# P.I. Proportional-integral temperature controller with limits function

# DB-TA-31A

## WARNINGS

Installation and maintenance operations must be carried out by qualified personnel, with the appliance disconnected from the power supply and from external loads. Industrietechnik shall not be responsible for any damage caused by inadequate installation and/or from the unauthorised opening or removal of safety devices. Install the thermostat in a location away from sources of heat and away from direct airflow, at about 1.5 m above the floor. Do not install the thermostat on particularly cold or hot walls.

## APPLICATION

The series of DB-TA-31A controllers controls the temperature inside buildings in heating and air-conditioning plants with 2 or 4 pipes with proportional-integral (P.I.) control. The equipment is fitted with one 0.10 V output (2 pipes) or two 0.10 V outputs (4 pipes) according to the chosen configuration. There is a special lower and upper limit temperature measuring function on the second sensor and this makes it the ideal tool to control small air treatment units with elementary configurations as it can be used to manage:

- a single battery (2 pipes);
- a double battery (4 pipes);
- a season change using a local switch (DB-TA-31A-110);
- remote season change contact (DB-TA-31A-100);
- on/off switches to turn on or switch off the appliance;
- duct sensor for lower and/or upper limit.

The appliance is fitted with a 3-digit display in order to show the room temperature and the 2 + and - key parameters for the programming functions.

Instructions for setpoint settings (level 1):
The display shows the room temperature.
Press the + button, the "SEH" message appears on the display. This corresponds to the heating setpoint.
To find the cooling setpoint, (SEC), press the - button.
Press the + button once and the setpoint value appears on the display.

To modify the setpoint value, press the + key or press - to increase or decrease the value.
To save the changes, wait for 6 s. The "SEH" or "SEC" message appears again on the display. After another 6 s, the temperature value appears again. The parameters are now saved and the appliance continues the regulation.

Instructions for setting of other parameters (level 2):
To have access to level 2 parameters, carry out the following procedure:
Press the - key until the "PAS" message appears on the display (a few seconds).

Press the + key and the 6.0 value appears. Then press the + key to bring the value to 0.5 (level 2 password).
Wait a few seconds until the display shows the name of the first parameter "tiP" (level 2 password).
It is now possible to:

- navigate the list of parameters
- modify a set parameter

To navigate the list of parameters, press the - key when the parameter names are displayed.
To modify the value of a set parameter, go to the name of the chosen parameter and then press the + key. Then press the + or - keys to increase or decrease the value. To return to the list of parameters, wait another 6 s until the parameter name is displayed again.

To save the changes to one or more parameters, wait until the room temperature value reappears on the display (12 seconds maximum).

## SIGNALS AND ALARMS

- Flashing "SEn" message on the display indicates:
  room temperature or limit sensor open or short-circuited.
- " C" message on the display alternating with the room temperature indicates:
  cooling season selected with room temperature display.
- " H" message on the display alternating with the room temperature indicates:
  heating season selected with room temperature display.
- " CL" message on the display alternating with the room temperature indicates:

cooling season selected with limit temperature display.
· " HL" message on the display alternating with the limit temperature indicates:
heating season selected with limit temperature display.
When switching on the tool, during the stabilization phase, a series of messages appear on the appliance display (" 15_0","14_0",... " 10_0", "3 IA") before the room temperature value is indicated. If the "Err" message is displayed instead of the temperature, please contact the technical assistance team.

## SETTING PARAMETERS

LEVEL 1:

**SEH** Heating setpoint:
Allows the setting of the intervention point, corresponding to the desired room temperature.

Value selection options: 6.0...45.0 °C default value: 20.0 °C

**SEC** Cooling setpoint:
Allows the setting of the intervention point, corresponding to the desired room temperature.

Value selection options: 6.0...45.0 °C default value: 24.0 °C

**PAS** Password:
Access code at level 2: PAS=6.5.

Value selection options: 6.0...45.0 default value: 6.0

LEVEL 2:

**t iP** Installation type:
Defines the type of installation selected: 2 pipes or 4 pipes. The various parameters are displayed according to the selection.

