Software description Modbus RTU

Summary

Description of the standard software of the Modbus RTU modules:

General commands

Bit rate setting with Modbus commands

Parity and bit rate have the same value as with the setting by the address switches.
If Parity or bit rate are 0, there will be no setting or storage.
The register content is stored in the EEPROM.

Modbus Function “06 (0x06) Write Single Register”

Modbus Function “16 (0x10) Write Multiple Registers”

Request

Valid Register Address 0x41 (65)
Valid Register Value 2 Bytes

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0x53								Parity				Bit rate			

Bit 15-8: Magic-Number 0x53 = 83 as protection against accidental writing.
The command will be further analyzed only with this number.

Bit 7-4	1	2	3
Parity	even	odd	none

Bit 3-0	1	2	3	4	5	6	7	8
Bit rate	1200	2400	4800	9600	19200	38400	57600	115200

Response

Echo of Request

Example for a frame:

Slave address	0x12	Rotary switch setting (18)
Function	0x06	Write Single Register
Register address Hi	0x00	
Register address Lo	0x41	Bit rate and Parity (65)
Register content Hi	0x53	Magic number
Register content Lo	0x15	Parity Even, 19200 Bit/s

All devices can be switched simultaneously with a Broadcast command (Slave address 0x00)
However, it is advised not to do so as this may cause problems:

- Devices from other manufacturers may have under this address a register for a different purpose that will then be operated in the wrong way.

There is no feedback from the individual devices. Consequently the control cannot immediately recognize if the command was correctly received.

It is safer to address and switch each device individually. The device will then answer with the old settings of parity and bit rate. Switching will take place afterwards. However, the answer can get lost if the bus is disturbed.

When all devices are switched; it is advised to check communication. Any function of the device providing a feedback is suitable. If a single function is to be used being independent from the process periphery then the function „Diagnostic“ sub-function „Return Query Data“ is suitable, it returns the transferred data.

If bit rate and parity setting of a device are unknown it is possible to address the device successively with all combinations of bit rate and parity until the device answers. Try the most likely combinations first. Try the lower bit rates last as they take longer.

Test of the communication system

Modbus Function “08 (0x08) Diagnostics”

Subfunction “0 (0x0000) Return Query Data”
Data Field Any
Response: Echo of Request

Subfunction “1 (0x0001) Restart Communication Option”
Data Field 0x0000 or 0xFF00
Response: Echo of Request
Action: Clears all Error Counters, Restarts node

Subfunction “4 (0x0004) Force Listen Only Mode”
Data Field 0x0000
No Response
Action: No response until Node Reset or Function Code 08 Subcode 01

Subfunction “10 (0x000A) Clear Counters”
Data Field 0x0000
Response: Echo of Request
Action: Clears all Error Counters

Subfunction “11 (0x000B) Return Bus Message Count”
Data Field 0x0000
Response: Quantity of messages that the remote device has detected on the communications system since its last restart, clear counters operation, or power-up.

Subfunction “12 (0x000C) Return Bus Communication Error Count”
Data Field 0x0000
Response: Quantity of errors encountered by the remote device since its last restart, clear counters operation, or power-up. (CRC, Length <3, Parity, Framing

Subfunction “13 (0x000D) Return Bus Exception Error Count”
Data Field 0x0000
Response: Quantity of Modbus exception responses returned by the remote device since its last restart, clear counters operation, or power-up.

Subfunction “14 (0x000E) Return Slave Message Count”
Data Field 0x0000
Response: quantity of messages addressed to the remote device, or broadcast, that the remote device has processed since its last restart, clear counters operation, or power-up.

Subfunction “15 (0x000F) Return Slave No Response Count”
Data Field 0x0000
Response: Quantity of messages addressed to the remote device for which it has returned no response (neither a normal response nor an exception response), since its last restart, clear counters operation, or power-up.

MR-DO4 / MR-DOA4

I/O commands

Modbus Function "01 (0x01) Read Coils"

Request
Valid Coil Starting Address 0 .. 7
* for MR-DOA4 Address 4 .. 7 = 0
Valid Quantity of Outputs 1 .. 8

Response
Byte Count 1
Output Status Bit0 .. Bit7

Bit	Information
0	0 = Status relay 1 off
	1 = Status relay 1 on
1	0 = Status relay 2 off
	1 = Status relay 2 on
2	0 = Status relay 3 off
	1 = Status relay 3 on
3	0 = Status relay 4 off
	1 = Status relay 4 on
4*	0 = relay 1 switched via bus
	1 = relay 1 switched via manual control
5*	0 = relay 2 switched via bus
	1 = relay 2 switched via manual control
6*	0 = relay 3 switched via bus
	1 = relay 3 switched via manual control
7*	0 = relay 4 switched via bus
	1 = relay 4 switched via manual control

Modbus Function "05 (0x05) Write Single Coil"

Request

Valid Output Address	0 .. 3
Valid Output Value	0x0000 or 0xFF00

Response

Echo of the request

Modbus Function "15 (0x0F) Write Multiple Coils"

Request

Valid Coil Starting Address	0 .. 3
Valid Quantity of Outputs	1 .. 4
Valid Byte Count	1
Output Value	0 or 1 in Bit0 .. Bit3

Bit	Information
0	0 = Status relay 1 off
	1 = Status relay 1 on
1	0 = Status relay 2 off
	1 = Status relay 2 on
2	0 = Status relay 3 off
	1 = Status relay 3 on
3	0 = Status relay 4 off
	1 = Status relay 4 on

Response

Function Code, Starting Address, Quantity of Outputs

Modbus Function "03 (0x03) Read Holding Registers"

Request

Valid Register Starting Address	0..1 or 66
Valid Quantity of Registers	2 or 1

Response

Function Code, Byte Count, Register Values

Values Register 0:

Bit	Information
0	0 = Status relay 1 off
	1 = Status relay 1 on
1	0 = Status relay 2 off
	1 = Status relay 2 on
2	0 = Status relay 3 off
	1 = Status relay 3 on
3	0 = Status relay 4 off
	1 = Status relay 4 on
4	0 = relay 1 switched via bus
	1 = relay 1 switched via manual control
5	0 = relay 2 switched via bus
	1 = relay 2 switched via manual control
6	0 = relay 3 switched via bus
	1 = relay 3 switched via manual control
7	0 = relay 4 switched via bus
	1 = relay 4 switched via manual control

Values Register 1:

Bit	Information
0	0 = Initial state after Reset or communication; monitoring relay 1 off
	1 = Initial state after Reset or communication; monitoring relay 1 on
1	0 = Initial state after Reset or communication; monitoring relay 2 off
	1 = Initial state after Reset or communication; monitoring relay 2 on
2	0 = Initial state after Reset or communication; monitoring relay 3 off
	1 = Initial state after Reset or communication; monitoring relay 3 on
3	0 = Initial state after Reset or communication; monitoring relay 4 off
	1 = Initial state after Reset or communication; monitoring relay 4 on

Value Register 66:
Time constant for communication monitoring.
Register Value = 0 (0x0000) (default) there is no communication monitoring, all other values are for communication monitoring with a solution of 10 ms.
0x0001 to 0xFFFF => 0.01 to 655.35 seconds = 10.9 minutes

Modbus Function "06 (0x06) Write Single Register"

Request

Register Address	0 or 1 or 66
Register Value	Bits 0 – 3 according to tables or the description above

Response

Echo of the request

Modbus Function "16 (0x10) Write Multiple Registers"

Request

Valid Register Starting Address	0 or 1 or 66
Valid Quantity of Registers	1 or 2
Byte Count	2 x Quantity of registers
Registers Value	Quantity of registers x 2 Byte Bits 0 – 3 according to tables

Response

Function Code, Register Starting Address, Quantity of Registers

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x06
Object Value	"MR-DO4"
Object ID	0x02
Object Length	0x04
Object Value	"V1.4"

MR-TO4

I/O commands

Modbus Function "01 (0x01) Read Coils"

Request
Valid Coil Starting Address 0 .. 7
Valid Quantity of Outputs 1 .. 8

Response
Byte Count 1
Output Status Bit0 .. Bit7

Bit	Information
0	0 = Status Triac 1 off
	1 = Status Triac 1 on
1	0 = Status Triac 2 off
	1 = Status Triac 2 on
2	0 = Status Triac 3 off
	1 = Status Triac 3 on
3	0 = Status Triac 4 off
	1 = Status Triac 4 on
4*	0 = Triac 1 switched via bus
	1 = Triac 1 switched via manual control
5*	0 = Triac 2 switched via bus
	1 = Triac 2 switched via manual control
6*	0 = Triac 3 switched via bus
	1 = Triac 3 switched via manual control
7*	0 = Triac 4 switched via bus
	1 = Triac 4 switched via manual control

Modbus Function “05 (0x05) Write Single Coil”

Request

Valid Output Address	0 .. 3
Valid Output Value	0x0000 or 0xFF00

Response

Echo of the request

Modbus Function “15 (0x0F) Write Multiple Coils”

Request

Valid Coil Starting Address	0 .. 3
Valid Quantity of Outputs	1 .. 4
Valid Byte Count	1
Output Value	0 or 1 in Bit0 .. Bit3

Bit	Information
0	0 = Status Triac 1 off
	1 = Status Triac 1 on
1	0 = Status Triac 2 off
	1 = Status Triac 2 on
2	0 = Status Triac 3 off
	1 = Status Triac 3 on
3	0 = Status Triac 4 off
	1 = Status Triac 4 on

Response

Function Code, Starting Address, Quantity of Outputs

Modbus Function “03 (0x03) Read Holding Registers”

Request

Valid Register Starting Address	0..1 or 66
Valid Quantity of Registers	2 or 1

Response

Function Code, Byte Count, Register Values

Values Register 0:

Bit	Information
0	0 = Status Triac 1 off
	1 = Status Triac 1 on
1	0 = Status Triac 2 off
	1 = Status Triac 2 on
2	0 = Status Triac 3 off
	1 = Status Triac 3 on
3	0 = Status Triac 4 off
	1 = Status Triac 4 on
4*	0 = Triac 1 switched via bus
	1 = Triac 1 switched via manual control
5*	0 = Triac 2 switched via bus
	1 = Triac 2 switched via manual control
6*	0 = Triac 3 switched via bus
	1 = Triac 3 switched via manual control
7*	0 = Triac 4 switched via bus
	1 = Triac 4 switched via manual control

Values Register 1:

Bit	Information
0	0 = Initial state after Reset or communication; monitoring Triac 1 off
	1 = Initial state after Reset or communication; monitoring Triac 1 on
1	0 = Initial state after Reset or communication; monitoring Triac 2 off
	1 = Initial state after Reset or communication; monitoring Triac 2 on
2	0 = Initial state after Reset or communication; monitoring Triac 3 off
	1 = Initial state after Reset or communication; monitoring Triac 3 on
3	0 = Initial state after Reset or communication; monitoring Triac 4 off
	1 = Initial state after Reset or communication; monitoring Triac 4 on

Value Register 66:
Time constant for communication monitoring.
Register Value = 0 (0x0000) (default) there is no communication monitoring, all other values are for communication monitoring with a solution of 10 ms.
0x0001 to 0xFFFF => 0.01 to 655.35 seconds = 10.9 minutes

Modbus Function "06 (0x06) Write Single Register"

Request

Register Address	0 or 1 or 66
Register Value	Bits 0 – 3 according to tables or the description above

Response

Echo of the request

Modbus Function "16 (0x10) Write Multiple Registers"

Request

Valid Register Starting Address	0 or 1 or 66
Valid Quantity of Registers	1 or 2
Byte Count	2 x Quantity of registers
Registers Value	Quantity of registers x 2 Byte Bits 0 – 3 according to tables

Response

Function Code, Register Starting Address, Quantity of Registers

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x06
Object Value	"MR-TO4"
Object ID	0x02
Object Length	0x04
Object Value	"V1.4"

MR-DI4 / MR-DI4-IP

Modbus Function “02 (0x02) Read Discrete Inputs“

Request	
Valid Input Starting Address	0 .. 3
Valid Quantity of Inputs	1 .. 4
Response	
Byte Count	1
Input Status	Bit0 .. Bit3 (Bit 4 .. 7 = 0)

Information
1= Status input closed
0= Status input open

Modbus Function “04 (0x04) Read Input Registers”

Request	
Valid Register Starting Address	0
Valid Quantity of Registers	1
Response	
Byte Count	2
Values Register	Input Status Bit 0..3

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request	
Read Device ID code:	0x01
Object ID	0x00
Response	
Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x06
Object Value	“MR-DI4”
Object ID	0x02
Object Length	0x04
Object Value	“V1.4”

MR-DI10

Modbus Function “02 (0x02) Read Discrete Inputs“

Request

Valid Input Starting Address	0 .. 9
Valid Quantity of Inputs	1 .. 10

Response

Byte Count	1 or 2
Input Status	Bit0 .. Bit9

Information

1= Status input closed
0= Status input open

Modbus Function “04 (0x04) Read Input Registers”

Request

Valid Register Starting Address	0
Valid Quantity of Registers	1

Response

Byte Count	2
Values Register	Input Status Bit 0..9

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x07
Object Value	“MR-DI10”
Object ID	0x02
Object Length	0x04
Object Value	“V1.4”

MR-SI4

I/O functions

Modbus Function "02 (0x02) Read Discrete Inputs"

Request

Valid Input Starting Address	0 .. 3
Valid Quantity of Inputs	1 .. 4

Response

Byte Count	1
Input Status	Bit0 .. Bit3 (Bit 4 .. 7 = 0)

Information

1= Status input closed
0= Status input open

Modbus Function "04 (0x04) Read Input Registers"

Request

Valid Register Starting Address	0
Valid Quantity of Registers	21

Response

Byte Count	2
Values Register	Input Status Bit 0..3

Counter functions

The following functions are used to read or write the registers. The valid address ranges are indicated in brackets.

"04 (0x04) Read Input Registers"	(0-20)
„03 (0x03) Read Holding Registers"	(0-43)
"06 (0x06) Write Single Register"	(20-43)
"06 (0x06) Write Single Register"	(65)
"16 (0x10) Write Multiple Registers	(0-43, 65)

For long data types with a length of several registers, these registers are listed directly one after the other and the one with the highest value is indicated first. This data can only be transmitted as complete set.

Input Register (Read-Only)		
Address	Name	Description
0 – 11	IZ	Pulse counter Data type uint48_t (3 registers each)
12 – 19	BZ	Calculated counter reading Data type uint32_t (2 registers each)
20	INPUT	Bits 0-3 include Discrete Input 0-3

Holding Register		
Address	Name	Description
0 – 11	IT	Copy of the pulse counter after having pressed the key Data type uint48_t (3 registers each) (EEPROM)
12 – 19	AZ	Initial counter reading Data type uint32_t (2 registers each) Factory setting 0 (EEPROM)
20 – 23	IE	Pulses per unit Data type uint16_t (1 register each) Factory setting 1 (EEPROM)
24 – 27	WI	Transformation factor for current Data type uint16_t (1 register each) Factory setting 1 (EEPROM)
28 – 31	WU	Transformation factor for voltage Data type uint16_t (1 register each) Factory setting 1 (EEPROM)
32 – 35	WP	Operating mode for calculation with transformation factor Data type uint16_t (1 register each, only Bit 0 is valid) Value range 0…1, see below Factory setting 0 (EEPROM)
36 – 39	ZS	Format of the counter digit display Data type uint16_t (1 register each) (EEPROM) High-Byte for counter digits, Value range 0…9, factory setting 7, higher values are limited to 9. Low-Byte for places after the decimal point, Value range 0…3, factory setting 1, higher values are limited to 3.
40 – 43	TA	Flag for key activation Data type uint16_t (1 register each, only Flag in Bit 0) 0: key is blocked, 1: key is operational Factory setting 1 (EEPROM)
65	Bit rate	Codes for bit rate and Parity Factory setting 19200 bit/s, Even Parity (EEPROM)

Operating mode for calculation with transformation factor

In the WP register, there is a code 0…1 that determines, together with the transformation factors WI and WU, the way how they are included in calculation. WP, WI and WU depend on whether the transformers are switched by the counters, whether the counter indicates the consumption in a primary or secondary way and whether the emitted pulses correspond primarily or secondarily to the consumption.

