Assisting the automation industry since 1986

User manual
CONTROLLER
PUR-99

- Firmware: v.1.07 or higher
- Input type: universal
- Two rows of dispalys

Read the user's manual carefully before starting to use the unit or software.
Producer reserves the right to implement changes without prior notice.

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Explanation of symbols used in the manual:

- This symbol denotes especially important guidelines concerning the installation and operation of the device. Not complying with the guidelines denoted by this symbol may cause an accident, damage or equipment destruction.

IF THE DEVICE IS NOT USED ACCORDING TO THE MANUAL THE USER IS RESPONSIBLE FOR POSSIBLE DAMAGES.

- This symbol denotes especially important characteristics of the unit. Read any information regarding this symbol carefully

1. BASIC REQUIREMENTS AND USER SAFETY

- **The manufacturer is not responsible for any damages caused by inappropriate installation, not maintaining the proper environmental conditions and using the unit contrary to its assignment.**
- Installation should be conducted by qualified personnel . During installation all available safety requirements should be considered. The fitter is responsible for executing the installation according to this manual, local safety and EMC regulations.
- If the device is equipped with PE connector, it should be connected to PE wire. Otherwise PE wire should be connected to GND connector.
- The unit must be properly set-up, according to the application. Incorrect configuration can cause defective operation, which can lead to unit damage or an accident.
- **If in the case of a unit malfunction there is a risk of a serious threat to the safety of people or property additional, independent systems and solutions to prevent such a threat must be used.**
- **The unit uses dangerous voltage that can cause a lethal accident. The unit must be switched off and disconnected from the power supply prior to starting installation of troubleshooting (in the case of malfunction).**
- Neighbouring and connected equipment must meet the appropriate standards and regulations concerning safety and be equipped with adequate overvoltage and interference filters.
- **Do not attempt to disassemble, repair or modify the unit yourself. The unit has no user serviceable parts. Defective units must be disconnected and submitted for repairs at an authorized service centre.**

- In order to minimize fire or electric shock hazard, the unit must be protected against atmospheric precipitation and excessive humidity.
- Do not use the unit in areas threatened with excessive shocks, vibrations, dust, humidity, corrosive gasses and oils.
- Do not use the unit in areas where there is risk of explosions.
- Do not use the unit in areas with significant temperature variations, exposure to condensation or ice.
- Do not use the unit in areas exposed to direct sunlight.
- Make sure that the ambient temperature (e.g. inside the control box) does not exceed the recommended values. In such cases forced cooling of the unit must be considered (e.g. by using a ventilator).

The unit is designed for operation in an industrial environment and must not be used in a household environment or similar.

2. GENERAL CHARACTERISTICS

The **PUR-99** device has a universal input that can be configured to work as: a current input (in the range 0 – 20 mA), as a voltage input (in the range 0-10V and 0-150 mV), as an RTD input (operating with Pt 100/500/1000 sensors) and as a TC input (operating K, S, J, T, N, R, B and E type thermocouples). The device automatically compensates the temperature of cold junction of thermocouple sensor. RTD and TC inputs feature full linearization of characteristics. Only one input type can be used at a time. The exact measurement ranges of the inputs are quoted in the next chapter. The measurement is shown on a 4-digit LED display.

The device can be equipped with 1, 2 or 4 relay outputs and nulll or one OC-type output (not available in the 4 relay output version), which can be controlled from the measuring inputs, via Modbus protocol or a PID controller implemented in the device with two control loops and an auto-tuning option. Optionally, the device (in version with two relays and OC-type output) can be equipped with: an active current output, a passive isolated current output or an active voltage output. An RS-485 communication interface and a sensor transducer power supply output are available as standard. The device is available in two power supply versions.

Exact description of functions is provided in further section of the instruction.

The **PUR-99** is designed to regulate such processes as heating / cooling temperatures with adjustable delay times for the operation of the output relays and controlling of valve levels.

3. TECHNICAL DATA

Power supply voltage	85...**230**...260 V AC/DC; 50÷60 Hz (separated)
(depending on version)	or 19...**24**...50 V DC and 16...**24**...35 V AC (separated)
External fuse (required)	T - type, max. 2 A
Power consumption	max. 7 VA @ 85 V÷260 V AC/DC max. 7 VA @ 16 V÷35 V AC max. 7 W @ 19 V÷50 V DC

Current input (20 mA)	0÷20 mA, 4÷20 mA overload protected, input current is limited to 50 mA (typically)
Current measurement accuracy	± 0.1% @ 25°C; ± one digit (for 0÷20 mA range)
Current input resistance	< 65 Ω (typical 30 Ω)
Accepted prolonged input overload	20%

Voltage input (10V range)	0÷5 V, 1÷5 V, 0÷10 V, 2÷10 V
Voltage measurement accuracy	± 0.1% @ 25°C; ± one digit (for 0÷10 V range)
Input resistance	> 100 kΩ (while maintaining correct polarization)
Accepted prolonged input overload	20%

Voltage input (150mV range)	0÷60 mV, 0÷75 mV, 0÷100 mV, 0÷150 mV
Voltage measurement accuracy	± 0.1% @ 25°C; ± one digit (for 0÷150 mV range)
Input resistance	> 1,5 MΩ
Accepted prolonged input overload	20%

RTD input (resistive)	Pt 100, Pt 500,Pt 1000
Measurement range	-100°C÷600°C
Measurement accuracy	± 0,1% @ 25°C; ± one digit
Measurement wires resistance	max. 20 Ω (every wire)

Thermocouple input	K, S, J, T, N, R, B, E
Thermocouple input range	K: -200˚C ÷ +1370˚C S: -50˚C ÷ +1768˚C J: -210˚C ÷ +1200˚C T: -200˚C ÷ + 400˚C N: -200˚C ÷ +1300˚C R: -50˚C ÷ +1768˚C B: +250˚C ÷ +1820˚C E: -200˚C ÷ +1000˚C
Measurement accuracy	K, J, E: ± 0.1% @ 25°C; ± one digit N: ± 0.2% @ 25°C; ± one digit S, T, R, B: ± 0.5% @ 25°C; ± one digit
Accuracy of cold ends temperature compensation	± 1˚C
Sensor power supply output	24 V +5%, -10% / max. 100 mA, stabilized
Relay output	1, 2 or 4 NO 5 A/250 V AC (resistance) 3 A/250 V AC (reactance)
OC-type output	0 or 1; 30 mA / 30V DC / 100mW
Active current output (optional, for two relays and one OC-type output version only)	range max. 0÷24 mA
Load resistance max.	700 Ω
Passive isolated current output (optional, for two relays and one OC-type output version only)	range max. 2.8÷24 mA
Supply voltage	Us = 9.5÷36 V
Load resistance max.	(Us – 9.5V) / 24 mA [kΩ]
Active voltage output (optional, for two relays and one OC-type output version only)	range max. 0÷11 V
Load resistance min.	2000 Ω
Temperature stability	50 ppm / °C

Communication interface	RS-485, 8N1 and 8N2, Modbus RTU, not separated
Baud rate	1200÷115200 bit/s
Displays (depending on version)	LED, main PV 20 mm height green, auxiliary SV 13 mm height red, single 10 mm height green or LED, main PV 20 mm height red, auxiliary SV 13 mm height green single 10 mm height red
Main PV display range	-999 ÷ 9999 plus decimal point
Data memory	non-volatile memory, EEPROM type
Protection level	IP 65 optional version with panel cut-out sealing available
Terminals protection	IP 20
Housing type Housing material Housing dimensions Mounting hole Assembly depth Panel thickness	panel NORYL - GFN2S E1 96 x 96 x 100 mm 90.5 x 90.5 mm 102 mm max. 5 mm
Operating temperature (depending on version)	0°C to +50°C or -20°C to +50°C
Storage temperature (depending on version)	-10°C to +70°C or -20°C to +70°C
Humidity Altitude	5 to 90% no condensation up to 2000 meters above sea level
Screws tightening max. torque	0,5 Nm
Max. connection leads cross section	2,5 mm^2
Safety requirements	according to: EN 61010-1 installation category: II pollution degree: 2 voltage in relation to ground: 300 V AC insulation resistance: >20 MΩ insulation strength between power supply and input/output terminal: 1min. @ 2300 V AC insulation strength between relays terminal: 1 min. @ 1350 V AC
EMC	according to: EN 61326-1

This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

4. DEVICE INSTALLATION

The unit has been designed and manufactured in a way assuring a high level of user safety and resistance to interference occurring in a typical industrial environment. In order to take full advantage of these characteristics installation of the unit must be conducted correctly and according to the local regulations.

- Read the basic safety requirements on page **3** prior to starting the installation.
- Ensure that the power supply network voltage corresponds to the nominal voltage stated on the unit's identification label.
- The load must correspond to the requirements listed in the technical data.
- All installation works must be conducted with a disconnected power supply.
- Protecting the power supply connections against unauthorized persons must be taken into consideration.

4.1. UNPACKING

After removing the unit from the protective packaging, check for transportation damage. Any transportation damage must be immediately reported to the carrier. Also, write down the unit serial number located on the housing and report the damage to the manufacturer.

Attached with the unit please find:
- user's manual,
- warranty,
- assembly brackets - 2 pieces.

4.2. ASSEMBLY

- The unit is designed for mounting inside housings (control panel, switchboard) insuring appropriate protection against surges and interference. Metal housings must be connected to ground in a way that complies with the governing regulations.
- Disconnect the power supply prior to starting assembly.
- Check the connections are wired correctly prior to switching the unit on.

In order to install the unit, a 90.5 x 90.5 mm mounting hole (**Figure 4.1**) must be prepared. The thickness of the material of which the panel is made must not exceed 5 mm. When preparing the mounting hole take the grooves for catches located on both sides of the housing into consideration (**Figure 4.1)**. Allowable mounting hole dimensions are shown in **Figure 4.2**.Place the unit in the mounting hole inserting it from the front side of the panel, and then fix it using the brackets (**Figure 4.3**). The minimum distances between the centre points of multiple units - due to the thermal and mechanical conditions of operation - are 115 mm (**Figure 4.4**).

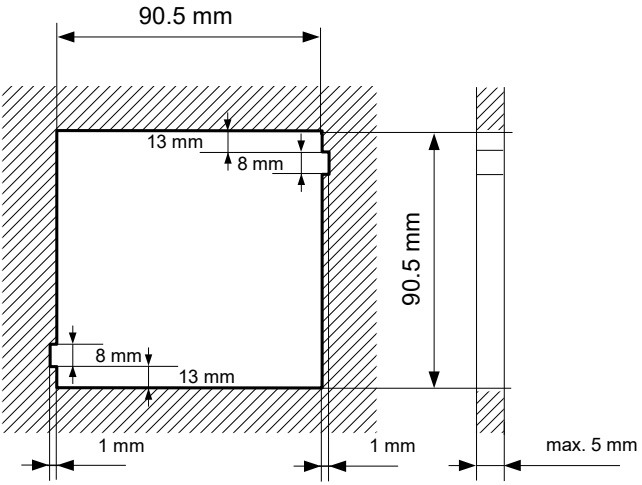


Figure 4.1. Recommended mounting hole dimensions

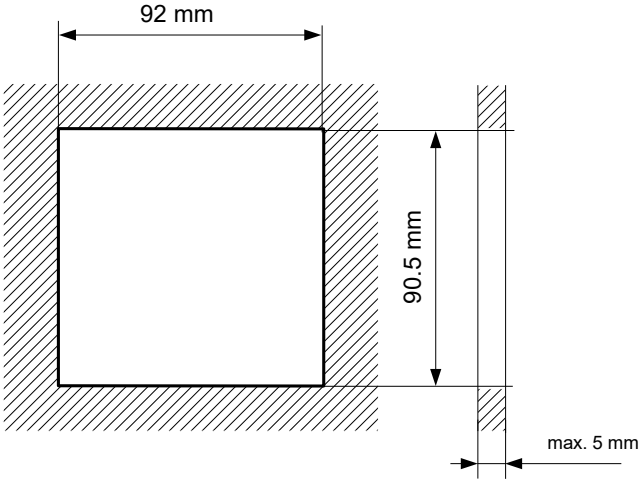


Figure 4.2. Allowable mounting hole dimensions

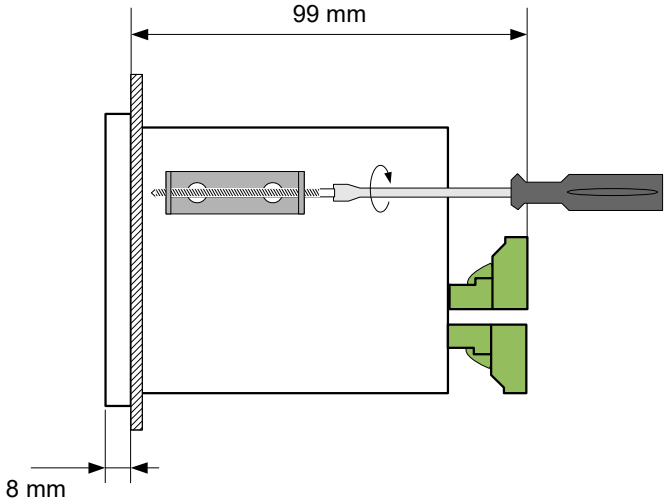


Figure 4.3. Installing of brackets

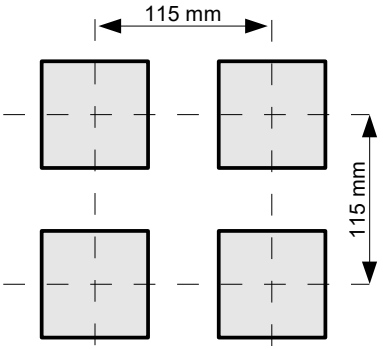


Figure 4.4. Minimum distances when assembly of a number of units

4.3. CONNECTION METHOD

Caution

- Installation should be conducted by qualified personnel. During installation all available safety requirements should be considered. The fitter is responsible for executing the installation according to this manual, local safety and EMC regulations.

- The unit is not equipped with an internal fuse or power supply circuit breaker. Because of this an external time-delay cut-out fuse with a small nominal current value must be used (recommended bipolar, max. 2A) and a power supply circuit-breaker located near the unit. In the case of using a monopolar fuse it must be mounted on the phase cable (L).

- The power supply network cable diameter must be selected in such a way that in the case of a short circuit of the cable from the side of the unit the cable shall be protected against destruction with an electrical installation fuse.

- Wiring must meet appropriate standards and local regulations and laws.

- In order to secure against accidental short circuit the connection cables must be terminated with appropriate insulated cable tips.

- Tighten the clamping screws. The recommended tightening torque is 0.5 Nm. Loose screws can cause fire or defective operation. Over tightening can lead to damaging the connections inside the units and breaking the thread.

- In the case of the unit being fitted with separable clamps they should be inserted into appropriate connectors in the unit, even if they are not used for any connections.

- Unused terminals (marked as n.c.) must not be used for connecting any connecting cables (e.g. as bridges), because this can cause damage to the equipment or electric shock.

- If the unit is equipped with housing, covers and sealing to, protecting against water intrusion, pay special attention to their correct tightening or clamping. In the case of any doubt consider using additional preventive measures (covers, roofing, seals, etc.). Carelessly executed assembly can increase the risk of electric shock.

- After the installation is completed do not touch the unit's connections when it is switched on, because it carries the risk of electrical shock.

Due to possible significant interference in industrial installations appropriate measures assuring correct operation of the unit must be applied. To avoid the unit of improper indications keep recommendations listed below.

- Avoid running signal cables and transmission cables together with power supply cables and cables controlling inductive loads (e.g. contactors). Such cables should cross at a right angle.

- Contactor coils and inductive loads should be equipped with interference protection systems, e.g. RC-type.

- Use of screened signal cables is recommended. Signal cable screens should be connected to the earthing only at one of the ends of the screened cable.

- In the case of magnetically induced interference the use of twisted pair of signal cables is recommended. Twisted pair (best if shielded) must be used with RS-485 serial transmission connections.

- In the case of measurement or control signals are longer than 30m or go outside of the building then additional safety circuits are required.

- In the case of interference from the power supply side the use of appropriate interference filters is recommended. Bear in mind that the connection between the filter and the unit should be as short as possible and the metal housing of the filter must be connected to

the earth with the largest possible surface. The cables connected to the filter output must not be run with cables with interference (e.g. circuits controlling relays or contactors).

Connections of power supply voltage and measurement signals are executed using the screw connections on the back of the unit's housing.

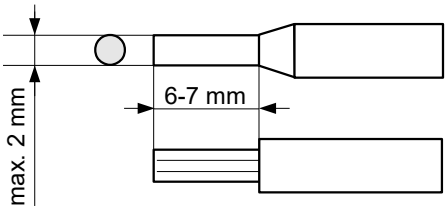


Figure 4.5. Method of cable insulation replacing and cable terminals

All connections must be made while power supply is disconnected !

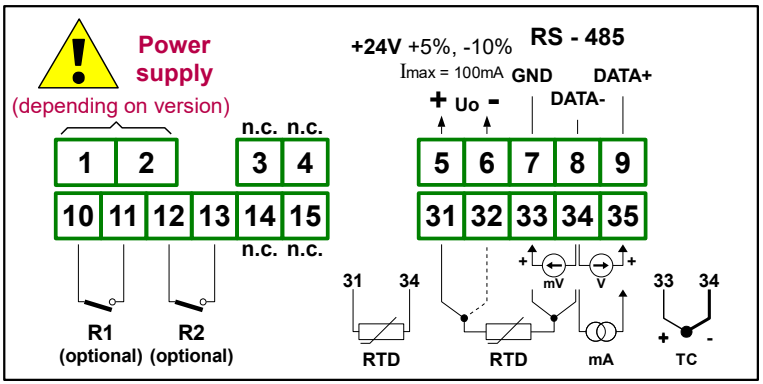


Figure 4.6. Terminals description (two relay outputs)

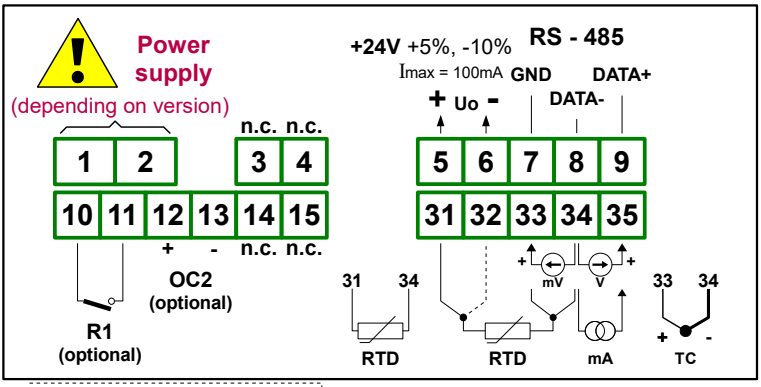


Figure 4.7. Terminals description (one relay and one OC-type outputs)

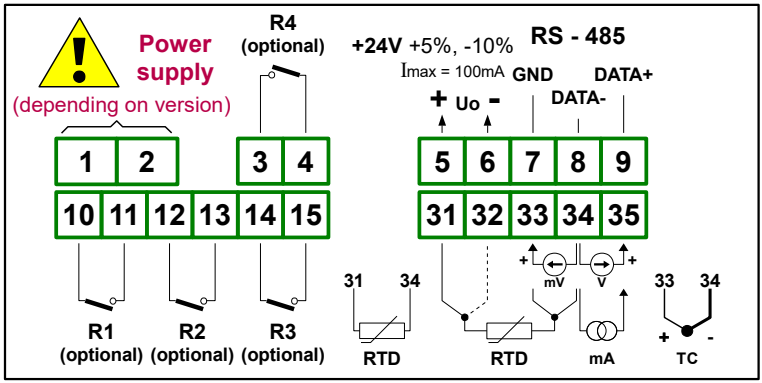


Figure 4.8. Terminals description (four relay outputs)

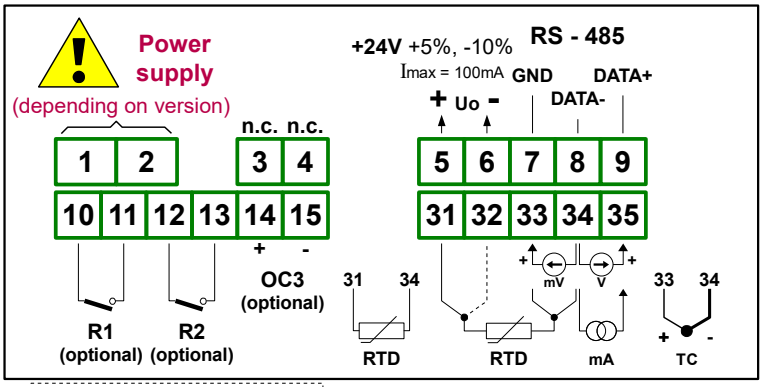


Figure 4.9. Terminals description (two relay and one OC-type outputs)

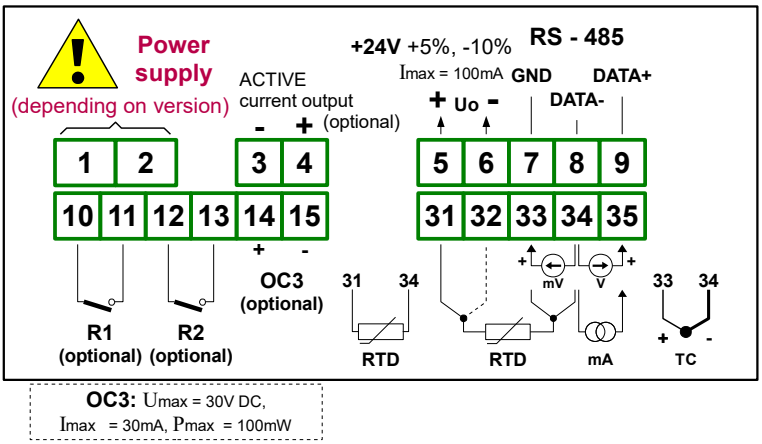


Figure 4.10. Terminals description (two relay, one OC-type and one active current outputs)

