

LUMEL

TEMPERATURE CONTROLLER **RE55**



USER'S MANUAL

CE

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1. APPLICATION

The R55 controller is a microprocessor controller with an analog setting and digital measurement of the measured value. The controller controls the temperature in objects through switching on and off the electrical control device, in accordance with the definite set point by the controller. The controller co-operates directly with RTD and TC temperature sensors.

The controller is destined to control temperature in plastics industry, food and dehydration industries, and everywhere when it is necessary to stabilize temperature changes.

2. CONTROLLER SET

The controller set is composed of:

1. controller..... 1 pc
2. plug with 16 screw terminals 1 pc
3. holder to fix in the panel 2 pcs

When unpacking the controller, please check whether the type and option code on the data plate correspond to the order.

3. CONTROLLER PREPARATION to WORK

3.1. Safety

The RE55 controller meets requirements concerning the safety of electrical measuring devices in automatics acc. to the EN 61010-1 standard, requirements concerning the immunity against electromagnetic interference acc. to the

EN 61000-6-2 standard and the emission of electromagnetic interference occurring in industrial environments, acc. to the EN 61000-6-4 standard.

When connecting the supply, one must remember that a switch or a circuit-breaker should be installed in the building. This switch should be located near the device, easy accessible by the operator, and marked as an element switching the device.

3.2. Controller Installation in the panel

Fix the controller in the panel by means of two screw holders included in the standard accessory set, acc. to the fig. 1. The panel hole should be $91^{+0,6} \times 91^{+0,6}$ mm. The thickness of the material which the panel is made of, cannot exceed 6 mm.

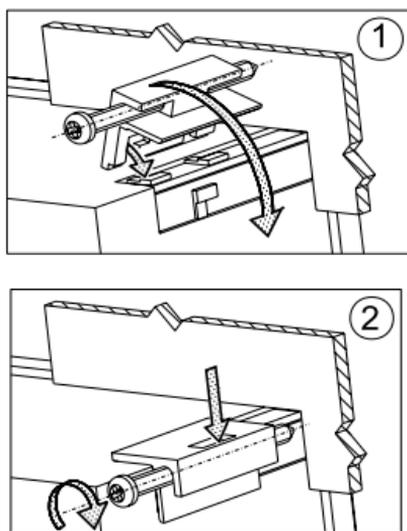


Fig. 1. Way of controller fixing.

Controller overall dimensions are presented below, on the fig. 2.

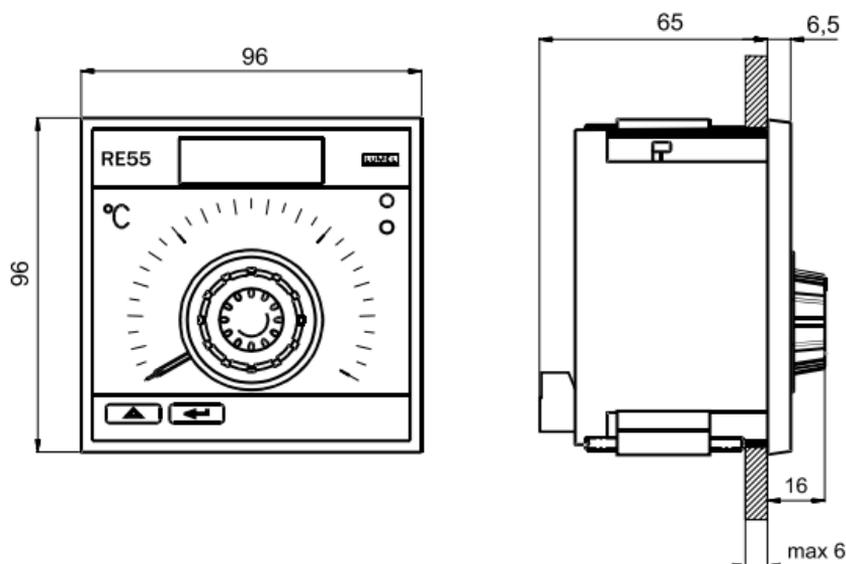


Fig.2. Overall dimensions of the RE55 controller.

3.3. Electrical connections

Carry out electrical connections in compliance with the fig. 3.

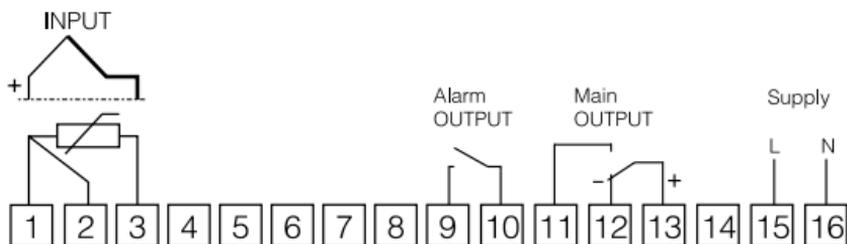


Fig. 3. Scheme of electrical connections.

Note:

1. *When connecting the Pt100 sensor in two-wire version, one must short terminals 1 and 2.*
2. *One cannot connect any wires to not used controller terminals.*

3.4. Installation recommendations

The RE55 controller fulfils requirements concerning immunity against electromagnetic interference in industrial environments acc. to binding standards.