A difference must be made between the following electricity meter types:

Type 1: Directly measuring counter, display: primary, pulse: primary

Note:	Indicates the real consumption
Species:	DIN rail counter with mechanical drum-type counting mechanism, Ferraris counter
Formula type:	WP = 0
Factors:	WI = WU = 1

$$BZ = \left(\frac{IZ - IT}{IE} + AZ \right) \cdot WI \cdot WU \quad , \quad BZ = \text{counter reading} = \text{consumption}$$

Type 2: Transformer counter, display: primary, pulse: secondary

Note:	Indicates the real consumption
Species:	counter with LCD display
Formula type:	WP = 1
Factors:	WI and WU correspond to the transformers

$$BZ = \left(\frac{IZ - IT}{IE} \cdot WI \cdot WU \right) + AZ \quad , \quad BZ = \text{counter reading} = \text{consumption}$$

Type 3: Transformer counter, display: primary, pulse: primary

Note:	Indicates the real consumption
Species:	counter with LCD display, multi-function counters
Formula type:	WP = 0
Factors:	WI = WU = 1

$$BZ = \left(\frac{IZ - IT}{IE} + AZ \right) \cdot WI \cdot WU \quad , \quad BZ = \text{counter reading} = \text{consumption}$$

Type 4: Transformer counter, display: secondary, pulse: secondary

Note:	Indicates the consumption reduced by the transformation factors
Species:	DIN rail counter with mechanical drum-type counting mechanism, Ferraris counter
Formula type:	WP = 0

Consumption and display of the transformer counter are different. Both can be calculated using a different configuration (WI, WU).

Factors:	WI = WU = 1: The calculated counter reading corresponds to the display of the transformer counter.
Species:	DIN rail counter with mechanical drum-type counting mechanism, Ferraris counter.

$$BZ = \left(\frac{IZ - IT}{IE} + AZ \right) \cdot WI \cdot WU \quad , \quad BZ = \text{counter reading or consumption}$$

Start of operation

The user reads on site the initial count from the electricity meter and presses the key on the MR-SI4. After this key press, the pulse counter of register IZ is copied into register IT. Afterwards, the user configures the MR-SI4 via the Modbus using a service program. The following must be entered:

- initial counter reading from the counter
- pulses per unit,
  e.g. indication on the electricity meter 2000 pulses per kWh
- formula type for calculation with transformation factors
- factor for current transformation,
  e.g. indication on the transformer 200/5A → factor = 40
- factor for voltage conversion,
  e.g. indication on the transformer 20000/100V → factor = 200
- number of digits and places after the decimal point
- deactivate the key to protect the IT register

Details for calculation

The calculated counter reading should behave exactly as the electricity meter. This requires that there should be no overflows and rounding errors for the intermediate results. Therefore, particularly large data types are used for counting and calculation

Every 60 milliseconds, a pulse can be emitted by the electricity meter. This results in up to 1,440,000 pulses per day or about 526,000,000 pulses per year.
If the pulse counter was realized with 4 bytes, it could be count to 4,294,967,295. At highest pulse frequency, this would be enough for approx. 8.2 years.
Therefore it is provided with 6 bytes and cannot overflow.

The number of places after the decimal point is considered as an additional multiplier with a power of ten during the calculation. Furthermore, it determines the place of the decimal point in the display of BZ and AZ.
As for the electricity counter which only has a specified number of decimal places, the number of places is limited with the last step in the calculation. This is why the calculated counter reading of the MR-SI4 overflows to 0 as often as the counter reading of the electricity meter.

Calculated counter reading if WP = 0:
BZ = ((uint96_t) (IZ - IT) * WU * WI * power of ten [places after decimal point] / IE +
(uint96_t) AZ * WU * WI)
% power of ten [counter digits]

Calculated counter reading if WP = 1:
BZ = ((uint96_t) (IZ - IT) * WU * WI * power of ten [places after decimal point] / IE +
(uint96_t) AZ)
% power of ten [counter digits]

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x06
Object Value	“MR-SI4”
Object ID	0x02
Object Length	0x04
Object Value	“V2.1”

MR-DIO4/2 / MR-DIO4/2S
MR-DIO4/2-IP

I/O commands

Modbus Function “01 (0x01) Read Coils“

Request
Valid Coil Starting Address 0 .. 3
Valid Quantity of Outputs 1 .. 4

Response
Byte Count 1
Output Status Bit0 .. Bit3 (Bit4 .. 7=0)

Bit	Information
0	0 = Status relay 1 off
	1 = Status relay 1 on
1	0 = Status relay 2 off
	1 = Status relay 2 on
2	0 = relay 1 switched via bus
	1 = relay 1 switched via manual control
3	0 = relay 2 switched via bus
	1 = relay 2 switched via manual control

Manual operations of the outputs are enabled in Direct_Control mode only.

Modbus Function “02 (0x02) Read Discrete Inputs“

Request
Valid Input Starting Address 0 .. 3
Valid Quantity of Inputs 1 .. 4

Response
Byte Count 1
Input Status Bit0 .. Bit3 (Bit 4 .. 7 = 0)

Information
1= Status input closed
0= Status input open

Modbus Function "05 (0x05) Write Single Coil"

Request

Valid Output Address	0 .. 1
Valid Output Value	0x0000 or 0xFF00

Response

Echo of the request

Modbus Function "04 (0x04) Read Input Registers"

Request

Valid Register Starting Address	0
Valid Quantity of Registers	1

Response

Byte Count	2
Values Register	Input Status Bit 0..3

Modbus Function "15 (0x0F) Write Multiple Coils"

Request

Valid Coil Starting Address	0 .. 1
Valid Quantity of Outputs	1 .. 2
Valid Byte Count	1
Output Value	0 or 1 in Bit0 .. Bit1

Bit	Information
0	0 = Status relay 1 off
	1 = Status relay 1 on
1	0 = Status relay 2 off
	1 = Status relay 2 on

Response

Function Code, Starting Address, Quantity of Outputs

Modbus Function "03 (0x03) Read Holding Registers"

Request
Valid Register Starting Address 0..17 or 66
Valid Quantity of Registers 1..18 or 1

Response

Function Code, Byte Count, Register Values

Values Register 0:

Bit	Information
0	0 = Status relay 1 off
	1 = Status relay 1 on
1	0 = Status relay 2 off
	1 = Status relay 2 on
2	0 = relay 1 switched via bus
	1 = relay 1 switched via manual control
3	0 = relay 2 switched via bus
	1 = relay 2 switched via manual control

Manual operations of the outputs are enabled in Direct_Control mode only.

Values Register 1:

Bit	Information
0	0 = Initial state after Reset or communication; monitoring relay 1 off
	1 = Initial state after Reset or communication; monitoring relay 1 on
1	0 = Initial state after Reset or communication; monitoring relay 2 off
	1 = Initial state after Reset or communication; monitoring relay 2 on

Value Register 66:
Time constant for communication monitoring.
Register Value = 0 (0x0000) (default) there is no communication monitoring, all other values are for communication monitoring with a solution of 10 ms.
0x0001 to 0xFFFF => 0.01 to 655.35 seconds = 10.9 minutes

Registers in operating modes for fire dampers

Values Register 2: Operating mode for channel 1 (OperMode_1) or
Values Register 3: Operating mode for channel 2 (OperMode_2) or

Value	Name	Description
0	Direct_Control	Direct control of inputs and outputs, factory setting 0
1	Motorized_SafetyOpen	Motorized fire damper, safe position open (smoke damper)
2	Motorized_SafetyClose	Motorized fire damper, safe position closed
3	LimitSwitch_Open_Close	Mechanical fire damper with OPEN and CLOSE limit switch
4	LimitSwitch_Open	2 mechanical fire dampers only with OPEN limit switch (NO contact)
5	LimitSwitch_Close	2 mechanical fire dampers only with CLOSE limit switch (NC contact)

Values Register 4: Maximum opening duration of fire damper 1 (DriveTime_1) or
Values Register 5: Maximum opening duration of fire damper 2 (DriveTime_2)

Value	Information
0…65535	Resolution 0.1 seconds, factory setting 240 seconds, storage in EEPROM

Values Register 6: Maximum closing duration of fire damper 1 (TurnOffTime_1) or
Values Register 7: Maximum closing duration of fire damper 2 (TurnOffTime_2)

Value	Information
0…65535	Resolution 0.1 second, factory setting 35 seconds, storage in EEPROM

Values Register 8: Maximum duration between write accesses to ActuDrive_1 (RcvHeartBeat_1) or
Values Register 9: Maximum duration between write accesses to ActuDrive_2 (RcvHeartBeat_2)

Value	Information
0…65535	Resolution 0.1 second, factory setting 0 seconds, storage in EEPROM

Values Register 10: Position control of fire damper 1 (ActuDrive_1) or
Values Register 11: Position control of fire damper 2 (ActuDrive_2)

Value	Information
1	Open fire damper
2	Close fire damper

Values Register 12: Position request of the 1st fire damper (ActuPos_1) or
Values Register 13: Position request of the 1st fire damper (ActuPos_2)

Value	Information
1	Fire damper open
2	Fire damper closed
3	Fire damper moving

Values Register 14: Position request of the 2nd fire damper (ActuPos_1a) or
Values Register 15: Position request of the 2nd fire damper (ActuPos_2a)

Value	Information
1	Fire damper open
2	Fire damper closed
3	Fire damper moving

Values Register 16: Reporting and reset of alarm codes Channel 1(AlarmCode_1) or
Values Register 17: Reporting and reset of alarm codes Channel 2(AlarmCode_2)

Value	Information
1	OK, no alarm
3	Runtime_Error
4	Manipulation
5	Update_Error
6	Alarm
7	Alarm_a

Detailed description for operating modes for fire dampers

ActuDrive_1…2

Only with operating mode Motorized_SafetyOpen and Motorized_SafetyClose.
The damper position is controlled in this register.
Values: open (1), close (2), basic setting after reset is the normal position.

ActuPos_1…2

Operating modes Motorized_SafetyOpen, Motorized_SafetyClose and LimitSwitch_Open_Close:
The damper position is reported in this register.
The report comes from limit switches OPEN1, CLOSED1, OPEN2, CLOSED2 (NO).
Values: open (1), close (2), running (3).

Operating modes LimitSwitch_Open and LimitSwitch_Close:
The damper position is reported in this register.
The report comes from limit switches at inputs OPEN1/CLOSE1, OPEN2/CLOSE2
(NO contact for LimitSwitch_Open, NC contact for LimitSwitch_Close).
Values: open (1), close (2).

ActuPos_1a…2a

Operating modes Motorized_SafetyOpen, Motorized_SafetyClose and LimitSwitch_Open_Close:
Values: inactive (0).

Operating modes LimitSwitch_Open and Limit_Switch_Close:
In this register, the position of the second fire damper is reported.
The report comes from the limit switches at inputs OPEN1a/CLOSE1a, OPEN2a/CLOSE2a
(NO contact for LimitSwitch_Open, NC contact for LimitSwitch_Close).
Values: open (1), close (2).

AlarmCode_1…2

In this register, the error states are reported. The first error code (3…7) is stored until it has been eliminated, only after that another error message is possible.
The values and resetting of errors are described below.

Values with operating mode Motorized_ SafetyOpen and Motorized_ SafetyClose:
OK (1), Runtime_Error (3), Manipulation (4), Update_Error (5), Alarm (6).

Values with operating mode LimitSwitch_Open_Close:
OK (1), Manipulation (4), Alarm (6).

Values with operating modes LimitSwitch_Open and LimitSwitch_Close:
OK (1), Alarm (6) for inputs OPEN1/CLOSE1, OPEN2/CLOSE2,
Alarm_a (7) for inputs OPEN1a/CLOSE1a, OPEN2a/CLOSE2a.
Alarm (6) has priority over Alarm_a (7), if both dampers are in Fire position.

DriveTime_1…2

Only with operating mode Motorized_SafetyOpen and Motorized_SafetyClose.
The maximum opening duration of the damper is set in this register.
If the time is exceeded, the alarm code Runtime_Error is reported.
For value 0, the time measurement is off.
Values: 0…6553.5 sec., resolution 0.1 sec., factory setting 240 sec.

TurnOffTime_1…2

Only with operating mode Motorized_SafetyOpen and Motorized_SafetyClose.
The maximum closing duration of the damper is set in this register.
If the time is exceeded, the alarm code Runtime_Error is reported.
For value 0, the time measurement is off.
Values: 0…6553.5 sec., resolution 0.1 sec., factory setting 35 sec.

RcvHeartBeat_1…2

Only with operating mode Motorized_SafetyOpen and Motorized_SafetyClose.
The maximum duration between write accesses is set in ActuDrive_1…2. It can be used to implement connection monitoring.
If the time is exceeded, the alarm code Update_Error is reported.
For value 0, the time measurement is off.
Values: 0…6553.5 sec., resolution 0.1 sec., factory setting 0 sec.

Limit switches of fire dampers

The limit switches are connected to the input terminals as follows:

Terminals	**Damper**	**Operating modes** Motorized_SafetyOpen, Motorized_SafetyClose, LimitSwitch_Open_Close (NO contact)	**Damper**	**Operating modes** LimitSwitch_Open (NO contact), LimitSwitch_Close (NC contact)
1 – C1	OPEN1	Damper 1 open	OPEN1/CLOSE1	Damper 1
2 – C1	CLOSED1	Damper 1 closed	OPEN1a/CLOSE1a	Damper 1a
3 – C1	OPEN2	Damper 2 open	OPEN2/CLOSE2	Damper 2
4 – C1	CLOSED2	Damper 2 closed	OPEN2a/CLOSE2a	Damper 2a

The operating modes LimitSwitch_Open and LimitSwitch_Close only have different names and are completely identical. If the damper is open completely, the contact is closed.

Fire position

Depending on the operating mode, the fire position is derived from the limit switches.

Operating mode	**Fire position if**
Motorized_SafetyClose	Damper not OPEN
Motorized_SafetyOpen	Damper not CLOSED
LimitSwitch_Open_Close	Damper not OPEN
LimitSwitch_Open	minimum 1 damper not OPEN
LimitSwitch_Close	minimum 1 damper CLOSED

If the damper position is Fire position and no other alarm code has been reported yet, alarm is reported in the AlarmCode register.

For the operating modes LimitSwitch_Open and LimitSwitch_Close, the alarm for the first damper or alarm_a for the second damper is reported. Alarm has priority over Alarm_a.

In the operating modes Motorized_SafetyOpen and Motorized_SafetyClose, self-holding in the safe position can be activated via the Fire position. Then the relay is switched to the safe state. To move the fire damper to the normal position, first, the normal position is written in ActuDrive and then the AlarmCode is reset to OK. Then the alarm reset is initiated during which the self-holding is interrupted.