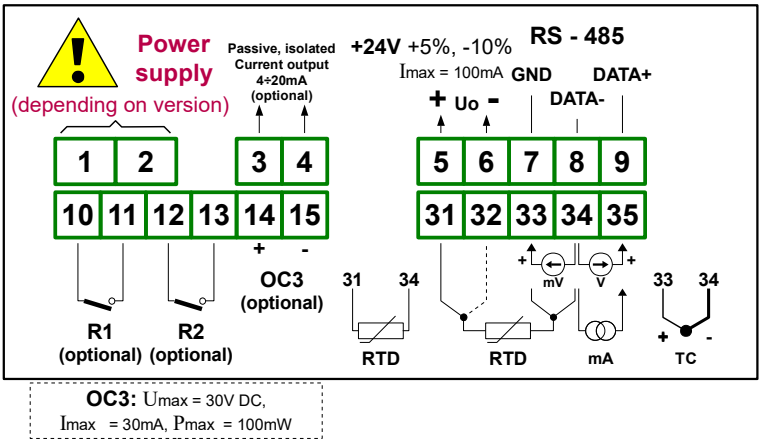


Figure 4.11. Terminals description (two relay, one OC-type and one passive current outputs)

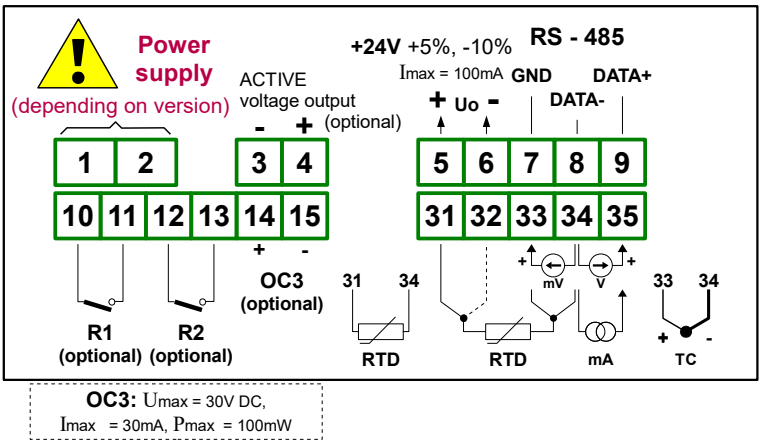


Figure 4.12. Terminals description (two relay, one OC-type and one active voltage outputs)

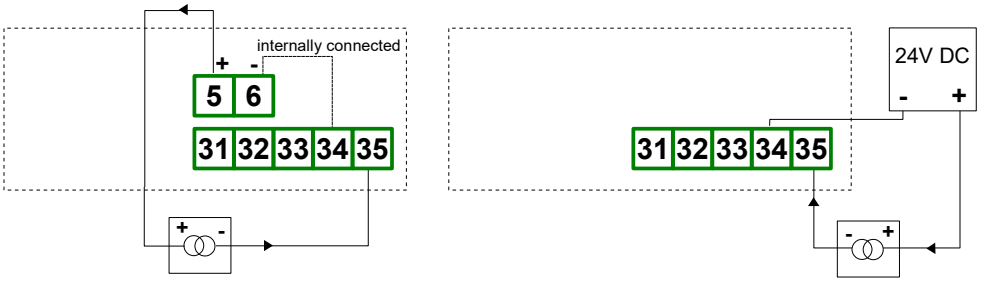


Figure 4.13. Connection of 2-wire current transducer

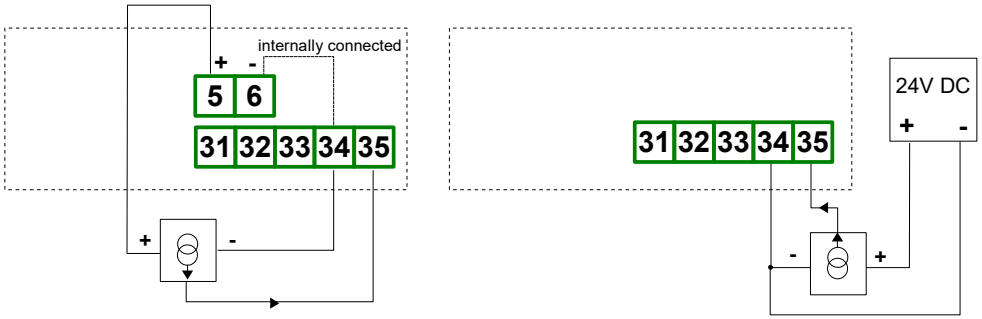


Figure 4.14. Connection of 3-wire current transducer

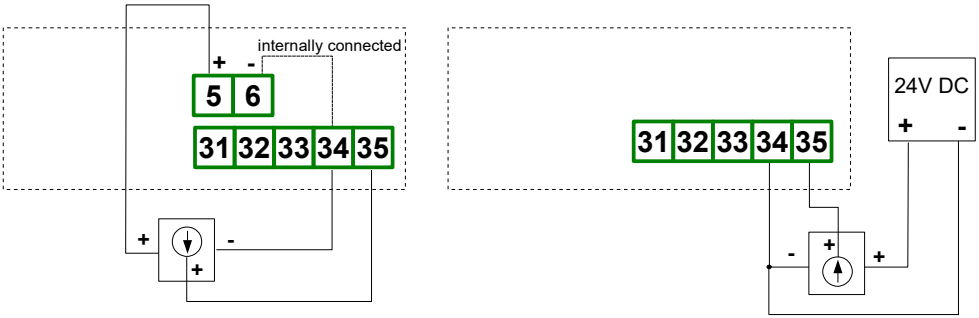


Figure 4.15. Connection of voltage transducer

Temperature sensor can be connected to the device in typical 4-wire circuit (**Figure 4.16a**) or 3-wire circuit (**Figure 4.16b**). Due to precision of measurement 4-wire circuit is recommended.

If 2 wire circuit is used, the resistance of wires should be as small as possible, to avoid of measurement errors. Measured value can be corrected (constant correction) using „**toFS**" parameter from menu „**inPt**". Due to low precision 2-wire connection is not recommended.

When 4-wires or 2-wires connection is used, the resistance of particular wires (Ra ÷ Rd) **CAN BE DIFFERENT**. When 3-wires connection is used, the resistance of particular wires (Ra ÷ Rd) **MUST BE IDENTICAL** to enable proper compensation of it's resistance. The resistance of particular wire **should not be greater than 20 Ω.**

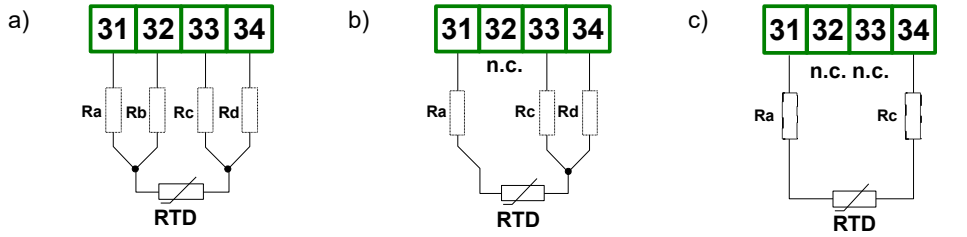


Figure 4.16. Connection of RTD sensors:
a) 4-wires circuit; b) 3-wires circuit; c) 2-wires circuit

The connection circuit should not be changed while unit is powered. While using TC, RTD or voltage inputs (0-150mV) the device is able to detect wire breaks. Wire breaks are detected within about 2 seconds. For connectors number 32 and 33 of RTD input it may take up to about 7 seconds. During detection measurements will be incorrect. If wire break is detected **"S.Err"** (sensor error) message is displayed.

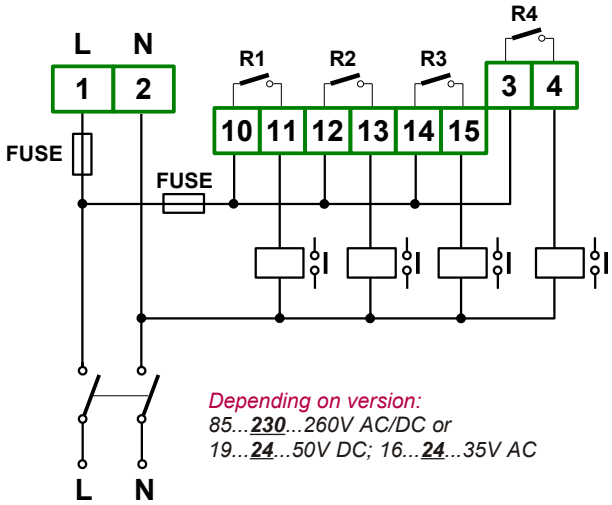


Figure 4.17. Connection of power supply and relays

Contacts of relay outputs are not equipped with spark suppressors. While use the relay outputs for switching of inductive loads (coils, contactors, power relays, electromagnets, motors etc.) it is required to use additional suppression circuit (typically capacitor 47nF/ min. 250VAC in series with 100R/5W resistor), connected in parallel to relay terminals or (better) directly on the load. In consequence of using the suppression circuit, the level of generated electromagnetic disturbances is lower, and the life of relay contacts rises.

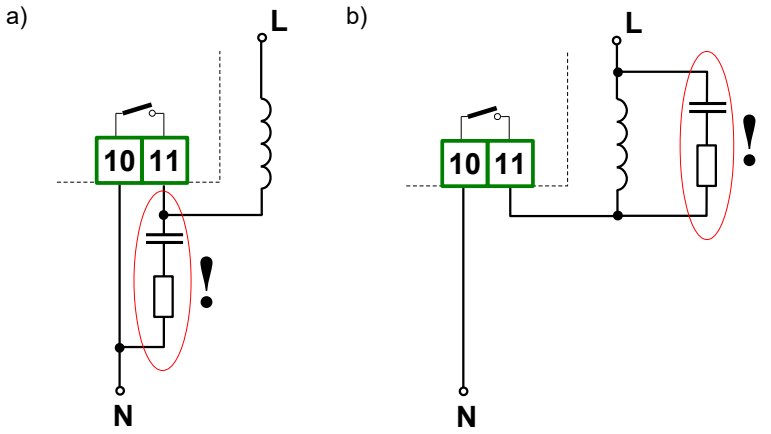


Figure 4.18. Examples of suppression circuit connection:
a) to relay terminals; b) to the inductive load

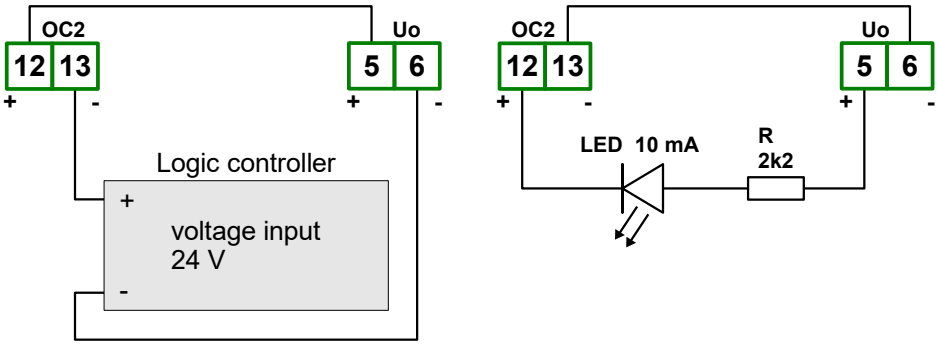


Figure 4.19. Example of OC-type outputs connection
(for device with OC-type output only)

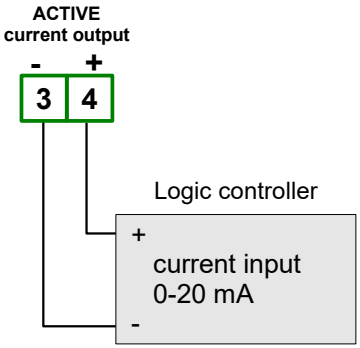


Figure 4.20. Example of active current outputs connection (for device with active current output only)

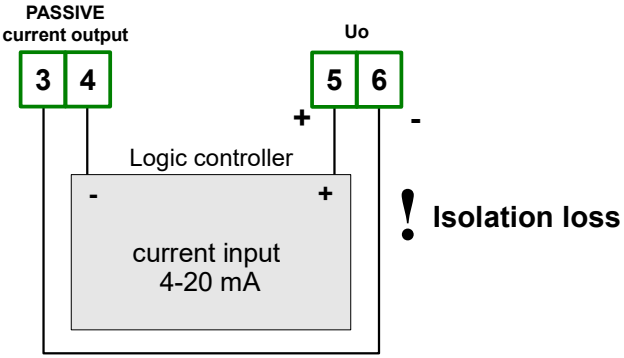


Figure 4.21. Example of passive current outputs connection (for device with passive current output only)

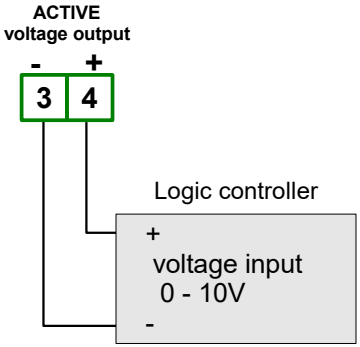


Figure 4.22. Example of active voltage outputs connection (for device with active voltage output only)

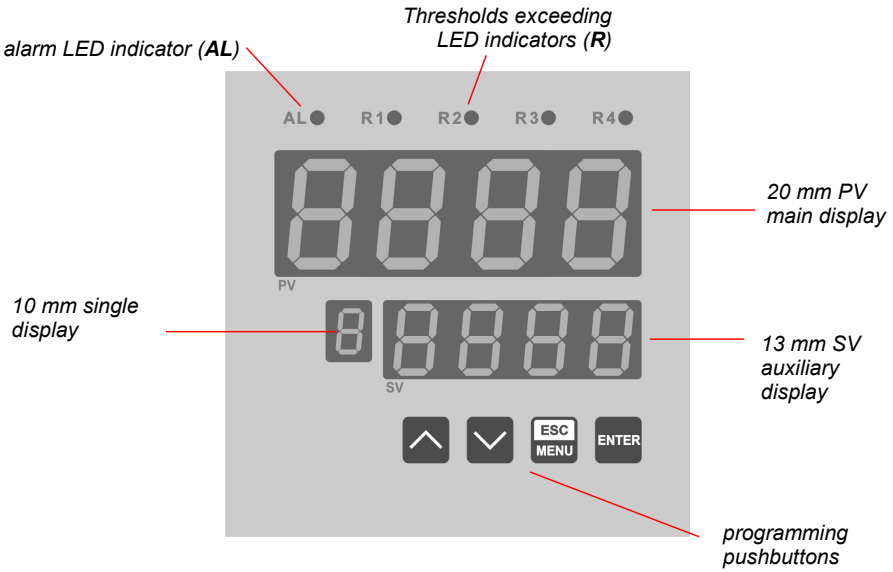
4.4. MAINTENANCE

The unit does not have any internal replaceable or adjustable components available to the user. Pay attention to the ambient temperature in the room where the unit is operating. Excessively high temperatures cause faster ageing of the internal components and shorten the fault-free time of the unit's operation.
In cases where the unit gets dirty do not clean with solvents. For cleaning use warm water with small amount of detergent or in the case of more significant contamination ethyl or isopropyl alcohol.

Using any other agents can cause permanent damage to the housing.

Product marked with this symbol should not be placed in municipal waste. Please check local regulations for disposal of electronic products.

5. FRONT PANEL DESCRIPTION



Symbols and functions of push-buttons:

ESC MENU

Symbol used in the manual: **[ESC/MENU]**
Functions:

- Enter to main menu (press and hold by at least 2 sec.),
- Exit the current level and Enter to previous menu (or measure mode),
- Cancel the changes made in parameter being edited.

Symbol used in the manual: **[ENTER]**
Functions**:**
- Start to edit the parameter,
- Enter to the sub-menu,
- Confirmation of changes made in parameter being edited.

Symbol used in the manual: **[^] [v]**
Functions**:**
- Change of the present menu,
- Modification of the parameter value,
- Change of the display mode.

6. PRINCIPLE OF OPERATION

After turning the power supply on, device ID and software version are showed on the display, next the controller goes to the measurement mode.

6.1. MEASUREMENT MODE

In the measure mode, the measurement results, converted over selected characteristic, are displayed on the LED display. The measurement range equal to the nominal range is called: ***nominal measurement range,*** and the measurement range equal to the extended nominal range is called: ***permissible measurement range*** (**Figure 6.1, 6.2**).

For temperature inputs (TC and RTD) there is linear characteristic available only. For this kind of inputs ***nominal measurement range,*** and ***permissible measurement range*** are the same (no range extension available, **Figure 6.3**).

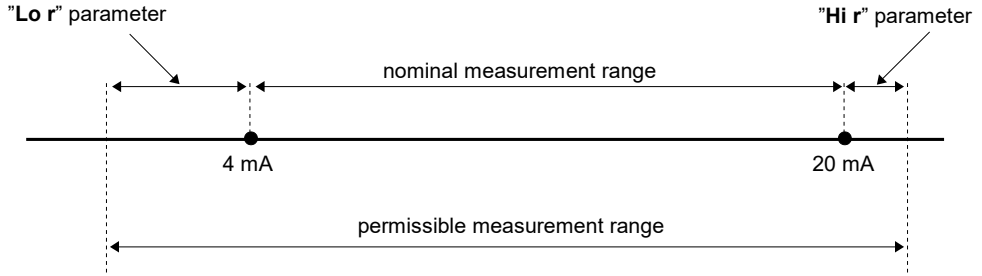


Figure 6.1. Definitions of measurement ranges in mode 4 ÷ 20mA

If the result of measurement exceeds the ***permissible measurement range***, warning **"-Hi-"** or **"-Lo-"** is displayed rather than input signal, depending on exceeded value (see description of **"Lo r"** and **"Hi r"** parameters, paragraph ***"inPt" menu***). The warning can be effect of measurement circuit malfunction. In that case **"-Lo-"** means shortcut and **"-Hi-"** means break of measurement circuit. If sensor failure will be detected (e.g. broken wires), then **"S.Err"** warning will be displayed.

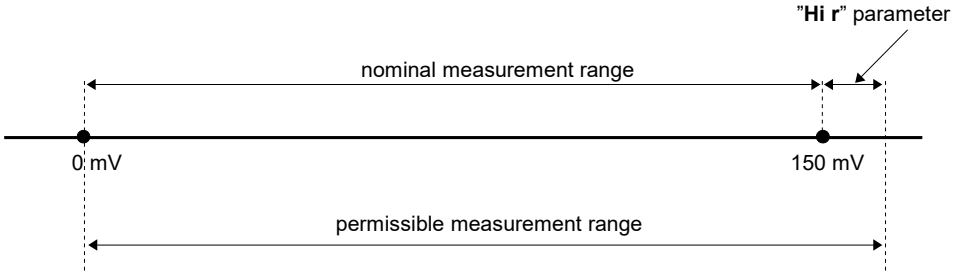


Figure 6.2. Definitions of measurement ranges in mode 0 ÷ 150mV

If the measurement value do not exceeds ***permissible measurement range*** but displayed value exceeds range -999 ÷ 9999, the warning "**-Ov-**" is displayed rather than the calculated result.

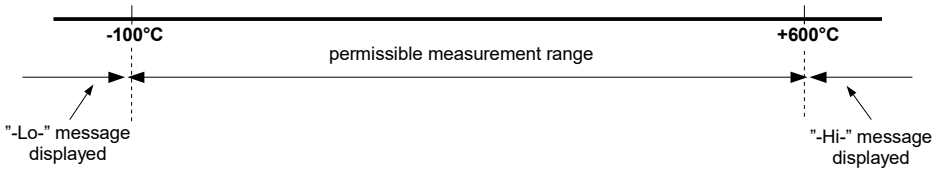


Figure 6.3. Definitions of measurement ranges in mode Pt100

In the measurement mode and PID mode user can check main thresholds values. After pressing **[^]** or **[v]** button, name of the threshold (e.g. **"1 rEL"**) and his value will be displayed on the display in alternating mode. If **[^]** or **[v]** will be pressed in 5 sec again, the next threshold will be displayed, else the device comes back to the measurement mode. If a ***free access*** is enabled (see description of ***"SECu" menu***), user can change the value of particular threshold pressing button **[ENTER]** (see: ***PARAMETERS EDITION***).

All accessible parameters can be changed by entering the menu (see chapter **7.3. DEVICE PROGRAMMING**). Use the local keyboard or RS-485 interface to do it. (Note: all parameters can be remote changed via RS-485 interface).

Configuration of the device (via menu or RS-485 interface) **does not stop measures**.

6.1.1. Detection OF THE PEAK VALUES

The **PUR-99** controller is equipped with peaks detection function. It can detect a peaks of the input signal and display their values. Presets connected with this function are placed in **"HOLd"** menu (see description of ***"HOLd" menu***). The detection of the peak can be done if the measured signal raises and drops of value at least equal to parameter **"PEA"**. Detected peaks are displayed during the time defined by parameter **"timE"**. If a new peak will be detected while one is displayed, this new peak will be displayed and display time counter will be cleared (**Figure 6.4**).

If no peaks are detected while time **"timE"** elapses**,** device starts to show the current

value of input signal again. If „**HdiS**”=”**HOLD**” then setting parameter **"timE"=0.0** causes holding peak value until **[ESC]** button is pressed. If „**HdiS**”=”**rEAL**” then value **"timE"=0.0** means no holding. Displaying peak value is signalized by flashing most right decimal point.

The relays/LEDs can be controlled depend on the current value of input signal or the peak value (see ***”HOLd” menu***).

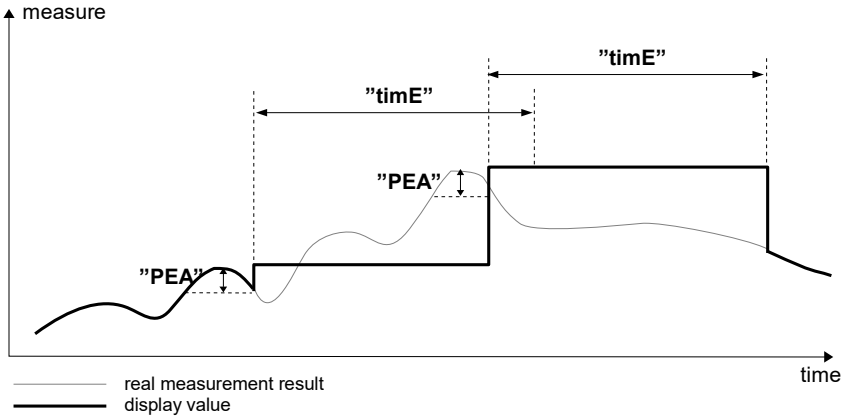


Figure 6.4. Process of peaks detection

6.2. PID REGULATORS

Operation of the PID controller involves calculating the error value ensuing from the difference between the setpoint and the measured value and responding in such a way as to minimize the calculated error by appropriately adjusting the signal connected to the input of the regulated object.

Controllers are mainly used in industrial control systems that have large time constants vulnerable to interference from the input of the regulated object, and therefore are suitable for constant value regulating of the object or technological processes that contain such elements as furnaces, boilers, etc.

