Merus® HPQ – Hybrid Power Quality Filter User Manual

24.01.2025 Version 1.0

MERUS POWER

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Merus Power designs, manufactures, and markets a wide range of reliable power quality and energy storage solutions across the world. Our customers in industries, commercial buildings, renewable energy and infrastructure segments benefit from improved power quality in terms energy efficiency, operational excellence and compliance with technical regulations.

1. Scope of this manual

This manual applies to Merus Power Oy's HPQ-series hybrid power quality filter (AHF) modules.

2. General safety instructions

Misuse of electrical equipment may lead to injury. Therefore, the following symbols have been used in this manual and in the Merus® HPQ-module to warn of the risks involved.

The live parts of the HPQ-modules are partially contact protected. Only qualified personnel are permitted to operate the HPQ-module. The safety instructions according to EN 50110-1 and local electrical safety standards must be followed!

Disconnect the HPQ-module from the AC supply and wait for at least five minutes to allow any capacitive charge to be discharged through the discharge resistors before any maintenance or other work that involves working inside the HPQ-module. Always verify by measurement that the capacitors have been discharged.

	Hazardous voltage may exist!
	Dangerous! Attention!

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3. Merus® HPQ-modules

HPQ is a modern, flexible, high performance and cost-effective solution that provides an instantaneous and effective response to power quality problems in low-voltage electrical power systems. It enables longer equipment service life, higher process reliability, improved power system capacity and stability, and reduced energy losses, complying with most demanding power quality standards and grid codes. HPQ is the ultimate answer to power quality problems caused by a low power factor, waveform distortions, voltage variations and fluctuations, and load unbalance pertaining to a wide range of segments and applications.

The state-of-the-art controller, modern touch-screen user interface and modular technical design are combined in a fast, reliable and compact device that is both easy to operate and complies with standard communication protocols. The construction principle is modular, enabling the connection of up to two HPQ-modules in parallel with a detuned capacitor bank, combining passive and dynamic reactive power compensation, harmonics mitigation and load balancing.

3.1 Operating principle of the Merus® HPQ hybrid power quality filter

The operating principle of the HPQ is illustrated in Figure 1. Merus® HPQ-modules are power electronic devices connected in parallel with the non-linear load. The HPQ consists of an active harmonic filter (AHF) module(s) with parallel connected capacitor steps. The capacitor steps are automatically controlled with the HPQ-module Digital Output (DO) relays. The HPQ-module operates as a controlled current source, providing any kind of current waveform in real time. The HPQ-module is equipped with an energy storage element and a control system, which enables it to inject desired current to the network. The HPQ-module, connected in parallel with the non-linear load, compensates the harmonic currents caused by the non-linear load. Therefore, only sinusoidal active current is drawn from the network.

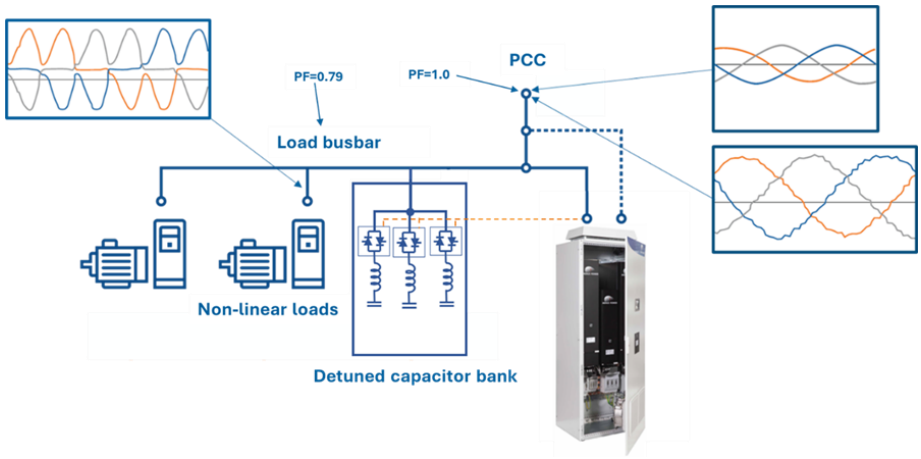

Figure 1: Operational principle of the Merus® HPQ-Series hybrid power quality filter.

The HPQ utilizes the capacitor steps to fulfil the most of the capacitive reactive power needs and the active harmonic filter module takes care of the middle-steps and inductive side. Due to that, there is no need to use different size capacitor steps. The HPQ can use standardized, cost-effective sizes in all the steps (1:1:1:1:1:1).

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3.2 Operation and compensation modes of the hybrid power quality filter

3.2.1 Operation modes

There are two **operation modes** in the HPQ.

- The ULTRA FAST (UF) -mode for the fast-changing loads in Open-Loop configurations.
- The PFC -mode for more stable loads in Closed-Loop configurations (Traditional PFC control).

The user can program the HPQ-module(s) to mitigate harmonics and load balancing in both operation modes.

In UF-mode, the HPQ-module measures the LOAD currents in Open-Loop. The connections of the steps happen within milliseconds. Due to fast switching, the capacitors need to be controlled via Thyristor Switches (TC). Magnetic switches (MC) cannot be used in this operation mode*. This mode is mainly for mitigating voltage fluctuation.

- The steps are available when the MASTER-module is in RUNNING-state.
- The HPQ tries to reach the power factor defined in the Target PF-setting.
- The capacitor steps are connected when ½ of the step size is needed.
- The HPQ-module(s) take care of the remaining reactive power and middle steps.
- The HPQ-module(s) take care of the harmonics and unbalance if programmed to do so.
- Steps are connected and disconnected with FILO principle.
- No discharge or re-connection delays → TC needed.
- The step will go into off-state when the load has decreased below the “Hysteresis” -amount from the last connection. The hysteresis limit is set in the HPQ-settings, and it can be 0-50% of one capacitor step size. The hysteresis range is the load reactive power range where no connection is formed in the critical control point.
- When the HPQ is stopped or tripped, the capacitor banks are instantly disconnected to protect the capacitor steps from overloading due to harmonic voltage.

*With TCs the system avoids connecting a charged capacitor into the network with all phases at once, which might lead to damage in the capacitors and in the network (discharge problems).

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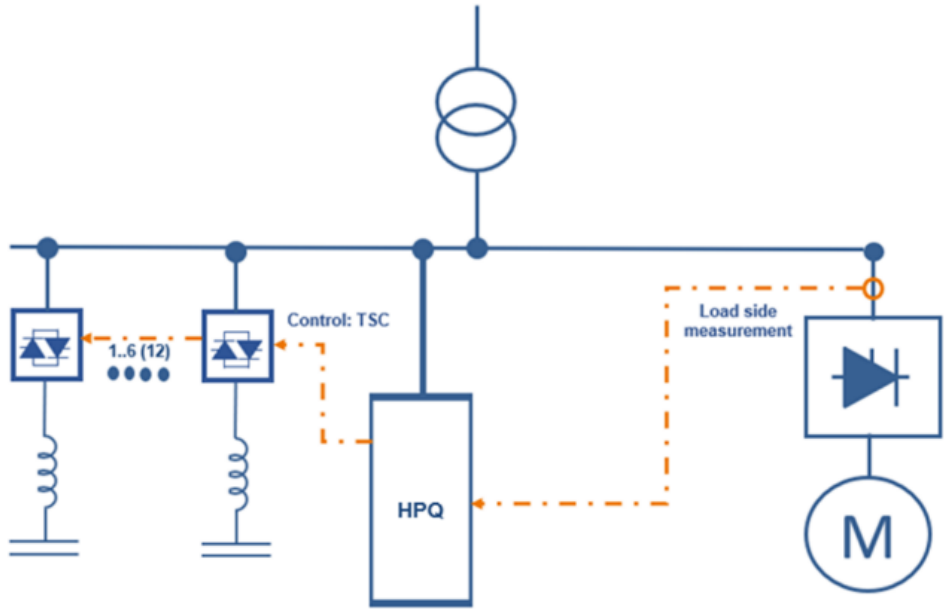

Figure 2: The UF-mode.

In PFC-mode the HPQ-module is measuring the NETWORK currents in Closed-Loop. The PFC-controller keeps track of every connection event, and there is settable delay for reconnecting the step. Due to that, both TCs and MCs are optional for this mode. This mode is the most used one.

- The steps are available when the MASTER-module is in RUNNING-state.
- The HPQ tries to reach the power factor defined in the Target PF-setting.
- The capacitor steps are connected when ½ of the step size is needed.
- The HPQ-module(s) takes care of the remaining reactive power and middle steps.
- The HPQ-module(s) takes care of the harmonics and unbalance if programmed.
- Steps are connected with the CYCLIC principle. The least used bank will be connected first and the most used will be disconnected first.
- If the network power factor is between the target PF and Capacitive PF limit, the HPQ will not produce reactive power, allowing lower energy losses.
- 1 second connection delay: One connection/disconnection in 1 s period.
- Configurable discharge time allows the use of MCs and TCs.
- The step will go into off-state when the load has decreased below the “Hysteresis” -amount from last the connection. The hysteresis limit is set in the HPQ-settings, and it can be 0-50% of one capacitor step size. The hysteresis range is the load reactive power range where no connection is formed in the critical control point.
- When the HPQ is stopped or tripped, the capacitor banks are instantaneously disconnected to protect the capacitor steps from overloading due to harmonic voltage.

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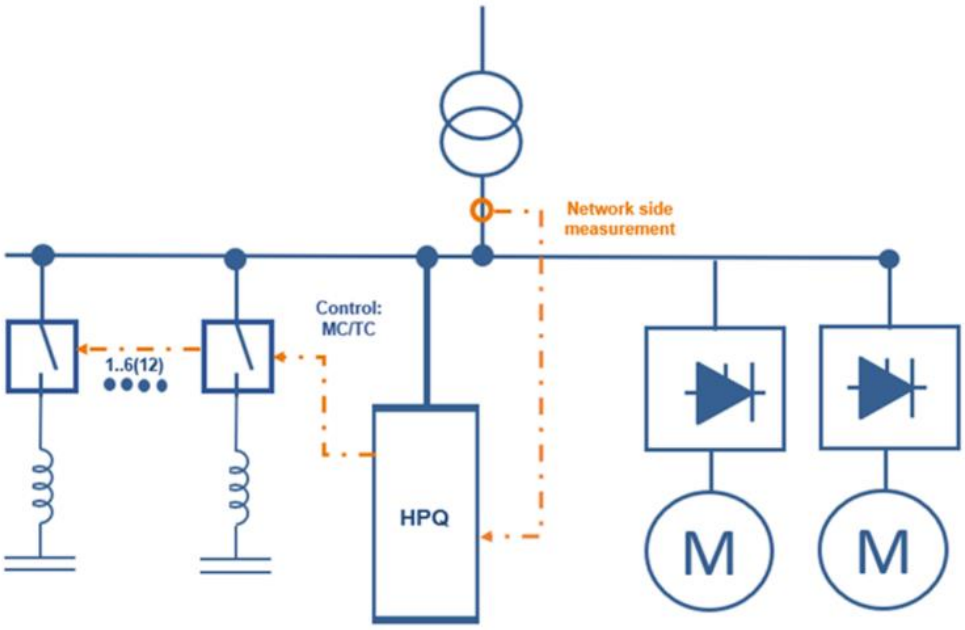

Figure 3: The PFC-mode.

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3.2.2 Compensation modes

In addition to the operation modes, Merus® HPQ has two basic **compensation modes**. Therefore, the HPQ-module can be easily tailored to solve specific power quality problems. The basic compensation modes are:

Compensation Mode I – Selectable

- Offers the possibility to select the harmonic order to be compensated (odd and even).
- The percentage of compensation degree for harmonics 1 to 25 can be set to 0–100% for each harmonic individually.
- Fundamental current load balancing is programmable in this mode.
- Typically used for compensating relatively stable harmonic problems such as VFDs.
- The response time with this mode equals that of the fundamental frequency cycle time.
- **Recommended option for the majority of cases.**

Compensation Mode II – All harmonics

- This operation mode is the most dynamic, offering real-time compensation of all harmonics and fundamental reactive power.
- Fundamental current load balancing is programmable in this mode.
- The remaining current in the network consists of positive sequence active current and a negligible amount of harmonic currents.
- **In the All harmonics -mode, the resonance phenomenon between the module and network components is possible due to the fast response time and higher frequency range. The resonance phenomenon is due to the resonance points in the system, and is a widely known fact with all AHFs. In the worst-case scenario, it can lead to damage and module malfunction. Without knowledge about possible resonance points in the system, it is highly recommended to use the SELECTABLE compensation mode to avoid this issue.**

***Note:** The default compensation mode in HMI version 2.1 and later is **Selectable**. Compensation mode is moved to advanced settings on the HMI. If there is a need for other compensation modes, the technical service should be contacted in order to access the password for this setting.

3.3 HPQ-module properties

The important features of the HPQ-module are explained in this section.

3.3.1 Standby

The HPQ-module is equipped with a standby feature. In Standby mode, the HPQ-module stops the IGBTs from producing current if the required compensation current is below a configurable limit. Standby mode increases the component's service life and provides energy savings for the customer. An example is provided in Figure 4.

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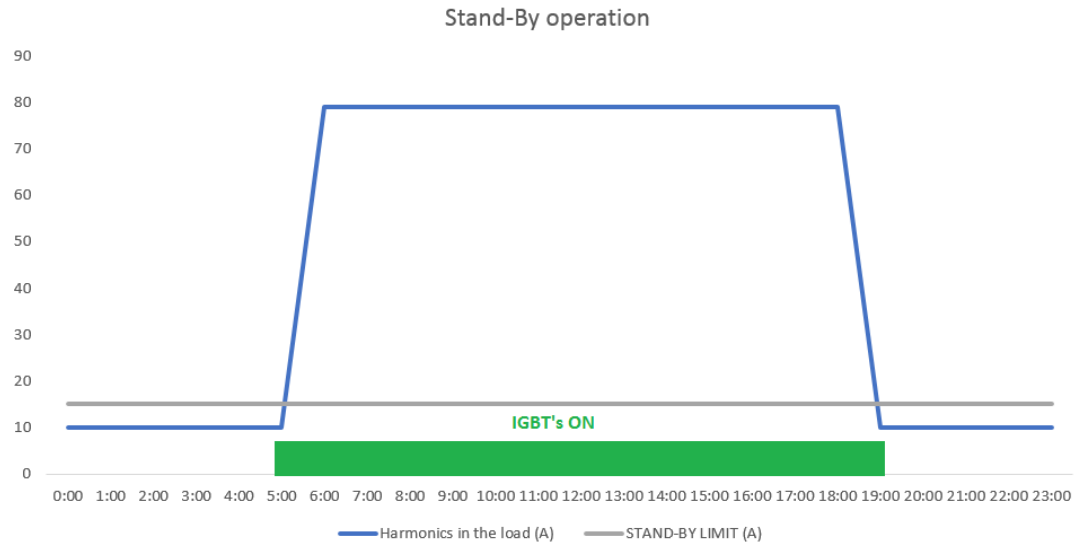

Figure 4: Standby example

- Standby mode is activated when harmonics in the measurement point decrease below the limit of 30 s.
- Standby mode is deactivated when harmonics are above the limit of one network period.
- The time limit between modes is 30 s.
- Standby trigger level is the module reference (output) current in amperes (A). It is not the actual load current level.
- As an example, typical value for a standby trigger might be 10 A. This means that when the needed compensation for that module is less than 10 A, the module goes to sleep.
- The setting on the HMI refers to a single module reference level and not the total system output in parallel module cases.

3.3.2 Load balancing

Load balancing allows the user to balance unbalanced loads in the three-phase (four-wire or three-wire) networks without making larger system changes. The user enters the percentage (from 0% to 100%) of the unbalanced current. This setting is disabled by default, and it should be turned on only after the module configurations are correct and if balancing is needed. An example of load balancing is presented in Figure 5.

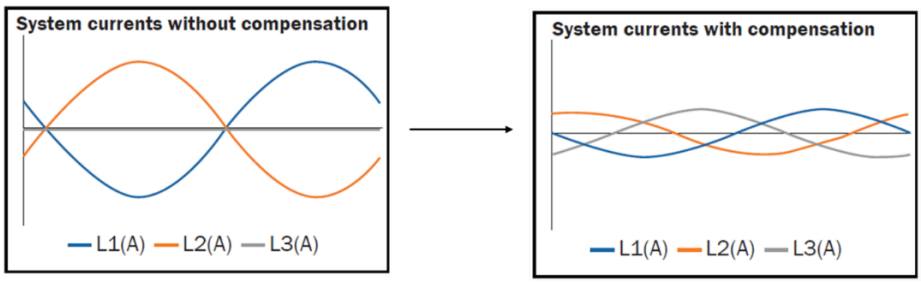

Figure 5: An example of fundamental cycle current load balancing.

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3.3.3 Reactive power compensation (Power Factor Correction)

The HPQ-module can dynamically compensate both inductive and capacitive fundamental reactive power. The compensation can be done up to the module's nominal current. The HPQ-module will either try to compensate all or some of the reactive power from the network with the capacitor bank, depending on the target power factor setting (see Table 12).

The reactive power of the HPQ-module can be calculated based on the nominal voltage with the following equation:

$$Q = \sqrt{3} * U_{ll} * I,$$

where U_{ll} is the main voltage, and I is the HPQ-module current. The reactive power output for the different HPQ-modules is shown below in Table 1.

Table 1: Reactive power output

Nominal voltage	50 A	100 A	125 A	150 A	200 A
200 VAC	-17 to +17 kvar	-35 to +35 kvar		-52 to +52 kvar	-69 to +69 kvar
220 VAC	-19 to +19 kvar	-38 to +38 kvar		-57 to +57 kvar	-76 to +76 kvar
380 VAC	-33 to +33 kvar	-66 to +66 kvar		-99 to +99 kvar	-132 to +132 kvar
400 VAC	-35 to +35 kvar	-69 to +69 kvar		-104 to +104 kvar	-139 to +139 kvar
415 VAC	-36 to +36 kvar	-72 to +72 kvar		-108 to +108 kvar	-144 to +144 kvar
440 VAC	-38 to +38 kvar	-76 to +76 kvar		-114 to +114 kvar	-152 to +152 kvar
480 VAC	-42 to +42 kvar	-83 to +83 kvar	-104 to +104 kvar	-125 to +125 kvar	-166 to +166 kvar
525 VAC	-45 to +45 kvar	-91 to +91 kvar	-114 to +114 kvar		
600 VAC	-52 to +52 kvar	-104 to +104 kvar	-130 to +130 kvar		
690 VAC	-60 to +60 kvar	-120 to +120 kvar	-149 to +149 kvar		

Example of the reactive power compensation with the dynamic HPQ-module and the fixed capacitor steps is presented below in Figure 6, which shows how the module load rate is always kept at a minimum and the main part of the reactive power is produced with the capacitor banks.

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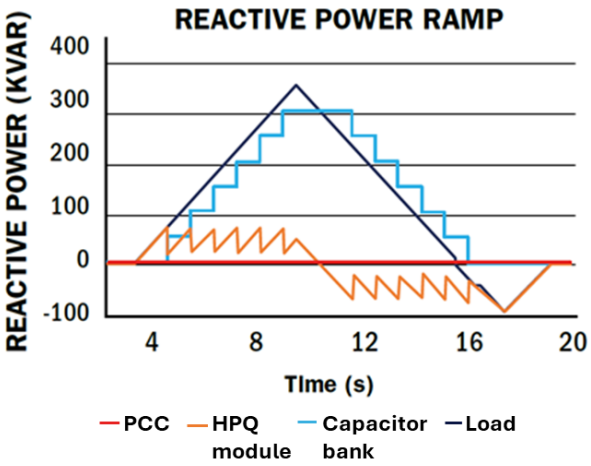

Figure 6: HPQ reactive power compensation.

3.3.4 AutoStart

The AutoStart feature allows the HPQ-module to start automatically after a network power failure. This setting is disabled by default and should be turned on only after the module configurations are correct and if this functionality is required. Note that if AutoStart is enabled, it will start automatically if the main power switch has been turned off and then turned on after a while.

Figure 7: AutoStart flowchart

3.3.5 AutoAck

The AutoAck feature allows the HPQ-module to acknowledge non-severe errors (not IGBT-error) after tripping and automatically start again. The HPQ-module stops acknowledging errors if acknowledging has occurred five times within 30 minutes. In this case, the HPQ-module will not work (result in **(TRIP) Too many AutoAcks have occurred**), until it is powered off for five minutes and the cause of the trip is cleared. This setting is disabled by default and it should be turned on only after the module configurations are correct and if such functionality is required.

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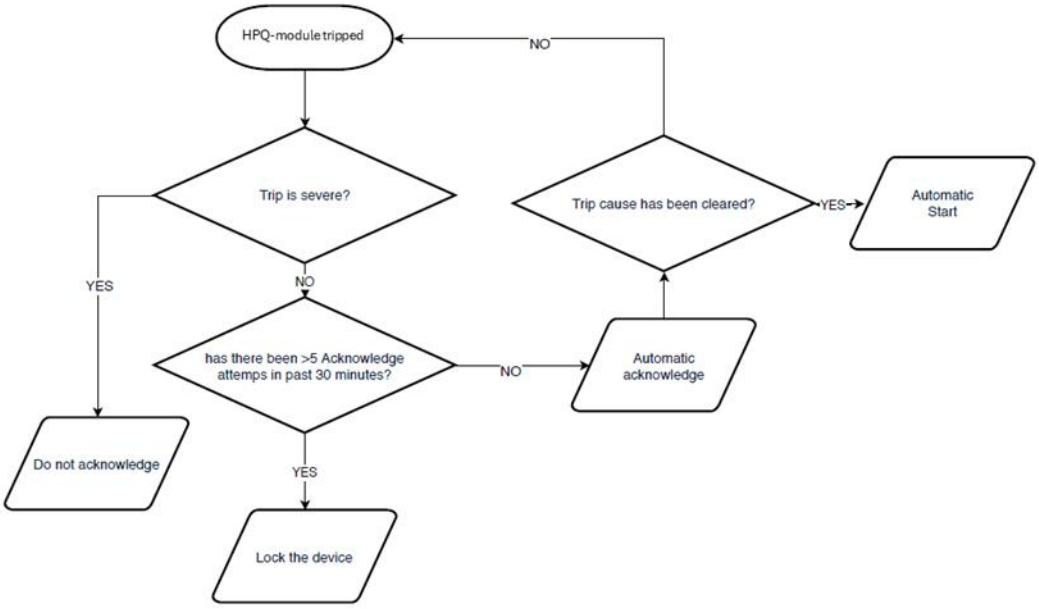

Figure 8: AutoAck flowchart

3.3.6 Internal fans

There is an easy-to-replace fan tray in the HPQ-module. The fans are temperature controlled, and their speed is adjusted linearly based on the HPQ-module temperatures. The speed adjustment allows longer fan and air filter service life while enabling energy savings.

Figure 9: Internal fan tray

3.4 Derating

In the normal operating environments (see technical data in Chapter 10), the HPQ-module operates with 100% capacity. If the HPQ-module is installed in a different environment, it will derate the output current automatically depending on the ambient temperature.

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3.4.1 Altitude

100% of the nominal capacity will be used if the installation altitude is max. 1000 m from sea level. **If the installation altitude is higher than 1000 m from sea level**, the following derating values will take effect:

- 1% of derating for every additional 100 m
- Maximum installation altitude is 3000 m above sea level for 200–480 VAC modules and 2000 m for 690 VAC modules

3.4.2 Temperature

At the nominal operating temperature, the HPQ-module works at 100% of the nominal capacity (see technical data in Chapter 10). However, if the installation temperature **is higher,** the HPQ-module will reduce the maximum output current automatically. The general capacity above the nominal temperature is presented in a generic model in Figure 10*.

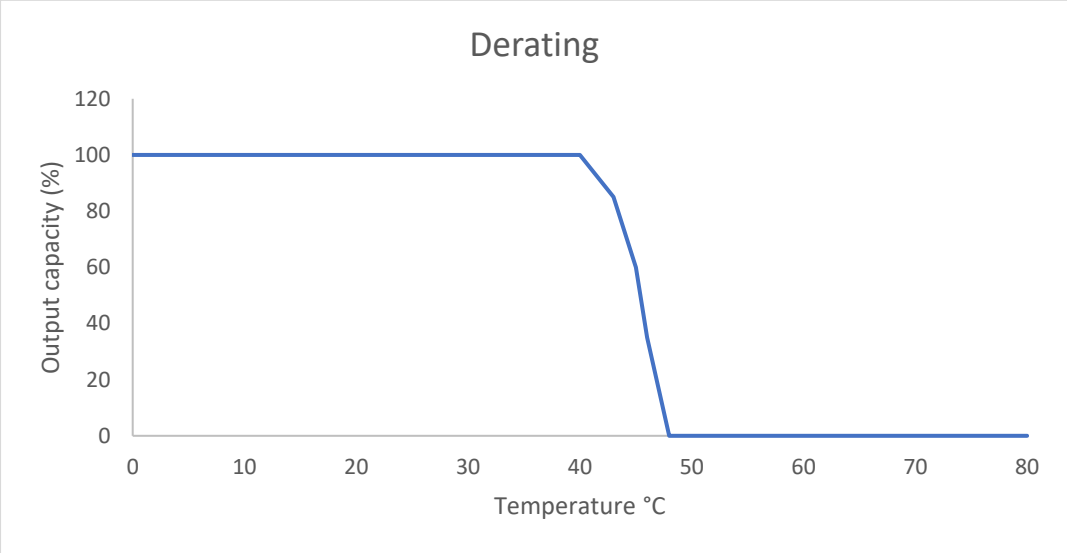

Figure 10: Derating coefficient in the function of the temperature

***Figure 10 is for illustration purposes only.** The actual operation capacity depends on the actual installation environment and the load current harmonics spectrum.*

3.4.3 Harmonic order

The HPQ-module is capable of mitigating harmonics up to the 50th harmonic. The full nominal current capacity can be used up to the 25th harmonic. Figure 11 shows an illustration of higher derating of harmonics. Note: This curve shows the potential maximum for each harmonic. The system should not be dimensioned for the 25th harmonic's full nominal capacity in 24/7 operation.

