Merus® A2 – Active Harmonic Filter User Manual

14.01.2025 Version 3.7

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 A2-series active harmonic 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® A2 module to warn of the risks involved.

The live parts of the A2 modules are partially contact protected. Only qualified personnel are permitted to operate the A2 module. The safety instructions according to EN 50110-1 and local electrical safety standards must be followed.

Disconnect the A2 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 A2 module. Always verify by measurement that the capacitors have been discharged.

	Hazardous voltage may exist!
	Dangerous! Attention!

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3. Merus® A2 modules

A2 modules are modern, flexible, high performance and cost-effective solutions that provide an instantaneous and effective response to power quality problems in low-voltage electrical power systems. They enable 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. A2 modules are the ultimate answer to power quality problems caused by waveform distortions, a low power factor, 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, which means that multiple A2 modules can be connected parallel, to increase the total installed capacity of the system.

3.1 Operating principle of the Merus® A2 module active harmonic filter

The operating principle of the A2 module is illustrated in Figure 1. Merus® A2 modules are power electronic devices connected in parallel with the non-linear load. The A2 module operates as a controlled current source, providing any kind of current waveform in real time. The A2 module is equipped with an energy storage element and a control system, which enables it to inject desired current to the network. The A2 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.

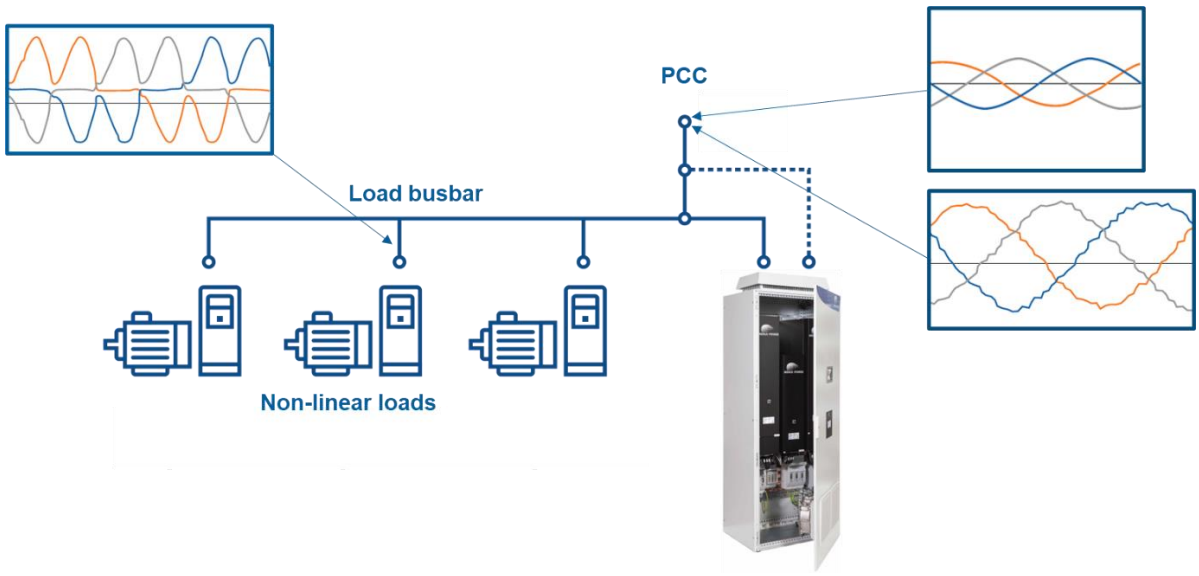

Figure 1: Operational principle of the Merus® A2-Series active harmonic filter module

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3.2 Operation modes of the active harmonic filter

The Merus® A2-AHF has three basic operation modes. Therefore, the A2 module can be easily tailored to solve specific power quality problems. The basic operation 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 current.
- **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.**

Compensation Mode III – All harmonics, excluding fundamental frequency

- This operation mode is the most dynamic, offering real time compensation of all harmonics, but does not include reactive power mitigation.
- Fundamental current load balancing is programmable in this mode.
- The remaining current in the network consists of active current, fundamental reactive current, and a negligible amount of harmonic currents.

Note: The default compensation mode in the HMI version 2.1 and later is **Selectable**. Compensation mode is moved to advanced setting 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 Other A2 module applications

The standard A2 module works as an AHF. In addition to the regular AHF-application, the A2 module can be modified by Merus Power to be used in several other applications, such as:

- as an AHF and capacitor step controller in Hybrid Power Quality (HPQ) applications
- as an inverter module in STATCOM applications

For more application-specific information about these and other applications, contact Merus Power sales.

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3.4 A2 module properties

Important features of the A2 module are explained in this section.

3.4.1 Standby

The A2 module is equipped with a standby feature. In Standby mode, the A2 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 2.

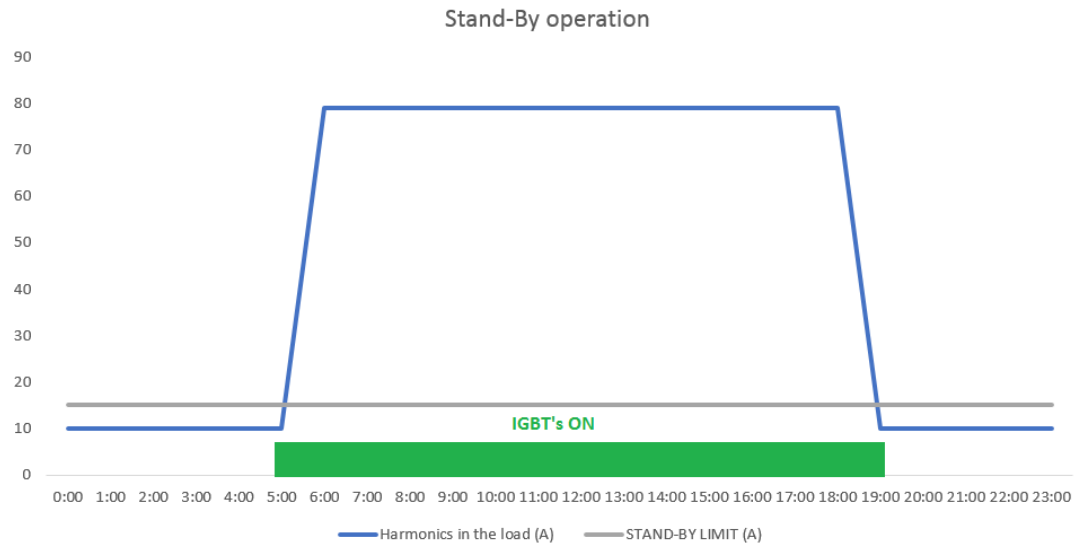

Figure 2: Standby example

- 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.
- 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, a 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 will go to sleep.
- The setting on the HMI refers to a single module reference level and not the total system output in parallel module cases.

3.4.2 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 3.

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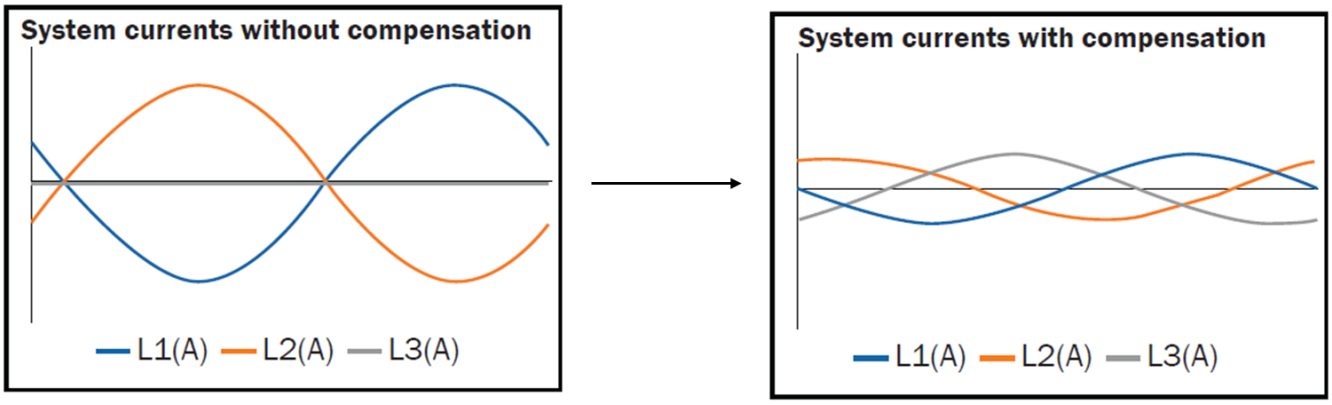

Figure 3: An example of fundamental cycle current load balancing

3.4.3 Reactive power compensation (Power Factor Correction)

The A2 module can dynamically compensate both inductive and capacitive fundamental reactive power. The compensation can be done up to the module nominal current. The A2 module will either try to compensate all, none or some of the reactive power from the network, depending on the operational mode (see 3.2).

The reactive power 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 A2 module current.

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		

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3.4.4 AutoStart

The AutoStart feature allows the A2 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 off and then turned on after a while.

Figure 4: AutoStart flowchart

3.4.5 AutoAck

The AutoAck feature allows the A2 module to acknowledge a non-severe error (not IGBT-error) after tripping and automatically start again. The A2 module stops acknowledging errors if acknowledging has occurred five times within 30 minutes: in this case, the A2 module will lock operation (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.

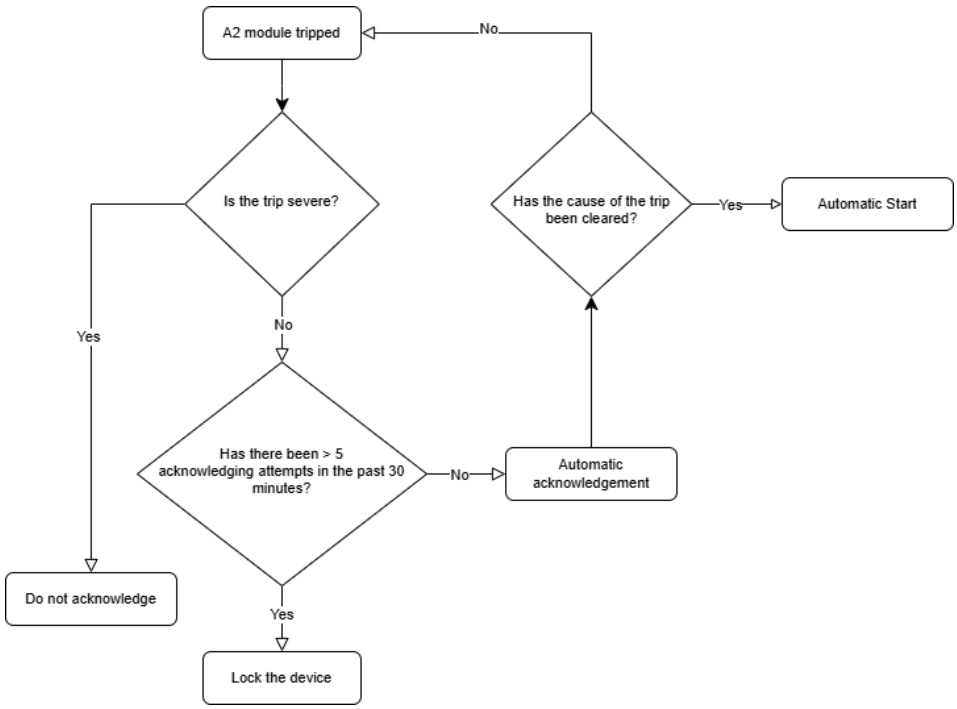

Figure 5: AutoAck flowchart

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3.4.6 Internal fans

There is an easy-to-replace fan tray in the A2 module. The fans are temperature controlled, and their speed is adjusted linearly based on the A2 module temperatures. The speed adjustment allows longer fan and air filter service life while enabling energy savings.

Figure 6: Internal fan tray

3.5 Derating

In normal operating environments (see technical data in Chapter 10) the A2 module operates with 100% capacity. If the A2 module is installed in a different environment, it will derate the output current automatically depending on the ambient temperature.

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

3.5.2 Temperature

At the nominal operating temperature, the A2 module works at full 100% of the nominal capacity (see technical data in Chapter 10). However, if the installation temperature **is higher,** the A2 module will reduce the maximum output current automatically. The general capacity above the nominal temperature is presented in a generic model in Figure 7*.

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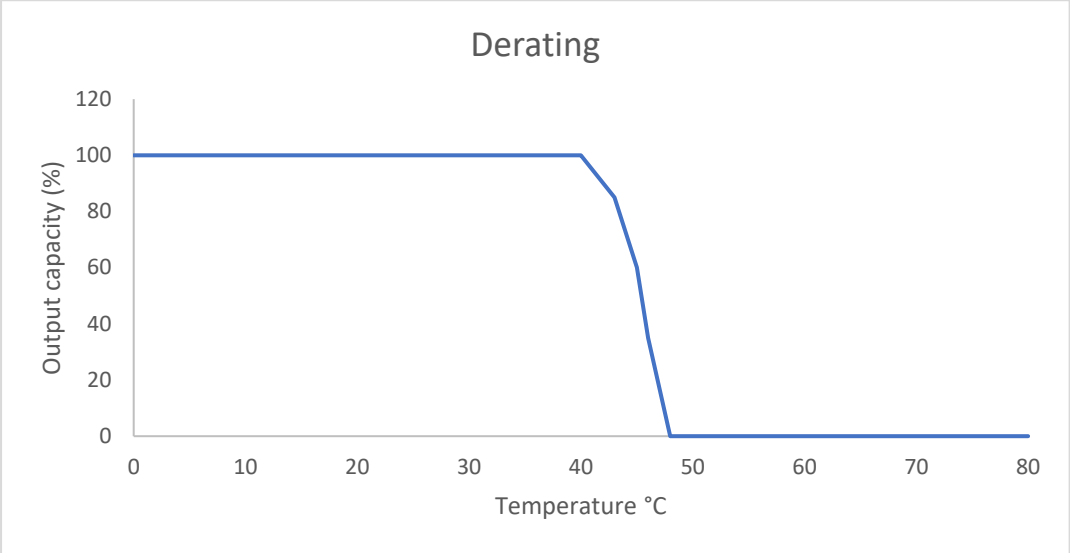

Figure 7: Derating coefficient in the function of the temperature

***Figure 7 is for illustration purposes only.** The actual operation capacity depends on the actual installation environment and the load current harmonics spectrum.*

3.5.3 Harmonic order

The A2 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 8 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 for full nominal capacity in 24/7 operation.

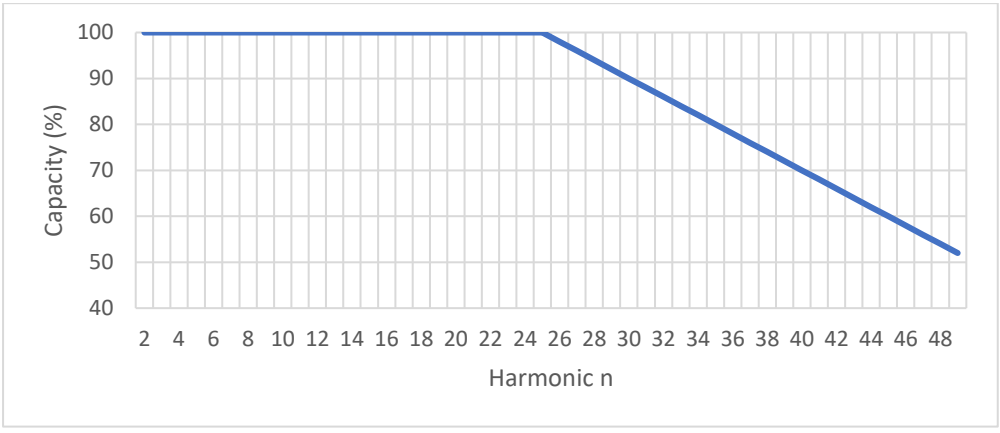

Figure 8: Higher harmonic derating linearization on the A2 module at 400 VAC 50 Hz

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4. Delivery inspection and unpacking

All A2 modules are factory-tested before they are sent to customers. Nevertheless, there is always a chance that the device has been damaged during transportation. It is therefore important to check the A2 module and package on arrival. Special care must also be used during the installation process.

4.1 Before opening

Carefully check the external condition of the shipment before opening it. Ensure 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, inspect the shipment thoroughly. If you notice any discrepancies, such as damage, bruising, or missing items, it is crucial to 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 clearly, 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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4.2 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 A2 module).
- 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 A2 module front panel rating plate).

When the A2 module is removed from the pallet, note that:

- The device is heavy
- 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 9 – this may damage the bottom connectors

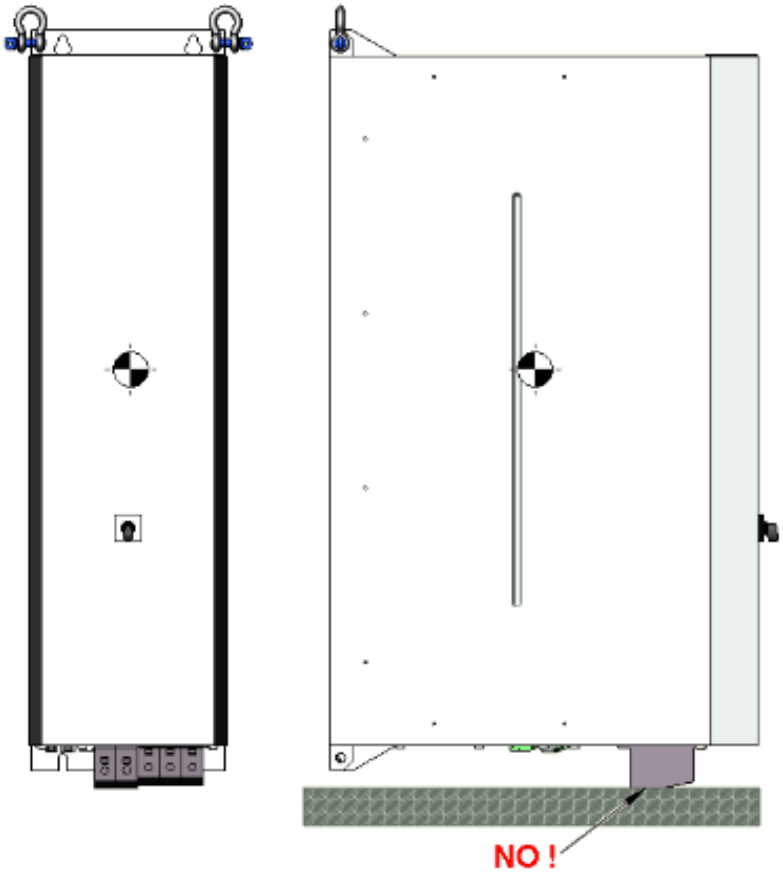

Figure 9: A2 module's centre of gravity

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4.3 Storage

It is recommended to keep the module in its own delivery package until installation. The A2 modules must be stored inside a warm and dry location (see specification in Table 14). A long storage period is not recommended. If the storage time is more than nine months, a local distributor must be consulted.

4.4 Lifting

The device has two Ø11 mm holes in the back top corners for shackles, as shown in Figure 10.

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

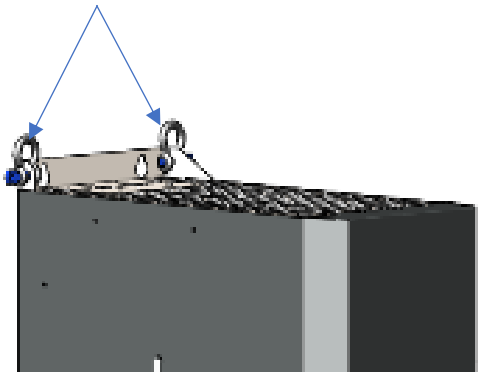

Figure 10: Lifting points

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.

