microsyst

COMPETENCE IN
MEASUREMENT

Universal Microprocessor-based

PID and ON/OFF controller

MS8120 / MS8130

TECHNICAL DESCRIPTION AND INSTRUCTION FOR USAGE

PLOVDIV 2004

I. TECHNICAL DATA

Analog inputs	1
Linear current	0 (4) ... 20 mA DC
Linear voltage	0 … 1 (10) V DC
Resistive thermal sensor	Pt 100
Thermocouple	Type J, K, S, B
Relay outputs	3
K1 – ON / OFF or PWM	Relay 250 V / 5 A or OC for TTL
K2 – ON / OFF or PWM (or Alarm)	Relay 250 V / 5 A or OC for TTL
K3 – Alarm	Relay 250 V / 5 A or OC for TTL
Options	Triac 250 V / 2 A; Relay 250 V / 5, 10 A or OC for TTL
For the instrument MS8120, at realization of the output by relays, in parallel with the contacts the relays there are RC groups for better noise immunity.	
Analog output	2
Transmitting or controlling current	0 (4) ... 20 mA DC
Transmitting or controlling voltage	0 … 1 (10) V DC
Indication and keypad	
Display	1x4 digits LED
Range of the display	-1999 ... 9999
Accuracy	± 1 LSB
Format of the display	X.XXX XX.XX XXX.X XXXX
Keypad	Four membrane keys
Power supply	
Power voltage	80 … 250 V AC 24 V AC/DC 12 V AC/DC
Operating conditions	
Operating temperature	0 … 50 °C
Operating relative humidity	0 … 80 % RH
Dimensions	
MS8130	
Overall Dimensions (WxHxL)	72 x 36 x 55 mm
Installation	panel in hole 71 x 29 mm
MS8120	
Overall Dimensions (WxHxL)	48 x 48 x 97 mm
Installation	panel in hole 44+ x 44+ mm
Weight	max 200 g
Storage	
Storage Temperature	-10 … 70 °C
Storage Relative humidity	0 … 95 % RH

The model MS8120 differs from MS8130 only by the case and respectively by the front and the back panels. The instrument 8120 has 8 LED, and 8130 has 6 – it has not A/M (Automatic/Manual Operating Mode) and AT (activated autotune). For indication of the autotune in both models there is a running decimal point, which in 8120 doubles with LED A/M. Indication for Manual Operating mode is the flashing point, which in 8130 is always entered, while in 8120 there are operating mode without it (there is LED A/M).

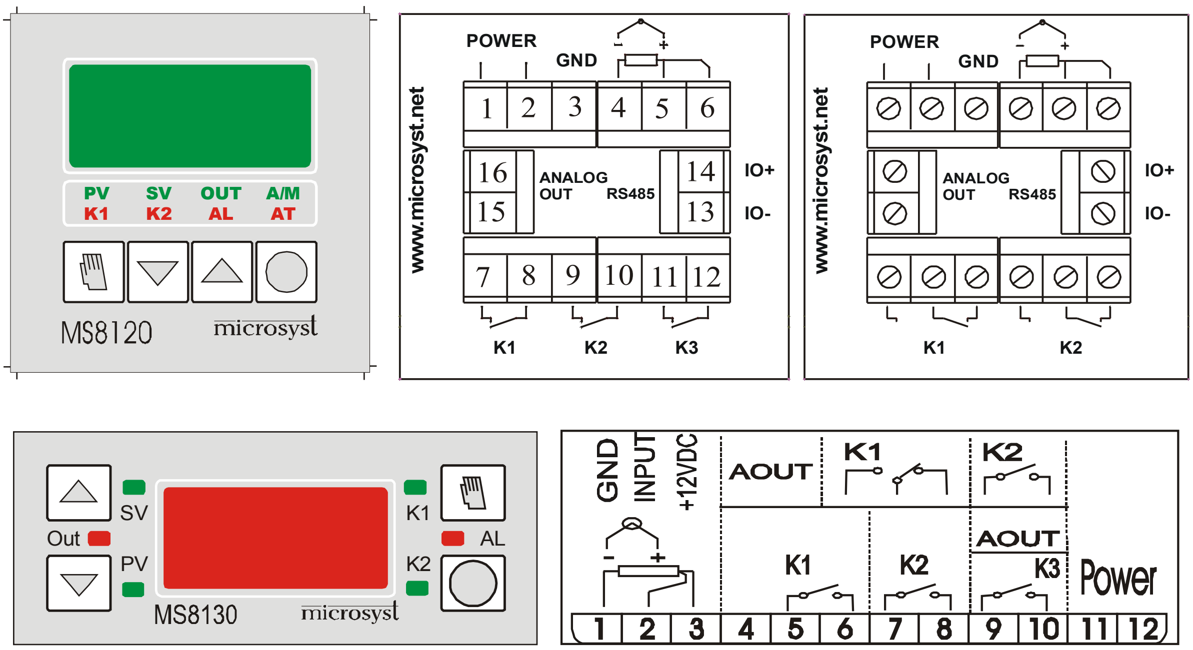
II. DESIGNATION

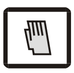
The compact microprocessor-based PID controllers produced by MICROSYST, of the production batch MS8120/8130 are designed for measurement and control of different process parameters. They can realize P, PI or PID algorithm of controlling (program selectable), and there is a possibility of limiting of the integral component. There are also built-in 2and 3-ON/OFF operating modes. The outputs are controlled by pulse width modulation (PWM), there is a possibility for set point of different times for formation of “positive” (K1) and “negative” (K2) output.