Error detection and alarm codes

There are 3 error sources which are reported as alarm code and partially lead to automatic control of the motorized fire damper.

Runtime_Error
(Operating mode Motorized_SafetyOpen, Motorized_SafetyClose)

The time during which the damper opens or closes can be measured. If the allowed duration is exceeded, this error will be reported.

The time measurement with DriveTime_1…2 starts when the relay is switched on (open damper) and ends when the limit switches report the OPEN position.
The time measurement with TurnOffTime_1…2 starts when the relay is switched off (close damper) and ends when the limit switches report the CLOSED position.

Each of the 2 time measurements can be switched off using the value 0.
An error remains stored, then the relay switches to the safe position.

Possible causes: damper becomes jammed, limit switch defective, input for limit switch defective, cable to the limit switch interrupted, cable to the motor interrupted, motor defective.

Manipulation
(Operating mode Motorized_SafetyOpen, Motorized_SafetyClose, LimitSwitch_Open_Close)

If both limit switches are switched on simultaneously, this error will be reported.
In ActuPos_1…2, the running value is reported at the same time.
An error remains stored, then the relay is switched off.

Possible causes: limit switch defective, input for limit switch defective, cable to the limit switch short-circuited.

Update_Error
(Operating mode Motorized_SafetyOpen, Motorized_SafetyClose)

The time interval between write accesses to ActuDrive_1…2 can be monitored. If the allowed duration (RcvHeartBeat_1…2) is exceeded, this error will be reported.
The monitoring also starts if the error is reset or RcvHeartBeat is set to unequal to 0.
The time measurement can be switched off using the value 0.
An error remains stored, then the relay switches to the safe position.

Possible causes: remote terminal on the bus out of operation, bus connection interrupted (e.g. cable, repeater, switch).

Several errors simultaneously

Even if several errors occur in one channel simultaneously, the error handling is carried out only for the first detected error. Only after confirmation by resetting it to OK (alarm reset), another error can be detected.

Fire damper (Motorized_SafetyClose)

Depending on the alarm reset, fire position, ActuDrive1…2 and error state, the relay is switched as follows (evaluation from top to bottom):

Other	ActuDrive_1…2	AlarmCode_1…2	Relay 1…2
Alarm reset	open (1)	OK (1)	On
Fire position	any	any	Off
-	any	Runtime_Error (3)	Off
	any	Update_Error (5)	Off
	any	Manipulation (4)	Off
	open (1)	OK (1)	On
	close (2)	OK (1)	Off

Initialization after switch-on / reset:
ActuDrive is set to open. AlarmCode is set to OK. The alarm reset starts to interrupt the self-holding in the safe state via fire position.

Smoke damper (Motorized_SafetyOpen)

Depending on the alarm reset, fire position, ActuDrive1…2 and error state, the relay is switched as follows (evaluation from top to bottom):

Other	ActuDrive_1…2	AlarmCode_1…2	Relay 1…2
Alarm reset	close (2)	OK (1)	Off
Fire position	any	any	On
-	any	Runtime_Error (3)	On
	any	Update_Error (5)	On
	any	Manipulation (4)	Off
	open (1)	OK (1)	On
	close (2)	OK (1)	Off

Initialization after switch-on / reset:
ActuDrive is set to close. AlarmCode is set to OK. The alarm reset starts to interrupt the self-holding in the safe state via fire position.

Modbus Function “06 (0x06) Write Single Register”

Request

Register Address	0.. 17 or 66
Register Value	according to tables or the description above

Response

Echo of the request

Modbus Function “16 (0x10) Write Multiple Registers”

Request

Valid Register Starting Address	0.. 17 or 66
Valid Quantity of Registers	1.. 18
Byte Count	2 x Quantity of registers
Registers Value	Quantity of registers x 2 Byte according to tables above

Response

Function Code, Register Starting Address, Quantity of Registers

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01	
Conformity level	0x01	
More follows	0x00	
Next object ID	0x00	
Number of objects	0x03	
Object ID	0x00	
Object Length	0x11	
Object Value	“METZ CONNECT GmbH”	
Object ID	0x01	
Object Length	0x09	0x0E
Object Value	“MR-DIO4/2”	“MR-DIO4/2IP65”
Object ID	0x02	
Object Length	0x04	
Object Value	“V1.6”	

MR-TP

I/O commands

Modbus Function "02 (0x02) Read Discrete Inputs"

Request	
Valid Input Starting Address	0 .. 15
Valid Quantity of Inputs	1 .. 16
Response	
Byte Count	1..2
Input Status	Bit0 .. Bit15
Information	
Discrete Input 0-5:	switching status of the digital inputs, 0: OFF, 1: ON
Discrete Input 6-7:	feedback of transistor outputs, 0: OFF, 1: ON
Discrete Input 8-9:	feedback of switching status of relay 1, 0: Off, 2: level 1 (open), 3: level 2 (close)
Discrete Input 10-11:	Cause of the switching status of relay 1, for sunblind mode see table of priorities, otherwise 3: trigger switch, 0: Modbus coils
Discrete Input 12-13:	feedback of switching status of relay 2, 0: OFF, 2: level 1 (open), 3: level 2 (close)
Discrete Input 14-15:	Cause of the switching status of relay 2, for sunblind mode see table of priorities, otherwise 3: trigger switch, 0: Modbus coils

Modbus Function "04 (0x04) Read Input Registers"

Request	
Valid Register Starting Address	0
Valid Quantity of Registers	1
Response	
Byte Count	2
Values Register	Bit0 .. Bit15

Information

See information Discrete Input 0-15

Modbus Function “01 (0x01) Read Coils”

Request
Valid Coil Starting Address 0 .. 5
Valid Quantity of Outputs 1 .. 6

Response
Byte Count 1
Output Status Bit0 .. Bit5

Bit	Information	
0	0 = Status digital output 1 off	
	1 = Status digital output 1 on	
1	0 = Status digital output 2 off	
	1 = Status digital output 2 on	
2-3	Status relay 1 in “switch” mode:	0: relay contact 11-14-24 open 1: relay contact 11-14-24 open 2: relay contact 11-14 closed 3: relay contact 11-24 closed
4-5	Status relay 2 in “switch” mode:	0: relay contact 31-34-44 open 1: relay contact 31-34-44 open 2: relay contact 31-34 closed 3: relay contact 31-44 closed

Modbus Function “05 (0x05) Write Single Coil”

Request
Valid Output Address 0 .. 5
Valid Output Value 0x0000 or 0xFF00

Response
Echo of request

Modbus Function “15 (0x15) Write Multiple Coils”

Request

Valid Coil Starting Address	0 .. 5
Valid Quantity of Outputs	1 .. 6
Valid Byte Count	1
Output Value	0 or 1 in Bit0 .. Bit5

Bit	Information	
0	0 = Status digital output 1 off	
	1 = Status digital output 1 on	
1	0 = Status digital output 2 off	
	1 = Status digital output 2 on	
2-3	Status relay 1 in “switch” mode:	0: relay contact 11-14-24 open 1: relay contact 11-14-24 open 2: relay contact 11-14 closed 3: relay contact 11-24 closed
4-5	Status relay 2 in “switch” mode:	0: relay contact 31-34-44 open 1: relay contact 31-34-44 open 2: relay contact 31-34 closed 3: relay contact 31-44 closed

Response
Function Code, Starting Address, Quantity of Outputs

Modbus Function “03 (0x03) Read Holding Registers”

Request

Valid Register Starting Address	0 .. 7 or 66
Valid Quantity of Registers	8 or 1

Response
Function Code, Byte Count, Register Values

Value Register 0:
Bits 0 – 5 according to the tables or the description above
Bits 6 – 15 have no function

Value Register 1:
Sunblind command (in Low-Byte)

The following registers are stored in the EEPROM.
The time constants have the unit 10 ms:

Value Register 2:
Operating mode (Low-Byte) and Flags (High-Byte)
Factory setting 1, storage in EEPROM

Value Register 3:
Bits 0-5 contain the basic setting for coils 0-5
Factory setting 0, storage in EEPROM

Value Register 4:
Time constant push-button short/long,
Unit 10 ms, factory setting 2 s, storage in EEPROM

Value Register 5:
Time constant short pulse,
Unit 10 ms, factory setting 0,5 s, storage in EEPROM

Value Register 6:
Time constant long pulse,
Unit 10 ms, factory setting 60 s, storage in EEPROM

Value Register 7:
Time constant rotating pulse (position the blades horizontally),
Unit 10 ms, factory setting 1 s, storage in EEPROM

Value Register 66
Time constant for connection monitoring
Unit 10 ms, factory setting 0 s, storage in EEPROM

Modbus Function "06 (0x06) Write Single Register"

Request

Register Address	0 - 7 or 66
Register Value	according to tables or descriptions above and below

Response
Echo of the request

Modbus Function "16 (0x10) Write Multiple Registers"

Request

Valid Register Starting Address	0 – 7 or 66
Valid Quantity of Registers	1 – 8
Byte Count	2 x Quantity of registers
Registers Value	according to tables or descriptions above and below

Response
Function Code, Register Starting Address, Quantity of Registers

Operating modes

The operating mode is selected by using the low bits of the operating mode register. The high bits contain more flags for sunblind operation (sunblind 1 / 2).
In all operating modes, a pause of 0.5 seconds of the Off status is included between level 1 and level 2 when the relay outputs are switched.

Operating mode 0 (Modbus Off)

The digital inputs and transistor outputs are queried and controlled by the Modbus.
The relay outputs are only controlled via the built-in trigger switches.
Function of the trigger switches: Top = level 1, center = OFF, bottom = level 2.

Operating mode 1 (Switch 0-1-2)

The digital inputs and transistor outputs are queried and controlled by the Modbus.
The relay outputs are controlled by the Modbus or by the built-in trigger switches.
Function of the trigger switches: Top = OFF, center = level 1, bottom = level 2.

Operating mode 2 (Switch 1-0-2)

The digital inputs and transistor outputs are queried and controlled by the Modbus.
The relay outputs are controlled by the Modbus or by the built-in trigger switches.
Function of the trigger switches: Top = level 1, center = OFF, bottom = level 2.

Operating mode 3 (Sunblind 1)

Unused digital inputs and transistor outputs are queried and controlled by the Modbus.
The relay outputs and digital inputs are used to control 2 sunblinds.
Used for AC/DC motors with separate coils for opening and closing.

Relay contact 11: operating voltage for motor 1
Relay contact 14: motor and limit switch 1 for opening
Relay contact 24: motor and limit switch 1 for closing
Relay contact 31: operating voltage for motor 2
Relay contact 34: motor and limit switch 2 for opening
Relay contact 44: motor and limit switch 2 for closing

Operating push-buttons and switching contacts are connected to the digital inputs.

Input 1: open sunblind 1
Input 2: close sunblind 1
Input 3: optional wind contact (NC or NO contact)
Input 4: open sunblind 2
Input 5: close sunblind 2
Input 6: optional door contact (NC or NO contact)

Operating mode 4 (Sunblind 2)
Unused digital inputs and transistor outputs are queried and controlled by the Modbus.
The relay outputs and digital inputs are used to control the sunblind.
Used for a DC motor that changes its direction of movement with polarity.

Relay contact 11: motor limit switches, open +, close –
Relay contact 14: operating voltage +
Relay contact 24: operating voltage –
Relay contact 31: motor limit switches, open –, close +
Relay contact 34: operating voltage –
Relay contact 44: operating voltage +

Operating push-buttons and switching contacts are connected to the digital inputs.

Input 1: open sunblind
Input 2: close sunblind
Input 3: optional wind contact (NC or NO contact)
Input 6: optional door contact (NC or NO contact)

Sunblind operating modes

Function of the trigger switches:
top = level 1 / opening, center = OFF, bottom = level 2 / closing.

Priorities of relay control, value is returned with relay status		
Priority	**Value**	**Description**
Highest	3	Trigger switch in the device
	2	Wind and door contact
	1	Sunblind command
Lowest	0	Inputs for operating keys

When the optional wind contact is activated, the sunblind is opened.
The activation of the wind contact has the same effect as the sunblind command 2.
When the optional door contact is activated, the sunblind is prevented from closing.

Different operation modes and time constants can be set for the operation pushbuttons.

Flags in operating mode register for sunblind mode		
Bit	**Value**	**Description**
15	0 1	No wind contact at input 3 Wind contact at input 3
14	0 1	Wind contact is NO contact Wind contact is NC contact
13	0 1	No door contact at input 6 Door contact at input 6
12	0 1	Door contact is NO contact Door contact is NC contact
10-8	0-3	Short pulse starts with key press
	0 1 2 3	Short pulse ends after the time constant „Short“ Short pulse ends after the minimum of time constant „Short“ and key press Short pulse ends after the maximum of time constant „Short“ and key press Short pulse ends with key press
	4 7	Short pulse starts at the end of key press, ends after the time constant „Short“ Pulse lasts as long as key press
	0-4 7	Long pulse starts after time constant „pushbutton“, ends after time constant „Long“ and ends earlier in case of a short key press No long pulse

Simultaneous control of both sunblinds with the sunblind command register is possible via the bus. The command sequence begins as soon as the register content is changed.

