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USER MANUAL

AR653 **AR663**

UNIVERSAL TWO-CHANNEL CONTROLLERS

Version 1.1.5
2016.02.24

Thank you for choosing our product.
This manual 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 manual.
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 programming of the device without any deterioration of the technical parameters.

1. SAFETY RULES

- before you start to use the device, become familiar with the present instructions
- in order to avoid electrocution or damage to the device, its mechanical and electrical installation must be performed by qualified workers;
- before switching on the power supply, make sure that all cables and wires are properly connected;
- before making any modifications to the wire and cable connections, switch off the voltage supplied to the device;
- ensure proper operating conditions compliant with the technical specification of the device (chapter 5, power supply voltage, humidity, temperature).

2. INSTALLATION GUIDELINES

The device is designed so as to ensure an appropriate level of immunity to most interferences that may occur in industrial 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:

- do not supply the device from the same lines as high-power equipment without using appropriate power line filters;
- 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;
- avoid running measurement (signal) cables in the direct vicinity of and parallel to power and supply cables;
- it is recommended to use twisted pair signal cables;
- in the case of sensing resistors in 3-wire connections, use identical wires;
- 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;
- ground or zero metal rails on which rail-mounted devices are installed.

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

3. GENERAL CHARACTERISTICS OF THE CONTROLLERS

- control and monitoring of temperature and other physical values (humidity, pressure, level, speed, etc.) processed to a standard electrical signal (0/4÷20mA, 0÷10V, 0÷60mV, 0÷2,5kΩ);
- 2 universal measurement inputs (thermoresistant, thermocouple, and analog) with mathematical functions (subtraction, addition, and average of measurements from two inputs);
- programmable functional button to change the operating mode of the controller: start/stop of control, manual mode for outputs, step change of the set value (day/night), keyboard lock, view of measured values;
- 3 independent ON/Off type outputs (2- and 3-way adjustment) with the following control characteristics:
  - output 1 (main): ON-OFF with hysteresis, PID, AUTOTUNING PID
  - output 2, 3 (auxiliary/alarm): ON-OFF with hysteresis
- analog output 0/4÷20mA or 0/2÷10V (continuous-control, retransmission)
- possibility to convert the input signals into the analog output standard in the retransmission mode;
- selection of the value controlling the operation of each output (any input, subtraction, addition, average of measurements);
- advanced PID parameter selection function with fuzzy logic elements;
- manual mode (open control loop) available for binary outputs and the analog output, which makes it possible to set the value of the output signal in the range of 0-100%; possibility of self-activation in the event of sensor failure;
- programmable operating characteristics (process controller, ramping);
- an integrated 24 V DC power supply supplying the field transducers;
- a two-line digital LED display with control of illumination brightness: a TOP display - measured value 1

(e.g. input 1, difference between measured values, etc.); a BOTTOM display - measured value 2 or set value of output 1;

- a RS485 serial interface (galvanically isolated, MODBUS-RTU protocol, SLAVE);
- compensation of line resistance for resistance sensors and of temperature of cold thermocouple tips;
- programmable values to be displayed (measurements or mathematical functions), types of inputs, indication ranges (for analog inputs), control, alarms, communication, and access options, and other configuration parameters;
- access to configuration parameters protected with a user password;
- parameter configuration methods:
  - from the film keypad located on the front panel of the device;
  - through RS485 or the AR955/956 programmer and the ARSOFT-WZ1 free software (Windows Vista/7/8/10);
- software and the AR956 (or AR955) programmer that enables viewing the measured value and quick configuration of single or ready sets of parameters that were saved earlier on the computer for future use, e.g. in other controllers of the same type (copying of configuration);
- AR653 - panel enclosure (IP65 on the front); AR663 - enclosure for the DIN35 rail (IP20);
- options to be selected (in the ordering method): 24 V AC/DC power supply, SSR control outputs, 0/2-10 V analog output, and RS485 interface;
- high accuracy, long-term stability, and immunity to interferences;
- available accessories:
  - AR955 or AR956 programmer;
  - RS485/USB converter.

NOTE: 

Before starting to work with the controller, you must become familiar with these operating instructions, properly prepare the electrical system and the mechanical system, and correctly configure the parameters.

4. CONTENTS OF THE SET

- a controller (AR653 with grips for installation in the panel window);
- a user manual;
- a warranty card.

5. TECHNICAL DATA

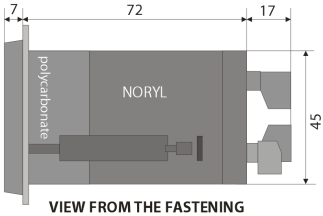
2 universal inputs (set with parameters inP)	**measurement range**
- Pt100 (RTD, 3- or 2-wire)	-200 ÷ 850 °C
- Ni100 (RTD, 3- or 2-wire)	-50 ÷ 170 °C
- Pt500 (RTD, 3- or 2-wire)	-200 ÷ 620 °C
- Pt1000 (RTD, 3- or 2-wire)	-200 ÷ 520 °C
- thermocouple J (Fe-CuNi)	-40 ÷ 800 °C
- thermocouple K (NiCr-NiAl)	-40 ÷ 1,200 °C
- thermocouple S (PtRh 10-Pt)	-40 ÷ 1,600 °C
- thermocouple B (PtRh30PtRh6)	300 ÷ 1800 °C
- thermocouple R (PtRh13-Pt)	-40 ÷ 1,600 °C
- thermocouple T (Cu-CuNi)	-25 ÷ 350 °C
- thermocouple E (NiCr-CuNi)	-25 ÷ 820 °C
- thermocouple N (NiCrSi-NiSi)	-35 ÷ 1,300 °C

- current (R_{in} = 50 Ω)			0/4 ÷ 20 mA
- voltage (R_{we} = 33 kΩ)			0 ÷ 10 V
- voltage (R_{in} > 2 M Ω)			0 ÷ 60 mV
- resistance (3- or 2-wire)			0 ÷ 2,500 Ω
Response time (10 ÷ 90%)			0.5 ÷ 4 s (programmable with parameters F ił)
Resistance of leads (RTD, Ω)			R_d < 25 Ω (for each line)
Resistance input current (RTD, Ω)			400 µA (Pt100, Ni100), 200 µA (others), impulse for input 1, continuous for input 2
Processing errors (at ambient temperature of 25 °C):			
- basic	- for RTD, mA, V, mV, Ω		0.1% of the measurement range ±1 digit
	- for thermocouples		0.2% of the measurement range ±1 digit
- additional for thermocouples			<2 °C (temperature of cold tips)
- additional from ambient temperature changes			< 0.003% of the input range /°C
Resolution of measured temperature			programmable, 0.1 °C or 1 °C
Range of indications (resolution of analog inputs)			-1999 ÷ 9999, programmable
Position of the decimal point for analog inputs			programmable, 0 ÷ 0.000
Communication interfaces (RS485 and PRG, do not use simultaneously)	- RS485 (galvanically isolated), optional		- speed 2.4 ÷ 115.2 kb/s, - character format 8N1 (8 data bits, 1 stop bit, no parity bit) - MODBUS-RTU protocol (SLAVE)
	- PRG programming connection (no isolation), standard		
Bi-state outputs (3-transmitter or SSR)	- relay (P1, P2, P3), standard		8A / 250V~ (for resistance loads), 1 main (SPDT), 2 additional (SPST-NO)
	- SSR (SSR1, SSR2, SSR3), option		transistor type NPN OC, 11 V, internal resistance 440 Ω,
Analog output (1 current or voltage)	- current 0/4 ÷ 20 mA (standard)		maximum resolution 1.4 µA (14 bit)
			load capacity of the load Ro < 350 Ω
	- voltage 0/2 ÷ 10 V (option)		maximum resolution 0.7 mV (14 bit)
			load capacity of the output Io < 3.7 mA (Ro > 2.7 kΩ)
	- basic error of the output		< 0.1% of the output range
A 7-segment LED display (2 lines 4 digits each, with brightness adjustment)		- upper	red, 14 mm (AR653) or 10 mm (AR663) height
		- lower	green, 10 mm (AR653) or 7 mm (AR663) height
Signaling	- transmitter activity		LED diodes, red
	- messages and errors		LED display
Power supply (Usup)	- 230 VAC (standard)		85-260 Vac/ 3VA
	- 24 VAC/DC (option)		20-50 VAC/ 3 VA, 22-72 VDC/ 3W
Power supply of field transducers			24 VDC / 50 mA
Rated operating conditions			0 ÷ 50 °C, <90% RH (no condensation)
Operating environment			air and neutral gases
Protection rating			AR653 - panel, IP65 from the front, IP20 from the side of the connections AR663 - enclosure for the DIN35 rail, IP20
Weight			AR653 ~200 g, AR663 ~160 g
Electromagnetic compatibility (EMC)			immunity: according to the PN-EN 61000-6-2:2002(U) standard
			emissivity: according to the PN-EN 61000-6-4:2002(U) standard

