User Manual

Temperature Controller

AR601

Version 3.1
2013.02.13

Thank you for choosing our product.

This user manual will help you with proper handling and safe operation of the controller.

Before installation and first use please read this user manual with understanding.

In case of additional questions please contact our technical advisor.

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1. SAFETY PRECAUTIONS ⚠

- **Please read user manual carefully before using this product.**
- To avoid damage to the device, make sure that all wires have been connected properly before turning on the device.
- Ensure proper working conditions, according to the specification of the device (supply voltage, humidity, temperature)
- To avoid electric shock, before making any modifications to wiring connections, turn off the power applied to the device.

2. INSTALLATION INSTRUCTIONS ⚠

This device was designed to provide an adequate level of resistance to most disturbances that may occur in industrial environments. In environments with unknown noise level it is recommended to use the following measures to prevent any possible disturbance to the instrument:

- Do not power the device from the same line which is used to power high power devices without appropriate line filters.
- Use shielded power cables, sensors and signal wires. Grounding of the shield should be single-point and connected as close to the device as possible.
- Avoid placing test (signal) leads directly next to and parallel to power lines and supply cables.
- It is recommended to twist signal wires in pairs.
- Resistance sensors in 3-wire connection should be connected with all wires identical.
- Avoid proximity of remote controlled devices, electromagnetic meters, high power loads, loads with phase or group power regulation and other devices that generate large impulse disturbances.

3. AR601 CONTROLLER GENERAL CHARACTERISTICS

- Universal thermoresistance measurement input Pt100 and thermocouple J, K, S
- Panel case IP64 from front, IP20 from connections side
- Designed for constant value regulation
- 1 relay regulating output or SSR output with ON-OFF characteristics with hysteresis, PID, AUTOTUNING PID
- LED digital display with brightness regulation
- Relay state LED indication
- Password protected access to configuration parameters
- Parameters configuration by 3-key keyboard
- Possibility to lock changes of preset values
- Software digital filtration
- High precision and resistance to disturbances that may occur in industrial environments

4. TECHNICAL SPECIFICATIONS

Universal input (keyboard selection), display and regulation range:

- Pt100 (3- or 2-wires)..... -100 ÷ 850°C (**factory input setting**)
- Thermocouple J..... 0 ÷ 800°C
- Thermocouple K..... 0 ÷ 1200°C
- Thermocouple S..... 0 ÷ 1600°C
- Electronic temperature compensation for thermocouple cold ends

Pt100 lead resistance..... Rd < 30Ω (3-wires, each line)

Pt100 input current..... ~250µA

Digital reading..... 4 LED digits, red

- Display range..... -999 ÷ 9999
- Display resolution..... 0.1°C or 1°C
- Display digits height..... 9mm

Accuracy:

- Pt100..... 0.2% of measurement range ±1 digit
- Thermocouples..... 0.3% of measurement range ±1 digit
- Thermocouple inputs additional... ±2°C (cold ends temperature)

Response time..... 0.5 ÷ 2s (programmed by parameter 2: )

Relay outputs (P1)

- For resistance loads..... 8A / 250Vac
- For inductive loads..... 2A / 250Vac
- Full load durability..... min. 2 x 10^5 switching

SSR output..... 12V, transistor OC, current limiting resistance 440Ω

Signalization

- Detected errors..... display messages
- Relay activity..... 1 red LED (1)

Table housing..... 48 x 48 x 79mm

- Table window..... 46 x 46mm

Sealing class..... IP64 – front panel, IP20 – connections

Power supply..... 230Vac (85 ÷ 260Vac) / 3VA

- Low voltage ac..... 24Vac (15 ÷ 50Vac) / 3VA
- Low voltage dc..... 24Vdc (18 ÷ 72Vdc) / 3W

Working temperature range..... 0 ÷ 50°C

Relative humidity range..... 0 ÷ 90% RH (no condensation)