In order to obtain a full fastness of the controller against electromagnetic interference in an unknown environment interference level, it is recommended to observe following principles:

- do not supply the controller from the network near devices generating high impulse interference,
- apply network filters,
- apply metallic shields in the shape of tubes or braided screens to conduct supplying wires,
- wires supplying the measuring signals should be twisted in pairs, and for resistance thermometers in a 3-wire connection, twisted with wires of the same length, cross-section and resistance, and led in a shield as above,
- all screens should be one-side earthed, and led the nearest possible to the controller,
- apply the general principle that wires leading different signals should be led the farthest possible between them (not less than 30 cm), and their crossing executed at a right angle.

4. WORK STARTING

After the correct installation and supply connection, the controller carries out the display test and displays the type of controller on the upper display inscription **ESS**, the program version and next, the measured value.

A character message informing about abnormalities may appear on the display (table 4).

4.1. Kind of execution

The controller is available in following executions:

ON-OFF controller

- analog setting of the set point and digital measurement of the measured value,
- control algorithm of on-off type with hysteresis set on 0.7% of the measuring range.

PID controller

- analog setting of the set point and digital measurement of the measured value,
- control algorithm of PID type with manufacturer's setting depending on the execution (see table 1).

Configurable controller

- analog setting of the set point and digital measurement of the measured value,
- control algorithm of on-off or PID type and parameters set by the user,
- programming of controller parameters by means of  and  push-buttons,
- autotuning function,

- alarm output,
- programmable change of control between heating and cooling,
- possible safe-guard of parameters through a password.

4.2. Controller service

The view of the frontal controller plate in the on-off or PID execution is presented on the fig.4a, and in the configurable execution with push-buttons and the alarm, on the fig.4b.

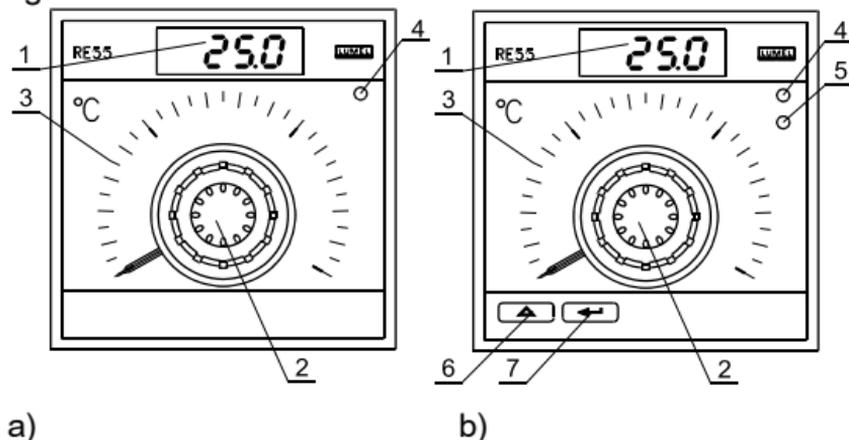


Fig. 4. Frontal plate of the controller.

Following elements are situated on the frontal plate of the controller:

- 1 - display of the measured value,
- 2, 3 - hand-setting knob with the indicating dial to set the set point value,
- 4 - green diode signalling the output state,
- 5 - red diode signalling the alarm state,
- 6, 7 - push-buttons.

4.3. Setting of the set point value

The setting of the set point is carried out after pressing the internal part to the external part of the hand-setting knob. The controller displays automatically the set point value in case of the potentiometer movement. The return to display the measured value follows after 5 seconds since the potentiometer movement steady-state. In the controller version with push-buttons, the monitoring of the set point is possible after pressing the  push-button. During the display of the set point, the display pulsates.

5. PROGRAMMING of CONTROLLER PARAMETERS - CONFIGURABLE EXECUTION

5.1. Scheme of the controller menu

The scheme of the controller menu is presented on the fig.5. After pressing and holding down the  push-button during at least 2 seconds, it is possible to program parameters. The transition between parameters is carried out by means of the  push-button. The description of parameters is contained in the table 1. The return to the normal working mode follows after the simultaneous pressure of  and  push-buttons or automatically after 30 seconds since the last push-button pressure.

Some parameters may be invisible. It depends on the current controller configuration.

