

Manual

QC-PC-PID-01

Peltier-Controller

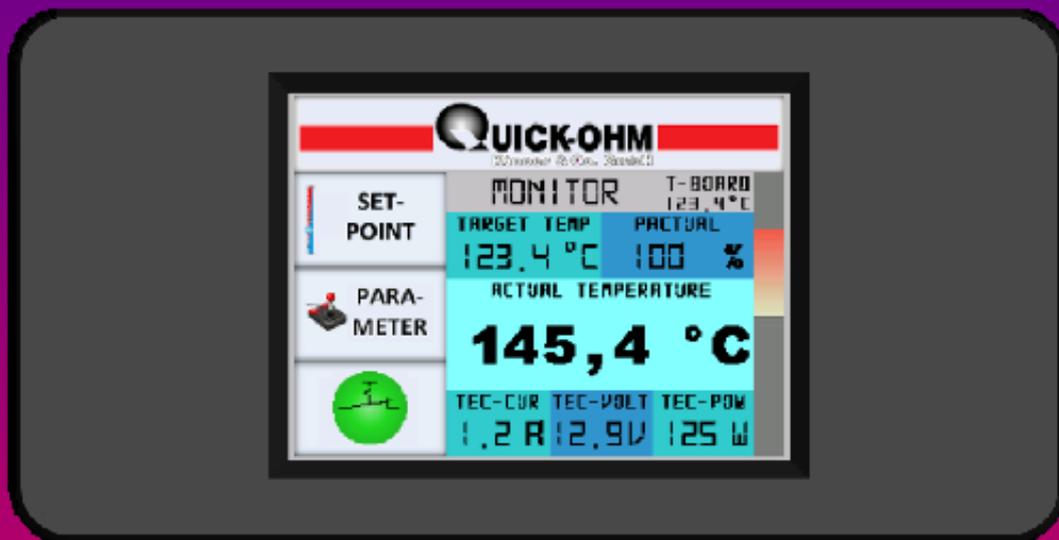


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Technical specifications

Control range:	-50°C to +150°C
Temperature measurement range:	-60°C to +170°C
Sensitivity:	0,06 Kelvin
Accuracy:	± 1 Kelvin
Voltage supply:	$V_{\text{supply}} = 12\text{VDC} - 24\text{VDC}$
Maximum output current:	8A
Maximum output voltage:	approx. 95% V_{supply}
Measurement cycle:	approx. 3 measurements / second
Sensor type:	PT1000
Additional output signal:	0 – 10VDC / max. 80mA
„Open-Collector“ output:	$I_{\text{max}} 100\text{mA}$ / Emitter on ground

Intended use and description of the controller

The QC-PC-PID-01 is used for controlling temperature.

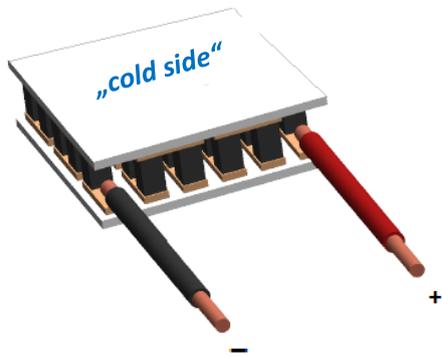
The controller detects the temperature via a PT1000 sensor (deliverables) and controls a peltier element with a continuously regulated DC voltage.

The control can optionally be set to a P, PI, PD or PID modes.

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.

Correct polarity of the Peltier element

In order for the controller to work, it is important to connect the Peltier element correctly. If the Polarity of Peltier element is incorrect, uncontrollable high or low temperatures will occur during operation.