All data are saved in non-volatile memory, including the current status of the controller, i.e. after restoring of the power supplying voltage, it enters the same operating mode of controlling, in which it has been before its power fault (the integral component has to be zeroed in that case, so till its second accumulation interference in the controlled parameter for PI or PID controller will be realized).

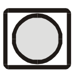
Also there is shockless switching between automatic and manual operating mode with direct supervision of the process variable (PV), the set point (SP) and the output (Out). By the function Auto tuning the PID parameters can be easy tuned.

III. FRONT AND BACK PANEL



 – Selection of operating mode: manual – automatic

– Tuning of the parameters;
– Editing of the set point for control (heating)

 – Tuning of system parameters

– Confirmation of the made correction
– Exit from operating mode TUNING OF THE PARAMETERS

 – Change of the parameter, which appears on the display

– Change of parameters

 – As the upper, but it functions in opposite direction

IV. CONNECTION OF TEMPERATURE SENSORS AND TRANSMITTERS

For the correctness of the work it is important the sensors to be installed at a suitable place in the environment, in which the temperature will be controlled. When they are installed in a hole it is good a seal, which improve the heat release, to be used.

1. Connection of resistive sensors (Pt100 or other)

The sensors can be connected by two-wire or three-wire line. The connection of two-wire sensors with three-wire line can be done as it is shown on fig.1, and cable jumper must be placed obligingly between the shown terminals.

When the distances between the sensor and the controller are longer it is recommended a three-wire line to be used, because the error in measurement of the temperature, made by the added resistance of the connecting wires, is compensated with it. The connection of three-wire sensors with the controller can be done as it is shown on fig.2, and to terminals 2 and 3 of MS8130 (5 and 6 of MS8120) must be connected the connected shortly cables in the sensors.

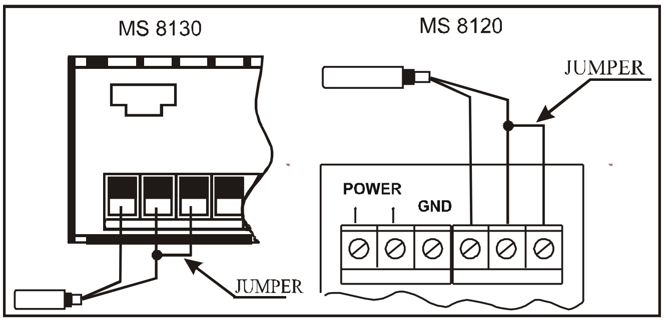


Fig. 1

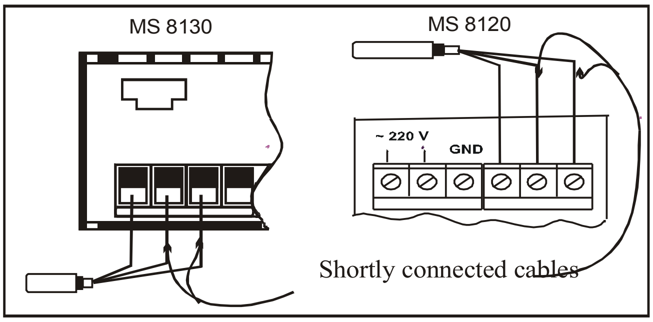


Fig. 2

2. Connection of thermocouples

When a sensor – thermocouple is connected, we have to pay attention to the polarity of the sensor. When the polarity is not right the indications of the instrument will be incorrect.

When you work with thermocouples it is necessary to use compensating cable, suitable for the type of the used thermocouple (fig. 3).

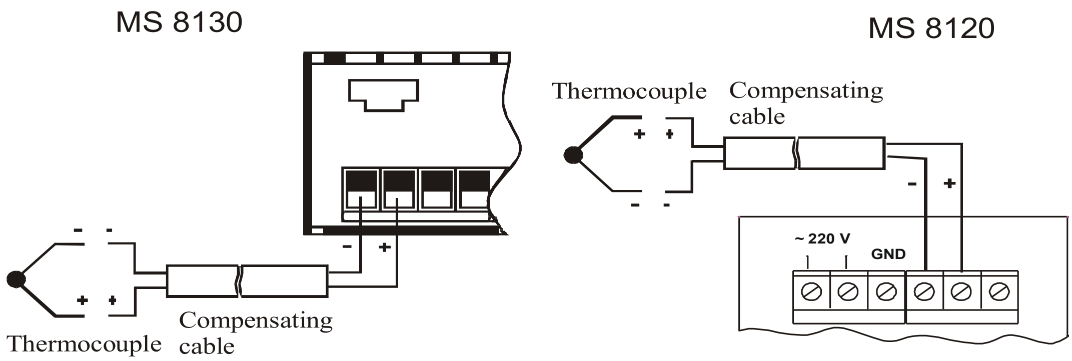


Fig. 3

3. Connection of transmitters

1) Transmitters with two-wire switching on (loop powered)

The power of the transmitter is supplied by the instrument.