6. ENCLOSURE DIMENSIONS AND INSTALLATION DATA

a) AR653

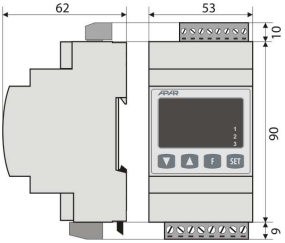
Enclosure type	panel, Incabox XT L57
Material	self-extinguishing NORYL 94V-0, polycarbonate
Enclosure dimensions	96 x 48 x 79 mm (W x H x D)
Panel window	92 x 46 mm (W x H)
Fixing methods	grips on the side of the enclosure
Conductor cross-sections (separable connectors)	2.5 mm^2 (supply and bi-state outputs), 1.5 mm^2 (others)



VIEW FROM THE FASTENING HOLDER SIDE

b) AR663

Enclosure type	rail-mounted, Modulbox 3MH53
Material	ABS/PC
Enclosure dimensions	53 x 90 x 62 mm (W x H x D)
Fixing methods	on a TS35 rail (DIN EN 50022-35)
Conductor cross-sections (separable connectors)	2.5 mm^2 (supply and bi-state outputs), 1.5 mm^2 (others)



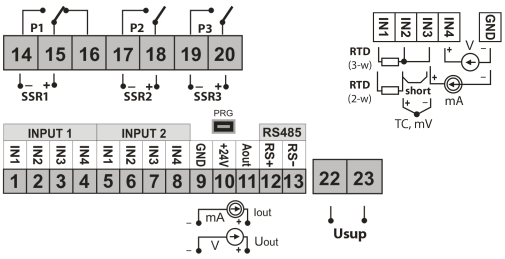
7. DESCRIPTION OF TERMINAL STRIPS AND ELECTRICAL CONNECTIONS

Table 7. Numbering and description of terminal strips

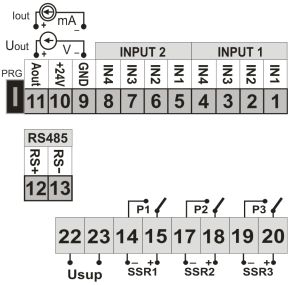
Terminals	Description
IN1- IN2- IN3	input Pt100, Ni100, Pt500, Pt1000, resistance, (2- and 3-wire)
IN2- IN3	thermocouple input TC (J, K, S, B, R, T, E, N) and voltage input 0÷60 mV
IN3- GND (9)	current input 0/4÷20 mA
IN4- GND (9)	voltage input 0÷10 V
10	output +24 V (in relation to 9-GND) of the integrated power supply of field transducers
11- GND (9)	analog current output (0/4-20 mA) or voltage output (0/2-10 V)
PRG	programming connection for cooperation with the programmer **(only AR955 or AR956)**
12-13	RS485 serial interface (MODBUS-RTU transmission protocol)
22-23	power supply input 230 VAC or 24 VAC/DC
14-15-16	transmitter output P1 or SSR1 (14-15)
17-18	transmitter output P2 or SSR2
19-20	transmitter output P3 or SSR3

a) numbering of connections on the back panel and method of connecting sensors and measurement signals

a.1) AR653 (clamp terminal description Table 7



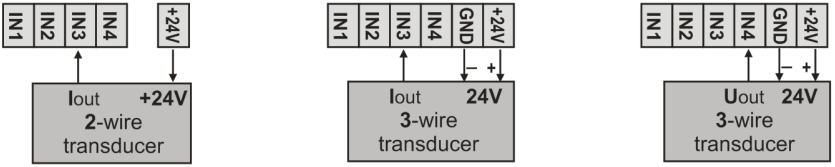
a.2) AR663 (clamp terminal description Table 7)



NOTE:

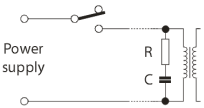
For connecting the device with a computer through the **PRG** socket, use only the **AR956 or AR956** programmer. A connection made with a regular USB cable may cause damage to the equipment.

b) connection of a 2- and 3-wire transducer (**I**out - output current, **U**out - output voltage)



8. IMPORTANT TIPS – using the suppression systems

If an inductive load (e.g. contactor coil, transformer) is connected to the relay contacts, overvoltage and arc appear often during opening as a result of discharge of energy accumulated in the inductance. Particularly harmful effects of such overvoltage include reduced life of contactors and relays, destruction of semiconductors (diodes, thyristors, triacs), damage or disturbance of control and measurement systems, emission of electromagnetic fields causing interference with local devices. To avoid such effects, the overvoltage must be reduced to a safe level. The easiest method is connecting a suitable suppression module **directly** to the inductive load terminals. Generally, a suitable type of suppression system should be selected for each inductive load. Modern contactors usually have factory-installed suitable suppression systems. If they do not, a contactor with a built-in suppression system should be bought. Temporarily, you can shunt the load using the RC system, e.g. R=47Ω/1W and C=22nF/630V. Connect the suppression system to the inductive load terminals. This will limit burning of the relays contacts in the controller and reduce the probability that they will get stuck.



9. FUNCTIONS OF BUTTONS AND LED INDICATORS

Description of the front side using the example of the AR653 device

a) button functions in the measurement display mode

Button	**Description** [and marking in the contents of the instructions]
▲ or ▼	**[UP]** or **[DOWN]**: changes the set value for output 1 (parameter 20: SEt 1, or 42: HSEt when output 1 is in the manual mode, see chapters 10 and 12.8)
SET	**[SET]** : - go to the quick access menu (chapter 11)

▲ + ▼	**[UP]** and **[DOWN]** (at the same time): input in the parameter configuration menu (after hold time longer than 1 s). If parameter 49: PPro = on (password protection is activated) enter the access code (chapter 10)
F	**[F]**: activation of a function programmed with parameter 50: Func (after holding for more than 1 second, chapters 9.1 and 10)

b) button functions in the parameter configuration menu and the quick access menu (chapters 10 and 11)

Button	**Description** [and marking in the contents of the instructions]
SET	**[SET]** : - selection of the item displayed in the configuration menu (entering a lower level) - edits the current parameter (the value blinks in the lower display) - approves and saves the edited parameter value
▲ or ▼	**[UP]** or **[DOWN]**: - moves to the next or previous parameter (submenu) - changes the value of the edited parameter
▲ + ▼ or F	**[UP]** and **[DOWN]** (simultaneously) or **[F]**: - returns to the previous menu (higher level) - cancels changes to the edited value (the blinking stops) - returns to the measurement display mode (only **[UP]** and **[DOWN]** after hold time >0.5 s)

c) functions of the LED signaling diodes

Diode [marking]	**Description**
1 2 3 **[1] [2] [3]**	signals switching on of outputs P1/SSR1, P2/SSR2, and P3/SSR3

9.1. FUNCTION BUTTON

The **[F]** function button starts the function that is programmed with parameter 50: Func (chapter 10). Activation or deactivation of the function is indicated by appropriate messages on the lower display (described below).

