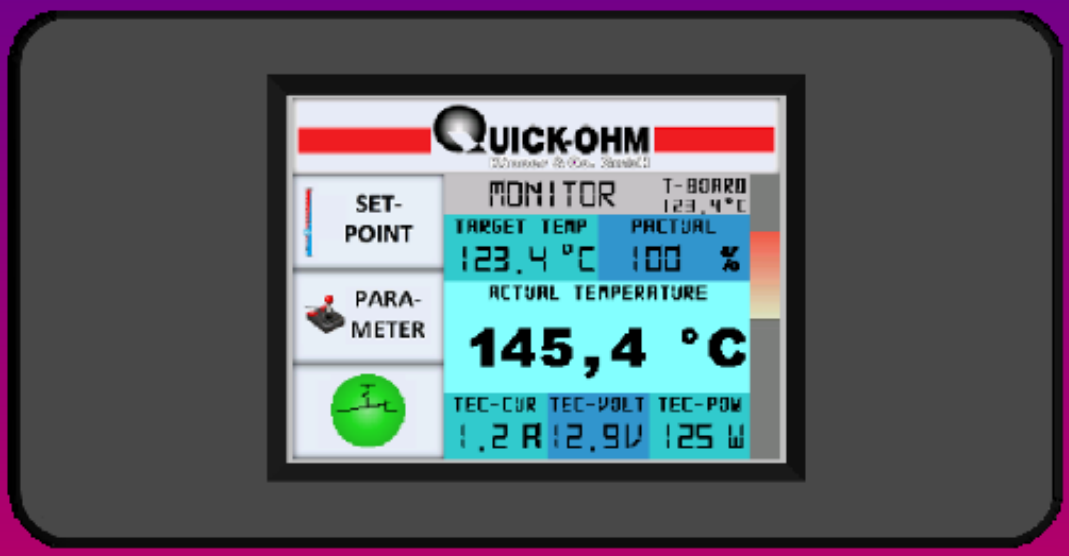
operation manual

QC-PC-PID-01

Peltier-Controller



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www.quick-ohm.de

www.quick-cool.de

Technical specifications

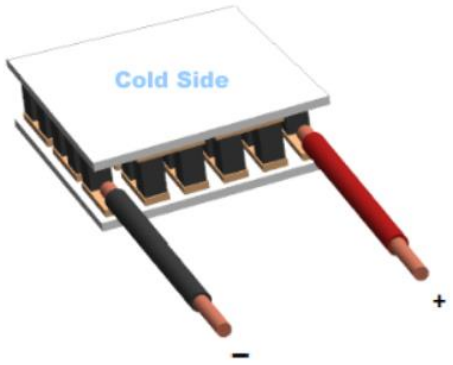
Control range:	-50°C to +150°C
Temperature measurement range:	-60°C to +170°C
sensitivity:	0,06 Kelvin
Regulatory control:	± 1 Kelvin
Supply voltage:	12VDC – 24VDC
maximum output current:	8A
maximum output voltage:	approx. 0,9-mal supply voltage (10V – 22V)
measure cycle:	approx. 3 measurements / second
sensor type:	PT1000
Additional output signal:	0 – 10VDC / max. 80mA
„Open-Collector“ output:	I_{max} 100mA / Emitter on ground

Intended use and description of the controller

The QC-PC-PID-01 is used for temperature control of objects using Peltier technology.
The controller detects the temperature of the object to be tempered via a PT1000 sensor and controls the Peltier element with a continuously regulated DC voltage.
The control can optionally be set to a P, PI, PD or PID behavior.
The controller is operated and set using the integrated touchscreen. The user interface is embedded in a menu structure. The controller may only be used up to a maximum current of 8A.

Correctly polarity of the Peltier element

In order for the controller to work, it is imperative to connect the Peltier element correctly. If the Peltier element is poled incorrectly, uncontrolled high or low temperatures will occur during operation.

