DESCRIPTION AND OPERATING INSTRUCTIONS FOR R251 PROGRAMMABLE TEMPERATURE REGULATOR

The **R251** programmable temperature regulator from the **SMART Brno** Company is designed for temperature control of electric furnaces and heating sets using contactors or semiconductor relays (SSR – Solid State Relay). The regulator allows you to program temperature cycles with one to four segments. A segment consists of a section of temperature rise or drop to the target value and a section of time at the target temperature. The operating period and target temperature are adjusted for all program sections; moreover it is necessary to set the total program cycle duration. The regulator also allows programmable control of a supplementary servomechanism at the chosen temperature, e.g. damper servo.

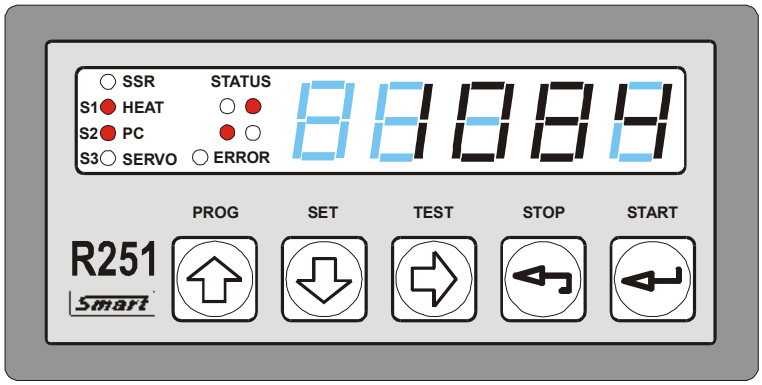


Fig 1 – R251 regulator front panel

R251 software provides many options for quality heating regulation with adjustable parameters and adjustable switching frequency. The regulator allows one week delayed program start. Setting of required parameters is done via a 5-button foil keyboard with mechanical response in a simple dialog mode. Temperature and time are indicated on a five-digit LED display. The cycle course is indicated by four LED diodes, while another four LED diodes indicate states of individual regulator outputs. The regulator control is divided into four levels.

1. regulator operator level – possible to start and stop existing programs
2. technology level – allows you to carry out program operations and regulation parameter adjustment (technological process control)
3. service level – regulator adjustment which influences its behaviour radically
4. manufacturer level – for regulator calibration and recording the serial number

Access to individual levels is password protected to limit the possibility of unauthorized changes to the regulator configuration; the use of a password on the technological level can be switched off.

The **R251** regulator is linked with the well-known **TEMPREG 250** series of temperature regulators from the **SMART Brno** Company. It provides the option of automated compensation of the temperature of the thermocouple cold end, and the modular software concept allows easier adjustment of control programs for various applications.

I. BASIC REGULATOR PARAMETRES

Input:
- Voltage - thermocouple B, C, E, J, K, N, R, S, T, voltage measuring 0 to 25mV or 0 to 50mV
- Resistance - 0 to 300Ω (Pt100 or resistance measuring)
  - 0 to 3 000Ω (Pt500, Pt1000, Ni1000 or resistance measuring)
  - 0 to 30 000Ω (Ni10000 or resistance measuring)

  Resistance input is double wire connected, regulator compensates line resistance by software
- Current - 0 to 20mA (includes range 4 to 20mA)

Input type (voltage, resistance 0-300Ω, resistance 0-3000Ω, resistance 0-30 000Ω or current) must be specified in Purchase Order

Outputs:
- relay switching contact 230V/2A (S1) for heating contactor control
- relay switching contact 230V/2A (S2) for protective contactor control
- relay switching contact 230V/2A (S3) for control of alarm, ventilator or supplementary servo mechanisms (damper)
- output 15V/10mA (on/off mode) for semiconductor relay control (SSR)

Options:
- Possible to save up to 50 programmable cycles (programs), each program can contain 1 to 4 segments
- segments consist of controlled rise (drop) to target temperature and time in temperature section, target temperature, period of rise (drop) and time in period are set
- Operation with existing program – modification, reading and overwriting
- Operation with program and setting of the regulator can be carried out during regulation
- Selection of one of the preset regulation modes
- Option of selection of input sensor from the keyboard
- Real time clock set
- Delayed program start with maximum one week delay
- Setting heating control using a relay or semiconductor relay (SSR)

Protection:
- Set parameters remain the same after power supply interruption
- Individual settings and operations are password protected; this protection on the technological level can be switched off.
- Detection of input sensor fault
- Detection of program and regulator setting errors
- Setting of limit temperature (maximum values of driven quantity), if exceeded, the heating protective contactor and running program are turned off

Detection:
- Interruption and input sensor polarity reversal
- Exceeding set maximum temperature
- Errors in temperature regulation settings
- Errors in input sensor settings
- Maximum temperature wrongly set
- Program errors

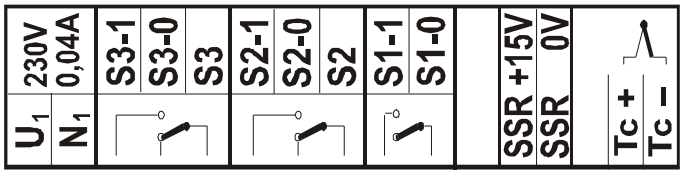
Supply: 230V/0,04A, 50Hz
Dimensions: 96x48x130mm (wxhxd), assembly hole 92x43mm
Cover: IP 50, IP 54 upon request
Weight: 450g

II. REGULATOR INSTALLATION

The regulator is fitted in the switchboard panel by inserting it into the prepared assembly hole (92 x 43 mm) and fixing it with two clamps slipped on a pair of fastening pins located on the regulator sides.

Power supply connection, control of contactors or semiconductor relay, supplementary servo mechanisms and connection of input sensor are carried out using a terminal block situated on the regulator's rear panel.

Connection of regulator terminals in thermocouple design



Connection of regulator terminals in resistor input design

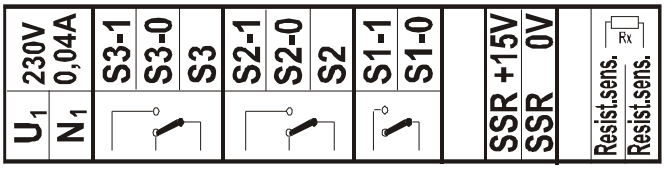
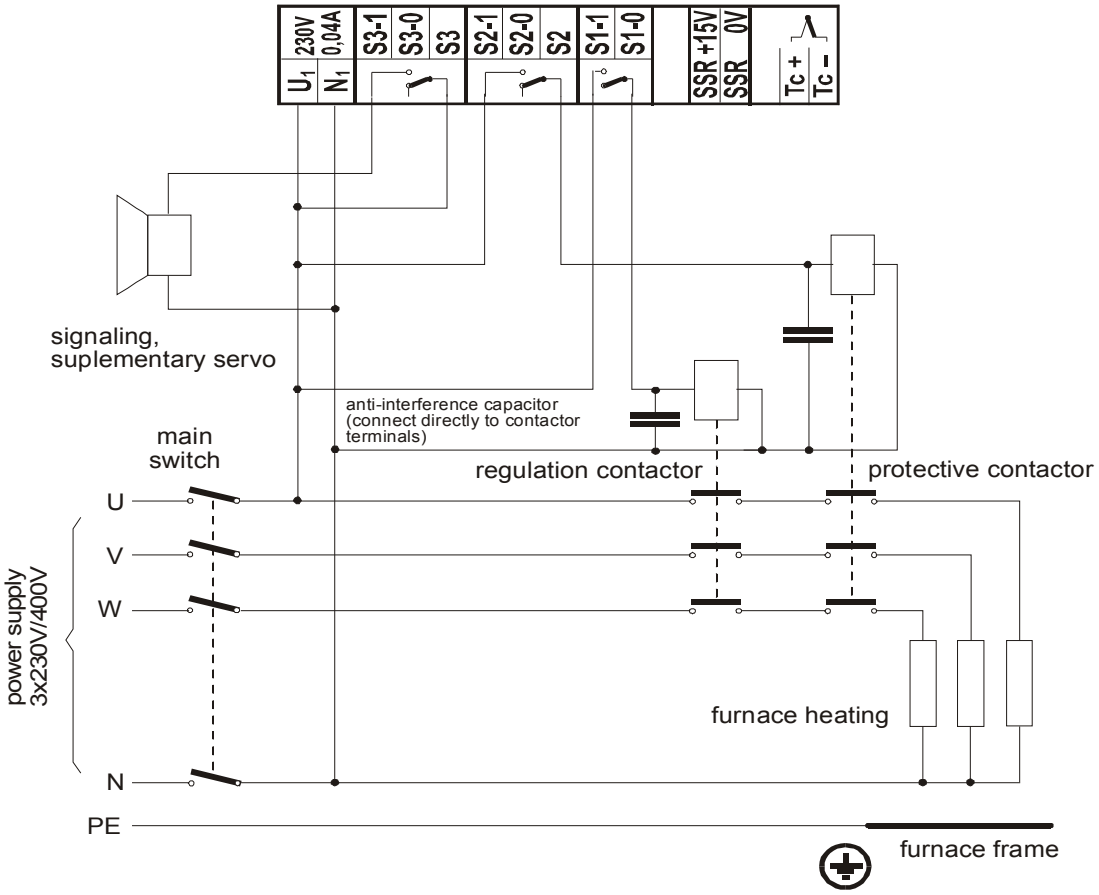