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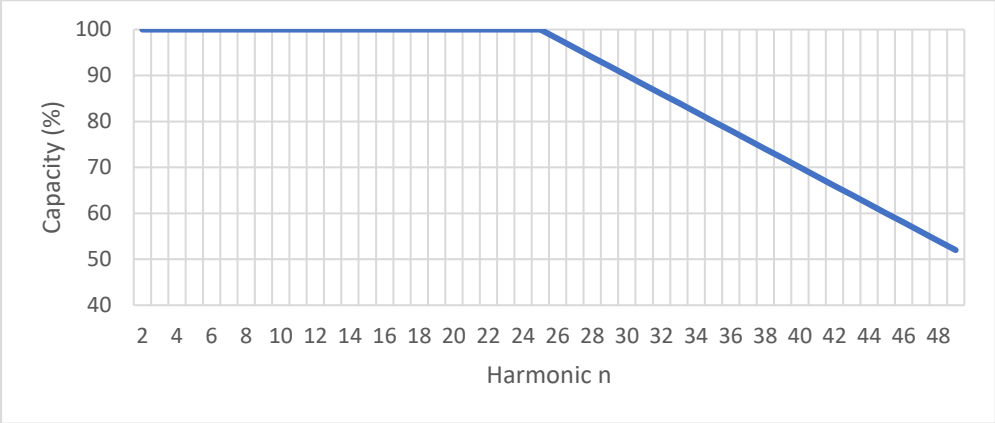

Figure 11: Higher harmonic derating linearization on HPQ-module @ 400 VAC 50 Hz

This information can be used for dimensioning the module(s).

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4. Application selection and sizing

4.1 Application selection

Determining the needed application can be difficult in some cases. An example application selection table is presented in Figure 12.

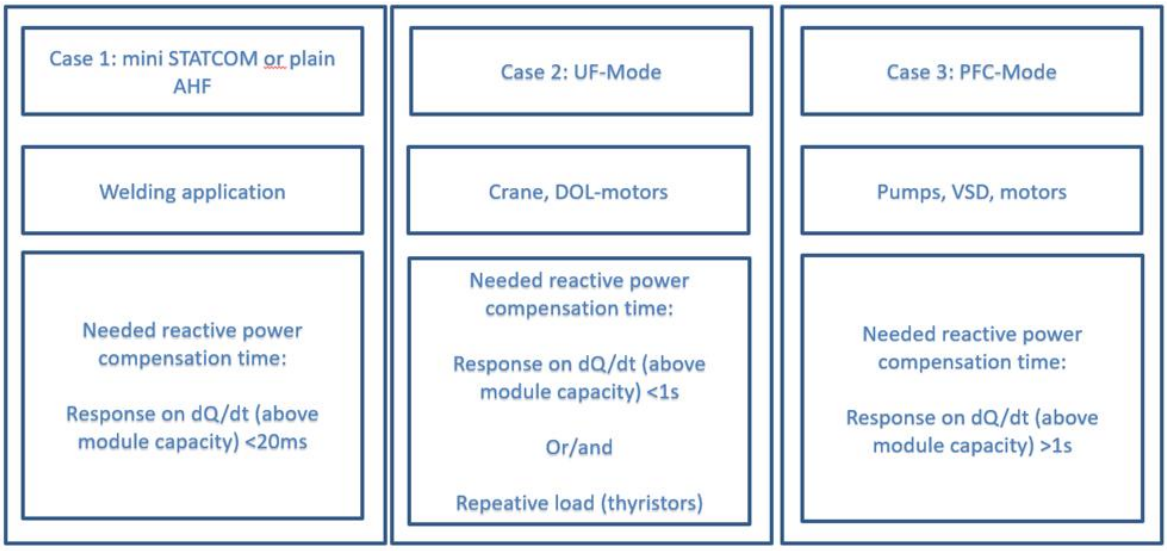

Figure 12: Application selection example.

Application types are divided into three categories:

1. Plain AHF or AHF with fixed capacitors.
    - This is needed in a welding application where the reactive power is changing rapidly, and the needed response time is less than one network cycle. In one network cycle, even the thyristor-controlled step is usually too slow even when the application works. In this case the flicker is not mitigated as well with HPQ as with regular AHF.
2. UF-mode
    - This is needed in an application where the load is changing over the HPQ-module(s) capacity of under one second and a higher response time is needed. Typical loads are cranes and DOL-motors that often have a repetitive load profile and where thyristors should be used.
3. PFC-mode
    - In most loads, the response time for dQ/dt over HPQ-module capacity is not less than one second. When the load has a repetitive cycle, consider using thyristorsin this mode.

Typical load profiles are presented in Figure 13.

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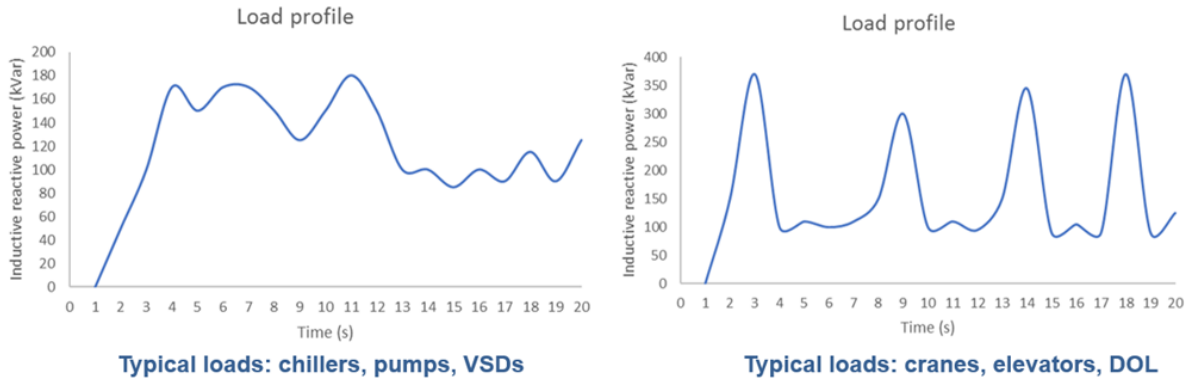

Figure 13: Load profiles.

4.2 Current distribution between fundamental and harmonic current

All the HPQ-modules have a nominal output capacity. This nominal current can be divided into a fundamental current and harmonic current so that the following equation is true.

$$I_{nominal} = \sqrt{I_{fundamental}{}^2 + I_{harmonic}{}^2},$$

Where $I_{fundamental}$ equals current for reactive power and $I_{harmonic}$ equals current for harmonics (I_{h2}→). This is illustrated in Figure 14.

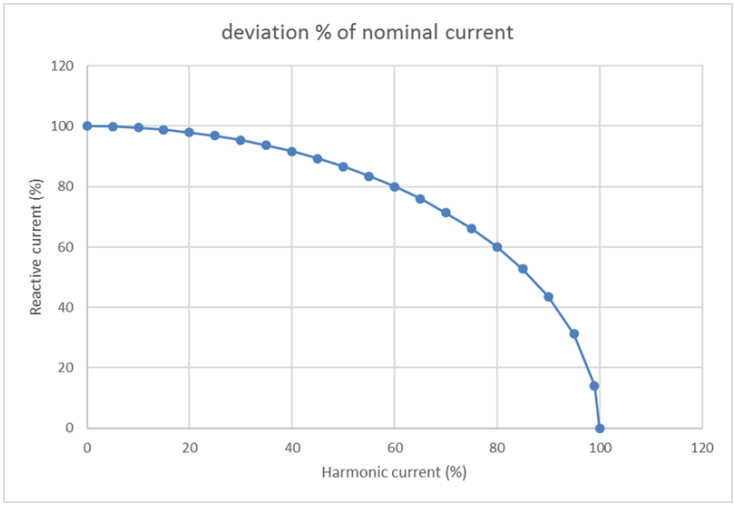

Figure 14: RMS current distribution between fundamental and harmonic current.

From the equation and Figure 14, it can be seen that even when 50% of the total nominal current of the HPQ-module is used for harmonics, there is still 86% of the nominal current capacity left for fundamental compensation. **This is one of the biggest advantages of the HPQ.**

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4.3 Module and capacitor sizing

The rules of thumb for dimensioning:

Dimensioning of the capacitor:

- Minimum capacitor system size:
  - Maximum reactive power – The HPQ-module's reactive power capacity.
- Step size:
  - Based on the installation network and the HPQ-modules' size.
  - Typically, 50–100 kVAr.

Dimensioning of the HPQ-module(s):

- Based on step size: HPQ-module is ~1 step size (**or higher if dQ/dt is high**).
- Based on the inductive side's reactive power needs (if higher than one step).
- Add harmonics and unbalance needs for the total I_{RMS} needs.

Merus Power provides a sizing tool for HPQ-systems. Contact sales for more information.

4.4 Typical layout

The typical layout is shown below, combining two standard cubicles with control wires.

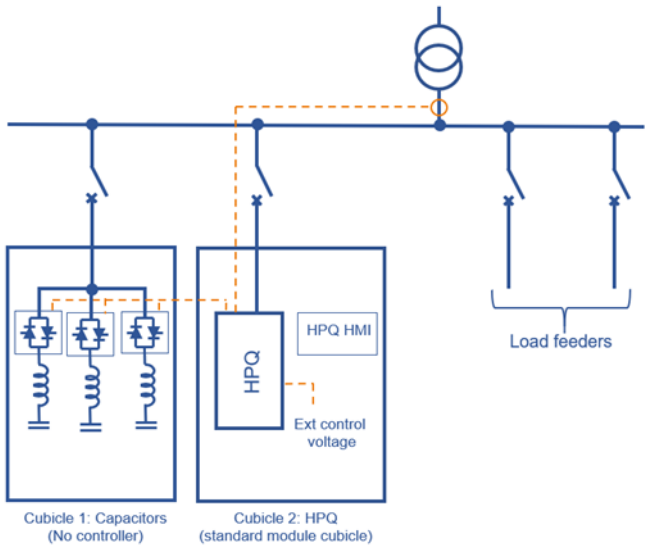

Figure 15: Typical layout.

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5. Delivery inspection and unpacking

All HPQ-modules are factory-tested before they are sent to the customers. Nevertheless, there is always a chance that the device has been damaged during transportation. It is therefore important to check the HPQ-module and package upon arrival. Careful attention must be paid during the installation process.

5.1 Before opening

Carefully check the external condition of the shipment before opening it. Ensure that the packaging is intact with no visible damage such as holes, dents, tears or contamination. Count the number of goods and verify that it matches the quantity listed on the waybill or transfer document

Verify that all tilt indicators are in the correct position. These indicators confirm that the shipment remained upright during transport. If any tilt indicator shows that the goods were tilted or turned upside down, note this on the waybill and immediately notify our customer service before opening the goods. This may indicate that the goods have tilted during transport.

Inspect impact indicators on the goods. These indicators react to significant impacts or shocks that could damage the contents. If an impact indicator has been triggered, note this on the waybill or transfer document and immediately notify our customer service before opening the goods. This could indicate that the goods experienced a severe impact during transport.

Before signing the waybill, thoroughly inspect the shipment. If you notice any discrepancies, such as damage, bruising, or missing items, it is crucial to clearly note the details of loss or damage on the waybill or transfer document when the goods are received. Document your observations on the waybill or transfer document, for example, "package bruised" or "1 carton missing."

Ensure that your note appears on all copies of the waybill or transfer document, including the one retained by the carrier. This claim is necessary to file a claim with the carrier. Without it, it is impossible to prove that the shipment was damaged at the time of receipt. If you make a claim, take photos of the situation and promptly inform our customer service. This will expedite the handling of any potential claims.

Scan the QR-code to view a video presentation of how to inspect a shipment.

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5.2 After opening

After opening the package:

- The condition of the protective bag/plastic must be checked for dirt and moisture. Moisture can damage the electrical components of the HPQ-module.
- The shipping list and package must be compared with one another.
- The serial numbers and rating plate must be compared with the order/shipping documents (device specifications are located on the HPQ-module front panel rating plate).

When the HPQ-module is removed from the pallet, note that:

- The device is heavy
- The edges of the sheet metal can be sharp
- The centre of gravity is relatively high
- The device MUST NOT stand on its own as shown in Figure 16 – this may damage the bottom connectors

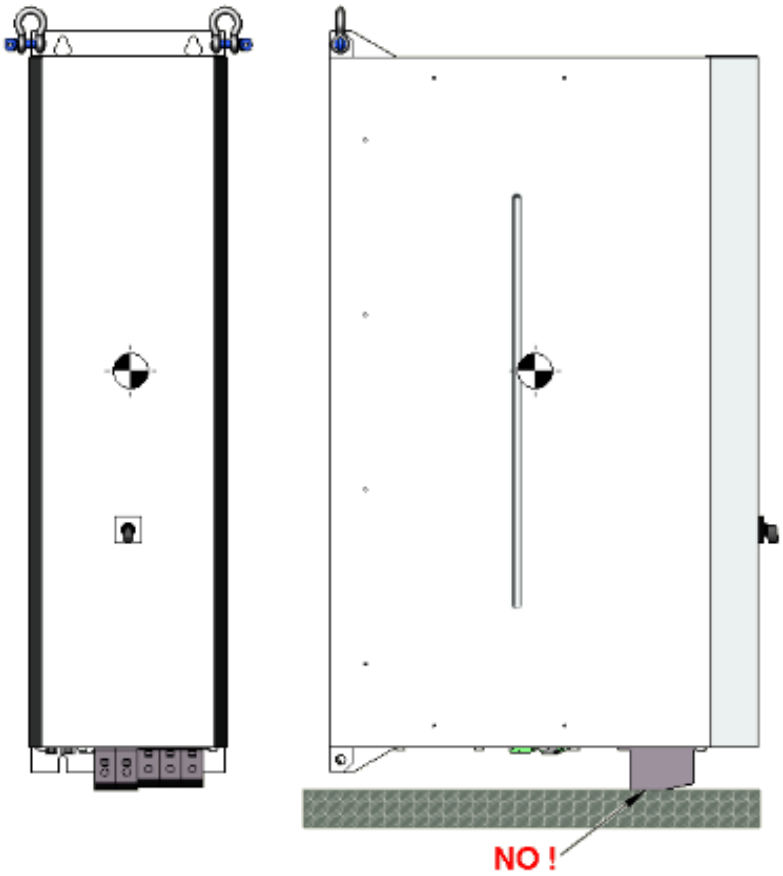

Figure 16: HPQ-module's centre of gravity

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5.3 Storage

It is recommended to keep the module in its own delivery package until installation. The HPQ-modules must be stored inside a warm and dry location (see specification in Table 17). A long storage period is not recommended. If the storage time is more than nine months, a local distributor must be consulted.

5.4 Lifting

The device has two Ø11 mm holes in the back top corners for shackles, as shown in Figure 17.

Note that when the device is lifted from the lifting points, it tilts about 30°!

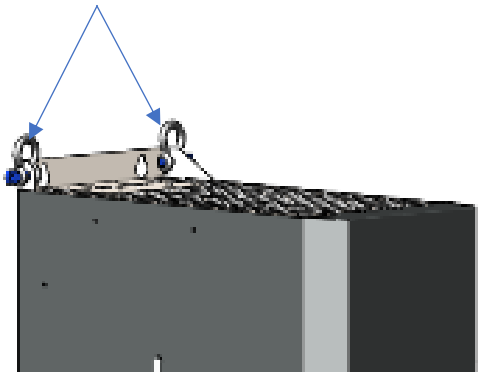

Figure 17: Lifting points

It is possible to use lifting accessories to lift the module, such as in the example below. By using these accessories, the module stays in vertical position when lifted.

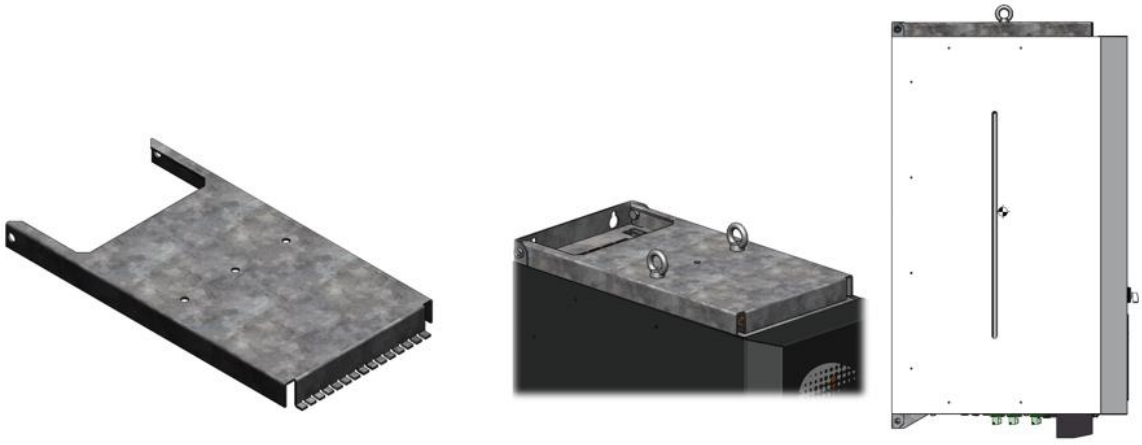

Figure 18: Lifting accessories*

** Sold as accessories upon ordering the module.*

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6. Physical properties and installation

The HPQ-module's dimensions, electrical connections, and cabinet installation are covered in this chapter.

6.1 The HPQ-module physical properties

The physical dimensions and other physical properties are covered in this section.

6.1.1.1 Dimensions

The HPQ-modules come in two physical frame sizes:

- **Smaller module size (Case 1):** for 400 VAC modules with current rating below 100 A
- **Larger module size (Case 2):** for 690 VAC modules and current ratings of 150 A and 200 A

The dimensions of the smaller HPQ-module size are illustrated in Figure 19. The dimensions for the larger HPQ-module are illustrated in Figure 20.

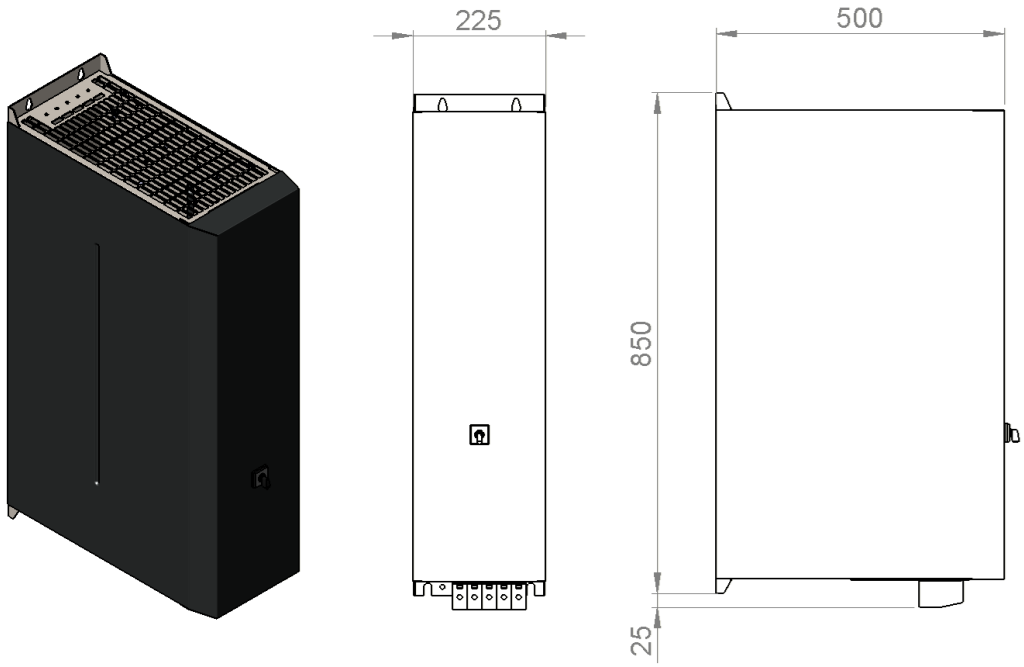

Figure 19: Smaller module (bottom-entry) dimensions in mm.

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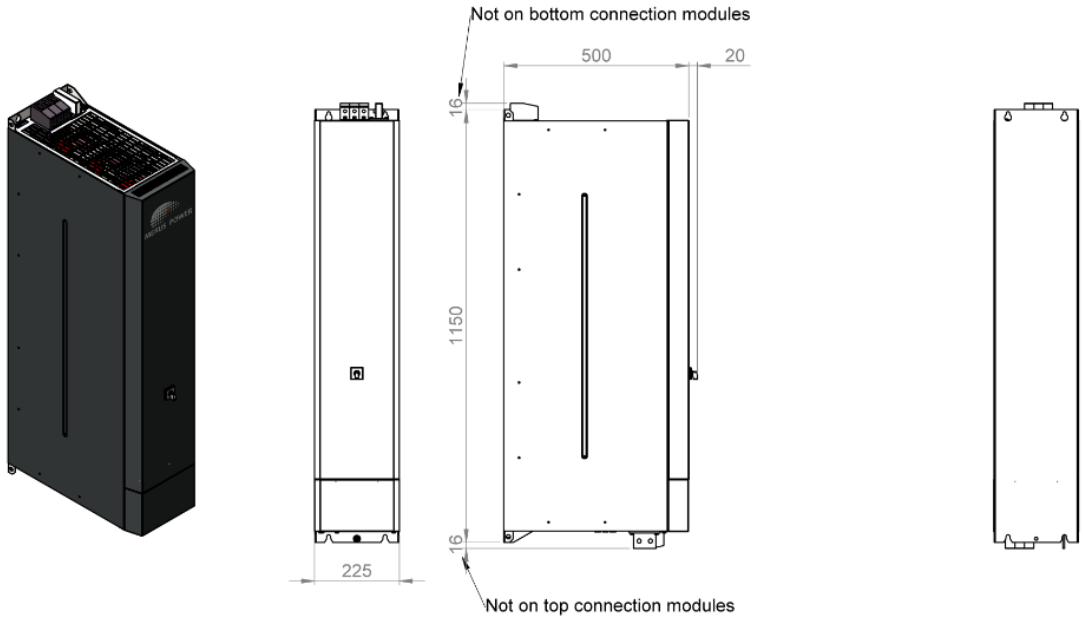

Figure 20: Larger module dimensions in mm.

6.1.2 Main power cable entries

The HPQ-modules can have main cables fed from the bottom of the module or from the top of the module. This allows for easier installation in various kinds of cubicles. The standard delivery is the bottom-entry module. Apart from the main cable entry location, the top- and bottom-entry devices are identical. As a result, some of the pictures and explanations are only for bottom-entry devices. The illustrative picture of the top entry module is presented in Figure 21.

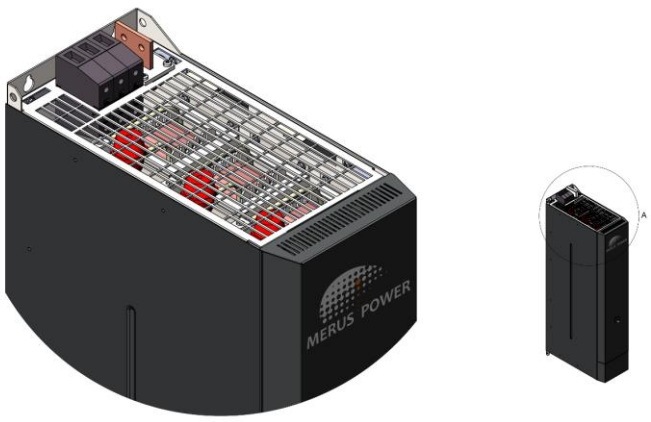

Figure 21: An illustrative picture of the larger top-entry module

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6.1.3 HPQ-module front panel

The HPQ-module has the main power switch in the front of the module. The main power switch connects/disconnects internal DC-control voltage from the control electronics. **It does not disconnect AC voltages in the module.** The main power switch is shown in Figure 22.

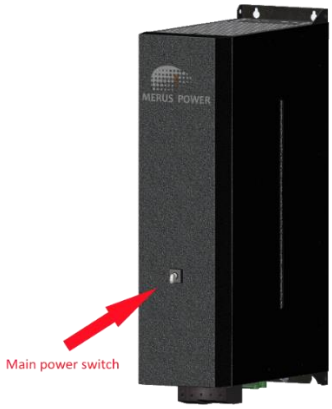

Figure 22: Main power switch

The front panel can be opened when access inside the module is needed. When removing the front panel, be careful not to break the main power switch, as the wiring is attached to the panel. The front panel can be removed by removing the two T25 screws at the bottom of the front panel, tilting, lifting, and then removing the main power switch plug.

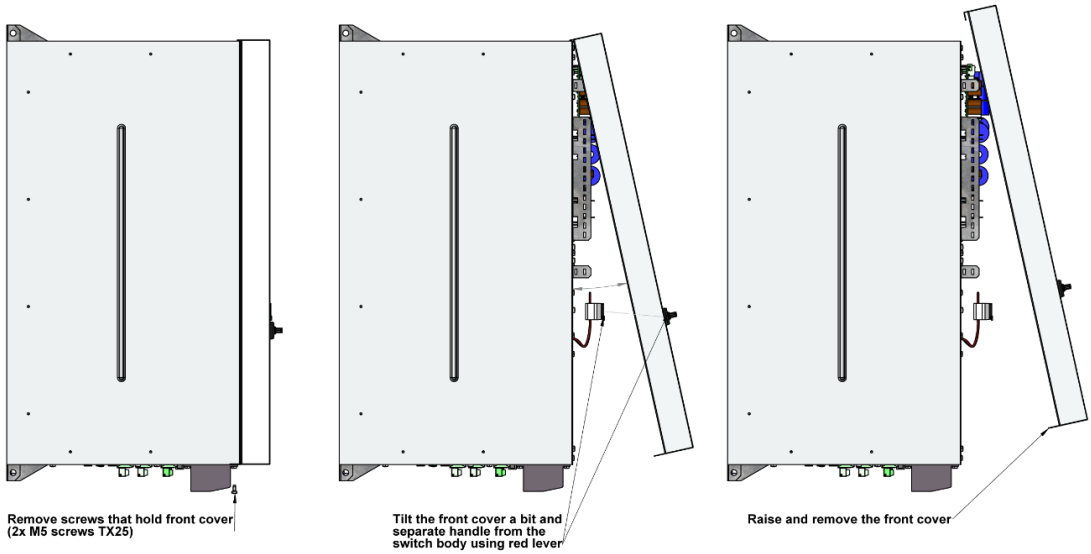

Figure 23: Removing the front panel of the HPQ-module

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6.1.4 Terminals and connectors

The following connections are found in the HPQ-module:

MAIN TERMINALS

- Main power cable terminals: L1, L2, L3 (35 mm^2–95 mm^2, tightening torque 15–20 Nm)
  - Suggested cable sizes are 50 mm^2 for 50 A–100 A modules and 70 mm^2 for 125 A–200 A modules.
    *Always consider factors such as local standards and installation type.
- Neutral terminal: N (tightening torque 15–20 Nm)
- Protective Earth terminal: PE

SIGNAL TERMINALS

- HMI power output: 12 VDC
- Current measurement terminals X1–X4
- Ethernet terminals: 1 and 2
- Banana plugs for DC voltage
  - Only for service use

Figure 24 shows the terminal locations of the smaller module.

