Power Quality Controller – PQC
Blindleistungsregler

PQC Application Note

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1 Control profiles and their fields of application

Control profiles:
The PQC has a four-quadrant control function, which is defined by the control profile with its four quadrants power import inductive (II), power import capacitive (IC), power export inductive (EI) and power export capacitive (EC). The power import inductive (II) quadrant is by far the most frequent state of operation, prevailing in most consumer networks. In networks where power is generated (hydropower plants, wind turbines, etc.), the usual control mode is in the export capacitive (EC) quadrant. The remaining two quadrants find only little or no practical application. In most cases, control in the export inductive (EI) quadrant gives rise to reactive power charges and should therefore be avoided. The control profile characteristic curve is formed by the following parameter settings:

- $\cos(\varphi)_{target}$: value to be achieved by power factor correction
- Parallel shift (PS): produces a shift of the control characteristic curve in the inductive (+) or capacitive (-) direction parallel to the selected value of $cos(\varphi)$
- Limitation (L): produces a kink in the control characteristic curve, for example to prevent the control response veering into the capacitive zone (overcorrection). The limitation shifts the control characteristic curve in the inductive (+) or capacitive (-) direction parallel to $cos(\varphi) = 1$. It is thus possible to construct virtually every conceivable control characteristic curve.

1.1 Fields of application

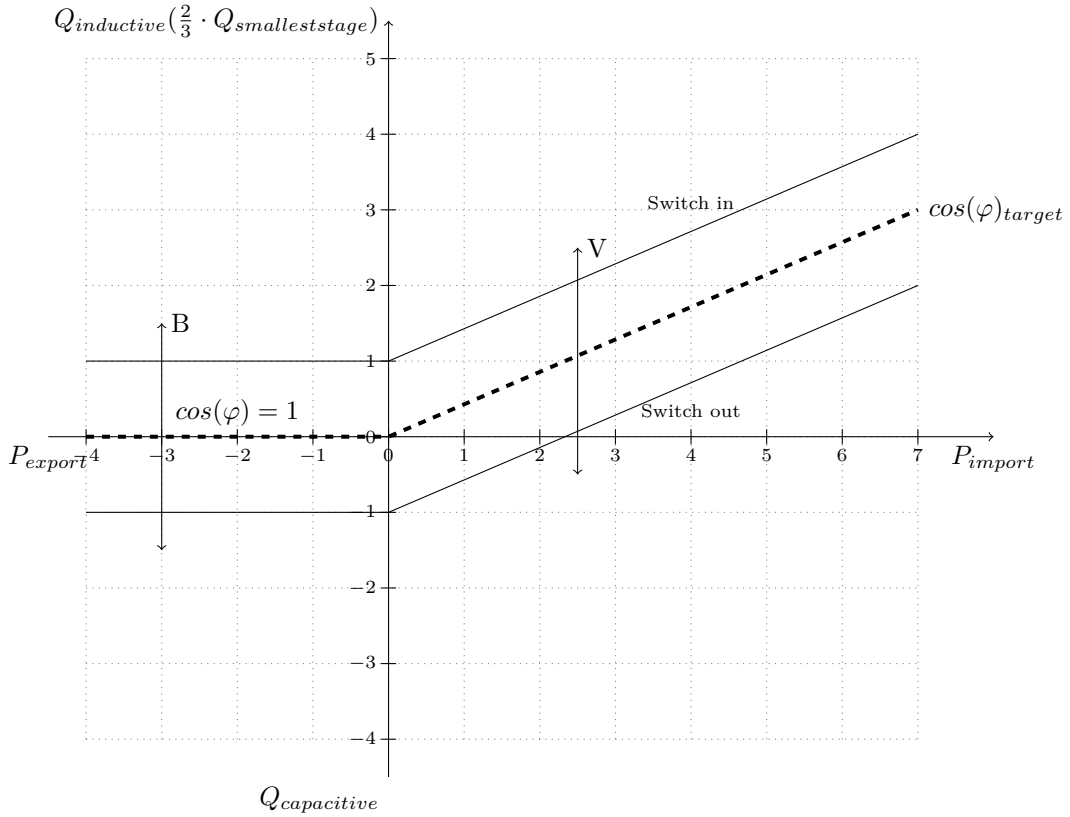

Figure 1

Parameter	**Setting ranges**
cosφ target	0,80 inductive to 0,90 capacitive in increments of
Parallel shift (PS)	-2.0 to +4.0 in increments of 0.5
Limitation (L)	-2.0 to +2.0 in increments of 0.5

