LUMEL

4-CHANNEL MODULE OF ANALOG INPUTS

SM2

USER'S MANUAL

CE

CONTENTS

1. APPLICATION

the SM2 4-channel module of analog inputs is destined to convert standard signals, resistance or temperature signals into numerical data accessible through the RS-485 or RS-232 port by means of the MODBUS protocol.

The measurement is carried out independently on four, galvanically insulated between them channels. RS-485 and RS-232 output ports are galvanically insulated from input signals and the supply. The module programming is possible by means of the RS-485 or RS-232 port. In the set of SM2 module there is a connecting cable, to connect with the PC computer (RS-232).

The SM2 module realises following functions:

- mathematical operations on channels and between measuring channels,
- conversion of measured or calculated quantities basing on the individual linear characteristic,
- storage of maximal and minimal values for each channel,
- programmable digital filter for measurement, independently for each channel,
- handling of RS-485 and RS-232 interfaces in MODBUS protocol, in RTU mode,
- change of the OC type output state basing on set alarm values.

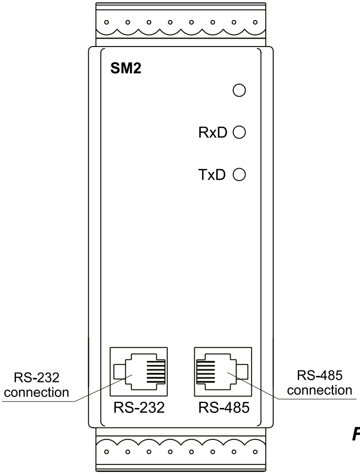


Fig. 1. View of the SM2 module

2. SET OF THE SM2 MODULE

The set consists of:

- SM2 module ....1 pc.
- plug with screw terminals ....4 pcs
- hole plug of the RS-485 and RS-232 sockets ....2 pc

When unpacking the module, please check whether the type and execution code on the data plate correspond to the order.

3. BASIC REQUIREMENTS, SAFETY INFORMATION

Symbols located in this service manual mean:

WARNING!
Warning of potential, hazardous situations. Especially important. One must acquaint with this before connecting the module.
The non-observance of notices marked by these symbols can occasion severe injuries of the personnel and the damage of the module.

CAUTION!
Designates a general useful note. If you observe it, handling of the module is made easier. One must take note of this, when the module is working inconsistently to the expectations. Possible consequences if disregarded!

In the security scope the module meets the requirements of the EN 61010-1 standard.

Remarks concerning the operator safety:

<u>1. General</u>

- The SM2 module is destined to be installed in measuring systems.
- Non-authorized removal of the required housing, inappropriate use, incorrect installation or operation create the risk of injury to personnel or damage to equipment. For more detailed information please study the user’s manual.

- All operations concerning transport, installation, and commissioning as well as maintenance must be carried out by qualified, skilled personnel and national regulations for the prevention of accidents must be observed.
- According to this basic safety information, qualified, skilled personnel are persons who are familiar with the installation, assembly, commissioning, and operation of the product and who have qualifications necessary for their occupation.

2. Transport, storage

Please observe the notes on transport, storage and appropriate handling.

Observe the climatic conditions given in Technical Data.

3. Installation

- The module must be installed according to the regulation and instructions given in this user's manual.
- Ensure proper handling and avoid mechanical stress.
- Do not bend any components and do not change any insulation distances.
- Do not touch any electronic components and contacts.
- Modules may contain electrostatically sensitive components, which can easily be damaged by inappropriate handling.
- **Do not damage or destroy any electrical components since this might endanger your health!**

4. Electrical connection

- Before switching the module on, one must check the correctness of connection to the network.
- In case of the protection terminal connection with a separate lead one must remember to connect it before the connection of the module to the mains.
- When working on live modules, the applicable national regulations for the prevention of accidents must be observed.
- The electrical installation must be carried out according to the appropriate regulations (cable cross-sections, fuses, PE connection). Additional information can be obtained from the user's manual.
- Apply a two-wire cable for the connection to the network acc. to the EN 61010-1 standard.
- Do not connect the module to the network through an autotransformer.
- In the building installation, a cut-out or a circuit-breaker should exist, situated near the device and easy accessible to the operator. It should be marked as the element switching the device out.

- The documentation contains information about installation in compliance with EMC (shielding, grounding, filters and cables). These notes must be observed for all CE-marked products.
- The manufacturer of the measuring system or installed devices is responsible for the compliance with the required limit values demanded by the EMC legislation.

5. Operation

- Measuring systems including SM1 modules must be equipped with protection devices according to the corresponding standard and regulations for prevention of accidents.
- After the instrument has been disconnected from the supply voltage, live components and power connections must not be touched immediately because capacitors can be charged.
- The housing must be closed during operation.
- The RS-232 socket serves only to connect the device (Fig.5) working with the MODBUS protocol. When the module is not used place the hole plug in the RS-232 socket of the module.

6. Maintenance and servicing.

Please observe the manufacturer's documentation.

Read all product-specific safety and application notes in this user's manual.

- Before taking the module out, one must turn the supply off.
- The removal of the module housing during the warranty contract period may cause its cancellation.

4. INSTALLATION

4.1 Way of fixing

The SM2 module is fixed on a 35 mm rail in accordance with EN 60715. The module housing is made of a self-extinguishing plastic. Overall dimensions of the housing: $45 \times 120 \times 100$ mm. One must connect to the module, external wires with cross-section up to 2.5 mm^2

Overall dimensions and the fixing way are presented on the fig. 2.

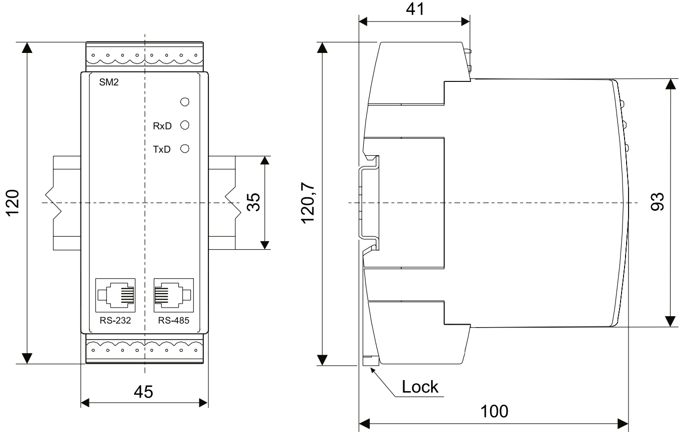


Fig.2. Overall dimensions and way of fixing the module

4.2. External connection diagrams

Make the connection of input signals, supply and interface acc. to the fig. 3, 4 and 5

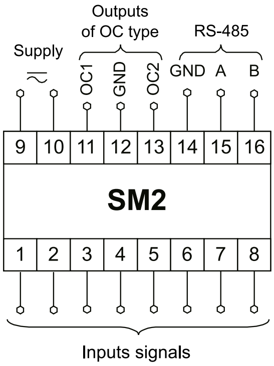


Fig. 3
Connection way of external signals. The connection diagram is also placed on the module housing

The polarization is optional when supplying by d.c. voltage.

