iSMA**CONTROLLI**

SfAR-S-ETH

User Manual

Expansion Module - Modbus TCP Gateway

Table of Contents

1 Introduction

Thank you for choosing our product.

This manual will help you with proper handling and operating of the device.

The information included in this manual have been prepared with utmost care by our professionals and serve as a description of the product without incurring any liability for the purposes of commercial law. This information does not discharge you from the liability of your own judgement and verification.

We reserve the right to change product specifications without notice.

Please read the instructions carefully and follow the recommendations concluded therein.

> **WARNING!**
>
> Failure to follow instructions can result in equipment damage or impede the use of the hardware or software.

1.1 Revision History

Rev.	Date	Description
3.2	25 May 2022	Rebranded

Table 1. Revision history

2 Safety Rules

- Improper wiring of the product can damage it and lead to other hazards. Make sure that the product has been correctly wired before turning the power on.
- Before wiring or removing/mounting the product, make sure to turn the power off. Failure to do so might cause an electric shock.
- Do not touch electrically charged parts such as power terminals. Doing so might cause an electric shock.
- Do not disassemble the product. Doing so might cause an electric shock or faulty operation.
- Use the product only within the operating ranges recommended in the specification (temperature, humidity, voltage, shock, mounting direction, atmosphere, etc.). Failure to do so might cause a fire or faulty operation.
- Firmly tighten the wires to the terminal. Failure to do so might cause a fire.
- Avoid installing the product in close proximity to high-power electrical devices and cables, inductive loads, and switching devices. Proximity of such objects may cause an uncontrolled interference, resulting in an instable operation of the product.
- Proper arrangement of the power and signal cabling affects the operation of the entire control system. Avoid laying the power and signal wiring in parallel cable trays. It can cause interferences in monitored and control signals.
- It is recommended to power controllers/modules with AC/DC power suppliers. They provide better and more stable insulation for devices compared to AC/AC transformer systems, which transmit disturbances and transient phenomena like surges and bursts to devices. They also isolate products from inductive phenomena from other transformers and loads.
- Power supply systems for the product should be protected by external devices limiting overvoltage and effects of lightning discharges.
- Avoid powering the product and its controlled/monitored devices, especially high power and inductive loads, from a single power source. Powering devices from a single power source causes a risk of introducing disturbances from the loads to the control devices.
- If an AC/AC transformer is used to supply control devices, it is strongly recommended to use a maximum 100 VA Class 2 transformer to avoid unwanted inductive effects, which are dangerous for devices.
- Long monitoring and control lines may cause loops in connection with the shared power supply, causing disturbances in the operation of devices, including external communication. It is recommended to use galvanic separators.
- To protect signal and communication lines against external electromagnetic interferences, use properly grounded shielded cables and ferrite beads.
- Switching the digital output relays of large (exceeding specification) inductive loads can cause interference pulses to the electronics installed inside the product. Therefore, it is recommended to use external relays/contactors, etc. to switch such loads. The use of controllers with triac outputs also limits similar overvoltage phenomena.
- Many cases of disturbances and overvoltage in control systems are generated by switched, inductive loads supplied by alternating mains voltage (AC 120/230 V). If they do not have appropriate built-in noise reduction circuits, it is recommended to use external circuits such as snubbers, varistors, or protection diodes to limit these effects.

3 Module Features

3.1 Purpose and Description of the Module

The SfAR-S-ETH module is an innovative device converting Modbus TCP into Modbus RTU/ASCII.

The device is equipped with the Ethernet and RS485 interface, 4 digital inputs with counters, and 3 relay outputs. All inputs are insulated from logic using opto-isolators.

The communication with SfAR-S-ETH is via the Modbus TCP protocol. Every received request from the Modbus TCP client is checked considering the address. If the address is different than the SfAR-S-ETH device's address, an automatic conversion of the request frame into the Modbus RTU/ASCII protocol is carried out. Later on, the correctly received answer is sent to the Modbus TCP client.

The usage of a 32-bit processor with ARM core assures fast data processing and smart communication.