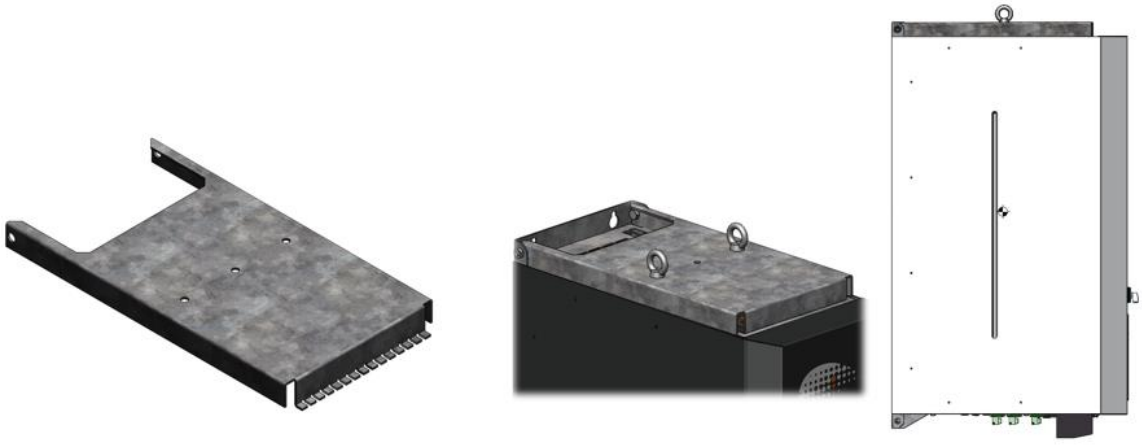

Figure 11: Lifting accessories*

** Sold as accessories upon ordering the module.*

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5. Physical properties and installation

The A2 module dimensions, electrical connections, and cabinet installation are covered in this chapter.

5.1 The A2 module physical properties

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

5.1.1.1 Dimensions

The A2 modules come in two physical frame sizes:

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

The dimensions of the smaller A2 module are illustrated in Figure 12. The dimensions for the larger A2 module are illustrated in Figure 13.

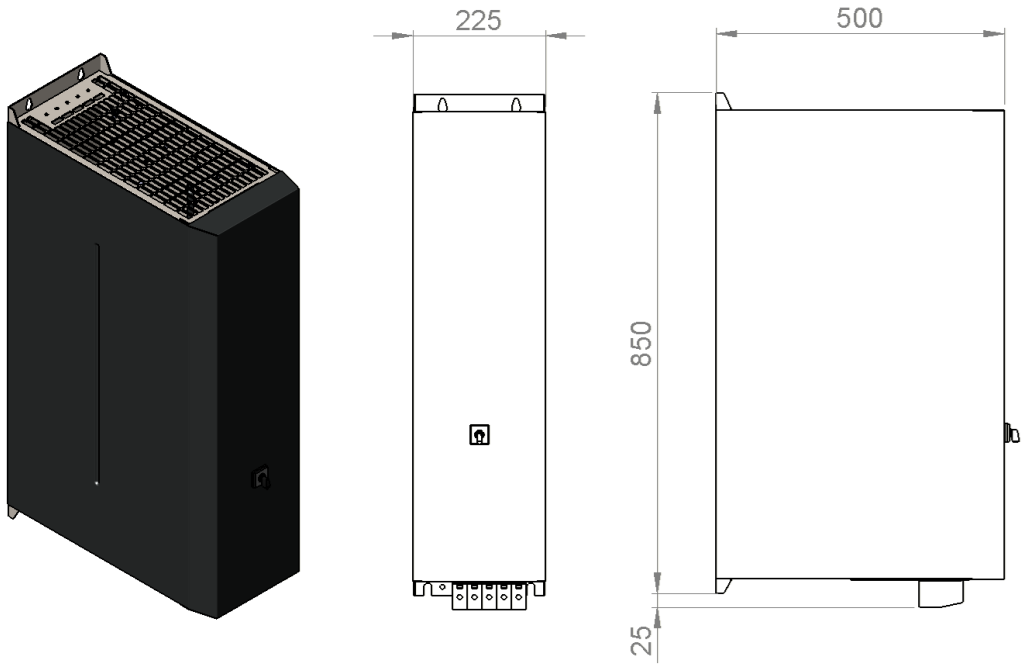

Figure 12: Smaller module (bottom-entry) dimensions in mm

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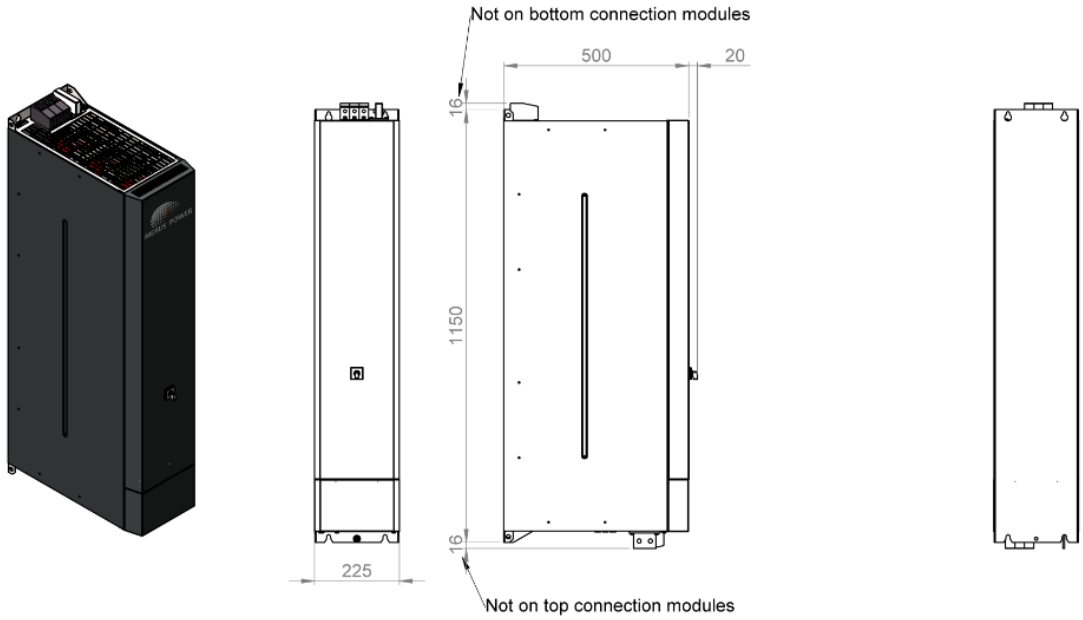

Figure 13: Larger module dimensions in mm

5.1.2 Main power cable entries

The A2 modules can have main cables fed from the bottom of the module or from the top of the module. This allows installation in various kinds of cubicles more easily. 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 14.

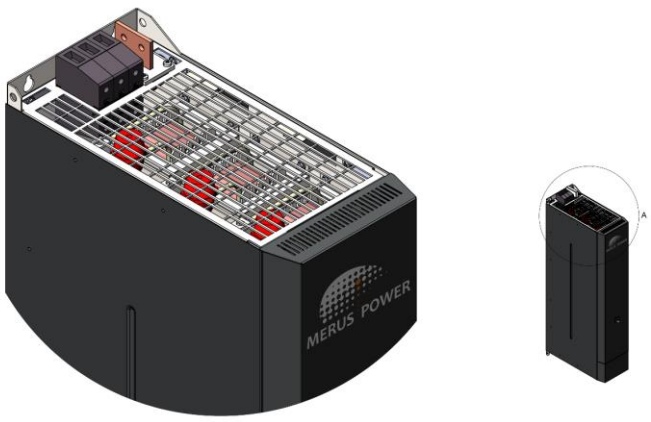

Figure 14: An illustrative picture of the larger top-entry module

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5.1.3 A2 module front panel

The A2 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 connect or disconnect AC voltages in the module.** The main power switch is shown in Figure 15.

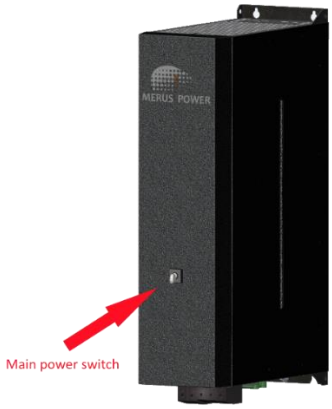

Figure 15: Main power switch

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 in 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.

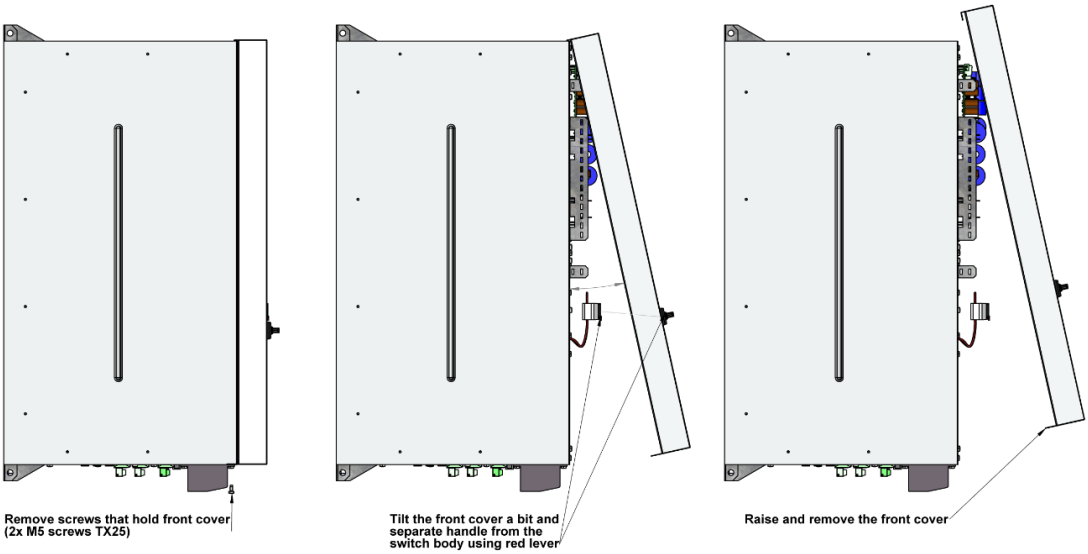

Figure 16: Removing the front panel of the A2 module

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5.1.4 Terminals and connectors

The following connections are found in the A2 module:

MAIN TERMINALS

- Main power cable terminals: L1, L2, L3 (35–95 mm^2, tightening torque 15–20 Nm)
  - Suggested cable sizes are 50 mm^2 for 50–100 A modules and 70 mm^2 for 125–200 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 17 shows the terminal locations of the smaller module.

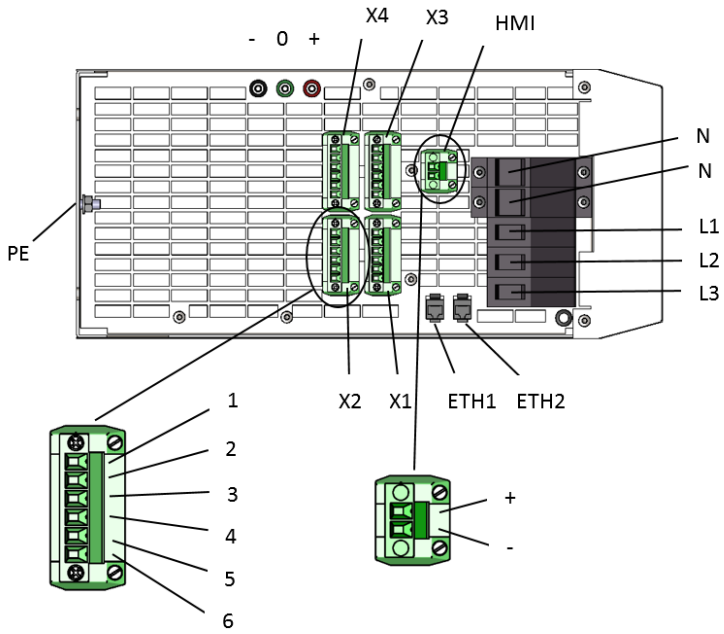

Figure 17: Terminals in the smaller bottom entry module

One current transformer terminal and an HMI terminal are magnified in Figure 17. 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 5.4.

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In the larger modules, you can find the signal terminals inside the bottom-front cover as shown in Figure 18 and Figure 19: The bottom front cover of the 690 VAC modules. To access the terminals, unscrew the two T25 screws (from the bottom front cover).

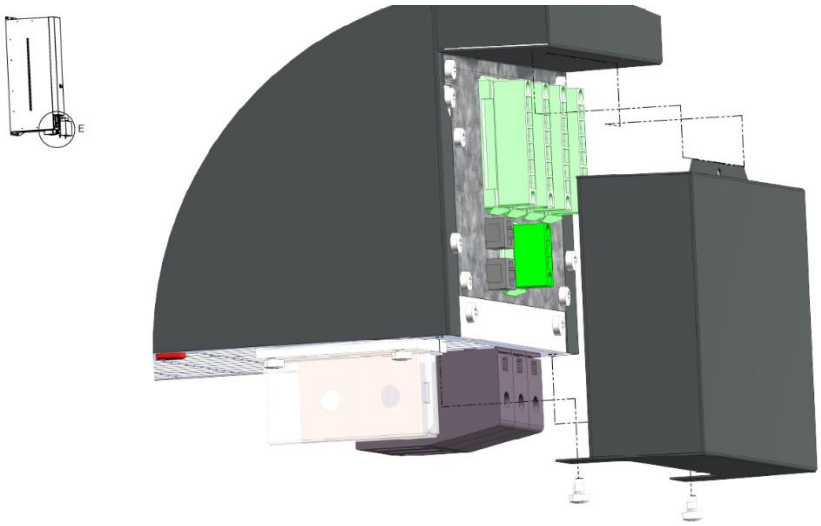

Figure 18: The bottom front cover of the A2 150/200 A device

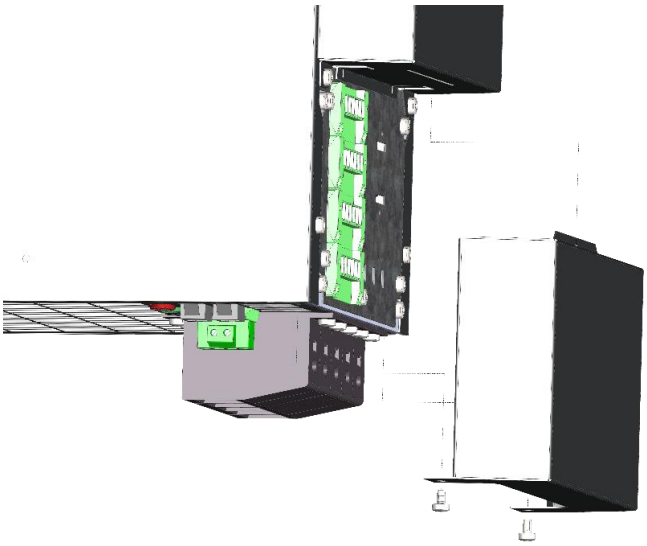

Figure 19: The bottom front cover of the 690 VAC modules

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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 20.

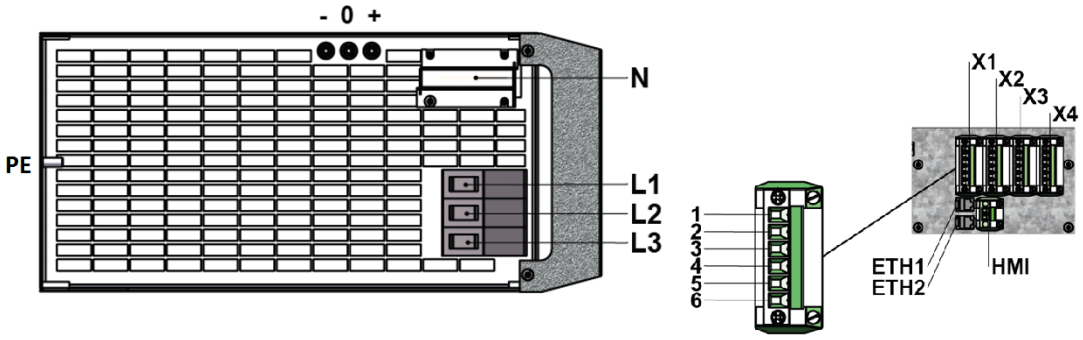

Figure 20: A2150/200 A terminals in the bottom entry module

In 690 VAC modules, the connectors can be found in Figure 21 and Figure 22.

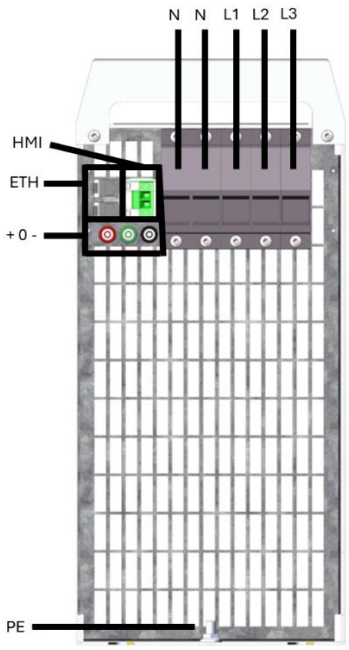

Figure 21: Bottom connectors in the 690 VAC module

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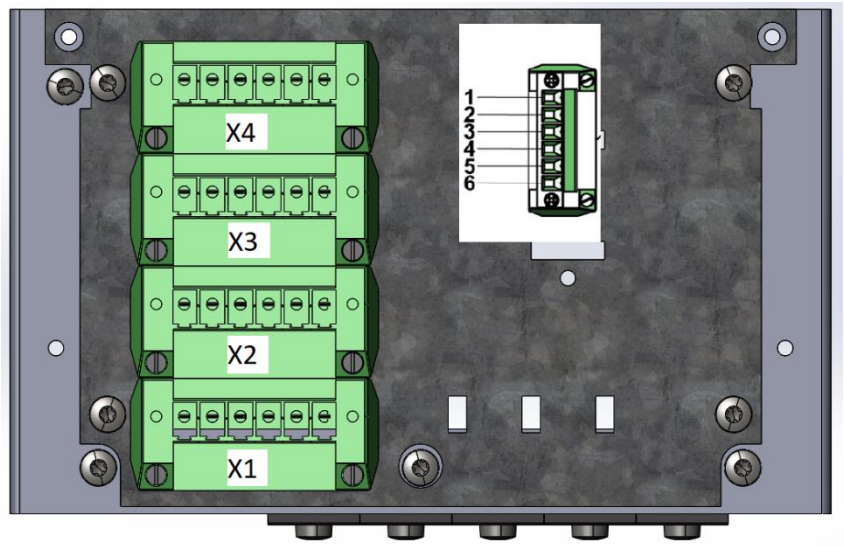

Figure 22: Front connectors of the 690 VAC module

In 150A/200A module(s) the neutral is a touch-protected busbar with a plastic cover. If 4W operation is desired, remove the cover and re-install the screws. An example is shown in Figure 23.