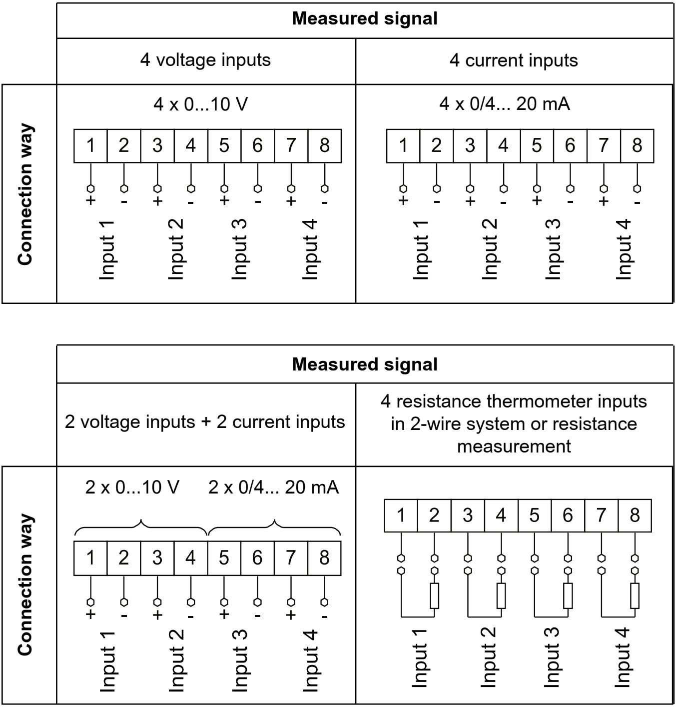


Fig. 4 connection way of input signals

Taking in consideration electromagnetic interference one must use shielded wires to connect input signals and output signals. The supply must be connected by a two-wire cable, with the appropriate wire diameter ensuring its protection by means of a safety fuse.

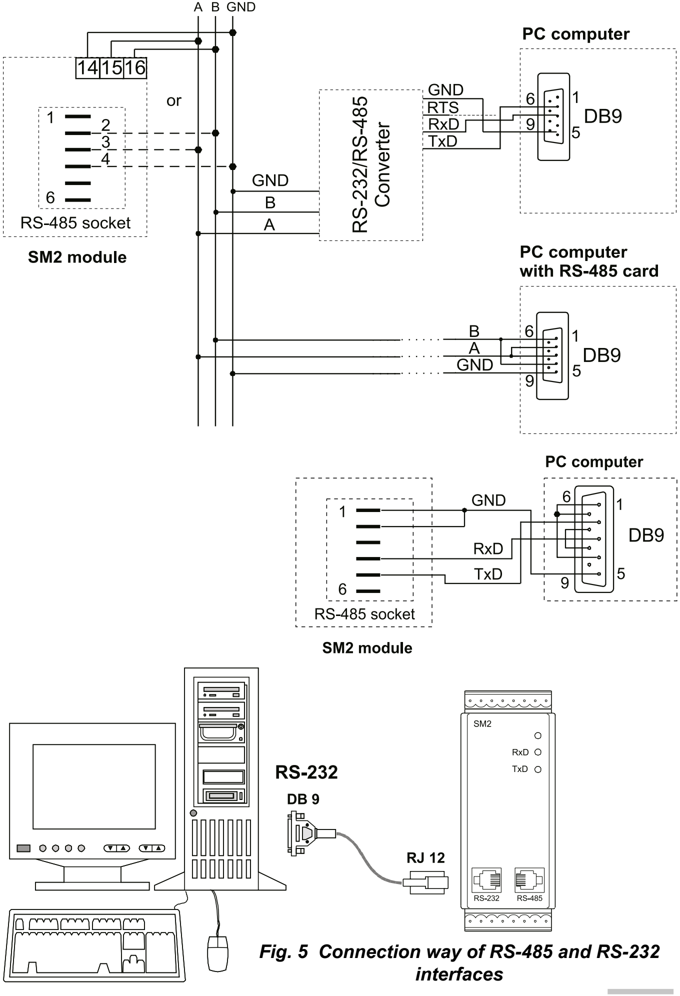


Fig. 5 Connection way of RS-485 and RS-232 interfaces

5. HANDLING

After connecting external signals and switching the supply on, the SM2 module is ready to work.

The lighted green diode signals the module work. The green diode (RxD) signals the module polling, however the yellow diode (TxD) signals the module response. Diodes should ignite in cycles during the data transmission, both through the RS-232 and the RS-485 interface. One can program all module parameters by means of RS-232 or RS-485.

The RS-232 port has constant transmission parameters in accordance with technical data, what enables the connection with the module even when programmed parameters of the RS-485 digital output are unknown (address, mode, rate). The RS-485 standard allows to the direct connection to 32 devices on a single serial link up to 1200 m. To connect a greater number of devices, it is necessary to use additional intermediate-separating systems.

The way of the interface connection is given in the user's manual (fig.5). To obtain the correct transmission, it is necessary to connect **A** and **B** lines in parallel with their counterparts in other devices. The connection must be carried out with a screened wire. The screen must be connect to the protective terminal in a single point. The **GND** line serves to the additional protection of the interface line at long connections. One must connect it to the protective terminal (it is not necessary for the correct interface work). To obtain the connection with the PC computer through the RS-485 port, an RS-232/RS-485 converter (e.g. PD51) or an RS-485 interface card is indispensable. The marking of transmission lines for the card in the PC computer depends on the card manufacturer. To obtain the connection through the RS-232 port, the wire added to the module is sufficient. The connection way of both ports (RS-232 and RS-485) is shown on the fig. 5.

The module can be connected to the device of master type only through one interface port. In case of a simultaneous connection of both ports, the module will work through the RS-232 interface.

5.1. Description of MODBUS protocol implementation

The transmission protocol describes ways of the information exchange between devices through serial links.

The MODBUS protocol has been implemented in the module in accordance with the PI-MBUS-300 Rev G specification of the Modicon company.

Set of parameters of the module serial link in the MODBUS protocol:

- Module address - 1... 247
- Baud rate - 2400, 4800, 9600, 19200, 38400, 57600, 115200 bit/s
- Working modes - RTU

- Information unit - RTU: 8N2, 8E1, 8O1, 8N1
- Maximal response time - 100 ms.
- Maximal number of read/written register with one command - 30

The parameter configuration of the serial link is described in the further part of the user's manual. It consists on establishing the baud rate (**Rate parameter**), device address (**Adr parameter**) and the information unit type (Mode parameter).

In case of the module connection with the computer through the RS-232 wire, the module set automatically following transmission parameters:

Baud rate: 9600 bps,

Working mode: RTU 8N1,

Address: 1.

Notice: Each module connected to the communication network must:

- have a unique address, different from addresses of other devices connected to the network,
- identical baud rate and information unit type,
- the message sent with the address „0" is identified as the data transmission mode (transmission to many devices)

Only one module can be connected to the master's RS-232.

5.2. Description of the MODBUS protocol function

Opis funkcji

Code	***Signification***
03 (03 h)	Readout of n-register
06 (06 h)	Write of a single register
16 (10 h)	Write of n-registers
17 (11 h)	Slave device identification

Following functions of the MODBUS protocol have been implemented in the SM2 module

Readout of n-registers (code 03h)

The function is not accessible in the broadcast mode.