A function, called Modbus Device Table, allows the user to define their own enquiries to Modbus RTU/ASCII from the accessible internal registers of the device. This function allows e.g. automatic reading of the statuses of the modules' inputs on the RS485 and inscribing these statuses into the SfAR-S-ETH internal registers. Internal registers are accessible for the Modbus TCP clients without additional delays resulting from using the RS485 bus. This solution strongly accelerates the communication. All the bit orders and registry orders of the Modbus protocol are available.

The module is designed for mounting on a DIN rail in accordance with DIN EN 5002.

The module is equipped with a set of LEDs to indicate the status of inputs and outputs, which is useful for diagnostic purposes and helping to find errors.

Module configuration is done via built-in website or USB by using a dedicated computer program. It also allows for changing the parameters using the Modbus protocol or set the Modbus address using the DIP switches under the front panel.

3.2 Technical Specification

Power Supply	Voltage	10-38 V DC; 10-28 V AC
	Power consumption (with active Modbus transmission, all outputs on and high state on all inputs)	7 W at 24 V DC
		9 VA at 24 V AC
Digital inputs	No. of inputs	4
	Voltage range	0-36 V
	Low state "0"	0-3 V
	High state "1"	6-36 V
	Input impedance	4 kΩ
	Isolation	3650 Vrms

	Inputs type	PNP or NPN
Counters	No.	4
	Resolution	32-bit
	Frequency	1 kHz (max.)
	Pulse width	500 µs (min.)
Relay Outputs	No. of outputs	3
	Maximum current and voltage (resistive load)	3 A 230 V AC
		3 A 30 V DC
Temperature	Work	-10°C to +50°C (14°F to 122°F)
	Storage	-40°C to +85°C (-40°F to 185°F)
Connectors	Power supply	2 pin
	Communication RS485	3 pin
	Communication Ethernet	RJ45
	Inputs and outputs	2 x 5 pin
	Quick connector	IDC10
	Configuration	mini USB
Size	Height	119.1 mm (4.689 in)
	Length	110.8 mm (4.362 in)
	Width	22.7 mm (0.894 in)
Interface	Ethernet	10/100 Mbps
	RS485	Up to 128 devices

Table 2. Technical specification

3.3 Dimensions

The appearance and dimensions of the module are shown below. The module is mounted directly to the rail in the DIN industry standard. Power connectors, communication and IOs are at the bottom and top of the module. USB connector configuration and indicators are located on the front of the module.
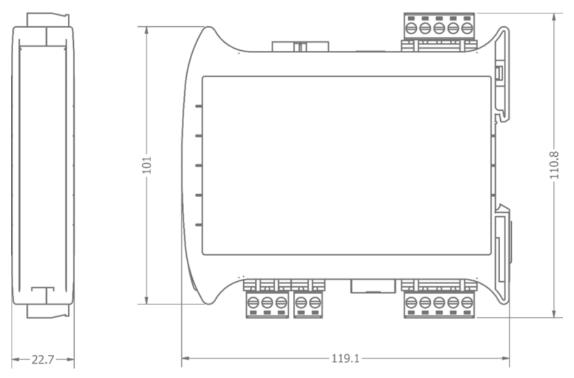
Figure 1. Dimensions

4 Communication

4.1 Grounding and Shielding

In most cases, I/O modules will be installed in an enclosure along with the other devices, which generate electromagnetic radiation. Relays, contactors, transformers, motor invertors, etc., are examples of such devices. Radiation can induce electrical noise into both power and signal lines, as well as direct radiation into the module. Whether or not the SfAR modules are immune to such effects, the interferences must be suppressed at their source if possible to ensure the proper functioning of the entire system. Appropriate grounding, shielding and other protective steps should be taken at the installation stage to prevent these effects. It is recommended to at least follow the rules below:

- line power cables must be routed with spatial separation from signal and data transmission cables;
- analog and digital signal cables should also be separated;
- it is recommended to use shielded cables for analog signals, cable shields should not be interrupted by intermediate terminals;
- the shielding should be earthed directly after the cable enters the cabinet.

It is recommended to install interference suppressors when switching inductive loads (e.g., coils of contactors, relays, solenoid valves). RC snubbers or varistors are suitable for AC voltage and freewheeling diodes for DC voltage loads. The suppressing elements must be connected as close to the coil as possible.