The **PUR-99** device includes a proportional-integral-derivative (**PID**) controller with two independent control loops, one for controlling the heating process and the second for the cooling system (a general diagram of the controller is shown in **Figure 6.5**). Hereafter these loops are called **PID H** loop and **PID C** loop respectively, as shown in **Figure 6.5**. Each of these loops is composed of the following blocks: **P** proportional, **I** integral and **D** derivative, whose proper summing up gives the output signal controlling the object **Figure 6.6**.

The controller’s signal may be redirected to any output of the device, which means that the **PUR-99** may be used to control most objects used in the industry.

The PID controller can be used to adjust such values as temperature, humidity, pressure, force, speed, flow rate, or level of a liquid or loose material etc. Note, however, that the controllers included in the device have a common setpoint (**SEtP** parameter), and so should be used in applications where one of the controllers (e.g. **PID H**) is used to control actuators that increase the state of the regulated object (e.g. heating), and the other controller (e.g. **PID C**) is used to control actuators reducing the state of the regulated object (e.g. cooling).

Additional controller parameters such as: dead zone, fuzzy logic block or inertial block, enables even more precise control over the physical object, optimizing, but also protecting the

object against over-regulation or an excessive rise of the control value.

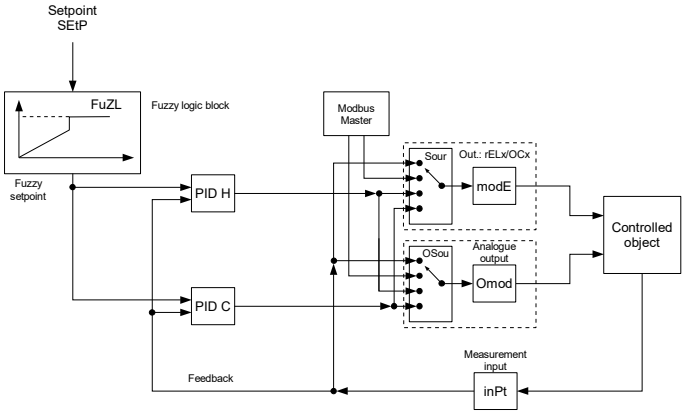


*Figure 6.5. The general structure of the **PUR-99** device*

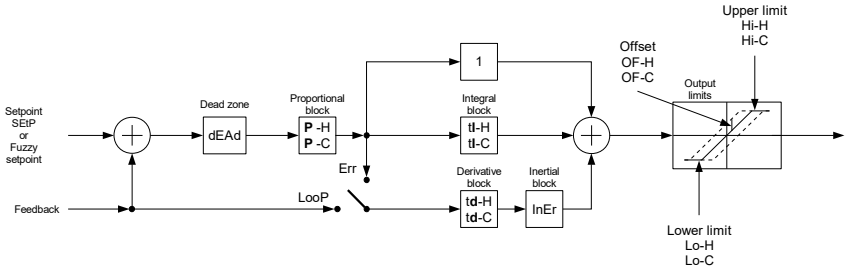


*Figure 6.6. General scheme of the PID controller implemented in the **PUR-99** device*

Depending on the operating mode, the regulators can operate as shown in **Figure 6.7**:

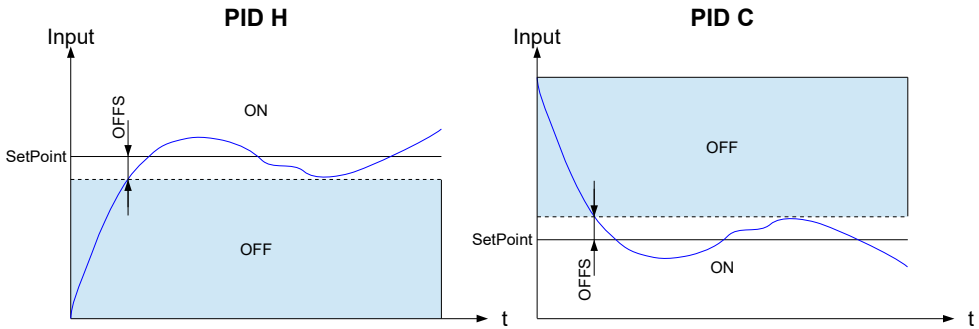


Figure 6.7. Relay control characteristics depending on the operating mode

Configuring the PID controller

The PID controller can be configured in two ways: manually and automatically.

In manual mode, the user defines all factors and additional elements of the controllers (fuzzy logic, inertia, output limiting and dead zone) at their own discretion. The settings chosen by the device in automatic mode can also be improved and fine-tuned. The user can disable each block of the PID controller as well as additional blocks. This is done by setting the zero value or **OFF** option in the selected parameter.

In automatic mode, in the auto-tuning process using the **Ziegler-Nichols** method, the device calculates and tunes the parameters **P, I** and **D** of one of the controller's loops. Additional blocks (fuzzy logic, inertia, output limiting and dead zone) are not configured in this mode and the user must choose them himself according to respective applications. The auto-tuning process is described later in this chapter.

Fuzzy logic block (FuZL submenu)

Step changes in the setpoint can be mitigated by the use of the fuzzy logic block, which inserts speed control of the setpoint change. Thanks to its application the user may dictate how quickly a fuzzy value approximates the target value in the process (**SEtP**).

This feature is particularly useful in systems where too rapid change in the setpoint and, as it is possible in such a situation, the control signal, could lead to unwanted behaviour on the part of a object, for instance destruction of the product being manufactured. It is also possible to set the minimum difference between the setpoint (**SEtP**), and the fuzzy setpoint, beyond which the controller step changes the fuzzy setpoint to the setpoint (**SEtP**). This is defined by the **HYST** parameter. Both controllers use the same settings of the fuzzy logic block.

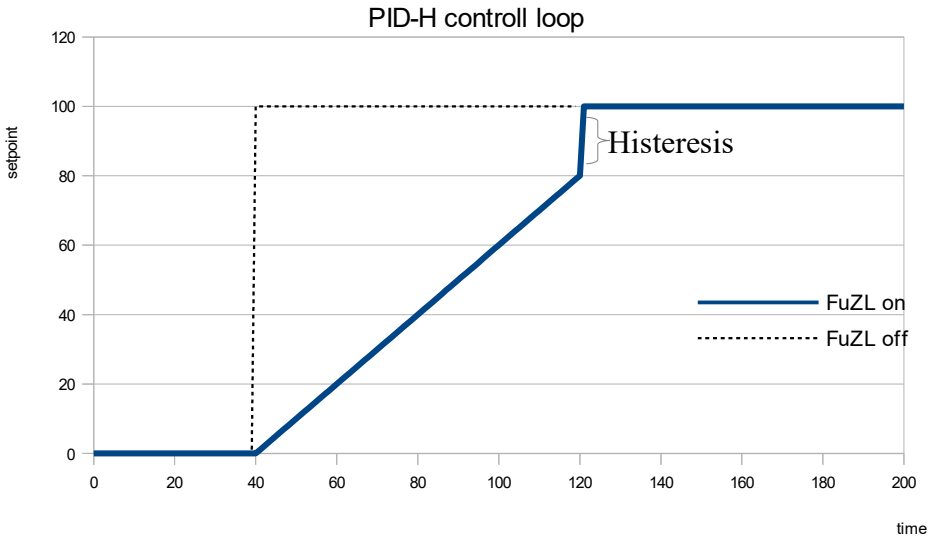


Figure 6.8. Comparison of the PID-H controller's response to a change in the setpoint using and without the use of fuzzy logic

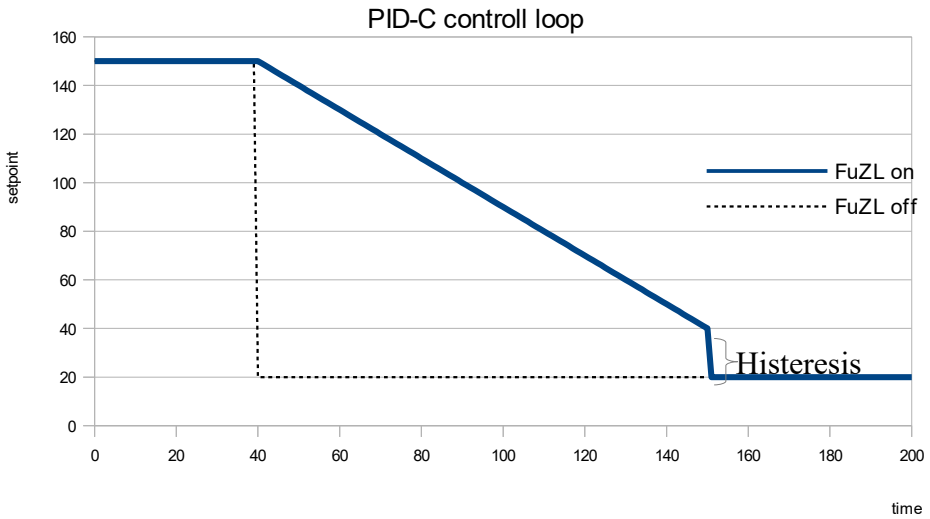


Figure 6.9. Comparison of the PID-C controller's response to a change in the setpoint using and without the use of fuzzy logic

The inertial block

This is used to smooth the progress of the derivative block response, in other words to eliminate overly dynamic changes in the output signal's value caused by the presence of measurement process noise. The use of the inertial block lengthens response time, but provides protection against over-regulation that could lead to failures in the controlled system.

Dead zone

The insertion of this parameter provides the possibility of "anesthetising" the control system to small deviations in the measured value from the setpoint. The **dEAd** parameter specifies the minimum deviations to which the controller should react. The use of the dead zone is justified in systems for which oscillation around the setpoint is a natural behaviour.

Auto-tuning

If the user does not know the dynamic parameters of the controlled system, and is unable to select the suitable controller coefficients or simply doesn't have the time or patience, the controller auto-tuning system included in the device can be used instead.

Thanks to auto-tuning, the controlled system is identified and controller settings are selected using the **Ziegler-Nichols** method, which involves measuring the set oscillation parameters of the system. The auto-tuning process is divided into three phases, during which no device settings can be changed, and after their completion the device automatically switches to operation in the **Pid** mode. The duration of the auto-tuning process depends on the properties of the controlled system.

During auto-tuning, the user is warned against regulating the actual technological processes, because auto-tuning may damage the products manufactured in the process.

There are 3 auto-tuning modes available, as a result of which the settings of one of the controllers will be selected:

The **At-F** mode:

Auto-tuning using both the controller's control loops (**At-F** mode), during which two outputs of the device can be controlled. In this process, the device determines (based on the setpoint and the measured value), which loop is to be tuned. The second loop receives the same settings. When the setpoint is greater than the measured value, the **PID-H** controller's loop will be tuned, and when the setpoint is less than the measured value, the **PID-C** controller's loop will be tuned.

The process of auto-tuning in this mode may commence subject to the following conditions:

1) The value measured by the device must be 1/5 (20%) less of the setpoint (when the **PID-H** controller is tuned) or the value measured by the device must be greater than 1/5 (20%) of the setpoint (when the **PID-C** controller will be tuned)
2) The source of at least one of the device's outputs must be **PidH** if the loop of the **PID-H** controller will be tuned, or the source of at least one of the outputs must be **PidC**, if the loop of the **PID-C** controller will be tuned. In addition, these outputs can not be set in the **noAC** mode.

First auto-tuning should be made in **At-F** mode, because otherwise, the regulator can work inappropriately. When first **At-F** auto-tuning is done, the user can ajdust regulator's settings according to his needs or execute any auto-tuning mode.

The **At-H** mode:

Auto-tuning of the **PID-H** loop (the **At-H** mode), during which the device uses and adjusts only that loop. The second loop remains idle and its setting will not change following the process.

The process of auto-tuning in this mode may commence subject to the following conditions:

1) The value measured by the device must be 1/5 (20%) less of the setpoint,
2) The source of at least one of the device's outputs must be **Pid-H**. Additionally, those outputs cannot be set in the **noAC** mode.

The **At-C mode:**

Auto-tuning of the **PID-C** loop (the **At-C** mode), during which the device uses and adjusts only that loop. The second loop remains idle and its setting will not change following the process.

The process of auto-tuning in this mode may commence subject to the following conditions:

1) The value measured by the device must be 1/5 (20%) less of the setpoint,
2) The source of at least one of the device's outputs must be **PID-C**. Additionally, those outputs cannot be set in the **noAC** mode.

Auto-tuning that is already underway is a very sensitive process. So the user should pay attention to events that could interrupt the tuning of the settings. These events include:

1) Loss of power to the device.
2) Time for auto-tuning exceeded (24 h).
3) When the PID controller's operating mode is switched over.
4) Measurement error (e.g. sensor failure).
5) Change in the parameters of the device.

6.3. CONTROL OF THE RELAY OUTPUTS

The control of the object (measured signal) is realized via relay outputs. Front panel LEDs named "**R**" indicates the state of particular relay output.

If device is not equipped with one or more relay outputs, menus refer to this relays are available, but apply to LED indicators only. In such case LEDs indicates exceeding of particular thresholds.

Modes of the control can be changed depend on the values of parameters **"SEtP"**, **"SEt2", "HYSt"**, **"modE"**, **"t on"**, **"toFF"**, **"unit"** and **"AL".** Depend on **"modE"** parameter, relays can be not used or controlled over one or two thresholds values.

If one threshold is used (**Figure 6.10**) the relay can be turned on (**"modE"** = **"on"**) or off (**"modE"** = **"oFF"**) when the input signal value is contained in ***zone A.*** If two thresholds are used (**Figure 6.11**) the relay will be turned on when value of input signal is contained in ***zone A*** (**"modE"** = **"in"**) or ***zone B*** (**"modE"** = **"out"**) and turned off if the signal is contained in the second one.

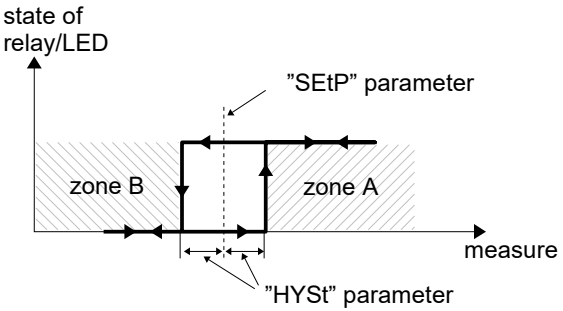


Figure 6.10. One threshold control of the relay/LED outputs

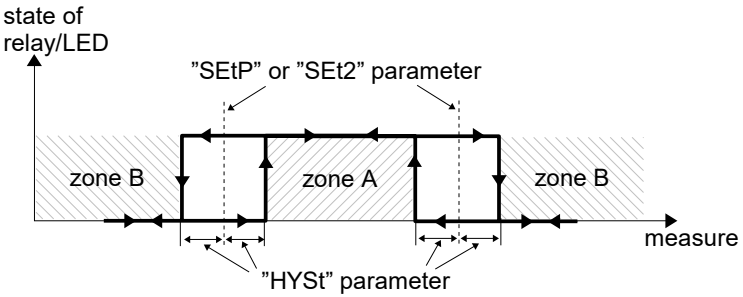
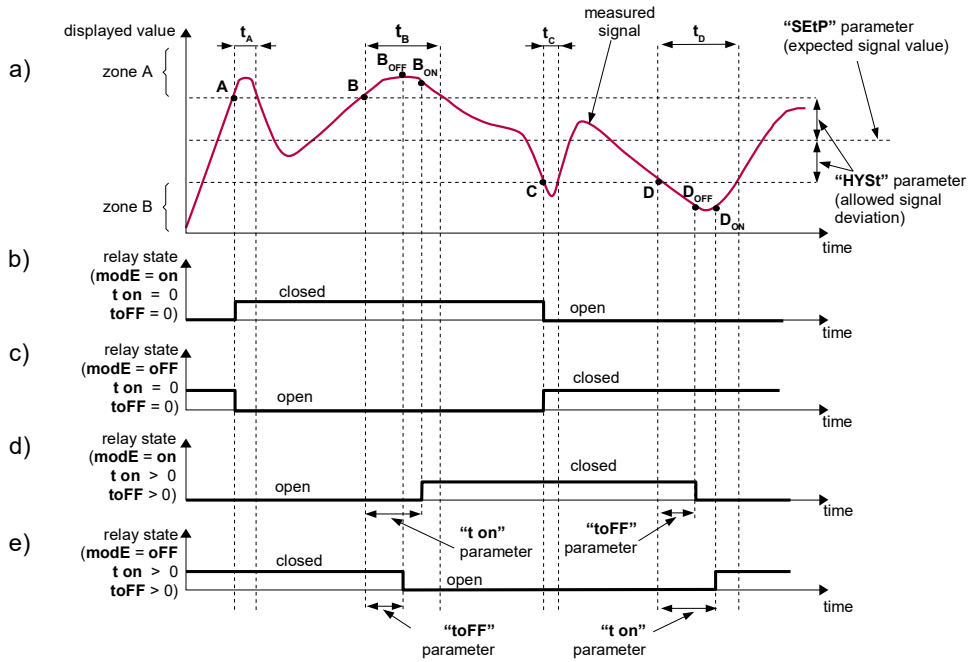


Figure 6.11. Two threshold control of the relay/LED outputs

The relay outputs and LEDs (named **R**) can be controlled depend on both - the current value and the peak value (when peak detection is active) of the input signal.

6.3.1. One threshold mode

Figure 6.12 presents the principle of relay outputs operation for one threshold mode for an example values of other parameters.



Description:

A, B, C, D	- points where measured signal exceeds border values (expected value ± allowed deviation)
B_{ON} ,B_{OFF} ,D_{ON} ,D_{OFF}	- relays state changes moments: (for **"t on"** > 0, **"toFF"** > 0)
t_A , t_B , t_C , t_D	- time periods while input signal is in zone A or zone B

Figure 6.12. Principle of LED/relay output operation for one threshold mode

Parameter **"SEtP"** sets a **threshold** of the relay, and parameter **"HYSt"** sets a **hysteresis** of the relay (**Figure 6.12a**). The relay can change his state only when input value exceeds (over or under) border value and t_A ,t_B ,t_C ,t_D times (**Figure 6.12**) are bigger than the time defined by parameters **"t on"**, "**toFF**" and "**unit**". ***Border values*** means values equal ***threshold+hysteresis*** and ***threshold-hysteresis*** respectively.

If **"t on"** and **"toFF"** parameters are set to "**0**", then the relay state will be changed **as soon** as input value exceeds any of the ***border values*** (see points A and C, **Figure 6.12 a, b, c**).

If values of **"t on"** or/and **"toFF"** are positive, then relay state will be turned on if the input value exceeds the ***border values*** and stay bigger (or lower) during at least **"t on"** (see points B_{ON}, D_{ON}, **Figure 6.12 a, d, e**). Similarly, the relay will be turned off if time **"toFF"** elapse since the input signal value exceeds any of the ***border values*** (see points B_{OFF}, D_{OFF}, **Figure 6.12a, d, e**).

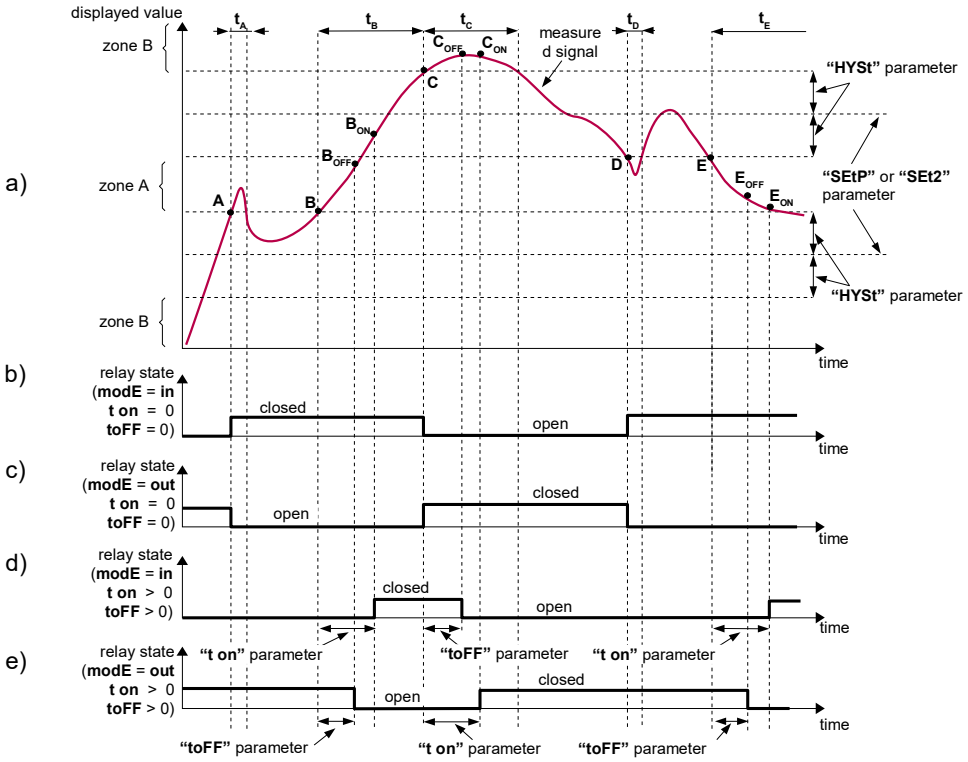
If time t_A ,t_B ,t_C ,t_D (when input signal stay in ***zone A*** or ***zone B***) are lower than parameters "**t on**" or "**toFF**", the relay will not change his state (see points A and C, **Figure 6.12 a, d, e**).

The state of relay output while the input value exceeds the ***border values*** (points A, B, C, D) is described by parameter **"modE".** The relay can be turned on (**"modE"** = **"on"**), or turned off (**"modE"** = **"oFF"**) when input signal value is contained in ***zone A*** (**Figure 6.12a**).

The parameter **"AL"** allow user to set the relay output behaviour in critical situations (e. g. input values exceeds ***permissible measurement range***). User can select that the relays will be turned on, turned off,or not changed in critical situations.