Note!
The regulations of the power supply company concerned must be complied with when the characteristic control curve is specified.
If the selection Main menu | Initial start-up→ Detection → Stage or Stage + Connect. has been made, the width of the control band is 1.3 · Qsmallest stage. The same applies if the value of c/k has been calculated from the formula on page 10 or taken from Table 5 in the Operating Manual.
The PQC has 5 control characteristic curves. These are programmed in the menu Control profiles → Profiles 1 to 5 where they can be activated selectively. As factory default setting, these 5 profiles are chosen to serve the most common applications. This simplifies the initial start-up, since the profile that best suits the application in question can be selected, which then only needs to be fine-tuned. In most cases, it suffices just to change the target $cos(\varphi)$ to meet the requirements of the power supply company concerned. Only one profile at a time can be activated. Control profile 1 is activated as default setting in the instrument as delivered.

1.1.1 Control profile 1

Control profile 1 offers the ideal characteristic curve for all **consumer networks** where an **inductive** $cos\varphi$ is called for, so the operating quadrant is power import inductive (II). The selected target $cos\varphi$ also constitutes the lower set limit of the control characteristic curve. At the point where the upper set limit reaches the $cos\varphi$ value of 1, there is a kink in the control curve. In normal operation under load, this ensures that the selected target $cos\varphi$ is the lower set limit, at the same time preventing overcorrection when the consumer is only lightly loaded. The maximum possible inductive power under low load conditions is $1,3 \cdot Q_{smallestStage}$. This control profile can also be selected for sites that have their own generating facilities (e.g. CHP units), provided that there is no—or only very sporadic—feed-in to the supply network.

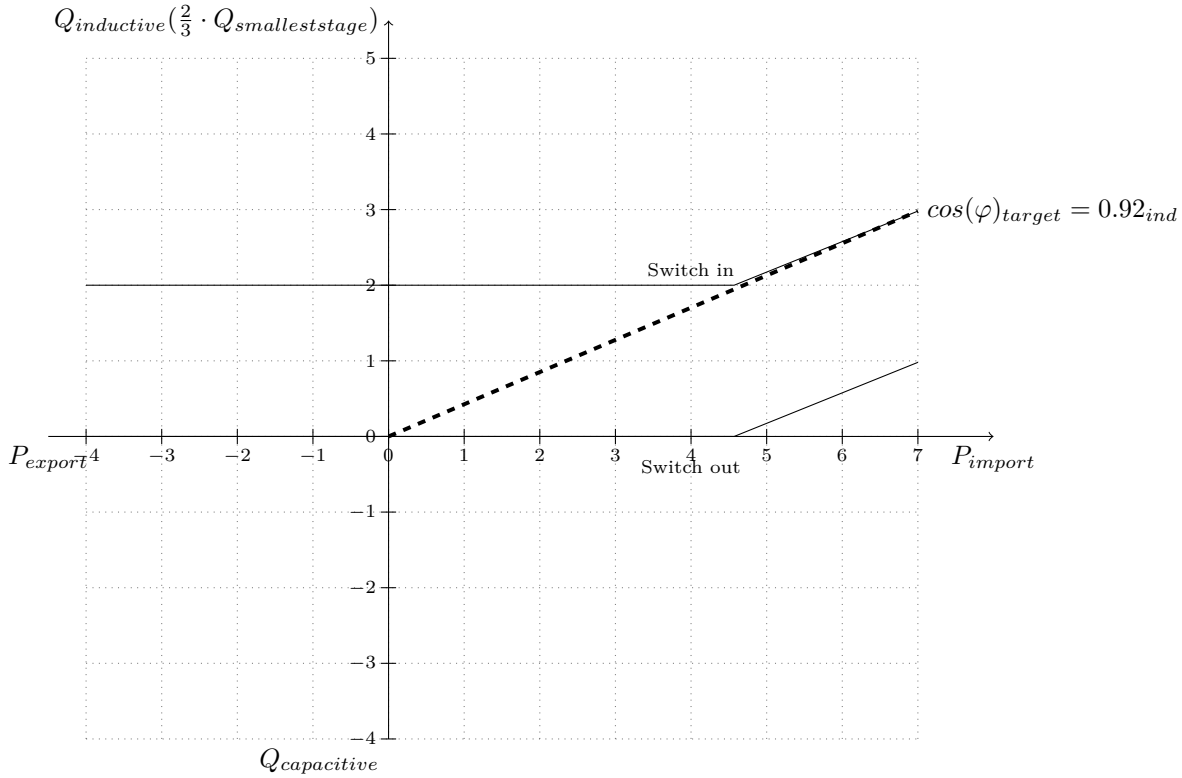

Figure 2

Parameter	**Default setting**
$cos\varphi$ target	0.92 inductive
Parallel shift (PS)	-1.0
Limitation (L)	+1.0

1.1.2 Control profile 2

Control profile 2 is for **consumer networks** in which an average $cos\varphi = 1$ is to be achieved. The operating zones are in the power import inductive (II) and power import capacitive (IC) and power import capacitive (IC) quadrants. The maximum possible inductive reactive power is $\frac{2}{3} \cdot Q_{smalleststage}$. The maximum possible capacitive reactive power is $\frac{2}{3} \cdot Q_{smalleststage}$.