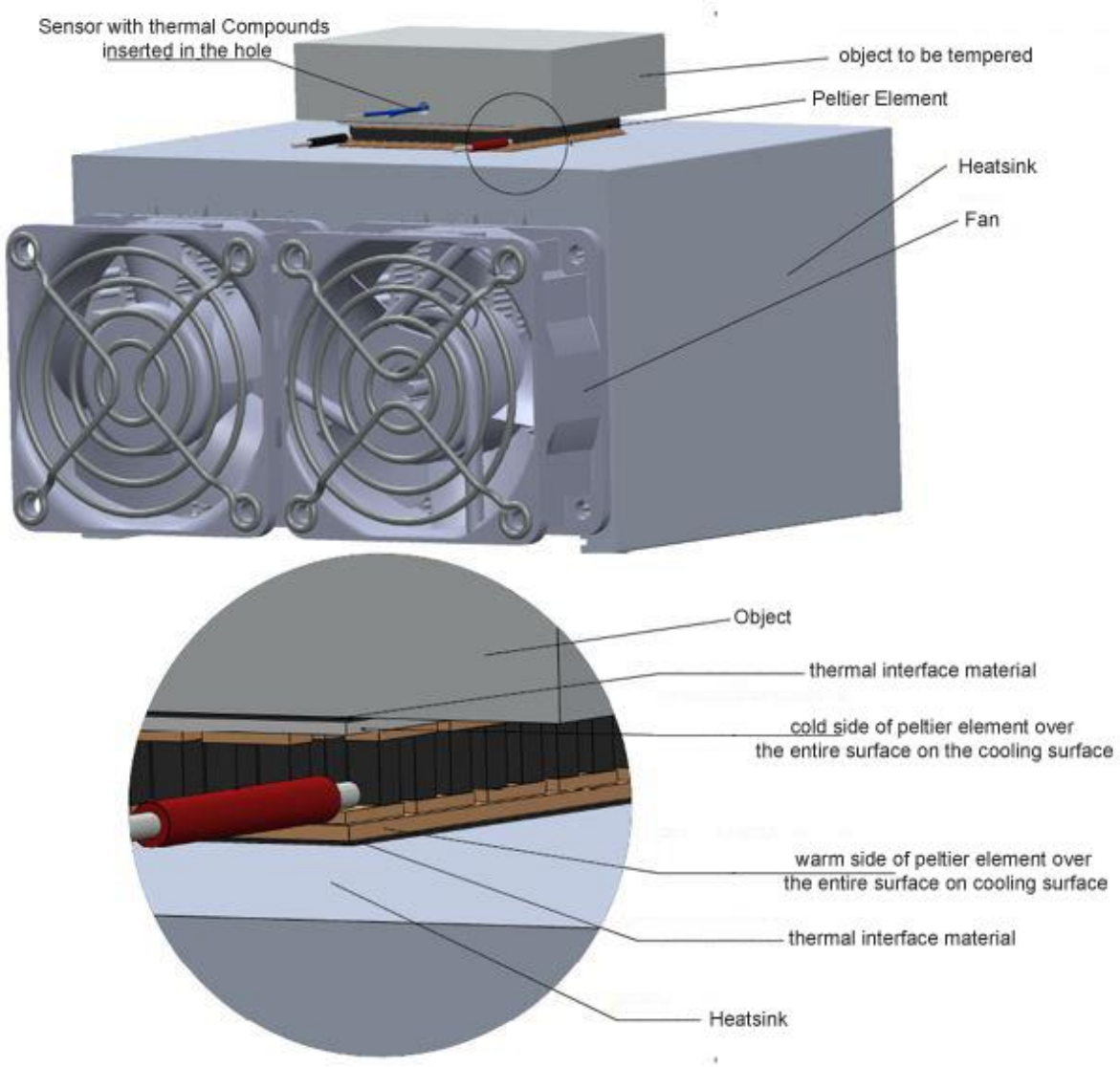


Quick Ohm Peltier elements have their electrical connections on the "warm side" of the Peltier element. If you direct the connecting wires towards the viewer with the red wire to the right, the "cold side" is at the top. The object to be tempered must be thermally coupled to the cold side. The lower side must be thermally coupled to a heat sink. This side is called the "warm side". If a voltage is applied to the connections, the cold side becomes cold when the voltage on the red line is electrically positive compared to the voltage on the black line. With modules other than Quick Ohm Peltier elements, it is imperative to check this relationship. Depending on the description, these modules may have to be connected the other way round.

Caution: A Peltier element may only be supplied with electricity if it is in thermal contact with a sufficiently large heat sink. The heat can be given off here. A module that is not connected to such a heat sink cannot dissipate the energy supplied. Such a Peltier element is destroyed by overheating within a few seconds.

The thermal structure

The Peltier element must lie on the entire surface on both sides. The cold side is contacted with the object to be tempered. The object must accommodate the PT1000 sensor. The temperature is recorded via this sensor. The "warm side" must rest on a heat sink over the entire surface, The heat sink must be able to dissipate the thermal energy without the “warm side” heating up excessively. The complete structure has to look like in the picture below. It is irrelevant whether you are cooling with air or another medium.



The surfaces that are contacted with the Peltier element must have good planicity. For a good thermal connection, the contact surfaces should also be filled with thermal paste, thermal oil or thermal foil.