Available functions of the **[F]** button

Source	**Description** (depending on the value of parameter 50: Func)		**Message**
F	Func = nonE	**[F]** button is inactive (factory setting)	-
	Func = SEt3	step-wise change of the set value for the P1/SSR1 output (day = parameter 20: SEt1 /night = 30: SEt3, Table 10)	SEt1 / SEt3
	Func = bLoc	keyboard lock (with the exception of button **[F]**)	bLoc / boFF
	Func = hAn1	unconditional manual mode for the P1/SSR1 output (chapter 12.8)	hAnd / hoFF
	Func = hAn2	unconditional manual mode for the P2/SSR2 output	hAnd / hoFF
	Func = hAn3	unconditional manual mode for the P3/SSR3 output	hAnd / hoFF
	Func = hAnA	unconditional manual mode for the analog output	hAnd / hoFF
	Func = StSP	control start/stop (applies to all outputs)	StAr / StoP
	Func = inPu	unconditional view of the measured values from inputs 1 and 2	inoF / inPu

10. SETTING OF THE CONFIGURATION PARAMETERS

All the controller's configuration parameters are saved in a non-volatile (permanent) internal memory.
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 or not one that is factory-programmed. In such an event, the proper sensor or analog signal must be connected and the configuration must be programmed.

There are two parameter configuration methods:

1. From the film keypad located on the front panel of the device:

- from the mode where the input measurements are displayed in the configuration menu (press the **[UP]** and **[DOWN]** buttons simultaneously for more than 1 second) If parameter 49: PrOt = on (password protection is on) the display will show the message CodE, and then 0000 with the first digit blinking, use the buttons **[UP]** or **[DOWN]** to enter the password (default parameter 48: PASS = 1111), to move to successive items and to approve the code, use the **[SET]** button
- after entering the main configuration menu (with the message CnF) the upper display shows a mnemonic name of the submenu (parameter groups: diSP <-> in1 <-> in2 <-> etc.)
- use the**[UP]** or **[DOWN]** button to move to the relevant submenu and then use the **[SET]** button to approve selection (the name of the parameter is displayed in the upper display and the value - in the lower display)
- by pressing the **[UP]** button, you can move to the next parameter, and by pressing the **[DOWN]** button - to the previous parameter (e.g. inP <-> FiLt <-> dot <-> etc., the list of the configuration parameters is presented in Table 10)
- to change the value of the current parameter, press briefly the **[SET]** button (the parameter blinks in the edition mode)
- use buttons **[UP]** or **[DOWN]** 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 **[F]** or **[UP]** and **[DOWN]** buttons (the latter two must be briefly pressed simultaneously) - by pressing the **[UP]** and **[DOWN]** buttons or the **[F]** button again, you will return to the main configuration menu (a higher level)
- to exit the configuration: press the **[UP]** and **[DOWN]** buttons for a long moment or wait approx. 2 minutes

2. Use the RS485 or the PRG port (AR955/AR956 programmer) and the ARSOFT-CFG software (chapter 14):

- to connect the controller to a computer port and to start and configure the ARSOFT-CFG application;
- after the connection has been established, the current measured value is displayed in the window of the software
- 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 current configuration can be saved in a file or set using values read from a file

NOTE: ⚠

- before disconnecting the device from a computer, press the ***Disconnect device*** button (ARSOFT-CFG)
- in the event of no response:
- in the ***Program options*** check the configuration of the port and the ***MODBUS Address of the device***
- make sure that the serial port drivers in the computer have been properly installed for the RS485 converter or the AR955/AR955 programmer
- disconnect for a few seconds and then reconnect the RS485 converter or the AR956/AR955 programmer
- restart the computer

In the event of indications different than the actual value of the input signal, the zero and the sensitivity of a sensor can be tuned: parameters 8: CAL1 and 15: CAL2 (zero), and 9: CAL1 and 16: CALC (sensitivity).

To restore the factory settings, when the power supply is switched on press buttons **[UP]** and **[DOWN]** and hold them until the password menu appears (CodE), and then enter the following code 9112. As an alternative, a file with default configuration can be used in the ARSOFT-WZ1 software.

⚠ **Do not perform configuration of the device with the keypad and through the serial interface (RS485 or AR955/AR956) at the same time.**

Table 10. List of configuration parameters

Parameter	Range of variability of the parameter and description		Default
DISPLAY OPTIONS – submenu dSP			
0: dS1 value for the upper display	inP1 = measurement from input 1, inP2 = measurement from input 2, Subt = difference between measurements (1-2), Add = sum of measurements (1+2), Aurd = average value of measurements (sum of measurements from two inputs divided by 2), SEt1 = set value of output 1 (17: SEt1 or 39: HSEt in manual mode)		inP1
1: dS2 value for the lower display			inP2
2: br id illumination brightness	20 ÷ 100 %	brightness of the display, a 20% increase	100 %
CONFIGURATION OF MEASUREMENT INPUTS (submenu in1 for input 1 and similarly in2 for input 2) – the parameters of input 1 are shown below			
3: inP1 Type of measurement input	Pt	thermoresistance sensor (RTD) Pt100 (-200 ÷ 850°C)	Pt
	ni	thermoresistance sensor (RTD) Ni100 (-50 ÷ 170°C)	
	Pt5	thermoresistance sensor (RTD) Pt500 (-200 ÷ 620°C)	
	Pt10	thermoresistance sensor (RTD) Pt1000 (-200 ÷ 520°C)	
	tc-J	thermoelectric sensor (thermocouple) type J (-40 ÷ 800°C)	
	tc-K	thermoelectric sensor (thermocouple) type K (-40 ÷ 1,200°C)	
	tc-S	thermoelectric sensor (thermocouple) type S (-40 ÷ 1,600°C)	
	tc-b	thermoelectric sensor (thermocouple) type B (-300 ÷ 1,800°C)	
	tc-r	thermoelectric sensor (thermocouple) type R (-40 ÷ 1,600°C)	
	tc-t	thermoelectric sensor (thermocouple) type T (-25 ÷ 350°C)	
	tc-E	thermoelectric sensor (thermocouple) type E (-25 ÷ 820°C)	
	tc-n	thermoelectric sensor (thermocouple) type N (-35÷ 1,300°C)	
	4-20	current signal 4 ÷ 20 mA	
	0-20	current signal 0 ÷ 20 mA	
	0-10	voltage signal 0 ÷ 10 V	
	0-60	voltage signal 0 ÷ 60 mV	
	rES	resistance signal 0 ÷ 2,500 Ω	
4: FiL1 filtration **(1)**	1 ÷ 10	digital filtration of measurements (response time)	5
5: dot1 position of the point/resolution	0	no point **(2)** or 1°C for temperature	1 (0.1 °C)
	1	0.0 **(2)** or resolution 0.1 °C for temperature	
	2	0.00 **(2)**	
	3	0.000 **(2)**	
6: Lo1 lower limit or bottom of the indication range (**2**)	-199.9 ÷ 1800	lower setting limit for the set value 20: SEt1 or 25: SEt2	-199.9 °C
	-1999 ÷ 9999	indication 0/4 mA, 0 V, 0 Ω - start of the input scale (**2**)	
7: Hi1 upper limit 1 or top of the indication range	-199.9 ÷ 1800	upper setting limit for the set value 20: SEt1 or 25: SEt2	850.0 °C
	-1999 ÷ 9999	indication for 20 mA, 10 V, 60 mV, 2.5 kΩ - end of the input scale **(2)**	
8: cAL1 calibration of the zero	zero offset for measurements: -500 ÷ 500 °C or -500 ÷ 500 units **(2)**		0.0 °C
9: cAG1 gain	850 ÷ 1150 %	calibration of inclination (sensitivity) for measurements	1000 %