Fig. II.1 – connection of regulator terminals

It is not permitted to bus input element wiring (thermocouple, resistor thermometer) with regulator power supply cables and cables for regulated system control. The connection of the input sensor must be separated to avoid ineligible influence of the quantity measured. If it is not possible to separate this wiring for any reasons, it is necessary to shield it.

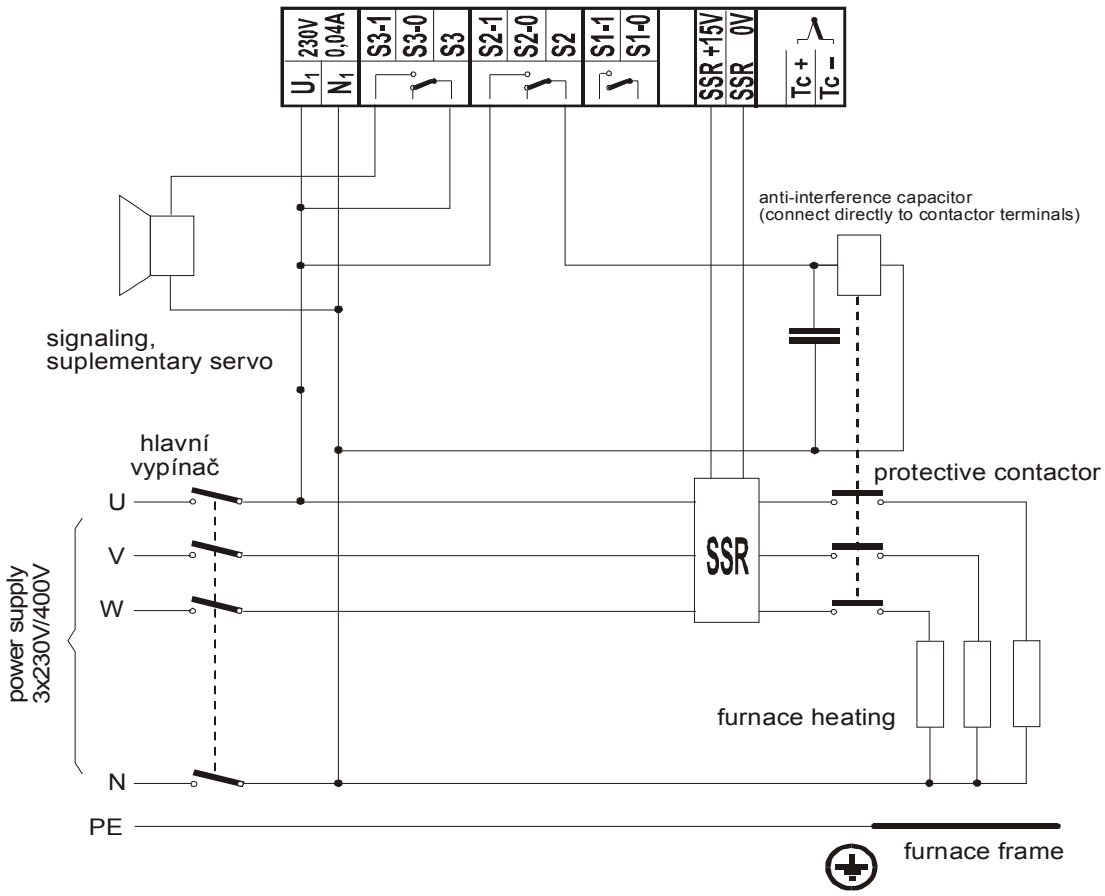
REGULATOR CONNECTION EXAMPLE
(heating switching on using contactor)



Using the protective contactor

In case the furnace heating is activated by a contactor controlled by relay contacts S1 (S1-0, S1-1), the S2 relay output can be used for switching on the protective contactor. If an error state is not detected by the regulator, the protective contactor activates after switching on of regulator power supply and switches off only in case the limit temperature is exceeded, thermocouple fault, memory error or another serious fault. Unlike the regulation contactor, the contacts do not wear out due to frequent switching and in case of a fault (sticking contact) in the regulation contactor, the protective contactor prevents serious damage or destruction of the furnace. The protective contactor activates again after all errors have been eliminated.

REGULATOR CONNECTION EXAMPLE
(heating switched on using SSR - Solid State Relay)



If the semiconductor relay (SSR) is used for switching on heating, **it is essential to connect an appropriately dimensioned protective contactor to the heating power supply** (the protective contactor is not part of delivery). The semiconductor relay does not wear out mechanically, and can operate in far shorter intervals than the contactor, but in case of disruptive discharge of semiconductor transition, the relay cannot be switched off. As a result of such a fault, the furnace would operate uncontrollably at full power and the batch or the furnace could be damaged.

III. OPERATION OF THE REGULATOR

Switching on regulator, regulator status after power supply reset

After connecting the regulator to the power supply, all display segments light up for several seconds and the regulator is activated. In case of power supply interruption during the regulation cycle, the regulator checks the period and compares it with the preset maximum breakout period. If the breakdown time is shorter, the regulator continues the interrupted program from the point of breakdown, otherwise the program is ended.

Regulator run

After activation, the regulator displays the measured temperature (or corresponding data from input sensor). This status, when the regulator measures or measures and controls, is called the **measuring status;** if the operator operates the regulator using the keyboard, the status is called the **service status**.

Regulator control

The regulator is controlled using the five-button keyboard. After individual buttons have been pressed, the following options for work with the regulator are made accessible. Individual options contain sets of items; their selection and setting in service status is carried out using buttons⇧, ⇩ and ⇨, while the chosen item is confirmed by the ↵ key.

Button functions in regulator measuring status

PROG	- option of program operations – writing, modifications, display of programs
SET	- option of regulator setting
TEST	- testing regulator and display of possible error
STOP	- option of program run changes and program finish
START	- program activation

In service status

⇧ - increase values/back movement in menu
⇩ - decrease values/forward movement in menu
⇨ - cursor shift to the right
← - exit without changes/exit from options
↵ - confirmation of set value or confirmation of item in option

Program number assignment

The regulator offers the option of using up to 50 programs. When operating the program, the regulator requires a program number that will be used for the desired operation. The inquiry for program number assignment looks like this:

PRG xx

The selected program number must be lie between 0 and 49, otherwise it is impossible to continue. Setting the required number is realised in regulator service status using the buttons⇧, ⇩ and ⇨, while program number must be confirmed by the ↵ key.

