B. Nikolica-Serjoze 12, 18000 Nis, Serbia; Phone/Fax:+38118 211-212, 217-468; office@nigos.rs; www.nigos.rs

User manual for air humidity and temperature controller DRV-913P

- **Controls relative air humidity and air temperature**
- **Types of control: P, PI, ON/OFF, ON/OFF with time relay**
- **Output functions: heating/cooling and relative humidity increase/decrease**
- **Inputs: 2**
- **Outputs: 3**
- **Communication EIA485**

DRV-913P

Microprocessor controller DRV-913P is specialized device whose main purpose is control of air temperature and relative humidity.
Device has 2 inputs for linear voltage (0 to 1V) or linear current (0 to 20mA) signals and 3 really outputs for equipment control.
First input receives signal from temperature transmitter. Second input receives signal either from humidity transmitter, or temperature transmitter in which case psychrometric method for relative humidity calculation is used.
Output 1 is used for temperature control, output 2 for relative humidity control, while output 3 can be assigned to first or second output, or it can be turned off. Third output is assigned to first or second control loop when additional output is required for more effective control of temperature or humidity. Increase or decrease of value is selectable for all 3 outputs.

First and second outputs can operate with ON/OFF, P or PI type of control. Third output support only ON/OFF type of control which can be implemented as “time relay”.

There are 2 levels of parameter protections to avoid unauthorized access and parameter change.

TECHNICAL DATA

Main characteristics	
Power supply	90 to 250 Vac; 40 to 400 Hz; 4VA max
Number of inputs	2
Number of outputs	3
Display	Double, 4 - digits x 7 segment LED, 13mm, red
Operating conditions	T: 0 to 50 ^{0}C; RH: 5 to 90%
Storage	T: - 40 to 85 ^{0}C; RH: 5 to 90%
Dimensions (WxHxD)	96 x 96 x 145 (mm)
Mounting hole (WxH)	91 x 91 (mm)
Weight	560g

Input		
Linear inputs	Type of signal	Linear current or voltage
	Range of signal values on input 1	0 to 20mA (for current input); 0 to 1V (for voltage input)
	Range of signal values on input 2	0 to 20mA (for current input); 0 to 1V (for voltage input)
Measurement	Measurement range	- 0.1 to 1.1V for voltage, -1 to 21mA for current signal
	Measurement frequency	5Hz (200ms)
	Total measurement error	< 0.1% ± 1 digit

Output		
Relay	Characteristics	3-pin (SPDT); 8A / 250 Vac, 3A max permanent load
	Use	Output 1 – heating or cooling; Output 2 – increase or decrease of relative humidity; Output 3 – heating/cooling for temperature and increase/decrease of relative humidity; (depending on parameter settings)

Control function		
Control	Type of control	ON/OFF, ON/OFF with time relay, P, PI

Communication		
Digital	Communication standard	EIA 485
	Protocol	EI - BISYNC

Ordering code
Ordering code is given in form:

TYPE - X
X - input

Example:
DRV-913P - 0 to 20mA

1. Installation

Device dimension and mounting hole dimension are given in technical data. Device is secured against the front panel of the installation board using Π type profile.
When planning installation, make sure device has enough room for ventilation and that power cables are distant from cables carrying measurement signals to avoid signal corruption.

1.1. Power supply

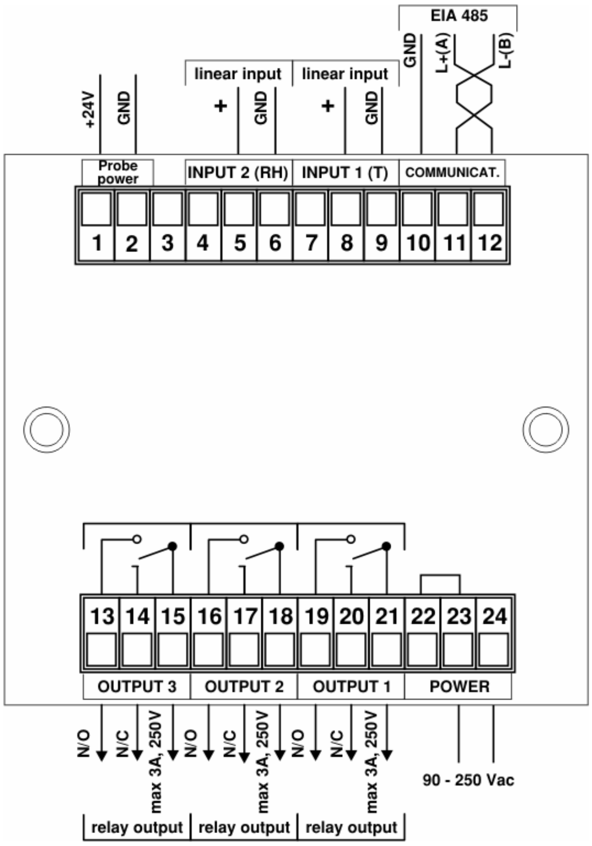
Power supply is connected to pins 23 and 24. Pins 22 and 23 are internally short circuited. Controller will start to operate immediately upon power supply connection.

1.2. Output connection

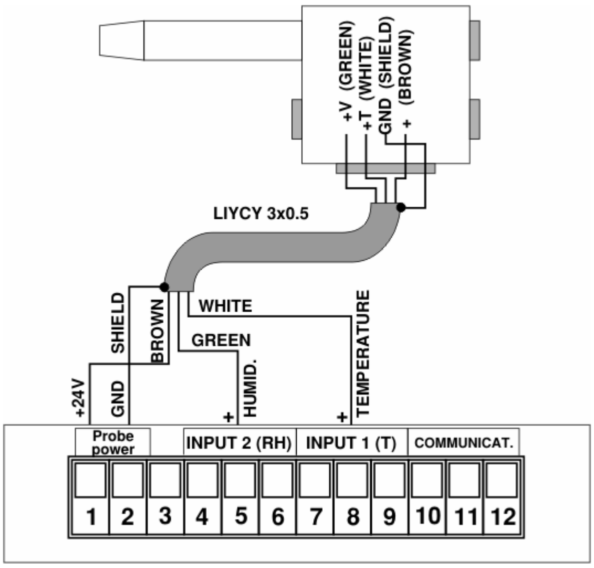
All 3 outputs are relay type with common, NC and NO contact. NC contact use only for signaling purposes. **Maximal permanent load current is 3A. Fuse must be installed!**

1.3. Input connection

Linear voltage (0 to 1V) or current (0 to 20mA) signals from appropriate transmitters are connected to controller inputs. Both inputs must be of same type (voltage or current).
"NIGOS - elektronik" recommends use of its probe for air temperature and relative humidity SVT-01P. This probe can be powered via DRV-913P, or it can use auxiliary power supply.
When probes are installed at greater distance, it is recommended to use auxiliary power supply for probe. At short distances, power supply from DRV-913P as shown on picture 1.2 can be used.



