akYtec

MU210–501

Analog output module

User guide

MU210–501_3-EN-35846-1.10
Subject to technical changes and misprints

Contents

Warning notice system

Explanation of the symbols and keywords used:

⚠ **DANGER**
DANGER indicates an **imminent dangerous situation** that will result in death or serious injuries if not prevented.

⚠ **CAUTION**
CAUTION indicates a **potentially dangerous situation** that could result in minor injuries.

🛈 **NOTICE**
NOTICE indicates a **potentially dangerous situation** that could result in damage to property.

ℹ️ **NOTE**
NOTE indicates helpful tips and recommendations, as well as information for efficient and trouble-free operation.

Safety

Read this manual carefully before installing, operating or servicing the device.

The device has been designed and built solely for the intended use described in this guide, and can only be used accordingly. The technical specifications contained in this guide must be observed.

Any other use is considered improper.

⚠️ **CAUTION**
This device must not be used for medical devices which receive, control or otherwise affect human life or physical health.

When installing and using this product, all applicable state, federal and local regulations must be observed.

Based on safety considerations and compliance with the data provided in the documents, the repair of the components of the products is carried out exclusively by the manufacturer.

There is a dangerous voltage on the terminal block. Any connections to the device and maintenance operations must be carried out only when the power of the device is turned off.

The device's method of protection against electric shock meets the terms of class II, IEC 61131-2-2012.

The device installation must be performed in particularized equipment cabinet, the inner access to which is allowed only to approved specialists.

⚠️ **CAUTION**
It is forbidden to use the device in corrosive environments with acids, alkalis, oils, etc. in the atmosphere.

Obey all the necessary rules and instructions when using programmable logic controllers in areas where technical safety requirements apply.

Failure to obey these warnings could result in personal injury or equipment damage.

Akytec company shall not be liable for technical or editorial errors or omissions contained in this document.

Introduction

This document provides detailed information about the operation principle, design, configuration, installation and maintenance of the analog output module MU210-501, hereinafter referred to as the Device or Module.

Connection, adjustment and maintenance of the Device must be carried out only by qualified personnel after reading this operating manual.

Order code: **MU210-501**.

Abbreviations

– **DAC** – digital-to-analog converter.
– **PC** – personal computer.
– **PLC** – programmable logic controller.
– **RTC** – real time clock.
– **USB** – an industry standard that establishes specifications for cables, connectors and protocols for connection, communication and power supply between personal computers and their peripheral devices.
– **UTC** – coordinated universal time.

1 Overview

The Module is intended for connection of executive devices at automation objects. The Device is controlled by a PLC, panel controller, PC or other control device.

The Device has 8 analog outputs of unified signals of the following types:

– 0…20 mA;
– 4…20 mA;
– 0…1 V;
– 0…10 V.

Each of the 8 outputs can be programmatically configured to one of the types.

The Module is intended for use in industry and agriculture.

2 Specifications

2.1 Specifications

Table 2.1 Specifications

Characteristic	Value		
Power supply			
Power supply	24 (10…48) V DC		
Power consumption	5 W		
Protection against reverse polarity of supply voltage	Yes		
Analog output			
Analog output supply voltage	12 … 36 V		
DAC resolution	12 bits		
DAC warm-up time	10 minutes		
Output signal type	0 … 20 mA 4 … 20 mA	0 … 1 V	0 … 10 V
Accuracy	± 0.25 %	± 0.25 %	± 0.25 %
Maximum output ripple	25 µA	10 mV	
Maximum additional error caused by a change in ambient temperature for every 10 °C	0.04 %	0.04 %	0.02 %
Maximum additional error due to electromagnetic interference	0.2 %	0.2 %	0.2 %
Output short circuit protection	Yes		
Output state diagnostics	Yes		
Customizable output slope limits	1...1024 mA/s	0.25…1024 V/s	0.5…1024 V/s
Interfaces			
Data transfer interface	Dual Port Ethernet 10/100 Mbit		
Configuration interface	USB 2.0 (MicroUSB), Ethernet 10/100 Mbit		
Date transfer protocol	Modbus TCP		
Protocol version	IPv4		
Flash-memory (log-file)			
Maximum log file size	2 KB		
Maximum number of log files	1000		
Minimum log writing interval	10 s		
Real time clock			
Inaccuracy	at +25 °C	max. 3 s per day	
	over the entire temperature range	max. 10 s per day	

Characteristic	Value
Battery type	CR2032
Average life time of one battery	6 years
General specifications	
Dimensions	42 × 124 × 83 mm
IP code	IP20
Error-free running time*	60,000 h
Average service life time	10 years
Weight	0.4 kg

* Except real-time clock battery

2.2 Isolation of the Device Components

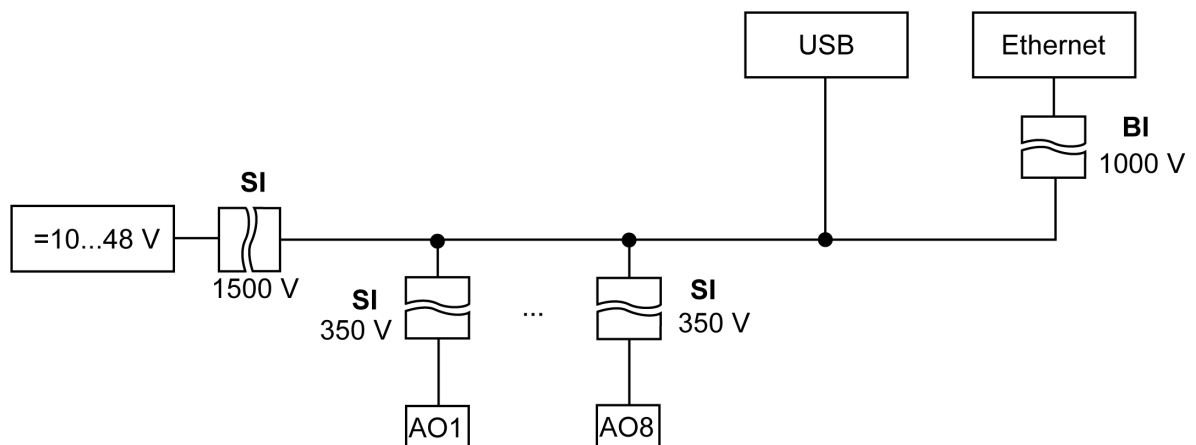The circuit of galvanic isolated components and the strength of galvanic isolation are shown in *Figure 2.1*.

Fig. 2.1   Isolation of the Device Components

Table 2.2 Insulation types

Type	Description
Basic insulation (BI)	The insulation used for active parts of equipment to provide protection against electric shock. The electrical strength of the basic insulation is checked by type tests: by applying a test AC voltage, the value of which is different for different circuits of the Device
Supplementary insulation (SI)	Independent insulation used in addition to the basic insulation in order to guarantee protection against electric shock in the event of a failure of the main insulation The electrical strength of the supplementary insulation is checked by type tests: by applying an alternating test AC voltage of various levels (RMS value)

NOTICE
The value of the insulation strength is indicated for testing under normal climatic conditions, the exposure time is 1 minute according to IEC 61131-2.

2.3 Environmental conditions

The Module meets the requirements for immunity to interference in accordance with IEC 61000-6-4:2006. According to the level of emission of radio interference (noise emissions) the Device

complies with the standards established for equipment of class A by CISPR 22-97. The Device is designed for operation in the following conditions:

– ambient temperature: –40 … +55 °C;
– relative humidity: up to 95% (at +35 °C, non-condensing);
– closed non-hazardous areas, free of corrosive or flammable gases.
– permitted pollution degree 1 according to IEC 61131-2.

