

Operation and Maintenance Manual

Operation of the controller

TABLE OF CONTENTS

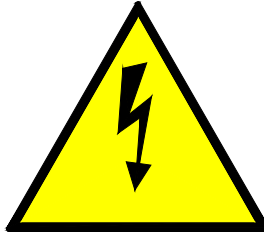
1.	Important information	3
2.	Structure of the control system	4
3.	Algorithm of the compressor operation	6
3.1	Operation mode according to CAL calendar	7
4.	Operation of the controller	8
4.1	Main screen	8
4.2	Menu language	11
4.3	Menu structure	11
4.4	Introducing changes in the settings	144
4.5	Diagrams and counters	155
4.6	Access levels	155
4.7	Record of events	166
4.8	Servicing activities	188
4.9	Communication in Modbus TCP protocol	199
4.10	Changing the network settings	222
5.	Web server	244

1. Important information

Please read this manual carefully and watch the equipment before its start-up.

Safety warnings

POWER SUPPLY: 400V/50Hz – danger of electrocution



Electrical equipment may only be operated by fully qualified personnel. This document is not intended for use by unqualified people.

The persons responsible for installation and operation of the equipment should ensure that they have met all the regulations, laws and rules and safety requirements required during installation and operation of electrical equipment.

Before installation, dismounting, connection or maintenance, always disconnect the equipment from power supply.

Use only the appropriate voltage to supply the equipment.

BERG shall not be responsible for any consequences arising or resulting from the incorrect use of the equipment, changes in the control program of the controller operation and network attacks after connection to the LAN network.

.

2. Structure of the control system

The compressor controller consists of the PLC unit, analogue extension modules and HMI touch control panel. It provides supervision of the compressor operation and introduction of changes in the parameter settings. The panel is equipped with the touch screen which is presented in Fig. 1.

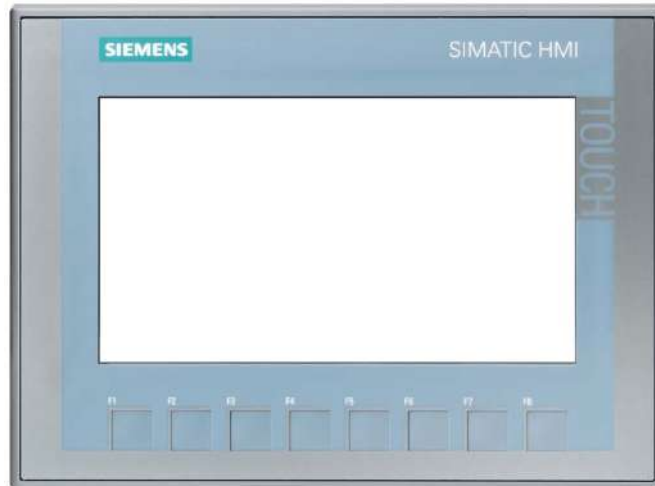










Fig. 1 Arrangement of the screen elements

Description of the functions of the conventional keys on the control panel are presented in Table 1.

Table 1 Functions of the conventional keys

Icon	Description	Function
	Start	Activating the compressor in the AUTO mode. If all conditions are met, the compressor will be started.
	Stop	After pressing this key in the AUTO mode, the compressor will be stopped. When the key is pressed and hold for two seconds in a mode other than AUTO, the compressor will be stopped and switched to AUTO mode.
	Main	Activating of main screen
	Menu	Activating of manu screen
	Events	Activating of evants screen
	Previous	Activating of the previously displayed screen
	Nearer	Activating of a higher menu level screen or previously displayed screen on the same level
	Further	Activating of the next screen on the same menu level

The compressor is equipped with the potential-free change-over contact used for signalling a failure or power supply failure. The contact is controlled if the compressor controller is operating and there is no events causing the compressor stop.

The control system monitors the status of the compressor parameters by using sensors, transducers and protective devices that are listed in Table 2.

Table 2 **List of sensors of the control system**

Symbol	Measured quantity	Sensor type	Input signal to PLC
B1	Air temperature after 1st stage	PT100	resistive
B2	Air temperature after 1st stage cooler	PT100	resistive
B3	Air temperature after 2nd stage	PT100	resistive
B4	Air temperature after 2nd stage cooler	PT100	resistive
B5	Oil temperature	PT100	resistive
B6	Ambient temperature in the compressor space	PT100	resistive
B7	Dirty air filter	SPST (NO)	binary
T1	Air pressure after 1st stage cooler	-	4÷20mA
T2	Air pressure after 2nd stage cooler	-	4÷20mA
T3	Oil pressure	-	4÷20mA
M1-B1	Drive motor temperature	KTY84	resistive

3. Algorithm of the compressor operation

The compressor may be inactive (the compressor is not started when pressure drops below the switching on pressure threshold) or active (the compressor is started when pressure drops below the switching on pressure threshold). Activation of the compressor is carried out in different ways depending on the selected operation mode. Below there are presented the available operation modes including the ways of the compressor activation:

- AUTO mode – the compressor activation requires pressing the START key (active only in this mode) on the control panel (pressing the STOP key will deactivate the compressor)
- REM mode – the signal for the compressor activation is closing the external potential-free contact connected to the compressor terminal block (the contact opening results in the compressor deactivation)
- CAL mode – the compressor activation and deactivation occurs according to the setting calendar
- NET mode - the compressor activation and deactivation occurs according to the commands sent in the Modbus TCP protocol

The signal that causes the compressor to start and its loading is the signal from transducer after 2nd stage cooler T2. Fig. 2 presents an example diagram of pressure changes in time with indicated states of the compressor operation.