IV. CYCLE COURSE

Display of cycle course

During the program cycle, the regulator displays the present status and status of individual relays.

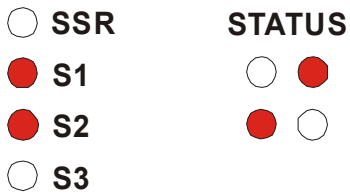


Fig. IV.1 – Graphic display unit

symbol	Meaning
SSR	Signals closing of output for SSR relay
HEATING	Signals closing of S1 relay used for heating (use of the relay must be set in configuration)
PC	Signals status of S2 protective contactor
SERVO	Signals status of S3 relay
STATUS	Displays program course / rise — holding time, \ drop

Regulation modes

The regulator has four preset regulation modes. Each mode has fixed functions of the S3 relay and a way of finishing the program. Modes can be modified in technological options, program-setting item (P-SET).

Important notice!

It is necessary to choose the most suitable mode that meets your requirements.

Mode 1

In mode 1, the S3 relay switches on the supplementary servomechanism, e.g. ventilation control. The relay is switched on when the **S3 ON** preset temperature is exceeded in the first or second program segment and switched off when the temperature drops below the **S3OFF** preset value in the third or fourth program segment, or in the section of uncontrolled cooling. Moreover, the regulator monitors the total maximum period of the course of **TIM-C.** The program finishes when the period is over.

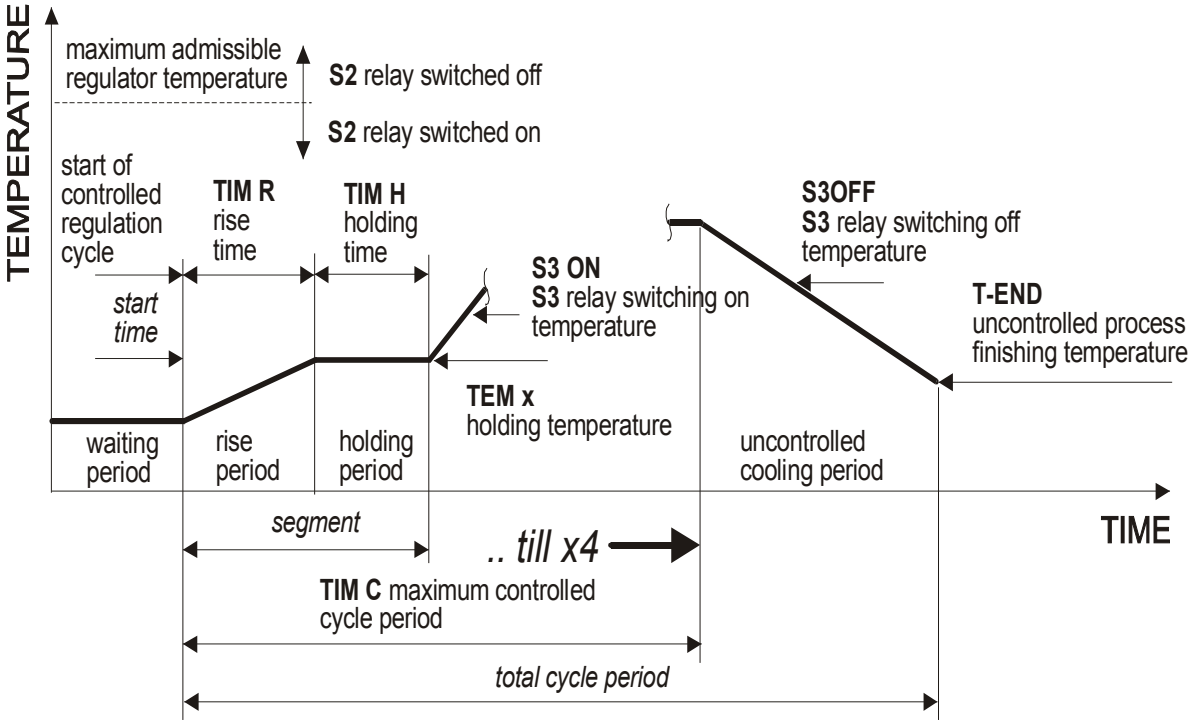


Fig. IV.2 Diagram of cycle course in mode 1

Mode 2

In preset mode 2, the S3 relay activates the alarm of exceeding maximum admissible regulator temperature set by the furnace manufacturer as the limit design furnace temperature (**SERVI - INPUT - MAX T** option of service level). The relay is switched on when the maximum temperature is exceeded and switched off when the temperature drops below the maximum temperature. Moreover, the regulator monitors the total maximum period of the course of **TIM-C.** The program finishes when the period is over.

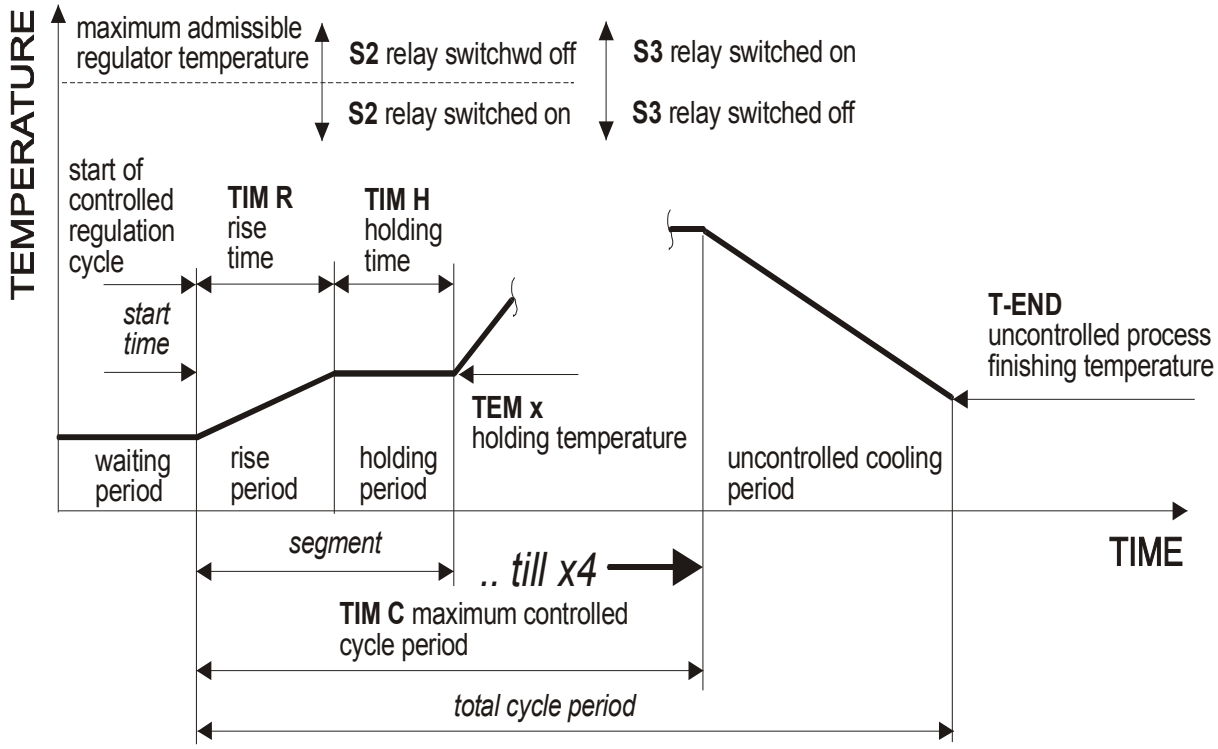


Fig. IV.3 Diagram of cycle course in mode 2

Mode 3

In preset mode 3, the S3 relay 3 activates the alarm of exceeding the preset variation **VTEM+** or **VTEM-**. The relay is switched on when the variation is exceeded and switched off when the temperature is within the preset variation interval. After the program has finished, the regulator keeps the final temperature of the last program segment until it is finished via the keyboard.

