APAR – COMMERCIAL OFFICE
05-090 Raszyn, ul. Gałczyńskiego 6, Poland
Tel: +48 22 853 48 56, 853 49 30,101 27 31
E-mail: automatyka@apar.pl
Web: www.apar.pl

USER MANUAL

AR603

AR613

CONTROLLER WITH TIME FUNCTIONS

Version 2.0.0
2018.02.23

Thank you for choosing our product.
This manual will enable proper handling, secure
and full use of the regulator's capabilities.
Before assembling and starting the device please read
and understand this manual.
If you have additional questions, please contact our technical consultant.

CONTENTS

Special attention should be paid to texts marked with this sign

The manufacturer reserves the right to make changes to the design and software of the device without any deterioration of technical parameters (some functions may not be available in older versions).

1. SAFETY RULES

- before using the device, please read this manual carefully
- in order to avoid electric shock or damage to the device mechanical and electrical assembly should be commissioned to qualified personnel
- before turning on the power, make sure that all cables have been connected correctly
- before making any modifications to the wiring connections, turn off the voltage supplied to the device
- ensure proper working conditions, in accordance with the technical specifications of the device (supply voltage, humidity, temperature, chapter 5)

2. INSTALLATION RECOMMENDATION

The device has been designed to provide an adequate level of resistance to most of the disturbances that can occur in industrial and home environments. In environments with an unknown level of interference it is recommended to use the following measures to prevent any possible disruption of the device's operation:

a) without proper line filters do not provide the power supply to the controller from the same lines which supply large equipment;

b) use screened power supply, sensor and signal cables; the screen earthing shall be one-point type, located as close to the device as possible;

c) avoid placing the measuring (signal) leads in direct vicinity of and parallel to power supply cables or lines;

d) it is recommended to twist the signal leads in pairs;

e) avoid proximity of remotely controlled devices, electromagnetic meters, large electrical loads, loads with phase or group power control, and other devices generating large pulse disturbance;

f) provide earthing or neutralization to metal rails on which the rail-mounted devices are installed.

Before starting working with the device, remove the protective foil of the display.

3. GENERAL CHARACTERISTIC OF THE CONTROLLER

- 1 universal measuring input (supporting thermo-resistance, thermocouple sensors or digital probes of temperature AR182 and AR183)
- binary input START / STOP to control the time function
- 2 control outputs, relay or SSR control, on/off type (ON-OFF) with hysteresis, PID, PID AUTOTUNING
- automatic selection of PID parameters function
- time functions (timer) starting automatically or manually
- signaling the clock operation with LED and output 2 (relay or SSR)
- LED signaling of relay status and type of setpoint on the lower display
- programmable work characteristics (process controller, ramping)
- two-line LED display with adjustable brightness:
  UPPER display - measured value, **LOWER** - reference values
- line resistance compensation for resistive sensors
- temperature compensation of cold ends of thermocouples
- programmable input type, digital filtration, regulation and access options and other configuration parameters
- access to configuration parameters protected by a user's password
- option to block setpoint changes and START/STOP keyboard button
- methods to parameters configuration:
  - from the foil keyboard and tuning knob (encoder) located on the front panel of the device
  - via PRG port (AR955/AR956 programmer) and the free ARSOFT-CFG program (Windows 7/8/10)
- software and programmer enabling the preview of the measured value and fast configuration of single or ready parameter sets previously stored in the computer for the purpose re-use, for example in other controllers

of the same type (duplication of configuration)

- panel housings, IP40 from the front, IP20 from the connectors
- high accuracy, long-term stability and resistance to noise
- wide supply voltage range: 15 ÷ 250 Vac (alternating voltage 50/60 Hz), 20 ÷ 350 Vdc (direct voltage)
- available accessories:
  - AR955 programmer
  - digital temperature probes AR182, AR183

NOTE:

Before starting operating the controller please read this manual and correctly perform electrical and mechanical installation and parameter configuration.

NOTE:

The controller is set in the time-limited regulation mode with manual triggering. After turning the power on, the outputs are off, the regulation is started after the START/STOP signal from the keyboard or the START/STOP binary input.

4. CONTENTS OF THE SET

- controller with fastening holders ti install in the board window
- user manual
- warranty card

5. TECHNICAL DATA

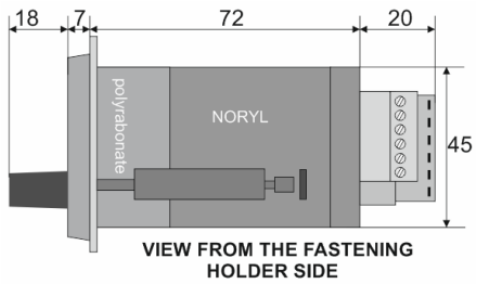
1 universal input (set by parameter 0: inP)		**measuring range**
- Pt100 (3- or 2-wire)		-100 ÷ 850 °C
- J (Fe-CuNi) thermocouple		0 ÷ 880 ° C
- K (NiCr-NiAl) thermocouple		0 ÷ 1200 ° C
- S (PtRh 10-Pt) thermocouple		0 ÷ 1750 ° C
- B (PtRh30PtRh6) thermocouple		300 ÷ 1800 ° C
- R (PtRh13-Pt) thermocouple		0 ÷ 1600 ° C
- T (Cu-CuNi) thermocouple		0 ÷ 380 ° C
- E (NiCr-CuNi) thermocouple		0 ÷ 700 ° C
- N (NiCrSi-NiSi**)** thermocouple		0 ÷ 1300 ° C
- AR182 digital temperature probe		-50 ÷ 120 °C
- AR183 digital temperature probe		-50 ÷ 80 °C
Response time (10 ÷ 90%)		0.5 ÷ 2 s (programmable with parameter 1: FiLt)
Lead resistance (Pt100)		R_d <30 Ω (for each line)
Resistance input current (Pt100)		~ 250 µA
Processing errors (at an ambient temperature of 25° C):		
- basic	- for Pt100	0,2% of the measuring range ± 1 digit
	- for thermocouples	0,3% of the measuring range ± 1 digit
- additional for thermocouples		<2 ° C (temperature of cold ends)
Resolution of the measured temperature		programmable, 0.1 ° C or 1 ° C