The resistance to mechanical influences during operation of the Device is in accordance with IEC 61131-2-2012.

The resistance to climatic influences during the operation of the Device is in accordance with IEC 61131-2-2012.

3 Installation

Module is to install in the electrical cabinet. The design of the cabinet must protect Module from moisture, dirt and foreign objects.

To install Module:

1. Make sure that there is enough free space to connect the wire harness. You need 50 mm above the Module and below it.

2. Fasten the Device to the DIN rail or to a vertical surface using screws (see *Figure 3.1*).

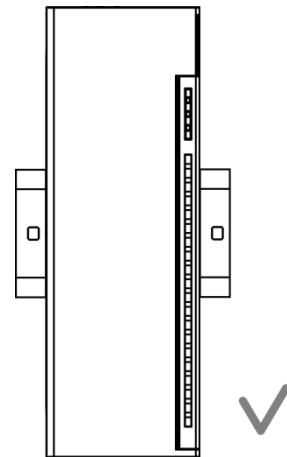*Fig. 3.1   Proper installation*
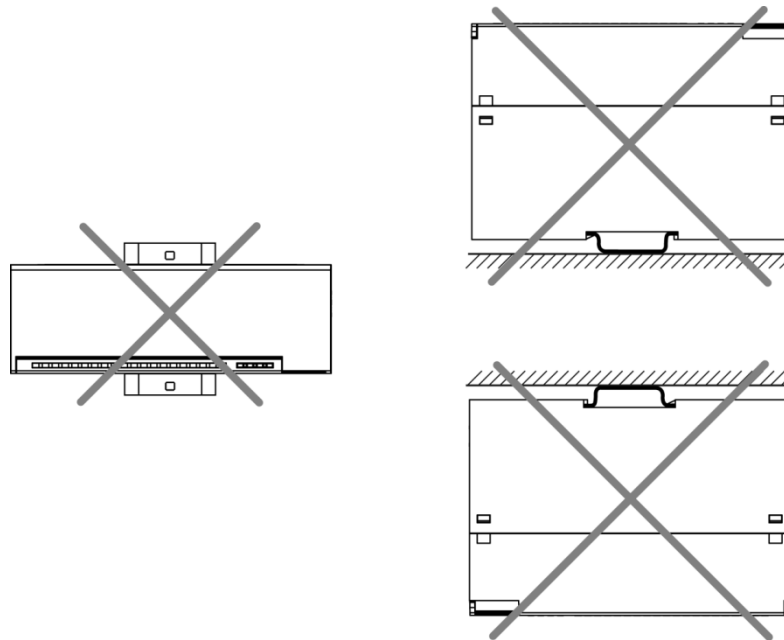

Fig. 3.2   Improper installation

⚠️ **CAUTION**
Long-term operation of Module with improper installation can lead to damage (see *Figure 3.2*).

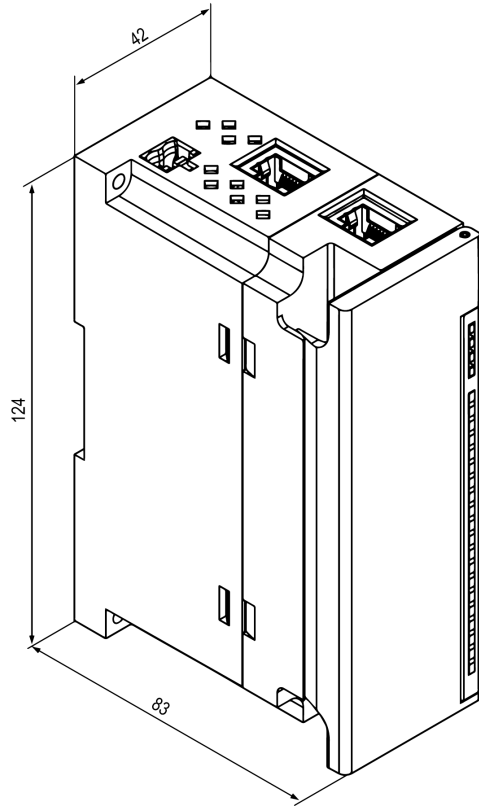*Fig. 3.3   Dimension drawing*
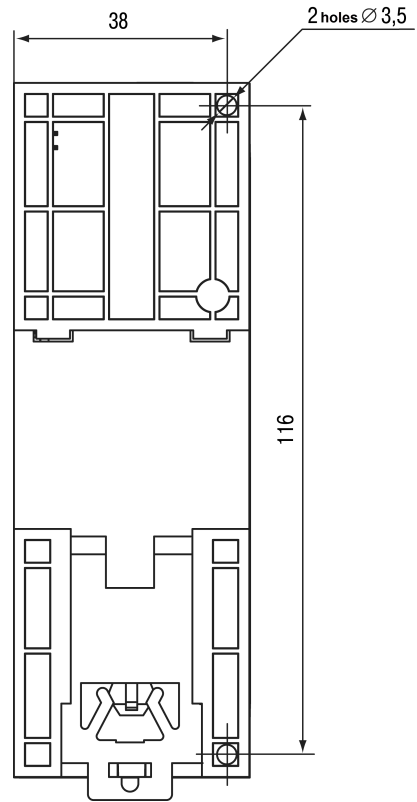
Fig. 3.4   Mounting dimensions

4 Connection

4.1 Connection recommendations

Mounting of external connections must be carried out by a wire with a cross section of not more than 0.75 mm².

For stranded wires, use end sleeves.

After mounting, put the wires into the cable channel of Module housing and close the cover.

If necessary, remove the terminal blocks of Module, loosen the two screws at the corners of the terminal blocks.

The power wires must be mounted using the supplied return terminal block.

⚠️ **CAUTION**
Connection and maintenance is performed only when power of Module and devices connected to it is turned off.

⚠️ **CAUTION**
Do not connect wires of different cross-sections to one terminal.

⚠️ **CAUTION**
Do not connect more than two wires to one terminal.

4.2 Terminal block layout
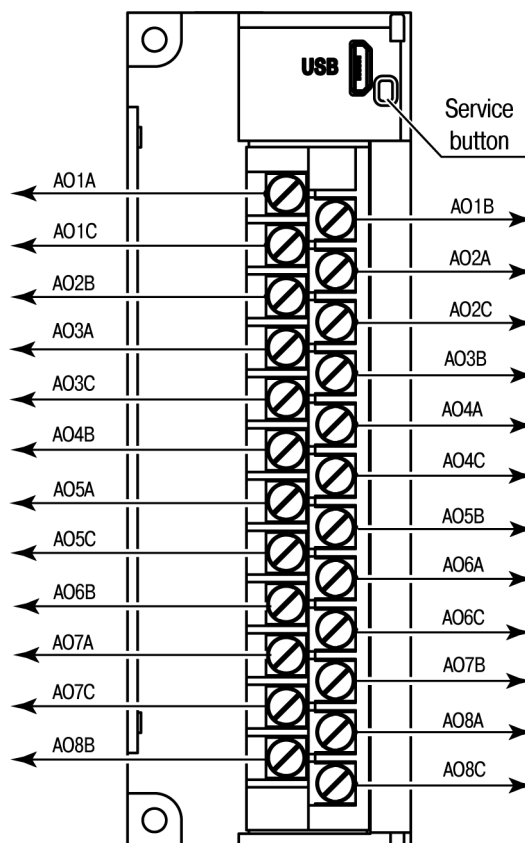
Fig. 4.1   Terminal block layout

Table 4.1   Contact function

Denomination	Function
AOxA	Output power supply (+)
AOxB	Outputs AO1...AO8
AOxC	Common power contacts (-) of the outputs (the length of the power line of the analog outputs is not more than 30 m)

⚠️ **CAUTION**
It is not allowed to connect wires to NC contacts (Not connected).