All parameters connected with relay outputs are described in paragraph **7.3.1. "1 rEL" menu.**

6.3.2. Two thresholds mode



Objaśnienie:

A, B, C, D, E - points where measured signal exceeds border values (expected value ± allowed deviation)

B_{ON} ,B_{OFF} ,C_{ON} ,C_{OFF} ,E_{ON} ,E_{OFF} - relays state changes moments: (for **"t on"** > 0, **"toFF"** > 0)

t_A , t_B , t_C , t_D , t_E - time periods while input signal is in zone A or zone B

Figure 6.13. Principle of LED/relay output operation for two thresholds mode

Figure 6.13 presents the principle of relay outputs operation for two thresholds mode for an example values of other parameters. In this mode parameter **"SEt2"** is accessible in common with **"SEtP"**, this parameter describes a second threshold of the relay output. The parameters **"HYSt"**, **"modE"**, **"t on"**, **"toFF"**, **"unit"** and **"AL"** are connected with both **"SEtP"** and **"SEt2"** thresholds. While the controlling process, the relay output changes his state depends of both **"SEtP"** and **"SEt2"** thresholds in similar way as it was described in one threshold mode.

If two threshold mode is used, **"modE"** parameter defines state of the relay output when the input value occurs in a particular zone defined by ***border values*** of both **thresholds**. The relay can be turned on if the input value is contained in ***zone A*** (**"modE"** = **"in"**) or ***zone B*** (**"modE"** = **"out"**) and turned off if it is contained in the second one (**Figure 6.13**).

The sequence of thresholds "**SEtP**" and "**SEt2**" can be set in any order, due to the control of relay outputs is done depend on difference between thresholds values (**zone A**) and outside of threshold values (**zone B**).

6.3.3. PWM Controlling

In devices equipped with the OC type output, the user can switch this output to the special **"PULS"** mode. This mode allows the user to adjust the output pulse width (Pulse Width Modulation) by means of a source signal defined in the parameter **"Sour"** and the parameter settings **"InLo"**, **"InHi"**, **"PEri"**, **"H on"**, **"HoFF"** and **"AL"** (for the exact description of these parameters, see chapter **7.3.1. "1 rEL" menu**).

PWM allows the user to change the width (duration) of high and low levels by defining the range of the input signal (in **"InLo"** and **"INHi"** parameters), the duration of this signal (**"PEri"** parameter) and the source value (**"Sour"** parameter). The input signal, changing within this range, will linearly vary the percentage share of the high status over the entire period of the signal in accordance with fill factor **D**. In those cases where the source value is less than the value of the **"InLo"** parameter, the fill is equal to **0**% (i.e. the output signal will always be in low level state), and when the source value is greater than the value of the **"INHi"** parameter the fill will be equal to 100% (i.e. the output signal will always be in high level state).

Factor **D** is defined by the following formula:

$$D = \frac{t}{T}$$

where:

t – the duration of the high status for a single pulse,

T – the duration of the signal.

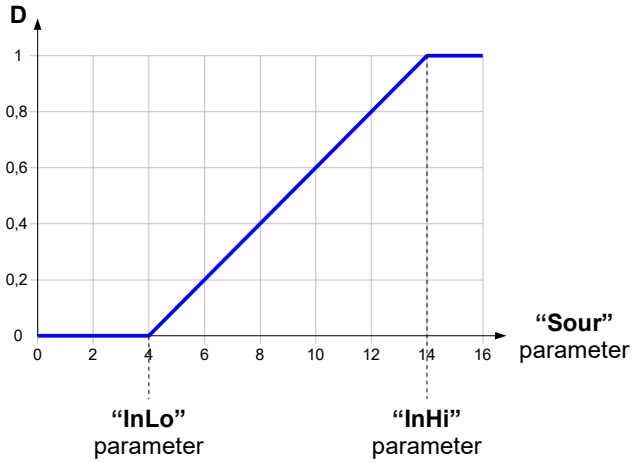


*Figure 6.14. Example characteristics of an input - output signal in the **"PULS"** mode **for parameters: “InLo”** = 4, **“InHi”** = 14*

There is also a possibility of protecting the signal from too high or too low fill factor, by inserting the parameters **"H on"** and **"HoFF"**. These specify the minimum duration of the high signal and low signal respectively. When setting the output status, the parameters **"H on"** and **"HoFF"** have a higher priority than the fill factor.

It should be noted that the sum of the values of the parameters **"H on"** and **"HoFF"** does not exceed the value of the parameter **"Peri"**, since this will cause the OC output to move to a low status.

The **"AL"** parameter specifies the permanent fill (as a percentage) that is to be forced on the output at the time of an alarm, regardless of the state of the source value.

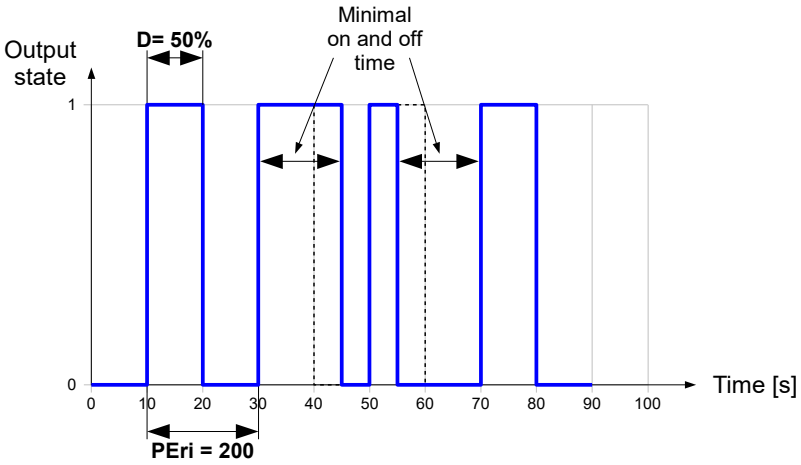


Figure 6.15. An example of the progress of an OC type PWM output signal in PULS mode

7. DEVICE PROGRAMMING

The device menu allow user to set all parameters connected to operation of measurement input, control modes, critical situations behaviour, communication via RS-485 and access settings. The meaning of the particular parameters is described in chapter **7.3. MENU DESCRIPTION**.

Some of the parameters can be accessed without menu entering (quick view mode). On SV display is showing the controller **SEtP** value. After pressing one of **[^]** or **[v]** button and after pressing button **[ENTER]** user can change his value directly. If a ***free access*** is enabled (see chapter **7.3.11. "SECu" menu**), user can change the value of selected threshold (**[^]** or **[v]** button) and pressing button **[ENTER]** (see chapter **7.2. PARAMETERS EDITION**). After again pressing **[^]** or **[v]** button is displayed thresholds set relays and threshold of alarm **AL**. If none button in 5 sec. will not be pressed, the device returns to showing the controller **SEtP** value on the SV display.

7.1. PROGRAMMING MENU

To enter main menu (being in the measurement mode) user must to press and hold at least 2 sec. **[ESC/MENU]** button.

If the user password is defined (see parameter **"Scod"**, menu **"*SECU"***), operator have to enter correct one before proceeding to menu options . Entering of the passwords is similar to the edition of numeric parameters (see chapter **7.2. PARAMETERS EDITION**), however presently editing digit is showed only on the display, other digits are replaced by "-" sign. After entering of last digit of the password first menu position will be displayed (if the password is correct) or warning "**Err**" in other case.

Pay attention when device parameters are being changed. If it is possible, turn off controlled installation (machine).

Functions of the buttons while sub-menu and parameters choice:

Selection of sub-menu or parameter for editing. Name of selected item (sub-menu or parameter) is displayed.

Operation of **[ENTER]** button depend on present menu position:
- if the name of some sub-menu is displayed - enter this sub-menu; name of the first parameter (or next level sub-menu) is displayed,
- if the name of some parameter is displayed - enter the edition of this parameter; present value of the parameter is displayed.

[ESC/MENU] button allow user to exit present menu level and goes to upper level menu (or measurement mode).

After about 1 min. since last use of the buttons, device exits the menu mode and returns to the measurement mode (only if no parameters are in editing mode).

7.2. PARAMETERS EDITION

To start edition of any parameter user should select name of desired one using **[^] [v]** buttons and then press **[ENTER]**.

7.2.1. Numeric parameters (digit change mode)

Numerical parameters are displayed as decimal numbers. The mode of its new value entering depends on chosen edit method (see parameter „**Edit**").

In mode "by digit" ("**Edit**"="**dig**") pressing one of the keys **[^]** or **[v]** causes change of current position (flashing digit) or the sign (+/-). Short pressing of the **[ENTER]** button causes change of the position (digit).

Press **[ENTER]** at least 2 seconds to accept the changes, after that question **"SEt?"** is displayed, and user must to confirm (or cancel) the changes. To confirm changes (and story it in EEPROM) press **[ENTER]** button shortly after **"SEt?"** is displayed. To cancel the changes press **[ESC]** button shortly after **"SEt?"** is displayed. After that device returns to the menu.

7.2.2. Numeric parameters (slide change mode)

In "slide change" mode ("**Edit**"="**Slid**"), buttons **[^]** and **[v]** has different functions.

To increase edited value press (or press and hold) **[^]** button only. The increasing became quickest as long as button **[^]** is pressed. To slow down the increasing, button **[v]** can be used. If **[v]** is pressed shortly (and button **[^]** is still pressed), increasing slow down for a moment only, if **[v]** is pressed and held while button **[^]** is still pressed the increasing slow down and will be kept on lower speed.

To decrease edited value press (or press and hold) **[v]** button only. The decreasing became quickest as long as button **[v]** is pressed. To slow down the decreasing, button **[^]** can be used. If **[^]** is pressed shortly (and button **[v]** is still pressed), decreasing slow down for a moment only, if **[^]** is pressed and held while button **[v]** is still pressed the decreasing slow down and will be kept on lower speed.

Press **[ENTER]** at least 2 seconds to accept the changes, after that question **"Set?"** is displayed, and user must to confirm (or cancel) the changes. To confirm changes (and story it in EEPROM) press **[ENTER]** button shortly after **"SEt?"** is displayed. To cancel the changes press **[ESC]** button shortly after **"SEt?"** is displayed. After that device returns to the menu.

7.2.3. Switch parameters ("LIST" type)

Switch parameters can be described as a sets of values (a lists) out of which only one of the options available on the list can be selected for the given parameter. Options of switching parameter are selected using **[^]**, **[v]** keys.

Short pressing of **[ENTER]** causes in displaying of the acknowledge question (**"SEt?"**). If key **[ENTER]** is pressed again, the changes are accepted, stored in EEPROM end the edition process finished. Pressing the key **[ESC]** after **"SEt?"** causes in cancelling of made changes and returning to menu.

Functions of buttons when editing numeric and switching parameters:

While editing numeric parameter:
- change of current (flashing) digit,
- slide change of value (acceleration, deceleration, direction change).

While editing switch parameter - selection of switch parameter.

If numerical parameter is being edited, a short press of **[ENTER]** button change edited position. A long press of **[ENTER]** button (at lest 2 sec.) causes of display a **"SEt?"** ask, which allow user to make sure if change of the parameter value is correct. If switch parameter is being edited, a short press of **[ENTER]** button causes of display a **"SEt?"** ask. When **[ENTER]** button is pressed again (while **"SEt?"** is displayed) the new value of the parameter is stored in EEPROM memory.

Pressing this button operator can cancel the changes done up to now (if they were not approved by **[ENTER]** button after the **"SEt?"** ask) and come back to menu

7.3. MENU DESCRIPTION

"- - - -" - password checking. If some password different from "**0000**" is set, then every enter to main menu follows the entering of password. If entered password is correct then first menu position will be displayed else warning "**Err**", and unit returns to measurement mode.

Due to problem with direct displaying of "**m**" and "**K**" letters, they are exchanged with special signs " ⊓ " for "m" and " ⊢ " for "K" respectively. However, in user manual letters "**m**" and "**K**" are used to make it more readable (example: **"modE", "tc K"**).

7.3.1. "1 rEL" menu

This menu allows to configure the operation mode of relays and LEDs marked „**R**" (e.g. „**R1**").

If there are few relay outputs available, then every output has its own configuration menu (e.g. menu "**2 rEL**" for relay (LED) "**R2**"). Principle of the relays operation is described in paragraph ***CONTROL OF THE RELAY OUTPUTS***.

- The relay outputs and LEDs (named **R**) can be controlled depend on both - the current value and the peak value (when peak detection is active) of the input signal.
- If device is not equipped with one or more relay outputs, menus refer to this relays are available, but apply to LED indicators only. In such case LEDs indicates exceeding of particular thresholds.

"Sour" - this parameter specifies the source of the signal controlling the output.
- ***"InPU"*** - output is controlled using signals from the measurement input,
- ***"modb"*** - control via Modbus registers,
- ***"PidH"*** - control via the control loop of the **PidH** controller,
- ***"PidC"*** - control via the control loop of the **PidC** controller,

***"*modE"** - relay operation mode.

- ***"noAC"*** - the relay is not active (permanent turned off),
- **"on"** - one threshold mode, the relay is turned **ON** when input signal exceeds **SEtP + HYSt** value**,** and is turned **OFF** back when the input signal became lower than **SEtP – HYSt**,
- **"oFF"** - one threshold mode, the relay is turned **OFF** when input signal exceeds **SEtP** + **HYSt** value**,** and is turned **ON** back when the input signal became lower than **SEtP – HYSt**,
- **"in"** - two threshold mode, the relay is turned **ON** when the input signal is bigger than "**lower threshold** + **HYSt**" and lower than "**bigger threshold – HYSt**", and turned **OFF** when the input signal is contained in the second zone. The **bigger threshold** means bigger one of **"SEtP"** and **"SEt2"** thresholds, the **lower threshold**" means lower one of **"SEtP"** and **"SEt2"** thresholds,
- **"Out"** - two threshold mode, relay is turned **ON** when the input value is bigger than "**bigger threshold + HYSt**" or lower than "**lower threshold – HYSt**", and turned **OFF** when the input signal is contained in the second zone. The **bigger threshold** means bigger one of **"SEtP"** and **"SEt2"** thresholds, the **lower threshold** means lower one of **"SEtP"** and **"SEt2"** thresholds,
- ***"PULS"*** - available only for OC-type output. Turns on PWM mode for OC-type output.

"SEtP" - first threshold of the relay (range -999 ÷ 9999). Negative values can be input by selecting a "**-**" sign on first digit (to change value use **[^]** and **[v]** buttons). **Threshold is the medium value of relay hysteresis**.

"SEt2" - second threshold of the relay (range -999 ÷ 9999). Negative values can be input by selecting a "-" sign on first digit (to change value use **[^]** and **[v]** buttons). This

threshold is accessible when **"modE"** parameter is set to **"in"** or **"out"** value. **Threshold is the medium value of relay hysteresis.**

"HYSt" - hysteresis of relay (range 0 ÷ 999). Full hysteresis of the relay is equal to 2 times **"HYSt"** parameter. The relay state can change when an input signal is out of **threshold-hysteresis** to **threshold+hysteresis** zone.

Presented parameters should be set to ensure that **"SEtP" + "HYSt", "SEt2" + "HYSt", "SEtP" - "HYSt"** or **"SEt2" - "HYSt"** does not exceed the measure range. Additionally, in two threshold mode (**"modE"**= **"in"** or **"out"**), the hysteresis for both thresholds must not cover each other (in other case relay can't change his state).

- **LEDs light when relays are closed**, independently of relays' mode.
- When power supply fail, unit do not store relays state selected by RS-485 interface.

"OFFS" - this parameter specifies the difference between the setpoint value to the controller and the signal measured by the device, which will cause an output response to that signal,

"SEnS" - this parameter specifies what percentage of the controller's output status must be achieved in order for the output to react to the status of the controller,

In a situation where the parameters **"OFFS"** and **"SEnS"** are other than zero, the controller only responds to the signal when the conditions described for both of these parameters are met simultaneously.

"t on" - turn on delay time, the relay is turned **ON** with delay equal **"t on"** if the input value exceeds appropriate ***border value*** (defined with ***threshold*** and ***hysteresis***), at least **"t on"** time. **"t on"** range 0 ÷ 99.9, defined with 0.1 sec. resolution. Unit of this parameter is set by **"unit"** parameter,

"toFF" - turn off delay time, the relay is turned **OFF** with delay equal **"toFF"** if the input value exceeds appropriate ***border value*** (defined with ***threshold*** and ***hysteresis***), at least **"toFF"** time. **"toFF"** range 0 ÷ 99.9, defined with 0.1 sec. resolution. Unit of this parameter is set by **"unit"** parameter,

If time when the input signal exceeds some border value is shorter than **"t on"** or **"toFF"** time, the relay do not change its state (see paragraph: **6.3. CONTROL OF THE RELAY OUTPUTS**).

"unit" - unit of time for **"t on"** and **"toFF"** parameters. Can be set on one of two values:
"min" - minutes,
"SEC" - seconds,

The above-mentioned parameters do not occur when the "**modE"** parameter is set to **"PULS"**. In such a configuration the user has at his disposal the parameters: **"InLo", "INHi", "Peri", "H on"** and **"HoFF"**.

"InLo" - the lower limit of the range within which a change in the signal source causes a change in the PWM output signal fill factor. Below this limit the PWM output signal will have the fill factor equal to 0%,

"InHi" - the upper limit of the range within which a change in the signal source causes a change in the PWM output signal fill factor. Above this limit the PWM output signal will have the fill factor equal to 100%,

"PEri" - the duration of one cycle of the PWM output signal in the range 0 ÷ 999.9 s,

"H on" - low state minimal time,

"HoFF" - high state minimal time,

To ensure proper operation, the sum of the values of the **"H on"** and **"HoFF"** parameters should not exceed the value of the **"Peri"** parameter.

The duration of the high and low status (parameters **"H on"** and **"HoFF"**) are calculated for each period (the **"Peri"** parameter) separately.

"AL" - this parameter defines how the relay reacts to an alarm state.
The following options are available:

"noCH" - relay do not change his state,
"on" - relay will be turned on,
"oFF" - relay will be turned off,
"Acti" - this occurs only when the **"modE"** parameter is set to **"PULS"**; it turns on and disables responses to alarm state for the OC type output,

"noCH" - the output status does not change during alarm state,
"USdu" - in an alarm state the output sets itself to the fill factor as set in the **"duty"** parameter

"duty" - this occurs only when the **"modE"** parameter is set to **"PULS"**; it specifies the fill factor in the event of an alarm state,

If parameter **"modE"** is set to **"on"** , **"oFF"**, **"in"**, **"Out"** or **"PULS"** the "critical situation" means that allowable measurement range is exceeded.

- If option **"noCH"** is selected for **"AL"** parameter, behaviour of the relay may depend on "**FiLt**" parameter in some cases. If "**FiLt**" is set to big value and the input signal drops, result value of the measure will change slow, causing turning **ON** or **OFF** relay due to thresholds values. The critical situation is slowly detected, so it is impossible to predict the relay state in that situations.
- If parameter "**AL**" = "**on**", the relay will be turned on in the critical situations, even if his parameter "**modE**" = "**noAC**".

7.3.2. "bEEP" menu

This menu contains options connected with acoustic signal.

"AL" - if this parameter is set to "**on**", any critical situation causes acoustic signal
"1 rEL" - if this parameter is set to "**on**", activation of relay **R1** causes acoustic signal
"2 rEL" - if this parameter is set to "**on**", activation of relay **R2** causes acoustic signal
"3 rEL" - if this parameter is set to "**on**", activation of relay **R3** causes acoustic signal
"4 rEL" - if this parameter is set to "**on**", activation of relay **R4** causes acoustic signal

Acoustic signal (turned on by e.g. relay) can be turned off by pressing of any button

7.3.3. "inPt" menu (common parameters)

This menu presets the measurement input.

"**tYPE**" - type of the input / sensor. This parameter can be set to values:

"0-20" - current input - range 0..20 mA,
"4-20" - current input - range 4..20 mA,

"0-5" - voltage input - range 0..5 V,
"1-5" - voltage input - range 1..5 V,
"0-10" - voltage input - range 0..10 V,
"2-10" - voltage input - range 2..10 V,

"60" - voltage input - range 0..60 mV,
"75" - voltage input - range 0..75 mV,
"100" - voltage input - range 0..100 mV,
"150" - voltage input - range 0..150 mV,

"Pt 1" - Pt 100 input,
"Pt 5" - Pt 500 input,
"Pt10" - Pt 1000 input,

"tc k" - thermocouple input, type K,
"tc S" - thermocouple input, type S,
"tc J" - thermocouple input, type J,
"tc t" - thermocouple input, type T,
"tc n" - thermocouple input, type N,
"tc r" - thermocouple input, type R,
"tc b" - thermocouple input, type B,
"tc E" - thermocouple input, type E.

For current and voltage inputs displayed values are defined by parameters **"Lo C"**,**"Hi C"** (or by user defined characteristic points) and parameter **"Pnt"**.

"FiLt" - option allows to change the filtration time constant. Expressed in seconds. Acceptable values range from 0 (no filtration) to 255.

7.3.4. "inPt" menu (parameters of temperature inputs)

"Conn" - connection method of RTD input. This parameter can be set to values:
- ***"4 in"*** - 4-wire method,
- ***"3 in"*** - 3-wire method,
- ***"2 in"*** - 2-wire method.

"toFS" - offset expressed in °C, range ± 9.9°C (for RTD input) or ± 99°C (for TC input). This parameter allows shifting of measurement scale, and express value added to calculated (measured) result.

The offsetting of a scale is realised independently of cold ends automatic compensation.

7.3.5. "inPt" menu (parameters of current and voltage inputs)

"CHAr" - this option presets type of the conversion characteristic, and can be set to:
- ***"Lin"*** - linear
- ***"Sqr"*** - square
- ***"Sqrt"*** - square root

} When one of those characteristics is chosen display range is defined by **"Lo C"** and **"Hi C"**,

"USEr" - user defined characteristic. Maximal length 20 points. Every point is defined by user. Adding, Editing and Deleting of points is done by options „**AddP**", „**EdtP**", „**dELP**" („**InPt**" menu) respectively.

If user defined characteristic is selected, and if number of defined points is lower than 2 then warning "**Errc**" is displayed in measurement mode.

The process of displayed result calculation is described in details in ***DISPLAY VALUES CALCULATION*** paragraph.

"Pnt" - decimal point position. It can be set to one of:
" 0", " 0.0", " 0.00", "0.000"
Decimal point position is changed by **[^]**, **[v]** buttons,

"Lo C" These parameters describe the values displayed for minimum and maximum input **"Hi C"** current. For example, if input type is set to 4-20 mA **"Lo C"** parameter defines the value displayed when input current is equal 4 mA, and **"Hi C"** parameter defines the value displayed for 20 mA of input current. Available range for these parameters: -999 ÷ 9999. Negative values can be set by entering **'-'** sign on the first position (by use of **[^]**, **[v]** buttons).

If user defined characteristic is selected (parameter **"CHAr"** = **"USEr"**) the parameters „**Lo C**" and „**Hi C**" are not available for modification, due to their values are calculated from defined characteristic.