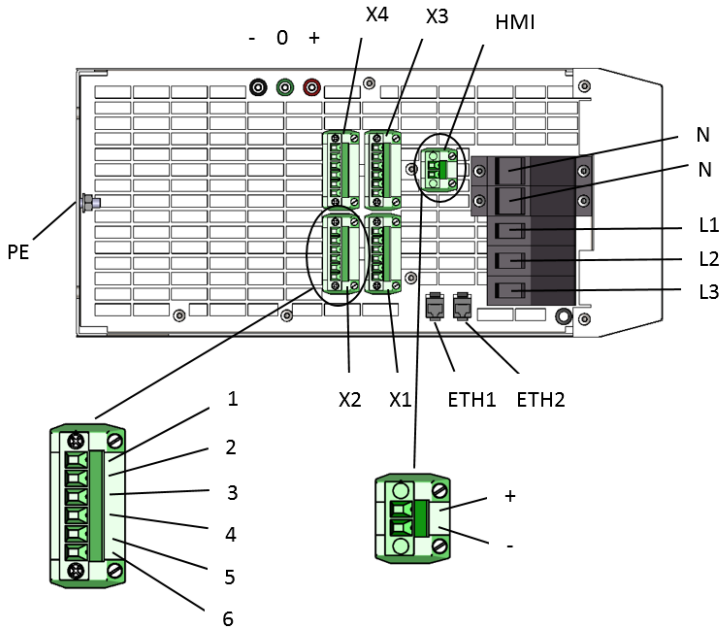

Figure 24: Terminals in the smaller bottom entry module

One current transformer terminal and an HMI terminal are magnified in Figure 24. All four current transformer terminals have the same pin order. Terminals X2 and X4 have their pins shorted in standard delivery. In the case of parallel connected modules, the jumpers should be removed. More information about external current transformer connections in single and parallel modules is provided in section 6.4.

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In the larger modules, you can find the signal terminals inside the bottom-front cover as shown in Figure 25 and Figure 26: Bottom front cover for 690 VAC modules. To access the terminals, unscrew the two T25 screws from the bottom front cover.

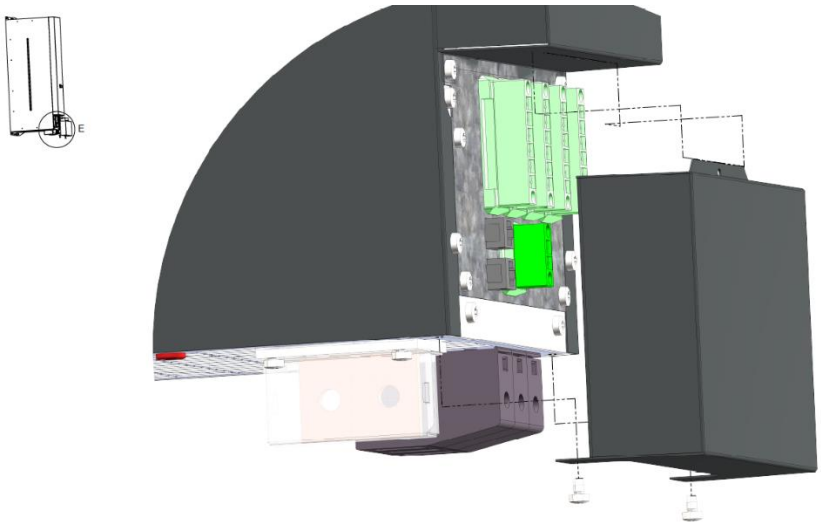

Figure 25: HPQ-150/200 A Device bottom front cover.

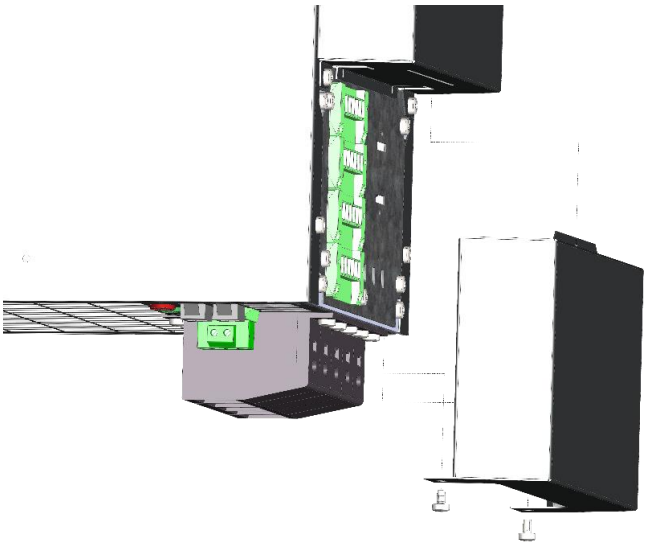

Figure 26: Bottom front cover for 690 VAC modules.

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The main terminals are either at the bottom or at the top of the module. An image of these terminals (bottom entry) is presented in Figure 27.

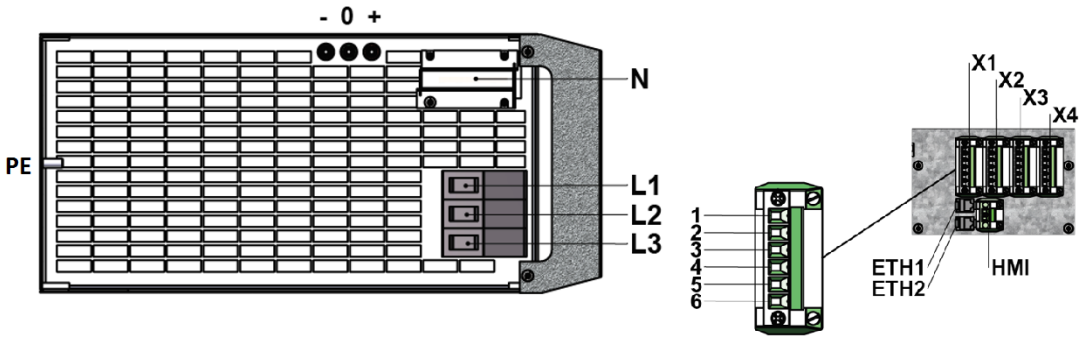

Figure 27: HPQ-150/200 A terminals in bottom entry module.

For 690 VAC modules, the previous connectors can be found in Figure 28 and Figure 29.

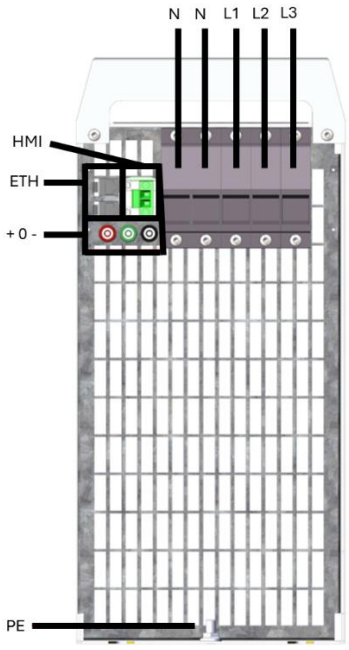

Figure 28: 690 VAC module bottom connectors.

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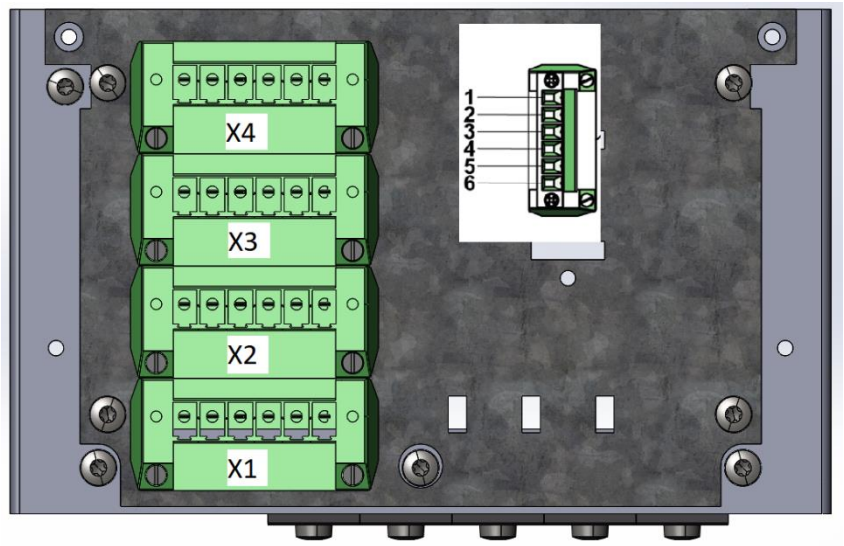

Figure 29: 690 VAC module front connectors.

In 150 A/200 A modules, the neutral is a touch-protected busbar with a plastic cover. If 4 W operation is desired, remove the cover and install the screws back in. An example is shown in Figure 30.

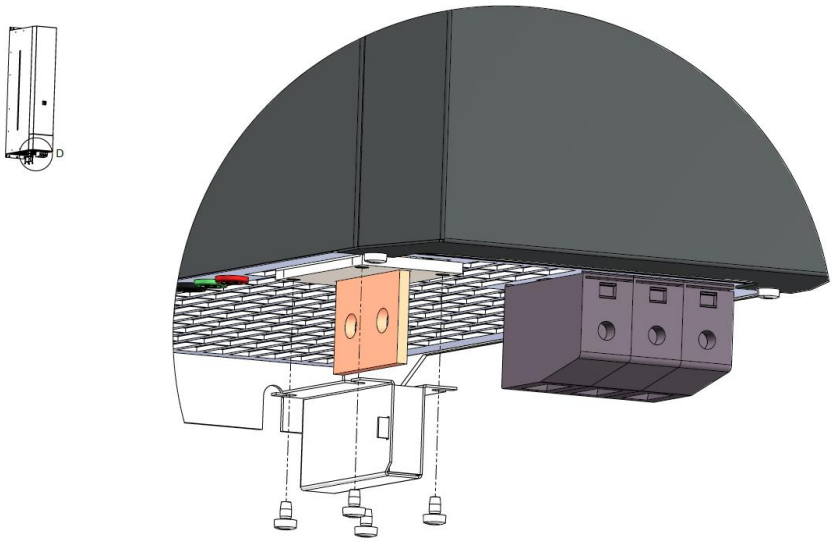

Figure 30: Neutral cover of the HPQ-150A/200A module

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6.2 Electronic boards, hardwired signals, and fibre optics communication

The electronic board locations in the module, hardwired I/O-signals, and communication control communication methods are covered in this section.

6.2.1 Location of the electronic boards

There are two main electronic boards in the module.

- AUX board (measurement and auxiliary card)
- MCC board (control card)

The location of these boards for the smaller module size is shown in Figure 31. The locations in the larger module are similar.

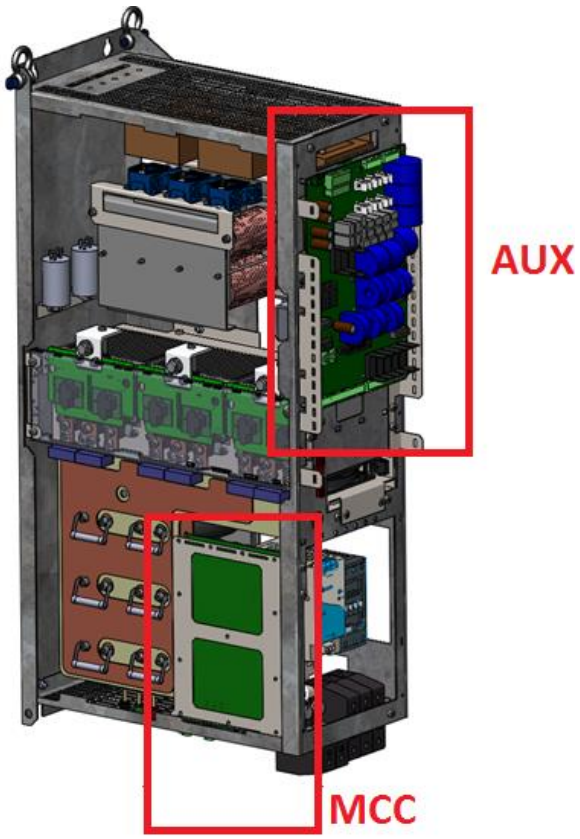

Figure 31: Location of the electronic boards in the HPQ-module

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6.2.2 Overview of the boards

6.2.2.1 MCC-card

An overview of the MCC card is presented in Figure 32.

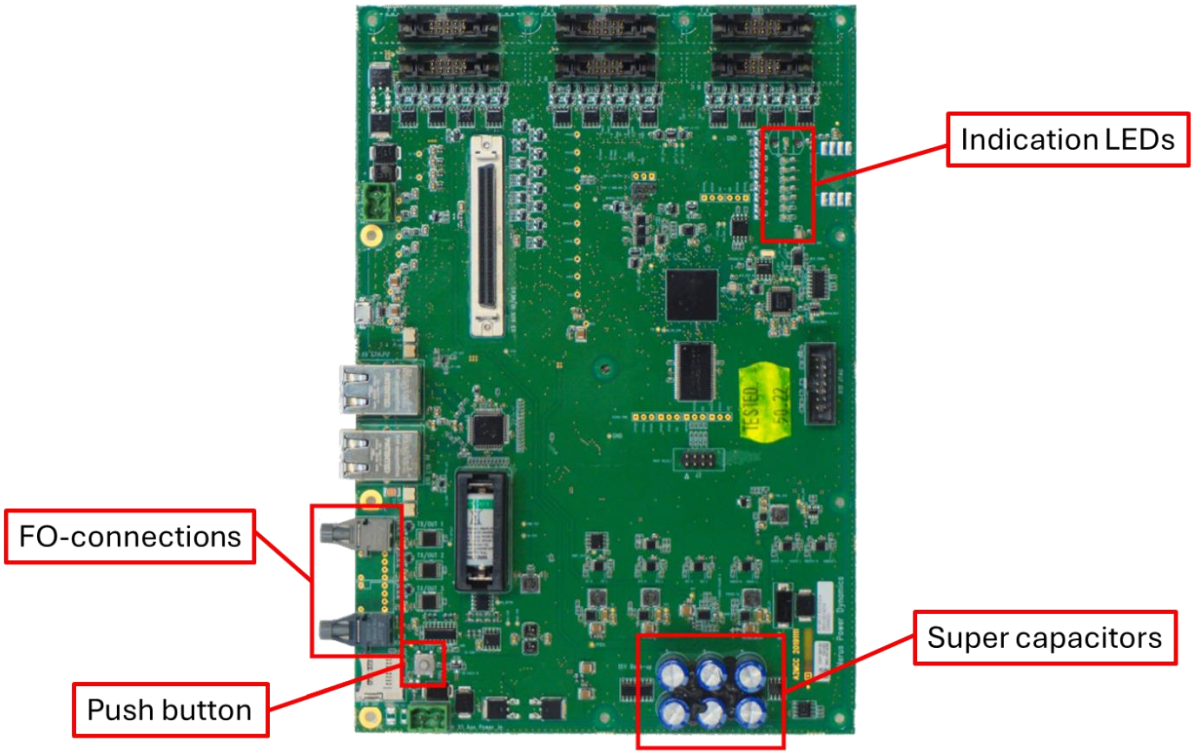

Figure 32: MCC card overview.

The following points are highlighted:

- FO connections (section 6.2.4)
- Super capacitors
  - Maintain control voltage after an AC power failure for < 5 min
- Push button
  - Used as a service button. Normally not needed.
- Indication LEDs (Figure 33)

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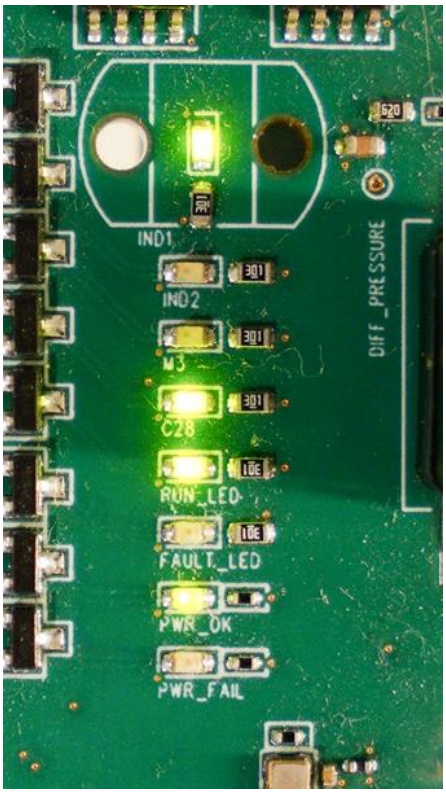

Figure 33: MCC card indication LEDs.

The indication LEDs can be seen from the front of the module. They indicate various states as follows:

- IND 1: System state blinking light
- IND 2: Not in use
- M3: Blinks in 1 s periods if communications processor is functional
- C28: Blinks in 1 s periods if controls processor is functional
- RUN_LED: Not in use
- FAULT_LED: Red in case of a fault or if USB connection is open
- PWR_OK: Green if power is OK
- PWR_FAIL: Red in the case of a power supply fault

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6.2.2.2 AUX card

An overview of the AUX card is presented in Figure 34.

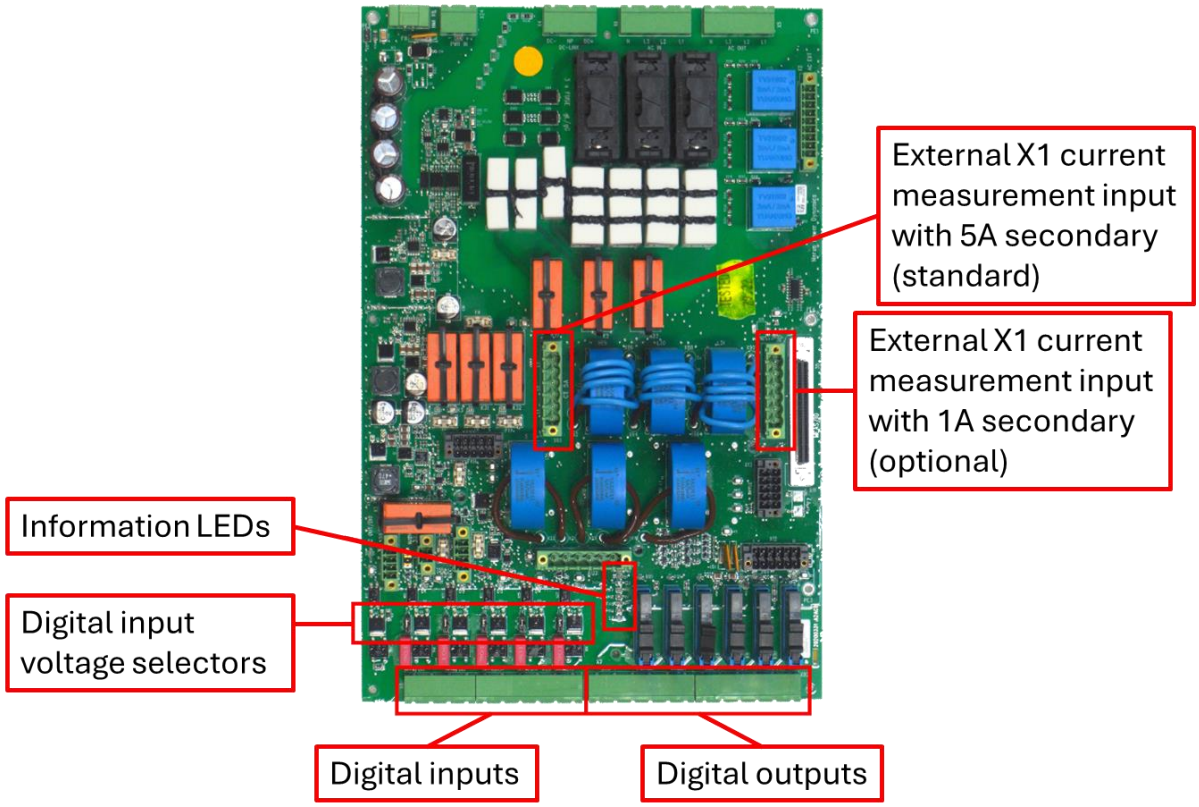

Figure 34: AUX card overview.

The following points are highlighted:

- Digital inputs (section 6.2.3)
- Digital input voltage selector (section 6.2.3)
- Digital Output (section 6.2.3)
- External current measurement secondary selection (section 6.4.10)
  NOTE: Unplugging the internal CT secondary selection connector will break the CT secondary loop. Remember to short circuit the CT secondaries!
- Information LEDs
  - Service information

6.2.3 Hardwired I/O signals

Note: Hazardous voltage might exist inside the module when external hardwired signals are used even though the module itself is powered down. Always measure voltages before touching.

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The HPQ-module has several hardwired inputs and outputs prebuilt in the system. The inputs can be connected to an external I/O logic, e.g. a SCADA system or fan control, while the outputs are used for capacitor bank step control signals. The I/O ports can be found on the AUX card as shown in Figure 34. There are:

- Five input ports
- Six output ports

Ports are presented in Figure 35.

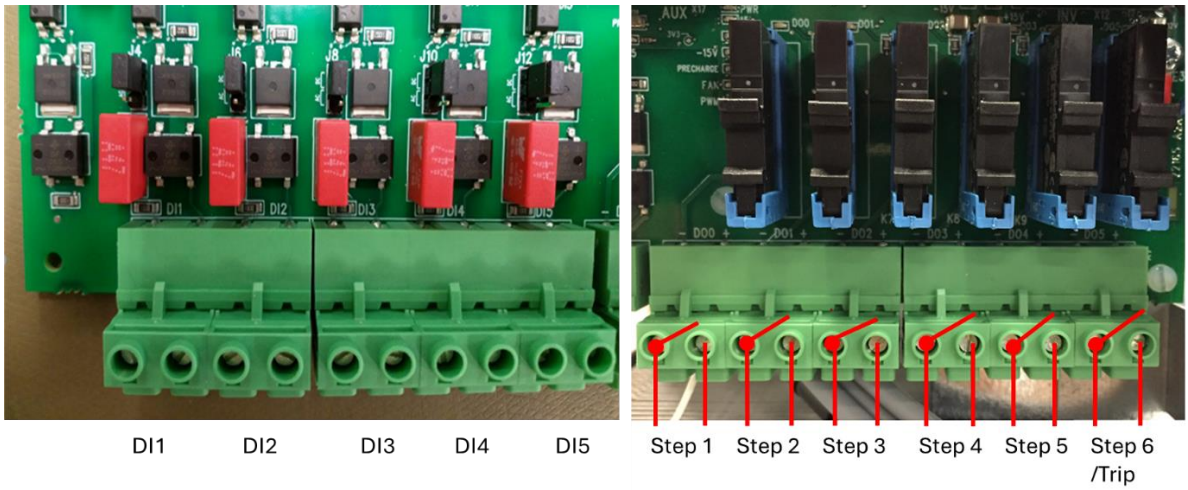

Figure 35: Digital inputs and outputs of an HPQ-module

All outputs and inputs are potential free and galvanically isolated. The voltage ranges in the input terminals are:

- 15 - 48 VDC
- 15 - 277 VAC

Note that the choice between DC and AC voltage in input terminals is made by changing the two-pin jumpers' configuration on the AUX board, as shown in Figure 36.

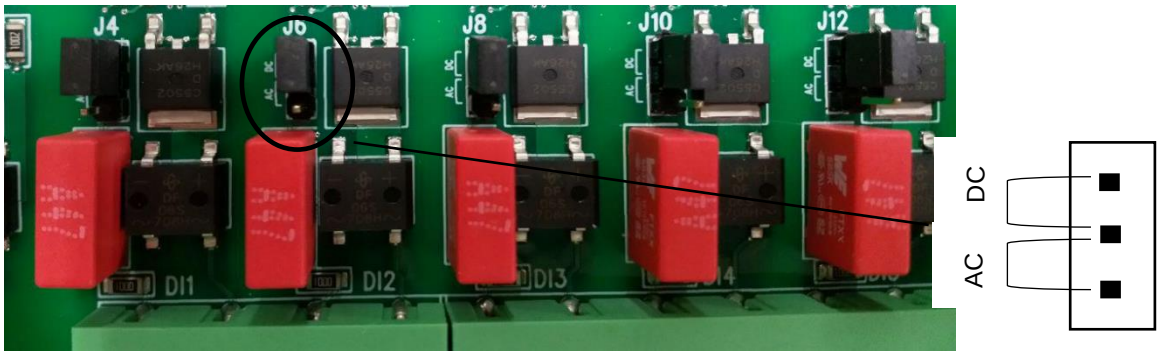

Figure 36: Input voltage choice on the AUX board, with one of the inputs magnified.

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The user must bring the desired control voltage level into the digital output terminal (< 48 VDC or < 277 VAC, the voltage source should be separate from the module). These outputs are potential free, but the relays are not designed to draw high currents. The user should not wire anything other than control signals into the terminals. The actual controlling of the capacitor bank will be done with either MCs or TCs.

Standard output relay specifications:

- Voltage range: 15 – 48 VDC / 15 – 277 VAC
- Rated operational current: 2 A (VDC) / 6 A (VAC)
- Electrical durability: 60 000 cycles
- Mechanical durability: 10 000 000 cycles
- Operate time: 12 ms
- Release time: 5 ms

The last DO-channel can be used for trip signal in the master module. In that case, the maximum outputs are (5 pcs MASTER + 6 pcs SLAVE). The connection is explained in Figure 35.