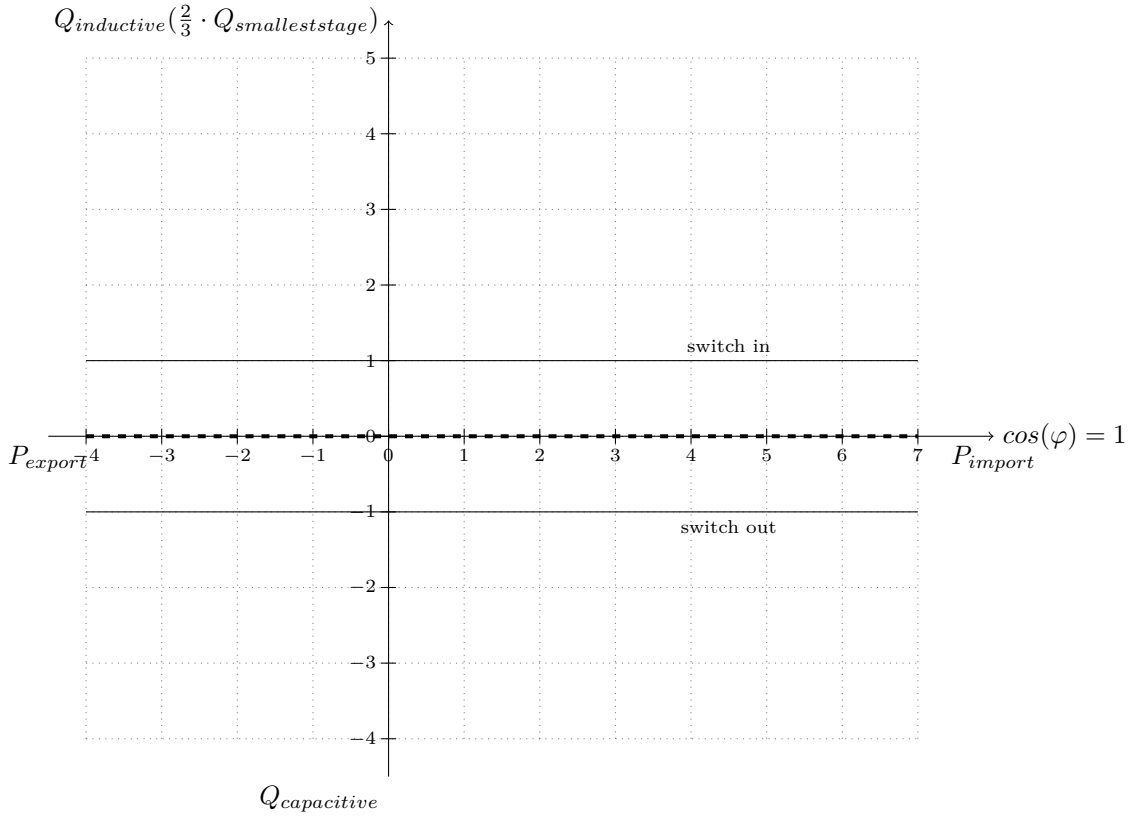

Figure 3

Parameter	**Default setting**
$cos\varphi$ target	1.00
Parallel shift (PS) (V)	0.0
Limitation (L)	OFF

1.1.3 Control profile 3

Control profile 3 is for **consumer networks** in which $cos\varphi$ is required to be close to 1 but at the same time no overcorrection is desired. The operating quadrant is power import inductive (II). The maximum possible inductive reactive power is $1,3 \cdot Q_{smallestst age}$.