Picture 1.1. **Rear clamps connection layout**

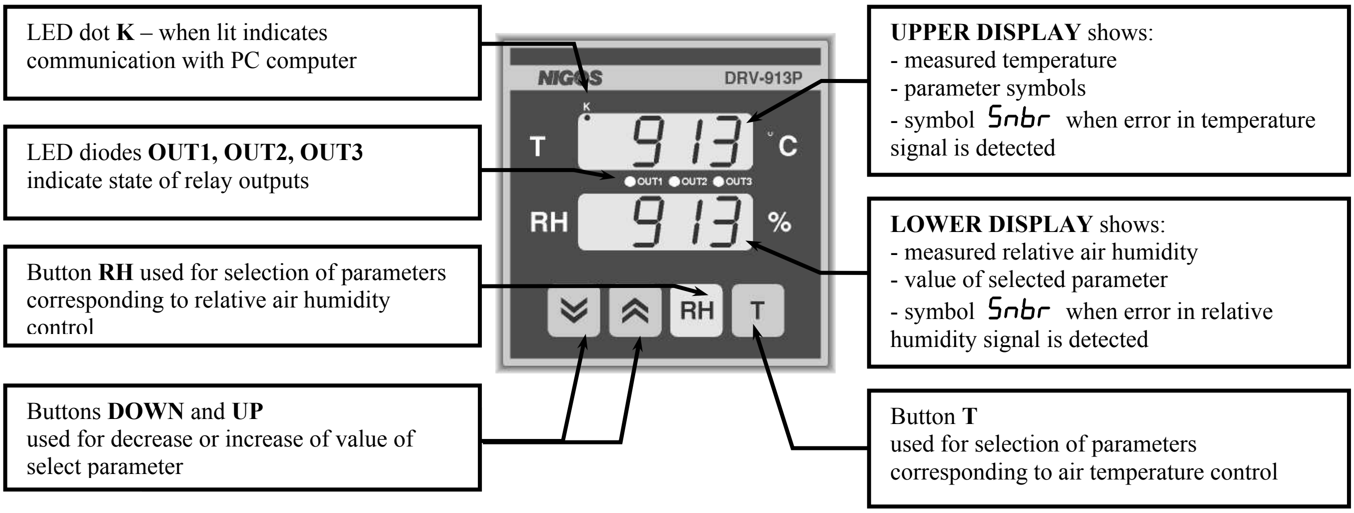


Picture 1.2. Probe SVT-01P connection
(for short distances between DRV-913P and SVT-01P)

1.4. Communication connection

DRV-913P can be connected to a communication line which supports EIA 485 standard. 2 wires shielded cable with maximal length of 1200m can be used. Most common characteristic impedance of the cable is 120 Ω, so equal resistors should be put at the end of the cable in order to achieve maximum power transfer and minimum signal reflection at the destination. Cable shield should be connected to ground of the communication device (PC computer, or some other device used).

2. Operation



2.1. Temperature and humidity setpoint setting

Temperature and humidity setpoint setting is possible only when controller is in **standard display mode** – upper display displays measured temperature while lower display displays measured relative humidity. Controller will enter this regime automatically few seconds upon powering and software version displaying, or few seconds after any button is pressed. Setpoint setting is performed in following way:

- Press button [T]. Upper display will show SP_t while lower display will show setpoint value for temperature.
- Use buttons [DOWN] and [UP] to adjust desired setpoint value for temperature.
- Press button [RH]. Upper display will show SP_h while lower display will show setpoint value for relative humidity.
- Use buttons [DOWN] and [UP] to adjust desired setpoint value for relative humidity.
- Wait few seconds until controller enters standard display mode.

2.2. Access to code protected parameters (CodE)

NOTE: Before proceeding with any parameter change, read this manual carefully!

In order to enable protection from accidental change and unauthorized access, certain parameters are stored in code protected parameter list. To access these parameters follow procedure bellow:

- Use either button [T] or [RH] to select parameter CodE (shown on upper display). Lower display will display zero (0).
- Use buttons [DOWN] and [UP] to set the value on lower display to 913. This is default setting of access code.
- Press either button [T] or [RH].

After this procedure code protected parameters are accessible and will remain accessible until controller is connected to power supply. After power reconnection, parameters will become inaccessible, and access code must be entered again.
Value 913 is default (factory) code and can be changed. Access code change is described in Chapter 3.2.

Code protected list of parameters contains parameters which are describing process characteristics and are directly influencing quality of control, so eventual adjustment of these parameters is required.
Parameter values are set to their default values which might not be appropriate for actual situation, so parameter adjustment is necessary. Values of most parameters are adjustable, but some values are only displayed, but can not be changed. These parameters are critical for system operation so they are additionally protected using **access level protection**. They are only displayed to show vital information about the control system and can not be changed.

2.3. Parameter selection and adjustment

Parameters are selected using buttons T or RH. Parameter symbols are shown on upper display, and their value on lower display.

Parameters for temperature control (output 1) are accessible via button T and their symbols end with letter t.

Parameters for relative humidity control (output 2) are accessible via button RH and their symbols end with letter h.

Parameter value shown on lower display is changed when buttons ˅ and ˄ are pressed. Holding the parameter pressed increase the speed of change. When one parameter is adjusted, press button T or RH to select next parameter.

We emphasize that unauthorized and not trained personnel should not alter default parameter values because each change can severely affect system behavior.

2.3.1. Parameters for temperature control – output 1

Output 1 on DRV-913P is used for temperature control. Parameters used for temperature control have symbols ending with letter t and become accessible when button T is pressed. Output function and type of control are parameter selectable.

Output 1 function: heating or cooling – are defined by parameter Out.t. Value of this parameter can be HEAt or COOL :
- HEAt – output 1 will operate with temperature **increase** function (heating function), i.e. it will be active whenever measured temperature is **lower** then temperature setpoint (SP_t)
- COOL - output 1 will operate with temperature **decrease** function (cooling function), i.e. it will be active whenever measured temperature is **higher** then temperature setpoint (SP_t)

Output 1 type of control: ON/OFF, P or PI is defined by parameter Ctr.t.