4.3 Connectors

The connectors of the interfaces and of the power supply of the Device are shown in *Figure 4.2*.
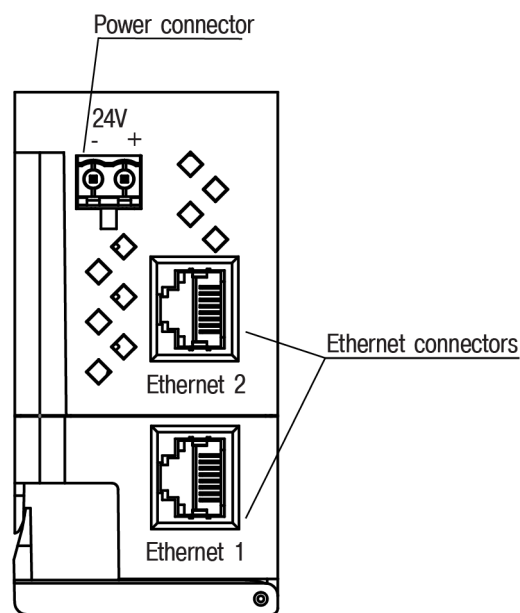
Fig. 4.2   Device's connectors

4.4 Power supply
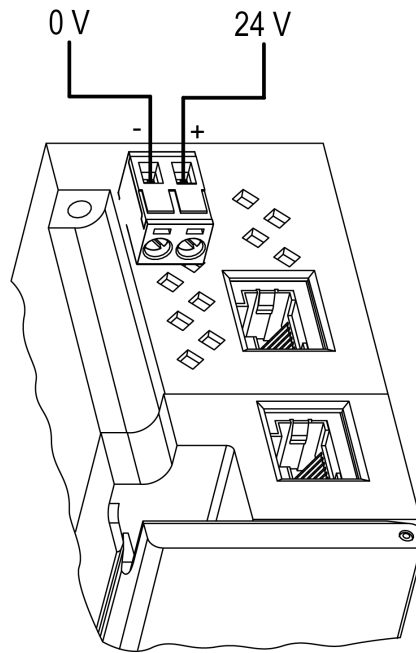
Fig. 4.3   Power supply contacts

⚠ **CAUTION**
Using power supplies without potential isolation or with basic isolation of low voltage circuits from AC lines can lead to dangerous voltage in the circuits.

4.5 Connection to the outputs

Figure 4.4 shows the connection diagram to the analog outputs.
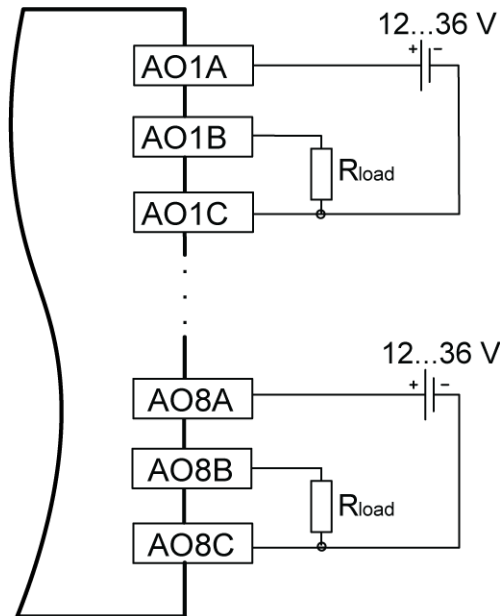
Fig. 4.4   Output wiring

The length of the power line of analog outputs is not more than 30 m.

Table 4.2 Power Supply Voltage Settings

Operation mode	Resistance (Ω)	Output supply voltage (V)
4…20 mA, 0…20 mA	200…400	12
	350…560	15
	800…1000	24
	1100…1300	30
	1400…1600	36
0…10 V, 0…1 V	not less than 1000	12…36

If during operation in modes **0 … 20 mA** and **4 … 20 mA** the load resistance is less than the allowable one for the corresponding supply voltage, then the limiting resistor must be connected in series with the load.
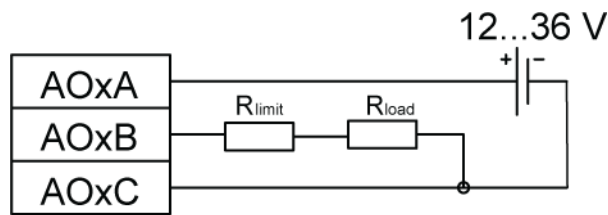
Fig. 4.5   Limiting resistor wiring

The limiting resistor must be selected so that the total resistance in the load circuit is within the range specified in *Table 4.2*. The power of the limiting resistor must be at least 1 W.

If the load resistance is more than acceptable, then a power supply with a higher output voltage must be used.

4.6 Ethernet connection

To connect modules to an Ethernet network, you can use the following schemes:
– Wye (*Figure 4.6*),
– Daisy-chain (*Figure 4.7*).
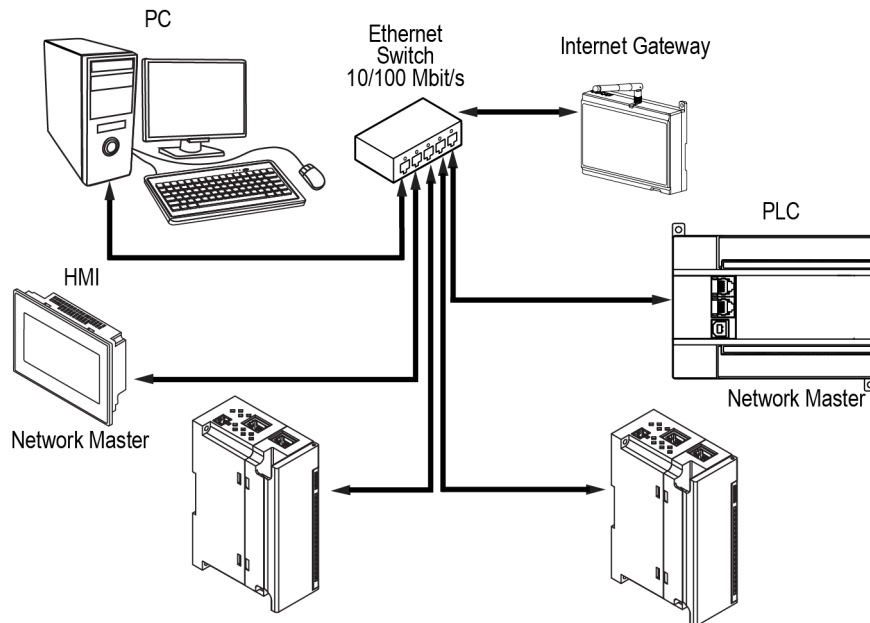
Fig. 4.6   Wye connection

(!) **NOTICE**
1. Maximum length of communication lines: 100 m.
2. Connection is possible to any Ethernet port of the module.
3. The unused Ethernet port must be closed with a blanking plug.