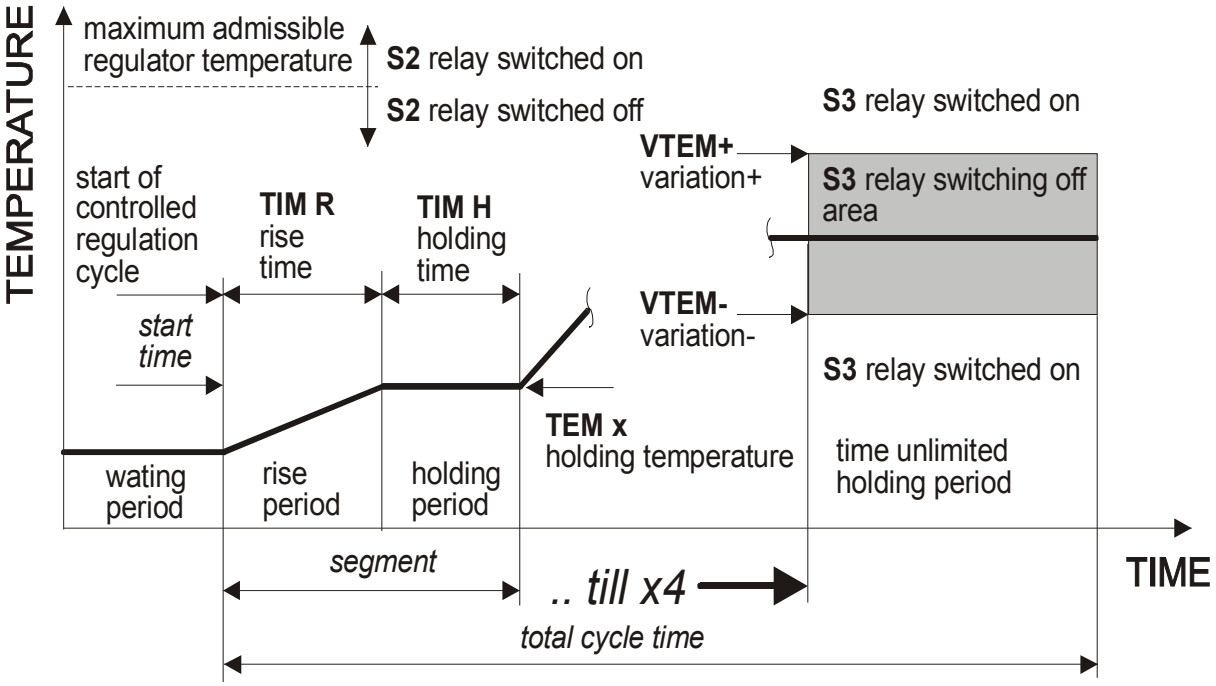


Fig. IV.4 Diagram of cycle course in mode 3

Mode 4

In preset mode 4, the S3 relay activates the alarm of exceeding the maximum admissible regulator temperature set by furnace manufacturer as the limit design furnace temperature (**SERVI - INPUT - MAX T** option of service level). The relay is switched on when the maximum temperature is exceeded and switched off when the temperature drops below the maximum temperature. After the program has finished, the regulator keeps the final temperature of the last program segment until it is finished via the keyboard.

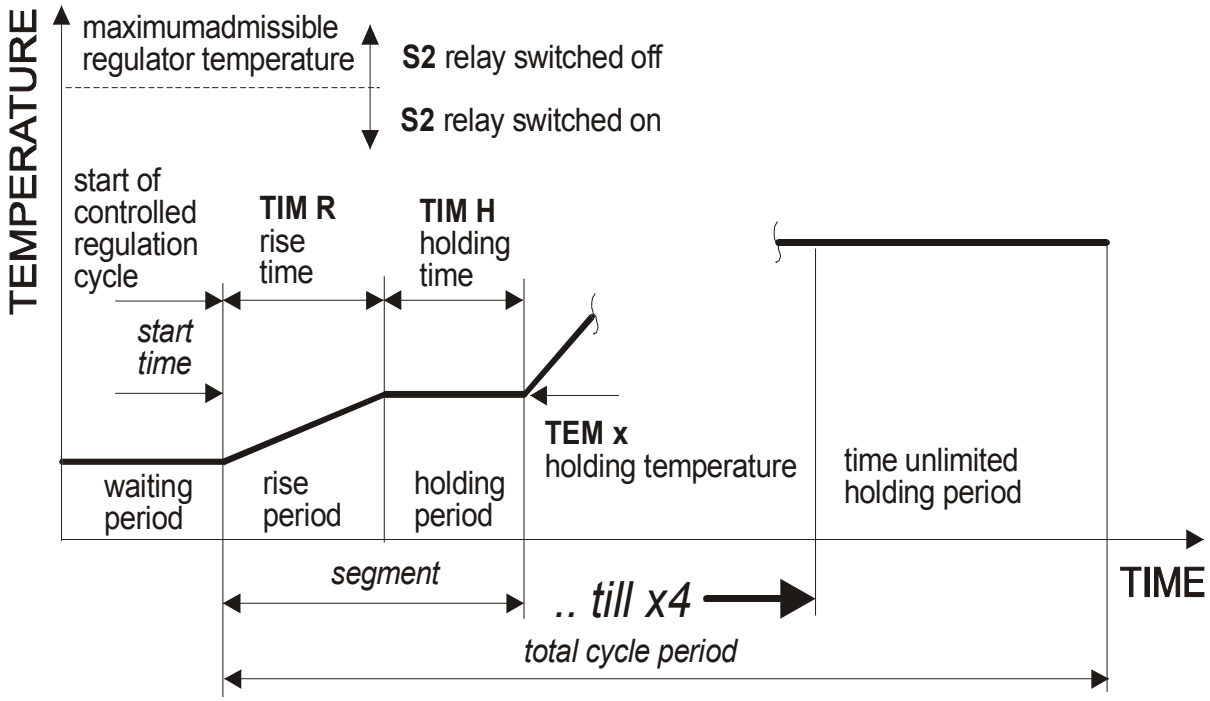


Fig. IV.5 Diagram of cycle course in mode 4

V. REGULATOR PROGRAMMING AND OPERATIONS WITH PROGRAM (PROG KEY)

By pressing the **PROG** key in the measuring status, you enter the menu of operations with the program. If use of a password is activated, the regulator displays instructions for setting: **P0000**. After entering the correct password and confirmation using the ↵ key, you enter the menu of operations with the program. The regulator displays an inquiry for the program number, in which it offers the number of the last used program: **PRG xx**. Using buttons ⇧, ⇩ and ⇨ we set it and by pressing ↵**,** we confirm the number of the required program. The regulator checks the existence of the program with the number given. If the program does not exist, the regulator changes to creation – program writing.

Program writing

Each program consists of one to four segments. Each segment consists of:

Target temperature: temperature to be reached in a segment
Period of rise (drop): period to reach the target temperature
Holding time: period of holding the temperature

Important notice!

The program must contain at least one segment!

The target temperature cannot be higher than the preset **maximum temperature**. In case a higher temperature is set, it is impossible to continue the writing program (it is impossible to record the temperature). Times are written in the program in the **HH-MM** style.