Table 2.1. **Parameters used for temperature control - output 1**

PARAMETER LABEL		RANGE OF VALUES	DEFAULT VALUE
SP_t	Temperature setpoint	From -9.9 °C to HSP.t	25.0
Out.t	Output 1 function	HEAt - heating – output is active when measured value is lower than SP_t COOL - cooling - output is active when measured value is higher than SP_t	HEAt
Ctr.t	Type of control on output 1	ProP – proportional or PI type of control (depending on int.t) On.OF - ON/OFF type of control	On.OF
dSP.t	Temperature setpoint delta (value shift)	From -99.9 to 99.9	0.0
Pro.t	Proportional range for output 1 (shown only if Ctr.t is set to ProP)	From 0.1 °C to 999.9 °C	10.0
int.t	Integral time constant for output 1 (shown only if Ctr.t is set to ProP)	OFF – turned off – only proportional control (P) is selected From 1 second to 9999 seconds - PI control is selected	300
tP_t	Cycle duration for output 1 (shown only if Ctr.t is set to ProP)	From 1 second to 250 seconds	20
HiS.t	Hysteresys for output 1 (shown only if Ctr.t is set to On.OF)	From 0.1 °C to 100.0 °C	0.5
HSP.t	High limit of temperature setpoint	From -9.9 °C to 100.0 °C	80.0
OFS.t	Temperature offset	From -9.9 to 99.9	0.0

2.3.2. Parameters for relative humidity control – output 2

Output 2 on DRV-913P is used for relative humidity control. Parameters used for relative humidity control have symbols ending with letter h and become accessible when button RH is pressed. Output function and type of control are parameter selectable.
Output 2 function: increase or decrease of relative humidity - is defined by parameter OUt.h. Value of this parameter can be HEAt or COOL:

- HEAt - output 2 will operate with humidity **increase** function - it will be active when measured value is **lower** then setpoint (SP_.h)
- COOL - output 2 will operate with humidity **decrease** function - it will be active when measured value is **higher** then setpoint (SP_.h)

Output 2 type of control: ON/OFF, P or PI is defined by parameter Ctr.h.

Table 2.2. **Parameters used for relative humidity control - output 2**

PARAMETER LABEL		RANGE OF VALUES	DEFAULT VALUE
SP_.h	Relative humidity setpoint	From -0.0 % to 99.9 %	25.0
OUt.h	Output 2 function	HEAt – humidity increase – output is active when measured value is lower than SP_.t COOL – humidity decrease – output is active when measured value is higher than SP_.t	COOL
Ctr.h	Type of control on output 2	ProP – proportional or PI type of control (depending on int.t) OnOF - ON/OFF type of control	OnOF
dSP.h	Relative humidity setpoint delta (value shift)	From -99.9 to 99.9	0.0
Pro.h	Proportional range for output 2 (shown only if Ctr.h is set to ProP)	From 0.1 % to 999.9 %	10.0
int.h	Integral time constant for output 2 (shown only if Ctr.h is set to ProP)	OFF – turned off – only proportional control (P) is selected From 1 second to 9999 seconds – PI control is selected	300
tP_.h	Cycle duration for output 2 (shown only if Ctr.h is set to ProP)	From 1 second to 250 seconds	20
HiS.h	Hysteresys for output 2 (shown only if Ctr.h is set to OnOF)	From 0.1 % to 100.0 %	5.0
OFS.h	Relative humidity offset	From -9.9 to 99.9	0.0

2.3.3. Parameters for output 3

Output 3 on DRV-913P can be turned off, or it can be assigned to first or second output (first or second control loop). It is assigned to temperature or humidity control when 2 outputs are required for better control. Parameter in_.3 defines assignment to first or second control loop and can be visible either by pressing button T, or button RH. Other parameters are accessible when button T is pressed – in case output 3 is assigned to temperature control (output 1), or when button RH is pressed - in case output 3 is assigned to humidity control (output 2).
Output 3 function - increase or decrease of selected value - is defined by parameter Out.3. Parameter values are:

- HEAt – output 3 will work with increase function, i.e. it will be active whenever measured value is **lower** then setpoint
- COOL – output 3 will work with decrease function, i.e. it will be active whenever measured value is **higher** then setpoint

Third output supports only ON/OFF type of control which can have "time relay" function using parameters tOn and tOFF.

Table 2.3. **Parameters used for output 3**

PARAMETER LABEL		RANGE OF VALUES	DEFAULT VALUE
in_.3	Selection of control loop (output) to which output 3 is assigned	OFF – output 3 is turned off in.t – output 3 assigned to temperature control (to output 1) in_.h – output 3 assigned to humidity control (to output 2)	in_.h
OUt.3	Output 3 function	HEAt – output active when measured value is lower than setpoint COOL - output active when measured value is higher than setpoint	HEAt
dSP.3	Setpoint delta (value shift) for output 3	From -99.9 to 99.9	0.0
HiS.3	Hysteresys for output 3	From -0.1 to 99.9	5.0
tOn	Duration of activated output 3 in one cycle	From 1 second to 9999 seconds	5
tOFF	Duration of deactivated output 3 in one cycle	From 0 second to 9999 seconds	30

2.4. Selection of probe type for relative air humidity measurement

Controller DRV-913P supports several ways of relative air humidity measurement:

- Direct measurement – using special sensor (capacity sensor) and transmitter which turns original signal into linear DC voltage signal 0 to 1V, or linear DC current signal 0 to 10mA. This signal is connected to input 2 on DRV-913P and directly calculated to relative humidity.

- Psychrometric method measurement – humidity is calculated based on temperature difference between wet and dry bulb. Signal from wet bulb is converted in transmitter into 0 to 1V or 0 to 20mA signal and connected to input 2,. Signal from dry bulb is converted to same type of signal and connected to input 1.

- Dew point temperature calculation – This method uses same way and data types as first method. Main difference is that lower display shows value of dew point temperature instead of relative humidity in %RH.

- Equilibrium moisture content (EMC or UGL) calculation – DRV-913P supports signals from specific devices for air humidity measurement in wood dryers made by NIGOS. Such devices measure resistance of samples exposed to certain humidity and temperature in drying chamber. Information is transferred to DRV-913P as analogue voltage signal, and EMC in drying chamber is calculated based on this signal.

Desired measurement method is selected using parameter Snd.h. This parameter is accessible when either button T or button RH is pressed.

Table 2.4. **Parameter Snd.h**

PARAMETER LABEL		RANGE OF VALUES	DEFAULT VALUE
Snd.h	Selection of air measurement method	CAP.S – direct method for relative humidity measurement using capacitive sensor PS ih – air humidity measurement using psychrometric method dEm.P – Dew point method UGL – Equilibrium moisture calculation (device specific option)	CAP.S

NOTE: Signals from transmitter connected to both inputs must be same type for both temperature and humid. This data must be provided when ordering.

2.5. Error reporting

DRV-913P can report errors detected in device operation, or measurement signal. Appropriate error symbols are displayed.

Displaying of symbol Snbr on any display indicates error in either temperature or humidity signal. When displayed on upper display, error is in temperature signal, and if displayed on lower display, error is detected in humidity signal. Main causes for these situations are:

- interrupt or braking of connection between controller and transmitter
- improper connection of inputs
- transmitter malfunction
- controller malfunction

In case standard display is interrupted periodically with symbols CS.Er or E2.Er, it is an indication that there is an error in controller functioning. In that case controller must be taken to service.

