TEF
PI Controller and Thermostat

Features

- Controller: Floating point temperature controller and positioner
- On/Off thermostat for 4-pipe systems or 2-pipe systems with fan function.
- Temperature control depending on room or return air temperature
- Integrated room temperature sensor
- Programmable user and control parameters
- Minimum, maximum set point limitation
- Enable or Disable change of set points and heating/cooling changeover
- Temperature display in Celsius or Fahrenheit
- Selectable Frost protection
- Operating Voltage 24V

Applications

- Individual PI-control of the temperature in rooms that are heated or cooled with 2-pipe systems or 4-pipe systems using spring return fan coil valves.
- Cost efficient control of pressure dependent VAV units.
- Positioning of an on/off actuator by using the running time of the actuator
- Controlling the temperature output of a simple air-handling unit with one heating or cooling coil.
- Radiator or floor heating, cooling ceiling.

General Description

The TEF is a stand-alone electronic temperature controller with one PI control loop. It features 1 PI sequence and 2 binary sequences. The TEF features 1 NTC temperature sensor input. One additional function is the manual positioning of a floating actuator.
The TEF features 2 binary outputs (Relays). 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.
Floating Actuators: Any actuators with less than 250 VAC, 100W are acceptable. Actuators with constant running time are preferred for optimum functionality.
Binary auxiliary devices: E.g. pumps, fans, on/off valves, humidifiers, etc. Do not directly connect devices that exceed 250 VAC, 100W.

Technical Specification

Power	Power Supply	21.5 - 26.5 V AC 50/60 Hz
	Power Consumption	Max 2 VA
	Electrical Connection	Terminal Connectors

	Output Signal
	   Switching medium
	   Maximum Load
		2 digital outputs,
		Relays contacts
		1A, 24V DC

	Temperature Sensor	NTC resistor 10k$_\varsigma$ at 25 °C
	Maximum allowed 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) 10 to 35 °C (50…94 °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% rH Non Condensing

Standards	$C \in$ 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)	215 g

Dimensions
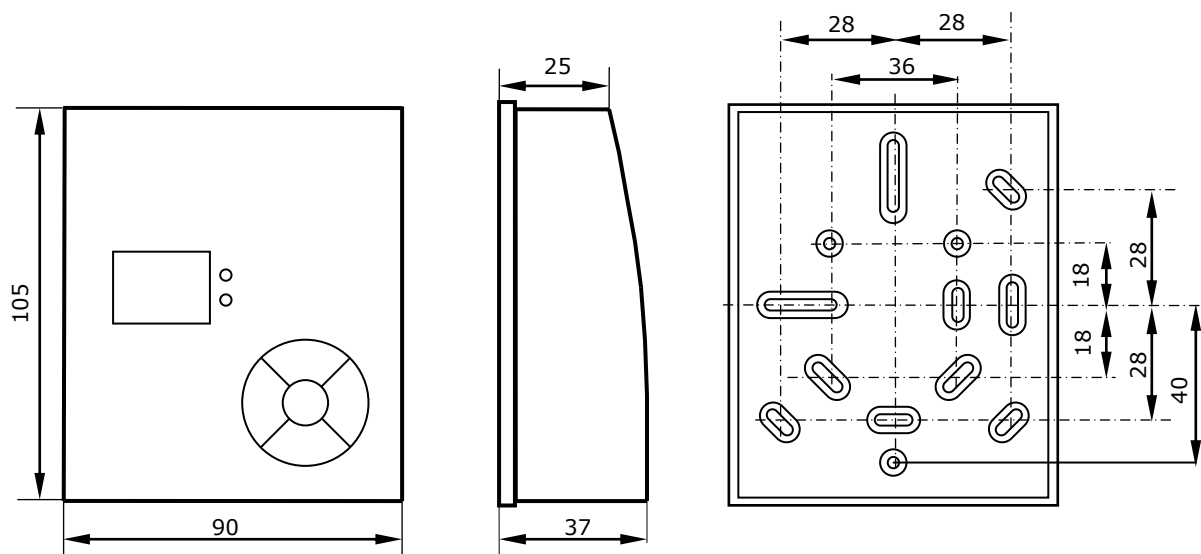
Display and Operation
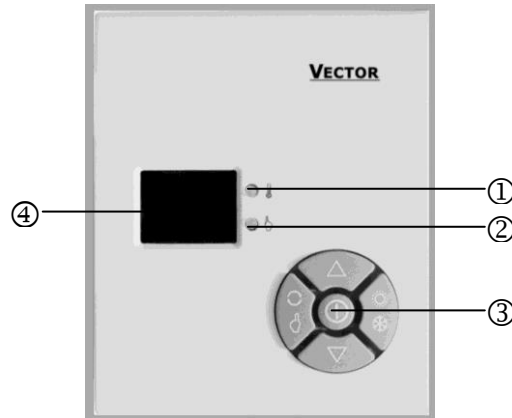
Legend
1. Status LED for temperature control mode. Green = Cooling, Red = Heating, Orange = setpoint or parameter menu active.
2. Status LED for analog control mode. Green = Input is equal to setpoint, Red = Input is not equal to setpoint, Orange = setpoint or parameter menu active.
3. Buttons for operating 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 TEF 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. If required the unit would perform a reset cycle after resuming of power supply. A reset is necessary if the unit was in operation during power failure. The actuator position would then be lost and has to be regenerated. The controller assumes it is in the fully open position at the return of power, completely close the actuator and then return to the mode of operation and setpoint it was in before the power failure.

Frost Protection

The controller will activate if the temperature drops below 10°C
(50°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

Using an External Sensor

In order to utilize the external sensor, the internal sensor needs to be cut. The internal sensor is located in the lower middle section of the PCB. It is marked with **RT.** It is recommended to cut one leg with a cutting tool and bend the sensor to the side.

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. There is as well a potentiometer located in the lower middle section on the PCB. Adjusting this will alter the temperature as well.

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. **Positioner, Fan activation**
   Press the LEFT button while in temperature mode to activate the positioner.
   In case fan control is enabled in 2-position mode, pressing the left key will override automatic fan control.
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 both modes are enabled, See P4). In case 4-pipe system is enabled, it is not required to switch between heating and cooling.
   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 – E7. 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 Enter after selecting 09.
3. Once logged in, **P0** 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.
4. Change a parameter by pressing the RIGHT key. 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 POWER key once or do not press a key for more than 10 sec.

User Parameters

Parameter	Description	Range	Factory
P0	Celsius or Fahrenheit	C, F	C
P1	Light intensity of display, 1 = dark, 10 = bright	1…10	10
P2	Enable control modes 1 = Temperature only, 2 = Positioner 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 = Enable set point access for temperature loop, 2 = Enable set point access for positioner 3 = Enable set point access for both loops	0, 1, 2, 3	3
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	Dead zone span. Difference between heating & cooling set point	0…10 K	1 K
P6	Minimum set point limit	10…33/50…97	10C, 50F
P7	Maximum set point limit	11…34/51…98	34C, 98F
P8	Frost protection enable/disable	no, FP	FP
P9	Calibration value of temperature. This value is calibrated at manufacturing of the thermostat. If required it is possible to shift the temperature −3° to +3° in 0.5° K steps.	-3…3	~
PA	Display in analog mode, 0 = 0-10, 1 = 0-100	0,1	0

Control Function

Temperature Control Mode: PI Control E2=0

The controller reads the temperature either by using its integrated temperature sensor or by using an external sensor. The controller maintains the temperature set point by calculating the position of the actuator using a 3-point modulating signal. The on/off actuator is positioned based on its opening and closing time. The temperature is controlled using a PI control function. If both P and I parts are enabled, they will be added together to calculate the output position. Following control parameters decide the function of the PI loop:

- E3: P-band in °K. The p-band corresponds to the temperature difference of current value to setpoint, which is required for fully opening the output.
- E4: 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.
- E5: 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. The setting very much depends on the application it is used for. For temperature control of a medium sized room, a setting of 5 minutes should be appropriate.
- P5: Dead Zone Span. The cooling setpoint W_C consists of the heating setpoint and the dead zone span. Changing the cooling setpoint therefore changes as well the heating setpoint. The factory setting for the dead zone span is 1K.
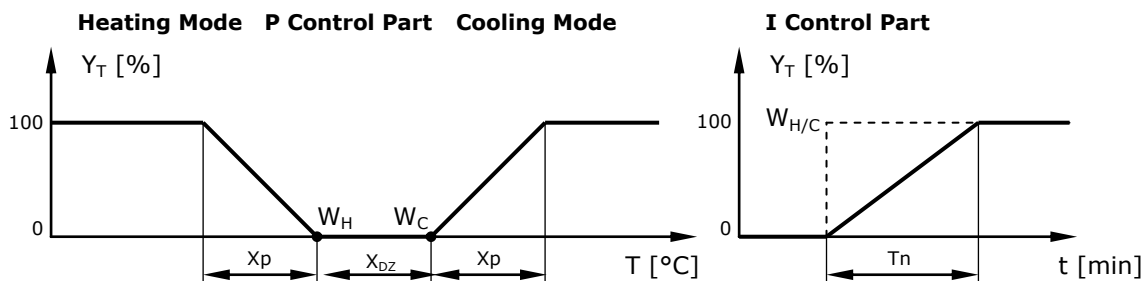

T	Room Temperature	w_H Setpoint Heating
Xp	E3: Proportional Band	w_C Setpoint Cooling
Y_T	Output signal of temperature loop	X_{DZ} P5: Dead Zone Span
Tn	E5: Integral Reset Time	

Switching frequency

The TEF works with two digital outputs to modulate a floating actuator. The position of the actuator is calculated with above described PI algorithm. The controller moves the actuator to the calculated position by either opening or closing the actuator. The actuator should not be moved for every little change in position, since this would reduce the lifetime of the actuator. We differentiate if we are moving the actuator in the same direction as the previous move or if we reverse direction.

- E7: Switching difference: For example the last actuator movement was opening and we open again. The actuator will only move, if the difference to the current actuator position is larger than this parameter.
- E6: Reversing difference: For example the last actuator movement was opening and we want to close now. The actuator will only move, if the difference to the current actuator position is larger than this parameter.

Below are examples of switching and reversing difference after the actuator has been opening on its previous move.
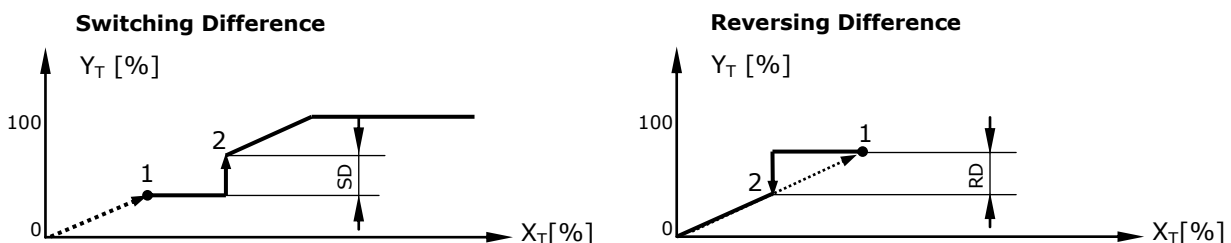

X_T	Calculated actuator position		RD	E6: Reversing Difference
Y_T	Actual actuator position		1	Opening up to step 1
SD	E7: Switching Difference		2	Actuator acting point

Temperature Control Mode: On/Off control E2=1

On/Off control can be used to operate fan coil valves, reheat or cooling compressor stages.
Outputs used are D OUT 1 for heating, D OUT 2 for cooling.
Control functions:

- E3: The hysteresis defines when an output is switched on and off again. The aim is to avoid unnecessary switching and thus increasing the life span of involved equipment as well as saving energy. Factory setting is 2 K.
- E6: Enable 4-pipe system. Using a 4-pipe system, both heating and cooling valves are present. It is not necessary to switch between heating and cooling mode.
- E7: Fan control: In 2-pipe mode it is possible to control a fan. The fan will run if heating or cooling is required, in auto mode it will stop when the measured temperature reaches the setpoint. The fan can be operated even the setpoint is reached by using the LEFT key to activate fan operation in idle mode.
- P5: Dead Zone Span. The cooling setpoint W_C consists of the heating setpoint and the dead zone span. Changing the cooling setpoint in 2-pipe mode therefore changes as well the heating setpoint. The factory setting for the dead zone span is 1K.
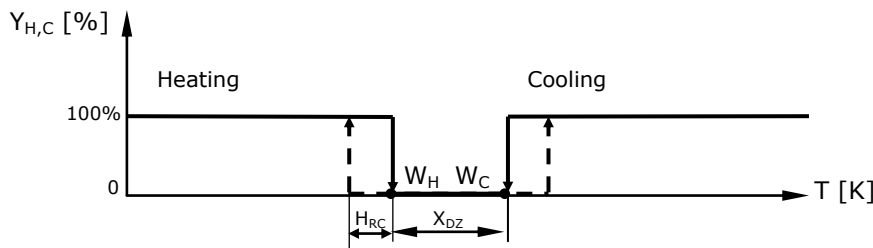
T	Room Temperature	w_H	Setpoint Heating
H_{RC}	E3: Hysteresis Heating/Cooling	w_C	Setpoint Cooling = $W_H + X_{DZ}$
X_{DZ}	P5: Dead Zone Span		

Analog Control Mode: Positioner

The positioner mode only operates, if the unit is set to PI control mode (E2 = 0).
While programmed to work as positioner the controller will move the actuator to the setpoint position. The on/off actuator is positioned based on its opening and closing time. The setpoint can either be a percentage from 0…100% or a step signal from 0…10. (See parameter P10 for details.)

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 Mode: Positioner

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. 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.

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	Display	Standard
E0	Actuator running time Opening, 10…990 seconds	01 - 99	10
E1	Actuator running time Closing, 10…990 seconds	01 – 99	10
E2	Control mode 0 = PI control, 1 =On/Off control	0, 1	0
E3	P – Band / Hysteresis Temperature loop, Select the accuracy of the temperature loop in degrees Kelvin.	0.5…8.0	2.0
E4	Maximum of I part of Analog Loop, Limits the influence of the integral part on the output signal. 0 disables the I part	0.0…A0 (100)	0.0
E5	Tn, Reset time of Analog loop integral, 0.5 - 30 min	0.5…30	02
E6	For on/off control only: 2 pipe or 4 pipe system 0 = 2 pipe system, 1 = 4 pipe system	0, 1	0
E7	For 2-pipe systems only: Enable Fan Control 0 = No Fan control, 1 = Fan Control	0, 1	0
E8	Reversing Difference in percentage of actuator position	00…A0 (100)	10
E9	Switching Difference in percentage of actuator position	00…A0 (100)	5

## 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
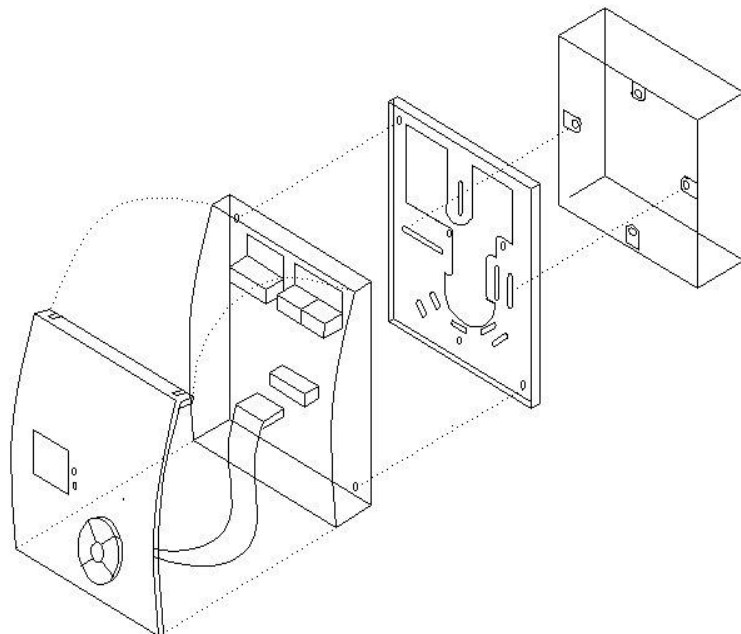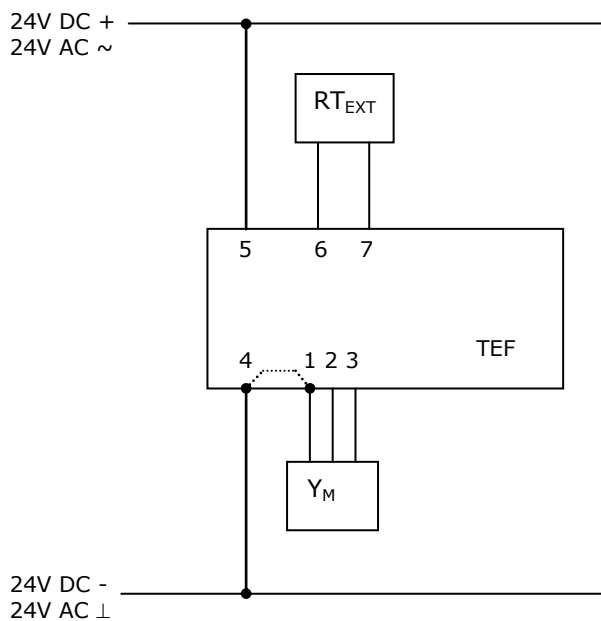
Connection terminals
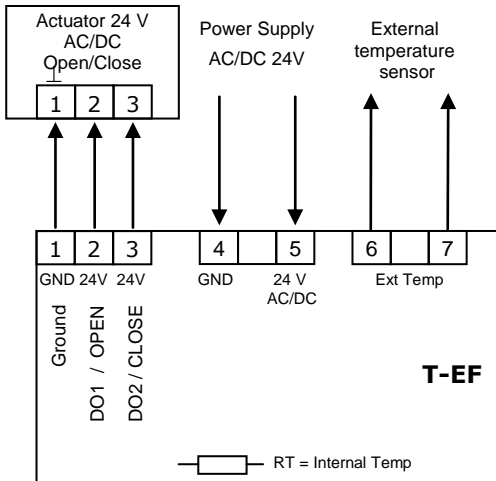
Legend:
1. Signal Ground (= 4)
2. Open Signal 24V AC or DC (= 5)
   Digital Output 1
3. Close Signal 24V AC or DC (= 5)
   Digital Output 2
4. Power Supply Ground
5. Power supply 24 V AC/DC
6. External temperature Sensor
7. External temperature Sensor

In order to activate External sensor, RT **must** be cut.

Connection Diagram

Legend:
RT$_{EXT}$ External temperature sensor
Y$_M$ Actuator

Subject to alteration