

Power Quality Filter PQFS

Installation, operation and maintenance instructions



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1. Introduction to this manual

1.1. What this chapter contains

This chapter gives basic information on this manual.

1.2. Intended audience

This manual is intended for all people that are involved in integrating, installing, operating and/or maintaining the PQFS active filter range products. People involved in the integration, installation and maintenance of the equipment are expected to know the standard electrical wiring practices, electronic components and electrical schematic symbols. End users should focus on the Operating instructions (Cf. [Chapter 9](#)) and Maintenance instructions (Cf. [Chapter 10](#)) of this manual.

1.3. Compatibility

The manual is compatible with all filters of PQFS-range with color touchscreen PQF-Manager or higher.

- V1 : V26 r3001
- V2 : V11 r23
- V3 : V2 r0
- V4 : V0.1 r8

Technical specifications of this product range are given in [Chapter 12](#) of this manual. This product is not backward compatible with any other PQFx (x: A, B, L, T, I, M, K, S) filter product.

1.4. Contents

- [Chapter 1](#): Introduction to this manual
- [Chapter 2](#): Safety instructions
- [Chapter 3](#): Upon reception
- [Chapter 4](#): Hardware description
- [Chapter 5](#): Mechanical design and installation
- [Chapter 6](#): Electrical design and installation
- [Chapter 7](#): The PQF-Manager user interface
- [Chapter 8](#): Commissioning instructions
- [Chapter 9](#): Operating instructions
- [Chapter 10](#): Maintenance instructions
- [Chapter 11](#): Troubleshooting guide
- [Chapter 12](#): Technical specifications

1.5. Related publications

- [Power Quality Filters PQFS-PQFS-PQFS Catalogue \[English\]](#)
- [PQ-Link Installation and user's guide \[English\]](#)
- [PQF Modbus documentation](#)
- [Quick start-up guide](#)

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2. Safety Instructions



These safety instructions are intended for all work on the PQFS. Neglecting these instructions can cause physical injury and death. All electrical installation and maintenance work on the PQFS should be carried out by qualified electricians. Do not attempt to work on a powered PQFS.



After switching off the supply to the PQFS, always wait at least 25 minutes before working on the unit in order to allow the discharge of DC capacitors through the discharge resistors. Always verify by measurement that the capacitors have discharged. DC capacitors may be charged to more than 800 Vdc.

Before manipulating current transformers, make sure that the secondary is short-circuited. Never open the secondary of a loaded current transformer.

You must always wear isolating gloves and eye-protection when working on electrical installations. Also make sure that all local safety regulations are fulfilled.

DANGER: To ensure safe access, supplies to each individual enclosure must be isolated before entry/opening

WARNING: This equipment contains capacitors that are connected between phase and earth. A leakage current will flow during normal operation. Therefore, a good earth connection is essential and must be connected before applying power to the filter.

WARNING: There are AC capacitors & DC capacitors connected inside this filter. Before performing any maintenance work, please short and ground the three-line terminals. The DC capacitor needs 25 minutes to discharge after disconnection. Please wait for this duration before touching any live parts even after discharging the AC capacitors to avoid electrical shock.

WARNING: Never discharge DC capacitors through short circuit. Always use a current limiting resistor of minimum 100Ω.

WARNING: To avoid electrical shock due to residual voltage on the capacitors, the left side cover of the filter should not be removed once the filter is commissioned.

WARNING: If the ground is not done properly, under certain fault conditions in the unit or in the system to which it is connected it can result in full line voltage between chassis and earth ground. Severe injury or death can result if the chassis and earth are touched simultaneously.

WARNING: The neutral current in a PQFS filter may be as high as 3 times the line current hence do not use a 4-pole breaker to connect this type of filter as the rating of the neutral pole may not be adequate.

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3. Upon Reception

3.1. What this chapter contains

This chapter gives basic information on how to inspect, transport, identify and store the PQFS active filter.

3.2. Delivery inspection

Each PQFS is delivered in a box designed to protect adequately the equipment during shipment. Upon reception of the equipment, make sure that the packing is in good condition. Verify the state of the shock and tilting indicators (if mounted on the enclosure).

