APAR - SALES OFFICE
05-090 Raszyn, ul. Gałczyńskiego 6
Tel. +48 22 101-27-31, +48 22 853-49-30
E-mail: automatyka@apar.pl
Internet: www.apar.pl

USER INSTRUCTION

AR654

UNIVERSAL FOUR-CHANNEL CONTROLLER WITH PROCESS RECORDING AND A TIMER

Version 1.0.1
2017.03.24

Thank you for choosing our product.

This instruction is intended to facilitate correct operation, safe use, and taking full advantage of the controller's functionalities.

Before you start the device, please read and understand this instruction.

In the event of any additional questions, please contact our technical adviser.

CONTENTS

Please pay particular attention to the text marked with this sign.

The manufacturer reserves the right to make changes to the design and the software (firmware) of the device without any deterioration of the technical parameters (some functions may not be available in older versions). Updating to the latest version of the firmware may require a repeated configuration of the device.

1. *SAFETY PRINCIPLES*

Before you start to use the device, become familiar with the present instructions.

a) in order to avoid electrocution or damage to the device, its mechanical and electrical installation must be performed by qualified workers;

b) before switching on the power supply, make sure that all cables and wires are properly connected;

c) before making any modifications to the wire and cable connections, switch off the voltage supplied to the device;

d) ensure proper operating conditions compliant with the technical specification of the device (chapter 5, power supply voltage, humidity, temperature, etc.); do not expose the device to direct and intense heat.

2. INSTALLATION GUIDELINES

The device is designed so as to ensure an appropriate level of immunity to most interferences that may occur in industrial and household environments. In environments of unknown level of interferences, it is recommended to implement the following measures so as to prevent potential interference with the operation of the device:

a) do not supply the device from the same lines as high-power equipment without using appropriate power line filters;

b) use shielded supply, sensor, and signal cables, whereby the earthing of the shield should be single-point and located as close to the device as possible;

c) avoid running measurement (signal) cables in the direct vicinity of and parallel to power and supply cables;

d) it is recommended to twist the signal wires in pairs or to use a finished twisted-pair cable;

e) in the case of sensing resistors in 3-wire connections, use identical wires;

f) avoid proximity of remotely controlled devices, electromagnetic meters, high power loads, loads with phase or group power control, and other devices that cause high impulse disturbances;

g) ground or zero metal rails on which rail-mounted devices are installed.

Make sure to remove the protective film from the LCD display before the first use of the device.

3. GENERAL CHARACTERISTICS OF THE CONTROLLER

- the device is intended for control, monitoring, and recording of temperature and other physical values (humidity, pressure, level, flow rate, speed, etc.) processed into a standard electric signal (0/4÷20 mA, 0÷10 V, 0÷60 mV, 0÷850 Ω), with the possibility to present 1 to 4 measurement channels;
- 4 universal inputs (for thermoresistance and thermocouple sensors and for standard analogue signals, not galvanically isolated) with the possibility to create inter-channel mathematical formulas such as difference, average, sum, larger or smaller than, and ratio of measured values;
- 4 control/alarm outputs with independent adjustment algorithms:
  ON-OFF with hysteresis, PID, autotuning PID, 12-section programmed control;
- an optional module of 4 analogue outputs (0/4÷20 mA and 0/2V÷10V) and 5 functional binary inputs (BIN) to change the operating modes of the associated outputs (control start/stop, selection of the day/night setpoint value, manual/automatic mode for outputs); the analogue outputs are logically connected to the two-state outputs (P/SSR) and are used for control or retransmission of measurements and setpoint values; the inputs and the outputs are not insulated (common ground);
- selection of setpoint values for outputs from among 2 defined for each output, the common value from the 1st output (without and with offset for 3-way control), from the selected program or measurement from any input;
- selection of independent PID sets (from the 8 available sets) for individual setpoint values (gain scheduling);
- advanced automatic PID parameter selection function with fuzzy logic elements for each of the outputs;
- 4 programs with the possibility to define for each section such parameters as type (gradient/time/stop), setpoint value, hysteresis, set of PID parameters, selection and status of auxiliary output, sound alarm, etc.;
- time control/timer, options: continuous operation, periodic daily (hourly), or limited by date and time;
- manual mode (open control loop) available for 2-state and analogue outputs with setting of the output signal value in the range of 0÷100% (the impulse period or the entire range of variability for mA/V);
- possibility to select the measured values to be displayed and, independently, the type of control signals for the outputs (associated inputs or mathematic functions on the measurement signals, such as difference, average, etc.);
- possibility to assign many outputs to one measurement channel and many inputs to one output;
- available sound and visual signalling of the status of operation of outputs and email alarm notification;
- programmable type of control/alarm: heating, cooling, in the band, outside of the band, manual mode;
- recording of data in a standard text file located in the internal memory of the controller (4 GB) or an USB memory in a FAT system, with possibility to edit in spreadsheet software, e.g. Microsoft Excel;
- rich standard equipment with serial interfaces: USB (for work with a computer and USB memories), RS485 (MODBUS-RTU), and Ethernet (100base-T, TCP/IP protocols: MODBUS-TCP, HTTP, SMTP, etc.);
- a WWW server for work with any web browser (Opera, IE, Firefox, etc.); the site contains information about active

measurement channels, control parameters and status, real time, status of the outputs, recording, etc., with the possibility to show diagrams using the Google Chart API service (diagrams require constant Internet access);

- the DDNS service, which enables easy access over the Internet to a controller connected to a network that has no fixed public IP address, through a friendly Internet address defined by the user; the service is available only for registered users of popular DDNS services, such as DynDNS (www.dyndns.org), No-IP (www.no-ip.com), and DNS-O-Matic (www.dnsomatic.com);
- a colour LCD TFT graphic display 320x240 dots (QVGA), with a touch screen, brightness adjustment, and programmable background colour for individual measurement channels;
- intuitive use, quick configuration, and clear signalling of device operating statuses and menu position;
- a programmable language of the menu (Polish, English), which also covers the version of the site saved on the WWW server;
- graphic and text methods of presentation of the measured values (numerical values, bar graph, counter, graph);
- grouping of measurement channels to be displayed, with automatic formatting of the screen (font size, etc.);
- (programmable screen function buttons (F1) for each of the displayed control channels for quick selection of one of the available functions (the same as for the binary inputs (BIN) of the optional module);
- a programmable F button for quick selection of one of the available functions: start/stop of control for all outputs, status of the device and of the Internet services, start/stop of recording, copying or moving archives to a USB memory, blocking of sound alarms or the touch screen and the keypad;
- a broad selection of recording start methods (continuous, limited by date and time, periodic daily, above or below the permission threshold related to any measurement signal, only during control);
- internal real time clock with a battery backup power supply (up to 8 years of continuous operation);
- an integrated 24 V DC power supply supplying the field transducers (current output depending on the version);
- compensation of line resistance for resistance sensors (automatic or permanent);
- compensation of thermocouple cold tip temperature (automatic or permanent);
- free software provided (for Windows 7/8/10) that enables presentation in a graphic or text form of the recorded results (ARSOFT-LOG-WZ3) and configuration of parameters (ARSOFT-CFG-WZ1);
- programmable display options, presented measured values and control signals for the outputs (measurements, mathematic functions, etc.), types of measurement inputs, indication ranges, alphanumeric description of measurement channels and groups, control/alarm, recording, communication, and access options, and other configuration parameters;
- two levels of access to the configuration parameters: full, protected with an administrator's password, and limited, to the quick configuration screen (for the basic control parameters), protected with the user's password;
- parameter configuration methods:
  - from the film keypad and a touch screen located on the front panel of the device;
  - through the USB, RS485, or Ethernet and free ARSOFT-CFG-WZ1 software or a user's application, communication protocol MODBUS-RTU and MODBUS-TCP;
  - from configuration files saved in the USB memory or on a computer disk;
- available protection of saved measurement data against unauthorized modification (check sum);
- possibility to differentiate archives from many devices of the same or similar type by assigning individual identification (ID) numbers;
- clearly visible status of operation of control, recording, memory, USB port, alarms, file and disk operations, serial transmission (USB, RS485, Ethernet), etc.;
- recording of data until the memory is full (at least 2 years of continuous operation with recording of 4 channels every 1 s);
- possibility to transfer archive data and configuration data to a USB memory or using the USB port of a computer, or via Ethernet;
- simultaneous recording of data from all active measurement channels;
- an enclosure for panel installation, leak-tightness from the front side IP65 or IP30 (depending on the version);
- high accuracy and immunity to interferences;
- possible user's update of the controller's software to the latest version from a USB memory;

- available accessories: a USB memory (2 or 4 GB).

NOTE:

- **Before you start working with the controller, make sure to become familiar with this operating instruction and perform proper electrical and mechanical installation, as well as configuration of the parameters in accordance with chapters 6, 7, and 12.**
- **Do not use sharp-edged objects to work with the touch screen.**
- **As a default, the controller is configured for presentation of temperature from the Pt100 sensors from inputs 1-4 and for independent control of the ON-OF type with hysteresis for each of the P1/SSR1-P4/SSR4 outputs** (a description is provided in chapter 12).

4. CONTENTS OF THE SET

- controller
- a USB cable for connecting the device to a computer, 2 m long;
- a CD with the drivers and the software (Windows XP/7/8/10);
- a user instruction and a warranty card.

5. TECHNICAL DATA

Number of measurement inputs	4 universal, without galvanic separation (common earth)		
Universal inputs(programmable, 16 types, 18-bit A/C processing), measurement ranges			
- Pt100 (RTD, 3- or 2-wire)	-200 ÷ 850 °C	- thermocouple R (TC, PtRh13-Pt)	-40 ÷ 1,600 °C
- Ni100 (RTD, 3- or 2-wire)	-50 ÷ 170 °C	- thermocouple T (TC, Cu-CuNi)	-25 ÷ 350 °C
- Pt500 (RTD, 3- or 2-wire)	-200 ÷ 620 °C	- thermocouple E (TC, NiCr-CuNi)	-25 ÷ 850 °C
- Pt1000 (RTD, 3- or 2-wire)	-200 ÷ 620 °C	- thermocouple N (TC, NiCrSi-NiSi)	-35 ÷ 1,300 °C
- thermocouple J (TC, Fe-CuNi)	-40 ÷ 800 °C	- current (mA, R_{in} = 100 Ω)	0/4 ÷ 20 mA
- thermocouple K (TC, NiCr-NiAl)	-40 ÷ 1,200 °C	- voltage (V, R_{in} = 180 kΩ)	0 ÷ 10 V
- thermocouple S (TC, PtRh10-Pt)	-40 ÷ 1,600 °C	- voltage (mV, R_{in} > 2 M Ω)	0 ÷ 60 mV
- thermocouple B (TC, PtRh30PtRh6)	300 ÷ 1,800 °C	- resistance (R, 3-p or 2-p)	0 ÷ 850 Ω
Response time for measurements (10÷90%)		0.5 ÷ 2.5 s (programmable)	
Resistance of leads (RTD, R)		R_d < 25 Ω (for each line), compensation of line resistance	
Resistance input current (for RTD and R, multiplexed)		650 µA (Pt100, Ni100, 850Ω), 150 µA (Pt500, Pt1000)	
Processing errors (at ambient temperature of 25 °C):			
- basic	- for RTD, mA, V, mV, R	≤0.1% of the measurement range ±1 digit	
	- for thermocouples (TC)	≤0.2% of the measurement range ±1 digit	
- additional for thermocouples		≤2 °C (compensation of temperature of cold tips)	
- additional from ambient temperature changes		≤ 0.005% of the input range /°C	
Indication range (programmable)		total for measurement channel: -9999 ÷ 99999, for analogue inputs: -9999 ÷ 19999 (resolution)	
Resolution of indications/position of the decimal point		programmable, for thermometric inputs 0.1°C or 1 °C, for other inputs 0 ÷ 0.000	
2-state outputs (4 independent)	- relay (P1÷P4, standard)	5A / 250VAC (for resistance loads), SPST	
	- SSR (transistor, type NPN OC, optional)	24V, internal resistance 850 Ω, (SSR1÷SSR4)	

Analogue outputs (optional, 4 current and voltage, not separated galvanically) **(1)**	- current 0/4 ÷ 20 mA (OUTPUT5 ÷ OUTPUT8, mA, common earth)		load capacity of the output Ro < 1,000 Ω, maximum resolution 0.33 µA, 16 bit
	- voltage 0/2 ÷ 10 V (OUTPUT5 ÷ OUTPUT8, V, common earth)		load capacity of the output Io < 3.7 mA (Ro > 2.7 kΩ), maximum resolution 0.17 mV, 16 bit
	- basic error of the output		< 0.1% of the output range
Digital inputs BIN (quantity 5, contact or voltage < 24 V)			bistable, active level: short circuit or <0.8 V, optional
Power supply:	- 230 VAC (standard)		85 ÷ 260 VAC/ 10 VA
	- 24 VAC/DC (option)		20 ÷ 50 VAC/ 10 VA, 22 ÷ 72 VDC/ 10 W
Power supply of field transducers 24 VDC (note 2)	for power supply 230 V_{AC}/24$V_{AC/DC}$		200/100 mA (without the optional module mA/V and BIN)
	for power supply 230 VAC + module mA/V		150 mA-21 mA*N (N=number of active current outputs)
	power supply 24 VAC/DC + module mA/V		50 mA-21 mA*N (N=number of active current outputs)
Display (graphical LCD TFT, 320x240 points - QVGA)			3.5" (diagonal), background brightness adjustment
Touch screen			resistance, integrated with the LCD display
Communication interfaces (standard equipment)	- **USB** (connection type A4, IP30 version also accessible from the front, programmable mode of operation)	- slave mode (device)	communication with a computer, drivers for the Windows 2000/XP/Vista/7/8/10 system: exchangeable disk (mass memory, readout speed approx. 335kB/s) + virtual COM serial port (MODBUS-RTU protocol)
		- master mode (host)	support of USB memory (pendrive) up to 4 GB, writing speed approx. 135kB/s (depending on the type of the memory)
	- **RS485** (MODBUS-RTU protocol, SLAVE)		speed 2.4÷115.2 kbit/s, sign format 8N1, galvanic separation
	- **Ethernet** (type 100base-T, socket RJ45, data transfer up to 135 kB/s - depending on the network)		web server, MODBUS-TCP, e-mail client (SMTP), DDNS server client, TCP/IP protocols: DHCP (client, server), SMTP, NetBIOS, ICMP, UDP, TCP
Real time clock (**RTC**, lithium battery CR1220)			quartz, date, time, takes leap years into account)
Data recording interval			programmable 1 s to 8 hours **(3)**
Data storage memory (non-volatile, recording of approx. 59 million measurements from 4 channels and 4 GB memory):			
- internal (micro SDHC card, industrial, MLC)			4 GB, FAT32 file system
- external USB memory (pendrive, A4 type socket)			FAT16, FAT32, maximum size 4 GB
Rated operating conditions			0 ÷ 50 °C, <100% RH (no condensation)
Operating environment			air and neutral gases, no dust
Protection rating			IP65 or IP30 from the front, IP20 from the side of the connections
Weight			approx. 420 g
Electromagnetic compatibility (EMC)			immunity: according to the PN-EN 61000-6-2 standard
			emission: according to the PN-EN 61000-6-4 standard

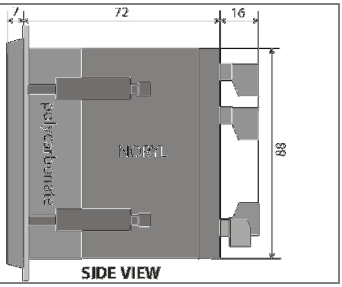
Notes: **(1) -** each of the outputs can work in only one programmed standard: 0/4 ÷ 20 mA or 0/2 ÷ 10 V;

(2) - the output power depends on the equipment version (type of power supply, presence and number of current outputs used); in the case of insufficient current efficiency, an external power supply and/or voltage outputs instead of current outputs should be used;

(3) - for a recording interval equal to 1 s, uneven recording may take place during transfer of an archive via Ethernet and also because of an excessive number of files, their sizes, and type and manufacturer of the USB memory (pendrive) used.