"AddP" - this menu allows the user to add single point to the user defined characteristic. After selection of this option device waits for „**X**" and „**Y**" coordinates of new point. Modification of the coordinates is done accordingly to numerical parameters edition. Coordinate „**X**" defines the percentage ratio of input current to selected current range. The „**X**" range: -99,9 ÷ 199,9. Coordinate „**Y**" defines displayed value for particular „**X**" value. The „**Y**" value can be changed in range: -999 ÷ 9999, decimal point position depend on **„Pnt"** parameter (menu **"inPt "**).

- User can not enter two points with the same value of „**X**" coordinate. If user trays to do it, **"Err"** warning is displayed. To modify any defined point use **"EdtP"** option.
- To distinguish „**X**" and „**Y**" coordinates, if „**X**" coordinate is displayed an additional decimal point on utmost right position is displayed.
- If user defined characteristic is selected, and if number of defined points is lower than 2 then warning "**Errc**" is displayed in measurement mode.

"dELP" - this option allows user to delete any of the points of the user defined characteristic. After selection current number of points of the user defined characteristic is displayed for about approx. 1.5 sec. After that device waits for selection of point being deleted (by **[^]**, **[v]** buttons). The short pressing of **[ENTER]** button causes switching between **X** and **Y** value of the displayed point. The long press (press and hold at least 2 sec) of **[ENTER]** button causes displaying **„dEL?"** ask. If **[ENTER]** button is pressed again, current point is deleted and new updated number of points of the user defined characteristic is displayed.

"EdtP" - this option allows user to modify of particular point of the user defined characteristic. After selection current number of points of the user defined characteristic is displayed for about approx. 1.5 sec. After that device waits for selection of point being edited (by **[^]**, **[v]** buttons). The short pressing of **[ENTER]** button causes switching between **X** and **Y** value of the displayed point. The long press (press and hold at least 2 sec) of **[ENTER]** button causes entering to edit the selected coordinate of the point. Modification of the coordinates is done accordingly to numerical parameters edition.

"AddP", **"dELP"** and **"EdtP"** options are available only if the user defined characteristic is used (it means when parameter **"CHAr"** = **"USEr"**).

"Lo r", **"Hi r"** - these parameters define the expansion of nominal range in percent. They determine the permissible range of input signal (**Figure 7.1**).

The permissible range allow user to exceed the ***nominal range*** of input signal. If input value is contained in the permissible range a proper result is displayed. If input signal exceeds this range (defined by **"Lo r"** and **"Hi r"**), **"-Lo-"** or **"-Hi-"** warning is displayed depend on input signal value.

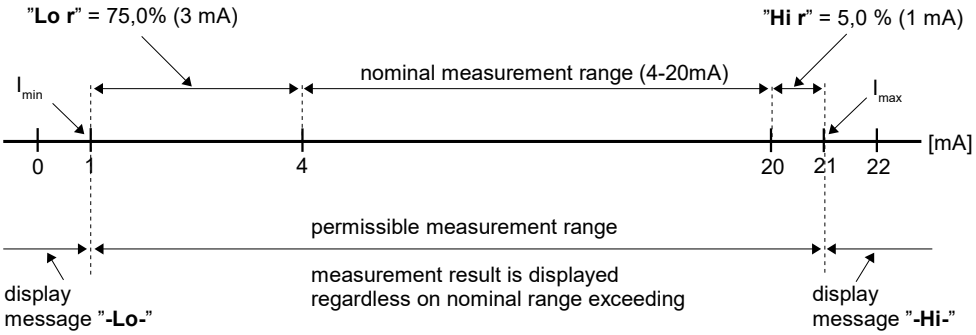


*Figure 7.1 Example of definition of permissible range of input signal - "**Lo r**" and "**Hi r**" parameters (**"4-20"** mode)*

The **"Lo r"** parameter is important if input is set to **"4-20"**, **"1-5"** or **"2-10"** mode only, and determines lower border of the permissible range. In the other cases (for current and voltage ranges), lower border of the permissible range is always 0.
For example if input is set to **"4-20"** mode, then lower border is calculated due to expression: I_{min} = 4 mA - 4 mA × **"Lo r"** %.
The **"Lo r"** value can be set from 0 to 99.9%.
Parameter **"Hi r"** determines the upper border of the permissible range accordingly to the expression (for all modes).
For example if input is set to **"4-20"** mode, then upper border is calculated due to expression: I_{max} = 20 mA + 20 mA × **"Hi r"** %.
The value of **"Hi r"** can be set from 0 to 19.9%

In example No. 1 of the ***DISPLAY VALUES CALCULATION*** paragraph the procedure of the permissible input range determining is presented in details.

If the measurement value do not exceeds ***permissible measurement range*** but displayed value exceeds range -999 ÷ 9999, the warning **"-Ov-"** is displayed rather than the calculated result.

7.3.6. "OutP" menu

This menu contains parameters of analogue output control. Menu is available if the device is equipped witch analogue output.

Analogue output can be controlled depend on both present measured value and peak value (if peak detection is enabled).

"OSou" - the source for the analogue output.

- ***"InPU"*** - the output is controlled using signals from the measurement input,
- ***"modb"*** - the output is controlled using Modbus registers,
- ***"PidH"*** - the output is controlled by the positive part of the PID controller's characteristics,
- ***"PidC"*** - the output is controlled by the negative part of the PID controller's characteristics,

"Omod" - analogue output mode. Depending on version of the device there are following options:

For active current output:
- *"**oFF**"* - current output disabled,
- *"**4-20**"* - current output enabled with 4 ÷ 20 mA mode,
- *"**0-20**"* - current output enabled with 0 ÷ 20 mA mode,

For passive current output:
- *"**oFF**"* - current output disabled,
- *"**4-20**"* - current output enabled with 4 ÷ 20 mA mode,

For active voltage output:
- *"**oFF**"* - voltage output disabled,
- *"**0-5**"* - voltage output enabled with 0 ÷ 5V mode,
- *"**1-5**"* - voltage output enabled with 1 ÷ 5V mode,
- *"**0-10**"* - voltage output enabled with 0 ÷ 10V mode,
- *"**2-10**"* - voltage output enabled with 2 ÷ 10 V mode,

"OUtL" - this parameter defines the value for which the output signal is equal to the **lower** limit of the defined range (according to chosen mode of operation of the "**Omod**" output).

It depends on the source of the analog output:
- for the source type "**InPU**" this is the display value,
- for the source type "**PidH**" or "**PidC**" is percentage value of the PID alghorithm's output,

"OUtH" - this parameter defines the value for which the output signal is equal to the **upper** limit of the defined range (according to chosen mode of operation of the "**Omod**" output).

It depends on the source of the analog output:
- for the source type "**InPU**" this is the display value,
- for the source type "**PidH**" or "**PidC**" is percentage value of the PID alghorithm's output.

The analogue output value is calculated due to formula given below:

$$Out = \frac{W - "OUtL"}{"OUtH" - "OUtL"} \times (B - A) + A$$

where: **W** – displayed value,
Out – analogue output value,
B – higher range limit (20mA / 5V / 10V),
A – lower range limit (0mA / 4mA / 0V / 1V / 2v),

"**OutL**" parameter can be greater than "**OutH**". In this case the conversion characteristic is reversed, it means that if input value raises the output value falls.

"**Lo r**", "**Hi r**" - this parameters define the output value range. If calculated output value **Out** exceeds defined range then analogue output generates signal equal to the upper or lower limit of the defined range. These parameters defines the percentage extension of nominal analogue range (with 0,1% resolution).

Parameter "**Lo r**" defines lower border of the range due to formula:
$\mathbf{Out}_{min}$ = **A** - (**A** × "**Lo r**" %), where:
A – lower signal value range limit.

This parameter can be set from 0 to 99.9% (for active current output and active voltage output) or from 0 to 29.9% (for passive current output).

Parameter **"Hi r"** defines higher border of the range due to formula:
$\mathbf{Out}_{max}$ = **B** + (**B** × "**Hi r**" %), where:
B – higher signal value range limit.
This parameter can be set from 0 to 19.9% (for active and passive current output) or from 0 to 9.9% (for active voltage output).

In example on page **60** of the **DISPLAYED VALUES CALCULATION** paragraph the procedure of the analogue outputs determining is presented in details.

"**AL**" - this parameter determines the behaviour of analogue output if any critical situation occurs. According to version of the device, this parameter can be set:

For active current output:
- ***"noCH"*** - current will not change,
- ***"22.1"*** - current will be set to 22.1 mA,
- ***"3.4"*** - current will be set to 3.4 mA,
- ***"0.0"*** - current will be set to 0 mA,

For passive current output:
- ***"noCH"*** - current will not change,
- ***"22.1"*** - current will be set to 22.1 mA,
- ***"3.4"*** - current will be set to 3.4 mA,

For active voltage output:
- ***"noCH"*** - voltage will not change,
- ***"11.0"*** - voltage will be set to 11 V,
- ***"5.5"*** - voltage will be set to 5.5 V,
- ***"1.2"*** - voltage will be set to 1.2 V,
- ***"0.6"*** - voltage will be set to 0.6 V,
- ***"0.0"*** - voltage will be set to 0 V.

When the critical situation goes, the output signal will be set to value calculated due to formulas given above.

7.3.7. "CtrL" Menu

The menu includes configuration options for the control loops of the PID controller featured in the device.

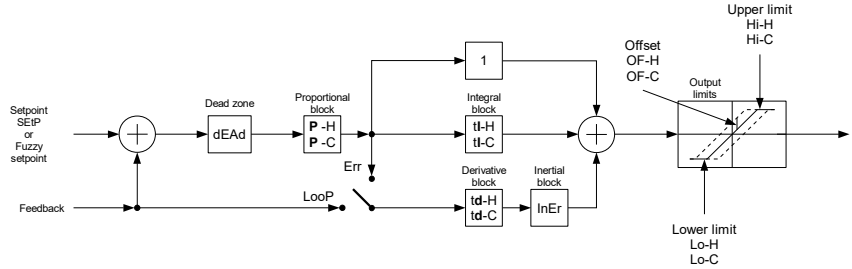


Figure 7.2. General diagram of the PID controller featured in the **PUR-99** device

"modE" - operating mode of the controllers.

- **"oFF"** - the controller is switched off. Outputs of control loops are set at idle, but all their parameters are available for configuration,
- **"Pid"** - normal operating mode of the controller,
- **"At-F"** - the auto-tuning procedure for one of the control loops of the controller in an arrangement with two actuator elements. Selection of the control loop to be tuned depends on the setting of the **SetP** parameter. Following this procedure, the device automatically switches to **PiD** mode,
- **"At-H"** - the auto-tuning procedure for the **PiD-H** loop in an arrangement with a single actuator element. Once completed, the device automatically switches to **PiD** mode,
- **"At-C"** - the auto-tuning procedure for the **PID-C** loop in an arrangement with a single actuator element. Once completed, the device automatically switches to **PiD** mode,

"SEtP" - the setpoint of the controllers. The initial state of the controlled object to which the controllers will progress,

"PArH" - **PID-H** control loop coefficients,

- **"H P"** - proportional gain factor **P** (expressed in thousandths of units e.g. value "**1234**" in "**P -H**" parameter means **0.1234** of **P** factor),
- **"H tI"** - integral gain factor **I**,
- **"H td"** - derivative gain factor **D**,
- **"H OFFS"** - value by which control loop limitations are shifted,
- **"H Lo"** - lower limit of the control loop's characteristics,
- **"H Hi"** - upper limit of the control loop's characteristics,

"PArC" - **PID-C** control loop coefficients,

- **"C P"** - proportional gain factor **P** (expressed in thousandths of units e.g. value "**1234**" in "**P -C**" parameter means **0.1234** of **P** factor),
- **"C tI"** - integral gain factor **I**,
- **"C td"** - derivative gain factor **D**,
- **"C OFFS"** - value by which control loop limitations are shifted,
- **"C Lo"** - lower limit of the control loop's characteristics,
- **"C Hi"** - upper limit of the control loop's characteristics,

“ConF” - input settings of the controller.

“dEAd” - width of the dead zone. For the definition of the dead zone, see chapter **6.2. PID REGULATORS**,

“StAr” - the parameter (expressed in %) allowing to set the controller’s output status at the time of launch, depending on the controller’s output parameters,

“dSrC” - this parameter defines how to interpret the feedback used to calculate the controller’s response,

“Err” - used for calculations is the output of the controlled object following prior calculation of the error at the controller’s input and a check on the condition of the controller’s operation as a result of dead zone range being exceeded,

“LooP” - used for calculations is the object's output without calculating the error on the controller’s input or taking into account the dead zone,

“InEr” - the settings of the inertial block. For the definition of the inertial element refer to chapter **6.2. PID REGULATORS**,

$$Iner = \frac{e^{-\frac{t}{T}}}{T}$$

where: **Iner** – response of the inertial block,
t – successive moments in time,
T – the inertia factor specified by the parameters:

“oFF” - inertia is disabled. The **Iner** block = 1,
“HArd” - factor T = 0,07,
“mEdi” - factor T = 0,14,
“SoFt” - factor T = 0,21,

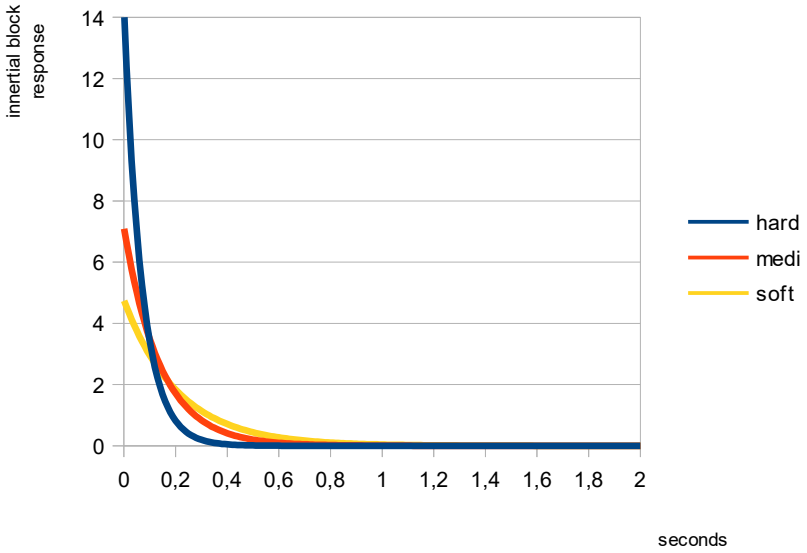


Figure 7.3. Responses of the inertial block depending on factor T

“FUZL” - an additional fuzzy logic block. It enables a smooth change of the setpoint for the soft control of the object,

“SLOP” - this parameter specifies the change in the setpoint fuzzy logic block, for every unit specified in the parameter as **"unit"**. Setting a "0" value disables the fuzzy logic block,

“unit” - this parameter specifies the unit of time in which the setpoint of the fuzzy logic block will increase,

“HySt” - the difference between setpoint specified for the controller (specified in the **"SEtP"** parameter) and the setpoint of the fuzzy logic block, to which the setpoint of the fuzzy logic block will seamlessly progress,

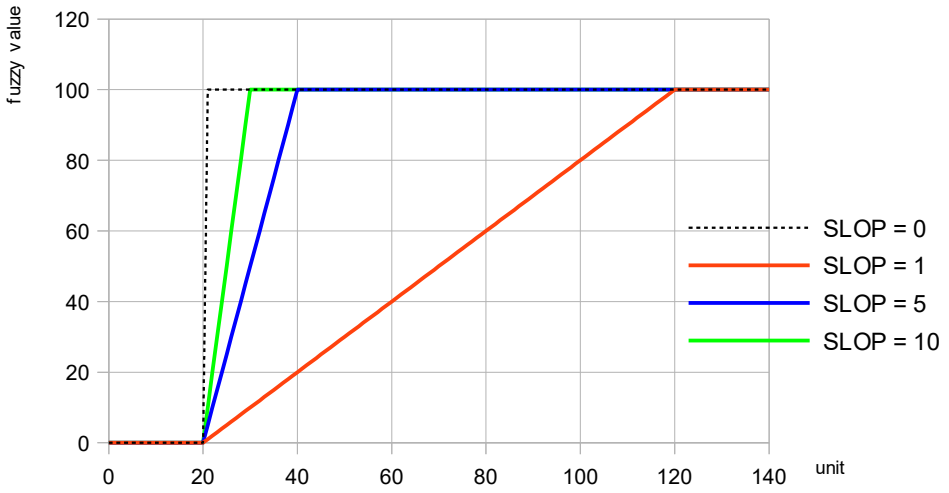


Figure 7.4. Change in the fuzzy setpoint depending on the setting of the **SLOP** parameter

7.3.8. ”bri” parameter

This parameter allows the user to set brightness of the LED display, brightness can be set to conventional values from 1 to 8.

7.3.9. ”HOLd” menu

This menu contains parameters connected with peak detection function. See also full description of the peak detection function in paragraph: **DETECTION OF THE PEAK VALUES**.

“modE” - the type of detected changes of the input signal, can be set to values:

”norm” - peaks: peak and next drop of the input signal of value equal at least **“PEA”**,
”inv” - drops: drop and next peak of the input signal of value equal at least **“PEA”**,

“PEA” - minimal detected signal change classified as peak or drop (see **Figure 6.4**),

“timE” - maximum time of displaying of the peak (drop) value, can be set from 0.0 to 19.9 sec, with 0.1 sec. resolution. If „**HdiS**”=”**HOLD**” then setting parameter **"timE"=0.0** causes holding peak value until **[ESC]** button is pressed. If „**HdiS**”=”**rEAL**” then value **"timE"=0.0** means no holding,

“HdiS” - type of displayed values.

”rEAL” - current value is displayed,
”HOLd” - peak (drop) value is displayed,

“H r1” ÷ “H r4”- relay/LED outputs (R1÷R4) operation mode.

”rEAL” - relay/LED operates depend on the current value,
”HOLd” - relay/LED operates depend on the peak (drop) value,

”HOUt” - current output operation mode.

”rEAL” - current output operates depend on the current value,
”HOLd” - current output operates depend on the peak (drop) value.

7.3.10. ”diSP” menu

The menu allows selection of the value displayed on the SV auxiliary display when the current measurement value is displayed on the main PV display.

”no” - nothing will appear on the SV display,

”rEL1” - on the SV display appears **SEtP** of relay **R1**, and when it is in **rEL:Mode:In** or **rEL:Mode:Out** mode, both **SEtP** and **SEt2** values will alternate,

”rEL2” - on the SV display appears **SEtP** of relay **R2**, and when it is in **rEL:Mode:In** or **rEL:Mode:Out** mode, both **SEtP** and **SEt2** values will alternate,

”rEL3” - on the SV display appears **SEtP** of relay **R3**, and when it is in **rEL:Mode:In** or **rEL:Mode:Out** mode, both **SEtP** and **SEt2** values will alternate,

”rEL4” - on the SV display appears **SEtP** of relay **R4**, and when it is in **rEL:Mode:In** or **rEL:Mode:Out** mode, both **SEtP** and **SEt2** values will alternate,

”Ctrl” - the controller **SEtP** value appears on the SV display,

”OutP” - on the SV display appears the value of the analog output, given in mA or V, depending on the type of output.

7.3.11. ”SECu” menu

This menu contains presets connected with availability of other parameters.

“Scod” - user password (4-digits number). If this parameter is set at value **“0000”**, user password is turned off.

If the user do not remember his password, the access to the menu is possible by the “one-use password”. To get this password please contact with Marketing Division. “One-use password” can be used only one time, after that it is destroyed. Entering this password causes in clearing of user password, it means sets the user password to „0000”.

The “one-use password” can be used **ONE TIME ONLY**, it is impossible to use it again! The “one-use password” can be restored by Service Division only.

“A r1 ÷ A r4” - this option permits user (**”on”**) or prohibits (**”oFF”**) to modify the thresholds

of the relays/LEDs R1 ÷ R4 without knowledge about user password.

"ACtr" - this option enables one to permit (**"on"**) or prohibit (**"oFF"**) modification of the controller's setpoint in measurement mode without knowing the user password

7.3.12. "rS" menu

This menu is connected with RS-485 interface, and sets his properties.

"Addr" - this parameter defines the address of the device, accordingly to Modbus protocol. It can be set in range from 0 to 199. If the value 0 is set then device, responds to frames with address 255 (FFh),

"bAud" - this parameter determines RS-485 interface baud rate. It can be set to one of 8 possible values: **"1.2"**, **"2.4"**, **"4.8"**, **"9.6"**, **"19.2"**, **"38.4"**, **"57.6"**, **"115.2"**, which respond to the baud rates of 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 bit/s respectively,

"mbAc" - this parameter sets the access to the configuration registers of the device. Possible values:

"on" - configuration registers can be set via RS-485 interface,
"oFF" - configuration registers can not be set via RS-485 interface.

The access to registers no 04h and 05h cant be denied by **"mbAc"** parameter (see chapter ***12.1. List of registers***).

"mbtO" - this parameter defines maximal time (sec) between following frames received by the device. If the delay will be greater than the value of **"mbtO"** parameter, the relays which are controlled via RS-485 interface, will set to alert state (see ***"OUtP" menu,*** and ***"1 rEL" menu*** description). Parameter "**mbtO**" can be set to values from 0 to 99 seconds. The value 0 means that the time will be not controlled,

"rESP" - this parameter defines minimal (additional) delay between the Modbus message and the answer of the device (received and sent via RS-485 interface). This additional delay allows the device to work with poor RS-converters which do not works properly on baud rates higher than 19200. This parameter can be set to one of values:

"Std" - answer as quick as possible, no additional delay,

" 10c"
" 20c"
" 50c"
"100c"
"200c"

- answer delayed of 10, 20, 50, 100 of 200 chars respectively, where one character time depends on selected baud rate.

In the most cases parameter **"rESP"** should be set to **"Std"** (no additional delay). Unfortunately for some third party RS-converters **"rESP"** should be adjusted experimentally. Table 7.1 contains most frequently used values.

"bAud" parameter	"38.4"	"57.6"	"115.2"
"rESP" parameter	" 10c"	" 20c"	" 50c"

*Tab.7.1. Settings of **"rESP"** parameter*

7.3.13. "Edit" parameter

This parameter allows to change the edition mode of numerical parameters.

"dig" - "by digit" change mode,
"Slid" - slide change mode.