To connect to the Daisy-chain scheme, you must use both Ethernet ports of Module. If Module fails or the power is turned off, the data will be transferred from port 1 to port 2 without disconnecting.
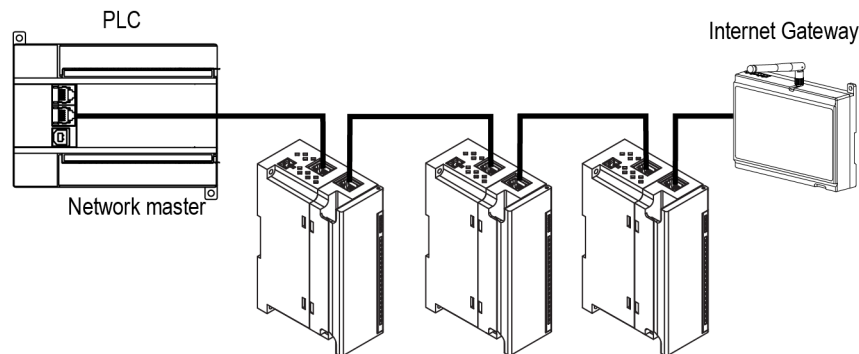
Fig. 4.7   Daisy-chain connection

(!) **NOTICE**
1. The maximum length of the communication line between two adjacent active devices when connected with the "Daisy-Chain" must be not more than 100 m.
2. An adjacent connection scheme is allowed.
3. The unused Ethernet port should be closed with a blanking plug.

5 Construction and operation

5.1 Operation principle

The Module receives commands to control outputs from the Network Master.
As a Network Master you can use:
– PC;
– PLC;
– Operator panel.

5.2 Indication and control

On the front panel there are indication LEDs. The decoding of the LED indications is given in *Table 5.1*.
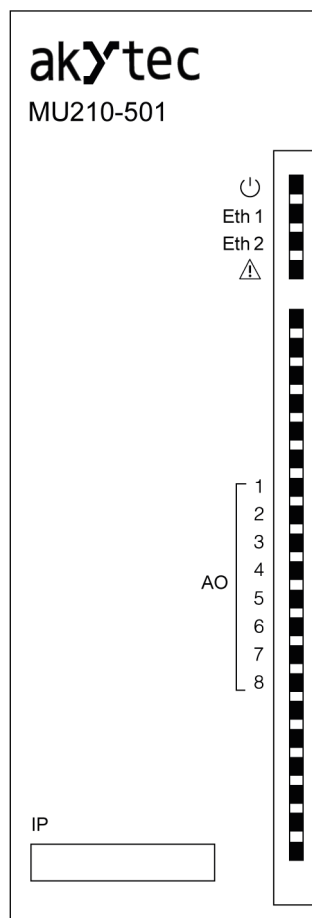
Fig. 5.1   Faceplate

NOTE
The IP field is located at the bottom of the front panel.
The IP field is intended for applying the IP address of the Module with a thin marker or on a paper sticker.

Table 5.1 LED States

LED	LED Status	Function
Power ⏻ (green)	ON	Device operating voltage is applied
Eth 1 (green)	Flashing	Data transfer via Ethernet port 1

LED	LED Status	Function
Eth 2 (green)	Flashing	Data transfer via Ethernet port 2
Fault ⚠ (red)	OFF	Normal operation
	ON	Main application and / or configuration failure
	Lights 200 ms once every 3 seconds	RTC battery must be replaced
	Lights 100 ms twice a second (after a pause of 400 ms)	Module is in a safe state
	Lights 100 ms twice a second(after a pause of 400 ms)	Hardware peripheral failure (Flash, RTC, Ethernet Switch)
Output status indicators (red/ green)	Green	Output enabled
	OFF	Output off
	Red	Output fault

Under the module cover there are terminal blocks and a service button (*Figure 4.1*).

The service button performs the following functions:

– Factory settings restore (*Section 6.6*);

– IP-address assignment (*Section 6.2*);

– Firmware update (*Section 6.4*).

5.3 Real time clock

The Module has a built-in real time clock (RTC). Its source of power is a battery.

The timing is in seconds, starting with January 1, 2000 at midnight UTC. RTC indication is used for writing entries into the log file.

5.4 Log file

The module has built-in encrypted flash memory. The encryption algorithm is Data Encryption Standard (DES) in cipher block chaining (CBC) mode. The key is the string **superkey**. An initialization vector is generated using a hash function. The function argument is the password specified in akYtecToolPro. A checksum is calculated by the CRC32 algorithm and saved in the file end. The checksum is also encrypted.

Log file of Module will be saved as a few files. The log interval, the restriction on the size of one file and their number is set by the user in akYtecToolPro. If the log file is full, then the data is overwritten, starting with the oldest data in the oldest file.

A log file is a collection of records. Entries are separated by line break characters (0x0A0D). Each entry corresponds to one parameter and consists of fields separated by the ";" character (without quotes). Entry format is shown in table.

Table 5.2 Entry format

Parameter	Type	Size	Comment
Time stamp	binary data	4 bytes	In seconds from 00:00 01.01.2000 (UTC+0)
Separator	string	1 byte	Character ";" (without quotes)
Unique identifier of the parameter (UID)	string	8 byte	As a string of HEX characters with leading zeros
Separator	string	1 byte	Character ";" (without quotes)

Parameter	Type	Size	Comment
Parameter value	string	depending on the parameter	As a string of HEX characters with leading zeros
Separator	string	1 byte	Character ";" (without quotes)
Parameter Status	binary data	1 byte	parameter status in the log file (0 – the parameter value is correct, 1 – the parameter value is incorrect and its further processing is not recommended).
Line break	binary data	2 bytes	\n\r (0x0A0D)

Example of decrypted entry:

0x52 0x82 0xD1 0x24 **0x3B** 0x30 0x30 0x30 0x30 0x61 0x39 0x30 0x30 **0x3B** 0x30 0x30 0x30 0x30 0x30 0x30 0x30 0x31 **0x3B** 0x31 *0x0A 0x0D*

where

– 0x52 0x82 0xD1 0x24 – time stamp. To get the date and time in UnixTime format, it is necessary to reverse the byte order and add the offset constant (number of seconds between 00:00:00 01/01/1970 and 00:00:00 01/01/2000): 0x24D18252 (HEX) + 946684800 (DEC) = 1564394971 (DEC, corresponding to July 29, 2019, 10:09:31);

– **0x3B** – separator;

– 0x30 0x30 0x30 0x30 0x30 0x61 0x39 0x30 0x30 – unique identifier of the parameter (00003ba00);

– **0x3B** – separator;

– 0x30 0x30 0x30 0x30 0x30 0x30 0x30 0x31 – parameter value (00000001);

– **0x3B** – separator;

– 0x31 – parameter status (1 – parameter value is correct);

– *0x0A 0x0D* – line break characters.

The time is written to the file from the built-in real time clock. You can also set the time zone, which will be read by external software.

The log file in the Device is written with a interval specified by user. Writing occurs with a certain frequency, calculated in such a way that the resource of Device flash memory is sufficient for a period of at least 10 years of operation.

Log file can be read:

– by akYtecToolPro;

– by user software (using Modbus function 20).

The list of logged parameters is available in the akYtecToolPro software on the *Device Information* tab. The order of writing parameters to the log file corresponds to the order of parameters on the tab.

> **NOTE**
> After updating the firmware, all device settings except the network settings will be reset to the factory settings.

The log file is read using the Modbus function 20 (0x14). This function returns the contents of the registers of the memory file. The function allows using one request to read one or several records from one or several files.