MAIN OUTPUT CONFIGURATION (P1/SSR1) – submenu **out1** - chapter 12 (12.2)		
17: **co51** control signal for output 1 (assignment of input)	**inP1** = measurement from input 1, **inP2** = measurement from input 2, **Subt** = difference between measurements (1-2), **Add.** = sum of measurements (1+2), **Aurg** = average value of measurements (sum of measurements from two inputs divided by 2)	**inP1**
18: **fto1** failure status of output 1 **(3)**	output status in the case of lack of or damage to the measurement sensor (signal): **noCh** = no change, **oFF** = switched off, **on** = switched on, **hAnd** = manual mode with set output signal level (parameter 26: **HSEt** , chapter 12.8)	**noCh**
19: **Fun1** function of output 1	**oFF** = off, **hAnd** = manual mode, **inv** = heating, **dir** = cooling	**inv**
20: **SEt1** set value 1	applies to output 1, changes in scope 6: **Lo1** ÷ 7: **H.1** or 13: **Lo2** ÷ 14: **H.2** (only when 17: **co51** = **inP2**)	**1000** °C
21: **H1** hysteresis of output 1 or PID tuning zone	hysteresis or insensitivity zone of PID tuning in mode **Auto** , chapter 12.5 **0.0** ÷ **9999** °C or **0** ÷ **9999** units **(2)**	**1.0** °C
CONFIGURATION OF AUXILIARY OUTPUTS (P2/SSR2 and P3/SSR3) – submenu **out2** for output 2 and analogously **out3** for output 3 - chapter 12 - the parameters for output 2 are shown below		
22: **co52** control signal for output 2 (assignment of input)	**inP1** = measurement from input 1, **inP2** = measurement from input 2, **Subt** = difference between measurements (1-2), **Add.** = sum of measurements (1+2), **Aurg** = average value of measurements (sum of measurements from two inputs divided by 2)	**inP2** (**inP1** for output 3)
23: **fto2** failure status of output 2 **(3)**	output status in the case of lack of or damage to the measurement sensor (signal): **noCh** = no change, **oFF** = switched off, **on** = switched on, **hAnd** = manual mode with set output signal level (parameter 26: **HSEt** , chapter 12.8)	**noCh**
24: **Fun2** function of output 2 (chapter 12.2)	**oFF** = off, **hAnd** = manual mode, **inv** = heating, **dir** = cooling, **bAon** or **bAoF** = band 2* **SEt2** (**SEt3** for output 3) around **SEt1** , **dEoF** or **dEon** = deviation from **SEt1** , **rEon** , **rEoF** , **rEP3** = controlled by the process controller (ramping), chapter 12.7	**inv** (**oFF** for output 3)
25: **SEt2** set value 2	applies to output 2, changes in scope 13: **Lo2** ÷ 14: **H.2** or 6: **Lo1** ÷ 7: **H.1** (only when 22: **to52** = **inP1**)	**1000** °C
26: **H2** hysteresis of output 2	**0.0** ÷ **9999** °C or **0** ÷ **9999** units **(2)**	**1.0** °C
ANALOG OUTPUT CONFIGURATION – submenu **outA** - (chapter 12.3)		
32: **coSA** signal for the function of retransmission of measurement for the analog output (assignment of input)	**inP1** = measurement from input 1, **inP2** = measurement from input 2, **Subt** = difference between measurements (1-2), **Add.** = sum of measurements (1+2), **Aurg** = average value of measurements (sum of measurements from two inputs divided by 2)	**inP1**
33: **AtyP** type of analog output	depending on the order code: for current output **0-20** or **4-20** mA, for voltage output **0-10** or **2-10** V	**0-20** mA (**0-10** V)
34: **FunA** function of analog output	**oFF** = off, **hAnd** = manual mode, **rEtr** = retransmission of measurement, **cont** = control output, a detailed description is provided in chapter 12.3	**oFF**
35: **A-Lo** lower indication for retransmission	start of the output scale - for output signal value 0/4 mA or 0/2 V (the parameter is active only for measurement retransmission when 34: **FunA** = **rEtr**)	**0.0** °C
36: **A-H.** upper indication for retransmission	end of the output scale - for output signal value 20 mA or 10 V (the parameter is active only for measurement retransmission when 34: **FunA** = **rEtr**)	**1000** °C

CONFIGURATION OF THE PID ALGORITHM AND THE MANUAL MODE – submenu PidH				
37: tunE type of PID tuning	oFF = off, Auto = automatic selection (continuous tuning), StEP = run-up (quick) method, oSct = oscillation (slower) method, chapter 12.5			oFF
38: Pb range of PID proportionality	00 ÷ 1800 or 0 ÷ 9999 units **(2)**, 0 - switches off the PID's action, a description of the PID algorithm and associated topics can be found in chapters 12.4 ÷ 12.6			00 °C
39: Ti PID integration time constant	0 ÷ 3600 s	PID algorithm doubling time 0 switches off the integrating component of the PID algorithm		0 s
40: td PID differentiation time constant	0 ÷ 999 s	PID algorithm lead time 0 switches off the differentiating component of the PID algorithm		0 s
41: tc impulse period	3 ÷ 360 s	for bi-state outputs (1, 2, 3) in the manual mode and the PID		5 s
42: MSEt set value of the manual mode	0 ÷ 100 % 1% step	control value for outputs in the manual mode, applies to all outputs (1, 2, 3, and the analog output), chapter 12.8		500 %
PROCESS CONTROLLER CONFIGURATION (programmed work characteristics, ramping, chapter 12.7) – submenu ProG				
43: rAMP work mode of process controller	oFF = off, MAnu = manual start, Auto = start after each activation of power supply and control (using the **[F]** button when 50: Func = St.SP)			oFF
44: rAr gradient of stage 1	concerns stage Pr-1, 0.1 ÷ 300 °C/min. or 1 ÷ 3000 units/min. **(2)**			0.1 °C
45: th1 time of stage 2	0 ÷ 8540 min.	duration of stage Pr-2, 0 maintains stage Pr-2 permanently		30 min.
46: th3 time of stage 4	0 ÷ 8540 min.	duration of stage Pr-4, 0 maintains stage Pr-4 permanently		30 min.
ACCESS OPTIONS – submenu AccE				
47: bSEt value change block SEt1, SEt2	oFF = no block, SEt1 = block of parameter 20: SEt1, SEt2 = block 25: SEt2, both = simultaneous block of changes to parameters 20: SEt1 and 25: SEt2			oFF
48: PASS password	0000 ÷ 9999	password for the parameter configuration menu		1111
49: PPro protection of the configuration with a password	oFF	entry into the configuration menu is **not** password-protected		on
	on	entry into the configuration menu is password-protected		
COMMUNICATION OPTIONS AND OTHER CONFIGURATION PARAMETERS – submenu othE				
50: Func function of the **[F]** button (chapter 9.1)	nonE	the **[F]** button is inactive		nonE
	SEt3	change of the set value (day/night) for output 1		
	bLoc	keyboard lock (with the exception of button **[F]**)		
	MAn1	unconditional manual mode for output 1 (P1/SSR1)		
	MAn2	unconditional manual mode for output 2 (P2/SSR2)		
	MAn3	unconditional manual mode for output 3 (P3/SSR3)		
	MAnA	unconditional manual mode for the analog output		
	St.SP	control start/stop (applies to all outputs)		
	inPu	unconditional view of the measured values from inputs 1 and 2		
51: Addr MODBUS-RTU address	1 ÷ 247	individual address of the device in the RS485 network (chapter 16)		1
52: br speed for the RS485 and the PRG port	2.4 kbit/s	4.8 kbit/s	9.6 kbit/s	19.2 kbit/s	19.2 kbit/s
	38.4 kbit/s	57.6 kbit/s	115.2 kbit/s		