Before switching on

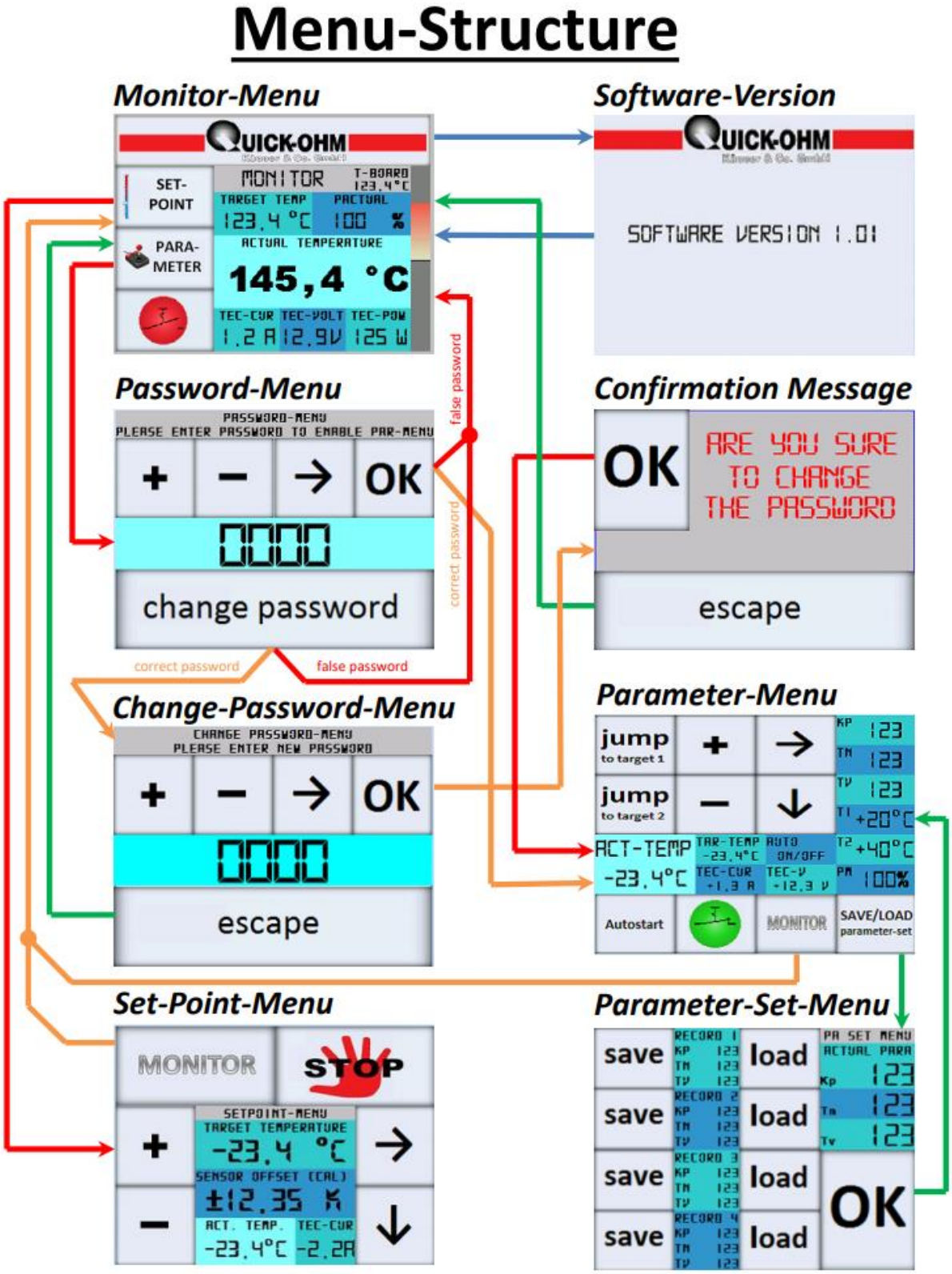
Before switching on, the contents of these operating instructions must be carefully studied and understood. The controller may only be connected to a professional installation.

Before switching on, make sure that the maximum permissible current of 8 amperes cannot be exceeded. The data sheet of the Peltier element must be consulted for this.

Please read these instructions carefully. The menu is explained below. This is followed by a description of a step-by-step commissioning.

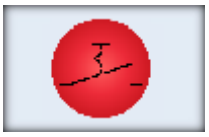
The user interface (menu)

After applying the supply voltage, the monitor menu is displayed on the touchscreen. All important values and states of the control are visualized here. From here you can access the individual submenus.

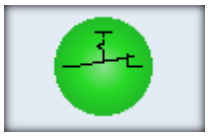


Monitor menu

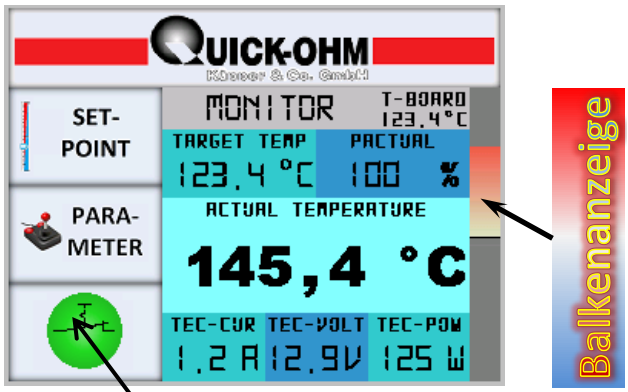
The monitor menu is used to control the control process. The monitor menu shows all important values for controlling the control process.



display function:
Power supply to the consumer interrupted
key function:
Switches the power supply to the consumer on



display function:
Power supply to the consumer closed
Key funktion:
Interrupts power supply to the consumer



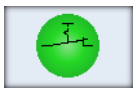
dual function:
Operating signal lamp & ON / OFF switch

Function keys:

jumps to the software version menu

jumps to the setpoint menu

Jumps into the parameter menu with password protection


interrupts the power supply or  turns on the power

Display fields:

T-BOARD shows the temperature of the electronics. The controller has a fan that continuously drives air through the housing. This cools the electronic components. With sufficient cooling, the board temperature is highlighted in green. If the color changes to yellow, the cooling is insufficient. Check the function of the fan, the load current and the free air supply and discharge. If the board temperature exceeds a critical value, the color changes to red and the control switches off. The controller can only be restarted when the board temperature has returned to the green area.

TARGET TEMPE shows the set target value for the temperature

PM shows the maximum output voltage as a percentage of the supply voltage

ACTUAL TEMPERATURE shows the temperature currently measured on the sensor

TEC-CUR shows the current flow through the connected element

TEC-VOLT shows the current voltage at the output

TEC-POW shows the electrical power that is supplied to the connected element.

(TEC-POW = TEC-VOLT X TEC-CUR)

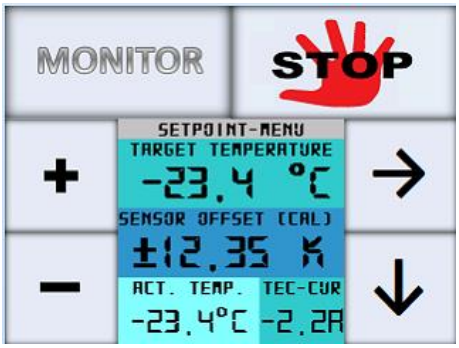
bar display = MV Monitor (Tacho)

The bar shows the current status of the control.

- up red: heating - Full deflection at maximum heating
- down blue: cooling - Full deflection with maximum cooling

SETPOINT-MENU

The target temperature value is set in the setpoint menu. If necessary, the sensor can be calibrated via the sensor offset.