The file read request for each entry indicates:

– link type, 1 byte (should be equal to 6);

– file number, 2 bytes;

– starting address of the register inside the file, 2 bytes;

– number of registers to read, 2 bytes.

> **NOTE**
> The file number in the Mobus request is calculated as 4096 + the file sequence number. Sequential file numbering is from scratch. The Last log file index contains the sequential number of the log file for the last time data were written.

The number of readable registers in the request should be selected so that the length of the response does not exceed the allowable length of the Modbus packet (256 bytes).

The size of the log file is not known in advance, so you should read portions of the data using separate queries. If in response to the request a message is received with error code 0x04 (MODBUS_SLAVE_DEVICE_FAILURE), then you can conclude that the addresses of the registers in the request are outside the file. To read the latest file data, you need to reduce the number of registers in the request.

> **CAUTION**
> When the Module power is turned off, the last entry made at the time of power off may not be saved.

5.5 Data exchange modes

The Module has the following data exchange modes:

– exchange with the Master via the Modbus TCP protocol (port 502) – up to 4 simultaneous connections with different Network Masters;

– connection and data exchange with a PC using the akYtec Tool Pro.

5.5.1 Modbus TCP communication

Table 5.3 Reading and writing parameters using the Modbus TCP protocol

Operation	Function
Reading	3 (0x03) or 4 (0x04)
Writing	6 (0x06) or 16 (0x10)

The list of Modbus registers is read from the device using the "akYtec Tool Pro" program in the "Device Parameters" tab. This list of Modbus registers is presented in the tables below.

Table 5.4 General Registers for Online Modbus Communication

Name	Register	Size/type/description
Device name (DEV)	0xF000	Character string up to 32 bytes, Win1251 encoding
Device firmware version (VER)	0xF010	Character string up to 32 bytes, Win1251 encoding
Time	0xF080	4 bytes, in seconds since 2000
Time zone	0xF082	2 bytes, INT16, offset in minutes from Greenwich
Serial number	0xF084	Character string 32 bytes, encoding Win1251, 17 characters are used

Table 5.5 Modbus communication registers

Parameter	Value (unit)	De-fault	Register address DEC	Register address HEX	Access	Data format
Value on output 1 in percent	0…1000 (0.10 %)	0	3000	0xBB8	Read and write	UINT 16
Value on output 2 in percent		0	3001	0xBB9	Read and write	UINT 16
Value on output 3 in percent		0	3002	0xBBA	Read and write	UINT 16
Value on output 4 in percent		0	3003	0xBBB	Read and write	UINT 16

Parameter	Value (unit)	De-fault	Register address		Access	Data format
			DEC	**HEX**		
Value on output 5 in percent		0	3004	0xBBC	Read and write	UINT 16
Value on output 6 in percent		0	3005	0xBBD	Read and write	UINT16
Value on output 7 in percent		0	3006	0xBBE	Read and write	UINT 16
Value on output 8 in percent		0	3007	0xBBF	Read and write	UINT 16
Safe state value for output 1	0…1000 (0.10 %)	0	3032	0xBD8	Read and write	UINT 16
Safe state value for output 2		0	3033	0xBD9	Read and write	UINT 16
Safe state value for output 3		0	3034	0xBDA	Read and write	UINT 16
Safe state value for output 4		0	3035	0xBDB	Read and write	UINT 16
Safe state value for output 5		0	3036	0xBDC	Read and write	UINT 16
Safe state value for output 6		0	3037	0xBDD	Read and write	UINT 16
Safe state value for output 7		0	3038	0xBDE	Read and write	UINT 16
Safe state value for output 8		0	3039	0xBDF	Read and write	UINT 16
Value on output 1 in µA/mV	µA/mV	0	3064	0xBF8	Read and write	UINT 16
Value on output 2 in µA/mV		0	3065	0xBF9	Read and write	UINT 16
Value on output 3 in µA/mV		0	3066	0xBFA	Read and write	UINT 16
Value on output 4 in µA/mV		0	3067	0xBFB	Read and write	UINT 16
Value on output 5 in µA/mV		0	3068	0xBFC	Read and write	UINT 16
Value on output 6 in µA/mV		0	3069	0xBFD	Read and write	UINT 16
Value on output 7 in µA/mV		0	3070	0xBFE	Read and write	UINT 16
Value on output 8 in µA/mV		0	3071	0xBFF	Read and write	UINT 16
Slew rate on output 1	see *Table 5.11*	No limits	3096	0xC18	Read and write	UINT 16
Slew rate on output 2			3098	0xC1A	Read and write	UINT 16

Parameter	Value (unit)	De-fault	Register address		Access	Data format
			DEC	**HEX**		
Slew rate on output 3			3100	0xC1C	Read and write	UINT 16
Slew rate on output 4			3102	0xC1E	Read and write	UINT 16
Slew rate on output 5			3104	0xC20	Read and write	UINT 16
Slew rate on output 6			3106	0xC22	Read and write	UINT 16
Slew rate on output 7			3108	0xC24	Read and write	UINT 16
Slew rate on output 8			3110	0xC26	Read and write	UINT 16
Status of output 1	0 – normal; 1 – no connec-tion; 2 – no load; 3 – DAC over-heating; 4 – CRC error; 5 – channel disa-bled; 6 – short circuit	—	3128	0xC38	Read only	UINT 16
Status of output 2		—	3129	0xC39	Read only	UINT 16
Status of output 3		—	3130	0xC3A	Read only	UINT 16
Status of output 4		—	3131	0xC3B	Read only	UINT 16
Status of output 5		—	3132	0xC3C	Read only	UINT 16
Status of output 6		—	3133	0xC3D	Read only	UINT 16
Status of output 7		—	3134	0xC3E	Read only	UINT 16
Status of output 8		—	3135	0xC3F	Read only	UINT 16
Work mode for output 1	0 – off; 1 – 0 … 1 V; 2 – 0 … 10 V; 3 – 0 … 20 mA; 4 – 4 … 20 mA	0	3160	0xC58	Read and write	UINT 16
Work mode for output 2			3161	0xC59	Read and write	UINT 16
Work mode for output 3			3162	0xC5A	Read and write	UINT 16
Work mode for output 4			3163	0xC5B	Read and write	UINT 16
Work mode for output 5			3164	0xC5C	Read and write	UINT 16
Work mode for output 6			3165	0xC5D	Read and write	UINT 16
Work mode for output 7			3166	0xC5E	Read and write	UINT 16

Parameter	Value (unit)	De-fault	Register address		Access	Data format
			DEC	**HEX**		
Work mode for output 8			3167	0xC5F	Read and write	UINT 16
Outputs state diagnostic	0…FF	—	3192	0xC78	Read only	UINT 8
Time (ms)	—	—	61563	0xF07B	Read only	UINT 32
New time	Date/ Time in seconds from January 1st, 2000.	—	61565	0xF07D	Read and write	UINT 32
Save new time	0 – do not write; 1 – write	0	61567	0xF07F	Read and write	UINT 16
Time and date (UTC)	Date/ Time in seconds from January 1st, 2000.	—	61568	0xF080	Read only	UINT 32
Time zone	Offset in minutes from Green-wich	0	61570	0xF082	Read and write	INT 16
Device status	—	—	61620	0xF0B4	Read only	UINT 32
MAC-address	—	—	61696	0xF100	Read only	UINT 48
DNS server 1	—	—	12	0xC	Read and write	UINT 32
DNS server 2	—	—	14	0xE	Read and write	UINT 32
Assign IP address	—	—	20	0x14	Read and write	UINT 32
Enter subnet mask	—	—	22	0x16	Read and write	UINT 32
Set the gateway IP address	—	—	24	0x18	Read and write	UINT 32
Current IP address	—	192.1-68.1.9-9	26	0x1A	Read only	UINT 32
Current subnet mask	—	255.2-55.25-5.0	28	0x1C	Read only	UINT 32
Current gateway IP address	—	192.1-68.1.1	30	0x1E	Read only	UINT 32
DHCP Mode	0 – off; 1 – on;	2	32	0x20	Read and write	UINT 16