For the UF-mode, the AUX relays can be changed to Solid State Relays* (SSR) to achieve faster response time and longer lifetime. SSR specifications:

- Voltage range: 15 – 24 VDC
- Rated operational current: 2 A (VDC)
- Electrical durability: >1 000 000 cycles
- Operate time: 0.02 ms
- Release time: 0.2 ms

Three of the input ports can be configured with any of these features on HMI*:

Input ports (behaviour with active signal)

- TRIP (trips the device)
- Alarm (alarm for the HMI log)
- Standby (forces STANDBY-mode)
- Start (starts the device, push the button for 1.5 seconds)
- Stop (stop the device, push the button for 1.5 seconds)
- Acknowledge (acknowledge errors, push the button for 1.5 seconds)
- Not in use (no actions)

The input ports can also be used for a secondary power factor target setpoint.

**For more or different options, please contact a Merus Power sales person.*

6.2.4 Fibre Optics communication

If two HPQ-modules are installed parallel to each other, there is a need for fast communication between the modules. For this purpose, there is a fibre optic (FO) communication option in the MCC card. The secondary HPQ-module (slave) can be added to the system if one module output is not enough. In that case, the

secondary module is connected in parallel to the first module, and FO cables are connected between the modules. This way, the maximum step count increases to 12 pcs. The connection points and the connection method are presented in Figure 37.

Note that no regular A2 Active Harmonic Filter modules should be connected in the same loop for reactive current compensation. A2 modules that are used only for harmonic filtering can be applied parallel to HPQ-modules, but FO communication is not used between the A2 and the HPQ.

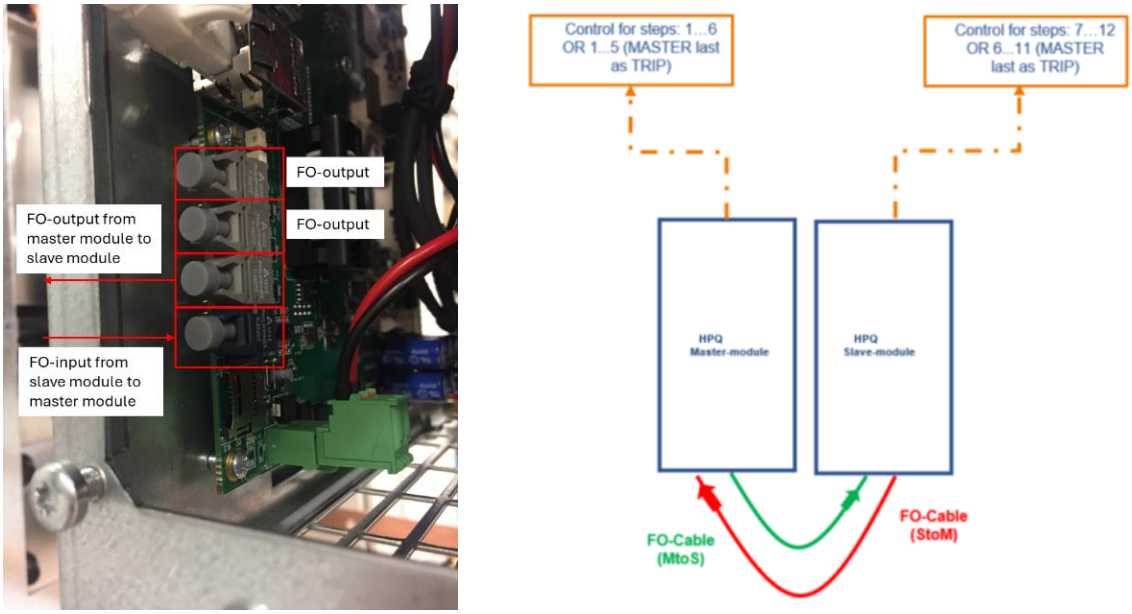

Figure 37: FO connection between parallel modules.

In installations with only one HPQ-module, a fibre optic connection is not required.

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6.2.5 Hardwire signal routes

Signals can be hardwired from the bottom of the front panels. An illustrative image is presented in Figure 38.

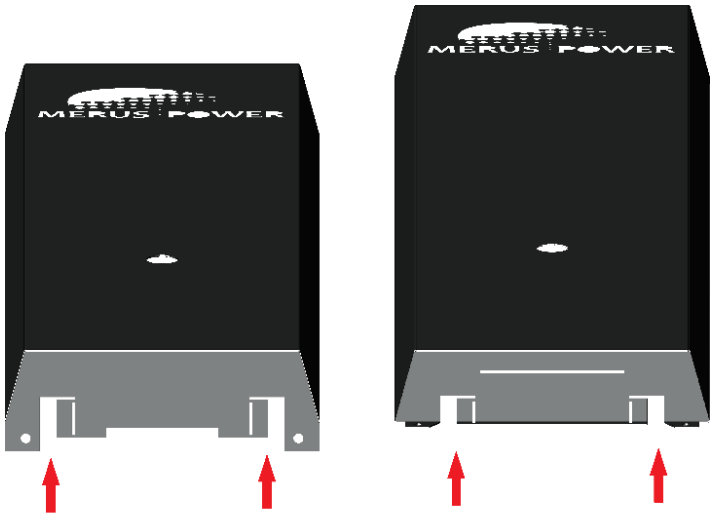

Figure 38: Hardwire signal routes on the front panel.

6.3 Mechanical installation

6.3.1 Typical cabinet installation

The HPQ-modules are designed to be installed in cabinets. The cabinets serve multiple roles such as:

- Creating higher IP-class for the module
- A place for external fuses, busbars, etc
- Dust prevention

An example of a full cabinet is presented in Figure 39:

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Figure 39: Example of a full cabinet

6.3.2 Module installation

The HPQ-modules are designed to be installed vertically inside a cabinet, as in the example shown in Figure 40.

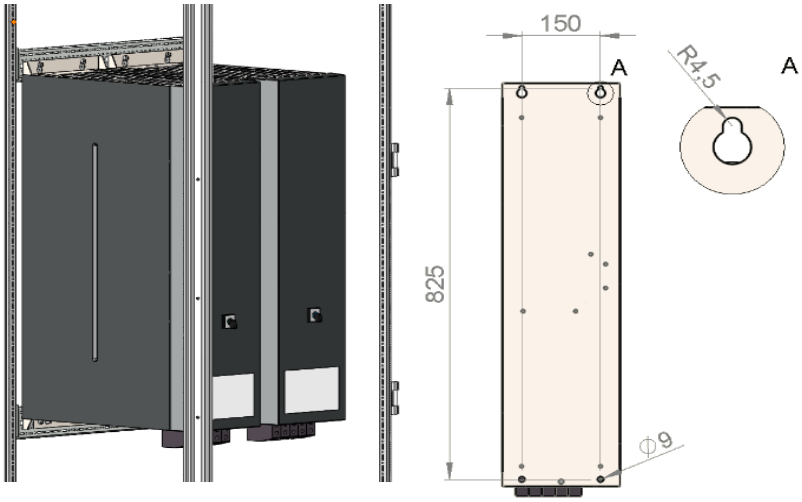

Figure 40: Fixing dimensions for smaller module size in millimetres

There are four fixing points on the back of the HPQ-module. When designing the installation of the module to the cabinet, the following guidelines must be considered:

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- Class 8.8 or better M8 bolts, nuts, and washers must be used.
- The fastening material/wall must be strong enough to hold the weight of the module.
- The shape of the top holes must be noted. To make installation easier, there are openings for the washers and heads.
- The bolts must be long and strong enough to carry the weight of the device.

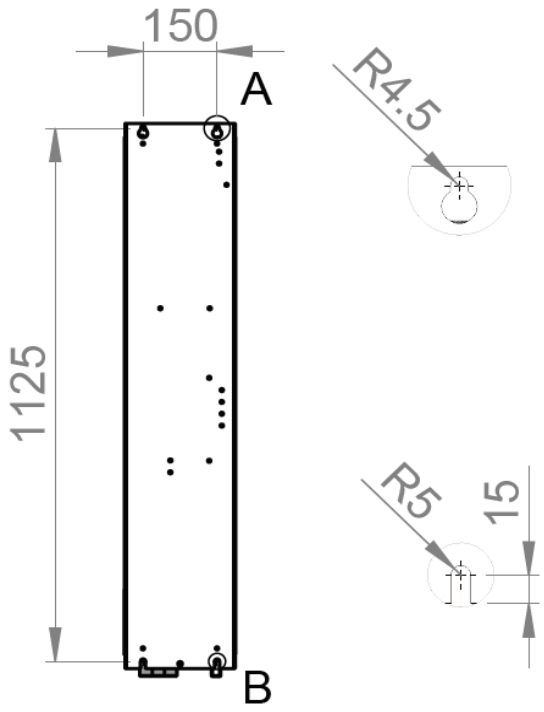

Figure 41: Fixing dimensions for larger module sizes in mm

6.3.3 HMI installation

The HMI panel should be installed in the cabinet door. Only one HMI panel is needed for up to seven parallel-connected modules. The cut-out dimensions for HMI installation are shown in Figure 43. HMI requires two cables from the module:

- RJ45 (CAT 5 or higher) (NOT INCLUDED IN THE DELIVERY)
- Two-pole power cable (≥ 1.5 mm² Cu, 12 Vdc) from the first module (NOT INCLUDED IN DELIVERY)

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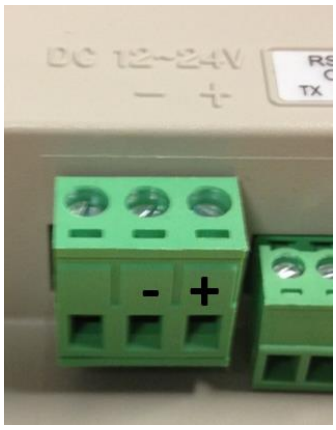

Figure 42: HMI power connection

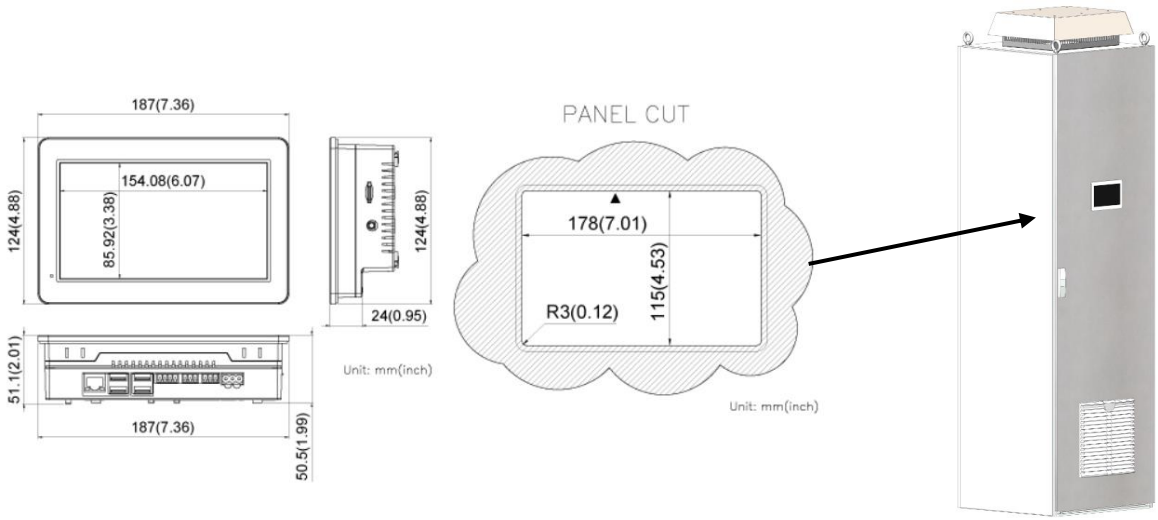

Figure 43: Example of installation of the HMI panel on a cabinet door. Dimensions in mm.

Merus Power also has an alternative HMI panel to ensure availability of panels. The alternative panel is slightly larger and presented in Figure 44. The alternative HMI specs can also be found in

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Table 21. It is recommended to ensure the correct HMI type upon ordering.

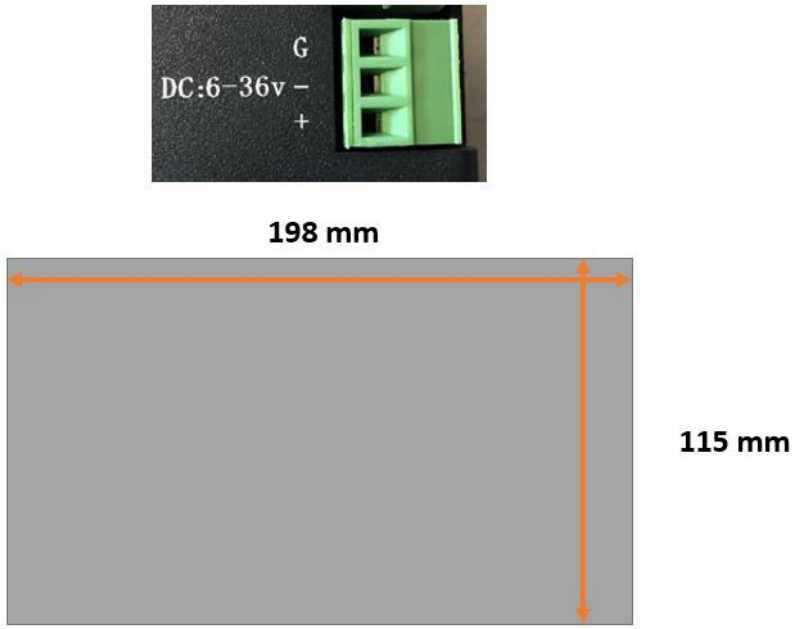

Figure 44: Alternative HMI panel power terminal and cut-out dimensions

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6.3.4 Air circulation

The HPQ-module airflow is shown in Figure 45. Cold air enters from the bottom and hot air exits through the top of the module. Therefore, some free space must be left above and below the HPQ-module when it is installed. Internal air circulation inside the cabinet must be blocked. Detailed requirements of cabinet installation and required air flow can be seen in the technical specification in Table 17.

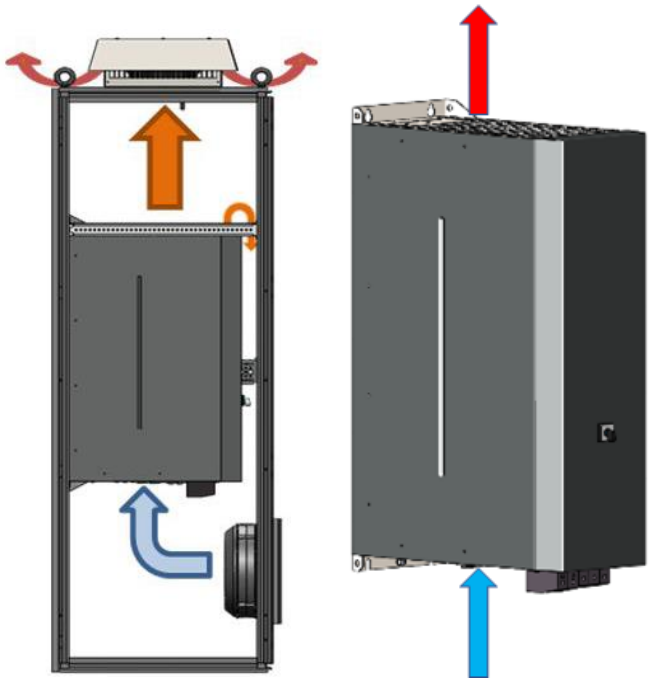

Figure 45: Air circulation of the HPQ cabinet (left) and HPQ-module (right).

Install HPQ-modules according to the technical specifications in Table 17. In cabinet installations, Merus uses door fans by default. These fans create an overpressure inside the cabinet, and it prevents dust entering inside the cabinet from any unwanted openings. In some designs, for example in the IP54 integration, there is also a rooftop fan, where the openings are smaller due to a higher degree of protection, and the air flow must be forced.

Merus Power's own cabinet design includes air filters to prevent excessive dust from entering the cabinet and to increase the IP-class. It is also possible to build a system without air filters, but it is not recommended in most cases, because it might lead to conductive dust entering the modules. The use of air filters must be evaluated based on the installation environment.

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6.4 Electrical installation

This section covers electrical installation such as capacitors, power cables, current measurements, and physical changes between 3 W and 4 W HPQ-modules.

6.4.1 Capacitor requirements

Capacitors must be detuned with reactors and no plain capacitor banks can be used! The series inductance needs to be in range 6–20%

The safety instructions according to EN 50110-1 and local electrical safety standard must be considered!

- Some capacitors have limits for U_{thd} limits for the operation.
- The capacitor's rated voltage must be higher than system voltage due the voltage increase.
- Resonance frequency must be noted, especially in harmonics between 2^{nd} – 5^{th}.
- Note also requirements from IEC 60831-1 for voltage rating.

See more information in Table 19.

6.4.2 Network requirements

There should **not be** a considerable quantities of voltage harmonics higher than 50^{th} harmonics in the network where the modules are installed. Higher harmonics can lead to situations where the modules are not able to work correctly.

Typical loads for HPQ-modules are recommended to have line reactors with > 3% inductance.

6.4.3 Selecting between 3 W and 4 W operation for the module

The selection between 3 W and 4 W configuration is based on the main points below:

The most typical configuration is 3 W.

Select 3 W if:

- There are no zero-sequence harmonics (3rd, 9th, 15th 21st etc.) in the load
  or
  these harmonics do not need to be mitigated.
- Voltage level is > 440 VAC (> 525 VAC for 690 VAC modules).
- The load consists purely of 3-phase equipment.
- There are zero-sequence harmonics, but they are not over needed limits.
- **Neutral wire in the load/network does not automatically mean that the module should be connected in 4 W configuration.**

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Select 4 W if:

- The zero-sequence harmonics (3rd, 9th, 15th 21st etc.) need to be mitigated or there is a need to balance the neutral current in the fundamental frequency + neutral wire is available.
- Typically, 4 W is used in an infrastructure where there are single phase loads.

6.4.4 Power cables and earthing

Select power cables based on the rating of the protective fuse and the cable installation environment. The following information must be taken into account:

Cables:

- HPQ-module power cables should have a maximum cross-sectional area of 95 mm² for phase cables.
- Merus Power uses 50 mm^2 phase conductor cables for 50 A – 100 A modules and 70 mm^2 phase conductor cables for 125 A – 200 A modules.
- The neutral cable cross-section should be three times the cross-section of a phase conductor.
- Proper cables/busbars defined in the local electrical standards must be used.
- The locations of the power cables are shown in section 6.1.
- **Note: The phase cables connected to L1:L3 must be installed in the standard phase sequence (A-B-C)!**

Three-wire and four-wire application

- In 3-wire applications the neutral wires must be left **unconnected.**
  - In HPQ-modules with a rating of 150 A/200 A: remember to leave the plastic cover in top of the neutral terminal.
  - Internal modifications for a three-wire application must be performed (explained in section 6.4.6).
- In 4-wire applications the neutral wires must be **connected.**
  - Note: Neutral current can be up to three times the rated phase current.
  - In smaller module sizes: the neutral must be connected with two cables, in order to fulfill the current carrying capacity of the neutral terminals.
  - In HPQ-modules with rating 150 A/200 A, the neutral must be connected in the busbar.
  - Internal modifications for a four-wire application must be done (explained in section 6.4.6).

- For safety reasons, the earth point (PE) of the HPQ-module must be connected to the protective earth point (PE) of the installation with a reliable fixed connection. A minimum of 16 mm^2 Cu conductor is recommended, but local regulations should be fulfilled as well. The colour of the HPQ-module PE conductor is always yellow-green. The connection point of the PE conductor is shown in Figure 24 and Figure 27.

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- Merus HPQ-modules require external short circuit protection. In Chapter 110: 'Technical specification', presents fuses for various models. However, the customer can also use other types of short circuit protections such as MCCBs and fuse-switch devices. The general design rule is to set the protection level at roughly 1.3 times the nominal current of the device. The short circuit protection must also fulfil local regulations and design principles.

6.4.5 Busbar dimensioning

Busbar dimensioning must be carried out by the party responsible for the installation as based on several factors including, but not limited to:

- Airflow (free/forced air flow, encapsulated)
- Busbar
  - count (1, 2, 3…)
  - material (aluminium/copper)
  - position (vertical/horizontal and on short/wide edge)
  - shape (flat, round, tube, square, special)
  - surface treatment (uncoated, painted, tinned, etc…)
- Frequency and harmonic content of current (skin effect)
- Phase distance
- Ambient and max. allowed surface temperature of the busbar

Commonly used values for continuous AC current (max. 60 Hz) for uncoated E-Cu and E-Al rectangular busbars in indoors installations are shown in Table 2 and in Table 3. In those tables, the prerequisites are:

- Ambient temperature is +35 °C
- Busbar surface temperature is +65 °C
- Busbars are unenclosed and installed vertically

Table 2: Continuous current for busbars at 35 °C ambient temperature according to DIN 43671 (Cu)

Dimensions [mm]	Cross-section	Busbars I	II	III
20x5	99	274	500	690
20x10	199	427	825	1180
30x5	149	379	672	896
30x10	299	573	1060	1480
40x5	199	482	836	1090
40x10	399	715	1290	1770
50x5	249	583	994	1260
50x10	499	852	1510	2040

Material: E-Cu F30 (electrical conductivity 56 m / Ω)

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Table 3: Continuous current for busbars at 35 °C ambient temperature, according to DIN 43670 (Al).

Dimensions [mm]	Cross-section [mm²]	Busbars I	II	III
20x5	99	200	370	505
20x10	199	310	605	885
30x5	149	275	495	650
30x10	299	420	780	1130
40x10	399	526	970	1380
50x10	499	630	1140	1615
20x5	99	200	370	505
20x10	199	310	605	885

Material: E-AMgSi-T6 (electrical conductivity 31,9 m / Ω mm²)

If a pre-made busbar system is used, consult the manufacturer or distributor to find the correct busbar system for your requirements.

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6.4.6 3-wire and 4-wire modifications

The choice between the HPQ-module's 3-wire and 4-wire application is made in the terminal block located next to the contactor as shown in Figure 46. For instructions on how to access this block, read section 6.1.3. The locations for the terminal blocks are presented in Figure 46 and Figure 47.

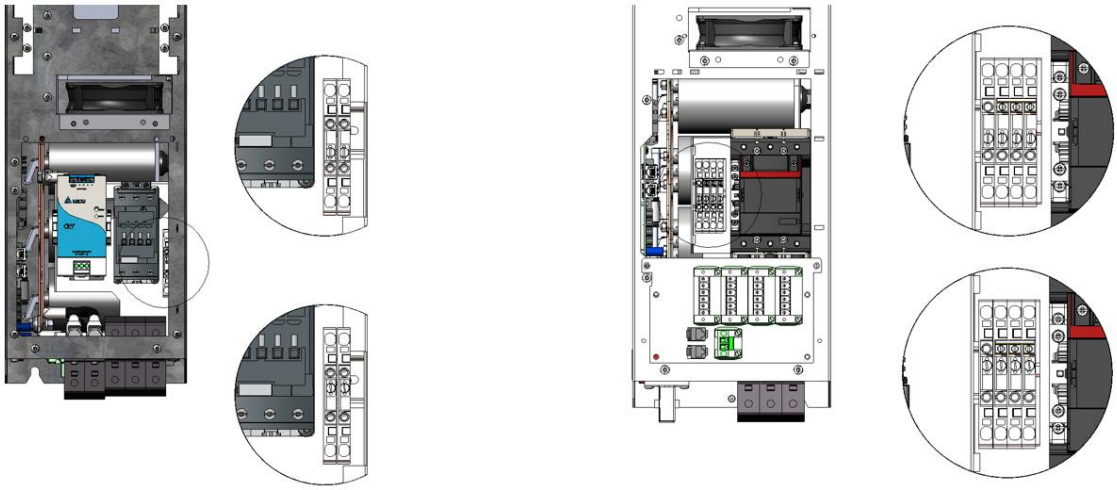

Figure 46: 3 W/4 W terminal block locations in HPQ-modules (50 A/100 A: left, 150 A/200 A: right)

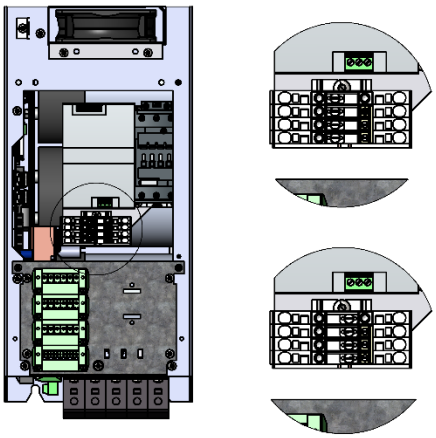

Figure 47: 3 W/4 W terminal block location in 690 VAC modules

- Three-wire application: all screws need to be tightened in the **disconnected** position
- Four-wire application: all screws need to be tightened in the **connected** position.

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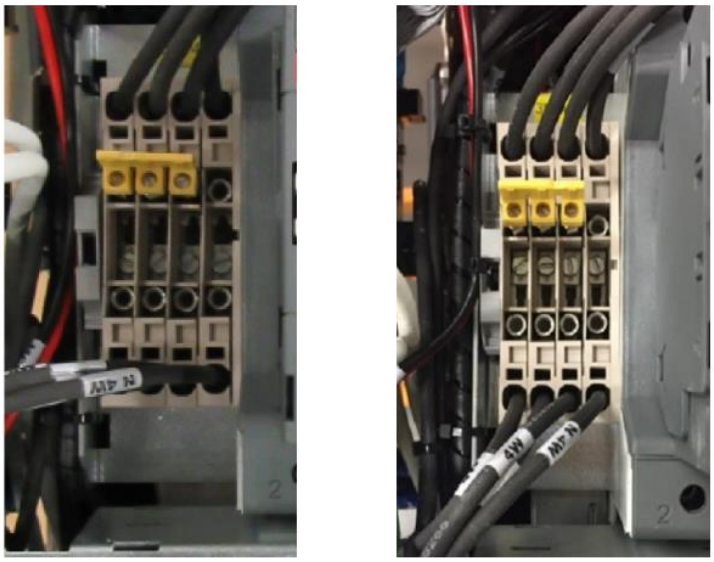

Figure 48: Example of 3 W/4 W terminals in 150 A/200 A modules (Left: 3 W, right: 4 W)

Attention! The user must not connect the neutral in 3-wire application and must connect the neutral in 4-wire application. **The connection in neutral wire and module 3 W/4 W terminals must match the HMI settings. Otherwise, damage can occur.**

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6.4.7 Current transformers and current signal

The current signals from the electrical system must be provided to the HPQ-module to allow the control system to determine the appropriate compensation current. The three current transformers must have identical characteristics.