Calibrate the temperature measurement:

In order to calibrate the temperature detection of the controller, the object temperature at the point of the sensor must be recorded with a sufficiently precise thermometer and with the display value ACT. TEMP. of the controller can be compared.

The offset to be set is calculated from this as follows:

SENSOR OFFSET (CAL) = Objekttemperatur – ACT. TEMP.

When the SETPOINT-MENU is reached the first digit of the setpoint temperature flashes (**TARGET TEMPERATURE).** The regulation is maintained with the original target temperature. Changed values are only accepted when you exit the setpoint menu.


increases the flashing digit


decreases the flashing digit


jumps one digit to the right or back to the first digit when the last digit is reached.


alternates between **TARGET TEMPERATURE** and **SENSOR OFFSET (CAL)**

jumps back to the monitor menu (MONITOR) [and changes the old - to the new values]

Key function: interrupts the power supply Display function: power supply eingeschaltet

Key function: switches on the power supply Display function: power supply switched off

TARGET TEMPERATURE shows the set target temperature

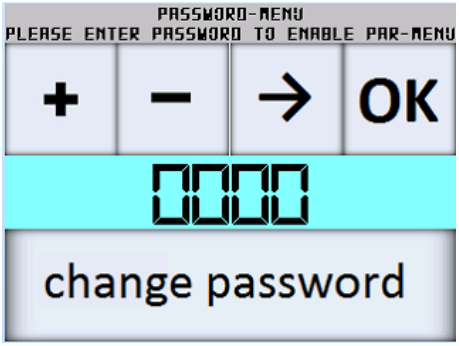
SENSOR OFFSET (CAL) shows the correction value for the temperature sensor

ACT. TEMP. shows the temperature currently measured on the sensor

TEC-CUR shows the current current through the connected element

PASSWORD-MENU

The password menu protects the parameter menu against unauthorized access.Sie gelangen in das Password menu if you select the parameter menu.



The first digit flashes when entering the password menu. + erhöht die blinkende Ziffer

− decreases the flashing digit

→ jumps to the next digit

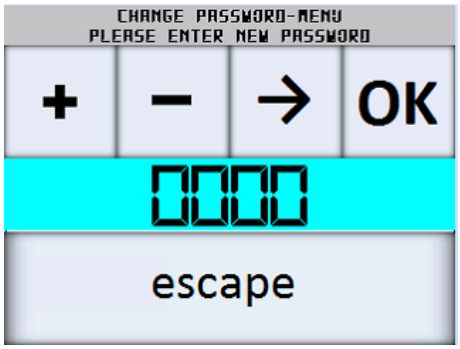
OK jumps to the parameter menu (if the correct password has previously been entered, otherwise the system jumps back to the monitor menu)

The password can be changed.

change password jumps to the change password menu (if the correct password was entered beforehand, otherwise the system jumps back to the monitor menu)

CHANGE PASSWORD-MENU

can only be reached after entering the currently valid password.



When the change password menu is reached, the first digit of the new password flashes

increases the flashing digit

decreases the flashing digit

jumps to the next digit

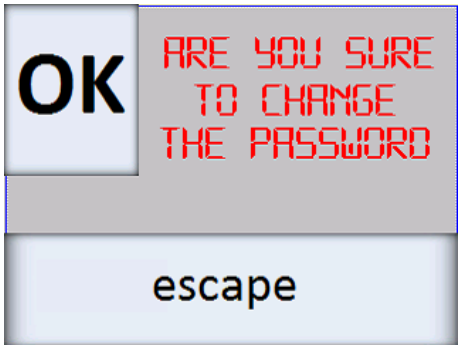
jumps to the security question (Password Save Menü)

aborts the process and returns to the monitor menu without changing the password

Before the password can be overwritten, a confirmation prompt appears in the password save menu to prevent the password from being changed accidentally.

Safety query

The security query protects against unwanted password changes.



changes the password and jumps to the parameter menu

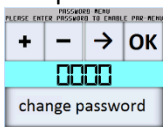
<u>The new password is now valid. The old password is no longer authorized.</u>

aborts the process and returns to the monitor menu.

<u>The old password remains.</u>

Parameters menu

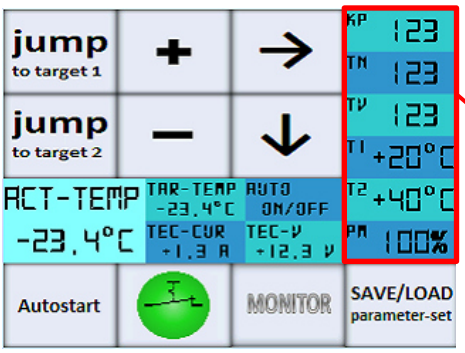
The parameter menu is password protected..



To access the parameter menu, the password must be entered correctly and confirmed with OK. If the entry is incorrect, the system jumps back to the monitor menu. In the delivery state, the password is 0000.

The dynamic properties of the control are set in the parameter menu and the output voltage for the connected Peltier element is adjusted.

*** Parameter changes only become effective after pressing the touch-sensitive area (* see figure below).**



* Touch sensitive area. Touch here to make the parameter change take effect.