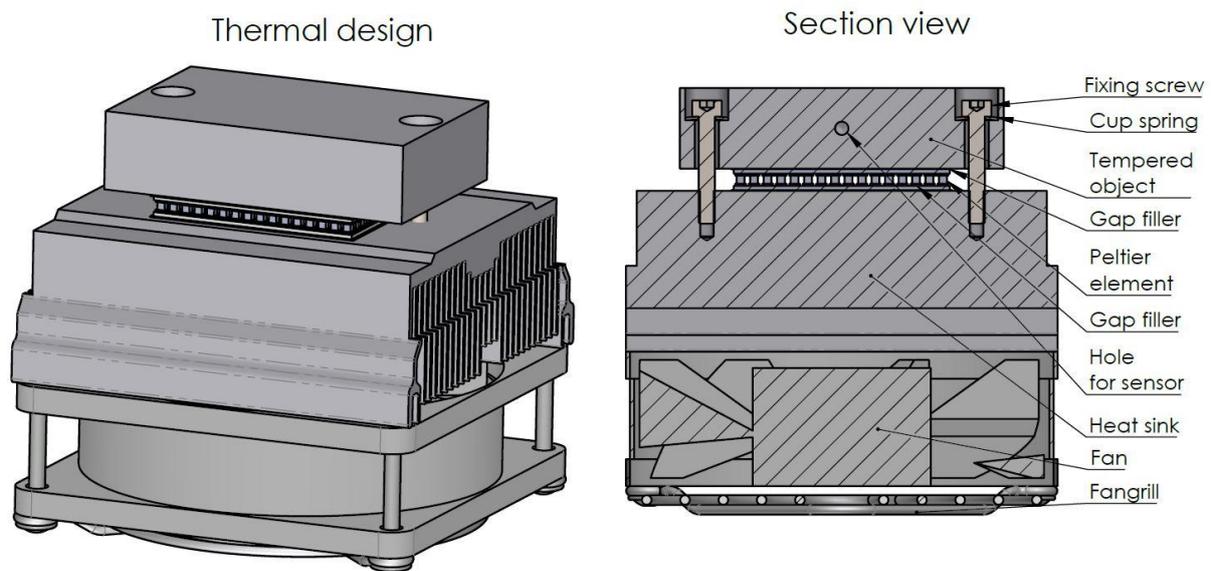
Quick Ohm Peltier elements have their electrical connections on the passive side (also called "hot side") of the Peltier element. If the connecting wires face towards the user with the red wire to the right, the active side (also called "cold side") is at the top. Quick-Ohm peltier elements have their imprint on the "cold side". The object to be tempered must be thermally coupled to the cold side. The other side must be thermally coupled to a

heat sink. 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. For modules other than Quick Ohm peltier elements, it is recommended to check the polarity. Depending on their description, these modules might 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, where heat can be dissipated. Areas that remain free and thus have no possibility to dissipate thermal power can overheat in a few seconds.

The thermal design

The Peltier element must be contacted 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. For this purpose, a hole of $\varnothing 3.1\text{mm}$ must be drilled in the body to be tempered. Ideally, this hole should be at least 30mm deep. The temperature is recorded via this sensor. The "hot side" must contact a heat sink over the entire surface. The heat sink must be able to dissipate the thermal energy without the "hot 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 flatness $\leq 0,02\text{mm}$. For a good thermal connection, the contact surfaces should also be filled with thermal conductive paste, thermal oil or thermal conductive foil.

You can find information about the use of Peltier elements in our [library](#) on our homepage.

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 installed system.