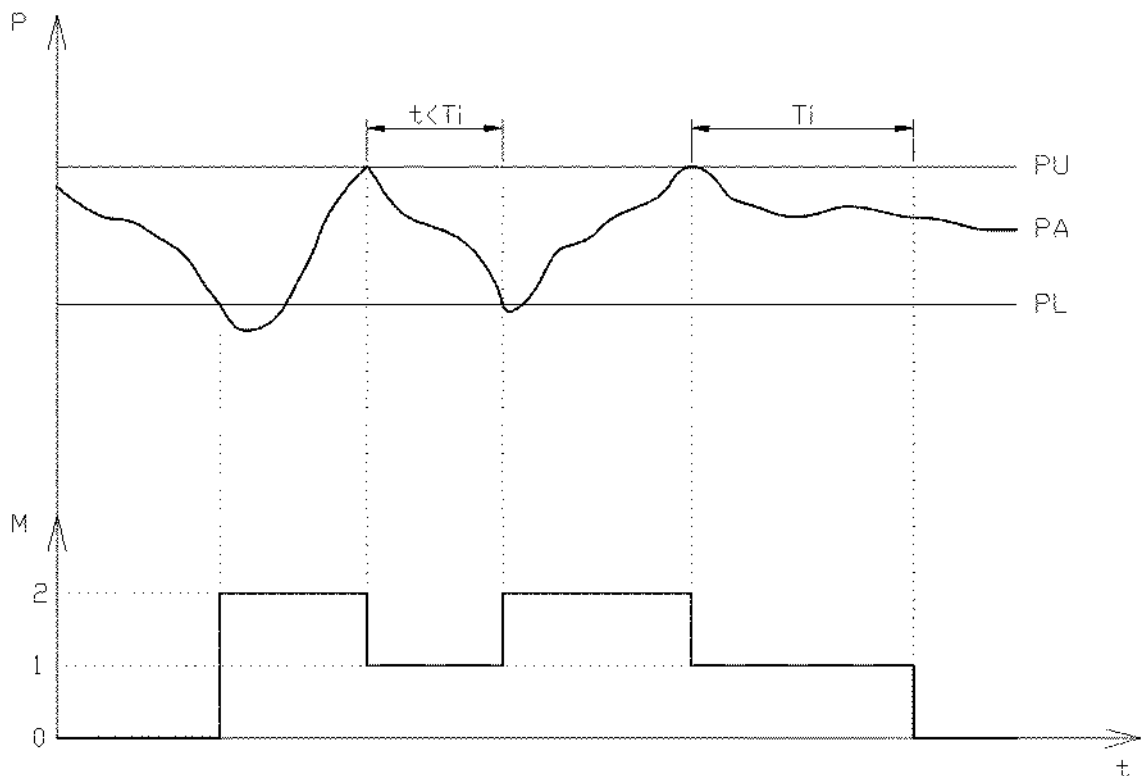


Fig. 2 Algorithm of the compressor operation

The above diagram assumes that the compressor is active all the time. If the present pressure (PA) drops below the switching on pressure threshold (PL), the compressor will start and change from the stop state (0) to the compression state (2). This state will be continued until pressure reaches the switching off pressure (PU). Then the compressor will switch to the idle running operation status (1). It means that the compressor is running but it does not compress. The next compression will occur when pressure drops below the switching on pressure. If that does not occur for the set idle running time (Ti), the compressor will stop and the cycle will be repeated.

Holding the STOP key pressed (in an operation mode other than AUTO) for 2 seconds results in the compressor deactivation and switching to the AUTO mode.

When an event resulting in the machine stop occurs, the compressor changes its operation mode to AUTO. It is necessary to confirm the events occurred and activate again the set operation mode.

It is possible to switch on the Auto restart function in the AUTO mode. It means that when the controller is switched on, the compressor is activated automatically.

3.1 Operation mode according to CAL calendar

In the operation mode according to the calendar, a user has the possibility of configuring the compressor activation in five time intervals, individually for each day of the week. Table 3 presents an example configuration of the calendar for one day of the week.

Table 3 Example configuration in CAL mode

Mo	0:00	✗	6:00	✓	13:45	✗	15:00	✓	22:45	✗	23:59
-----------	------	---	-------------	---	--------------	---	--------------	---	--------------	---	-------

The above example shows that the compressor will be active in hours from 6:00 to 13:45 and from 15:00 to 22:45 on each Monday. Time can be set with accuracy up to the minute in each of the fields in bold format. The controller has the algorithm implemented to prevent entry of false settings. Therefore, the settings entered may be automatically changed to the correct ones. The end of one interval is the beginning of the next one. The compressor activation in a particular time interval involves in clicking the key between the hours when the compressor is to be active. The signal to apply load to the compressor is the present pressure, similarly to the operation in the AUTO mode.