After removal of the packing, check visually the exterior and interior of your filter for transportation damage.

3.3. Unpacking instructions



Figure 1: PQFS packing material opened

After removal of the top cover, check visually the exterior and interior of your filter for transportation damage.

- this manual
- the electrical drawing
- the rubber seal to cover a knock-out (to be used for multi-unit operation)
- the communication cable needed for multi-unit operation
- the two eyebolts

Any loss or damage should be notified immediately to your Hitachi Energy representative.

3.4. Lifting and transportation guidelines

Please note that filter equipment weighs approximately 130 kilograms. Care should be taken to ensure that correct handling facilities are used. In order to transport the equipment use a forklift or similar equipment. PQFS enclosures are best transported horizontally.

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Table 1: Maximum allowed ambient conditions during transportation

	Transportation (in the protected package)
Temperature	-25 to 70°C (-13 to 158°F)
Relative humidity	Max. 95%
Contamination levels (IEC 60721-3-3)	Chemical class 3C3 ^(a) Mechanical class 3S3 ^(b)

Remarks:

(a) Locations with normal levels of contaminants, experienced in urban areas with industrial activities scattered over the whole area, or with heavy traffic. Also applies to locations with immediate neighborhood of industrial sources with chemical emissions.

(b) Locations without special precautions to minimize the presence of sand or dust. Also applies to locations in close proximity to sand or dust sources.

In order to lift the equipment once it is at the installation location:

- Remove the top cover of the protecting box (see Figure 1).
- Remove the 4 panel securing screws at the bottom and the top of the enclosure (see Figure 2).

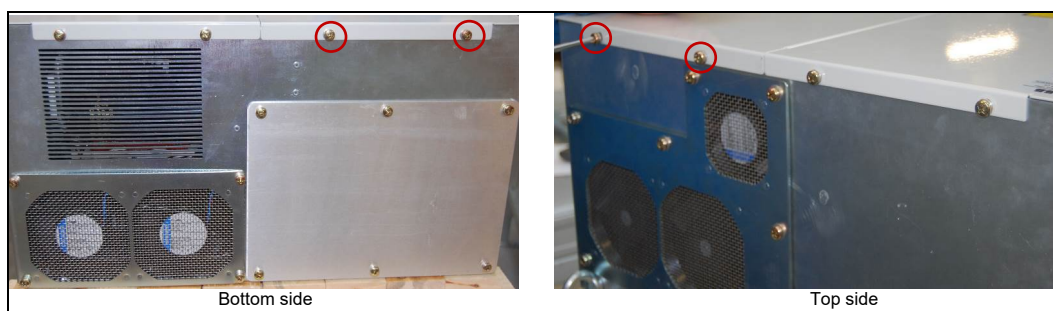


Figure 2: Locating the 4 panel securing screws

- Remove first the right side of the protective cover and put it aside (see Figure 3).

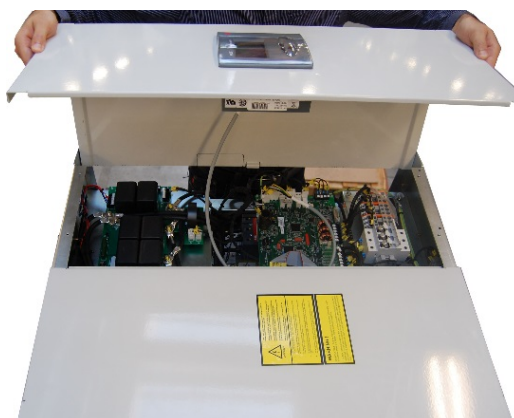


Figure 3: Lifting the right protective cover and putting it aside

- Unplug the PQF-Manager from the main system (see Figure 4). Then the protective cover can be safely put aside.