Example: Readout of 2 registers beginning by the register with the 1DBDh

Device address	Function	Register address		Number of registers		Checksum CRC
		Hi	Lo	Hi	Lo	
01	03	1D	BD	00	02	52 43

address (7613)

Device address	Function	Number of bytes	Value from the register 1DBD (7613)				Value from the register 1DBE (7614)				Check-sum CRC
01	03	08	3F	80	00	00	40	00	00	00	42 8B

Demand:

Answer:

Write of values in the register (code 06h)

The function is accessible in the broadcast mode.

Device address	Function	Register address		Value for the register 1DBD (7613)				Checksum CRC
		Hi	Lo					
01	06	1D	BD	3F	80	00	00	85 AD

Answer:

Device address	Function	Register address		Value from the register 1DBD (7613)				Checksum CRC
		Hi	Lo					
01	06	1D	BD	3F	80	00	00	85 AD

Write in n-registers (code 10h)

The function is accessible in broadcast mode.

Example: Write of two registers beginning from the register with 1DBDh (7613) address

Demand:

Device address	Function	Register address		Number of registers		Number of bytes	Value for the register 1DBD (7613)				Value for the register 1DBE (7614)				Checksum CRC
		Hi	Lo	Hi	Lo										
01	10	1D	BD	00	02	08	3F	80	00	00	40	00	00	00	03 09

Answer:

Device address	Function	Register address		Number of registers		Checksum CRC
		Hi	Lo	Hi	Lo	
01	03	1D	BD	00	02	52 43

Report identifying the device (code 11h)

Demand:

Device address	Function	Checksum (CRC)
01	11	C0 2C

Answer:

Device address	Function	Number of bytes	Device identifier	Device version	Check-sum
X	11	08	89	„SM2 c0XXX fY.YY -vSTANDARD”	

Device address	- depends on the set value	
Function	- function number: 0x11	
Number of bytes	- 0x08	
Device identifier	- 0x89	
Device state	- 0xFF	
Field depended of the device	- XXXXXX	
Output of OC type	- 0x01 - 2 outputs of OC type,	01 X X X X X
Type of input	- Field depended on the module execution code:	
	- 0x00 - four 0...10 V voltage inputs,	X 00 X X X X
	- 0x01 - four 0/4...20 mA current inputs,	X 01 X X X X
	- 0x02 - two 0...10 V voltage inputs, two 0/4...20 mA current inputs,	X 02 X X X X
	- 0x03 - four Pt100 inputs or four resistance inputs up to 400 Ω ,	X 03 X X X X
Number of the software version	- software version implemented in the module X X_ _ _ _4 - byte variable of float	
Checksum	- 2 bytes in case of work in RTU mode - 1 byte in case of work in ASCII mode	

Example:

Work in **RTU** mode, e.g. **Mode = RTU 8N2** (value 0x02 in case of readout/write through the interface

The device address is set on **Adr=0x01**

For the SM2 module the answer frame has the following shape:

Device address	Function	Number of bytes	Device identifier	Device state	Field depending on the device type	Check-sum
01	11	08	89	FF	01 01 3F 80 00 00	C3 60

Example: Write the register with 1DBDh (7613) address

Demand:

It is the SM2 module:

- with two OC type outputs
- with four 0/4...20 mA current inputs
- software version: 1.00

5.3. Register map

Address range	***Value type***	***Description***
7000-7200	float (32 bit)	The value is placed in two successive 16-bit registers. Registers contain the same data as 32-bit registers from the area 7500. The register is for readout only
7200-7400	float (32 bit)	The value is placed in two successive 16-bit registers. Registers contain the same data as 32-bit registers from the area 7600. Registers can be read out and written.
7500-7600	float (32 bit)	The value is placed in the 32-bit register. The register is for readout only.
7600-7700	float (32 bit)	The value is placed in the 32-bit register. Registers can be read out and written.

5.4. Registers only for readout

<table>
<tr><th>The value is located in two successive 16-bite registers. These registers include the same data as 32-bite registers from the area 7500.</th><th>The value is placed into 32-bite registers.</th><th>Name</th><th>Write (w)/Readout (r)</th><th>Unit</th><th>Quantity name</th></tr>
<tr><td>7000</td><td>7500</td><td>Identifier</td><td>r</td><td>-</td><td>Constant identifying the device</td></tr>
<tr><td colspan="5"></td><td><table>
<tr><th>Value</th><th></th></tr>
<tr><td>0x89 - - h</td><td>SM2 identifier</td></tr>
<tr><td>0x - - 00h</td><td>Four 0...10 V voltage inputs</td></tr>
<tr><td>0x - - 01h</td><td>Four 0/4...20 mA currents</td></tr>
<tr><td>0x - - 02h</td><td>Two 0...10 V voltage input
Two 0/4...20 mA current input</td></tr>
<tr><td>0x - - 03h</td><td>Four Pt100 inpus or
Four resistance inputs up to 400 Ω</td></tr>
</table></td></tr>
<tr><td>7002</td><td>7501</td><td>Status 1</td><td>r</td><td>-</td><td>Status 1 is the register describing the present module state</td></tr>
<tr><td>7004</td><td>7502</td><td>Status 2</td><td>r</td><td>-</td><td>Status 2 is the register describing the present module state</td></tr>
<tr><td>7006</td><td>7503</td><td>W1</td><td>r</td><td>-</td><td>Measured value on the input 1</td></tr>
<tr><td>7008</td><td>7504</td><td>W2</td><td>r</td><td>-</td><td>Measured value on the input 2</td></tr>
<tr><td>7010</td><td>7505</td><td>W3</td><td>r</td><td>-</td><td>Measured value on the input 3</td></tr>
<tr><td>7012</td><td>7506</td><td>W4</td><td>r</td><td>-</td><td>Measured value on the input 4</td></tr>
<tr><td>7014</td><td>7507</td><td>WF</td><td>r</td><td>-</td><td>Calculated value basing on the function</td></tr>
<tr><td>7016</td><td>7508</td><td>Min 1</td><td>r</td><td>-</td><td>Minimum of the measured value on the input 1</td></tr>
<tr><td>7018</td><td>7509</td><td>Max 1</td><td>r</td><td>-</td><td>Maximum of the measured value on the input 1</td></tr>
<tr><td>7020</td><td>7510</td><td>Min 2</td><td>r</td><td>-</td><td>Minimum of the measured value on the input 2</td></tr>
<tr><td>7022</td><td>7511</td><td>Max 2</td><td>r</td><td>-</td><td>Maximum of the measured value on the input 2</td></tr>
<tr><td>7024</td><td>7512</td><td>Min 3</td><td>r</td><td>-</td><td>Minimum of the measured value on the input 3</td></tr>
<tr><td>7026</td><td>7513</td><td>Max 3</td><td>r</td><td>-</td><td>Maximum of the measured value on the input 3</td></tr>
<tr><td>7028</td><td>7514</td><td>Min 4</td><td>r</td><td>-</td><td>Minimum of the measured value on the input 4</td></tr>
<tr><td>7030</td><td>7515</td><td>Max 4</td><td>r</td><td>-</td><td>Maximum of the measured value on the input 4</td></tr>
<tr><td>7032</td><td>7516</td><td>WF Min</td><td>r</td><td>-</td><td>Minimum of the calculated value</td></tr>
<tr><td>7034</td><td>7517</td><td>WF Max</td><td>r</td><td>-</td><td>Maximum of the calculated value</td></tr>
</table>