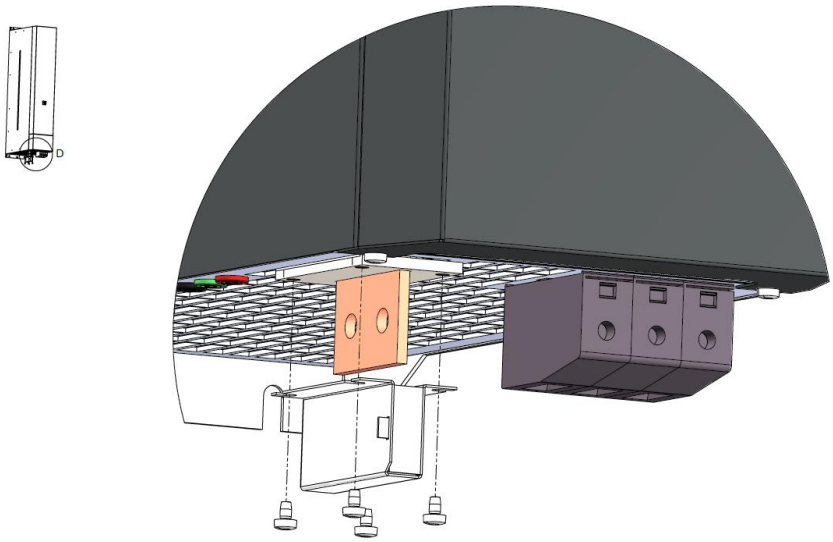

Figure 23: Neutral cover of the A2 150/200 A module

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5.2 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.

5.2.1 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 is shown in Figure 24. The locations in the larger module are similar.

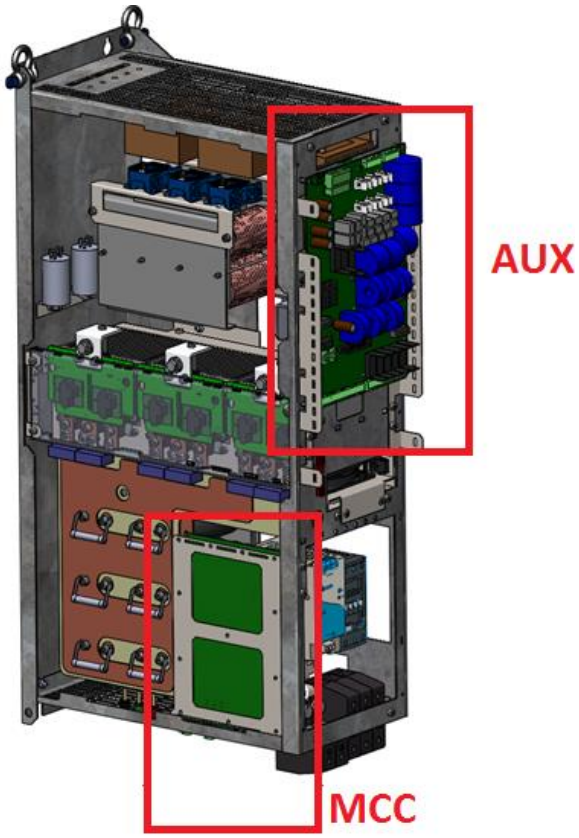

Figure 24: Locations of the electronic boards in the A2 module

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5.2.2 Overview of the boards

5.2.2.1 MCC-card

An overview of the MCC card is presented in Figure 25.

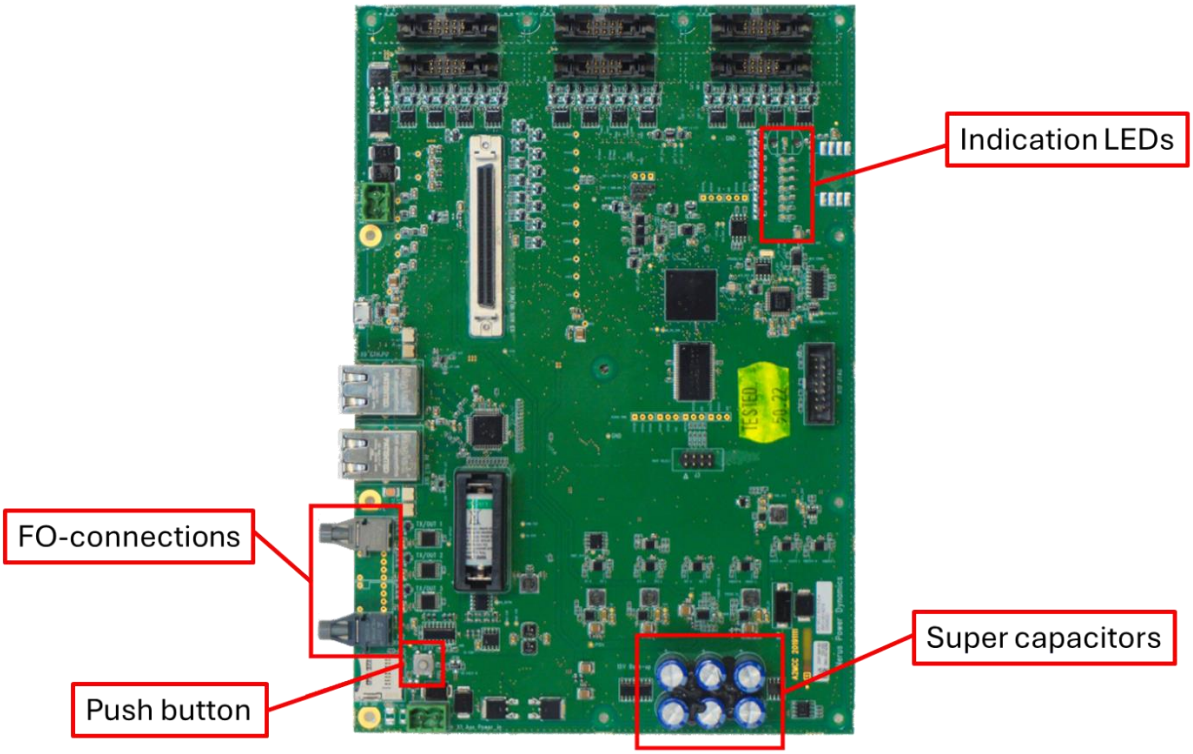

Figure 25: MCC card overview

The following points are highlighted:

- FO connections (section 5.2.4)
- Supercapacitors
  - Maintain control voltage after AC power failure for < 5 min.
- Push button
  - Used as service button. Normally not needed.
- Indication LEDs (Figure 26)

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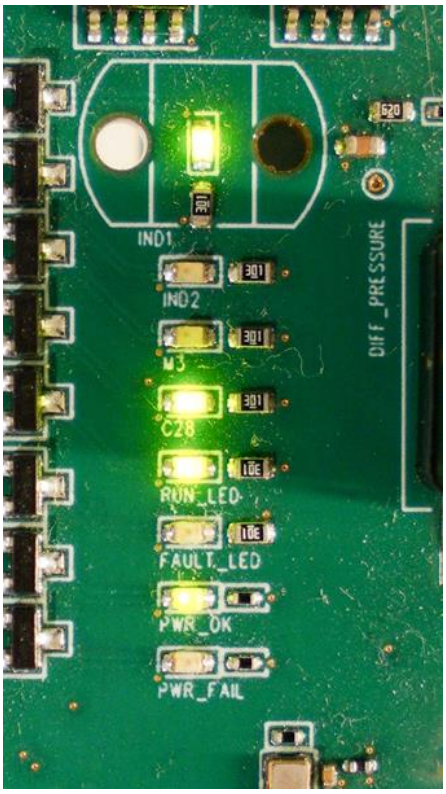

Figure 26: MCC card indication LEDs

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

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5.2.2.2 AUX card

An overview of the AUX card is presented in Figure 27.

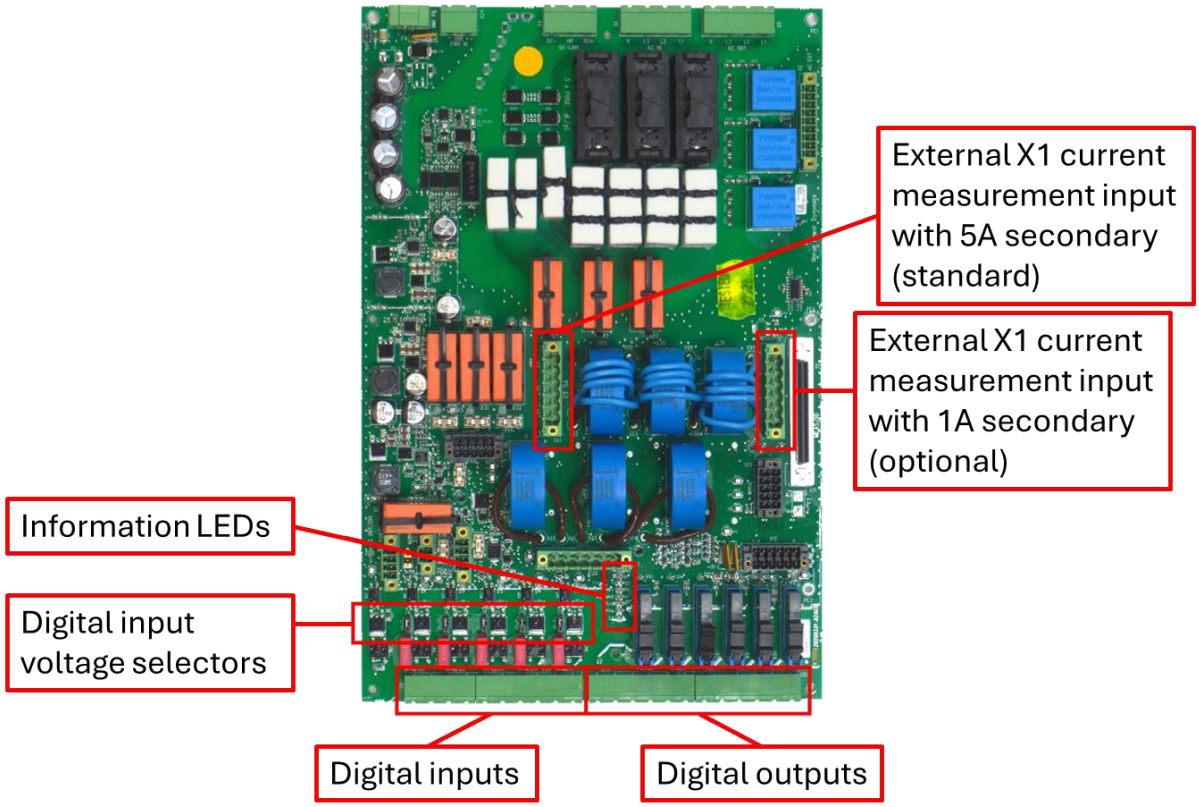

Figure 27: AUX card overview

The following points are highlighted:

- Digital inputs (section 5.2.3)
- Digital input voltage selector (section 5.2.3)
- Digital Output (section 5.2.3)
- External current measurement secondary selection (section 5.4.10)
  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

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5.2.3 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.

The A2 module has several hardwired inputs and outputs prebuilt in the system. Those inputs and outputs can be connected to an external I/O logic, e.g. a SCADA system or fan control. The I/O ports can be found on the AUX card as shown in Figure 27. There are:

- Five input ports
- Six output ports

Ports are presented in Figure 28.

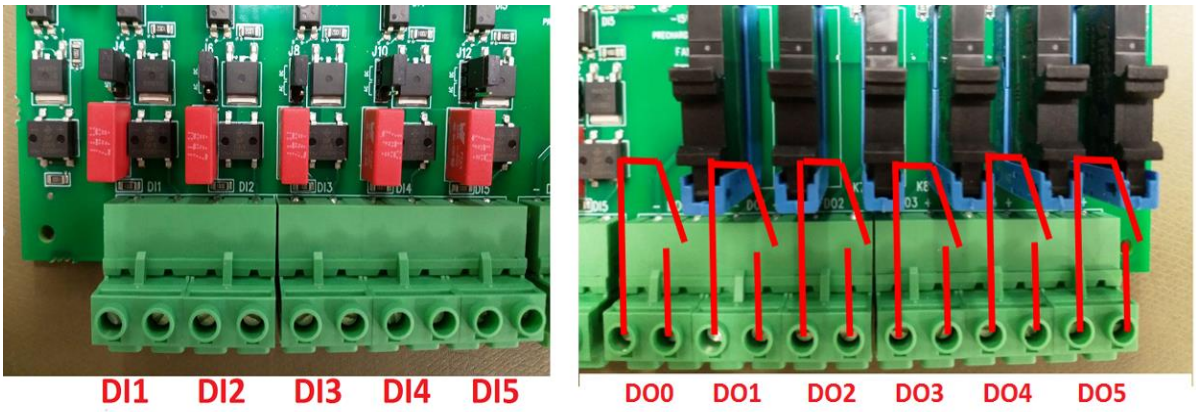

Figure 28: Digital inputs and outputs of an A2 module

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 29.

Output terminal 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

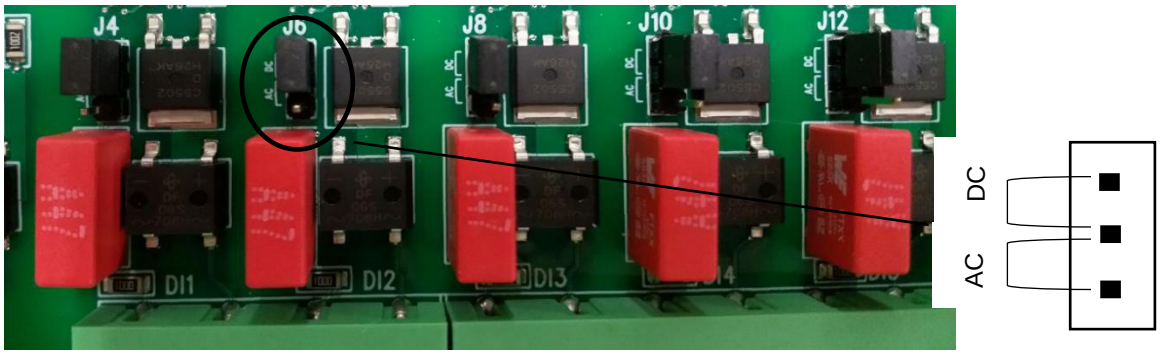

Figure 29: Input voltage choice on the AUX board, with one of the inputs magnified

Three input and four output ports can be configured with any of these features on HMI*:

Output ports

- Running (normal open)
- Alarm (normal closed)
- TRIP (normal closed)
- Trip or Alarm (normal closed)
- Ready To Run (normal open, only available in certain variants)
- Discharging (normal open, only available in certain variants)
- Force active (always ON)
- Not in use (always OFF)

Input ports (behaviour with active signal)

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

**For more or different hardware I/O-options, please contact a Merus Power salesperson.*

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5.2.4 Fibre optic communication

In some applications (such as A2-HPQ), there is a need for fast communication methods between the installed A2 modules. For this purpose, there is a fibre optic (FO) communication possibility in the MCC card. The connection points are presented in Figure 30.

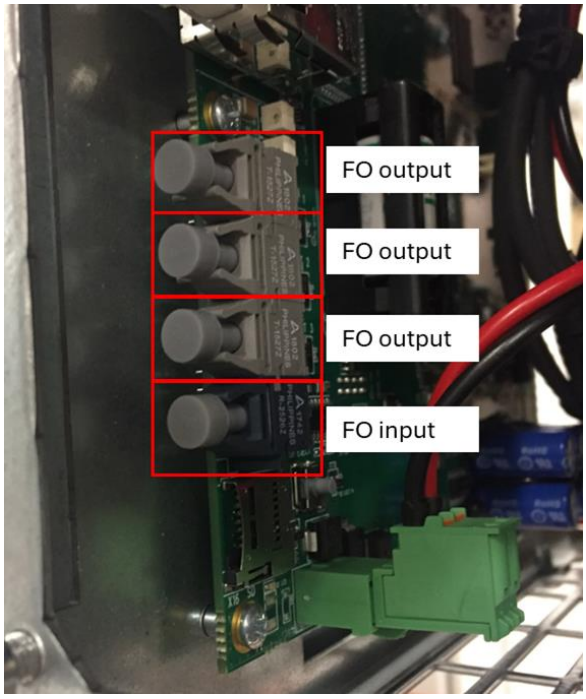

Figure 30: FO connection on MCC-card

In standard A2-AHF modules, fibre optic connections do not need to be used.

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5.2.5 Hardwire signal routes

Signals can be hardwired from the bottom of the front panels. An illustrative image is presented in Figure 31.

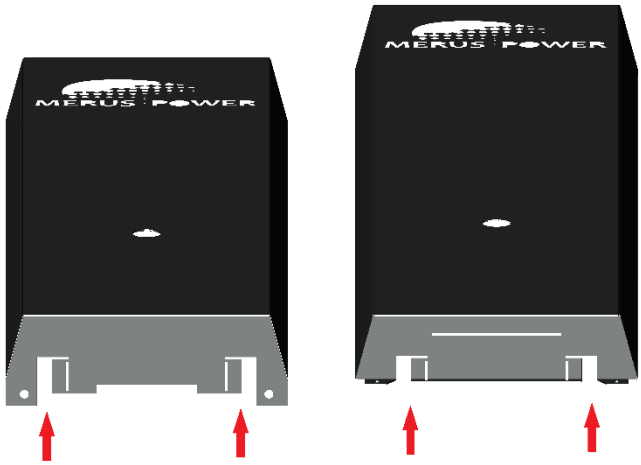

Figure 31: Hardwire signal routes on the front panel

5.3 Mechanical installation

5.3.1 Typical cabinet installation

The A2 modules are designed to be installed in cabinets. The cabinet serves multiple roles such as:

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

An example of a full cabinet is presented in Figure 32:

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Figure 32: Example of a cabinet

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5.3.2 Module installation

The A2 modules are designed to be installed vertically inside a cabinet, as in the example shown in Figure 33.

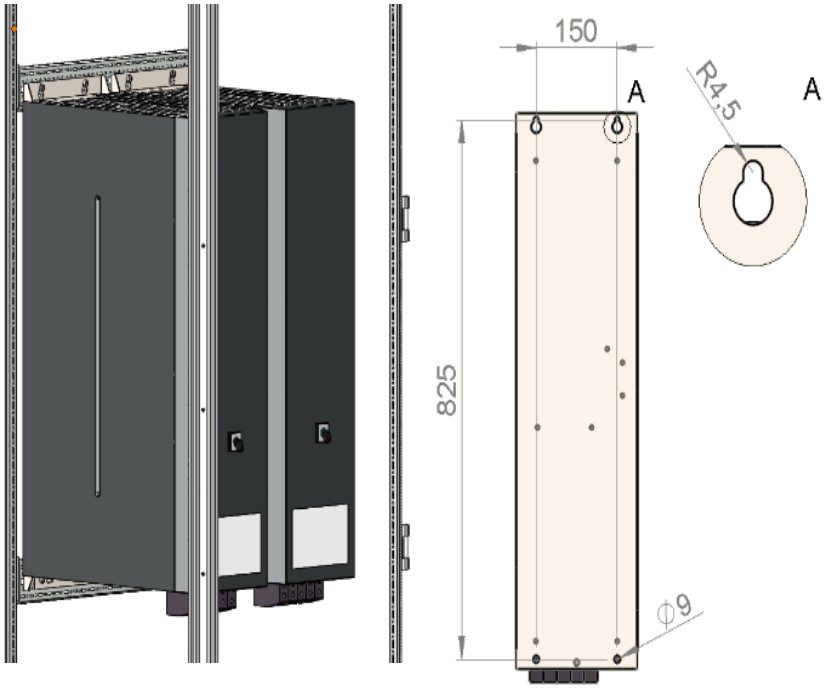

Figure 33: Fixing dimensions for smaller module in millimetres

There are four fixing points on the back of the A2 module. When designing the installation of the module to the cabinet, the following guidelines must be considered:

- 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.