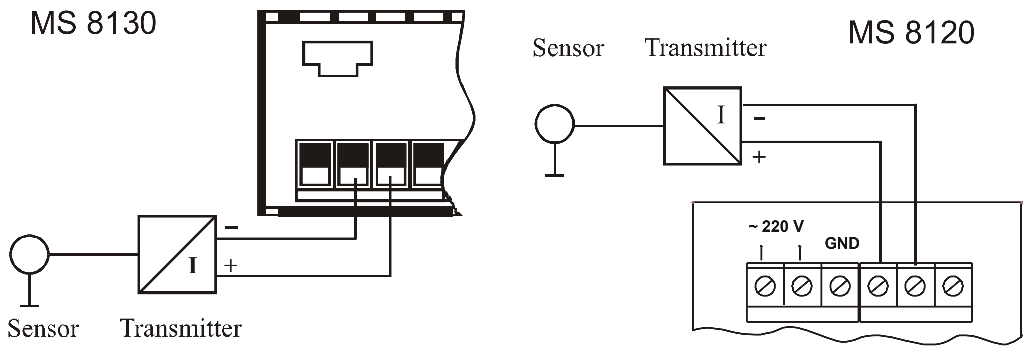


Fig. 4

* The voltage, which is provided by the instrument, is not stable.

2) Transmitter with own power supply

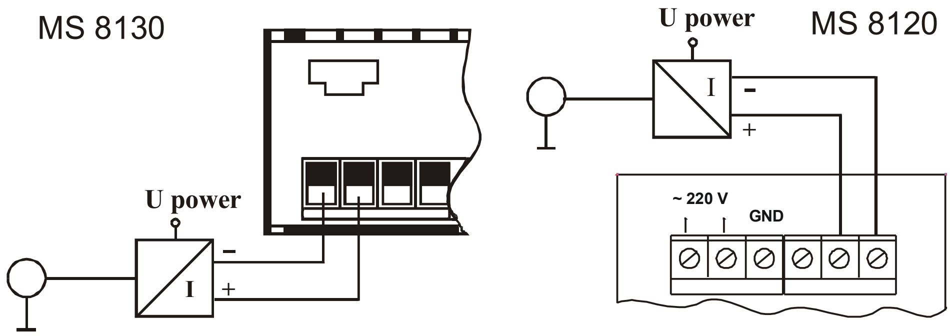


Fig. 5

3) Three-wire transmitter supplied by the instrument

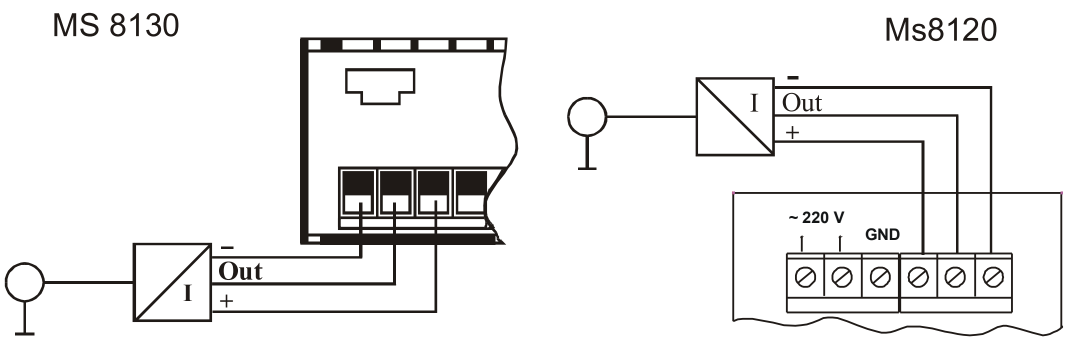


Fig. 6

* The voltage, which is provided by the instrument, is not stable.

V. CONNECTION OF THE OUTPUTS OF THE CONTROLLER

For the instrument MS8120, when the outputs are realized by relays, in parallel with the contacts of the relays there are RC groups for better noise immunity. *Minimal current flows in trough* the opened contact of the relay in an AC circuit. The connection of an output of the controller, when it is type SSR, with the charge can be done as it is shown on fig. 7.

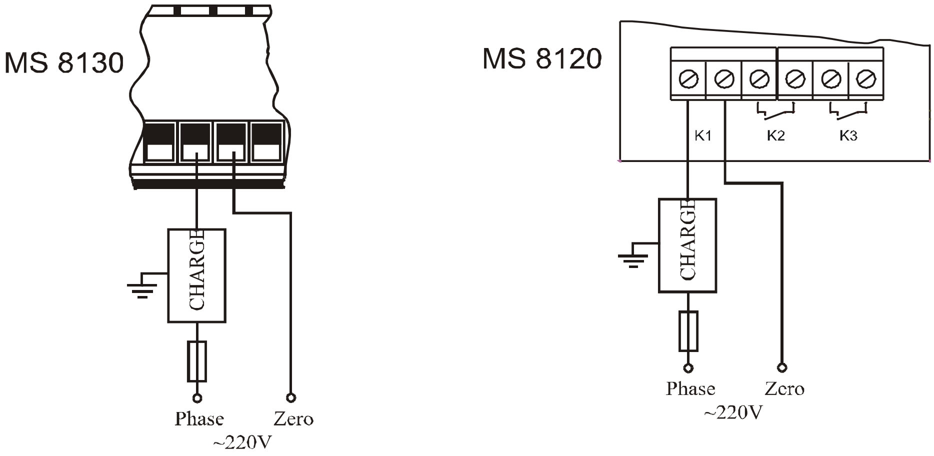


Fig. 7

VI. OPERATION PRINCIPLE

Formation of the output at PID controlling:

$$Out_{(n)} = \frac{1}{\mathbf{Pb}} \times \Delta_{(n)} + \frac{1}{\mathbf{Pb}} \times \frac{\mathbf{T_0}}{\mathbf{Ti}} \times \sum_{j=1}^{n} \Delta_{(j)} + \frac{1}{\mathbf{Pb}} \times \frac{\mathbf{Td}}{\mathbf{T_0}} \times [\Delta_{(n)} - \Delta_{(n-1)}] + OFFS$$

Formation of the output at 2-ON/OFF controlling:

$$Out_{(n)} = +100\% \qquad \{PV < SP - \mathrm{HIST1}\}$$
$$Out_{(n)} = -100\% \qquad \{PV > SP + \mathrm{HIST1}\}$$
$$Out_{(n)} = Out_{(n-1)} \qquad \{(SP - \mathrm{HIST1}) \le PV \le (SP + \mathrm{HIST1})\}$$

Formation of the output at 3-ON/OFF controlling:

$$Out_{(n)} = +100\% \qquad \{PV < SP - Db - \mathrm{HIST1}$$
$$Out_{(n)} = -100\% \qquad \{PV > SP + Db + \mathrm{HIST2}\}$$
$$Out_{(n)} = 0\% \qquad \{SP - Db < PV < SP + Db\}$$
$$Out_{(n)} = Out_{(n-1)} \qquad \left\{ \begin{array}{c} (SP - Db - HIST1) \le PV \le (SP - Db) \text{ или} \\ (SP + Db) \le PV \le (SP + Db + HIST2) \end{array} \right\}$$

Logically the controllers of the production batch MS8120/8130 are designed as it is shown on Fig.8.

