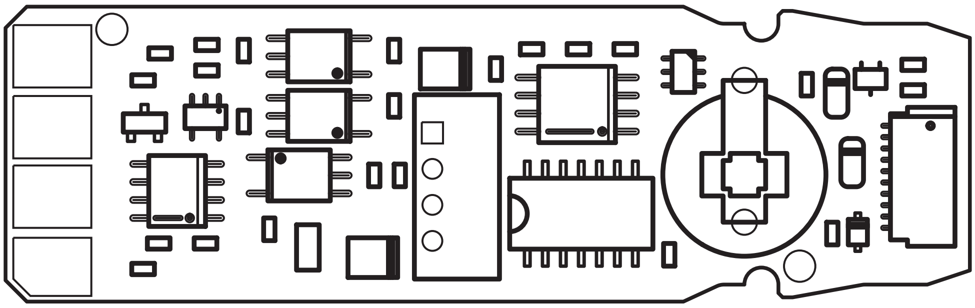
Address	Data type	Parameter
		21: Controller 2 setpoint value 2
0x145	16-bit int.	Display on top 0: No signal 1: Main value 2: Uncompensated main value 3: Temperature entry 4: Option input 1 5: Uncomp. option input 1 6: Option input 2 7: Uncomp. option input 2 8: Option input 3 9: Uncomp. option input 3 10: Math 1 11: Math 2 12: Differential signal 13: Flow rate 14: Partial quantity 15: Total quantity 16: Output level of controller 1 17: Output level of controller 2 18: Controller 1 setpoint value 1 19: Controller 1 setpoint value 2 20: Controller 2 setpoint value 1 21: Controller 2 setpoint value 2
0x146	16-bit int.	Timeout
0x147	Float	Start of display scaling (bar graph / trend curve) for measuring range 1
0x149	Float	End of display scaling (bar graph / trend curve) for measuring range 1
0x14B	Float	Start of display scaling (bar graph / trend curve) for measuring range 2
0x14D	Float	End of display scaling (bar graph / trend curve) for measuring range 2
0x14F	16-bit int.	Signal source bar graph / trend curve 0: No signal 1: Main value 2: Uncompensated main value 3: Temperature entry 4: Option input 1 5: Uncomp. option input 1 6: Option input 2 7: Uncomp. option input 2 8: Option input 3 9: Uncomp. option input 3 10: Math 1 11: Math 2

Address	Data type	Parameter
		12: Differential signal 13: Flow rate 14: Partial quantity 15: Total quantity
0x150	16-bit int.	Contrast
0x151	16-bit int.	Trend curve sampling time
0x152	16-bit int.	Temperature unit 0: °C 1: °F

The optional board "Datalogger with interface RS422/485", part no. APM-10000D, and optional board "Interface RS422/485", part no. APM-10000S, and optional board "PROFIBUS-DP interface", part no. APM-10000P, may only be fitted once each (to optional slot 3)!



7.1 General description



The "data logger" optional board adds three functions to the device:

- Ring buffer to store measured values and record switching status
- Real-time clock
- RS485 interface

☞ The data logger must not be used at the same time as the "PROFIBUS-DP" and "RS422/485 interface" optional boards.

7.2 Data logger

The data logger stores up to 43,500 data records in a ring buffer (i.e. data record 43501 overwrites data record 1, etc.). A data record consists of max. 4 analog and max. 16 digital values (tracks). Data is saved with the date and time.

Depending on the selected recording interval, it is possible to record data over a period ranging from about 10 hours to 150 days. The recording interval (sampling rate) can be adjusted in the range of 1 to 300 seconds. Using fewer than 4 analog or 16 digital tracks does not increase recording capacity.

The data records of the data logger are saved to flash memory. Adjustable parameters are saved in an EEPROM. Data is retained after a power failure.

Analog values include the input signals (actual values) of the relevant sensors, analog output values, analog results from the math modules, continuous controller outputs, etc.