Description of the Status1 register

bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
					Signalling of the lower input 4 range exceeding	Signalling of the upper input 4 range exceeding	Signalling of the lower input 3 range exceeding	Signalling of the upper input 3 range exceeding	Signalling of the lower input 2 range exceeding	Signalling of the upper input 2 range exceeding	Signalling of the lower input 1 range exceeding	Signalling of the upper input 1 range exceeding	Individual characteristic of the input 4	Individual characteristic of the input 3	Individual characteristic of the input 2	Individual characteristic of the input 1
	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	MSB															LSB

Bit-15...12 Empty
Bit value is always equal 0

Bit-11 Signalling of the lower range exceeding of input 4
0 - normal work
1 - range exceeding

Bit-10 Signalling of the upper range exceeding of input 4
0 - normal work
1 - range exceeding

Bit-9 Signalling of the lower range exceeding of input 3
0 - normal work
1 - range exceeding

Bit-8 Signalling of the upper range exceeding of input 3
0 - normal work
1 - range exceeding

Bit-7 Signalling of the lower range exceeding of input 2
0 - normal work
1 - range exceeding

Bit-6 Signalling of the upper range exceeding of input 2
0 - normal work
1 - range exceeding

Bit-5 Signalling of the lower range exceeding of input 1
0 - normal work
1 - range exceeding

Bit-4 Signalling of the upper range exceeding of input 1
0 - normal work
1 - range exceeding

Bit-3 Individual characteristic of the input 4
0 - individual characteristic switched on
1 - individual characteristic switched off

Bit-2 Individual characteristic of the input 3
0 - individual characteristic switched on
1 - individual characteristic switched off

Bit-1 Individual characteristic of the input 2
0 - individual characteristic switched on
1 - individual characteristic switched off

Bit-0 Individual characteristic of the input 1
0 - individual characteristic switched on
1 - individual characteristic switched off

Description of the Status 2 register

		Output 2 state of OC type	Output 1 state of OC type	State of input 4	State of input 3	State of input 2	State of input 1	Working mode and information unit			Baud rate			Type of inputs		
	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	MSB															LSB

Bit-15 Empty
Bit value is always equal 0

Bit-14 Output 2 state of OC type
0 - OC switched off
1 - OC switched on

Bit-13 Output 1 state of OC type
0 - OC switched off
1 - OC switched on

Bit-12 State of measuring input 4
0 - input switched off (lack of measurement)
1 - input switched on

Bit-11 State of measuring input 3
0 - input switched off (lack of measurement)
1 - input switched on

Bit-10 State of measuring input 2
0 - input switched off (lack of measurement)
1 - input switched on

Bit-9 State of measuring input 1
0 - input switched off (lack of measurement)
1 - input switched on

Bit-8...6 Working mode and information unit
100 - 8N2 - RTU
101 - 8E1 - RTU
110 - 8O1 - RTU
111 - 8N1 - RTU

Bit-5...3 Baud rate
000 - 2400 bit/s
001 - 4800 bit/s
010 - 9600 bit/s
011 - 19200 bit/s
100 - 38400 bit/s
101 - 57600 bit/s
110 - 115200 bit/s

Bit-2...0 Type of inputs
000 - 4 x 0...10 V
001 - 4 x 0/4...20 mA
010 - 2 x 0...10 V, 2 x 0/4...20 mA
011 - 4 x Pt100 resistance thermometer inputs or
4 x resistance inputs up to 400 Ω

5.5. Registers for readout and write

Table 1

The value is placed in two successive 16-bytes registers. These registers include the same data as 32-bit registers from the area 7600.	The value is placed in 32-bit registers.	Symbol	Write (w)/Readout (r)	Range	Description	
7200	7600	**Identifier**	r	-	Device identifier	
					Value	
					0x89 - - h	SM2 Identifier
					0x - - 00h	Four 0...10 V voltage inputs
					0x - - 01h	Four 0/4...20 mA current inputs
					0x - - 02h	Two 0...10 V voltage input Two 0/4...20 mA current input
					0x - - 03h	Four Pt100 inputs or Four resistance inputs up to 400 Ω
7202	7601	**Rate**	W/r	0... 6	Baud rate of the RS-485 interface (bit/s)	
					Value	
					0	2400
					1	4800
					2	9600
					3	19 200
					4	38400
					5	57600
					6	115200
7204	7602	**Mode**	W/r	0... 7	Kind of transmission through the RS-485 interface	
					Value	
					4	RTU 8N2
					5	RTU 8E1
					6	RTU 8O1
					7	RTU 8N1

7206	7603	**Adr**	W/r	0... 247	Device address	
7208	7604	**Apply**	W/r	0... 1	Acceptation of module transmission parameter changes	
					Value	
					0	Lack of reaction
					1	Acceptation of changes
7210	7605	**Input 1**	W/r	0... 1	Switching ON/OFF of the measuring input 1	
					Value	
					0	Measuring input switched off
					1	Measuring input switched on
					In case of the input off the value 0 is returned	
7212	7606	**W1 type**	W/r	0... 1	Input 1 type	
					Range	
					0	0...10 V for SM2-00XXX execution 0...10 V for SM2-02XXX execution 0/4...20 mA for SM2-01XXX execution
					0... 1	0 - Pt100 1 - Resistance < 400 Ω
					Notice! The range change of this parameter depends on the execution code	
7214	7607	**Cnt W1**	W/r	0... 30	Filter time constant of the input 1	
					Value	
					0	Filter is switched off
					0.1...100.0	Time constant in seconds
7216	7608	**Ind W1**	W/r	0... 1	Individual characteristic of the input 1	
					Value	
					0	off
					1	on

7218	7609	**X1 W1**	W/r	-99999...99999	Parameters of the individual characteristic of input 1
7220	7610	**Y1 W1**	W/r	-99999...99999	On the base of given co-ordinates of two points by the user the module determines (from the system of equations) coefficients a and b of the individual characteristic. $$\begin{cases} Y1W1 = a\cdot X1W1 + b \\ Y2W1 = a\cdot X2W1 + b \end{cases}$$ where: X1 W1 and X2 W1 - measured value Y1 W1 and Y2 W1 - Expected value on the digital output. The graphical presentation of the individual characteristic is presented on the fig. 6. At output signal recalculations, at first the module recalculates the value on the base of the individual characteristic and then, this result is transmitted to the arithmetic function,
7222	7611	**X2 W1**	W/r	-99999...99999	
7224	7612	**Y2 W1**	W/r	-99999...99999	
7226	7613	**Input 2**	W/r	0... 1	Switching ON/OFF of the measuring input 2
					Value: 0 – Measuring input switched off; 1 – Measuring input switched on. In case of the input off the value 0 is returned
7228	7614	**Typ W2**	W/r	0... 1	Input 2 type
					Range of changes as for the **W1** type
7230	7615	**Cnt W2**	W/r	0... 6500	Measurement averaging time of the input 2
					Range of changes as for the **Cnt W1** type
7232	7616	**Ind W2**	W/r	0... 1	Individual characteristic of the input 2
					Value: 0 – off; 1 – on
7234	7617	**X1 W2**	W/r	-99999...99999	Parameters of the individual characteristic of input 2
7236	7618	**Y1 W2**	W/r	-99999...99999	The range changes as for: **X1 W1, Y1 W1, X2 W1, Y2 W1**
7238	7619	**X2 W2**	W/r	-99999...99999	
7240	7620	**Y2 W2**	W/r	-99999...99999	