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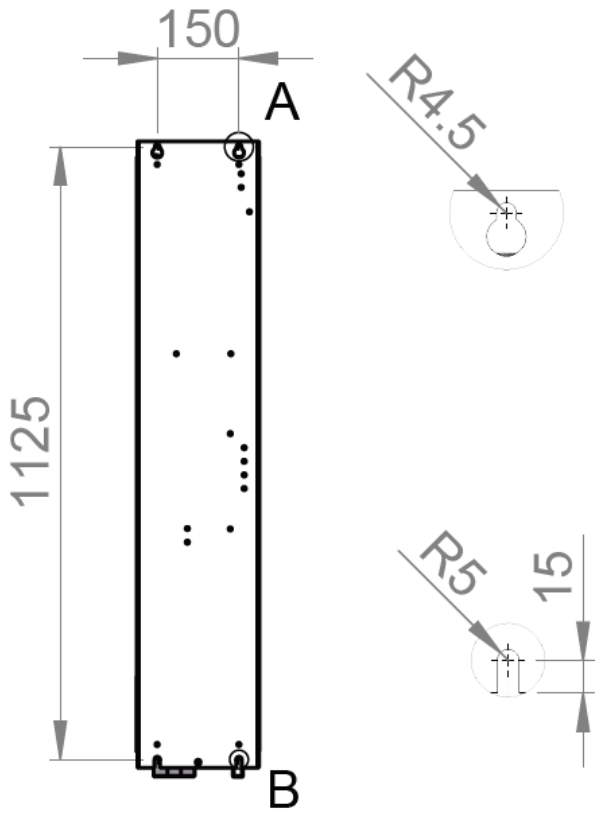

Figure 34: Fixing dimensions for larger modules in mm

5.3.3 HMI installation

The HMI panel should be installed in the cabinet door. Only one HMI panel is needed for parallel-connected modules of up to seven modules. The cut-out dimensions for HMI installation are shown in Figure 36. HMI requires two cables from the module:

- RJ45 (CAT 5 or higher).
- Two-pole power cable (≥1.5mm² Cu, 12Vdc) from the first module.
  Note: Cables are not included upon HMI delivery.

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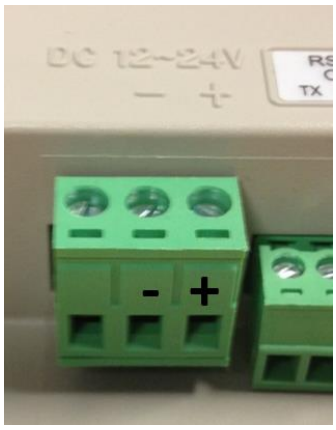

Figure 35: HMI power connection

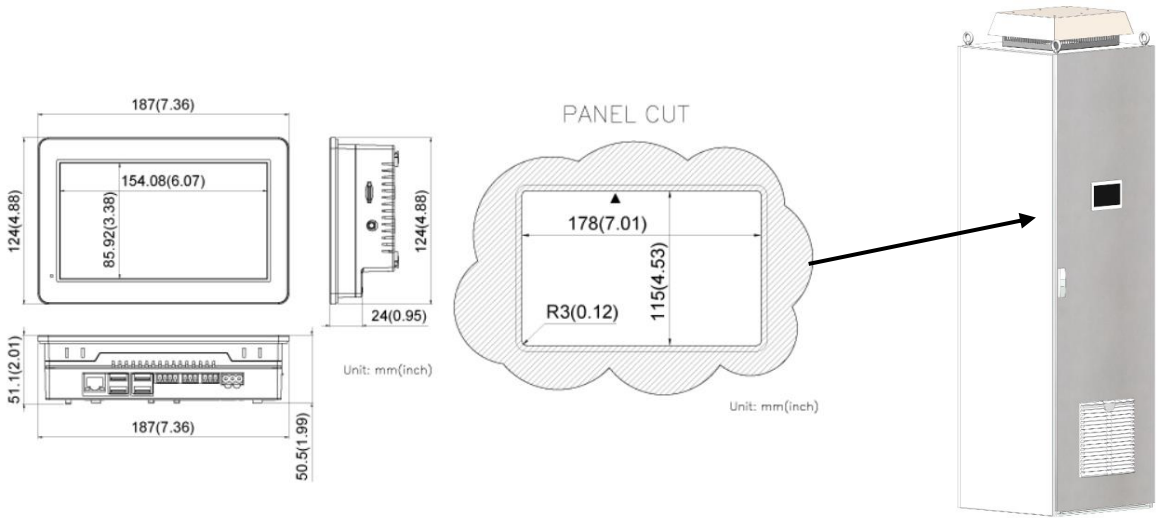

Figure 36: Example of installation of the HMI panel on a cabinet door (dimensions in mm)

Merus Power also has an alternative HMI panel to ensure availability of panels. The alternative panel is slightly larger and presented in Figure 37. The alternative HMI specifications can be found in

Table 17. It is recommended to ensure the correct HMI type upon ordering.

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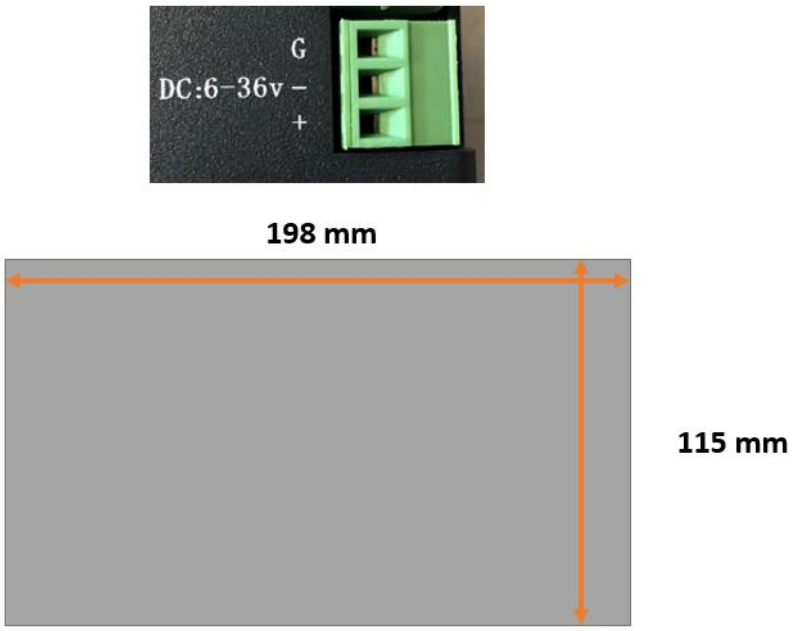

Figure 37: Alternative HMI panel power terminal and cut-out dimensions

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5.3.4 Air circulation

The A2 module airflow is shown in Figure 38. 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 A2 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 14.

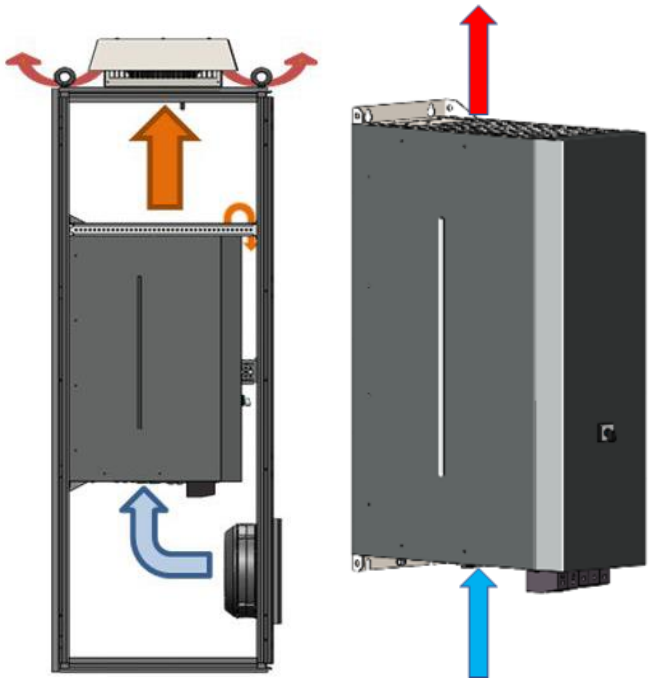

Figure 38: Air circulation of the A2 cabinet (left) and A2 module (right).

Install the A2 modules according to the technical specifications in Table 14. In cabinet installations, Merus uses door and roof 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 also 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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5.4 Electrical installation

This section covers electrical installation such as power cables, current measurements, and physical changes between 3W and 4W A2 modules.

5.4.1 Existing capacitor banks in the network

Capacitors have a low impedance in high frequencies. For this reason, they can absorb high frequency currents produced by the A2 module. This can render the system unstable or even lead to system failures. Capacitor banks without detuned reactors (e.g. plain capacitor banks) cannot be used in the same installation with an active filter. The plain capacitor bank must be switched off or changed to a capacitor bank with detuning reactors. Generally, it is not recommended to have other compensation systems installed downstream of the active filter, as stability issues may rise.

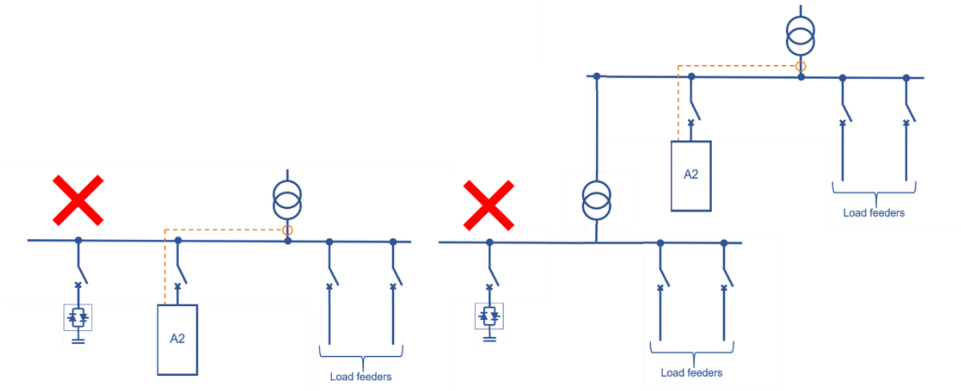

Figure 39: Incorrect installations

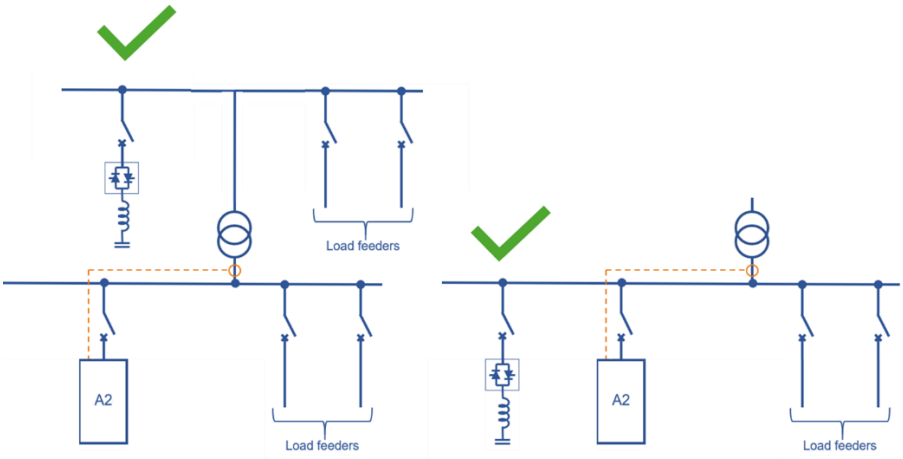

Figure 40: Correct installations

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5.4.2 Network requirements

There should **not be** a considerable quantity of voltage harmonics higher than the 50th harmonic, in the network where modules are installed. This can lead to situations where the modules are not able to work correctly.

Typical loads for A2 modules such as variable speed drives are recommended to have line reactors > 3% inductance.

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

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

The most typical configuration is 3W.

Select 3W 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 4W configuration.**

Select 4W 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, 4W is used in infrastructure where there are single phase loads.

5.4.4 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:

- A2 module power cables should have a maximum cross-sectional area of 95 mm² for phase cables.
- Merus Power recommends 50 mm² phase conductor cables for 50–100 A modules and 70 mm² phase conductor cables for 125–200 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 5.1.
- **Note: The phase cables connected to L1:L3 must be installed in the standard phase sequence (A-B-C)!**

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Three-wire and four-wire application

- In 3-wire applications the neutral wires must be left **unconnected**
  - In A2 modules with rating 150A/200A: remember to leave the plastic cover on top of the neutral terminal
  - Internal modifications for a three-wire application must be performed (explained in section 5.4.6).
- 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 modules: the neutral must be connected with two cables, in order to fulfill the current carrying capacity of the neutral terminals.
  - In A2 modules with rating 150A/200A, the neutral must be connected in the busbar.
  - Internal modifications for a four-wire application must be done (explained in section 5.4.6).

- For safety reasons, the earth point (PE) of the A2 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 have to be considered. The colour of the A2 module PE conductor is always yellow-green. The connection point of the PE conductor is shown in Figure 17 and Figure 20.

- Merus A2 modules require external short circuit protection. ‘Chapter 110 Technical specification’ presents some fuses for various modules. 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.

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5.4.5 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 temperature 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 mm²)

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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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5.4.6 3-wire and 4-wire modifications

The choice between the A2 module's 3-wire and 4-wire application is made in the terminal block located next to the contactor as shown in Figure 41. To access these, read section 5.1.3. The locations for the terminal blocks are presented in Figure 41 and Figure 42.

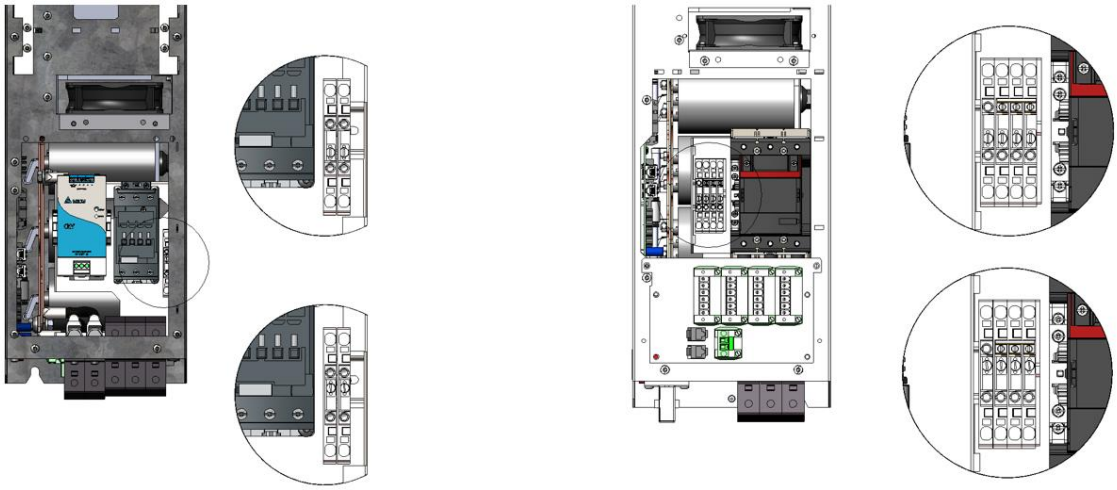

Figure 41: 3W/4W terminal block locations in A2 modules (50/100 A: left, 150/200 A: right)

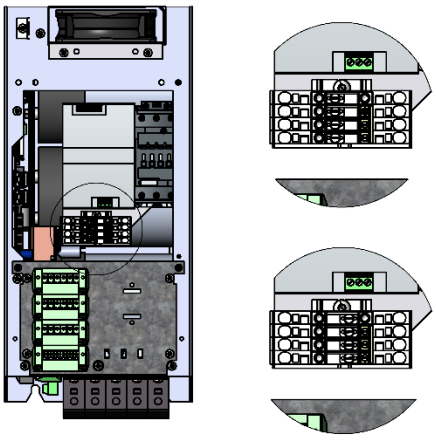

Figure 42: 3W/4W terminal block location in 690 VAC modules

- 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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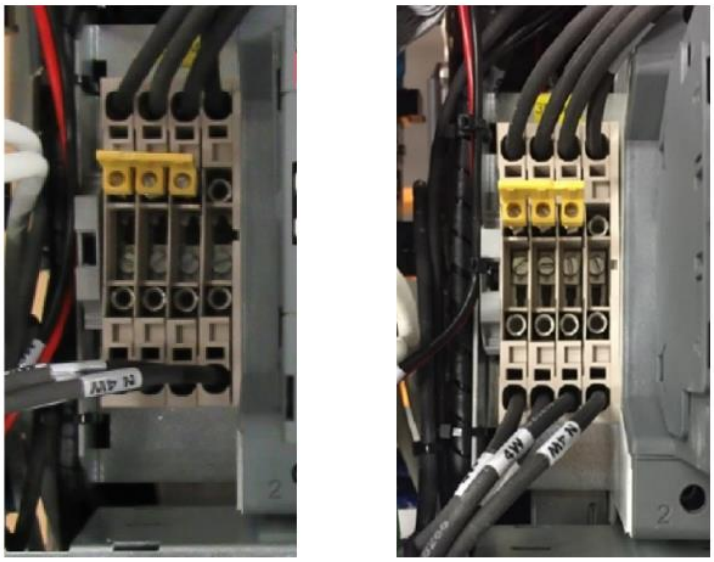

Figure 43: Example of 3W/4W terminals in 150/200 A modules (Left: 3W, right: 4W)

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 3W/4W terminals must match the HMI settings. Otherwise, damage can occur.**

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5.4.7 Current transformers and current signal

The current signals from the electrical system must be provided to the A2 module in order 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 44.
  - (CTs measure **ONLY** the load side currents, **NOT** the A2 module(s) currents)
- In the closed loop connection, the current transformers are situated on the supply side, as shown in Figure 45.
  - (CTs measure **BOTH** the load side currents and the A2 module(s) currents)

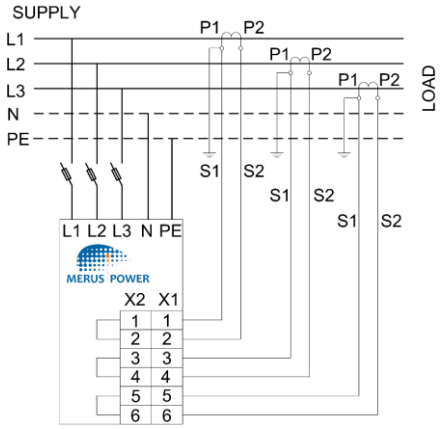

Figure 44: Open loop installation diagram

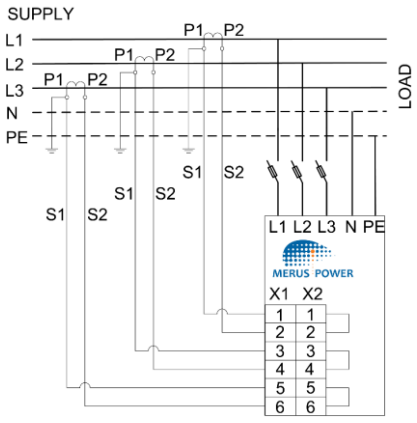

Figure 45: Closed loop installation diagram

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In both cases (open or closed loop connection), the current signals are connected in the X1 terminal in the order shown in Figure 44 and Figure 45.

It is recommended that the current transformers be earthed on the current transformer side for safety purposes, as shown in Figure 44 and Figure 45. Current transformers should be earthed on the secondary side (S1 or S2) and on the same side for all current transformers.

5.4.8 Individual modules

For individual modules the connection is made as in Figure 44 and Figure 45.