3. Parameter protection and access levels

DRV-913P has 2 levels of parameter protection:
- **operator level** (code protected parameters)
- **configuration level**

Operator level is formed with main purpose to protect certain parameters from accidental change of parameters or unauthorized use of controller. This level mostly protects parameters which may influence control process and which should be accessed periodically for overview and eventual correction. Access to parameters on operator level (code protected parameters) is allowed after correct access code is entered (see Chapter 2.2 for more details).

As additional protection, **configuration level** is implemented. This level determines which parameters will be visible, which can have their value adjusted, and which will be hidden from showing on operator level because they are essential for controller operation and should be changed only by authorized personnel. Access level is adjusted on configuration level using special access rights assignment procedure.

Configuration level provide highest protection level and request special access procedure. Once accessed, configuration level enables access to all parameters - including those vital to proper system function. Procedures for access right assigning and access code change are only possible on this level.

Configuration level is accessible depending on the position of special switch inside the device. While this switch is closed, only operator level is accessible. Once this switch is opened, configuration level access is possible. This operation should be performed only by trained personnel.

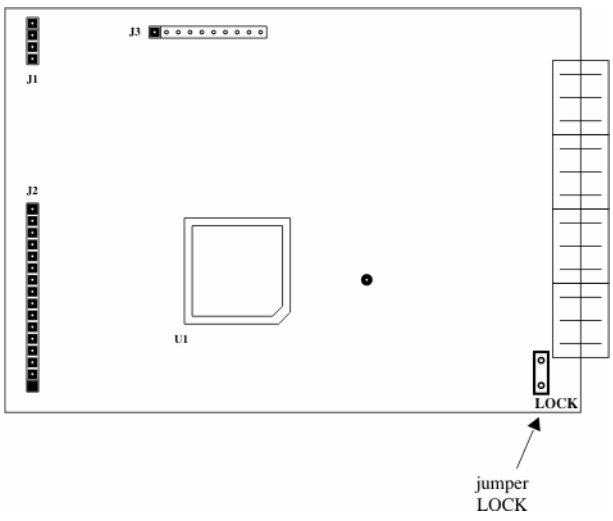
Regardless of current access level, certain parameters determine existence of other parameters in the list. In case some parameter is not shown in the list, it is because for current device setup their showing has no sense.

3.1. Configuration level access

Since this procedure require operations on the hardware, it should not be performed very carefully and only if very needed.

To access configuration level follow this procedure:
- Turn off power supply, remove all clamps from the back side of device (if necessary label the clamps to ensure proper returning).
- Remove back lid and take PCBs out of device's case.
- Unlock jumper **LOCK** at lower right side of main PCB (see picture 3.1)
- Return PCBs in the case, close the lid and reconnect clamps on the back side.
- Reconnect power supply.

Access to configuration level is now available. After all required changes on parameters are made, exit configuration level, and proceed with above procedure, only this time, return jumper LOCK to locking position (as it was prior to unlocking).



Picture 3.1. **Main PCB layout with positions of jumper LOCK**

3.2. Access code setup procedure

Changing of access code, which protects the parameters on operator level, is possible only on configuration level. Factory set password 913 (default value) can be changed using following procedure:

- Enter configuration level (chapter 3.1).
- Now, all parameters are accessible and one of them is parameter CodE - access code. Press buttons T or RH to scroll to this parameter. Parameter symbol is shown on upper display, and parameter value is shown on lower display.
- Use buttons ⏬ and ⏫ to set new desired code on lower display
- Wait for controller to return to standard display mode
- Exit configuration level (chapter 3.1).

This ends access code change procedure. From now on, new password will be required to login to operator level. Make sure to memorize new code.

3.3. Access right limitation setup

Configuration level enables procedure for selection which parameters will be accessible, read only or hidden on operators level. This is access right limitation procedure. For certain selectable parameters access right can be assigned as:

- ALtr - free access - fully accessible and alterable parameter on operator's level,
- rEAd - partially accessible - parameter value is shown on operator's level, but can not be altered,
- HidE - forbidden access - parameter is hidden from list of parameters visible on operator's level - available only on configuration level.

Controller DRV-913P is delivered with default setting of access right for each parameter which can be altered using following procedure:

- Enter configuration level (chapter 3.1.).
- Press buttons T or RH to select symbol ACCS on upper display. This enables access right setup procedure.
- Press button ⏫ to select first parameter (symbol is shown on upper display, access right on lower display).
- Press button ⏬ to change access right for selected parameter.
- Press button ⏫ to select next parameter, and repeat above procedure for all parameters which require access right change.
- After completion, leave the programmer untouched to return to standard display (and save all changes into memory).
- Exit configuration level (chapter 3.1).

When access right for specific parameter is chosen, it is essential to pay attention to purpose of this procedure which is protection of certain key parameters for system operation, and limitation of parameters displayed on operator's level for faster and easier access. Operator level list of parameters should not contain parameters which are rarely changed or not changed at all during operation.

4. CONTROL PARAMETERS AND TYPE OF CONTROL

Controller DRV-913P provides 3 types of control:
- ON/OFF type of control
- proportional control (P)
- proportional – integral control (PI)

Type of control is selected by setting parameter Ctr.t for temperature (output 1) and Ctr.h for relative air humidity (output 2). These parameters can have values:
- OnOF – ON/OFF type of control is selected for specific output
- ProP – P or PI type of control is selected. Further selection is available via other parameters.

Output 3 is intended to use only ON/OFF type of control with possibility to be configured as “time relay”.

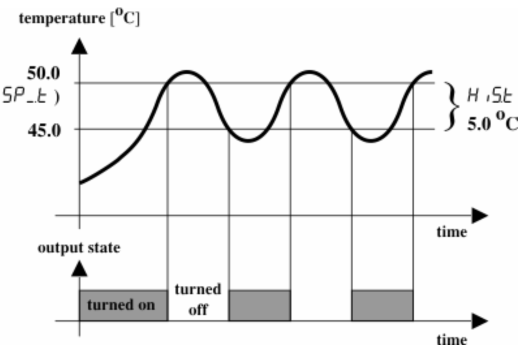
4.1. ON/OFF type of control on first and second output

ON/OFF type of control assumes turning on and off appropriate output at defined temperature limits. These limits are relative to setpoint and defined by the parameter **hysteresys**. Symbols for hysteresys parameters are HiSt for temperature (output 1) and HiSh for relative humidity (output 2).

ON/OFF type of control is used in systems which do not demand high precision control, but certain deviation from setpoint is allowed. This type of control is also recommended for systems where frequent turning on and off of the outputs is not desired.
To select this type of control, set the value of parameter Ctrl to value OnOF.

Example of ON/OFF control on output 1 is shown on picture 4.1. Heating function is selected OUt.t = HEAt, temperature setpoint is set to SP_t = 50.0 °C and hysteresys is HiSt = 5.0 °C. Lower graph shows output 1 states (turned on or off). At start, output 1 is turned on until measured temperature reaches setpoint. When setpoint is reached (50°C in example) – output is turned off and stays turned off until measured temperature drops below setpoint for hysteresys value (45°C in example because hysteresys is 5°C) – and then it is turned on again.

