TEM
PI Controller, Positioner and Thermostat

Features

- Multi Function controller: Temperature controller, positioner, analog PI controller or P-PI-cascade controller. In one unit.
- 2 Control loops in one, Modulating PI-control analog loop and PI-control temperature loop.
- Output for a DC 0...10V actuator
- Input for a DC 0…10V sensor
- Transformation of display value according to analog sensor range
- Temperature control depending on room or return air temperature
- Integrated room temperature sensor
- Programmable user parameters
- Minimum, maximum set point limitation
- Minimum, maximum limitation of output and input.

- Enable or Disable change of set points and heating/cooling changeover
- Temperature display in Celsius or Fahrenheit
- Programmable control parameters
- Selectable Frost protection
- Operating Voltage 24V

Applications

- Controlling the temperature output of a simple air-handling unit with one heating or cooling coil.
- Individual room control for pressure dependent, Independent VAV systems.
- Temperature control of radiators, floor heating and chilled ceilings.
- Positioning of an actuator with a 0-10V input/output signal
- Controlling the pressure for clean room or VAV applications.
- Various universal control situations requiring PI control and one analog input/output.

General Description

The TEM is a stand-alone electronic temperature controller with two PI control loops. It features 2 PI sequences. The TEM features 1 NTC temperature sensor and one analog input.
The TEF features one analog 0…10VDC output. A detailed parameterization is possible with the use of a simple configuration routine. The TEF can be configured using the standard operation terminal. No special tools or software is required.

Ordering

| Item Name	Description/Option
TEF	Compact PI controller 1 TI internal & external, 2 DO (Relays)
TEM	Compact PI controller 1AI, 1 TI int & ext, 1 AO

Selection of actuators and sensors

Temperature Sensors: Use only our approved NTC sensors to achieve maximum accuracy. Recommended is SDA-Tn10-20 as Duct sensor, SRA-Tn10 as Room sensor and SPA-Tn10-10 as immersion sensor.

Modulating Actuators: Choose actuators with an input signal type of 0-10V DC. Minimum and maximum signal limitations may be set in software.

Technical Specification

Power	Power Supply	21.5 - 26.5 V AC 50/60 Hz
	Power Consumption	Max 2 VA
	Electrical Connection	Terminal Connectors
	Input Signal Resolution	0-10V DC, min and max adjustable via software 39 mV

	Output Signal
	    Resolution
	    Maximum Load
		0-10V DC, min and max adjustable via software
		39 mV
		20 mA, 500ς

	Temperature Sensor	NTC resistor 10kς at 25 °C
	Maximum cable length with copper cable 1.5 mm^2 for external connections	80 m
Operation	Control Temperature Range Measured Temperature Range	10 to 35 °C (50…95 °F) 0 to 40 °C (32…104 °F)
	Display precision	0.5 K

Environment	Operation
	    Climatic Conditions
	    Temperature
	    Humidity
		To IEC 721-3-3
		class 3 K5
		0…50°C
		<95% r.h.

	Transport & Storage
	    Climatic Conditions
	    Temperature
	    Humidity
	    Mechanical Conditions
		To IEC 721-3-2 and IEC 721-3-1
		class 3 K3 and class 1 K3
		-25…70°C
		<95% r.h.
		class 2M2

	Ambient Humidity	0 to 95% r.h. Non Condensing

Standards	CE conform according to
	    EMC Standard 89/336/EEC
	    EMEI Standard 73/23/EEC
		EN 61 000-6-1/ EN 61 000-6-3

	Product standards
	    Automatic electrical controls for
	    household and similar use
	    Special requirement on
	    temperature dependent controls
		EN 60 730 –1
		
		EN60 730 – 2 - 9

	Pollution Class	Normal
	Degree of Protection	IP30 to EN 60 529
	Safety Class	III to EN 60 730
General	Housing	ABS plastic
	Servicing	Maintenance Free
	Dimensions	105 x 90 x 37 mm (H x W x D)
	Dimensions of package	160 x 100 x 40 mm (H x W x D)
	Weight (including package)	212 g

Dimensions
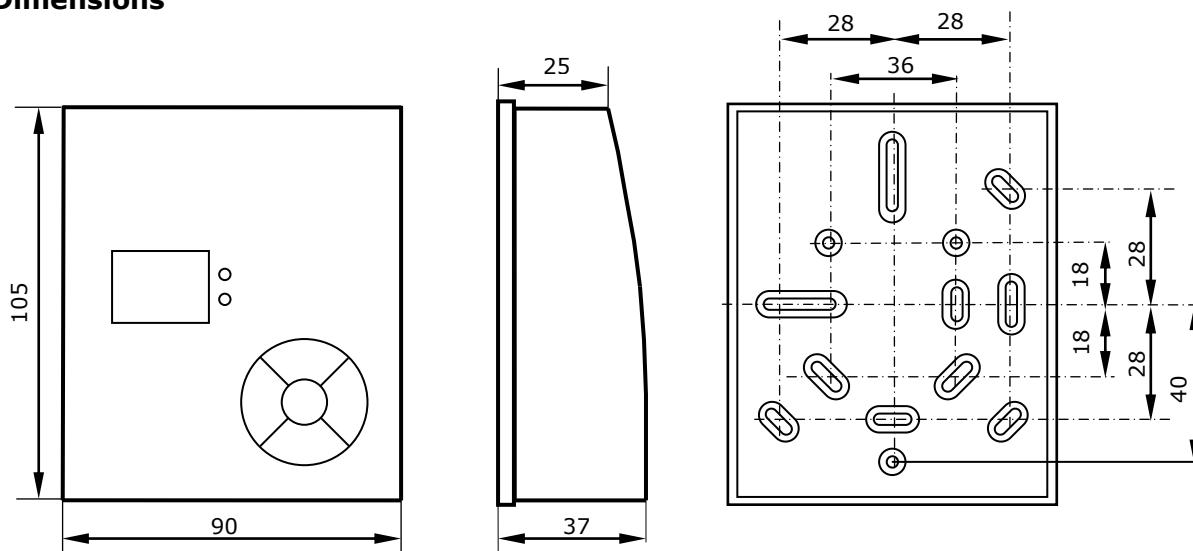
Display and Operation
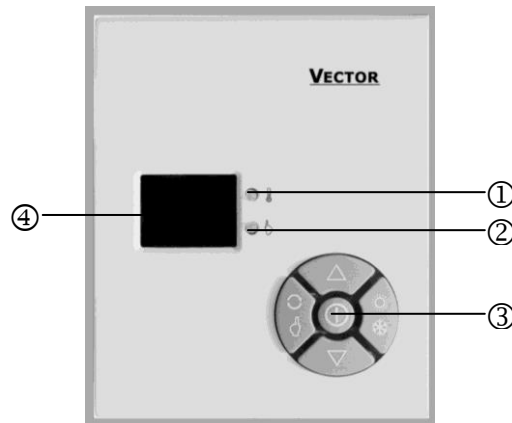
Legend
1. Status LED for temperature control mode. Green = Cooling, Red = Heating, Orange = setpoint or parameter menu active.
2. Status LED for analog control mode. Green = Input is equal to setpoint, Red = Input is not equal to setpoint, Orange = setpoint or parameter menu active.
3. Buttons for operating the unit:

   ⊙   POWER button, switches the controller on or off

   △▽   UP and DOWN buttons, change setpoints and parameters.

   ☌ ↻   LEFT button, Activates analog control mode or
         acts as ESC if in parameter menu.

   ☀ ✳   RIGHT button, Activates temperature control mode, Heat / Cool change or
         acts as ENTER if in parameter menu

4. Numerical LED display with 2 digits. Indication of current value or setpoint

Display

The TEM controller features a two digit number display and two dual colors status-LED.

Power Failure

All the parameters and set points are memorized and will not have to be reentered. The unit will return to the operation mode it was in before the power failure.

Special Functions

- **Frost Protection**: The controller will activate itself if the temperature drops below 7°C (44°F). It will control the environmental temperature up to 15° C (59° F) and then return to its previous mode. The LED will show FP and the status LED blink alternating. Frost protection can be enabled/disabled using user parameter P7

NEW! Daily valve exercise: If enabled the output will once per day fully open for 3 minutes and afterwards return to normal operation. Valve exercise function is independent of operation mode.

Operation

1. **Switching ON**
   The unit is switched on by pressing the POWER button. It will start up in its previous mode.

2. **Temperature Control**
   Press the RIGHT button once to activate temperature control mode if in analog mode. The temperature set point is indicated by pressing the UP or DOWN key once. The set point will be changed, if either one of this keys is pressed again within 4 seconds.

3. **Analog Control**
   Pressing the LEFT button while in temperature mode activates the analog output.

4. **Switching OFF**
   The unit is switched off by pressing the POWER button once.

5. **Changing HEATING/COOLING mode.**
   Pressing the Auto button for more than 3 seconds will change the temperature control mode. (In case Heat/Cool change is enabled, See P4). The mode of the unit is indicated by the upper status LED. Green is for cooling and red is for heating.

Setting of parameters

A number of parameters can be set in order to optimize the control performance and adapt the unit to various applications. These parameters can be set during operation without opening the unit.

The parameters are password protected in order to avoid unauthorized tampering. There are two levels of parameters: User parameters P0-P10 and Expert control parameters E0 – E12. The passwords for user levels and expert levels are different. Only control experts should be given the control parameter password.

The parameters can be changed as follows:

1. Press LEFT and RIGHT button together for three seconds. The display will indicate PP and both status LED's are blinking in orange.
2. Select a password using UP or DOWN buttons. Dial **09** in order to get access to the user parameters. The RIGHT key will work as ENTER key and the LEFT key as ESC key. Press RIGHT key after selecting 09.
3. Once logged in, **PO** is displayed and the two status LEDs show a steady orange light. Now you can select the parameters by pressing the up or down key. Press RIGHT key after selecting parameter.
4. The two status LEDs will now blink alternatively in orange color. Change the parameter using UP or DOWN keys.
5. After you are done, press RIGHT again in order to return to the parameter selection level. In order to leave the menu press the LEFT key once or do not press a key for more than 5 minutes.
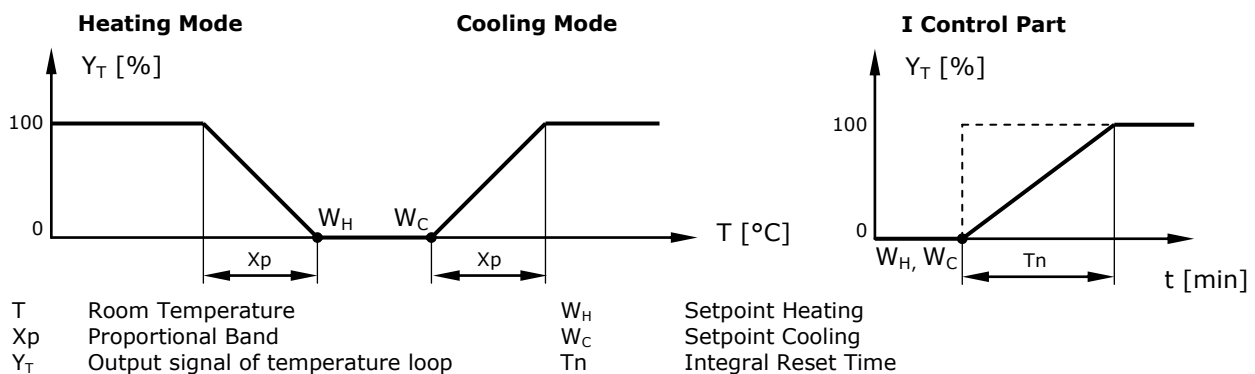
User Parameters

Parameter	Description	Setting Range	Factory Setting
P0	Celsius or Fahrenheit Select either temperature indication standard. All temperature values are indicated accordingly	°C, °F	°C
P1	Light intensity of display, 1 = dark, 10 = bright	1…10	10
P2	Enable control modes 1 = Temperature only, 2 = Analog only, 3 = Both modes are enabled	1,2,3	3
P3	Choose if the end user is allowed to change set points 0 = Disabled, 1= Enabled	0,1	1
P4	Heat/Cool change Enable, Choose if the end user is allowed to change heating/cooling mode 0 = Disabled, 1 Enabled	0,1	1
P5	Minimum set point limitation for temperature loop	5°C…max 41°F…max	10°C 50°F
P6	Maximum set point limitation for temperature loop	min…35°C min…95°F	40°C 104°F
P7	Frost protection enable/disable	no, FP	FP
P8	Calibration value of temperature. This value is calibrated at manufacturing of the thermostat. If required it is possible to shift the temperature −3 K to +3 K in 0.5 K steps.	-3…3 K	0 (Different for each controller)
P9	Calibration value for analog input. The value represents % of the input range.	-9…9%	0
P10 (PA)	Display in analog mode, 0 = 0-10, 1 = 0-100	0,1	1

Control Function

Temperature Control Mode

The controller reads the temperature either by using its integrated temperature sensor or by using an external sensor. The sensors are selectable with a jumper. The controller maintains the temperature set point by delivering a continuous 0…10V DC signal to an actuator of either a valve or an air damper. The temperature is controlled using a proportional and integral control function (PI control). Following control parameters decide the function of the PI loop:

- E0 = P-band in Kelvin or ° Fahrenheit depending on P0. Selecting 0 disables the P part. Factory setting is 2 Kelvin.
- E3 = A large I part increases the swinging tendency of the control loop. Limiting the integral part may reduce this tendency. The I-part is disabled if 0 is selected.
- E4 = Tn, Reset time of Analog loop integral. Tn is the time needed for the integral to run from 0 to 100%. The range is 0.5 - 30 min. Ideal setting is 10 minutes for temperature control. A too short time for Tn will result in an instable control loop.

T	Room Temperature		W_H	Setpoint Heating
Xp	Proportional Band		W_C	Setpoint Cooling
Y_T	Output signal of temperature loop		Tn	Integral Reset Time

Analog Control Mode:

In analog control mode the TEM is able to work in three different ways. The functions are chosen with Expert parameter E5.
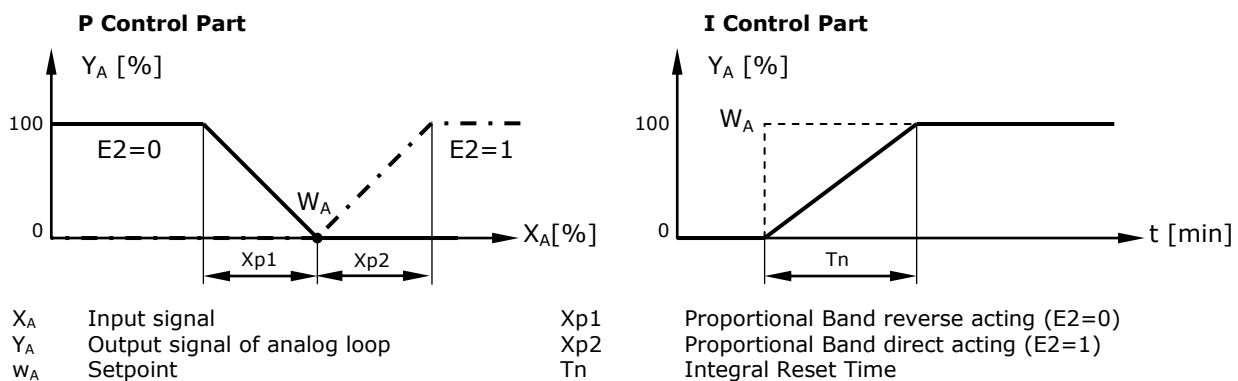
Positioner (Parameter E5 = 0)

While programmed to work as positioner the controller will generate an output signal corresponding to the analog setpoint. The input is not taken into account; the output voltage is generated only based on the setpoint. The setpoint can either be a percentage from 0…100% or a step signal from 0…10. (See parameter P10 for details.)

PI-Controller (Parameter E5 = 1)

The controller reads the analog input value and maintains it using a continuous 0…10V DC output signal. The control function used is PI control. If both P and I parts are enabled, they will be added together to generate the output signal. Following control parameters decide the function of the PI loop:

- E1 = P-band in % of the output. Range is 0 – 100%. Selecting 0 disables the P part.
- E2 = Action of P-control. Set E2 = 1 for direct action and E2 = 0 for reverse action.
- E3 = Limitation of I-part. The I-part is disabled if 0 is selected.
- E4 = Tn, Reset time of Analog loop integral.

X_A	Input signal	$Xp1$	Proportional Band reverse acting (E2=0)
Y_A	Output signal of analog loop	$Xp2$	Proportional Band direct acting (E2=1)
w_A	Setpoint	Tn	Integral Reset Time

Cascade Controller (E5 = 2)

It is possible to link the two control loops into a P-PI cascade control. The temperature loop will work as a proportional loop (I-part is disabled). Its output serves as setpoint to the analog PI-loop. Target application for this usage is VAV control.

Temperature Control Mode: The upper status LED lights up red for heating, green for cooling. The number display shows the room temperature. The point in the lower right corner of the display will indicate 0.5-degree steps. The setpoint is displayed for 5 seconds if either UP or DOWN buttons are pressed once.

Analog Control Mode: The lower status LED serves as indication for the analog loop. It lights up green if the input matches the setpoint and red if the input is off target. In cascade control only the temperature LED are active. The number display shows either the input or the output value in percent, depending on parameter E5. Pressing UP or DOWN key will display the setpoint. The setpoint is, depending on parameter P10, a value either from 0…10 or 0…100. Since the display has only 2 digits, 100 is indicated as A0. The display range can be adapted to specific sensors using parameters E11 and E12. The display of the input/output will then be transformed according to these settings.

Calibrating the sensor

If the room temperature displayed does not agree with the room temperature effectively measured, the temperature sensor can be recalibrated by adjusting user parameter P8.

Setting of control parameters

Warning! Only experts should change these settings!
The password for the expert user is **14**. See setting for user parameters for login details.

Expert	Description	Setting Range	Factory Setting
E0	P – Band Temperature loop, Select the P Band of the temperature loop in K or °F. 0 disables the P part	0…10.0 K/°F	2.0 K
E1	P – Band Analog Loop, Select the P Band of the analog loop in percent. Selecting 0 disables the P part.	0…100 %	10 %
E2	Action of P-Band. 0 = reverse acting, 1 = direct acting	0,1	0
E3	Maximum of integral, Limits the influence of the integral part on the output signal. 0 disables the I part	0.0…100 %	0.0 %
E4	Tn, Reset time of integral, 0.5 - 30 min	0.5…30 Min	2 Min
E5	Function of analog control mode 0 = positioner, 1 = PI-controller, 2 = cascade-controller	0,1,2	0
E6	Display in Analog Mode, 0 = Input, 1 = Output	0,1	1
E7	Minimum limitation of output voltage	0 – max. V DC	0 V DC
E8	Maximum limitation of output voltage	Min – 10.0 V DC	10.0 V DC (A0)
E9	Minimum limitation of input voltage	0 – max. V DC	0 V DC
E10 (EA)	Maximum limitation of input voltage	Min – 10.0 V DC	10.0 V DC (A0)
E11 (Eb)	Lower display transformation value in analog loop	0…Max %	0 %
E12 (EC)	Upper display transformation value in analog loop	Min…100 %	100 % (A0)
E13 (Ed)	NEW! Daily valve exercise	0,1	0

Mechanical Design

The unit consists of three parts:
- The base unit, which contains the terminal connecters, temperature sensors and control logic
- The front plate, which holds the buttons
- The base plate, to ease installation

Mounting location

- On an easy accessible interior wall, approx.
  1.5 m above the floor in an area of average temperature.
- Avoid direct sunlight or other heat sources, e.g. the area above radiators and heat emitting electrical equipment.
- Avoid locations behind doors, outside walls and below or above air discharge grills and diffusers.
- Location of mounting is less critical if external temperature sensors are used.

Installation

1. Install the mounting plate on the wall box. The type of screws required depends on the wall box. For Chinese standard M4x25 screws are most suitable. The mounting plate provides holes for most international standards. Horizontal distance of mounting screws ranges from 35 to 65 mm; vertical distances are 58 to 85 mm.
2. On the upper side of the controller, there are two clips. Press them inside using a small screwdriver.
3. Separate the front plate of the controller with the base by opening it carefully. Unplug the connector from the button.
4. Connect the wirings as shown in the diagram below. Pay attention to follow local guidelines regarding insulation and wire sizes.
5. Connect the main body to the mounting plate by holding it in place and inserting the two small screws that are part of the package in the upper left and lower right corner.
6. Reconnect the plug of the button and press the front plate into place. Insert the lower part first and then press down the upper part until hearing a click
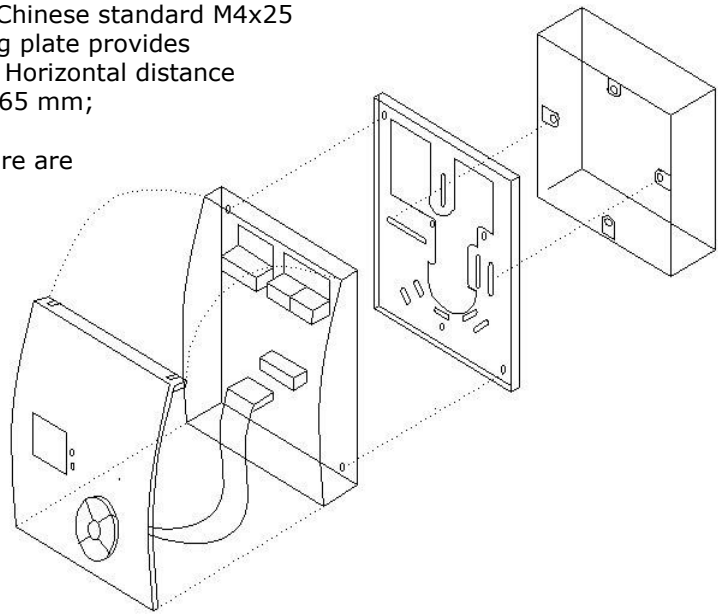
Connection terminals
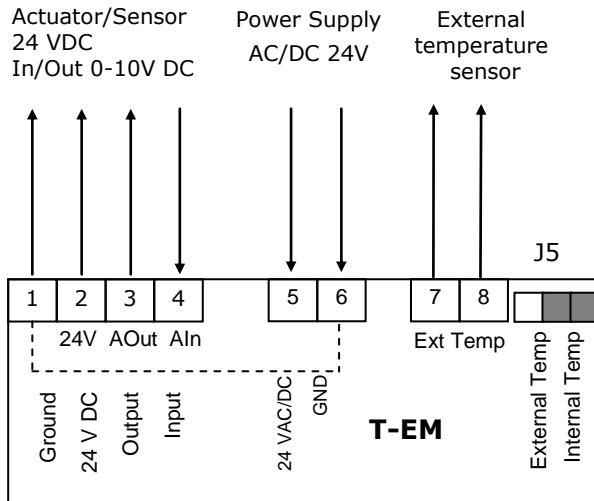
Legend:
1. Signal Ground
2. Actuator/Sensor power supply 24V DC. For AC powered actuators/sensors use power from terminals 5/6.
3. 0…10V DC Output
4. 0…10V DC Input
5. Power supply 24 V AC/DC
6. Power supply Ground (linked to Signal Ground)
7. External temperature Sensor
8. External temperature Sensor
J5 Jumper for external or internal temperature sensor

Connection Diagram
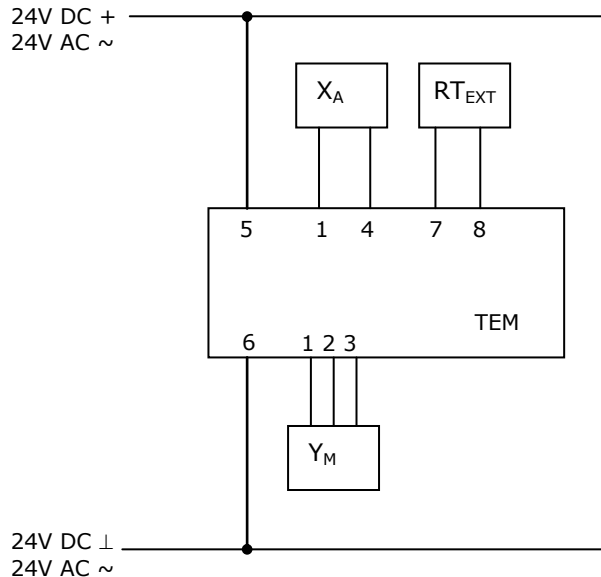
Legend:

X_A Analog sensor
RT_{EXT} External temperature sensor
Y_M Actuator

Subject to alteration