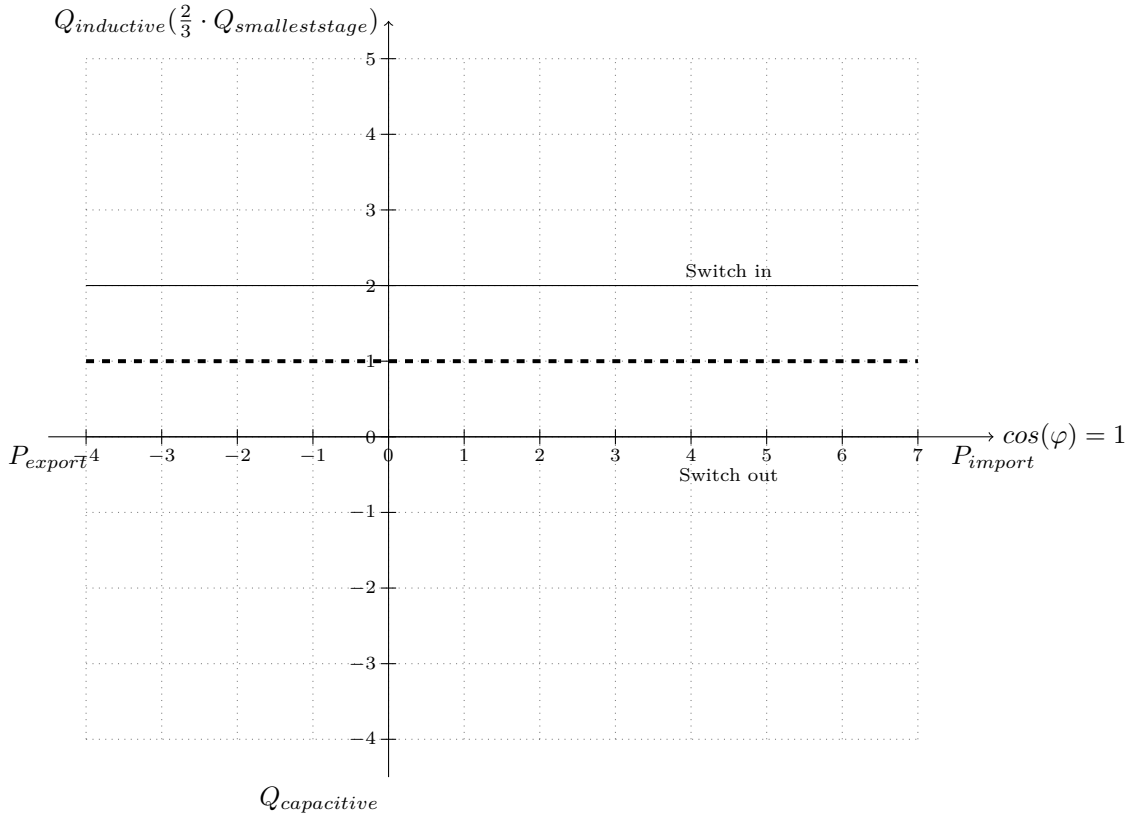

Figure 4

Parameter	**Default settings**
$cos\varphi$ target	1.00
Parallel shift (PS)	1.0
Limitation (L)	OFF

1.1.4 Control profile 4

Control profile 4 is for **consumer networks**as described for control profile 1, but which their own power generating facilities (such as CHP) with continuous or frequent feed-in to the supply network. The operating quadrants are power import inductive (II), power import capacitive (IC) under low load conditions and power export capacitive (EC) during feed-in (regeneration) to the supply network. The maximum possible capacitive power is $1,3 \cdot Q_{smalleststage}$.

Note!
When power factor correction systems are operated together with electricity generators, this has an impact on their design and dimensions. They must therefore be engineered specifically for this individual application.