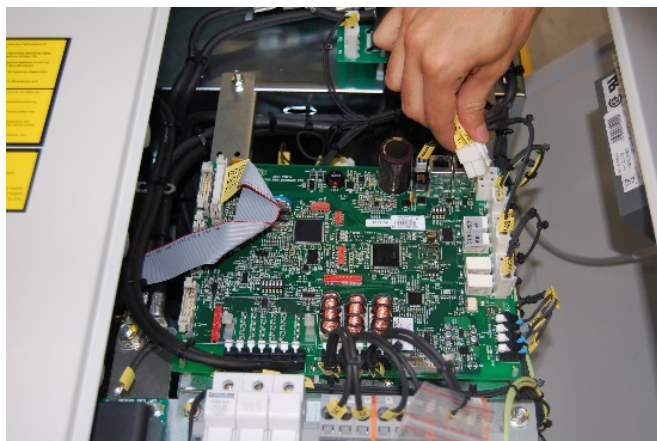


Figure 4: Unplugging the PQF-Manager from the main system

- Remove the two screws fixing the filter unit to the wooden support (see Figure 5).

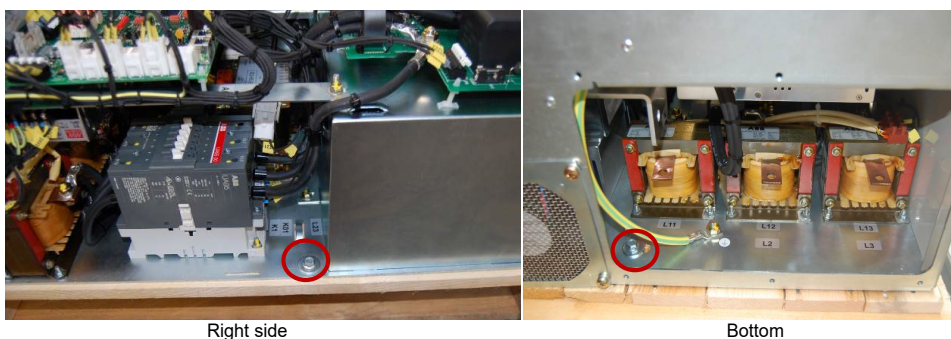


Figure 5: Position of the filter fixation screws that need to be removed

- Fix the two eyebolts provided with the filter (see Figure 6).

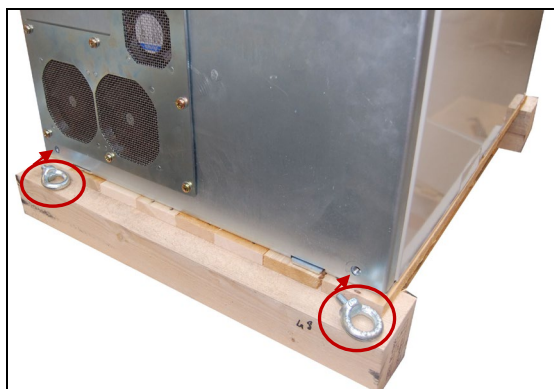


Figure 6: Fix the eyebolts before lifting the PQFS

Fix an appropriate lifting device to the eyebolts to lift the filter from the wooden support. It can then be positioned at the desired location (see Figure 7).

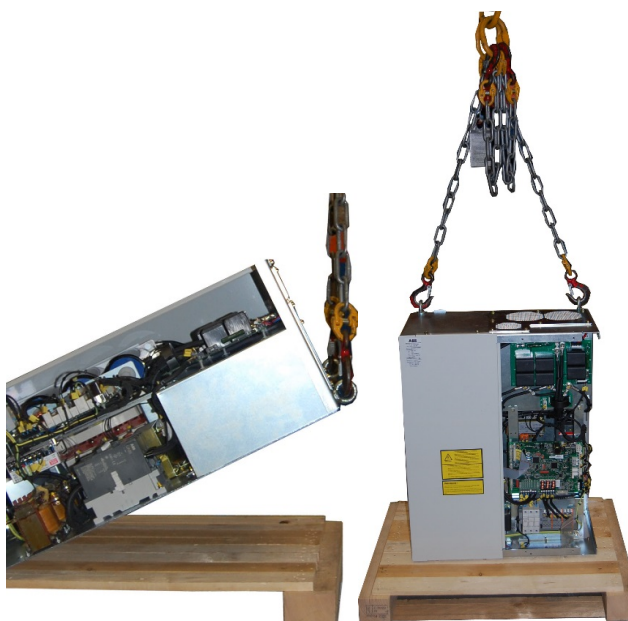


Figure 7: Lifting a PQFS unit by using the lifting lugs

3.5. Identification tag

Each PQFS is fitted with nameplates for identification purposes.