<table>
<tr><td>7242</td><td>7621</td><td>Input 3</td><td>W/r</td><td>0... 1</td><td colspan="2">Switching ON/OFF of the measuring input 3</td></tr>
<tr><td colspan="5" rowspan="4"></td><td>Value</td><td></td></tr>
<tr><td>0</td><td>Measuring input switched off</td></tr>
<tr><td>1</td><td>Measuring input switched on</td></tr>
<tr><td colspan="2">In case of the input off the value 0 is returned</td></tr>
<tr><td>7244</td><td>7622</td><td>W3 type</td><td>W/r</td><td>0... 1</td><td colspan="2">Input 3 type</td></tr>
<tr><td colspan="5" rowspan="4"></td><td>Range</td><td></td></tr>
<tr><td>0</td><td>0...10 V
for SM2-00XXX execution
0/4...20 mA
for SM2-01XXX execution,
for SM2-02XXX execution</td></tr>
<tr><td>0... 1</td><td>0 - Pt100
1 - Resistance < 400 Ω</td></tr>
<tr><td colspan="2">Notice!
The range change of this parameter depends on the execution code</td></tr>
<tr><td>7246</td><td>7623</td><td>Cnt W3</td><td>W/r</td><td>0... 100</td><td colspan="2">Filter time constant of the input 3</td></tr>
<tr><td colspan="5"></td><td colspan="2">Range of changes as for the Cnt W1 type</td></tr>
<tr><td>7248</td><td>7624</td><td>Ind W3</td><td>W/r</td><td>0... 1</td><td colspan="2">Individual characteristic of the input 3</td></tr>
<tr><td colspan="5" rowspan="3"></td><td>Value</td><td></td></tr>
<tr><td>0</td><td>off</td></tr>
<tr><td>1</td><td>on</td></tr>
<tr><td>7250</td><td>7625</td><td>X1 W3</td><td>W/r</td><td>-99999...99999</td><td colspan="2">Parameters of the individual characteristic of input 3</td></tr>
<tr><td>7252</td><td>7626</td><td>Y1 W3</td><td>W/r</td><td>-99999...99999</td><td colspan="2" rowspan="3">The range changes as for: X1 W1, Y1 W1, X2 W1, Y2 W1</td></tr>
<tr><td>7254</td><td>7627</td><td>X2 W3</td><td>W/r</td><td>-99999...99999</td></tr>
<tr><td>7256</td><td>7628</td><td>Y2 W3</td><td>W/r</td><td>-99999...99999</td></tr>
<tr><td>7258</td><td>7629</td><td>Input 4</td><td>W/r</td><td>0... 1</td><td colspan="2">Switching ON/OFF of the measuring input 4</td></tr>
<tr><td colspan="5" rowspan="4"></td><td>Value</td><td></td></tr>
<tr><td>0</td><td>Measuring input switched off</td></tr>
<tr><td>1</td><td>Measuring input switched on</td></tr>
<tr><td colspan="2">In case of the input off the value 0 is returned</td></tr>
</table>

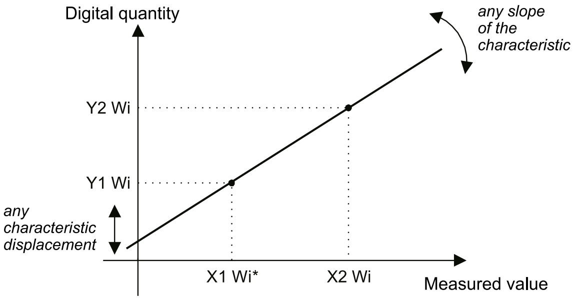
7260	7630	**W4 type**	W/r	0... 1	Input 4 type
					Range of changes as for **W1 type**
7262	7631	**Cnt W4**	W/r	0... 6500	Czas uśredniania pomiaru wejścia 4
					Zakres zmian jak dla **Cnt W1**
7264	7632	**Ind W4**	W/r	0... 1	Individual characteristic of the input 4
					Value
					0 – off
					1 – on
7266	7633	**X1 W4**	W/r	-99999...99999	Parameters of the individual characteristic of input 4
7268	7634	**Y1 W4**	W/r	-99999...99999	The range changes as for: **X1 W1, Y1 W1, X2 W1, Y2 W1**
7270	7635	**X2 W4**	W/r	-99999...99999	
7272	7636	**Y2 W4**	W/r	-99999...99999	
7274	7637	**A**	W/r	0... 12	Parameters of the mathematical function
7276	7638	**B**	W/r	0... 12	**Value**
7278	7639	**C**	W/r	0... 12	0 – Parameter switched off
7280	7640	**D**	W/r	0... 12	1 – Result 1 (input 1) (W1)
					2 – Result 2 (input 2) (W2)
					3 – Result 3 (input 3) (W3)
					4 – Result 4 (input 4) (W4)
					5 – Root of the result 1 $\sqrt{W1}$
					6 – Root of the result 2 $\sqrt{W2}$
					7 – Root of the result 3 $\sqrt{W3}$
					8 – Root of the result 4 $\sqrt{W4}$
					9 – Result 1 squared ($W1^2$)
					10 – Result 2 squared ($W2^2$)
					11 – Result 3 squared ($W3^2$)
					12 – Result 4 squared ($W4^2$)
					Parameters of the mathematical function serves to recalculate the measured input quantity into th output quantity (WF) basing on the function: **WF=A<Operator1>B<Operator2>C<Operator3>D** When recalculating the input signal.the module recalculates at first the value basing on the individual characteristic and then, this result is transmitted to the arythmetical function. Examples of using mathematical functions are presented in the section „Examples of module programming”.

7282	7641	**Operator1**	W/r	0... 3	Operators of the mathematical function	
7284	7642	**Operator2**	W/r	0... 3	**Value**	
7286	7643	**Operator3**	W/r	0... 3	0	Addition „+”
					1	Subtraction „-”
					2	Multiplication „*”
					3	Division „/”
					The calculation of the output value is carried out basing on the assumpted operator weight i.e.: At first multiplication and division operations are realised and after addition and subtraction operations. „*” and „/” operators and „+” and „-” operators have the same importance weight. Examples of using mathematical functions are presented in the section „Examples of module programming”.	
7288	7644	**WF Operator**	W/r	0... 3	Mathematical operations on the result of **WF** function	
					Value	
					0	Operator switched off
					1	Extraction of roots $\sqrt{WF}$
					2	Squaring WF^2
					3	Inverse 1/WF
					The module at first calculates the function programmed by the user and then, its result can be submitted to further operations described in this point. In the case of the WF operator switching on the final result is situated in the WF register, however the result from before this operation is not accessible.	
7290	7645	**OC1**	W/r	0... 4	Input quantity, on which the output 1 of OC type has to operate.	
					Value	
					0	Input 1 (W1)
					1	Input 2 (W2)
					2	Input 3 (W3)
					3	Input 4 (W4)
					4	Result of the function (WF)
					Recalculated results, basing on the individual user’s characteristic (if it is switched on) and basing on programmed mathematical function (if the value 4 has been selected and the function is switched on) are transmitted to the output. In case of choosing the value 4 and switching the mathematical function off, the value 0 is transmitted to the output.	

7292	7646	**OC1 type**	W/r	0... 4	Output 1 type of OC type	
					Value	
					0	Normal
					1	Schwitched on
					2	Schwitched off
					3	Manually schwitched on
					4	Manually schwitched off
					The graphical imaging of the OC type output operation is presented on the fig. 7.	
7294	7647	**Prl OC1**	W/r	-99999...99999	Lower threshold of output 1 OC type operation	
7296	7648	**Prh OC1**	W/r	-99999...99999	Upper threshold of output 1 OC type operation	
7298	7649	**Dly OC1**	W/r	0... 6500	The operation delay of the output 1 of OC type in seconds. The OC output will be steered up if the alarm active state will be longer than the programmed value.	
7300	7650	**OC2**	W/r	0... 4	The input quantity on which the output 2 of OC type is to operate.	
					Value	
					0	Result 1 (W1)
					1	Result 2 (W2)
					2	Result 3 (W3)
					3	Result 4 (W4)
					4	Result of (WF) function
					Recalculated results, basing on the individual user's characteristic (if it is switched on) and basing on programmed mathematical function (if the value 4 has been selected and the function is switched on) are transmitted to the output. In case of choosing the value 4 and switching the mathematical function off, the value 0 is transmitted to the output.	
7302	7651	**OC2 type**	W/r	0... 4	Output 2 type of OC type	
					Value	
					0	Normal
					1	Schwitched on
					2	Schwitched off
					3	Manually schwitched on
					4	Manually schwitched off
					The graphical imaging of the OC type output operation is presented on the fig. 7.	

7304	7652	**Prl OC2**	W/r	-99999...99999	Lower threshold of output 2 OC type operation
7306	7653	**Prh OC2**	W/r	-99999...99999	Upper threshold of output 2 OC type operation
7308	7654	**Dly OC2**	W/r	0... 6500	The operation delay of the output 2 of OC type in seconds. The OC output will be steered up if the alarm active state will be longer than the programmed value.
7310	7655	**Del min 1**	W/r	0... 1	Erasing of the input 1 minimal value
7312	7656	**Del max 1**	W/r	0... 1	Erasing of the input 1 maximal value
7314	7657	**Del min 2**	W/r	0... 1	Erasing of the input 2 minimal value
7316	7658	**Del max 2**	W/r	0... 1	Erasing of the input 2 maximal value
7318	7659	**Del min 3**	W/r	0... 1	Erasing of the input 3 minimal value
7320	7660	**Del max 3**	W/r	0... 1	Erasing of the input 2 maximal value
7322	7661	**Del min 4**	W/r	0... 1	Erasing of the input 4 minimal value
7324	7662	**Del max 4**	W/r	0... 1	Erasing of the input 2 maximal value
7326	7663	**Del min WF**	W/r	0... 1	Erasing of the function result minimal value
7328	7664	**Del max WF**	W/r	0... 1	Erasing of the function result maximal value
7330	7665	**Del min max**	W/r	0... 1	Erasing of minimal and maximal value
					Range 0 – lack of operation 1 – erasing **Caution!** After carrying out the erasing operation the value of this register is zero.
7332	7666	**Comp W1**	W/r	0... 40	Resistance value of wires connecting the sensor with the module input 1 The register is used only in the execution for the resistance or temperature measurement
7334	7667	**Comp W2**	W/r	0... 40	Resistance value of wires connecting the sensor with the module input 2 The register is used only in the execution for the resistance or temperature measurement

7336	7668	**Comp W3**	W/r	0... 40	Resistance value of wires connecting the sensor with the module input 1 The register is used only in the execution for the resistance or temperature measurement
7338	7669	**Comp W4**	W/r	0... 40	Resistance value of wires connecting the sensor with the module input 1 The register is used only in the execution for the resistance or temperature measurement
7340	7670	**Standard**	W/r	0... 1	Restoration of manufacturer's parameters
					Value |
					0 | lack of operation
					1 | Write of manufacturer' s parameters
					Introduction of the value 1 will cause the write of manufacturer's parameters into the module acc. to the table. 2



** i = 1... 4*

X1 Wi value in the module input of systems => Y1 W1 digital value
X2 Wi value in the module input of systems => Y2 W1 digital value
Other points of the characteristic are calculated

Fig. 6. Individual user's characteristic

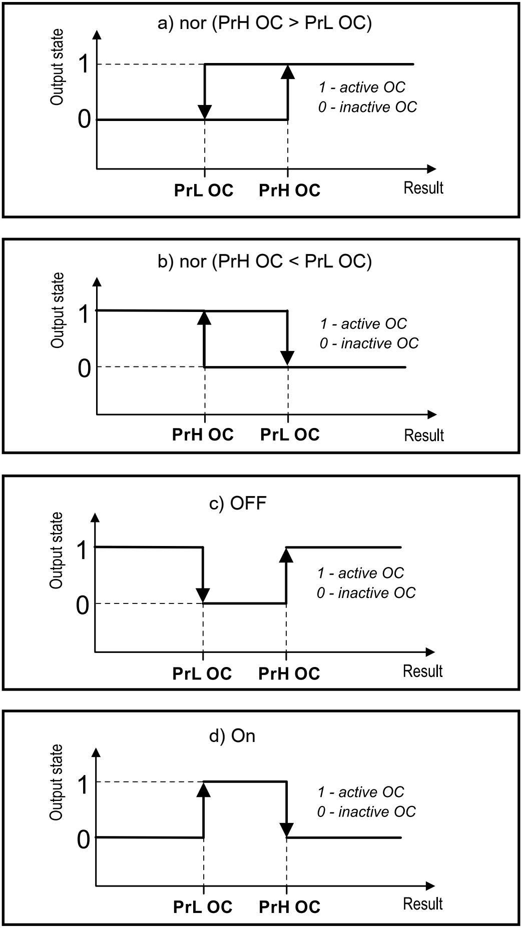


Fig. 7. Types of OC1 and OC2 output

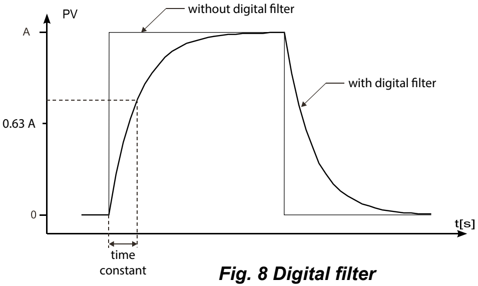


Fig. 8 Digital filter

In the case where the measurement is unstable, you can enable the digital filter with a programmable time constant. You need to set the minimum filter time constant at which the measurement is stable. A high time constant can cause delays in reading the rapid changes in the measurement.

Caution!

- In the execution for the measurement of resistance or temperature (Pt100) only the two-wire method is accessible. The resistance of the wire connecting the sensor with the module must be introduced from the master device (e.g. PC). For this purpose we propose:

- switch the module into the resistance measurement mode,
- short-circuit the ends of wires which the sensor is fixed to,
- read out the numeric value which represents the resistance of both wires,
- introduce the read out value into the Comp WX (X = 1... 2) register of the appropriate input.

  Each input has a separate compensation register. The described procedure must be carried out for switched on measuring inputs. The resistance can be also measured by any meter (class < 0.1%) and introduced into registers.

- In case on user's individual characteristic switched on, the measured result is linearly transformed in accordance with introduced **X** and **Y** parameters. Then, the calculated value is found in the result register.

- In case of mathematical operations switching on, the result in the **WF** register is calculated in accordance with the equation introduced to the module. Sequence of calculations: result recalculation basing on the user's individual characteristic (if it is switched on), calculation of the introduced function, carrying out the operation on the function result.

- The module supervises currently the value of the introduced parameter . In case when the introduced value is beyond the range of changes given in the table 1, the module does not make the parameter write.

Manufacturer' parameters of the SM2 module Table 2

Symbol	*Manufacturer's value*
Input 1,2,3,4	1 (switched on)
Cnt W1, Cnt W2, Cnt W3, Cnt W4	1 (1 s)
Ind W1, Ind W2, Ind W3, Ind W4	0 (switched off)
X1 W1, X1 W2, X1 W3, X1 W4	0
Y1 W1, Y1 W2, Y1 W3, Y1 W4	0
X2 W1, X2 W2, X2 W3, X2 W4	0
Y2 W1, Y2 W2, Y2 W3, Y2 W4	0
A,B,C,D	0 (switched off)
Operator 1,2,3	0 („+”)
Operator WF	0 (switched off)
Rate	2 (9600)
Mode	4 (RTU 8N2)
Address	1
OC1	0 (input 1)
Typ OC1	4 (switched off manually)
Prl OC1	0
Prh OC1	0
Dly OC1	0 (lack of delay)
OC2	0 (Input 1)
Typ OC2	4 (switched off manually)
Prl OC2	0
Prh OC2	0
Dly OC2	0 (lack of delay)
Comp W1, Comp W2, Comp W3, Comp W4	0

6. TECHNICAL DATA

INPUTS:

Depending on the execution code for individual channels:

- voltage measurement	0...10 V	input resistance > 1 MΩ
- current measurement	0...20 mA	input resistance < 10 Ω
- resistance measurement	0... 400 Ω	
- Pt100	(- 200... + 850)°C	

Current flowing through the Pt 100 sensor:	< 250 μA
Resistance of leads connecting the resistance thermometer with the module:	max 20 Ω /wire
Pt100 characteristic	acc. to EN 60751+A2

Error detection in measuring circuit:

voltage measurement	below -0.5 V and above 10.5 V
current measurement	below -1 mA and above 21 mA
Pomiar rezystancji	below 420 Ω
Pt100	measuring range exceeding

OUTPUTS:

- **open collector (OC)**

  voltageless of OC type with npn transistor (maximal load 25 mA)

  range of added voltages: 5... 24 V d.c.

- **digital**

  a) RS-485 interface

transmission protocol	MODBUS
RTU	8N2, 8E1, 8O1, 8N1
baud rate	2400...115200 bauds
address	1... 247

  b) RS-232 interface

transmission protocol	MODBUS
RTU	8N1
baud rate	9600 bauds
address	1

  maximal response time to the query frame: 100 ms[1)].

Basic error	0.1% of measuring range
Additional error from ambient temperature changes	± (0.1% of range/10K)
Measurement time of a single input:	100 ms...400 ms

Rated operation conditions:

- supply voltage depending on the execution code	85... 253 V a.c./d.c. 20... 50 V a.c./d.c.
- supply voltage frequency	40... 440 Hz
- ambient temperature	-10...23...55°C
- storage temperature	-25...+85°C
- relative humidity	< 95% (condensation inadmissible)
- preheating time	10 min

Sustained overload:

- resistance thermometers	1%
- measurement of voltage, current and resistance	10%

Short-duration overload (3 s):

- voltage input	10 Un
- current input	10 In

Ensured protection grade acc. to EN 60529:

- through the housing	IP 40
- electrical connections	IP 20

Dimensions	45 × 120 × 100 mm
Weight	< 0.3 kg
Fixing	on a 35 mm rail
Power consumption	< 4 VA
Resistance against decays	acc. to EN 50082-2

Electromagnetic compatibility:

- immunity	acc. to EN 50082-2
- emission	acc. to EN 50081-2
- additional error from electromagnetic hazard	< 0.2%

Safety requirements acc. to EN 61010-1 standard:

- installation category	III
- pollution grade	2
- phase-to-earth working voltage:	
- supply	300 V
- input	50 V
- output	50 V

[1]) response time for readout

7. BEFORE A FAILURE WILL BE DECLARED

In case of incorrect symptoms please to acquaint with the table below.

SYMPTOMS	PROCEDURE	REMARKS
1. The module diode is not illuminated.	Check the connection of the network cable	
2. The module does not communicate with the device master via the RS-232 port. Lack of transmission signalling on RxD and TxD diodes.	Check if the wire is connected to the appropriate module socket. Check if the device master is set on 9600 baud rate, 8N1 mode and address 1.	(RS-232 has constant transmission parameters)
3. The module does not communicate with the device master via the RS-485 port. Lack of transmission signalling on RxD and TxD diodes.	Check if the wire is connected to the appropriate module terminal. Check if the device master is set on the same transmission parameters as the module (baud rate, mode, address). In case of necessity to change transmission parameters when we cannot communicate through RS-485 one can use the RS-232 port which has constant transmission parameters (in case of further problems, see the section 2). After changing e RS-485 parameters into the required one, one can switch over on RS-485 port.	
4. The module returns the value 0 on the given input.	Check if the input which the value 0 is returned on, is not switched out and if the averaging time is > 0.1 s. Check if the user's individual characteristic with zero parameters is not switched on.	
5. The result in WF register (function result) is inconsistent with our expectations,	Check the correctness of the introduced formula. Check if the operation sequence is correct. The operator weight is essential - at first, multiplication and division are carried out and next, addition and subtraction. Perhaps it is sufficient to reorder results in the formula. See programming examples in the section 8	
6. In result registers the IE20 value is min or max	Check the correctness of the input signal connection. The IE20 value is set when the measured signal is beyond the measuring range. The recorded IE20 value in max and min registers remains till the time of its erasing by the user.	
7. The value of the measured resistance or temperature is overstated.	Check if correct values of the wires' resistance have been introduced to Comp W1, Comp W2, Comp W3 and Comp W4 registers. In case of necessity, one must introduce this value. See the user's manual under the description of the Status 2.	Concerns only the module for resistance measurement or for co-operation with a Pt100 sensor.