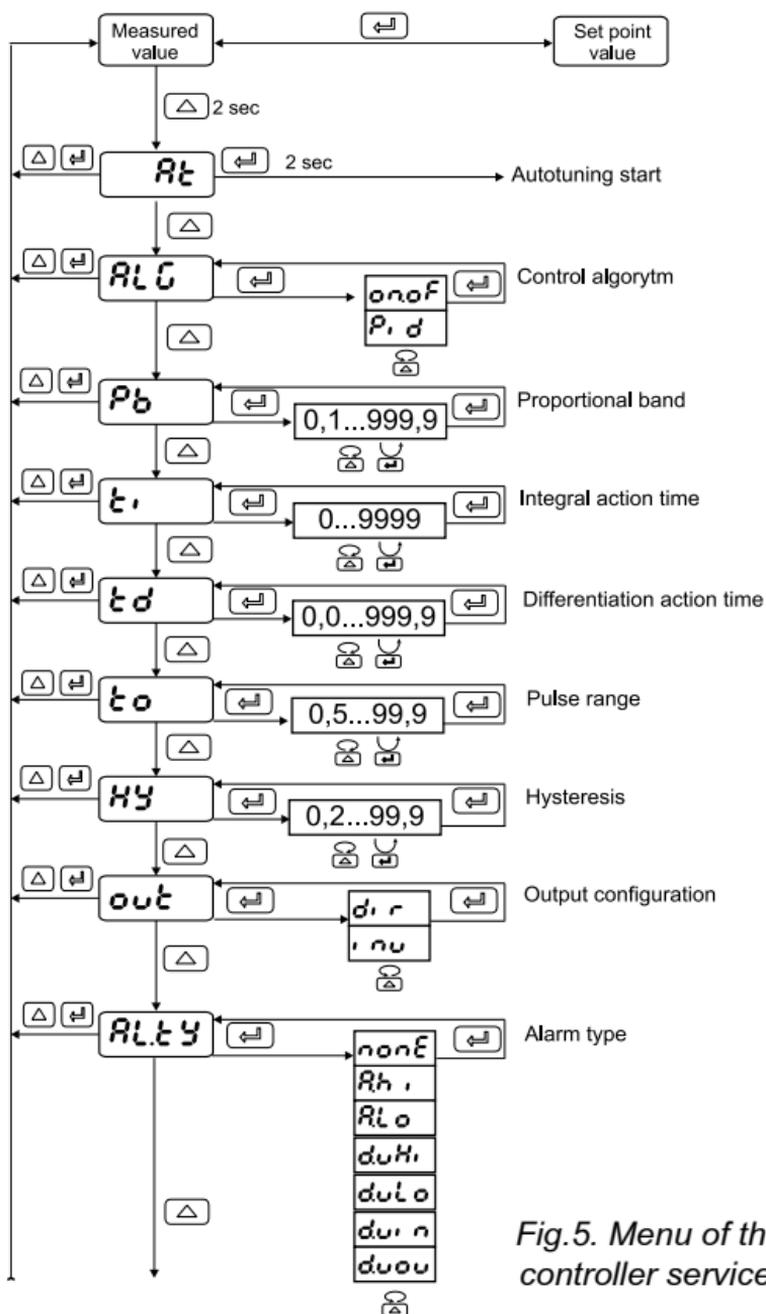


Fig.5. Menu of the controller service.

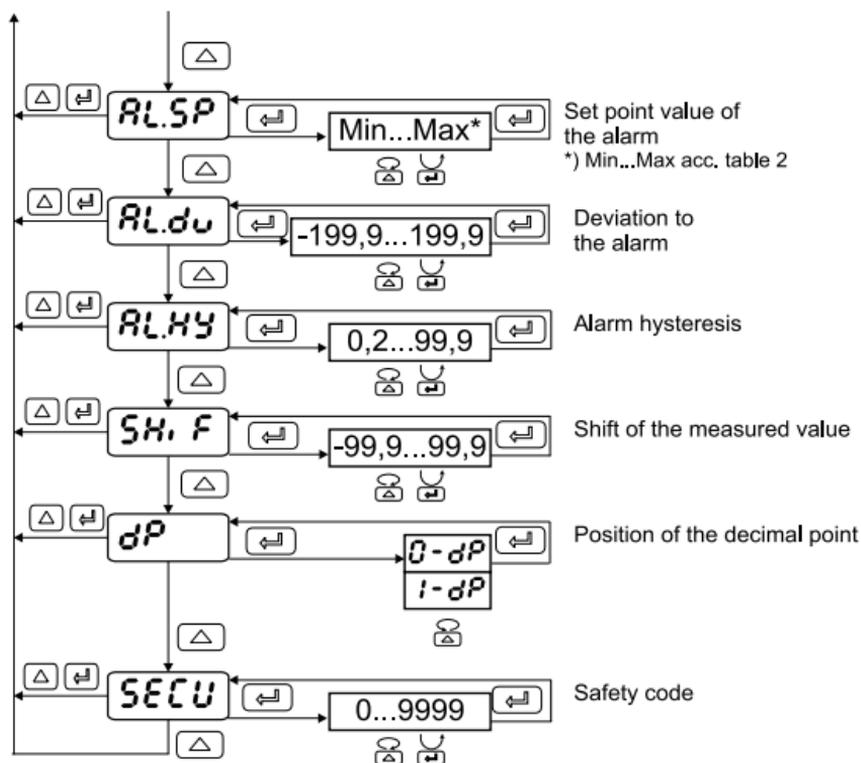


Fig. 5. Menu of the controller service.

One can protect by a code the access to parameters. If the parameter is set (the *SECU* parameter is higher than zero), one must give it during the entry to the menu. First, the inscription *code* appears and after the release of the push-button, one can introduce the code value. If an incorrect code value will be introduced, the inscription *Err* appears on the display and the user will be able only to review parameter values. The introduction of the safety code is shown on the fig.6.

