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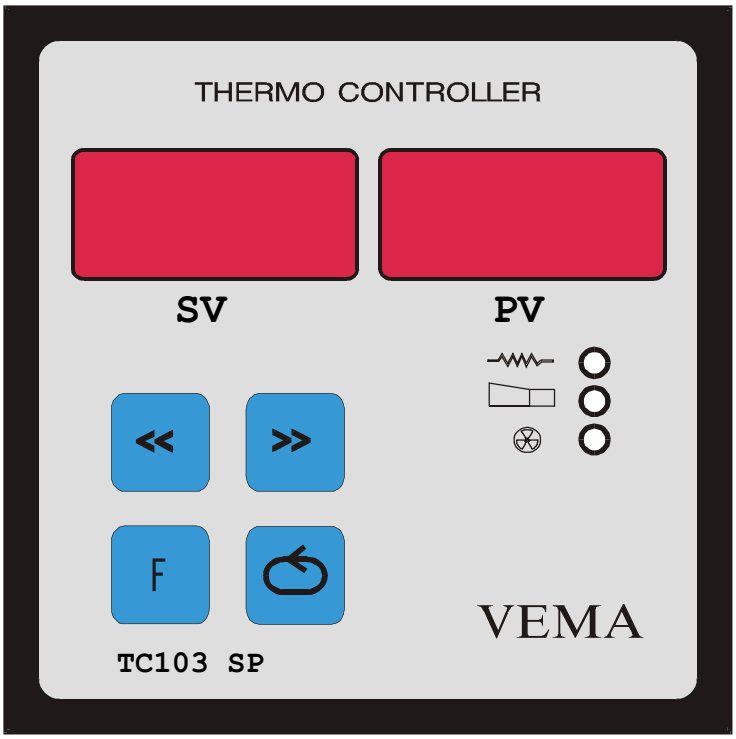
Temperature Controller TC 103 SP



Thermocontroller with **auto-tuning** of the PID-parameters to the controlled object and option for gradually reaching the set value for a preset time (**ramp function**)

USER'S MANUAL

I. INTRODUCTION

The microprocessor Temperature Controllers TC103-J/K/R/P offer optimal comfort of service and visualization of information.

The Temperature Controllers TC103-J(/K/R) are assigned to work with thermocouples of type J, K or R, the TC103-P Temperature Controllers - with thermistors of type Pt100.

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

The Controller can be set as a 2- or 3-position regulator. A non-cycle on-off control mode can be also achieved if the alarm relay is used to control the heater (cooler) instead of the control output.

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 16 programmable modes, non-latch standby sequence included.

The desired temperature SV (Set Value) and the current temperature PV (Process Value) are constantly displayed.

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.

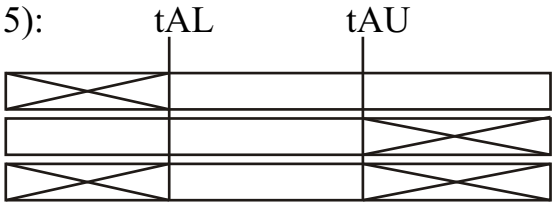
II. TECHNICAL FEATURES

2.1. Range of regulation of temperature:	-199°C to 999 °C
2.2. Accuracy:	0.2 to 1 %
2.3. Ranges of parameters:	
- gain factor P:	0 to100 %
- differential constant time Td:	0 to 250 sec.
- integral constant time Ti:	0 to 999 sec.
- length of cycle Tc:	0 to 200 sec.
- alarm limits TAl and TAH:	-199°C to 999 °C
2.4. Indication:	seven-segment, height 14.2 mm
2.5. Control output:	
- relay type:	max. 250 V/2A, cosΦ=1
- open collector type:	0/18V up to 30 mA
- direct current:	up to 20 mA

2.6. Supply voltage: 187 to 242 V at 48/62 Hz
2.7. Size: 96x96x85 mm
2.8. Ambient temperature: 0 to 50 °C

III. MNEMONICS OF THE PARAMETERS

3.1. tSU - set temperature (SV)
3.2. tAL - lower alarm limit of temperature
3.3. tAU - upper alarm limit of temperature
3.4. ALn - number (type) of an alarm mode (0 to 15):