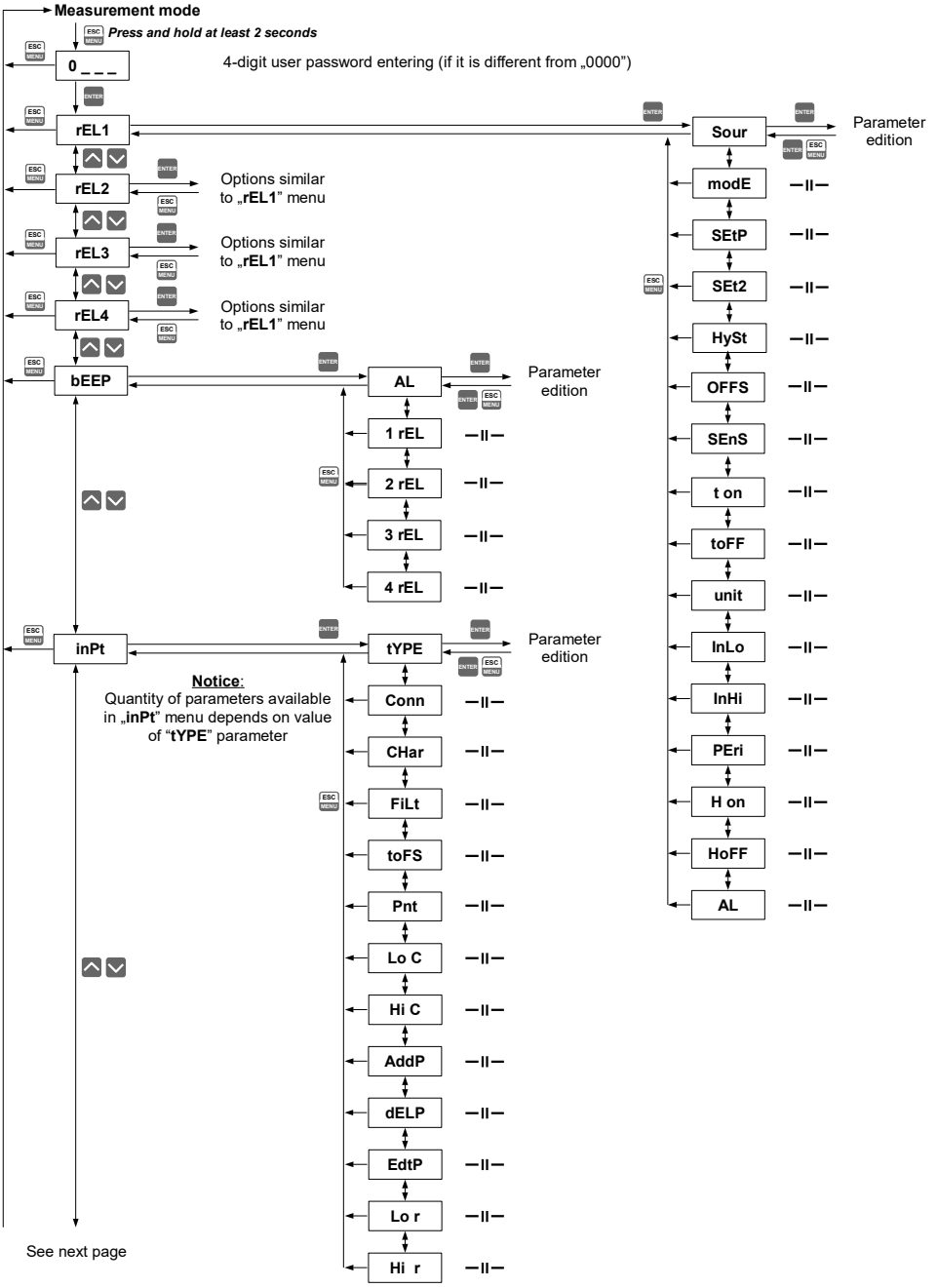
7.3.14. "dEFS" parameter

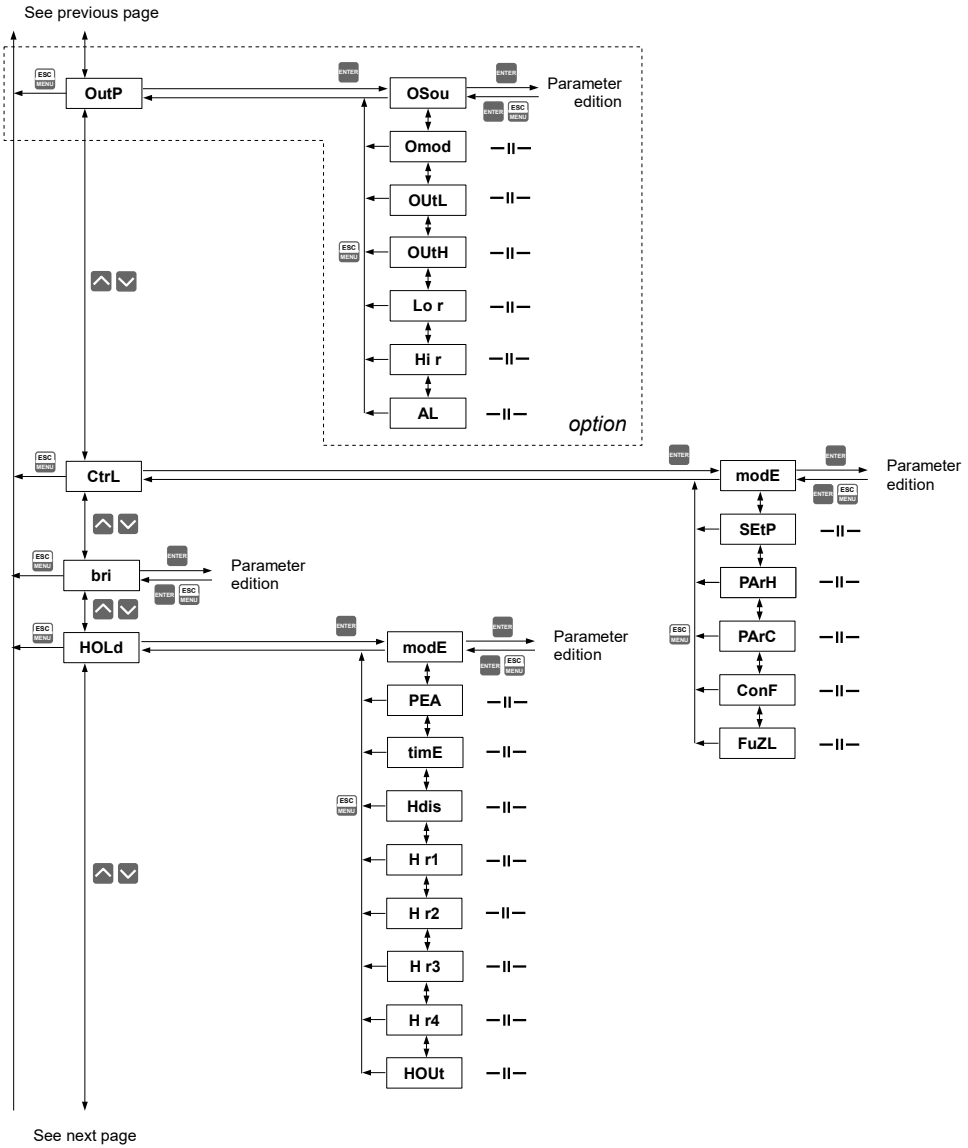
This setting allows to restore the factory settings of the device. To get the access to this option special password is required: „5465", next the device displays acknowledge question **„SEt?"**. Press **[ENTER]** to acknowledge the restoring of factory settings or **[ESC]** to cancel.

7.3.15. "SErv" menu

This menu contains the parameters for authorized service only. To enter this menu proper service password must be entered. Improper settings can causes of damage of the device.

7.4. MENU STRUCTURE

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OutP
OSou
Parameter edition
Omod
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OUtH
Lo r
Hi r
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option
CtrL
modE
Parameter edition
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PArH
PArC
ConF
FuZL
bri
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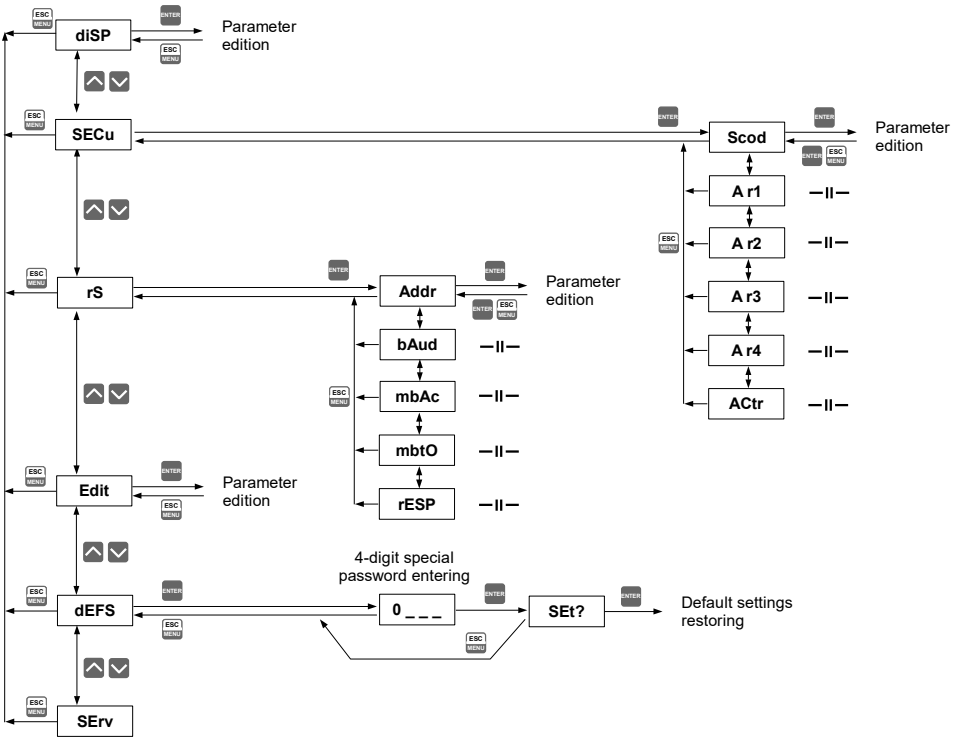


8. THE ALARM LED

The alarm LED (**AL**) lights in cases:

- exceeding of ***permissible measurement range***,
- detection of sensor malfunction (shortcut or break of measurement circuit),
- apprears an error of auto-tuning process (see chapter **11. SIGNALISATION OF ERRORS IN AUTO-TUNING PROCESS**).

9. OVER-CURRENT PROTECTION

The current input of the device is equipped with over-current protection circuit. This circuit protects the measuring resistor from damage. Maximum input current is set to 50mA (typical). When temperature of the measuring resistor falls, the protection circuit will turn off himself automatically, and the device will measure the input current again. Due to thermal phenomenon in the measuring resistor, precision of the measurement may be lower, during few minutes (up to the measuring resistor temperature will falls to the environment temperature).

10. DISPLAYED VALUES CALCULATION

For simplicity of examples it's assumed that current input is selected, and all calculations are related to this input. When voltage input is selected calculations are similar (be sure of particular ranges and units).

The first step to compute the result of measure is the calculation of the normalized result (it means result of 0-1 range). To do it, the begin of the input range (0 mA for 0-20 mA range, and 4 mA for 4-20 mA range) must be subtracted from measured value. Next, received result must be divided by the width of the input range (it means 20 mA for 0-20 mA range, and 16 mA for 4-20 mA range). So normalized result can be expressed by expressions:

$$I_n = \frac{I_{inp.} - 4}{16} \qquad for \quad 4 \div 20\,mA \quad range$$

$$I_n = \frac{I_{inp.}}{20} \qquad for \quad 0 \div 20\,mA \quad range$$

where $I_{inp.}$ Means input current (in mA), and I_n – normalized result.

If measured value exceeds the nominal input range (0-20mA or 4-20mA), and do not exceed the permissible input range, then received normalized I_n result will exceed 0-1 range, e.g. input range 4-20 mA, input current = 3 mA, the normalized result is equal -0,0625, and for input current = 22 mA, the normalized result is equal 1,125. In such cases presented expressions are still correct.

10.1. ADDITIONAL CALCULATIONS (USED CONVERSION CHARACTERISTIC)

The manner of the additional computation of the displayed result depends on selected conversion characteristic. All presented charts are connected with the input range 4 - 20 mA.

10.1.1. Linear characteristic

The normalized result is converted by fixed coefficients determined by **"Lo C"** and **"Hi C"** parameters (when the normalized results is equal 0, then value **"Lo C"** is displayed, and when the normalized results is equal 1, then value **"Hi C"** is displayed). Expression presented below shows the manner of result calculation:

$$W = I_n \times ("Hi\ C" - "Lo\ C") + "Lo\ C",$$

where **W** means the displayed value.

The value of the **"Lo C"** parameter can be higher than the value of **"Hi C"** parameter. In such a case, for an increasing value of input current the displayed value decreases.

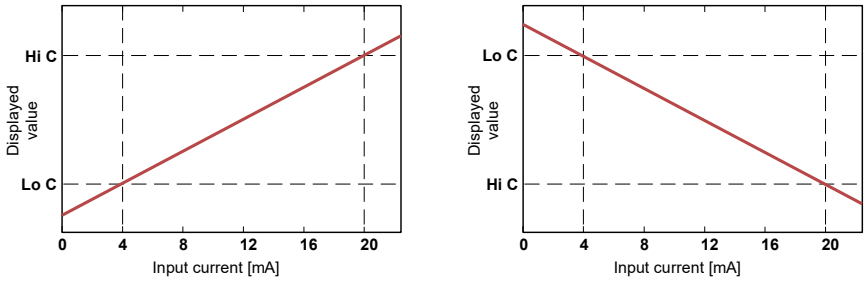


Figure. 10.1 Normal („Lo C" < "Hi C) and inverted („Lo C" > "Hi C) characteristic

10.1.2. Square characteristic

The normalized result is squared and further conversion is done as for linear characteristic. Conversion is made accordingly with the expression:

$$W = I_n^2 \times ("Hi\ C" - "Lo\ C") + "Lo\ C",$$

where **W** means the displayed value.

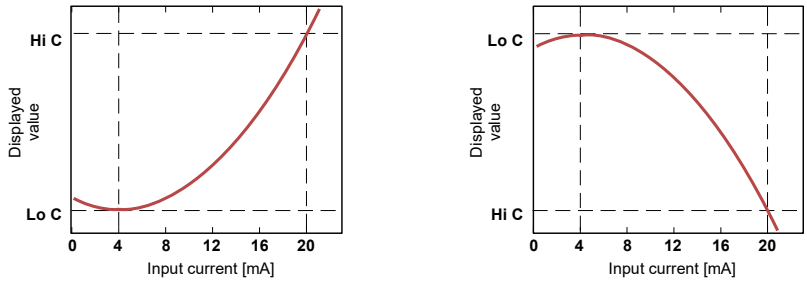


Figure. 10.2 Normal („Lo C" < "Hi C) and inverted („Lo C" > "Hi C) characteristic

10.1.3. Square root characteristic

The normalized result is rooted and further conversion is done as for linear characteristic. Conversion is made accordingly with the expression:

$$W = \sqrt{I_n} \times ("Hi\ C" - "Lo\ C") + "Lo\ C",$$

where W means the displayed value.

Showed above expression is not valid when normalized result is negative. It is possible for 4-20 mode only. In this case (I_n<0) the displayed result is equal **"Lo C"** (see graphs below).

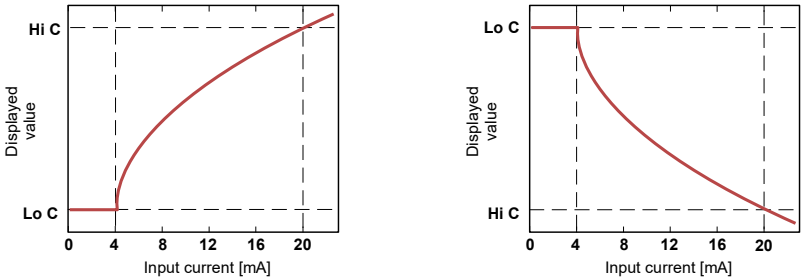


Figure. 10.3 Normal („Lo C" < "Hi C) and inverted („Lo C" > "Hi C) characteristic

10.1.4. User defined characteristic

User defined characteristic is defined as set of X-Y points. Number of the points is variable and may be set from 2 to 20 points which make linear segments (see graph and see ***Menu "inPt"***). Due to the normalized result I_n , the device computes specific segment, e.g. for characteristic from figure below, and I_n = 0,65 the segment between points X = **"50.0."** and X = **"70.0."** will be chosen.
Let's mark those points as PL (point low) and PH (point high) - in this example PL= **"50.0,"** and PH = **"70.0."**, and the normalized result I_n for the point PL as I_p (in this example I_p = I_n(PL) = 0,5). The displayed result is calculated accordingly to the expression:

$$W = (I_n - I_p) \times \frac{[Y(PH) - Y(PL)]}{[X(PH) - X(PL)]} \times 100 + Y(PL)$$

where Y(PH), X(PH), Y(PL), X(PL) mean values of X and Y coordinates of PH and PL points.

If the normalized result exceeds the user defined characteristic values, then specific utmost segment, defined by two next points, is used for calculations. If characteristic from figure below is used, and if I_n>1 then segment defined by points X(PL) = **"90.0."**, X(PH) = **"100.0."** will be used.

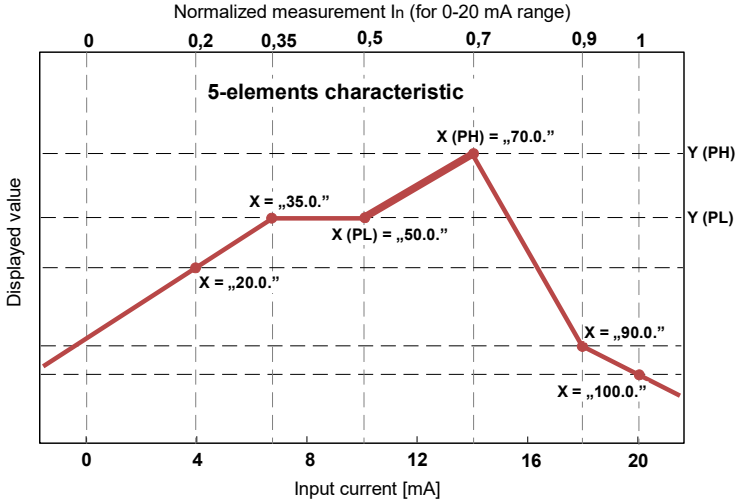


Figure. 10.4 Example of user defined characteristic

10.2. EXAMPLES OF CALCULATIONS

Example 1: Selection of the permissible input range ("4-20" mode)

If in "**4-20**" mode the user sets **"Lo r"** = 20,0% and **"Hi r"** = 10,0%, then permissible input currents range will be equal: 3,2 mA ÷ 22 mA. Lower border of the range is the result of calculations: 4 mA - 4 mA × 20%, and the higher : 20 mA + 20 mA × 10%.

Example 2: The normalized I_n result calculation

Let the input mode = 4-20 mA. The normalized I_n result is calculated accordingly to the expression on page 55, so if I_{in} = 10 mA then 10 mA - 4 mA = 6 mA, and this result should be divided by the width of input range (16 mA). Finally the normalized result: I_n = 6/16 = 0,375.

In case when input current exceeds nominal measurement range, calculations are similar. For example if input current is equal 2,5 mA then I_n = (2,5 - 4)/16 ≅ -0,0938, and if input current is equal 20,5 mA then I_n = (20,5 - 4)/16 ≅ 1,0313.

Example 3: The linear characteristic

Let the input mode = 4-20 mA, and parameters **"Lo C"** and **"Hi C"** equal to -300 and 1200 respectively. The calculations will be done for three different input currents from example 2.

a) I_{in} =10 mA and I_n = 0,375
Accordingly to expression on page 56 for linear characteristic:
0,375 × [1200 -(- 300)] ≅ 562 and next, the **"Lo C"** value is added to the result , so the displayed value:
W ≅ 562 + (-300) = 262

b) I_{in} = 2,5 mA and I_n = -0,0938.
W ≅ -441.

c) I_{in} = 20,5 mA and I_n = 1,0313.
W ≅ 1247.

***Example 4:* The square characteristic**

Let the input mode = 4-20 mA, and parameters **"Lo C"** and **"Hi C"** equal to -300 and 1200 respectively. The calculations will be done for theree different input currents from example 2.

a) I_{in} =10 mA and I_n = 0,375
Accordingly to expression on page 56 for square characteristic: $(0,375)^2$ × [1200 -(- 300)] ≅ 211.
and next, the **"Lo C"** value is added to the result, so the displayed value:
W ≅ 211 + (-300) = -89

b) I_{in} = 2,5 mA and I_n = -0,0938.
W ≅ -287.

c) I_{in} = 20,5 mA and I_n = 1,0313.
W ≅ 1295.

***Example 5:* The square root characteristic**

Let the input mode = 4-20 mA, and parameters **"Lo C"** and **"Hi C"** equal to -300 and 1200 respectively. The calculations will be done for there different input currents from example 2.

a) I_{in} =10 mA and I_n = 0,375
Accordingly to expression on page 57 for square root characteristic:
$\sqrt{0,375}$ × [1200 -(- 300)] ≅ 919.
and next, the **"Lo C"** value is added to the result, so the displayed value:
W ≅ 919 + (-300) = 619

b) I_{in} = 2,5 mA and I_n = -0,0938 , normalized result is negative, so the displayed value is equal to **"Lo C"** parameter: W ≅ **"Lo C"** = -300.

c) I_{in} = 20,5 mA and I_n = 1,0313.
W ≅ 1223.

***Example 6:* The user defined characteristic**

Let the input mode = 4-20 mA, and the user selected the 10 segment characteristic. To do this it is necessary to enter X and Y coordinates of 11 points (see ***Menu "inPt"***).
The calculations will be done for three different input currents from example 2, so in calculations some of the segments will be used only.