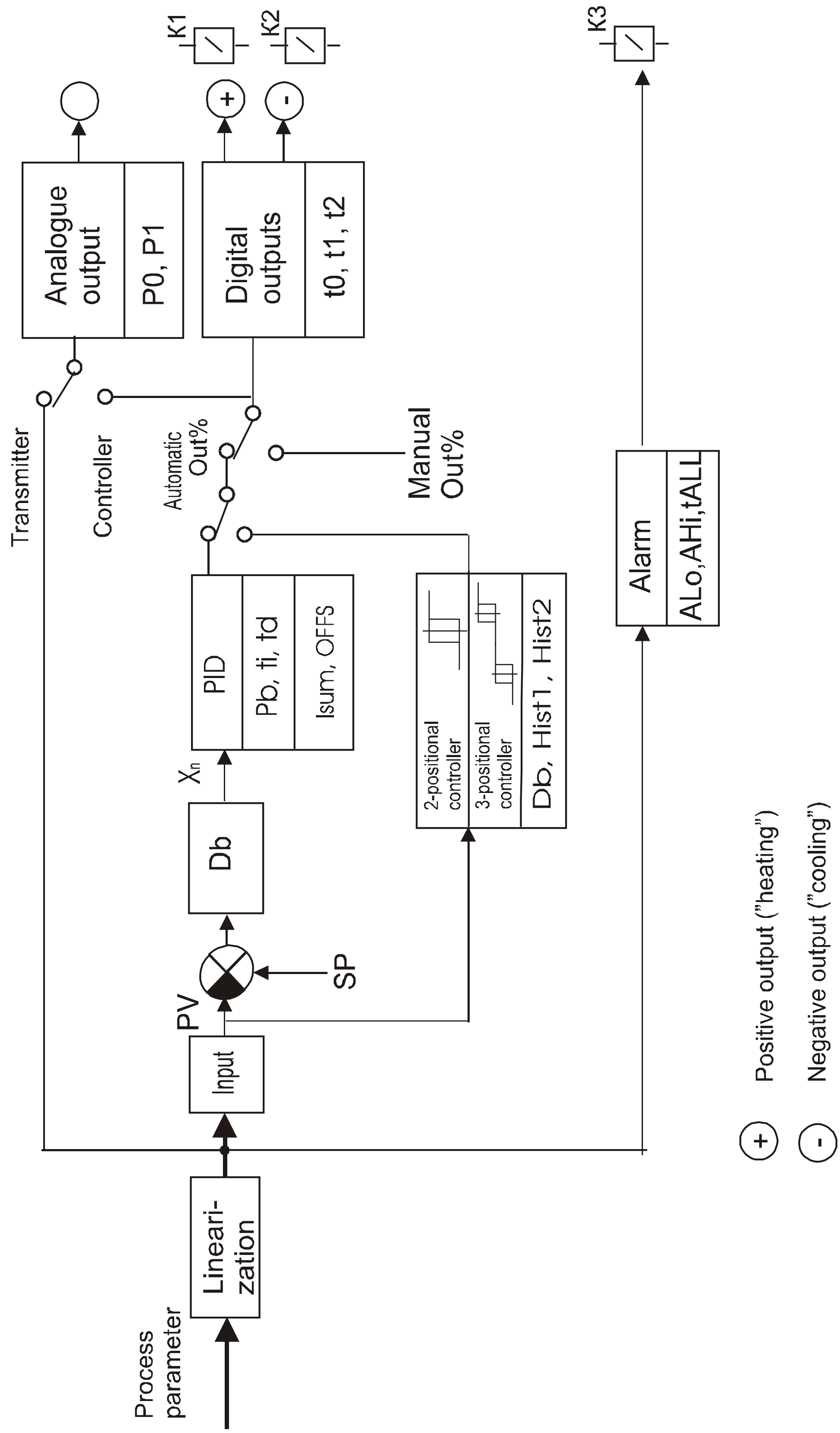


Fig. 8 Block-scheme

VII. OPERATING MODE

After the power is supplied the controller enters the last operating mode – automatic or manual, and the basic parameter appears on the display - OUT% for Manual operating mode and PV for automatic operating mode. In manual operating mode the output is with its value of the time before the power fault. This operating mode differs by the flashing of the decimal point and by the LED A/M (for instruments with 8 LEDs) of the face panel – then it emits light.

LEDs K1 and K2 indicate if the respective output K1 or K2 is active. The presence of alarm conditions before the activation of the alarm outputs is indicated by flashing LED AL and the activated output by emitting light AL.

1. Selection of operating mode – automatic/manual

Pass from Manual to Automatic Operating mode

– Pass to automatic operating mode, it is indicated by the inscription"Auto" and stopping of the flashing of the decimal point. The LED A/M does not emit light (for instruments with 8 LEDs).

Pass from Automatic to Manual Operating mode

 or 

– Select parameter Out on the display

– Pass to Manual operating mode, it is indicated by the inscription"HAND" and flashing of the decimal point. The LED A/M on the front panel starts emitting light (for instruments with 8 LEDs).

The instrument realizes shockless switching between the two types of operating modes – from automatic to manual and back, i. e. at switching of the operating modes the value of the output, which has been in the previous operating mode, is saved the same in the new selected operating mode. In manual operating mode when the indication on the display is **Out %** you can directly manipulate the output (p.4)

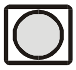
Each change of the output to manual operating mode stops **the auto tune of** PID parameters, if this function has been activated (see part.IX).

2. Change in the parameter on the display

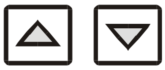
 or 

– You have to enter consecutively the name and the value of the parameter. If the instrument is in Automatic Operating mode 10 seconds after releasing of a button it returns to the basic parameter of the operating mode -PV

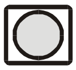
3. Editing of the set-point for controlling (SP)



– When the parameter SP is on the display and the button is pressed the value of the set-point (SP) starts flashing and its editing is permitted. If you do not press any button in 5 seconds the controller returns to normal operating mode.



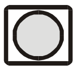
– Editing of the set-point



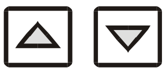
– Accepting of the new value (it can be realized automatically 5 seconds after the last pressed button).

4. Editing of the of the output action (Out)

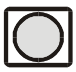
Editing of the output action is possible only in Manual Operating mode.



– When the parameter Out is on the display by pressing the button the value of the output starts flashing and its editing is permitted. If you do not press any button in 5 seconds the controller returns to normal operating mode.



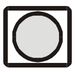
– Editing of the value of the output



– Accepting of the new value (it can be realized automatically 5 seconds after the last pressed button).

5. Lock/Unlock the keypad

When the keypad is locked it is not possible to change the parameters and the operating mode, you can only select the parameter of the display by the pointers. This function is for protection from unintentional influence on the work of the instrument, in this situation an inscription **Loc** appears on the display.

 and 

Press at one and the same time, but  have to be first

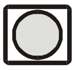
– Switches from unlocked to locked status of the keypad (**Inscription Loc**) and back (**Inscription UnLc**)

VIII. LEVELS OF PROGRAMMING

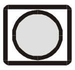
1. Level “system parameters”

The entry in these operating mode can be realized only when the parameter on the display is PV.

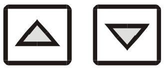
The activation of this menu does not change the work of the controller. The change of a parameter influences on the current controlling immediately after its confirmation. Two minutes after the last action it returns to normal work menu.



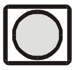
– When the input parameter is on the display press and hold for entering operating mode TUNING OF PARAMETERS. Inscription "ProG" appears on the display, till the releasing of the button.



– Look at the parameters and their values consecutively



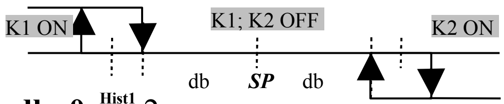
– Change the value of the selected parameter
– Look at the parameters consecutively



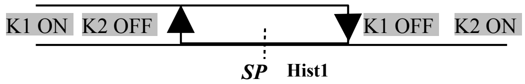
– Confirm the change
– When on the display there can be seen a name of a parameter, hold till inscription End_ has appeared on the display for exit from operating mode TUNING OF PARAMETERS.