6. ENCLOSURE DIMENSIONS AND INSTALLATION DATA

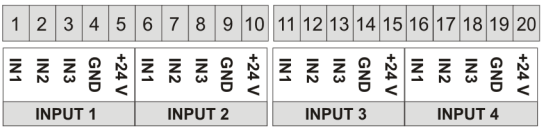
Enclosure type	panel, Incabox XT L57
Material	self-extinguishing NORYL 94V-0, polycarbonate
Enclosure dimensions	96 x 96 x 79 mm
Panel window	92 x 89 mm
Fixing methods	grips on the side of the enclosure
Conductor cross-sections (separable connectors)	2.5 mm^2 (supply and alarm outputs), 1.5 mm^2 (others)

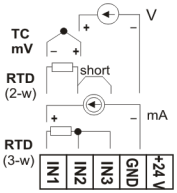


7. DESCRIPTION OF TERMINAL STRIPS AND ELECTRICAL CONNECTIONS

The numbering, location, and description of the connections on the back panel and the method of connecting sensors and electrical signals:

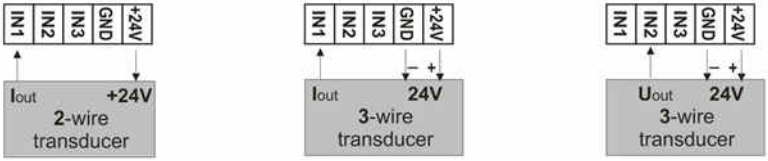
a) measurement connections (RTD, TC, mA, V, mV, R), INPUT1÷ INPUT4; the parameters configuration is described in chapter 12.3



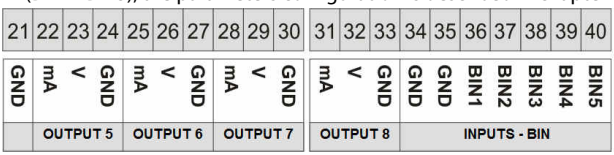


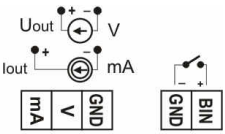
Terminal clamps (connections)	Description
IN1-IN2-IN3	RTD and R (Pt100, Pt500, Pt1000, Ni100, 850Ω) inputs, in a 2- and 3-wire connection
IN1-IN2	thermocouple input TC (J, K, S, B, R, T, E, N) and voltage input 0÷60 mV
IN1-GND	current input 0/4÷20 mA
IN2-GND	voltage input 0÷10 V
+24 V	output +24 V (in relation to the GND) of the integrated power supply of field transducers

a.1) connection of the 2- and 3-wire transducer (Iou – output current, Uou – output voltage)



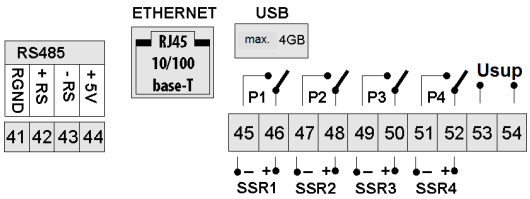
b) connections of the optional analogue output module (OUTPUT5÷OUTPUT8) and of functional binary inputs (BIN1÷BIN5); the parameters configuration is described in chapter 12.4





Terminal clamps (connections)	Description	
mA - GND	current output 0/4÷20 mA	each of OUTPUTS 5÷8 can work in only one programmed standard (mA or V), chapter 12.4
V - GND	voltage output 0/2÷10 V	
BIN1÷4 - GND	functional inputs related with control/alarm outputs (chapter 12.4)	
BIN5-GND	functional input Start/Stop for all control outputs (global, chapter 12.9)	

c) other connections



NOTE:
In the IP30 version, a USB connection is also available on the front panel.
DO NOT USE SIMULTANEOULY WITH THE BACK CONNECTION!

Terminal clamps (connections)	Description
41÷44	RS485 serial interface (MODBUS-RTU transmission protocol)
45÷52	relay outputs P1÷P4 or SSR1÷SSR4 (transistor NPN OC), chapter 12.4
53-54	power supply input 230 VAC or 24 VAC/DC
ETHERNET	serial Ethernet interface (type 100base-T, RJ45 socket, TCP/IP protocols)
USB	serial USB interface (programmable operation mode: device or host, chapter 12.8, **in the IP30 version, do not use two USB sockets at the same time**)

8. CONNECTING TO A COMPUTER AND INSTALLATION OF USB DRIVERS

Connecting the controller to a USB port of a computer may be useful in order to configure the names of channels, groups, measurement units, and other parameters of the device, and to download files with recorded data. The available support software is described further in the present instructions. Before connecting the cable to a USB port of a computer, switch on the power supply of the controller and make sure that the ***USB operation mode*** parameter is set to ***Available for a computer*** (chapter 12.8, ***Communication settings*** menu). After you connect for the first time, the Windows (XP/Vista/7/8/10) system detects the controller named "***Apar Composite Device***" and demands installation of drivers of the virtual COM serial port (MODBUS-RTU protocol, also used by the ARSOFT-CFG-WZ1 software). In the device manager or the new device wizard, **manually** indicate the location of the drivers (a CD-ROM, a ***DRIVERS*** folder, or drivers downloaded from the www.apar.pl website).
In Windows 7/10 systems, one can use automatic downloading of the driver software from the Windows Update website. In the Windows 7 system, from the ***Device Manager*** level, manual installation is performed in the following manner:
1. Right-click the item "***Apar Composite Device***" and select "***Update the driver software***", and then "***Browse my computer to find the driver software***".
2. Use the "***Browse...***" button to indicate a location on the disk (the *DRIVERS* folder) where the drivers are saved, and then click "***Continue***".
3. The virtual COM port "***USB Serial Port***" is installed; press "***Close***".
4. Additionally, in the "***Disc drives***" branch, the system detects and installs the "***Microchip Mass Storage USB Device***". After the installation is completed, the controller is listed in the system as an exchangeable 4 GB disk with the label

AR654 and a virtual COMx serial port (x - port number: 1, 2, etc.). The serial port uses the MODBUS-RTU protocol. In the internal memory two configuration text files are shown: *AR654.cfg* and *AR654.txt* (chapter **12**). Communication with the device can also be established using the Ethernet and the RS485 interfaces, which are a part of the controller's standard equipment and do not require installation of additional drives. However, if an RS485 converter for USB is used in the computer, it is necessary to install the serial port drivers provided by the manufacturer.

NOTE:

- do not disconnect the device from the computer before completion of installation of the drivers
- connection of the controller to a USB port of a computer stops recording until the cable is disconnected and blocks the performance of file operations available from the menu level and transmission of files with measurement data via Ethernet from the ARSOFT-LOG-WZ3 level.

9. INSTALLATION OF SOFTWARE

In the "***SOFTWARE***" folder of the CD-ROM that is provided with the device there is a free software installation set for the controller. The installation set comprises the following applications (for Windows 2000/XP/Vista/7/8/10):

Name	Software description
ARSOFT-CFG-WZ1 (**for on-line configuration**)	- display of current measurement data, as well as the date and the time, - configuration of the real time clock (**RTC**) and other parameters, such as types measurement inputs, names of measurement channels, units, and groups, ranges of indications, recording, alarm, display, communication, and access options etc. (chapter 12), - creation on the disk of configuration files containing the current parameter settings for the purpose of repeated use (backup copy or multiplication of the configuration on other devices), - the program requires communication with the recorder via the USB, RS485 or Ethernet port
ARSOFT-LOG-WZ3	graphic or text presentation of recorded results with the possibility to print, input data is taken from a *csv* text file created in the controller in the internal memory or the USB memory (chapter 14), data can also be taken via Ethernet

The latest versions of the aforementioned software are also available at the website (***www.apar.pl,*** *Download → Software* section). The detailed descriptions of the aforementioned applications can be found in the installation folders.

10. FUNCTIONS OF HARDWARE BUTTONS AND ELEMENTS OF THE TOUCHSCREEN

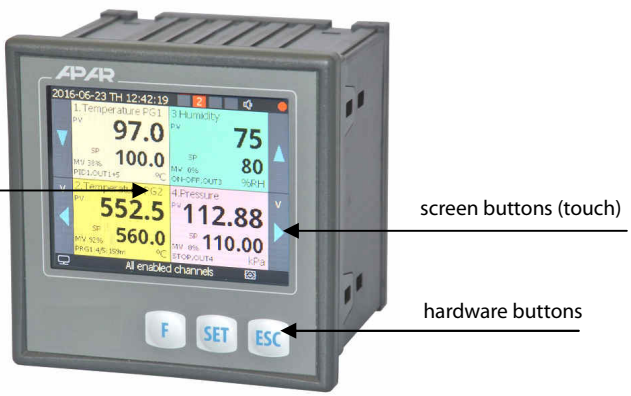


Fig. 10. A description of the front panel using the example of the IP65 version (the IP30 version has an additional USB socket on the front)

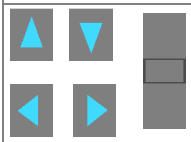
NOTE:

Do not use sharp-edged objects to work with the screen buttons and other screen objects

a) functions of buttons and elements of the touch panel in the measurement display mode (chapter 11)

Button or touch	**Description** [and marking in the contents of the instruction]
SET	**[SET]**, hardware button: - input in the parameter configuration and file operations menu. If the ***Password protection*** in the ***Access and other options*** menu is switched on, then the password must be entered, chapter 12.9 - closes the message window appearing on the screen (chapter 15)
 PV or SP area of the measu-rement channel	calling the ***Quick configuration screen*** for the main control parameters of the measurement channel selected by touching (the area of the presented measured value ***PV*** or the setpoint value ***SP***, chapter 11). If the ***Password protection*** in the ***Access and other options*** menu is switched on and the ***User password*** is other than zero, then the password must be entered, chapter 12.9
	**[UP]** or **[DOWN]**, screen buttons: - change of the displayed measurement group or a single measurement channel in the CHART type presentation mode - change of the ***Quick configuration screen*** for the next associated control output
	**[LEFT]** or **[RIGHT]**, screen buttons: a change of the measurement data presentation method (CONTROL, TEXT, BAR GRAPH, ANALOG INDICATOR, DIAGRAM, chapter 11)
F	**[F]**, hardware button: activation of a function programmed with the ***F button function*** parameter (chapter 12.9), active only in the measurement presentation mode, sub-item c
ESC	**[ESC]**, hardware button: closing the message window appearing on the screen (chapter 15)
F + ESC	**[F]** and **[ESC]** (simultaneously): calling the ***Device status*** screen (hardware information, operation and Ethernet services parameters, current record number in the *csv* archive file, etc.); the function is available also from the level of the **[F]** button (sub-item **c** and chapter 12.9)

b) functions of the buttons in the parameter configuration and file operations mode (***Main Menu***, chapter 12)

Button	**Description**
SET	- selects the marked item in the menu (entering a lower menu level or edition of a parameter); the action is also available from the touch screen level - approves of the edited parameter value (saving in the non-volatile internal memory takes place after leaving the *Main Menu* or disconnecting the USB from the computer) - closes the message window appearing on the screen (chapter 15)
	**[UP]** or **[DOWN]** and the screen scroll bar: - moves to the next or previous item in the menu - changes the value of the edited parameter (also **[LEFT]** or **[RIGHT]**)
ESC	- returns to the previous menu (higher level) - cancels the changes to the edited parameter - exits the *Main Menu* and returns to the measurement presentation mode - closes the message window appearing on the screen (chapter 15)

c) meaning of the function button **[F]** (active only in the measurement presentation mode)

Button	**Description** (depending on the value of the ***F button function*** parameter in the ***Access and other options*** menu, chapter 12.9)	**Status signalling/icon**
F	***Device status*** - device status screen (factory setting, function available also by simultaneously pressing buttons **[F]** and **[ESC]**, described in item **a** above)	screen
	Stop/Start of recording - change of the ***Type of recording*** parameter to ***Off*** or ***Continuous*** (chapter 12.5), after the power supply is switched on, the recording is always on (continuous)	● or none

	Copy the archives to the USB memory (operation available also in the ***Memory and files options*** menu, chapter 12.6)	messages
	Move the archives to the USB memory - the files in the controller are deleted after they have been copied	messages
	Disable/Enable sound alarm - change of the ***Alarm sound signal*** parameter to ***Disabled*** or ***Enabled*** (chapter 12.4.1, ***Control and alarm options*** menu -> ***Output***...); after the power supply is switched on, the sound signalling of active alarms is always switched on	or none
	Start/Stop of control for all outputs - after the power supply is switched on, the control status is exactly the same as at the time of switching off the power supply (no change), (chapter 12.4)	or none
	Touch panel lock – touch screen and keypad lock (except for **[F]**)	or none

d) functions of the screen elements in the presentation mode of the ***Quick configuration screen*** of the control channel (chapter 11.7)

Button or touch	Description
SP change or	**[SP change]** or touching the area of the displayed measured value (***PV***) or setpoint value (***SP***): change of the setpoint value selected with the ***Setpoint (SP) selection*** parameter (chapter 12.4.1), limit of settings defined by parameters ***Bottom*** and ***Top of the range for graphics and SP*** (chapter 12.2)
Start	**[Start]** or **[Stop]**: Start or Stop of control with the icon signalling the ***Control time*** mode (continuous: ∞ or temporary: 12 and); after the power supply is switched on, the button is set in accordance with the ***State of control after power up*** parameter, chapter 12.4.1
F1	function button **[F1]** programmable with the ***F1 button and BIN input function*** *(select SP1/SP2, set Auto/Manu, None*, etc.); a detailed description is given in chapter 12.4.1

11. DESCRIPTION OF DATA PRESENTATION ON THE LCD DISPLAY

The controller enables presentation of the measurement data in various modes in accordance with the following diagram. The selection and methods of configuration of data for the displayed measurement channels are described in chapter 12.2.

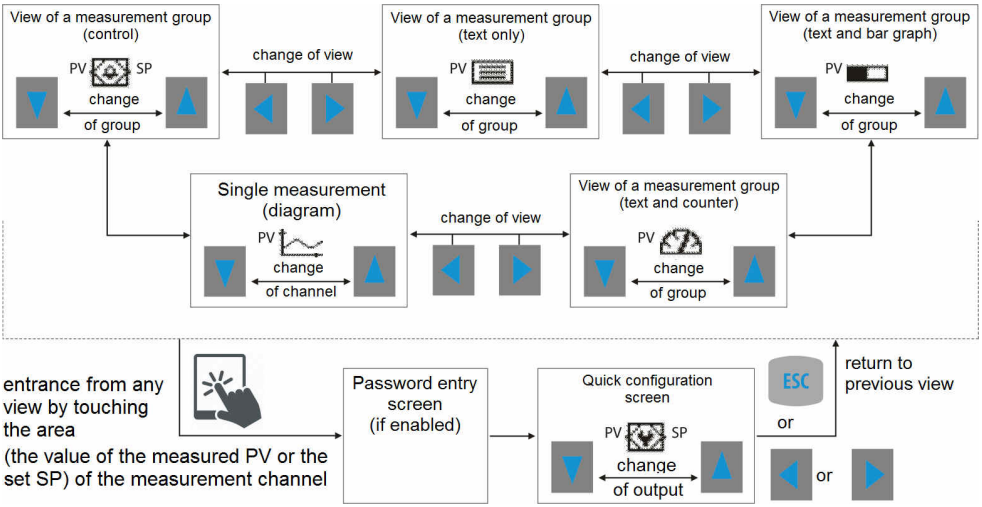


Fig. 11. A block diagram of the available measurement data presentation modes (the detailed descriptions are provided in successive chapters)

11.1. UPPER AND LOWER DEVICE STATUS BAR

The status bars can be seen in the upper and lower part of the display only in the measurement presentation modes. The meaning of the individual graphic elements is described below.

a) lower status bar

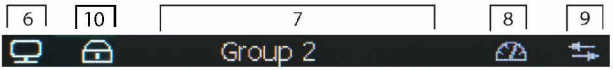


Fig. 11.1.1. Lower status bar

Object		Description [and marking in the contents of the instructions]		
6		no USB connection with the computer	the USB port is accessible for the computer (device)	signalling of the operation mode and the status of the USB port (chapter 12.8, Table 12.8, ***USB operation mode*** parameter)
		the USB port is connected to the computer		
		no USB memory, **do not connect to the computer!**	USB memory support (host), chapter 13	
		USB memory (pendrive) was detected		
7		measurement group name (up to 16 characters per group, taken from the *AR654.txt* file, chapter 12.2)		
8		view of a measurement group (control)		signalling of measurement data presentation mode (type of view) and of control parameters
		view of a measurement group (text only)		
		view of a measurement group (text and a bar graph)		
		view of a measurement group (text and an analogue indicator)		
	none	single measurement (chart)		
		Quick configuration screen (for main parameters of the control channel)		
9		**[Tx/Rx]** - signalling of presence of serial transmission (via the RS485, a USB port or the Ethernet)		
10		signalling of the touch screen and keypad lock (one of the **[F]** button functions), chapter 12.9		

b) upper status bar

Fig. 11.1.2. Upper status bar

Object		Description [and marking in the contents of the instructions]
1		date (yyyy-mm-dd), day of the week and time (hh:mm:ss) on the real time clock (RTC, chapter 12.10)
2		status of control/alarm outputs, in the order from the 1st to the 4th, (configuration in the ***Control and alarms options*** menu, chapter 12.4), grey colour - the output is off (the alarm is inactive), red colour (with the numbers of the measurement inputs that activate the output) - the output is switched on
3		at least one of the output has the ***Alarm sound signal*** parameter is set to the ***Enabled*** value (chapter 12.4.1)
		all the control/alarm outputs are blocked with the programmable [**F**] button (chapters 10 and 12.9)
4		**[R/W]** - signalling of writing to or reading from the internal memory or the USB memory
5		signalling of ongoing recording in the internal memory or the USB memory (**)**