- 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)

5.4.9 Parallel connected modules

Multiple A2 modules can be connected in parallel configuration. With multiple A2 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 A2 module connections for the open loop are presented in Figure 46.

The next module will receive the current signal from the previous module's X2 (load measurement) and X4 (A2 modules' current). Parallel A2 module connections for open loop and closed loop are presented in Figure 46 and Figure 47.

- 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)

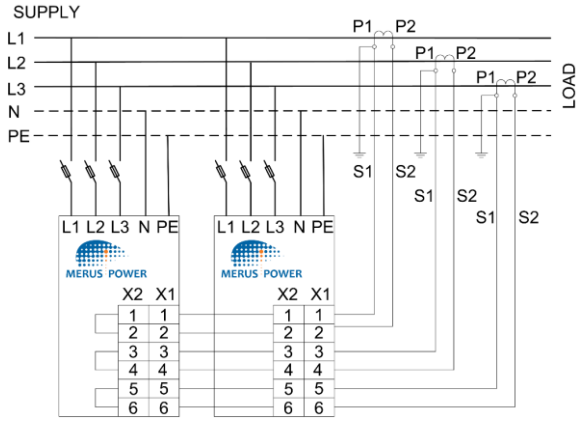

Figure 46: Open loop parallel connection

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Parallel A2 module connection in closed loop is shown in Figure 47. 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 A2 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

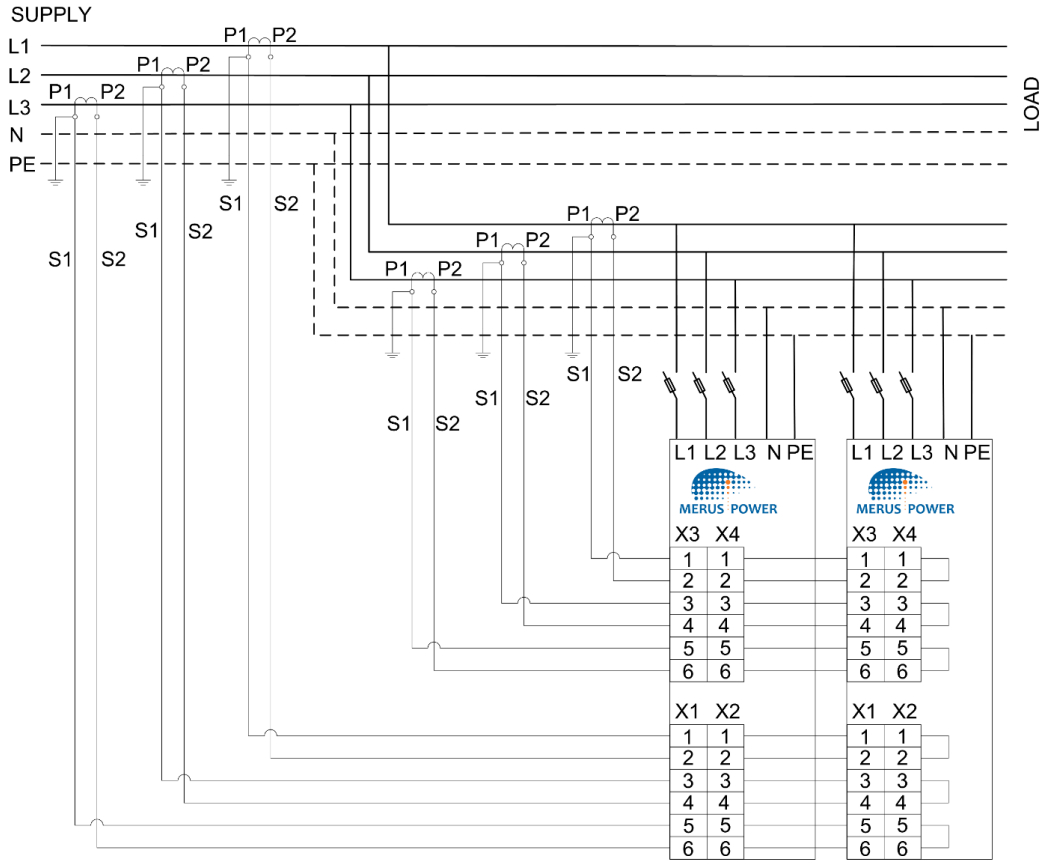

Figure 47: Closed loop parallel connection

The last parallel A2 module must have its X2 and X4 terminals shorted.

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5.4.10 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 A2 module's terminal block X1 and X3. The Merus® A2 module burden, excluding the external current transformer cables, is presented in Table 4.

Table 4: The Merus® A2 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 1 A secondary: Change the internal connection point in the AUX card from 5 A secondary to 1 A secondary (as shown in Figure 27). **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 6.6.1).

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

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5.4.11 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 A2 module, or the case of a single A2 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.

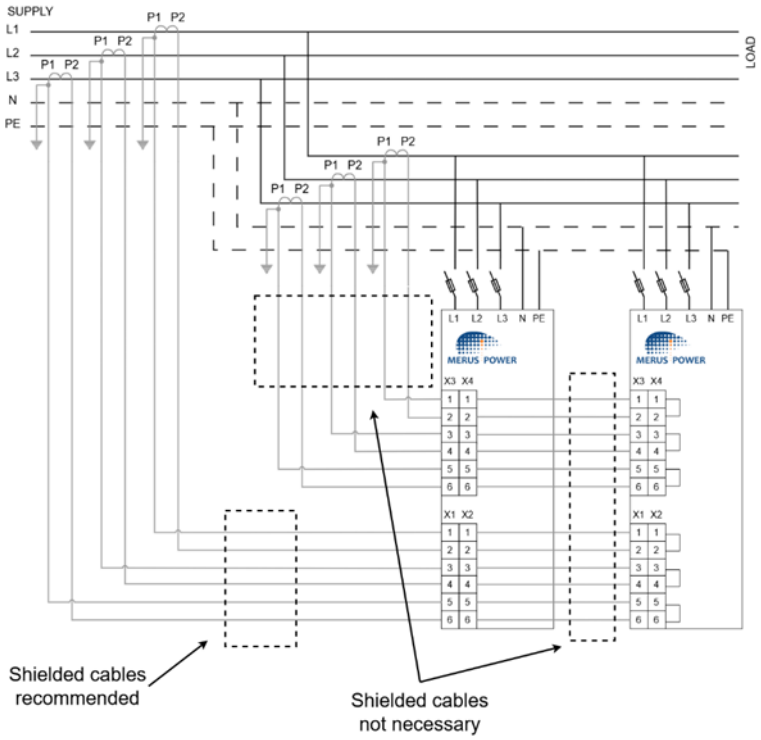

Figure 48: Current signal cables.

Hazard! If the CT secondary cable must 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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5.4.12 Installation in the higher voltages

A2 modules can be installed to a higher voltage supply than stated in the technical specification (see Chapter 10), e.g. to medium voltage with a step-up transformer. This allows the A2 modules to compensate medium voltage loads and power plants such as wind farms*.

Note: Special-rated transformer required. Contact Merus Power sales personnel for more information.

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6. HMI

The A2 module is controlled via a touchscreen PC, HMI (Human Machine Interface).

- The HMI allows the user to start/stop the module or modules, see power quality monitors, and change settings.
- There can be up to seven A2 modules connected within one A2-HMI.
- Communication between the module and the HMI is conducted via the Modbus TCP protocol.
- The HMI has a resistive touchscreen display, so 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.

6.1 HMI overview

Overview of the A2-HMI menu structure is included in this section. The HMI main structure is presented in Figure 49.

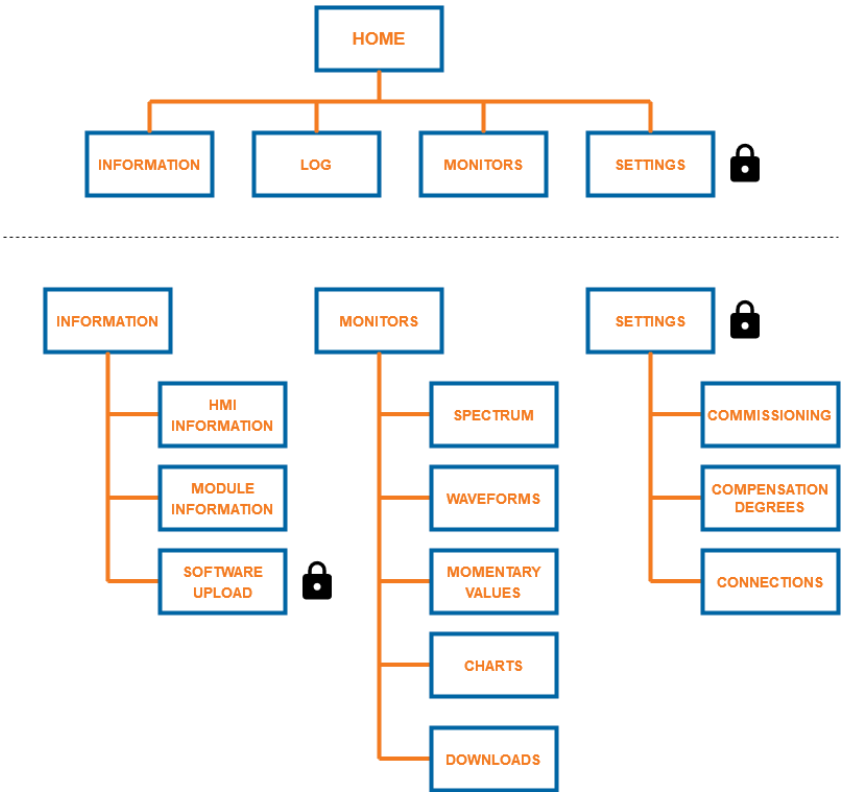

Figure 49: HMI structure map

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

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6.2 Home screen

The home screen is the root of the HMI. In the main view, the user can control the A2 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 50.

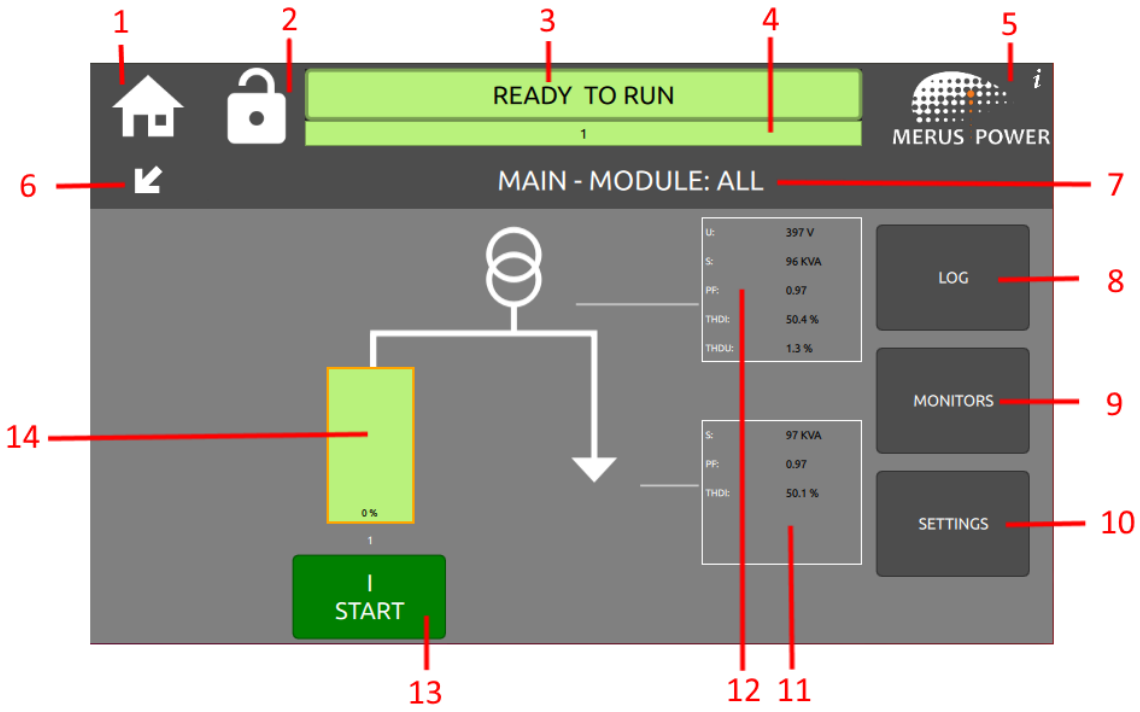

Figure 50: The HMI home screen

The numbers in Figure 50 explained:

1. **HOME:** Go to home screen.
2. **LOCK:** Lock/unlock some of the HMI settings.
3. **MAIN STATUS:** See combined status for all the connected modules or select 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 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 (output current/nominal current*100%)

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6.2.1 HMI lock

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

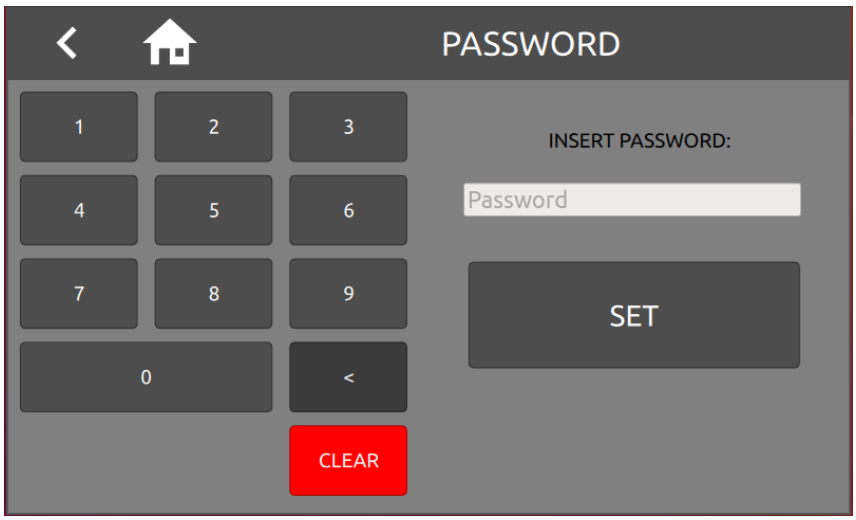

Figure 51: Password input

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

6.2.2 Parallel modules

When there is more than one module in the system, the user can select which module values are being shown in **MONITORS** and which module **SETTINGS** are being changed. In Figure 52, two parallel modules are presented in the home screen. By default, the HMI shows the momentary values, waveforms and spectrum of module #1 or the first active module connection.

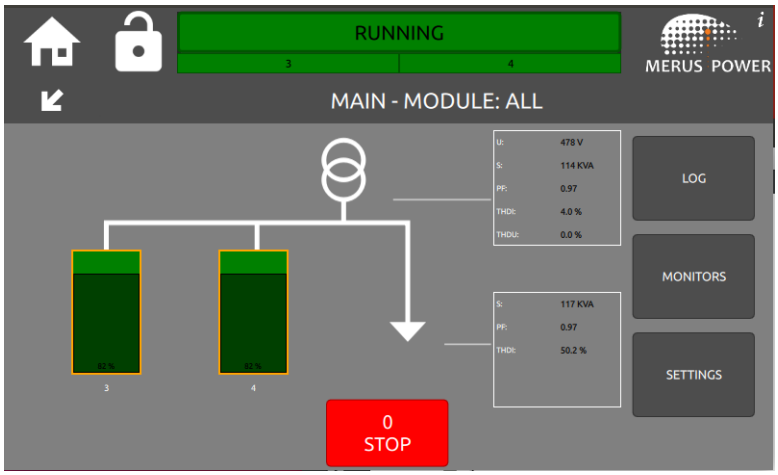

Figure 52: Two modules in parallel

In selecting the currently active module, the user should press the **MAIN STATUS** button shown in Figure 50. When pressed, the selector screen will pop up and the user can select the currently active module.

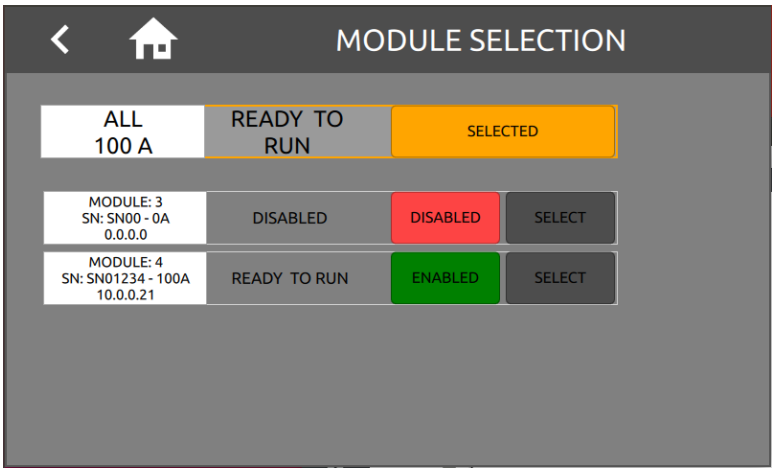

Figure 53: Selecting the active module

- 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 engaged, 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.

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6.2.3 Module statuses and colours

The different colours in the main screen and module status fields are explained in Table 5.

Table 5: A2 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	Module/system DC-link is charged. IGBT operation is disabled.
RUNNING	Green	The module/system is running.
STANDBY	Green	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.

6.2.4 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.

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6.3 Information

The **INFORMATION** view, found in the upper right corner of the home screen, includes three separate pages. These pages are explained in this section.

