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

USER MANUAL



AR601



AR651



AR621



AR661

PROGRAMMABLE MICROPROCESSOR CONTROLLERS

Version 4.0.1
2018.09.05

Thank you for choosing our product.

This manual will help you use your controller correctly, safely and to its full potential.

Read this manual carefully before installing and putting your controller to use.

In case of additional questions, please contact the technical advisor.

TABLE OF CONTENTS

1. SAFETY RULES....3
2. INSTALLATION RECOMENDATION....3
3. GENERAL FEATURES OF CONTROLLERS....3
4. CONTENTS OF THE SET....4
5. TECHNICAL DATA....4
6. DIMENSIONS AND INSTALLATION DATA....5
7. DESCRIPTION OF TERMINAL STRIPS AND ELECTRICAL CONNECTIONS....6
8. IMPORTANT TIPS – using the suppression systems....7
9. DESCRIPTION OF BUTTONS AND SIGNAL LED INDICATORS....7
   9.1. BINARY INPUT....8
10. SETTING THE CONFIGURATION PARAMETERS....8
11. QUICK ACCESS MENU....11
12. OUTPUT OPERATION CONFIGURATION....11
   12.1. CHANGE OF SETPOINTS FOR OUTPUTS....11
   12.2. TYPES OF OUTPUT CHARACTERISTICS....11
   12.3. PID CONTROL....12
   12.4. AUTOMATIC SELECTION OF PID PARAMETERS....12
   12.5. MANUAL PID PARAMETERS SELECTION....13
   12.6. ADJUSTMENT OF PID PARAMETERS....13
13. MESSAGES AND ERRORS....14
14. CONNECTING TO THE PC AND AVAILABLE SOFTWARE....14
15. NOTES....15



Please pay particular attention to fragments marked with this sign.

The manufacturer reserves its rights to modify the design and software of the device without deteriorating its technical parameters.

1. SAFETY RULES

- read this manual carefully before starting to use the device
- to prevent the hazard of electric shock or equipment damage the mechanical and electrical installation should be performed by qualified personnel
- before powering the device make sure all leads have been connected correctly
- disconnect the power supply before making any modifications of the leads configurations
- ensure correct operating conditions (supply voltage, temperature, humidity, see section 5)

2. INSTALLATION RECOMENDATION

The controller has been designed to provide an adequate level of immunity to most disturbances which can appear in industrial environments. In environments with unknown disturbance level it is recommended to use the following preventive measures:
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 using the device, remove the screen protective film from LED display.

3. GENERAL FEATURES OF CONTROLLERS

- 1 universal measuring input (supporting thermo-resistance, thermocouple sensors or digital probes of temperature AR182 and AR183)
- programmable BIN input for changing the controller's operating mode: control start/stop, key lock
- 1 output, relay or SSR, ON-OFF with hysteresis, PID, PID AUTOTUNING
- advanced function of selecting PID parameters
- LED display with adjustable brightness
- line resistance compensation for resistive sensors
- temperature compensation of cold ends of thermocouples
- programmable input type, regulation and access options and other configuration parameters
- access to configuration parameters protected by a user's password
- methods of parameters configuration:
  - from the keypad on the controller front panel
  - via RS485 or AR955 programming device and ARSOFT-WZ1 freeware (Windows 2000/XP/Vista/7)
- software and programmer device which allows viewing the measured value and a quick configuration of single or ready-to-use parameter sets previously saved in the computer to be reused, for example in other controllers of the same type (configuration duplication)
- panel housing, IP65 from the front (AR601, AR621, AR651), rail housing IP40 (AR661)
- high accuracy, long-term stability and immunity to disturbance;
- wide range of supply voltages: 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 to use the controller read this manual and correctly perform the electrical, mechanical installation and the parameter configuration.