Two freely selectable temperatures can be set in the parameter menu. The jump to target 1 and jump to target 2 buttons change the target temperature to these values. Current, voltage, setpoint and actual value are continuously displayed so that the control can continue to be monitored. The parameterization can be evaluated based on the development of the current temperature and readjusted if necessary. These two jump buttons are a useful aid when parameterizing the control loop. When you exit the parameter menu, the original setpoint of the temperature is accepted again.
In the parameter menu, the controller can be adapted to the connected temperature control system. The controller has a PID characteristic. When the parameter menu is entered, the currently set control status is retained. **TAR-TEMP** shows the set target temperature.
When you reach the parameter menu, the first digit of the proportional gain ***KP*** flashes..

first digit K_P flashes

+ increases the flashing digit

− decreases the flashing digit

→ jumps to the next digit

↓ changes to the next line (from Kp to Target2 and back to Kp)

K_P Proportional part of the PID control

T_N Integral part of the PID control 0 switches off the integral part

T_V Differential component of the PID control 0 switches off the differential part

The controller can thus be set to pure P, PI, PD or PID control behavior.

PM shows the set voltage limit as a percentage of the input voltage

T 1 freely selectable temperature value 1

T 2 freely selectable temperature value 2

suddenly changes the setpoint (TAR-TEMP) to the temperature value 1 T 1

suddenly changes the setpoint (TAR-TEMP) to the temperature value 2 T 2

ACT-TEMP *(actual temperature)* shows the actual temperature measured at the sensor

TAR-TEMP *(target temperature)* shows the set target temperature

TEC-CUR shows the current flow through the connected element

TEC-V shows the current voltage at the output

AUTO ON/OFF shows the status of the autostart function

switches the autostart function on or off.

In the autostart on mode, the control starts immediately after the supply voltage is switched on, if it was previously switched off when the output was switched on. In autostart-off mode, the control always starts with the power supply switched off.


Key function: interrupts the power supply Display function: power supply switched on


Key function: switches on the power supply Display function: power supply switched off

jumps back to the monitor menu (MONITOR)

Press key to jump to the parameter memory menu (parameter set menu). The values KP, TN and TV can be stored here.

Parameter memory menu

The parameter memory (storage) menu offers the possibility to save intermediate parameter values during parameter determination and to recall them if necessary. Save stable parameter sets here before you make further optimizations.
The currently effective PID parameter set is displayed under CURRENT PARA. This parameter set can be saved in one of the four parameter storage locations via **save**. It is also possible to load one of the stored parameter sets into the current memory using **load**. With **OK** you get back to the parameter menu. Attention, only the control parameters KP, TN and TV are stored here. The PM value is not saved.

ACTUAL PARA shows the currently effective parameter set of the PID control

record 1 shows the PID parameter set in memory location 1

record 2 shows the PID parameter set in memory location 2

record 3 shows the PID parameter set in memory location 3

record 4 shows the PID parameter set in memory location 4

save overwrites the currently effective parameter set **ACTUAL PARA** with the selected parameter set **RECORD 1/2/3/4**

load overwrites the respective **RECORD 1/2/3/4** Data record with the currently effective parameter set **ACTUAL PARA**

OK jumps back to the parameter menu the old parameter set may now be overwritten

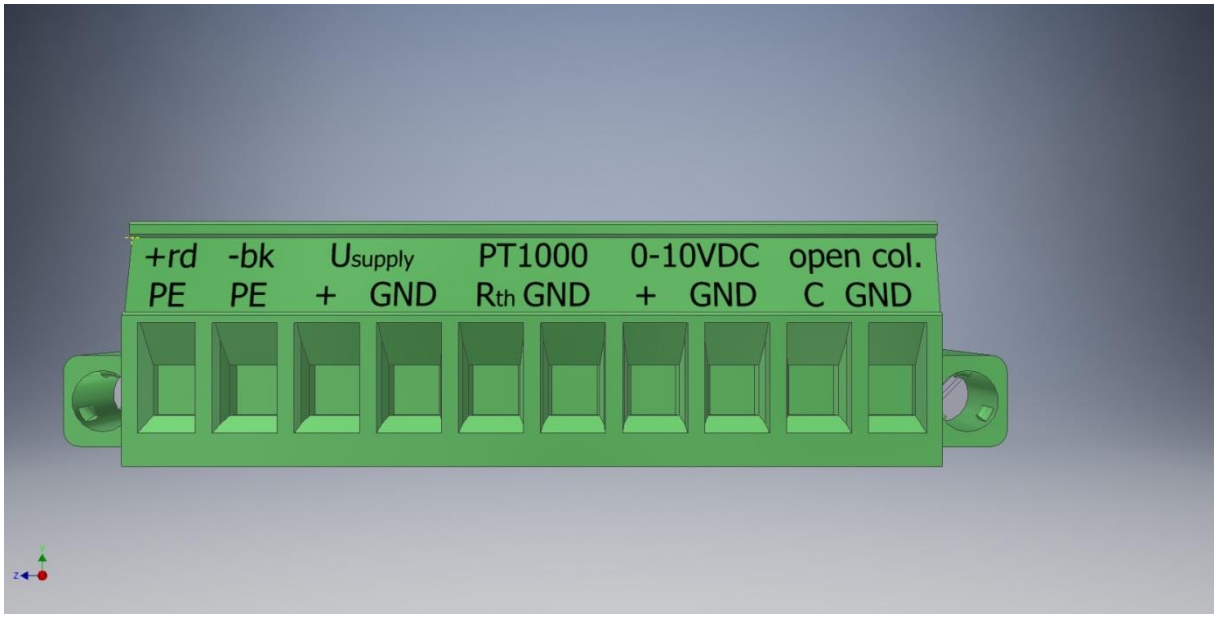
Software Version

The software version can be read in the software version window

Touching the center of the display switches back to the monitor menu.

Regulator connection

The electrical components of the control circuit are connected to the controller via a 10-pin plug with screw contacts.