Let the following points will be given:
X1 = **"00.0."**, Y1 = **"-50.0"**,
X2= **"10.0."**, Y2 = **"-30.0"**,
....
X6 = **"30.0."**, Y6 = **"30.0"**,
X7 = **"40.0."**, Y7 = **"80.0"**,
....
X10 = **"90.0."**, Y10 = **"900.0"**,
X11 = **"100.0."**, Y11 = **"820.0"**,

Additionally all other points must to be defined and stored in the device memory.

a) I_{in} =10 mA and I_n = 0,375

The segment defined by X6 = **"30.0."** and X7 = **"40.0."** for this I_n will be selected. Accordingly to expressions given for user defined characteristic (see page 57) X6(PL) = 30, Y6(PL) = 30, X7(PH) = 40**,** Y7(PH) = 80 and I_p = 0,3 , the displayed value :

$$W = (I_n - I_p) \times \frac{[Y(PH) - Y(PL)]}{[X(PH) - X(PL)]} \times 100 + Y(PL) =$$

$$= (0{,}375 - 0{,}3) \times \frac{[80 - 30]}{[40 - 30]} \times 100 + 30 \simeq 67$$

b) I_{in} = 2,5 mA and I_n = -0,0938, because of the normalized I_n value is lower than 0, the segment defined by X1 and X2 will be selected. X1(PL) = 0, Y1(PL) = -50, X2(PH) = 10**,** Y2(PH) = -30 and I_p = 0. For these values the displayed value W ≅ -69.

c) I_{in} = 20,5 mA and I_n = 1,0313. , because of the normalized I_n value is higher than 1, the segment defined by X10 and X11 will be selected, and X10(PL) = 90, Y10(PL) = 900, X11(PH) = 100**,** Y11(PH) = 820 and I_p = 0,9 for these values the displayed value W ≅ 795.

***Example 7:* Current output value calculation**

Lets assume that we have active current output and its parameters are:
"modE" = **"4-20"**, **"OUtL"** = 100, **"OUtH"** = 200, **"Lo r"** = 5.0, **"Hi r"** = 5.0
Parameters **"Lo r"** and **"Hi r"** define working range of current output to 3.8 ÷ 21 mA.
Output current will be calculated for three displayed values „D":

a) D = „17.5"
According to formula from page 43:
I_{out} = (17.5-10.0) / (20.0-10.0) × 16 mA + 4 mA = 0.75 ·16 + 4 = 16 mA

Calculated I_{out} do not exceeds the output working range (3.8 - 21 mA).

b) D = „20.5”
According to formula from page 43:
I_{out} = (20.5-10.0) / (20.0-10.0) × 16 mA + 4 mA = 1.05 ·16 + 4 = 20.08 mA
Calculated I_{out} do not exceeds the output working range (3.8 - 21 mA).

c) D = „30.0”
According to formula from page 43:
I_{out} = (30.0-10.0) / (20.0-10.0) × 16 mA + 4 mA = 2 ·16 + 4 = 36 mA.
Calculated I_{out} exceeds the output working range (3 - 21 mA), so current output will generate current equal to the upper border of range defined by parameter **“Lo r”** and **“Hi r”** (it means 21 mA).

Example 8: Connecting and preparing the system for the auto-tuning process

Let’s assume that we want to carry out the auto-tuning process of the PID-H controller’s loop connected to an OC type output in the **PULS** mode. In such an arrangement the device is to control the temperature of an oven (in a free state of 20°C) using a high power SSR relay, and the feedback concerning the temperature is obtained using a Pt100 sensor.

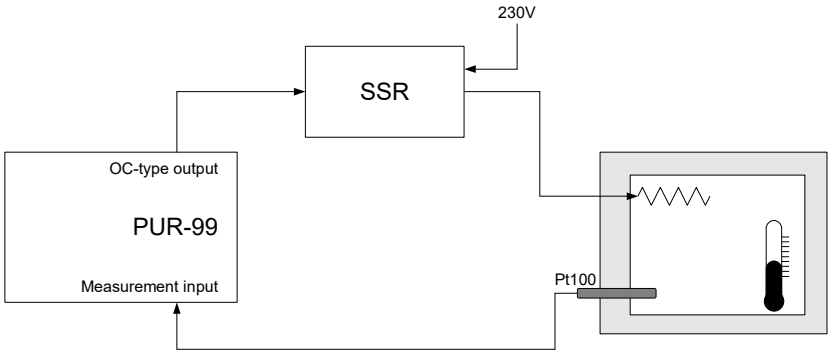


Figure. 10.5 Example arrangement of connections for auto-tuning

Preparatory steps to launch the auto-tuning process:

a) Connect the system in accordance to the diagram in **Figure. 10.5**.
b) In the selected OC type output set:
parameter **Sour** as **PidH**,
parameter **modE** as **PULS**,
parameter **Peri** at **6.0**,
c) Set the **tYPE** parameter (in the **inPt** menu) as **Pt 1**,
d) Set the setpoint to 120°C (the **SEtP** parameter in the **CtrL** menu),
e) Set the **modE** parameter (in the **CtrL** menu) as **At-H**,
f) Wait until the device carries out auto-tuning (at which time the display will blink),
g) Once the display stops blinking, the device automatically sets up in the **PiD** operating mode (the **modE** parameter in the **CtrL** menu) and the calculated settings of the **PID-H** controller’s loop will be stored in the appropriate parameters.

11. SIGNALISATION OF ERRORS IN AUTO-TUNING PROCESS

During the auto-tuning process, various types of errors may occur, as shown below. Some errors are shown on the SV auxiliary display, at the same time the main PV display shows the measurement value, and for errors related to the measuring input the error is showing on the SV auxiliary display and the main display shows "- - - -":

Displayed description	*Meaning*
„PPCh ”	Parameter change during auto-tuning process
„ PbPA ”	Regulator's output range error (Lo>=Hi for COOL or Lo>=Hi for HEAT)
„PtOu”	Tuning time exceeded
„Pbdr”	Direction error
„Pbdi”	Distance error (Set point and measured value are to similar)
„PbSo”	Source for regulator error
„PnPS”	The device restart during auto-tuning process error
„Pbln”	Input error during auto-tuning
„S.Err”	Sensor error
„-CH-”	Awaiting for temperature measurement
„ErrC”	User characteristic error

12. THE MODBUS PROTOCOL HANDLING

Transmission parameters: 1 start bit, 8 data bits, 1 or 2 stop bit (2 bits are send, 1 and 2 bits are accepted when receive), no parity control
Baud rate: selectable from: 1200 to 115200 bits/second
Transmission protocol: MODBUS RTU compatible

The device parameters and display value are available via RS-485 interface, as HOLDING-type registers (numeric values are given in U2 code) of Modbus RTU protocol. The registers (or groups of the registers) can be read by 03h function, and wrote by 06h (single registers) or 10h (group of the registers) accordingly to Modbus RTU specification. Maximum group size for 03h and 10h functions can not exceeds 16 registers (for single frame).

The device interprets the broadcast messages, but then do not sends the answers.

12.1. LIST OF REGISTERS

Register	*Write*	*Range*	*Register description*
01h	No	-999 ÷ 9999	Measurement value (no decimal point)
02h	No	0h, A0h, 60h, C0h, 10h, 20h	The status of the measurement; **0h** - data valid; **A0h** - top border of the measurement range is exceeded; **60h** - bottom border of the measurement range is exceeded; **C0h** - sensor failure; **10h** - error of user characteristic; **20h** - waiting for the first measure
03h	Yes	0 ÷ 3	"**Pnt** " parameter in "**InPt**" menu (decimal point position) **0** - " **0**"; **1** - " **0.0**"; **2** - " **0.00**"; **3** - "**0.000**"
04h	Yes	see descr.	State of the relays and alarm LED (binary format) (1 - on, 0 - off): **00000000 000edcba** **a** - relay R1; **b** - relay R2; **c** - relay R3; **d** - relay R2; **e** - alarm LED; If written, only **a**, **b**, **c**, **d** bits are important (others are ignored) these bits allows user to control the relays via RS-485 interface
05h[1]	Yes	0h ÷ 1800h	State of active current output, expressed in 1/256 mA units – it means that high byte express integer part, and low byte fractional part of desired output current.
	Yes	2CCh÷1800h	State of passive current output, expressed in 1/256 mA units – it means that high byte express integer part, and low byte fractional part of desired output current.
	Yes	0h ÷ 1600h	State of active voltage output, expressed in 1/512 V units – it means that high byte express integer part, and low byte fractional part of desired output voltage.
06h	No	-999 ÷ 9999	Peak (drop) value (no decimal point)
08h	No	0 ÷ 50	Temperature inside device housing expressed by 1°C

Register	Write	Range	Register description
10h	Yes	0 ÷ 20	"**tyPE**" parameter in "**InPt**" menu (nominal input range): **0** - 0-20 mA range; **1** - 4-20 mA range; **2** - 0-5 V range; **3** - 1-5 V range; **4** - 0-10 V range; **5** - 2-10 V range; **6** - 0-60 mV range; **7** - 0-75 mV range; **8** - 0-100 mV range; **9** - 0-150 mV range; **10** - Pt-100; **11** - Pt-500; **12** - Pt-1000 **13** - thermocouple input K; **14** - thermocouple input S; **15** - thermocouple input J; **16** - thermocouple input T; **17** - thermocouple input N; **18** - thermocouple input R; **19** - thermocouple input B; **20** - thermocouple input E;
11h	Yes	0 ÷ 3	"**CHAr**" parameter in "**InPt**" menu (characteristic type) **0** - linear ; **1** - square; **2** - square root; **3** - user defined
12h	Yes	0 ÷ 255	"**FiLt**" parameter in "**InPt**" menu (time constant in seconds)
13h	Yes	0 ÷ 3	"**Pnt** "parameter in "**InPt**" menu (the copy of 03h register, decimal point position): **0** - " **0**"; **1** - " **0.0**"; **2** - " **0.00**"; **3** - "**0.000**"
14h	Yes	-999 ÷ 9999	"**Lo C**" parameter in "**InPt**" menu, no decimal point included
15h	Yes	-999 ÷ 9999	"**Hi C**" parameter in "**InPt**" menu, no decimal point included
16h	Yes	0 ÷ 999	"**Lo r**" parameter in "**InPt**" menu, in 0.1%
17h	Yes	0 ÷ 199	"**Hi r**" parameter in "**InPt**" menu, in 0.1%
18h	Yes	-99 ÷ 99	"**toFS**" parameter in "**InPt**" menu (shift of measurement scale), expressed by 0.1°C (for RTD input) or by 1.0°C (for TC input)
19h	Yes	0 ÷ 2	"**Conn**" parameter in "**InPt**" menu (RTD input connection method): **0** - "**4 in**"; **1** - "**3 in**"; **2** - "**2 in**"
20h[2]	Yes	0 ÷ 199	Device address
21h	No	22DFh	Device identification code (ID)
22h[3]	Yes	0 ÷ 7	**"bAud"** parameter in **"rS"** menu (baud rate); **0** - 1200 baud; **1** - 2400 baud; **2** - 4800 baud; **3** - 9600 baud; **4** - 19200 baud; **5** - 38400 baud; **6** - 57600 baud; **7** - 115200 baud
23h[4]	Yes	0 ÷ 1	**"mbAc"** parameter in **"rS"** menu (permission to write registers via RS-485 interface); **0** - write denied ; **1** - write allowed
24h	Yes	see descr.	Parameters of "**SECU**" menu (binary format (0 - „**oFF**", 1 - „**on**"): **bit 0** - "**A r1**" parameter; **bit 1** - "**A r2**" parameter **bit 2** - "**A r3**" parameter; **bit 3** - "**A r4**" parameter; **bit 4** - "**A Pid**" parameter;
25h	Yes	0 ÷ 5	**"rESP"** parameter in **"rS"** menu (additional response delay); **0** - no additional delay; **1** - "**10c**" option; **2** - "**20c**" option; **3** - "**50c**" option; **4** - "**100c**" option; **5** - "**200c**" option;
27h	Yes	0 ÷ 99	**"mbtO"** parameter in **"rS"** menu (maximum delay between received frames); **0** - no delay checking; **1** ÷ **99** - maximum delay expressed in seconds
28h	Yes	0 ÷ 1	"**AL**" parameter in "**bEEP**" menu: **0** - off; **1** - on
29h	Yes	0 ÷ 1	"**R1**" parameter in "**bEEP**" menu: **0** - off; **1** - on
2Ah	Yes	0 ÷ 1	"**R2**" parameter in "**bEEP**" menu: **0** - off; **1** - on

Register	Write	Range	Register description
2Bh	Yes	0 ÷ 1	"**R3**" parameter in "**bEEP**" menu: **0** - off; **1** - on
2Ch	Yes	0 ÷ 1	"**R4**" parameter in "**bEEP**" menu: **0** - off; **1** - on
2Dh	Yes	1 ÷ 8	"**bri**" parameter (display brightness); **1** - the lowest brightness; **8** - the highest brightness
2Eh	Yes	0 ÷ 6	"**diSP**" parametr (value on the SV display); **0** - "**no**" mode; **1** - "**1 rEL**" mode; **2** - "**2 rEL**" mode; **3** - "**3 rEL**" mode; **4** - "**4 rEL**" mode; **5** - "**Ctrl**" mode; **6** - "**OutP**" mode;
2Fh	Yes	0 ÷ 1	"**Edit**" parameter (numerical parameters edit mode); **0** - „**dig**" mode; **1** - „**SLid**" mode
30h	Yes	0 ÷ 3	"**Sour**" parameter in "**1 rEL**" menu: **0** - "**InPU**" option; **1** - "**modb**" option; **2** - "**PidH**" option; **3** - "**PidC**" option;
31h	Yes	0 ÷ 5	"**modE**" parameter in "**1 rEL**" menu: **0** - "**noAC**" mode; **1** - "**on**" mode; **2** - "**oFF**" mode; **3** - "**in**" mode; **4** - "**out**" mode; **5** - "**PULS**" mode
32h	Yes	-999 ÷ 9999	"**SEtP**" parameter in "**1 rEL**" menu, no decimal point included
33h	Yes	-999 ÷ 999	"**HySt**" parameter in "**1 rEL**" menu, no decimal point included
34h	Yes	0 ÷ 999	**"t on"** parameter in **"1 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 36h)
35h	Yes	0 ÷ 999	**"toFF"** parameter in **"1 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 36h)
36h	Yes	0 ÷ 1	**"unit"** parameter in **"1 rEL"** menu: **0** - seconds; **1** - minutes
37h	Yes	0 ÷ 2	**"AL"** parameter in **"1 rEL"** menu (only when **1 rEL** is relay output): **0** - no changes; **1** - on; **2** - off
38h	Yes	-999 ÷ 9999	"**SEt2**" parameter in "**1 rEL**" menu, no decimal point included
39h	Yes	-999 ÷ 9999	"**InLo**" parameter in "**1 rEL**" menu, no decimal point included
3Ah	Yes	-999 ÷ 9999	"**InHi**" parameter in "**1 rEL**" menu, no decimal point included
3Bh	Yes	0 ÷ 9999	"**PEri**" parameter in "**1 rEL**" menu, no decimal point included
3Ch	Yes	0 ÷ 9999	"**H on**" parameter in "**1 rEL**" menu, no decimal point included
3Dh	Yes	0 ÷ 9999	"**HoFF**" parameter in "**1 rEL**" menu, no decimal point included
3Eh	Yes	0 ÷ 1	"**Acti**" parameter in "**AL**" menu, (only when **1 rEL** is OC-type output): **0** - "**noCH**" option; **1** - "**USdu**" option;
3Fh	Yes	0 ÷ 1000	"**duty**" parameter in "**AL**" menu (only when **1 rEL** is OC-type output)
40h	Yes	0 ÷ 1000	Current OC type output fill factor expressed as a percentage without the decimal point (only where **1 rEL** is the OC type output)
41h	Yes	-999 ÷ 9999	"**OFFS**" parameter in "**1 rEL**" menu, no decimal point included

Register	Write	Range	Register description
42h	Yes	0 ÷ 1000	"**SEnS**" parameter in"**1 rEL**" menu, no decimal point included
43h	Yes	0 ÷ 3	"**Sour**" parameter in "**2 rEL**" menu: **0** - "**InPU**" option; **1** - "**modb**" option; **2** - "**PidH**" option; **3** - "**PidC**" option;
44h	Yes	0 ÷ 5	"**modE**" parameter in "**2 rEL**" menu: **0** - "**noAC**" mode; **1** - "**on**" mode; **2** - "**oFF**" mode; **3** - "**in**" mode; **4** - "**out**" mode; **5** - "**PULS**" mode
45h	Yes	-999 ÷ 9999	"**SEtP**" parameter in "**2 rEL**" menu, no decimal point included
46h	Yes	-999 ÷ 999	"**HySt**" parameter in "**2 rEL**" menu, no decimal point included
47h	Yes	0 ÷ 999	**"t on"** parameter in **"2 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 47h)
48h	Yes	0 ÷ 999	**"toFF"** parameter in **"2 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 47h)
49h	Yes	0 ÷ 1	**"unit"** parameter in **"2 rEL"** menu: **0** - seconds; **1** - minutes
4Ah	Yes	0 ÷ 2	**"AL"** parameter in **"2 rEL"** menu (only when **2 rEL** is relay output): **0** - no changes; **1** - on; **2** - off
4Bh	Yes	-999 ÷ 9999	"**SEt2**" parameter in "**2 rEL**" menu, no decimal point included
4Ch	Yes	-999 ÷ 9999	"**InLo**" parameter in "**2 rEL**" menu, no decimal point included
4Dh	Yes	-999 ÷ 9999	"**InHi**" parameter in "**2 rEL**" menu, no decimal point included
4Eh	Yes	0 ÷ 9999	"**PEri**" parameter in "**2 rEL**" menu, no decimal point included
4Fh	Yes	0 ÷ 9999	"**H on**" parameter in "**2 rEL**" menu, no decimal point included
50h	Yes	0 ÷ 9999	"**HoFF**" parameter in "**2 rEL**" menu, no decimal point included
51h	Yes	0 ÷ 1	"**Acti**" parameter in "**AL**" menu, (only when **2 rEL** is OC-type output): **0** - "**noCH**" option; **1** - "**USdu**" option;
52h	Yes	0 ÷ 1000	"**duty**" parameter in "**AL**" menu (only when **2 rEL** is OC-type output)
53h	Yes	0 ÷ 1000	Current OC type output fill factor expressed as a percentage without the decimal point (only where **2 rEL** is the OC type output)
54h	Yes	-999 ÷ 9999	"**OFFS**" parameter in "**2 rEL**" menu, no decimal point included
55h	Yes	0 ÷ 1000	"**SEnS**" parameter in"**2 rEL**" menu, no decimal point included
56h	Yes	0 ÷ 3	"**Sour**" parameter in "**3 rEL**" menu: **0** - "**InPU**" option; **1** - "**modb**" option; **2** - "**PidH**" option; **3** - "**PidC**" option;
57h	Yes	0 ÷ 5	"**modE**" parameter in "**3 rEL**" menu: **0** - "**noAC**" mode; **1** - "**on**" mode; **2** - "**oFF**" mode; **3** - "**in**" mode; **4** - "**out**" mode; **5** - "**PULS**" mode
58h	Yes	-999 ÷ 9999	"**SEtP**" parameter in "**3 rEL**" menu, no decimal point included

Register	Write	Range	Register description
59h	Yes	-999 ÷ 999	"**HySt**" parameter in "**3 rEL**" menu, no decimal point included
5Ah	Yes	0 ÷ 999	**"t on"** parameter in **"3 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 58h)
5Bh	Yes	0 ÷ 999	**"toFF"** parameter in **"3 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 58h)
5Ch	Yes	0 ÷ 1	**"unit"** parameter in **"3 rEL"** menu: **0** - seconds; **1** - minutes
5Dh	Yes	0 ÷ 2	**"AL"** parameter in **"3 rEL"** menu (only when **3 rEL** is relay output): **0** - no changes; **1** - on; **2** - off
5Eh	Yes	-999 ÷ 9999	"**SEt2**" parameter in "**3 rEL**" menu, no decimal point included
5Fh	Yes	-999 ÷ 9999	"**InLo**" parameter in "**3 rEL**" menu, no decimal point included
60h	Yes	-999 ÷ 9999	"**InHi**" parameter in "**3 rEL**" menu, no decimal point included
61h	Yes	0 ÷ 9999	"**PEri**" parameter in "**3 rEL**" menu, no decimal point included
62h	Yes	0 ÷ 9999	"**H on**" parameter in "**3 rEL**" menu, no decimal point included
63h	Yes	0 ÷ 9999	"**HoFF**" parameter in "**3 rEL**" menu, no decimal point included
64h	Yes	0 ÷ 1	"**Acti**" parameter in "**AL**" menu, (only when **3 rEL** is OC-type output): **0** - "**noCH**" option; **1** - "**USdu**" option;
65h	Yes	0 ÷ 1000	"**duty**" parameter in "**AL**" menu (only when **3 rEL** is OC-type output)
66h	Yes	0 ÷ 1000	Current OC type output fill factor expressed as a percentage without the decimal point (only where **3 rEL** is the OC type output)
67h	Yes	-999 ÷ 9999	"**OFFS**" parameter in "**3 rEL**" menu, no decimal point included
68h	Yes	0 ÷ 1000	"**SEnS**" parameter in"**3 rEL**" menu, no decimal point included
69h	Yes	0 ÷ 3	"**Sour**" parameter in "**4 rEL**" menu: **0** - "**InPU**" option; **1** - "**modb**" option; **2** - "**PidH**" option; **3** - "**PidC**" option;
6Ah	Yes	0 ÷ 5	"**modE**" parameter in "**4 rEL**" menu: **0** - "**noAC**" mode; **1** - "**on**" mode; **2** - "**oFF**" mode; **3** - "**in**" mode; **4** - "**out**" mode; **5** - "**PULS**" mode
6Bh	Yes	-999 ÷ 9999	"**SEtP**" parameter in "**4 rEL**" menu, no decimal point included
6Ch	Yes	-999 ÷ 999	"**HySt**" parameter in "**4 rEL**" menu, no decimal point included
6Dh	Yes	0 ÷ 999	**"t on"** parameter in **"4 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 69h)
6Eh	Yes	0 ÷ 999	**"toFF"** parameter in **"4 rEL"** menu, expressed in tenth of seconds or tenth of minutes depend on **"unit"** parameter - register no. 69h)
6Fh	Yes	0 ÷ 1	**"unit"** parameter in **"4 rEL"** menu: **0** - seconds; **1** - minutes
70h	Yes	0 ÷ 2	**"AL"** parameter in **"4 rEL"** menu (only when **4 rEL** is relay output): **0** - no changes; **1** - on; **2** - off