On the occurrence of any event resulting in the compressor stopping, the compressor is switched to the AUTO mode, but the calendar settings are not cancelled.

4. Operation of the controller

After switching on the power supply, the PLC controller and HMI control panel are started. The PLC unit switches to the operation mode after approx. 5 seconds. However, the compressor start-up is possible after initialization of the control panel, which takes approx. 30 seconds.

Operation of the compressor controller involves in moving between different screens, where you can, among other things,:

- read present values of the compressor parameters
- watch changes of the compressor parameters on the diagrams
- modify different types of the settings
- view the lists of events
- get the present readings from the running hours counter, energy counter etc.

4.1 Main screen

The main screen is displayed as the first one after initialization of the control panel. You can always return to it by pressing the home icon key. The view of the main screen is presented in Fig. 3. A view of elements on this screen is changed dynamically depending on the compressor status.

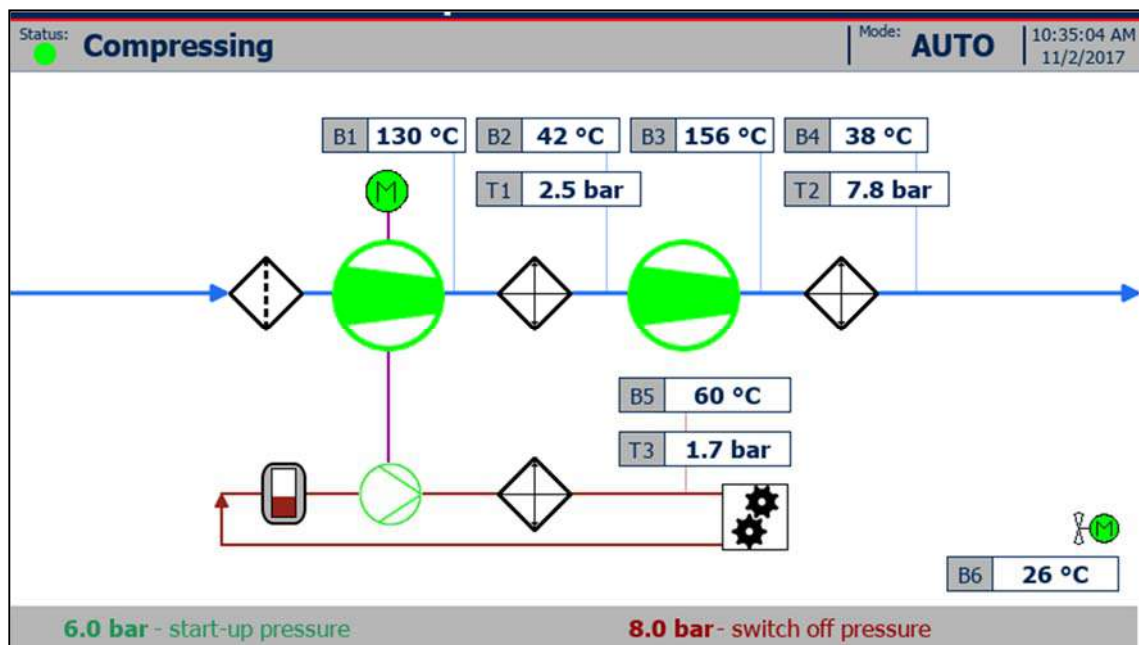


Fig. 3 View of the main screen

The main screen consists of the status bar and graphic field presenting the schematic operation of the compressor. The main elements of the status bar are:

- The status LED changing colour depending on the compressor status (description of the LED colours is included in Tab. 4)
- The status text changing according to the compressor status (possible status texts are presented in Tab. 5)
- The operation mode defining a source of the signal activating the compressor
- The system date and time (the clock backed up by the super capacitor; check the controller indications when it is not supplied for several days)

The graphic field consists of:

- The equipment symbols, whose meaning is presented in Tab. 6
- The multicolour lines and arrows connecting the equipment from individual circuits (of air, oil, drive systems) and indicating the flow direction
- The bargraph of output air and oil pressure
- The fields with present values of the compressor parameters
- The fields with set values of the compressor operating pressure

Table 4 **State of the status LED**






LED colour	Description of the compressor status
White	The compressor is not running and there are no events.
Green	The compressor is running and there are no events.
White and orange	The compressor is not running and there are warning events.
Green and orange	The compressor is running and there are warning events.
Red	The compressor is not running and there are errors (with warnings possible at the same time).


Table 5 **Status texts**

Text	Explanation
Stop	The compressor is stopped
Automatic stop	The compressor is in the ready status (it will start when the present pressure is lower than the switching on pressure)
Delayed start	The compressor will be started when the set time passes

Start	The compressor is started
Compression	The compressor is running and compressing
Idle running	The compressor is running, but it is not compressing
Delayed stop	The compressor will be stopped when the set time passes
Failure	Active event causing the compressor stop
Service	Compressor is stopped, oil shut-off valves from the radiator are opened by the operator.
Maximum number of starts	The maximum number of the compressor starts per hour has been reached. The compressor will be started automatically when the number of starts per hour is lower than the permissible one.
Autorestart	Initiated autorestart procedure.