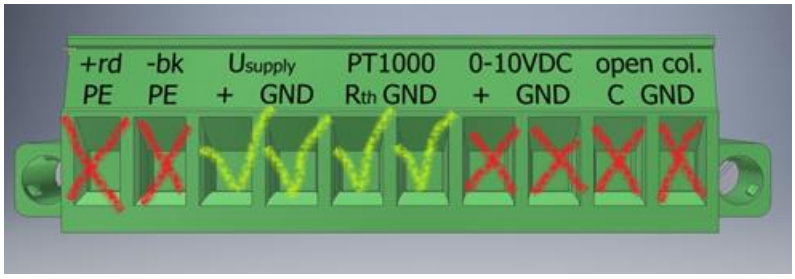
Contact number:	description	function	
1	+rd PE	Peltier element connection red wire	**Attention:** Specifications apply to Quick-Ohm modules from other manufacturers if necessary. (See also **Correct polarity of the Peltier element)**
2	-bk PE	Peltier element connection black wire	
3	U_{supply} +	Connection positive supply voltage 12 VDC - 24 VDC	
4	U_{supply} -	Connection GND zero potential supply voltage	
5	PT1000 R_{th}	connection PT1000 sensor	
6	PT1000 GND	connection PT1000 sensor	
7	0-10VDC +	output Control signal → 0-10VDC	**Experts only** Control signal outputI_{max} = 80mA U_{max} = PM x 10V
8	0-10VDC GND	output control signal → 0V / GND	
9	Open col. C	Open collector output collector connection	**Experts only** Open collector output Emitter on ground Imax = 100mA
10	Open col. GND	Open collector output Zero potential / GND	

Before start-up

The user is expected to control and master his thermal structure. This instruction cannot provide any relevant training. The user must ensure that they have completely read and understood these operating instructions beforehand. Furthermore, there must be a thermal structure that is reasonably dimensioned. The assembly must completely contact the "cold side" of the Peltier element with the object to be tempered. The object to be tempered must be thermally correctly connected to a PT1000 sensor. On the other hand, the "warm side" must be fully connected to a sufficiently effective heat sink (heat sink, heat exchanger). A Peltier element is considered to be sufficiently connected in this context, the “warm side” of which heats up or cools down by a maximum of 10 Kelvin compared to its cooling medium. An insufficiently cooled Peltier element will overheat in operation within a few seconds and be destroyed. A poorly cooled Peltier element will not achieve the set goal.

First commissioning step by step

To prevent incorrect parameter settings from causing defects in the Peltier element or controller, no load must be connected before the first start-up.



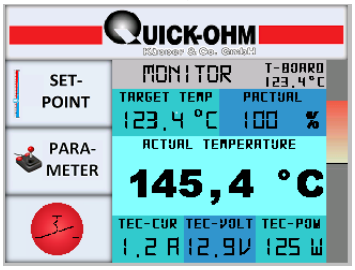
Connect the supply voltage and the sensor to terminals 3 to 6 as described under Controller connection. Please leave the remaining connections free.

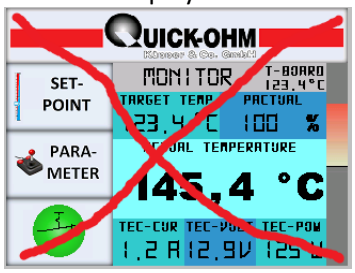
Check your structure and switch on the supply voltage.

Check the **ACTUAL TEMPERATURE** temperature value. If an unrealistic temperature is displayed, switch off the supply voltage and please check its structure and the sensor. The controller may only be operated with a PT1000 sensor.

Switch off current flow

After the device is switched on, the monitor menu appears on the display.





Make sure that the operation indicator appears red  as shown in the picture. The output is not switched through. If the display lights up green  so tap this field to switch off the output.

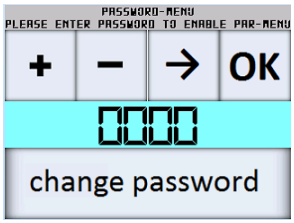
 correct

 not correct

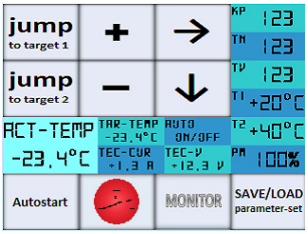
Set parameters

Switch from the MONITOR to the parameter menu

To do this, tap 

- You get into the password menu: 

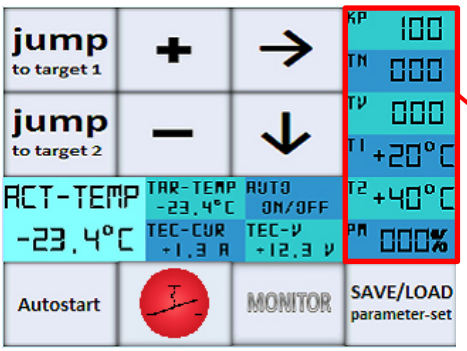
You will be asked to enter the password. In the delivery state, the password is **0000.** Press **OK**.

You will now end up in the parameter menu. 

If you enter the password incorrectly, the screen returns to the MONITOR menu.

Without further knowledge, Kp should be set to 100, Tn and Tv to 0. *The control is thus in the pure P control mode.*

To transfer the values to the controller, the entry must be confirmed. To do this, touch the parameter display area on the right edge of the screen after setting the parameters. (See picture below) Without this confirmation, the controller works with its old values.



* Touch sensitive area. Press here to make the parameter change take effect.

The setting of T1 and T2 will be explained later.