4.2 Network Termination

Transmission line effects often present problems for data communication networks. These problems include reflections and signal attenuation. To eliminate the presence of reflections of signal from the end of the cable, the cable must be terminated at both ends with a resistor across the line adequate to its characteristic impedance. Both ends must be terminated since the propagation is bidirectional. In case of an RS485 twisted pair cable, this termination is typically 120 Ω.

4.3 Setting Module Address in RS485 Modbus Network

Changing the address of the SfAR-S-ETH is possible with the aid of a built-in www website. After logging in, choose the Network tab, insert the module address in the Device Address field, and click Save. The device will save the given address and will remember it even after disconnecting from the power supply.

WARNING! The address is reset during the restoration of default configuration (more details in Default settings section).

4.4 Types of Modbus Functions

There are 4 types of Modbus functions supported by the SfAR modules.

Type	Beginning Address	Variable	Access	Modbus Command
1	00001	Digital Outputs	Bit Read/write	1, 5, 15
2	10001	Digital Inputs	Bit Read	2
3	30001	Input Registers	Registered Read	3
4	40001	Output Registers	Registered Read/write	4, 6, 16

Table 3. Types of Modbus functions supported by the module

4.5 Communication Settings

The settings of TCP communication are stored in the memory of the device. The Modbus TCP network configuration is only accessible through the website (more details in Network section). The communication data of the module in the RS485 network is stored in the16-bit registers. The access to the registers is possible with the Modbus TCP protocol or through the website (details in Modbus Config section).

4.5.1 Default Settings

The default configuration can be restored with the DIP switch, SW6.

Modbus TCP		Modbus RTU/ASCII	
Address IP	192.168.1.135	Transmission speed	19200
Mask	255.255.255.0	Parity	No
Gateway	192.168.1.1	Data bits	8
Port Modbus	502	Stop bits	1
Port HTTP	80	Modbus mode	RTU
Timeout of connection	60 s	The device address	1
Login	admin	Timeout of RS485	500 ms
Password	0000	Mode	Gateway
		Device Table Refresh Slow	10000 ms
		Device Table Refresh Normal	2000 ms
		Device Table Refresh Fast	500 ms

Table 4. Default settings

4.6 Restoring Default Configuration

To restore the default configuration, follow the steps below:

- Turn the power off;
- Turn the switch sw6 on;
- Turn the power on;
- When power and communication led flash turn the switch SW6 off.

4.6.1 WARNING!

After restoring the default configuration, all values stored in the registers will be cleared as well.

4.7 Configuration Registers

Modbus Address	Decimal Address	Hex Address	Name	Values
40003	2	0x02	Baud Rate	0 – 2400 1 – 4800 2 – 9600 3 – 19200 4 – 38400 5 – 57600 6 – 115200 other – value * 10
40005	4	0x04	Parity	0 – none 1 – odd 2 – even 3 – always 0 4 – always 1
40004	3	0x03	Stop Bits	1 – one stop bit 2 – two stop bits
40004	3	0x03	Data Bits	7 – 7 data bits 8 – 8 data bits
40007	6	0x06	Modbus Mode	0 – RTU 1 – ASCII

Table 5. Configuration registers

4.8 Watchdog

This 16-bits register specifies the time in milliseconds to watchdog reset. If module does not receive any valid message within that time, all digital and analog outputs will be set to the default state.

This feature is useful if there is an interruption in data transmission and for security reasons. Output states must be set to the appropriate state in order to reassure the safety of persons or property.

The default value is 0 milliseconds, which means the watchdog function is disabled.
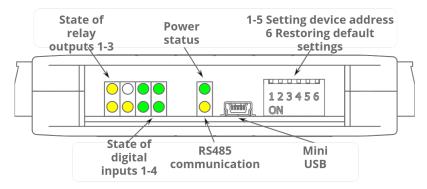
5 Indicators

Figure 2. Indicators

Indicator	Description
Power Supply	The LED indicates that the module is correctly powered
Communication	The LED lights up when the unit received the correct packet Modbus TCP, converted to Modbus RTU/ASCII and sent it over the RS485 network
Inputs State	The LED indicates that the input is on
Outputs State	The LED indicates that the output is on