Table 6 Equipment icons in the graphic field

Icon	Symbol description
	<p>Symbol of the screw unit in different forms:</p> <ul style="list-style-type: none"> Presented – the compressor stopped Centre filled partially – idle running or start Centre filled totally – compression Exclamation mark in the central field – an event causing the compressor stop occurred Hourglass in the central field – start-up is awaited
	<p>Oil pump unit in different forms:</p> <ul style="list-style-type: none"> Presented – pump is not operating Green contour– pump is operating
	<p>The driving motor in different forms:</p> <ul style="list-style-type: none"> Presented – the compressor is not started Filled with green – the compressor is started Filled with red – an event concerning the driving motor occurred
	<p>Fan motor in different forms:</p> <ul style="list-style-type: none"> Presented – the fan is not started Filled with green – the fan is started Filled with red – an event concerning the fan motor occurred No symbol – no fan motor in the system
	<p>Air filter at the suction side in different forms:</p> <ul style="list-style-type: none"> Presented – air filter in a good condition With a red centre line - dirty air filter

	Air or oil cooler
---	-------------------

The compressor parameters currently displayed change their highlight colour to red when permissible values are exceeded. Highlighting of the particular value results in recording an event on the list of active events. The particular parameter value will be highlighted on the main screen until an event is accepted.

Displaying of some elements on the main screen and menus may depend on the current status of the compressor, operation mode and other factors.

4.2 Menu language

The operator panel supports four menu languages: Polish, English, Russian and German. To change the language, press the flag symbol placed in the upper left corner of the menu screen. Switching is sequential and cyclical. Changing the language also changes the flag symbol.

4.3 Menu structure

The controller menu has the sequential tree structure, which is shown in Fig. 5. It means that you call the lower, more detailed level from the higher level. The menu structure does not include successive screens at the same level and existence of some screens is dependent on the compressor configuration.

The structure of all screens in menu is based on one pattern that is presented in Fig. 4. Each screen consists of the following elements:

- The present menu level or the key with a flag icon of the country, whose language is used for menus (being displayed in the top left corner; language change by pressing the key)
- The header describing the contents of the particular screen
- The number on white background to call the lower menu level
- The content of the particular screen that may include e.g. diagrams, selection lists, fields with parameter values etc.