Coding of the sunblind commands	
0	Normal operation, control by operating pushbuttons possible
1	Switch off relay, lock control by operation pushbuttons (lock)
2	Long pulse for opening, then lock
3	Long pulse for closing, then lock
4	Long pulse for closing, then rotating pulse (blades horizontal), then lock

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x05
Object Value	“MR-TP”
Object ID	0x02
Object Length	0x04
Object Value	“V1.2”

MR-AO4

I/O commands

Modbus Function “03 (0x03) Read Holding Registers”

Holding Register 0-3:	output value of the outputs, Signed Integer16,
Holding Register 4-7:	basic settings of the output values

Request

Valid Register Starting Address	0..7 or 66
Valid Quantity of Registers	1..8 or 1

Response

Byte Count	2 x Quantity of Registers
Values Register 0..7	0x0000 to 0xFFFF (0x7FFF = 10.24 Volt)

Unit = 10.24V / 215 = 1V / 3200 = 0.3125 mV

Value Register 66
Time constant for communication monitoring.
Register Value = 0 (0x0000) there is no communication monitoring, all other values are for communication monitoring with a solution of 10 ms.
0x0000 to 0xFFFF => 0 to 655.35 seconds = 10.9 minutes

Modbus Function “06 (0x06) Write Single Register”

Request

Valid Register Address	0..7 or 66
Valid Value Register 0..7	0x0000 to 0xFFFF (0x7FFF = 10.24 Volt)
Valid Value Register 66	0x0000 to 0xFFFF (0 to 655.35 seconds)

Response
Echo of the request

Modbus Function “16 (0x10) Write Multiple Registers”

Request

Valid Register Starting Address	0..7 or 66
Valid Quantity of Registers	1..8
Valid Byte Count	2 x Quantity of Registers (QoR)
Valid Value Register 0..7	QoR x 0x0000 to 0xFFFF (0x7FFF = 10.24 Volt)

Response
Function Code, Register Starting Address, Quantity of Registers

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x06
Object Value	"MR-AO4"
Object ID	0x02
Object Length	0x04
Object Value	"V1.4"

MR-AOP4

I/O commands

Modbus Function "01 (0x01) Read Coils"
Modbus Function "02 (0x02) Read Discrete Inputs"
Modbus Function "04 (0x04) Read Input Registers"

Request

Valid Starting Address	0 .. 3
Valid Quantities	1 .. 4

Response

Byte Count	1
Status Bit0 .. Bit3	1 = manual mode 0 = automatic mode

Modbus Function "03 (0x03) Read Holding Registers"

Holding Register 0-3:	output values of the outputs, Signed Integer16,
Holding Register 4-7:	basic settings of the output values

Request

Valid Register Starting Address	0..7 or 66
Valid Quantity of Registers	1..8 or 1

Response

Byte Count	2 x Quantity of Registers
Values Register 0..7	0x0000 to 0xFFFF (0x7FFF = 10.24 Volt)

Unit = 10.24V / 215 = 1V / 3200 = 0.3125 mV

Value Register 66
Time constant for communication monitoring.
Register Value = 0 (0x0000) there is no communication monitoring, all other values are for communication monitoring with a solution of 10 ms.
0x0000 to 0xFFFF => 0 to 655.35 seconds = 10.9 minutes

Modbus Function "06 (0x06) Write Single Register"

Request

Valid Register Address	0..7 or 66
Valid Value Register 0..7	0x0000 to 0xFFFF (0x7FFF = 10.24 Volt)
Valid Value Register 66	0x0000 to 0xFFFF (0 to 655.35 seconds)

Response
Echo of the request

Modbus Function "16 (0x10) Write Multiple Registers"

Request

Valid Register Starting Address	0..7 or 66
Valid Quantity of Registers	1..8
Valid Byte Count	2 x Quantity of Registers (QoR)
Valid Value Register 0..7	QoR x 0x0000 to 0xFFFF (0x7FFF = 10.24 Volt)

Response

Function Code, Register Starting Address, Quantity of Registers

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x07
Object Value	"MR-AOP4"
Object ID	0x02
Object Length	0x04
Object Value	"V1.4"

MR-AI8

I/O commands

Modbus Function "04 (0x04) Read Input Registers"

Request
Valid Starting Address 0 .. 15
Valid Quantities 1 .. 16 (1 .. 8 inputs)

Response
Byte Count 2 x Quantity o. R.
Registers Values Quantity o. R. x 12 Bytes

Input	Register	Information
1	0-1	Measured values are supplied in 2 registers each (4 Bytes). Data type in the registers can be configured. (see register 16-23) Float value needs 2 registers (figure 1) Signed in value is in the 1st register Signed in 0 fills the 2nd register Value remains 0 until a measurement takes place Data types composed from 2 registers start at an even address
2	2-3	
3	4-5	
4	6-7	
5	8-9	
6	10-11	
7	12-13	
8	14-15	

Figure 1

Byte1 Bit7	Byte1 Bit6..0	Byte2 Bit7	Byte2 Bit6..0	Byte3	Byte4
Sign	Exponent	Exponent	Mantissa	Mantissa	Mantissa

Configuration registers

Input circuit and measuring range, data type and value unit and the sensor characteristic for usual temperature sensors are set for the 8 inputs with the 8 configuration registers.

Modbus Function "03 (0x03) Read Holding Registers"
Modbus Function "06 (0x06) Write Single Registers"
Modbus Function "03 (0x03) Write Multiple Registers"

Holding Register 0-15:	Offset Register is added to the measured value in 2 succeeding registers, (Input 1 = Register 0 - 1) Float in both or Signed Integer 16 in the first one, same as for measured value
Holding Register 16-23:	Configuration register (EEPROM), used to set measuring range, data type of the measured value (Float / Integer16), unit of the measured value and sensor characteristic (input 1 = register 16)
Holding Register 24-63:	Register for interpolation charts (EEPROM), alternately temperature and resistance, Float in 2 succeeding registers each.

Configuration registers for voltage or resistance measurement

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0								0	range		number				

Bit 15-8: reserved
Bit 7: 0 = voltage or resistance
Bit 6-5: range, defines input circuit or measuring range
- 0 0 voltage 0 to 10V
- 0 1 voltage 0 to 10V, Pullup 2k at 5V
- 1 0 resistance
- 1 1 reserved

Bit 4-0: Number, defines presentation of the measured value

For voltage measurement:
- 0 measured value with data type float, unit = 1V
- 1 measured value with data type signed int, unit = 10.24V/2^15=1V/3200 =0.3125mV
- 2-31 reserved for other presentations

For resistance measurement:
- 0 measured value with data type float, unit = 1 Ohm
- 1 measured value with data type signed int, unit = 0.1 Ohm (max. 3.2767 kOhm)
- 2 measured value with data type signed int, unit = 1 Ohm (max. 32.767 kOhm)
- 3 measured value with data type signed int, unit = 10 Ohm (max. 327.67 kOhm)
- 4 measured value with data type signed int, unit = 100 Ohm (max. 3276,7 kOhm)
- 5-31 reserved for other presentations

Configuration registers for temperature measurement

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0								1	Number						Type

Bit 15-8:	reserved		
Bit 7:	1 = temperature with sensor characteristic		
Bit 6-1:	Number, is used to distinguish between sensor and characteristic		
	0	Sensor PT100	(-50..150°C)
	1	Sensor PT500	(-50..150°C)
	2	Sensor PT1000	(-50..150°C)
	3	Sensor NI1000-TK5000	(-50..150°C)
	4	Sensor NI1000-TK6180	(-50..150°C)
	5	Sensor BALCO 500	(-50..150°C)
	6	Sensor KTY81-110	(-50..150°C)
	7	Sensor KTY81-210	(-50..150°C)
	8	Sensor NTC-1k8	(-50..150°C)
	9	Sensor NTC-5k	(-50..150°C)
	10	Sensor NTC-10k	(-50..150°C)
	11	Sensor NTC-20k	(-50..150°C)
	12	Sensor LM235	(-40..120°C)
	13	Sensor NTC-10k CAREL	(-50..110°C)
	14-55	Reserved for other sensors	
	56-61	Use of the interpolation chart see below	
	62-63	Reserved	
Bit 0:	Data type of the measured value		
	0	float,	unit 1°C
	1	signed int,	unit 0.1°C

Configuration registers to use the interpolation chart

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0								1	7			range		Intp	Type

Bit 15-8:	reserved	
Bit 7:	1	Temperature with sensor characteristic
Bit 6-4:	7	Interpolation chart
Bit 3-2:	Range, defines input circuit or measuring range	
	0 0	Voltage 0 to 10V
	0 1	Voltage 0 to 10V, Pullup 2k at 5V
	1 0	Resistance
	1 1	Reserved
Bit 1:	Selection of interpolation	
	0	Sensor characteristic is nearly linear
	1	Sensor characteristic is nearly exponential (for ex. NTC)
Bit 0:	Data type of the measured value	
	0	float, unit 1°C
	1	signed int, unit 0.1°C

Configurations registers are shown above in a way to display the meaning of the individual bit. For the application it is more convenient if the register contents is displayed as a whole, see the following chart.

Dec	Hex	Measuring range voltage or resistance	Data type	Unit	Maximum
0	0x00	voltage 0 to 10V	float	1V	10.24 V
1	0x01		signed int	0.3125mV	
32	0x20	voltage/pullup	float	1V	10.24 V
33	0x21		signed int	0.3125mV	
64	0x40	resistance	float	1 Ohm	4 MOhm
65	0x41		signed int	0.1 Ohm	3.2767 kOhm
66	0x42		signed int	1 Ohm	32.767 kOhm
67	0x43		signed int	10 Ohm	327.67 kOhm
68	0x44		signed int	100 Ohm	3276.7 kOhm

Temperature measurement with data type float:

Dec	Hex	Measuring range	Data type	Unit	Maximum
128	0x80	Sensor PT100	float	1°C	-50..150°C
130	0x82	Sensor PT500			-50..150°C
132	0x84	Sensor PT1000			-50..150°C
134	0x86	Sensor NI1000-TK5000			-50..150°C
136	0x88	Sensor NI1000-TK6180			-50..150°C
138	0x8A	Sensor BALCO 500			-50..150°C
140	0x8C	Sensor KTY81-110 NXP			-50..150°C
142	0x8E	Sensor KTY81-210 NXP			-50..150°C
144	0x90	Sensor NTC-1k8 Thermokon			-50..150°C
146	0x92	Sensor NTC-5k Thermokon			-50..150°C
148	0x94	Sensor NTC-10k Thermokon			-50..150°C
150	0x96	Sensor NTC-20k Thermokon			-50..150°C
152	0x98	Sensor LM235			-40..120°C
154	0x9A	Sensor NTC-10k CAREL			-50..110°C

Temperature measurement with data type signed int (register number is by 1 larger than above):

Dec	Hex	Measuring range	Data type	Unit	Maximum
129	0x81	Sensor PT100	signed int	0.1°C	-50..150°C
131	0x83	Sensor PT500			-50..150°C
133	0x85	Sensor PT1000			-50..150°C
135	0x87	Sensor NI1000-TK5000			-50..150°C
137	0x89	Sensor NI1000-TK6180			-50..150°C
139	0x8B	Sensor BALCO 500			-50..150°C
141	0x8D	Sensor KTY81-110 NXP			-50..150°C
143	0x8F	Sensor KTY81-210 NXP			-50..150°C
145	0x91	Sensor NTC-1k8 Thermokon			-50..150°C
147	0x93	Sensor NTC-5k Thermokon			-50..150°C
149	0x95	Sensor NTC-10k Thermokon			-50..150°C
151	0x97	Sensor NTC-20k Thermokon			-50..150°C
153	0x99	Sensor LM235			-40..120°C
155	0x9B	Sensor NTC-10k CAREL			-50..110°C

Measurement with interpolation chart:

Dec	Hex	Measuring range	Data type	Interpolation
240	0xF0	Voltage 0 to 10V	float	linear
241	0xF1		signed int	linear
242	0xF2		float	exponential
243	0xF3		signed int	exponential
244	0xF4	Voltage/Pullup	float	linear
245	0xF5		signed int	linear
246	0xF6		float	exponential
247	0xF7		signed int	exponential
248	0xF8	Resistance	float	linear
249	0xF9		signed int	linear
250	0xFA		float	exponential
251	0xFB		signed int	exponential

Registers 24-63 (0x18-0x3F) interpolation chart

This chart can be used to convert and linearize values for sensors without a characteristic already defined in the device. The chart contains up to 10 nodes of the sensor characteristic to interpolate between.

Example: transformation from resistance to temperature for temperature sensors.

Register contents is stored in the EEPROM.

The description refers to temperature sensors. Other sensors than temperature sensors (e.g. humidity) are also possible and it is also possible to measure voltage instead of resistance.

These properties can be set in the configuration register:

Measuring range	voltage voltage, pullup 2k at 5 V (for ex. for LM235) resistance (normal case with temperature sensors)
Interpolation	sensor characteristic is nearly linear sensor characteristic is nearly exponential (for NTCs)
Data type of measuring range	float (unit 1 °C) signed int (unit 0.1 °C)

Node	Registers	Registers
	Temperature	Resistance
1	24-25	26-27
2	28-29	30-31
3	32-33	34-35
4	36-37	38-39
5	40-41	42-43
6	44-45	46-47
7	48-49	50-51
8	52-53	54-55
9	56-57	58-59
10	60-61	62-63

The nodes are filled beginning at the top of the chart, with a maximum of 10, and end with temperature = resistance = 0, if there are less nodes. Temperature and resistance values have to be in ascending or descending order. So the combination 0,0 as a node is not allowed. Data type in the registers: float temperature, float resistance.

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x06
Object Value	“MR-AI8”
Object ID	0x02
Object Length	0x04
Object Value	“V1.6”

MR-CI4

I/O commands

Modbus Function "04 (0x04) Read Input Registers"

Request

Valid Register Starting Address	0 .. 3
Valid Quantity of Registers	1 .. 4

Response

Byte Count	2 x Quantity o.R.
Input Registers Values	2 x Quantity o.R.

Information

Measured values of the inputs 1-4, Signed Integer16,
Value range:
0x0000 .. 0x7FFF (32767) = 0 .. 10.24 V
0x0000 .. 0x7FFF (32767) = 0 .. 20.48 mA
0x0000 .. 0x7FFF (32767) = 4 .. 20.38 mA

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x06
Object Value	"MR-CI4"
Object ID	0x02
Object Length	0x04
Object Value	"V1.3"

MR-AIO4/2-IP

I/O commands

Modbus Function “04 (0x04) Read Input Registers”

Request

Valid Starting Address	0 .. 7
Valid Quantities	1 .. 8 (1 .. 4 inputs)

Response

Byte Count	2 x Quantity o. R.
Registers Values	Quantity o. R. x 12 Bytes

Input	Registers	Information
1	0-1	The measured values are supplied in2 registers each (4 Bytes). Data type in the registers can be configured. (see registers 16-19) Float value needs 2 registers (figure 1) Signed in value is in the 1st register Signed in 0 fills the 2nd register Value remains 0 until a measurement takes place Data types composed from 2 registers start at the even address
2	2-3	
3	4-5	
4	6-7	

Figure 1

Byte1 Bit7	Byte1 Bit6..0	Byte2 Bit7	Byte2 Bit6..0	Byte3	Byte4
Sign	Exponent	Exponent	Mantissa	Mantissa	Mantissa

Configuration registers

These 4 configuration registers are used for the setting of input circuit and measuring range, data type and unit of the measured value and the sensor characteristic for usual temperature sensors for each of the 4 inputs.

The register content is stored at the EEPROM.