Record of individual program segments

If there is no program in the position chosen, the regulator displays an option for recording the first segment of a new program:

SEG-N	Allows you to record first segment of a new program

After confirmation of **SEG-N** using the ↵ key, the regulator waits for the first segment target temperature to be entered. Confirm the temperature with the ↵ key and the regulator displays a request to enter the period of rise (drop) **TIM-R**. Confirm the request by pressing any key; the regulator waits for the period of rise (drop) in hours and minutes to be entered. Confirm the time with the ↵ key, then the regulator displays a request to enter the holding time **TIM-H**. After entering this, setting of the first segment is finished, the regulator offers the option to write the next sequence (again by displaying **SEG-N** inscription). When writing all required program segments, we progress in the same way as with the first segment. Then, according to the set regulation mode **(SAVE – S- PROG – MODE**), it is necessary to set parameters complying with the chosen mode:

OPT 1	Mode 1 - fig IV.2 page.8. In item finish (**FINIS**) switching on temperature (**S3 ON**) and switching off temperature (**S3OFF**) of S3 relay is set, then temperature of finishing uncontrolled drop (**T-END**) and maximum cycle period (**TIM C**) are set
OPT 2	Mode 2 – fig. IV.3 page.9. temperature of finishing of uncontrolled drop (**T-END**) and maximum cycle period (**TIM C**) are set
OPT 3	Mode 3 – fig. IV.4 page 10. In item finish (**FINIS**) variations of temperature from target temperature of last program sequence (**VTEM+**) a (**VTEM-**) are set
OPT 4	Mode 4 – fig. IV.5 page11. In this mode, no other parameters are set.

Temperature of uncontrolled drop finishing

If a mode with uncontrolled drop is chosen, the regulator controls the running cycle until the temperature measured drops to the temperature of uncontrolled drop finishing. After the temperature of cycle finishing has been reached, the S3 relay is controlled according to the chosen regulation cycle, when the temperature of cycle finishing has been reached, the regulator resets the S3 relay and finishes the program.

If the program contains e.g. two sequences and the regulator is set to mode 1 (fig. IV.2, page8), after recording set parameters the regulator offers the following options:

SEG 1	Allows you to modify the first program segment
SEG 2	Allows you to modify the second program segment
SEG N	Allows you to create a new (third) program segment
FINIS	Allows you to modify the temperature of switching on (**S3 ON**) and off (**S3OFF**) of S3 regulator relay
T-END	Allows you to modify the temperature of uncontrolled drop finishing
TIM-C	Allows you to modify maximum period of controlled program cycle setting
SAVE	Saving modifications in regulator memory
DEL-S	Deleting last program segment (**impossible to delete first segment!**)

If the program segment quantity is different or a different regulator program is chosen, the previous option will be slightly different and will correspond to the specific regulator setting and number of program segments.
Having checked the written parameters, it is necessary to choose the **SAVE** item and, pressing the ↵ key, save the program created. When the program is saved, the regulator displays a notice about successful carrying out of the **PRGOK** operation.

Modifications of existing program

If there is a program in the chosen position, the regulator displays a menu of possible operations with the existing program.

MODIF	Modify chosen program (edit)
DISPL	Display chosen program
COPY	Copy chosen program to another number
OVER	Overwrite chosen program with a new one (delete original record and write a new one)

MODIF item

Allows you to modify the existing program. The program can be traversed by segments and it is possible to modify their settings. If the program does not contain a complement of segments (four), the regulator offers the option to create a new segment (**SEG-N**). Similarly, if the program contains more than one segment, it is possible to delete the last (the highest) program segment using the item delete segment **DEL-S**). Depending on the preset regulation mode (**SAVE – S-PROG – MODE** key), the regulator offers the option of modification of parameters, depending on the regulator mode chosen. Modification progress and work with the regulator are the same in this item as in the check and modifications of a newly written program.

When modifications of all required parameters have been completed, it is necessary to choose the SAVE item and press the ↵ key to save the modified program. After program save, the regulator displays a message of successful finish of the **PRGOK** operation**.**

DISPL item

Displays the chosen program, it is not possible to modify the program in this item

COPY item

Allows copying of the chosen program under a new number. After entering, the copy mode displays a prompt to type the number of the program you will copy to.

PRG xx

After submitting the number, the regulator checks:

- if the program numbers are different; if they are the same, it displays **FR=TO** (from=to) and finishes the operation.
- if the program of the submitted number exists; if so, it displays a prompt to overwrite it: **OVER,** after the ↵ key has been pressed, it overwrites the present program, other keys finish the operation without copying.

After checking, the regulator copies the program and after finishing, it displays a message about successful finish of the **PRGOK** operation. Pressing any key returns you to the measuring mode.

OVER item

Allows overwriting of an existing program with a new program. After confirmation with the ↵ key, the original program is deleted and the regulator offers the option of writing the first segment of the new program instead of the original one.

VI. STARTING THE PROGRAM (START KEY)

The program is activated by pressing the **START** key in the measuring mode. The regulator displays a prompt for the number of the program that should be activated: **PRG xx**. After submitting the number and confirming it with the ↵ key, the regulator displays program activation:

NOW	Activate program immediately
WAIT	Delayed program activation

Program start

The regulator checks settings before program start; in case of detection of an error, the program does not start. If no error is found, the regulator displays the text **START** and activates the program. After start-up, it displays the measured temperature.

Delayed program start

The program is activated when the preset time is over. The regulator displays a prompt to submit the start time **TIM S**. After confirmation, it is necessary to submit the start time in the form **HH-MM** (hours-minutes). Then the start day is submitted (MONDA to SUNDA), where the first five letters of a weekday are used. The regulator moves into waiting mode, in which it displays the temperature and waits to reach time preset. The measured temperature is displayed for four seconds, and then the preset program start time is displayed for one second with a less bright display. Simultaneously, the first lower LED lights on the course display are set. Once the preset time is over, the regulator activates the program.

Quantities shown during program course

If the program is running, the regulator displays the measured temperature and the mode corresponding with the program segment is indicated on the graphic display unit. According to the program segment, the regulator displays these parameters for one second with less brightness:

Rise/drop:	segment target temperature
Holding time:	segment time elapsed

Interruption of program course (STOP key)

The program can be interrupted at any time by pressing the **STOP** key. When it is depressed, the regulator displays the program interruption menu

END	End of running program
SKIP?	Skip to following program step
AGAIN	Presently running program segment starts again
STOP	Alternately stops / activates program, command used mainly in remote control

VII. REGULATOR SETTING (SAVE KEY)

Regulator control is divided into four levels. First, the lowest level is the level of regulator operation, which allows you to activate and finish programs only. The second level is a technological one and allows you to set all parameters of regulation, modes etc. The third level is a service level. It is accessible from the technological level and allows you to set the input sensor type, maximum temperature and choose the heating switching element. The fourth and highest is the regulator manufacturer level. It is accessible from the service level and is used for input calibration and writing the regulator serial number. To enter the service level and manufacturer level, it is necessary to submit the appropriate password, for access to the technological level and for operations with programs, the use of a password is optional.

Technological level

We can move to the technological level from the regulator measuring mode by pressing the **SET** key. If use of a password is enabled, the regulator displays a prompt to submit: **P0000**. After submitting the right password and confirmation by pressing the ↵ key, we enter the basic menu for regulator parameters settings:

REGUL	Setting basic regulation constants
S-PROG	Program type setting
TIME	Time setting
VERSI	Number of regulator software version and regulator serial number
SERVI	Enter service level of regulator setting
PAS-U	Setting technological level password use and operations with program
MAN-C	Manual control of individual relays and SSR

Using the ⇧ or ⇩ button, you can choose and pressing the ↵ key opens the required menu option. In the same way, you can choose individual items and after confirmation with the ↵ key, it is possible to modify them using the ⇧, ⇩ and ⇨ keys. Set values must be confirmed with the ↵ .key. Returning to a higher level or cancelling set values is possible using the ← key.