Current transformers can be connected in an open or closed loop.

- In the open loop connection, the current transformers are situated on the load side, as shown in Figure 49.
  - (CTs measure **ONLY** the load side currents, **NOT** the HPQ-module(s) currents)
- In the closed loop connection, the current transformers are situated on the supply side, as shown in Figure 50.
  - (CTs measure **BOTH** the load side currents and the HPQ-module(s) currents)

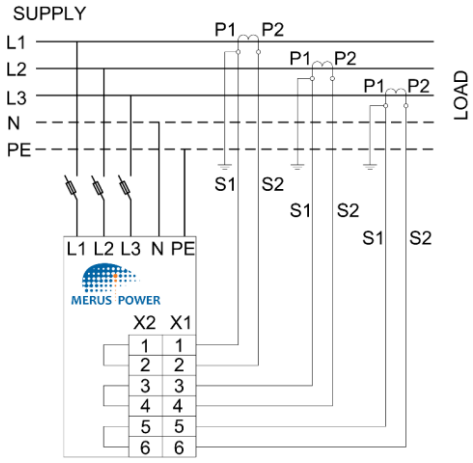

Figure 49: Open loop installation diagram

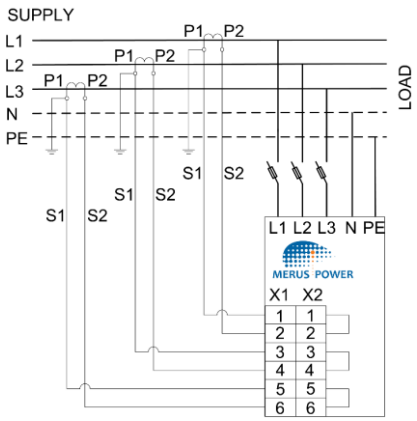

Figure 50: Closed loop installation diagram

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In both cases (open or closed loop connection), the current signals are connected to the X1 terminal in the order shown in Figure 49 and Figure 50.

It is recommended that the current transformers be earthed on the current transformer side for safety purposes, as shown in Figure 49 and Figure 50. Current transformers should be earthed on the secondary side (S1 or S2) and on the same side for all current transformers.

6.4.8 Individual modules

For individual modules, the connection is made as in Figure 49 and Figure 50.

- X1 Connected into the external measurement
- X2 Shorted (pins: 1-2, 3-4 and 5-6)
- X3 Not needed
- X4 Shorted (pins: 1-2, 3-4 and 5-6)

6.4.9 Parallel connected modules

Two HPQ-modules can be connected in parallel configuration. With two HPQ-modules, the CT signal cables need to be connected to the X1 terminal of one module. The next module will receive the current signal from the X2 terminal of the previous module. Parallel HPQ-module connections for the open loop are presented in Figure 51.

The next module will receive the current signal from the previous module's X2 (load measurement) and X4 (HPQ-module's current). Parallel HPQ-module connections for open loop and closed loop are presented in Figure 51 and Figure 52.

- X1 Connected into the external measurement
- X2 Shorted (pins: 1-2, 3-4 and 5-6) /connected to the next module's X1 terminal
- X3 Not needed
- X4 Shorted (pins: 1-2, 3-4 and 5-6)

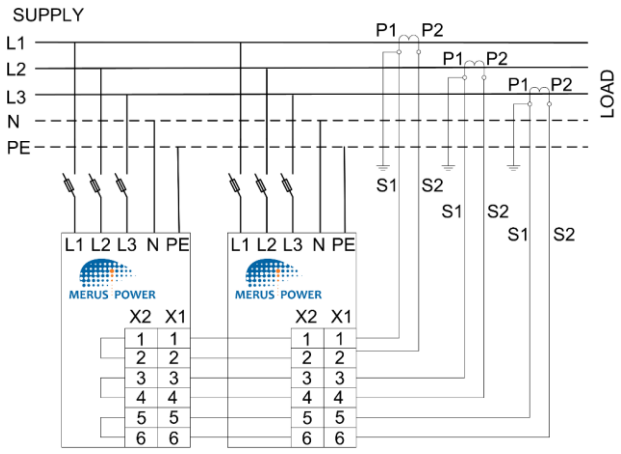

Figure 51: Open loop parallel connection

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Parallel HPQ-module connection in a closed loop is shown in Figure 52. The next module will get the current signal from the previous modules, X2 and X4.

- X1 Connected into the external measurement
- X2 Shorted (pins: 1-2, 3-4 and 5-6)/connected to the next module's X1 terminal
- X3 Connected to auxiliary CTs measuring the HPQ-modules' output current (typically inside the module cabinet)
- X4 Shorted (pins: 1-2, 3-4 and 5-6)/connected to the next module's X3 terminal

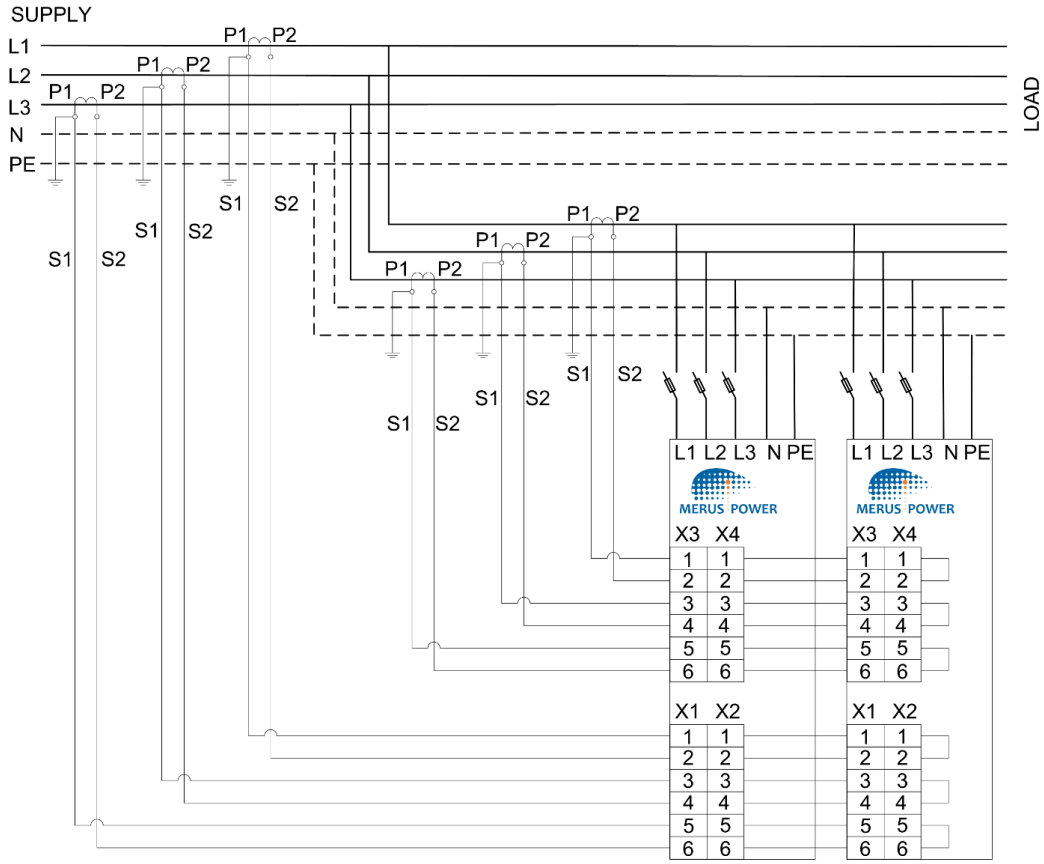

Figure 52: Closed loop parallel connection

The last parallel HPQ-module must have its X2 and X4 terminals shorted.

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6.4.10 Nominal rating of current transformers

The harmonic compensation performance is dependent on the accuracy of the current transformers. When selecting Current Transformers (CTs), the following guidelines must be taken into account:

- Accuracy: minimum accuracy class 1.0 or better.
- If performance is critical, a better accuracy class is recommended.
- The primary rating of the CTs should be chosen according to the maximum primary RMS current, excluding transients. The crest factor of the load current should also be considered. The measurement input circuitry limits the maximum crest factor of the CT input to 2.0. In case of an even higher crest factor, the primary RMS current rating needs to be adjusted accordingly.
- The auxiliary CTs' (X3) primaries should be > 1.3 times the total nominal current of parallel modules, as these CTs are measuring the harmonic current from the module(s).
- X1 secondary current: rated secondary current of 5 A or 1 A, 5 A is preferred.*
- X3 secondary current: 5 A.
- Burden must be considered when selecting current transformers. The burden for the current transformers depends on the cable lengths between the current transformers and the HPQ-module's terminal block X1 and X3. The Merus® HPQ-module burden, excluding the external current transformer cables, is presented in Table 4.

Table 4: The Merus® HPQ-module burden for current transformers.

Parallel modules	Total burden at 1 A (VA)	Total burden at 5 A (VA)
1	0.12	0.80
2	0.23	1.60
3	0.34	2.40
4	0.45	3.20
5	0.55	4.00
6	0.66	4.80
7	0.77	5.60

*In case of a 1 A secondary current: Change the internal connection point in the AUX card from a 5 A secondary current to a 1 A secondary current (as shown in Figure 34). **Note: Unplugging the internal CT secondary selection connector will break the CT secondary loop. Remember to short circuit the CT secondaries!**

In case of 1 A secondary, the external CT ratio must be divided by 5 in the settings (see Chapter 7.6.1).

→1 A secondary terminal in the AUX card
→CT ratio divided by 5 (e.g. 1000/1 = 200, not 1000)

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6.4.11 Current signal cable and terminals

The current signals from the load or from the network must be connected to terminal blocks X1:1 - 6. In case of the last parallel-connected HPQ-module, or the case of a single HPQ-module, the terminals X2 and X4 must have their pins 1-2, 3-4 and 5-6 shorted. The shorting of X2 and X4 terminals is included in standard delivery.

The current signal cable from the load or network must be protected and is recommended to be shielded, based on the local regulations. If shielded, the cable shield must be connected to the cubicle frame potential via cable duct. The recommended grounding location is in the CT-side of the cables. Only one side should be grounded to avoid circulating currents in the PE.

The cables connected to terminals X2, X3 and X4 (between parallel modules) do not have to be shielded, if allowed by local regulations. Terminals in blocks X1- X4 are suitable for cables with a maximum cross section of 4 mm2. The maximum tightening torque is 0.5–0.6 Nm.

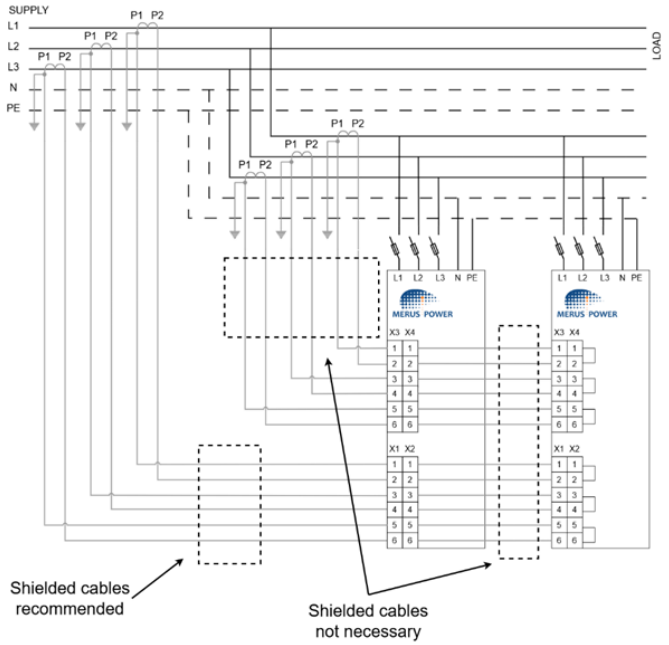

Figure 53: Current signal cables.

Hazard! If the CT secondary cable has to be disconnected when the primary circuit of the main CT is conducting current, the secondary cables of the CTs must be short circuited. This way the low impedance current paths for the secondary currents are always present. Otherwise, fatal voltages may be present in the conductors and/or terminals, and irreversible damage may be caused. **Never open a live secondary circuit!**

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7. HMI

The HPQ-module is controlled via a touchscreen PC HMI (Human Machine Interface).

- The HMI allows the user to start/stop the module or modules. For more information, see power quality monitors and change settings.
- Communication between the module and the HMI is conducted via the Modbus TCP protocol.
- The HMI has a resistive touchscreen display. Either fingers or a touchscreen pen can be used to operate it. If nothing happens when touching the screen, wait a second and try again.
- Some lists are scrollable (similar to mobile devices).
- The HMI is not part of the control system. Thus, HMI operation is not critical for module operation.

The basic HMI structure and properties are explained in this chapter.

7.1 HMI overview

Overview of the HPQ-HMI menu structure is included in this section. The HMI main structure is presented in Figure 54.

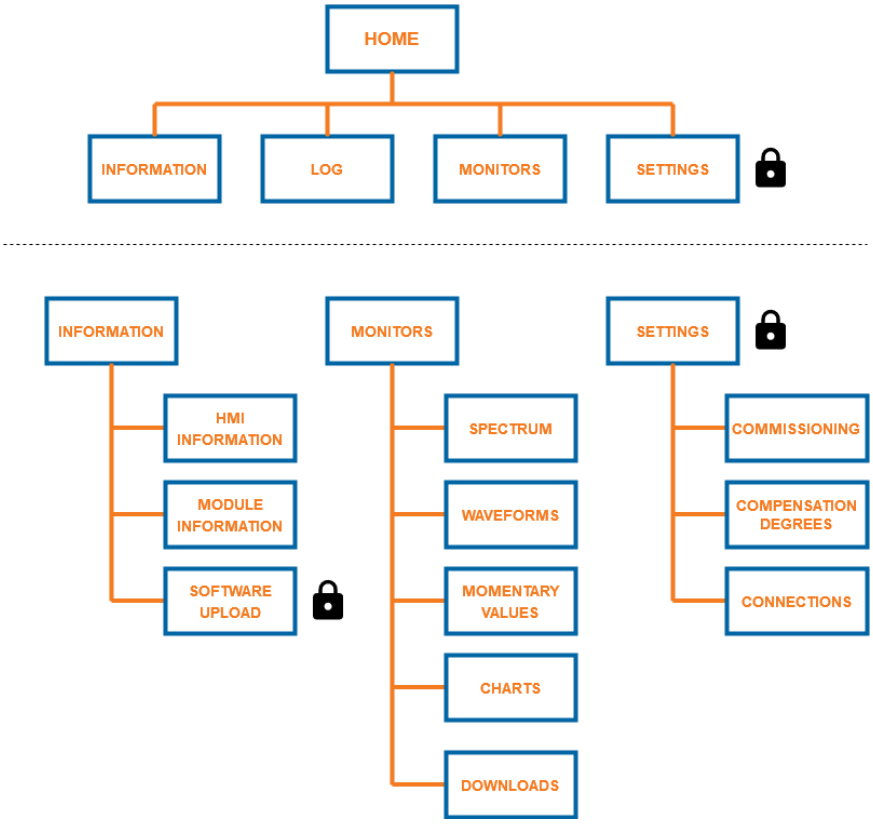

Figure 54: HMI structure map

Some of the settings are hidden if the system lock is locked.

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7.2 Home screen

The home screen is the root of the HMI. In the main view, the user can control the HPQ-module(s) via START/STOP-buttons and see the current status of the modules. The main view is also a gateway to other parts of the HMI. The HMI home screen is shown in Figure 55.

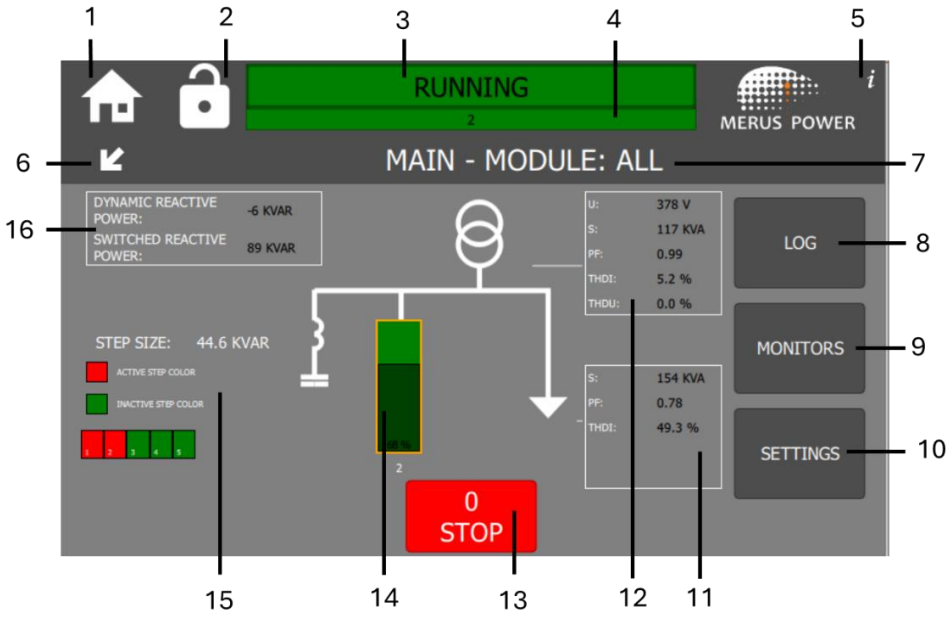

Figure 55: The HMI home screen

The numbers in Figure 55 explained:

1. **HOME:** Go to home screen
2. **LOCK:** Lock/unlock some of the HMI settings
3. **MAIN STATUS:** See the combined status for all the connected modules or select a module to control
4. **MODULE STATUS:** Visualise every module's status in colours
5. **INFO:** See system information and modify system settings
6. **RETURN:** Return to the previous page or close opened pop-ups
7. **PAGENAME:** Show the current page and selected module(s)
8. **LOG:** See the log and acknowledge system errors
9. **MONITORS:** See monitored values and download data
10. **SETTINGS:** Change settings for the modules. Visible only when LOCK is open.
11. **LOAD MOMENTARY:** Show LOAD-side basic values
12. **NETWORK MOMENTARY:**Show NETWORK-side basic values
13. **START/STOP:** START/STOP the module(s)
14. **MODULE(S):** Show module status in colours and load rate ($\frac{I_{output}}{I_{nominal}} \cdot 100\ \%$)
15. **CAPACITORS:** Show capacitor step size and status in colours
16. **REACTIVE POWER PRODUCTION:** Show dynamic reactive power (kVARs inserted dynamically with the HPQ-module) and switched reactive power (kVArs inserted using capacitor steps

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7.2.1 HMI lock

When the user presses the LOCK icon in the main screen, it opens the password input screen. The user is required to input the proper password here.

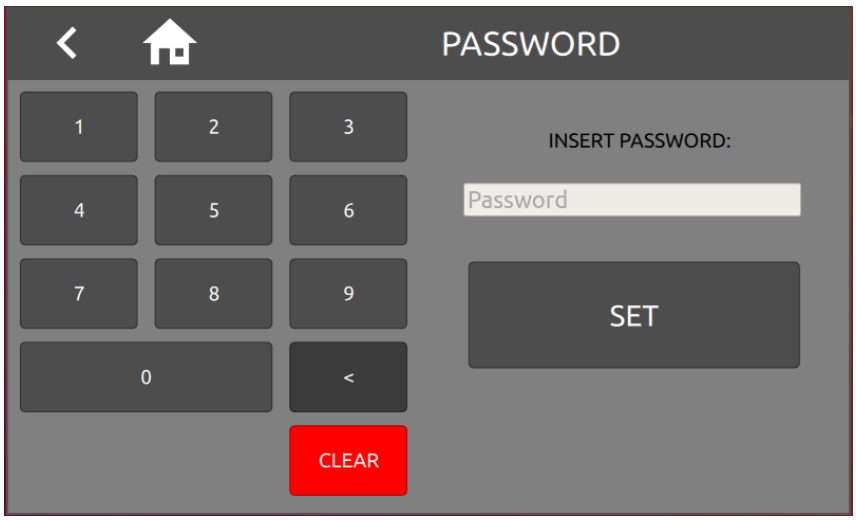

Figure 56: Password input

When the password is inserted correctly, the lock icon in the home screen opens and some settings become visible. The lock will stay open until the lock icon is pressed again or when the screensaver activates. You can obtain the password from the supplier.

7.2.2 Parallel modules

When there are two modules in the system, the user can select which module values are shown in the **MONITORS** and which module **SETTINGS** are changed. In Figure 57, master and slave modules are presented in the home screen. By default, the HMI shows the momentary values, waveforms, and spectrum of the master module or the first active module connection.

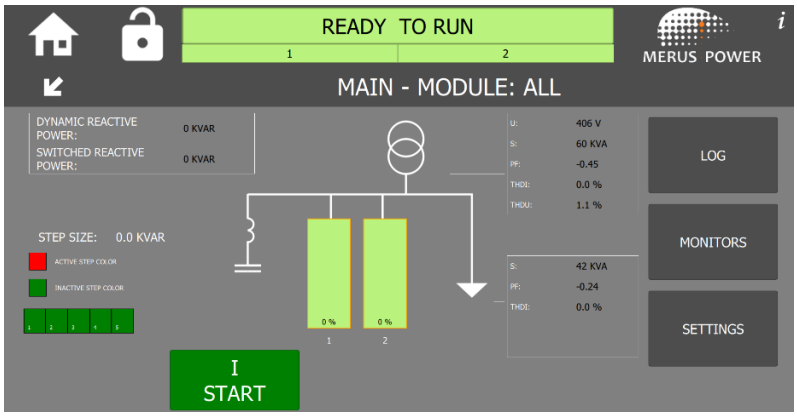

Figure 57: Two modules in parallel.

When selecting the currently active module, the user should press the MAIN STATUS button shown in Figure 55. When pressed, the selector screen will pop up and the user can select the currently active module.

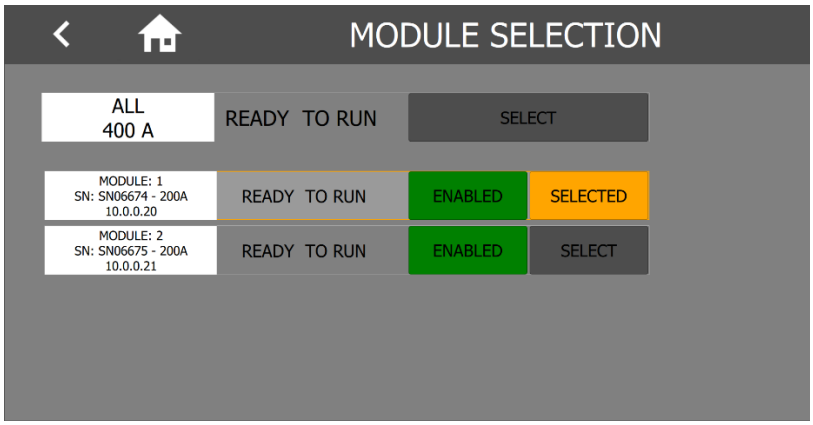

Figure 58: Selecting the active module

- When ALL is selected, all commands will go to all connected modules.
- When one module is selected, all commands will go only to that module.
- The user can also disable module connection via the ENABLED/DISABLED button. If DISABLED, all communication will be prevented for that particular module.

When ALL is selected, MOMENTARY VALUES will display the total system values: e.g. ‘Compensation current’ is the total system output current, and ‘temperatures’ are the highest values of the system.

System states and trips for two module operation are shown in Table 5 and Table 6.

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Table 5: System states with secondary module.

System state	Action
Master and Slave module running	All the steps from both modules are available or in action.
Master module in TRIP-state	All the steps are disabled when the master A2-module is not running.
Master module is running, Slave module is in trip	The A2-Master module steps are in operation, the secondary module steps are disabled and out of action. Alarm will be displayed.
Master module is running, Slave module is in READY TO RUN -state.	All the steps from both modules are available.

Table 6: System trips with secondary module.

Trips	Explanation
(TRIP)FO-TRIP	The FO connection is not correct. If the trip is not cleared in the ack, check the FO cable and settings.
(TRIP) FO:SECONDARY MODULE PROBLEM	The slave module is not configured correctly. The HPQ-mode is **DISABLED,** the operation mode is not **SLAVE** or the secondary module communication is not enabled
(ALARM) HPQ SECONDARY MODULE IN TRIP-STATE	The **HPQ-slave** A2-module has tripped, all the steps > 6 are in **OFF** state. They will start operating after the trip is cleared.
(ALARM) UNIT ROLE CONFLICT IN THE HPQ MODULES	The unit role is the same for both modules. Change roles to **MASTER-SLAVE**.

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7.2.3 Module statuses and colours

The colours in the main screen and module status fields are explained in Table 7.

Table 7: HPQ-module status table.

Status	Background colour	Explanation
READY TO RUN	Light green	The module/system is ready to start without trips
START UP	Light green	Part of the start sequence
PRECHARGING	Dark orange	Charging the DC-link. Part of the start sequence
IGBTS READY	Blue	The module/system DC-link is charged. IGBT operation is disabled
RUNNING	Green	The module/system is running
STANDBY	Green	The module/system is in Standby mode
TRIP	Red	The module/system has tripped
ALARM	Yellow	Indication of alarm in the module/system
DISCHARGING	Dark orange	Discharging the DC link capacitors
NO MODULE CONNECTION	Dark grey	No module connection over IP/TCP
DISABLED	Blue	Module(s) has been disabled
MIXED	Dark orange	Various states with parallel modules

7.2.4 Screensaver

The HMI has a built-in screensaver. The brand logo will become visible after 10 minutes, and the backlight will be turned off after 20 minutes. When the screensaver is enabled, the HMI LOCK becomes locked. When the screen is touched after the screensaver has appeared, the display will wake up within two seconds.

7.3 Information

The INFORMATION view, in the upper right corner in the home screen, includes four separate tabs. These tabs are explained in this section.

7.3.1 HMI Info

The HMI Info tab visualises the HMI information such as HMI versions, time, and language. Some of the properties are editable.