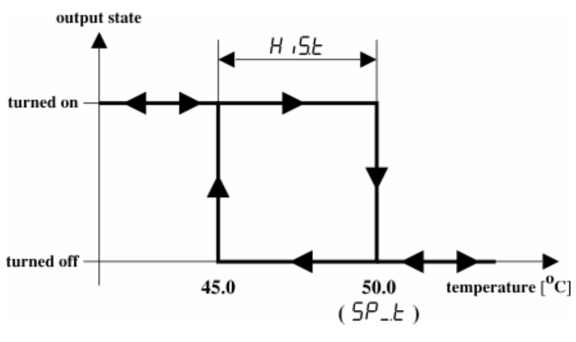
Same logic described here for temperature control (output 1) apply for relative humidity control (output 2).



Picture 4.1. **Example of ON/OFF control on output 1**

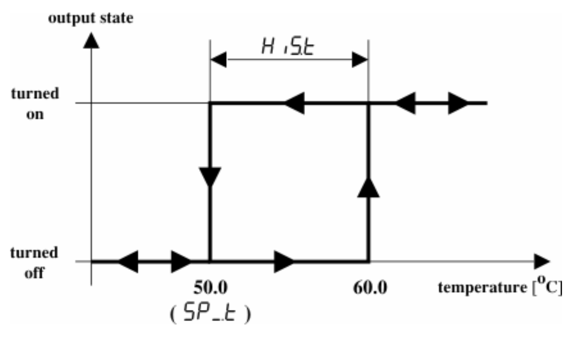
Example of ON/OFF control for heating:

SP_t = 50.0 [°C] Ctr.t = OnOF
OUt.t = HEAt HiSt = 5.0 [°C]



Example of ON/OFF control for cooling:

SP_t = 50.0 [°C] Ctr.t = OnOF
OUt.t = COOL HiSt = 10.0 [°C]

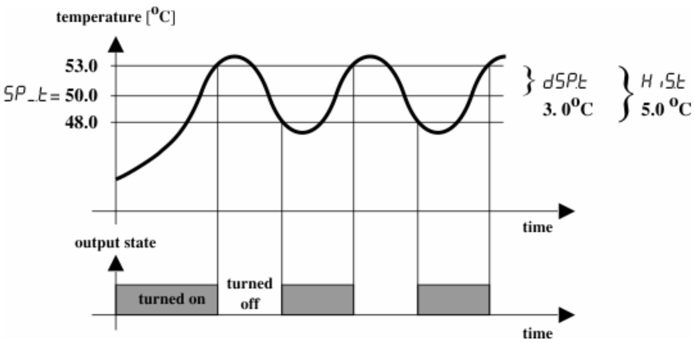


It is clearly shown that in second example (cooling function) hysteresys has reversed when compared to first example (heating function).

For both examples output is **turned off** at setpoint SP_t, while it is **turned on** at the temperature in the band where output is active. This temperature is lower than setpoint for heating function, and higher than setpoint for cooling function. Same logic apply for all outputs.

Beside the parameters which determine function and hysteresys fro certain output, there are also parameters which determine delta (value shift) from setpoint. Values of parameter dSP.t for temperature (output 1) and dSP.h for relative humidity (output 2) are added to setpoints SP_t (output 1) and SP_h (output 2) and thus determine new - **shifted setpoints**.

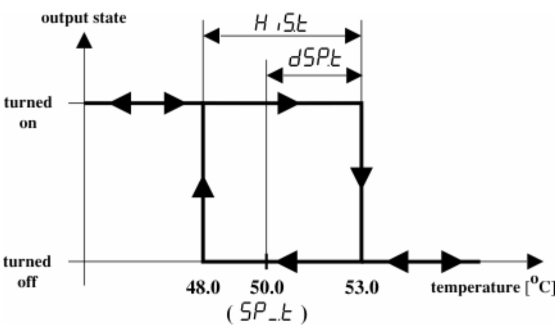
For example: if in previous example we set parameter dSP.t to 3.0 °C and leave all other parameters unchanged, we will have altered temperature process as shown on picture 4.2. Turn off limit is now at "shifted temperature" equal to 53°C which now became new setpoint. This new setpoint is calculated when temperature delta parameter dSP.t = 3.0 °C is added to original temperature setpoint SP_t = 50.0 ^{0}C, while temperature at which output is turned on is determined again by the hysteresys value (HiSt = 5.0 °C) and is equal to 48 °C.



Picture 4.2. **Example of ON/OFF control on output 1**
with included delta (dSP.t) parameter

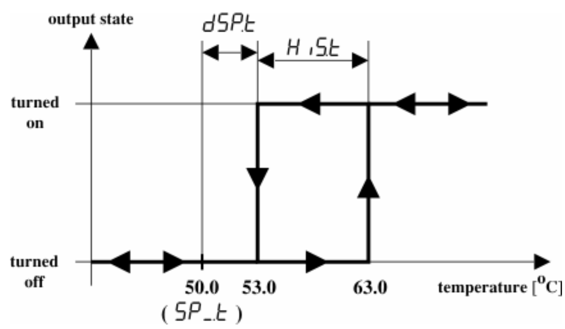
Setpoint delta for heating function:

SP_t = 50.0 [^{0}C]   HiSt = 5.0 [^{0}C]
OUt.t = HEAt   dSP.t = 3.0 [^{0}C]
Ctr.t = OnOF



Setpoint delta for cooling function:

SP_t = 50.0 [^{0}C]   HiSt = 10.0 [^{0}C]
OUt.t = COOL   dSP.t = 3.0 [^{0}C]
Ctr.t = OnOF



In same way parameter dSP.h influence relative humidity control because new setpoint is calculated when delta dSP.h is added to original setpoint SP_h.

Parameters dSP.t and dSP.h can have negative values, so setpoint shifting can be toward both higher and lower values. In case these parameters are set to 0.0, there is no setpoint shifting and outputs are turned off at SP_t, i.e. SP_h.

Parameters dSP.t and dSP.h can be useful when output 3 is used for control in combination to output 1 or 2 and be considered as main control output. In this case original setpoint for out 3 is unchanged, and outputs 1 or 2 can operate with shifted values.

4.2. ON/OFF control on output 3

Third output can have only ON/OFF type of control with certain additional capabilities. Beside parameters OUt.3 (output function - increase or decrease of selected value) and HiS3 (hysteresys), parameters dSP.3, tOn and tOFF are used to additionally influence process control.