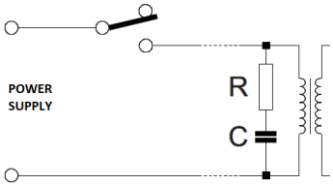
Weight..... 125g

EMC..... resistance: PN-EN 61000-6-2:2002(U)

emissivity: PN-EN 61000-6-4:2002(U)

5. IMPORTANT USAGE INFORMATION – suppression systems use

If inductive load is connected to relay contacts (i.e. contactor coil or transformer) then during its contacts disconnection surges and electric arc often occurs. They are caused by discharge of energy stored in the inductor. The most negative effects of these surges are: reducing the life of the contactors and relays, destruction of semiconductors (diodes, thyristors, triacs), measurement and control systems damage or distortion, emission of electromagnetic field that interferes local devices. To avoid these consequences, surges have to be reduced to a safe level. The easiest way to achieve it is to connect suitable suppression module directly to inductive load contacts. In general to each type of inductive load suitable suppression module should be selected. Modern contactors are usually factory equipped with suppression module. When there is no suppression module, you should buy contactor with built in suppression module. Temporary you can shunt the load with RC circuit, i.e. R=47Ω/1W and C=22nF/630V.



Suppression module should be connected to inductive load contacts.

Suppression circuit usage reduces relay contacts burning and reduces probability of contacts sticking.

6. HOUSING AND INSTALLATION METHOD

Panel INCABOX..... **48 X 48 XT L57**

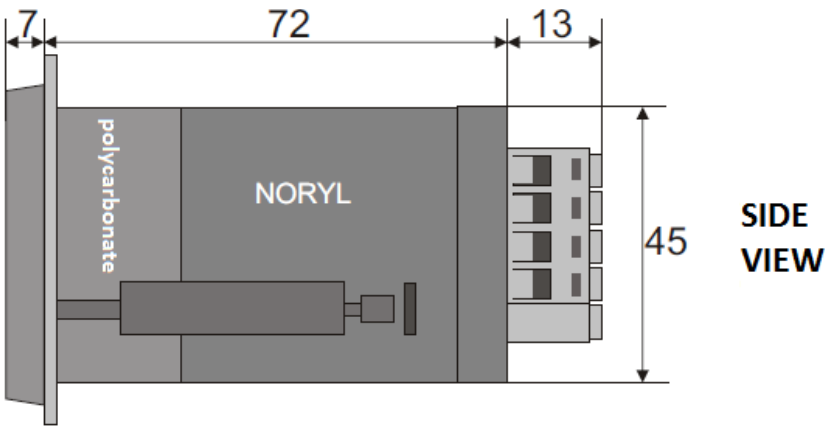
Front panel..... polycarbonate, protection level IP65

Housing body..... self-extinguishing NORYL 94V-0

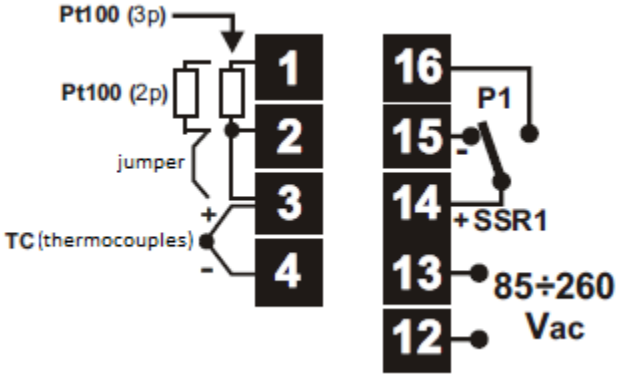
Housing dimensions..... 48 x 48 x 79mm

Table window..... 48 x 46mm

Fitting..... brackets on case sides



7. TERMINAL STRIPS AND ELECTRICAL CONNECTIONS DESCRIPTION



Connectors	Description
1-2-3	Pt100 input (2- and 3- wires)
3-4	Thermocouple input TC (J, K, S)
12-13	Power supply input 230Vac
14-15-16	P1 relay output or SSR1