4. CONTENTS OF THE SET

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

5. TECHNICAL DATA

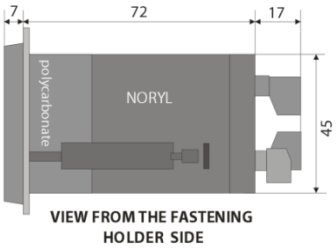
1 universal input (set by parameter 0: inP)		**measuring range**
- Pt100 (3- or 2-wire)		-100 ÷ 850 °C
- J (Fe-CuNi) thermocouple		0 ÷ 880 °C
- K (NiCr-NiAl) thermocouple		0 ÷ 1200 °C
- S (PtRh 10-Pt) thermocouple		0 ÷ 1750 °C
- B (PtRh30PtRh6) thermocouple		300 ÷ 1800 °C
- R (PtRh13-Pt) thermocouple		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)		Rd <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
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 data bits, 1 stop bit, no parity bit) - MODBUS-RTU protocol (SLAVE)
Two-state output (relay or for SSR control)	- relay (P1), standard	8 A / 250 Vac, for resistive loads
	- SSR (SSR1), option **Marked on the device sticker.**	transistor type NPN OC, 10.5 ÷ 11 V, with current limitation up to ~ 25 mA
7 segment LED display (with brightness adjustment)		red, 4 digits 9 mm
Signalling	- relay activity	LED diode, red
	- messages and errors	LED display
Power supply (Usup)	universal, compliant with 24 V and 230 V standards	15 ÷ 250 Vac, <2 VA (alternating voltage, 50/60 Hz)
		20 ÷ 350 Vdc, <2 W (direct voltage)

Rated operating conditions		0 ÷ 50 ° C, <90% RH (non-condensing)
Working environment		air and neutral gases
Protection rate	IP65 from the front (AR601, AR621, AR651), IP40 (AR661), IP20 from the connectors side	
Weight	~ 125g (AR601), ~ 115g (AR621), ~ 170g (AR651), ~ 160g (AR661)	
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. DIMENSIONS AND INSTALLATION DATA

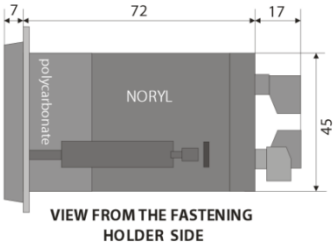
a) AR601

Enclosure type	panel, Incabox XT
Material	self-extinguishing polycarbonate NORYL 94V-0
Enclosure dimensions (W x H x D)	48x48x79 mm
Window in the board (W x H)	46 x 46 mm
Mounting	holders on the enclosure side
Cable cross-sections (for separable connectors)	2.5mm^2 (2-status outputs and power supply),1.5mm^2 (remaining)



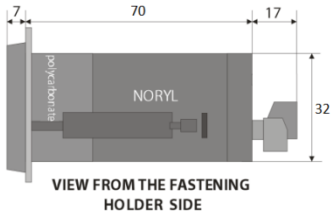
b) AR651

Enclosure type	panel, Incabox XT
Material	self-extinguishing polycarbonate NORYL 94V-0
Enclosure dimensions (W x H x D)	96x48x79 mm
Window in the board (W x H)	92 x 46 mm
Mounting	holders on the enclosure side
Cable cross-sections (for separable connectors)	2.5mm^2 (2-status outputs and power supply),1.5mm^2 (remaining)



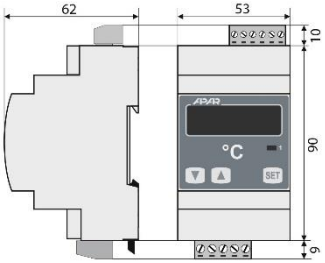
c) AR621

Enclosure type	panel, Incabox XT
Material	self-extinguishing polycarbonate NORYL 94V-0
Enclosure dimensions (W x H x D)	72x36x77 mm
Window in the board (W x H)	67 x 32 mm
Mounting	holders on the enclosure side
Cable cross-sections (for separable connectors)	2.5mm^2 (2-status outputs and power supply),1.5mm^2 (remaining)



d) AR661

Enclosure type	Modulbox 3MH53
Material	ABS, PC
Enclosure dimensions (W x H x D)	53x90x62 mm
Mounting	on the TS35 rail (DIN EN 50022-35)
Cable cross-sections (for separable connectors)	2.5mm^2 (2-status outputs and power supply),1.5mm^2 (remaining)