Accuracy of time measurement		< 2 %
Binary input (contact or voltage <24 V)		bistable, active level: short circuit or <0.8 V
Communication interfaces	- PRG programming connector (without separation), standard	- 2,4 kb/s speed, - 8N1 character format (8 bits of data, 1 bit of stop, no parity bit) - MODBUS-RTU protocol (SLAVE)
Switching outputs (relay or for SSR control)	- relay (P1), standard	8 A / 250 Vac, for resistive loads
	- relay (P2), standard	**AR603:** 5 A / 250 Vac, **AR613:** 8 A / 250 Vac, for resistive loads
	- SSR (SSR1, SSR2), option **Marked on the device sticker.**	transistor ones of NPN OC type, 10.5 ÷ 11 V, with current limitation up to ~ 25 mA
7-segment LED display, two lines (with brightness adjustment)		- upper, red 20mm (AR613), 7mm (AR603) - bottom, green 14mm (AR613), 7mm (AR603)
Signalling	- relay activity	LED diode, red
	- edited setpoint	LED diodes, red (under the display window)
	- messages and errors	LED display
Power supply (Usup)	universal, compliant with 24 V and 230 V standards	15 ÷ 250 Vac, <3 VA (alternating voltage, 50/60 Hz)
		20 ÷ 350 Vdc, <3 W (direct voltage)
Rated operating conditions		0 ÷ 50 ° C, <90%RH (without condensation)
Working environment		air and neutral gases
Degree of protection	IP40 from the front, IP20 from the connectors	
Weight	~ 135 g (AR603), ~ 245 g (AR613)	
Electromagnetic compatibility (EMC)		resistance: according to PN-EN 61000-6-2 norm
		emissivity: according to PN-EN 61000-6-4 norm
Safety requirements according to PN-EN 61010-1		installation category - II
		pollution degree - 2
		value of voltage to earth for the power supply circuit, output - 300 V
		value of voltage to earth for input circuits - 50 V
		insulation resistance> 20 MΩ
		altitude above the sea level <2000 m

6. ENCLOSURE DIMENSIONS AND ASSEMBLY DATA

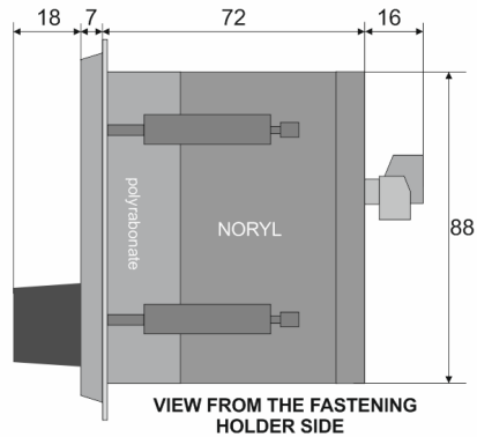
a) AR603

Enclosure type	panel, Incabox XT
Material	self-extinguishing NORYL 94V-0, polycarbonate
Enclosure dimensions (W x H x D)	48x48x79 mm
Panel window (W x H)	46 x 46 mm
Mounting	with handles on the side of the housing
Cable cross sections (for separable connectors)	2.5mm^2 (power supply and outputs), 1,5mm^2(other)



b) AR613

Enclosure type	panel, Incabox XT
Material	self-extinguishing NORYL 94V-0, polycarbonate
Enclosure dimensions (W x H x D)	96x96x79 mm
Panel window (W x H)	92 x 89 mm
Mounting	with handles on the side of the housing
Cable cross sections (for separable connectors)	2.5mm^2 (power supply and outputs), 1,5mm^2 (other)

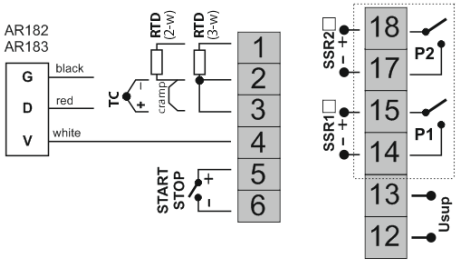


7. DESCRIPTION OF TERMINAL STRIPS AND ELECTRICAL CONNECTIONS

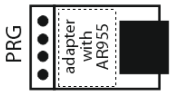
Table 7. Numbering and description of clamping rails

Clamps	Description
1-2-3	Pt100 input (2- and 3-wires)
2-3	thermocouple input TC (J, K, S, B, R, T, E, N)
2-3-4	input for digital temperature probes AR182, AR183
5-6	binary input START / STOP (contact or voltage <24V), chapter 9.1
PRG	programming connector for cooperation with the programmer **(only AR955, AR956)**
12-13	24V, 230V power input
14-15 (AR603) 14-15-16 (AR613)	P1 relay output or SSR1 control (transistor NPN OC)
17-18	P2 relay output or SSR2 control (transistor NPN OC)