11.2. VIEW OF A MEASUREMENT GROUP AND CONTROL PARAMETERS (CONTROL)

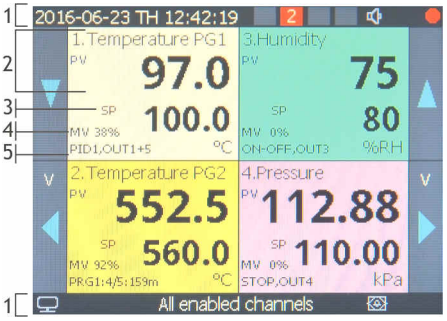
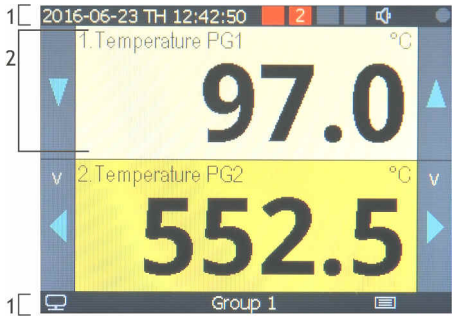


Fig. 11.2. Appearance of the measurement group screen in the *CONTROL* mode

Object	Description
1	status bars (chapter 11.1)
2	measurement panel: number, name (up to 16 characters) and unit (up to 4 characters) of the measurement channel (name and unit taken from the *AR654.txt* file, chapter 12.2), measured value (**PV**) with signalling of exceeded measurement range (chapters 12.3 and 15)
3	current setpoint value (**SP**) for the related control/alarm output (chapter 12.4)
4	output signal value (**MV**) in the range of 0÷100% (of the impulse period for the P/SSR output or the full range of variability for the mA/V output)
5	control status: *control mode* (***ON-OFF***, ***PID***, ***ST-PID*** - autotuning, ***MANU*** - manual mode, ***STOP***), *the number of the related output* (control/alarm and retransmission) and alternating information about the status of the program control (***PRG***, if activated); the details are given in chapter 12.4

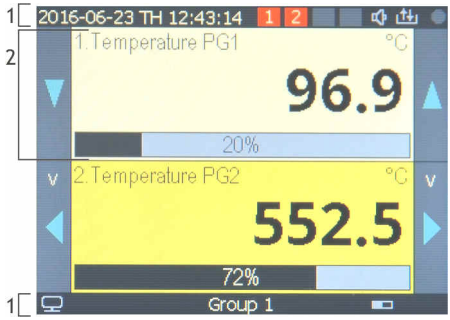
11.3. VIEW OF A MEASUREMENT GROUP (TEXT ONLY)



Object	Description
1	status bars (chapter 11.1)
2	measurement panel: number, name (up to 16 characters) and unit (up to 4 characters) of the measurement channel (name and unit taken from the *AR654.txt* file, chapter 12.2), measured value (PV) with signalling of exceeded measurement range (chapters 12.3 and 15)

Fig. 11.3. Appearance of a measurement group screen in the *TEXT ONLY* mode (an example of a group consisting of two channels)

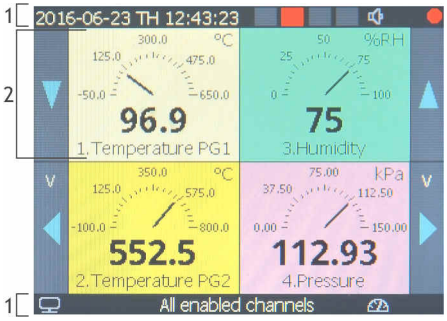
11.4. VIEW OF A MEASUREMENT GROUP (TEXT AND A BAR GRAPH)



Object	Description
1	status bars (chapter 11.1)
2	measurement panel: number, name, measured value (PV), and unit of the measurement channel (chapters 11.2 and 11.3), graphic presentation of the measurement (bar graph) works in the range set by the parameters ***Bottom of the range for graphs*** and ***Top of the range for graphs*** (chapter 12.2)

Fig. 11.4. Appearance of the measurement group screen in the *TEXT AND BAR GRAPH* mode

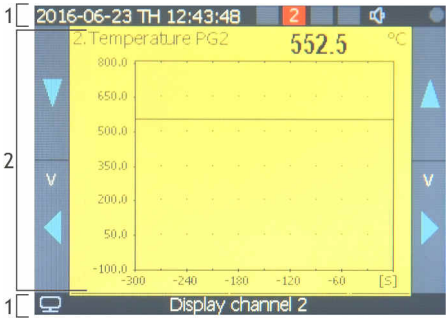
11.5. VIEW OF A MEASUREMENT GROUP (ANALOG INDICATOR, COUNTER)



Object	Description
1	status bars (chapter 11.1)
2	measurement panel: number, name, measured value (PV), and unit of the measurement channel (chapters 11.2 and 11.3), graphic presentation of the measurement (analogue indicator) works in the range set by the parameters ***Bottom of the range for graphs*** and ***Top of the range for graphs*** (chapter 12.2)

Fig. 11.5. Appearance of the measurement group screen in the ANALOG INDICATOR mode

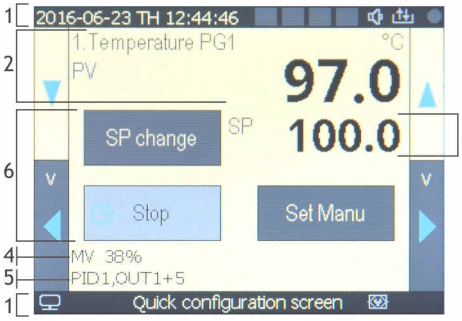
11.6. SINGLE MEASUREMENT (DIAGRAM)



Object	Description
1	status bars (chapter 11.1)
2	measurement panel: number, name, measured value (PV), and unit of the measurement channel (chapters 11.2 and 11.3), graphic presentation of the measurement (diagram) works in the range set by the parameters ***Bottom of the range for graphs***, ***Top of the range for graphs*** (chapter 12.2), and ***Diagram time range*** (chapter 12.7)

Fig. 11.6. Appearance of a single measurement screen in the DIAGRAM mode (possibility to present one channel)

11.7. QUICK CONTROL PARAMETERS CONFIGURATION SCREEN



Object	Description
1	status bars (chapter 11.1)
2	measurement panels (details are given in chapter 11.2)
3	current setpoint value (**SP**) for the related control/alarm output (chapter 12.4)
4	output signal value (**MV**) in the range of 0÷100% (of the impulse period for the P/SSR output or the full range of variability for the mA/V output)
5	control status (the meaning is described in chapter 11.2)
6	the screen buttons are described in chapter 10, item d)

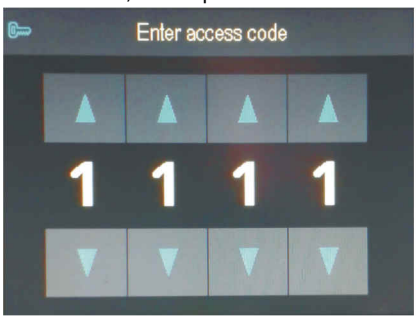
Fig. 11.7. Appearance of the ***Quick configuration screen*** (possibility to present one control channel)

Entry into this display mode (a description is given in chapter 11) can be secured with a password screen when the value of the ***Password protection*** parameter applies to *manual configuration* and the ***User's password*** is other than zero (***Access and other options*** menu, chapter 12.9). As an alternative, the ***Administrator's password*** can be used.

12. SETTING PARAMETERS AND OPERATIONS ON FILES (MAIN MENU)

All the configuration parameters and names of channels and groups, as well as measurement units of the controller are stored in the non-volatile internal memory in two text files: *AR654.cfg* (numerical parameters) and *AR654.txt* (names, units, groups, etc.) - changes can be implemented only using a computer in the ARSOFT-CFG-WZ1 software via the USB port or the Ethernet, as well as in any text editor, e.g. Windows Notebook).
When the device is switched on for the first time, an error message may be shown in the display due to the lack of a sensor or the fact that the sensor that is connected is not one that is factory-programmed. In such an event, the proper sensor or analogue signal must be connected and the configuration must be programmed.
As a standard, the parameter configuration can be performed using one of the following three methods (**do not use them at the same time**):

1. From the film keypad and a touch screen located on the front panel of the device:
- from the mode where the input measurements are displayed in the ***Main Menu*** (**[SET]** button). If ***Password protection*** in the ***Access and other settings*** is on, the administrator's password must be entered - the factory-set value is **1111**, see chapter 12.9.



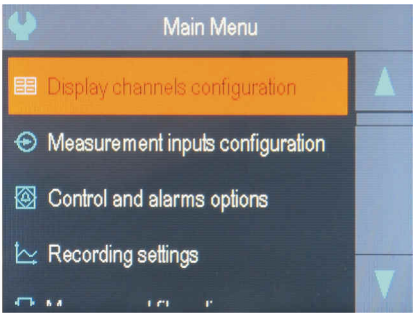


Fig. 12. Appearance of the password screen and the ***Main Menu***

- use the **[UP]** or **[DOWN]** button, or the scroll bar to select an appropriate sub-menu or parameter to be changed/viewed
- use the **[SET]** button or touch the selected item in the menu (also in order to edit the parameter)
- use the **[UP]**, **[DOWN]**, **[LEFT]**, or **[RIGHT]** button, or the scroll bar to change the value of the edited parameter
- approve the changed value of the parameter by pressing the **[SET]** button or cancel it by pressing the **[ESC]** button

2. Use the USB or RS485 port, or the Ethernet and the ARSOFT-CFG-WZ1 software (**on-line configuration**) to:
- connect the recorder to a computer port and start and configure the ARSOFT-CFG-WZ1 application
- after the connection has been established, the current measured values and the internal time and date of the controller are displayed; the **[Tx/Rx]** icon indicates the presence of transmission (lower status bar, chapter 11.1)
- setting and viewing of the device parameters is possible in the parameter configuration window
- new parameter values must be approved with the ***Approve changes*** button
- the software enables synchronization of the time and the date with the computer
- the current configuration can be saved in a file on the disk or set using values read from a file
- **the recorder updates** the configuration files and **the displayed names after it is disconnected from the computer's USB port**
- online configuration via the USB port is possible only when the ***USB operation mode*** parameter is set as ***Available for computer (device)***, chapter 12.8.

NOTE: ⚠
- before disconnecting the device from a computer, press the ***Disconnect device*** button
- in the event of no response:
- in the ***Program options*** check the configuration of the port and the ***MODBUS Address of the device*** (in the case of the RS485)

- make sure that the serial port drivers have been installed correctly (chapter 8) - disconnect for a few seconds and then reconnect the controller to the USB port - restart the computer
3. From the configuration file created in the ARSOFT-CFG-WZ1 software or copied from another controller of the same type to copy the configuration, **off-line configuration**: - in ARSOFT-CFG-WZ1 set the required parameters (except for the **RTC** and the identification number **ID**) - a current configuration can also be prepared by modifying the values read from the existing files - save the created configuration in an *AR654.cfg* or *AR654.txt* file and save it in a USB memory - in the ***Memory and file options*** of the controller, import the configuration from the USB memory, chapter 12.6. - after the configuration has been completed, the memory can be disconnected from the USB socket

As an alternative to the configuration methods described above, the user can prepare his own application using the available serial interfaces and the MODBUS-RTU or MODBUS-TCP communication protocol.
In the event of differences between the indications and the actual value of the input signal, the zero and the sensitivity of a sensor can be adjusted in the ***Measurement inputs configuration*** menu: the ***Offset calibration*** and the ***Slope calibration*** (sensitivity) parameters, chapter 12.3.
In order to restore the factory settings, the ***Restore default*** file action can be used, which is described in chapter 12.6.

NOTE: ⚠
Do not shut down the power supply during the configuration performed using the keypad or on-line (via the computer's USB port) because the changed parameter values are stored in the internal memory after the user exits the ***Main Menu*** (by pressing the **[ESC] button)** or disconnects the device from the USB socket.

12.1. MEANING OF ICONS IN THE MENU ITEMS

In order to improve the ease of use and configuration of the device, additional graphic descriptive elements were added to the menu in the form of icons (pictograms).
The shared meaning of some icons described the type of menu item is the following:

Icon	Type of menu item (parameter)
P	parameter that can be modified using the buttons and the touch screen, saved in the internal memory
i	informative item, not modified directly using the buttons and the touch screen
A	file or disk action (operation) (chapter 12.6)

12.2. CONFIGURATION OF MEASUREMENT CHANNELS OF THE DISPLAY

The controller has 4 measurement channels to present the measured values on the display. ***The measured values*** can be directly the measurements from inputs 1÷4 or their mathematical formulas, such as difference, average, sum, larger or smaller than, or ratio of the measurements. The measurement channels, together with the assigned and switched on control and retransmission outputs, form control channels that are shown on the screen, for which ***Quick configuration screens*** are also available (chapter 11.7) for the basic control/alarm parameters (setpoint values **SP**, Start/Stop, etc.). If there are no related outputs, the message ***STOP, no output*** is displayed in the control status and the message "**------**" is displayed in the field of the ***SP*** and ***MV*** values (if they are present in the specific view, chapter 11). The method of assignment and configuration of the control and retransmission outputs is described in detail in chapter 12.4.

Table 12.2. Configuration parameters in the ***Display channel configuration*** menu for the selected channel (1÷4)

Parameter	**Range of variability of the parameter and description**		**Default settings**
Name, unit and group	edition of the name of the channel and the group (max. length 16 characters) and of the measurement unit (4 characters) is possible on the computer (via the USB port or the Ethernet and the ARSOFT-CFG-WZ1 software or by copying the configuration - chapter 12.9). The format of a single section in the *AR654.txt* file is the following: *[Chan1] Name=**Channel 1**, Unit=**°C**, [Group1] Name=**Group 1***		*Channel i* (for i=1÷4), *°C*, *Group j (*for j=1÷4*)*
Measured value to be displayed	***None*** - the measurement channel is absent in the presentation and in the recording		*Measurement from the input IN i* (for i=1÷4)
	Measurement from the input IN1	***Average (IN1+IN2+IN3)/3***	
	Measurement from the input IN2	***Average (IN1+IN2+IN3+IN4)***	
	Measurement from the input IN3	***The largest of the measurements IN1 and IN2***	
	Measurement from the input IN4	***The largest of the measurements IN3 and IN4***	
	Difference between the measurements IN1-IN2	***The largest of the measurements IN1, IN2, and IN3***	
	Difference between the measurements IN3-IN4	***The largest of the measurements IN1, IN2, IN3, and IN4***	
	Difference between the measurements IN1-IN2-IN3	***The smallest of the measurements IN1 and IN2***	
	The difference IN1-IN2-IN3-IN4	***The smallest of the measurements IN3 and IN4***	
	Sum of the measurements IN1+IN2	***The smallest of the measurements IN1, IN2, and IN3***	
	Sum of the measurements IN3+IN4	***The smallest of IN1,IN2,IN3,IN4***	
	Sum of the measurements IN1+IN2+IN3	***(IN1+IN2)/2 - (IN3+IN4)/2***	
	Sum of IN1+IN2+IN3+IN4	***The ratio of the measurements IN1/IN2***	
	Average (IN1+IN2)/2	***The ratio of the measurements IN3/IN4***	
	Average of the measurements (IN3+IN4)/2		
Assigned and active outputs	the numbers (***1***÷***4*** or ***None***) of the control/alarm outputs are displayed for which the same type of ***control signal*** was assigned as the ***Measured value*** of the current display channel, chapter 12.4.1, when ***None*** for the output is not related or switched off (the parameter ***Control type*** = ***Off***)		*1÷4*
Bottom range for graphics and SP	***-999.9*** ÷ ***9999.9°C*** or ***-9999*** ÷ ***99999*** units **(1)** – the lower value of the range of variability for graphic elements (bar graph, counter, diagram) and for the setpoint values SP of the related control outputs (1÷8)		*-100.0 °C*
Top range for graphics and SP	***-999.9*** ÷ ***9999.9°C*** or ***-9999*** ÷ ***99999*** units **(1)** – the upper value of the range of variability for graphic elements (bar graph, counter, diagram) and for the setpoint values SP of the related control outputs (1÷8)		*800.0 °C*
Assignment of the measurement group	channel ***Belongs to all*** groups or only to one group in the range of ***1*** ÷ ***4***, channel grouping is used in the measurement presentation modes		*Group i* (for i=1÷4)
Background colour	selection of the background colour in the measurement presentation modes, 23 colours are available		*colour*

Notes: (1) - applies to analogue inputs (mA, V, mV, Ω)

12.3. CONFIGURATION OF MEASUREMENT INPUTS

The controller has 4 universal measurement inputs for connecting temperature sensors and electrical signals. Table 12.3. Configuration parameters in the ***Measurement inputs configuration*** menu for the selected input (numbers 1÷4)