Modbus Function “03 (0x03) Read Holding Registers“ (max 20 at once)
Modbus Function “06 (0x06) Write Single Registers“
Modbus Function “03 (0x03) Write Multiple Registers“ (max 20 at once)

Holding Register 0-7:	Offset register, is added to the measured value in 2 succeeding registers each, (input 1 = register 0-1) Float in both or Signed Integer16 in the first same as for measured value
Holding Register 8-15:	Freely usable register
Holding Register 16-19:	Configuration register, is used to set measuring range, data type of the measured value (Float / Integer16), unit of the measured value and sensor characteristic (input 1 = register 16)
Holding Register 20-21:	Output registers, output values of the outputs, Signed Integer16, Value range: 0 = 0 V .. 32767 = 10.24 V
Holding Register 22-23:	Basic settings of the output values, Signed Integer16, factory setting 0
Holding Register 24-63:	Interpolation chart registers, alternately temperature and resistance, Float in 2 succeeding registers each.
Holding Register 66:	Time constant for connection monitoring factory setting 0

Configuration registers for voltage or resistance measuring

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0								0	Range		Number				

Bit 15-8: reserved
Bit 7: 0 = voltage or resistance range,
Bit 6-5: defines input circuit or measuring range

0 0 voltage 0 to 10V
0 1 voltage 0 to 10V, pullup 2k at 5 V
1 0 resistance
1 1 reserved

Bit 4-0: Number, defines the presentation of the measured value

For voltage measurement:

0 measured value with data type float, unit = 1V
1 measured value with data type signed int, unit = 10.24V/2^15=1V/3200 =0.3125mV
2-31 reserved for other presentations

For resistance measurement:

0 measured value with data type float, unit = 1 Ohm
1 measured value with data type signed int, unit = 0.1 Ohm (max. 3.2767 kOhm)
2 measured value with data type signed int, unit = 1 Ohm (max. 32.767 kOhm)
3 measured value with data type signed int, unit = 10 Ohm (max. 327.67 kOhm)
4 measured value with data type signed int, unit = 100 Ohm (max. 3276.7 kOhm)
5-31 reserved for other presentations

Configuration registers for temperature measurement

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0								1	Number						Type

Bit 15-8:	reserved		
Bit 7:	1 = temperature with sensor characteristic		
Bit 6-1:	Number, is used to distinguish sensor and measuring range		
	0	Sensor PT100	(-50..150°C)
	1	Sensor PT500	(-50..150°C)
	2	Sensor PT1000	(-50..150°C)
	3	Sensor NI1000-TK5000	(-50..150°C)
	4	Sensor NI1000-TK6180	(-50..150°C)
	5	Sensor BALCO 500	(-50..150°C)
	6	Sensor KTY81-110	(-50..150°C)
	7	Sensor KTY81-210	(-50..150°C)
	8	Sensor NTC-1k8	(-50..150°C)
	9	Sensor NTC-5k	(-50..150°C)
	10	Sensor NTC-10k	(-50..150°C)
	11	Sensor NTC-20k	(-50..150°C)
	12	Sensor LM235	(-40..120°C)
	13	Sensor NTC-10k CAREL	(-50..110°C)
	14-55	reserved for other sensors	
	56-61	use of the interpolation chart see below	
	62-63	reserved	
Bit 0:	Data type of the measuring range		
	0	float,	Unit 1°C
	1	signed int,	Unit 0.1°C

Configuration registers to use the interpolation chart

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0								1	7			Range		Intp	Type

Bit 15-8:	reserved	
Bit 7:	1	temperature with sensor characteristic
Bit 6-4:	7	interpolation chart
Bit 3-2:	Range, defines input circuit or measuring range	
	0 0	voltage 0 to 10V
	0 1	voltage 0 to 10V, pullup 2k at 5 V
	1 0	resistance
	1 1	reserved
Bit 1:	Selection of interpolation	
	0	sensor characteristic is nearly linear
	1	sensor characteristic is nearly exponential (for ex. NTC)
Bit 0:	Data type of the measured value	
	0	float, unit 1°C
	1	signed int, unit 0.1°C

Configurations registers are shown above in a way to display the meaning of the individual bit. For the application it is more convenient if the register contents is displayed as a whole, see the following chart

Dez	Hex	Measuring range Voltage or resistance:	Data type	Unit	Maximum
0 1	0x00 0x01	Voltage 0 to 10V	float signed int	1 V 0.3125 mV	10.24 V
32 33	0x20 0x21	Voltage/Pullup	float signed int	1 V 0.3125 mV	10.24 V
64 65 66 67 68	0x40 0x41 0x42 0x43 0x44	Resistance	float signed int signed int signed int signed int	1 Ohm 0.1 Ohm 1 Ohm 10 Ohm 100 Ohm	4 MOhm 3.2767 kOhm 32.767 kOhm 327.67 kOhm 3276.7 kOhm

Temperature measurement with data type float:

Dez	Hex	Measuring range	Data type	Unit	Maximum
128	0x80	Sensor PT100	float	1°C	-50..150°C
130	0x82	Sensor PT500			-50..150°C
132	0x84	Sensor PT1000			-50..150°C
134	0x86	Sensor NI1000-TK5000			-50..150°C
136	0x88	Sensor NI1000-TK6180			-50..150°C
138	0x8A	Sensor BALCO 500			-50..150°C
140	0x8C	Sensor KTY81-110 NXP			-50..150°C
142	0x8E	Sensor KTY81-210 NXP			-50..150°C
144	0x90	Sensor NTC-1k8 Thermokon			-50..150°C
146	0x92	Sensor NTC-5k Thermokon			-50..150°C
148	0x94	Sensor NTC-10k Thermokon			-50..150°C
150	0x96	Sensor NTC-20k Thermokon			-50..150°C
152	0x98	Sensor LM235			-40..120°C
154	0x9A	Sensor NTC-10k CAREL			-50..110°C

Temperature measurement with data type signed int (register number is by 1 larger then above):

Dez	Hex	Measuring range	Data type	Unit	Maximum
129	0x81	Sensor PT100	signed int	0.1°C	-50..150°C
131	0x83	Sensor PT500			-50..150°C
133	0x85	Sensor PT1000			-50..150°C
135	0x87	Sensor NI1000-TK5000			-50..150°C
137	0x89	Sensor NI1000-TK6180			-50..150°C
139	0x8B	Sensor BALCO 500			-50..150°C
141	0x8D	Sensor KTY81-110 NXP			-50..150°C
143	0x8F	Sensor KTY81-210 NXP			-50..150°C
145	0x91	Sensor NTC-1k8 Thermokon			-50..150°C
147	0x93	Sensor NTC-5k Thermokon			-50..150°C
149	0x95	Sensor NTC-10k Thermokon			-50..150°C
151	0x97	Sensor NTC-20k Thermokon			-50..150°C
153	0x99	Sensor LM235			-40..120°C
155	0x9B	Sensor NTC-10k CAREL			-50..110°C

Measurement with interpolation chart:

Dez	Hex	Measuring range	Data type	Interpolation
240	0xF0	Voltage 0 to 10V	float	linear
241	0xF1		signed int	linear
242	0xF2		float	exponential
243	0xF3		signed int	exponential
244	0xF4	Voltage/Pullup	float	linear
245	0xF5		signed int	linear
246	0xF6		float	exponential
247	0xF7		signed int	exponential
248	0xF8	Resistance	float	linear
249	0xF9		signed int	linear
250	0xFA		float	exponential
251	0xFB		signed int	exponential

Registers 24-63 (0x18-0x3F) interpolation chart

This chart can be used to convert and linearize values for sensors without a characteristic already defined in the device. The chart contains up to 10 nodes of the sensor characteristic to interpolate between.
Example: transformation from resistance to temperature for temperature sensors.

Register contents is stored in the EEPROM.

The description refers to temperature sensors. Other sensors than temperature sensors (e.g. humidity) are also possible and it is also possible to measure voltage instead of resistance.

These properties can be set in the configuration register:

Measuring range	voltage voltage, pullup 2k at 5 V (for ex. for LM235) resistance (normal case with temperature sensors)
Interpolation	sensor characteristic is nearly linear sensor characteristic is nearly exponential (for NTCs)
Data type of measuring range	float (unit 1 °C) signed int (unit 0.1 °C)

Node	Register	Register
	Temperature	Resistance
1	24-25	26-27
2	28-29	30-31
3	32-33	34-35
4	36-37	38-39
5	40-41	42-43
6	44-45	46-47
7	48-49	50-51
8	52-53	54-55
9	56-57	58-59
10	60-61	62-63

The nodes are filled beginning at the top of the chart, with a maximum of 10, and end with temperature = resistance = 0, if there are less nodes. Temperature and resistance values have to be in ascending or descending order. So the combination 0,0 as a node is not allowed. Data type in the registers: float temperature, float resistance.

Function block PID controller (PID1-PID2)

General information on the controller type

The MR-AIO4/2 contains 2 PID controllers for applications for temperature control.

T1 filter

An ideal PID controller causes problems due to differentiation component:

- Quick changes at the input lead to restriction at the controller output and, thus, to non-linear behavior. (This may also be desired.)
- Noise and other interferences of the input measured values are intensified.

Therefore, real PID controllers are implemented with an additional T1 filter with smaller time constant T1 (PIDT1 controller). The filter can only be assigned to the D component or to P, I and D components together. For this controller, it applies only to the D component.

Differentiator input

The D component can be calculated from the difference of nominal value and actual value ± (X – W) or directly from the actual value ± X (this option can be switched). A quick change of the nominal value does not affect the output if the actual value is used directly.

Differential equation

This differential equation is used to define the function and variables:

$$Y = Yp + Yi + Ydt$$

$$Yp = Fp \cdot Xw$$

$$Yi = Fp \cdot \frac{1}{Ti} \cdot \int_0^t (Xw) d\tau$$

$$Ydt + T1 \cdot \frac{d(Ydt)}{dt} = Fp \cdot Td \cdot \frac{d(Xwd)}{dt}$$

with W = nominal value
X = actual value
Xw = difference ± (X – W)
Xwd = Xw or ± X
Y = controller output
Yp = proportional component
Yi = integral component
Ydt = differential component filtered
Fp = gain
Ti = integration time constant, reset time
Td = differential time constant, derivative action time
T1 = filter time constant

Output limitation

The I-share Yi and the Y output are limited by the Ymin and Ymax constants.
In addition, the Y output is limited by the values which can be changed during operation.
PID1 controller has the input Amin which represents the lower limit for its Y output.
PID2 controller has the Bmax input which represents the upper limit for its Y output.

Dead range

This parameter can be used to prevent continuous small changes at the Y output.
Otherwise, they can lead to wear of the valve controlled by the output.
The Y output changes if the change is greater than DeadR and remains constant in all other cases.

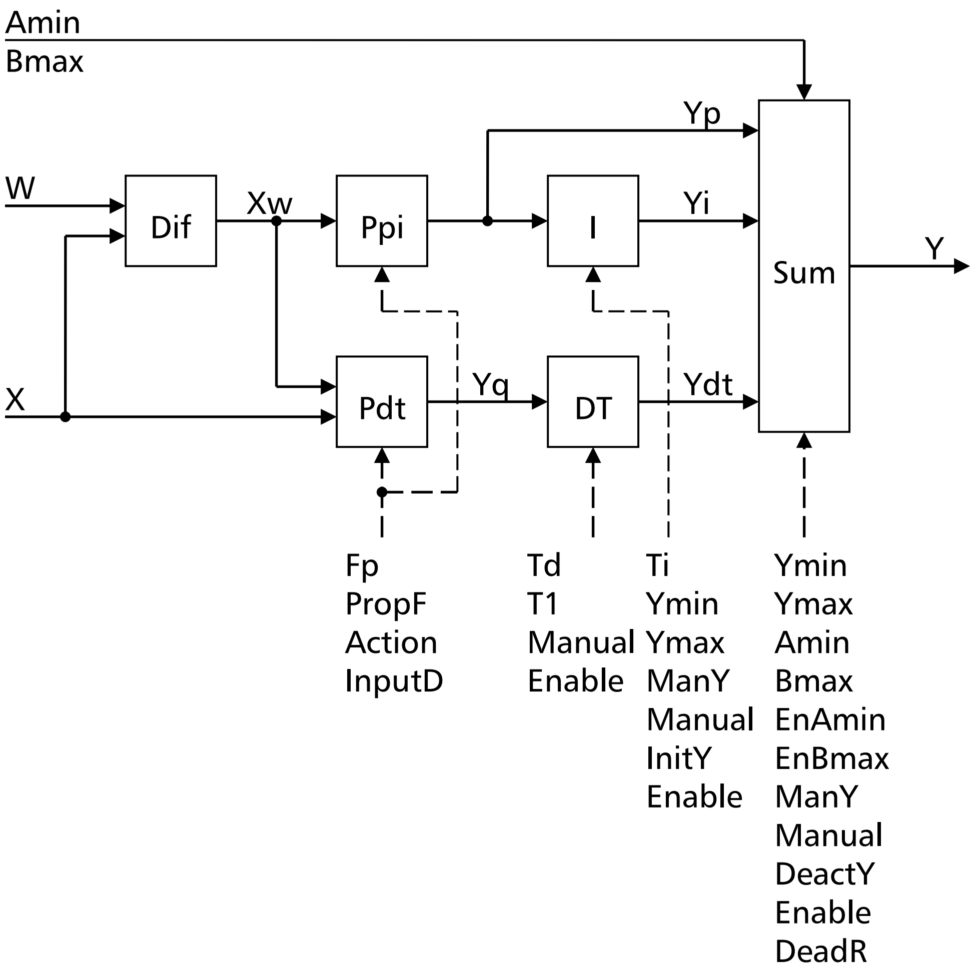
Manual operation

In the Automatic mode, the value at the Y output is also constantly saved in ManY register.
If the controller is switched to the Manual mode, it keeps its last value.
By changing the ManY in the Manual mode, the Y output is set to the new value.
If the Manual mode is quit, the Y output starts controlling at the current value.

Activity

The controller can be set to activated or deactivated.
If it is deactivated, the Y output is set to DeactY permanently.
If it is activated, the Y output starts its controlling activity with the InitY value.

Controller structure



Controller algorithm

(Parameter):	if (PropF)	Fp = (Ymax – Ymin) / Fp_Xp	
	else	Fp = Fp_Xp	
Block Dif:		Xw = X – W	
Block Ppi:		Yp = Fp * Xw	
	if (Action)	Yp = – Yp	
Block Pdt:	if (InputD)	Yq = Fp * X	
	else	Yq = Fp * Xw	
	if (Action)	Yq = – Yq	
Block I:		Yi = Yi_1	
	if (Enable 0 –> 1)	Yi = InitY – Yp	(Start PID)
	if (Manual 1 –> 0)	Yi = ManY – Yp	(Auto PID)
	if (Ti > 0)	Yi = Yi + Yp * Te / Ti	
	if (Yi < Ymin)	Yi = Ymin	
	if (Yi > Ymax)	Yi = Ymax	
	if (!Enable)	Yi = 0	
	if (Manual)	Yi = 0	
Block DT:		Yd = 0	
	if (Td > 0)	Yd = (Yq – Yq_1) * Td / Te	
		Ydt = Yd	
	if (T1 > 0)	Ydt = Ydt_1 + (Yd – Ydt_1) * Te / T1	
	if (!Enable)	Ydt = 0	
	if (Manual)	Ydt = 0	
Block Sum:		Ys = Yp + Yi + Ydt	
	if (Ys < Ymin)	Ys = Ymin	
	if (Ys > Ymax)	Ys = Ymax	
	if (EnAmin)	if (Ys < Amin) Ys = Amin	(only PID1)
	if (EnBmax)	if (Ys > Bmax) Ys = Bmax	(only PID2)
	if (Manual)	Ys = ManY	
	if (!Enable)	Ys = DeactY	
	if (!Manual)	ManY = Ys	
		if (|Y – Ys| > DeadR) Y = Ys	

(Time Step Te): Yi_1 = Yi, Yq_1 = Yq, Ydt_1 = Ydt

Modbus registers

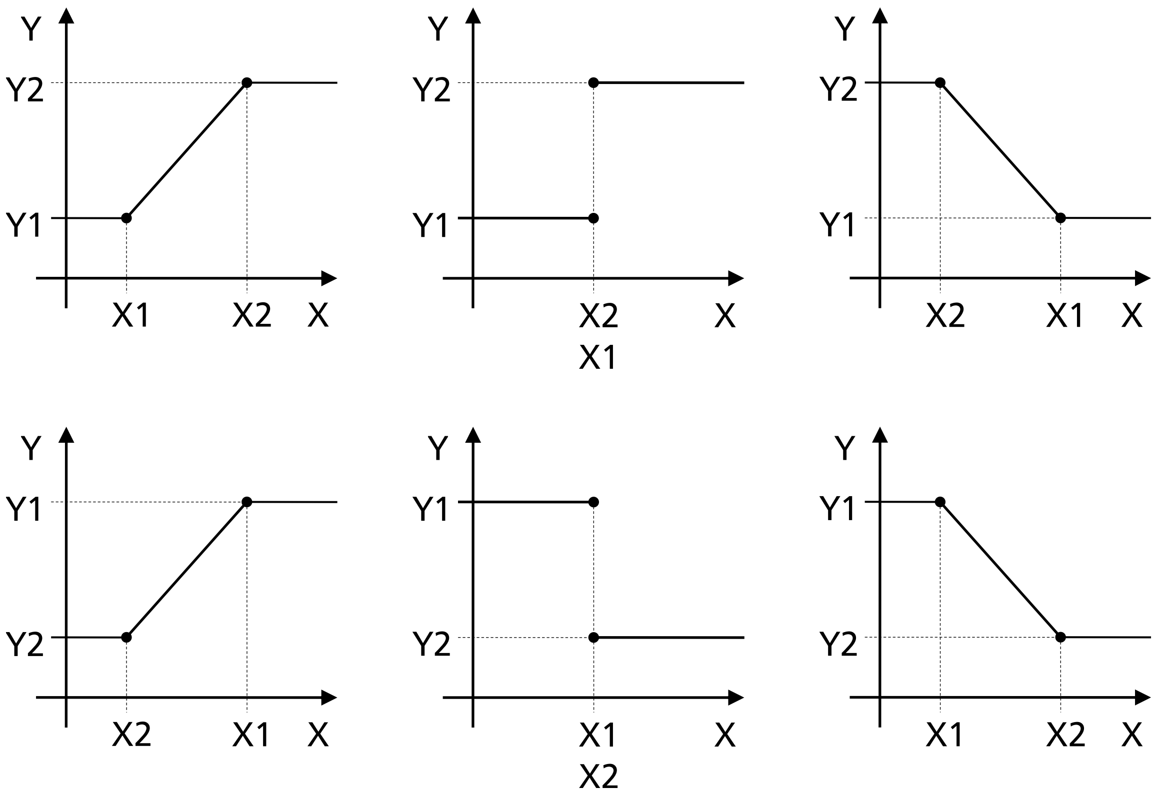
The controller parameters belong to the data type float. They are saved permanently in EEPROM.
They can be accessed using the following Modbus registers.