REGUL option – setting regulation constants

When you open this option, it is possible to adjust the following regulator parameters:

T-CON	Time constant	1 to 250 seconds
VAR-T	Admissible temperature variation	1 to 250 °C
PRO-C	Proportional constant	1 to 250
DER-C	Derivation constant	0 to 250
INT-C	Integration constant	0 to 250
MAX-R	Maximum temperature of reduced output	
TYP-R	Regulation type	

Time constant

Determines the frequency that is used for regulation and switching on heating. The time constant corresponds to the transport delay of the run system. The slower the system, the greater the time constant will be.

Permissible temperature variation

Permissible temperature variation determines the range around required temperature in which the regulator maintains the actual temperature. This range is called the proportional range. The wider the proportional range, the wider the temperature's total amplitude. The narrower the proportional range, the more precisely time, derivation and integration constants must be set. If the regulator is not able to maintain the temperature within the set proportional range, it is necessary to change the regulation constant settings.

Proportional constant

Determines the influence of the proportional range on regulation course. The narrower the proportional constant, the shorter the regulator action.

Derivation constant

Determines the influence of the derivation component of regulation, i. e. the influence of regulated quantity change speed. The higher the derivation constant value, the more considered the regulated quantity change speed will be in regulation. The regulator will react to changes in speed faster and more powerfully. If the set value is near 1, the influence of the derivation component is minimal and regulation is more PI than PID.

Integration constant

Determines the influence of the integration regulation component, and influences the long-term deviation from the target value. The integration component carries out long-term balancing of the regulated system to zero variation. It is used in the temperature holding phase only. The higher the integration constant value, the faster the balancing to zero variation, but the higher system inclination to variations. If the set value is 1, integration component influence is minimal, and regulation is more PD than PID.

Recommended process of regulation constant settings

At first, it is suitable to set a permissible variation to the value required. For the first setting, a value of less than 3°C is not recommended. Setting the time and proportional constants follows. For fast furnaces with output excess, it is possible to set a value of 1 to 3s, for larger and slower furnaces a value of 5 to 10s. The derivation constant should be set to half the range, i. e. roughly 100, and the integration constant should be set to as low value as possible. After program activation and change to the driven part, it is necessary to monitor the frequency of heating switching on and by changing the time constant to reach the status where the regulator first switches on. At the same time, it is necessary to monitor variation between the required and actual temperature. The derivation constant should be modified according to the range of the variation. If the regulator reacts to temperature drop slowly, it is suitable to increase the derivation constant, if it reacts quickly and overheats, it is good to decrease the derivation constant. If the regulator falls below the temperature required in the long term, it is necessary to increase the integration constant.

Maximum temperature of reduced output

This is the temperature at which regulator regulates at reduced output. This setting improves the regulation course at lower temperatures. The regulator reduces the heating output by periodical switching on, until the maximum reduced output temperature is reached. By doing this, inadmissible temperature overshoots are reduced. If the maximum reduced output temperature is set to 0, output reduction is not carried out. Upon first activation of the regulator with the regulated system (furnace), it is suitable to set the reduced output temperature to 0, and in the test run gradually increase the target temperature and check the value at which ineligible temperature overshoots occur. This value can then be set as the maximum reduced output temperature.

Regulation type

The regulator allows you to choose the regulation type used for process driving:

PD-I	Proportionally derivative regulation with integration in holding time - continuous and exact regulation containing PID algorithm in holding time sequences and PD algorithm in other sequences. It is sensitive to correct setting of proportional, derivation, integration and time constant. Integration constant is used in holding sequences, where it carries out long-term balancing of regulated system to minimum variation.
PID	Proportionally integrative and derivation regulation – continuous and exact regulation containing PID algorithm in all segments. It is sensitive to correct setting of proportional, derivation, integration and time constant. Integration constant is used in all segments, regulation can incline to overshoots with big changes in regulated quantity.
PI	Proportionally integrative regulation – continuous regulation, unlike PID regulation, regulated quantity change speed influence on regulator operation does not apply here. Integration segment of regulation carries out long-term balancing of regulated system to minimum variation.
OFF	Regulation switched off – regulator does not affect regulated system, displays measured values only.
ONOFF	Incoherent regulation – the simplest type of regulation. Dependent on rate between actual and required regulated quantity value, individual output relays of regulator are switched on directly.
P	Proportional regulation – continuous regulation that does not utilize influence of derivation or integration component on regulator operation. Regulator action on regulated system is proportional to regulation variation value.
PD	Proportional derivative regulation – continuous regulation, unlike PID regulation long-term balancing of regulated system to minimal variation using integration regulation component is not carried out. Regulator reacts faster to regulated quantity changes under influence of derivation component.

S-PROG option – program setting

Allows setting of the following parameters:

PER-I	Max. permissible period of power supply interruption minutes	1 to 250
MODE	Regulation mode selection	

Maximum permissible period of regulator power supply interruption

Determines the maximum period of regulator power supply interruption. If a program is running and regulator power supply interruption occurs, then after power supply recovery, the regulator checks the time of interruption. If the period is shorter than the preset value, the program will continue from the point of interruption, otherwise it will finish.

Regulation mode

Allows adjustment of regulator operation to the requirements of the manufacturer of a device (furnace), see Chapter IV. Cycle course, page 7. The form of program finishing and S3 relay function varies according to the chosen mode.

OPT 1	Uncontrolled drop + reduced program period; S3 controls servo mech., Fig. IV.2
OPT 2	Uncontrolled drop + red. period; S3 signals exceeded max. temperature, Fig. IV.3
OPT 3	Endless holding; S3 signals leaving preset temp. range, Fig.IV. 4
OPT 4	Endless holding; S3 signals exceeded max. temperature IV. 5

TIME option – regulator clock setting

The regulator is equipped with a real time clock which needs the exact time and date to be set during first activation.

HOUR	Setting of hours and minutes in form	**HH-MM**	(hours-minutes)
DAY S	Setting of a weekday (in words)	**MONDA**	(MONDA to SUNDA)
DATE	Setting of date in form	**DD-MM**	(day-month)
YEAR	Setting of year in form	**YYYY**	

Version option – program version

After pressing any key, the regulator serial number is shown. These numbers should be shown to the manufacturer when discussing problems as it will help clarify the situation. It is also necessary to enter the serial number and then set its address in service mode during first identification of the regulator with the RS485 communication interface to the network.

SERVI option – entering service level

Adjustments that in principle influence regulator behaviour are set on the service level. It is used for service actions only and is protected by a password to prevent changes by unauthorized persons.

PAS-U password usage

It allows a technologist to switch off password-protected access to operations with the program and to enter the technological level. Password usage can be changed only by a person who knows the password. After entering the correct password, the regulator offers these options:

YES	Use technological password
NO	Do not use technological password

M-CON option – manual control

The regulator allows manual control of individual relays and output for SSR driving. In versions for thermocouple inputs, it also displays the temperature of the thermocouple reference junction. Using the ⇧ or ⇩ keys, it is possible to choose the required function and after confirmation with the ↵ key, it is possible to change the mode of the chosen relay with the ⇧ or ⇩ keys. The regulator manual control option contains these items:

SSR	Manual control of output for driving SSR
S1	Manual control of S1 relay
S2	Manual control of S2 relay
S3	Manual control of S3 relay
T-REF	Display of reference temperature (thermocouple inputs only)

Service level

You can change from the technological level to the service level via the **SERVI** option only after entering the correct service password. This is the level of the manufacturer of a device (furnace) and allows toy to carry out basic regulator settings according to the character of the furnace. It contains the following regulator setting options:

INPUT	Setting regulator input parameters
OUTP	Setting regulator output parameters
CALIB	Enter manufacturing regulator setting level (input calibration, not accessible)
SER-N	Enter manufacturing regulator setting level (serial number entry, not accessible)

ENTER option

Allows setting of regulator input circuit parameters

TYP- S	Setting input sensor type
MAX-T	Setting maximum admissible temperature of a device (furnace)
SHIFT	Setting shift of temperature displayed
COMP	Setting compensation of connecting cables resistance (for resistor inputs only)
LIMIT	Setting limits of input quantity (for current inputs only)

Type of input sensor

Each sensor has a maximum and minimum permissible value of measured temperature assigned for possible sensor operation. The regulator can work with one of the five following groups of input sensors, the required group must be entered in the regulator purchase order.