6.3.1 HMI info

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

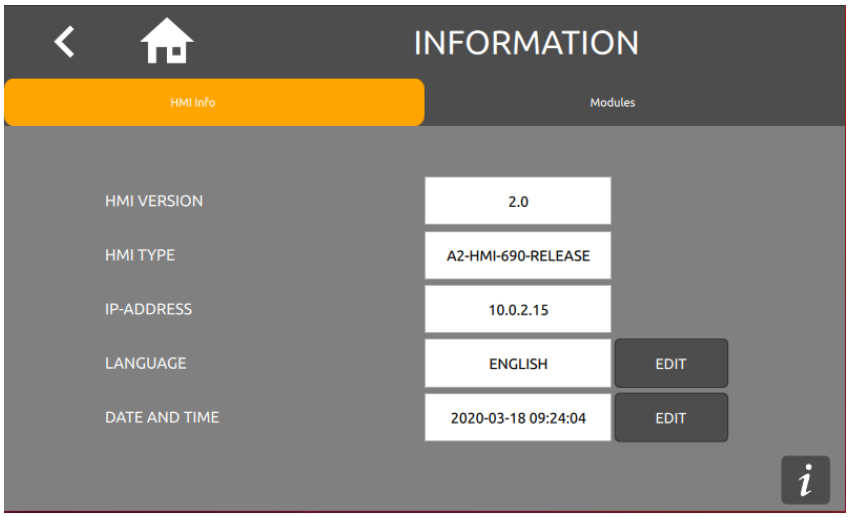

Figure 54: HMI information screen when locked

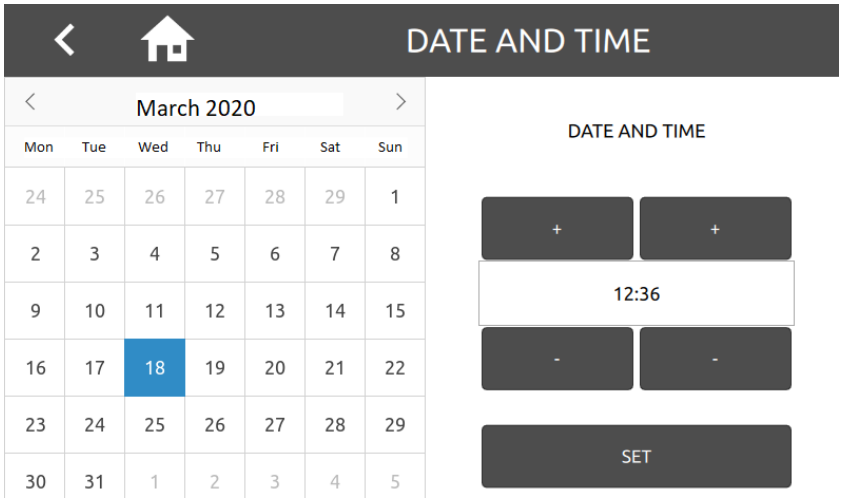

Figure 55: HMI date and time edit

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6.3.2 Modules

The **Modules** tabshows 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)

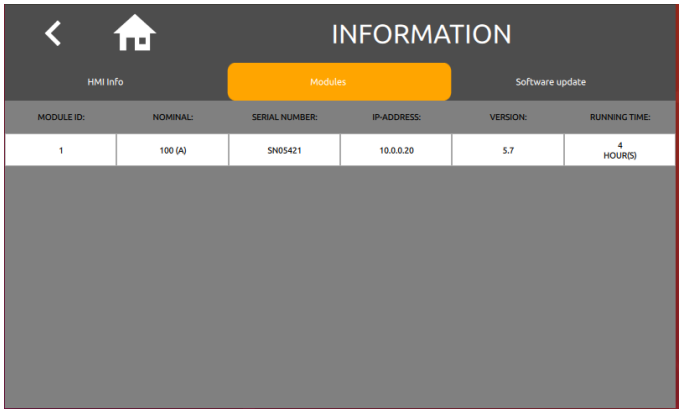

Figure 56: Module information

6.3.3 Software update

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

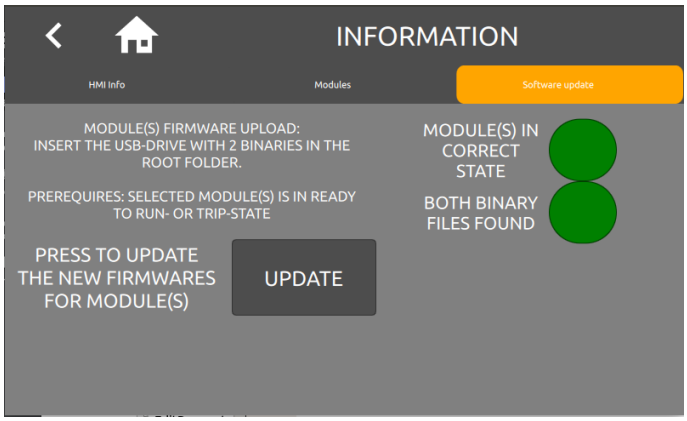

Figure 57: Module firmware upload

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

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

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6.4 Log

The LOG view includes the latest events that the HMI has encountered. An illustrative image can be found in Figure 58.

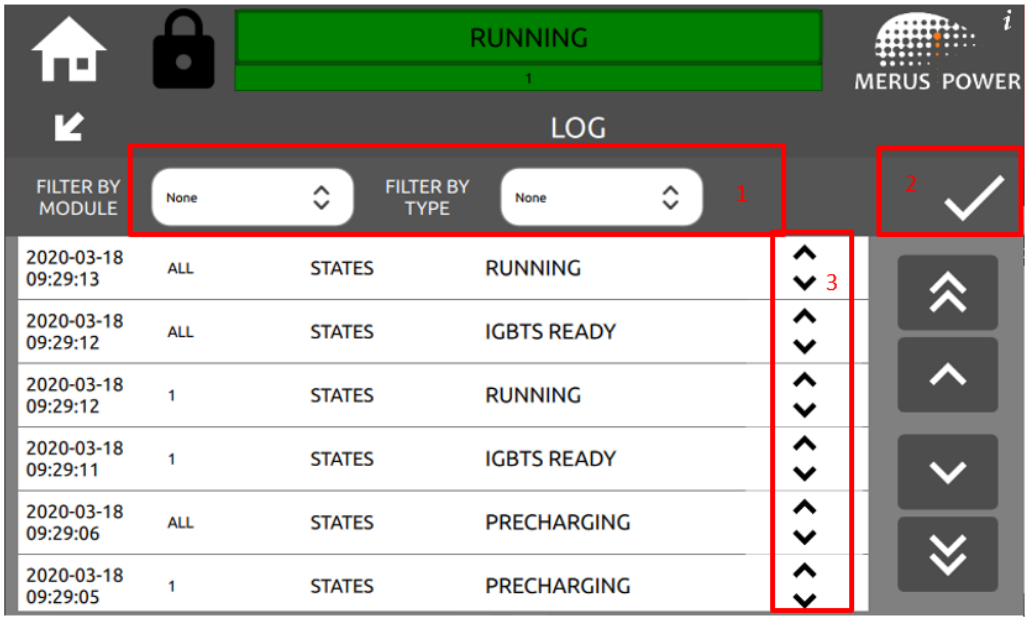

Figure 58: LOG screen

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. In the case of active trips, please refer to Merus® A2 Troubleshooting guide or contact our service department for additional information. Trips can also be acknowledged if AutoAck is enabled (see section *3.4.5*) or the module is powered down.

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

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

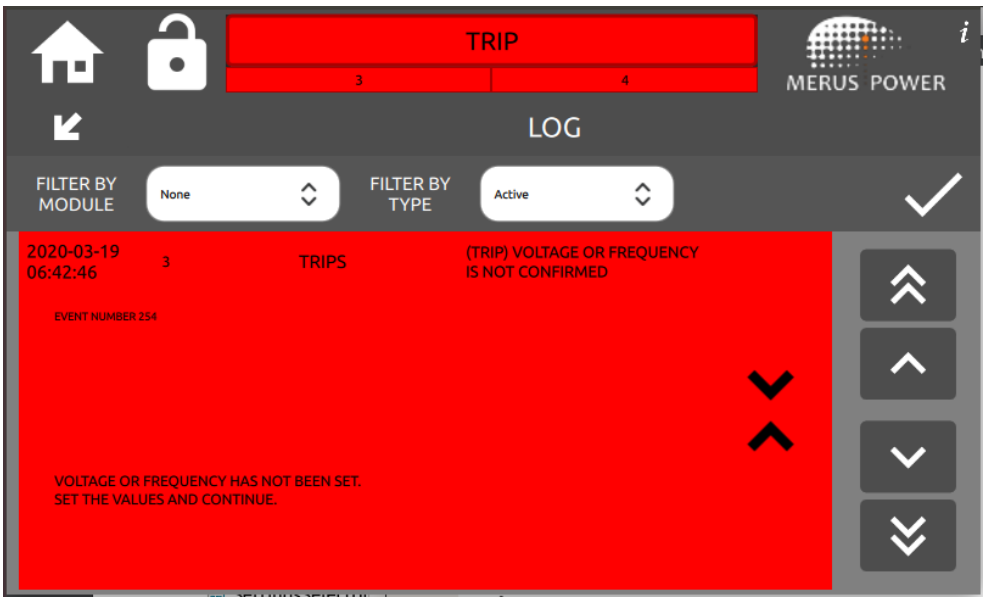

Figure 59: Expanded trip information

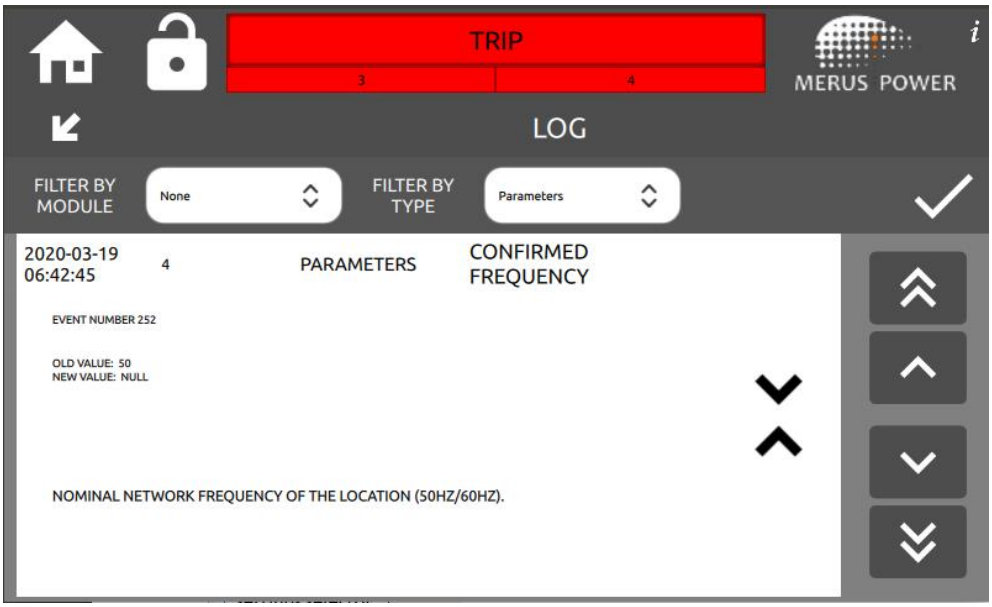

Figure 60: Expanded parameter information

TRIPS are error conditions that cause protective tripping of the device. If any of the TRIPS are active, the A2 module will cease operation and will not start until the trips have been cleared.

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6.5 Monitors

The Monitors basic view includes several different screens, and it is presented in Figure 61.

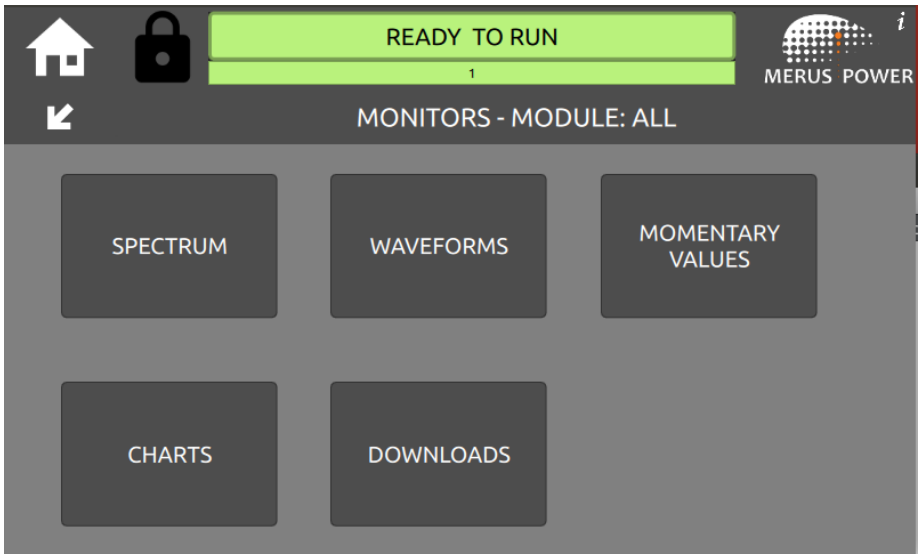

Figure 61: Monitors

6.5.1 Spectrum

In the **SPECTRUM** view, the user can display the harmonics spectrum from the 1st to the 25th, as well as the total RMS harmonics:

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

There are options in the Spectrum screen for:

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

A typical spectrum view can be found in Figure 62.

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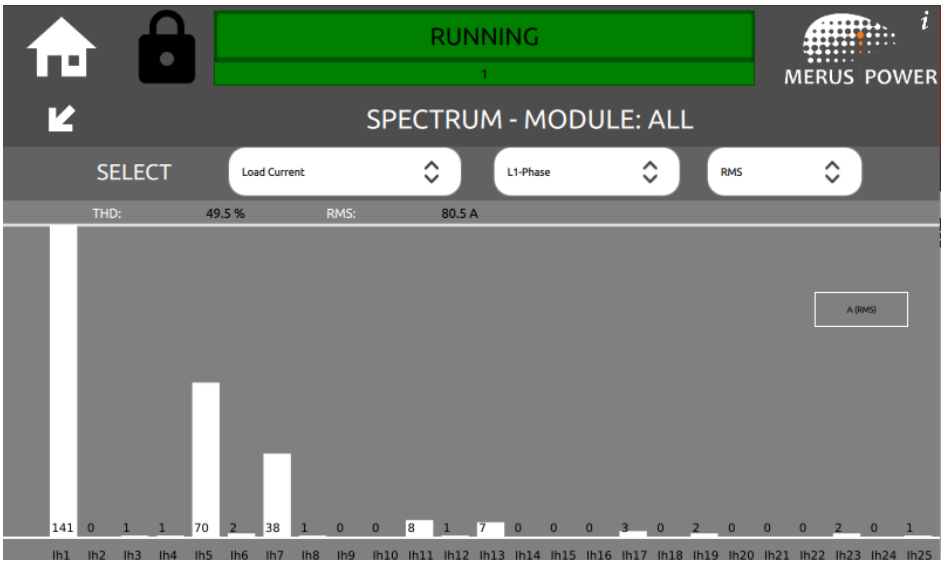

Figure 62: Spectrum view

6.5.2 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 63.

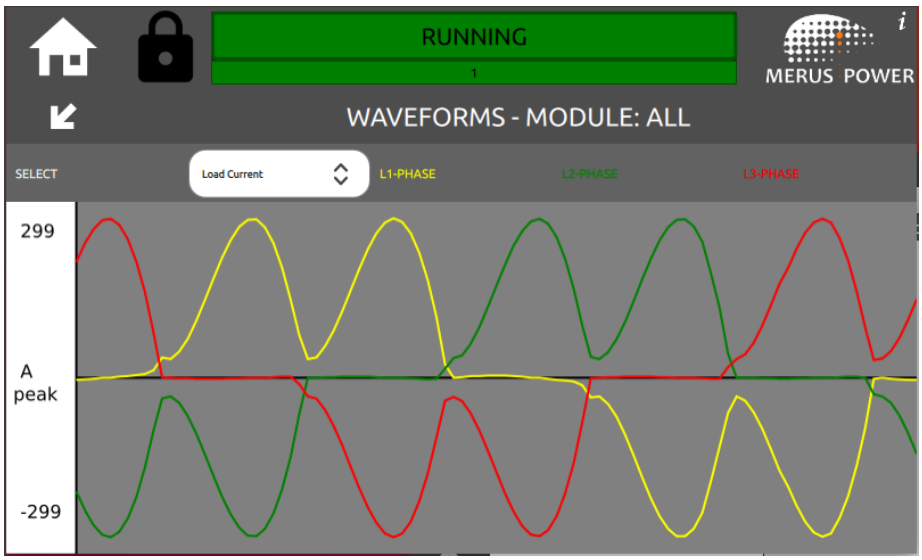

Figure 63: Waveform view

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6.5.3 Momentary values

The **MOMENTARY VALUES** view displays the most common device- or power quality-related values. An illustrative image can be found in Figure 64. These values are updated successively after a period of 1 second. Note that if the module selection is "**ALL MODULES**", the values will display the status of the total system.

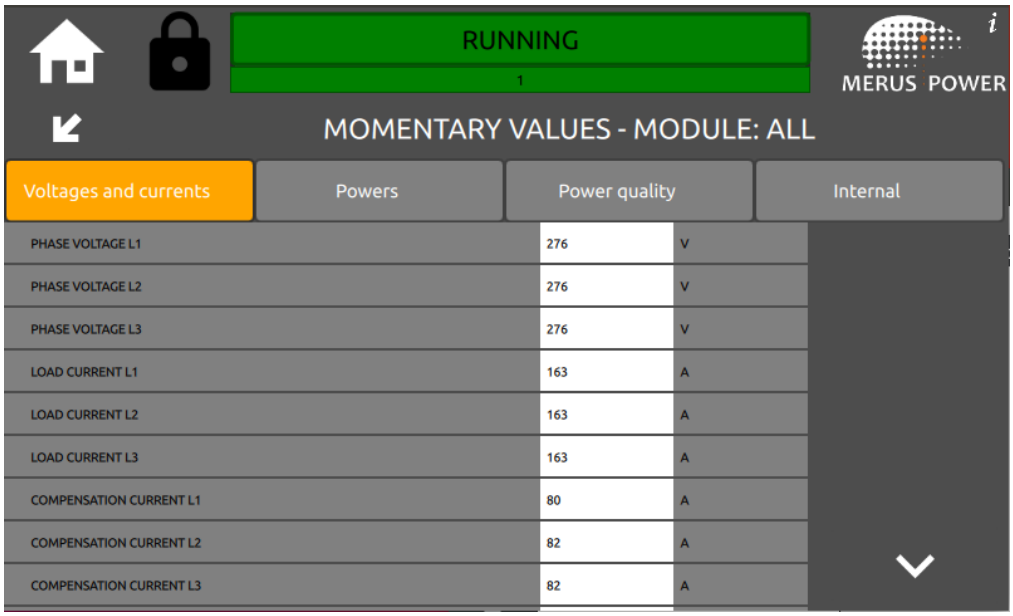

Figure 64: Momentary values

Momentary values are divided in four categories and presented in Table 6,

Table 7, Table 8, and Table 9.

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Table 6: 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 7: 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 8: 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 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 9: 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

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6.5.4 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 65.

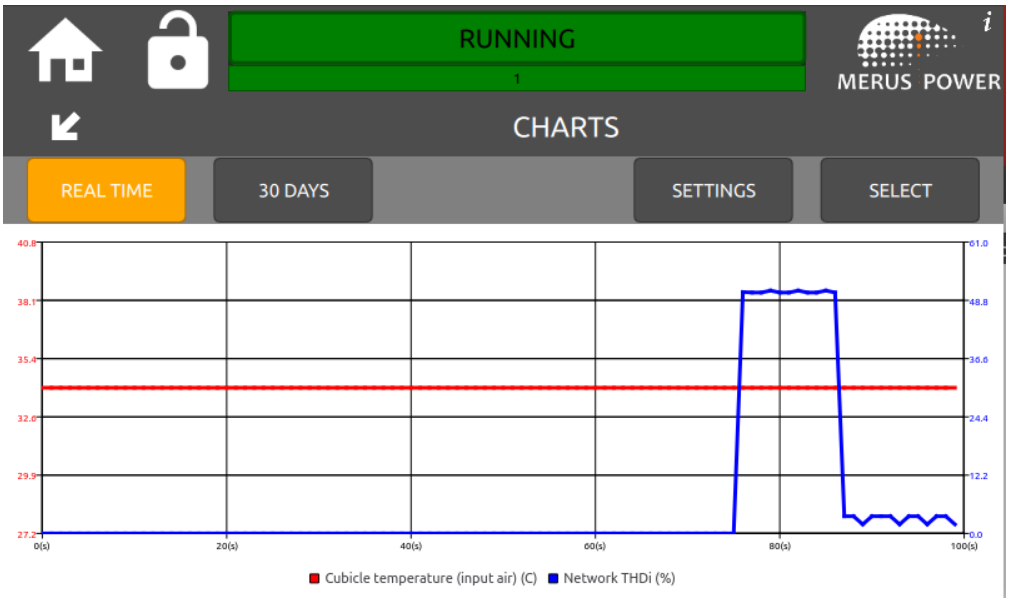

Figure 65: Charts screen

Buttons explained:

- **Real time:** Sets a real time graph into the screen.
- **30 days:** Sets a 30 days' graph into the screen.
- **Settings:** Here you can select the values for recording. Note: This button is hidden when the HMI LOCK is in locked mode
- **Select:** Select the graphs you wish to present (max. two simultaneously).

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An example of a 30-day chart is presented in Figure 66.