Determine and set PM

Correctly setting PM adjusts the controller output to the load. Without a correct adjustment, both the connected consumer and the controller can be destroyed. The value PM determines which maximum part of the supply voltage is output to the load. In the delivery state, the value is set to 000 in order to avoid an impermissibly high current when switching on. As long as the value is zero, the output cannot be switched on. The value for PM is determined as follows:

$$PM = \frac{Umax}{Usupply} \times 100\%.$$

Take the value U_{max} from the data sheet of the Peltier element used. U_{supply} is the value of the connected supply voltage. This value must be in a range between 12Volt and 24V. Only a smoothed DC voltage may be connected.

Example:

> If the supply voltage is 24 volts and the Peltier element is to be operated with a maximum of 12 volts, set the value PM to 50%.

$$\frac{12V}{24V} \times 100\% = 50\%$$

Values over 100% cannot be setValues smaller than the one determined are permissible and may be useful.

When you have set TM to the determined value, tap the value range again to write it to the memory.

Check whether autostart is switched "off" or "on".

If necessary, tap 

to switch off the autostart function (off). This prevents the Peltier element from being energized immediately when the device is switched on.

The controller is now ready for use and can be used.

Start temperature control

Switch off the supply voltage.

Connect the red wire of the Peltier element to terminals 1 and the black wire to terminal 2.

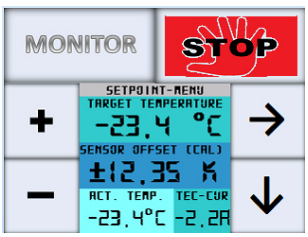
Check your structure.

Switch on the supply voltage.

You are now in the monitor menu and the operating light shows  .

Tap on 

to set a target temperature. You end up in the setpoint menu



Set a target temperature that differs from the current temperature. Tap to switch back to the monitor. The newly set target temperature is then adopted.

Tap on  to start tempering. The operating display changes to green  .

Check the power indicator. If a value above 8A or above the value I_{max} (data sheet Peltier element) is displayed, tap the operating display again and switch off the output. Check your structure and the parameters. Correct the mistake. And then turn it on again.

Important!!!

Observe the ***ACTUALTEMP*** value**.** This value must move towards the set target value ***TARGET TEMP***.

If the current temperature moves away from the target value, then the Peltier element is poled incorrectly. **In this case, switch off the supply voltage immediately.**

In this case, check their structure and correct the error.

Then switch on the supply voltage again.

If the actual value moves towards the target value, you can continue. Otherwise there is still an error and the operation must be stopped.

The controller now controls the set target temperature.

When the target temperature is reached, the controller regulates. In order to keep the temperature stable, the control parameters must now be adapted to the connected structure.

Adjust control parameters to the connected structure

If you have carried out the steps according to the instructions, the controller is now in P-control mode. In this mode, the output controls the Peltier element fully until the measured temperature on the object is close to the target temperature. Then the output is turned down. If the measured temperature is equal to the set target temperature, the output is regulated to zero. The setpoint is therefore never reached in the P control mode. The larger the value KP is selected, the stronger the controller reacts to a deviation and the closer the temperature of the object comes close to the target temperature. If the KP is too large, the controller will vibrate. In this case the value should be reduced. There remains a rule deviation.

In order to be able to correct this control deviation, the controller must be given an I component. The controller recognizes the control deviation via this value T_N erkennt der Regler die Regelabweichung und kann nun die Abweichung ausregeln. Mit einem Wert $T_N > 000$ befindet sich der Regler nun im PI-Regel-Modus.

Es kommt vor, dass die Regelung nicht stabil einregelt und die Temperatur um den Sollwert schwingt. Eine solche Schwingung kann über den Differenzialparameter T_V and can now correct the deviation. As this value increases, the control algorithm reacts more strongly to changes in temperature and prevents the temperature from being regulated too strongly.

Optimizing the parameters using this method requires a lot of experience. Without this experience, we recommend the method for determining the parameters according to Ziegler & Nichols. This procedure is described below for this controller.

General remarks on the control parameters KP, TN and TV

The cooling capacity and the heating capacity of the Peltier element in relation to the thermal load determine the dynamics of the temperature control. These two performance values are strongly dependent on the temperatures on the cold and warm sides of the Peltier element. In addition, these two performance values are very different from each other. This means that the parameterization of the Peltier control differs from conventional controls. A parameter set for the regulation to a temperature X1 differs from such a parameter set for reaching the temperature X2. If the controller is to control a certain temperature range, the best compromise must be found for this range.

The parameter determination according to the Ziegler & Nichols vibration method has proven to be useful.

Parameterization according to Ziegler & Nichols

With this Ziegler Nichols method, the controller is operated for the first time as a pure P controller. Starting with a small gain factor KP, this is slowly increased until the gain factor is found for which the control is just becoming unstable. This means that the regulation is just starting to vibrate.

Method:

- Start up the controller as described
- Switch off the output 
- Leave the controller switched off until the temperature is stable. The controller has now reached the temperature T_{Medium} dictated by the cooling medium.
- Switch to the parameter menu
- Set KP to 100 (or less. This value should not cause any vibration yet)
- Set TN to 000
- Set TV to 000 (The controller now has pure P characteristics)
- Set T1 to a value just above (about 10 Kelvin) above T_{Medium}
- Set T2 to a value just below (about 10 Kelvin) below TMedium T_{Medium}
- Confirm the change
- Confirm “jump to target1”
- Observe the temperature development.
- Press “jump to target2”
- Observe the temperature development.
- Increase the KP value
- Press “jump to target1”
- Observe the temperature development.
- In this way, increase the KP value until the controller begins to oscillate around the target value. This value is the „critical gain factor“ KP_{Krit}
- Determine the period of the vibration. That is, the time in seconds that elapses during a full vibration.
- According to ***Ziegler & Nichols,*** the controller now has the following parameters:
- $KP = 0{,}6\ KP_{Krit}$ $TN = 5\ T_{Krit}$ $TV = 1{,}25\ T_{Krit}$

If you enter these values in the controller, the control should work well.