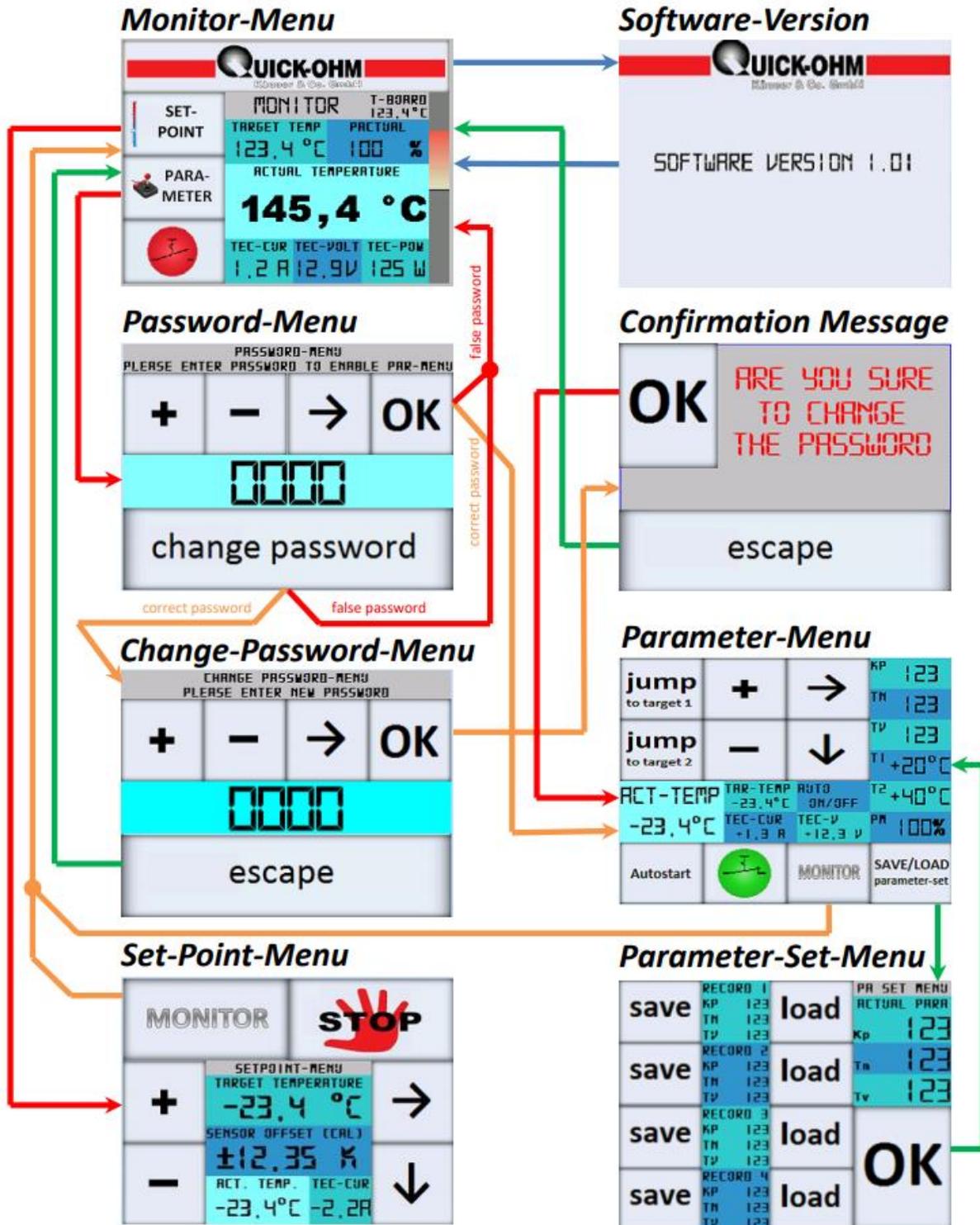
Before switching on, make sure that the maximum permissible current of 8 amperes cannot be exceeded. The data sheet of the Peltier element must be consulted for this.

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

The user interface (Menu)

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

Menu-Structure



MONITOR-menu

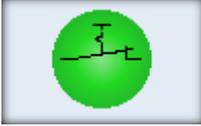
The **MONITOR**-menu controls the process.

The **MONITOR**-menu shows all important values for controlling the control process.



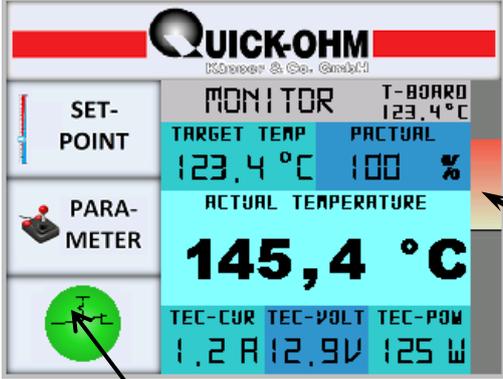
Display Function:
Indicates power supply to the consumer is OFF

Key Function:
Tap to Turn ON the power supply to the consumer



Display Function:
Indicates power supply to the consumer is ON

Key Function:
Tap to Turn OFF the power supply to the consumer



Dual function:
Operation indicator light & Switch ON/OFF



Bar Display

Function Keys:



jumps to the software version menu



jumps to the **SETPOINT-MENU**



jumps into the **PARAMETER-MENU** with password protection



switches off peltier supply resp.



switches on the peltier supply

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 colour changes to yellow, the cooling is insufficient. Check if the fan is running. Check also the load current and the free air supply. If the board temperature exceeds a critical value, the colour 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 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)

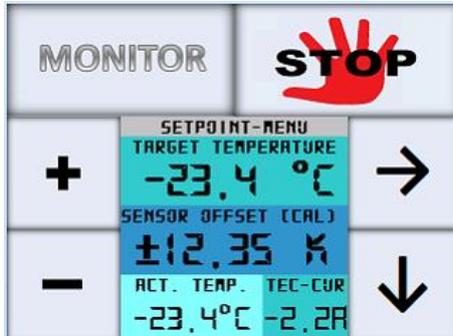
Bar display = Control value display (tacho)

The bar indicates the current status of the control system.