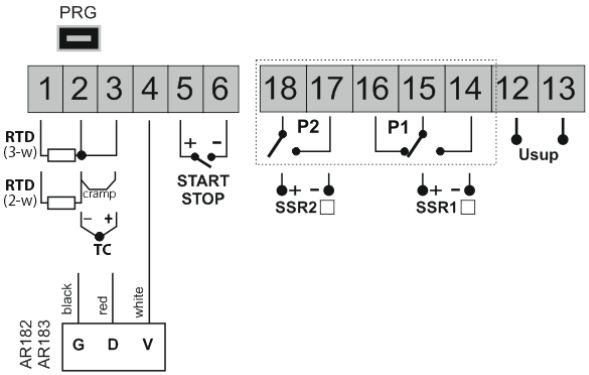
a) AR603 - terminals description Table 7



the PRG socket is available from the top of the housing

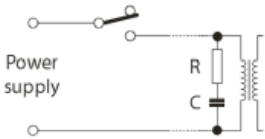


b) AR613 - terminals description Table 7



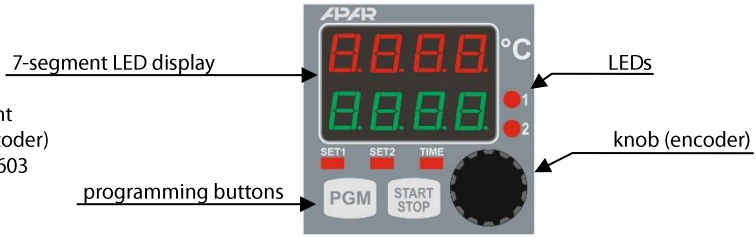
8. IMPORTANT TIPS – *using the suppression systems*

If an inductive load is connected to the relay contacts (eg contactor coil, transformer, motor), then when they open, overvoltages and electrical arc appear, triggered by discharging the energy stored in the inductance. The particularly negative effects of these overvoltages include: reduced service life of contactors and relays, destruction of semiconductors (diodes, thyristors, triacs), damage or disturbance of control and measurement systems, emission of electromagnetic field interfering with local devices. In order to avoid such effects, overvoltages must be reduced to a safe level. The simplest method is to connect the appropriate extinguishing module **directly** to the inductive load clamps. Generally, appropriate types of extinguishing systems should be selected for each type of inductive load. Modern contactors generally have the appropriate factory extinguishing systems. In the absence of them, a contactor with a built-in extinguishing system should be purchased. You can temporarily shunt the load with the RC circuit, e.g. R=47Ω/1W and C=22nF/630V. Connect the extinguishing system to the clamps of the inductive load. The use of the extinguishing circuit limits the burning of the relay contacts in the controller and reduces the likelihood of them sticking together.



9. FUNTIONS OF BUTTONS AND LED DIODES

Description of the front with tuning knob (encoder) on the example of AR603



a) functions of buttons and a tunning knob

Button	Description [and the method of marking in the content of the manual]
PGM	**[PGM]** : - switching of subsequent setpoints on the lower display (SEt1, SEt2, t.tAE, chapt. 9) and start/stop of autotuning and ramping (t-St, P-St) with simultaneous signaling with LED diodes, no LED signaling for the parameter t-St - entry to the parameter configuration menu (after holding time longer than 2 seconds, in the measurement display mode), hold down > 1s exit from the config. menu.
START STOP	**[START STOP]** : - start or stop for time functions
	**[ENCODER TUNNING KNOB]** : - pressing : - entering the edit mode (change of values) of the current parameter, - saving the changed parameter value in edit mode, - turning the knob to the left decreases and to the right increases the set value (saving entered value by pressing the knob or canceling changes with **PGM** button), viewing parameters

DISPLAYS' FUNCTIONS:

- **UPPER** : displaying measured value, parameter names or messages and errors,
- **LOWER** : setpoints, parameter values or messages

b) LED signal diodes functions

Diode [marking]	Description
SET1	- indication of the setpoint selection SEt1 or start/stop of auto-tuning and ramping (t-St, P-St, occur only when parameters 19: tunE and 20: rAMP are different from oFF)
SET2	- indication of the setpoint selection SEt2
TIME	- slow flashing (1 per second) indicates the time counting, - fast flashing (4 times per second) after the START signal indicates that the timer is waiting for triggering the countdown (occurs only when parameter 25: tr.td = SEt1 or SEt2 and the measured value is below the threshold value)
1	- indication of the P1/SSR1 output status
2	- indication of P2/SSR2 output status

9.1. PREVIEW AND CHANGING PROGRAMMED VALUES

The selection of the appropriateset point (SEt1, SEt2, t.tAE) is made by briefly pressing the **PGM** button with simultaneous LED diodes signaling. Pressing the knob introduces the selected setpoint into the edit mode (provided that parameter 27: bSEt enables the change of the current setpoint on the lower display). Turn the knob to set the required value, confirm by pressing the knob or cancel changes by briefly pressing the **PGM** button. The initial time value is loaded from parameter 26: t.tAE.

10. CONFIGURATION PARAMETERS SETTING

All configuration parameters of the controller are contained in non-volatile (permanent) internal memory. When switching on the device for the first time, an error signal (chapter 14) may appear on the display due to the lack of a sensor or an attached one other than the factory programmed one. In this case, the appropriate sensor should be attached or the configuration parameters should be corrected.