Summary of commissioning

Establish temperature control:

- Select heat sink
- Press the entire Peltier element hot side onto the heat sink
- Press the Peltier element cold side over the entire surface of the object to be tempered
- Attach the PT1000 sensor to the object to be cooled

Connect controller:

- Connect PT1000 to terminals 5 and 6
- Connect supply voltage to terminals 3 and 4
- Terminals 1 and 2 as well as 7, 8, 9 and 10 remain open

Switch on the supply voltage

Check temperature value

Check the operating indicator light, switch off if necessary

Switch to the parameter menu

Determine and set PM

Determine and set parameters Kp, TN and TV

Save parameters in controller

Switch to the monitor menu

Switch to the setpoint menu

Set the desired target temperature

Switch to the monitor menu

Switch off the supply voltage

Connect the Peltier element to terminals 1 and 2

Switch on the supply voltage

Switch operating indicator light to On

Monitor current temperature (temperature value must move towards target temperature)

Adjust parameters if necessary

Reset controller to factory setting

In the Software Version menu there are hidden touch areas in all four corners. These fields are in the order:

„Top left“ „top right“ „bottom left“ „bottom right

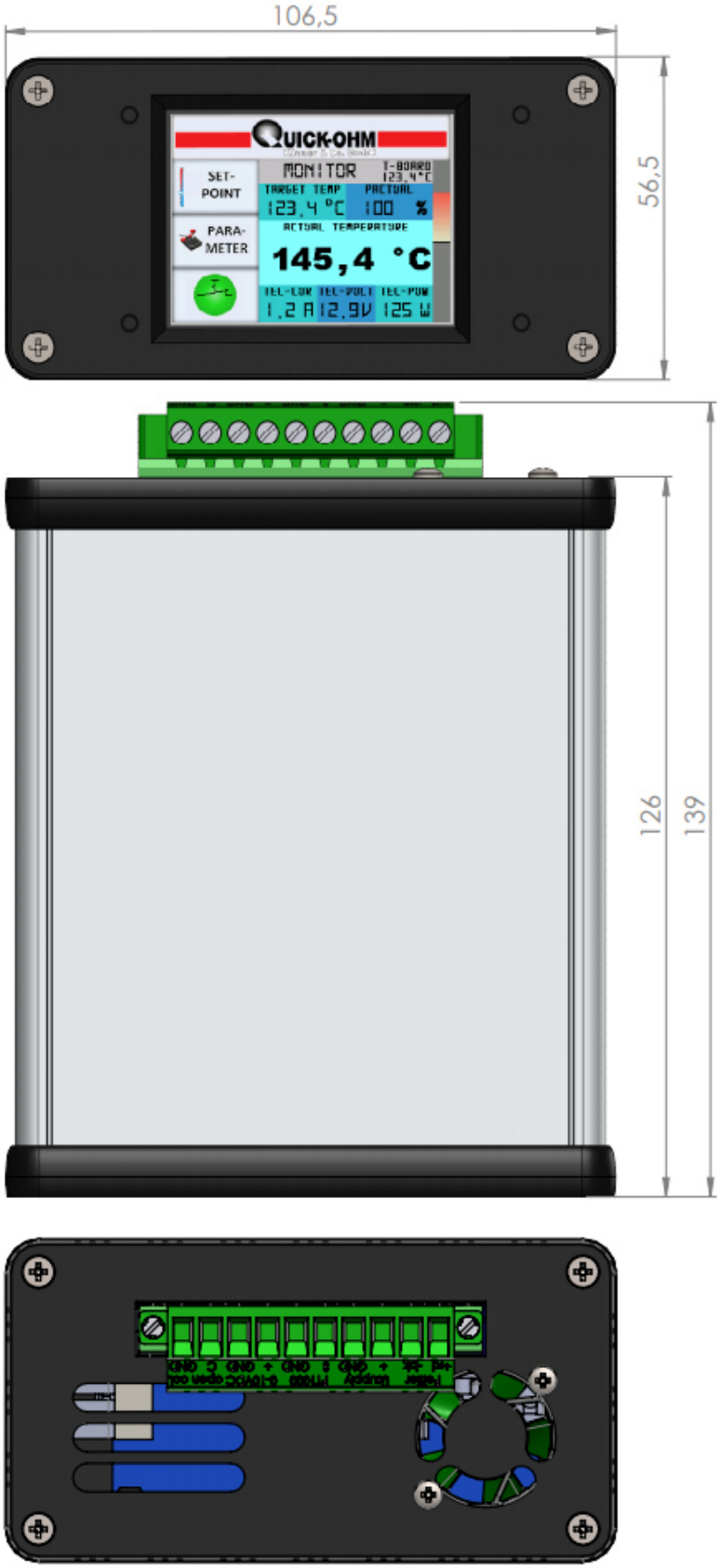
touched, the controller is reset to the factory setting. An existing password is hereby deactivated and reset to 0000.

The individual keystroke is not communicated to the user via feedback.

If the buttons are pressed successfully in the order mentioned, the controller is reset with all parameters in the delivery state. All saved values will be lost.

Drawing:

Peltier Controller



PT1000-Sensor