- up / red: Heating
- Full deflection at maximum heating
- down / blue: Cooling
- Full deflection at 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.



Calibrating the temperature measurement:

In order to calibrate the temperature measurement of the controller, the *object temperature* at the location of the sensor must be measured with a sufficiently precise thermometer and compare it with the ACT. TEMP. value on the display of the controller.

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

$$\text{SENSOR OFFSET (CAL)} = \textit{object temperature} - \text{ACT. TEMP.}$$

The first digit of the **TARGET TEMPERATURE** flashes when the **SETPOINT-MENU** is entered. The regulation is maintained with the previously selected 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 [and changes the old - to the new values]



Key function: Switches OFF peltier element

Display function: Output is ON



Key function: Switches ON peltier element

Display function: Output is OFF

TARGET TEMPERATURE shows target temperature

SENSOR OFFSET (CAL) shows sensor offset

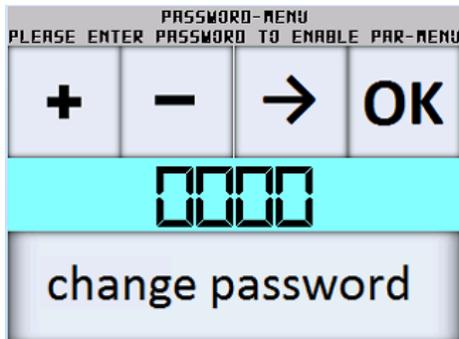
ACT. TEMP. Shows the actual temperature measured with the sensor

TEC-CUR shows the actual current through the peltier element

PASSWORD-MENU

The **PASSWORD-MENU** protects the **PARAMETER-MENU** against unauthorized access.

You reach the **PASSWORD-MENU**, when you call up the **PARAMETER-MENU**.



The first digit flashes after entering the **PASSWORD-MENU**.



increases the flashing digit



decreases the flashing digit

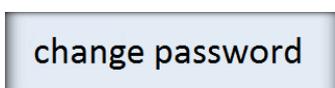


jumps to the next digit



jumps into the **PARAMETER-MENU** (only if the correct password was entered beforehand, otherwise the system jumps back to the monitor menu)

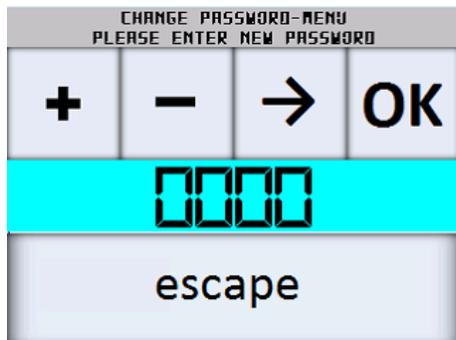
The password can be changed.



jumps into the **CHANGE PASSWORD-MENU** (only 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.



The first digit of the new password flashes, when the **CHANGE PASSWORD-MENU** is reached.



increases the flashing digit



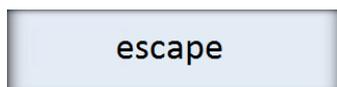
decreases the flashing digit



jumps to the next digit



jumps to the **Safety query**

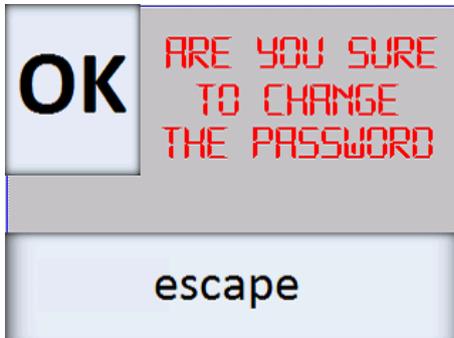


aborts the process and returns to the **MONITOR**-menu without changing the password

Before the password can be overwritten, a safety query appears to prevent the password from being changed accidentally.