Digital values include the switching status of relays or switching outputs as well as binary results from the math modules.

Recorded data cannot be changed by the user. This makes the data records practically tamper-proof.

The selection of signals to be recorded can be done mostly without restrictions through corresponding programming in the device or with the convenient PC setup program.

Data is normally evaluated by the setup interface included in the device. Data is read and can be saved as a data file. Data can also be transferred using the RS422/485 interface included on the data logger board.

Subsequently the values can be displayed in table format or as a graphic in the setup program. No changes can be made to the data at this point. For example, a zoom and search function is available for detailed data analysis.

An export function can be used to convert data to another format. This allows further processing in commonly-used spreadsheet programs.

Areas of application

- Recording batch processes
- Data backup
- Analysis of chemical processes
- Fault analysis
- System monitoring
- Controller optimization (settling processes)
- As a documentation aid for creating a monitoring system based on IFS Food 5 (HACCP) in food production and storage.

7.3 Real-time clock

The data logger option board contains a real-time clock. It is used as the basis for data recording of the logger with date and time. It also expands several functions of the device:

- Showing the time in the status line display (format hh:mm:ss)
- Date stamp is added to the calibration logbook
- The time can be shown in large format in the display (with measurement and control still running normally in the background)

The real-time clock has a gold-cap capacitor buffer and retains the date/time for about 14 days in the event of a power failure (at an ambient temperature of 25 °C). The accuracy within the permissible ambient temperature range is ±60 s per month.

7.4 RS485 interface

As an additional technological option the data logger board provides a digital RS485 interface. It can be used as a device interface to integrate the device into a corresponding bus system:

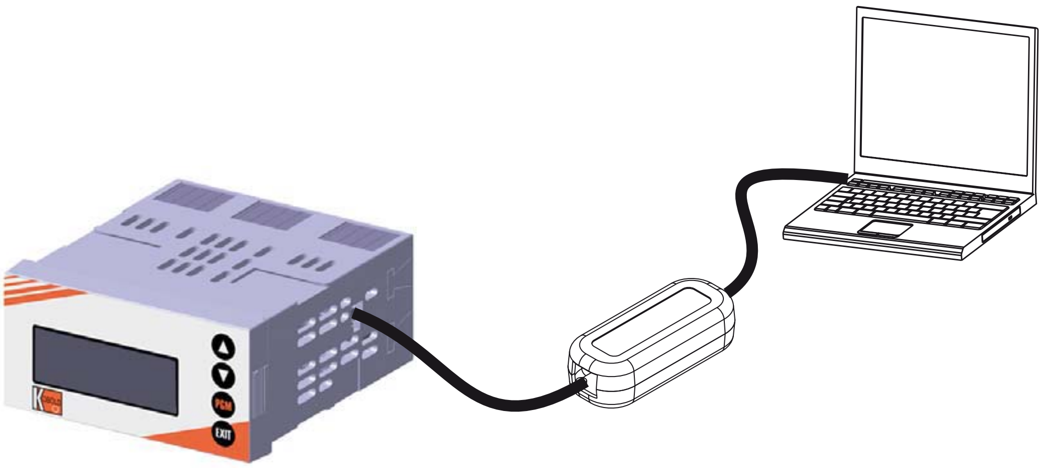
Protocol:	Modbus
Baud rate:	Max. 38.4 kbaud (adjustable)
Max. transmission distance:	<1200 m
Max. number of bus nodes	32

☞ Using the RS485 and setup interface simultaneously should be avoided.

7.5 Reading data with the setup program

The data can be completely configured and the data logger can be read with the optionally available setup program (part no. ACM-Soft).

Preparation Connect a PC or laptop with the PC interface line and USB/TTL converter (part no. ACM-Int). Start the software and establish the connection.