Parameter [P]	Range of variability of the parameter and description		Default settings
Input type	***Off***	the measurement input is absent in the presentation and in the recording	
	Pt100	thermoresistance sensor (RTD) Pt100 (-200 ÷ 850°C)	*Pt100*
	Pt500	thermoresistance sensor (RTD) Pt500 (-200 ÷ 620°C)	
	Pt1000	thermoresistance sensor (RTD) Pt1000 (-200 ÷ 620°C)	
	Ni100	thermoresistance sensor (RTD) Ni100 (-50 ÷ 170°C)	
	J *(Fe-CuNi)*	thermoelectric sensor (thermocouple) type J (-40 ÷ 800°C)	
	K *(NiCr-NiAl)*	thermoelectric sensor (thermocouple) type K (-40 ÷ 1,200°C)	
	S *(PtRh 10-Pt)*	thermoelectric sensor (thermocouple) type S (-40 ÷ 1,600°C)	
	B *(PtRh30PtRh6)*	thermoelectric sensor (thermocouple) type B (-300 ÷ 1,800°C)	
	R *(PtRh13-Pt)*	thermoelectric sensor (thermocouple) type R (-40 ÷ 1,600°C)	
	T *(Cu-CuNi)*	thermoelectric sensor (thermocouple) type T (-25 ÷ 350°C)	
	E *(NiCr-CuNi)*	thermoelectric sensor (thermocouple) type E (-25 ÷ 850°C)	
	N *(NiCrSi-NiSi)*	thermoelectric sensor (thermocouple) type N (-35÷ 1,300°C)	
	4÷20 mA	current signal 4...20 mA	
	0÷20 mA	current signal 0...20 mA	
	0÷10 V	voltage signal 0...10 V	
	0÷60 mV	voltage signal 0...60 mV	
	0÷850 Ω	resistance signal 0...850 Ω	
Line resistance **(1)**	***0.00÷50.00 Ω***	total resistance of leads for 2-wire RTD sensors and 850 Ω	*0.00 Ω*
Thermocouple cold tip temperature	***Auto*** ***0.1÷ 60.0 °C***	automatic or constant compensation of temperature of the cold junction of thermocouples, ***Auto*** = ***0.0°C***	*Auto*
Decimal dot position/resolution	***None***	0, no point **(2)** or resolution 1 °C for temperature	*Position 1 (0.1°C)*
	Position 1	0.0 **(2)** or resolution 0.1 °C for temperature	
	Position 2	0.00 **(2)**	
	Position 3	0.000 **(2)**	
Start of the input scale	***-199.9*** ÷ ***1999.9 °C*** or ***-9999*** ÷ ***19999*** units **(2)** – indication for 0 mA, 4 mA, 0 V, 2 V, 0 mV, 0 Ω - start of the input scale		*-100.0 °C*
End of the input scale	***-199.9*** ÷ ***1999.9 °C*** or ***-9999*** ÷ ***19999*** units **(2)** – indication form 20 mA, 10 V, 60 mV, 850 Ω - end of the input scale		*800.0 °C*
Filtration **(3)**	***1*** ÷ ***10***	digital filtration of measurements (response time)	*1*
Offset calibration	zero offset: ***-50.0*** ÷ ***50.0 °C*** or ***-500*** ÷ ***500*** units **(2)**		*0.0 °C*
Slope calibration	sensitivity (gain): ***85.0*** ÷ ***115.0 %***		*100.0 %*

Notes: (1) - in the case of 3-wire sensors, the ***Line resistance*** parameter must be equal to ***0.00 Ω*** (automatic compensation)

(2) - applies to analogue inputs (mA, V, mV, Ω)

(3) - in the case of ***FiLtration***=***1*** the response time is equal to 1 s, in the case of ***FiLtration*** = ***10*** it is equal to at least 2.5 s. Higher degree of filtration means a "smoother" measured value and a longer response time, which is recommended in the case turbulent measurements (e.g. water temperature in the boiler without an agitator)

12.4. CONTROL AND ALARMS OPTIONS

The programmable architecture of the controller enables using it in many fields and applications. Before the operation of the device starts, it is necessary to set the parameters according to specific requirements. A detailed description of the output operation configuration is given in the following subchapters. The company setting (default configuration) are the following: outputs P1/SSR1÷ P4/SSR4 related to inputs IN1÷IN4, constantly switched on control of the ON-OFF type with hysteresis, setpoint values *SP=SP1*, optional analogue outputs (mA/V) 5÷8 switched off.
The ***Control and alarms options*** menu consists of sets of parameters grouped in the way shown in the table below (12.4).

Table 12.4. Items in the ***Control and alarms options*** menu

Name of parameters set	Description
Output 1 (P1/SSR1)+5 (mA/V), BIN1 ÷ ***Output 4 (P4/SSR4)+ 8 (mA/V), BIN4***	4 identical sets of configuration parameters for individual bi-state outputs (P/SSR) and their related optional analogue outputs (mA/V) and binary inputs (BIN); a detailed description is given in chapter 12.4.1
Set of PID1 parameters ÷ ***Set of PID8 parameters***	8 independent parameters sets for control of the PID type, the sets can be assigned to different setpoint values; a detailed description is given in chapter 12.4.2
Program 1 ÷ ***Program 4***	4 parameters sets for 12-section program control, the programs can be freely assigned to control outputs; a description is given in chapter 12.4.3

12.4.1. OUTPUT (P/SSR, mA/v) AND FUNCTION INPUT (BIN, F1) CONFIGURATION

Outputs can be assigned to measurement inputs and their mathematic formulas completely independently from the measured values presented for the measurement channels. For outputs that are not related to any displayed measurement channels, the ***Quick configuration screen*** (chapter 11.7) is not available and the operating parameters of those outputs must be configured in the ***Control and alarms options*** menu. The device also enables configuration of the output operation time. If the control/alarm status depends on the real time clock, it is necessary to program the ***Control time*** and ***Start*** and ***End of time control*** parameters, respectively, and to set the ***State of control after power up*** parameter to the ***No change*** value. If it is necessary to start the control for a strictly defined time (timer function), it is necessary to additionally use the functionalities offered by the program control (chapter 12.4.3). Moreover, at any time, the user can check the control status using the **[F]** button and the **[Start]**/**[Stop]** and **[F1]** buttons available in the ***Quick configuration screen***, as well as the optional function inputs **BIN**. Detailed descriptions of the configuration parameters and problems related to the operation of the control outputs can be found in the following table and in the successive subchapters.

Table 12.4.1. Configuration parameters in the ***Control and alarms options*** menu for the selected output (numbers 1÷4)

Parameter [P]	Range of variability of the parameter and description	Default settings
Assignment of control signal	***None*** - the output is switched off or can work only in the manual mode	*Measurement from the input IN i* (for i=1÷4)
	menu items (values) the same as for the ***Measured value to be displayed*** parameter in the ***Display channels configuration*** menu (chapter 12.2)	
	Program auxiliary output 1÷4 - output controlled from the program control level (related to the program and the status of the output set by the parameters ***Auxiliary output selection*** and ***Auxiliary output state*** for any of the sections of ***Program 1÷4***; a description is given in chapter 12.4.3)	

<table>
<tr><td rowspan="5">Control/alarm type

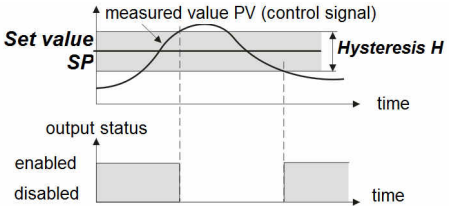
(applies to each type of control: ON-OFF with hysteresis, PID, and program)</td><td>Off</td><td>constantly switched off output</td><td rowspan="5">Disabled</td></tr>
<tr><td>Inverted /heating</td><td> 

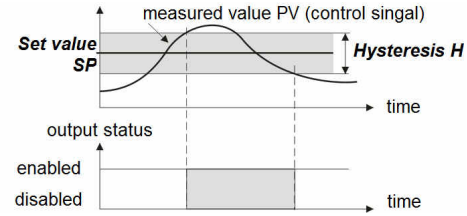
Fig. 12.4.1.1. Characteristics of the Heating type (for ON-OFF)</td></tr>
<tr><td>Direct/cooling</td><td> 

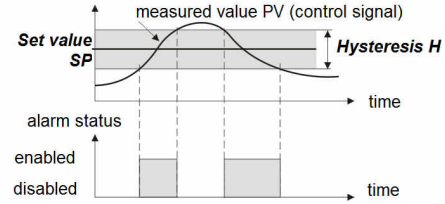
Fig. 12.4.1.2. Characteristics of the Cooling type (for ON-OFF)</td></tr>
<tr><td>Inside of the band (only alarm, not available for control of the PID type and program control)</td><td> 

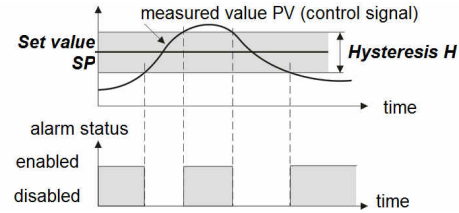
Fig.12.4.1.3. Characteristics of an Inside of the band alarm (ON-OFF)</td></tr>
<tr><td>Outside of the band (only alarm, not available for control of the PID type and program control)</td><td> 

Fig.12.4.1.4. Characteristics of an Outside of the band alarm (ON-OFF)</td></tr>
<tr><td>M Manual mode</td><td>the output works in the manual mode controlled with the parameters Setpoint value for the manual mode and Pulsing period for the manual mode (described further in this table)</td></tr>
<tr><td rowspan="6">Setpoint value (SP) selection</td><td colspan="2">Setpoint/alarm value SP1 – applies to SP1 and H1 from the current output</td><td rowspan="6">Set/alarm value SP1</td></tr>
<tr><td colspan="2">Setpoint/alarm value SP2 – applies to SP2 and H2 from the current output</td></tr>
<tr><td colspan="2">Measurement from input IN1 ÷ Measurement from input IN4</td></tr>
<tr><td colspan="2">Setpoint value SP from Program 1 ÷ Setpoint value SP from Program 4 – assignment of program control to the current output, chapter 12.4.3</td></tr>
<tr><td colspan="2">Selected value SP from Output 1 – both SP and Hysteresis and Selection of PID parameters for SP are common and taken from the 1st output</td></tr>
<tr><td colspan="2">SP from Output 1 + actual SP1 (SP1 as an offset for 3-way control)</td></tr>
<tr><td>Setpoint/Alarm value SP1</td><td colspan="2">-999.9 ÷ 9999.9°C or -9999 ÷ 99999 units (1) – setpoint value 1</td><td>50.0 °C</td></tr>
<tr><td>Hysteresis H1</td><td colspan="2">0÷500.0°C or 0÷5000 units (1) - hysteresis 1 or tuning zone PID (chapt. 12.4.2.2)</td><td>1.0 °C</td></tr>
</table>

PID selection for SP1 and SP=IN	***None (ON-OFF)*** – control/alarm of the ON-OFF type with hysteresis PID ***Set of PID1 ÷ PID8 parameters*** - control of the PID type, chapter 12.4.2		assignment of a set of PID parameters to the ***Set point value SP1*** and to the ***Setpoint value SP*** taken from ***input IN*** when the measurement is smaller than or equal to the ***SP1*** value (SP=IN and SP≤SP1), so-called gain scheduling	*None (ON-OFF)*
Setpoint/Alarm value SP2	***-999.9 ÷ 9999.9°C*** or ***-9999 ÷ 99999*** units **(1)** – setpoint value 2			*50.0 °C*
Hysteresis H2	***0÷500.0°C*** or ***0÷5000*** units **(1)** - hysteresis 2 or tuning zone PID (chapt. 12.4.2.2)			*1.0 °C*
PID Selection for SP2 and SP=IN	***None (ON-OFF)*** – control/alarm of the ON-OFF type with hysteresis PID ***Set of PID1 ÷ PID8 parameters*** - control of the PID type, chapter 12.4.2		assignment of a set of PID parameters to ***Set point value SP2*** and to ***Set point value SP*** taken from ***input IN*** when the measurement is larger than the ***SP1*** value (SP=IN and SP>SP1), so-called gain scheduling	*None (ON-OFF)*
Autotuning of PID parameters (a description can be found in chapter 12.4.2.2)	***Disabled*** ***Automatic selection (continuous mode)*** ***Step response method (quick)*** ***Oscillation method (slower)***		selection of the PID parameters selection algorithm (autotuning), the calculated data is saved in the ***Set of PID parameters*** related to the ***Selected setpoint value SP*** for the current output	*Disabled*
Set point value for the manual mode	***0 ÷ 100 %*** 1% step	control value for outputs in the manual mode (open control loop), chapter 12.4.1.3		*50 %*
Pulsing period for the manual mode	***1 ÷ 360*sec.**	applies only to bistate outputs (P/SSR), in the case of analogue outputs (mA/V), the parameter is insignificant, chapter 12.4.1.3		*5 sec.*
Output emergency state	***No change*** ***OFF state (MV=0%)*** ***ON state (MV=100%)*** M ***Manual mode with a set value***		status of the control/alarm outputs if the measurement range of the control signal is exceeded or in the case of a failure/error of a sensor/measurement module, chapter 15	*No change*
State of control after power up	***Disabled (Stop)***	***Enabled (Start)***	***No change (Start or Stop)***	*No change*
Control time (with the possibility of manual control using the **[Start]**/**[Stop]**, **[F]**, and **[F1]** buttons - chapter 10, and function inputs **BIN**, chapter 7b)	∞ ***Continuous***	constantly enabled control		*Continuous*
	Limited by date and time	recording is active within the range of the ***Date*** and the ***Time*** defined by the parameters ***Start*** and ***End of time control***		
	Periodic daily (hourly)	hourly control is active within the range of the ***Time*** defined by the parameters ***Start*** and ***End of time control***		
Start of control time ***End of control time***	***Date***: ***01.06.2008 ÷ 31.12.2099***, ***Time***: ***00:00:00 ÷ 23:59:59***, the parameters are active when ***Control time*** = ***Date and time limited*** or ***Periodic daily (hourly)***			*2013.06.01 00:00:00*
Alarm sound signal	***Disabled*** ***Enabled***	signalling of enabling of the P/SSR output with a built-in buzzer. The alarm can also be controlled from the level of the **[F]** function button, chapter 10, item c.		*Disabled*
E-mail alarm notifications	***Disabled*** ***Enabled***	a service that enables signalling of enabling of the P/SSR output via an email message; a description can be found in chapter 12.4.1.4		*Disabled*
F1 button and BIN input function	***None*** ***Selection of the setpoint SP (SP1/SP2)*** ***Manual mode for outputs (Auto/Manu)*** ***Start/Stop control***		applies to the P/SSR and mA/V output when it is present and the parameter ***Analogue output (mA/V) function*** = ***Control***, the **BIN** input always has a higher priority than the **[F1]** button	*None*

***Analogue output (mA/V) function* (2)** (a description can be found in chapter 12.4.1.2)	***Off***		inactive output (0 mA or 0 V)		*Off*
	Retransmission of the measured value		in the scope defined by the parameters ***Start*** and ***End of scale...***		
	Retransmission of the setpoint (SP)				
	Control (according to control type)		the control parameters are in force		
***Output (mA/V) and standard selection* (2)**	***0÷20 mA***	***4÷20 mA***	***0÷10 V***	***2÷10 V***	*0÷20 mA*
***Start of the retransmission scale (mA/V)* (2)**	start of the output scale = for signal value of 0/4 mA or 0/2 V (the parameter is active when the ***Analogue output (mA/V) function*** = ***Retransmission...***)				*0.0 °C*
***End of the retransmission scale (mA/V)* (2)**	end of the output scale = for signal value of 20 mA or 10 V (the parameter is active when the ***Analogue output (mA/V) function*** = ***Retransmission...***)				*100.0 °C*

Notes: **(1)** – applies to analogue inputs (mA, V, mV, Ω)

(2) – the parameter is not available in the version of the controller without the optional mA/V outputs and BIN inputs module

12.4.1.1. SELECTION OF SETPOINT VALUES , OPERATION MODES, AND START OF CONTROL

Each of the control outputs of the controller has the possibility to select the type of the setpoints and of the hystereses for control/alarm directly with the parameters ***Setpoint (SP) selection*** or directly with functional buttons **[F1]** or optional inputs **BIN** programmable with the parameters ***F1 button and BIN input function*** described in table 12.4.1. Two setpoints values are available (SP1, SP2), measurement from any input (INPUT1÷4), setpoint value from one of the programs (1÷4), common setpoint value taken from the 1st output (which also enables performance of 3-way control on 2 outputs with an insensitivity/offset, e.g. for simultaneous control of heating and cooling, humidifying, and drying elements, or for three-way valves). The possibility to take the setpoint value from any measurement input may be useful, e.g. for connecting controllers in cascades and/or for remote setting setpoint values using standard electrical signals (mA, V, resistance) generated by other controllers, setters, potentiometers, etc.

The simplest way to change the edited setpoint values for inputs related to the displayed measurement channel is to use the ***Quick configuration screen*** (chapter 11.7). As an alternative, it is possible to change the setpoint values in the parameter configuration mode (using the methods described in chapter 12).

The outputs can work in the automatic mode (ON-OFF type with hysteresis, PID, autotuning PID, program control) or in the manual mode (chapter 12.4.1.3), which is indicated in the control status visible in the window of the *CONTROL* type (chapter 11.2) and on the ***Quick configuration screen*** (chapter 11.7). The selection between the ON-OFF and PID types of control is made using the parameters ***PID selection for SP...*** both for the setpoint values of individual outputs (chapter 12.4.1), and for sections of program control (chapter 12.4.3). Program control is selected using the ***Setpoint (SP) selection*** parameters. Detailed descriptions of the parameters can be found in chapter 12.4.1.