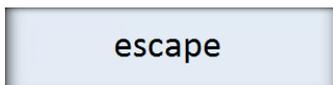
Safety query

The security query protects against unwanted password changes.



changes the password and jumps to the **PARAMETER-MENU**

The new password is set. The old password is no longer valid.

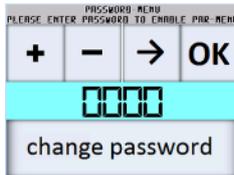


aborts the process and returns to the **MONITOR**-menu.

The old password remains unchanged.

PARAMETER-MENU

The **PARAMETER-MENU** is password protected.



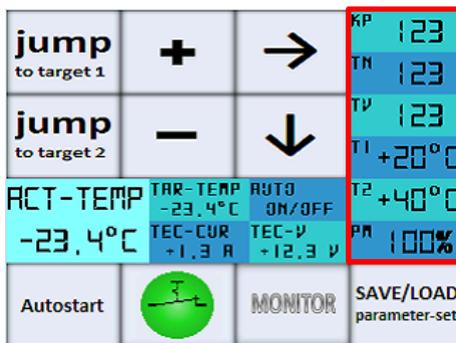
To access the **PARAMETER-MENU**, the password must be entered correctly and confirmed with



. If the password 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.

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



* Touch-sensitive area. Touch here to make the parameter change effective.

Two freely selectable temperatures can be set in the **PARAMETER-MENU**. The  and  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 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-regulation 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.

KP flashes



increases the flashing digit



decreases the flashing digit



jumps to the next digit



changes to the next line (from **KP** to **PM** and back to **KP**)

KP Proportional part of the PID control

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

TV 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 characteristic.

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

T1 freely selectable temperature value 1

T2 freely selectable temperature value 2



changes the setpoint (**TAR-TEMP**) to the temperature value 1 **T1**



changes the setpoint (**TAR-TEMP**) to the temperature value 2 **T2**

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 actual output-voltage

AUTO ON/OFF shows the status of the autostart function



switches the **Autostart** function ON or OFF.

In the autostart-ON mode, the controller starts immediately after the supply voltage is switched on, if it was previously switched off with the output switched on.

In autostart-OFF mode, the controller always starts with the output switched off.



Key Function: Stop output Display Function: Output is ON.



Key Function: Starts output Display Function: Output is OFF.



jumps back to the MONITOR-menu



jumps to the **PA**rameter **SET MENU**. The values **KP**, **TN** and **TV** can be stored here.

PA SET MENU

The **PA SET 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 **ACTUAL PARA** an. 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.

save	RECORD 1 KP 123 TN 123 TV 123	load	PA SET MENU ACTUAL PARA Kp 123
save	RECORD 2 KP 123 TN 123 TV 123	load	Tn 123 Tv 123
save	RECORD 3 KP 123 TN 123 TV 123	load	OK
save	RECORD 4 KP 123 TN 123 TV 123	load	

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 **ACTUAL PARA** with selected parameter **RECORD 1/2/3/4**

load overwrites **RECORD 1/2/3/4** with **ACTUAL PARA**

OK jumps back to **PARAMETER-MENU**. Now the last shown **ACTUAL PARA** is active.