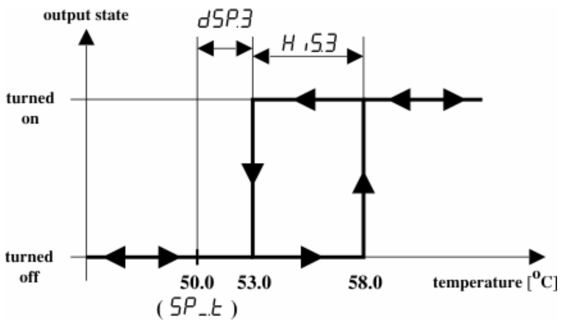
Parameter dSP.3 presents setpoint delta for output 3 with same function as parameters dSP.t and dSP.h. Example with hysteresys included is shown on picture 4.3.

"**Time relay**" is special feature of output 3 which imply that output 3 works according to ON/OFF type of control, but time when output should be turned on is divided into cycles. Each cycle is defined by the time (duration) when output is turned on (parameter tOn) and the time (duration) when output is turned off (parameter tOFF). Both parameters are given in seconds. Output operation with such ON/OFF "time relay" control is shown on picture 4.4.

Extra caution should be taken when parameters tOn and tOFF are used because they directly influence output operation and are always active. If standard operation is desired, value of the parameter tOFF should be set to zero.

SP_t = 50.0 [°C]
in_3 = in_t
OUt.3 = COOL

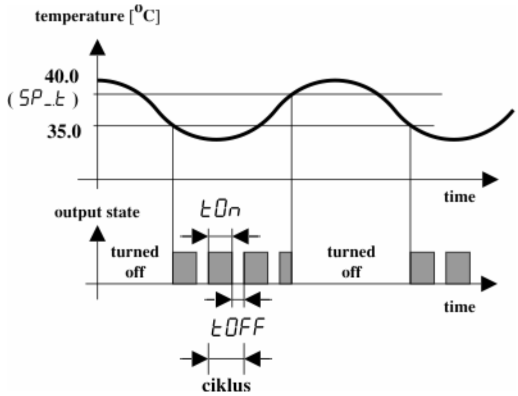
dSP.3 = 3.0 [°C]
HiS.3 = 5.0 [°C]



Picture 4.3. **Example of ON/OFF control on output 3**

SP_t = 40.0 [°C]
in_3 = in_t
OUt.3 = HEAt

dSP.3 = 0.0 [°C]
HiS.3 = 5.0 [°C]
tOn = 15 [sec]
tOFF = 10 [sec]



Picture 4.4. **Example of ON/OFF control with time relay option**

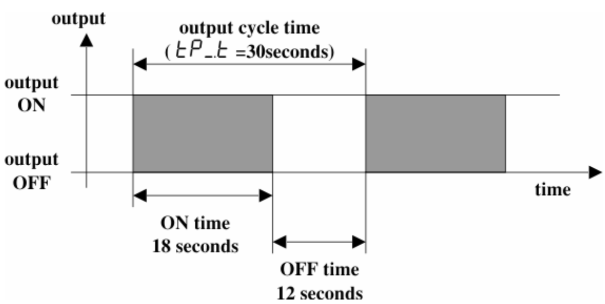
4.3. Proportional control (P and PI control)

4.3.1. Output activity cycle and output level

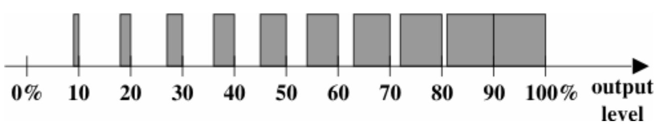
Proportional control imply turning on and turning off outputs in certain rhythm during process control, where duration of output activation depends on difference between measured and setpoint. This method gives much better control then ON/OFF type of control, but much more frequent turning on and off of the outputs is present. Relevant parameters are shown in the parameter list only when this type of control is selected, i.e. if parameters Ctr.t or Ctr.h are set to ProP.

Proportional control is performed by activation/deactivation output in certain rhythm. This rhythm is determined by **heat cycle time**. Cycle duration is time between 2 output activation, i.e. sum of times when output is active and inactive. This time is defined by parameter tP_t (for output 1) and tP_h (for output 2) and their value is given in seconds.

Output level is defined as ***percentage ratio of duration of activity within the cycle and total cycle time for an output***. Value is set in range 0 to 100%. For example, if output level is set to 60% and heat cycle time is 30 seconds (tP_t = 30), then time of output activity is 18 seconds, and time of inactivity is 12 seconds.



Picture 4.5: **Output activity within heat cycle with output level of 60%**



Picture 4.6: **Output activity depending on output level**

4.3.2. Proportional band

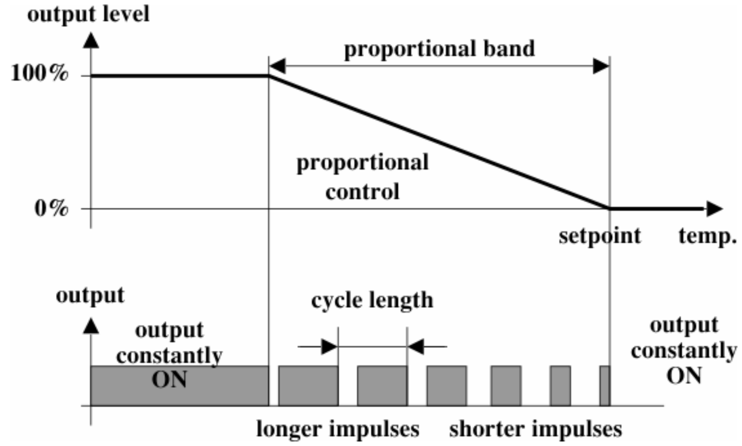
Proportional band is a band within which **proportional control** is performed. To set this band, one limit is on the setpoint, and second is below that setpoint (for heating) and above that setpoint (for cooling). As the setpoint shift during program run, so does this band also.

While measured temperature during program running is within proportional band, programmer will calculate error - difference between setpoint and measured temperature. Based on this error, programmer calculates output level, i.e. ratio of output activity and inactivity, in order to minimize this error. This way, programmer controls amount of energy induced to system. So when the error is great (meaning measured temperature is far from setpoint) - output level will be high, and vice versa - as the error is lowered, so will the output level.