Name	Configuration Registers, storage in EEPROM (Modbus Holding Registers)	Adr. PID1	Adr. PID2
Mode	Option Flags for Operating Mode:	101	151
.Enable	Activation signal of controller. 0: Controller is inactive 1: Controller is active (Default)	Bit 0	Bit 0
.PropF	The Proportional factor can be specified in two ways. 0: Amplification Fp (Default) 1: Range Xp	Bit 1	Bit 1
.Action	The difference Xw = ± (X – W) can be used directly or negated. 0: Difference used directly, Xw = + (X – W) 1: Difference used negated, Xw = – (X – W) (Default)	Bit 2	Bit 2
.InputD	The derivated part can be calculated from Xw or X. 0: D-Part calculated from ± Xw (Default) 1: D-Part calculated from ± X	Bit 3	Bit 3
.EnAmin	Enable for minimum input Amin (only PID1). 0: Disable (Default) 1: Enable	Bit 4	---
.EnBmax	Enable for maximum input Bmax (only PID2). 0: Disable (Default) 1: Enable	---	Bit 4
.Manual	0: Automatic mode (Default) 1: Manual mode	Bit 5	Bit 5
Fp_Xp	Proportional factor specified in one of two ways: - Amplification Fp (Default 3, Unit % / °C) - Range Xp (Unit °C) Relation: Fp * Xp = (Ymax – Ymin)	102	152
Ti	Integration time (Default 300, Unit s)	104	154
Td	Derivation time (Default 1, Unit s)	106	156
T1	Filter time (Default 10, Unit s)	108	158
Ymin	Lower limit of output Y (Unit %)	110	160
Ymax	Upper limit of output Y (Unit %)	112	162
DeadR	Dead range of output Y, Y changes in minimum steps of DeadR (Unit %)	114	164
DeactY	Y value when controller is inactive (Default 0, Unit %)	116	166
InitY	Y start value when controller is switched to active (Default 0, Unit %)	118	168

Name	Visualization / Control Registers (Modbus Holding Registers)	Adr. PID1	Adr. PID2
Yp	Proportional part (Unit %, Read Only)	130	180
Yi	Integral part (Unit %, Read Only)	132	182
Ydt	Derivate part, filtered (Unit %, Read Only)	134	184
ManY	Y value when using manual mode (Unit %)	142	192

Function block Linear mapping with limitation (LCL1-LCL4)

Description LCL1 - LCL2
The function block has the X input and Y output. Between two limits (X1, X2), the input values are shown on a linear map relative to the output values (Y1…Y2). Outside the limits, the output values are limited to Y1 or Y2.



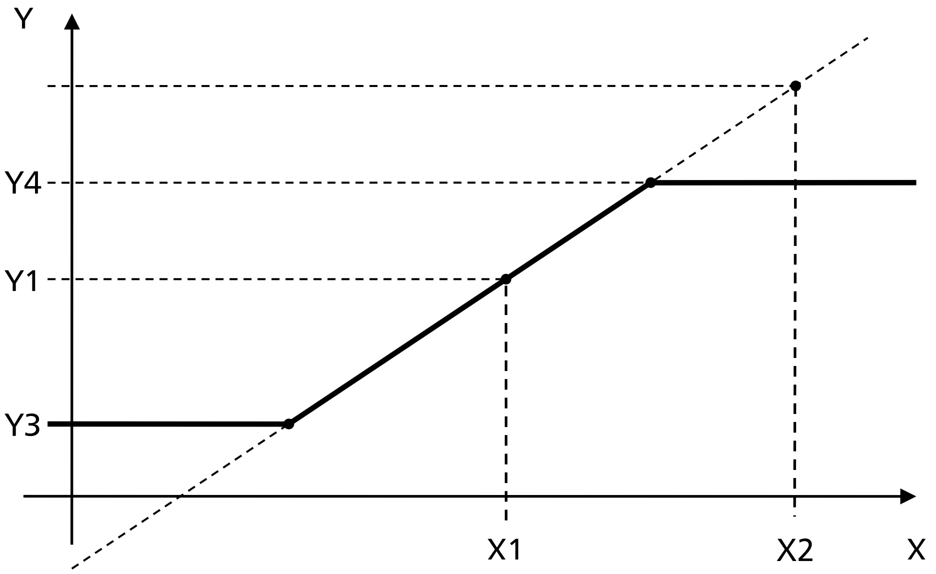
Modbus registers

The parameters belong to the float data type. They are saved permanently in EEPROM.
Separate holding registers for each function block LCL1…LCL2:

Name	Configuration Registers, storage in EEPROM (Modbus Holding Registers)		Adr. LCL1	Adr. LCL2
Y1	Point1, output Y	(Default 0)	200	208
Y2	Point2, output Y	(Default 100)	202	210
X1	Point1, input X	(Default 0)	204	212
X2	Point2, input X	(Default 100)	206	214

Description LCL3 - LCL4

The function block has the X input and Y output. Two points (X1, Y1) and (X2, Y2) define how the input values are mapped to the output values.
The output values are limited to Y3 (minimum) or Y4 (maximum).



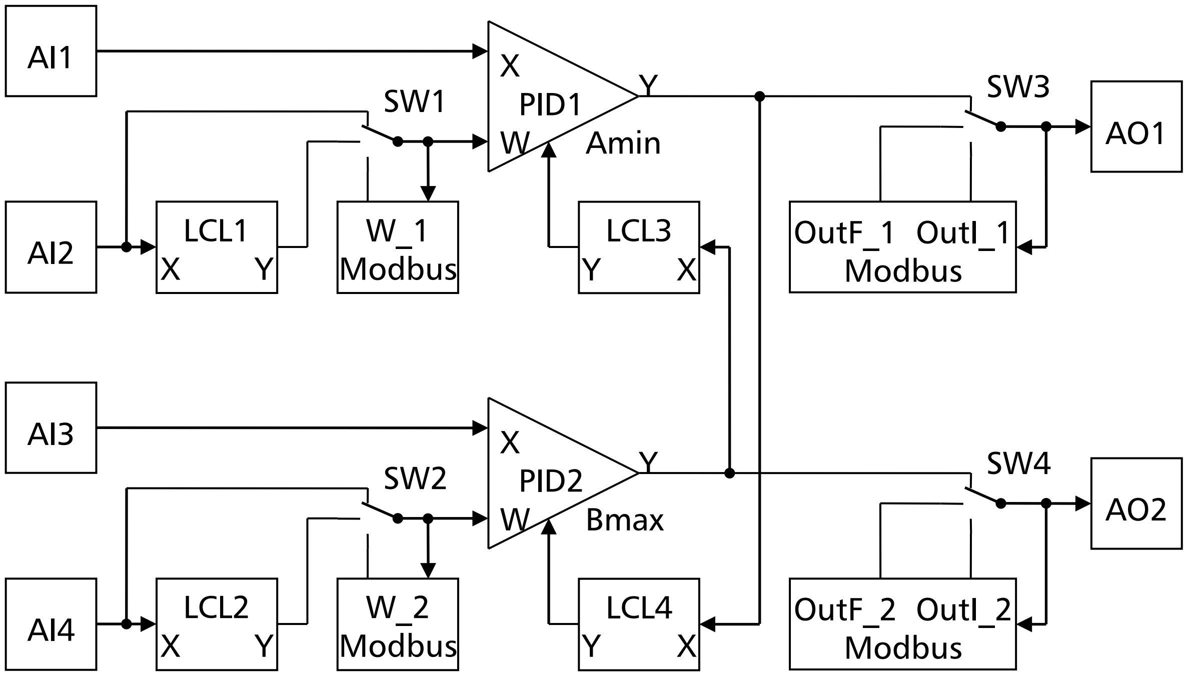
Modbus registers

The parameters belong to the float data type. They are saved permanently in EEPROM. Separate holding registers for each function block LCL1…LCL4:

Name	Configuration Registers, storage in EEPROM (Modbus Holding Registers)		Adr. LCL3	Adr. LCL4
Y1	Point1, output Y	(Default 0)	216	228
Y2	Point2, output Y	(Default 100)	218	230
X1	Point1, input X	(Default 0)	220	232
X2	Point2, input X	(Default 100)	222	234
Y3	Lower limit of output Y	(Default 0)	224	236
Y4	Upper limit of output Y	(Default 100)	226	238

Wiring the function blocks

Overview



Depending on the operating mode, nominal value and actual value can originate from the analog inputs. These inputs provide values in Volts, Ohms or degrees of Celsius. If the function block Linear conversion / limit or freely programmable interpolation table is used in the analog input, adjustment to other value ranges and units can be performed at the controller input.

If the controller nominal value is set via Modbus, there are 2 separate registers:
- The initial nominal value InitW_1/2 is saved permanently in EEPROM.
- The nominal value W_1/2 can be written or read out anytime using Modbus.

The output value for an analog output can originate from the registers OutI and OutF or from a PID controller. After each selection, the output value is reported in OutL and OutF.

When switching on the device and after the Watchdog timer has elapsed, these registers are copied:

Default setting		Current value
InitOutI_1/2	→	OutI_1/2
InitOutF_1/2	→	OutF_1/2
InitW_1/2	→	W_1/2

Modbus registers

One PID controller is assigned to one output and 2 inputs respectively.
A register contains fields for the switches shown in the figure.
Other registers contain the nominal value and output value.

Name	Configuration Registers, storage in EEPROM (Modbus Holding Registers)	Adr.
Switch	Selection of signals (Default 0)	100
.SW1	Selection of setpoint W for controller PID1: 0: Analog input In2 1: Analog input In2 with Linear Conversion / Limit LCL1 2: Modbus register W_1 In each selection the setpoint W is shown in Modbus register W_1.	Bits 0 – 1
.SW2	Selection of setpoint W for controller PID2: 0: Analog input In4 1: Analog input In4 with Linear Conversion / Limit LCL2 2: Modbus register W_2 In each selection the setpoint W is shown in Modbus register W_2.	Bits 2 – 3
.SW3	Selection of output value for analog output Out1: 0: Modbus register OutI_1 (int16_t) 1: Modbus register OutF_1 (float %) 2: Output value Y of controller PID1 In each selection the output value is shown in both Modbus registers.	Bits 4 – 5
.SW4	Selection of output value for analog output Out2: 0: Modbus register OutI_2 (int16_t) 1: Modbus register OutF_2 (float %) 2: Output value Y of controller PID2 In each selection the output value is shown in both Modbus registers.	Bits 6 – 7
InitW_1	Initial setpoint for controller PID1 (Default 0, Unit °C)	120
InitW_2	Initial setpoint for controller PID2 (Default 0, Unit °C)	170

Name	Visualization /Control Registers (Modbus Holding Registers)		Adr.
W_1	Setpoint W for controller PID1	(Unit °C)	136
W_2	Setpoint W for controller PID2	(Unit °C)	186
Amin	Minimum value for PID1	(Unit %, Read only)	140
Bmax	Maximum value for PID2	(Unit %, Read only)	190

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x09
Object Value	"MR-AIO4/2"
Object ID	0x02
Object Length	0x04
Object Value	"V1.3"

MR-SM3

I/O commands

Modbus Function "03 (0x03) Read Holding Registers" (R)

Modbus Function "04 (0x04) Read Input Registers" (R)

Modbus Function "06 (0x06) Write Single Register" (W)

Modbus Function "16 (0x10) Write Multiple Registers" (W)

Information

The Input Registers 0 and 31 to 38 are only relevant for production process.

Read Holding Registers (0 - 127, 256 – 383, 512 – 639, 768 - 895)

Read Input Registers (0 - 127, 256 – 383, 512 – 639, 768 - 895)

Write Single Register (0, 31, 32, 42 to 59, 65, 120 - 127)

Write Multiple Registers (42 to 59, 65, 120 - 127)

Input Register, Holding Register			
Register Address	Description	Data type	Solution Unit
0	Calibration command Is only used during production.	Unsigned R / W	-
1 2 3	Voltage 1 RMS Voltage 2 RMS Voltage 3 RMS	Unsigned R	0.1 V
4 5 6	Current 1 RMS Current 2 RMS Current 3 RMS	Unsigned R	0.01 A
7 8 9	Voltage 1 Peak value Voltage 2 Peak value Voltage 3 Peak value	Unsigned R	0.1 V
10 11 12	Current 1 Peak value Current 2 Peak value Current 3 Peak value	Unsigned R	0.01 A
13 14 15	Frequency 1 Frequency 2 Frequency 3	unsigned	0.01 Hz

16 17 18	Active power 1 Active power 2 Active power 3	Signed R	1 W
19 20 21	Apparent power 1 Apparent power 2 Apparent power 3	Unsigned R	1 VA
22 23 24	Active power 1 Active power 2 Active power 3	Signed R	0.1 W
25 26 27	Apparent power 1 Apparent power 2 Apparent power 3	Unsigned R	0.1 VA
28 29 30	Reactive power 1 positive at inductive load Reactive power 2 negative at capacitive load Reactive power 3	Signed R	0.1 VAR
31	Calibration voltage	Unsigned R / W	0.01 V
32	Calibration current	Unsigned R / W	0.001 A
33 34 35	Calibration status flags 1 Calibration status flags 2 Calibration status flags 3	Bits 0-15 R	-
36 37 38	Calibration status flags 1 Calibration status flags 2 Calibration status flags 3	Bits 16-31 R	-
39 40 41	Reactive power 1 positive at inductive load Reactive power 2 negative at capacitive load Reactive power 3	signed R	1 VAR
42-43 44-45 46-47	Active energy 1 Range 0 to 999.999.999 Active energy 2 Active energy 3 Counts absorbed active energy increasing order and generated active energy decreasing order Begins after device power-on with the value 0.	unsigned long R / W	1 Wh
48-49 50-51 52-53	Reactive energy 1 Range 0 to 999.999.999 Reactive energy 2 Reactive energy 3 Counts absorbed active energy increasing order and generated active energy decreasing order Begins after device power-on with the value 0.	unsigned long R / W	1 VARh