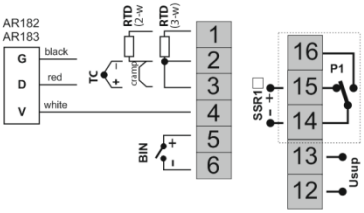


7. DESCRIPTION OF TERMINAL STRIPS AND ELECTRICAL CONNECTIONS

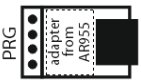
Table 7. Number and designation of terminals

Clamps	Description
1-2-3	Pt100 input (2- and 3-wire)
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 (contact or voltage <24V), chapter 9.1
PRG	programming connection for the programming device **(only AR955 or AR956)**
12-13	power supply input
14-15-16	P1 relay output or SSR1 control (transistor NPN OC)

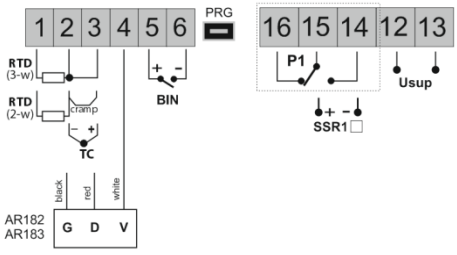
a.1) AR601 - terminals description Table 7



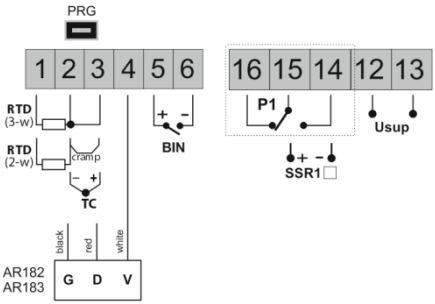
PRG socket is available from the top of enclosure



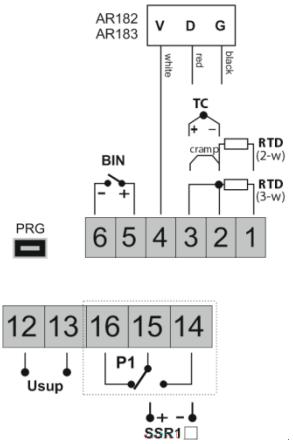
a.2) AR651 - terminals description Table 7



a.3) AR621 - terminals description Table 7

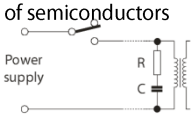


a.4) AR661 - terminals description Table 7

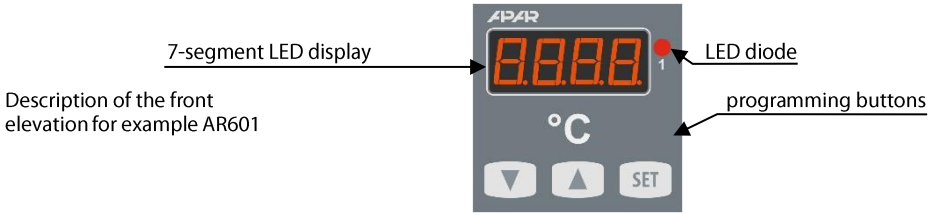


8. *IMPORTANT TIPS* – using the suppression systems ⚠

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. *DESCRIPTION OF BUTTONS AND SIGNAL LED INDICATORS*



a) functions of buttons in the measurement display mode

Button	**Description** [and designation in the manual]
▼ or ▲	**[UP]** or **[DOWN]**: change of the setpoint for output 1 (parameter 7: SEt 1)

SET	**[SET]** : - go to the quick access menu (chapter 11)
▼ + ▲	**[UP]** and **[DOWN]** (simultaneously): go to the parameter configuration menu (if pressed for longer than 1 s). If the parameter 33: PPro = on (password protection on), enter the access password, section 10)

b) functions of buttons in the parameter configuration menu and quick access menu (sections 10 and 11)

Button	**Description** [and designation in the manual]
SET	**[SET]** : - edit current parameter (the value in the bottom display is flashing) - confirm and save the edited parameter
▼ or ▲	**[UP]** or **[DOWN]:** - go to the next parameter - change the value of current parameter
▼ + ▲	**[UP]** and **[DOWN]** (simultaneously): - cancel the modifications of edited value (flashing stops) - return to the measurement display mode (if held for > 0.5s)

c) functions of signal LED indicators

Diode [designation]	**Description**
1	signalling of switching P1 / SSR1 outputs

9.1. BINARY INPUT

The **BIN** binary input has the function programmed with parameter 18: Func (section 10). The binary input works with a bistable signal, i.e. the supplied signal (voltage or switch) must be permanent (of the on / off type). The start or stop of the function is indicated by appropriate messages on the display (described in Table 9.1).