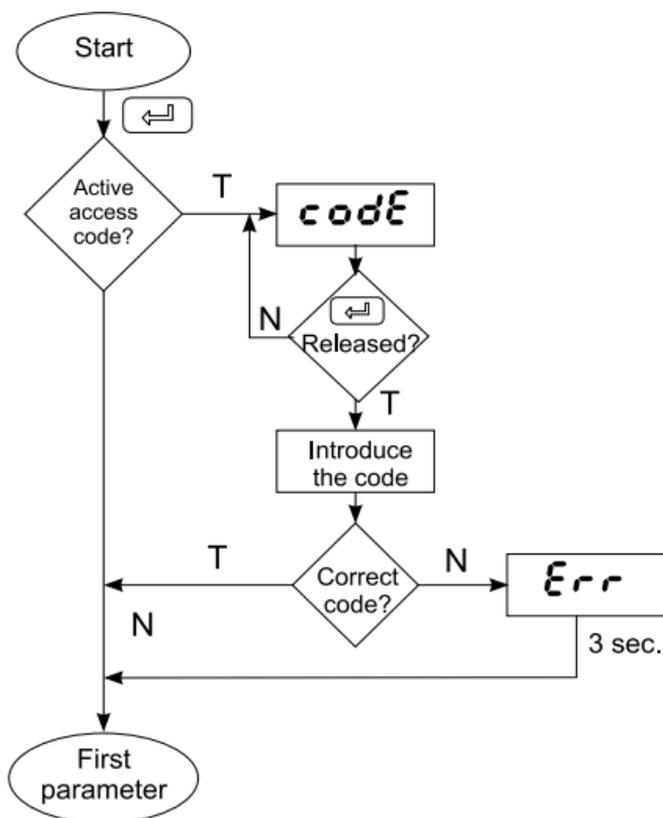


Fig. 6. Introduction of the access code.

5.2. Setting change

The change of the parameter setting begins after pressing the  push-button. By means of the  push-button one can increase the flickering digit or the non-numerical parameter, and by the  push-button, one can transit it between digits or accept the non-numerical parameter. The change cancellation follows after the simultaneous pressure of  and  push-buttons, or automatically after the laps of 30 sec. since the last push-button pressure.

The way to change the setting is shown on the fig. 7.

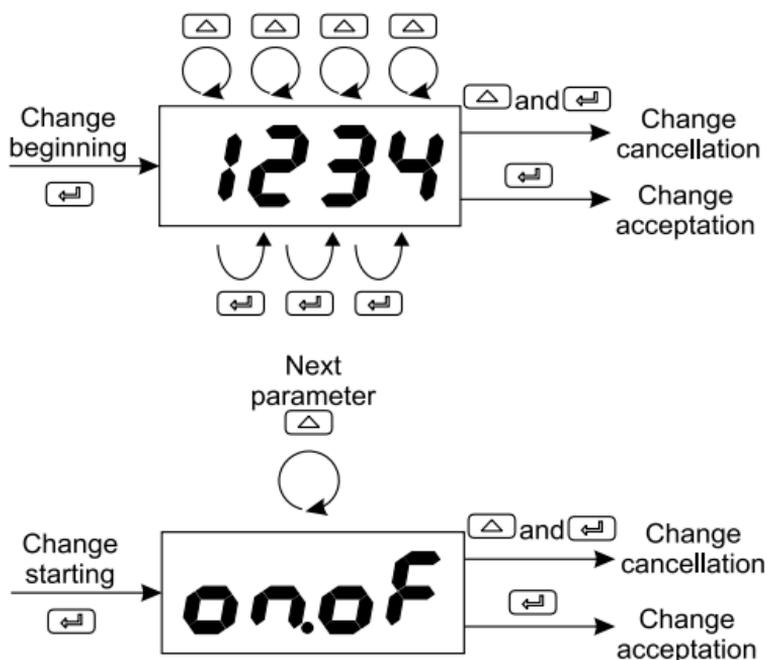


Fig. 7. Setting change of numerical and textual parameters.

5.3. List of parameters

The list of controller parameters is presented in the table 1.

List of configuration parameters

Table 1

Parameter symbol	Parameter descriptions	Range of parameters changes	Manufacturer's setting
<i>ALG</i>	Controller algorithm	<i>onof</i> : on-off control algorithm <i>P, d</i> : PID control algorithm	<i>onof</i> ⁶⁾ <i>P, d</i> ⁷⁾
<i>Pb</i>	Proportional band ¹⁾	0.1...999.9 °C	PB FABR acc. to table 2
<i>t_i</i>	Integration time-constant ¹⁾	0...9999 s (0 - unit disabled)	300
<i>t_d</i>	Differentiation time-constant ¹⁾	0.0...999.9 s (0 - unit disabled)	60.0
<i>t_o</i>	Pulse repetition period ¹⁾	0.5...99.9 s	20.0
<i>HY</i>	Hysteresis ²⁾	0.2...99.9 °C	HY MANUF acc. table 2

out	Configuration of the control output	dir : control of cooling type hnu : control of heating type	nu
RLtY	Configuration of the alarm output	nonE : disabled RHi : absolute upper alarm RLo : absolute lower alarm dUH : relative upper alarm dUL : relative lower alarm dui : absolute internal alarm duou : absolute external alarm	nonE
RLSP	Alarm set value ³⁾	MIN...MAX acc. to table 2	0
RLdU	Deviation of the set value for the relative alarm ³⁾	-199.9...199.9 °C	0.0
RLHY	Hysteresis for the alarm ³⁾	0.2...99.9 °C	2.0
ShiF	Shift of the measured value	-99.9...99.9 °C	0.0

<i>dp</i>	Position of the decimal point for the measured value ⁴⁾	0 . <i>dp</i> : without decimal point 1 . <i>dp</i> : 1 decimal place	DP MANUF acc. table 2
<i>SECU</i>	Safety code ⁵⁾	0...9999	0

- 1) parameter hidden at on-off control,
- 2) parameter hidden at proportional control,
- 3) parameter visible when there is an appropriate configuration of the input alarm,
- 4) only for executions with resolution 0.1 (see table 5),
- 5) parameter hidden in the mode of parameter review and only for readout,
- 6) for the execution, in execution code: on-off controller and configurable controller,
- 7) for the execution, in execution code: PID controller.