 Menu	
1	Status
2	Setpoints
3	Events
4	Counters
5	Diagrams
6	Users
7	Information

Fig. 4 View of the menu screen

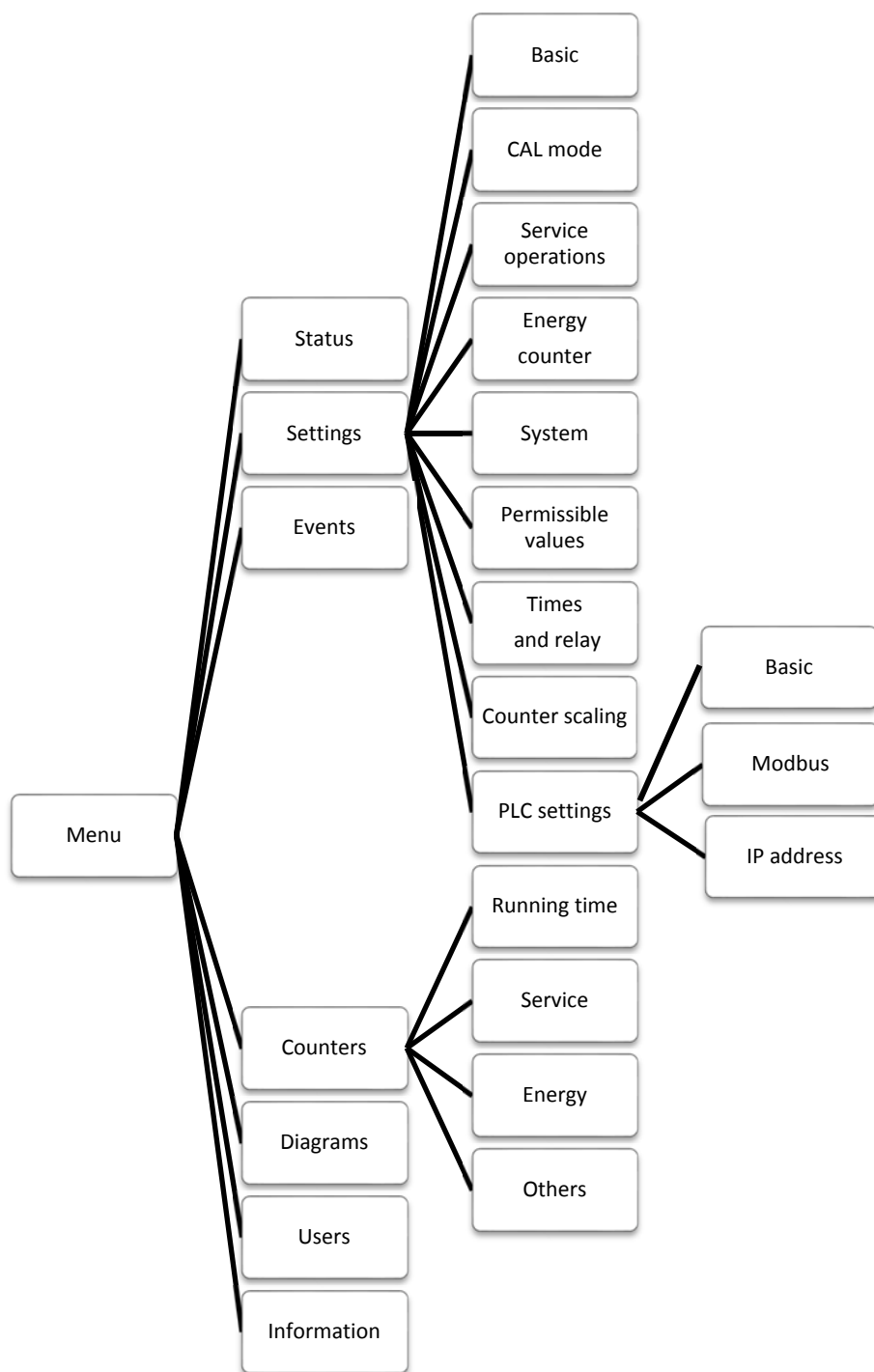


Fig. 5 Menu structure of the compressor controller

4.4 Introducing changes in the settings

To introduce changes in the settings, you must call the screen, where the parameter searched for is located. Then click the element you want to edit. Depending on a type of the element edited, you must select text/graphics from the drop-down list or enter a value with the numeric keypad presented in Fig. 7. Fig. 6 presents the screen of basic settings including the most important parameters.

2-1 Basic set-points		
1	Start-up pressure	6.0 bar
2	Switch off pressure	8.0 bar
3	Idling time	300 s
4	Operating mode	AUTO ▾
5	Autorestart	60 s

Fig. 6 Screen of basic settings



Fig. 7 Numeric keypad for introducing the settings

4.5 Diagrams and counters

On the control panel you can monitor changes of the compressor parameter values in time. Viewing is carried out by means of the diagrams that make it possible to increase, decrease, scroll and stop the time scope displayed by using the keys located under the diagram. Power supply disconnection resets the memory of the history recorded.

The controller is also equipped with different types of counters as follows:

- Running time and load running time counters
- Controller working time counter
- Energy counter
- Time to next service counters (information function – the detailed list of service operations is included in the mechanical part of the operation and maintenance manual)

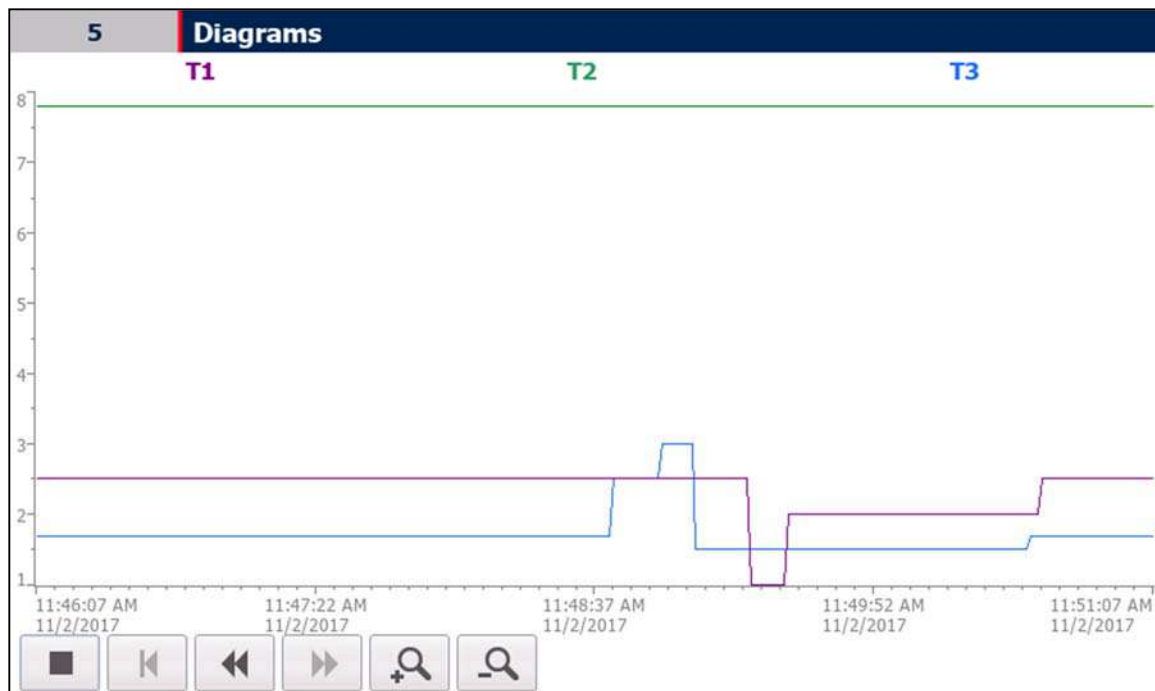


Fig. 8 View of the diagram screen

4.6 Access levels

It may be required to log at the defined access level to get an access to edition of some parameters. Logging may be performed by the selection of the user management screen or by the dialog window appearing when the parameter selected is edited. To log, you need the following:

- User name – connected with an authorisation scope

- Password – necessary to authorise logging process

User names and passwords are given to the authorised persons according to the needs.