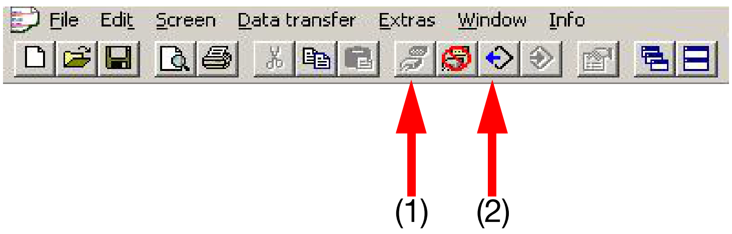


Reading and saving data

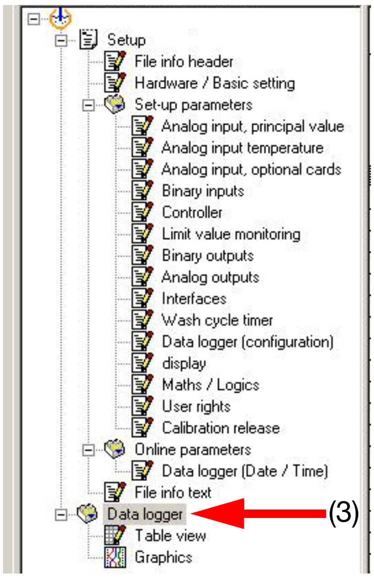
✱Start the setup program.

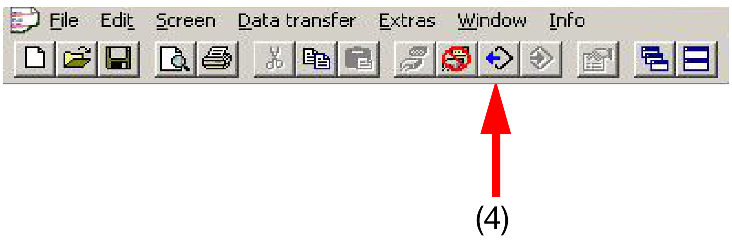
✱Establish the connection to the device (1).

✱Read the device configuration (2).

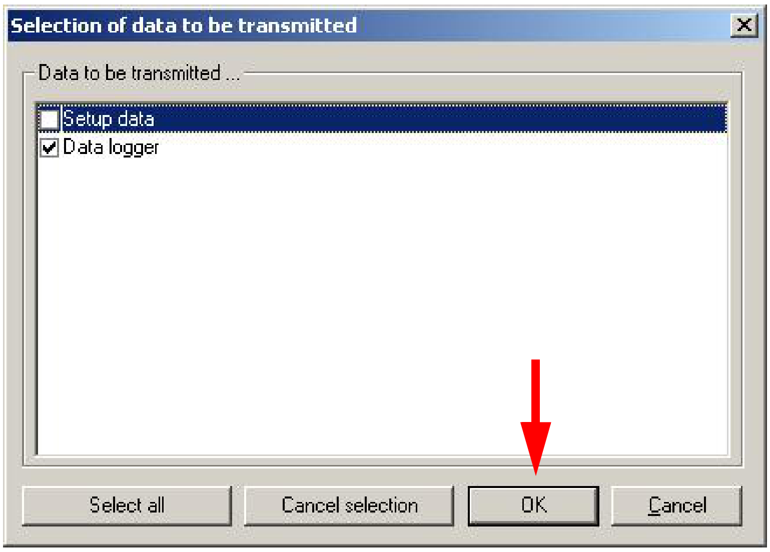


✱Read data from the data logger (in table view, for example).
- Mark the data logger icon (3)
- Read values from the device (4)





The user can decide in the window that follows ("Select data to be transferred") whether to read the parameterization data of the connected device (setup data) and/or the logger data simultaneously.



After the user clicks OK, data is read from the data logger. Depending on the set baud rate of the setup interface this process may take several minutes. At the fastest (recommended) baud rate of 38,400 bits/s the read process lasts about 10 to 15 minutes.

The progress of the data transfer is shown on the PC/laptop.

The duration of the data transfer depends on how many analog or binary tracks were actively recorded.