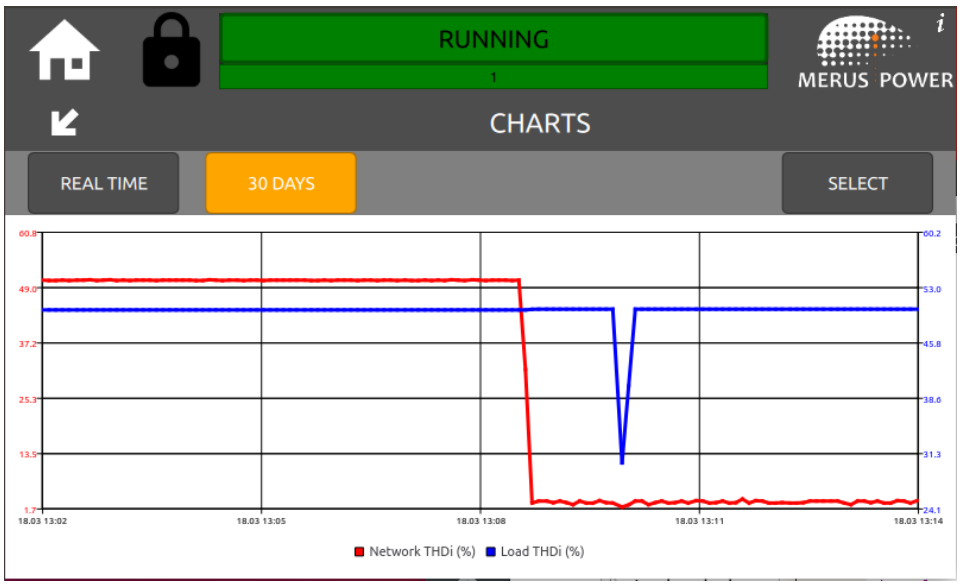

Figure 66: Example of a 30-day graph

Settings are presented in Figure 67. 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.

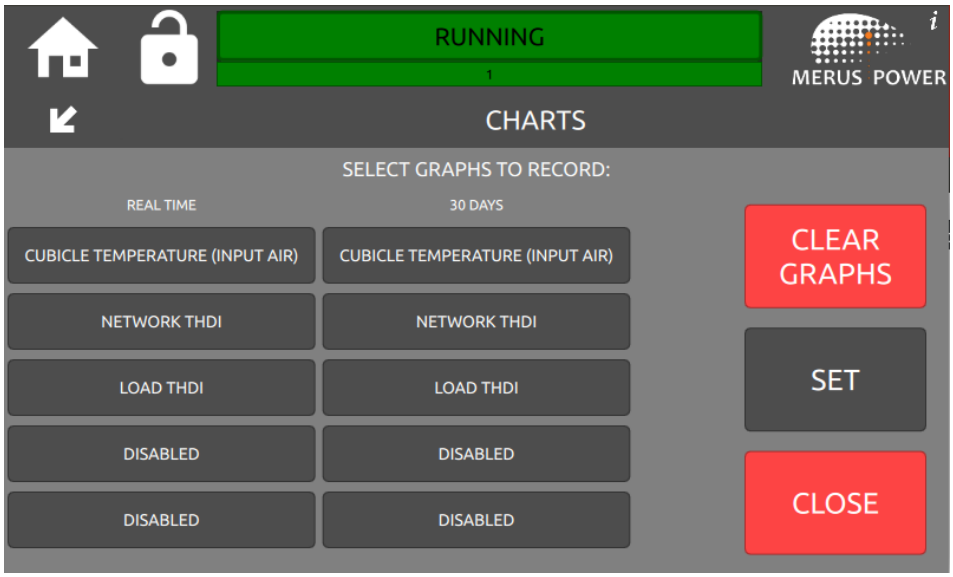

Figure 67: Chart settings

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Selection of the graphs is presented in Figure 68. 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.

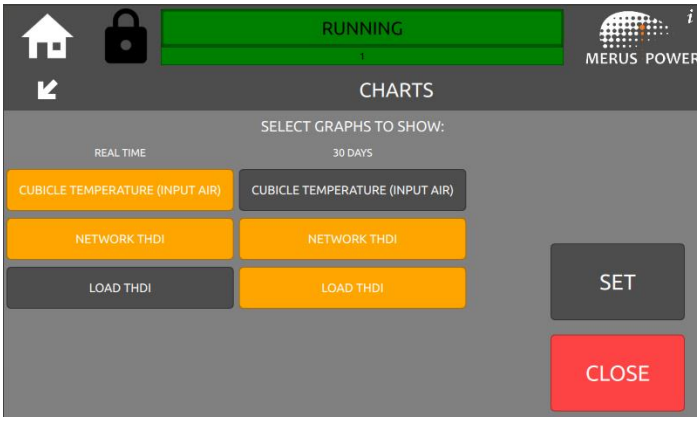

Figure 68: Chart selection

6.5.5 Downloads

The **DOWNLOADS view** includes several options for USB drive data retrieval. An illustrative image is presented in Figure 69.

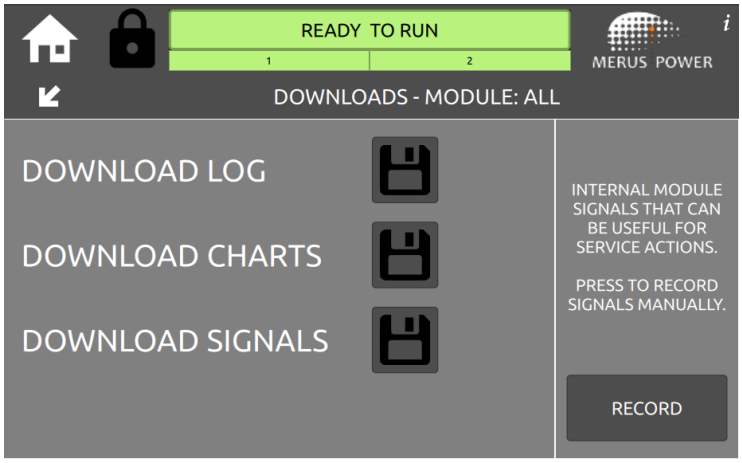

Figure 69: Downloads

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

- **LOG:** Saves the most recent 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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6.6 Settings

The Settings page can be found on the home screen when the HMI LOCK is opened.* There are several tabs on the Settings page. The basic structure for the Settings page is presented in Figure 70.

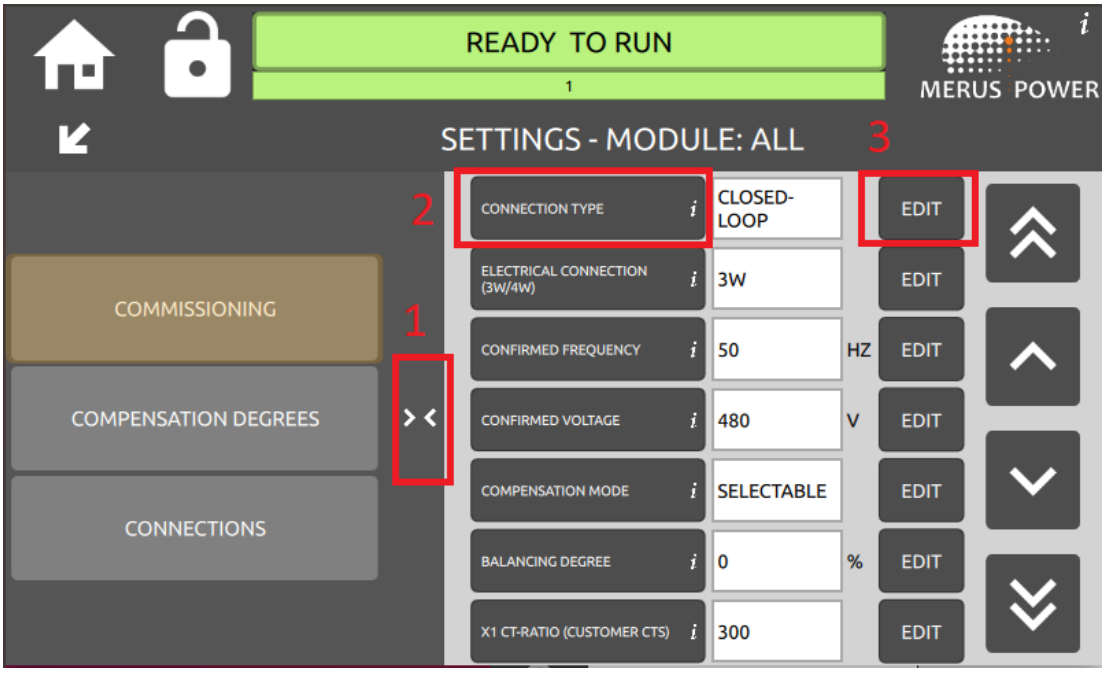

Figure 70: Settings view

The numbers in Figure 70 show the following:

1. Hide/unhide the left-hand side toolbar. Hiding also occurs by pressing on the active tab on the left.
2. Information about the current settings: A **double click** opens an information screen concerning the current parameter.
3. Edit current settings: Opens the edit view.

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**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.*

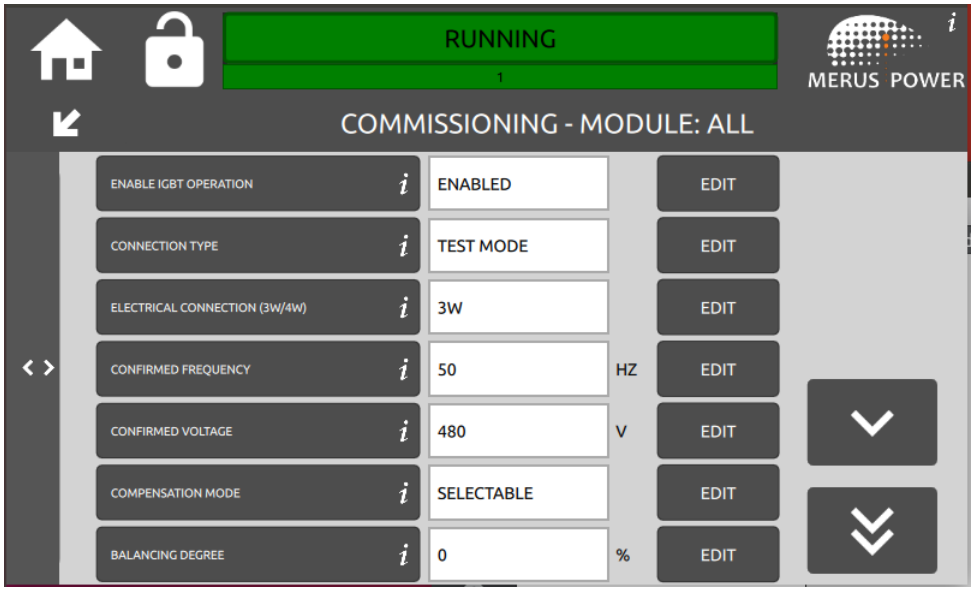

Figure 71: Settings view when the toolbar is hidden

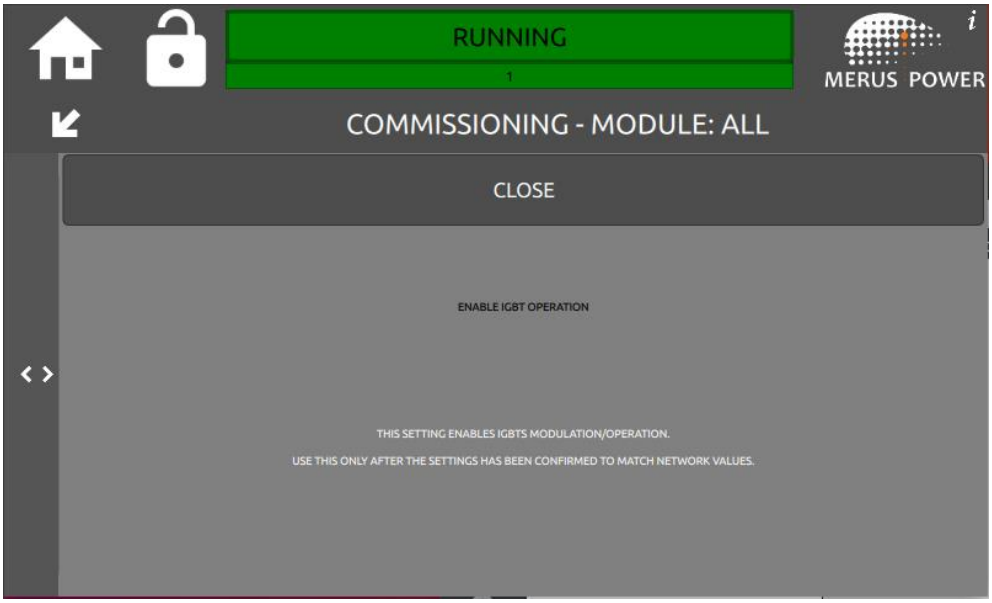

Figure 72: Settings info

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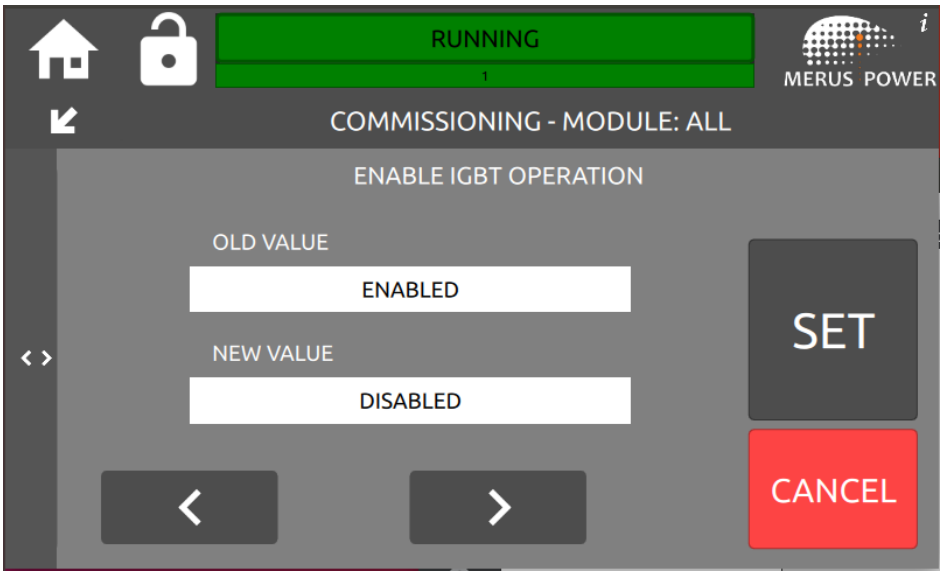

Figure 73: Edit screen when the setting has options

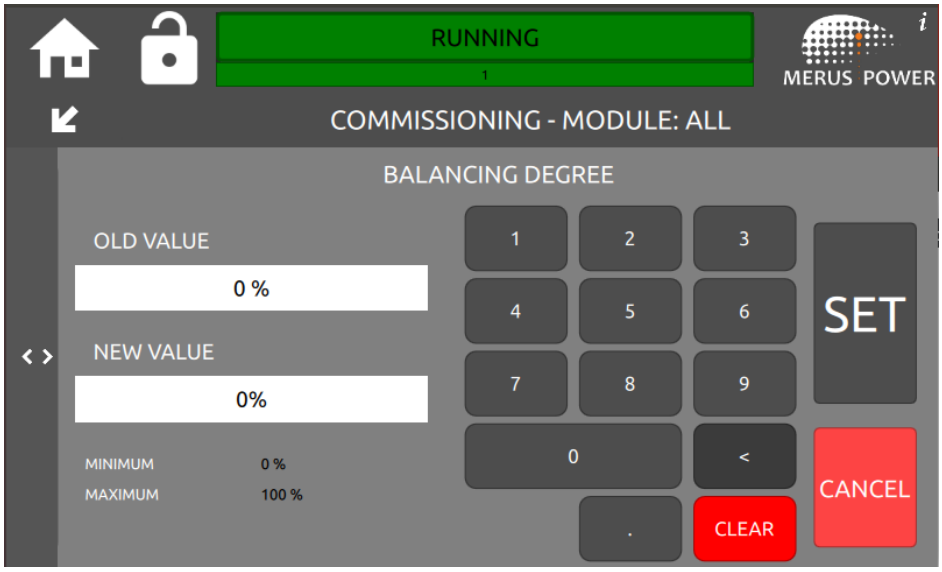

Figure 74: Edit screen when the setting has numerical input

When the selected module is ‘ALL MODULES’, the HMI will display differences in the settings. Different settings are displayed with the colour yellow, as in Figure 75.

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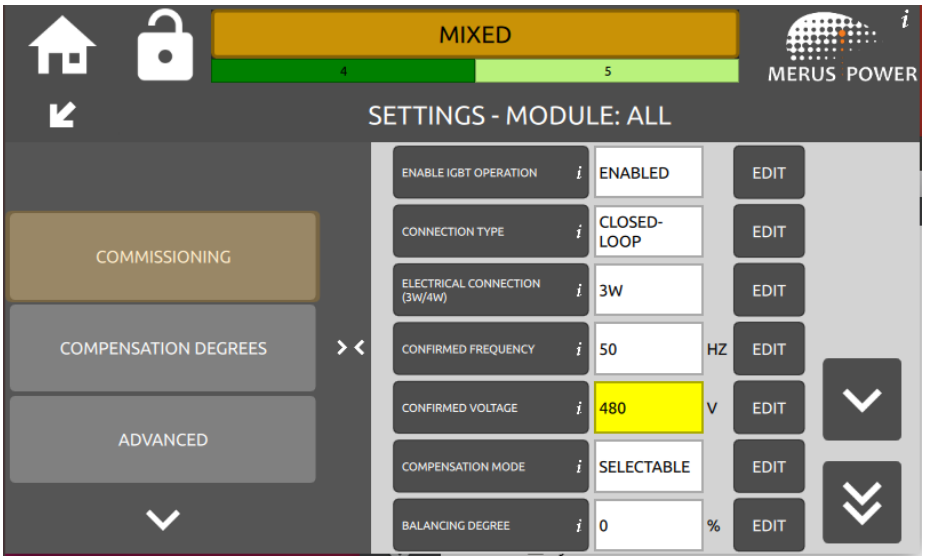

Figure 75: Various settings

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6.6.1 Commissioning

The Commissioning settings include the basic settings that are usually changed during commissioning. The list of settings is presented in Table 10.

Table 10: 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 5.4.6.	3W/4W
CONFIRMED FREQUENCY	Select the nominal system frequency	NULL/50Hz/60Hz
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 three compensation modes are explained in detail in section 3.2.	SELECTABLE/ ALL HARMONICS / ALL BUT NOT FUNDAMENTAL *Read notes
BALANCING DEGREE	See section 3.4.2	0–100%
X1 CT ratio (CUSTOMER CTS)	Put the CT ratio of external measurement CTs (e.g. 2500A/5A →500) In case of 1A secondary, see section 5.4.10	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 A2 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 5.4): Use the CT ratio from the CTs connected in the output of the A2 module	1–10,000
ENABLE AUTOSTART	See section 3.4.4	DISABLED/ENABLED
ENABLE AUTOACK	See section 3.4.5	DISABLED/ENABLED
ENABLE STANDBY	See section 3.4.1	DISABLED/ENABLED
STANDBY TRIGGER LEVEL	Select a reference current value when the A2 module enters the Standby mode (see section 3.4.1)	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 5.2.3	NOT IN USE/RUNNING/ALARM/TRIP/ TRIP OR ALARM/FORCE ACTIVE
DIGITAL INPUT x	The digital input choices are explained in detail in section 5.2.3	NOT IN USE/ STANDBY/ALARM/TRIP/ START/STOP/AKNOWLEDGE

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

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6.6.2 Compensation degrees

Compensation degrees are settings that have 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 76 presents the compensation degree view. Compensation degrees edit operates similarly to other edits.