4.7 Record of events

The controller records many events that are saved together with event occurrence time in the memory of the control panel. If a number of events is higher than the available memory, part of them is erased to make space for new records. Moreover, the controller displays currently active events. To view records, use the list of events screen that is shown in Fig. 9.

When an event causing the compressor stop occurs, the status text, status LED and the compressor symbol on the main screen change their colour to red. The events not causing the compressor stop are signalled by the status LED colour change to orange. To identify an event occurred, go to the screen of active events by entering the menu and clicking the key number 3 described as the event.



Klasa	Nr	Czas	Data	Status	Tekst
E	19	11:54:56	2017-11-02	I	Błąd sterownika PLC.

Potwierdzenie zdarzeń

Fig. 9 View of the list of events screen

Texts on the list of active events remain visible until a user confirms reading of events with the key located under the list. Confirmation of events is possible when the cause of the particular event is eliminated.

Each event has the defined structure that is presented in Tab.7. The message elements are as follows:

- The date of an event occurrence
- The time of an event occurrence

- The status defining the present event status (I – active event; IO – historic event)
- The code defining unambiguously an event
- The class defining an event type (E – an event causing the compressor stop; A – warning event, S- informing status event)
- The message content describing an event

Table 7 **Structure of an alarm message**

Date	Time	Status	Code	Class	Content
2012-06-01	12:00:00	IO	20	E	PLC controller error

Tab. 8 presents all events recorded by the compressor controller.

Table 8 **Events recorded by the controller**

Code	Class	Content
1	E	Bad sequence, power supply failure or asymmetry.
2	E	The compressor motor protection has tripped.
3	E	The fan motor protection has tripped.
4	E	Error of sensor: <i>sensor description</i> .
5	E	Compressor engine temperature too high.
6	E	Too high air temperature after 1st-stage.
7	E	Too high air temperature after 1st-stage cooler
8	E	Too high air temperature after 2nd-stage
9	E	Too high air temperature after 2nd-stage cooler
10	E	Too high oil temperature
11	E	Too low oil temperature.
12	E	The retentive memory has been lost. All control parameters should be checked and set.
13	E	Compressor is blocked. Please enter the unlock code
14	E	Too high air pressure after 1st-stage
15	E	Too high air pressure after 2nd-stage
16	E	Too high oil pressure
17	E	Too low oil pressure
18	E	No connection between the HMI panel and PLC controller.
19	E	Error of PLC controller.
49	A	The suction air filter is dirty
50	A	Too high ambient temperature in the compressors space
51	A	Too low ambient temperature in the compressors space
52	A	Compressor service is required.
53	A	The permissible number of the compressor starts per hour has been exceeded.
54	A	The settings of the real-time clock have been lost.
55	A	Web server error
81	S	Last PLC shutdown: time and date. Current PLC activation: time and date. Number of PLC's connections: number.

4.8 Servicing activities

The driver informs the user about the necessity of proceeding with servicing activities. After completing an inspection, one should enter the amount of working hours and the date when the next servicing should take place. In order to record these changes, the below procedure should be applied:

- log in with the appropriate permissions,

- go to the servicing activities settings screen,
- click on the field with the working time counter and enter the counter value at which the next inspection has to be carried out,
- click on the date field and enter the date until which the next inspection has to be carried out,
- check the correctness of the entered settings on the servicing counters screen,
- log out,

Tab. 9 Presents exemplary servicing counter settings.

Table 9 **Examples of servicing activity counter settings**

Current run and time	Inter-inspection intervals	Settings on the servicing activities screen	Values on the servicing counter screen
2996 h	3000 h	5996 h	3000 h
01-12-2017	1 year	01-12-2018	365 days

4.9 Communication in Modbus TCP protocol

The PLC controller makes the records presented in Tab. 10 available via the Modbus TCP protocol as the Modbus server. The information contained in the records may be used for visual presentation of the compressor status in master control systems. When you use that communication form, pay attention to the following:

- Communication is performed via Ethernet,
- The records 40011÷40050 are only for reading, and you can write values into the records 40001÷40010,
- Each record is in a 16-bit fixed point number format with a mark (int16),
- It is possible to read all records during one calling,
- The available records are of holding type and 03 Modbus function must be used for their reading,
- The default PLC controller address is in the range of 192.168.0.11, the precise address can be read on the information screen on the control panel,
- The communication port is 502,
- The communication can be switched off on the PLC settings screen on the control panel,
- It is possible to control the compressor operation by sending a command (record 40001) and PIN code (record 40002) when the compressor is in the NET operation mode,
- Execution of the command depends on the current level of control in NET mode (record 40045),

- If the value of the record 40002 is compliant with the PIN code located in the controller memory, the command from the record 40001 will be executed. Irrespective of the PIN code compliance, the record 40001 and 40002 will be set to value 0 and status of the record 40011 will be updated,
- The default PIN code for control via the Modbus TCP protocol is 1234.