There are two parameter configuration methods:

1. Using the foil keyboard and the knob placed on the front panel of the device:
- from the input measurement display mode in the configuration menu (press the **[PGM]** button for longer than 3 secs.) If parameter 29: PPro = on (password protection is enabled) the upper display will show the message CodE, and the lower one will show 0000 with the first digit flashing, enter the access password with the knob (company parameter 28: PASS = 1111) in order to move to further positions and confirm the code use the knob
- after entering the configuration menu (with the message Conf) the upper display shows the mnemonic name of the parameter (inP <-> FiLt <-> dot <-> etc.) and the lower display shows the value of the given parameter
- turning the knob to the right causes the transition to the next, to the left to the previous parameter (collective list of the configuration parameters is included in Table 10)
- to change the value of the current parameter, briefly press the **knob** (flashing in edit mode)
- by turning the knob change the value of the edited parameter
- confirm the changed parameter value by pressing the knob or cancel with the **[PGM]** button (simultaneous, short press), takes you back to displaying the parameter name
- exit from the configuration: long press the **[PGM]** button or automatically after approx. 2 minutes of inactivity

2. Through the PRG port (AR955/AR956 programmer) and the ARSOFT-CFG computer program (Chapter 15):
- connect the controller to the computer port, run and configure the ARSOFT-CFG application
- after establishing the connection, the current measured value is displayed in the program window
- setting and viewing device parameters is available in the parameter configuration window
- new parameter values must be confirmed with the ***Confirm changes*** button
- the current configuration can be saved to a file or set with values read from the file

NOTE: ⚠
- before disconnecting the device from the computer, use ***the Disconnect the device*** button (ARSOFT-CFG)
- in the absence of a response:
  - check the port configuration and ***MODBUS address of the device*** in the ***Options of the program*** (speed of the transmission 2400bit/s, MODBUS address=1)
  - make sure that the serial port drivers on the computer have been correctly installed for AR955/AR956 programmer
  - disconnect for a few seconds and reconnect the AR955/AR956 programmer
  - restart the computer

If there is a discrepancy between the indications and the actual value of the input signal, it is possible to tune the zero and sensitivity to a given sensor: parameters 31: CALo (zero) and 32: CALG (sensitivity).

To restore the factory settings the **[PGM]** button when the power is turned on until the password entry menu appears (CodE), and then enter the kod code 0112. Alternatively, you can use the file with the default configuration in the ARSOFT-CFG program.

NOTE:

Do not configure the device simultaneously from the keyboard and through the serial interface (AR955/AR956).

Table 10. A list of configuration parameters

Parameter	Range of parameter variability and description		Default settings
0: inP type of measurement input	Pt	thermoresistance sensor Pt100 (-100 ÷ 850 ° C)	Pt
	tc-J	thermoelectric sensor (thermocouple) type J (0 ÷ 880° C)	
	tc-K	thermoelectric sensor (thermocouple) type K (0 ÷ 1200° C)	
	tc-S	thermoelectric sensor (thermocouple) type S (0 ÷ 1750° C)	
	tc-b	thermoelectric sensor (thermocouple) type B (300 ÷ 1800° C)	
	tc-r	thermoelectric sensor (thermocouple) type R (0 ÷ 1600° C)	
	tc-t	thermoelectric sensor (thermocouple) type T (0 ÷ 380° C)	
	tc-E	thermoelectric sensor (thermocouple) type E (0 ÷ 700° C)	
	tc-n	thermoelectric sensor (thermocouple) type N (0 ÷ 1300° C)	
	Ar18	digital temperature probe AR182 or AR183	
1: FiLt filtration **(1)**	1 ÷ 15	digital filtration of measurements (response time)	1
2: dot dot position / resolution	0	resolution 1° C	1 (0.1° C)
	1	resolution 0.1° C	
3: Lo1 lower limit 1	-199 ÷ 1800	low settings limit for the set value 9: SEt1	-199 °C
4: Hi1 upper limit 1	-199 ÷ 1800	high settings limit for the set value 9: SEt1	1800 °C
5: Lo2 lower limit 2	-199 ÷ 1800	low settings limit for the set value 13: SEt2	-199 °C
6: Hi2 upper limit 2	-199 ÷ 1800	high settings limit for the set value 13: SEt2	1800 °C
CONFIGURATION OF MAIN OUTPUT (P1/SSR1) - chapter 11.2			
7: Fto1 emergency status of output 1 **(2)**	the output status if the measurement sensor (signal) is missing or damaged: noCh = unchanged, oFF = off, on = on		oFF
8: out1 output function 1	oFF = off, inu = heating, cool = cooling		inu
9: SEt1 set value 1	applies to output 1, changes in the range 3: Lo1 ÷ 4: Hi1		1000 °C
10: H1 output hysteresis 1	hysteresis 0.0 ÷ 999.9 ° C		1.0 °C
CONFIGURATION OF AUXILIARY OUTPUTS (P2/SSR2) - chapter 11.2			
11: Fto2 emergency status of output 2 **(2)**	the output status if the measurement sensor (signal) is missing or damaged: noCh = unchanged, oFF = off, on = on		oFF
12: out2 output function 2	oFF = off, inu = heating, cool = cooling, bAon or bAoF = band 2 * SEt2 around SEt1, dEoF or dEon = deviation from SET1, rEPu = 3 second signal informing about the end of timing, rEon or rEoF = signaling the operation in timer (chapter 13) and process controller (chapter 12) mode		inu
13: SEt2 set value 2	applies to output 2, changes in range 3: Lo2 ÷ 4: Hi2		1000 °C
14: H2 output hysteresis 2	hysteresis 0.0 ÷ 999.9 ° C		1.0 °C
CONFIGURATION OF PID ALGORITHM			
15: Pb PID proportionality range	0.0 ÷ 2000, 0 - disables PID action, description of PID algorithm and related topics in chapters 11.3 ÷ 11.6		0.0 °C