Control outputs are started at the time when control is started automatically (***after power supply is switched on*** or by ***Control time***), or manually (using the **[Start]**/**[Stop]**, **[F]**, and **[F1]** buttons available in the ***Quick configuration screen*** and using the optional function inputs **BIN)**, depending on the configuration of the parameters in table 12.4.1.

12.4.1.2. ANALOG OUTPUTS (mA/V)

Analogue outputs are present when the optional output (OUTPUT5÷8) and binary input (BIN1÷5) module is present; they are logically connected to outputs 1÷4 (P/SSR). The parameters ***Output (mA/V) and standard selection*** define the type of signal used: mA or V (chapter 12.4.1). The mode of operation of the output is defined by the ***Analogue output (mA/V) function*** parameters. In the mode ***Retransmission of the measured value*** or ***the setpoint value (SP)***, the output signal is proportional to the measured ***Assigned control signal*** or the ***Selected setpoint value SP*** in the range set by the parameters ***Start*** and ***End of the retransmission scale (mA/V)*** (e.g. 0 mA for the measured value 0 °C when ***Start of the scale*** = 0 °C, 20 mA for 100 °C when ***End of the scale*** = 100 °C and, as appropriate, 10 mA for the half of the range, i.e. 50 °C). In the control output mode, the control parameters and the functions performed are the same as for the P/SSR outputs (all configuration parameters for the P/SSR outputs, the PID algorithm, and the program control are applied). In the control mode, the range of variability of the analogue

signal is continuous (i.e. MV=0÷100%) only for the PID algorithm (chapter 12.4.2.1) and the manual mode (chapter 12.4.1.3), for ON-OFF type control with hysteresis, the output accepts only limit values (lower value, MV=0%, or upper value, MV=100%, e.g. 0 mA or 20 mA), without intermediate values (e.g. 5 mA).

12.4.1.3. MANUAL AND REMOTE CONTROL FUNCTION

The manual mode enables continuous setting of the value of the output signal in the entire range of its variability (0-100%), thus enabling operation in an open control loop (no automatic coupling between the measured value and the output signal). The step of the changes is equal to 1% and the start value is the ***Set point value for the manual mode*** (after the power supply is switched on) or the last value in the automatic mode (in the course of operation). Manual operation is available individually for each output of the controller and is programmed using the ***Control/alarm type*** parameters. Details are given in the chapter and in table 12.4.1. Also, the outputs can be configured for quick manual mode controlled by:

- function buttons **[F1]** or the optional binary inputs **BIN**, programming the parameters ***F1 button and BIN input function*** to have the value ***Manual mode for outputs (Auto/Manu)***
- an error of the measurement channel (range exceeded or defective sensor) when the ***Output emergency state*** is set as ***Manual mode with a set value***

In the case of bistate outputs (P/SSR), a change of the output signal consists in setting a filling coefficient (with the parameter ***Setpoint value for the manual mode***), with a defined ***Pulsing period for manual mode***. The ***Setpoint value for the manual mode*** = ***0*** means that the output is constantly disabled (OFF), and the value of 100 means that the output is constantly enabled (ON). This value can be set directly from the ***Quick configuration screen*** (chapter 11.7) or, as an alternative, using one of the parameter configuration methods (from the film keypad and the touch screen of the controller, or remotely using the Ethernet, RS485, or USB serial port, see chapter 12).
The manual mode can also be used as the ***Auxiliary output state*** for sections in the program control (chapter 12.4.3), which can be useful to control the actuator elements (e.g. heating/cooling) with power control or for impulse optical/acoustic signalling. The operation status and the setpoint value of the output signal (***SP***, ***MV***) can be seen in the window of the *CONTROL* type (chapter 11.2) and on the ***Quick configuration screen***.

12.4.1.4. EMAIL ALARM NOTIFICATIONS

The use of the email service requires a properly configured Ethernet interface (as described in chapter 12.8 *COMMUNICATION SETTINGS...)* and access parameters to the email account (SMTP outgoing mail server). The configuration data of the email client is stored in the *AR654.txt* file. The way to access this data is described above in chapter 12.8, in Table 12.8, in item ***Email settings and status***. In order to eventually start the configured service, the ***Email alarm notifications*** parameter must additionally be set to the ***Enabled*** value (chapter 12.4, Table 12.4.2). Message can be sent to multiple recipients at the same time. Notifications are sent whenever any of the alarm outputs is switched on.

The individual components of the email message are created in accordance with the following rules:

- the **Subject** field contains the *NetBIOS name* of the device (default value *AR654*; the description can be found in chapter 12.8, Table 12.8);
- the **From** (Sender) field contains the address of the email (SMTP server) user;
- in the **body** of the message there are the numbers of the active alarm outputs and the numbers, names, units, and measured values of the measurement channels that caused the alarms.

For the purpose of text representation, Windows-1250 code page is used.

If a new alarm occurs, the device attempts to send an email until it is successful or until the relevant alarm is switched off. Because the device only sends notifications about current alarms and does not create a queue (history) to be sent, one must keep in mind that if the mail server is not accessible the alarms taking place at that time may not be noticed.

The number of emails sent is displayed in the device status window (which can be called using the **[F]**+**[ESC]** or **[F]** button, see chapter 10) and in the menu item ***Email settings and status*** (Table 12.8).

By using online SMS gateways, the emails can also be sent in the form of text messages to cell phones operating in GSM networks.

NOTE: ⚠

Before the *AR654.txt* file is modified manually in a text editor, a backup copy must be made of the file (to use later in the event of problems with improper configuration and the need to restore the default settings).

12.4.2. SETS OF PID PARAMETERS

The controller has 8 independent sets of PID parameters that can be freely assigned to both setpoint values for individual outputs and to sections of program control using the ***PID selection for the SP*** parameters (directly to ***SP1*** and ***SP2*** for the outputs, chapter 12.4.1, and to ***SP*** for program sections, chapter 12.4.3). A description of the principles of operation of PID control and automatic selection of parameters (autotuning), and tips concerning manual correction can be found in the subchapters below (12.4.2.1÷12.4.2.3).

Table 12.4.2. Configuration parameters in the ***Control and alarms options*** menu for the selected PID set (1÷8)

Parameter [P]	**Range of variability of the parameter and description**		**Default settings**
[i] ***Assigned and active outputs***	the numbers (***1***÷***4*** or ***None***) are displayed of the control outputs to which the presented PID set is assigned (related by the parameters ***PID selection for the SP...***, a description is given in chapters 12.4.1 and 12.4.3), when ***None***, the set is not used or the outputs are disabled (parameter ***Control type*** = ***Off***)		*None*
Proportional band Pb	***0.1***÷ ***1800.0 °C*** or ***1*** ÷ ***18000*** units **(1)** , the related subjects are described in chapters 12.4.2.1÷12.4.2.3		*1.0 °C*
Integration time constant Ti	***0*** ÷ ***3600*** **sec.**	PID algorithm doubling time, ***0*** switches off the integrating component of the PID algorithm	*0 sec.*
Differentiation time constant Td	***0*** ÷ ***999*** **sec.**	PID algorithm lead time, ***0*** switches off the differentiating component of the PID algorithm	*0 sec.*
Pulsing period Tc for the P/SSR output	***3*** ÷ ***360*** **sek**	applies only to bistate outputs (P/SSR), in the case of analogue outputs (mA/V), the parameter is insignificant	*5 sec.*

Notes: **(1)** – applies to analogue inputs (mA, V, mV, Ω)

12.4.2.1. PID REGULATION

The PID algorithm enables achieving smaller control errors (e.g. temperature) than the ON-OFF method with hysteresis. However, the algorithm requires selecting the characteristic parameters for the specific controlled object (e.g. a furnace). In order to simplify the operation, the controller is provided with the advanced PID parameter selection functions described in chapter 12.4.2.2. Also, it is always possible to manually correct the settings (chapter 12.4.2.3).

PID type control is active when the ***PID Selection for the SP...*** parameter (both for the setpoint values for the individual outputs, chapter 12.4.1, and for sections of program control, chapter 12.4.2) indicates one of the ***Sets of PID parameters*** (chapter 12.4.2). The location of the ***Proportional band Pb*** in relation to the setpoint value ***SP*** is shown in drawings 12.4.2.1 a) and b). The impact of the integrating and differentiating component of the PID control is set by the parameters ***Integration time constant Ti*** and ***Differentiation time constant Td***. The parameter ***Impulse parameter Tc*** applies only to outputs of the P/SSR type. If the PID algorithm is implemented by the 0/4÷20 mA or 0/2÷10 V analogue output, the ***Pulsing period Tc*** parameter is insignificant. Then the output signal may assume intermediate values from the entire range of variability of the output. Regardless of the type of the output, the correction of its state always takes place every 1 s.

The principle of P-type control (proportional control) for the P/SSR output is shown in figures d) and e) and, that for the analogue output, in figure c).

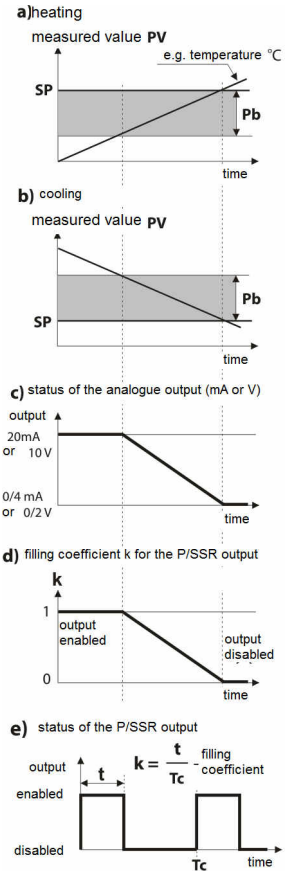


Fig. 12.4.2.1. Principle of operation of PID control:

a) location of the range of proportionality ***Pb*** in relation to the setpoint value ***SP*** for heating (parameter ***Control type*** = ***Reverse/heating***)

b) location of the range of proportionality ***Pb*** in relation to the setpoint value ***SP*** for cooling (***Control type*** = ***Direct/cooling***)

c) state of the 0/4÷20 mA or 0/2÷10 V analogue output

d) filling coefficient for the bistate output of the P/SSR type

e) state of the P/SSR output (for the measured value within the proportionality range ***Pb***)

12.4.2.2. AUTOTUNING OF PID PARAMETERS

In order to use the PID parameter selection function for a specific control output, it is firs necessary to select the ***Set of PID parameters*** (using the parameters ***PID selection for SP1*** or ***SP2***, chapter 12.4.1) for which the calculated data will be saved, and then to set the autotuning type (using the parameter ***Autotuning of PID parameters***). The autotuning starts at the time of start of the control (automatic or manual, chapter 12.4.1.1). Operation of autotuning is independent for each of the outputs and is signalized with the message ***ST-PID*** in the status of the control channel shown in the window of the *CONTROL* type (chapter 11.2) and in the ***Quick configuration screen*** (chapter 11.7).

The value of the ***Autotuning of PID parameters*** determines the selection of the method of selection of PID parameters:

a) ***Automatic selection (continuous mode)*** - the controller continuously checks if there are appropriate conditions for starting the tuning and tests the object in order to select the proper method. The algorithm continuously forces operation in the PID mode. The necessary condition for initiation of the PID parameters selection procedure is the location of the current measured value ***PV*** (indicated by the parameter ***Assignment of control signal***) outside of the insensitivity zone defined as the sum of the values of the parameters ***Proportional band***

Pb and the associated ***Hysteresis H*** (***H1*** or ***H2***) in relation to the ***Selected setpoint value SP***, as shown in figure 12.4.2.2.

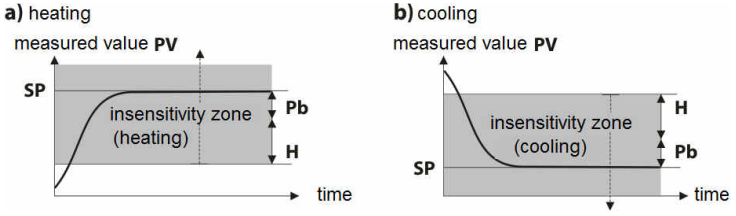


Fig. 12.4.2.2. Location of the insensitivity zone for the ***Control type*** of ***heating*** and ***cooling***.

In order to avoid unnecessary activation of tuning, which may slow down the process, it is recommended to set the highest possible value of the assigned ***Hysteresis H***, not less than 10÷30% of the range of variability of the process (e.g. the measured temperature). Testing of the object with temporary switchoff of the output and the ***ST-PID*** message in the control status also takes place in the insensitivity band if sudden changes in the measured value ***PV*** or the setpoint value ***SP*** are detected. The choice of the parameter selection method depends on the nature of the initial conditions. In the case of a stabilized controlled value, the ***Step response method (quick)*** is selected; otherwise, the ***Oscillation method (slower)*** is selected.

Automatic selection enables optimum selection of the PID parameters for the current conditions at the object, without the user's involvement. It is recommended for variable value regulation (disturbance of the conditions determined during the operation due to the change of, e.g. the setpoint value or the weight of the furnace batch).

b) ***Step response method (quick)*** - selection of parameters in the run-up phase (response to step function). During determination of the object's characteristics, the algorithm does not cause any additional delay in reaching the setpoint value. This method is intended specifically for objects of stabilized initial value of the controlled value (e.g. temperature in a cold furnace). In order to avoid disturbing stabilized initial conditions, before the automatic tuning is switched on, the power supply of the operating element (e.g. a heater) should be switched off using an external connector or the regulation start/stop function should be used (buttons or **BIN** inputs). The power supply must be switched on immediately after the tuning is started, in the output switch-on delay phase. If the power supply is switched on later, an erroneous analysis of the object and improper selection of PID parameters will result.

c) ***Oscillation method (slower)*** - selection of parameters using the oscillation method. The algorithm consists in measuring the amplitude and the period of oscillation on a slightly lower level (in the case of heating; higher level - in the case of cooling) than the setpoint value, thus eliminating the risk of exceeding the target value at the object testing stage. During determination of the object's characteristics, the algorithm causes additional delays in reaching the setpoint value. This method is intended specifically for objects of unstable initial value of the controlled value (e.g. temperature in a hot furnace).

The algorithms described in items **b** and **c** comprise the following steps:
- delay of output switch-on (approx. 15 s);
- time for switching on the power supply of the operating element (heating/cooling power, fan, etc.);
- determination of the object's characteristics;
- calculation and permanent saving of data (***Pb***, ***Ti***, ***Td***, and ***Tc***, chapter 12.4.2), in a selected ***Set of PID parameters***
- enabling control for a selected output with new PID settings

Program interruption of autotuning **b** or **c** (with a window with information on the cause of the interruption of the algorithm, chapter 15) may take place if the conditions for proper operation of the algorithm are not met, such as:
- the initial value ***PV*** is larger than the setpoint value ***SP*** for heating or smaller than the setpoint value for cooling;
- the maximum tuning time (4 hours) has been exceeded;
- the process value is changing too fast or too slowly.

It is recommended to restart the automatic tuning **b** or **c** after a significant change in the ***SP*** threshold or the controlled object's parameters (e.g. the heating/cooling power, the batch weight, the initial temperature, etc.).
Due to its own time relationships and other operating parameters, autotuning does not work in the program control mode.

12.4.2.3. CORRECTION OF PID PARAMETERS

The automatic tuning function correctly selects the PID regulation parameters for most processes; however, sometimes it may be necessary to correct them. Due to the strong correlation between those parameters, only one parameter should be changed in the selected ***Set of PID parameters*** and the impact of the change on the process should be observed:

a) oscillations around the threshold - increase the ***Proportional band Pb*** or the ***Integration time constant Ti***, decrease the ***Differentiation time constant Td*** (or reduce by a half the ***Pulsing period Tc for the output***)

b) slow response - decrease the ***Proportional band Pb***, the ***Differentiation time constant Td***, and the ***Integration time constant Ti***

c) over-regulation - increase the ***Proportional band Pb***, the ***Differentiation time constant Td***, and the ***Integration time constant Ti***

d) instability - increase the ***Integration time constant Ti***

12.4.3. SETS OF PROGRAM CONTROL PARAMETERS

The controller makes it possible to create 4 independent control programs, each consisting of a maximum of 12 sections. The programs can be freely assigned to individual control outputs with the parameters ***Setpoint (SP) selection*** set to ***Setpoint value from Program 1÷4*** (chapter 12.4.1). Also, it is possible to define auxiliary outputs and sound alarms for individual sections of the program, which may be used for indicating the operation status and for switching on additional devices (fans, additional heating sections, etc.) The option of power control (when the ***Auxiliary output state*** parameter is set to ***Manual mode with a set value***); a description is given in the table 12.4.3. The diagram with an example of a configuration of a program consisting of 4 sections is shown in chapter 12.4.3.1. The program is started at the time of start of the control (automatically or manually, chapter 12.4.1.1) and is always performed from the start (the 1st section). In the *CONTROL* type window (chapter 11.2) and in the ***Quick configuration screen***, the status of operation of the program is shown in the line starting with the phrase PRGx (where x is the number of the program; the meaning of the individual fields is the following: *PRGx: the number of the current section/the number of all sections: the type of the stage*, e.g. *PRG1:4/5:60m* (program 1, section four out of the five sections used, remaining time of the section 60 minutes). Depending on the ***Stage type*** parameter, the *stage type* field can have the values described in the table below (12.4.3).