Parameters depending on the measuring range

Table 2

Sensor	MIN	MAX	PB FABR	HY FABR	DP FABR
RTD Pt100 - 50...100°C	-50,0	100,0	15,0	1,1	<i>1. dP</i>
RTD Pt100 0...100°C	0,0	100,0	10,0	0,7	<i>1. dP</i>
RTD Pt100 0...150°C	0,0	150,0	15,0	1,1	<i>1. dP</i>
RTD Pt100 0...250°C	0,0	250,0	20,0	1,8	<i>1. dP</i>
RTD Pt100 0...400°C	0,0	400,0	25,0	2,8	<i>1. dP</i>
RTD Pt100 0...600°C	0,0	600,0	30,0	4,2	<i>1. dP</i>
TC of J type 0...250°C	0,0	250,0	20,0	1,8	<i>1. dP</i>
TC of J type 0...400°C	0,0	400,0	25,0	2,8	<i>1. dP</i>
TC of J type 0...600°C	0,0	600,0	30,0	4,2	<i>1. dP</i>
TC of J type 0...900°C	0,0	900,0	40,0	6,3	<i>1. dP</i>
TC of K type 0...600°C	0,0	600,0	30,0	4,2	<i>1. dP</i>
TC of K type 0...900°C	0,0	900,0	40,0	6,3	<i>1. dP</i>
TC of K type 0...1300°C	0	1300	45,0	9,1	<i>0. dP</i>
TC of S type 0...1600°C	0	1600	50,0	11,2	<i>0. dP</i>

6. CONTROLLER INPUTS and OUTPUTS

6.1. Measuring inputs

The controller has one measuring input to which, one can connect a resistance thermometer or thermocouple sensor acc. to the execution code. For the resistance thermometer Pt100 in a three-wire connection, the compensation of the line resistance is carried out automatically.

In the two-wire connection, one can take into consideration that the line resistance introduces an additional measurement error. For thermocouples, the compensation of the reference junction is carried out automatically. An additional parameter is the number of digits after the decimal point, parameter dP which defines if the measured temperature is to be shown with a place after the decimal point (only for execution with resolution 0.1°C).

The correction of the measured value indication is carried out by the Sh, F parameter.

6.2. Output

The controller has one control output. On this output, it is possible to select the on-off control or proportional PID control. For the proportional control, one must additionally set the pulse repetition period.

The pulse repetition period is the time which goes by, between successive switching of the output on during the proportional control.

The length of the pulse repetition period must

be chosen depending on dynamic properties of the object and suitably to the actuator. It is recommended to use solid-state relays (SSR) for quick processes. The relay output is used to control contactors in slow-speed processes. The use of a too high pulse repetition period to control high-speed processes may give undesirable effects in the shape of oscillations. Theoretically, the lower pulse repetition period, the better control is, however for the relay output it should be as high as possible in order to lengthen the relay life.

Recommendations concerning the pulse repetition period

Table 3

Output	Pulse repetition period to	Load
Electromagnetic relay	recommended >20s min. 10 s	2A/230V a.c. or contactor
	min. 5 s	1A/230V a.c.
Transistor output	1...3 s	solid-state relay (SSR)

7. CONTROL

7.1. On-off control (ON-OFF)

The choice of the on-off control type requires following settings, the $R_L C$ parameter must be set on `ONOFF`, the hysteresis value given in the parameter - HY , and the way of the output operation established by the parameter - `OUT`.

The operation way of the output on heating (fig.8) is set by the parameter $out = 100$, and on cooling by the parameter $out = 010$.

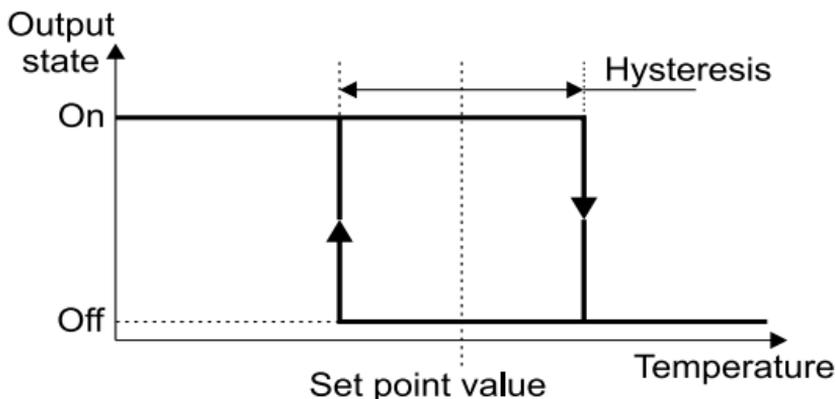


Fig.8. Operation way of the output heating type.

7.2. PID control

The choice of the PID or also PI, PD or P control type requires following settings, the RLU parameter must be set on P, d , and suitably set parameter values - proportional range (Pb), integrating unit (t_i) and differentiating unit (t_d). The switching of the given unit off consists on setting the parameter on zero. The operation way of the output on heating is chosen by setting the $out = 100$, parameter, and on cooling by setting the parameter $out = 010$. The next parameter to set, is the pulse repetition period (t_o).