16: `t.i` PID integral time constant	`0` ÷ `3600` secs.	integral time of the PID algorithm, `0` disables the integrator of the PID algorithm	`0` sec
17: `t.d` the PID derivative time constant	`0` ÷ `999` secs.	derivative time of the PID algorithm, `0` disables the derivative of the PID algorithm	`0` sec
18: `t.c` pulse period	`4` ÷ `250` secs.	switching period for the switching output	`4` sec
19: `tunE` PID auto tuning operating mode (ch. 11.4)	`oFF` = off, `MAnu` = manual start, `Auto` = after each start of the power supply		`oFF`
CONFIGURATION OF THE PROCESS CONTROLLER (programmable work characteristics, ramping, chapter 11.7)			
20: `rAMP` process controller operating mode (chapter 12) **(3)**	`oFF` = off, `MAnu` = manual start, `Auto` = after each start of the power supply		`oFF`
21: `rAt` gradient of stage1 **(3)**	applies to stage `Pr-1`, `0.1` ÷ `300` ° C/min		`0.1` °C
22: `th1` time of stage **2 (3)**	`0` ÷ `8540` min	duration of stage `Pr-2` (up to 144 hours)	`120` min
23: `th2` time of stage 4 **(3)**	`0` ÷ `8540` min	duration of stage `Pr-2` (up to 144 hours)	`30` min
24: `ctyP` regulation type (chapter 13)	`cont` = continuous, `t.AE` = time limited, `dELA` = continuous with delayed start		
25: `tr.G` way of triggering the time counting (chapter 18)	`MAnu` = manual, `SuPL` = at power supply start, `SEt1` = SET1 set value, `SEt2` = SET2 set value		`MAnu`
26: `t.AE` time set value **(4)**	`1` ÷ `8540` min	time set value	`120` min
ACCESS OPTIONS AND OTHER CONFIGURATION PARAMETERS			
27: `bSEt` set value settings lock	`oFF` = no locks, `SEt1` = parameter 9 lock: `SEt1`, `SEt2` = parameter 13 lock: `SEt2`, `both` = lock `SEt1` and `SEt2`, `t.AE` = time setpoint, `t.S1` = time and `SEt1`, `t.S2` = time and `SEt2`, `ALL` = everything without the START/STOP button, `ALLS` = everything with the START/STOP button		`oFF`
28: `PASS` access password **(5)**	`0000` ÷ `9999`	password to access the parameter configuration menu	`1111`
29: `PPro` configuration protection with access password **(5)**	`oFF`	entering the configuration menu is **not** protected with password	`on`
	`on`	entering the configuration menu is protected with an access password	
30: `br.G` brightness	`50` ÷ `100`%	display brightness, 10% increments	`100` %
31: `cALo` zero calibration	zero offset for measurements: `-500` ÷ `500` ° C		`0.0` °C
32: `cALG` amplification	`850` ÷ `1150`%	slope calibration (sensitivity) for measurements	`1000` %

Notes: (1) - for `FiLt` = `3` the response time is about 0,5 second, for `FiLt` = `15` at least 2 s.
Higher degree of filtration means more "smoothed" measured value and longer response time, recommended for turbulent measurements (eg water temperature in a boiler)

(2) - the parameter also determines the output status outside the measuring range, and when there is lack of communication with digital temperature probes AR182, AR183

(3) - applies to programmed work characteristics (process controller, ramping, chapter 12)

(4) - this is the initial setpoint for time counting, automatically loaded.
The current value of the measured time is available on the lower display

(5) - when `PPro` = `oFF` access to the parameter configuration does not require entering the access password

11. OUTPUT OPERATION CONFIGURATION

Programmable architecture of the controller allows its use in many fields and applications. Before starting the device, the parameters should be set to individual needs (chapter 10). A detailed description of the output operation configuration is included in chapters 11.1 ÷ 11.6. The default (factory) configuration is as follows: output 1 and 2 in ON / OFF control mode with hysteresis, time limited (Table 10, column *Company settings*).

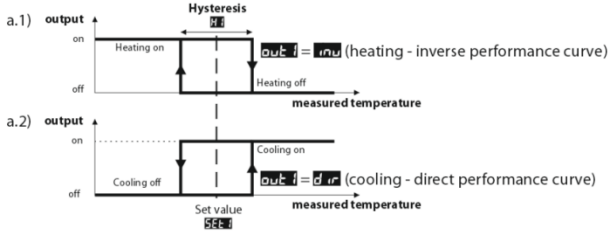
11.1. CHANGING THE OUTPUTS SET VALUES

In the measuring mode, the upper display shows the measured value and the lower display shows the selected set value. The easiest way to change set value is to press the knob and turn it to set the given value. After pressing the knob, the lower display starts flashing, then the given set value can be edited. The **PGM** button switches between set value. The current set value selection is indicated diodes on the front panel of the device. Alternatively, the change in the set value is available in the parameter configuration mode (using the methods described in chapter 10).