Software Version

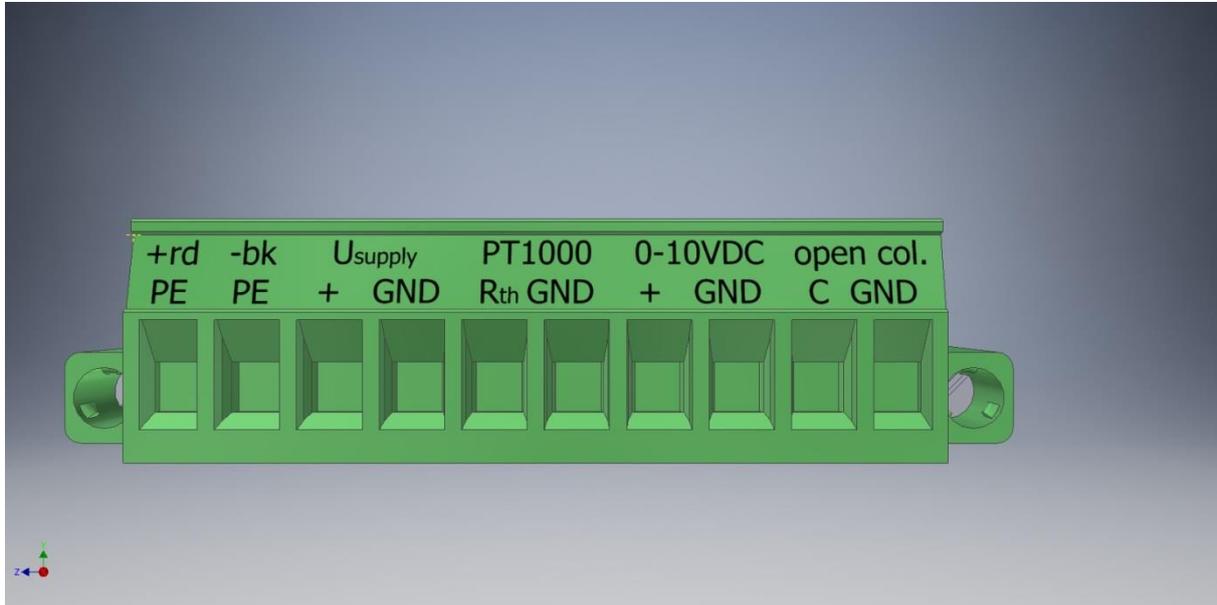


Here you get the information about the software version.

Touching the centre of the display switches back to the **MONITOR**-menu.

Controller 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	Comments
1	+rd PE	Peltier element connection red wire	Attention: Specifications apply to Quick-Ohm modules. It may differ for other manufacturers. (See also Correct polarity of the Peltier element)
2	-bk PE	Peltier element connection Black wire	
3	V _{supply} +	Connection positive voltage supply 12 VDC – 24 VDC	
4	V _{supply} -	Connection GND potential zero voltage supply	
5	PT1000 R _{th}	Connection PT1000 sensor	
6	PT1000 GND	Connection PT1000 sensor	
7	0-10VDC +	Output Control signal → 0-10VDC	Experts only Control output I _{max} = 80mA V _{max} = PM x 10V
8	0-10VDC GND	Output Control signal → 0V / GND	
9	Open col. C	Output open collector Collector connection	Experts only Control output Open-Collector Emitter GND I _{max} = 100mA
10	Open col. GND	Output emitter / Potential zero / GND	

Before start-up

The user is expected to control and master his thermal design. This instruction does not provide any relevant training. The user must ensure that he has completely read and understood these operating instructions beforehand. Furthermore, there must be a thermal design that is reasonably dimensioned. The assembly must contact the object to be tempered on the entire "cold side" of the Peltier element. The object to be tempered must have good thermal connection with PT1000 sensor. On the other hand, the entire "hot side" must be connected to a sufficiently effective heat sink (heat sink, heat exchanger). A Peltier element is considered to be sufficiently connected, if the "hot side" heats up or cools down by a maximum of 10 K compared to its cooling medium. An insufficiently cooled Peltier element will overheat during operation within a few seconds and consequently get damaged. A poorly cooled Peltier element will not achieve the set goal.

You can find helpful information on our homepage under the heading [Library](#).

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.



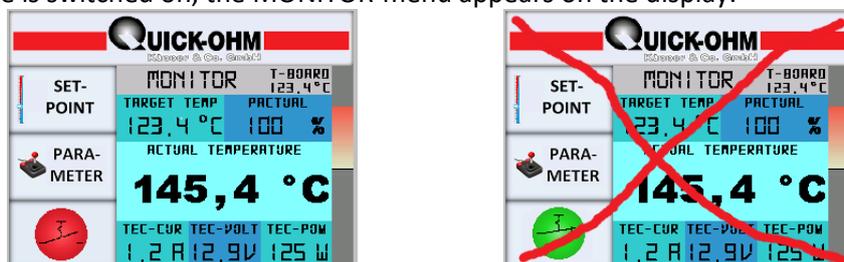
Connect the supply voltage and the sensor to terminals 3 to 6 as described under Controller connection. Please leave the remaining connections free.

Check your design and switch on the supply voltage.

Check the *ACTUAL TEMPERATURE*. value. If an unrealistic temperature is displayed, switch off the supply voltage and please check your assembly 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.