Notes: **(1)** – for FiL = 1 the response time is equal to 0.5 s, for FiL = 20 it is equal to at least 4 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).
(2) – applies to analog inputs (mA, V, mV, Ω)
(3) – the parameter also defines the state of the output outside of the measurement range

11. QUICK ACCESS MENU

In the measurement mode (when the measured value is displayed), it is possible to immediately access certain configuration parameters and functions without the need to enter a password. This possibility is offered by the quick menu, which can be accessed by pressing the **[SET]** button. The parameter is selected and edited in the same way as described above (in chapter 10).

Table 11. List of elements accessible in the quick configuration menu.

Element	Description
SEt1	set value 1 (parameter 20: SEt1), optional element - unavailable when parameter 19: out1 = HAnd, changes blocked during selection of parameters (tuning) of the PID (chapter 12.5) and in the process control mode (chapter 12.7) and the mode of change of the set value 1 to SEt3 (chapter 9.1)
SEt2	set value 2 (25: SEt2), optional element - unavailable when parameter 24: Fun2 = oFF or HAnd
SEt3	set value 3 (30: SEt2), optional element - unavailable when parameter 29: Fun3 = oFF or HAnd
t-St	start/stop of PID tuning (chapter 12.5), optional element - unavailable when parameter 37: tunE = oFF
P-St	start/stop of the process controller (chapter 12.7), optional element - unavailable when parameter 43: -AAP = oFF
MSEt	set value of the manual mode (42: MSEt), optional element - available for outputs in the manual operation mode

12. OUTPUT OPERATION CONFIGURATION

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 (chapter 10). A detailed description of configuration of the operation of outputs is given in chapters 12.1÷ 12.8. The default (factory) configuration is the following: outputs 1 is related to input 2 and output 2 is related to input 2, control mode ON/OFF with hysteresis, output 3 and the analog outputs are switched off (Table 10, *Factory settings* column).

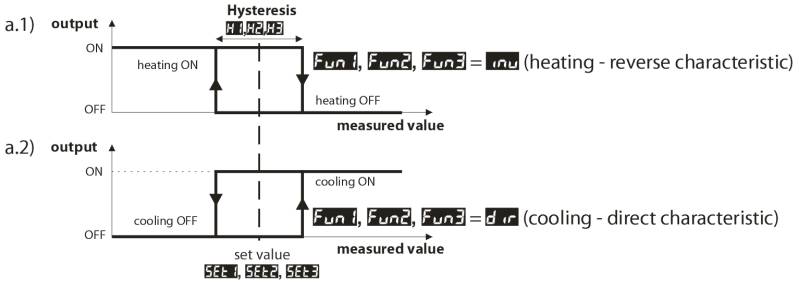
12.1. CHANGING THE OUTPUTS SET VALUES

The simplest way to change the set value for output 1 (parameter 20: SEt1 or 42: MSEt when output 1 is in the manual mode) is to use the **[UP]** button or the **[DOWN]** button. In the case of the other outputs, the quick menu can be used (chapter 11). As an alternative, it is possible to change the set value in the parameter configuration mode (using the methods described in chapter 10).

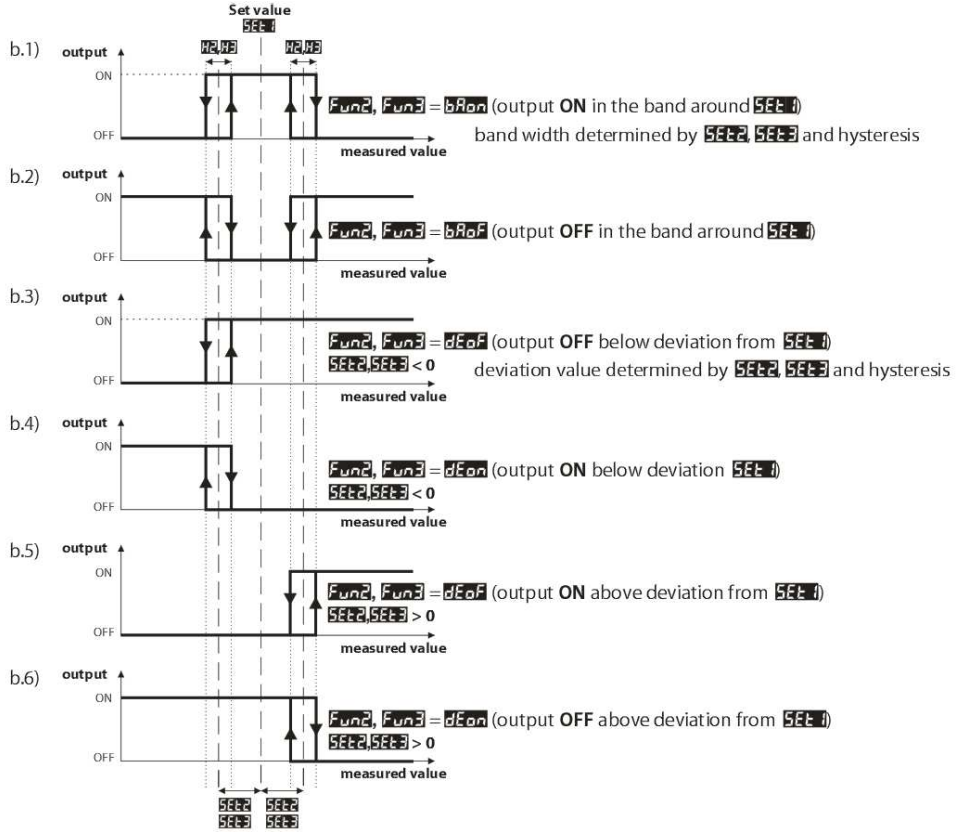
12.2. TYPES OF OUTPUT CHARACTERISTICS

The mode of operation of each output is programmed using parameters 19: Fun1, 24: Fun2, and 29: Fun3, chapter 10, Table 10.

a) basic operating characteristics of outputs



b) additional operating characteristics of outputs (applies only to outputs 2 and 3)