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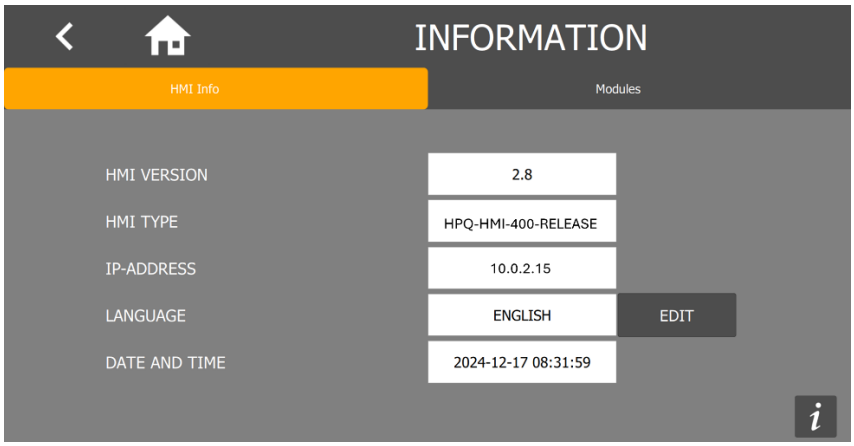

Figure 59: HMI Info tab when locked

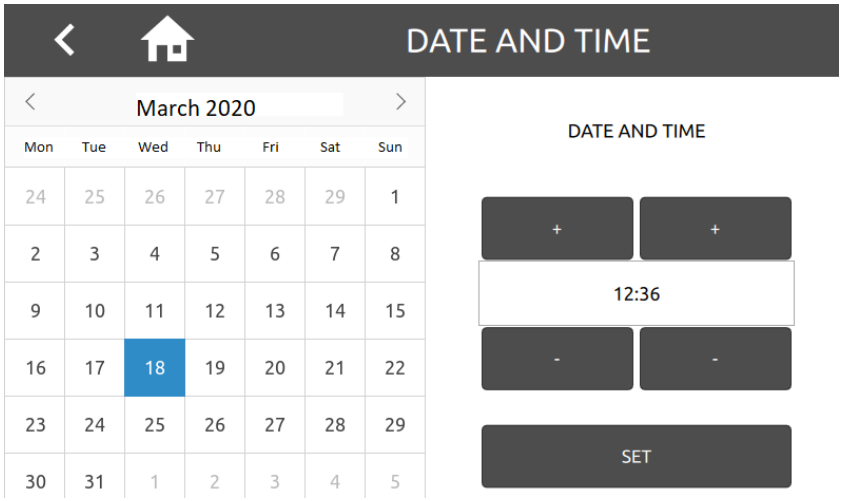

Figure 60: HMI date and time edit

7.3.2 Module

The Modules tab shows more details about the connected modules such as:

- Nominal current
- Serial number
- Software version number
- IP address
- Running times (recursive counter when module has been running)

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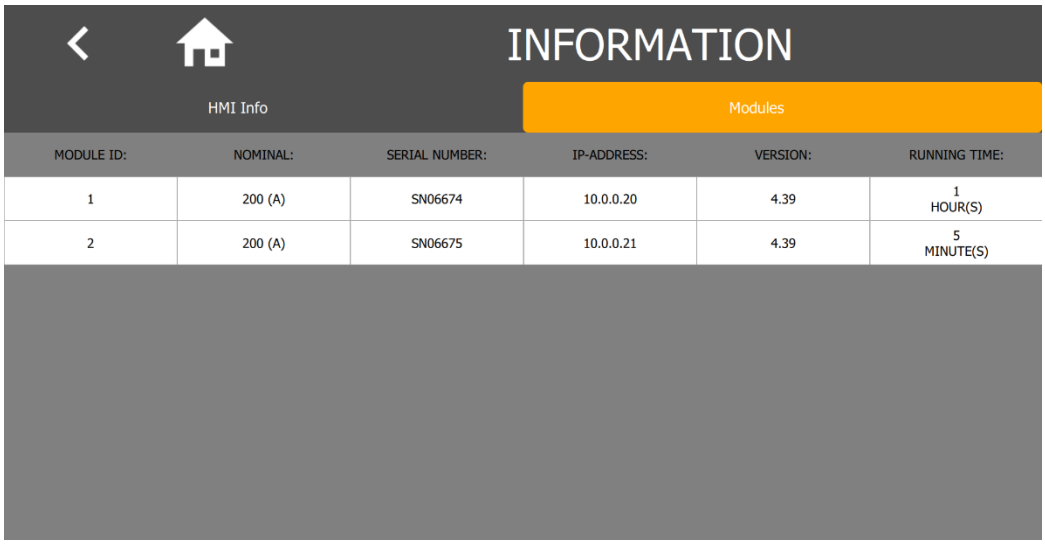

Figure 61: Module(s) tab

7.3.3 Capacitor information

There is an additional table for the capacitors in the HPQ Info tab, as shown in Figure 62.. The HPQ Info tab shows every step's active time and how many times the step has been switched (with an accuracy of 100 switching events). This table can be used in service actions.

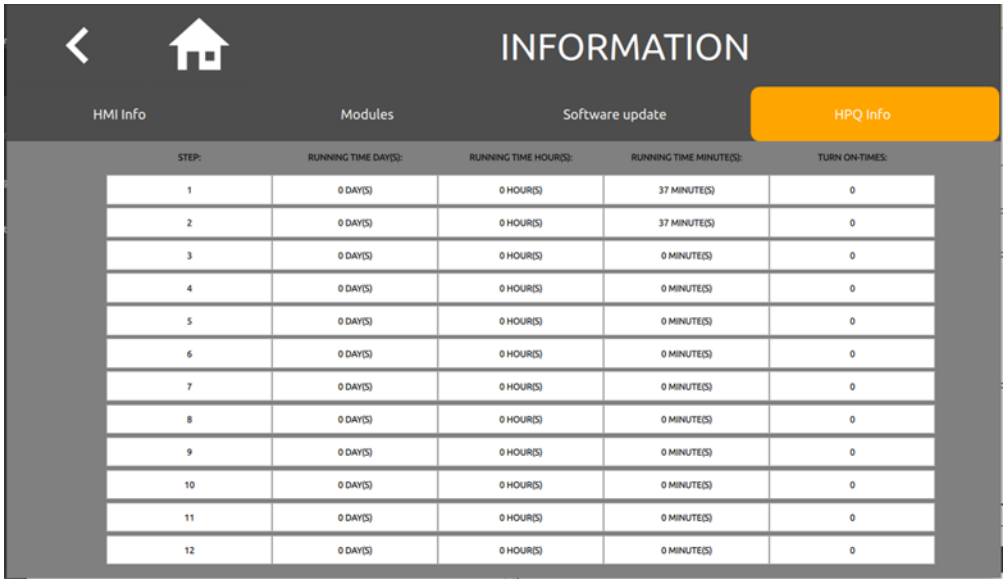

Figure 62: Capacitor information.

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7.3.4 Software update

The final tab is available when the HMI LOCK is open. It allows the user to upload new firmware for the module(s).

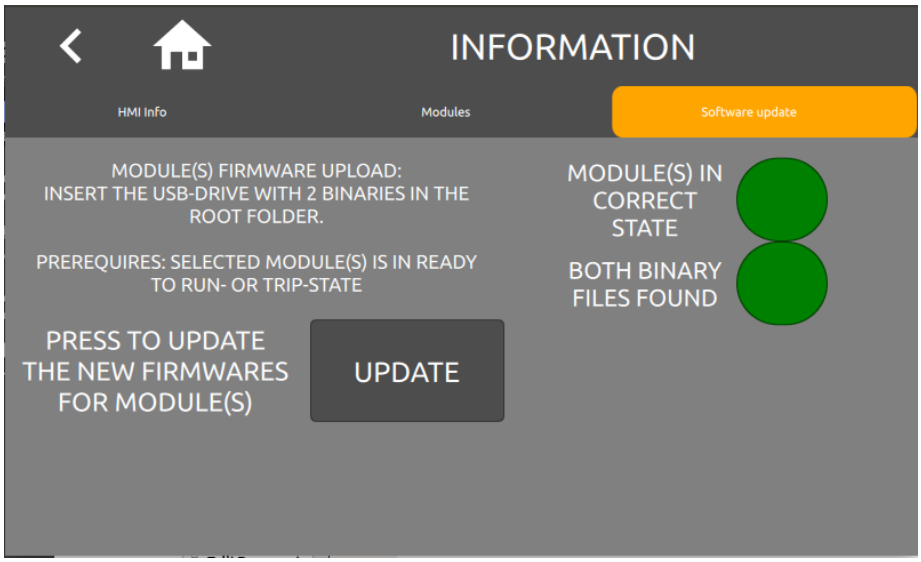

Figure 63: Module firmware upload

To update the module(s) firmware, the following conditions must be met:

- Module state is either TRIP or READY TO RUN.
- The USB drive is inserted in the HMI USB port andthe needed binaries are found in the root of the USB drive.

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7.4 LOG

The LOG view includes the latest events that the HMI has encountered. An illustrative image can be found in Figure 64.

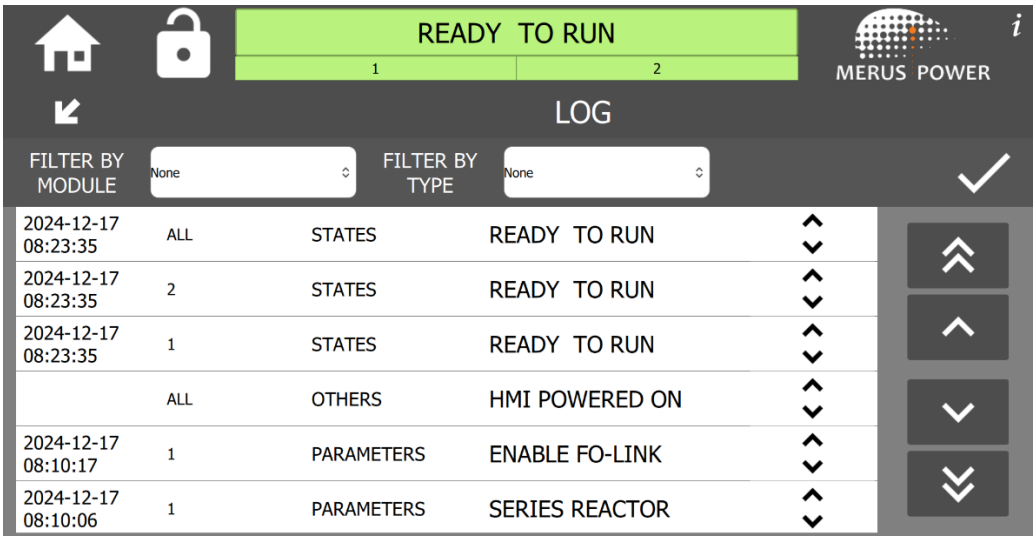

Figure 64: LOG view

1. **Selecting how events are filtered**
    a. Module ID:
        i. e.g. “ALL”, “1”, “2”
    b. Event type:
        i. **Parameters:** parameter changes
        ii. **States:** state changes
        iii. **Trips:** trips
        iv. **Alarms:** alarms
        v. **Actives:** Displays all the active trips/alarms. Active events are highlighted with colours.
        vi. **Others:** system level information such as HMI starts, etc.
2. **Acknowledging trips and alarms**
    a. Acknowledging TRIPS and ALARMS happens when the user presses the **ACKNOWLEDGE button.** If the trips are not active, they will disappear. However, if reasons for the trips still exist, the trips will remain active. Trips can also be acknowledged if AutoAck is enabled (see section *3.3.5*) or the module is powered down.

3. **More information**
    a. Expands the event details

The latest 1000 events can be seen from this screen. To download more events, go to **MONITORS→DOWNLOADS.**

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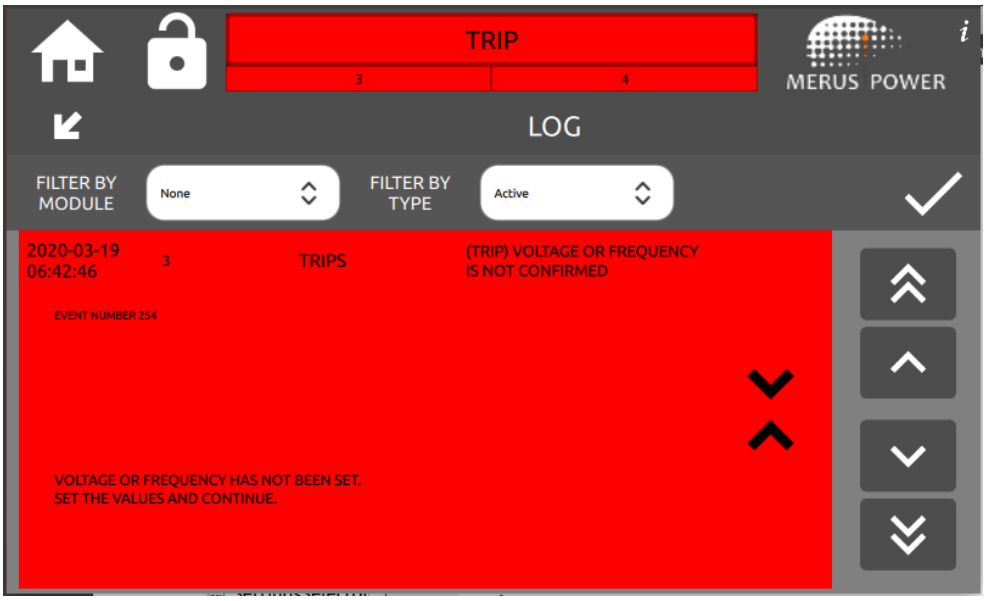

Figure 65: Expanded trip information.

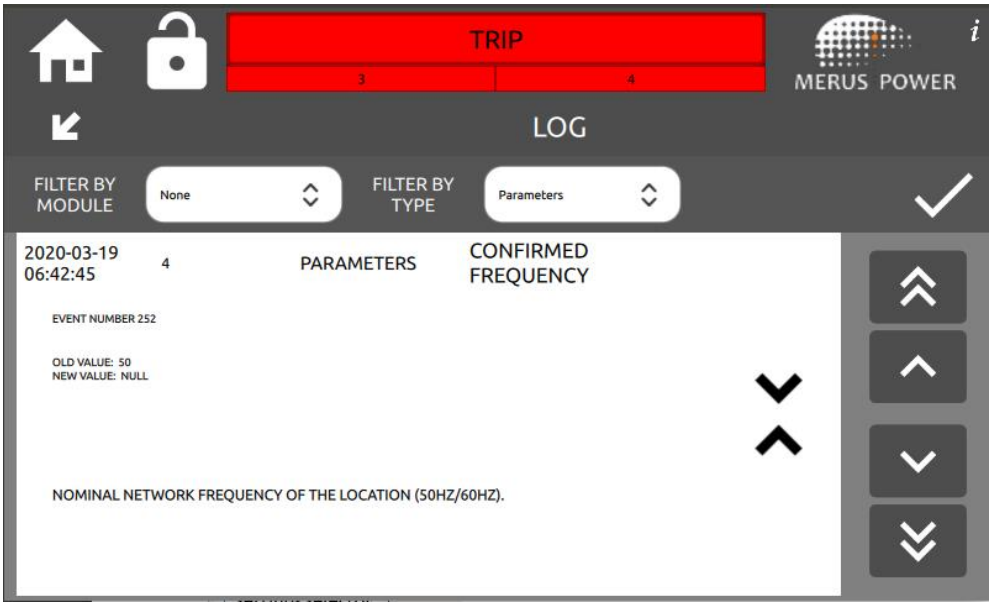

Figure 66: Expanded parameter information.

TRIPS are error conditions that cause protective tripping of the device. If any of the TRIPS are active, the HPQ-module will cease operation and will not start until the trips have been cleared.

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7.5 Monitors

The MONITORS basic view includes several different screens. It is presented in Figure 67.

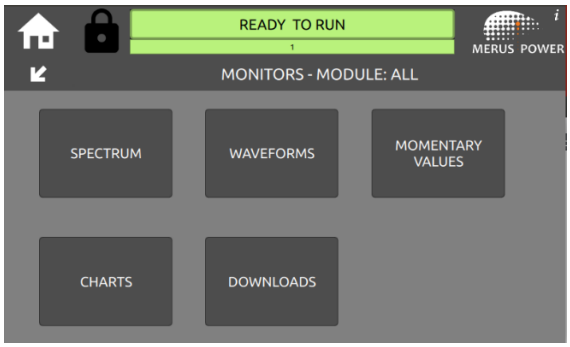

Figure 67: MONITORS view

7.5.1 Spectrum

In the SPECTRUM view, the user can display the harmonics spectrum from the 1st to the 25^{t,h} as well as the total RMS harmonics:

- AC system voltages
- Load side current*
- Network side currents*

There are options in the SPECTRUM view for:

- Selecting the phase
- Selecting between RMS/% values in the bars

A typical spectrum view can be found in Figure 68.

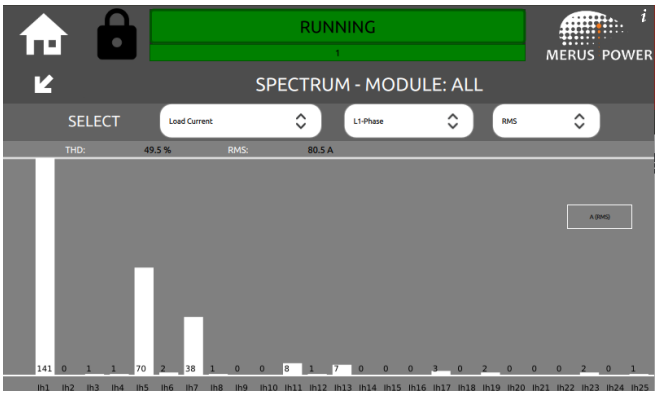

Figure 68: SPECTRUM view.

**In PFC-mode, the load side measurements for harmonic spectrum and waveforms are not showing correct values for the fundamental current. In UF-mode, the network side measurements for harmonic spectrum and waveforms are not showing correct values for the fundamental current.*

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7.5.2 Waveforms

In the WAVEFORMS view, the user can see one network period of the waveforms. The user can select between:

- AC voltages
- Load side currents
- Network side currents

The waveforms are PLL-locked. This allows the user to see if some of the CTs or phases are not in the correct location. A typical waveform can be seen in Figure 69.

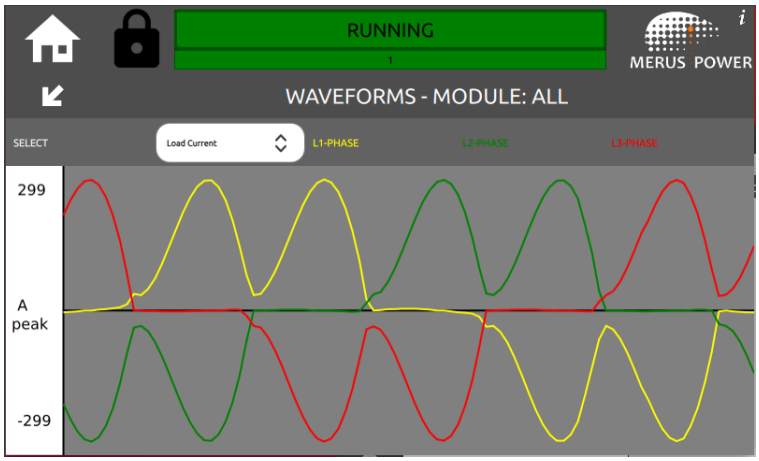

Figure 69: WAVEFORMS view

7.5.3 Momentary values

The MOMENTARY VALUES viewdisplays the most common device- or power quality-related values. An illustrative image can be found in Figure 70. These values are updated successively in one second periods. Note: If the module selection is “ALL MODULES”, the values will display the status of the whole system.

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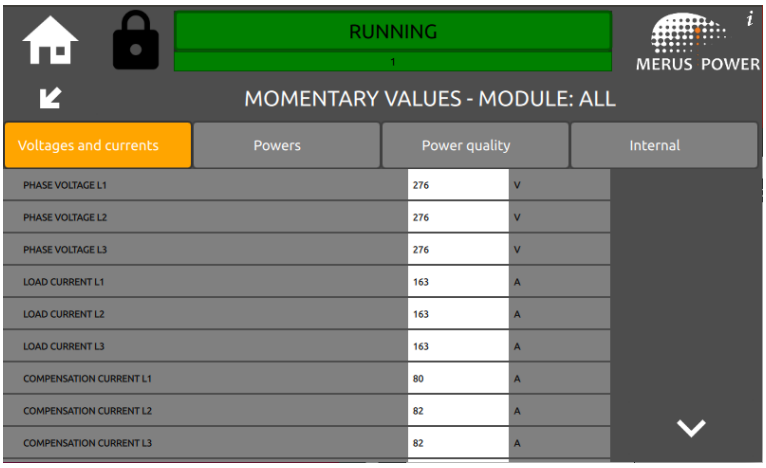

Figure 70: MOMENTARY VALUES view

Momentary values are divided into four categories and presented in Table 8, Table 9, Table 10 and Table 11.

Table 8: Voltages and current

item	Explanation	Unit
PHASE VOLTAGE Lx	Phase RMS voltage	V
LOAD CURRENT Lx	Load side RMS current	A
COMPENSATION CURRENT Lx	Module(s) RMS output current	A
NETWORK CURRENT Lx	Network side RMS current	A

Table 9: Powers

item	Explanation	Unit
LOAD ACTIVE POWER Lx	Load side active power	kW
LOAD REACTIVE POWER Lx	Load side reactive power	kVAr
LOAD APPARENT POWER Lx	Load side apparent power	KVA
NETWORK ACTIVE POWER Lx	Network side active power	kW
NETWORK REACTIVE POWER Lx	Network side reactive power	kVAr
NETWORK APPARENT POWER Lx	Network side apparent power	KVA

Table 10: Power Quality

item	Explanation	Unit
LOAD PF Lx	Power factor	-Sign is capacitive
NETWORK PF Lx	Power factor	-Sign is capacitive
LOAD THDi	Current total harmonic distortion: load side	%

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	THDr calculation style. Single phase value.	
NETWORK THDi	Current total harmonic distortion: network side THDr calculation style. Single phase value.	%
LOAD HARMONICS	Load side harmonics RMS. Only from one phase.	A
NETWORK HARMONICS	Network side harmonics RMS. Only from one phase.	A

Table 11: Internals

item	Explanation	Unit
DC VOLTAGE 1 or 2	Internal DC-link voltages	VDC
FAN SPEED	Fan speed	%
CUBICLE TEMPERATURE	Module input air temperature (bottom of the module)	Celsius
IGBT-MODULE TEMPERATURE LX	IGBT-module temperature	Celsius
DIGITAL INPUT X	Digital input state	I/O

7.5.4 Charts

The CHARTS view presents monitoring charts for momentary values. There are two separate charts available:

- Real time:
  - Number of recordings: 5 pcs
  - Sampling interwall: 1 sec
  - Averaging: None
  - USB download: No
  - Display length: 100 samples
  - Recording length: 100 sec
- 30 days:
  - Number of recordings: 5 pcs
  - Sampling interwall: 1 sec
  - Averaging: 5 minutes
  - USB download: Yes, five-minute averages
  - Display length: 1–1000 Samples
  - Recording length: Up to 30 days

The main view of the monitoring charts is presented in Figure 71.

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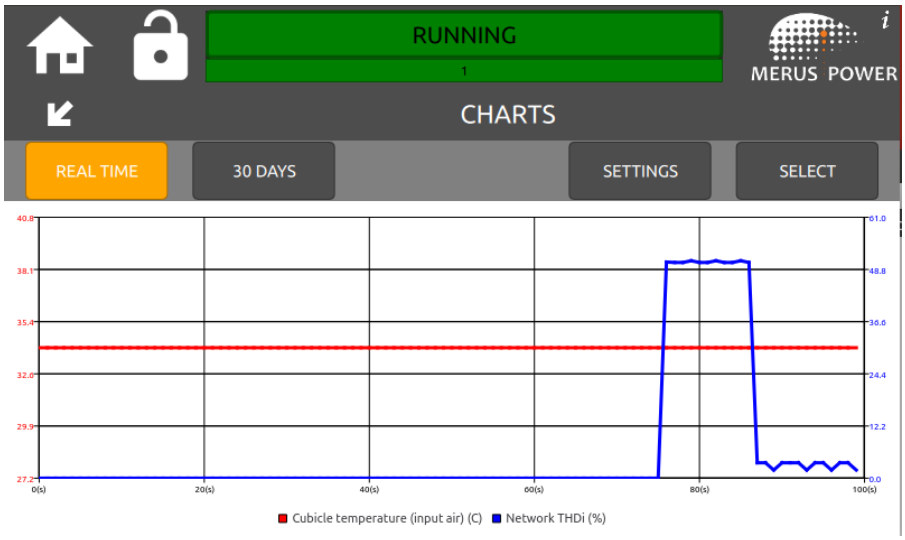

Figure 71: CHARTS view

Buttons explained:

- **Real time:** Shows a real-time graph
- **30 days:** Shows a graph of the past 30 days
- **Settings:** Here you can select the valuesfor recording. Note: This button is hidden when the HMI LOCK is locked.
- **Select:** Select the graphs you wish to present (max two simultaneously)

An example of a 30-day chart is presented in Figure 72.

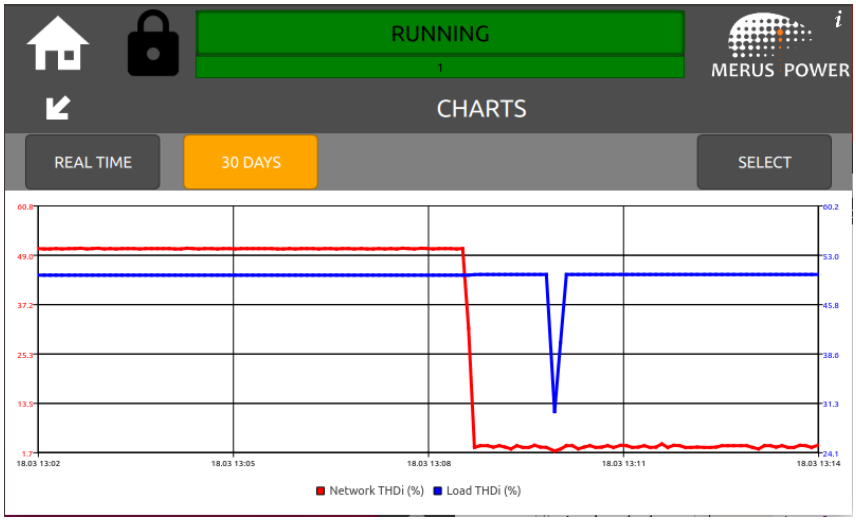

Figure 72: Example of a 30-day graph

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Settings are presented in Figure 73. Five recording slots are available for both displays. The user can pop the selection grid up by pressing the buttons below for **real time** and **30 days**. There is also an option to clear all the graphs from the database.