Table 10 Description of the PLC controller records

Record No	Description
40001	Control word: <ul style="list-style-type: none"> • 1 – stop • 2 – start • 3 – entry of pressures from records 40003 and 40004 • 4 – compressor unloaded • 5 – compressor under load
40002	PIN code of transmission within the range 0000÷9999.
40003	Remote switching off pressure [kPa] (resolution 10 kPa).
40004	Remote switching on pressure [kPa] (resolution 10 kPa).
40011	Return message of the last operating command: <ul style="list-style-type: none"> • 0 – no command • 1 – command done • 3 – command unrecognized • 4 – non-compliant PIN code • 5 – compressor in an operating mode other than NET
40012	Compressor status: <ul style="list-style-type: none"> • 0 – stop • 1 – automatic stop • 2 – delayed stop • 3 – start • 4 – idle running • 5 – compression • 6 – delayed start • 7 – failure • 10 – maximum number of starts • 11 – autorestart
40013	Operation mode of the compressor: <ul style="list-style-type: none"> • 0 – local • 1 – remote • 2 – calendar • 3 – net
40014	System events status signaling. If a particular bit is set, its corresponding event is active. Bit number 0 corresponds to event 1 and bit number 15 to event 16.

40015	System events status signaling. If a particular bit is set, its corresponding event is active. Bit number 0 corresponds to event 17 and bit number 15 to event 32.
40016	System events status signaling. If a particular bit is set, its corresponding event is active. Bit number 0 corresponds to event 33 and bit number 15 to event 48.
40017	System events status signaling. If a particular bit is set, its corresponding event is active. Bit number 0 corresponds to event 49 and bit number 15 to event 64.
40018	System events status signaling. If a particular bit is set, its corresponding event is active. Bit number 0 corresponds to event 65 and bit number 15 to event 80.
40019	System events status signaling. If a particular bit is set, its corresponding event is active. Bit number 0 corresponds to event 81 and bit number 15 to event 96.
40020	Air pressure after 1st-stage cooler in kPa.
40021	Air pressure after 2nd-stage cooler in kPa.
40022	Oil pressure in kPa.
40023	Air temperature after 1st-stage in °C.
40024	Air temperature after 1st-stage cooler in °C.
40025	Air temperature after 2nd-stage in °C.
40026	Air temperature after 2nd-stage cooler in °C.
40027	Oil temperature in °C.
40028	Ambient temperature in compressor space in °C.
40029	Current setting of the max. compressor switching off pressure in kPa
40030	Current setting of the compressor switching on pressure in kPa
40031	Current setting of the compressor switching off pressure in kPa
40032	Number of hours run.
40033	Number of rewinds of the hour counter. Total time of hours run is equal to the value of record 40032 + 32767 * value of record 40033.
40034	Number of hours run (under load)
40035	Number of rewinds of the hour counter (under load). Total time of hours run is equal to the value of record 40034 + 32767 * value of record 40035.
40036	Number of hours to next service.
40037	Number of days to next service.
40038	Control level in NET mode: <ul style="list-style-type: none"> • 0 – remote start and stop • 1 – remote pressure setting • 2 – remote under loading of compressor
40039	Equipment compatibility program version number.
40040	Program function version number.
40041	Revision number for a given program function version.

4.10 Changing the network settings

Notice

Most activities in the procedures presented in the further part of this document are handled via and with the assistance of the operator panel firmware, which has been created by its manufacturer. Due to this, the progress or availability of each of these procedures may change depending on the firmware version. Handling any of the presented procedures or changing other firmware settings requires specialist knowledge from the scope of IT and automation. Therefore, the compressor manufacturer does not recommend interfering with the firmware settings and does not take responsibility for the results of changes done to the firmware settings or by using its tools.

In order to change the PLC driver network settings, one should proceed with the following procedure:

- Change the network parameters in 1 parameters on the 2-9-7 screen, presented on Fig.10
- Confirm the entered settings by pressing V button in the 1 parameters on the 2-9-7 screen.
- Close the operating system with use of 3 parameter on 2-3 screen and proceed with the further procedures.

2-9-3		Ustawienia IP			
Ustawienia sieciowe sterownika PLC					
1	IP	192.	168.	0.	11
	Maska	255.	255.	255.	0
	Bramka	192.	168.	0.	1

Fig. 10 View of the IP settings screen

In order to change the HMI operator panel network settings, one should proceed with the following procedure:

- Shut down the operating system with the 3 parameter on the 2-3 screen.
- Press Settings in Start Center.
- Press Network Interface in Transfer, Network & Internet group
- Give new network settings.

In order to change the connection between the HMI operator panel and PLC controller, one should proceed with the following procedure:

- Shut down the operating system with the 3 parameter on the 2-3 screen.
- Press Settings button in Start Center.
- Press Service & Commissioning button in System group.
- Select from the list Edit Connections.
- Wait for appropriate connection in 1/3 step and go to the next steps.
- In IP address enter PLC controller address and select Override option on ON in 2/3 Step and go further.
- Confirm your settings by clicking Accept in 3/3 Step.