Parameter	Value (unit)	De-fault	Register address		Access	Data format
			DEC	**HEX**		
	2 – one-off setting with service button					
Connection to OwenCloud	0 – off; 1 – on	0	35	0x23	Read and write	UINT 16
Safe state activation timeout	in seconds	—	700	0x2BC	Read and write	UINT 8
Battery status (power supply)	0…3300 (mV)	—	801	0x321	Read only	UINT 16
Log interval	10…3600 (се-кунд); завод-ская нас-тройка — 30	—	900	0x384	Read and write	UINT 16

Table 5.6 Used data formats

Data format	Registers quantity	Size	Description
Unsigned 8	1	1 byte	Unsigned integer
Unsigned 16	1	2 bytes	
Unsigned 32	2	4 bytes	
Signed 16	1	2 bytes	Signed integer
Date time 32	2	4 bytes	Date/Time in seconds from January 1st, 2000.

5.5.2 Error codes for Modbus protocol

When working on the Modbus protocol, errors may occur. These errors are described in *Table 5.7*. In case of an error, Module sends a response to the Network Master with an error code.

Table 5.7 List of possible errors

Name	Code	Description
MODBUS_ILLEGAL_ FUNCTION	01 (0x01)	Illegal function code. The error occurs if Module does not support the Modbus function specified in the request.
MODBUS_ILLEGAL_DATA_ ADDRESS	02 (0x02)	Illegal register address. The error occurs if the request contains register addresses that are not in Module.

Name	Code	Description
MODBUS_ILLEGAL_DATA_VALUE	03 (0x03)	Illegal data value. The error occurs if the request contains an invalid value for writing to the register
MODBUS_SLAVE_DEVICE_FAILURE	04 (0x04)	The error occurs if the requested action cannot be completed.

During the exchange via the Modbus protocol, Module checks the compliance of the requests with the Modbus specification. Requests that fail verification are ignored by the module. Requests that specify an address that does not match the module address are also ignored.

Next, the function code is checked. If a request is received by the module with a function code not specified in *Table 5.8*, a MODBUS_ILLEGAL_FUNCTION error occurs.

Table 5.8 List of supported functions

Name	Code	Description
MODBUS_READ_HOLDING_REGISTERS	3 (0x03)	Reading values from one or more holding registers
MODBUS_READ_INPUT_REGISTERS	4 (0x04)	Reading values from one or more input registers
MODBUS_WRITE_SINGLE_REGISTER	6 (0x06)	Writing a value to single register
MODBUS_WRITE_MULTIPLE_REGISTERS	16 (0x10)	Writing values to multiple registers
MODBUS_READ_FILE_RECORD	20 (0x14)	Reading log from file
MODBUS_WRITE_FILE_RECORD	21 (0x15)	Writing log to file

Situations leading to errors during operation with registers are described in *Table 5.9*.

Table 5.9 Errors while working with registers

Function	Error name	Possible causes
MODBUS_READ_HOLDING_REGISTERS	MODBUS_ILLEGAL_DATA_ADDRESS	– number of requested registers is greater than the maximum possible number (125); – request for nonexistent parameter
MODBUS_READ_INPUT_REGISTERS	MODBUS_ILLEGAL_DATA_ADDRESS	– number of requested registers is greater than the maximum possible number (125); – request for nonexistent parameter

MODBUS_WRITE_SINGLE_REGISTER	MODBUS_ILLEGAL_DATA_ADDRESS	– attempt to write a parameter whose size exceeds 2 bytes;
		– attempt to write a parameter, access to which is denied;
		– attempt to write a parameter of this type, which cannot be written to by this function. Supported Types:
		  – signed and unsigned integers (max. 2 bytes);
		  – enumerated type;
		  – float16 (currently this type is not used for Module).
		– request for nonexistent parameter

Function	Error name	Possible causes
MODBUS_WRITE_MULTIPLE_REGISTERS	MODBUS_ILLEGAL_DATA_VALUE	– value outside the parameter limits
	MODBUS_ILLEGAL_DATA_ADDRESS	– writing of a nonexistent parameter; – attempt to write a parameter, access to which is denied; – number of writable registers is greater than the maximum possible number (123)
	MODBUS_ILLEGAL_DATA_VALUE	– no terminating character (\0) was found in the string parameter; – size of the requested data is less than the size of the first or last parameter in the request; – value outside the parameter limits

Situations leading to errors during operation with the log file are described in *Table 5.10*.

Table 5.10 Errors while working with the log file

Function	Error name	Possible causes
MODBUS_READ_FILE_RECORD	MODBUS_ILLEGAL_FUNCTION	– illegal data size (0x07 <= data length <= 0xF5)
	MODBUS_ILLEGAL_DATA_ADDRESS	– reference type does not meet specification; – could not open the file for reading (it may be missing)
	MODBUS_ILLEGAL_DATA_VALUE	– could not move to the desired offset in the file
	MODBUS_SLAVE_DEVICE_FAILURE	– file deletion error when deleting; – request too much data (more than 250 bytes); – illegal record number (more than 0x270F); – illegal record length (more than 0x7A)
MODBUS_WRITE_FILE_RECORD	MODBUS_ILLEGAL_FUNCTION	– illegal data size (0x09 <= data length <= 0xFB)
	MODBUS_ILLEGAL_DATA_ADDRESS	– reference type does not meet specification; – could not open file for writing
	MODBUS_SLAVE_DEVICE_FAILURE	– requested file is missing; – requested file is read-only; – failed to write the required number of bytes

5.6 Analog outputs operation modes

The device has 8 analog outputs. Each output can be configured for the following operation mode:
– 0 … 20 mA;
– 4 … 20 mA;
– 0 … 1 V;

– 0 … 10 V.

Each output can be configured to any of the above modes of operation, regardless of the mode of operation of other outputs.

The level of the analog output can be set by writing values to the corresponding registers using the Modbus protocol. The value is set in fractions of percent from 0 to 1000 (which corresponds to a value from 0 to 100% with an accuracy of 0.1%) or in physical quantities – microamperes (for the modes **0 … 20 mA** and **4 … 20 mA**) or in millivolts (for the modes **0 … 1 V** and **0 … 10 V**). When setting a value in one register, the value in the other is automatically recalculated.

For each output, you can adjust the maximum rate of change of the output signal. The rate of change is selected from the full list of possible limitations of the rate of change of the signal, which is shown in *Table 5.11*.

Table 5.11 Possible limitations of the rate of change of the output signal

Rate of change, V/s or mA/s	Output work mode		
	0 … 20 mA, 4 … 20 mA	**0 … 1 V**	**0 … 10 V**
No limits	+	+	+
0.25	—	+	—
0.5	—	+	+
1	+	+	+
2	+	+	+
4	+	+	+
8	+	+	+
16	+	+	+
32	+	+	+
64	+	+	+
128	+	+	+
256	+	+	+
512	+	+	+
1024	+	+	+

⚠️ **CAUTION**
The value of the rate of change is calculated to work with an active load. In case of the connection of a capacitive or inductive load, the rate of change will depend on the characteristics of the load.