12.3. ANALOG OUTPUT

The standard of the output signal is determined by parameter 33: AtyP (chapter 10, Table 10). The analog output can work in one of the following modes: retransmission of measurement (parameter 34: outA = rEtr), manual mode (34: outA = hAnd) and as an automatic control output (34: FunA = out1). In the mode of retransmission of a selected measurement (32: coSA) the output signal is proportional to the signal measured in the range set by

parameters 35: A-Lo and 36: A-H, (e.g. 0 mA for the measured value 0 °C when A-Lo = 0 °C, 20 mA for 100 °C when A-H, = 100 °C and, as appropriate, 10 mA for the half of the range, i.e. 50°C).
Manual operation (chapter 12.8) enables smooth change of the output signal in the range of 0-100% with an increment of 1% and the initial value equal to the last value in the automatic mode (measurement retransmission or control mode, applies to the controller firmware release starting from v- 13, which is displayed when power is switched on). In the control output mode, the control parameters and their functions are identical as in the case of output 1 (the applicable parameters are 17: coS1, 18: Fto1, 19: Fun1, 20: SEt1, 21: H1, PID algorithm and tuning parameters and process controller parameters). In the control mode, the range of variability of the analog signal is continuous only for the PID algorithm (chapter 12.4), in the case of ON-OFF control with hysteresis, the output assumes the limit values (lower or upper, e.g. 0mA or 20mA) without the intermediate values, which may be used to switch on, e.g. the SSR relay.

12.4. 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 12.5. Also, it is always possible to manually correct the settings (chapter 12.6).
The controller works in the PID mode when the proportionality range (parameter 38: Pb) is not a zero value. The location of the proportionality range Pb in relation to the set value SEt1 is shown in drawings 12.4 a) and b). The impact of the integrating and differentiating components of PID control is determined by parameters 39: t1 and 40: td . Parameter 41: tc determines the pulsing period for output 1 (P1/SSR1). If the PID algorithm is implemented by the 0/4÷20 mA or 0/2÷10 V analog output, the 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 regulation (proportional regulation) for output 1 is shown in figures d) and e) for the analog output figure c).

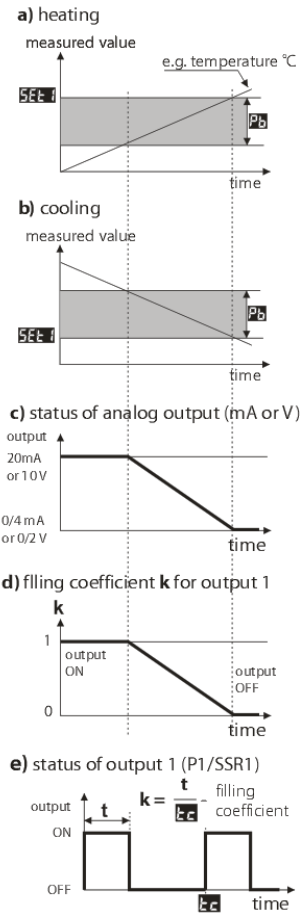


Fig. 12.4. Principle of the PID regulation:
a) location of the proportionality range Pb in relation to the set value SEt1 for heating (Fun1 = inu)
b) location of the proportionality range Pb in relation to the set value SEt1 for cooling (Fun1 = dir)
c) state of the 0/4÷20 mA or 0/2÷10 V analog output
d) filling coefficient for output 1 (P1/SSR1)
e) state of output 1 (for the measured value within the proportionality range)

12.5. AUTOMATIC PID PARAMETER SELECTION

The first step to use the PID parameter selection function is to choose the type of tuning (parameter 37: tunE, chapter 10). The tuning is started automatically when the control starts (after the power supply is switched on, and by pressing the **[F]** function button, when parameter 50: Func = St.SP, chapter 9.1). Moreover, tuning can be stopped (oFF), and then started (on) at any time using the t-St function available in the quick menu (chapter 11). During the tuning (when the display shows, alternately with the measured value, the message tunE) the set value must not be changed (20: SEt 1 or 30: SEt 3 when 50: Func = SEt 3).

The value of parameter 37: tunE determines the selection of the PID parameter selection method:

a) 37: tunE = Auto - automatic selection - 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 initiating the PID parameter selection procedure is that the current measured value must be located outside of the insensitivity zone defined as the sum of the values of parameter 38: Pb and 21: HY 1 in relation to the set value 20: SEt 1, as shown in figure 12.5.

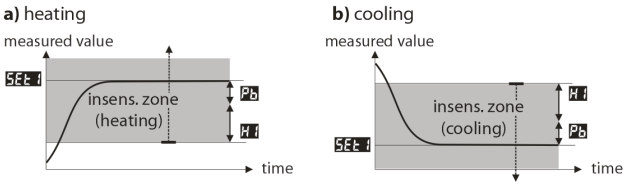


Fig. 12.5. Location of the insensitivity zone for heating (19: Fun 1 = inv) and cooling (19: Fun 1 = dir)

In order to avoid unnecessary activation of tuning, which may slow down the process, it is recommended to set the highest possible value of HY 1, 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 tunE message also takes place in the insensitivity band if sudden changes in the measured value or set value 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 run-up (quick) method will be selected; in other cases, the oscillation method (slower) will be 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 set value or the weight of the furnace batch).

b) 37: tunE = StEP – 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 set 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 control start/stop function should be used (the **[F]** button). 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) 37: tunE = oSCi – 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 set 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 set 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 saving in the controller's permanent memory parameters 38: Pb , 39: t i , 40: t d and 41: t c
- switching on the regulation with new PID settings;

Programmed interruption of the auto-tuning **b** or **c** (with the message Err1) may take place, if the conditions for proper operation of the algorithm are not met, such as:
- the initial value is higher than the set value for heating or lower than the set 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 SEt 1 threshold or the controlled object's parameters (e.g. the heating/cooling power, the batch weight, the initial temperature, etc.).

12.6. PID PARAMETER CORRECTION

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 and the impact of the change on the process should be observed:

a) oscillations about the threshold - increase the range of proportionality 38: Pb , increase the integration time 39: t i , reduce the differentiation time 40: t d , (or change by a half the impulse period of output 1, parameter 41: t c)

b) slow response - decrease the range of proportionality Pb , differentiation times t d and integration times t i

c) over-regulation - increase the range of proportionality Pb , differentiation times t d and integration times t i

d) instability - increase the integration time t i .

12.7. PROGRAMMED OPERATING CHARACTERISTICS (RAMPING)

Setting of parameter 43: rAMP (see chapter 10, Table 10) to value MAnu or AUto makes it possible to program the device as a 4-step process controller, implemented through output 1, acting in accordance with the diagram shown here (Fig. 12.7). This type of operation can be started both manually at any time (when parameter 43: rAMP = MAnu or AUto) and automatically (rAMP = AUto) at the time when the control is started (after power supply is switched on and by using the **[F]** function button when parameter 50: Func = St.SP , chapter 9.1). In order to manually switch on (on) or switch off (oFF) the process controller, use the P-St function available in the quick menu (chapter 11).