Table 9.1. Available **BIN** input functions

Source	**Description** (depending on the value of parameter 18: Func)		**Message**
+ BIN	Func = nonE	**BIN input** is inactive (default setting)	-
	Func = bLoc	Keypad locked	bLoc / boFF
	Func =StSP	start / stop of regulation and automatic selection of PID parameters when parameter 13: tunE = AutO, section 12.4	StAr / StoP

10. SETTING THE CONFIGURATION PARAMETERS

All controller configuration parameters are contained in non-volatile (permanent) internal memory. When switching on the device for the first time, an error message (section 13) may appear indicating that there is no sensor or that the sensor is different than programmed. Connect the right sensor or perform the configuration programming.
There are two ways to configure the parameters:

1. From the membrane keyboard placed on the front panel of the device:
- from the measurement display mode go to the configuration menu (simultaneously press [**UP**] and [**DOWN**] buttons for longer than 2 s). If the parameter 33: PPro = on (password protection on), the display

will show the message CodE and then 0000 with the first digit flashing. Use the [**UP**] or [**DOWN**] buttons to enter the access password (default parameter 32: PASS = 1111). Use the **[SET]** button to go to successive positions and to approve the code;

- after entering the configuration menu (with the ConF message) the main display shows the mnemonic name of the parameter (inP <-> FiLt <-> dot <->, etc.), and the bottom one its value;
- use the [**UP**] button to go to the next parameter, and the [**DOWN**] button to return to the previous parameter (the list of all parameters is given in table 10)
- to change the value of selected parameter, briefly press [**SET**] (flashing in the edit mode);
- change the value of parameter using [**UP**] or [**DOWN**] buttons;
- confirm the changed parameter value with the **[SET]** button or cancel it with **[UP]** and **[DOWN]** (simultaneous, short press), takes you back to displaying the parameter name
- to exit the configuration menu: press [**UP**] and [**DOWN**] simultaneously for a longer time. The controller will exit the configuration menu automatically after about 2 min. of inactivity

2. Via the RS485 port or PRG (AR955 / AR956 programmer) and the ARSOFT-WZ1 application (section 14)):

- connect the controller to the computer, start and configure the ARSOFT-WZ1 application
- when the connection is made, the program window will show the current measured value
- setting and viewing of parameters is possible in the parameter configuration window
- press the **Accept Changes** button to approve new values
- 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*** (ARSOFT-CFG) button
- if the program does not respond:
  - check the port configuration and ***MODBUS address of the device*** in the ***Program*** options (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 the indications are different that actual input signal value, you can tune the zero and sensitivity to a given sensor: parameters 19: cALo (zero) and 20: cALG (sensitivity).

In order to restore the factory settings, press the **[UP]and [DOWN]** buttons before (and keep pressed) power supply turn on, until the password entry menu appears (CodE), and then enter the 0112 code. Alternatively, use the file with default configuration in the ARSOFT-WZ1

NOTE:
Do not configure the device from the keypad and via the serial interface (RS485 or AR955) at the same time.