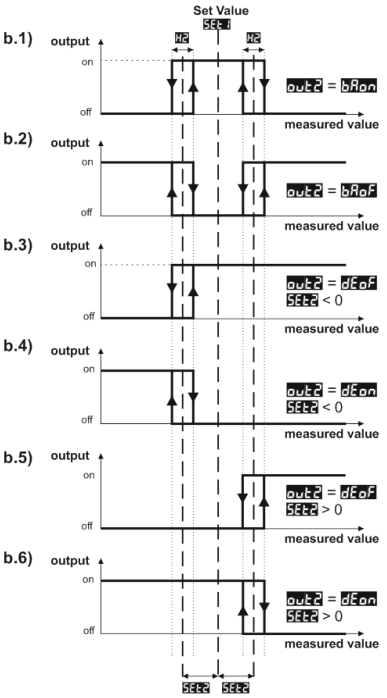
11.2. TYPES OF OUTPUT CHARACTERISTICS

The output operating type is programmed with parameter 8: out1, 12: out2, chapter10, Table 10.
Basic characteristics of the output operation:

a) basic characteristics of the output operation



b) additional characteristics of the output operationin relation to the setting SEt 1 (applies only to output 2)



11.3. PID CONTROL

The PID algorithm makes it possible to obtain smaller temperature regulation errors than the ON-OFF with hysteresis method. However, this algorithm requires selection of parameters characteristic for a specific regulation object (eg. a furnace). In order to simplify the handling, the controller has been equipped with PID parameter selection functions described in chapter 11.4. In addition, it is always possible to manually adjust the settings (chapter 11.6).

The controller operates in PID mode when the proportionality range (parameter 15: Pb) is non-zero. The position of the proportionality range 15: Pb against the set value 9: SEt 1 is shown in Figures 11.3 a) and b). The influence of the integrator and derivative of PID regulation is determined by parameters 16: t i and 17: td. Parameter 18: tc sets the pulse period for output 1 (P1/SSR1). The output status adjusment is always carried out every 1s. The principle of operation of P-type regulation (proportional regulation) for output 1 is shown in figures c), d).

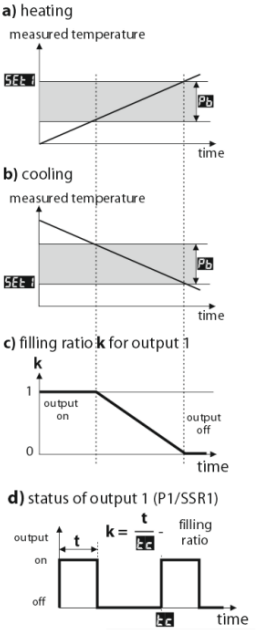


Fig. 11.3. PID control - principle of operation:

a) the position of the proportionality range Pb against the set value SEt 1 for heating (out 1 = inv)

b) the position of the proportionality range Pb against the set value SEt 1 for cooling (out 1 = dir)

c) duty cycle for output 1 (P1/SSR1) d) output 1 status for the measured value in the proportionality range

11.4. AUTOMATIC SELECTION OF PID PARAMETERS

Autotuning automatically selects the PID parameters characteristic for a given regulation object (eg a furnace). To start auto tuning, set parameter 19: tunE (chapter 10, Table 10) accordingly, where the value tunE = mAnu allows you to start tuning manually at any time, tunE = Auto starts tuning each time you turn on the controller power supply and enbles manual start. It is advisable to start auto tuning on an object with a stable temperature. Before turning on the auto tuning, turn off the power supply of executive element with external switch. The power supply must be turned on immediately after starting the tuning, when the controller output is still turned off (for about 1 minute). Turning on the power supply at a later stage will result in an incorrect analysis of the object and, as a result, incorrect selection of PID parameters. For the correct automatic selection of PID parameters, it is recommended that the difference between the set value and the initial value is greater than 40 ° C.
To manually turn on/off autotuning, do the following:

- briefly press PGM until the lower display shows t-St, press the setting knob
- the lower display shows the value of this parameter (oFF - off, on - on),
- turn the knob to select t-St = on (pressing the knob starts autotuning), when t-St = oFF pressing the knob stops autotuning, the PGM button cancels changes

During tuning, the lower display shows alternately with the set value the message tunE , displayed every 5 seconds, do not change the set value SEt 1 during the autotuning. When determining the object's characteristics, the algorithm does not cause an additional delay in reaching the set value 9: SEt 1.

Autotuning consists of the following stages:

- delaying the tuning activation (approx. 1 minute - time to turn on the power supply of the executive element, i.e. heating / cooling power, etc.),
- determining the characteristics of the object,
- calculation and saving, in the permanent memory of the controller, parameters 15: Pb , 16: t 1, 17: td oraz 18: tc,
- enabling regulation with new PID settings.

Autotuning software interrupt (with the message Err t) can occur if the conditions of the proper operation of the algorithm are not met, such as:

- the initial temperature value is higher than the setpoint for heating or lower than the setpoint for cooling,
- the maximum tuning time has been exceeded (4 hours),
- the measured temperature changes too fast or too slow.

It is recommended to restart the autotuning after a significant change of the threshold SEt 1 or the parameters of the regulation object (eg heating/cooling power, batch mass, initial temperature, etc.).

NOTE: In the controller, the PID algorithm works only on output 1 (relay P1, parameters SEt 1, H 1, out 1, ...)

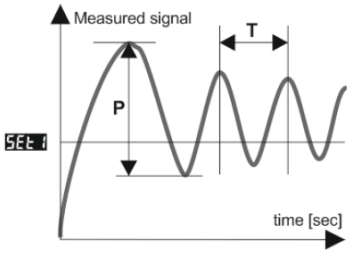
11.5. MANUAL PID PARAMETERS SELECTION

In the situation when we are dealing with an object with unstable initial temperature (eg in a heated furnace) or the measurement is turbulent (eg water temperature in the boiler) then the built-in autotuning algorithm may not work properly. It is then necessary to manually adjust the PID regulation parameters. The following algorithm using the oscillation method enables the own selection of PID action parameters: the proportionality range 15: Pb, the integration time 16: t 1, the derivative time 17: td and the pulse period 18: tc.

1. Set the controller to ON-OFF mode (parameter 15: Pb = 0), the required threshold value 9: SEt 1 and 10: H 1 = 0. If the overshoots are not recommended, the value SEt 1 should be set at the level lower than required.
   The controller should be connected with the applied measurement and regulation system.