0 - no alarm output;
1 - the alarm zone is under tAL:
2 - the alarm zone is above tAU:
3 - the alarm zone is under tAL and above tAU:
4 to 7 - same as types 0 to 3, however the alarm output is inverted;
8 to 15 - same as types 0 to 7 but with a non-latch standby sequence. The standby sequence is initiated upon startup of the Controller or end of Program Mode, and finished at the first occurrence of a non-alarm zone. During the standby sequence the SV display is blinking and the alarm output works as if in a non-alarm zone, i.e. the alarm output is off for types 8-11 and on for types 12-15.
3.5. P H - the gain factor for the heating PID;
3.6. P C - the gain factor for the cooling PID;
3.7. tdH - the differential constant for the heating PID;
3.8. tdC - the differential constant for the cooling PID;
3.9. tcH - the length of cycle of heating;
3.10. tcC - the length of cycle of cooling;
3.11. tiH - the integral constant for the heating PID;
3.12. tiC - the integral constant for the cooling PID;
3.13. POS - type of the regulator
2 - for a 2-positional regulator (only heating and off);
3 - for a 3-positional regulator (heating, cooling and off);
3.14. r P (ramp function) - time (in minutes) for the set temperature to gradually move from the current temperature (at startup or parameter change) to the tSU.

IV. PROGRAM, MONITOR AND AUTO-TUNING MODES

Program Mode is switched on by pressing the "F" button. The display reads "tSU xxx", where xxx is the Set Value of the temperature. Now the first parameter (Set Value) can be changed using the arrow buttons "<<" and ">>". To save the new value and go back to Monitor Mode, press "□". To get to any parameter in Program Mode, keep pressing (or hold pressed) the "F" button until the mnemonics of the parameter shows up on the "SV" display.

Simultaneously pressing of both arrow buttons while in Monitor Mode will invoke the Auto-tuning Mode (s. CHARACTERISTICS) of the Controller. The display reads "OPt xxx", where xxx is the current temperature and the "OPt" is blinking. In any other mode, pressing both arrows will put the Controller back into Monitor Mode.

In Monitor Mode, the display reads the desired temperature (Set Value) and the current temperature (Process Value). Blinking of "SV" indicator means that the standby sequence (s. CHARACTERISTICS) is on, i.e. the Controller has not reached a non-alarm zone yet. In Monitor Mode are displayed all possible errors:

- "EPr Err", if the EEPROM chip is damaged, or is just replaced;
- "Adc Err", if the AD/C chip is damaged;
- "xxx oFF", if the thermocouple is loose.

V. SPECIFIC CHARACTERISTICS

5.1. 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 electric noises, incorrect placement of the temperature sensors or damages.

5.2. 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 mode is greater than 7 (Aln>7). During the alarm standby sequence, the "SV" display is blinking and the alarm output is working as if in a non-alarm zone, i.e. "off" for alarm modes 8 to 11 and "on" for alarm modes 12 to 15. 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.

5.3. 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 tSU and the POS parameters. The auto-tuning can be started in Monitor Mode by pressing both arrow buttons "<<" and ">>". The "SV" display reads a blinking "OPt", indicating that the (self-)optimization routine is still going on. Pressing the both arrow buttons once more will cancel the auto-tuning. 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.

VI. 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-103 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, alarm modes ALn 9 or 11 must be selected, so the alarm standby sequence can be used. If it is not acceptable for the temperature to rise above a certain limit, then TAU and alarm modes 10 or 11 are used. Alarm modes 12 and higher are used when the alarm output must work inversely.

The time r P for gradually reaching of the set temperature tSU should be a lot 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 Monitor Mode will interrupt the ramp function.

VII. MECHANICAL CONNECTION AND MOUNTING

The Controller is assigned for mounting on facet panels of electrical units. The slot for mounting should have a square shape of 92x92 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 of minimal diameter of 0.5 mm. Direct control of powerful heating/cooling elements should be avoided. Use thyristor elements as shown on the figure below is recommended, since they are not exposed to frequent commutations and fast wear-out.