Table 6. Description of indicators

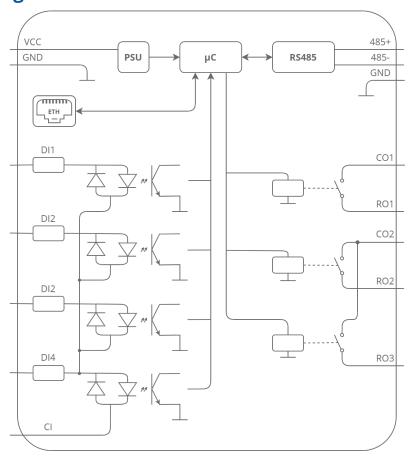# 6 Connections

6.1 Block Diagram

Figure 3. Block diagram

6.2 Power Supply Connection
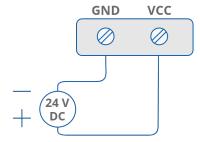
6.2.1 DC Power Connection

Figure 4. DC power connection

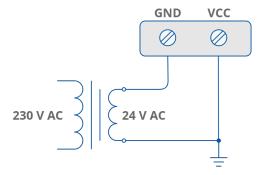## 6.2.2 AC Power Connection

Figure 5. AC power connection

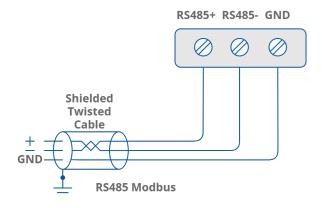## 6.3 Communication Bus Connection

Figure 6. Communication bus connection

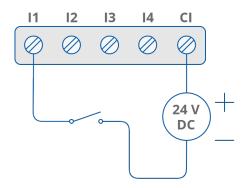## 6.4 Connection of Digital Inputs

Figure 7. Connection of digital input

6.5 Connection of Relay Outputs

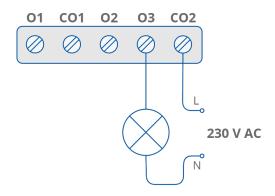### 6.5.1 Connection of Resistive Load

Figure 8. Connection of resistive load
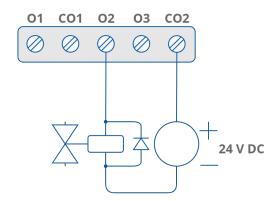
6.5.2 Connection of Electrovalve

Figure 9. Connection of electrovalve

6.6 Quick Connect

The Quick Connector is a unique feature of modules that allows for quickly connecting a group of devices with a flat ribbon cable. Thanks to this solution, it is enough to connect power an RS485 communication to one of the devices in the group, and the others will be powered and communicated with ribbon cable.

The Quick Connector is sufficient to connect up to 10 devices next to each other. It is important that the various types of modules in the SfAR-S family can be connected with the ribbon cable.

Figure 10. Quick Connector

7 DIP Switch

Figure 11. DIP switch

Switch	Function	Description
1	None	-
2	None	-
3	Bias Pull Up	Switching pull-up resistor
4	Bias Pull Down	Switching pull-down resistor
5	Network Termination	Switching terminating resistor 120 Ω
6	Restoring default settings	Restoring default settings

Table 7. Description of switches

8 Module Registers

8.1 Registered Access

Modbus Address	Decimal Address	Hex Address	Register Name	Access	Description
30001	0	0x00	Version/Type	Read	Version and type of the device
30002	1	0x01	Address	Read	Module address
40003	2	0x02	Baud Rate	Read/write	Transmission speed
40004	3	0x03	Stop Bits	Read/write	Stop bits
40005	4	0x04	Parity	Read/write	Parity
40007	6	0x06	Modbus Mode	Read/write	Modbus protocol type
40009	8	0x08	Watchdog	Read/write	Function watchdog for outputs [ms]
40013	12	0x0C	Default Outputs State	Read/write	Default state of outputs
40014	13	0x0D	Operating Mode	Read/write	Modbus mode TCP0 – Device Table; 1 – Gateway Modbus TCP
40015	14	0x0E	Slow Rate	Read/write	Frequency of queries in Device Table mode [ms]
40016	15	0x0F	Normal Rate	Read/write	Frequency of queries in Device Table mode [ms]
40017	16	0x10	Fast Rate	Read/write	Frequency of queries in Device Table mode [ms]
40033	32	0x20	Received Packets LSR (Least Significant Register)	Read/write	The amount of received packets
40034	33	0x21	Received Packets MSR (Most Significant Register)	Read/write	
40035	34	0x22	Incorrect Packets LSR	Read/write	The amount of received incorrect packets
40036	35	0x23	Incorrect Packets MSR	Read/write	