Table 12.4.3. The parameters in the ***Control and alarms options*** menu for the selected section (1÷12) of the program (1÷4)

Parameter	**Range of variability of the parameter and description**		**Factory settings**
Assigned and active outputs	the numbers (***1÷4*** or ***None***) are displayed of the control outputs to which the presented program is related (using the parameters ***Setpoint (SP) selection***) and of the auxiliary outputs for the current section of the program (set with the ***Assignment of the control signal*** parameter for the outputs and the ***Selection of auxiliary output*** parameter for the section); a description of the parameters is given in chapter 12.4.1 and in this table; if the value is ***None***, the program is not used or the outputs are disabled.		*None*
Stage type	***Gradient (PV/min)***	achievement of the ***Set point value SP*** with the set gradient (ramping) defined by the parameter ***Gradient (PV/min)***, the *stage type* field in the operation status has the value of *PV/min*	*Gradient (PV/min)*
	Stage time after reaching of the SP	the time countdown starts after the measured value reaches the band defined by the parameter ***Hysteresis and band for the start of the stage time***, the *stage type* field in the status shows *PV->SP* (achievement of the ***Setpoint value SP***) or the remaining ***Stage time*** (in minutes or seconds when time<1 min.)	
	Continuous (without a time limit)	the *stage type* field in the status always has the value *PV->SP* (achievement of the ***Setpoint value SP***), at the same time this is the last section of the program with constantly enabled control	
	End (stop)	the last section of the program, control stopped, status field *stage type = Stop*	

	Total stage time	the time is counted for the entire section, the field *stage type* in the status shows the remaining ***Stage time***	
Setpoint value (SP)	***-999.9 ÷ 9999.9°C*** or ***-9999 ÷ 99999*** units **(1)** – set value for the selected ***Control type***, chapter 12.4.1		*50.0 °C*
Hysteresis and band for the stage time start	***0 ÷ 500.0°C*** or ***0 ÷ 5000*** units **(1)** - the location and the importance of the hysteresis/band in relation to the ***Setpoint value (SP)*** are shown in chapter 12.4.1 in figures 12.4.1.1 and 12.4.1.2		*1.0 °C*
Gradient (PV/min) (inclination)	***-50.0 ÷ 50.0°C*** or ***-500 ÷ 500*** units **(1)** - for the performance of the gradient (ramping), the parameter is active when the ***Stage type*** = ***Gradient (PV/min)***		*1.0 °C*
Stage time	***0 ÷ 1440 min***, a step every 1 min, the parameter is active when the ***Stage type*** = ***Stage time after achievement of the SP*** or ***Total stage time***		*60 min*
PID parameters selection for the SP	***None (ON-OFF)*** – control of the ON-OFF type with hysteresis	assignment of a ready set of PID parameters selected for the ***Setpoint value (SP)***, PID autotuning does not work in the program control mode	*None (ON-OFF)*
	Set of PID1 ÷ PID8 parameters - control of the PID type, chapter 12.4.2		
Auxiliary output selection	***None*** or ***Program auxiliary output 1 ÷ 4*** - assignment of the defined output as an auxiliary output (under the same number) in the parameter ***Assignment of control signal***, chapter and table 12.4.1		None
Auxiliary output state	***OFF state (MV=0%)***	***ON state (MV=100%)***	*OFF state (MV=0%)*
	Manual mode with the set value and the ***Pulsing period*** taken from the parameters of the associated auxiliary output, chapter and table 12.4.1		
Sound signal	***Disabled***	signalling of the duration of the section with a built-in acoustic transducer (buzzer).	*Disabled*
	Enabled		

Notes: **(1)** – applies to analogue inputs (mA, V, mV, Ω)

12.4.3.1. CONFIGURATION OF AN EXAMPLE PROGRAM

A diagram showing example characteristics of program control for the ***Control type*** of the ***heating*** type (table 12.4.1) is shown here. At the time of the start of the process (control), the initial setpoint value for section 1 is the actual measured value (PV_0, e.g. 25 °C), the target value SP_C (e.g. 700 °C), which is achieved at the rate (gradient) of N1 (e.g. 25 °C/min). After the SP_C value is achieved and after control on this level for the time T2 set for the 2nd section (e.g. 90 min.), the program continues to the 3rd section which contains a cooling function at the rate of N3 (e.g. -10 °C/min.) to the level of SP_K (e.g. 60 °C). During the cooling, the auxiliary output can be used for example for switching on a fan. The program is stopped (and the control output is disabled) after the SP_K is achieved and after the program moves to the 4th section. The basic configuration parameters for the different sections are shown in the table below:

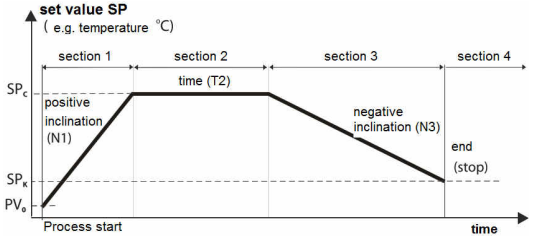


Fig. 12.4.3.1. A diagram showing an example program.

Section parameters	section 1	section 2	section 3	section 4
Stage type	***Gradient (PV/min)***	***Stage time after reaching of the SP***	***Gradient (PV/min)***	***End (stop)***
Setpoint value (SP)	**SP_C** (e.g. 700 °C)	**SP_C**	**SP_K** (e.g. 60 °C)	not applicable
Gradient (PV/min)	**N1** (e.g. 25 °C/min)	not applicable	**N3** (e.g. -10 °C/min)	not applicable
Stage time	not applicable	**T2**	not applicable	not applicable

12.5. RECORDING SETTINGS

Data is archived in a text file with a *csv* extension in the internal memory or the USB memory; a detailed description of the storage format is given in chapter 14. Data is recorded until the memory is full (at least 2 years of continuous operation with recording of 4 channels every 1 s) and then the recording is stopped and the message "*Memory full. Recording rejected*" is displayed (chapter 15). The recording must then be stopped (the ***Recording type*** must be set to the ***Off*** value, Table 12.5), the archive files must be copied for further analysis, and space must be freed up in the memory for future recordings. The selection of the memory for recording and the copying and deleting of existing *csv* files are accessible in the ***Main Menu*** -> ***Memory and file options***; a detailed description of operations performed on files is given in chapter 12.6. The ***Data recording interval*** must be adjusted according to the needs of a specific application.

Table 12.5. Configuration parameters in the ***Recording settings*** menu

Parameter	**Range of variability of the parameter and description**			**Default settings**
Data recording interval	1 s to 8 h (note 3 in the technical data, chapter 5) **(1)**			1 minute
Recording type **(2)** (chapter 14)	***Off***	recording switched off permanently	possibility to set those values using the **[F]** button, chapter 10, item c	*Disabled*
	Continuous	recording switched on permanently		
	Limited by date and time	recording is active within the range of the ***Date*** and the ***Time*** defined by the parameters ***Start*** and ***End of time limit***		
	Periodic daily (hourly)	recording is active within the range of the ***Time*** defined by the parameters ***Start*** and ***End of time limit***		
	Above the permission threshold	recording is active when the measured value defined by the ***Selection of permission channel*** parameter is larger than the value of the ***Permission threshold value*** parameter		
	Below the permission threshold	recording is active when the measured value defined by the ***Selection of permission channel*** parameter is smaller than the value of the ***Permission threshold value*** parameter		
	Only during control	recording is active when there is a permission for control for all outputs (can be controlled from the **[F]** button level of from the level of the optional input **BIN5**, chapters 7b, 10c, and 12.0		
Start of time limit	***Date***: ***01.06.2008*** ÷ ***31.12.2099***, ***Time***: ***00:00:00*** ÷ ***23:59:59***, the parameter is active when the ***Type of recording*** = ***Limited by date and time*** or ***Cyclical daily***			*2013.06.01 00:00:00*
End of time limit	***Date***: ***01.06.2008*** ÷ ***31.12.2099***, ***Time***: ***00:00:00*** ÷ ***23:59:59***, the parameter is active when the ***Type of recording*** = ***Limited by date and time*** or ***Cyclical daily***			*2013.06.01 00:00:00*
Selection of permission channel	menu items (values) the same as for the ***Measured value to be displayed*** parameter in the ***Display channels configuration*** menu (chapter 12.2), the parameter is active when the ***Recording type*** = ***Above*** or ***Under the permission threshold***			*Measurement from input 1*
Permission threshold value	***-999.9*** ÷ ***9999.9°C***, ***-9999*** ÷ ***19999*** **(3)** or ***-9999*** ÷ ***99999*** units **(3)** the parameter is active when ***Type of recording*** = ***Above*** or ***Below the permission threshold***			*50.0 °C*

Notes: **(1)** - the recording interval is counted from the moment the device is disconnected from the USB port
(2) - the device does not record data in a file when it is connected to the computer's USB port
(3) – applies to analogue inputs (mA, V, mV, Ω)

12.6. MEMORY OPTIONS AND OPERATIONS ON FILES

The controller enables performing standard operations on files and disks from the menu level. A list of possible actions is given in the table below (12.6). These functions are blocked after the device is connected to a computer's USB port, which is due to the principle service of exchangeable disks (mass memories) by the operating system (Windows).

Table 12.6. Configuration parameters and file operations in the ***Memory and file options*** menu

Parameter or file action (operation)	Description of the available file operations and parameters		Default settings
Memory status	***Cancel***	 **Fig. 12.6.** Appearance of the internal memory status screen The field "***Storage capacity:***" takes into account the ***Data recording interval*** (chapter 12.5) and the number of active display measurement channels (12.2)	
	Internal memory		
	USB memory		
Copy archives to the USB memory **(1)**	***Cancel***	return to the previous menu (higher level)	
	Copy	copy the archive (files with the *csv* extension) from the internal memory to the USB	
Delete all archives	***Cancel***	return to the previous menu (higher level)	
	Internal memory	delete the archive (files with the *csv* extension) in the internal memory	
	USB memory	delete the archive (files with the *csv* extension) in the USB memory	
Archive storage memory **(2)**	***Internal only***	archive files are created only in the internal memory	*Internal only*
	Auto select	archive files are created in the USB memory (when detected) or the internal memory (when there is no USB memory)	
Identification number (ID)	**0÷999**	an individual device number entered into the initial records in the archive file (*csv*) in order to distinguish archives from different controllers of the same type; it should be set before the recording starts	*0*
Copy the configuration to the USB memory	***Cancel***	return to the previous menu (higher level)	
	Copy	copy the current settings (*AR654.cfg* and *AR654.txt*) into the USB memory	
Configure from the USB memory	***Cancel***	return to the previous menu (higher level)	
	Parameters	copy the configuration parameters (*AR654.cfg*) from the USB memory	
	Names	copy the names of channels, groups, and units (*AR654.txt*) from the USB memory	
	All	copy all settings (*AR654.cfg* and *AR654.txt*) from the USB memory	
Reset to the default settings	***Cancel***	return to the previous menu (higher level)	
	Parameters	set the default configuration parameters (*AR654.cfg*) in the controller	
	Names	set the default names and units (*AR654.txt*) in the controller	
	All	set the default parameters and names (*AR654.cfg* and *AR654.txt*)	
Format the memory **(3)**	***Cancel***	return to the previous menu (higher level)	
	Internal memory	format the internal memory in the FAT32 system, preserving the current settings (parameters in the file *AR654.cfg* and names in the *AR654.txt* file)	

Notes: **(1)** - in the case of a 90 MB file, the copying time is equal to approx. 11 min. (approx. 135 kB/s, also depending on the type of memory)

(2) - ***Archive storage memory*** = ***Internal only*** prevents unintentional creation of an archive in the USB memory installed in the port by accident, in order to perform file operations, or by unauthorized personnel

(3) – formatting deletes all data from the memory (with the exception of configuration files); this operation is recommended in the event of problems with accessing data

NOTE:

- during file operations or formatting of memory, **do not shut down the power supply** and **do not take out the USB memory,** as this may cause a loss of recorded data or the current configuration (parameters and names)
- until the file operations or memory formatting is completed, recording is stopped and transmission of files with measurement data over the Ethernet from the ARSOFT-LOG-WZ3 is blocked

12.7. DISPLAY SETTINGS

Table 12.7. Configuration parameters in the ***Display settings*** menu

Parameter	**Range of variability of the parameter and description**	**Default settings**
Screen backlight time	***0÷60 min.***, increase by 1 min., for the ***0*** value the illumination is on all the time, the time is counted from the last use of the keypad or the touch screen	*0 min.* (continuous)
Brightness of the screen	***20 ÷ 100 %***, change by 5%	*100%*
Channel and group auto switch time	***0 ÷ 60 s***, change every 2 s, for the ***0*** value, the automatic change is off, the time of automatic change of the channel (diagram) and the group in the measurement presentation modes	*0 s*
Chart time range	***100 s*** / ***300 s*** / ***15 min*** / ***30 min*** / ***60 min*** / ***150 min*** / ***5 h*** / ***10 h*** / ***25 h*** / ***50 h*** / ***5 days*** / ***10 days***	*100 s*
Language	***Polish***, ***English***, the language of the menu (also covers the version of the WWW server page)	*Polish*

12.8. SERIAL RS485, USB, AND ETHERNET COMMUNICATION SETTINGS

The available interfaces enable communication with the computer and, consequently, the readout of the measured value and configuration of the parameters and the names, as well as access to the archive files (with the exception of the RS485). Moreover, the Ethernet enables displaying information on the operating status and on measurements of the controller in any web browser (Opera, IE, Firefox, etc.) via the local network or the Internet and sending e-mail alarm notifications (chapter 12.4.1). The WWW server uses the HTTP protocol on the standard port **80**. The Internet connection requires a permanent global IP number and router (modem) configuration. To facilitate access to the networks with varying public IP address, one can start the built-in DDNS server service (described in chapter 12.8.1). **The selection of the TCP and UDP port number used by the controller and the forwarding of this port in the router (port forwarding), and other network parameters configurations should be performed by a qualified person (the network administrator)**. Moreover, one must make sure that the firewall does not block the ports and applications being used (ARSOFT-CFG and ARSOFT-LOG and the MODBUS-TCP protocol). Additional information about the RS485 interface and the MODBUS-RTU/TCP protocols is available in chapters 17÷20.

Table 12.8. Configuration parameters in the ***Communication settings*** menu

Parameter	**Range of variability of the parameter and description**			**Default settings**
USB operation mode	***Available for the computer (device)*** **(1)**	in order to establish communication with the computer, drivers must be installed (chapter 8); the USB connection is indicated in the lower status bar (chapter 11.1, item b)		*Available for a computer*
	USB memory support (host)	the presence of the USB memory is indicated in the lower status bar (chapter 11.1), **do not connect to the computer's USB port**		
Baud rate for the RS485	***2400 bit/s***	***4800 bit/s***	***9600 bit/s*** / ***19200 bit/s*** / ***38400 bit/s*** / ***57600 bit/s*** / ***115200 bit/s***	*19200 bit/s*

MODBUS-RTU address	***1 ÷ 247***	individual address of the device in the RS485 network (chapt.18)	*1*
Ethernet operation mode	***Disabled***	Ethernet constantly off (recommended when not in use)	*Disabled*
	Automatic configuration	the DHCP client is on, parameters ***IP address***, ***Subnet mask,***, ***Default gateway***, *and* ***DNS server*** are set automatically	
	Manual configuration	the DHCP client is off, parameters ***IP address***, ***Subnet mask,***, and ***Default gateway*** are set manually	
	DHCP server	useful for direct connection with a computer; do not use in networks with an existing DHCP server, after this option is set, the device must be restarted	
NetBIOS name	a unique name of the controller in the local network; may be used instead of the IP address in order to establish a connection with a computer. Edition of the name (no spaces, max. length 15 characters) is possible on the computer (via the USB port or the Ethernet and the ARSOFT-CFG-WZ1 software, or by copying of the configuration - chapter 12.6). The format of a section in the *AR654.txt* file is the following: *[Ethernet] NetBIOSName=**AR654***. The changed name may not be available on the network immediately (the update time depends on the configuration of the network).		*AR654*
UDP and TCP ports	***80 ÷ 32767*** *(*except for *137)*	the port number and the individual IP address of the device for communication using the MODBUS-TCP protocol and with the ARSOFT-CFG-WZ1 and LOG-WZ3 software, and the web browser (in the address field, enter *http://**IP address*** or ***NetBIOS name***, e.g. *http://192.168.0.254* or *http://AR654*)	*30654*
IP address	***0.0.0.0 ÷ 255. 255. 255.255***		*192.168. 0.254*
Subnet mask	***0.0.0.0 ÷ 255. 255. 255.255***	IP address mask in the local network	*255. 255.255.0*
Default gateway	***0.0.0.0 ÷ 255. 255. 255.255***	IP address of the router in the local network	*192.168.0.10*
DNS server	***0.0.0.0 ÷ 255. 255. 255.255***	domain name server address (DNS)	*192.168.0.10*
Dynamic DNS server (DDNS) client	***Disabled***	a DDNS service that enables access over the Internet to a controller connected to a network without a fixed public IP address; an active account in a DDNS service is required; the description can be found in chapter 12.8.1.	*Disabled*
	Enabled		
Dynamic DNS settings and status	Configuration data and status of the DDNS service. The data can be edited on the computer (via the USB port or the Ethernet and the ARSOFT-CFG-WZ1 software, or by copying of the configuration - chapter 12.6). Available parameters of the service: DDNS server index, host name, username and password. The default section *[DDNS]* in the *AR654.txt* file is the following: *ServiceIndex=**1*** (0=DYNDNS_ORG, 1=NO_IP_COM, 2=DNSOMATIC_COM), *Host=**AR654example.ddns.com***, *UserName=* ***DDNSuser***, *Password=* ***DDNSpassword***		
Website automatic refresh time	***0 ÷ 60 s***, change every 1 s, in the case of the ***0*** value, automatic refreshing is switched off (manual refreshing), it is used by the WWW server		*5 sec.*
Email settings and status	The configuration data of the email service and the number of email messages sent. The data can be changed on the computer (via the USB port or the Ethernet and the ARSOFT-CFG-WZ1 software, or by copying of the configuration - chapter 12.6). Available parameters of the service: SMTP server address, SMTP port number, username and password, and recipients' addresses (**separated with comas, with no spaces, max. length 120 characters**). The default section *[Email]* in the *AR654.txt* file is the following: *SMTP_ServerAddress =* ***smtp.example.com***, *SMTP_PortNumber=**25***, *UserName=**AR654@example.com***, *Password=**SMTPpassword***, *SendTo=**user1@domain1.com,user2@domain2.pl,***		
MAC physical address	a unique permanent hardware address of the Ethernet interface (factory-assigned, non-modifiable)		

Notes: **(1)**- connection of the controller to the USB port of a computer stops recording until the cable is disconnected and blocks the performance of file operations available from the menu level and transmission of files with measurement data via Ethernet from the ARSOFT-LOG-WZ3 level

NOTE:

Do not connect the device in the ***USB memory support (host)*** mode to the USB port of a computer as this leads to the risk of damage to ports. **In the IP30 version, do not use two USB sockets at the same time**.

12.8.1. DYNAMIC DNS SERVER (DDNS) CLIENT

The DDNS service enables easy access over the Internet to a controller connected to a network without a fixed public IP address using a friendly host name (Internet address) defined by the user. The service is available only to registered users of popular DDNS services, such as DynDNS (www.dyndns.org), No-IP (www.no-ip.com), and DNS-O-Matic (www.dnsomatic.com).

The use of the DDNS service requires a properly configured Ethernet interface (as described in chapter 12.8 *COMMUNICATION SETTINGS...)* and access parameters to the DNS server account. The configuration data of the DDNS service client is stored in the *AR654.txt* file. The way to access this data is described above in chapter 12.8, in Table 12.8, in item ***Dynamic DNS settings and status***. In order to eventually start the configured service, one must additionally set the ***Dynamic DNS server client*** to the value of ***Enabled*** (Table 12.8). In order for the changes in the DDNS configuration to be implemented immediately, switch off and on the DDNS service, disconnect the Ethernet cable for a brief moment, or restart the device; otherwise, the update will be implemented after not more than 10 minutes after the changes are made. Reliability of the service depends on the availability and load of the DDNS service and delays in the update of the address may reach several dozen minutes.

The public IP address of the network in which the controller is operating and the status of the DDNS service are displayed in the device status window (which can be called using the **[F]**+**[ESC]** or **[F]** buttons, see chapter 10) and in the menu item ***Dynamic DNS settings and status*** (Table 12.8). The *DDNS:OK* status indicates that the last update of the address in the DDNS service was implemented correctly; other codes may be of intermittent nature (e.g. DDNS:17 which means initiation and DDNS:13 or 15 - temporary unavailability of the service) or permanent nature, which indicates inadequate Internet connection, improper configuration of the connection or service (codes 2 to 12, e.g. DDNS:5 means invalid username or password, DDNS:8 means invalid host name, and DDNS:11 means unspecified error of the DDNS service).

Access to the Internet using a public IP address (host name) may be blocked by some Internet providers; in such cases, contact your operator's customer service office.

In order to use the services of other NO-IP (*ServiceIndex* =1 in *AR654.txt*) and DynDNS (*ServiceIndex* =0) service providers, configure an account in the Internet service DNS-O-Matic (*ServiceIndex* = 2) and in the controller (the host name can be set as *all.dnsomatic.com* or as the address of the host created in another service supported by DNS-O-Matic).

NOTE: 

Before the *AR654.txt* file is modified manually in a text editor, a backup copy must be made of the file (to use later in the event of problems with improper configuration and the need to restore the default settings).

12.9. ACCESS AND OTHER SETTINGS

Table 12.9. Configuration parameters in the ***Access and other settings*** menu

Parameter	**Range of variability of the parameter and description**		**Default settings**
***Password protection* (1)**	***Disabled*** - entry into the ***Main menu*** and the ***Quick configuration screen*** and remote access are not password-protected		*Manual configuration and remote access*
	Manual configuration and remote access - the ***Main menu***, the ***Quick configuration screen***, and remote access are protected		
	Only manual configuration - only the ***Main menu*** and the ***Quick configuration screen*** of the device are protected		
	Remote access only - only the remote access is protected		
Administrator access password	***0000*** ÷ ***9999***	a password to enter the ***Main menu***, the ***Quick configuration screen***, and the remote access, works when ***Password protection*** is not ***Disabled***	*1111*
User access password	***None*** (0) ***or 0001*** ÷ ***9999***	a password to enter the ***Quick configuration screen***, works when the ***Password protection*** applies to the *manual configuration* and the user's password is other than zero	*None* (disabled)

Buttons and touch sounds	***Disabled***	no sound indicating selection of elements of the screen and of hardware buttons	*Enabled*
	Enabled	the sound indicating selection of elements of the screen and of hardware buttons is active	
F button function (chapter 10)	***Device status*** - the status screen (accessible also using he buttons **[F]**+**[ESC]**)		*Device status*
	Stop/Start of recording - change of the ***Type of recording*** parameter to ***Off*** or ***Continuous*** (chapter 12.5), after the power supply is switched on, the recording is always on (continuous)		
	Copy archives to the USB memory (operation accessible also in the ***Memory options menu***, chapter 12.6)		
	Move the archives to the USB memory - the files in the controller are deleted after they have been copied		
	Disable/Enable sound alarm - change of the ***Alarm sound signal*** parameter to ***Disabled*** or ***Enabled*** (chapter 12.4.1, ***Control and alarm options*** menu -> ***Output***...); after the power supply is switched on, the sound signalling of active alarms is always switched on		
	Start/Stop of control for all outputs - after the power supply is switched on, the control status is exactly the same as at the time of switching off the power supply (no change), (chapter 12.6)		
	Touch panel lock – touch screen and keypad lock (except for **[F]**)		
BIN5 input function **(2)**	***None*** - the BIN5 function input is not used		*None*
	Start/stop of control for all outputs - has a higher priority than the **[F]** button		

Notes: **(1)** - password protection of remote access applies to a configuration with the ARSOFT-CFG-WZ1 software (for parameter configuration) and the ARSOFT-LOG-WZ3 software (for downloading files with measurements over the Ethernet interface)

(2) – the parameter is not available in the version of the controller without the optional mA/V outputs and BIN inputs module

12.10. DATE AND TIME

The current time and date are displayed in the status bar (chapter 11.1) in all measurement data presentation modes and are used as time stamps for recording.
In order to supply the internal clock (RTC) when the power supply is cut off, the device is fitted with a CR1220 lithium battery that suffices for at least 5 years of continuous operation.

Table 12.10. Configuration parameters in the ***Time and date*** menu

Parameter	Range of variability of the parameter
Date (yyyy-mm-dd)	***2008-06-01*** ÷ ***2099-12-31***
Time (hh:mm:ss)	***00:00:00*** ÷ ***23:59:59***

12.11. DEVICE INFORMATION

Element	Description
1	type of device (AR654), number of measurement module inputs and type of available modules
2	controller software (firmware) version

Fig. 12.11. Appearance of the ***Information on the device*** screen

13. USE AND FUNCTIONS OF USB MEMORY (PENDRIVE)

Due to the stationary (panel) installation of the controller, it may be useful to use a USB memory to transfer archive data or configuration data.
All the available file and disk operations can be found in the ***Main menu*** -> ***Memory and file options***, chapter 12.6. They enable copying and deleting archive and configuration files and checking the size of the memory and the file system. In the aforementioned operations, the presence of USB memory in the port is detected automatically.
Moreover, it is possible to select a USB memory for continuous storage of the archive. To do so, set the ***Archive storage memory*** parameter to the ***Auto select*** value (chapter 12.6) and also in the ***Main menu*** -> ***Communication settings***, set the ***USB operation mode*** parameter to the ***USB memory support (host)*** value, chapter 12.8.
In conclusion, a USB memory that is correctly installed in the socket has the following functions:
- storage of files with saved data in the course of recording
- off-line configuration of the device's parameters (from files *AR654.cfg* and *AR654.txt*, see chapter 12, item 3)
- copying archive files with the *csv* extension from the internal memory

NOTE: ⚠
In the IP30 version, **do not use** two USB sockets at the same time from the front as this leads to the risk of damage to the equipment.

14. VIEWING RECORDED MEASUREMENTS AND EVENTS

In order to archive the data, the controller creates text files with the *csv* extension in the internal memory or the USB memory. Additional, new *csv* files are created each time the power supply is switched on and each time a new recording is started (e.g. when the parameter ***Recording type*** = ***Periodic daily***, new files are created every day).
The file name contains the device type (AR654), the identification number (**ID**) (chapter 12.6), and the date and time of creation of the file, e.g. "AR654_1_2016-06-09_10-57-16.csv" (AR654, ID = 1, date = 2016-06-09, time = 10:57:16).
The format of a single data record is the following: "successive number of the event; date; time; identifier of the event; argument1; ...; argument n; check sum", where n=number of channels (4).
An example of a record containing measurements:
"1;2016-06-09;10:57:16;5;49,5;26,2;19,80;1020;8BE2" (measured values: "49,5;26,2;19,80;1020;…").
The types and the identifiers of the recorded events are:
- measurement (identifier of event **5**)
- connection to the USB port (**0**, "USB;CONNECTED")
- disconnection from the USB port (**1**, "USB;DISCONNEC")
- loading of a new configuration (identifier of event **3**), values of arguments:
  - "NEW;ON-LINE" - parameter configuration via the USB port, the RS485 port, or the Ethernet (on-line)
  - "NEW;OFF-LINE" - parameter configuration by way of modification of the *AR654.cfg* file (off-line)
  - "NEW;USER" - parameter configuration from the keypad and touch screen (user) level
  - "NEW;CH_TEXT" - name configuration by way of modification of the *AR654.txt* file
- creation of a new *csv* file (**4**, "ID; xxxx", where xxxx - value of the ***Identification number ID*** parameter of the device, chapter and table 12.6)

In order to present the recorded results graphically or as text or to print them, the data must be imported into the ARSOFT-LOG-WZ3 software via the USB or using the Ethernet interface. The quickest possible method is to import the data via the computer's USB; it is recommended in case of very large files (hundreds of megabytes and larger). The ARSOFT-LOG software also enables detecting unauthorized modifications of the archive.
As an alternative, *csv* files can be edited in spreadsheet software (e.g. OpenOffice Calc, Microsoft Excel) and in text editors (Windows WordPad, Notepad++, etc.).

NOTE:

When the parameter ***Archive storage memory*** = ***Auto select*** (chapter 12.6) then if the USB memory is installed or removed in the course of recording, a new *csv* file is created where the successive numbers of events are continued from the previous file.

15. MESSAGE AND ERROR SIGNALING

The measurement errors present in the field of the measured values in all presentation modes:

--HI-- - the value set by the ***End of the input scale*** is exceeded from the top (chapter 12.3, input configuration), the measurement range of the sensor is exceeded from the top or the sensor is damaged

--LO-- - the value set by the ***Start of the input scale*** is exceeded from the bottom (chapter 12.3, input configuration), the measurement range of the sensor is exceeded from the bottom or the sensor is damaged

Moreover, the controller has a clear way of informing of its operating status and the status of the file or disk operations being performed. In order to close the message window appearing in the display, use the **[SET]** or **[ESC]** button.

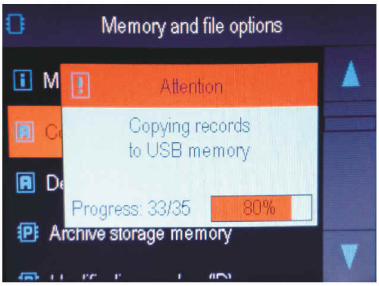


Fig. 15. Appearance of an example message window.

16. IMPORTANT COMMENTS PERTAINING TO OPERATION

In order to ensure problem-free and optimum operation of the controller, please observe the following guidelines:

- do not disconnect the device from the computer in the course of communication via the USB interface, which is indicated by the **[R/W]** and **[Tx/Rx]** icons. USB communication is in place when the internal memory is serviced and in the course of operation of the ARSOFT-CFG-WZ1 software.
- delete unnecessary files from the internal memory or the USB memory before new recording start
- save security copies of the current configuration files (*AR654.cfg* and *AR654.txt*) in external memories (USB, computer hard drives, etc.) for use in the event of problems
- **do not allow power supply loss during data saving** as this may leads to the risk of errors in the FAT file system and, consequently, to problems with recording/reading of data and loss of the current controller configuration and reverting to the default configuration. If this happens, perform the following actions from the ***Main menu*** level of the device or using a computer connected via the USB port:
  1. copy (if possible) the existing archive files to an external memory (a USB memory or the computer's disk)
  2. format the internal memory
  3. configure the controller (manually, on-line, or off-line by restoring the configuration file copies if they have been made by the user)
- **do not** establish communication with the device **simultaneously** from many applications of the same type (ARSOFT-CFG-WZ1/LOG-WZ3)

- do not use sharp-edged objects to work with the touch screen
- avoid exposing the device to direct sunlight and other sources of intensive heat
- connection of the controller to a USB port of a computer stops recording until the cable is disconnected and blocks the performance of file operations available from the menu level and transmission of files with measurement data via Ethernet from the ARSOFT-LOG-WZ3 level.

17. RS485 COMMUNICATION INTERFACE (acc. to EIA RS-485)

The installation specification for the RS485 interface is the following:
- maximum cable length - 1 km (observe the installation guidelines, chapter 2, sub-items b, c, and d)
- maximum number of devices in a RS485 line - 30, in order to increase the number, use RS485/RS485 amplifiers
- termination and polarizing resistors when the MASTER is at the start of the line (Fig. 17):
  - at the start of the line - 2 x 820 Ω to the ground and +5 V of the MASTER and 150 Ω between lines
  - at the end of the line - 150 Ω between lines
- termination and polarizing resistors when the MASTER is in the centre of the line:
  - at the converter - 2 x 820 Ω, to the ground and +5 V of the converter
  - at both ends of the line - 150 Ω each between lines

Equipment from different manufacturers that form the RS485 network (e.g. RS485 converters/USB) may have integrated polarizing and terminating resistors; in such a case there is no need to use external elements.