8. ALARMS - CONFIGURABLE EXECUTION

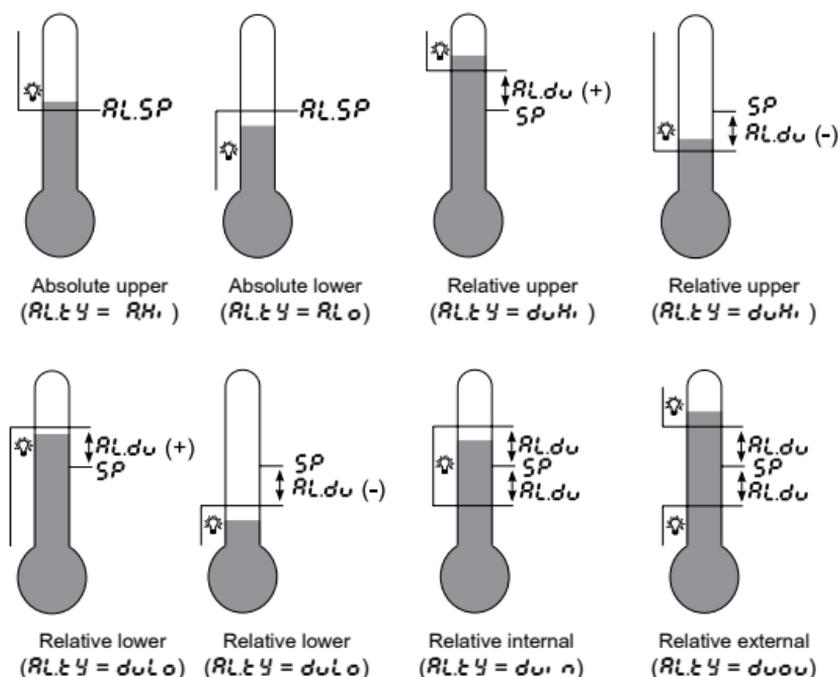


Fig.9. Kinds of alarms.

The alarm configuration requires the choice of the kind of alarm through setting the $RL.t.Y$ parameter. Accessible types of alarms are given on the fig.9. The set point value for absolute alarms is the value defined by the $RL.SP$ parameter, and for relative alarms, that is the deviation from the set point value in the main line - $RL.du$ parameter. The alarm hysteresis, that is the zone around the set point value, in which the output state is not changed, is defined by the $RL.HY$ parameter.

9. MANUFACTURER'S SETTINGS - CONFIGURABLE EXECUTION

Manufacturer's settings can be restored during the supply switching on, by holding down  and  push-buttons till the moment, when the **F R b r** inscription appears on the upper display.

10. SELECTION of PID PARAMETER SETTINGS - CONFIGURABLE EXECUTIONS

10.1. Autotuning

The controller has the function of automatic selection of the PID setting. Obtained settings ensure in most of cases an optimal control.

To start the autotuning, one must transit to the **Rt** parameter (acc.to the fig. 5) and hold down the  push-button during at least 2 sec.

The parameter is accessible only for the proportional control (**R L G = P, d**). However it is inaccessible when giving the incorrect safety code (if it was activated).

The flickering decimal point from the left side of the display informs about the autotuning function activity. The autotuning duration time depends on dynamic properties of the object and may lasts maximally 10 hours. During the autotuning or directly after it, over-regulations can arise, for this reason, one must set a lower set point value, if it is possible. After the autotuning termination, calculated PID settings are stored in the non-volatile memory and the control process starts with new settings.

The autotuning process may not start or be broken without calculation of PID settings, if:

- the measured value is higher than the set point value (for control of heating type),
- the difference between the set point value and the measured value is lower than 5% of the measuring range,
- the time of the preliminary object stabilization or the admissible time of the autotuning duration will be exceeded,
- when a controller supply decay occurs,
- any push-button has been pressed,
- the set point value has been changed,
- calculated parameter values are beyond the range.

In such cases, the control with previous PID settings will start.

The controller, depending on the control deviation, chooses the response method to the unitary jump or the oscillation method. The response method to the unitary jump is chosen when the difference between the set point value and measured value is at least 20% of the controller measuring range.

Response method to the unitary jump

The autotuning by the response method to the unitary jump is composed of following stages:

- switching the control signal off and stabilization of the object temperature (since 2 min till 3 hours),
- switching the control signal on (100 %) and determination of the object characteristic (max. 10 hours),
- calculation of PID settings and their storage in the non-volatile memory,
- beginning of the PID control with new settings.

