Proportional integral temperature regulator P.I.

DB-TA-33A

⚠ WARNING

Each single operation done on the unit, either installation or maintenance, must be done without main supply on the unit and external loads. Such operations are permitted only by skilled workers. Industrietechnik is not responsible for possible damages caused by an inadequate installation and/or by removed or exchanged security devices. The thermostat must be mounted in places far from heat sources and freely accessible for air convection at a height of approx. 1,5 m. Do not install the thermostat on particularly cold or heat walls.

APPLICATION

The series of thermostats DB-TA-33A allow the temperature control in buildings interiors for heating, air conditioning with 2 or 4 pipe systems with proportional integral regulation. The unit has one 0..10 V output (2 pipe system) or two 0..10 V outputs (4 pipe system) according to configuration choosen and it is possible to have:

- in 2 pipe system, local or centralized changeover by a single wire, or automatic changeover according to temperature of water sensor mounted upstream the valve. In 4 pipe system, the changeover is done automatically according to room temperature.
- switches on/off and 3 speeds (DB-TA-33A-13A) for power on and off the unit and fan-coil
- economy remote function with a single wire
- autotuning function with the use of remote sensor only

The unit has a display with 3 characters for visualizing room temperature, parameters setting and 2 keys **+ -** for parameters setting.

Instruction for setpoint setting (level 1):
The display indicates the room temperature.
Push the key **+** the message "**SEt**" is visualized on the display.
Push the key **+** again one time, the value of the setpoint is visualized on the display.
To modify the setpoint value push the key **+** or **-** to increase or decrease the value.
To save the modifications done wait for 4 s, the message "**SEt**" is then visualized again on the display. Wait for another 4 s until is visualized the room temperature on the display. The parameters are then saved and the unit is ready to do the regulation.

Instruction for other parameters setting (level 2 or 3):
To access the parameters of level 2 or 3 proceed with the following procedure:
Push **-** until the message "**PAS**" is visualized on the display (several seconds).
Push **+** the value 6.0 appears on the display.
Push the key **+** up to visualize **6.5** (level 2) or **8.5** (level 3).
Wait for 4 s for visualizing the name of the first parameter of level 2: "**tiP**" or level 3: "**LEA"**.
At this point it is possible:

- to move in the list of the parameters
- to modify a certain parameter.

To move in the list of parameters, push the key **-** when the names of them are visualized. To modify the value of one of them move to the name of the parameter to change and hit the key **+** to see the value on the display.
Then push the key **+** or **-** for increasing or decreasing it.
To return to the list of parameters wait for 4 s until is visualized the name of the parameter again.

To save modifications done to parameters wait until on the display appears the room temperature again (maximum 8 seconds).

INDICATIONS AND ALARMS

- **Flashing message "SEn" on the display** indicates:
  open sensor or short circuit on it.
- **Message " C" alternating with temperature** indicates:
  Cooling mode selected without economy function (setpoint = SEt see parameters).
- **Message " H" alternating with temperature** indicates:
  Heating mode selected without economy function (setpoint = SEt see parameters).
- **Message "EcC" alternating with temperature** indicates:
  Cooling mode selected with economy function (setpoint = SEo see parameters).
- **Message "EcH" alternating with temperature** indicates:
  Heating mode selected with economy function (setpoint = SEo see parameters).

When the unit is switched on during stabilization phase the following messages ("**15.0**","**14.0**",... **"10.0**", "**P-I**") appear on the display before seeing the value of temperature. If the message "**Err**" is then visualized instead of temperature, advise technical assistance.

PARAMETERS SETTING

LEVEL 1:

SEt **Setpoint:**
It allows to fix the setpoint that corresponds to the room temperature required.
Setting range:
6.0...45.0 °C default value: 20.0 °C

PAS **Password:**
access key to level 2: PAS=6.5.
access key to level 3: PAS=8.5. (only if remote sensor is used)
Setting range:
6.0...45.0 default value: 6.0