Modbus Address	Decimal Address	Hex Address	Register Name	Access	Description
40037	36	0x24	Sent Packets LSR	Read/write	The amount of sent packets
40038	37	0x25	Sent Packets MSR	Read/write	
30051	50	0x32	Inputs	Read	Inputs status lit bit → input active
40052	51	0x33	Outputs	Read/write	Outputs status
40053	52	0x34	Counter 0 LSR	Read/write	32-bits counter 0
40054	53	0x35	Counter 0 MSR	Read/write	
40055	54	0x36	Counter 1 LSR	Read/write	32-bits counter 1
40056	55	0x37	Counter 1 MSR	Read/write	
40057	56	0x38	Counter 2 LSR	Read/write	32-bits counter 2
40058	57	0x39	Counter 2 MSR	Read/write	
40059	58	0x3A	Counter 3 LSR	Read/write	32-bits counter 3
40060	59	0x3B	Counter 3 MSR	Read/write	
40061	60	0x3C	Reset Counters	Read/write	Reset counterslit bit → counter reset

Table 8. Registered access

8.2 Bit Access

Modbus Addess	Decimal Address	Hex Address	Register Name	Access	Description
193	192	0x0C0	Default State of Output 1	Read/write	Default state of output 1
194	193	0x0C1	Default State of Output 2	Read/write	Default state of output 2
195	194	0x0C2	Default State of Output 3	Read/write	Default state of output 3
801	800	0x320	Input 1	Read	Input 1 state
802	801	0x321	Input 2	Read	Input 2 state
803	802	0x322	Input 3	Read	Input 3 state
804	803	0x323	Input 4	Read	Input 4 state

Modbus Addess	Decimal Address	Hex Address	Register Name	Access	Description
817	816	0x332	Digital Output 1	Read/write	State of digital output 1
818	817	0x333	Digital Output 2	Read/write	State of digital output 2
819	818	0x334	Digital Output 3	Read/write	State of digital output 3
962	961	0x3E0	Reset Counter 0	Read/write	Reset counter 0
963	962	0x3E1	Reset Counter 1	Read/write	Reset counter 1
964	963	0x3E2	Reset Counter 2	Read/write	Reset counter 2
965	964	0x3E3	Reset Counter 3	Read/write	Reset counter 3

Table 9. Bit access

9 Configuration Software

The SfAR Configurator is the type of software, which is designed to set the communication module registers over Modbus network as well as to read and write the current value of other registers of the module. It is a convenient way to test the system as well as to observe real-time changes in the registers.

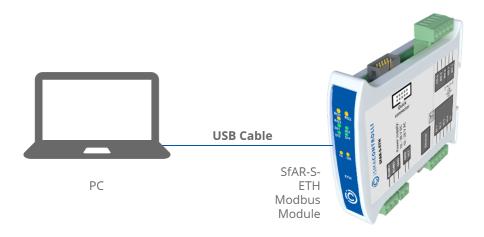Communication with the module is via the USB cable. The module does not require any drivers.

Figure 12. PC connection

The SfAR Configurator is a universal software, where it is possible to configure all available modules.
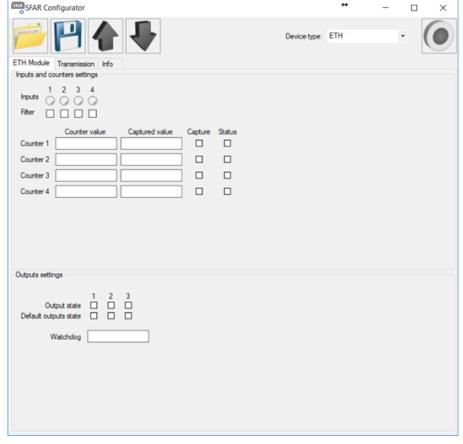

Figure 13. The SfAR Configurator

10 Web Page

The SfAR-S-ETH device has a built-in website, thanks to which the user is able to control its work. The website allows for accessing the configuration of the TCP and RS485 networks, up-to-date statuses of inputs and outputs, and the settings of the Device Table mode.