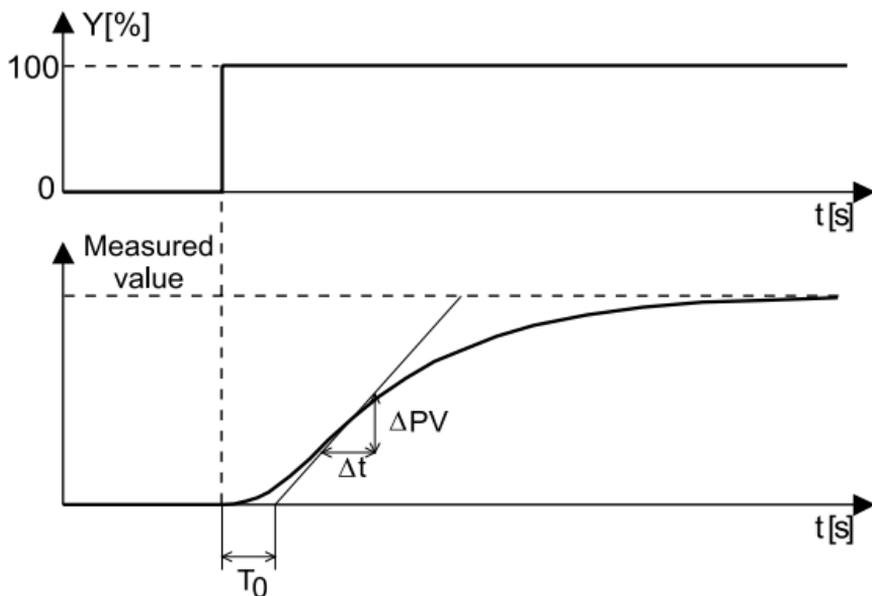


Fig.10. Selection of settings by the response method to the unitary jump

On the object characteristic presenting the controlled quantity in the function of time, one may see the delay time of the object to and the maximal temperature accretion (which is calculated from the dependence:

$$V_{max} = \frac{\Delta PV_{max}}{\Delta t} \quad).$$

PID settings are calculated acc. to following equations:

$$Pb = 1.1 \cdot V_{max} \cdot T_0 \quad - \text{proportional range}$$

$$t_i = 2.4 \cdot T_0 \quad - \text{integration time-constant}$$

$$t_d = 0.4 \cdot T_0 \quad - \text{differentiation time-constant}$$

Oscillation method around the set point value

The autotuning by the oscillation method is composed of following stages:

- on-off control acc. to fig.11,
- calculation of PID settings and their storage in the non-volatile memory,
- beginning of the PID control with new settings.

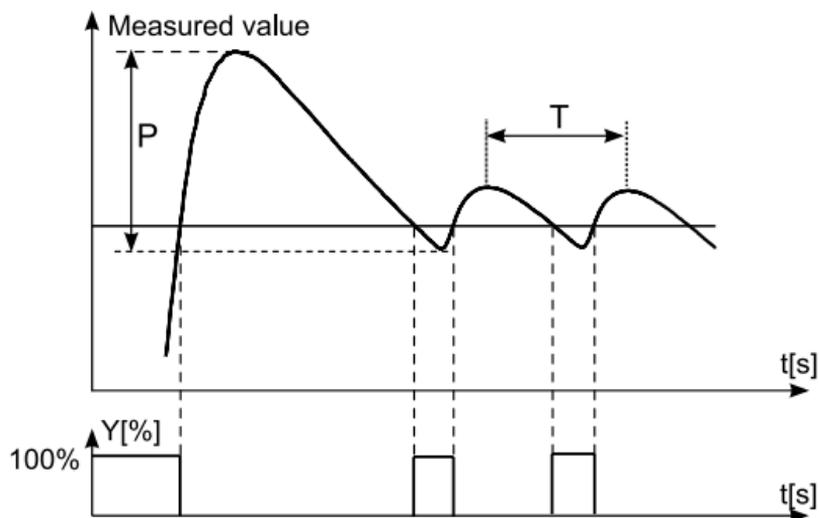


Fig.11. Selection by the oscillation method.

PID settings are calculated acc. to given formula:

$$P_b = P$$

$$t_i = T$$

$$t_d = 0.25 * T$$

10.2. Correction of PID settings

PID parameters interact between them and, one must introduce changes of only one parameter. The better is to match parameters, changing the value into a twice higher or twice lower value.

During changes, one must respect following principles:

a) *Slow response of the object:*

- decrease the proportional range,
- decrease integration and differentiation time-constants.

b) *Over-regulations:*

- increase the proportional range,
- increase the differentiation time.

c) *Oscillations:*

- increase the proportional range,
- increase the integration time,
- decrease the differentiation time.

d) *Instability:*

- increase the integration time.

11. ERROR SIGNALLING

Character messages

Table 4

Error code	Cause	Procedure
LErr	Exceeding of the measuring range down or shorting in the sensor circuit	Check, if the appropriate sensor was connected and if input signals are situated in the appropriate range , if yes, check if there is not a short-circuit in the sensor circuit.
HErr	Exceeding of the measuring range down or shorting in the sensor circuit	Check, if the type of the selected sensor is compatible with the connected sensor; check if values of input signals are situated in the appropriate range , if yes, check if there is not a break in the sensor circuit.
- - - -	Exceeding of the set value range down	Check, if the setting potentiometer index is not situated beyond the dial range.
- - - -	Exceeding of the set value range up	Check, if the setting potentiometer index is not situated beyond the dial range.

<i>At.Er</i>	Autotuning finished with failure	Check the cause of breaking the tuning process in the autotuning point.
<i>Er.Rd</i>	Input discalibrated	Connect again the controller supply, If that not help, contact the nearest service workshop.
<i>Er.SP</i>	Input of the set point value discalibrated	Connect again the controller supply, If that not help, contact the nearest service workshop.
<i>Er.EE</i>	Error of the readout verification from the non-volatile memory	Connect again the controller supply, if that not help, contact the nearest service workshop. The exploitation in this state may cause its unforeseen behaviour.