2. Observe and record temperature oscillations. Record the difference **P** between the highest and lowest value of the first oscillation and time **T** between the second and third oscillation.

3. Set the configuration parameters:
- proportionality range Pb = **P**
- integration time t.i = **T** [s]
- derivative time t.d = **T** / 4 [s]
- pulse period t.c = **T** / 8 [s]



11.6. ADJUSTMENT SELECTION OF PID PARAMETERS

The autotuning function correctly selects the PID regulation parameters for most processes, but sometimes it may be necessary to correct them. Due to the strong correlation of these parameters, only one parameter should be changed and the impact on the process should be observed:

a) oscillations around the threshold - increase the proportionality range 15: Pb, increase the integration time 16: t.i, decrease derivative time 17: t.d, (possibly decrease the pulse period of output 1 by half, parameter 18: t.c)

b) slow response - reduce the proportionality range Pb, derivative times t.d and integration times t.i

c) overshoot - increase the proportionality range Pb, derivative times t.d and integration times t.i

d) instability - increase the integration time t.i.

12. PROGRAMMABLE CHARACTERISTICS

Setting parameter 20: rAAP (see chapter 10, Table 10) to the value tAnu or Auto enables the programming the device as a 4-step process controller, implemented by output 1, operating according to the diagram (Fig.12.7). This type of work can be started both manually at any time (when parameter 20: rAAP = tAnu or Auto) and automatically at moment of starting power supply (when 20: rAAP = Auto).

To manually turn on (on) or turn off (oFF) the process controller, perform the following steps:

- briefly press **PGM** button until the lower display shows t-St, press the setting knob
- the lower display shows the value of this parameter (oFF - off, on - on),
- turn the knob to select P-St = on (pressing the knob starts the programmed process), when P-St = oFF pressing the knob stops the running process, the **PGM** button cancels the changes.

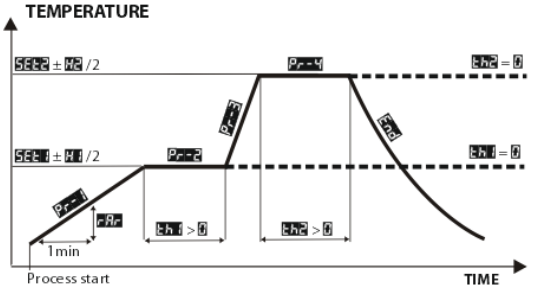


Fig. 12.7 Operation diagram of a 4-stage process controller

The next stages of the process are signaled by messages appearing every 5 seconds:
- Pr-1 - stage 1 - reaching threshold value 9: SEt1 with a set gradient (25: rAr) - ramping
- Pr-2 - stage 2 - implementation of the 1st holding time 22: th1 at level 9: SEt1 (with a hysteresis 10: H1), value of parameter th1 = 0 keeps the stage Pr-2 permanently
- Pr-3 - stage 3 - reaching threshold value 13: SEt2 at full power (output P1 permanently on)
- Pr-4 - stage 4 - implementation of the 2nd holding time 23: th2 at level 13: SEt2 (with hysteresis 14: H2), value of parameter th1 = 0 keeps the stage Pr-2 permanently
- End - process end (P1 permanently off)

In addition, it is possible to associate with the process of the second output (P2) when parameter 12: out2 equals:
rEon - switching on P2 after the end of the process (P2 switched off during it),
rEoF - switching off P2 after the end of the process (P2 switched on during it),
During normal (undisturbed) operation, the process can only be interrupted by the user in the same way as for manual activation of this function.

The process controller excludes PID autotuning and PID regulations. Output 1 works in ON/OFF mode.

13. TIME FUNCTIONS (TIMER)

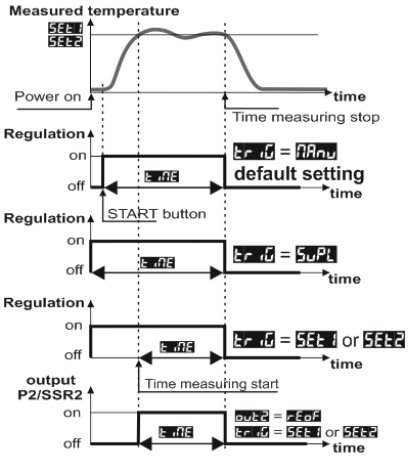
Using the timer it is possible to control the process in a time funcion. Controller operation with time counting is directly controlled by 3 configuration parameters: parameter 24: ttyP, 25: tr tU and 26: t tiE. The beginning of time counting is defined by parameter 25: tr tU and **START/STOP** signal from the keyboard or binary input, the end of the timer operation occurs after the programmed time is finished or at any time after the **START/STOP** signal from the keyboard or from the binary input.