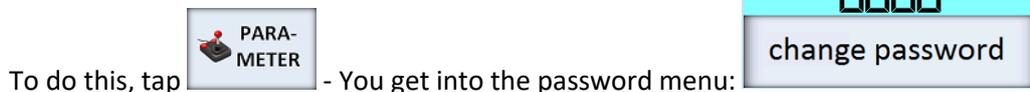


Make sure that the operation indicator  appears red as shown in the picture. The output is not switched through. If the display lights up green, then tap this field  to switch off the output.



Parameter settings

Switch from the MONITOR to the parameter menu



You will be asked to enter the password. By default, the password is **0000**.



Press . You will now enter the PARAMETER-MENU.

jump to target 1	+	→	KP 123
jump to target 2	-	↓	TN 123
ACT-TEMP	TAR-TEMP	AUTO	TV 123
-23.4°C	-23.4°C	ON/OFF	T1 +20°C
	TEC-CUR	TEC-V	T2 +40°C
	+1.3 A	+12.3 V	PM 100%
Autostart		MONITOR	SAVE/LOAD parameter-set

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 controller 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.

jump to target 1	+	→	KP 100
jump to target 2	-	↓	TN 000
ACT-TEMP	TAR-TEMP	AUTO	TV 000
-23.4°C	-23.4°C	ON/OFF	T1 +20°C
	TEC-CUR	TEC-V	T2 +40°C
	+1.3 A	+12.3 V	PM 000%
Autostart		MONITOR	SAVE/LOAD parameter-set

* Touch-sensitive area. Touch here to make the parameter change effective.

The setting of T1 and T2 will be explained later.

Determine and set PM

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

$$PM = \frac{V_{max}}{V_{supply}} \times 100\%.$$

Take the value V_{max} from the data sheet of the Peltier element used. V_{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 set. Values smaller than the one determined are permissible and may be useful.

If you set PM 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. This prevents the Peltier element from being energized immediately when the device is switched on.

The controller is now ready 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 assembly.

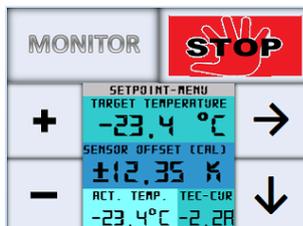
Switch on the supply voltage.



You are now in the MONITOR-menu and the operation indicator shows .



Tap  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  to start tempering. The operation indicator changes to green .



Check the power indicator. If a value of above 8A or above the I_{max} (data sheet Peltier element) is displayed, tap the operation indicator again to switch off the output. Check your assembly 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.**

Check the assembly 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. Correct the error.

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 adjusted to the connected assembly.

Adjustment of control parameters

If you have carried out the steps according to the instructions, the controller is now in P-mode. In this mode, the output supply to the Peltier element is max 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. Therefore the setpoint can never be reached in the P control mode. The larger the **KP** value, the stronger the controller reacts to a deviation as the temperature of the object comes closer to the target temperature. If the **KP** is too large, the controller will oscillate. In this case the value should be reduced. In this P-mode there always remains a control deviation.

In order to be able to correct this control deviation, the controller must be given an integral component **TN**. The controller recognizes the control deviation via this and can now compensate for the deviation. With a value **TN** > 000 the controller is now in the PI control mode.

It happens that the control does not regulate in a stable way and the temperature oscillates around the setpoint. Such an oscillation can be corrected via the differential parameter **TV**. 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 power and the heating power 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 K_P , 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 oscillate.

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 K_P to 100 (or less. This value should not cause any oscillation yet)
- Set T_N to 000
- Set T_V to 000 (The controller now has pure P characteristics)
- Set T_1 to a value just (about 10 Kelvin) above T_{Medium}
- Set T_2 to a value just (about 10 Kelvin) below T_{Medium}
- Confirm the changes
- Touch the area "jump to target1"
- Observe the temperature development. The controller should not reach the target value, otherwise reduce K_P .
- Touch the area "jump to target 2"
- Observe the temperature development. The controller should not reach the target value, otherwise reduce K_P
- Increase the K_P value
- Touch the area "jump to target1"
- Observe the temperature development.
- In this way, increase the K_P value until the controller begins to oscillate around the target temperature. This K_P -value is the „critical gain factor“ $K_{P_{\text{Krit}}}$.
- Determine the period of one oscillation. This is the time T_{Krit} in seconds that elapses during a full oscillation.
- According to Ziegler & Nichols, the controller now has the following parameters:
 - $K_P = 0,6 K_{P_{\text{Krit}}}$ $T_N = 5 T_{\text{Krit}}$ $T_V = 1,25 T_{\text{Krit}}$