5.7 Safe output status

For each output, it is possible to set the safe state of the output in the Safe state parameter (from 0 to 100%).

The output switches to the safe state, if at the time of turn-on or during the time-out there are no commands from the Network Master. If the time-out value is set to 0, then the output does not go to a safe state.

When the main power supply of the Module is disconnected and the output elements are powered, all outputs will switch to the 0 V (for modes **0…1 V** and **0…10 V**), 0 mA (for mode **0…20 mA**) and 4 mA (for mode **4…20 mA)** state. The maximum time to go to a safe state after the main power supply fails is 9 seconds.

5.8 Output state detection

For each output, the detection of the following malfunctions is provided:
– no DAC response (no output power supply);
– no output load (only for mode **0…20 mA** and **4…20 mA**);

- overheating of the output stage;
- CRC error (communication error with output DAC);
- load short circuit (only for modes **0…1 V** and **0…10 V**).

If a fault is detected, 1 is written to the corresponding bit of the bit mask of the status register of the analog outputs, the type of error is written in the output state register. The failed output indicator lights red.

In case of detection of overheating of the output stage and load short circuit, the faulty output is periodically turned off to maintain its operability.

6 Configuration

6.1 Connection to akYtec Tool Pro

The Module is configured in the akYtec Tool Pro program.

The Device can be connected to a PC using the following interfaces:

– USB (microUSB),

– Ethernet.

To select an interface:

1. Connect the module to the PC using a USB cable or Ethernet interface.

> **NOTICE**
> If the module is connected to the USB port, the main module power supply is not required.
> If the Module is powered with USB, the outputs do not function.
> In case of connecting via Ethernet interface it is necessary to supply the main power to the module.

2. Run akYtec Tool Pro.

3. Click the icon **Add devices** on the tool bar.

4. In the drop-down menu "Interface" select:
   – Ethernet (or other network card to which the module is connected): for Ethernet connection;
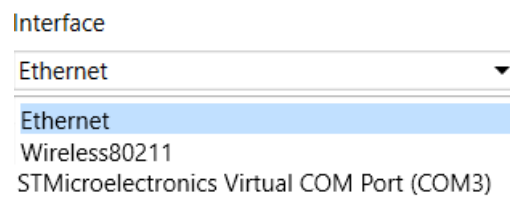   – STMicroelectronics Virtual COM Port: for USB connection.

Fig. 6.1   Interface selection menu

The next steps for finding a Device depend on the choice of interface.

To find and add a Device connected to the Ethernet interface to the project:

1. Select "Find device"

2. Enter IP-address of the connected device.

3. Click Find. A Module with the specified IP address is displayed in the window.

> **NOTICE**
> The default IP address (factory setting) is **192.168.1.99**.

4. Select the Device (place a check mark) and click OK. If the Device is password protected, you must enter the correct password. The Device will be added to the project.

To find and add a device connected via USB interface to the project:

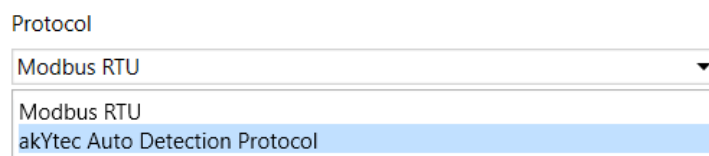1. In the drop-down menu, select the akYtec Auto Detection Protocol.

Fig. 6.2   Select Protocol

2. Select **Find device**.

3. Enter the address of the connected device (default is **1**).

4. Click **Find**. The module with the specified address is displayed in the window.

5. Select the device (place a check mark) and click OK. If the device is password protected, you must enter the correct password. The device will be added to the project.

For more information on connecting and working with Devices, see the AkYtec Tool Pro Help. To call help in the program, press **F1**.

6.2 Configuring Network Settings

The parameters shown in the table must be set for the Module for Ethernet connection:

Table 6.1 Module's network parameters

Parameter	Note
MAC-address	Set at the factory and is unchanged
IP address	Can be static or dynamic. The factory setting is **192.168.1.99.**
Subnet mask	Specifies the subnet of the IP addresses of other devices visible by the Module. The factory setting is **255.255.255.0**
Gateway IP Address	Specifies the gateway address to access the Internet. The factory setting is **192.168.1.1**

The IP address can be:

Static. This IP address is set using the akYtecToolPro program or the Service button.

To set a static IP address using the akYtecToolPro, proceed as follows:

1. Click on the line **Connection Settings** in the parameter field.

2. Select the **Ethernet settings**.

3. Specify new values for fields **Enter IP Address**, **Enter Subnet Mask** and **Assign gateway IP address**.

4. Set **DHCP Mode** to **Off**.

5. Click on symbol "Save data" in the menu bar.

With help of service button, you can set IP addresses immediately for the group of Modules.

To assign IP address using service button:

1. Connect a module or group of Modules to an Ethernet network.

2. Start the akYtecToolPro program on a PC connected to the same Ethernet network.

3. Click on symbol "IP addresses" in akYtecToolPro program.

4. Enter IP address for the first Module or Module group.

5. Push the service buttons sequentially on the Modules, monitoring the result in the program window. In this case, the information about the Module on which the button was pressed will be displayed in the program window, this Module will be assigned a specified static IP address and other network parameters. The program automatically increments the address by 1.

ⓘ **NOTICE**
If the IP address assignment with service button does not work, set the **DHCP mode** to **One-off setting with service button** in the akYtecToolPro program (default setting).

Fig. 6.3   DHCP mode settings

Dynamic. A dynamic IP address is used to work with the cloud service (not available yet) and does not imply working with the Modbus TCP Master. The IP address of the Module is set by the DHCP server of the Ethernet network.

> ⚠️ **CAUTION**
> Check with the system administration services if there is a DHCP server in the network area to which Module is connected. If using a dynamic IP address, you must enable the DHCP mode.

> 🛈 **NOTICE**
> To use the new network settings, you need to restart Module. If the module is connected via USB, it must also be disconnected.

6.3 Module access password

To limit access to read and write configuration parameters, a password is used.

You can set or change the password when configuring using the akYtec Tool Pro.

If the password is lost, the factory settings must be restored (see *Section 6.6*).

By default, the password is not set.

6.4 Firmware update

Firmware can be updated by the following ways:
– by using the USB interface;
– by using Ethernet (recommended).

To update via USB, follow the steps:

1. When the Module is powered on, press and hold the service button. The Module will enter the downloader mode.

2. Update the software with a special utility. The utility is available at www.akytec.de.

To update via Ethernet, follow the steps:

1. In the akYtec Tool Pro, click on **Firmware update**.

2. Follow the program's instructions (the firmware file is available on www.akytec.de);

3. Restart the Module.

During the update via Ethernet, the integrity of the firmware file and the checksum are checked.

> 🛈 **NOTICE**
> A restart of the Module is required to complete the update. If the Module is connected via USB, it must also be disconnected.

6.5 Real-time clock setting

The real-time clock (RTC) can be set or read from the Module via Modbus registers and also using the akYtec Tool Pro program (see the program help).

To set a new time via Modbus registers:

1. Write the time value in the appropriate registers.

2. Set the value **1** in the current time update register for at least 1 second.

3. Write the value **0** in the current time update register.

The next writing of the current time can be made after 1 second.