A detailed description of the parameters related to the timer:
ttyP - defines the type of control and the behavior of control outputs, it can take 3 values:
= cont - control outputs operate regardless of time settings (continuous control mode),
= t tiE - control outputs are controlled by a timer (time limited control mode),
in this mode, the beginning of time counting and start of control is defined by parameter 25: tr tU and signal **START/STOP** from the keyboard or binary input, after the end of time counting 26: t tiE control output goes into inactive status, turns off,
= dELA - during the countdown, the control outputs are turned off by the timer, and after the end of the countdown the continuous control starts (continuous control mode with delayed start),
tr tU - this parameter defines the start of time and control counting, can take the following values:
= MAnu - start and end of timecounting and control are always triggered manually with the **START/STOP** or by a signal from the binary input, after turning on the power supply the control is off,
= SuPL - start of time counting and control triggered by turning on the power supply
= SEt 1 or SEt2 - start of time counting when the setpoint SET1 or SET2 is reached,
after turning on the power supply, the control is switched on, quick flashing (4 times/sec.) of the TIME diode indicates waiting for the condition of starting the time counting.
t tiE - initial value for time counting, automatically loaded. Current value of counted time is available on the lower display.
Time counting is signaled by a flashing TIME diode with a frequency of 1 time/sec. Timer operation can be additionally signaled by means of the P2/SSR2 control output, the behavior of this output is determined by by the following values of parameter 12: out2 (chapter 10, Table 1):
= rEon - P2/SSR2 output is switched on after the end of time counting, switched off during it,
= rEoF - P2/SSR2 output is turned off after the end of time counting, switched on during it,
= rEPu - P2/SSR2 output is switched on for 3 seconds after the end of time counting.

NOTES:
- **START/STOP** button and binary input have the highest priority, which means that you can at any time start or stop performing time functions with them,
- the binary input is triggered by a low voltage (U <0,8V) or short of the contacts attached,
- do not use autotuning and programmed (ramping) mode simultaneously with the time functions controlling the operation of outputs, i.e. for 24: ttyP = t tiE or 24: ttyP = dELA,
- time functions and ON-OFF or PID controls can be used, but only with pre-selected parameters.

Controller operating rule depending on thevalues of parameters 24: ctYP, 25: tr iU (and 12: out2):

a) time-limited control: 24: ctYP = t iME



proccess progression

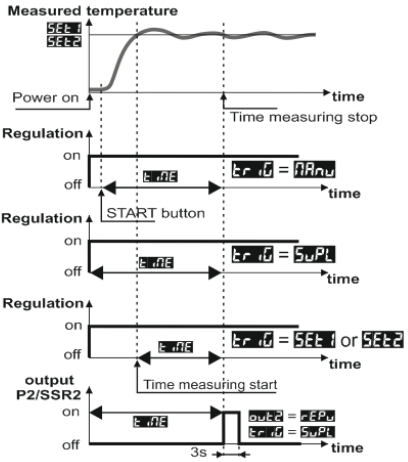
manual triggering

triggered after connecting

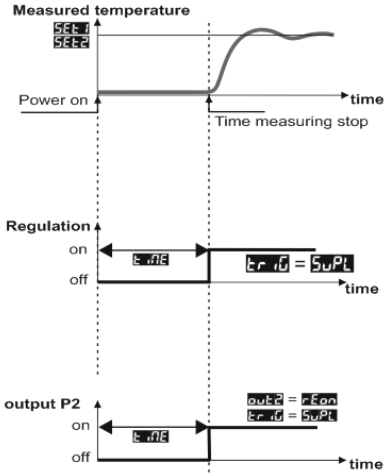
thershold value triggering SEt1 or SEt2

P2/SSR2 output connected to the timer

b) continuous control: 24: ctYP = cont



c) delayed start control: 24: ctYP = dELA



proccess progression

triggered after connecting

P2/SSR2 output connected to the timer

14. SIGNALING MESSAGES AND ERRORS

a) measurement errors:

Code	Possible causes of the error
---- / ----	- exceeding the measurement of thesensor range from top (----) or from bottom (----) - damaging or incorrect connection of the sensor - a sensor other than the one set in the configuration has been connected (chapter 10, parameter 0: inP)
----	- lack of communication with the AR182, AR183 digital probe - damage or incorrect connection of the digital probe - a sensor other than set in the configuration has been connected (chapter 10, parameter 0: inP)

b) messages and temporary errors (one time or periodic):

Code	Description of the message
CodE	the mode of entering the access password to configuration parameters, chapter 10
Err	incorrect access password has been entered
ConF	entry in the parameter configuration menu
tunE	implementation of the PID autotuning function, chapter 11.4
Errt	autotuning error, chapter 11.4, deleting the error with the **[PGM]** button
Pr-1 ... Pr-2 , End ...	implementation of program work characteristics (process controller), chapter 12
SAvE	recording of company parameter values (chapter 10)
bLoc	active lock of changing the value of the settings (parameter 27: b5Et)

15. CONNECTING TO THE PC AVAILABLE SOFTWARE

Connecting the controller to a computer can be useful in the following situations:
- quick configuration of parameters, including copying settings to other controllers of the same type
- monitoring and registration of the measured temperature and the status of the output.

The controllers are normally equipped with a PRG port enabling connection with a computer using the AR955/AR956 programmer (without galvanic separation, cable length ≈ 1.2m). The programmer requires installation of supplied serial port drivers on the computer. Please pay attention to the port configuration in the ARSOFT-CFG program options (transmission speed = 2400bit /s, MODBUS address = 1). Communication with devices is carried out using a protocol compatible with MODBUS-RTU. The ARSOFT-CFG application is available on the website ***www.apar.pl*** in the *Download* section (for Windows 7/8/10 operating systems). The main features of the program are as follows:

Name	Description of the program
ARSOFT-CFG (free of charge)	- displaying current measurement data from the connected device - quick configuration of controller parameters, type of measurement input, regulation options, access, etc. (chapter 10) - creating on a disk the file with the extension "cfg" containing the current configuration of the parameters for re-use (e.g., to duplicate configurations) - the program requires communication with the controller via the PRG port (AR955/AR956)

A detailed description of the above mentioned applications is in the installation folder.

NOTE: 

Before establishing connection, set the number of the COM serial port used in theARSOFT program options (for the AR956 or AR955 programmer, this is the number assigned by the operating system during the driver installation).