Parameter	Description	Range of Changing	Factory Value
Pb	Proportional band Pb>0 means P, PI, PID, PD controller Pb=0 - 2 or 3 Positional controller If it is zeroed during auto tuning, the auto tuning stops.	0 ÷ 9999 (Dimension and decimal point according to the measured parameter)	
The next 10 parameters to Atun including can be seen only if Pb > 0			
ti	Time constant for integration	0 ÷ 9999 Sec.	
td	Time constant for derivation	0.0 ÷ 999.9 Sec .	
ISuL	Lower limit of the accumulation of the integral component	-100 ÷ 0 %	
ISuH	Higher limit of the accumulation of the integral component ***Windup (overflowing of the integral component)***, independent from the parameters **ISuL and ISuH**	0 ÷ 100 %	
OFFS	Add PID algorithm	-100.0 ÷ 100.0 %	
t0	Cycle time for measurement of PID algorithm	1 ÷ 255 Sec.	
tn1	Time for action of relay K1 at 100% measured (or set-point) output.	1 ÷ t0 Sec.	
tn2	Time for action of relay K2 at 100% measured (or set-point) output.	1 ÷ t0 Sec.	
AoFt See part IX!	Deviation from the set point during auto tuning (Auto tuning). For smaller set-point you have to load negative values and for bigger – positive	-1999 ÷ 9999 (Dimension and decimal point according to the measured parameter)	
Atun See part IX!	Auto tuning of the parameters Pb, ti, td	0 – switched off (stop) 1 – switched on (start)	

db	**Dead zone** at P,PI, PID, PD controller (Pb>0) At ON/OFF controlling (Pb=0) : **db>0** - 3 ON/OFF algorithm	0 ÷ 9999 (Dimension and decimal point according to the measured parameter)



db=0 $\frac{Hist1}{2}$ - 2
ON/OFF algorithm

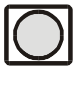


On the upper graphics Hist1>0; Hist2>0 ; K2 is not configured as 'Alarm'

The next 2 parameters can be seen only if Pb = 0

HYST1	Hysteresis at work of output: K1at 3 ON/OFF controller K1and K2 at 2 ON/OFF controller Negative value inverts the respective output	-1999 ÷ 9999 (Dimension and decimal point according to the measured parameter)
HYST2 It can be seen only if **db>0**	Hysteresis at work of output K2 at 3 ON/OFF controller Negative value inverts output K2	-1999 ÷ 9999 (Dimension and decimal point according to the measured parameter)
ALLo	Lower limit of the alarm	Lower limit of the parameter on the display ÷ AH (Dimension and decimal point according to the measured parameter)
ALHi	Higher limit of the alarm	AL ÷Higher limit of the parameter on the display (Dimension and decimal point according to the measured parameter).
Tall	Time for activation of the alarm	1 ÷ 100 Sec.

2. Level "hidden system parameters"



– When the power is supplied to instrument, press and hold the button. The hidden parameters appear at the beginning of the menu with basic parameters. The access to them is possible till the switching off of the instrument.

! Change them with great attention, because their change can be a reason for incorrect work of the instrument!

Parameter	Description	Values	Factory value
P0	Deviation of the analogue output	-1999 ÷ 9999	
P1	Multiplied coefficient of the analogue output	-1999 ÷ 9999	
dPnt	Decimal point The change of this parameter can be a reason for necessity of correction of all parameters by the dimension of the input parameter!	0 ÷ 4 (2) 0 – XXXX; 1- XXXX.; 2- XXX.X 3- XX.XX; 4-X.XXX Depending on the type of the input, 3 and 4 operating mode may be forbidden. Operating mode 0 is like 1 for instruments with 6 LED on the front panel.	
A db	Zone of work of the filter of ADC	0 ÷ 255 (Dimension and decimal point according to the measured parameter)	
Adbt	Time for the acceptance of value out of the zone **A db**	0 ÷ 255 c	
FILt	Coefficient of filter of ADC	1 ÷ 100	
SYST	Configuration of the outputs	0 ÷ 31	

The value of the output can be seen on the display in operating mode **Out** and varies from –100% ÷ 100%. From this parameter can be formed one analog and two (one, if the second is alarm) digital outputs in a way, depending on the parameter **SYST.**

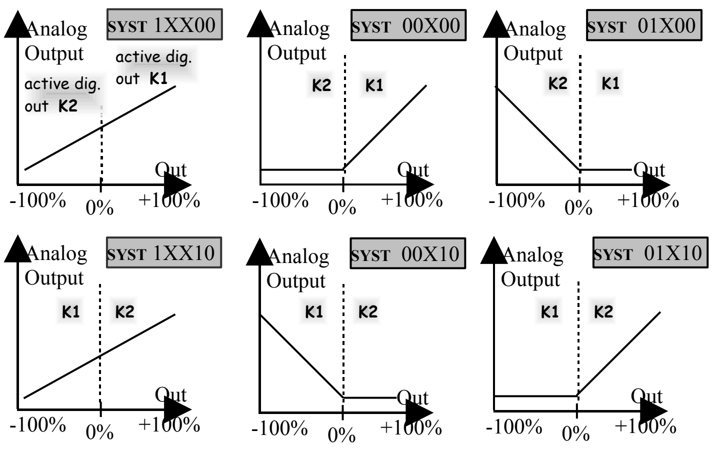
_ _ _ 16 8 4 2 1

bit 7 bit 0

bit 0 - 0 controlling analog output
1 transmitter analog output
bit 1 - 0 K1 "heating"; K2 "cooling"
1 K2 " heating"; K1 "cooling"
bit 2 - 0 absolute alarm
1 relative alarm
bit 3 - 0 controlling analog output on K1
1 controlling analog output on K2
bit 4 - 0 cont. analog output on K1or K2
1 cont. analog output on K1and K2