10.1 Login

The access to the website is possible through the web browser. The IP address should be put in the address field, then press the Enter button. The login site appears; insert the following credentials:

- login: admin
- password: (by default: 0000).

If the login and password are correct, after clicking the Login button, the default website with the Info tab appears.

The user is logged out if the default website is opened for at least 15 minutes with the Info, Network, or Modbus Config tab, or after clicking the Logout button.
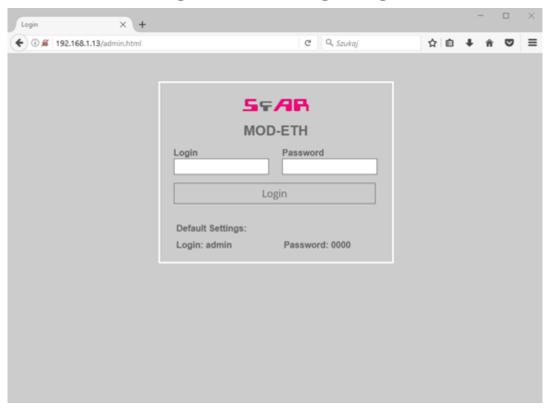

Figure 14. Login site

10.2 Info Tab

The Info tab provides links to the instructions of the device and information about the up-to-date version of the software. Changing the password to the website is also possible.

In order to change the password, the user should put the prevailing password in the Old Password field and then the new one in the New Password and Confirm Password fields. Then, click the Change Password button.

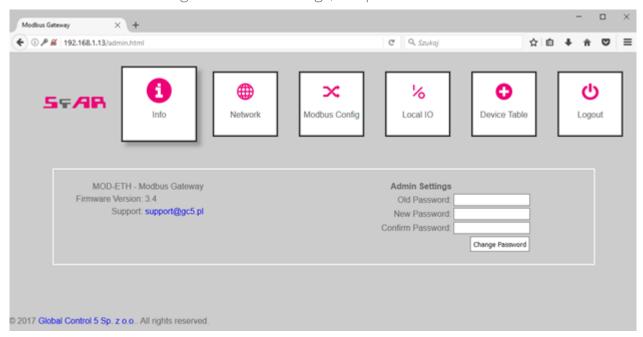WARNING! After restoring the default settings, the password is reset.

Figure 15. Info tab

10.3 Network Tab

The Network tab allows for the Modbus TCP network configuration. The following configurable parameters are available:

- IP: the module's IP address;
- Mask: the network's mask;
- Gateway: the gate;
- Modbus Port: the port to connect the PC with TCP Modbus;
- HTTP Port: the port to connect with the website;
- Connection Timeout: the maximum waiting time for the Modbus TCP requests; after this time, the connection on the Modbus port will be stopped (in seconds).

In order to confirm the changes, click the Save button. In the case of changing the IP address, mask, gateway, Modbus port, and/or HTTP port parameters, it is required to reset the module to implement the changes. The Reset Device button resets the device remotely. After clicking it, the browser tries to connect with the new IP address, and after a few seconds the login website with the prevailing IP address will be loaded.

WARNING! After the restoring the default settings, all the parameters are reset.

Figure 16. Network tab

10.4 Modbus Config Tab

In the Modbus Config tab, the configuration of the basic Modbus network parameters for both of the working modes can be performed. The following configurable parameters of the RS485 network to communicate with external modules are available