6.6 Restore default settings

⚠️ **CAUTION**
After restoring the factory settings, all previously configured settings, except network settings, will be deleted.

To restore the factory settings and reset the installed password:

1. Switch on the power.

2. Press and hold the service button for more than 12 seconds.

3. Switch off and switch on the Device.

After turning on, the Device will work with default settings.

7 Maintenance

7.1 General Instructions

During the maintenance work on the Device, the safety requirements must be considered.

Maintenance of the Device is carried out at least once every 6 months and includes the following procedures:

– checking the Device mounting;
– checking the screw connections;
– removal of dust and dirt from the device terminal block.

7.2 Battery replacement

A replaceable CR2032 type battery is used to power the real-time clock.

Replace the battery if at least one of the following events occurs:

– LED Fault blinks (it lights for 200 ms with a 3 second interval).
– The last battery change was 6 years ago.

To replace the battery:

1. Power off the module and all connected devices.

2. Remove the module from the DIN rail.

3. Raise cover 1.

4. Remove two screws 3.

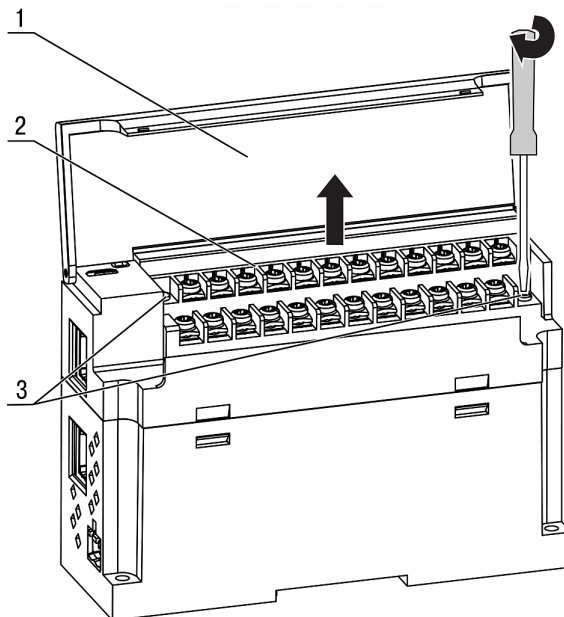5. Remove the terminal block 2 as shown in *Figure 7.1*.

Fig. 7.1   Remove terminal block

6. Alternately remove the hooks from the holes on one side and on the other side and remove the top cover.
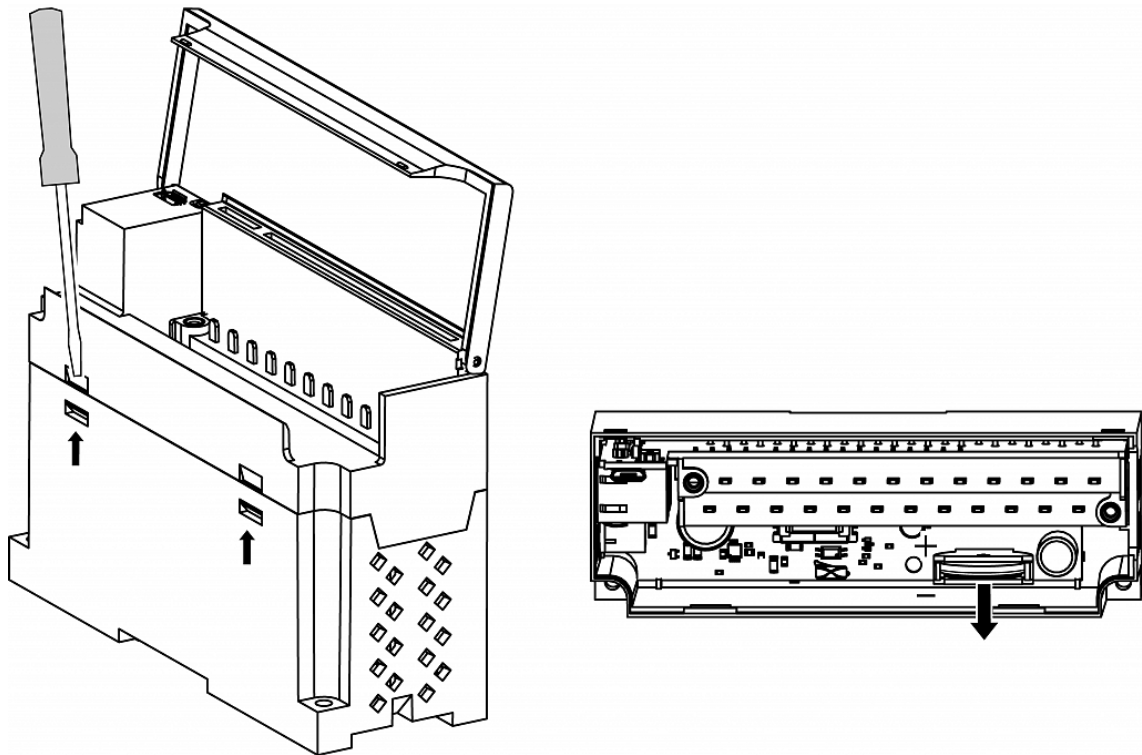
Fig. 7.2   Battery replacement

7. Replace the battery. Recommended time for replacing the battery is not more than 1 minute. If the battery is missing for a longer time, the real-time clock must be set up again.

8. Assembly and installation should be carried out in the reverse order.

NOTICE
Do not use a different type of battery. When installing the battery, observe the polarity.

After Module is assembled and turned on, make sure that the system time is correct. If necessary, configure the real-time clock in the akYtecToolPro program.

When loosing the fastening screws, the terminal block rises, so it is recommended to unscrew the screws by turns several turns at a time.

8 Transportation and storage

Device must be transported in closed transport of any kind. The fastening of containers during transport should be carried out in accordance with the rules applicable to the respective modes of transport.

The transport conditions must be in accordance with IEC 61131-2-2012 at ambient temperature from – 40 to + 55 °C in compliance with the protection measures against impacts and vibrations.

Transportation should be carried out in a shipping container individually or in over-packs.

The storage conditions in the packaging at the manufacturer's and consumer's warehouse must comply with IEC 61131-2-2012. In the air no aggressive impurities must be present.

Device should be stored in the racks.

9 Scope of delivery

Denomination	Quantity
Device	1 unit
Short guide	1 ex.
UTP patch cable 5e 150 mm	1 unit
Power supply terminal 2EGTK-5-02P-14	1 unit
Ethernet connector plug	1 unit

NOTICE
The manufacturer reserves the right to introduce amendments to the scope of delivery.

Appendix A Encrypting the log file

When decrypting the log file, a hash function should be used as the initialization vector. The hash function returns 8 bytes (type long long).

An example implementation of a hash function in C:

```c
typedef union {
        struct {
                unsigned long lo;
                unsigned long hi;
        };
        long long hilo;
}LONG_LONG;


long long Hash8(const char *str) {      // Based on Rot13
        LONG_LONG temp;
        temp.lo = 0;
        temp.hi = 0;

        for ( ; *str; )
        {
                temp.lo += (unsigned char) (*str);
                temp.lo -= (temp.lo << 13) | (temp.lo >> 19);
                str++;
                if (!str) break;
                temp.hi += (unsigned char) (*str);
                temp.hi -= (temp.hi << 13) | (temp.hi >> 19);
                str++;
        }
        return temp.hilo;
}
```