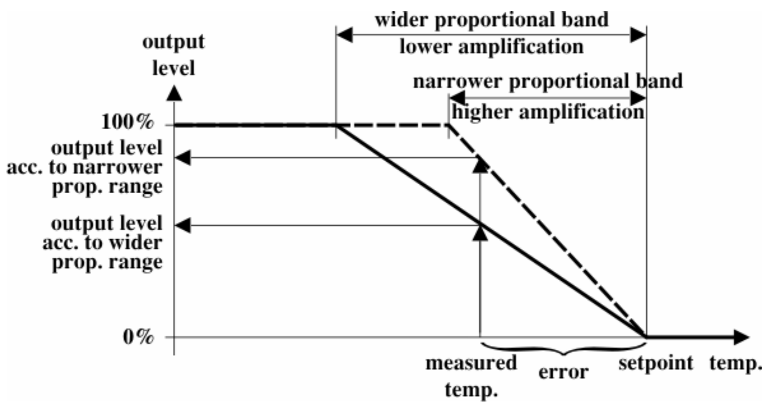
If measured temperature is out of proportional band and setpoint is overshot (setpoint is lower than measured temperature) controller will set the output level to 0% and completely turn off the output, and vice versa, if the temperature is undershoot, it will set output level to 100%. Parameter responsible for adjusting the **proportional band width** is labeled with symbol Pro.t for temperature control and Pro.h for relative humidity control. Value of this parameter is given in °C or %RH. Example of relation between proportional band and setpoint is given on picture 4.7.

Proportional band is indirectly proportional to gain which amplifies the error between setpoint and measured value to establish a power level. Narrow proportional band increase system sensibility to errors because of high gain (amplification), and wider proportional band lowers the system sensibility to errors because of low gain (amplification), as shown on picture 4.8, so it is crucial to select proper proportional band for each system. Too wide proportional band can produce significant inertia and settling the temperature away from setpoint. Too narrow proportional band will produce oscillations around setpoint due to high system sensibility to error.

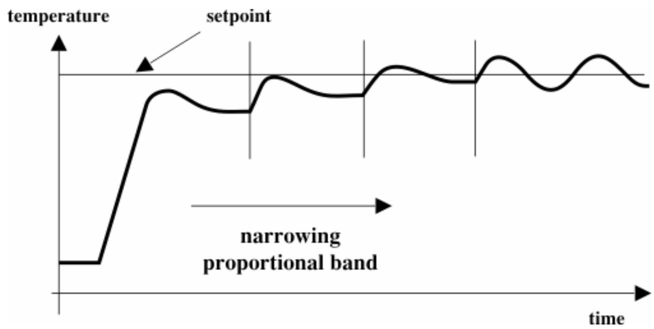
Influence of proportional band to quality of control is shown on example where only proportional control is changed during hold segment (picture 4.9). At first, wide proportional band is set so temperature stabilize at much lower value than setpoint, With gradual narrowing of the proportional band, temperature will come closer to setpoint. If too narrow proportional band is set, then the temperature will start to oscillate around setpoint. So, in conclusion, it is best to choose as narrow proportional band as possible, but in that way that temperature oscillations do not occur.



Picture 4.7: **Relation between proportional band and setpoint**



Picture 4.8: **Influence of proportional band width to amplification**

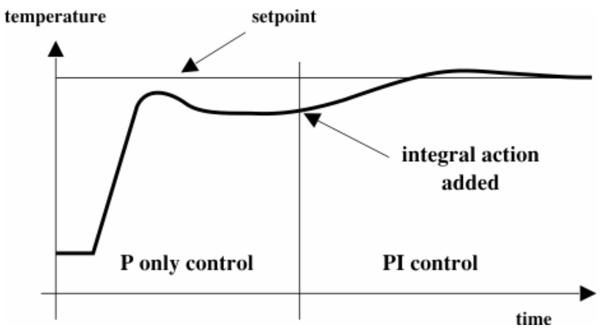


Picture 4.9: **Influence of narrowing the proportional band (P type of control)**

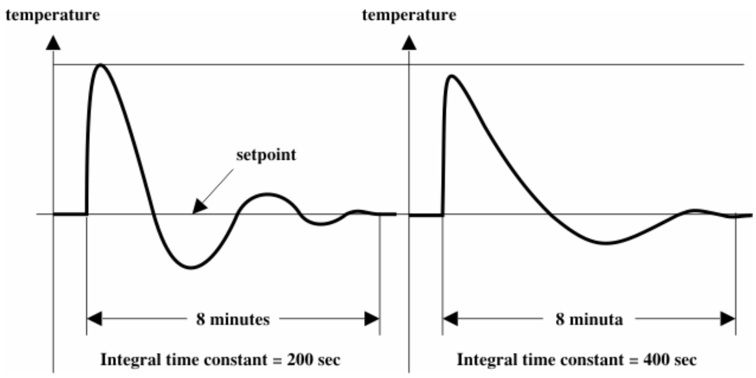
4.3.3. Integral time constant

Integral action, or Automatic Reset, is probably the most important factor governing control at setpoint. Parameter **integral time constant** (integral term) introduces integral action into control. This parameter is labeled with symbol int.t for temperature control and int.h for humidity control, and its value is given in seconds. If integral action is turned off by setting the parameter int.t or int.h to value OFF, only proportional control will remain.

Integral term slowly shifts the output level as a result of an error between setpoint and measured value. If the measured value is below setpoint the integral action will gradually increase the output power level in an attempt to correct this error. This action does not allow temperature to settle at the level far below setpoint, which is characteristic for pure proportional control. Picture 4.10 demonstrates the result of introducing integral action. In the beginning, only P control is used. Once the temperature settles at certain level below setpoint, integral action is introduced. After that, temperature slowly rises until it reaches setpoint.
If the integral time constant (term) is set to a fast value the power level could be shifted to quickly thus causing oscillation since the controller is trying to work faster than the load can change. Conversely, an integral time constant which is too long will result in very sluggish control. Picture 4.11 demonstrates influence of widening integral time constant. It is noticeable that lengthening the integral time constant result in slower system response.



Picture 4.10: **Adding integral action**



Picture 4.11: **Widening integral time constant**

5. Procedure of parameter settings for PID control

Each system has its own characteristics so it is necessary to adjust control parameters for each system independently in order to achieve best quality of control. There are many procedures for parameter adjustment. Most commonly used is **closed-loop cycling method**. This method is applicable where system allows overshoots during setup. For system which does not allow great temperature oscillations, some other method must be used.
Closed-loop cycling method is performed as follows:

- Make sure system is setup for normal operation (inputs and outputs connected, power supply provided, etc....)
- Select proportional control (set parameters Ctr.t to Ctr.h to ProP).
- Turn off integral action (set int.t and int.h to value OFF)
- Reduce duration of active output cycle as much as system allows it.
- Reduce the value of proportional band (ProP) to lowest possible value. This will force system into oscillation after setpoint is reached.
- Measure the time system requires for one full oscillation - **oscillation period T** - in seconds (if possible find the average of several oscillations for most accurate determination of oscillation period).
- Slowly increase proportional band until system stabilize. Value of proportional bend for which the system stabilize is referred to as **critical gain P** (or point of ultimate sensitivity).
- For values T and P calculated in this manner, set the PID control parameters according to following table:

Type of control	Proportional band	Integral action
P control	2 P	
PI control	2.2 P	0.8 T

Values of parameters calculated using above procedure do not necessarily have to be adequate for specific system, but can be used as starting values which can be then slightly corrected in order to achieve fine tuned system.
In cases when system (or any control loop) shows signs of instability with some oscillations present, values of parameters calculated using above procedure must be changed. It is required to compare oscillating period (in seconds) with value of integral action parameter. In case integral action is lower, increase its value to be equal to oscillating period. If the system continues to oscillate, try widening proportional band for that specific control loop.