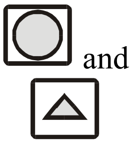
Digital outputs: If it is used in ON/OFF operating mode, they depend on the sign of the parameters **Hist1 and Hist2** - minus means inversion.
Otherwise **bit1** is important – 1 means logic 'cooling' of K1
Analogue output: first you have to check **bit 0** – controlling/ transmitting, after that bit **4** and at the end bit **3** and **bit 1.**

The necessary value is received when the numbers, corresponding to every set in 1 bit are summed (see up). For example for 10010 you have to enter 16 + 2 = ***18***



Parameter	Description	Values	Factory value
At ≡	Variants at auto tuning For operating mode "auto tuning" see p. IX.	1 ÷ 4	

3. Level “service parameters”



– When the power is supplied to the instrument, you have to press and hold the buttons.

Then the next parameters have to be added to the menu. The access to them is possible till the switching off of the instrument.

! Change them with a great attention, because their change can be a reason for incorrect work of the instrument!

Parameter	Description	Values	Factory value
SenS	Type of the input **Tuned by the producer!**	1 ÷ 7	
ConF	Operating mode of output K2; Front panel (instruments with 6 LEDs- 8130 always show decimal point on the display. It is to indicate **Manual Operating mode** – then it flashes. See the parameter **dPnt.** The result of the change of this bit can be seen at the next switching on of the instrument).	0 ÷ 31 _ _ _ _ _ _ 2 1 bit 0 bit 7 bit 0 bit 0 - 0 – K2 is controlling output 1 - K2 is output “Alarm” bit 1 - 0 – front panel with 6 LEDs 1 - front panel with 8 LEDs The necessary value is received when the numbers, corresponding to every set in 1 bit are summed (see up). For example for 11you have to input 2+1 = 3	

Measurement of the analog output :

Transmitting output

$$Aout = \frac{PV * 1023}{P1} + P0$$

Controlling output

$$Aout = \frac{Out * P1}{100} + P0$$

PV - value of the measured parameter;
Out - value of the controlling output, in percentages
1023 – range of DAC

IX. AUTOTUNING OF THE CONTROLLER

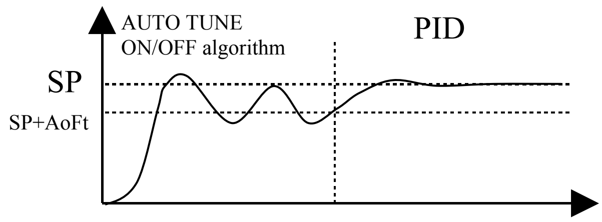
Indication: running decimal point and LED on the front panel in instruments with 8 LEDs

Activation: Atun = 1 **Deactivation: Atun = 0** (It can be done automatically too);
Change of the output in Manual Operating mode can stop it too

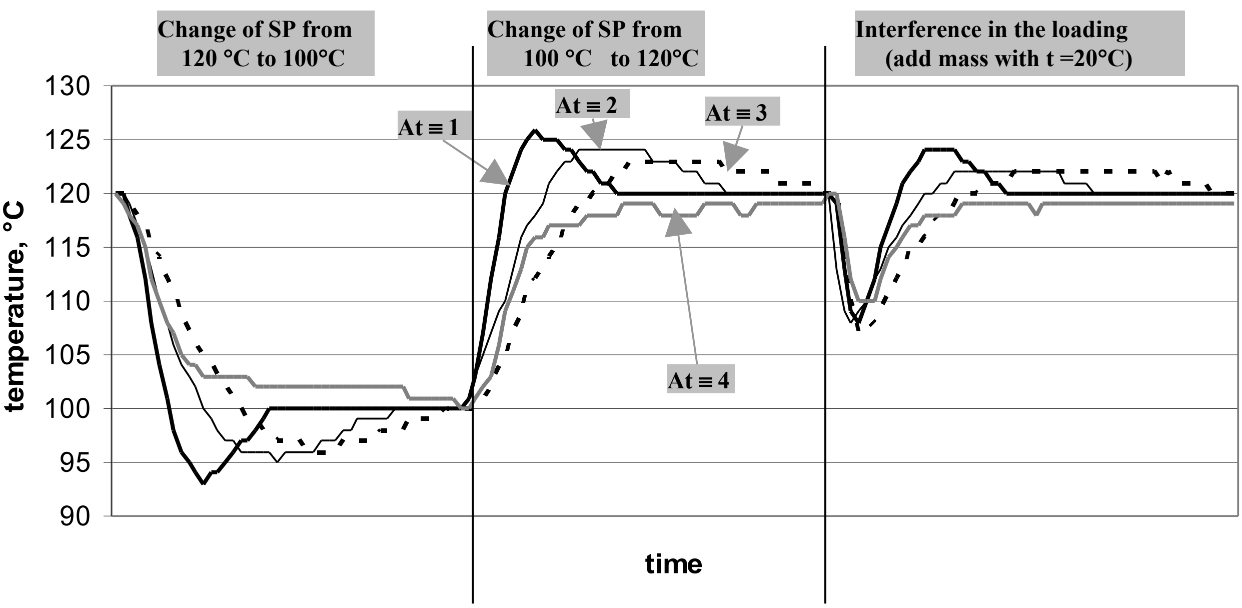
This function enables the device to specify the values of the parameters **Pb, Ti and Td**. Before the start of this function all parameters must be specified. To **Pb, Ti** and **Td** also must be set-pointed some protective values, which remain valid, if the autotuning is not successful – for example for PID controller big zone **Pb**, long time for integration **Ti**, little time for derivation **Td.** The activation of the auto tuning can be realized as to **Atun** add **1**. The procedure can be stopped always by **Atun = 0. Change of the output in Manual Operating mode deactivates it too.** After the retrieval of PID parameters it is realized automatically. The status of **Pb, Ti and Td** before the end of the procedure specifies the algorithm of controlling which will be realized: for **PID** the three parameters **Pb >0, Ti>0 and Td>0** must be set-pointed; for PI must be set-pointed **Pb>0, Ti>0, and Td= 0;** for **P** must be set-pointed **Pb>0, Ti=0 and Td= 0.** The auto tuning does not change the parameters with value 0; it conforms to the desired type controller. It is possible the controller to register unsuccessful auto tuning – then the original values of **Pb, Ti and Td** will not be changed automatically. So that it is good these values to be protective ones, with which inadmissible conditions do not appear**.**