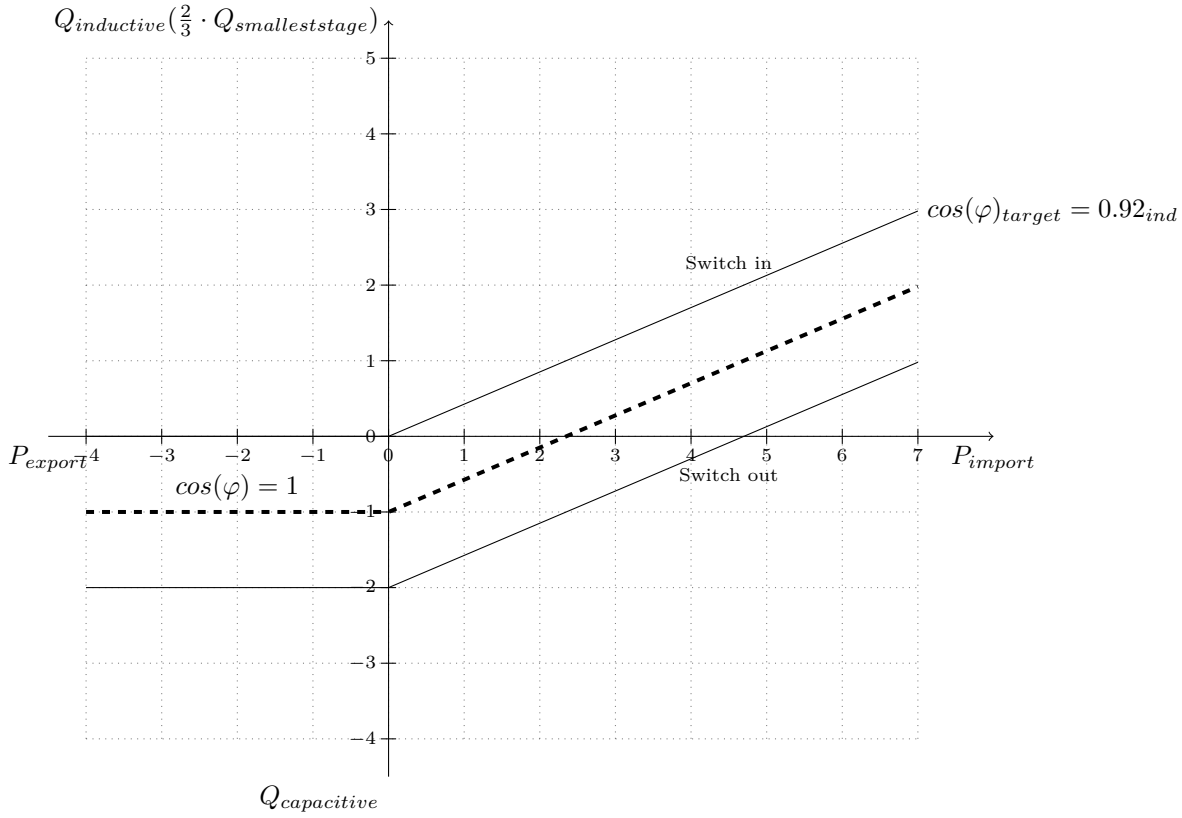

Figure 5

Parameter	**Default settings**
$cos\varphi$ target	0.92 inductive
Parallel shift (PS)	-1.0
Limitation (L)	OFF

1.1.5 Control profile 5

Control profile 5 is for **consumer networks**, such as hydroelectric plants or wind farms, in which a capacitive *cosφ* is desirable. The maximum allowable capacitive value should be selected for the target *cosφ*. The minimum achievable *cosφ* is then equivalent to $1,3 \cdot Q_{kleinsterStufe}$ capacitive.