6. Linear inputs settings (scaling)

Input signals can be linear voltage (0 to 1V) or current (0 to 20mA) signals and must be same type for both inputs. In order to adjust the controller to specific signals received from probes (or transmitters) if default setting is not suitable, certain parameters might need adjustment. Parameters for linear input settings are accessible on configuration level.

Controller setting requires procedure known as linear signal scaling. New setting will define which values will be shown as measured values for given signal values on inputs.

Inputs scaling is performed using following parameters:

Table 6.1. **Parameters for linear inputs scaling**

PARAMETER LABEL		RANGE OF VALUES	DEFAULT VALUE
_P1t	Display for minimal value of signal on temperature input	From -99.9 to 999.9	0.0
_P2t	Display for maximal value of signal on temperature input	From -99.9 to 999.9	100.0
_P1h	Display for minimal value of signal on temperature input	From -99.9 to 999.9	0.0
_P2h	Display for maximal value of signal on temperature input	From -99.9 to 999.9	100.0

Maximal possible range for given type of signal is defined by device construction characteristics (from 0 to 1000mV for voltage and 0 to 20mA for current inputs), where minimal and maximal value of measured signal are measured and memorized during production and can not be changed. To complete the scaling procedure, user must select only display values for lowest (minimal) and highest (maximal) values of linear input signal.

Parameter _P1t defines which value is shown on upper display when minimal value of signal (0mV or 0mA) is detected on temperature input while parameter _P2t is used to define display for maximal signal value (1000mV or 20mA) on same input. Similar to this, parameter _P1h defies which value is shown on lower display when minimal value of signal (0mV or 0mA) is detected on humidity input while parameter _P2h is used to define display for maximal signal value (1000mV or 20mA) on same input.

Parameters _P1t and _P2t are accessed via button T, while parameters _P1h and _P2h are accessed via button RH on configuration level.

Use following procedure to set these parameters:

- Enter configuration level (see chapter 3.1)
- Return electronics into plastic housing. Connect the clamps and reconnect power supply. Wait until controller enters standard display mode.
- Press button T consequently until parameter _P1t is reached (parameter symbol is shown on upper display). Then use buttons ▼ and ▲ to adjust value (on lower display) which corresponds to desired display when input signal for temperature measures 0mV (or 0mA) which is equal to minimum display value;
- Use same procedure to select parameter _P2t and set its value to desired display value when input signal for temperature measures 1000mV (or 20mA);
- Press button RH to select parameter _P1h (symbol is shown on upper display) and then use buttons ▼ and ▲ to adjusts value which will be displayed when input signal for humidity measures 0mV (or 0mA);
- Use same procedure to select parameter _P2h and adjust display value for 1000mV (or 20mA) input signal;
- Wait for controller to return to standard display mode;
- Exit configuration level using procedure described in chapter 3.1.

We emphasize that setting of these parameters is critical for correct display of measured value for both temperature and humidity, so any adjustment must be taken with extreme precaution.

7. Probe break limits and setpoint limits

Inputs on DRV-913P can accept signals for temperature and relative air humidity in range 0 to 1V or 0 to 20mA. It is possible to define limits within which input signals are considered to be correct. In case input signal is out of these limits appropriate display will show symbol Snbr which is used to indicate input signal value which is not allowed. When shown on upper display, error is found on temperature input, and when it is shown on lower display, error is detected on humidity input. When error is detected on input, corresponding output will stop to operate.
For both inputs, high and low limits for probe break can be adjusted. Pay attention to avoid settings with no sense such as: low limit value is higher than high limit value etc.
Following table shows parameters used for this limits definition:

PARAMETER LABEL		RANGE OF VALUES	DEFAULT VALUE
SbH.t	High limit for temperature probe break	From SbL.t to 120.0	110.0
SbL.t	Low limit for temperature probe break	From -9.9 to SbH.t	-9.9
SbH.h	High limit for relative humidity probe break	From SbL.h to 120.0	101.0
SbL.h	Low limit for relative humidity probe break	From -9.9 to SbH.h	-1.0

Sometimes it is necessary to limit highest value for setpoint in order to protect equipment from destruction at high temperatures. Since capacitive sensor for relative humidity can be damaged at temperatures higher than 80°C this is highest possible temperature setpoint during normal operation. If additional limiting of temperature setpoint is required, parameter HSP.t should be set to maximal temperature setpoint allowed.

8. Offset adjustment

In certain situation, it is required to perform measurement correction. Reasons can be various, here is few of them:

- **sensor "zero error" resolving: in case old probe is replaced with new one, measured value with new one might be different**
- **gradient compensation: in case sensor is placed away from actual point in space where measuring is required, but difference in value between position and desired measuring point is know, it can be compensated as if sensor is placed at actual point in space where measurement is required**
- **device pairing**: identical display is sometimes required on two or more devices. Certain difference might occur because of sensor zero error, or because there is actual difference in measuring values. Offset on one or more devices can provide same display on all devices.
- **elimination of cable length influence:** when probes use power supply from device, error due to cable length can occur. In this case actual values must be determined using referent instrument and then offset on DRV-913P must be set so that display becomes correct.

Offset adjustment for temperature and humidity is done using parameters OFS.t and OFS.h which are available on configuration level. Parameter OFS.t defines temperature offset, while parameter OFS.h defines relative humidity offset.
Values of these parameters are added to original measured values and resulting values are displayed and used as actual values for process control and all other calculations in the controller.
These parameters can have values in range -9.99 to 99.99, while default values are set to 0.00.

9. Input signal filtering

Certain disturbances during operation (on probe, cable, transmitter, or device itself) may cause measurement value instability which might disrupt normal process control and device operation.
To reduce influence of such disturbances on input, signal filtering is implemented. It is defined using parameter FiLt. This parameter can have only discrete values: 1, 2, 4, 8, 16, 32, 64 and 128. This number defines number of samples used for measurement value calculation. Increasing of the value reduces chance that disturbance on input will cause change in measured value, but will slow down measurement speed. So, filter value must be selected in such way that it eliminates disturbances but do not slow down measurement process greatly. Default value for this parameter is set to 4.

10. Software version

Immediately upon power supply connection, controller will display software version. Upper display will show symbol UEr, and lower display will show software version number. Message will be displayed few seconds and then replaced with standard display in case any button is not pressed. This data must be noted because it is used as important data whenever service or consultation with manufacturer is required.

B. Nikolica-Serjoze 12, 18000 Nis, Serbia; Phone/Fax:+38118 211-212, 217-468; office@nigos.rs; www.nigos.rs

TABLE OF CONTENTS: