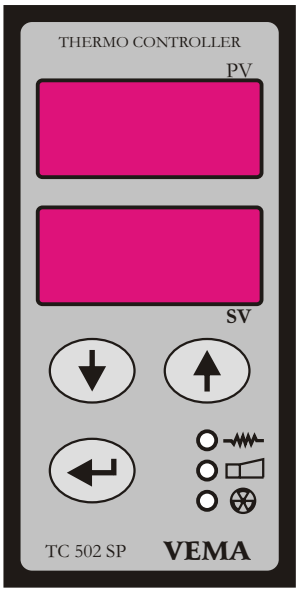
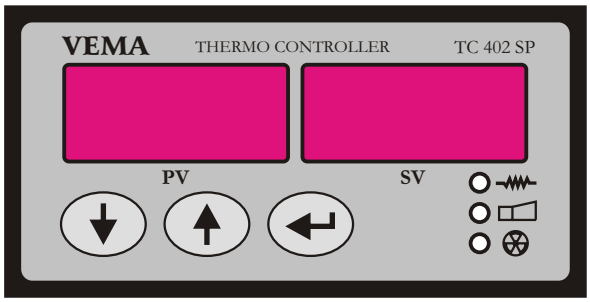
VEMA
Industrial electronic systems
Bulgaria, Pleven 5800, 27 Osogovo str.
tel./fax: +359-64-870172, tel.: +359-64-870170
e-mail: office@vema-bg.com http://vema-bg.com

Temperature Controllers TC 402 SP/ TC 502 SP



- programmable On/Off and PID control modes
- **ramp function** (gradual heating/cooling)
- continuous **heater current** measurement and **burnout detection**
- full **auto-tuning** for both PID regulators
- wide temperature range: -199 up to 999 °C



INSTRUCTION MANUAL

Introduction

The microprocessor Temperature Controllers TC402(502)-J/K/R/P offer optimal comfort of service and visualization of information.

The Temperature Controllers TC402(502)-J/K/R are designed to work with thermocouples of type J, K or R, the TC402(502)-P Temperature Controllers - with thermistors of type Pt100. Other temperature sensors' compatibility is also available on request.

The output signal is given either as a relay or a direct current output.

The Controller can be set as On/Off, 2- or 3-position PID regulator.

The auto-tuning algorithm explores the parameters of the object to be controlled and sets the corresponding PID-constants of the Controller.

The Controller is supplied with an alarm relay output for preventing the temperature from great detours in the technological mode of the controlled object. The alarm relay output can work in 32 programmable modes, non-latch standby sequence included.

The desired temperature SV (Set Value) and the current temperature PV (Process Value) are constantly displayed in the Control Mode. The Controller can also display the heater current in this mode by pressing and holding the "↵" button.

The processes of heating (), cooling( ) and alarm( ) are indicated by separate light diodes.

All parameters of the Controller can be set (changed) in Program Mode. In this case the mnemonics of the parameters are shown on the "SV" display and the current values of the parameters are shown on the "PV" display. Using the arrow buttons " ▲ " and " ▼ ", the parameters' values can be changed by one unit or at a faster rate (when the button is held pressed for a longer time). The values of the parameters are automatically restricted within their possible limits.

Technical specifications

1. Temperature range: -199 up to 999 °C.
2. Accuracy: 0,2% up to 1,0%.
3. Parameters' range:
   - gain factor - P 0 to 100 %;
   - differential constant time - td 0 to 200 s;
   - integral constant time ti 0 to 999 s;
   - cycle time - tc 0 to 200 s;
   - alarm limits - tA -199 to 999 °C;
   - hysteresis - HY 0 to 99 °C;
   - ramp time - r-P 0 to 240 min;
   - heater current - cur 0 to 25 A.

WARNING !!!

In order to measure the heater current, a current transformer with conversion coefficient 1000 must be used. Do not connect the heater directly to the Controller!

4. Indication - seven-segment LED, h=14,2 mm.
5. Control outputs:
   - relay type - max 2A/250V cosΦ=1;
   - open collector (on request) - 0/24V to 30 mA.
6. Supply voltage - 187 up to 242 V/48-62 Hz.
7. Dimensions - 48x96x135 mm.
8. Ambient temperature - 0 to 50 °C.

Mnemonics of the parameters

I) System parameters

The system parameters can be read and modified by pressing and holding of "↵" and depressing of "↑":

1. tAL - lower alarm limit of temperature.
2. ***tAU*** - upper alarm limit of temperature.
3. ***cur*** - lower limit of the heater current.
4. ***r-P*** - time (in minutes) for the set temperature to gradually change from the current temperature (at startup or upon paramater change) to the ***SV***.
5. ***At1*** - alarm zone type, could include any of the following zones:
   - ***"L"*** - the zone of temperatures under ***tAL***;
   - ***"U"*** - the zone of temperatures above ***tAU***;
   - ***"c"*** - the zone of heater current under ***"cur"***.

For example, if ***At1='LU'***, the alarm zone would include all temperatures under ***tAL*** and all above ***tAU***. If ***At1='oFF'***, the Controller will have an empty alarm zone.

6. ***At2*** - alarm output mode:

"nor" - (*normal*) the alarm output will work according to the alarm zones setup in ***At1***;

"Sb" - (*Stand-by*) the alarm output will work according to the alarm zones setup in At1 once a non-alarm zone is reached. Until that point, the alarm output will work as if in a non-alarm zone, and the "***SV***" indicator flashes as a sign that no safe (non-alram) zone has been reached yet;

"r" - (reverse) the alarm output will work inversely on the alarm zones setup in ***At1***, i.e. will be "off" in alarm zone, and "off" outside the alarm zone;

"Sbr" - both ***"Sb"*** and ***"r"*** modes**.**

7. ***Ctr*** - type of the Controller:

"oFF" - the Controller will only measure the temperature, but will not regulate;

"onF" - the Controller will work as an O***n/Off*** regulator (s. ***"HYH"*** and ***"HYC"***);

"Pid" - the Controller will work as a 2-PID regulator.

8. ***POS*** - heating and cooling setup:

"H" - 2-position regulator with heating;

"C" - 2-position regulator with cooling;

"HC" - 3-position regulator..

9. ***Opt*** - auto-tuning start:

"oFF" - no auto-tuning is initiated and the Controller goes off the Program Mode when "↵ " is pressed;

"on" - the auto-tuning routine is initiated upon pressing the "↵" button in order to find out the best PID parameters.

10. Internal self-test messages:

"EPr Err" - an error with the internal non-volatile memory has occured;

"o***FF Err" -*** no or false connection with the thermocouple has been detected.

II) PID and On/Off parameters:

These parameters can be read and modified by pressing and holding of "↵" and depressing of "↓ ":

1. ***tcH*** - cycle time (in seconds) for heating PID;
2. ***P H*** - gain factor for the heating PID;
3. ***tdH*** - differential constant for heating PID;
4. ***tiH*** - integral constant for heating PID;
5. ***HYH*** - heating hysteresis for O***n/Off*** regulator, i.e the heating output will go "on" when PV is under SV-HYH, and will go "off" when PV is above SV;
6. ***tc***C - cycle time (in seconds) for cooling PID;
7. ***P*** C - gain factor for the cooling PID;
8. ***td***C - differential constant for cooling PID;
9. ***ti***C- integral constant for cooling PID;
10. ***HY***C - cooling hysteresis for O***n/Off*** regulator, i.e. the cooling output will be "on" when PV is above SV+HYC, and will go "off" when PV falls below SV;

PROGRAM AND MONITOR MODES

In MONITOR mode, the arrow buttons are used to modify the set temperature. Pressing and holding any of these buttons for more than 1s will increase the pace of parameter change. To read and modify the other parameters of the Controller, the user must enter the PROGRAM mode by pressing and holding the "↵" button and then pressing "↑" to go to "System parameters", or pressing "↓" to go to "PID and On/Off". Once reached, each parameter can be modified using the arrow buttons. To save the current selected value of the parameter and go to the next parameter, press "↵". After all parameters of the selected mode have been passed, the Controller will go back to MONITOR mode.

The heater current can be displayed by pressing and holding of "↵" in MONITOR mode. In this case, the PV-indicator will read "cur", and the SV-indicator will display the value of the heater current in ampers. To go back to the normal SV and PV readings, press and hold "↵" again.

SPECIFIC CHARACTERISTICS

1. Deviations from the Set Value.
The normal deviation of the current temperature from the set temperature is about 1 °C or less. Greater deviations of 2-3 °C are sign of incorrect PID-parameters, unacceptable outer influences, intense electrical noises, incorrect placement of the temperature sensors or damages.

2. Alarm Standby Sequence.
The alarm standby sequence is initiated on startup of the Controller or on going back to the Monitor Mode after a parameter change, only when the alarm type At2 is "Sb" or "Sbr". During the alarm standby sequence, the "SV" display is blinking and the alarm output is working as if in a non-alarm zone. On the first occurrence of a non-alarm zone, the alarm standby sequence finishes up. Use this feature when alarm situations before the Controller has stabilized the temperature must be ignored, e. g. when wanting to prevent the extruder from running cold.

3. Auto-tuning.
The auto-tuning algorithm enables the Controller to adjust its PID- parameters to the characteristics of the controlled object for a more precise temperature regulation. The only parameters needed are the SV and the POS. The auto-tuning can be started in Program Mode by setting the "Opt" parameter to "on". The "SV" display reads a blinking "OPt", indicating that the (self-)optimization routine is still going on. Pressing and holding the "↵" button will cancel the auto-tuning routine. It is recommended to give a tolerance of at least 25 degrees Celsius between the starting and the set temperature before starting the auto-tuning algorithm, since the self-optimization uses the step response method.

If the gain factor after auto-tuning is greater than 100%, it will mean that the heater (cooler) is not powerful enough for this object. If this parameter is less than 10%, then the heater (cooler) has an exceeding power for the controlled object.

RECOMMENDATIONS

A better control of the temperature is achieved by a smaller cycle times. However, this leads to a more frequent commutation of the relay and to a faster wear-out. A compromised value in this respect is Tc=10 sec.

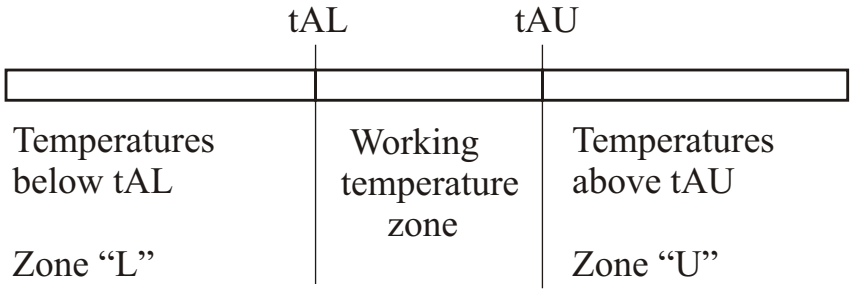
The differential time constant influences the forecasting action of the Controller, so to a great extend the initial oscillations of the temperature depend on this constant. When no auto-tuning is used, the recommended values for tdH and tdC to start with are 40 sec. and 20 sec. respectively.

The fast and smooth reaching of the set temperature depends greatly on the integral time constant. The temperature controllers TC-x02 are fuzzy-optimized with respect to the PID integral action, so that values tiH=tiC=200 give a sufficient result for a huge class of objects.

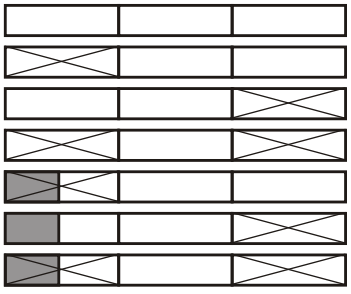
The gain factor depends entirely on the location of the set temperature on the characteristic of the heater (cooler), so it is not possible to give any recommended values. However, if the heater (cooler) are optimally constructed for the controlled object, PH=PC=25 will suffice.

All of these recommendations are only given for basic orientation, so the best recommendation is to run the auto-tuning algorithm and after that dynamically correct the evaluated parameters, if need may be.

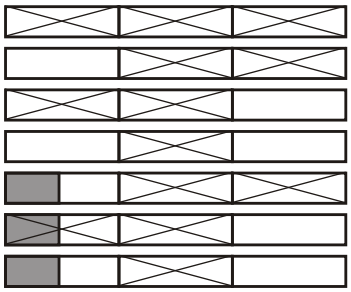
The alarm mode must be selected according to the technological assignment of the controlled object. For extruder machines, it is very hazardous to run the main motor before the temperatures have not been stabilized and the material along the shaft has not melted. In this case, "L" must participate in the value for At1, or the alarm standby sequence can be used (i.e. At2 is either "Sb" or "Sbr"). If it is not acceptable for the temperature to rise above a certain limit, then TAU and alarm values with "U" for At1 are used. Use "r" or "Sbr" for At2 when the alarm output must work inversely.



1). ***At1="Off"; At2="nor"***
2). ***At1="L" ; At2="nor"***
3). ***At1="U" ; At2="nor"***
4). ***At1="LU"; At2="nor"***
5). ***At1="L" ; At2="Sb"***
6). ***At1="U" ; At2="Sb"***
7). ***At1="LU"; At2="Sb"***



8). ***At1="Off"; At2="r"***
9). ***At1="L" ; At2="r"***
10). ***At1="U" ; At2="r"***
11). ***At1="LU"; At2="r"***
12). ***At1="L" ; At2="Sbr"***
13). ***At1="U" ; At2="Sbr"***
14). ***At1="LU"; At2="Sbr"***



The time ***r-P*** for gradually reaching of the set temperature SV should be much greater than the time for which the Controller would reach the set value, if no ramp function was used. The ramp function can be cancelled by setting ***r-P*** to zero. Switching to any other than the Monitor Mode will interrupt the ramp function.

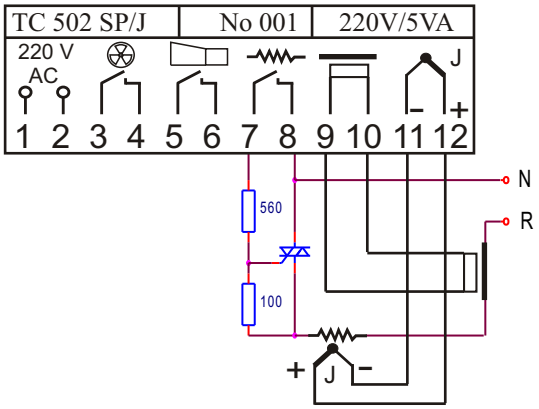
The ***cur*** limit must be more that 20% less than the nominal current in the heater, so that the oscillations in the main supply would not trigger the alarm.

MECHANICAL CONNECTION AND MOUNTING

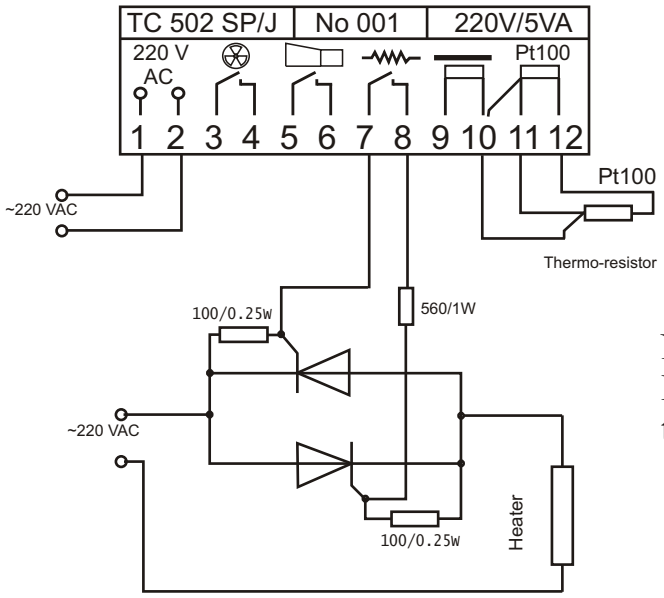
The Controller is assigned for mounting on facet panels of electrical units. The slot for mounting should have a shape of (45+0.8)x(92+0.6) mm. To secure the Controller on the panel, use the attaching screws.

The connector pin attachment of the Controller is pictured on its rear panel. The connecting wires must be isolated and have minimal diameter of 0.5 mm^2. Direct control of powerful heating/cooling elements should be avoided. Use of thyristor elements is recommended, since they are not exposed to frequent commutations and fast wear-out.

The figure below shows an example of how the Controller is to be connected using thyristor elements.

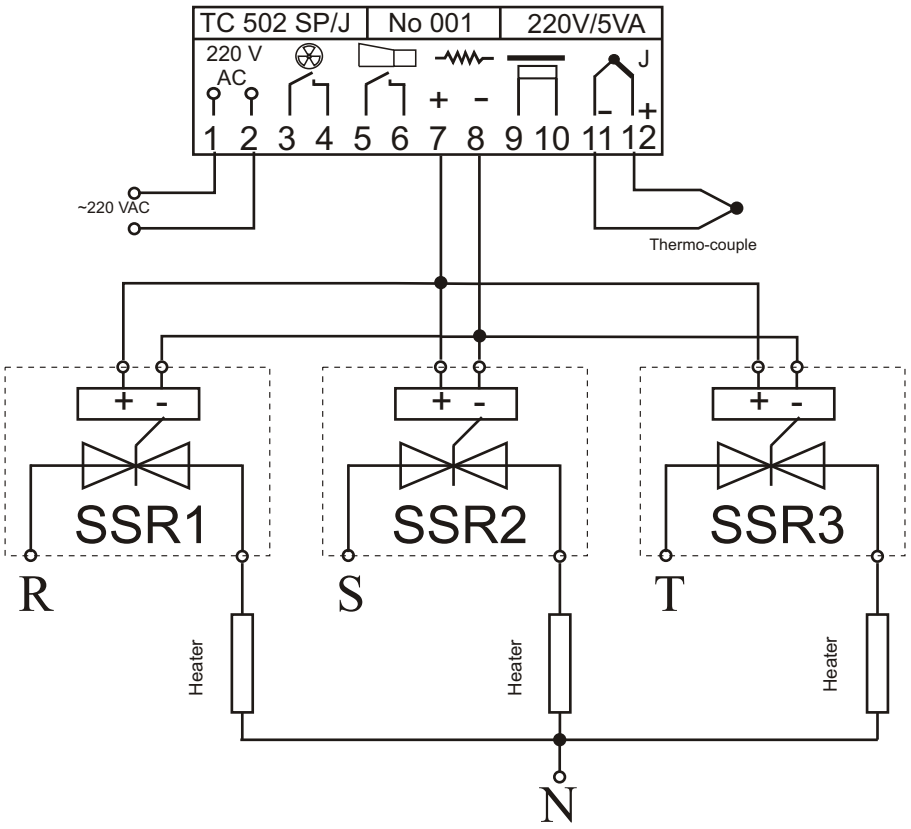


Pt100 pinout connections to TCx02:



Note:
For two-wire Pt100-connecting tie pin 10 and pin 11 together.

TCx02 connections to three-phase star-like loads using Solid state relay:



WARNING! In order to protect the power elements from damaging caused by accident shortcuts, the fuses MUST be fast-switching, automatic A-type.