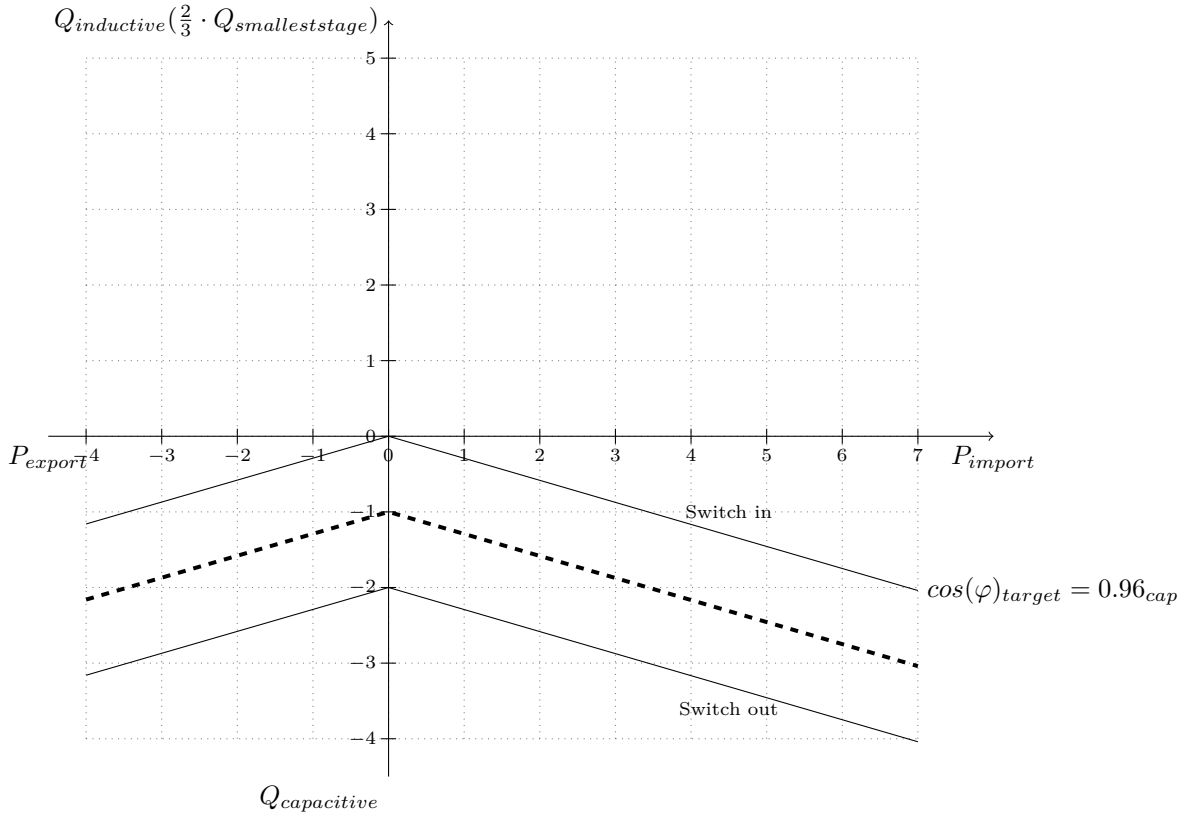

Figure 6

Parameter	**Default settings**
cosφ target	0.96 capacitive
Parallel shift (V)	-1.0
Limitation (L)	OFF

Formula for calculating response current c/k:

$$I_A = \frac{2}{3} \cdot \frac{Q_{smalleststage}}{V_{Nom} \cdot \sqrt{3} \cdot k} \cdot 1000[mA] \approx 0.375 \cdot \frac{Q_{smalleststage}}{V_{Nom} \cdot k} \cdot 1000[mA] \quad (1)$$

1.2 Switching delay

Switching delay is the time that elapses between the need for a switching action being determined and its actually being carried out. The corresponding switching command signal must be sustained without interruption for the entire duration of the switching delay, which relates to the need to switch a capacitor stage (smallest stage) in or out. If this need is for several stages to be switched, the switching delay is automatically shortened according to the following formula:

$$Actualswitchingdelay = \frac{Setswitchingdelay}{Numberofstagesneeded} \quad (2)$$

This means that large load fluctuations are compensated for quickly and small load fluctuations slowly, thus avoiding instability due to severe overcorrection while reducing wear of the power factor correction system.

Note!
The shorter the specified switching delay, the more frequent are the switching cycles, consequently increasing wear of the entire power factor correction system. We therefore recommend specifying short switching delays only when exceptional circumstances call for it.

Parameter	**Setting range**	**Default setting**
Switching delay	5 to 500 sec in increments of 1 sec	45 sec for all 5 control profiles

1.3 Parameterization of the control profiles

Control profiles 1–5: Use the ↑ ↓ keys to select a parameter, then unlock it with the ⇄ key.
Use the ↑ ↓ keys to change the parameter, then confirm with the ⇄ key.

Save all changes to control profile parameters before leaving the submenu:
Select the menu item Save with the **Save** mit ↑ ↓ keys. This can be activated and deactivated with the ⇄ key. If the changes are not saved, they will be discarded when this submenu is closed. The PQC will then continue to operate with the previously programmed parameters.
To activate a control profile, the menu item Active must be selected with the ↑ ↓ keys. Only one control profile can be active at any given time. When a profile is activated, all the other profiles are automatically deactivated. Selecting **Control diagram** in the **Main menu**, displays the currently active control characteristic curve for verification. Pressing the ESC key closes this submenu to return to the next higher menu level.

2 Optional temperature probe inputs and passive digital inputs and outputs[1]

A typical example of the circuits for passive digital inputs and outputs plus temperature probe inputs is shown in Fig. 7.

Temperature probe inputs:
The configuration of the temperature measurement inputs can be carried out in the PQC by navigating as follows: (Main menu -> Settings -> General -> Extensions -> Temp. I/O) (see Fig. 8). The units of the temperature display can be set as

- $°C$ (degrees Celsius)
- K (Kelvin)
- $°F$ (degrees Fahrenheit)

The temperature probes actually installed can be configured here as active or inactive. In tehe PQC the temperatures measured by active temperature probes connected to the inputs are displayed by navigating as follows: (main menu -> Info/status -> Temperatures) (see Fig. 10). If defined set limits are to be monitored with the temperature probe inputs, these can be configured in the PQC menu as described in the Operating Manual (see Fig. 9). The hysteresis is fixed at 1.5 K. Input connections are provided for a 4-wire Pt100/1000 RTD. In addition, one or two 2-wire NTC probes (FRAKO-Article No.: 29-20094, 7 m cable) can be connected.