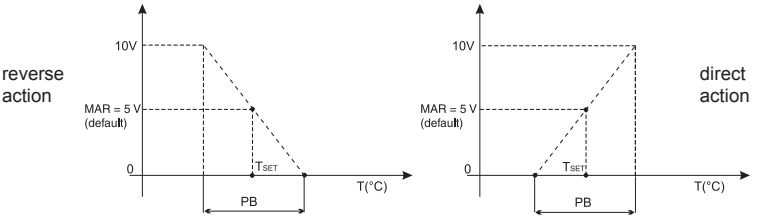
LEVEL 2:

t iP **Type of system**:
It defines the type of system choosen: 2 pipe o 4 pipe system. According to selection done different parameters are then visualized.
Setting range:
2P = 2 pipe systems
4P = 4 pipe systems default value: 2P

2 pipe systems operating mode

bP **Proportional band**:
The proportional band is the part of output that changes proportionally with error signal. The default setpoint is on the center of proportional band with parameter MAr = 5.0. Changing parameter MAr it is possible to move proportional band around the setpoint. Out of the proportional band, the output signal is always saturated at 0 V or at 10 V.
Setting range:
1.0...30.0 °C default value: 5.0 °C

Output with only proportional action (without integral action)

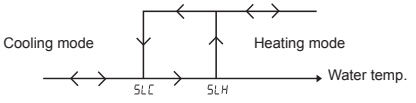


tI **Integral time**:
The integral time is the speed at which a corrective increase or decrease in ouput is made to compensate for offset which usually accompanies proportional only processes. The more integral time entered, the slower the action. The less integral time entered, the faster the action. A too small integral time can make the system oscillating.
To exclude integral action and make the unit a proportional regulator set the value of parameter to **nol** with key +.
Setting range:
1.0...30.0 minutes (with integral action)
nol (without integral action) default value: 20.0 minutes

StA **Working season**:
It defines if 0...10 V output operates in direct action (cooling) or in reverse action (heating). According to setting done it is possible to select the working season directly on unit or to decide to choose it remotely. On this last case it is possible to have two possibilities:

- with a remote centralized switch connected between terminals 3 and 13 (see figure 1, contact opened = cooling mode, contact closed = heating mode)
- with water sensor (buying code NTA020-027P) connected between terminals 13 and 14 and mounted upstream the valve (see figure 2).

Setting range:
H -> heating
C -> cooling
rEM -> remote selection default value: H



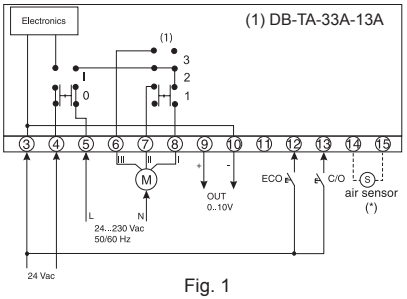


Fig. 1

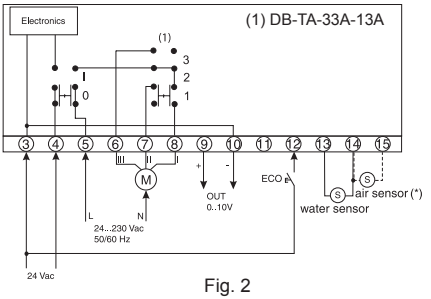
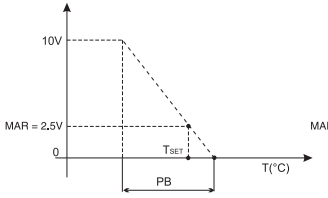


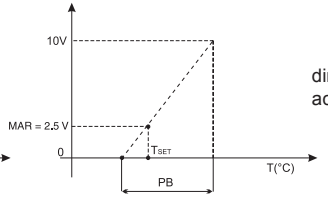
Fig. 2

rAr **Manual reset**:
Changing the value of this parameter it is possible to move the proportional band around the setpoint. The unit is in volt.
Setting range:

0.0... 10.0 Volt default value: 5.0 Volt

reverse action





direct action

CAr **Correction of temperature**:
It allows to add a value to the measured temperature to increase precision (let the unit switch on for 45 minutes before setting the parameter when the internal sensor is used)
Setting range:

-5.0...5.0 °C default value: 0.0 °C

PoE **Method of regulation**:
It defines if unit operates with PI or P regulation or if the unit operates in manual test mode for doing some test on the system to regulate in open loop mode. This type of test can be used only if one has a measuring system for temperature. In order to see how to use this parameter see APPENDIX 2, page 9, method 3.
Setting range:

0... 10.0 V -> manual operating
Pi -> proportional integral regulation default value: Pi

SoC **Economy setpoint for cooling:**
It defines the setpoint for economy function in cooling mode independently of main setpoint (SEt).
The unit works with main setpoint if the contact ECO connected between terminals 3 and 12 is open. If contact is closed, the unit works with economy cooling setpoint if cooling mode is selected.
Setting range:

6.0...45.0 °C default value: 25.0 °C

SoH **Economy setpoint for heatin:**
It defines the setpoint for economy function in heating mode independently of main setpoint (SEt).
The unit works with main setpoint if the contact ECO connected between terminals 3 and 12 is open. If contact is closed, the unit works with economy heating setpoint if heating mode is selected.
Setting range:

6.0...45.0 °C default value: 15.0 °C

SLC Cooling limit:
If water temperature sensor drops below the limit SLC, cooling is the working season if parameter Sta=rEM
Setting range:

0.2...21.0 °C default value: 21.0 °C

SLH Heating limit:
If water temperature sensor reaches the limit SLH, heating is the working season if parameter Sta=rEM
Setting range:

22.0...75.0 °C default value: 30.0 °C

Note: when unit is powered on, if water sensor is between SLC and SLH, heating is the working season if Sta=rEM

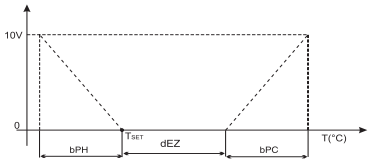
uiS Type of sensor visualized: "Ai"..."Li"
ui5 = " Ai" -> air sensor visualized

ui5 = " Li" -> liquid sensor visualized (temperature can be visualized up to a value around 75°C. If water temperature sensor is upper 75°C the message "97.0" is visualized)

4 pipe systems operating mode

bPH **Proportional heating band**:
The proportional heating band is the part of heating output that changes proportionally with error signal. The setpoint is at the beginning of the proportional heating band.
Setting range:
1.0...30.0 °C default value: 5.0 °C

bPC **Proportional cooling band**:
The proportional cooling band is the part of cooling output that changes proportionally with error signal. The setpoint for cooling is the setpoint added to neutral zone and is at the beginning of the proportional cooling band.
Setting range:
1.0...30.0 °C default value: 5.0 °C



Output with only proportional action (without integral action)

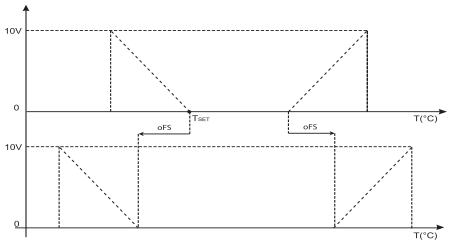
tI **Integral time**:
The integral time is the speed at which a corrective increase or decrease in ouput is made to compensate for offset which usually accompanies proportional only processes. The more integral time entered, the slower the action. The less integral time entered, the faster the action. A too small integral time can make the system oscillating.
To exclude integral action and make the unit a proportional regulator set the value of parameter to **noI** with key +.
Setting range:
1.0...30.0 minutes (with integral action)
noI (without integral action) default value: 20.0 minutes

dE2 **Dead zone**:
It defines the dead zone between heat and cool where there is not any regulation (only for proportional action)
Setting range:
0.5...4.0 °C default value: 1.0 °C

COr **Correction of temperature**:
It allows to add a value to the measured temperature to increase precision (let the unit switch on for 45 minutes before setting the parameter when the internal sensor is used)
Setting range:
-5.0...5.0 °C default value: 0.0 °C

PoE **Method of regulation**:
It defines if unit operates with PI or P regulation or if the unit operates in manual test mode for doing some test on the system to regulate in open loop mode. This type of test can be used only if one has a measuring system for temperature. In order to see how to use this parameter see APPENDIX 2, page 9, method 3.
Setting range:
0... 10.0 V -> manual operating
PI -> proportional integral regulation default value: PI

oFS **Offset for economy function**:
It allows the change of setpoint position for economy function. The unit works with main setpoint if the contact ECO connected between terminals 3 and 12 is open. If contact is closed, the unit works with modified setpoint and increased neutral zone. See diagram below for more details.
Setting range:
0...5.0 °C default value: 5.0 °C



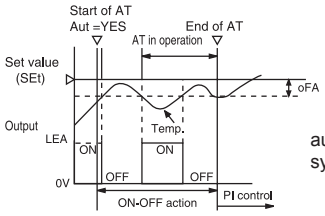
LIVELLO 3: AUTOTUNING

The level 3 is accessible only with the password 8.5 and if the unit uses remote air sensor. With the use of internal sensor it is not possible to use the autotuning function.
This function allows the calculation of parameters Bp, Ti automatically by doing an on/off cycle.
Before doing such a cycle, set the setpoint for autotuning.
The setpoint for autotuning in 2 pipe system can be done adding or substracting the value of parameter oFA (offset for autotuning) to the setpoint (main setpoint if the contact ECO is opened or economy setpoint if the contact ECO is closed) according to operating season (see parameters).
In 4 pipe system autotuning is done on setpoint (main setpoint if the contact ECO is opened or economy setpoint if the contact ECO is closed).

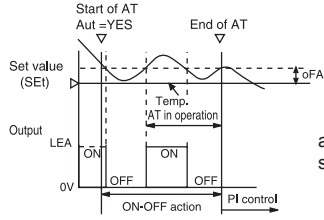
LEA **Level for autotuning:**
During the autotuning cycle the regulator outputs 0 V or the voltage defined by parameter LEA. The selection is done automatically considering the season working and temperature from setpoint:
- in heating if temperature is lower than setpoint, the output is equal to LEA Volt.
- in heating if temperature is upper than setpoint, the output is equal to 0 Volt.
- in cooling if temperature is upper than setpoint, the output is equal to LEA Volt.
- in cooling if temperature is lower than setpoint, the output is equal to 0 Volt.

In 2 pipe systems, the active output during autotuning is the 0..10 V single output.
In 4 pipe systems, the active output during autotuning is the 0..10 V heating output if at the beginning of autotuning cycle temperature is lower than setpoint. On this case autotuning is done in heating. If temperature is upper than the setpoint at the beginning of the autotuning cycle, the active 0..10 V output is the cooling output. The autotuning is done on this case in cooling.
Choose a level that avoid high oscillations.
Setting range:
0... 10.0 V default value: 5.0 V

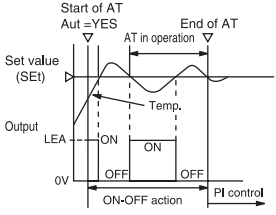
oFA **Offset for autotuning: (it appears only for 2 pipe systems)**
ECO opened and heating mode: set autotune = SEt - oFA
ECO opened and cooling mode: set autotune = SEt + oFA
ECO closed and heating mode: set autotune = SEo - oFA
ECO closed and cooling mode: set autotune = SEo + oFA
Setting range:
0...5.0 °C default value: 1.0 °C



autotuning in 2 pipe system: heating



autotuning in 2 pipe systems: cooling



autotuning in 4 pipe systems

AUt **Autotuning start:**
Setting the paramerter to YES, the autotuning cycle starts at once. During autotuning cycle it is not possible accessing to setpoint and others parameters. So before starting the cycle, verify parameters are correctly set. If they are not set correctly it is possible to stop the cycle inserting the password 8.5 and inserting *no* to parameter AUt or by powering off and on the unit.
During autotuning cycle the display alternates the indication of temperature and one of the following message:
AUt :initial phase of autotuning.
At1 :phase 1 of autotuning cycle.
At2 :phase 2 of autotuning cycle.
At3 :phase 3 of autotuning cycle.

At the end of autotuning cycle the display alternates one of the following messages and temperature:
End :autotuning cycle ended. In 2 pipe system proportional band and integral time are calculated. In 4 pipe system

proportional band BpH=BpC and integral time Ti are calculated.

ErC :initial autotuning cycle error. The cycle didn't begin correctly. For instance if operating season is heating in 2 pipe system and the temperature is upper than the setpoint at the begining of autotuning cycle, it is not possible to start the cycle. The cycle must begin with the voltage in output set to *LEA* (see autotuning cycle drawings indicated above).

Ert :maximum time for autotuning cycle reached. The maximum time for autotuning cycle is 4 hours. If this time is overcome, this message is shown on the display and parameters Bp and Ti are not calculated.

Er0 :parameters calculated at the end of autotuning cycle are out of range. The maximum or minimum value of parameter calculated is assigned. For instance, if Ti calculated is upper than 30 minutes (Ti max), Ti is set to 30. If Ti calculated is lower than 1 minute, the value 1 minute is set to parameter Ti.

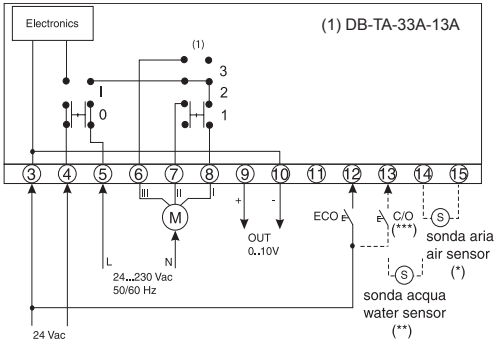
Setting range: *no...YES* default value: *no*

TECHNICAL FEATURES

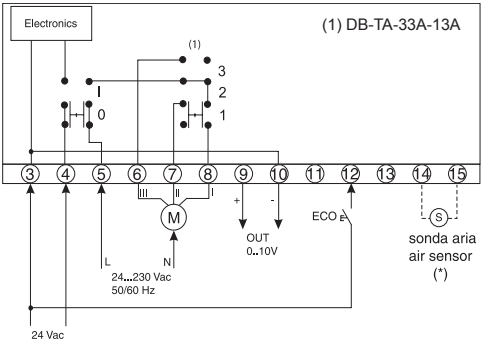
Power supply:	24 Vac +/-10% 50/60 Hz
Sensor:	internal NTC 10K or remote sensor (NT0220-NTC10-02 code).
Measuring range:	0..55°C
Setpoint range:	6..45°C
Resolution:	0.1°C
Inputs:	- remote change-over (only for 2 pipe configuration -> parameters tiP=2 and StA=rEM, see parameters setting). - economy function
Outputs:	valves: 1 or 2 outputs 0..10 Vdc (Rload>10Kohm) (see wiring diagrams) speeds: 6A 24/230 Vac, 50/60 Hz
Operating temperature:	0..45°C, 10..90%r.h. (with no condense)
Power consumption:	1 W
Visualization:	3 characters LCD display
Casing:	144 x 82 x 34 mm
Protection class:	IP30, class II
CE standards:	EN 60730-1, EN 61000-4-2, EN61000-4-4, EN 61000-4-5, EN 5014, ENV 50141

ELECTRICAL WIRING

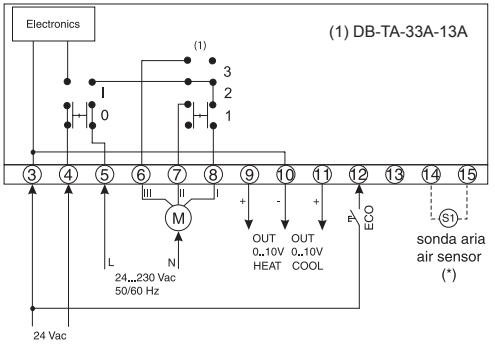
tiP = 2 (2 pipe system)
StA= rEM (see parameters)



tiP = 2 (2 pipe system)
StA=H o C (see parameters)

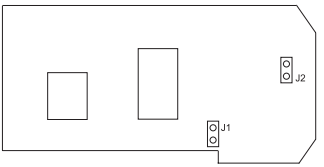


tiP = 4 (4 pipe system, see parameters)



(*) remote air sensor NT0220-NTC10-02
(**) water sensor NTA020-027P (see parameter StA)

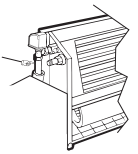
Jumper layout



J1, J2 closed = internal sensor
J1, J2 opened = remote air sensor

ECO closed = economy function on
ECO opened = without economy function

Water sensor mounting
(tiP=2, StA=rEM)



(***) remote centralized contact (see parameter StA)

C/O closed = heating
C/O opened = cooling

Warning: Pay attention to keep the cables of remote sensor and water sensor far from the power cables and EMI disturb sources. Use H05VC-K cable for pipe mounting or H05VC-F otherwise.

APPENDIX 1

Autotuning

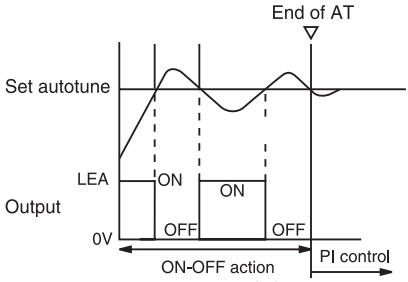
The regulator calculates optimum parameters PI for the room regulated and save them in EEPROM so that when the controller is powered up after being shut down, the controller does not need to be autotuned again. The regulator use the same parameters until the cycle is again initiated.
The autotune parameters are only good for the process the autotune function was used on. The autotune function should be performed again for the following conditions:

- setpoint significantly changed
- the load is changed or relocated,
- change of position for remote sensor
- other disturbances occur which might change the dynamics of the system.

The autotuned control parameters are not always perfect for every applications, but almost always give the operator a good starting point from which further refinement of control parameters can be performed manually.

In some cases the autotune function does not perform well or does not perform at all:

1. The system is affected by process disturbances external to the control loop during autotuning (windows opened, load variation)
2. The system is very dynamic. This is the case in which the heating or cooling power is too high for the volume of room regulated. Considering the conditions for autotuning cycle, some large overshoots can be verified.
3. The system is very insulated and cannot cool down (heating season) or heat up (cooling season) in a timely manner. For such systems the autotuning cycle would take a very long time to complete with questionable results.



During autotuning the period of oscillations, overshoots and undershoots are measured. At the end of the cycle Bp, Ti parameters are calculated.

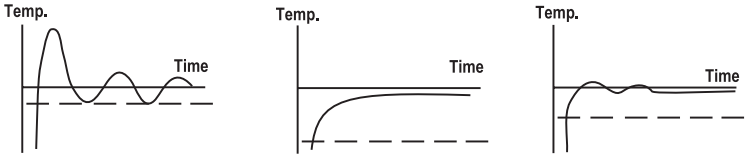
APPENDIX 2

Manual parameters setting

Proportional band

The width of the proportional band depends of the dynamics of the system. The first question to ask is, how strong must my output be to eliminate the error between the setpoint and temperature ?

The larger the proportional band (low gain), the less reactive the process. A proportional band too large, however, can lead to process wandering or sluggishness. The smaller the proportional band (high gain), the more reactive the output becomes. A proportional band too small, can lead to over-responsiveness leading to process oscillation.



Proportional band too small

Proportional band too large

Proportional band with correct width

A proportional band with is correct in width approaches the setpoint as fast as possible while minimizing overshoot. If a faster approach to setpoint is desired and process overshoot is not a problem, a smaller or narrower proportional band may be used. If process overshoot cannot be tolerated and the approach to setpoint does not have to be quick, a larger proportional band can be choosen.

Integral time

With proportional band alone, the process tend to reach a point away from setpoint. This offset is due to the difference between the output needed to mantain setpoint and the ouptut of the proportional band at setpoint.

In the case of 2 pipe system with MAr=5V (50% of proportional band) if it is necessary a voltage different from 50% to mantain the setpoint, the offset is the difference between them.The integral action eliminates this difference.

The integral action eliminates this difference by adding or substracting a value to the proportional action alone.

Integral time is the speed at which the controller corrects for offset. A short integral time means the controller corrects for offset quickly. If the integral time is too short, the controller would react before the effect of previous output shift, due to dead time or lag time, could be sensed causing oscillations.

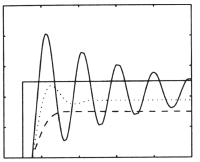
A long integral time means the controller corrects the offset over a long time. If the integral time is too long, the offset will remain for some time causing slow responding or sluggish control.

To set parameters manually, each parameter must be set. One can apply the method of test and error.

Method 1:

Proportional band setting:

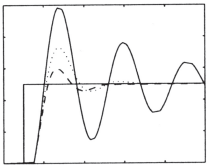
1. Set the parameter Ti to **no** in order to put the regulator in proportional regulator only.
2. Set a large proportional band.
3. Change the setpoint a little and observe how the system is reacting. The response will be sluggish.
4. Tighten by decreasing the value in half. Change the setpoint a little and observe how the system is reacting. If the system is still sluggish and does not oscillate, tighten by decrease the value in half again.
5. Repeat the point 4 until the system begins to oscillate constantly.
6. Multiply last proportional band set by 2.



Decrease of proportional band:
test 1: dotted line
test 2: line with points
test 3: continuous line

Integral time added

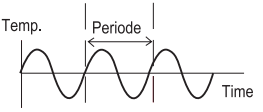
1. Set a large integral time.
2. Change the setpoint a little and observe how the system is reacting. The response will be sluggish.
3. Tighten integral time by decreasing the value in half and repeat the point 2 until an oscillating response is obtained with a small setpoint change.
4. Multiply last integral time obtained on point 3 by 2.



Decrease of Ti:
test 1: dotted line
test 2: line with points
test 3: continuous line

Method 2:

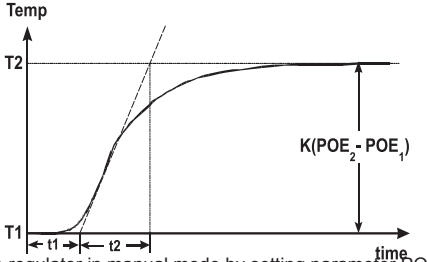
Another method is the Ziegler-Nichols method. Repeat point 1 to 4 of proportional band setting in order to find out the proportional band that creates stable oscillations. By measuring the period of oscillations and the proportional band limit Bp_{Lim} set, parameters Bp and Ti are calculated for regulation.



$Bp = 2\ Bp_{Lim}$
Ti = 0.83 period

Method 3:

A last method that can be used is the open loop test by doing a step change in output signal manually (output 9-10).
The goal is to suppose the response system temperature when a step change is done in output as indicated on the following picture:



1. Put the regulator in manual mode by setting parameter POE from PI to a value from 0 to 10V. Write this value (POE_1).
2. Let the temperature stabilizes.
3. Increase the ouput voltage to do a step change. Write the value choosen (POE_2).
4. Map the temperature as indicated on picture.
5. The gain of process is given from following expression

$$K = \frac{T2-T1}{POE_2 - POE_1}$$

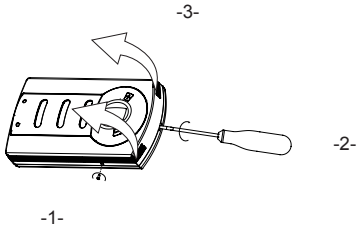
According to Ziegler-Nichols one obtain:

- for a P regulator: Bp = (t1 * K) / t2
- for a PI regulator: Bp = (1.11 * t1 * K) / t2
  Ti = 3.33 * t1

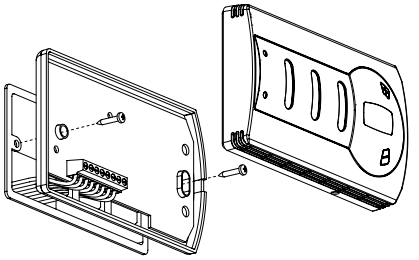
At the end of the test do not forget to set parameter POE to PI in order to use the unit as an automatic regulator.

MOUNTING

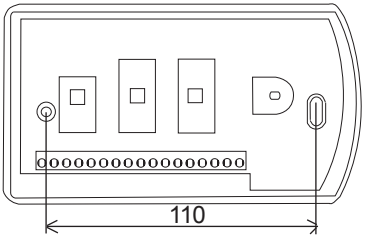
OPENING THE COVER



MOUNTING OF THE UNIT AND CLOSING OF THE COVER



MOUNTING ON THE WALL / SURFACE



1 - tight the screws on the wall box
2 - connect cables
3 - push on the cover

Tight the screws on the wall box.

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CE