Value selection options: 2P = 2 pipes
4P = 4 pipes default value: 2P

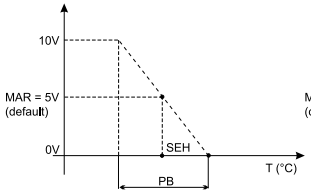
**2-pipe operation**

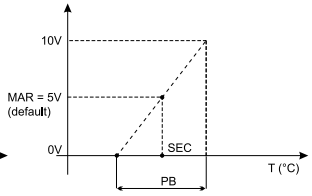
**bP** Proportional band (P-band):
Defines the part of the output that varies proportionally according to the error signal. The default setpoint is found at the centre of the P-band with the parameter MAr = 5.0. It is possible to move the P-band with respect to the setpoint by changing this parameter. Outside the P-band, the output signal is always in saturation at 0 V or 10 V.

Value selection options: 1.0...30.0 °C default value: 5.0 °C

Output with proportional action only (no integral action)

reverse action: heating function




direct action: cooling function

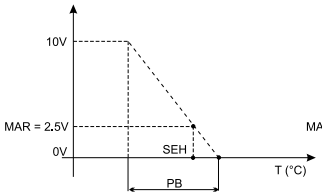
**t i** Integral time:
The integral time represents the velocity at which the correction intervenes on the output signal to cancel the permanent error that persists with the proportional action only. The higher the integral time, the lower the output signal variation. The lower the integral time, the higher the velocity of the output signal variation. A Ti time that is too low may cause the temperature to change. To exclude the integral action and to ensure that the controller is purely proportional, bring the value to noI using the + key.

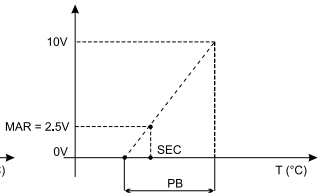
Value selection options: 1.0...30.0 minutes (with integral action)
noI (without integral action) default value: noI

rAr Manual reset:
It is possible to the move the P-band with respect to the setpoint by changing this parameter. The value is expressed in volts.

Value selection options: 0.0...10.0 Volt default value: 5.0 Volt

reverse action:
heating mode




direct action:
cooling mode

cor Temperature correction:
Enables a value to be added to the detected temperature for extra precision (leave the appliance on for at least 45 minutes before using the parameter in case the internal sensor is used):

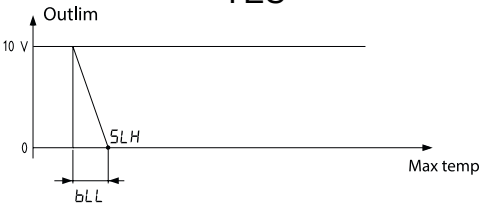
Value selection options: -5.0...5.0 °C default value: 0.0 °C

PoE Regulation method:
Defines whether the appliance is functioning with a PI or P regulation or whether the appliance is functioning in manual test mode to authorise system checks that require open loop control. This last mode is only used if a temperature detection device is available. For user instructions for this parameter, see APPENDIX 1, page 10, method 3.

Value selection options: 0...10.0 V manual mode
Pi proportional integral control default value: Pi

LLH Lower heating limit:
Defines whether a lower heating limit should be taken into account.

Value selection options: no
YES default value: no



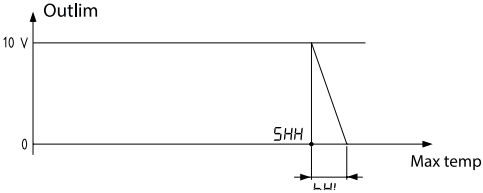

The output modulating signal is the maximum between the limit signal (Outlim) and the regulation signal.

SLH Lower heating limit setpoint:

Value selection options: 6.0...45.0 °C default value: 15.0 °C

HLH Upper heating limit:
Defines whether the upper heating limit should be taken into account.

Value selection options: no
YES default value: no



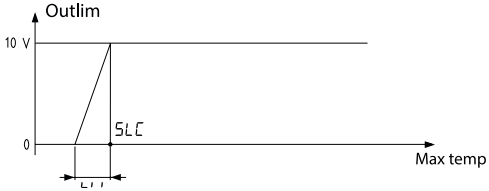

The output modulating signal is the minimum between the limit signal (Outlim) and the regulation signal.

SHH Upper heating limit setpoint:

Value selection options: 6.0...45.0 °C default value: 30.0 °C

LLC Lower limit in cooling mode:
Defines whether the lower cooling limit should be taken into account.

Value selection options: no
YES default value: no



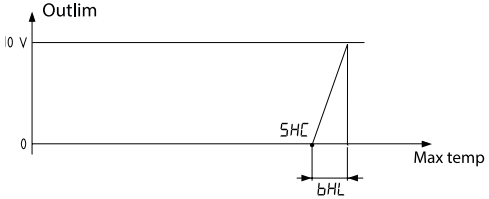

The output modulating signal is the minimum between the limit signal (Outlim) and the regulation signal.

SLC Lower cooling limit setpoint:

Value selection options: 6.0...45.0 °C default value: 10.0 °C

HLC Upper limit in cooling mode:
Defines whether the upper cooling limit should be taken into account.

Value selection options: no
YES default value: no




The output modulating signal is the maximum between the limit signal (Outlim) and the regulation signal.

SHC Upper cooling limit setpoint:

Value selection options: 6.0...45.0 °C default value: 30.0 °C

bLL Lower limit P-band:

Value selection options: 1.0...30.0 °C default value: 1.0 °C

bHL Upper limit P-band:

Value selection options: 1.0...30.0 °C default value: 1.0 °C

tSE Sensor type displayed:

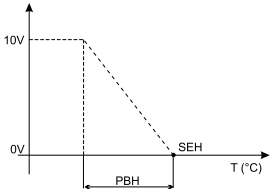
Value selection options: Air...LiM default value: Air
(Air= room temperature sensor displayed, LiM=limit sensor displayed)

**4-pipe operation**

bPH Heating P-band:
Defines the part of the output that varies proportionally according to the error signal. The setpoint is found at the start of the heating P-band.

Value selection options: 1.0...30.0 °C default value: 5.0 °C

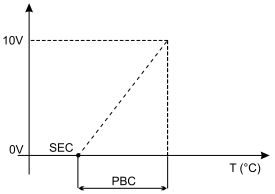
reverse action: heating function




bPC Cooling P-band:
Defines the part of the output that varies proportionally according to the error signal. The output is based on the setpoint.

Value selection options: 1.0...30.0 °C default value: 5.0 °C

direct action: cooling function




t i Integral time:
The integral time represents the velocity at which the correction intervenes on the output signal to cancel the permanent error that persists with the proportional action only. The higher the integral time, the lower the output signal variation. The lower the integral time, the higher the velocity of the output signal variation. A Ti time that is too low may cause the temperature to change. To exclude the integral action and to ensure that the controller is purely proportional, bring the value to nol using the + key.

Value selection options: 1.0...30.0 minutes (with integral action)
nol (without integral action) default value: nol

COr Temperature correction:
Enables a value to be added to the detected temperature for extra precision (leave the appliance switched on for at least 45 minutes before using the parameter in case the internal sensor is used):

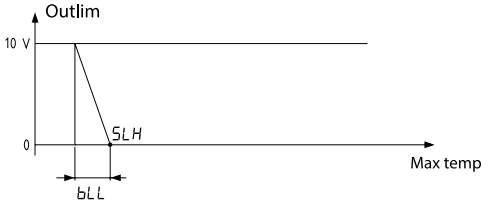
Value selection options: -5.0...5.0 °C default value: 0.0 °C

PoE Regulation method:
Defines whether the appliance is functioning with a PI or P regulation or whether the appliance is functioning in manual test mode to authorise system checks that require open loop control. This last mode is only used if a temperature detection device is available. For user instructions for this parameter, see APPENDIX 2, page 9, method 3.

Value selection options: 0...10.0 V manual mode
Pi proportional integral control default value: Pi

LLH Lower heating limit:
Defines whether a lower heating limit should be taken into account..

Value selection options: no
YES default value: no



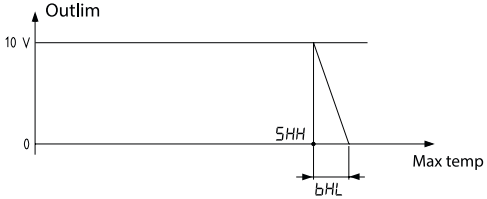

The output modulating signal is the maximum between the limit signal (Outlim) and the heating regulation signal during the winter season.

SLH Lower heating limit setpoint:

Value selection options: 6.0...45.0 °C default value: 15.0 °C

HLH Upper heating limit:
Defines whether the upper heating limit should be taken into account.

Value selection options: no
YES default value: no



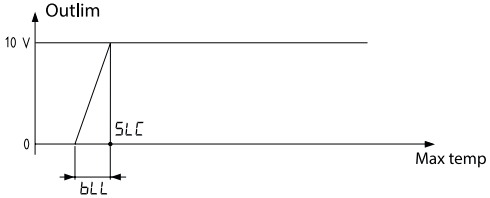

The output modulating signal is the minimum between the limit signal (Outlim) and the heating regulation signal during the winter season.

SHH Upper heating limit setpoint:

Value selection options: 6.0...45.0 °C default value: 30.0 °C

LLC Lower limit in cooling mode:
Defines whether the lower cooling limit should be taken into account.

Value selection options: no
YES default value: no



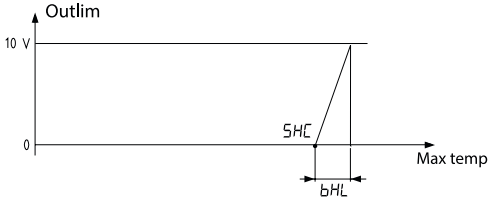

The output modulating signal is the minimum between the limit signal (Outlim) and the cooling regulation signal during the summer season.

SLC Lower cooling limit setpoint:

Value selection options: 6.0...45.0 °C default value: 10.0 °C

HLC Upper limit in cooling mode:
Defines whether the upper cooling limit should be taken into account.

Value selection options: no
YES default value: no




The output modulating signal is the maximum between the limit signal (Outlim) and the cooling regulation signal during the summer season.

SHC Upper cooling limit setpoint:

Value selection options: 6.0...45.0 °C default value: 30.0 °C

bLL Lower limit P-band:

Value selection options: 1.0...30.0 °C default value: 1.0 °C

bHL Upper limit P-band:

Value selection options: 1.0...30.0 °C default value: 1.0 °C

tSE Sensor type displayed:

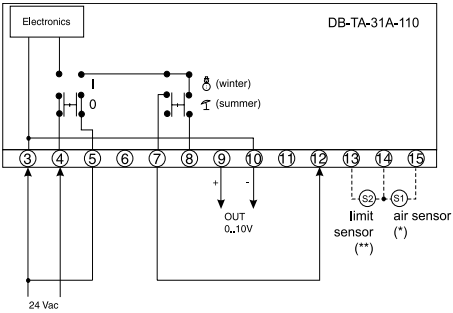
Value selection options: Air...LiM default value: Air
(Air= room temperature sensor displayed, LiM=limit sensor displayed)

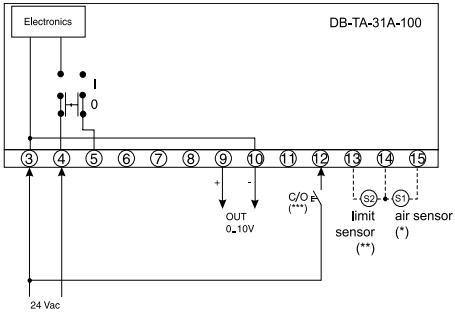
## TECHNICAL DATA

| | |
|---|---|
| Power supply: | 24 V AC +/-10% 50/60 Hz |
| Sensors: | - NTC 10K internal or remote (code NT0220-NTC10-02) for the air sensor,<br>- NTC 10K remote (code STC-NTC10-02) |
| Temperature reading range: | 0..55°C |
| Setpoint setting range: | 6..45°C |
| Resolution: | 0.1°C. |
| Inputs: | - season change<br>- limit sensor (to define in the order phase)<br>- remote room temperature sensor (optional) |
| Outputs: | 1 or 2 0.. 10 Vcc outlets (Rload>10Kohm) (see wiring diagrams) |
| Operating temperature: | 0..45°C, 10-90%r.h. (without condensation) |
| Power consumption: | < 1.5 W |
| Displays: | 3-digit LCD display |
| Container: | 144 x 82 x 34 mm |
| Protection class: | IP30, class II |
| EU compliance standards: | EN 60730-1, EN 61000-4-2, EN 61000-4-4, EN 61000-4-5, EN 55014, EN 50141 |

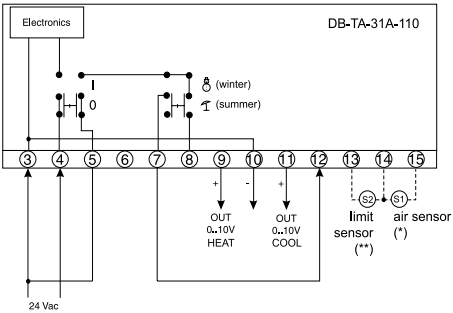
## WIRING DIAGRAMS

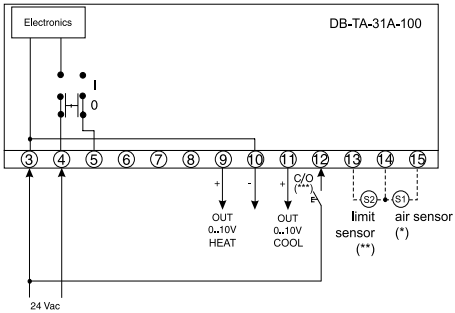
t iP = 2 (2 pipes)




t iP = 4 (4 pipes)



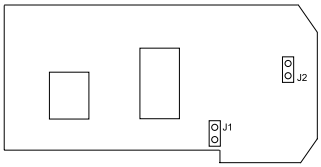




(*) remote air sensor NT0220-NTC10-02
(**) limit sensor
(***) centralised remote contact

Change-Over (C/O) closed = heating
C/O open = cooling

**Warning:** The limit and air sensor wires must follow a separate path to the power cables or sources that cause electromagnetic interference. Use H05VC-K type cables for cable troughs or H05VC-F for sight-assembly.

Jumper level

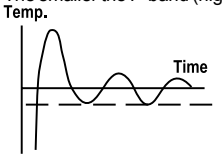



J1, J2 closed = internal air sensor
J1, J2 open = remote air sensor

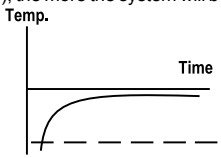
# APPENDIX 1

**Manual parameter settings**

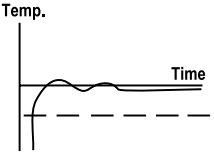
**P-band**
The size of the P-band depends on the dynamics of the system. Therefore, the question is: what dimension should the P-band be in order to eliminate the permanent error between the setpoint and the temperature?
The larger the P-band (low gain), the less the system will be reactive. A P-band that is too large causes the system to slow down. The smaller the P-band (high gain), the more the system will be reactive. A P-band that is too small may cause the system to oscillate.




P-band
too small



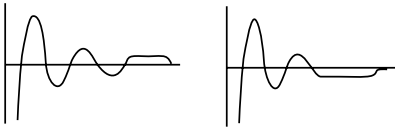

P-band
too large




P-band
correct size

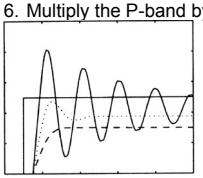
A P-band with the correct dimensions approaches the setpoint as quickly as possible, thus reducing any overshoot. If a quick setpoint approach is required and if overshoot is not an issue, then a smaller P-band may be chosen. If any overshoot may cause issues and the response speed is not a problem, than a larger P-band may be chosen.

**Integral time:**
With proportional action only, the temperature balances at a point that is near the setpoint without reaching it. An error is created (setpoint value - reached value).



The integral action eliminates the error by adding or subtracting a value to or from the proportional action only.
The integral time is the speed at which the controller corrects the error. A short integral time means that the controller corrects the error quickly. If the integral time is too short then the controller makes the correction before the system has time to react because of the delay or dead time, which causes oscillation.
If the integral time is too long, then the correction takes longer. If the integral time is too long, the error remains for a time that causes a very slow response.
When setting the parameters manually, every single parameter must be set. A trial and error method can be applied.

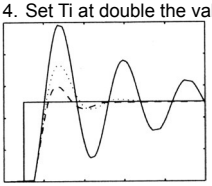
*Method 1:*
**Setting the P-band:**
1. Remove the integral action by setting the Ti parameter to the **no**l value.
2. Apply a big P-band.
3. Slightly change the setpoint and observe the system response. The response will be diminished.
4. Reduce the P-band in half. Slightly change the setpoint and observe the system response. If the system is still diminished and does not oscillate, reduce the P-band again by half.
5. Proceed with point 4 until the system starts to oscillate constantly.
6. Multiply the P-band by 2.



P-band decrease:
test 1: dashed line
test 2: dotted line
test 3: continuous line

**Adding the integral time**

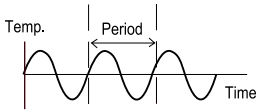
1. Set a long integral time.
2. Slightly change the setpoint and observe the system response. The response will be diminished.
3. Reduce the integral time by a factor of 2 and repeat point 2 until an oscillation response is obtained for a small setpoint variation.
4. Set Ti at double the value obtained in point 3.



Ti decrease:
test 1: dashed line
test 2: dotted line
test 3: continuous line

*Method 2:*

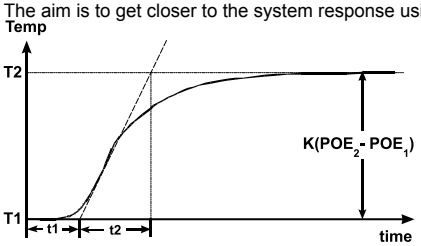
The Ziegler-Nichols method can also be applied. It involves repeating points 1 to 4 for setting the P-band and searching for the P-band limit that causes stable oscillations. By detecting the obtained oscillation period and knowing the set P-band limit $Bp_{Lim}$, the Bp, Ti parameters are calculated for the final setting.




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

*Method 3:*

Another possible method is the open loop test by carrying out a test in multiple steps on the output.
The aim is to get closer to the system response using multiple steps with the following function:




1. Put the controller in manual mode by modifying the POE parameter from PI to a voltage value between 0 and 10 V. Take note of the chosen value ($POE_1$).
2. Allow the temperature to stabilise.
3. Increase the output voltage value to carry out a variation in several stages. Take note of the chosen value ($POE_2$).
4. Measure the curve shown above.
5. The process gain is given by:

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

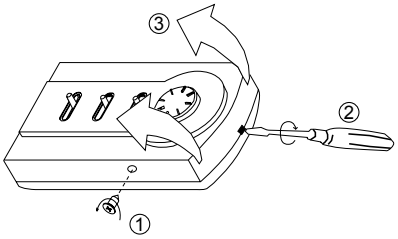
The following is obtained according to the Ziegler-Nichols method:

- for a P controller: $Bp = (t1 * K) / t2$
- for a PI controller: $Bp = (1.11 * t1 * K) / t2$
  $TI = 3.33 * t1$

At the end of the test, do not forget to reset the POE value to PI in order to use the appliance in automatic mode.

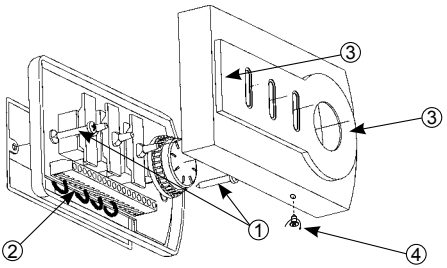
## INSTALLATION

OPENING THE COVER




1. unscrew the screw on the lower part of the appliance
2. - 3. open the cover using a screwdriver

ASSEMBLING THE APPLIANCE AND CLOSING THE COVER




1. tighten the screws on the box on the wall
2. connect the cables
3. put the cover back on
4. tighten the screw (on the lower part of the appliance)

ASSEMBLY ON A WALL / SURFACE