8. EXAMPLES OF SM2 MODULE PROGRAMMING

Example 1: Switching appropriate measuring inputs and digital filter on

Module operation with two inputs (e.g. 1 and 3). The first input has the filter with time constant of 100 ms (0.1s) and the third input with a 100 s constant time.

One must program the parameter:

- Input 1 = 1
- Input 2 = 0
- Input 3 = 1
- Input 4 = 0
- Cnt W1 = 0.1
- Cnt W3 = 100

The module will carry out the measurement on the input 1 and 3.

In the register corresponding to first input, the result will be refreshed every 100 ms and in the register corresponding to third register, every 10 minutes.

Example 2: Programming the user's individual characteristic

One must program the module in such a way that it measures the water level in a tank with characteristic: 4 mA => 0 m., 20 mA => 3.6 m. in the input 1, whereas on the input 2, the temperature with characteristic: 4 mA => 0°C, 20 mA => 50 °C

One must program the parameter:

- Ind W1 = 1
- X1 W1 = 0
- Y1 W1 = 0
- X2 W1 = 3.6
- Ind W2 = 1
- X1 W2 = 4
- Y1 W2 = 0
- X2 W2 = 20
- Y2 W2 = 50

Example 3: Programming mathematical function

One must program the module in such a way that it measures the current on the input 1, the voltage on the input 2, and calculate the apparent power of the variable signal. The module is working with transducers of variable signal into a standard signal, e.g. P11Z transducer. The measurement of max current = 1200 A (0 =→ 4 mA; 1200 A =→ 20 mA), measurement of max voltage = 400 V (0 V =→ 0 V; 400 V =→ 10 V).

One must program the parameter:

- Ind W1 = 1
- X1 W1 = 4
- Y1 W1 = 0
- X2 W1 = 20
- Y2 W1 = 1200
- Ind W2 = 1
- X1 W2 = 0
- Y1 W2 = 0
- X2 W2 = 10
- Y2 W2 = 400

one must carry out the following equation: $S = U \cdot I$

- A = 1 (result from input 1)
- B = 2 (result from input 2)
- Operator 1 = 2 (multiplication).

The apparent power 0...480 000 VA will be calculated in the WF register, whereas the 0...1200 A current in the result register 1, and the 0...400 V voltage in the result register 2.

Example 4: Programming mathematical function

The module is working with:

On the input 1 -> a.c. current transducer on standard signal, e.g. P11Z.

Current measurement on the 5 A range (transducer characteristic -> 0 A => 4 mA, 5 A => 20 mA).

On the input 2 -> a.c. voltage transducer on standard signal, e.g. P11Z.

Voltage measurement on the 400 V range (transducer characteristic -> 0 V => 0 V
400 V => 10 V)

On the input 3 -> active on standard signal, e.g. P34P or PP84

Active power measurement on the 2000 W range (transducer characteristic 0 W => 4 mA 2000 W => 20 mA.

Its task is to transmit voltage, current and reactive power values to the system.

One must program the parameter:

- Ind W1 = 1
- X1 W1 = 4
- Y1 W1 = 0
- X2 W1 = 20
- Y2 W1 = 5
- Ind W2 = 1

- X1 W2 = 0
- Y1 W2 = 0
- X2 W2 = 10
- Y2 W2 = 400
- Ind W3 = 1
- X1 W3 = 4
- Y1 W3 = 0
- X2 W3 = 20
- Y2 W3 = 2000

One must carry out the following formula:

$$Q = \sqrt{S^2 - P^2} = \sqrt{(U \cdot I)^2 - P^2} = \sqrt{U^2 \cdot I^2 - P^2}$$

And program as follows:

- A = 10 (squared result from the output 2)
- B = 9 (squared result from the output 1)
- C = 11 (squared result from the output 3)
- Operator 1 = 2 (multiplication)
- Operator 2 = 1 (subtraction)
- Operator WF = 1 (extraction of roots from the function result)

The reactive power 0...2000 var ($Q = \sqrt{S^2 - P^2}$) will be calculated in the WF register, whereas the current 0...5 A in the result 1 register, the voltage 0...400 V in the result 2 register and the active power 0...2000 W in the result 3 register.

Example 5 : Programming mathematical function

The example is based on the example 4, but instead the calculation of the reactive power, one must calculate cosφ.

- We program individual characteristic parameters acc to the example 4, however the function must be programmed acc. to the formula:

$$\cos\varphi = \frac{P}{S} = \frac{P}{U \cdot I}$$

We must program:

- A = 3 (result from the input 3, power)
- B = 2 (result from the input 2, voltage)
- C = 1 (result from the input 3, current)
- Operator1 = 3 (division)
- Operator2 = 3 (division)

We have to pay attention to the weight of mathematical operations. At first, the multiplication and division are carried out, and next, the subtraction and addition.

Since the weight of multiplication and division are the same, the first operation in the formula is carried out.

For this reason, the given formula above must be written as:

cosφ = P/U/I and not as P/U *I.

In the WF register, the phase displacement angle will be calculated:

$$(\cos\varphi = \frac{P}{S} = \frac{P}{U \cdot I}),$$

However, the current 0...5 A in the result 1 register, the voltage 0...400 V in the result 2 register and the active power 0...2000 W in the result 3 register.

Example 6 : Programming the OC type input

One must program the module such a way that the OC1 output could react on the input 1 and the OC2 output on the input 4. The signal on the input 4 is recounted into temperature (4 mA = 0°C ; 20 mA = 100 °C) The OC1 output is to be actice in the interval 2...4 V, and the OC2 output is to be active after exceeding 50°C and be desactivated below 20°C.

One must program the parameter:

- Ind W4 = 1
- X1 W4 = 4
- Y1 W4 = 0
- X2 W4 = 20
- Y2 W4 = 100
- OC1 = 0
- Typ OC1 = 1
- Prl OC1 = 2
- Prh OC1 = 4
- OC2 = 3
- Typ OC2 = 0
- Prl OC1 = 20
- Prh OC1 = 50

The OC1 output will operate acc. to the fig. 7a and the OC2 output acc. to the fig. 7d.

9. ORDERING CODES

SM2 Module	XX	X	X

Input signal*:

4 voltage inputs	0...10 V	**00**
4 current inputs	0/4...20 mA	**01**
2 voltage input + 2 current input	0...10V + 0/4...20 mA	**02**
4 resistance or Pt100 inputs	Pt100 or resistance < 400 Ω	**03**
on order**		**XX**

Supply:

85... 253 V a.c./d.c.	**1**
20... 50 V a.c./d.c.	**2**
on order **	**X**

Acceptance tests:

without a quality inspection certificate	**8**
with a quality inspection certificate	**7**
acc. customer's agreement**	**X**

* Possible version of a cheaper module with a smaller quantity of inputs. Possibility to mix input kinds (e.g. 1 voltage and 3 current inputs).

** Code numbers must be agreed with the manufacturer.

EXAMPLE OF ORDER

When ordering, please respect successive code numbers.

Code: **SM2 01 1 0** means:

SM2 - 2-channel module of analog inputs,
01 - module with 4 current inputs 0/4...20 mA,
1 - supply voltage: 85... 253 V a.c./d.c.
8 - without a quality inspection certificate.

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SM2-09C