8. BUTTONS, DISPLAY AND LED DESCRIPTION

Controller has 3 buttons:

- Parameter value display (marked as SET in manual)
- Preset value display and change mode enter (see section 9)
- Displayed errors deleting

or

- Move to next/previous parameter (marked as UP or DOWN in manual)
- Displayed errors deleting

Available keys combinations:

SET + DOWN or UP - increase / decrease parameter value

DOWN + UP **- fast return to measured value display (default value)**

- when pressed for more than 3 seconds – entering password set mode

Display function:

- display of measured value, parameters names and values, messages and errors

LED diode function:

- **P1/SSR1** output state display (according to parameter 5 value: 

9. OUTPUT SETPOINT VALUE DISPLAY AND CHANGE

When in measured value display mode, short press **SET** button to display **SET1** message:

- Next press **SET** button to display (preview) setpoint value
- Press **SET** button together with **UP** or **DOWN**, to change setpoint value (if settings lock is not turned on, parameter 17 - bSEt, see table 1, chapter 10)
- Exit setting mode: press and hold **UP** and **DOWN** buttons simultaneously for 5 seconds.

Setpoint value can be also configured in programming mode described in chapter 10.

10. CONFIGURATION PARAMETERS SETUP

- During first use display can show error caused by lack of the sensor or different connected sensor than factory programmed. In this situation you have to connect proper sensor or change configuration parameters.
- Press and hold **DOWN** and **UP** buttons simultaneously for a few seconds – display will show CodE symbol for a while and then 0000 with first digit blinking. Using **DOWN** and **UP** buttons enter the password (factory default value is 1111), moving to next digits is possible using **SET** button. Parameter 18 - PASS (password) can be changed
- After entering password correctly, each press of **SET** button will display ConF message and enter configuration parameters setup menu, where:
  - Mnemonic parameter name is shown on display (i.e. inP, F.Lt, dot,... – table 1),
  - After pressing **SET** button display will show this parameter value,
  - **DOWN** button moves to the next parameter and **UP** button moves to the previous parameter,
  - **SET** button together pressed simultaneously with **UP** or **DOWN** button will change value of current parameter,
  - Exit from configuration menu by pressing **UP** and **DOWN** buttons simultaneously (or waiting 2 minutes)
- In case you notice difference between displayed value and real input signal value it's possible to zero display and sensitivity of certain sensor – parameters 10-cALo (zero) and 11-cALG (sensitivity).

Table 1. Configuration parameters

Param. name change – UP or DOWN			Param. value change – SET + UP or DOWN	Settings	
No	Mnem	Param. Description	Param. value and range	Default	User
0	inP	Input type	0 = Pt100. 1 = J. 2 = K. 3 = S	0	
1	F.Lt	Filtration level (1)	3 ÷ 15	10	
2	dot	Display resolution	0 = 1°C, 1 = 0,1°C	1	
3	Lo1	Lower limit for SEt1	Within output measurement range	-99.9 °C	
4	H.1	Upper limit for SEt1	Within output measurement range	850.0 °C	
5	LEd1	Output 1 LED lights when	0 =P1 OFF, 1 =P1 ON	1	

6	rou1	Output 1 status out of measurement range (3)	0 = no changes, 1 = OFF 2 = ON	0	
7	out1	Output 1 characteristics (2)	0 = OFF, 1 = HEATING 2 = COOLING	1	
8	SEt1	Output 1 setpoint	Within range Lo1 ÷ H.1	1000 °C	
9	H1	Output 1 hysteresis	1 00 ÷ 9999 °C	10 °C	
10	cALo	Zero shift	-1000 ÷ 1000 °C	00 °C	
11	cALG	Magnification	-850 ÷ 1150 %	1000 %	
12	Pb	PID proportionality range	1 00 ÷ 2000 °C, (0 - turn off PID action)	00 °C	
13	t.i	integration time constant (PID)	1 0 ÷ 3600 s, (0 - turn off integration)	0 s	
14	td	derivative time constant (PID)	1 0 ÷ 999 s, (0 - turn off differentiation)	0 s	
15	tc	oscillation period (PID)	1 4 ÷ 360 s	4 s	
16	tunE	PID autotuning type (section 14)	0 = OFF, 1 = manual start 2 = start after each power on	0	
17	bSEt	SEt1 values change lock	0 = no locks, 1 = SET1	0	
18	PASS	Protection password (4)	0 ÷ 9999	1111	
19	Prot	Password protection (4)	0 = OFF, 1 = ON	1	
20	br.G	Display brightness	50 ÷ 100%, step 10%	80 %	

Cautions:

(1) – for FiLt=3 response time is 0.5 second, for FiLt=15 response time is about 2 seconds. Higher filtration level means more smooth measured value and longer response time.

(2) ON-OFF characteristics information can be found in chapter 12,

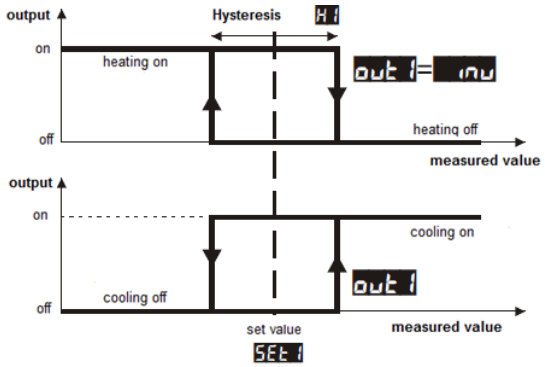
(3) Parameter also defines output state for sensor circuit damage.

(4) When Prot=0, parameters configuration access doesn't require password.

11. MESSAGES AND ERRORS LIST

---- ...	Upper display segments – upper sensor range exceeded or sensor damage
---- ...	Lower display segments – lower sensor range exceeded or sensor damage
Err ...	Incorrect protection password entered
Errt ...	Autotuning error, chapter 14 (error reset with any button)
tunE ...	Performing PID autotuning function
CodE ...	Configuration protection password entering mode
ConF ...	Entering parameters configuration menu

12. ON-OFF CHARACTERISTIC TYPES

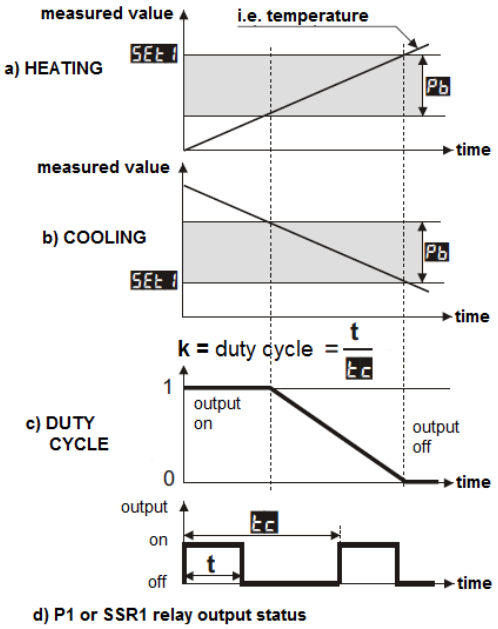


CAUTIONS:

Parameter name	Parameter number (p. 10, table 1)
out 1	**7**
SEt 1	**8**
HI	**9**

13. PID REGULATION

Controller works in PID mode when proportionality range (parameter 12: Pb) is different than zero. Proportionality range Pb position relative to set value SEt 1 is shown on illustrations a) and b). Influence of integral and derivative part of PID regulation is set by parameter 13: td and 14: tD. Parameter 15: tc sets pulsation period for output **P1** or **SSR1** (optional). Output state correction is performed every 1 second. The principle of operation for P type regulation (proportional control) for output P1 or SSR1 is shown in the illustration c), d). To select PID parameters suitable for certain regulation object it's recommended to use automatic settings selection – autotuning (chapter 14). Information about manual PID parameters selection and correction can be found in chapter 15 and 16.



d) P1 or SSR1 relay output status

Illustration. Principle of operation for PID regulation:

a) Proportionality range position Pb related to set value SEt 1 for heating (out 1 = inv).
b) Proportionality range position Pb related to set value SEt 1 for cooling (out 1 = dir).
c) Duty cycle for relay output P1 or SSR1.
d) P1 relay output or SSR1 output state (for measured value within proportionality range).

14. PID AUTOTUNING

Autotuning automatically selects PID parameters and consists of following stages:

Tuning start delay (about 1 minute, time for actuator power on, i.e. heating power, cooling power, fan,...), determining object characteristic, calculating and saving in non-volatile controller memory parameters Pb, t i, td and tc, start of regulation with new PID parameters.

To start autotuning it's necessary to set parameter 16-tunE correctly (see chapter 10, table 1), where value tunE=1 allows for manual tuning start at any time, tunE=2 will start tuning always when controller power is turned on and allows for manual start. **It's recommended to start autotuning on object with stabilized regulated value** (temperature, humidity,...). Before autotuning start actuator power supply needs to be turned off with external switch.

To manually start/stop autotuning, please perform below actions:

- Press **SET** button shortly, then using UP button, go to parameter t-St
- After pressing **SET** button display will show selected parameter value (0 = OFF, 1 = ON)
- Pressing **SET** button simultaneously with **UP** or **DOWN** button set t-St=1 (start), then within 1 minute turn on object power supply using external switch, setting t-St=0 stops tuning.
- Exiting from setting menu: press **UP** and **DOWN** buttons simultaneously or wait 5 seconds.

During autotuning every 5 seconds display will show tunE message together with measured value.

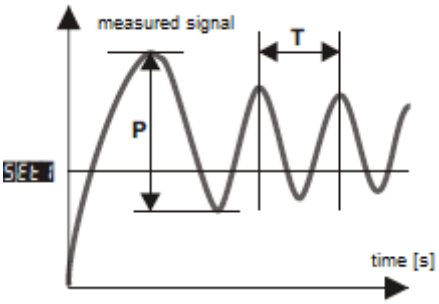
Software autotuning stop (with Errt message displayed) can occur if proper algorithm functioning conditions are not met:

- Difference between setpoint value and initial value is less than 40°C
- Initial value is greater than setpoint value for heating or smaller than setpoint value for cooling,
- Maximum tuning time was exceeded (9 hours),
- Process value changes too fast or to slow

After changing threshold value SEt 1 or regulated object parameters (i.e. heating/cooling power, batch weight, initial temperature,...), it's recommended to start autotuning again.

15. MANUAL PID PARAMETERS CONFIGURATION

Following algorithm allows PID action parameters choice – proportionality range Pb (parameter 12), integration time t.i, (13), differentiation time t.d (14) and pulsation period t.c (15).



1. Set regulator to ON-OFF mode (parameter Pb = 0), SEt i threshold required value and HY i=0. If overregulations are not desirable, SEt i value should be set to lower level than required. Regulator should be connected to measurement and regulation circuit used.
2. Watch and note process variable changes (temperature).
   Note the difference (P) between the highest and the lowest value of the first oscillation and time (T) between second and third oscillation.
3. Set configuration parameters:

- proportionality range Pb = P
- integration time t.i = T [s]
- differentiation time t.d = T/4 [s]
- pulsation period t.c = T/8 [s]

16. PID PARAMETERS CORRECTION

Autotuning function is able to set correct PID regulation parameters for most processes, however it may be necessary to correct them. Parameters are strongly dependent each other, so you should change only one parameter at time and watch its influence on the process:

- **oscillations near threshold** – increase proportionality range Pb, increase integration time t.i, decrease differentiation time t.d,
- **slow response** – decrease proportionality range Pb, differentiation times t.d and integration times t.i,
- **overregulation** – increase proportionality range Pb, differentiation times t.d and integration times t.i,
- **instability** - increase integration time t.i.