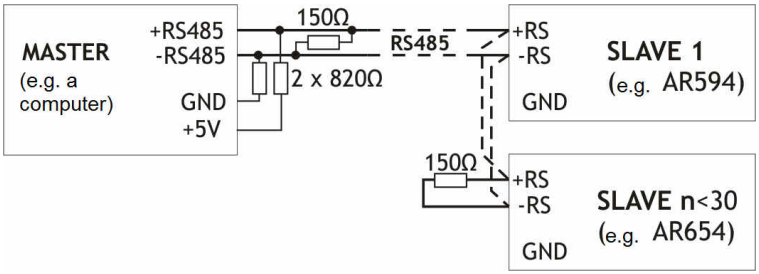


Fig. 17. Pictorial diagram of the RS485 network

18. MODBUS–RTU SERIAL TRANSMISSION PROTOCOL (SLAVE)

The MODBUS-RTU protocol is accessible to the RS485 interface and the USB (in the device mode). The parameters used by this service are described in chapter 12.8.
Character format : 8 bits, 1 stop bit, no parity bit
Available functions : READ - 3 or 4, WRITE - 6

Table 18.1. Request frame format for the READ function (frame length - 8 bytes):

address of the device	function 4 or 3	address of the read register from Table 20 (chapter 20)	number of read registers: 1 ÷ 66 (0x0042)	CRC check sum
1 byte	1 byte	2 bytes (HB-LB)	2 bytes (HB-LB)	2 bytes (LB-HB)

Example 18.1. Reading of a register with address 0: 0x01 - 0x04 - 0x0000 - 0x0001 - 0x31CA

Table 18.2. Request frame format for the WRITE function (frame length - 8 bytes):

address of the device	function 6	address of the write register from Table 20 (chapter 20)	write register value	CRC check sum
1 byte	1 byte	2 bytes (HB-LB)	2 bytes (HB-LB)	2 bytes (LB-HB)

Example 18.2. Write in a register with address 10 (0xA) with the 0 value: 0x01 - 0x06 - 0x000A - 0x0000 - 0xA9C8

Table 18.3. Response frame format for the READ function (minimum frame length - 7 bytes):

address of the device	function 4 or 3	number of bytes in the data field (max. 66*2=132 bytes)	data field - register value	CRC check sum
1 byte	1 byte	1 byte	2 ÷ 132 bytes (HB-LB)	2 bytes (LB-HB)

Example 18.3. Response frame for register value equal to 0: 0x01 - 0x04 - 0x02 - 0x0000 - 0xB930

Table 18.4. Response frame format for the WRITE function (frame length - 8 bytes):

copy of the request frame for the WRITE function (Table 18.2)

Table 18.5. Special answer (function field = 0x84 or 0x83 in the case of the READ function and 0x86 in the case of the WRITE function):

Error code (HB-LB in the data field)	**Error description**
0x0001	non-existing register address
0x0002	wrong write register value
0x0003	improper function number

Example 18.5. Error frame for a non-existing read register address:
0x01 - 0x84 - 0x02 - 0x0001 –0x5130

19. MODBUS–TCP SERIAL TRANSMISSION PROTOCOL

The MODBUS-TCP protocol is accessible to the Ethernet (RJ45) interface and uses the TCP/IP transport layer. The parameters used by the service, to include the TCP port number, are described in chapter 12.8.
Available functions : READ - 3 or 4, WRITE - 6

Table 19.1. Request frame format of the MODBUS-TCP protocol for the READ and WRITE functions (frame length -12B)

Heading of the MODBUS protocol (7 bytes)			Function code (READ or WRITE)	register address from Table 20 (chapter 20)	number of read registers (1 ÷ 66) or value of write register
Transaction and protocol identifiers	Length field (value = 6)	Unit identifier			
4 bytes	2 bytes	1 byte	1 byte	2 bytes (HB-LB)	2 bytes (HB-LB)

Example 19.1. Reading of a register with address 0: 0x00 - 0x00 - 0x00 - 0x00 - 0x00 - 0x06 - 0xFF - 0x04 - 0x0000 - 0x0001

Table 19.2. Response frame format for the READ function (minimum frame length - 11 bytes):

Heading of the MODBUS protocol (7 bytes)			Function code (READ)	number of bytes in the data field (2 ÷ 132)	data field - register value (2B)
Transaction and protocol identifiers	Length field (maximum 135)	Unit identifier			
4 bytes	2 bytes	1 byte	1 byte	1 byte	2 ÷ 132 bytes (HB-LB)

Example 19.2. Response frame for register value equal to 0:
0x00 - 0x00 - 0x00 - 0x00 - 0x00 - 0x05 - 0xFF - 0x04 - 0x01 - 0x0000

Table 19.3. Response frame format for the WRITE function (frame length - 12 bytes)

copy of the request frame for the WRITE function (Table 19.1)

The error codes are the same as in the case of the MODBUS-RTU protocol (Table 18.5)

Example 19.3. Error frame for a non-existing read register address:
0x00 - 0x00 - 0x00 - 0x00 - 0x00 - 0x05 - 0xFF - 0x84 - 0x02 - 0x0001

20. MAP OF DEVICE REGISTERS FOR THE MODBUS-RTU/TCP

Table 20. Map of registers for the MODBUS-RTU and MODBUS-TCP protocols

Register address HEX (DEC)	Range of variability or value of the register (HEX or DEC)	Description of register and access type (R- read only register, R/W - read and write register)		
0x00 (0)	0	not used		R
0x01 (1)	6541 ÷ 6542	device type identifier (depending on the hardware version)		R
0x02 (2)	100 ÷ 999	controller software (firmware) version		R
0x03 (3)	-100 ÷ 700	internal device temperature (resolution 0.1℃), no decimal point		R
0x04 (4)	0 ÷ 15	current status of outputs 1, 2, 3, 4: bits 3, 2, 1, 0 bit=1 means the output is switched on		R
0x05 ÷ 0x0B	-	not used or reserved		R
0x0C ÷ 0x0F	-9999 ÷ 19999	measurements from inputs 1÷4 (1 register/measurement, 16-bit)	Values in the U2 code, without a period (for thermometer inputs resolution 0.1°C)	R
0x10 ÷ 0x17	-9999 ÷ 99999	measurement channels 1÷4 (2 registers/channel, 32-bit)		R
0x18 ÷ 0x3C	-	not used or reserved		R
0x3D (61)	0 ÷ 6	day of the week in the internal RTC clock (counted based on the date)		R
0x3E (62)	0x0101 ÷ 0x630C	years (HB) and months (LB)	Internal real time clock (**RTC**, chapter 12.10)	R/W
0x3F (63)	0x0100 ÷ 0x1F17	days (HB) and hours (LB)		R/W
0x40 (64)	0x0000 ÷ 0x3B3B	minutes (HB) and seconds (LB)		R/W
0x41 (65)	-	not used or reserved		R
0x42 (66)	0x0101 ÷ 0x630C	years (HB) and months (LB)	Parameter ***Start of the time limit*** (chapter 12.5)	R/W
0x43 (67)	0x0100 ÷ 0x1F17	days (HB) and hours (LB)		R/W
0x44 (68)	0x0000 ÷ 0x3B3B	minutes (HB) and seconds (LB)		R/W
0x45 (69)	0x0101 ÷ 0x630C	years (HB) and months (LB)	Parameter ***End of the time limit*** (chapter 12.5)	R/W
0x46 (70)	0x0100 ÷ 0x1F17	days (HB) and hours (LB)		R/W
0x47 (71)	0x0000 ÷ 0x3B3B	minutes (HB) and seconds (LB)		R/W
0x48 (72)	1 ÷ 28800	Parameter ***Data recording interval*** (chapter 12.5) – number of seconds		R/W
0x49 (73)	0 ÷ 6	Parameter ***Recording type*** (chapter 12.5)		R/W
0x4A (74)	0 ÷ 27	Parameter ***Selection of permission channel*** (chapter 12.5)		R/W
0x4B ÷ 0x4C	-9999 ÷ 99999	Parameter ***Permission threshold value*** (chapter 12.5), 2 registers, a 32-bit value		R/W
0x4D (77)	0 ÷ 1	Parameter ***Archive storage memory*** (chapter 12.6)		R/W
Configuration parameters of the measurement input with the number **WP** = 0÷3, 0=input 1, 3=input 4, chapter 12.3				
0x4E + WP *12	0 ÷ 17	Parameter ***Input type*** (chapter 12.3)		R/W
0x4F + WP *12	0 ÷ 5000	Parameter ***Line resistance***		R/W
0x50 + WP *12	0 ÷ 600	Parameter ***Thermocouple cold tips temperature***		R/W
0x51 + WP *12	0 ÷ 3	Parameter ***Decimal dot position/resolution***		R/W
0x52 + WP *12	-9999 ÷ 19999	Parameter ***Start of input scale***		R/W
0x53 + WP *12	-9999 ÷ 19999	Parameter ***End of input scale***		R/W
0x54 + WP *12	0 ÷ 10	Parameter ***Filtration***		R/W
0x55 + WP *12	-500 ÷ 500	Parameter ***Offset calibration***		R/W
0x56 + WP *12	850 ÷ 1150	Parameter ***Slope calibration***		R/W
0x57 + WP *12	0	not used (3 consecutive registers)		R/W

Configuration parameters for the measurement channel of the display numbered **KP** = 0 ÷ 3, 0=channel 1, 3=channel 4, chapter 12.2				
0x7E + KP *7	0 ÷ 27	Parameter ***Measured value to be displayed*** (chapter 12.2)		**R/W**
0x7F + KP *7	-9999 ÷ 99999	Parameter ***Bottom range for graphics and SP***, 2 registers, 32-bit value		**R/W**
0x81 + KP *7	-9999 ÷ 99999	Parameter ***Top range for graphics and SP***, 2 registers, 32-bit value		**R/W**
0x83 + KP *7	0 ÷ 3	Parameter ***Assignment of measurement group***		**R/W**
0x84 + KP *7	0 ÷ 22	Parameter ***Background colour***		**R/W**
Configuration parameters for control output with the number **WY** = 0 ÷ 3, 0=output 1, 3=output 4, chapter 12.4.1				
0x9A + WY *32	0 ÷ 31	Parameter ***Assignment of control signal*** (chapter 12.4.1)		**R/W**
0x9B + WY*32	0 ÷ 5	Parameter ***Type of control/alarm***		**R/W**
0x9C + WY*32	0 ÷ 11	Parameter ***Setpoint value (SP) selection***		**R/W**
0x9D + WY*32	0 ÷ 3	Parameter ***Output emergency state***		**R/W**
0x9E + WY*32	0 ÷ 5000	Parameter ***Hysteresis H1***		**R/W**
0x9F + WY*32	-9999 ÷ 99999	Parameter ***Setpoint/Alarm value SP1***, 2 registers, 32-bit value		**R/W**
0xA1 + WY*32	0 ÷ 8	Parameter ***PID selection for SP1 and SP=IN***		**R/W**
0xA2 + WY*32	0 ÷ 5000	Parameter ***Hysteresis H2***		**R/W**
0xA3 + WY*32	-9999 ÷ 99999	Parameter ***Setpoint/Alarm value SP2***, 2 registers, 32-bit value		**R/W**
0xA5 + WY*32	0 ÷ 8	Parameter ***PID selection for SP2 and SP=IN***		**R/W**
0xA6 + WY*32	0 ÷ 3	Parameter ***Autotuning of PID parameters***		**R/W**
0xA7 + WY*32	0 ÷ 100	Parameter ***Setpoint value for manual mode***		**R/W**
0xA8 + WY*32	1 ÷ 360	Parameter ***Pulsing period of manual mode***		**R/W**
0xA9 + WY*32	0 ÷ 2	Parameter ***State of control after power up***		**R/W**
0xAA + WY*32	0 ÷ 2	Parameter ***Control time***		**R/W**
0xAB + WY*32	0x0101 ÷ 0x630C	years (HB) and months (LB)	Parameter ***Start of control time***	**R/W**
0xAC + WY*32	0x0100 ÷ 0x1F17	days (HB) and hours (LB)		**R/W**
0xAD + WY*32	0x0000 ÷ 0x3B3B	minutes (HB) and seconds (LB)		**R/W**
0xAE + WY*32	0x0101 ÷ 0x630C	years (HB) and months (LB)	Parameter ***End of control time***	**R/W**
0xAF + WY*32	0x0100 ÷ 0x1F17	days (HB) and hours (LB)		**R/W**
0xB0 + WY*32	0x0000 ÷ 0x3B3B	minutes (HB) and seconds (LB)		**R/W**
0xB1 + WY*32	0 ÷ 1	Parameter ***Alarm sound signal***		**R/W**
0xB2 + WY*32	0 ÷ 1	Parameter ***Email alarm notifications***		**R/W**
0xB3 + WY*32	0 ÷ 3	Parameter ***F1 button and BIN input function***		**R/W**
0xB4 + WY*32	0 ÷ 3	Parameter ***Analogue output (mA/V) function***		**R/W**
0xB5 + WY*32	0 ÷ 3	Parameter ***Output (mA/V) and standard selection***		**R/W**
0xB6 + WY*32	-9999 ÷ 99999	Parameter ***Start of retransmission scale (mA/V)***, 2 registers, 32-bit value		**R/W**
0xB8 + WY*32	-9999 ÷ 99999	Parameter ***End of retransmission scale (mA/V)***, 2 registers, 32-bit value		**R/W**
Configuration parameters of PID set number **ZP** = 0÷7, 0=set 1, 7=set 8, chapter 12.4.2				
0x11A + ZP *4	1 ÷ 18000	Parameter ***Proportional band Pb*** (chapter 12.4.2)		**R/W**
0x11B + ZP *4	0 ÷ 3,600	Parameter ***Integration time constant Ti***		**R/W**
0x11C + ZP *4	0÷999	Parameter ***Differentiation time constant Td***		**R/W**
0x11D + ZP *4	3 ÷ 360	Parameter ***Pulsing period Tc for the output***		**R/W**
0x13A (314)	0 ÷ 6	Parameter ***F button funtion*** (chapter 12.9)		**R/W**
0x13B (315)	0 ÷ 1	Parameter ***BIN5 input funtion*** (chapter 12.9)		**R/W**
0x13C (316)	0 ÷ 1	Parameter ***Buttons and touch sounds*** (chapter 12.9)		**R/W**
0x13D (317)	0 ÷ 3	Parameter ***Password protection*** (chapter 12.9)		**R/W**
0x13E (318)	0 ÷ 9,999	Parameter ***Administrator assess password*** (chapter 12.9)		**R/W**

0x13F (319)	0 ÷ 9,999	Parameter ***User access password*** (chapter 12.9)		**R/W**
0x140 (320)	0 ÷ 9,999	Parameter ***Identification number ID*** (chapter 12.6)		**R/W**
0x141 (321)	0 ÷ 60	Parameter ***Screen backlight time*** (chapter 12.7)		**R/W**
0x142 (322)	20 ÷ 100	Parameter ***Brightness of the screen*** (chapter 12.7)		**R/W**
0x143 (323)	0 ÷ 60	Parameter ***Channel and group automatic switch time*** (chapter 12.7)		**R/W**
0x144 (324)	0 ÷ 11	Parameter ***Chart time range*** (chapter 12.7)		**R/W**
0x145 (325)	0 ÷ 1	Parameter ***Language*** (chapter 12.7)		**R/W**
0x146 (326)	0 ÷ 1	Parameter ***USB operation mode*** (chapter 12.8)		**R/W**
0x147 (327)	1 ÷ 247	Parameter ***MODBUS-RTU address*** (chapter 12.8)		**R/W**
0x148 (328)	0 ÷ 6	Parameter ***Baud rate for the RS485*** (chapter 12.8)		**R/W**
0x149 (329)	0 ÷ 3	Parameter ***Ethernet operation mode*** (chapter 12.8)		**R/W**
0x14A (330)	*80 ÷ 32767*	Parameter ***UDP and TCP port*** (chapter 12.8)		**R/W**
0x14B (331)	0x0000 ÷ 0xFFFF	Octet4 (HB), Octet3 (LB)	Parameter ***IP address*** (chapter 12.8)	**R/W**
0x14C (332)	0x0000 ÷ 0xFFFF	Octet2 (HB), Octet1 (LB)		
0x14D (333)	0x0000÷ 0xFFFF	Octet4 (HB), Octet3 (LB)	Parameter ***Subnet mask*** (chapter 12.8)	**R/W**
0x14E (334)	0x0000 ÷ 0xFFFF	Octet2 (HB), Octet1 (LB)		
0x14F (335)	0x0000 ÷ 0xFFFF	Octet4 (HB), Octet3 (LB)	Parameter ***Default gateway*** (chapter 12.8)	**R/W**
0x150 (336)	0x0000 ÷ 0xFFFF	Octet2 (HB), Octet1 (LB)		
0x151 (337)	0x0000 ÷ 0xFFFF	Octet4 (HB), Octet3 (LB)	Parameter ***DNS server*** (chapter 12.8)	**R/W**
0x152 (338)	0x0000 ÷ 0xFFFF	Octet2 (HB), Octet1 (LB)		
0x153 ÷ 0x154	0	not used		**R/W**
0x155 (341)	0 ÷ 1	Parameter ***Dynamic DNS server client*** (chapter 12.8.1)		**R/W**
0x156 (342)	0 ÷ 60	Parameter ***Website automatic refresh time*** (chapter 12.8)		**R/W**

Parameters of section **N** of program **P** where **N**=0÷11, **P**= 0÷3, 0=program and section 1, 3=program and section 4, etc., chapter 12.4.3

0x157+N*10+P*120	0 ÷ 4	Parameter ***Stage type*** (chapter 12.3)	**R/W**
0x158+N*10+P*120	-9999 ÷ 99999	Parameter ***Setpoint value (SP)***, 2 registers, 32-bit value	**R/W**
0x159+N*10+P*120	0 ÷ 5000	Parameter ***Hysteresis and band for the stage time start***	**R/W**
0x15A+N*10+P*120	-500 ÷ 500	Parameter ***Gradient (PV/min)***	**R/W**
0x15B+N*10+P*120	0 ÷ 1440	Parameter ***Stage time***	**R/W**
0x15C+N*10+P*120	0 ÷ 8	Parameter ***PID parameters selection for the SP***	**R/W**
0x15D+N*10+P*120	0 ÷ 4	Parameter ***Auxiliary output selection***	**R/W**
0x15E+N*10+P*120	0 ÷ 2	Parameter ***Auxiliary output state***	**R/W**
0x15F+N*10+P*120	0 ÷ 1	Parameter ***Sound signal***	**R/W**

21. USER'S NOTES