Table 10. A cumulative list of configuration parameters

Parameter	Parameter range and description		Default settings
0: inP type of measurement input	Pt	thermo-resistance 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)	9
2: dot dot position / resolution	0	resolution 1° C	1 (0.1° C)
	1	resolution 0.1° C	
3: Lo1 low limit 1	-99.9 ÷ 1800	low setting limit for 7: SEt1	-99.9 °C
4: H1 high limit 1	-99.9 ÷ 1800	high setting limit for 7: SEt1	850.0 °C
OUTPUT CONFIGURATION (P1 / SSR1), section 12.2			
5: Sto1 emergency state of output 1 **(2)**	output state when the sensor (signal) absent or damaged: noCh = no change, oFF = off, on = on		oFF
6: out1 output function 1	oFF = off, inv = heating, dir = cooling		inv
7: SEt1 set value 1	for output 1, changes in the range 3: Lo1 ÷4: H1		1000 °C
8: H1 output 1 hysteresis	hysteresis 0.0 ÷ 99.9 ° C		1.0 °C
CONFIGURATION OF PID ALGORITHM			
9: Pb PID proportionality range	0.0 ÷ 2000, 0 - disables the PID action, description of the PID algorithm and related topics in chapters 12.3 ÷ 12.6		0.0 °C
10: tn PID integration time constant	0 ÷ 3600 seconds	time of doubling the PID algorithm, 0 disables the integrator of the PID algorithm	0 s
11: td the PID differentiation time constant	0 ÷ 999 seconds	advance time of the PID algorithm, 0 disables the derivative of the PID algorithm	0 s
12: tc impulse period	4 ÷ 360 seconds	switching period for the two-mode output	4 s
13: tunE PID auto tuning operating mode (chapter 12.4)	oFF = off, MAnu = manual start, Auto = start after each powering up and adjustment (when the **BIN** input in start / stop mode Func = StSP)		oFF
ACCESS OPTIONS AND OTHER CONFIGURATION PARAMETERS			
14: bSEt blocked changes in SEt1	oFF = changes not blocked, SEt1 = changes blocked in parameter 7: SEt1		oFF
15: PASS access password	0000 ÷ 9999	password to get access to parameter configuration	1111
16: PPro password-protected configuration	oFF	entry to the configuration menu is not password-protected	on
	on	entry to the configuration menu is password-protected	
17: br id brightness	50 ÷ 100%	display brightness, 10% increments	100 %
18: Func **BIN** input function (chapter 9.1)	nonE	**BIN input** is inactive	nonE
	bLoc	Keyboard lock	
	StSP	start / stop of regulation or auto tuning	
19: cALo zero calibration	zero offset for measurements: -50.0 ÷ 50.0 ° C		0.0 °C
20: cALG gain	85.0 ÷ 115.0%	slope calibration (sensitivity) for measurements	100.0 %

Notes: (1) - for FiLt = 1 the response time is about 0.5 seconds, for FiLt = 15 at least 2 s.
Higher level of filtration means a "smoother" measured value and longer response time recommended for turbulent measurements (e.g. water temperature in a boiler)

(2) - the parameter also determines the output state outside the measuring range, and when there is no communication with digital temperature probes AR182, AR183

11. QUICK ACCESS MENU

The measurement mode (measured value display mode) provides an opportunity of an immediate access to some configuration parameters and functions without entering the password. This opportunity is called quick access and is available after pressing the [SET] button. The selection and editing of the parameter is analogous to the description in section 10.

Table 11. List of all parameters available in the quick configuration menu.

Item	Description
SEt 1	Set value 1 (parameter 7: SEt 1)
t-St	PID tuning start/stop (section 12.4), optional element – unavailable when parameter 13: tunE = oFF

12. OUTPUT OPERATION CONFIGURATION

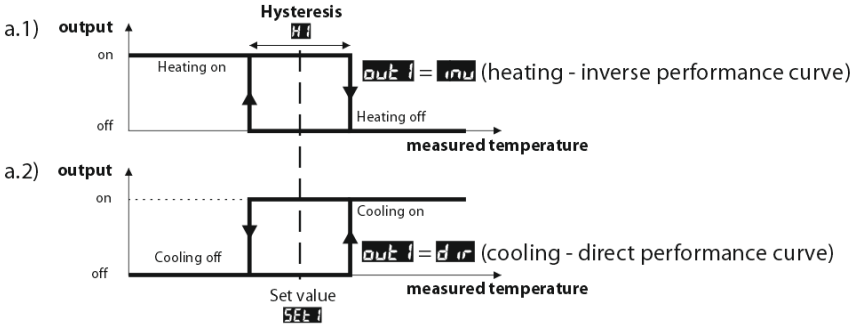
Programmable architecture of the regulator allows its use in many fields and applications. Before starting the device, the parameters should be set to individual needs (section 10). A detailed description of the output operation configuration is included in chapters 12.1 ÷ 12.6. The default (factory) configuration is as follows: output 1 in ON / OFF control mode with hysteresis (Table 10, column *Company settings*).