After the data transfer is complete it is recommended to save the data immediately. To do this click the diskette icon in the PC setup program. Logger data is part of the setup data and will be saved in a common file. The setup program suggests the file name "Setup1" for this purpose. This name can be changed (for example to "Logger_data_August_2011").

7.6 Data evaluation

Logger data is only available for viewing in the setup program. A table view and graphical display are available for selection. Data cannot be changed at this point (protection against tampering).

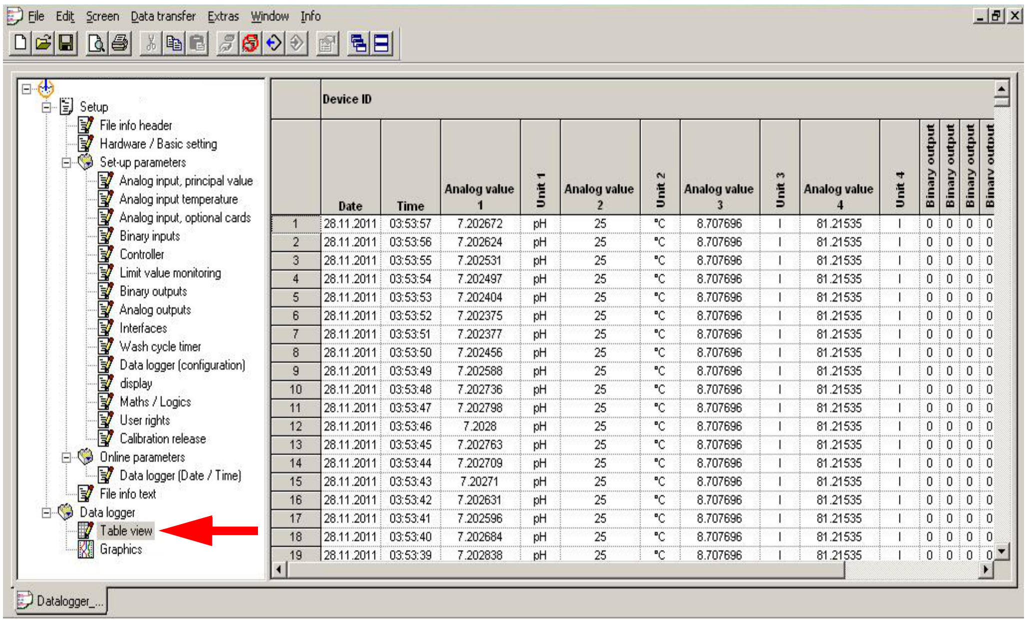
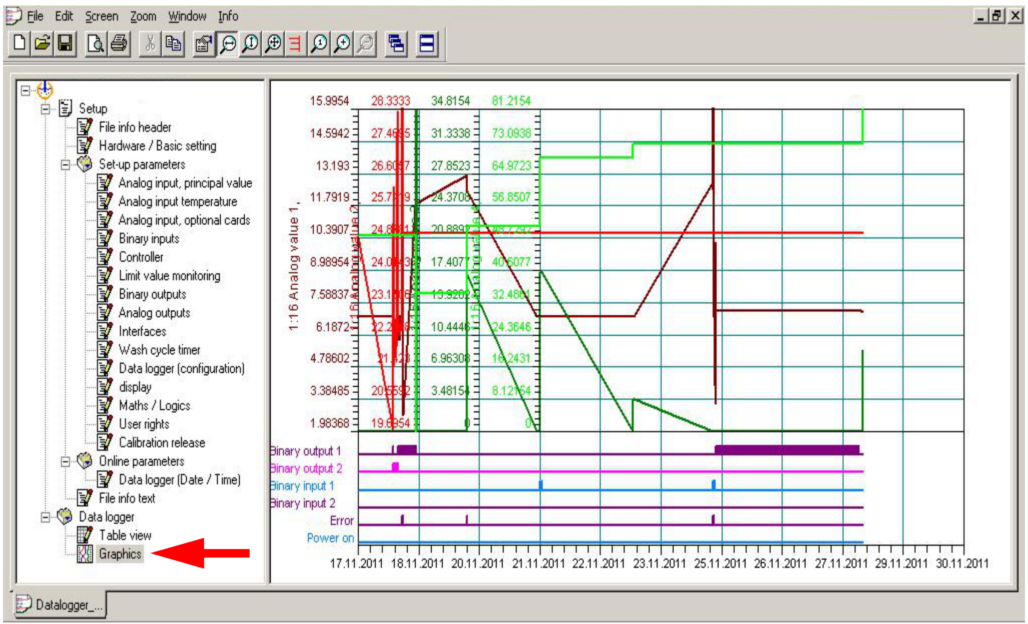
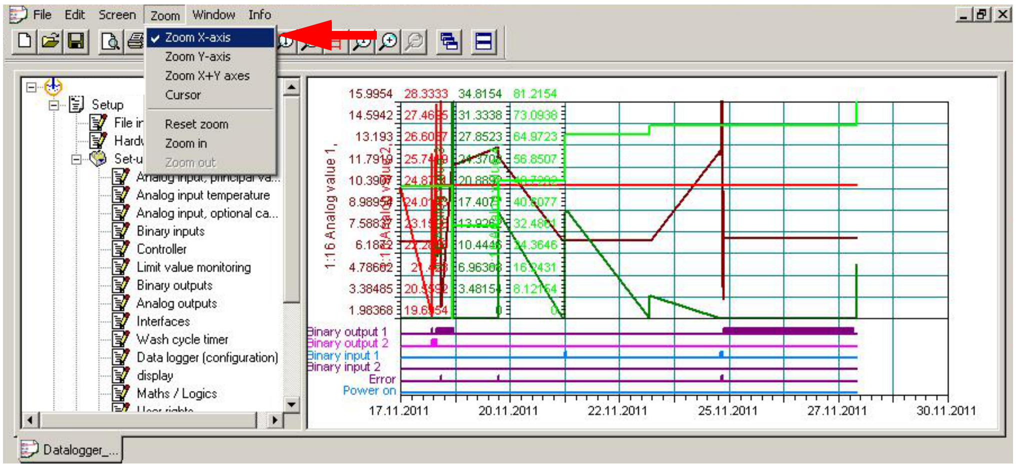