For the filter nameplate is located at the top left of the master panel door, at the outside.

The nameplate information should always remain readable to ensure proper identification during the whole life of the filter. The main filter nameplate includes the filter type, the nominal voltage range and frequency as well as a serial number, the DSP software version and an HITACHI internal article code.

3.6. Storage

If your PQFS is not installed once unpacked, it should be stored in a clean indoor, dry, dust free and non-corrosive environment. The storage temperature must be between -25°C (-13°F) and 70°C (158°F) with a maximum relative humidity of 95%, non-condensing.

Table 2: Maximum allowed ambient conditions for storage

	Storage (in the protected package)
Temperature	-25 to 70°C (-13 to 158°F)
Relative humidity	Max. 85%
Contamination levels (IEC 60721-3-3)	Chemical class 3C3 ^(a) Mechanical class 3S3 ^(b)

Remarks:

(a) Locations with normal levels of contaminants, experienced in urban areas with industrial activities scattered over the whole area, or with heavy traffic.

(b) Locations without special precautions to minimize the presence of sand or dust. Also applies to locations in close proximity to sand or dust sources.

4. Hardware description

4.1. What this chapter contains

This chapter describes a typical PQFS-filter system and discusses its main components.

4.2. Typical PQFS filter panel layout

The PQFS active filter is basically composed of two parts (Figure 8):

- A filter controller that determines the anti-harmonic current to be injected based on the line current measurements and the user's requirements. The line current measurements are obtained from current transformers (CTs) provided by the customer. The CTs must be connected upstream of the connection point of the filter and the loads. The user enters his requirements by means of the PQF-Manager user interface. This device also acts as the user's connection point for the alarm/warning contacts, the remote control functionality, the other digital input functionality and the interface for external communication.
- A current generator (power unit) that converts the control signals generated by the filter controller into the filter compensation current. The current generator is connected in parallel with the load(s). Up to eight power units may be connected in parallel in one filter unit. The enclosure(s) containing the/a filter GUI controller are referred to as master units. The other enclosures are referred to as the slave units. In an active filter system more than one master unit can be present.