12.1. CHANGE OF SETPOINTS FOR OUTPUTS

In the measuring mode, the display shows the measured value. The simplest way to change the set vaule for output 1 is to use the **[UP]** or **[DOWN]** buttons. You can also use the quick menu (chapter 11). Alternatively, the change in the set value is available in the parameter configuration mode (using the methods described in section 10).

12.2. TYPES OF OUTPUT CHARACTERISTICS

The output mode is programmed with parameter 6: out 1, chapter 10, Table 10.
Basic characteristics of the output operation:



12.3. PID CONTROL

The PID algorithm makes it possible to obtain smaller temperature regulation errors than the ON-OFF method with hysteresis. However, this algorithm requires selection of parameters characteristic for a specific regulation object (e.g. a furnace). In order to simplify the operation, the regulator has been equipped with PID parameter selection functions described in chapter 12.4. In addition, it is always possible to manually adjust the settings (section 12.6).

The controller operates in PID mode when the proportionality range (parameter 9: Pb) is non-zero. The position of the proportionality range 9: Pb in relation to the setpoint 7: SEt 1 are shown in Figures 12.3 a) and b). The parameters 10: t i and 11: t d determine the influence of the integral and differentiating element of PID control. Parameter 12: t c sets the pulse period for output 1 (P1 / SSR1). The output state correction 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).

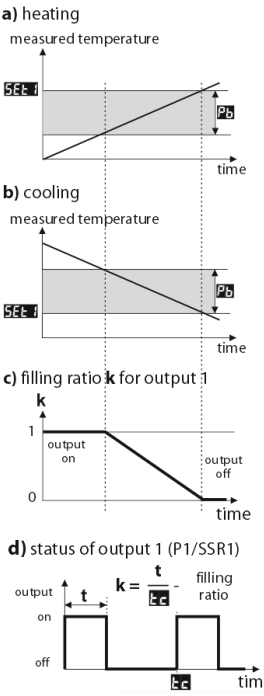


Fig. 12.3. PID control - principle of operation:

a) Relation between the proportionality range Pb and the set value SEt 1 for heating (out 1 = inv)

b) Relation between the proportionality range Pb and the set value SEt 1 for cooling (out 1 = dir)

c) filling ratio for output 1 (P1 / SSR1)

d) status of output 1 for measured value within the proportionality range..

12.4. AUTOMATIC SELECTION OF PID PARAMETERS

Auto tuning automatically selects the PID parameters characteristic of a given regulation object (e.g. a furnace).

To start the auto tuning algorithm, parameter 15 should be set properly: tunE (see section 10, Table 10), where the value tunE = MAnu allows manual start of tuning at any time, while tunE = Auto starts the tuning every time the regulation is started (after the power is turned on, and also by the binary input **BIN**, when parameter 20: Func = St.SP, section 9.1). In addition, the algorithm can be manually stopped or started at any time using the function t-St available in the quick menu (section 11). In order to do this, please perform the following actions:

- briefly press the **SET** button, and then press the **[UP]** button to move to the position named t-St
- after pressing **SET** the value of this parameter is shown on the display (oFF = tuning off, on = on)
- using the **[UP]** or **[DOWN]** buttons, select the appropriate value to set and confirm with the **SET button.**
- exit from the quick menu: simultaneous pressing of **[UP]** and **[DOWN]** buttons or waiting for approx. 5 seconds.

When determining the object's characteristics, the algorithm does not cause an additional delay in reaching the setpoint 7: SEt 1. This method is dedicated to objects with a stabilized initial temperature value (e.g. in a cold furnace). In order not to disturb the stabilized initial temperature, before switching on the auto tuning, it is recommended to turn off the power of the actuator (e.g. heater) with an external connector or use the start/stop function of the regulation (**BIN** input). The power supply should be turned on immediately after starting the tuning, when the controller output is still turned off (for about 15 seconds). Turning on the power at a later stage will result in an incorrect analysis of the object and, as a result, incorrect selection of PID parameters.