In order to start operating system press Start button in Start Center, as shown on the Fig.11

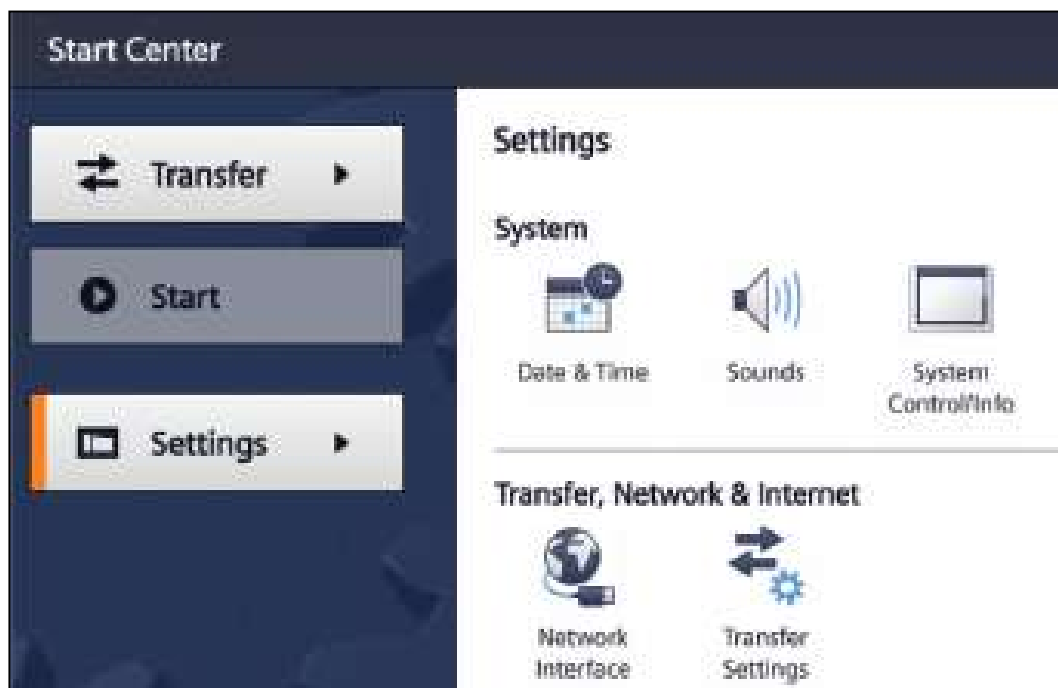


Fig. 11 Start Center view of the operating panel software

5. Web server

The compressor controller is provided with the possibility of remote monitoring of its status by the implemented function of the Web server. It means that a user may view the compressor status from the Web browser level when the controller is connected to a local network.

Note

By connection of the compressor controller to a local network, it is possible to watch the controller status by everyone who has an access to the network. It increases significantly the probability of attacks and unauthorised connections. Therefore, a user should take care of safety in the network that the controller is connected to.

The web server starting is carried out by typing the controller address in the web browser address bar. The web server parameters are presented in Tab. 11.

Table 11 Web server parameters

Parameter	Value
Web server IP address	The controller IP address can be read on the compressor control panel (one from the network range 192.168.0.11)
Communication protocol	TCP
Connector type	RJ45
Requirements of the web browser	Support for HTML 4.01, CSS and java script

The main page of the compressor controller is presented in Fig. 12. Its key elements are the menu located at the left side and content in the central part of the page that changes depending on the selected option in the menu. The Web server gives the possibility of watching the current status of the compressor and its parameters, viewing the settings and counter readings and checking the history of the events recorded.

From the web server, it is possible to control the compressor. However, it must be in NET mode, and the user of web server must be logged in. This is possible from the site of the controller manufacturer, which is shown in Fig. 13. In order to call it, use the link at the controller status on the web server homepage. After switching to the newly opened site of controller manufacturer use the login form located in the upper left corner of the page. Login data is shown below:

- user name: user
- password: 810575

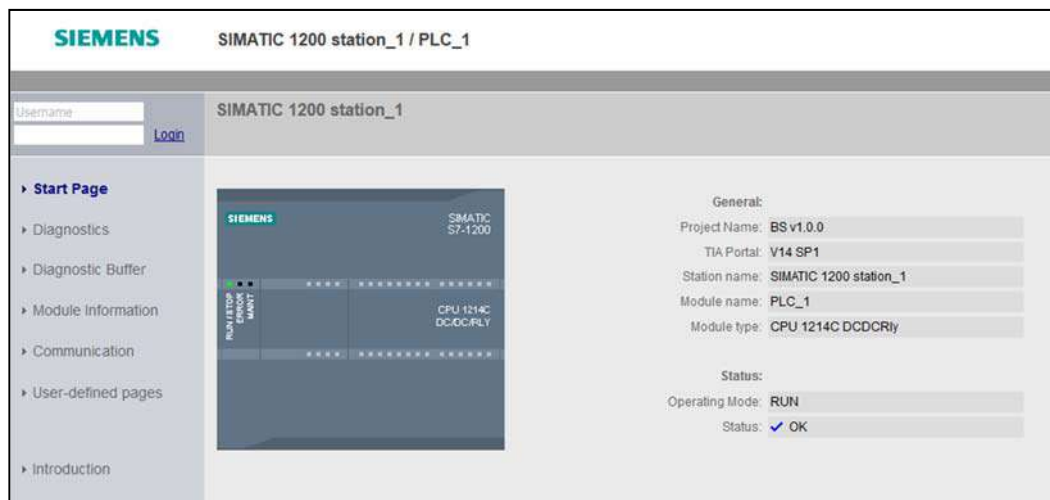


Fig. 12 Starting the Web sever