Voltage input sensor – thermocouple

Maximum operating temperature according to ITS-90 is written in the thermocouple name

B1600	B thermocouple with range 0 to 1 820 °C
C2300	C thermocouple with range 0 to 2315 °C
E 900	E thermocouple with range -270 to 1 000°C
J 750	J thermocouple with range -270 to 1 200°C
K1000	K thermocouple with range -270 to 1 372°C
N1300	N thermocouple with range -270 to 1 300°C
R1300	R thermocouple with range 0 to 1 768 °C
S1300	S thermocouple with range 0 to 1 768 °C
T 350	T thermocouple with range -270 to 400°C
U0-25	Voltage input 0.00 to 25.00 mV with range 0 to 25.00 mV
U0-50	Voltage input 0.00 to 50.00 mV with range 0 to 50.00 mV

Resistor input sensor – range 0 to 300Ω

PT100	Resistor thermometer with range –200 to 500°C
R 100	Resistor input 0 to 300 Ω

Resistor input sensor – range 0 to 3000Ω

P 500	Pt 500 resistor thermometer with range –200 to 500°C
P1000	Pt 1000 resistor thermometer with range –200 to 500°C
R 500	Resistor input 0 to 1500 Ω
R1000	Resistor input 0 to 3000 Ω

Resistor input sensor – range 0 to 30 000Ω

N 10k	Ni 10000 resistor thermometer with range – 50 to 200°C (Tk = 6180 ppm/°C)
R 10k	Resistor input 0 to 30000 Ω

Current input – range 0 to 20mA

Current input 0 to 20mA includes range 4 to 20mA

Important notice!

Input types U0-50, U0-25 and R100 are assigned mainly for input sensor diagnostics so we do not recommend using them for regulation. In case of the need to use a non-standard input sensor please contact the regulator manufacturer and discuss the use of such an input sensor.

Maximum temperature

This is the maximum design temperature permitted by the furnace manufacturer for operation. The regulator reacts to exceeded temperature by switching off the heating and protective contactor and displaying the _ character (lower horizontal segment of first digit) in front of the temperature. The maximum temperature must lie within the range described in the input sensor type setting table; the regulator will not set a value lying outside the range!

Important notice!

The regulator cannot be operated above maximum temperature; nowhere in the program can a higher temperature than the preset maximum temperature be set.

Temperature shift

For optional improvement of measuring accuracy, the regulator allows us to compensate for temperature sensor error (thermocouple, resistor thermometer). To detect the needed temperature shift, it is necessary to measure the temperature with an accurate thermometer at the location of the temperature sensor, at the temperature most frequently used. The difference between the measured temperature and the temperature shown on the regulator can be set in the item temperature shift with the appropriate sign.

Compensation of wiring – resistor input only

In the resistor input configuration, the regulator uses a double-wired connection for measuring. To ensure exact measuring, the regulator uses software compensation of wiring resistance. Compensation is carried out by subtracting wiring resistance. The wiring resistance value can be measured either by the regulator or it can be entered from the keyboard. For setting the wiring resistance value, it is possible to choose one of the following options:

REG	Compensation of wiring resistance will be carried out by regulator
KEY	Compensation of wiring resistance will be entered manually, from keyboard

Measuring of wiring resistance with regulator

The regulator displays **SHORT** writing. The regulator operator short-circuits the sensor terminals as near to the sensor as possible. After short-circuiting, ↵ must be pressed. The regulator measures wiring resistance and displays **SAVE?.** By pressing the ↵ key, the new resistance value is entered in memory. After saving the entry in memory, the regulator displays **OK** as confirmation of successful finish of operation.

Entering wiring resistance value from keyboard

The regulator displays the preset value of wiring resistance, and by using keyboard we set the wiring resistance value. Confirm the entered value by pressing the ↵ key, the regulator will display **SAVE?**. By pressing the ↵ key, the new value of resistance is entered in memory. After saving the entry in memory, the regulator displays **OK** as confirmation of successful finish of operation.

Setting limits of current input

Is assigned for setting the measuring range and alarm settings of current inputs

L-LIM	Setting lower limit of measuring range
U-LIM	Setting upper limit of measuring range
L-ALR	Setting lower alarm limit
U-ALR	Setting upper alarm limit

Setting lower range limit

Lower range limit assigns the displayed value corresponding with the minimum value of input current (0 or 4mA). It is possible to set any value in the range ±9999.

Setting upper range limit

Upper range limit assigns the displayed value corresponding with the maximum value of input current (20mA). It is possible to set any value in the range ±9999.

Setting lower alarm limit

Lower alarm limit can be set to any value in the range ±9999. In case the preset value of the lower alarm limit is less than the value of the lower limit of the measuring range, the alarm will not be signalled (limit must be smaller than the smallest value displayed).

Setting upper alarm limit

Upper alarm limit can be set to any value in the range ±9999. In case the preset value of the upper alarm limit is bigger than the value of the upper limit of the measuring range, the alarm will not be signalled (limit must be bigger than the biggest value displayed).

OUTP option – output element selection

The regulated device (furnace) can be controlled by the contacts of the S1 relay (control of power contactor) or by voltage for control of the power semiconductor relay (SSR). The S1 relay and controlled power contactor are electromechanical devices with limited service life (quantity of switching) and their use for fast and frequent switching is not suitable. The switching rate is given by the preset regulator time constant and by the dynamic behaviour of the regulated device (furnace).

RELA	regulator controls S1 relay together with output for SSR
SSR	regulator controls output for SSR only, S1 relay is not used

CALIB option – regulator input calibration

This is the manufacturer's setting of the regulator. Calibration can be entered from the service level by choosing the CALIB option after entering the production password. This password is not indicated by the manufacturer.

Regulator calibration is carried out by the manufacturer or an authorized Service Company. Calibration accuracy fundamentally influences regulator measuring accuracy.

Regulator calibration in thermocouple design
The regulator must be calibrated for input range 0 to 25 mV and for 0 to 50 mV. Voltage supply and a voltmeter with minimum accuracy 0,01mV can be used as a calibrating device.

Regulator calibration in resistor input R 300 design
The regulator must be calibrated for input range 0 to 300Ω, an accurate resistor (decade resistor is the best) with minimum accuracy 0,1Ω can be used as a calibration device.

Regulator calibration in resistor R 3 000 design
The regulator must be calibrated for input range 0 to 3 000Ω, an accurate resistor (a decade resistor is the best) with minimum accuracy 1Ω can be used as a calibration device.

Regulator calibration in resistor R 30 000 design
The regulator must be calibrated for input range 0 to 30 000Ω, an accurate resistor (a decade resistor is the best) with minimum accuracy 1Ω can be used as a calibration device.

Regulator calibration in current input 0 to 200mA design
The regulator must be calibrated for input current range 0 to 20mA, a current supply with minimum accuracy 0,01mA can be used as a calibration device.

SER-N option – entry of regulator serial number

This option can be entered from the service level by choosing the SER-N option after entering the production password. This password is not indicated by the manufacturer. The option is designed for entering the regulator serial number in the regulator's internal memory.