Passive digital Inputs and outputs:
Each of the terminals 1 to 5 can be configured in the PQC as an input or an output, to suit the application concerned, by navigating as follows: (Main menu -> Settings -> General -> Extensions -> Temp. I/O). If configured inputs or outputs are used as alarms, the alarm options can be set in the PQC. Please refer to the Operating Manual sections on alarm management and set limits. The current statuses of the inputs and outputs are displayed on the PQC by navigating as follows: (Main menu -> Info/status -> I/O status) (see Fig. 11).

One input can be used to switch between control profiles 1 and 2. This is configured in the PQC by navigating as follows: (Main menu -> Settings -> General -> Extensions -> Temp. I/O). When this option is active, profile switching takes place exclusively via this input (no profile switching is then possible from the PQC menu or optional Modbus RTU interface) and only between the stored control profiles 1 (input 1: low level) and 2 (input 1: high level)..

The **digital inputs** are suitable for electric signals from **5V DC** up to a maximum of **24V DC**.

The **digital outputs** (Open-collector type) are suitable for an externally applied voltage up to a maximum of **24V DC** and a maximum current of **100mA**.

[1] Applies to PQC types: PQC xxxxxxx-x1

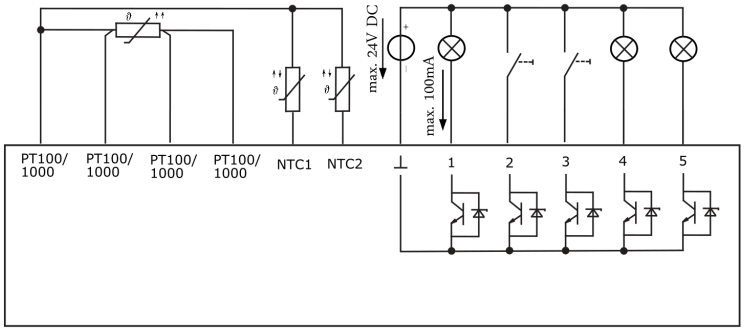

Figure 7: Typical connections

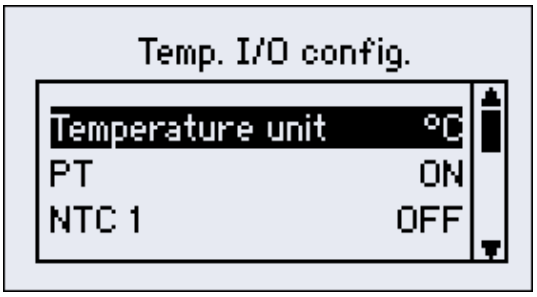

Figure 8: Temperature probe configuration

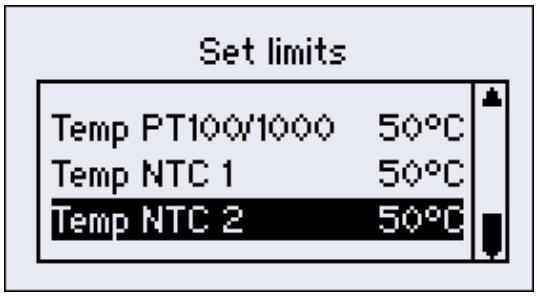

Figure 9: Configuration of set limits

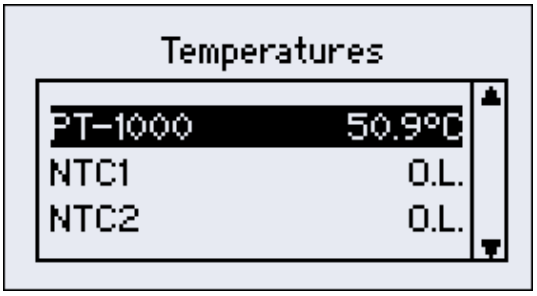

Figure 10: Display of temperatures

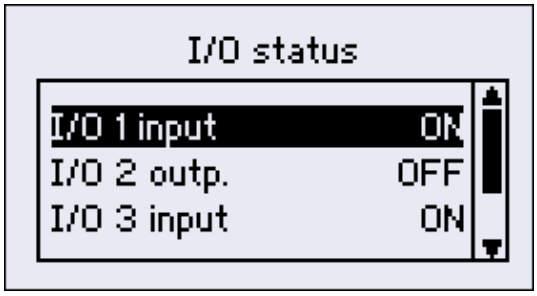

Figure 11: Display of statuses

3 Firmware update

- Open the program C2Prog on a laptop running on its battery.