Table view

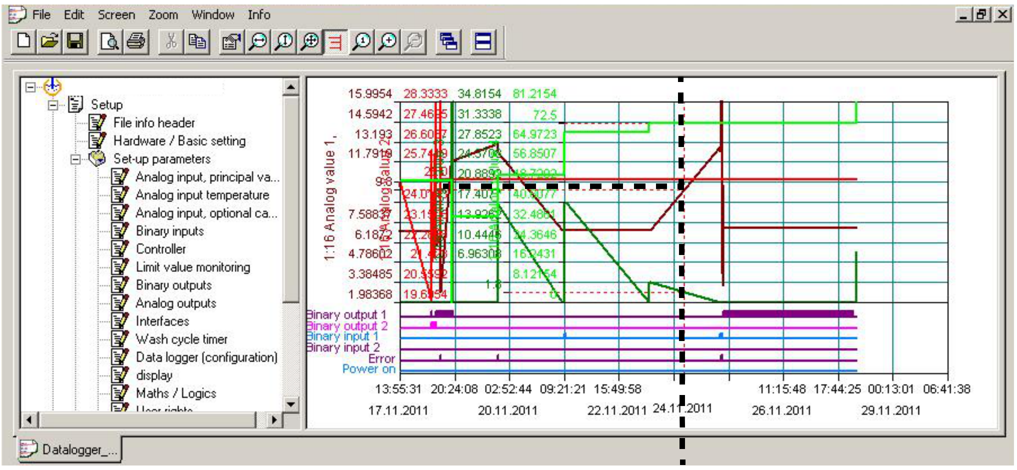


Graphical view

Zoom function and measurement cursor



Various zoom functions are available in the graphical display. Areas can be marked with the PC mouse (click and hold the right mouse button, then drag it over the graphic). At that point the areas can be displayed in enlarged format for detail analysis. A measurement cursor can be activated, thereby enabling measured value analysis with pinpoint accuracy.