With the starting of the function 'Auto tune' you can pass to controlling ON/OFF without hysteresis, which is a reason for the appearance of variations. It lasts two periods and after that the basic operating mode with tuned parameters returns. **Attention! In this ON/OFF operating mode the set-point may be considerably exceeded.** So during the auto tuning the set-point is the sum SP+AoFt. Thereby by the removing AoFt and SP you can select secure area at auto tuning, as closer as possible to the set-point at normal operating mode. For example at set-point SP=150° and AoFt= -20°the real set-point at auto tuning will be 130°. Till the process lasts changes in the characteristics of the object and interfering influences must be avoided. At the selection of **t0** it is necessary to be considered that at a period of the variations which is less than 8.**t0** or bigger than 1024.**t0** the procedure is unsuccessful. In this case the controller returns automatically in the same operating mode, in which it has been before the start of the procedure. The input parameter must be filtrated by the means left in the instrument and must not be out of the range of the device. **The stop of the power supply does not deactivate the procedure.** In that case after its recreation the auto tuning starts from the beginning.

The final result depends on the parameter **At ≡.** In comparison lower is shown the jumping process of a test object (controlling of the temperature) after auto tuning of PID controller at change of **SP and** at change in the loading for the four possible values of **At ≡.**



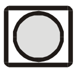
Reserves for improvement of the work of the device by manual correction of the parameters according to the object and the criteria may remain. **Note: In operating conditions the curves are equal, and for PI there is a difference only between At ≡ 3 and At ≡ 4**



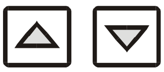
X. USER TUNING OF THE OFFSET OF THE ANALOG INPUT

In this operating mode, the users are free to input a programmable coefficient, which will be added always at the measurement of the input parameter (the so called "offset"). This operation must be realized with a great attention, because the instrument is tuned by the factory. The measuring can be realized indirectly.

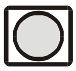
There is an access to that option if only the access to **"hidden system parameters"** is possible.



– When the input parameter is on the display and the instrument is in manual operating mode you have to press the shown button, inscription "OFSt" must appear till its releasing. The value, which is being tuned, is more accurate than the measured parameter with one order.



– Change the value of the deviation.



– Confirmation of the change and the new value is added to the previous value of the offset. (it can be realized automatically 5 seconds after the last pressed button).

EXAMPLES FOR USER TUNING OF THE OFFSET

1. Indication on the display: 129	Input offset: 3.4	
2. New indication on the display: 132	Input offset: 0.6	
3. New indication on the display: 133	Input offset: -1.0	New indication: 132

XI. MEASURES AGAINST INTERFERENCE

1. Recommendations for usage of connecting conductors

- Conductors, which carry signals close by type, can be packed together, but if the signals are different, the conductors have to be separated for to be prevented from capacitive and inductive interaction.

- When signals have to be crossed with different by type signals, this have to be done at right angles and maximum distance.

- Conductors, which carry weak signals and conductors which connect the sensors with the controller must not be near contactors, motors, generators, radio transmitters and conductors which carry big currents.

2. Limiting of the noise by using of the built-in filter

- If the input parameter is not stable you have to reduce the coefficient of the filter **FILt.** The smaller is the value of the coefficient of the filter, the heavier is the filter and the input parameter changes more slowly.

– If the input parameter overshoots periodically for short intervals of time it is necessary the parameter **AdBt** to be increased. At increase of that parameter the instrument responds more slowly at sharp change of the input parameter, but it ignores the brief interferences.

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