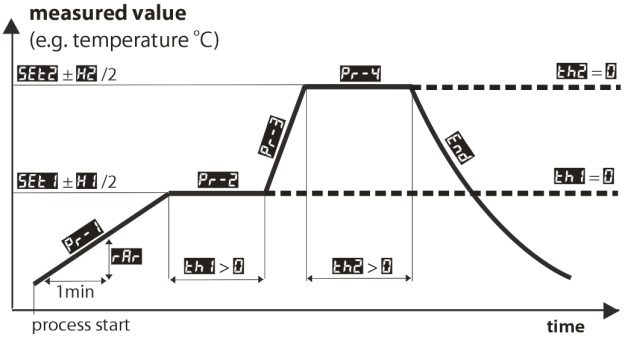


Fig. 12.7. Diagram showing the operation of the 4-step process controller

The successive steps of the process are shown on any display by messages shown every few seconds, alternately with the current displayed value:

- Pr-1 - stage 1 - reaching the value of threshold 20: SEt1 with set gradient (44: rAr) - ramping
- Pr-2 - stage 2 - implementation of the 1st holding time 45: th1 on level SEt1 (with hysteresis 21: H1), value of parameter th1 = 0 maintains step Pr-2 permanently
- Pr-3 - stage 3 - reaching the value of threshold 25: SEt2 with full power
- Pr-4 - stage 4 - implementation of the 2nd holding time 46: th2 on level SEt2 (with hysteresis 26: H1), value of parameter th1 = 0 maintains step Pr-2 permanently
- End - end of process (output 1 is switched off permanently)

Moreover, it is possible to relate to the process outputs 2 or 3 when parameter 24: Fun2 or 29: Fun3 is equal to:

rEon - switching the output on after the end of the process (switched off in the course)

rEoF - switching off the output after the end of the process (switched on in the course)

rEP3 - switching on the output for steps Pr-3 and Pr-4

12.8. MANUAL AND REMOTE CONTROL FUNCTION

The manual mode enables setting the value of the output signal in the entire range of its variability (0-100%), thus enabling operation in an open regulation loop (no automatic coupling between the measured value and the output signal). Manual operation is available individually for each output of the controller and is programmed using parameters 19: Fun1, 24: Fun2, 29: Fun2, and 34: Fun3, chapter 10, Table 10. Also, the outputs can be configured for quick (unconditional) manual mode controlled by:

- the **[F]** function button, by programming, as appropriate, parameter 50: Fun5 (chapter 9.1),
- measurement error of the sensor (range exceeded or a defect), when 18: Fto1, 23: Fto2, or 28: Fto3 is equal to HAnd

In the case of bi-state outputs (1, 2, 3), the change of the output signal consists in setting the filling coefficient (using parameter 42: HSEt) with impulse period defined by parameter 41: tS. The set value of the manual mode 42: HSEt = 0 stands for a permanently switched off output; value 100 stands for a permanently switched on output. The value can be set directly using the **[UP]** or **[DOWN]** button (only in the case of output 1, chapter 12.1) or using the quick menu (chapter 11), or alternatively, in the parameter configuration mode (from the membrane keypad or remotely using the RS485 or PRG serial port, chapters 10, 14-16).

13. MESSAGE AND ERROR SIGNALING

a) measurement errors:

Code	Possible causes of error
---- ____	- the measurement range of the sensor is exceeded from the top (----) or from the bottom (____) - the sensor is broken - the sensor that is connected is different than the one that is set in the configuration (chapter 10, parameter 3: inP1 or 10: inP2)

b) temporary messages and errors (one-time and recurring):

Code	Description of message
CodE	mode of entering the password for access to the configuration parameters, chapter 10
Err	the password is invalid,
ConF	the parameter configuration menu was accessed,
tunE	implementation of the PID automatic tuning function, chapter 12.5
Errt	automatic tuning error, chapter 12.5, error deletion using the **[UP]** and **[DOWN]** buttons (pressed simultaneously)

StAr / StoP	control start/stop, chapter 9.1
SEt1 / SEt3	change of the set value (day/night) for output 1, chapter 9.1
bLoc / boFF	keypad block on/off, chapter 9.1
hAnd / hoFF	unconditional manual mode on/off, chapter 9.1
Pr-1 ÷ Pr-4, End	implementation of the process control function (ramping), chapter 12.7
SAvE	saving of factory parameter values (chapter 10)

14. CONNECTING THE CONTROLLER TO A COMPUTER AND AVAILABLE SOFTWARE

It may be useful (or necessary) to connect the controller to a computer in the following situations:
- remote monitoring and recording of current measurement data and process (status of the outputs) control;
- quick configuration of parameters, to include copying of settings to other controllers of the same type

In order to establish communication over long distances, it is necessary to establish a connection in the RS485 standard with an available port in the computer (directly or using an RS485 converter), as described in chapter 15. Moreover, as a standard, the controllers are equipped with a PRG port which enables connecting to a computer using an AR955/956 programmer (without galvanic isolation, cable length approx. 1.2 m). Both the programmer and the RS485 converter require installation of the supplied serial port drivers on the computer. Communication with devices is effected using a protocol compatible with MODBUS-RTU (chapter 16). The following applications are available (on a CD supplied with the AR955/956 programmer or to be downloaded from the Internet at ***www.apar.pl***, *Download* section, for operating systems Windows Vista/7/8/10):

Name	Software description
ARSOFT-WZ1 (free)	- display of current measurement data from the connected device - configuration of the type of measurement input, the indication range, the control options, the alarms, the display, the communication, etc. (chapter 10) - creation on the disk of a "cfg" file with the current configuration of the parameters for future use (copying of configuration) - the software requires communication with the controller via the RS485 or PRG (AR955/AR956) port

The detailed descriptions of the aforementioned applications can be found in the installation folders.

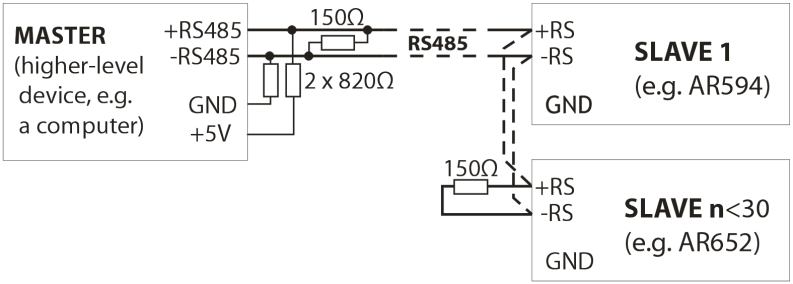
NOTE: ⚠

Before establishing the connection, make sure that the MODBUS address of the device (parameter 51: Addr) and the speed of transmission (52: br) are the same as the settings of the software. Moreover, in the software options, set the number of the COM serial port in use (in the case of the RS485 converter or the AR955/AR956 programmer it is the number assigned by the operating system during installation of the drivers).

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

It may be useful (or necessary) to connect the controller to a computer in the following situations:

The installation specification for the RS485 interface is the following:



Maximum cable length - 1 km

Maximum number of devices in a RS485 line - 30, in order to increase the number, use RS485/RS485 amplifiers

Termination resistors when the MASTER is at the start of the line (see the figure above):

- at the start of the line - 2 x 820 Ω to the ground and +5 V of the MASTER, and 150 Ω between the lines,
- at the end of the line - 150 Ω between lines,

Termination resistors when the MASTER is in the center 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.

During configuration of the network, make sure to observe the cable installation recommendations given in chapter 2.