- Device Address: the module's address in the Modbus TCP network;
- RS485 Timeout: the maximum waiting time for the response in the Modbus RTU/ASCII network (in milliseconds);
- Device Table Refresh Slow, Normal, Fast: the frequency of refreshing the request in the Device Table mode (in milliseconds);
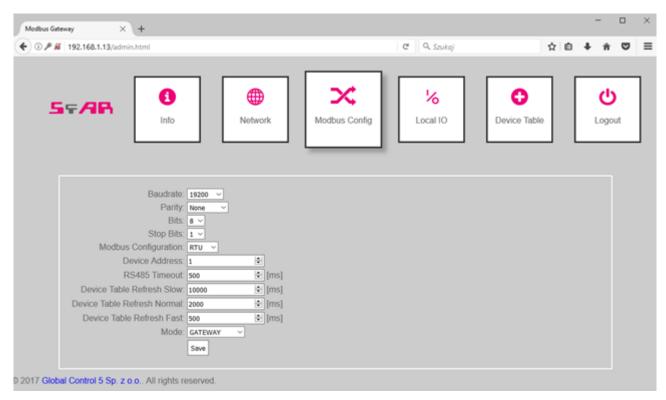- Mode: the working mode of the module.

Figure 17. Modbus Config tab

10.5 Local IO Tab

The Local IO tab enables to see the preview and to control the digital inputs and outputs of the device.

Four icons, marked as Digital input 1, 2, 3, 4, show the up-to-date status of digital inputs. The grey color indicates that the input is inactive, and the green color means that it is active. Icons marked as Digital output 1, 2, 3 allow to control the outputs. The grey color indicates that the particular output is off, and the orange color means that it is on. After clicking on a particular button, the information about the output's status is sent to the module.

The status of inputs and outputs is recurrently refreshed, so the icons described above present the up-to-date statuses of the inputs and outputs of the device.

In this tab, there are also fields showing the status of 4 counters, which count the pulses on the 1, 2, 3, and 4 input. The fields are read-only, and the counters can only be reset with the corresponding Reset buttons.

The module also permits to define default statuses of the outputs. On the website, they can be set analogously to the digital outputs–the grey color indicates that the default output is off, and the orange color means that it is on. The default status is assigned after connecting to a power supply and after the Watchdog time elapses, which is reset after each correct TCP Modbus package addressed to the SfAR-S-ETH module. If the Watchdog's value equals zero, the default statuses are only assigned after connecting the power supply.
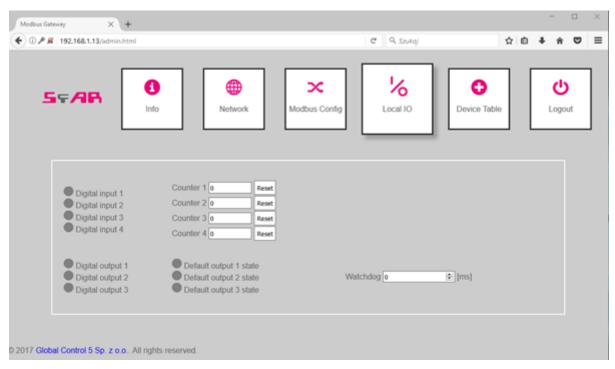
Figure 18. Local IO tab

10.6 Device Table Tab

The next tab includes configurations for the Device Table mode, which allows to define user's own Modbus RTU/ASCII requests from the accessible internal registers of the device.

Note: Up to 24 devices can be added in the Modbus Table mode.

The first tab, called Internal Registers, includes the table of internal registers of the SfAR-S-ETH module, which are recurrently refreshed by website. The second tab, called Devices, is used for adding remote requests. After clicking on the Add Device button, a line to define the request appears. Each line provides the following parameters:

- Device Address: the address of the device in the RS485 network, to which the SfAR-S-ETH module will send the request;
- Function: the Modbus request function;
- Size: the amount of bits/registers to read/save;
- Register Address: the address of the initial register;
- Internal Address: the initial address of the internal register, where the data to save/read will be stored;
- Speed: the choice of one of the three frequencies read (the values are configurable in the module's registers);
- ON/OFF: the active or inactive request;
- Status: presents the status of the request.