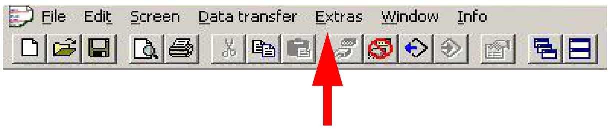


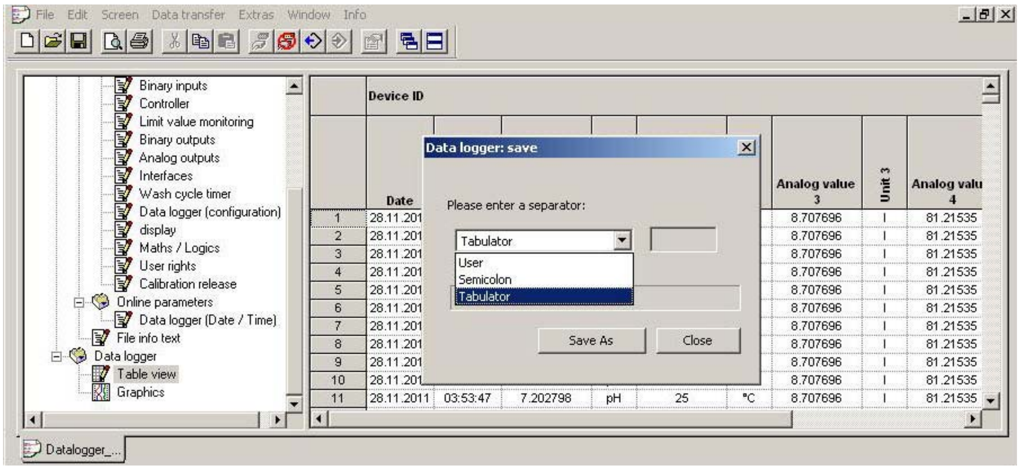
Click a point in the diagram with the mouse arrow. Cursor data display: measured value and time.

7.6.1 Data export

The PC setup program can be used to convert logger data into a commonly-used standard format, allowing for further processing of the data in a spreadsheet program, etc.

To do this first switch to the table view. Proceed by going in the "Extras" menu item to select "Save data logger".





A separator must be selected for the new data record. The separator must be defined based on the PC program available for further processing (spreadsheet program, database, etc.). Then logger data can be saved in a new file with the file extension *.txt.

7.6.2 Data import

Only original setup files can be loaded into the PC setup program (extension *.268).

☞ Any tampering with this file may result in loss of data.

No support can be provided for data import of *.txt files to another evaluation program (spreadsheet program, database, etc.) because the import depends on the PC software that is used and differs from one case to another.

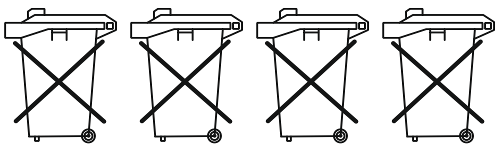
Disposal

Note!

- Avoid environmental damage caused by media-contaminated parts
- Dispose of the device and packaging in an environmentally friendly manner
- Comply with applicable national and international disposal regulations and environmental regulations.

Batteries

Batteries containing pollutants are marked with a sign consisting of a crossed-out garbage can and the chemical symbol (Cd, Hg, Li or Pb) of the heavy metal that is decisive for the classification as containing pollutants:



Cd[1] Hg[2] Pb[3] Li[4]

1. „Cd" stands for cadmium
2. Hg" stands for mercury
3. „Pb" stands for lead
4. Li" stands for lithium

Electrical and electronic equipment