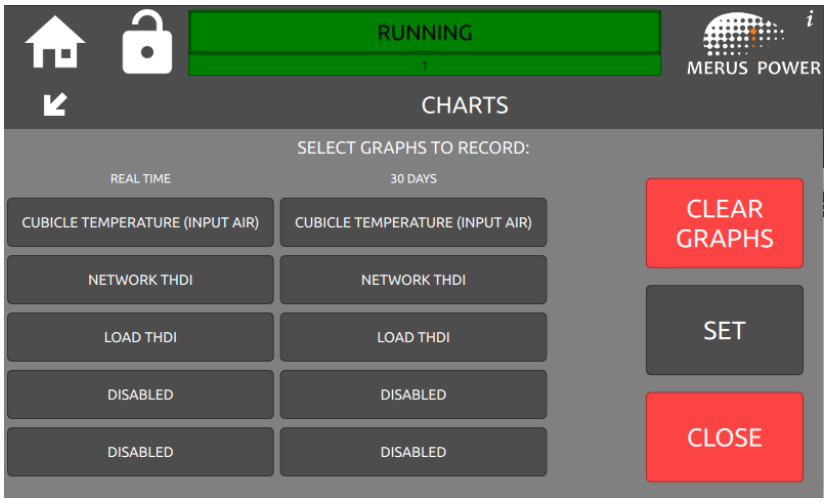

Figure 73: Chart settings

Selection of the graphs is presented in Figure 74. The user can select two visible graphs at the same time. This screen does not change any recording values. The only changes are for the display.

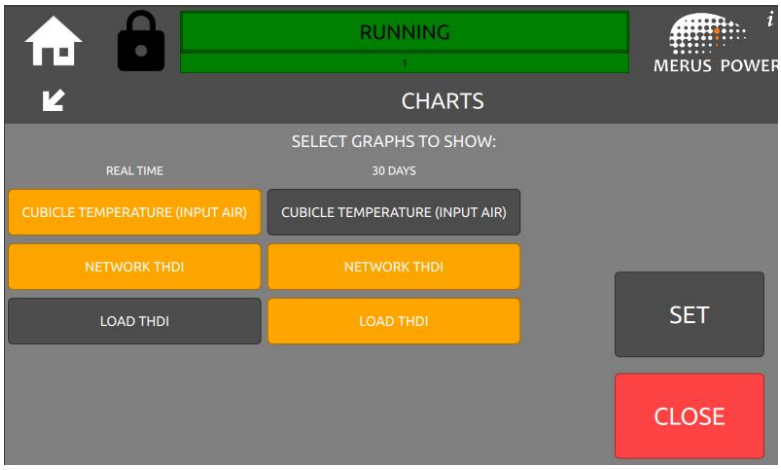

Figure 74: Graph selection

7.5.5 Downloads

The DOWNLOADS view includes several options for USB drive data retrieval. An illustrative image is presented in Figure 75.

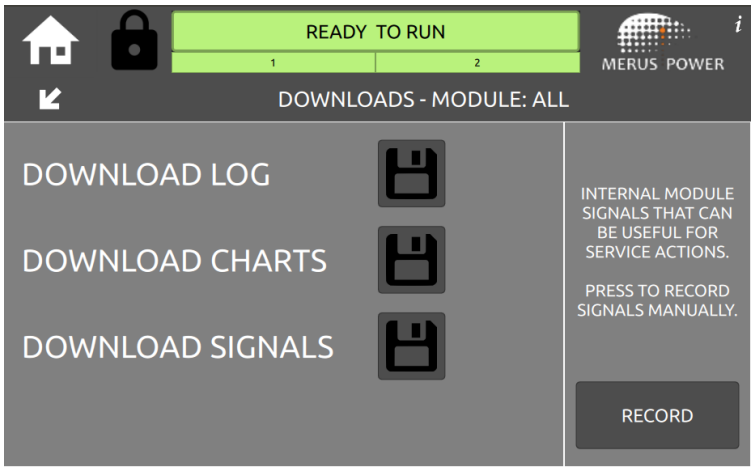

Figure 75: DOWNLOADS view

There are three downloads available. Insert a USB drive into the HMI USB port and press the required data:

- **LOG:** Saves the latest 5000 log events to the USB drive in English.
- **CHARTS:** Saves up to 30 days of recordings to the USB drive with five-minute averages.
- **SIGNALS:** Saves the internal module signals to the USB drive. Creates a new folder structure including time in each instance.

Internal signals include one network period of the data which is automatically recorded in case of a trip. These signals can also be recorded manually, using the button on the right side of the screen.

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7.6 Settings

The SETTINGS view can be found on the home screen when the HMI LOCK is opened.* There are several tabs. The basic structure for the SETTINGS view is presented in Figure 76.

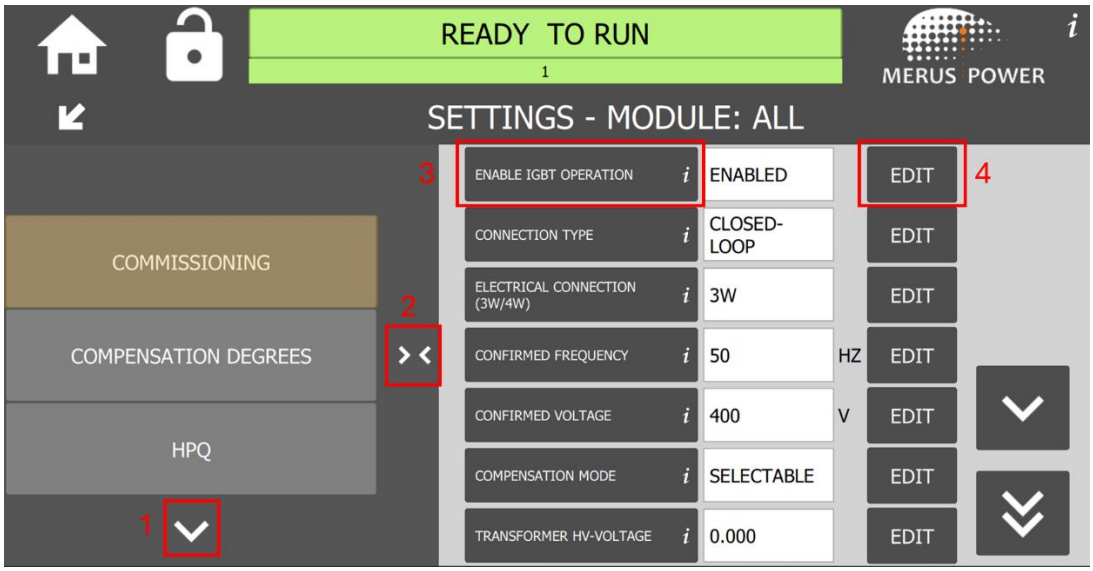

Figure 76: SETTINGS view

The numbers in Figure 76 show the following:

1. Scroll down: view more settings.
2. Hide/unhide the left-hand side toolbar. Hiding also occurs when the activetab on the left.
3. Information about the current settings: a double click opens an information screen concerning the current parameter.
4. Edit current settings: opens the edit view.

The HPQ settings are found in the HPQ-tab. When there is only one HPQ-module connected to the HMI, the screen will automatically display the settings for the master module as shown in Figure 77. When there are two modules connected and the selected module is not MASTER, some of the master module settings are hidden as in Figure 78.

**To enter this area, the user must be a partner in the Merus Power Oy's partner grid or must have acquired a password from Merus Power Oy. This prevents unqualified persons from making hazardous changes to settings.*

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Figure 77: HPQ settings in single / master-module.

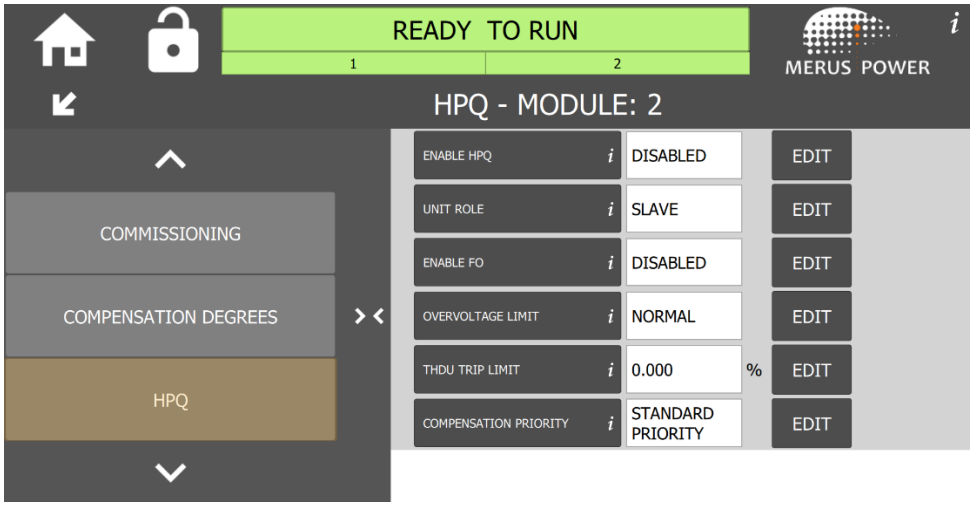

Figure 78: HPQ settings in slave module.

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The HPQ-settings are explained in Table 12.

Table 12: HPQ-settings.

Setting	Visibility on HMI	Explanation
ENABLE HPQ	Master, Slave	Disables normal DO-settings under COMMISSIONING and enables HPQ-mode and capacitor switching
HPQ MODE	Master	Selects which type of operation is wanted: The **PFC-MODE** or the **UF-MODE**
UNIT ROLE	Master, Slave	**MASTER/SLAVE**. Selects the role of the module. When using one module, select **MASTER** When using two modules, select **MASTER/SLAVE**
ENABLE FO	Master, Slave	**ENABLED/DISABLED.** Allows the system to use the fibre optic (FO) communication between modules when two modules are in use. When using one module, select **DISABLED** When using two modules, select **ENABLED** for both modules
OVER VOLTAGE LIMIT	Master, Slave	AC-overvoltage protection settings. Change between normal (15%), 10% or 20%
THDU TRIP LIMIT	Master, Slave	Trips the HPQ if THDu exceeds this limit. Can be set to comply with the capacitor bank operating THDu limit.
STEP COUNT	Master	How many capacitor steps are connected and need to be controlled
STEP SIZE	Master	Rated capacitor unit size in kVArs in the system voltage **OR** specified output of the step in certain voltage (**RATED CAPACITOR VOLTAGE)**
SERIES REACTOR	Master	Insert the series reactor %. If the **Step Size** already includes the series reactor, insert 0%.
RATED CAPACITOR VOLTAGE	Master	Rated voltage for the capacitor unit: **OR**

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		The voltage at which the **Step Size** is specified.
HYSTERESIS LIMIT	Master	Hysteresis range when no connection is formed in the critical control point. Value in % from one capacitor's step size.
DISCHARGE TIME	Master	Minimum time that one step is kept disconnected before connecting again (discharge time/re-connection delay). Used only in **PFC-MODE**. The time depends on the capacitor step's characteristics.
ENABLE LAST DO-CHANNEL AS TRIP	Master	If the last master output (DO05) is used for a trip signal instead of capacitor control. If this is selected the maximum step count for master is 5. The trip relay is closed when there are no trips and open when there are trips.
CONNECTION ALARM COUNT	Master	If the user wants an alarm on the HMI when OF/ON-connection amount > **SETTING VALUE**. Can be used for service information.
TARGET POWER FACTOR	Master	Desired power factor that the device tries to reach. Value is selected in the range of -0.7–0.7 e.g. 0.980 equals PF value 0.980_{Ind} **NOTE:** The module still works as PFC without steps if TARGET POWER FACTOR is selected and HPQ-Mode is disabled. Inserting 0 will clear the fundamental compensation if you want to use the module only for harmonics.
CAPACITIVE POWER FACTOR LIMIT	Master	This limit is used in **PFC-MODE**. Set the upper limit for the power factor. If the network PF is between the TARGET POWER FACTOR and the CAPACITIVE POWER FACTOR LIMIT, the HPQ-application will not produce reactive power, allowing Stand By -mode operation and energy savings.
SECONDARY POWER FACTOR TARGET	Master	**This parameter allows a secondary power factor target**. e.g. generator mode Desired power factor that the device tries to reach. Value is selected in the range of -0.7–0.7. e.g. 0.980 equals PF value 0.980_{Ind} **Note:** This parameter is only valid when the digital input channel under commissioning is set to "Secondary Power Factor Target" and the corresponding digital input has an active signal. CAPACITIVE POWER FACTOR LIMIT is not operational when this mode is activated

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COMPENSATION PRIORITY	Master, Slave	**STANDARD/PFC/HARMONICS**. Selects what happens if the needed compensation is bigger than the capacity of the device **STANDARD:** Both harmonics and fundamental are cut down linearly **PFC:** Fundamental compensation is prioritised. • (The maximum reactive power output is the **PRIORITY CURRENT LEVEL**. Any extra capacity can be used in harmonics) **HARMONICS:** Harmonic compensations are prioritised. • (The maximum harmonic current is the **PRIORITY CURRENT LEVEL**. Any extra capacity can be used in reactive power)
Priority Current Level	Master, Slave	The maximum ampere level for the priority current as stated above.
Manual Step Test	Master, Slave	Manual override for the DO step control. Operational/visible only when **ENABLE HPQ** is **DISABLED.** **Allows capacitor step control circuit test without actual operation.** 30 second minimum off state programmed

Figure 79: Settings view when the toolbar is hidden

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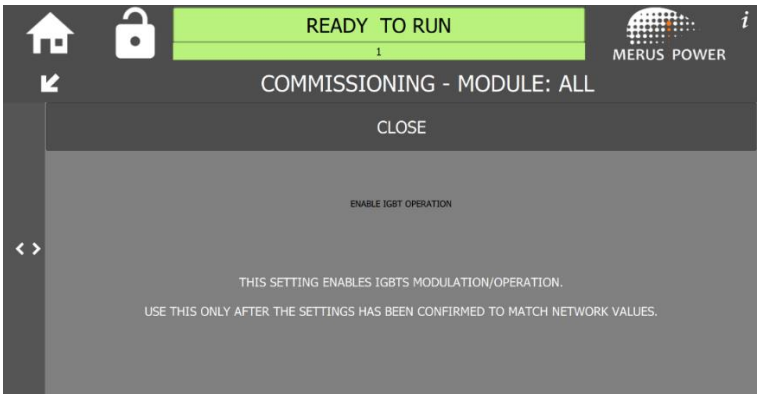

Figure 80: Setting info

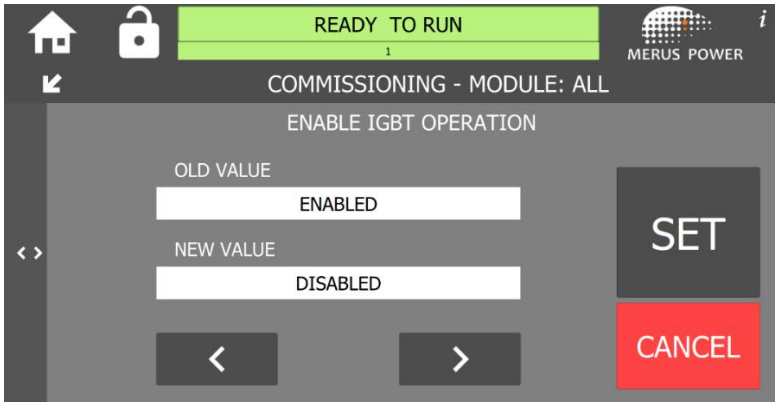

Figure 81: Edit screen when the setting has options

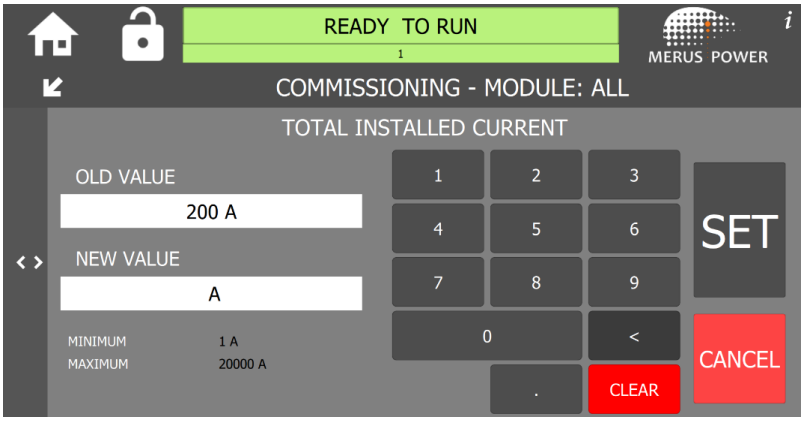

Figure 82: Edit screen when the setting has numerical input

The HMI will display differences in the settings if the selected module is ‘ALL MODULES’. Different settings are displayed in the colour yellow, as in Figure 83.

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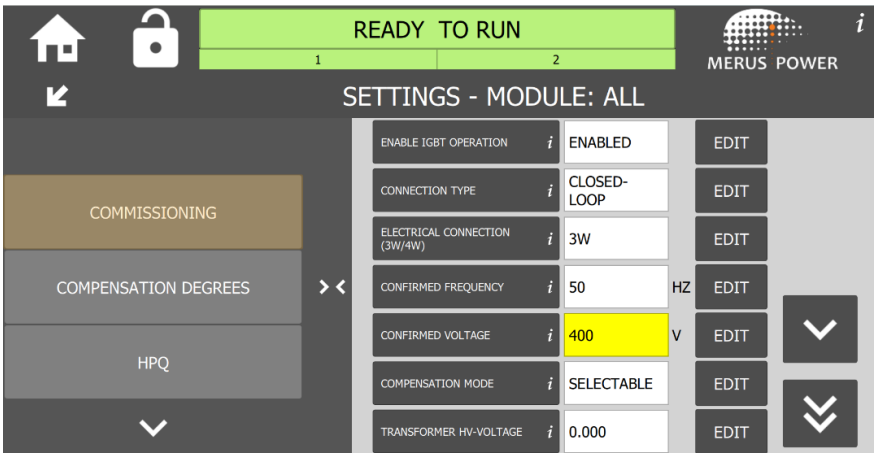

Figure 83: Differences in settings

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7.6.1 Commissioning

The commissioning settings include the basic settings that are usually changed during commissioning. The list of settings is presented in Table 13.

Table 13: Commissioning settings.

Setting	Explanation	Options/limits
ENABLE IGBT OPERATION	By enabling this, the device will enable the IGBTs. If this setting is disabled, the start sequence will end in 'IGBTs ready' -state	DISABLE/ENABLE
CONNECTION TYPE	Customer CT-locations: • In Open Loop, the CTs measure the load side current (module current not going through the CTs). • In Closed Loop, the CTs are in the network-side (module current going through the CTs). • The test mode can be utilized for testing purposes, and this **should not be activated without expert knowledge.**	OPEN LOOP/CLOSED LOOP/ TEST MODE
ELECTRICAL CONNECTION (3W/4W)	Select the corresponding electrical connection. See section 6.4.6.	3 W/4 W
CONFIRMED FREQUENCY	Select the nominal system frequency	NULL/50 Hz/60 Hz
CONFIRMED VOLTAGE	Select the nominal system mains voltage	NULL/200/208/220/240/380/ 400/415/440/460/480 (200–480 VAC devices) 480/500/525/550/575/600/625/650/690 (690 VAC devices)
COMPENSATION MODE	The compensation modes are explained in detail in section 3.2.	SELECTABLE / ALL HARMONICS *Read notes
BALANCING DEGREE	See section 3.3.2	0–100%
X1 CT ratio (CUSTOMER CTS)	Put the CT ratio of external measurement CTs (e.g. 2500 A/5 A →500). In case of 1 A secondary, see section 6.4.10.	1–10,000

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TOTAL INSTALLED CURRENT	○ **If the connected modules are not running in parallel (single module),** check that the value is the same as the nominal current of the module. ○ **In parallel connection,** put the combined compensation capacity in amperes **(**e.g. 2 pcs of 200 A HPQ-modules in parallel → Total installed current = 400 A).	1–20,000
X3 CT ratio (AUXILIARY CTS)	In case the X3 terminal is needed (see section 6.4), use the CT ratio from the CTs connected in the output of the HPQ-module.	1–10,000
ENABLE AUTOSTART	See section 3.3.4	DISABLED/ENABLED
ENABLE AUTOACK	See section 3.3.5	DISABLED/ENABLED
ENABLE STANDBY	See section 3.3.1	DISABLED/ENABLED
STANDBY TRIGGER LEVEL	Select a reference current value when the HPQ-module enters the Standby mode (see section 3.3.1)	0–200 A
X1 CT-POLARITY Lx	If one or more of the external CTs are connected with wrong polarity, it is possible to change the CT-polarity from the HMI without making hardwire modifications in the actual CTs. This can be done individually in each phase.	NORMAL/INVERSED
DIGITAL OUTPUT x	The digital output choices are explained in detail in section 6.2.3	NOT IN USE/RUNNING/ALARM/TRIP/ TRIP OR ALARM/FORCE ACTIVE
DIGITAL INPUT x	The digital input choices are explained in detail in section 6.2.3	NOT IN USE/ STANDBY/ALARM/TRIP/ START/STOP/AKNOWLEDGE

*** Compensation mode has been moved under advanced settings since HMI version 2.1. In case modes other than SELECTABLE-mode are needed, technical service should be contacted.**

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7.6.2 Compensation degrees

Compensation degrees are settings that have an effect when COMPENSATION MODE is selected as SELECTABLE (**DEFAULT**). With the SELECTABLE mode, the user can select how much each of the harmonics are mitigated. Figure 84 presents the COMPENSATION DEGREES view. Editing compensation degrees is edited like other settings.

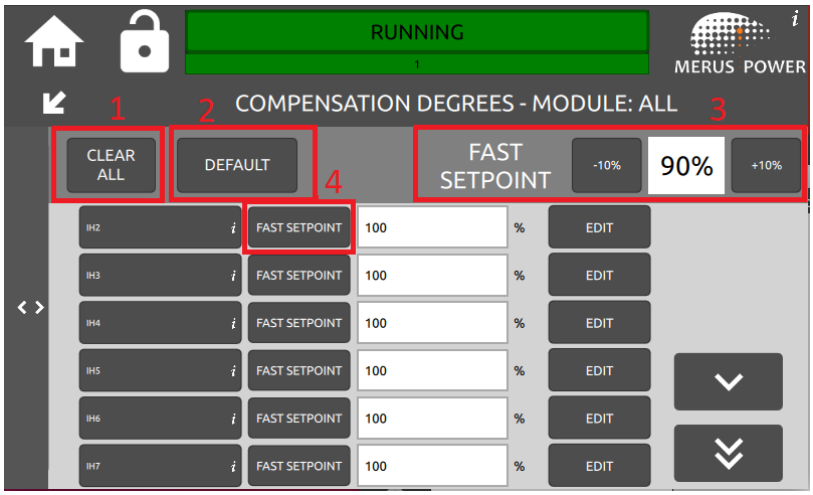

Figure 84: COMPENSATION DEGREES view.

The numbers in Figure 84:

1. Set all compensation degrees at 0%.
2. Set default compensation degrees for the frequency drive (5th, 7th, 11th and 13th).
3. Affect the fast setpoint edit. The value visible is the value set for the individual setting in 4.
4. Set the value of **Fast setpoint** in the current settings.

The settings are presented in Table 14.

Table 14: Compensation degree settings

item	Explanation	Range	Unit
Ih2–25	Selects the individual harmonic mitigation percentage	0–100	%
Ih1 (FUNDAMENTAL REACTIVE POWER)	Ih1 equals the fundamental harmonic current, and it also has a setting value from 0% to 100%. The Ih1, fundamental current, equals the reactive power of the load. When selecting Ih1 = 100% the module attempts to reach power factor = 1 and acts as a power factor compensator within the limits of the HPQ-module's capacity. The HPQ-module can produce both capacitive and inductive reactive power (see section 3.3.3).	0–100	%

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7.6.3 Connections

Connections are the settings in which the user is able to change the connections-related IP and ID settings. The main connection edit is presented in Figure 85.

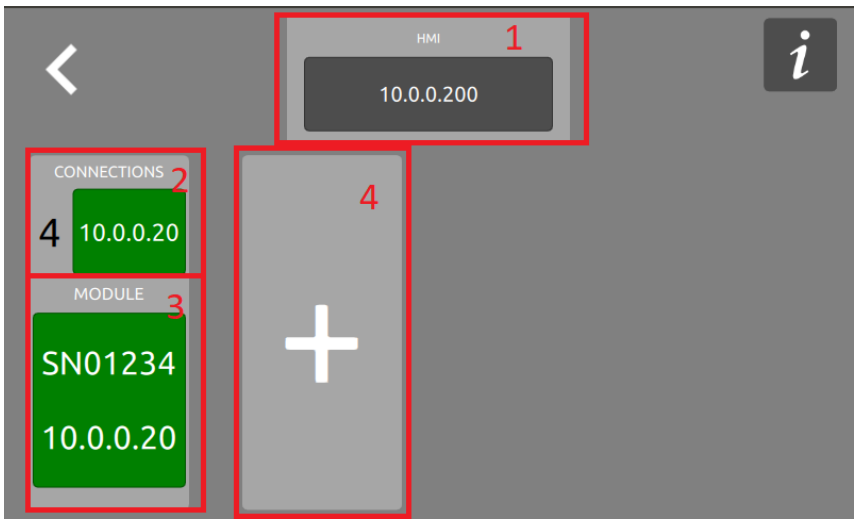

Figure 85: Connection settings

The numbers in Figure 85 explained:

1. Edit the HMI IP settings (new pop-up)
   - Edit IP, MASK or GW of the HMI panel
2. Edit the connections (new pop-up)
   - Connections represent the IP address where the HMI triesto find the modules
   - Colour RED indicates that the connection is not in the same IP address space as the HMI panel
   - Edit/delete the IP address for the connection or module ID
3. Edit the actual module IP settings (new pop-up)
   - The colour RED indicates that the module is not connected and settings cannot be opened
   - Edit IP, MASK or GW of the modules
   - Changes connections
4. Add new connection (new pop-up)
   - Add new connection.
   - This should only be used if the new module IP address is already different from the existing module(s).