During tuning (when the display shows the message tunE alternating every 5 seconds with the measured value),

do not change the setpoint SEt1.
Auto tuning consists of the following stages:
- delayed activation of tuning (approx.15 seconds - time for switching on the power of the actuator, i.e. power of heating / cooling, etc.),
- determining the characteristics of the object,
- calculation and saving in the permanent memory of the parameter regulator 9: Pb, 10: tn, 11: td and 12: tc,
- enabling regulation with new PID settings.

Auto-tuning software interrupt (with the message Errt) 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.

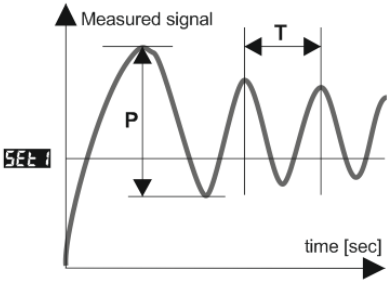
It is recommended to restart the auto tuning after a significant change in the threshold SEt1 or the parameters of the regulation object (e.g. heating/cooling power, batch mass, initial temperature, etc.).

12.5. MANUAL PID PARAMETERS SELECTION

In the situation when we are dealing with an object with unstable initial temperature (e.g. in a heated furnace) or the measurement is turbulent (e.g. water temperature in the boiler) then the built-in auto tuning 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 9: Pb, the integration time 10: tn, the differentiation 11: td and the pulse period 12: tc.

1. Set the controller to ON-OFF mode (parameter 11: Pb = 0), the required threshold value 7: SEt1 and 8: H1 = 0. If the overshoots are not indicated, the value SEt1 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. Write down the difference **P** between the highest and lowest value of the first oscillation and time **T** between the second and third oscillations.



3. Set the configuration parameters:
   - proportionality range Pb = **P**
   - integration time tn = **T** [s]
   - differentiation time td = **T** / 4 [s]
   - pulse period tc = **T** / 8 [s]

12.6. ADJUSTMENT OF PID PARAMETERS

The autotuning function correctly selects the PID control parameters for most processes, but sometimes the parameters need adjustment. Due to a strong interdependence of these parameters, adjust only one of them and observe the impact on the process:

a) <u>oscillations around the threshold</u> - increase the proportionality range 9: Pb, increase integration time 10: tn, decrease differentiation time 11: td, (possibly reduce the output 1 pulsing time by half, parameter 12: tc)
b) <u>slow response</u> - reduce the proportionality range Pb, differentiation times td and integration times tn
c) <u>over-regulation</u> - increase the proportionality range Pb, differentiation times td and integration times tn
d) <u>instability</u> - increase the integration time tn

13. MESSAGES AND ERRORS

a) measurement errors:

Code	Possible causes of the error
---- / ----	- sensor measurement range exceeding from top (----) or from bottom (----) - damage or incorrect connection of the sensor - other sensor than set in the configuration (section 10, parameter 0: inP)
----	- no communication with the AR182, AR183 digital probe - damage or incorrect connection of the digital probe - other sensor than set in the configuration (section 10, parameter 0: inP)

b) messages and instantaneous errors (single and cyclical):

Code	Description of the message
CodE	entering access password to configuration parameters, section 10
Err	wrong access password
ConF	parameter configuration menu
tunE	PID autotuning in progress, section r 12.4
Errt	autotuning error, section 12.4, to delete error simultaneously press **[UP]** and **[DOWN]**
StAr / StoP	control start/stop, section 9.1
bLoc / boFF	keypad lock on/off, section 9.1
SAvE	save parameter values (section 10)

14. CONNECTING TO THE PC AND 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 that the supplied serial port drivers are installed in 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 or on a CD provided with the AR955 / AR956 programmer (for Windows 7/8/10 operating systems). The main features of the program are as follows:

Name	Description of the program
ARSOFT-CFG (free)	- display of current measurement data from the connected device - quick configuration of controller parameters, type of measurement input, regulation options, access, etc. (chapter 10) - creation of a file with the extension "cfg" on the disc 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 application is in the installation folder.

NOTE: 

Before establishing the connection, make sure that the MODBUS address and the transmission speed in the ARSOFT program options are the same as the device settings. In addition, in the ARSOFT program options, set the number of the COM serial port used (for the AR956 or AR955 programmer it is the number assigned by the operating system during the installation of the drivers).

15. NOTES