12. TECHNICAL DATA

Range, resolution and based intrinsic error for different executions

Table 5

Sensor type	Range [°C]	Resolution [°C]	Intrinsic error [°C]
Resistance thermometer (acc. EN 60751+A2), measuring current 0.25 mA			
Pt100 ^{*)}	-50...100	0.1	±0.8
	0...100	0.1	±0.5
	0...150	0.1	±0.8
	0...250	0.1	±1.3
	0...400	0.1	±2.0
	0...600	0.1	±3.0
Thermocouple of J type (acc. EN 60584-1)			
Fe-CuNi	0...250	0.1	±2.0
	0...400	0.1	±2.0
	0...600	0.1	±3.0
	0...900	0.1	±4.0
Thermocouple of K type (acc. EN 60584-1)			
NiCr-NiAl	0...600	0.1	±3.0
	0...900	0.1	±4.0
	0...1300	1	±6.0
Thermocouple of S type (acc. EN 60584-1)			
PtRh10-Pt	0...1600	1	±8.0

^{*)} Sensor line resistance <10 Ω/wire, one must make the connection with wires of identical cross-section and length

Potentiometric setting of the set point:

- resolution of the set point setting 0.1% of the controller range
- difference between the set point and the value set on the graduation < 2% of the controller range
- detection of the set point setting overflow $\pm 1\%$ of the controller range

Measurement time 0.5 s

Error detection in the measurement circuit:

- thermocouple, Pt100 measuring range exceeding

Control algorithm:

- P, PD, PI, PID, ON-OFF with hysteresis

Setting range of controller parameters

- See table 1

Kinds of outputs:

for control output:

- relay without voltage load 2 A/230 V change-over contact
- logic voltage 5 V voltage, 10 Ω resistance limiting the current (without isolation from the sensor side for alarm output)

for alarm output:

- relay without voltage

normally open contact
(NOC)
load capacity 1 A/230 V,

Output operation:

- reverse

for heating

- direct

for cooling

Signalling:

- switching the main output on

- switching the main output off

Rated operating conditions:

- supply voltage

85...253 V a.c. / d.c.

- supply voltage frequency

40...440 Hz

- ambient temperature

0...23...50°C

- storage temperature

-20...+70°C

- relative air humidity
(condensation)

< 85% (without con-

- external magnetic field

< 400 A/m

- preliminary warm-up time

30 min.

- operating position

any

- resistance of wires connecting
the resistance thermometer
with the controller

<10 Ω/wire

Consumption

< 4 VA

Weight

< 0.3 kg

Overall dimensions

96 × 96 × 65 mm

Panel cut-out

91^{+0.6} × 91^{+0.6} mm

Protection degree ensured by the housing acc. to EN 60529:

- from the frontal plate side IP 40
- from terminal side IP 20

Additional errors in rated operating conditions caused by:

- compensation of the thermocouple reference junction temperature change $\leq 2^{\circ}\text{C}$,
- changes of the RTD line resistance $\leq 50\%$ of the intrinsic error
- change of ambient temperature $\leq 100\%$ of the intrinsic error /10 K.

Safety requirements acc. to EN 61010-1:

- isolation between circuit basic,
- installation category III,
- pollution degree 2,
- maximal working voltage in relation to earth:
 - for the supply circuit 300 V
 - for input circuits 50 V
- altitude above sea level under 2000 m

Electromagnetic compatibility:

- immunity acc. to EN 61000-6-2
- emission acc. to EN 61000-6-4

13. CONTROLLER EXECUTION CODES

The coding way is given in the table 6

Table 6

Temperature controller RE55 -	X	X	X	X	X
Input:					
Pt100/1,3850	-50...100°C.....	01			
	0...100°C.....	02			
	0...150°C.....	03			
	0...250°C.....	04			
	0...400°C.....	05			
	0...600°C.....	06			
Fe-CuNi (J)	0...250°C.....	07			
	0...400°C.....	08			
	0...600°C.....	09			
	0...900°C.....	10			
NiCr-NiAl (K)	0...600°C.....	11			
	0...900°C.....	12			
	0...1300°C.....	13			
PtRh10-Pt (S)	0...1600°C.....	14			
on order *	99			
Kinds of execution:					
on-off controller		1			
PID controller		2			
controller configurable by push-buttons and with an alarm..		3			
Control output relay:					
relay		1			
voltage 0/5V		2			
Version:					
standard		00			
custom-made		99			
Additional acceptance test requirements:					
without additional requirements		8			
with a quality inspection certificate.....		7			
acc. customer's requirements **		X			

*) - After agreement with the manufacturer

***) - The code will be established by the manufacturer

EXAMPLE OF ORDER

The code: **RE55 02 3 1 00 8** means:

- RE55** - temperature controller of RE55 type
- 02** - input Pt100, range: 0...100°C
- 3** - execution: controller configurable by push-buttons and with an alarm
- 1** - control output: relay
- 00** - standard version
- 8** - without an additional quality certificate.

14. MAINTENANCE and GUARANTEE

The RE55 controller does not require any periodical maintenance.

In case of some incorrect controller operations:

1. After the dispatch date and in the period stated in the guarantee card

One should return the instrument to the Manufacturer's Quality Inspection Dept. If the instrument has been used in compliance with the instructions, the Manufacturer warrants to repair it free of charge.

The disassembling of the housing causes the cancellation of the granted guarantee.

2. After the guarantee period:

One should turn over the instrument to repair it in a certified service workshop.

We reserves the right to make changes in design and specifications of any products as engineering advances or necessity requires.

LUMEL



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