The configuration of the requests can be saved by the user in an external file and after reading automatically re-enacted to the device. The configuration is saved in the memory of the device and is only reset after restoring the default configuration.
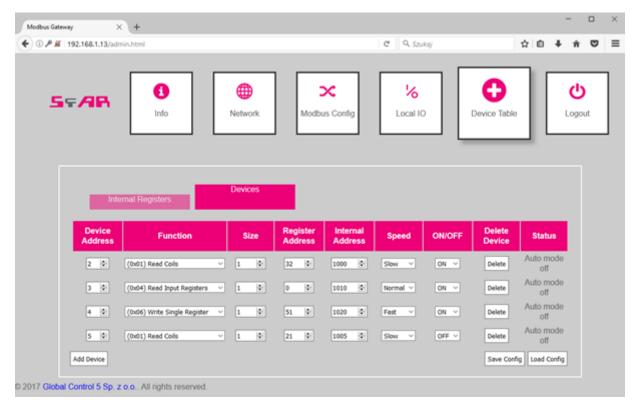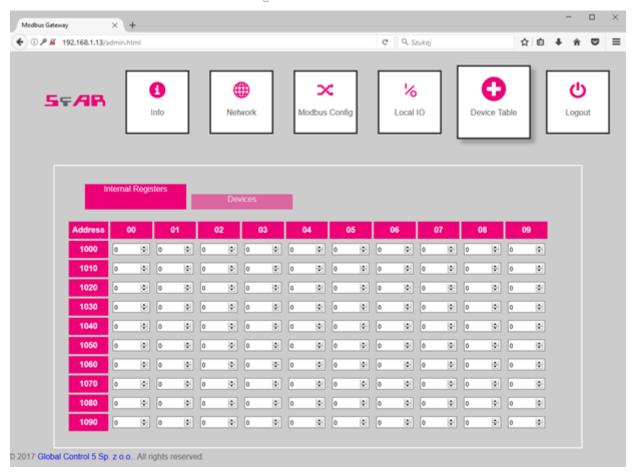
Figure 19. Device Table tab

Figure 20. Device Table tab

11 Modbus TCP Working Modes

The SfAR-S-ETH module has two different working modes. The first is the Modbus TCP gate, in which the device converts the frames of Modbus TCP into Modbus RTU/ASCII and sends them to the RS485 network's devices.
The second mode is the Device Table function, in which the module reads the RS485 network's devices only using the earlier-defined requests and ignores the requests addressed to other devices in the Modbus TCP network. The communication with external modules is only possible through the internal registers of the module in the range of addresses from 1000 to 1099.

11.1 Modbus TCP Gateway Mode

The SfAR-S-ETH module in the TCP gate mode serves maximum up to four clients simultaneously. After connecting to the module in the proper port, the module waits for the frames, which are compatible with the Modbus TCP specification. In the first instance, after receiving any package on this port, the device checks its correctness. If the length of the package will be incorrect, the device will send an error with the Modbus code 0x03 – Illegal Data Value. If the request is correct and addressed to the SfAR-S-ETH module, the function from the request is executed. If it is not a Modbus function, the device will send the error with the code 0x04 – Server Device Failure.

After processing the request and preparing the response, the module sends it accordingly to the Modbus TCP protocol's specification.

If the request is not addressed to the SfAR-S-ETH module, and the TCP gate mode is set, the device converts the request into the Modbus RTU/ASCII and sends it to RS485 bus. The SfAR-S-ETH waits for the defined time for the response and blocks the access to the RS485 bus for other clients, to avoid the packages' conflict. If the module receives the response or the time is out, the bus is released, and, in the case of receiving the package on the RS485, it is checked in terms of compatibility with the RTU or ASCII mode. In case of a correct package, it is converted into the Modbus TCP and sent to the client. In case of an error, the code 0x04 (if the response was not received before the defined time) or the code 0x03 (if the package is incorrect) is sent. If the module does not get the access to the RS485 network, the package is sent back with the error code 0x06 – Server Device Busy.

11.2 Device Table Mode

While working in the Device Table mode, the client connects with the device in the same way as in case of the gateway mode. One considerable difference is that the SfAR-S-ETH module ignores all requests, which are not addressed to it. The communication with external devices is only possible through the configuration of remote requests by the website and reading/saving from/to the internal registers of the SfAR-S-ETH module. Each request is automatically stored in the module's memory.

If the configuration of the request is correct, the device in this mode asks the modules online by saving the request and it saves the responses in the internal registers indicated by the user, in case of reading the data, or downloads the data from there registers, in case of their saving. In case of incorrectly configured request, or when there is no response from the device, an appropriate communicate is shown on the website in the Device Table tab, in the Status column.