VIII. REGULATOR TESTS (TEST KEY)

The regulator continuously checks whether the measured quantity has exceeded the maximum permissible limit or not (maximum temperature), whether the input sensor is short-circuited or not and whether input sensor polarity is correct or not. Moreover, it checks individual settings and when writing a program, the regulator checks it too. If the regulator detects an error, dots on the display start blinking until the error has been eliminated and the **TEST** key pressed. By pressing the TEST key it is possible to find out the error characteristic.

Regulator setting errors

E-I-S	Input sensor setting error
E-M-T	Maximum temperature setting error
E-INP	Input calibration setting error
E-REL	Relay setting error
E-SHI	Value shift error
E-REG	Regulation type error
E-COM	Wiring compensation

Measuring errors

TEM__	A/D converter out of range (underflow)
TEM^^	A/D converter out of range (overflow)
TEM_M	Temperature under minimum value
TEM^M	Maximum temperature exceeded
E-R -T	Reference temperature sensor error (for thermocouple inputs only)

Regulation setting errors

E-T-C	Time constant setting error
E-V-T	Maximum variation setting error
E-P-C	Proportional constant setting error
E-D-C	Derivation constant setting error
E-I-C	Integration constant setting error
E-R-O	Reduced output temperature setting error
E-R-T	Regulation type setting error

Program setting errors

E-PIS	Maximum power supply interruption period setting error
E-MOD	Program mode setting error
E-PRG	Non-existent program selection
E-STA	Program status quantity error
E-INT	Maximum admissible power supply interruption exceeded

Note: the **^** character in the message description replaces the upper horizontal display segment

Regulator behaviour during exceeded temperature or input sensor error

When maximum permissible temperature has been exceeded or disconnected or reversed thermocouple poles (or short circuited input resistor sensor) have been detected, the running program is interrupted and the protective contactor is disconnected. After error elimination, the regulator returns the protective contactor to switched status and continues the interrupted program. The display simultaneously shows, according to the error characteristic:

- **Maximum temperature exceeded:** upper horizontal display segment lights in upper left-hand corner and display dots blink
- **Input sensor disconnection:** all upper horizontal display segments light up
- **Thermocouple poles reversed or resistor sensor short-circuited:** all lower horizontal display segments light up

Regulator behaviour during reference temperature sensor error (for thermocouple inputs)

In case of a reference temperature sensor error, the display dots blink and the left vertical display segments of the first left digit light up. A fixed reference temperature of 25°C is used to calculate the thermocouple temperature. If this error occurs when the program is running, the regulator finishes the program course but does not allow another program to be started until the error has been eliminated.

Regulator behaviour during power supply interruption

If a program is running and the power supply is interrupted, then after power supply reset, the regulator checks the breakdown period. If the period is shorter than the preset value, program will continue from the point of interruption, otherwise the program will end.

Possible causes and progress during occurrence of error

In regular operation of a correctly set manufacturer and service regulator, measuring errors can occur and in case of power supply interruption during a running program, the error of exceeding the maximum permissible power supply interruption period and error of status quantity can also occur.

Measuring errors can be caused by a fault in the input sensor (or reversed poles), a fault in the reference temperature sensor or a fault in the power element in case of power supply interruption. Power element faults can be caused by a regulator mistake (regulator manufacturer service action necessary), or by a fault in the power element or semiconductor relay (stuck contacts of contactor, semiconductor relay breakdown, electric wiring faults etc.)

A fault caused by regulator power supply interruption can be eliminated after power supply reset by restarting the program.

If the regulator signals another error (regulator setting error, regulation setting or program setting, except for errors related to power supply interruption) and the production and service setting of the regulator was correct, then it is probably an error in the internal regulator memory; if the error persists even after switching off and restarting, regulator manufacturer service action is necessary.

IX. EXTENSION MODULES

Communication module

Allows regulator communication using the RS232 interface (with galvanic section upon request) or RS485 (always with galvanic section) with a PC or other regulators in a network. It is necessary to specify the communication interface in the regulator purchase order. Communication speed is adjusted to 19200 Bd and is run by the delivered program (Rx Commander). If you choose RS485, it is necessary to enter the regulator serial number during first connection to establish communication with the regulator, then it is possible to set the regulator address in the range from 0 to 240 using a PC:

Communication module with voltage or current output

This module, besides RS485 (or RS232), also contains circuits of voltage or current output with the range 0 to 10V or 0 (4) mA to 20mA. Output voltage of the voltage output is derived from regulation variation and is designed for driving the linear power element. Output current of the current output is the image of input regulator quantity (usually current). In both cases, outputs are galvanically separated from regulator circuits. The communication interface and type of output must be specified in the purchase order.

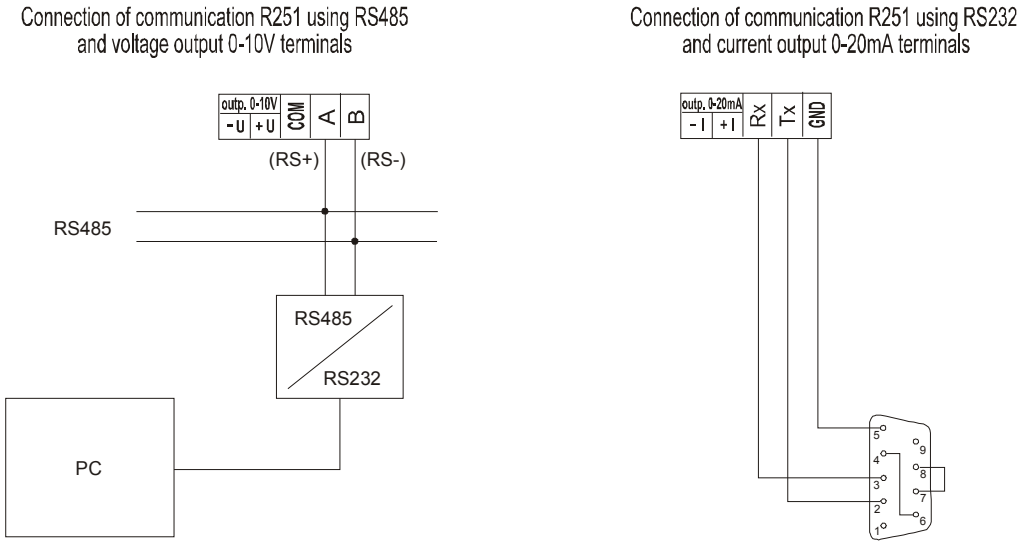


Fig. IX.1 connection of additional module terminals and communication diagram of RS485/RS232

X. X. CONDITIONS OF GUARANTEE

The manufacturer guarantees faultless regulator functioning for 24 months from the date of commissioning, but not later than 27 months from the date of sale to the customer. The manufacturer is obliged to remedy all defects caused by material defects or by hidden production defects free of charge during the period stated above.

The guarantee does not cover faults occurring as a result of mechanical damage of the regulator, wrong connection or using it for purposes other than those specified, breach of operation or storage conditions and breach of the manufacturer's instructions.

Caution:

In case of functional failure of the thermocouple input circuit (short circuit in the thermocouple wiring, failure of input amplifier or converter), the regulator can indicate the improper value of the measured quantity. The manufacturer of the regulator does not guarantee secondary damage caused by regulator failure. The manufacturer recommends protecting the regulated system by a second independent circuit which disconnects the regulated system in case of eventual max. admissible value of the measured quantity being exceeded.

XI. OPERATING CONDITIONS

The regulator can be operated in an environment protected against climatic effects, radiant heat, coarse foreign objects and aggressive vapours e.g. in laboratories. The regulator is calibrated by the manufacturer for the chosen input sensor.

Power supply:	230V/0,04A, 50Hz
Operating temperature:	0°C to 40°C
Storage temperature	-40°C to 65°C
Relative air humidity:	Max. 80% at 20°C
Dustiness:	max. 0,5 mg/m^3 of non-combustible and non-conductive dust

Serial number:

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