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. If you touch these areas in the order:

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

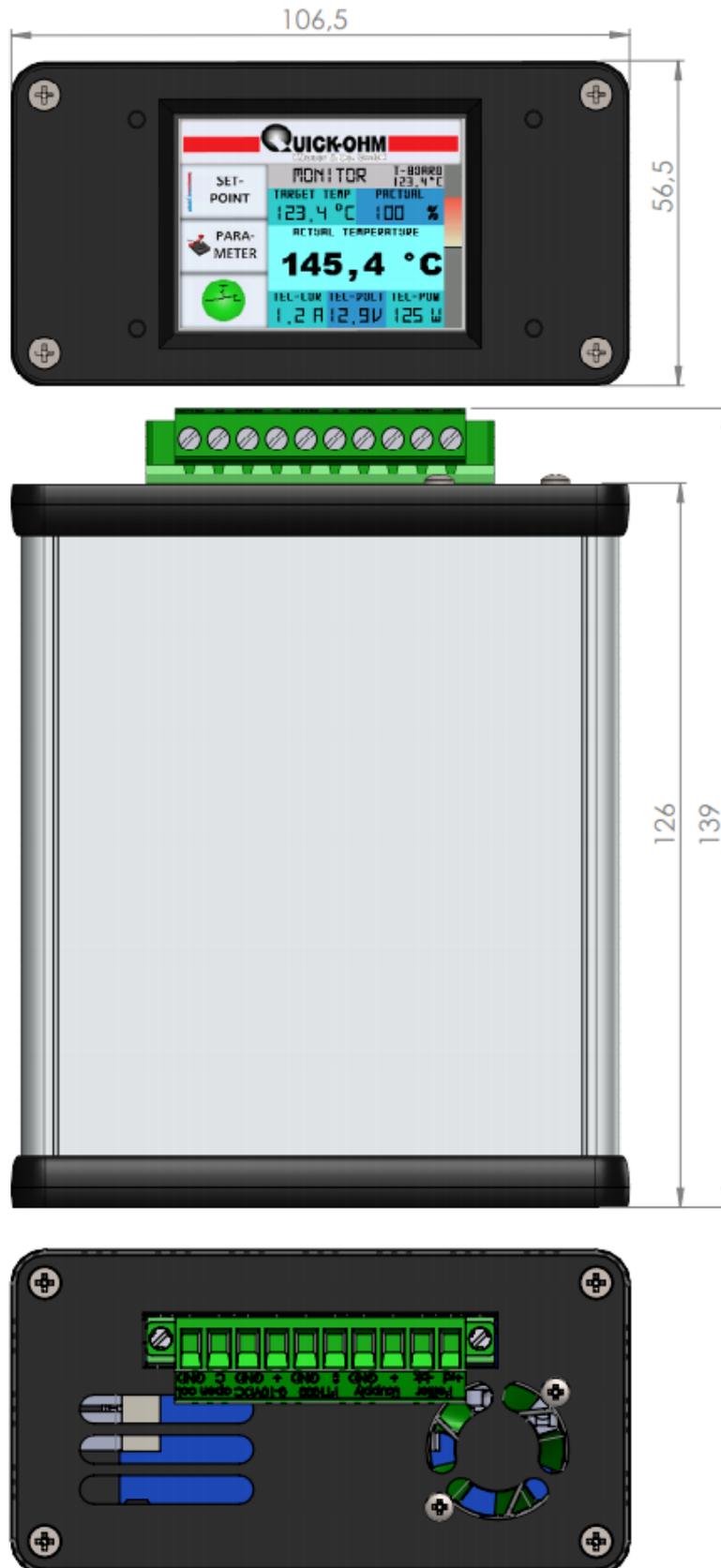
the controller is reset to the factory setting. An existing password is hereby deactivated and reset to 0000. Do this, if you have lost the password.

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 (default state). All saved values will be lost

Drawings:

Peltier controller



PT1000-Sensor