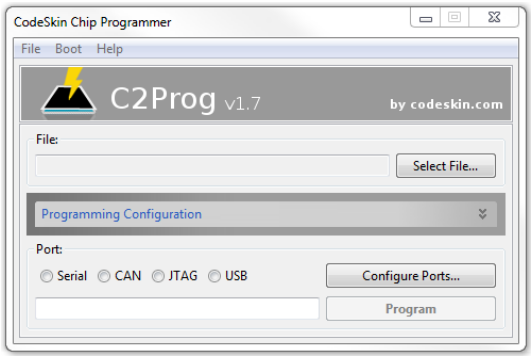

Figure 12: Starting the software C2Prog

- Isolate the PQC from its power supply.
- Connect the PQC via the USB service port to the laptop.
- In "Windows Device Manager" it can be seen which COM port the PQC is assigned to.

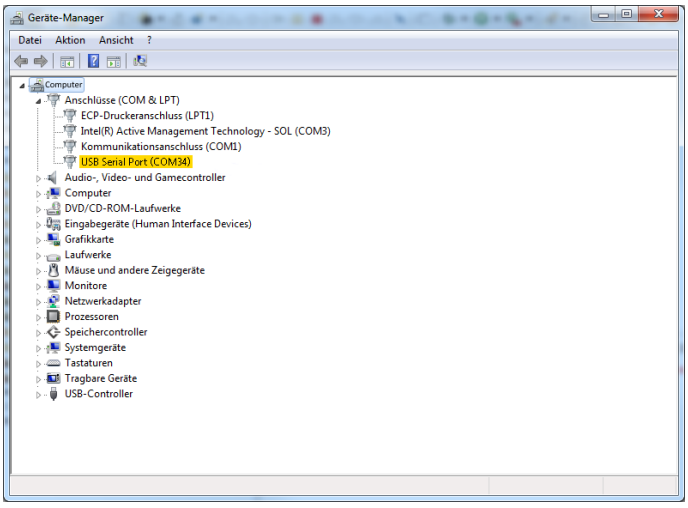

Figure 13: Ascertaining the COM port

- Switch the PQC power supply on again; the instrument's display should now be completely white.
- Now the first file in the Select File submenu in the program C2Prog (see Fig. 14) must be selected. This is the file **PQC_C28_Release_X_XX_XXXXXX.ehx**.After this file has been selected, the user is prompted to enter a passphrase.The appropriate password here is: **frakopqc**
- The correct COM port, which has already been ascertained in Device Manager ,(Abb.13 Geräte-Manager) can then be selected in the Scan Ports pull-down menu after the

Configure Ports button has been clicked. Confirm by clicking OK.

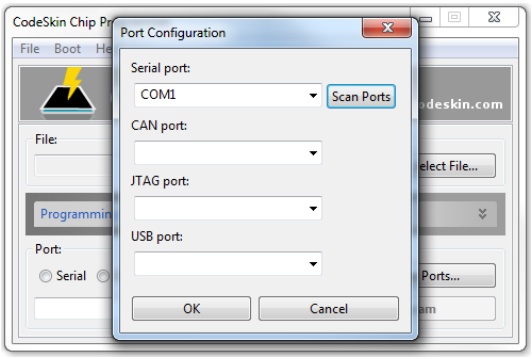

Figure 14: Start of the C2Prog software

- Auf "Program" Click Program to start the update.

- After the flashing procedure for the first file is complete, the second file must be selected, i.e **PQC_M3_Release_X_XX_XXXXXX.ehx**. Once this file has been selected, it only remains to start the second update by clicking the "Program" button.

- When both files have been transferred, the connector must be removed from the USB port and the PQC restarted. The instrument should start up normally with the previously configured settings.

4 Firmware Version 1.24 vs. 1.25

4.1 Bug fixes

- Automatic detection of connection and stage current at an apparent secondary current < 20 mA
- Manual connection and stage current detection carried out while alarms are present
- Reactive power demand must be sustained without interruption throughout the switching delay before a switching action may be carried out.
- In the event of a critical control relay trip, the control function is interrupted for an additional 240 s (i.e. 4 minutes) after the alarm condition is over. For all other alarms, after the alarm condition is over, the control function is suspended for the duration of the capacitor discharge time before resuming operation.
- Revision of the real time control characteristic curve and the cos φbar chart in the controller overview

4.2 Features

4.2.1 List of active alarms

The PQC has a list of those active alarms that are present in the instrument. As soon as an alarm occurs, this list can be displayed in the instrument window by pressing the Info key. If an alarm is acknowledged by pressing the Return key, further information about it is displayed:

- Does this alarm trigger a control relay trip?
- How high is the momentary measurement reading and the associated set limit?
- In a 3-phase system, which phases are affected?

4.2.2 Optional temperature measurement and optional inputs and outputs

Firmware support for the hardware of the optional temperature probe inputs and the digital inputs and outputs (see Section 2)