54 55 56	Transformation factor voltage 1 Values 1 to 254 Transformation factor voltage 2 Transformation factor voltage 3 Non-volatile storage in EEPROM. Has only an effect on the registers of energy or on the registers with data type float.	unsigned R / W	-
57 58 59	Transformation factor Current 1 Values 1 to 254 Transformation factor Current 2 Transformation factor Current 3 Non-volatile storage in EEPROM. Has only an effect on the registers of energy or on the registers with data type float.	unsigned R / W	-
60 61 62	Phase angle 1 Phase angle 2 Phase angle 3	signed R	1 °
65	Codes for bit rate and parity Factory setting 19200 bits, even parity. Non-volatile storage in EEPROM. Bit 0-3: Code for bit rate. Code 0x01 0x02 0x03 0x04 0x05 0x06 0x07 0x08 Bit/s 1200 2400 4800 9600 19200 38400 57600 115200 Bit 4-7: Code for parity. Code 0x10 0x20 0x30 Parity Even Odd None Bit 8-15: Value 0x53 enables changes with the commands Write-Single/Multiple-Registers. Then write this register as the only one.	unsigned R / W	-
66-67 68-69 70-71	Active power 1 Active power 2 Active power 3	float R	W
72-73 74-75 76-77	Apparent power 1 Apparent power 2 Apparent power 3	float R	VA
78-79 80-81 82-83	Reactive power 1 positive at inductive load Reactive power 2 negative at capacitive load Reactive power 3	float R	VAR

84-85 86-87 88-89	Voltage 1 RMS. Voltage 2 RMS Voltage 3 RMS	float R	V
90-91 92-93 94-95	Current 1 RMS Current 2 RMS Current 3 RMS	float R	A
96-97 98-99 100-101	Voltage 1 Peak value Voltage 2 Peak value Voltage 3 Peak value	float R	V
102-103 104-105 106-107	Current 1 Peak value Current 2 Peak value Current 3 Peak value	float R	A
108-109 110-111 112-113	Power factor 1 Power factor 2 Power factor 3	float R	-
114 115 116	Angle of phase 2 to 2 Angle of phase 3 to 2 Angle of phase 2 to 3 Used only with three-phase current, specified values -120° at normal direction of rotation (negative, right) 120° at reverse direction of rotation (positive, left)	signed R	0.1 °
117 118 119	Voltage value of positive sequence Voltage value of negative sequence Voltage value of zero sequence Values of the symmetrical components with three-phase current.	unsigned R	0.1 V
120	Undervoltage tolerance Effective voltage = 230 V * (100 % – tolerance_undervoltage) / 100 % Nonvolatile storage in EEPROM.	unsigned R / W	%

121	Overvoltage tolerance Effective voltage = 230 V * (100 % + tolerance_overvoltage) / 100 % Nonvolatile storage in EEPROM.	unsigned R / W	%
122	Asymmetry tolerance (negative sequence) Voltage_negative_system / voltage_positive_sequence = tolerance_asymmetry / 100 % Nonvolatile storage in EEPROM.	unsigned R / W	%
123	Asymmetry tolerance (zero sequence) Voltage_zero_sequence / voltage_positive_sequence = tolerance_asymmetry / 100 % Nonvolatile storage in EEPROM.	unsigned R / W	%
124	Initial setting of Enable bits of voltage monitoring Is copied to register 125 when the device is switched on. Nonvolatile storage in EEPROM.	unsigned R / W	-
125	Enable bits of voltage monitoring Each error bit in register 126 has one enable bit. Only if an enable bit is set, the respective error bit can be set. Recording of measured voltage values stops when error bits are set.	unsigned R / W	-
126	Error bits of voltage monitoring Bit 0-2: voltage drop 1-3 (< 25V) Bit 3-5: undervoltage 1-3 Bit 6-8: overvoltage 1-3 Bit 13: asymmetry (zero sequence) Bit 14: asymmetry (negative sequence) Bit 15: wrong direction of rotation The respective bit is automatically set in case of an error, it is not deleted when the error has been removed but has to be deleted via Modbus. It is also possible to set bits via Modbus.	unsigned R / W	-
127	Status of measured value recording Bit 0: recording (0) is running, (1) is stopped Bit 1: period of recording (0) 100ms, (1) 200ms	unsigned R R / W	-

256- 383 512- 639 768- 895	Recording of measured values voltage L1-N Recording of measured values voltage L2-N Recording of measured values voltage L3-N The wave shape of the three voltages can be determined with 128 recorded measured values of each phase. Recording of measured voltage values stops when error bits are set, so that the cause of error can later be determined on the basis of the wave shape.	signed R	0.1 V

At a RMS voltage less than 25 V the values of voltage, current, frequency and power are transmitted as 0.

The registers are updated with new measured values once per second.

Special data types

For Modbus applies, that in case of data with a length of several Bytes the High Byte will be transmitted first and the Low Byte last (Big-Endian). Data types with a length of multiple registers are described below.

If a data type needs several registers they should be read or written all together in one command to assure consistency of data. Registers can be accessed individually but then the user has to assure that data are consistent, for example with multiple queries.

Data type unsigned long

This data type uses 2 registers each, that means 4 Bytes.

Register addresses	Register + 0		Register + 1	
Bytes in order of transmission	Byte 1 High	Byte 2 Low	Byte 3 High	Byte 4 Low
Bit numbers	Bit 31-24	Bit 23-16	Bit 15-8	Bit 7-0

Data type float

This data type uses 2 registers each, that means 4 Bytes.

Register addresses	Register + 0		Register + 1	
Bytes in order of transmission	Byte 1 High	Byte 2 Low	Byte 3 High	Byte 4 Low
Bit numbers	Bit 31-24	Bit 23-16	Bit 15-8	Bit 7-0
Bits of float value	Sign, Exp 7-1	Exp 0, Mant 22-16	Mant 15-8	Mant 7-0

Indication of a compatibility problem:
4 different orders of the bytes in the registers are used in the market for data type "Float".

Configuration of the terminal block contacts

1La, 2La, 3La	Phase supply
1Lb, 2Lb, 3Lb	Phase consumer
1N, 2N, 3N	Neutral lead

At the contacts of the neutral lead the supply and consumer should not only be connected via the PC board because otherwise the power loss in the device is getting too high. The two neutral lead terminal blocks have to be connected by an external bridge if both are used.

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x06
Object Value	“MR-SM3”
Object ID	0x02
Object Length	0x04
Object Value	“V1.2”

MR-Multi I/O 12DI/7AI/2AO/8DO

I/O-commands

Modbus-Function “01 (0x01) Read Coils“ (R)
Modbus-Function “02 (0x02) Read Discrete Inputs“ (R)
Modbus-Function “03 (0x03) Read Holding Registers” (R)
Modbus-Function “04 (0x04) Read Input Registers” (R)
Modbus-Function “06 (0x06) Write Single Register” (W)
Modbus-Function “16 (0x10) Write Multiple Registers” (W)

Information

The holding registers 64 and 67 to 69 are only relevant for production process.

Read Discrete Inputs	(0 - 15)
Read Coils	(0 - 31)
Write Multiple Coils	(0 - 31)
Write Single Coil	(0 - 31)
Read Input Registers	(0 - 99)
Read Holding Registers	(0 - 99)
Write Multiple Registers	(0 - 99)
Write Single Register	(0 - 99)

Function block Bus-Watchdog

The Modbus communication may be controlled by a watchdog timer. The timer restarts with every valid message, that was directed to the device. Only the devices address is relevant, not the rest of the message. If the bus master or the connection fails and the timer will elapse, the outputs switch to their default values (save state) and the red LED will shine. With the time constants value of 0 the watchdog timer is inactive.

Holding Registers	
Addr.	Description
66	Time constant of communication monitoring Data type uint16, resolution 10 ms Maximum value = 65535 = 655.35 seconds = 10.9 minutes Factory default 0 (watchdog inactive) Storage in EEPROM

While defining the time constant you have to respect several items, which effects how offen the slave has to be addressed:

- Baudrate of the system
- Number of slaves
- Length of the messages of each slave
- Priorities while addressing the slaves
- Transmission errors cause timeouts and repetitions
- Capability and processor load of the master

Function block Digital Input

On each input a yellow LED shows the status.

Discrete Inputs	
Addr.	Description
0 - 10 11	Value of digital inputs 1…11 Value of digital input S0 (usable as counter input) Value 0: off, 1: on

Input Registers / Holding Registers	
Addr.	Description
70	Value of digital inputs Same as Discrete Inputs 0-15

Function block Digital Output

The relay outputs may be overdriven by push buttons, not the Photo-MOS outputs.
A long keystroke (> 1s) changes between automatic und manual operation.
A short keystroke (< 1s) changes in manual operation between Off and On.
On each output a yellow LED shows the status, a green LED shows if it is manual operation.

Coils	
Addr.	Description
0 - 3	Value of relay outputs 1…4 Value 0: off, 1: on
4 - 7	Value of Photo-MOS outputs 1…4 Value 0: off, 1: on

16 - 19	Operating mode of relay outputs 1…4 (read only) Value 0: automatic mode, 1: manual mode Storage in EEPROM

Holding Registers	
Addr.	Description
71	Value of digital outputs Same as Coils 0-15
72	Operating mode (automatic, manual) of digital outputs (read only) Same as Coils 16-31 Storage in EEPROM
73	Default values of digital outputs Factory default 0 Storage in EEPROM

Function block Analog Output

On each output a yellow LED shows with its brightness the outputs voltage.

Holding Registers	
Addr.	Description
74 - 75	Values of analog outputs O1…O2 Data type int16, Range: value 0 = 0 Volt ,… value 32767 = 10.24 Volt
78 - 79	Default values of analog outputs O1…O2 Data type int16, Factory default 0, Storage in EEPROM

Function block Analog Input

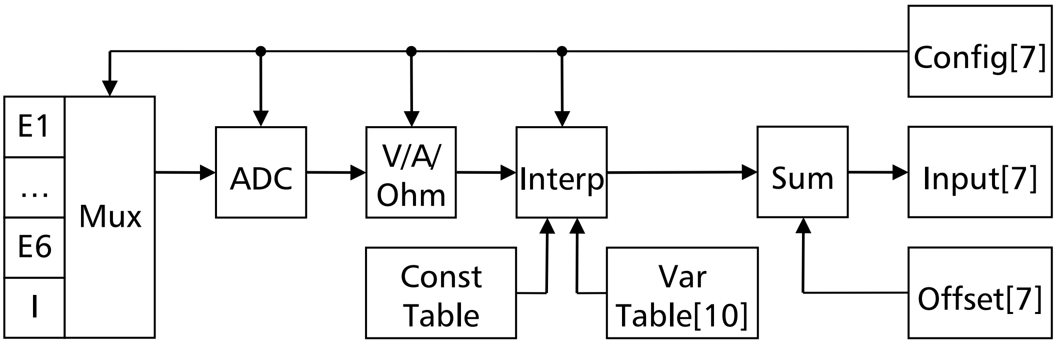
Overview

The inputs E1 to E6 universally serve for voltage measuring (0 to 11.5 V) and for resistance measuring (40 Ohm to 4 MOhm). The input I serves for current measuring (0 to 22 mA).

An analog to digital conversion takes about 0.2 seconds and measurements are taken alternatively at the inputs. A measurement is taken at each input with an interval of about 1.8 seconds, it takes a bit longer when the resistance measuring range is changed because several measurements are taken.

There are operating mode to calculate the temperature of standard temperature sensors. The measured voltage or resistance value is converted with a value chart and interpolation into the temperature. There are several pre-programmed charts for standard sensors and a freely programmable chart with up to 10 nodes.

An offset can be added to the measured value. This allows an adaptation to the sensor and the supply line or a fine tuning.



E1…E6, I	analog inputs, contacts E1 to E6 and I
Mux	input switch
ADC	analog-to-digital converter
V/A/Ohm	calculate voltage / current / resistance
Interp	interpolation with value charts
Sum	addition of an offset
ConstTable	value charts for standard sensors
	Modbus registers:
Config	Configuration Register
Input	Measured Value Register
Offset	Offset Register
VarTable	Value chart for specific sensor type

Modbus register

The messured values may be configured as float or 16 bit integer with leading sign.

Input Registers			
Addr.	AI	Name	Description
0	E1	Input 1…7	Measured value 2 consecutive registers, float in both or int16_t in first.
2	E2		
4	E3		
6	E4		
8	E5		
10	E6		
12	I		

Holding Registers			
Addr.	AI	Name	Description
0 - 1	E1	Offset 1…7	Offset register The offset is added to the measured value. 2 consecutive registers, float in both or int16_t in first, same data type as measured value. Factory default 0. Storage in EEPROM.
2 - 3	E2		
4 - 5	E3		
6 - 7	E4		
8 - 9	E5		
10 - 11	E6		
12 -13	I		
14 -15	-		
16	E1	Config 1…7	Configuration register Number (see below), used to select the - measuring range, - data type of measured value (float / int16_t), - unit of measured value, - sensor characteristic. Factory default 0 (Voltage 0-10V, float). Storage in EEPROM.
17	E2		
18	E3		
19	E4		
20	E5		
21	E6		
22	I		
23	-		
24 - 27 28 - 31 32 - 35 … 60 - 63	-	VarTable 1…10	Variable lookup table used for interpolation Alternately temperature and resistance (see below). Float in 2 consecutive registers each. Factory default 0. Storage in EEPROM.

Configuration registers

Input circuit and measuring range, data type and value unit and the sensor characteristic for usual temperature sensors are set for the 7 inputs with the 7 configuration registers. With the aid of the following charts the values of the registers are shown decimal and hexadecimal.

Voltage, Current or resistance:

Dec	Hex	Measuring range	Data type	Unit	Maximum
0 1	0x00 0x01	Voltage 0-10V	float int16_t	1 V 0.3125 mV	11.5 V 10.24 V
0 1	0x00 0x01	Current 0-20mA	float int16_t	1 mA 0.625 µA	22 mA 20.48 mA
32 33	0x20 0x21	Voltage 0-10V Pullup 2kΩ at 5V	float int16_t	1 V 0.3125 mV	11.5 V 10.24 V
64 65 66 67 68	0x40 0x41 0x42 0x43 0x44	Resistance	float int16_t int16_t int16_t int16_t	1 Ω 0.1 Ω 1 Ω 10 Ω 100 Ω	4 MΩ 3.2767 kΩ 32.767 kΩ 327.67 kΩ 3276.7 kΩ

For voltage with type signed integer: 10.24V / 2 ^ 15 = 1V / 3200 = 0.3125mV
For current with type signed integer: 20.48mA / 2 ^ 15 = 1mA / 1600 = 0.625µA

Temperature measurement with data type float:

Dec	Hex	Measuring range	Data type	Unit	Range
128	0x80	Sensor PT100	float	1°C	-50..150°C
130	0x82	Sensor PT500			-50..150°C
132	0x84	Sensor PT1000			-50..150°C
134	0x86	Sensor NI1000-TK5000			-50..150°C
136	0x88	Sensor NI1000-TK6180			-50..150°C
138	0x8A	Sensor BALCO 500			-50..150°C
140	0x8C	Sensor KTY81-110 NXP			-50..150°C
142	0x8E	Sensor KTY81-210 NXP			-50..150°C
144	0x90	Sensor NTC-1k8 Thermokon			-50..150°C
146	0x92	Sensor NTC-5k Thermokon			-50..150°C
148	0x94	Sensor NTC-10k Thermokon			-50..150°C
150	0x96	Sensor NTC-20k Thermokon			-50..150°C
152	0x98	Sensor LM235			-40..120°C

Temperature measurement with data type signed int (register number is by 1 larger than above):

129	0x81	Sensor PT100	int16_t	0.1°C	-50..150°C
131	0x83	Sensor PT500			-50..150°C
…	…	…			…
153	0x99	Sensor LM235 Register value is 1 larger than above			-40..120°C

Measurement with interpolation chart:

Dec	Hex	Measuring range	Data type	Interpolation
240	0xF0	Voltage 0-10V	float	linear
241	0xF1		int16_t	linear
242	0xF2		float	exponential
243	0xF3		int16_t	exponential
244	0xF4	Voltage 0-10V Pullup 2kΩ at 5V	float	linear
245	0xF5		int16_t	linear
246	0xF6		float	exponential
247	0xF7		int16_t	exponential
248	0xF8	Resistance	float	linear
249	0xF9		int16_t	linear
250	0xFA		float	exponential
251	0xFB		int16_t	exponential

Interpolation chart

This chart can be used to convert and linearize values for sensors without a characteristic already defined in the device. The chart contains up to 10 nodes of the sensor characteristic to interpolate between.