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7.6.3.1 Changing the HMI IP settings

The basic IP settings when modules are delivered are the following:

Table 15: The basic IP settings

	IP	MASK	GATEWAY
HMI	10.0.0.200	255.255.255.0	10.0.0.1
HPQ-module	10.0.0.20	255.255.255.0	10.0.0.1

Changing of the HMI IP settings is presented in Figure 86. The highlighted colour shows the currently active field. Ensure that you insert valid values and then press CHANGE. Note that there may be some delays before the change occurs. If no modifications are needed, there is a CLOSE button at the top of the page.

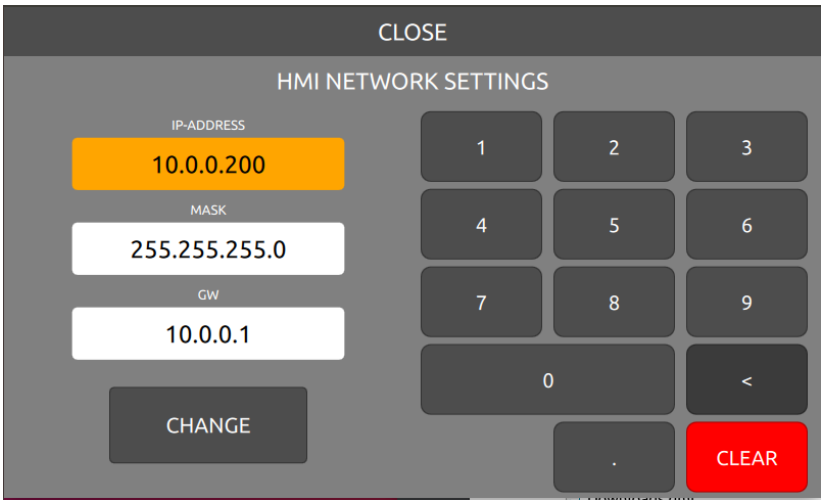

Figure 86: Changing the HMI IP settings

7.6.3.2 Changing the connection settings

Changing the connections is presented in Figure 87. The highlighted colour shows the currently active field. Ensure that you insert valid values and then press CHANGE. Note that there may be some delays before the change occurs. The upper field is the module identification number that is being displayed on the HMI settings.

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The DELETE button removes the current connections and is visible only if there is more than one module connection available. If no modifications are needed, there is a CLOSE button at the top of the page.

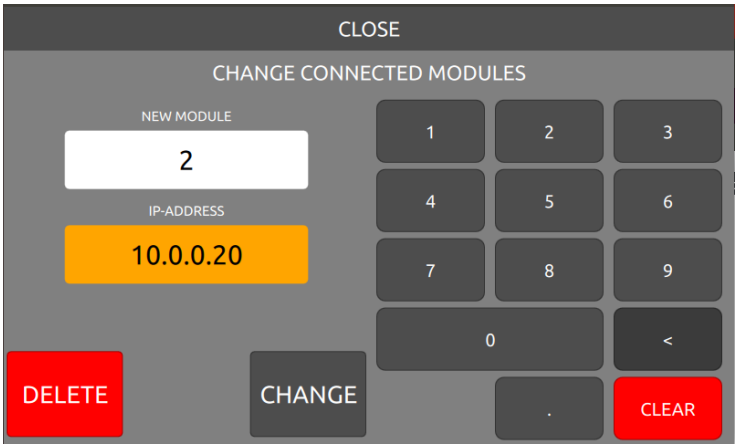

Figure 87: Changing the connections

7.6.3.3 Changing the module IP settings

Changing the module IP settings is presented in Figure 88. The highlighted colour shows the currently active field. Ensure that you insert valid values and then press CHANGE. Note that there may be some delays before the change occurs. If no modifications are needed, there is a CLOSE button at the top of the page.

The upper CONNECTIONS field selects how the connection settings are modified (in order to keep the connection alive)

- ADD:
  - Keeps the old connection alive and creates a new connection with a different module IP address.
- MODIFY:
  - Modifies the current connection, does not make a new connection.

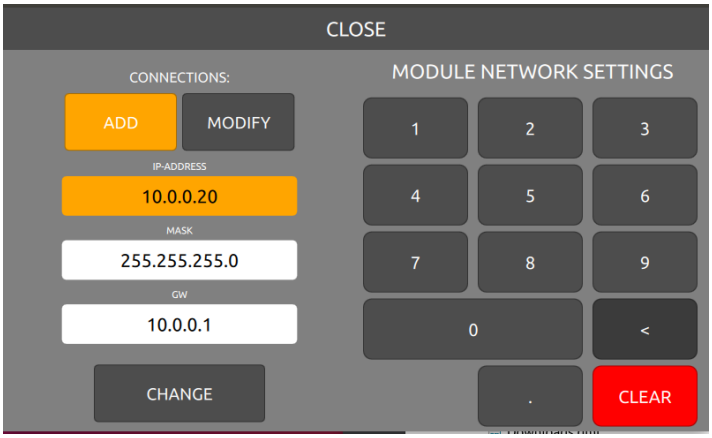

Figure 88: Changing module IP settings.

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7.6.3.4 Adding a new connection

Adding a new connection is presented in Figure 89. Ensure that you insert a valid IP address and then press ADD. Note that there may be some delays before the addition occurs. If no modifications are needed, there is a CLOSE button at the top of the page.

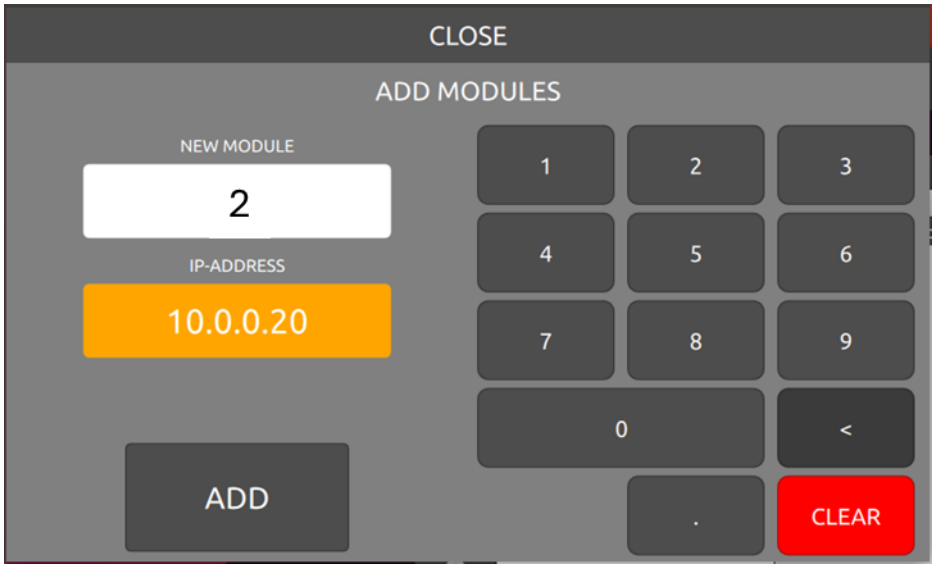

Figure 89: Adding a new connection.

7.6.4 Commissioning wizard

The HMI includes a commissioning wizard that automatically opens when there are no confirmed settings in the commissioning tab. The commissioning wizard is a simple program that helps the user get through basic installation and includes explanations.

Figure 90: Commissioning wizard start

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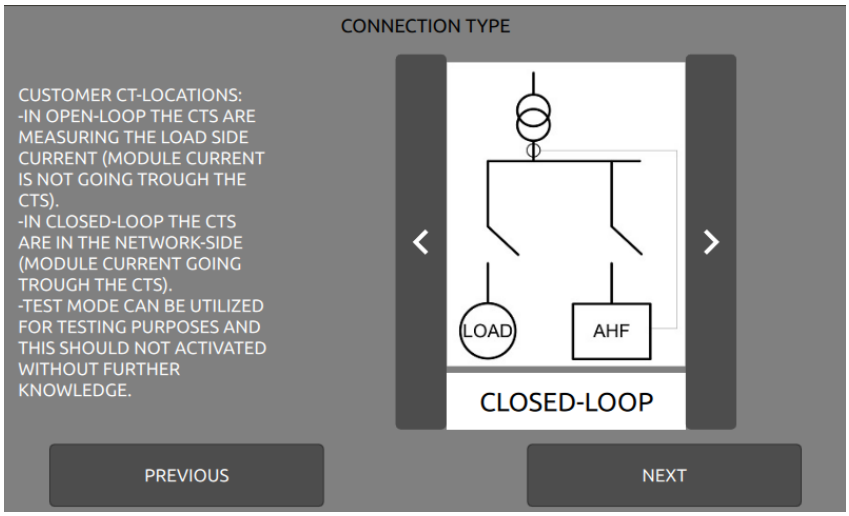

Figure 91: Part of the commissioning wizard.

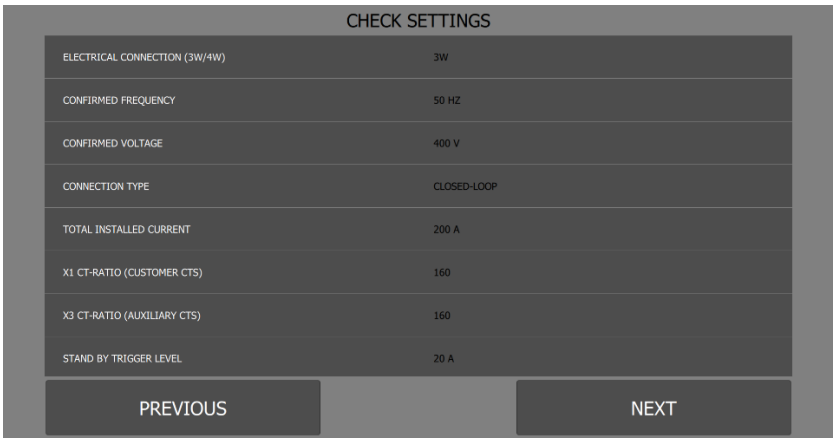

Figure 92: Checking commissioning settings

If you wish to start the commissioning wizard again after the parameters have been configured, set the confirmed frequency or voltage to NULL and restart the HMI.

8. Design standards and certificates

The HPQ-AHF module has been designed and manufactured in accordance with the following standards:

- **Safety:**
  - EN 50178:1997
  - UL 508 (UL 508 Standard for Industrial Control Equipment and CSA C22.2 No. 14 Industrial Control Equipment) **
- **EMC:**
  - EN61000-6-2:2007/A1:2011
  - EN61000-6-4: 2005

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The HPQ-AHF module conforms with the relevant European Union harmonisation legislation as follows:

- **Low Voltage Directive** (LVD) 2014/35/EU
- **Electromagnetic Compatibility Directive** (EMC) 2014/30/EU
- **Restriction of Hazardous Substances Directive** (ROHS 2) 2011/65/EU
- **Ecodesign Directive** 2009/125/EU
- **Waste Electrical and Electronics Equipment** (WEEE) 2012/19/EU

** See chapter 11 for UL features differences.

9. Environment

When the HPQ-module is at the end of its operational life, its various materials and contents can be recycled. To make sure the waste is recycled correctly, the waste should be delivered to a recycling centre to ensure proper recycling. The waste can also be sent to back to the manufacturer.

The local and other applicable regulations must be complied with when recycling the device or package.

The product is delivered packed in a plywood case, which can be recycled or reused.

This product complies with Directive 2011/65/EU (RoHS 2).

Table 16: Material declaration table

Merus® A2 module	Module size					
	Smaller module size		Bigger module size		Bigger module size (690 VAC)	
Steel	20.2kg	31.10 %	28.6kg	28.90 %	28.0kg	27.50 %
Aluminium	8.1kg	12.50 %	12.2kg	12.30 %	12.5kg	12.30 %
Copper	1.5kg	2.30 %	4.5kg	4.50 %	4.8kg	4.70 %
Plastics	0.1kg	0.20 %	0.2kg	0.20 %	0.3kg	0.30 %
PCBs	2.3kg	3.50 %	2.3kg	2.30 %	2.5kg	2.50 %
Electronic components	32.8kg	50.50 %	51.2kg	62.80 %	53.9kg	52.80 %
- Main reactor	*7.5kg*	*11.50 %*	*11.5 kg*	*11.60 %*	*9.2kg*	*9.00 %*
- AUX reactors	*7.9kg*	*12.20 %*	*11.4kg*	*11.50 %*	*8.1kg*	*7.90 %*
- Main capacitors	*1.8kg*	*2.80 %*	*3.6kg*	*3.60 %*	*11.4kg*	*11.20 %*
- Auxiliary transformer	*0kg*	*0 %*	*0kg*	*0 %*	*4.2kg*	*4.10 %*
- Others	*15.6kg*	*24.00 %*	*24.7kg*	*24.90 %*	*21.0kg*	*20.60 %*
Total	65.0kg	100.00 %	99.0kg	100.00 %	102.0kg	100 %

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10. Technical specification

Table 17: Technical data for core products.

Nominal current capacity	50 A	100 A	150 A	200 A
Electrical ratings				
Nominal voltage	**3 W:** 200 VAC – 480 VAC (±10%), **4 W:** 200 – 440 VAC (±10%) Higher voltages with a suitable step-up transformer			
Rated frequency	50/60 Hz (auto frequency sensing)			
Maximum neutral wire current	150 A	300 A	450 A	600 A
Network (3-wire/4-wire)	3 W/4 W			
System features				
Harmonics reaction / response time	Reaction time < 50 µs / Response time < 100 µs (one network cycle in selectable mode)			
Reactive power response time	< 20 ms			
Inverter topology	Three-level NPC topology			
Switching frequency	20 kHz			
Controller	Real time digital control with FFT			
Redundancy	Each module has an independent controller. If one module fails, the rest keep operating			
Harmonics filtering	2^{nd} to 50^{th} harmonics. Fully selectable and programmable up to the 25^{th} harmonic order in 'selectable' mode (standard deliveries).			
Interharmonics filtering	Interharmonics are filtered up to the 50th harmonic order when operating in 'all harmonics' mode.			
Filtering performance	Typically, < 5% THDi even with the most complex loads. < 3% THDi reachable (reduction with load harmonic above 50% module rating and the nonlinear load has > 3% inductive impedance)			
Harmonic attenuation	Typically > 90%			
Load balancing capacity	Programmable 0–100% * I_N of the module			
Power factor correction capacity	Programmable 0–100% * I_N of the module (lagging/leading)			
Operation modes	All harmonics / Selectable harmonics			
Protections	Overcurrent, overvoltage, undervoltage, over-temperature, and ripple circuit			
Smart operation modes	AutoStart, AutoAck, Standby			
Remote HW operation	Remote standby, start, stop, and ack			
Parallel modules	Up to two HPQ modules. Load is shared evenly between parallel modules.			
Harmonic generation function	Controlled & selectable harmonic injection can be used for validating the performance of various electrical system components			
Maximum step number	6 steps with one module, 12 steps with a secondary module. 5 or 11 if one output is selected for TRIP-state			
Minimum time between step changes	1 s in PFC-mode / < 20 ms in UF-mode (thyristor delay)			
Programmable turn off time	30–999 s in PFC mode / N/A in UF-mode			
Capacitor selection	Cyclic with RTC counter in PFC mode / FILO in UF-mode			
Hysteresis limit	0–50%			
Power factor target range	-0.7–0.7			
Overvoltage protection	Selectable 10%,15%, 20%			
Priority settings	Programmable priority between harmonics and fundamental compensation			
Certificates	CE, UL 508, RoHS 2			
Connections				
CT locations	Network/load side			
Number of CT's	3 pcs / 6 pcs (see section 6.4)			
CT polarity change	Installed CT polarity can be changed without HW changes in the network			
Minimum CT accuracy class	1.0 or better			
CT-primary/secondary	**Primary:** no limitations. **Secondary:** load currents: 1 A/5 A, auxiliary currents: 5 A.			

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Digital inputs	Five potentially free programmable ports. Three operational inputs selectable from the HMI in standard deliveries. 15–277 VAC 15–48 VDC			
Digital outputs	Six potentially free ports for capacitor bank control signals and trip signal. 15–277 VAC 6 A 15–48 VDC 2 A Optional SSR relays < 24VDC 2 A (check label for details)			
Interfaces and HMI				
HMI / display	7” touch screen with multilingual graphical HMI			
Communication capability	Ethernet, USB, Modbus TCP/IP			
Software update	Ethernet/USB drive			
Monitoring and reporting	On-site and remote monitoring capabilities Waveforms and spectrums from both load and network sides Trend charts			
Mechanical features				
Protection degree	IP 20 Pollution degree 2 Conformal coating on all PCBAs			
Enclosure material	Galvanised steel			
Cooling method	Forced air by temperature-controlled fans			
Losses	< 2.3%			
Typical noise at full load	60 dB	64 dB	67 dB	68 dB
	No audible switching frequency noise			
Dimension (WxDxH)	225x500x850 mm³	225x500x850 mm³	225x500x1150 mm³	225x500x1150 mm³
Weight	65 kg	65 kg	99 kg	99 kg
Installation and operation				
Needed airflow for the HPQ-module	350 m³/h	450 m³/h	750 m³/h	1000 m³/h
Temperature	5-40 °C, without derating (see section 13.4). Max ambient temperature 50 °C			
Altitude without derating	< 1000 m, without derating (see section 3.4)			
Humidity	Maximum 85% RH, non-condensing (operation) Maximum 95% RH, non-condensing (storage)			
Ventilation requirements	300 mm of free space below and above the module required for air ventilation			
External fuses (recommendation)	NH 00 gL/gG 63 A	NH 00 gL/gG 125 A	NH 01 gL/gG 200 A	NH 01 gL/gG 250 A
Main cable entry	Top/Bottom			

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Merus Power designs, manufactures, and markets a wide range of reliable power quality and energy storage solutions across the world. Our customers in industries, commercial buildings, renewable energy and infrastructure segments benefit from improved power quality in terms energy efficiency, operational excellence and compliance with technical regulations.

Table 18: Technical data for 690 VAC modules**

Nominal current capacity	50 A	100 A	125 A
Electrical ratings			
Nominal voltage	**3 W:** 500 VAC – 690 VAC (±10%), **4 W:** 480 – 525 VAC (±10%) higher voltages with suitable step-up transformer		
Rated frequency	50/60 Hz (auto frequency sensing)		
Max neutral wire current	150 A	300 A	375 A
Network (3-wire/4-wire)	3 W/4 W		
System features			
Harmonics reaction / response time	Reaction time < 50 µs / Response time < 100µs (one network cycle in selectable mode)		
Reactive power response time	< 20 ms		
Inverter topology	Three-level NPC topology		
Switching frequency	20 kHz		
Controller	Real time digital control with FFT		
Redundancy	Each module has independent controller. If one module fails, the rest keep operating		
Harmonics filtering	2^{nd} to 50^{th} harmonics. Fully selectable and programmable up to the 25^{th} harmonic order in 'selectable' mode (standard deliveries).		
Interharmonic filtering	Interharmonics are filtered up to the 50th harmonic order when operating in 'all harmonics' mode.		
Filtering performance	Typically, < 5% THDi even with the most complex loads. < 3% THDi reachable (reduction with load harmonic above 50% module rating and the nonlinear load has > 3% inductive impedance)		
Harmonic attenuation	Typically > 90%		
Load balancing capacity	Programmable 0–100% * I_N of the module		
Power factor correction capacity	Programmable 0–100% * I_N of the module (lagging/leading)		
Operation modes	All harmonics / Selectable harmonics		
Protections	Overcurrent, overvoltage, undervoltage, over-temperature, and ripple circuit		
Smart operation modes	AutoStart, AutoAck, Standby		
Remote HW-operation	Remote standby, start, stop, and ack		
Parallel modules	Up to two HPQ modules. Load is shared evenly between parallel modules.		
Harmonic generation function	Controlled & selectable harmonic injection can be used to validate the performance of various components of the electrical system		
Maximum step number	6 steps with one module, 12 steps with a secondary module. 5 or 11 if one output is selected for TRIP-state		
Minimum time between step changes	1 s in PFC-mode / < 20 ms in UF-mode (thyristor delay)		
Programmable turn off time	30–999 s in PFC mode / N/A in UF-mode		
Capacitor selection	Cyclic with RTC counter in PFC mode / FILO in UF-mode		
Hysteresis limit	0–50%		
Power factor target range	-0.7–0.7		
Overvoltage protection	Selectable 10%,15%, 20%		
Priority settings	Programmable priority between harmonics and fundamental compensation		
Connections			
CT-locations	Network/load side		
Number of CTs	3 pcs / 6 pcs (see section 6.4)		
CT-polarity change	Installed CT-polarity can be changed without HW changes in the network		
Minimum CT accuracy class	1.0 or better		
CT-primary/secondary	**Primary:** no limitations. **Secondary:** load currents: 1 A/5 A, auxiliary currents: 5 A.		
Digital inputs	Five potentially free programmable ports. Three operational inputs selectable from the HMI in standard deliveries. 15–277 VAC		

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	15–48 VDC		
Digital outputs	Six potentially free ports for capacitor bank control signals and trip signal. 15–277 VAC 6 A 15–48 VDC 2 A Optionally SSR relays < 24 VDC 2 A (check label for details)		
Interfaces and HMI			
HMI / display	7” touch screen with multilingual graphical HMI		
Communication capability	Ethernet, USB, Modbus TCP/IP		
Software update	Ethernet/USB drive		
Monitoring and reporting	On-site and remote monitoring capabilities Waveforms and spectrums from both load and network sides Trend charts		
Mechanical features			
Protection degree	IP 20 Pollution degree 2 Conformal coating on all PCBAs		
Enclosure material	Galvanised steel		
Cooling method	Forced air by temperature-controlled fans		
Losses	< 2.5%		
Typical noise at full load	< 70 dB	< 75 dB	< 75 dB
	No audible switching frequency noise		
Dimension (WxDxH)	225x500x1150 mm³	225x500x1150 mm³	225x500x1150 mm³
Weight	102 kg	102 kg	102 kg
Installation and operation			
Needed airflow for the HPQ-module	450 m³/h	750 m³/h	850 m³/h
Temperature	5-40 °C, without derating (see section 13.4). Max ambient temperature 50 °C.		
Altitude without derating	< 1000 m, without derating (see section 3.4)		
Humidity	Maximum 85% RH, non-condensing (operation) Maximum 95% RH, non-condensing (storage)		
Ventilation requirements	300 mm of free space below and above the module required for air ventilation		
External fuses (recommendation)	NH 01 gL/gG 63 A	NH 01 gL/gG 125 A	NH 01 gL/gG 160 A
Main cable entry	Top/Bottom		

** See chapter 11 for UL features differences.

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Table 19: Technical data for capacitor steps.

Configuration	The Power Factor Correction mode	The Ultra-fast compensation mode
Capacitor size per step (kVAr)	10–200 kVar*	10–200 kVar*
Possible step-ratios	1:1:1:1:1:1	1:1:1:1:1:1
Series reactor (%)	6–20%	6–20%
Switch type	Thyristor Switch or magnetic switch	**Thyristor Switch (TC) only**
Capacitor type	Three-phase	Three-phase

* The maximum step size depending on the nominal current level, voltage level and hysteresis.

* Multiple capacitor packs can be used as one step. e.g. 2*35 kvar steps together to have 70 kvar steps. Relay characteristics must be considered.

Table 20: Technical data of the Human Machine Interface (HMI)

Item	Specification
Dimensions	187 mm x 124 mm x 51.1 mm
Weight	0.50 kg
Mounting	Panel thickness 1.6 – 5.0 mm Tightening screws included Recommended tightening torque 0.4 Nm
Protection class	Flame retardant ABS IP65 Water-resistant front panel
Power	12..24 VDC (6 W)
Interfaces	RJ45, USB, (microSD)
Display	LCD 7” (resistive film type) 16:9 (800x480)
Backlight	Automatic screensaver after 30 minutes
CPU	1.2 GHz 64-bit Quad-Core ARM Cortex-A53 processor
Terminal plug on the HMI panel	Phoenix contact: 1828249
Terminal plug from the module	Wurth wr-tbl series 351

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Table 21: Technical data of the Human Machine Interface (HMI) **Alternative version**

Item	Specification
Dimensions	190 mm x 107.8 mm x 27.7 mm
Weight	0.70 kg
Mounting	Panel thickness 1.6 – 5.0 mm Tightening screws included Recommended tightening torque 0.4 Nm
Power	6–36 VDC (7 W)
Interfaces	RJ45, USB
Display	LCD 7” (capacitive film type) 16:9 (1024x600)
Backlight	Automatic screensaver after 30 minutes
CPU	1.5 GHz 64-bit Quad-Core ARM Cortex-A72 processor
Terminal plug on the HMI panel	Phoenix contact: 1803581
Terminal plug from the module	Wurth wr-tbl series 351

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11. UL/CSA related information

By default, HPQ-modules are non-UL variants but can be ordered as UL variants. When using UL-listed modules, the following points must be noted:

- UL 508 Voltage Range: 480–600 VAC
- For CSA Compliance:
    - “Transient surge suppression shall be installed on the line side of this equipment and shall be rated 346 V (phase to ground), 600 V (phase to phase), suitable for overvoltage category III, and shall provide protection for a rated impulse withstand voltage peak of 2546 V,” or equivalent.
    - “Surge suppressors of the metal oxide varistor type B are not considered acceptable overvoltage protection for equipment and circuits that operate in the primary circuit.”
- Main input terminals:

Table 22: Torques in main terminals

Model	Torque values
WGK95	132.76 Lb/in
HDFK95	250 Lb/in

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12. Revision history

Merus HPQ-module manual revisions

Changes	Revision number	Date
Initial version	1.0	24/01/2025

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