Register	Write	Range	Register description
71h	Yes	-999 ÷ 9999	"**SEt2**" parameter in "**4 rEL**" menu, no decimal point included
72h	Yes	-999 ÷ 9999	"**InLo**" parameter in "**4 rEL**" menu, no decimal point included
73h	Yes	-999 ÷ 9999	"**InHi**" parameter in "**4 rEL**" menu, no decimal point included
74h	Yes	0 ÷ 9999	"**PEri**" parameter in "**4 rEL**" menu, no decimal point included
75h	Yes	0 ÷ 9999	"**H on**" parameter in "**4 rEL**" menu, no decimal point included
76h	Yes	0 ÷ 9999	"**HoFF**" parameter in "**4 rEL**" menu, no decimal point included
77h	Yes	0 ÷ 1	"**Acti**" parameter in "**AL**" menu, (only when **4 rEL** is OC-type output): **0** - "**noCH**" option; **1** - "**USdu**" option;
78h	Yes	0 ÷ 1000	"**duty**" parameter in "**AL**" menu (only when **4 rEL** is OC-type output)
79h	Yes	0 ÷ 1000	Current OC type output fill factor expressed as a percentage without the decimal point (only where **4 rEL** is the OC type output)
7Ah	Yes	-999 ÷ 9999	"**OFFS**" parameter in "**4 rEL**" menu, no decimal point included
7Bh	Yes	0 ÷ 1000	"**SEnS**" parameter in"**4 rEL**" menu, no decimal point included
80h	Yes	0 ÷ 1	"**modE**" parameter in "**HOLd**" menu (type of detected changes): **0** - peaks; **1** - drops
81h	Yes	0 ÷ 9999	"**PEA**" parameter in "**HOLd**" menu (minimum detectable change, no decimal point included)
82h	Yes	0 ÷ 199	"**timE**" parameter in "**HOLd**" menu, maximum peaks' (or drops') display time expressed in seconds
83h	Yes	0 ÷ 1	"**HdiS**" parameter in "**HOLd**" menu: **0** - "**rEAL**" mode ; **1** - "**HOLd**" mode
84h	Yes	0 ÷ 1	"**H r1**" parameter in "**HOLd**" menu : **0** - "**rEAL**" mode ; **1** - "**HOLd**" mode
85h	Yes	0 ÷ 1	"**H r2**" parameter in "**HOLd**" menu: **0** - "**rEAL**" mode ; **1** - "**HOLd**" mode
86h	Yes	0 ÷ 1	"**H r3**" parameter in "**HOLd**" menu: **0** - "**rEAL**" mode ; **1** - "**HOLd**" mode
87h	Yes	0 ÷ 1	"**H r4**" parameter in "**HOLd**" menu: **0** - "**rEAL**" mode ; **1** - "**HOLd**" mode
88h	Yes	0 ÷ 1	"**HOUt**" parameter in "**HOLd**" menu: **0** - "**rEAL**" mode ; **1** - "**HOLd**" mode
A0h[5]	Yes	-999 ÷ 1999	The value of „**X**" coordinate of point **no. 1** of the user defined characteristic, expressed in 0.1%
A1h[5]	Yes	-999 ÷ 9999	The value of „**Y**" coordinate of point **no. 1** of the user defined characteristic, no decimal point included
A2h[5] ÷ C5h[5]			Further pairs of „**X**" - „**Y**" coordinates of points **no. 2** ÷ **19** of the user defined characteristic
C6h[5]	Yes	-999 ÷ 1999	The value of „**X**" coordinate of point **no. 20** of the user defined characteristic, expressed in 0.1%

Register	Write	Range	Register description
C7h[5]	Yes	-999 ÷ 9999	The value of „**Y**" coordinate of point **no. 20** of the user defined characteristic, no decimal point included
D0h	Yes	0 ÷ 3	"**OSou**" parameter in "**OutP**" menu: **0** - "**InPU**" option; **1** - "**modb**" option; **2** - "**PidH**" option; **3** - "**PidC**" option
D1h[1]	Yes	0 ÷ 3	"**Omod**" parameter in "**OUtP**" menu (active current output mode) **0** - current output disabled; **1** - current output enabled with **4÷20mA** mode; **2** - current output enabled with **0÷20mA** mode;
	Yes	0 ÷ 2	"**Omod**" parameter in "**OUtP**" menu (passive current output mode) **0** - current output disabled; **1** - current output enabled with **4÷20mA** mode;
	Yes	0 ÷ 5	"**Omod**" parameter in "**OUtP**" menu (active voltege output mode) **0** - voltage output disabled; **1** - voltage output enabled with **0÷5V** mode; **2** - voltage output enabled with **1÷5V** mode; **3** - voltage output enabled with **0÷10V** mode; **4** - voltage output enabled with **2÷10V** mode;
D2h[1]	Yes	-999 ÷ 9999	"**OUtL**" parameter in "**OUtP**" menu, no decimal point included
D3h[1]	Yes	-999 ÷ 9999	"**OUtH**" parameter in "**OUtP**" menu, no decimal point included
D4h[1]	Yes	0 ÷ 999	"**Lo r**" parameter in "**OUtP**" menu, for active current output and active voltage output, expressed in 0.1%
	Yes	0 ÷ 299	"**Lo r**" parameter in "**OUtP**" menu for passive current output, expressed in 0.1%
D5h[1]	Yes	0 ÷ 199	"**Hi r**" parameter in "**OUtP**" menu for active and passive current output, expressed in 0.1%
	Yes	0 ÷ 99	"**Hi r**" parameter in "**OUtP**" menu for active voltage output, expressed in 0.1%
D6h[1]	Yes	0 ÷ 3	"**AL**" parameter in "**OUtP**" menu (active current output value on critical exception): **0** - no change; **1** - 22.1 mA; **2** - 3.4 mA; **3** - 0 mA
	Yes	0 ÷ 2	"**AL**" parameter in "**OUtP**" menu (passive current output value on critical exception): **0** - no change; **1** - 22.1 mA; **2** - 3.4 mA
	Yes	0 ÷ 5	"**AL**" parameter in "**OUtP**" menu (active voltage output value on critical exception): **0** - no change; **1** - 11 V; **2** - 5.5; **3** - 1.2 V; **4** - 0.6 V; **5** - 0 V
F0h	Yes	0 ÷ 4	"**modE**" parameter in"**CtrL**" menu: **0** - "**oFF**" option; **1** - opcja **Pid**" option; **2** - "**At-F**" option; **3** - opcja **At-H**" option; **4** - "**At-C**" option;
F1h	Yes	-999 ÷ 9999	"**SEtP**" parameter in"**CtrL**" menu, no decimal point included
F2h	Yes	0 ÷ 9999	"**P -H**" parameter in"**PArH**" menu, no decimal point included
F3h	Yes	0 ÷ 9999	"**tI-H**" parameter in"**PArH**" menu, no decimal point included
F4h	Yes	0 ÷ 9999	"**td-H**" parameter in"**PArH**" menu, no decimal point included
F5h	Yes	-999 ÷ 9999	"**OF-H**" parameter in"**PArH**" menu, no decimal point included

Register	Write	Range	Register description
F6h	Yes	0 ÷ 999	"**Lo-H**" parameter in"**PArH**" menu, no decimal point included
F7h	Yes	1 ÷ 1000	"**Hi-H**" parameter in"**PArH**" menu, no decimal point included
F8h	Yes	0 ÷ 9999	"**P -C**" parameter in"**PArC**" menu, no decimal point included
F9h	Yes	0 ÷ 9999	"**tI-C**" parameter in"**PArC**" menu, no decimal point included
FAh	Yes	0 ÷ 9999	"**td-C**" parameter in"**PArC**" menu, no decimal point included
FBh	Yes	-999 ÷ 9999	**OF-C**" parameter in"**PArC**" menu, no decimal point included
FCh	Yes	0 ÷ 999	"**Lo-C**" parameter in"**PArC**" menu, no decimal point included
FDh	Yes	1 ÷ 1000	"**Hi-C**" parameter in"**PArC**" menu, no decimal point included
FEh	Yes	0 ÷ 9999	"**dEAd**" parameter in"**ConF**" menu, no decimal point included
FFh	Yes	0 ÷ 9999	"**StAr**" parameter in"**ConF**" menu, no decimal point included
100h	Yes	0 ÷ 1	"**dSrC**" parameter in "**ConF**" menu: **0** - "**Err**" option; **1** - "**LooP**" option;
101h	Yes	0 ÷ 3	"**InEr**" parameter in "**ConF**" menu: **0** - "**OFF**" option; **1** - "**HArd**" option; **2** - "**mEdi**" option; **3** - "**SoFt**" option;
102h	Yes	0 ÷ 9999	"**SLOP**" parameter in "**FuZL**" menu, no decimal point included
103h	Yes	0 ÷ 2	"**unit**" parameter in "**FuZL**" menu: **0** - "**SEC**" option; **1** - "**min**" option; **2** - "**hour**" option;
104h	Yes	0 ÷ 9999	"**HySt**" parameter in "**FuZL**" menu, no decimal point included
105h	No	-1000 ÷ 1000	Value of regulator's output (in percentage)

1 - these registers are active only if device is equipped with current or voltage output
2 - after writing to register no 20h the device responds with an "old" address in the message.
3 - after writing to register no 22h the device responds with the new baud rate.
4 - the value of the "**mbAc**" parameter is also connected to write to this register, so it is possible to block a writes, but impossible to unblock writes via RS-485 interface, The unblocking of the writes is possible from menu level only.
5 - the pairs of „**X** -**Y**" coordinates may be defined for any free point. The pair is "free" (it means that particular point is not defined) if „**X**" coordinate of this point is equal 8000h. After writing both X and Y coordinate the point is defined and used in calculation of result. The coordinates of any point can be changed at any time.

12.2. TRANSMISSION ERRORS DESCRIPTION

If an error occurs while write or read of single register, then the device sends an error code according to Modbus RTU specifications (example message no 1).

Error codes:
01h - illegal function (only functions 03h, 06h and 10h are available),
02h - illegal register address
03h - illegal data value
08h - no write permission (see: "**mbAc**" parameter)
A0h - exceed of upper border of input range
60h - exceed of lower border of input range

A0h and 60h codes can appear only during reg. 01h is reading by 03h function (read of a single register).

12.3. EXAMPLES OF QUERY/ANSWER FRAMES

Examples apply for device with address 1. All values are represent hexadecimal.

Field description:

ADDR	Device address on modbus network
FUNC	Function code
REG H,L	Starting address (address of first register to read/write, Hi and Lo byte)
COUNT H,L	No. of registers to read/write (Hi and Lo byte)
BYTE C	Data byte count in answer frame
DATA H,L	Data byte (Hi and Lo byte)
CRC L,H	CRC error check (Hi and Lo byte)

1. Read of the displayed value (measurement), PUR-99 device address = 01h:

ADDR	FUNC	REG H,L		COUNT H,L		CRC L,H	
01	03	00	01	00	01	D5	CA

a) The answer (we assume that the measure result is not out of range):

ADDR	FUNC	BYTE C	DATA H,L		CRC L,H	
01	03	02	00	FF	F8	04

DATA H, L - displayed value = 255, no decimal point.

Decimal point position can be read from reg. 03h.

b) The answer (if an error occur):

ADDR	FUNC	ERROR	CRC L,H	
01	83	60	41	18

ERROR - error code = 60h, bottom border of the measurement range is exceeded

2. Read of device ID code

ADDR	FUNC	REG H,L		COUNT H,L		CRC L,H	
01	03	00	21	00	01	D4	00

The answer:

ADDR	FUNC	BYTE C	DATA H,L		CRC L,H	
01	03	02	22	DF	E1	7C

DATA - identification code (22DFh)

3. Change of the device address from 1 to 2 (write to reg. 20h)

ADDR	FUNC	REG H,L		DATA H,L		CRC L,H	
01	06	00	20	00	02	09	C1

DATA H - 0
DATA L - new device address (2)

The answer (the same as the message):

ADDR	FUNC	REG H,L		DATA H,L		CRC L,H	
01	06	00	20	00	02	09	C1

4. Change of baud rate of all devices connected to the net (BROADCAST message).

ADDR	FUNC	REG H,L		COUNT H,L		CRC L,H	
00	06	00	22	00	04	29	D2

DATA H - 0
DATA L - 4, new baud rate 19200 baud

Device do not reply to BROADCAST-type messages.

5. Read of the registers 1, 2 and 3 in one message (example of reading a number of registries in one frame):

ADDR	FUNC	REG H,L		COUNT H,L		CRC L,H	
01	03	00	01	00	03	54	0B

COUNT L - the count of being read registers (max.16)

The answer:

ADDR	FUNC	BYTE C	DATA H1,L1		DATA H2,L2		DATA H3,L3		CRC L,H	
01	03	06	00	0A	00	00	00	01	78	B4

DATA H1, L1 - reg. 01h (10 - displayed value ”1.0”),
DATA H2, L2 - reg. 02h (0 - no errors),
DATA H3, L3 - reg. 03h (1 - decimal point position ” 0.0”).

There is no full implementation of the Modbus Protocol in the device. The functions presented above are available only.

13. DEFAULT AND USER'S SETTINGS LIST

Parameter	Description	Default value	User's value	Desc. page
Parameters of relay R1 operation ("1 rEL" menu)				
Sour	Relay R1 signal source	InPU		36
modE	Operation mode of relay R1	on		36
SEtP	Relay R1 threshold	20.0		36
SEt2	Relay R1 second threshold	40.0		36
HYSt	Hysteresis of relay R1	0.0		37
t on	Turn on delay of relay R1	0.0		37
toFF	Turn off delay of relay R1	0.0		37
unit	Unit of **"t on"**, **"toFF"** parameters of relay R1	SEC		37
InLo	The lower limit of the PWM range of relay R1	0.0		38
InHi	The upper limit of the PWM range of relay R1	100.0		38
PEri	Relay R1 output signal period	1.0		38
H on	Low state minimal time of relay R1 PWM signal	0.0		38
HoFF	High state minimal time of relay R1 PWM signal	0.0		38
AL	Reaction for critical situation of relay R1	oFF		38
OFFS	Relay R1 output offset	0.0		37
SEnS	Relay R1 output sensitivity	100.0		37
Parameters of relay R2 operation ("2 rEL" menu)				
Sour	Relay R2 signal source	InPU		36
modE	Operation mode of relay R2	on		36
SEtP	Relay R2 threshold	40.0		36
SEt2	Relay R2 second threshold	60.0		36
HYSt	Hysteresis of relay R2	0.0		37
t on	Turn on delay of relay R2	0.0		37
toFF	Turn off delay of relay R2	0.0		37
unit	Unit of **"t on"**, **"toFF"** parameters of relay R2	SEC		37
InLo	The lower limit of the PWM range of relay R2	0.0		38
InHi	The upper limit of the PWM range of relay R2	100.0		38
PEri	Relay R2 output signal period	1.0		38
H on	Low state minimal time of relay R2 PWM signal	0.0		38
HoFF	High state minimal time of relay R2 PWM signal	0.0		38
AL	Reaction for critical situation of relay R2	oFF		38

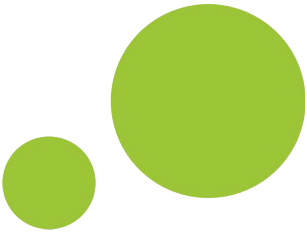
Parameter	*Description*	*Default value*	*User's value*	*Desc. page*
OFFS	Relay R2 output offset	0.0		37
SEnS	Relay R2 output sensitivity	100.0		37
Parameters of relay R3 operation (“3 rEL” menu)				
Sour	Relay R3 signal source	InPU		36
modE	Operation mode of relay R3	on		36
SEtP	Relay R3 threshold	60.0		36
SEt2	Relay R3 second threshold	80.0		36
HYSt	Hysteresis of relay R3	0.0		37
t on	Turn on delay of relay R3	0.0		37
toFF	Turn off delay of relay R3	0.0		37
unit	Unit of **“t on”**, **“toFF”** parameters of relay R3	SEC		37
InLo	The lower limit of the PWM range of relay R3	0.0		38
InHi	The upper limit of the PWM range of relay R3	100.0		38
PEri	Relay R3 output signal period	1.0		38
H on	Low state minimal time of relay R3 PWM signal	0.0		38
HoFF	High state minimal time of relay R3 PWM signal	0.0		38
AL	Reaction for critical situation of relay R3	oFF		38
OFFS	Relay R3 output offset	0.0		37
SEnS	Relay R3 output sensitivity	100.0		37
Parameters of relay R4 operation (“4 rEL” menu)				
Sour	Relay R4 signal source	InPU		36
modE	Operation mode of relay R4	on		36
SEtP	Relay R4 threshold	80.0		36
SEt2	Relay R4 second threshold	100.0		36
HYSt	Hysteresis of relay R4	0.0		37
t on	Turn on delay of relay R4	0.0		37
toFF	Turn off delay of relay R4	0.0		37
unit	Unit of **“t on”**, **“toFF”** parameters of relay R4	SEC		37
InLo	The lower limit of the PWM range of relay R4	0.0		38
InHi	The upper limit of the PWM range of relay R4	100.0		38
PEri	Relay R4 output signal period	1.0		38
H on	Low state minimal time of relay R4 PWM signal	0.0		38
HoFF	High state minimal time of relay R4 PWM signal	0.0		38
AL	Reaction for critical situation of relay R4	oFF		38

Parameter	Description	Default value	User's value	Desc. page
OFFS	Relay R4 output offset	0.0		37
SEnS	Relay R4 output sensitivity	100.0		37
Activation of acoustic signal (menu "bEEP")				
AL	Activation of acoustic signal by critical situation	oFF		39
r1	Activation of acoustic signal by relay R1	oFF		39
r2	Activation of acoustic signal by relay R2	oFF		39
r3	Activation of acoustic signal by relay R3	oFF		39
r4	Activation of acoustic signal by relay R4	oFF		39
Configuration of measurement input ("inPt" menu)				
tYPE	Input mode	„4-20"		39
Conn	Connection method	„4-in"		40
FiLt	Filtering time constant (in seconds)	0		40
toFS	Shifting of measurement scale	0.0		40
CHAr	Conversion characteristic mode	Lin		40
Pnt	Decimal point position	0.0		40
Lo C	Minimum displayed value (for nominal range)	000.0		40
Hi C	Maximum displayed value (for nominal range)	100.0		40
Lo r	Extension of the bottom of the nominal input range	5.0 (%)		41
Hi r	Extension of the top of the nominal input range	5.0 (%)		41
Active current output configuration ("OUtP" menu)				
OSou	Active current output signal source	„InPU"		42
Omod	Active current output mode	„0-20" (mA)		43
OUtL	Display value for 0 mA or 4 mA current output	0.0		43
OUtH	Display value for 20 mA current output	100.0		43
Lo r	Extension of the bottom of the nominal output range	5.0 (%)		44
Hi r	Extension of the top of the nominal output range	5.0 (%)		44
AL	Current output value on critical exception	22.1 (mA)		44
Passive current output configuration ("OUtP" menu)				
OSou	Passive current output signal source	„InPU"		42
Omod	Passive current output mode	„4-20" (mA)		43
OUtL	Display value for 4 mA current output	0.0		43
OUtH	Display value for 20 mA current output	100.0		43

Parameter	*Description*	*Default value*	*User's value*	*Desc. page*
Lo r	Extension of the bottom of the nominal output range	5.0 (%)		44
Hi r	Extension of the top of the nominal output range	5.0 (%)		44
AL	Current output value on critical exception	22.1 (mA)		44
Active voltage output configuration (“OUtP” menu)				
OSou	Active voltage output signal source	„InPU”		42
Omod	Active voltage output mode	„0-10” (V)		43
OUtL	Display value for 0 V, 1 V or 2 V voltage output	0.0		43
OUtH	Display value for 5 V or 10 V voltage output	100.0		43
Lo r	Extension of the bottom of the nominal output range	5.0 (%)		44
Hi r	Extension of the top of the nominal output range	5.0 (%)		44
AL	Voltage output value on critical exception	11.0 (V)		44
PID regulators configuration (“CtrL” menu)				
modE	Operation mode	oFF		45
SetP	Regulators setpoint	0.0		45
	PID-H regulator configuration (“ParH” menu)			45
P -H	proportional gain factor **P** of **PID-H** regulator	0		45
tI-H	integral gain factor **I** of **PID-H** regulator	0.0		45
td-H	derivative gain factor **D** of **PID-H** regulator	0.0		45
OF-H	Offset of **PID-H** regulator	0.0		45
Lo-H	The lower characteristic limit of **PID-H** regulator	0.0		45
Hi-H	The upper characteristic limit of **PID-H** regulator	100.0		45
	PID-C regulator configuration (“ParC” menu)			45
P -C	proportional gain factor **P** of **PID-C** regulator	0		45
tI-c	integral gain factor **I** of **PID-C** regulator	0.0		45
td-c	derivative gain factor **D** of **PID-C** regulator	0.0		45
OF-C	Offset of **PID-C** regulator	0.0		45
Lo-C	The lower characteristic limit of **PID-C** regulator	0.0		45
Hi-C	The upper characteristic limit of **PID-C** regulator	100.0		45
	PID regulators configuration (“ConF” menu)			46
dEAd	Dead zone	0.0		46

Parameter	*Description*	*Default value*	*User's value*	*Desc. page*
StAr	Start state of the regulators	0.0		46
dSrC	Feedback of the regulators	LooP		46
InEr	Inertial block	OFF		46
	PID regulators configuration (“FuZL” menu)			47
SLOP	Incline of the characteristics of the fuzzy logic block. FuZL menu parameter	0.0		47
unit	Time unit of incline of the characteristics of the fuzzy logic block. FuZL menu parameter	SEC		47
HySt	Hysteresis of incline of the characteristics of the fuzzy logic block. FuZL menu parameter	0.0		47
Display parameters				
bri	Display brightness	bri		48
Settings of SV display value (menu “diSP”)				
diSP	SV display value selection	no		49
Configuration of peaks detection function (“HOLd” menu)				
modE	Kind of detected changes	norm		48
PEA	Minimum detected change	0.0		48
timE	Maximum time of peak displaying	0.0		48
HdiS	The type of displayed value	HOLd		48
H r1	Source of relay R1, and LED R1 control	rEAL		49
H r2	Source of relay R2, and LED R2 control	rEAL		49
H r3	Source of relay R3, and LED R3 control	rEAL		49
H r4	Source of relay R4, and LED R4 control	rEAL		49
HOUt	Source of current output control	rEAL		49
Settings of access to the configuration parameters (“SECu” menu)				
A r1	Permission to changes of relay R1 threshold without of the user password knowledge	on		49
A r2	Permission to changes of relay R2 threshold without of the user password knowledge	on		49
A r3	Permission to changes of relay R3 threshold without of the user password knowledge	on		49
A r4	Permission to changes of relay R4 threshold without of the user password knowledge	on		49
APid	Permission to changes of regulator's setpoint without of the user password knowledge	on		50
RS-485 interface configuration (menu “rS”)				
Addr	Device address	0		50

Parameter	*Description*	*Default value*	*User's value*	*Desc. page*
bAud	Baud rate	9.6		50
mbAc	Permission to changes of configuration registers	on		50
mbtO	Maximum delay between received messages	0		50
rESP	Additional delay of answer transmission	Std		50
Configuration of numerical parameters edition				
Edit	Numerical parameters edit mode	dig		51



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