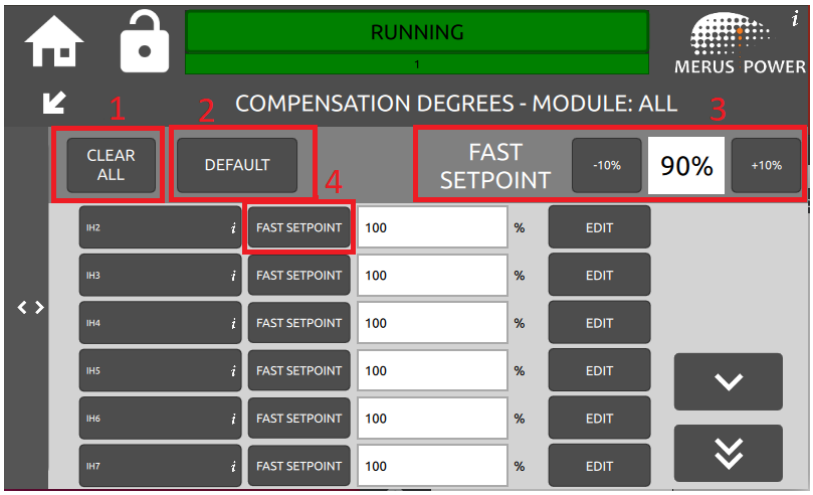

Figure 76: Compensation degrees view

The numbers in Figure 76:

1. Clear all compensation degrees to 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 11.

Table 11: 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 A2 module's capacity. The A2 module can produce both capacitive and inductive reactive power (see section 3.4.3).	0–100	%

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6.6.3 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 77.

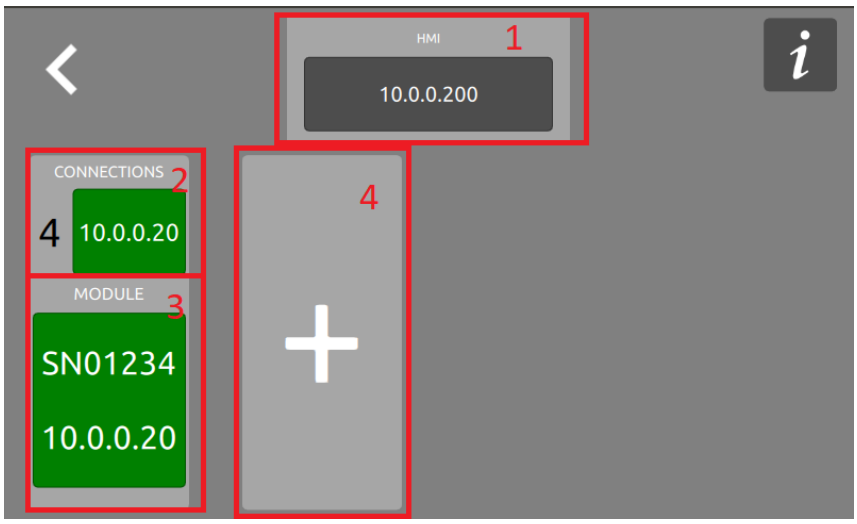

Figure 77: Connection settings

The numbers in Figure 77 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 is trying to 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 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.
   - Change 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 modules.

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6.6.3.1 Editing the HMI IP settings

Changing of the HMI IP settings is presented in Figure 78. 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.

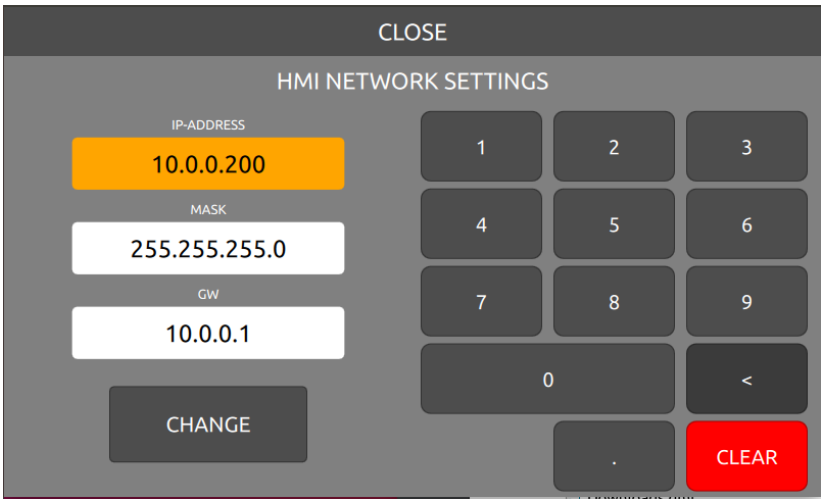

Figure 78: Changing the HMI IP settings

6.6.3.2 Editing the connection settings

Changing the connections is presented in Figure 79. 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. 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.

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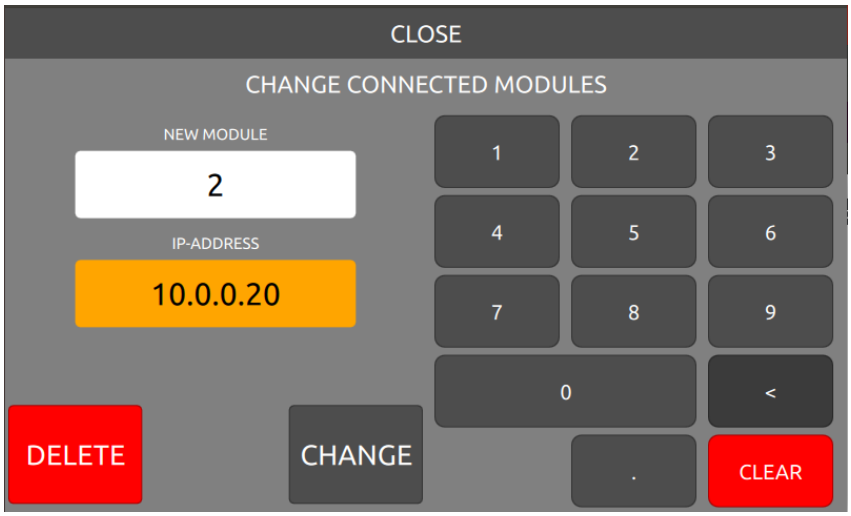

Figure 79: Changing the connections

6.6.3.3 Editing the module IP settings

The communication between the HMI and the A2 modules is done with Modbus TCP/IP protocol. To edit these settings, the user must be familiar with the communication method.

On delivery, the basic IP settings are the following:

Table 12: The basic IP settings

	IP	MASK	GATEWAY
HMI	10.0.0.200	255.255.255.0	10.0.0.1
A2 module	10.0.0.20	255.255.255.0	10.0.0.1

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Changing the module IP settings is presented in Figure 80. 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 setting are modified (in order to keep the connection alive):

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

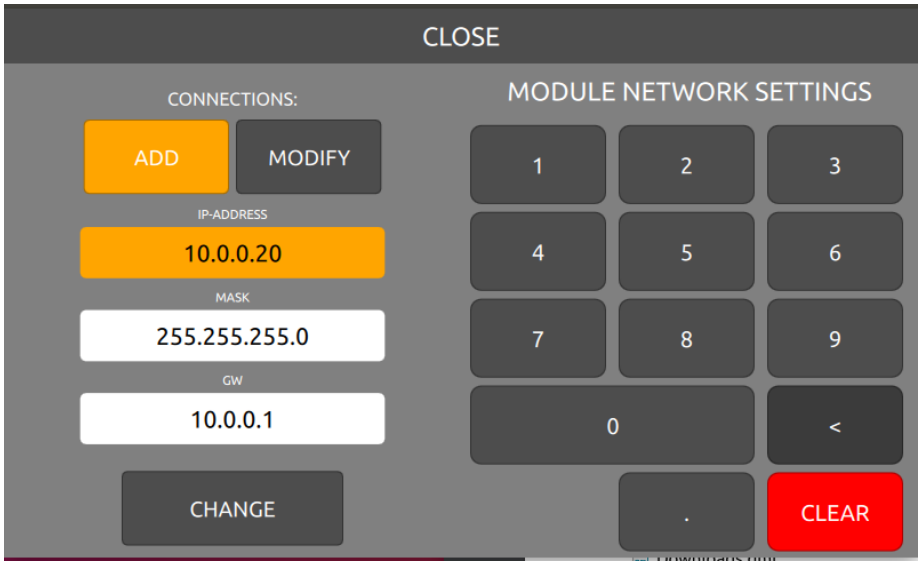

Figure 80: Changing module IP settings

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6.6.3.4 Adding a new connection

Adding a new connection is presented in Figure 81. 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.

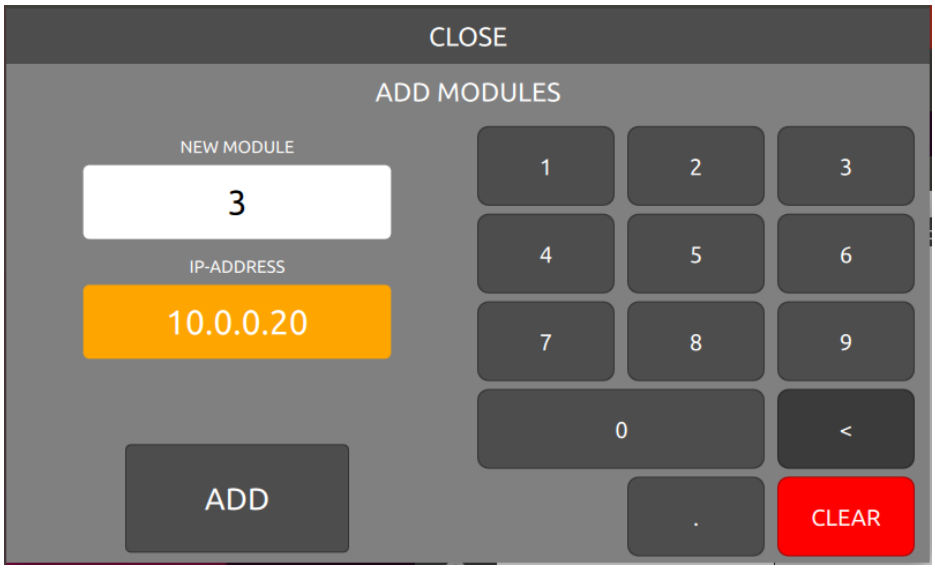

Figure 81: Adding a new connection

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6.6.4 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 82: Commissioning wizard start

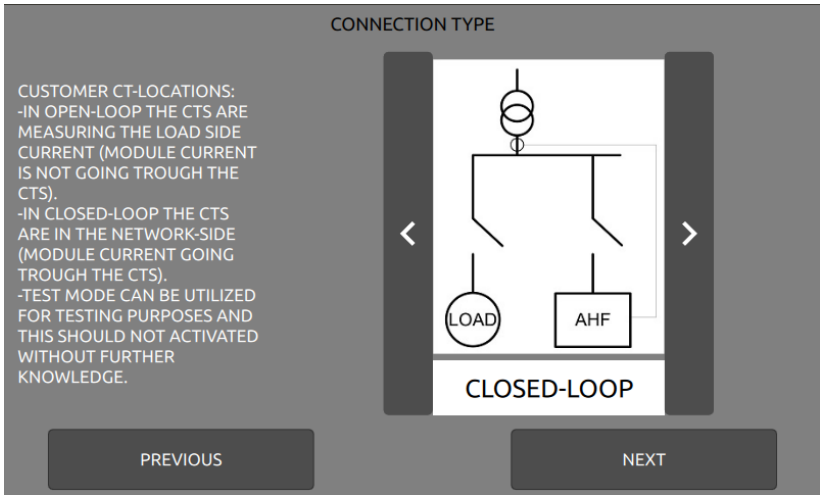

Figure 83: Part of the commissioning wizard

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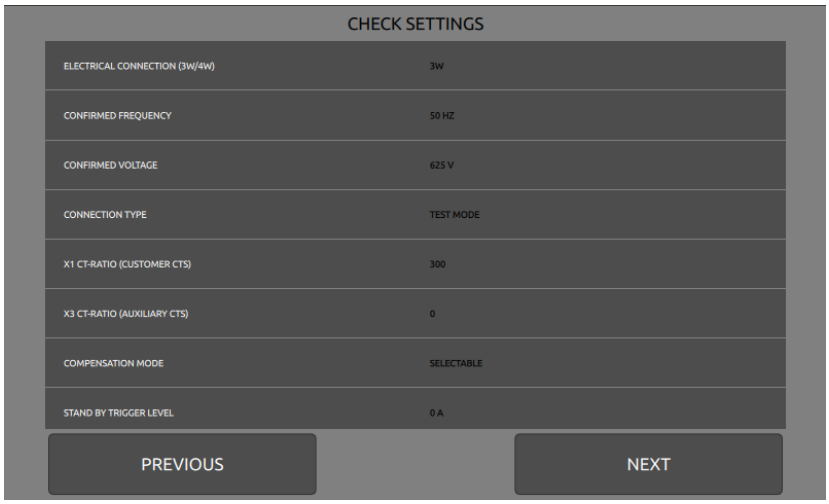

Figure 84: Checking commissioning settings

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.

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7. Troubleshooting and Maintenance

For troubleshooting guide and maintenance guidelines, please refer to Merus® A2 Troubleshooting guide or contact our service department for additional information.

8. Design standards and certificates

The A2-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

The A2-AHF module conforms with the relevant European Union harmonisation legislation as follows:

- **Low Voltage Directive** (LVD) 2014/35/EU
- **Electromagnetic Compatibility Directive** (EMCD) 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.

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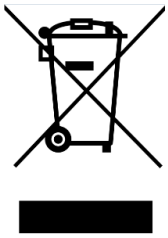
9. Environment



When the A2 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 13: 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 14: Technical data for core products

Nominal current capacity	50 A	100 A	150 A	200 A
Electrical ratings				
Nominal voltage	**3W:** 200–480 VAC (± 10%), **4W:** 200–440 VAC (± 10%) Higher voltages with 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)	3W/4W			
System features				
Reaction / Response time	Reaction time < 50 µs / Response time < 100 µs (1 network cycle in selectable mode)			
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).			
Interharmonic filtering	Interharmonics are filtered up to the 50th harmonic order when operating in 'all harmonics' or 'all harmonics but not fundamental' modes.			
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 / All harmonics but not fundamental / 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	Unlimited scalability. 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.			
Certificates	CE, UL 508, RoHS 2			
Connections				
CT locations	Network/load side			

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Number of CT's	3 pcs / 6 pcs (see section 5.4)			
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 15–48 VDC			
Digital outputs	Six potentially free programmable ports. Four operational outputs selectable from the HMI in standard deliveries. 15–277 VAC 6 A 15–48 VDC 2 A Optional SSR relays < 24 VDC 2 A (check label for details)			
Interfaces and HMI				
HMI / display	7" touch screen with multilingual graphical HMI			
Connections for HMI	1–7 module connections in one HMI. Unlimited number of HMIs			
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			
Dimensions (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 A2 module	350 m³/h	450 m³/h	750 m³/h	1000 m³/h
Temperature	5-40 °C, without derating (see section 13.5). Max. ambient temperature 50 °C			
Altitude without derating	< 1000 m, without derating (see section 3.5)			
Humidity	Maximum 85% RH, non-condensing (operation) Maximum 95% RH, non-condensing (storage)			
Ventilation requirements	300 mm free space below and above the module required for air ventilation			

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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			

Table 15: Technical data for 690 VAC modules**

Nominal current capacity	**50 A**	**100 A**	**125 A**
Electrical ratings			
Nominal voltage	**3W:** 500 VAC–690 VAC (± 10%), **4W:** 480–525 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	375 A
Network (3-wire/4-wire)	3W/4W		
System features			
Reaction / Response time	Reaction time < 50 µs / Response time < 100 µs (1 network cycle in selectable mode)		
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).		
Interharmonic filtering	Interharmonics are filtered up to the 50th harmonic order when operating in 'all harmonics' or 'all harmonics but not fundamental' – modes.		
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 / All harmonics but not fundamental / 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	Unlimited scalability. Load is shared evenly between parallel modules.		

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Harmonic generation function	Controlled & selectable harmonic injection can be used to validate the performance of various components of the electrical system		
Connections			
CT-locations	Network/load side		
Number of CTs	3 pcs / 6 pcs (see section 5.4)		
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 15–48 VDC		
Digital outputs	Six potentially free programmable ports. Four operational outputs selectable from the HMI in standard deliveries. 15–277 VAC 6 A 15–48 VDC 2 A Optional SSR relays < 24 VDC 2 A (check label for details)		
Interfaces and HMI			
HMI / display	7” touch screen with multilingual graphical HMI		
Connections for HMI	1–7 module connections in one HMI. Unlimited number of HMIs.		
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 A2 module	450 m³/h	750 m³/h	850 m³/h

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Temperature	5-40 °C, without derating (see section 13.5). Max. ambient temperature 50 °C		
Altitude without derating	< 1000 m, without derating (see section 3.5)		
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 16: 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

Table 17: 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 (7W)
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, A2 modules are non-UL variants but can be ordered as UL variants. When using UL-rated 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 346V (phase to ground), 600V (phase to phase), suitable for overvoltage category III, and shall provide protection for a rated impulse withstand voltage peak of 2546V,” 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 18: Torques in main terminals

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

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12. Revision history

Merus A2 module manual revisions

Changes	revision nro	Date
Initial version	1.0	22/12/2016
Changed Digital input pictures and explanations. Initial technical data for 200A module.	1.6	2/6/2017
Added special product table	1.7	20/6/2017
Revised CT-burden to match actual burden. Added pictures and explanations for 200A module. Added missing note of plain capacitor banks.	1.8	3/10/2017
Updated for the new HMI.	1.9	17/10/2017
Added short circuit protection chapter	1.10	19/10/2017
Highlighted ALL HARMONICS -mode resonance possibility in chapter 13.2	1.11	14/3/2018
Updated with new electronics. The whole document revised	2.0	14/9/2018
Added support for the hardwired start, stop and acknowledge	2.1	19/11/2018
Added chapter for design standards. Modified needs for load balancing (load balancing possible without reactive power compensation). Added redundancy in the technical data chapter. Removed temporary overloading	2.2	24/4/2019
Added note about auxiliary CT's primary circuit dimensioning DO channel "Trip or Alarm" option added Technical specification reviewed UL certificate revised	2.3a	11/6/2019
Added HMI datasheet Revised Technical datasheet UL508C→UL508 Added higher harmonics derating graphs	2.4	30/9/2019
Modified special modules UL Small modification for clarifications	2.5	22/1/2020
690 VAC module version included New HMI version included Modification on whole documents	3.0	21/04/2020
Transfer for new document type, added chapter **Error! Reference source not found.** Compensation mode hidden from regular commissioning settings	3.1	22/06/2020
Revised technical chapter Added information for mechanical installation Added note about 3W/4W selection	3.2	19/02/2021
Added new module current level (690 VAC 125A) Added secondary HMI panel information	3.3	08/11/2021
Modified UL information on chapter: 11 Revised information on hardwired signals Revised information on standby mode Small insignificant modification in overall	3.4	05/06/2022
Deleded non-standard version in the technical chapter	3.5	03/11/2022
General product information updated Updated figures and tables Updated instructions and recommendations	3.6	15/12/2024

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Troubleshooting and maintenance moved to separate documents Removed chapter 7 and moved the information to other chapters Updated material declaration table		
Proofread the document	3.7	14/01/2025

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