16. MODBUS–RTU SERIAL TRANSMISSION PROTOCOL (SLAVE)

Character format : 8 bits, 1 stop bit, no parity bit
Available functions : READ - 3 or 4, WRITE - 6

Table 16.1. Claim frame format for the READ function (frame length - 8 bytes):

address of the device	function 4 or 3	read register address: 0 ÷ 69 (0x0045)	number of read registers: 1 ÷ 70 (0x0046)	CRC check sum
1 byte	1 byte	2 bytes (HB-LB)	2 bytes (HB-LB)	2 bytes (LB-HB)

Example 16.1. Reading of a register with address 0: 0x01 - 0x04 - 0x0000 - 0x0001 - 0x31CA

Table 16.2. Claim frame format for the WRITE function (frame length - 8 bytes):

address of the device	function 6	write register address: 0 ÷ 69 (0x0045)	write register value	CRC check sum
1 byte	1 byte	2 bytes (HB-LB)	2 bytes (HB-LB)	2 bytes (LB-HB)

Example 16.2. Entry in a register with address 10 (0xA) with the 0 value: 0x01 - 0x06 - 0x000A - 0x0000 - 0xA9C8

Table 16.3. 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. 70*2=140 bytes)	data field - register value	CRC check sum
1 byte	1 byte	1 byte	2 ÷ 140 bytes (HB-LB)	2 bytes (LB-HB)

Example 16.3. Response frame for register value equal to 0: 0x01 - 0x04 - 0x02 - 0x0000 - 0xB930

Table 16.4. Response frame format for the WRITE function (frame length - 8 bytes):

copy of the claim frame for the WRITE function (Table 16.2)

Table 16.5. Special answer (errors: 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 16.5. Error frame for a non-existing read register address:
0x01 - 0x84 - 0x02 - 0x0001 –0x5130

Table 16.6. Map of registers for the MODBUS-RTU protocol

Register address HEX (DEC)	**Value (HEX or DEC)**	**Description of register and access type** (R- read only register, R/W - read and write register)	
0x00 (0)	0	not used or reserved	**R**
0x01 (1)	653	device type identifier	**R**
0x02 (2)	100 ÷ 999	controller software (firmware) version	**R**
0x03 ÷ 0x05	0	not used or reserved	**R**
0x06 (6)	0 ÷ 7	current status of outputs 1, 2, 3: bits 0, 1, 2, bit=1 means the output is switched on	**R**
0x07 (7)	0 ÷ 20,000	current state of the analog output (0 ÷ 20,000 µA or 0 ÷ 10,000 mV)	**R**
0x08 (8)	-100 ÷ 700	thermocouple cold tip temperature (resolution 0.1°C)	**R**
0x09 ÷ 0x0D	-1,999 ÷ 19,999	measured values (input 1, input 2, difference 1-2, sum 1+2, average)	**R**
0x0E ÷ 0x10	0	not used or reserved	**R**
Configuration parameters (chapter 10)			
0x11 (17)	0 ÷ 5	parameter 0: dSP1 value indicated for the upper display	**R/W**
0x12 (18)	0 ÷ 5	parameter 1: dSP2 value indicated for the lower display	**R/W**
0x13 (19)	20 ÷ 100	parameter 2: bright brightness of the display, a 20% increase	**R/W**
Configuration parameters for the measurement channel numbered **KP** = 0 ÷ 1 (0=channel 1, 1=channel 2)			
0x14 (20) +KP*7	0 ÷ 16	parameter 3+KP*7: inP type of measurement input (chapter 10)	**R/W**
0x15 (21) +KP*7	1 ÷ 10	parameter 4+KP*7: FiL digital filtration of measurements (response time)	**R/W**
0x16 (22) +KP*7	0 ÷ 3	parameter 5+KP*7: dot position of the point or resolution for temperature	**R/W**
0x17 (23) +KP*7	-1,999 ÷ 18,000	parameter 6+KP*7: Lo lower limit or bottom of the indication range	**R/W**
0x18 (24) +KP*7	-1,999 ÷ 18,000	parameter 7+KP*7: Hi upper limit or top of the indication range	**R/W**
0x19 (25) +KP*7	-500 ÷ 500	parameter 8+KP*7: oFFs zero offset for measurements	**R/W**
0x1A (26) +KP*7	850 ÷ 1,150	parameter 9+KP*7: CAL calibration of inclination (sensitivity) for measurements	**R/W**

0x22 (34)	0 ÷ 4	parameter 17: **coS1** control signal for output 1 (assignment of input)	**R/W**
0x23 (35)	0 ÷ 3	parameter 18: **Fto1** failure status of output 1	**R/W**
0x24 (36)	0 ÷ 3	parameter 19: **Fun1** function of output 1	**R/W**
0x25 (37)	-1,999 ÷ 18,000	parameter 20: **SEt1** set value 1	**R/W**
0x26 (38)	0 ÷ 9,999	parameter 21: **H1** hysteresis of output 1 or PID tuning insensitivity zone	**R/W**
Configuration parameters of auxiliary outputs 2 and 3 (output index **KA** = 0 ÷ 1, 0-output 2, 1-output 3)			
0x27 (39) +KA*5	0 ÷ 4	parameter 22+KA*5: **coS** control signal for output (2 or 3)	**R/W**
0x28 (40) +KA*5	0 ÷ 3	parameter 23+KA*5: **Fto** failure status of output (2 or 3)	**R/W**
0x29 (41) +KA*5	0 ÷ 10	parameter 24+KA*5: **Fun** function of output (2 or 3)	**R/W**
0x2A (42) +KA*5	-1,999 ÷ 18,000	parameter 25+KA*5: **SEt** set value (2 or 3)	**R/W**
0x2B (43) +KA*5	0 ÷ 9,999	parameter 26+KA*5: **H** hysteresis of output (2 or 3)	**R/W**
0x31 (49)	0 ÷ 1	parameter 32: **AtyP** type of analog output	**R/W**
0x32 (50)	0 ÷ 4	parameter 33: **coSA** measurement retransmission signal for analog output	**R/W**
0x33 (51)	0 ÷ 3	parameter 34: **FunA** function of analog output	**R/W**
0x34 (52)	-1,999 ÷ 18,000	parameter 35: **A-Lo** lower indication for retransmission	**R/W**
0x35 (53)	-1,999 ÷ 18,000	parameter 36: **A-H.** upper indication for retransmission	**R/W**
0x36 (54)	0 ÷ 3	parameter 37: **tunS** type of PID tuning	**R/W**
0x37 (55)	0 ÷ 18,000	parameter 38: **Pb** range of PID proportionality	**R/W**
0x38 (56)	0 ÷ 3,600	parameter 39: **t.i** PID integration time constant	**R/W**
0x39 (57)	0 ÷ 999	parameter 40: **t.d** PID differentiation time constant	**R/W**
0x3A (58)	3 ÷ 360	parameter 41: **tc** impulse period	**R/W**
0x3B (59)	0 ÷ 100	parameter 42: **MSEt** set value of the manual mode	**R/W**
0x3C (60)	0 ÷ 2	parameter 43: **rAmP** work mode of process controller	**R/W**
0x3D (61)	1 ÷ 300	parameter 44: **rAr** gradient of stage 1	**R/W**
0x3E (62)	0 ÷ 3,600	parameter 45: **t.h1** time of stage 2	**R/W**
0x3F (63)	0 ÷ 3,600	parameter 46: **t.h1** time of stage 4	**R/W**
0x40 (64)	0 ÷ 3	parameter 47: **bSEt** value change block **SEt1**, **SEt2**	**R/W**
0x41 (65)	0 ÷ 9,999	parameter 48: **PASS** password	**R/W**
0x42 (66)	1 ÷ 2	parameter 49: **PPro** protection of the configuration with a password	**R/W**
0x43 (67)	0 ÷8	parameter 50: **Func** function of the **[F]** button	**R/W**
0x44 (68)	1 ÷ 247	parameter 51: **Addr** MODBUS-RTU address in the RS485 network	**R/W**
0x45 (69)	0 ÷ 6	parameter 52: **br** speed for RS485	**R/W**

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