Example: transformation from resistance to temperature for temperature sensors.

Register contents is stored in the EEPROM.

The description refers to temperature sensors. Other sensors than temperature sensors (e.g. humidity) are also possible and it is also possible to measure voltage instead of resistance.

These properties can be set in the configuration register:

Measuring range	voltage voltage, pullup 2k at 5 V (for ex. for LM235) resistance (normal case with temperature sensors)
Interpolation	sensor characteristic is nearly linear sensor characteristic is nearly exponential (for NTCs)
Data type of measuring range	float (unit 1 °C) signed int (unit 0.1 °C)

Node	Register-Address Temperature	Register-Address Resistance
1	24-25	26-27
2	28-29	30-31
…	…	…
10	60-61	62-63

The nodes are filled beginning at the top of the chart, with a maximum of 10, and end with temperature = resistance = 0, if there are less nodes. Temperature and resistance values have to be in ascending or descending order. So the combination 0,0 as a node is not allowed. Data type in the registers: float temperature, float resistance.

Function duty cycle

The duty cycle of the counter input S0+/S0- will be messured. Sample rate is 1 ms.

Modbus register

Discrete Inputs	
Addr.	Description
11	Value of counter input (switch connected to digital input S0) 0: inactive (switch open), 1: active (switch closed)

Input Registers / Holding Registers	
Addr.	Description
70	Value of digital inputs (read only) Same as Discrete Inputs 0-15
82 - 83	Active time of counter input May be written to initialize second count, simultaneously resets millisecond count Data type uint32, resolution 1 second Storage in EEPROM

Function pulse counter
The pulse counter records pulses of a energy meter with S0 interface, which is connected to the counter input S0+/S0-. There are also other applications possible.

Modbus register

Discrete Inputs		
Addr.	Name	Description
11	IN_C	Value of counter input (switch connected to digital input S0) 0: off (switch open), 1: on (switch closed)

Input Registers		
Addr.	Name	Description
70	INPUT	Value of digital inputs Same as Discrete Inputs 0-15
84 - 87	IZ	Pulse counter Data type uint64 (lower 48 bits are used, highest 16 bits are 0)
88 - 89	BZ	Calculated counter reading Data type uint32

Holding Registers		
Addr.	Name	Description
84 - 87	IT	Copy of pulse counter when key was pressed Value may be overwritten Data type uint64 (lower 48 bits are used, highest 16 bits are 0) Storage in EEPROM
88 - 89	AZ	Initial calculated counter reading Data type uint32 Factory default 0 Storage in EEPROM
90	IE	Pulses per unit Data type uint16 Factory default 1 Storage in EEPROM
91	WI	Ratio of current transformer Data type uint16 Factory default 1 Storage in EEPROM

Holding Registers		
Addr.	Name	Description
92	WU	Ratio of voltage transformer Data type uint16 Factory default 1 Storage in EEPROM
93	WP	Mode of calculation with current/voltage transformer Data type: flag in bit 0 Value 0…1, see below Factory default 0 Storage in EEPROM
94	ZS	Format of counter display Data type uint16 High byte contains total counter digits, range 0…9, factory default 7, higher values are limited to 9 Low byte contains fractional counter digits, range 0…3, factory default 1, higher values are limited to 3 Storage in EEPROM
95	TA	Flag for enabling the key Data type: flag in bit 0 Value 0: key is disabled, 1: key is enabled Factory default 1 Storage in EEPROM

Operating mode for calculation with transformation factor

In the WP register, there is a code 0…1 that determines, together with the transformation factors WI and WU, the way how they are included in calculation. WP, WI and WU depend on whether the transformers are switched by the counters, whether the counter indicates the consumption in a primary or secondary way and whether the emitted pulses correspond primarily or secondarily to the consumption.

A difference must be made between the following electricity meter types:

Type 1: Directly measuring counter, display: primary, pulse: primary

Note:	Indicates the real consumption
Species:	DIN rail counter with mechanical drum-type counting mechanism, Ferraris counter
Formula type:	WP = 0
Factors:	WI = WU = 1

$$BZ = \left(\frac{IZ - IT}{IE} + AZ \right) \cdot WI \cdot WU$$, BZ = counter reading = consumption

Type 2: Transformer counter, display: primary, pulse: secondary

Note:	Indicates the real consumption
Species:	counter with LCD display
Formula type:	WP = 1
Factors:	WI and WU correspond to the transformers

$$BZ = \left(\frac{IZ - IT}{IE} \cdot WI \cdot WU \right) + AZ$$, BZ = counter reading = consumption

Type 3: Transformer counter, display: primary, pulse: primary

Note:	Indicates the real consumption
Species:	counter with LCD display, multi-function counters
Formula type:	WP = 0
Factors:	WI = WU = 1

$$BZ = \left(\frac{IZ - IT}{IE} + AZ \right) \cdot WI \cdot WU$$, BZ = counter reading = consumption

Type 4: Transformer counter, display: secondary, pulse: secondary

Note:	Indicates the consumption reduced by the transformation factors
Species:	DIN rail counter with mechanical drum-type counting mechanism, Ferraris counter
Formula type:	WP = 0

Consumption and display of the transformer counter are different. Both can be calculated using a different configuration (WI, WU).

Factors:	WI = WU = 1: The calculated counter reading corresponds to the display of the transformer counter.
Species:	DIN rail counter with mechanical drum-type counting mechanism, Ferraris counter.

$$BZ = \left(\frac{IZ - IT}{IE} + AZ \right) \cdot WI \cdot WU$$, BZ = counter reading or consumption

Start of operation

The user reads on site the initial count from the electricity meter and presses the key on the MR-Multi I/O. After this key press, the pulse counter of register IZ is copied into register IT. Afterwards, the user configures the MR-Multi I/O via the Modbus using a service program. The following must be entered:

- initial counter reading from the counter
- pulses per unit,
  e.g. indication on the electricity meter 2000 pulses per kWh
- formula type for calculation with transformation factors
- factor for current transformation,
  e.g. indication on the transformer 200/5A → factor = 40
- factor for voltage conversion,
  e.g. indication on the transformer 20000/100V → factor = 200
- number of digits and places after the decimal point
- deactivate the key to protect the IT register

Details for calculation

The calculated counter reading should behave exactly as the electricity meter. This requires that there should be no overflows and rounding errors for the intermediate results. Therefore, particularly large data types are used for counting and calculation

Every 60 milliseconds, a pulse can be emitted by the electricity meter. This results in up to 1,440,000 pulses per day or about 526,000,000 pulses per year.
If the pulse counter was realized with 4 bytes, it could be count to 4,294,967,295. At highest pulse frequency, this would be enough for approx. 8.2 years.
Therefore it is provided with 6 bytes and cannot overflow.

The number of places after the decimal point is considered as an additional multiplier with a power of ten during the calculation. Furthermore, it determines the place of the decimal point in the display of BZ and AZ.
As for the electricity counter which only has a specified number of decimal places, the number of places is limited with the last step in the calculation. This is why the calculated counter reading of the MR-Multi I/O overflows to 0 as often as the counter reading of the electricity meter.

Calculated counter reading if WP = 0:

BZ = ((uint96_t) (IZ - IT) * WU * WI * power of ten [places after decimal point] / IE +
(uint96_t) AZ * WU * WI)
% power of ten [counter digits]

Calculated counter reading if WP = 1:

BZ = ((uint96_t) (IZ - IT) * WU * WI * power of ten [places after decimal point] / IE +
(uint96_t) AZ)
% power of ten [counter digits]

Note for other applications

For applications with a current meter it is required in order to maintain consistency of data that the pulse counter IZ cannot be deleted. However, it is possible to create a deletable counter with the calculated meter reading BZ by changing the values of IT and/or AZ via the bus.

A simple example without the different factors:

Configuration with: WP = 0, WU = WI = 1, IE = 1, places after decimal point = 0

Calculation: BZ = IZ – IT + AZ

When writing AZ = 0 and IT = IZ, the result is BZ = 0.

Modbus Function “43 /14 (0x2B / 0x0E) Read Device Identification”

Request

Read Device ID code:	0x01
Object ID	0x00

Response

Device ID code	0x01
Conformity level	0x01
More follows	0x00
Next object ID	0x00
Number of objects	0x03
Object ID	0x00
Object Length	0x11
Object Value	“METZ CONNECT GmbH”
Object ID	0x01
Object Length	0x0B
Object Value	“MR-Multi-IO”
Object ID	0x02
Object Length	0x04
Object Value	“V1.1”

MR-LD6

I/O commands

Modbus Function "01 (0x01) Read Coils"

Modbus Function "03 (0x03) Read Holding Registers" (R)

Modbus Function "04 (0x04) Read Input Registers" (R)

Modbus Function "06 (0x06) Write Single Register" (W)

Modbus Function "16 (0x10) Write Multiple Registers" (W)

Information

Read Discrete Inputs	(0 - 15)
Read Coils	(0 - 31)
Write Multiple Coils	(0 - 31)
Write Single Coil	(0 - 31)
Read Input Registers	(0 - 99)
Read Holding Registers	(0 - 99)
Write Multiple Registers	(0 - 99)
Write Single Register	(0 - 99)

Function block Bus-Watchdog

The Modbus communication may be controlled by a watchdog timer. The timer restarts with every valid message, that was directed to the device. Only the devices address is relevant, not the rest of the message. If the bus master or the connection fails and the timer will elapse, the outputs switch to their default values (save state) and the red LED will shine. With the time constants value of 0 the watchdog timer is inactive.

Holding Registers		
Addr.	Description	
66	BusTimeout	Time constant of communication monitoring The time applies only when the relays are controlled via Modbus. The relays switch into the inactive state when the timeout is reached. The time restarts with each valid message that is addressed to the device. Data type uint16, resolution 10 ms Maximum value = 65535 (= 655.35 seconds = 10.9 minutes Factory default 0 (watchdog inactive) Storage in EEPROM

When defining the time constant several items have to be considered that influence how often a specific slave will be addressed:

- Baud rate of the system
- Number of slaves
- Length of the messages of each slave
- Priorities while addressing the slaves
- Transmission errors cause timeouts and repetitions
- Capability and processor load of the master

Discrete Inputs (Read-Only)		
Addr.	Name	Description
0…5	LeakDetect_1 … LeakDetect_6	Status bits for the identified leaks A bit is set when SensorResist < SensorThresh. The SensorThresh hysteresis of ± 5 % applies for comparison.
16…21	CableBreak_1 … CableBreak_6	Status bits for the identified cable breaks A bit is set when ZenerVoltage > ZenerThresh. The ZenerThresh hysteresis of ± 2.5 % applies for comparison.

Input Registers (Read-Only)		
Addr.	Name	Description
0	LeakDetect	Status register for identified leaks in bit 0…5, the bits LeakDetect_1…6 are collected here
1	CableBreak	Status register for cable breaks in bit 0…5, the bits CableBreak_1…6 are collected here
2…7	SensorResist_1 ... SensorResist_6	Measured resistance values of the sensor, resolution, unit: 100 Ohm Maximum: 10000 (= 1 MOhm)
8…13	ZenerVoltage_1 ... ZenerVoltage_6	Voltages at the Z-diodes for wire break monitoring, resolution, unit: 100 mV

Coils		
Addr.	Name	Description
0…1	Relay_1 … Relay_2	Switching state of a relay (0 = ON, 1 = OFF) read-only for leakage identification or level monitoring, also writable when controlled via Modbus. The inactive states are defined in RelayPolarity, the active states are oppositely in each case. Leakage message: Active state if a leak is signaled. Level monitor: Active state if both electrodes are touched, inactive state if none of the electrodes is touched keep state if only one of the electrodes is touched. Control via Modbus: Basic setting is the inactive state.

Holding Registers		
Addr.	Name	Description
0	Relay	Switching state of the relays in bit 0…1, the bits Relay_1…2 are combined here.
1	RelayPolarity	The two relays have make contacts with switching state “OFF” or “ON”. They are triggered with the states “inactive” or “active” by the leakage/level monitoring. The switching state can be inverted with this register. Bit 0…1 correspond to the inactive states of the two relays: 0: inactive = OFF, active = ON, 1: inactive = ON, active = OFF. Factory default 0b00, Storage in EEPROM

Holding Registers		
Addr.	Name	Description
2…7	SensorThresh_1 ... SensorThresh_6	Switching thresholds for the sensor resistances Data type uint16, Resolution: 100 Ohm, Factory default 200 (= 20 kOhm), Storage in EEPROM
8…13	ZenerThresh_1 ... ZenerThresh_6	Switching thresholds for the Z-diodes for wire break monitoring Data type uint16, Resolution 100 mV, Factory default 110 (= 11 V), Storage in EEPROM
14 15	Mode_1 Mode_2	Operating mode for relay 1 and 2 0: Leakage message, 1: Level monitor (input 1 top, 2 bottom), 2: Level monitor (input 3 top, 4 bottom), 3: Level monitor (input 5 top, 6 bottom), otherwise: control via Modbus. Factory default 0, Storage in EEPROM
16 17	LeakEnable_1 LeakEnable_2	Analog inputs for leakage message with relays 1 / 2. If bits 0…5 are set, the respective bits in LeakDetect in the operating mode leakage message make relays 1 or 2 switch into the active state. Factory default 0b000111 (LeakEnable_1), Factory default 0b111000 (LeakEnable_2), Storage in EEPROM
18	ZenerEnable	Inputs with installed cable monitoring. The respective bits in CableBreak are only set in case of a cable break if bits 0…5 are set. Factory default 0b111111, Storage in EEPROM

Holding Registers		
Addr.	Name	Description
19 20	BreakEnable_1 BreakEnable_2	Inputs for the cable break message with relays 1 / 2. If bits 0…5 are set, the respective bits in CableBreak in the operating mode leakage message make relays 1 or 2 switch into the active state. Factory default 0b000000 (BreakEnable_1), Factory default 0b000000 (BreakEnable_2), Storage in EEPROM

Modbus Function "43 /14 (0x2B / 0x0E) Read Device Identification"

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Object ID	0x00
Object Length	0x11
Object Value	"METZ CONNECT GmbH"
Object ID	0x01
Object Length	0x06
Object Value	"MR-LD6"
Object ID	0x02
Object Length	0x04
Object Value	"V1.0"