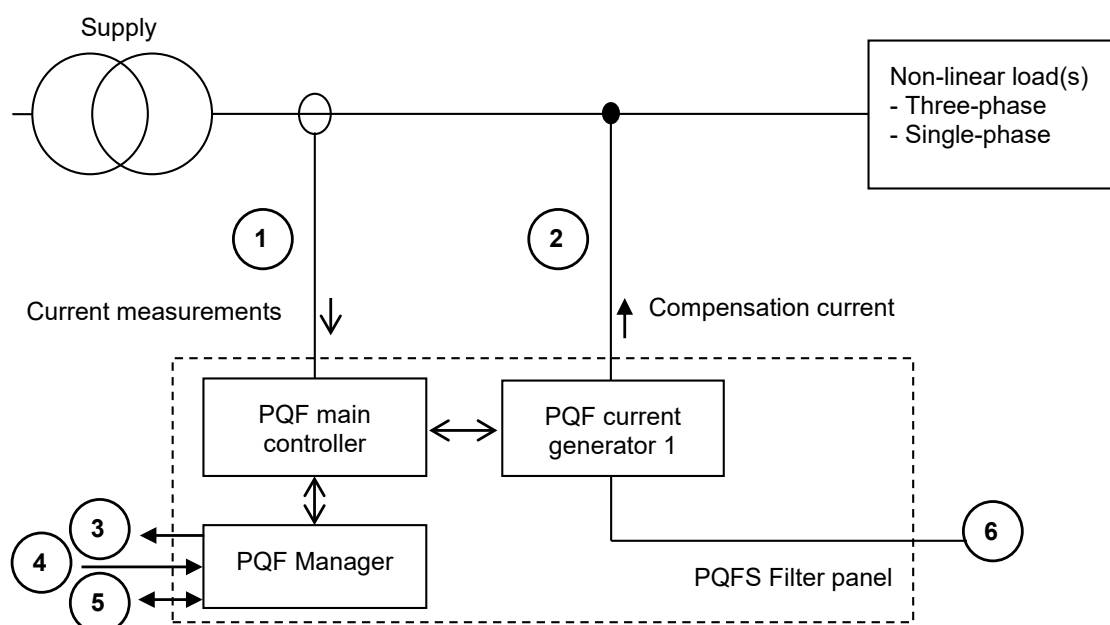


Figure 8: PQFS schematic overview with user connections

The user connection description is given in Table 3.

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Table 3: User connections for PQFS

Item	User connections	Connection requirement
1	CT connections	Mandatory
2	Power cable connection to the supply (including neutral connection if 4-wire operation is desired)	Mandatory
3	Programmable digital outputs (warnings...)	Not mandatory
4	Remote control contact connection or/and local on/off buttons or/and main/auxiliary settings control	Not mandatory
5	PQ-link (USB-Ethernet) – Modbus RTU – Modbus TCP communication connection	Not mandatory
6	Earth connections from the enclosure to installation earth	Mandatory

Mandatory connections are connections that must be present to make the filter operational. Connections that are not mandatory can be made to enhance the filter's basic functionality. For more information on cabling the user connections, please refer to [Chapter 6](#).

[Figure 9](#) shows a typical PQFS master filter panel.

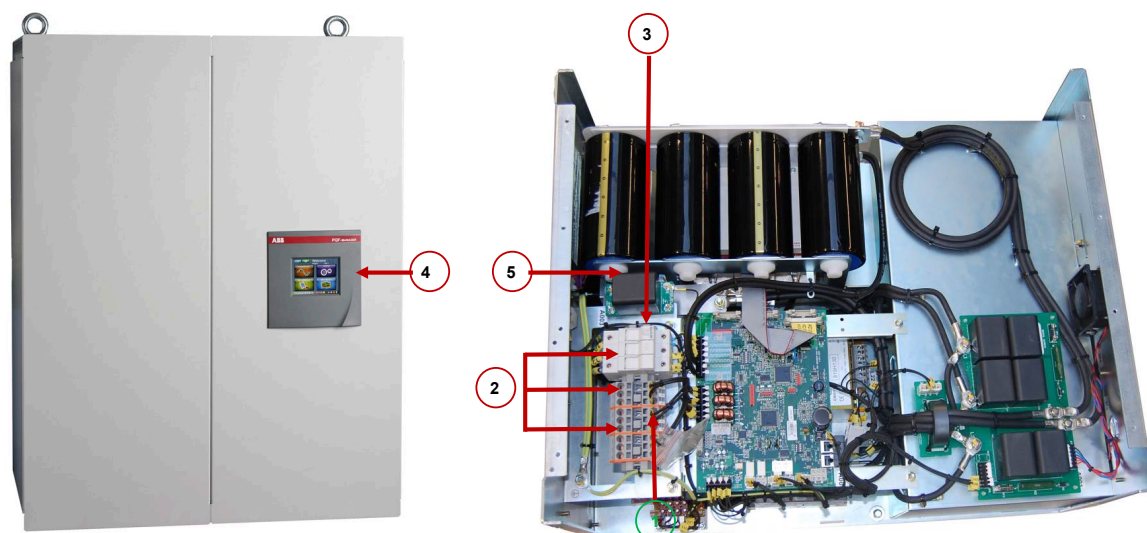


Figure 9: Example of a typical PQFS master filter panel

The input/output connections and protection description is given in [Table 4](#).

Table 4: Input/Output connections

Item	Input/output connections
1	CT connection terminals
2	Main power connection
3	Auxiliary fuse protection
4	PQF-Manager user interface with connection terminals for user I/O (e.g. alarm contact) and communication interfaces
5	Neutral connection

Up to 8 PQFS master panels can be connected in parallel providing full redundancy to the customer. In addition to using master panels only, PQFS units can be connected in a master-slave arrangement.

4.3. The PQF current generator hardware

The power circuit of a PQFS unit is represented hereafter.

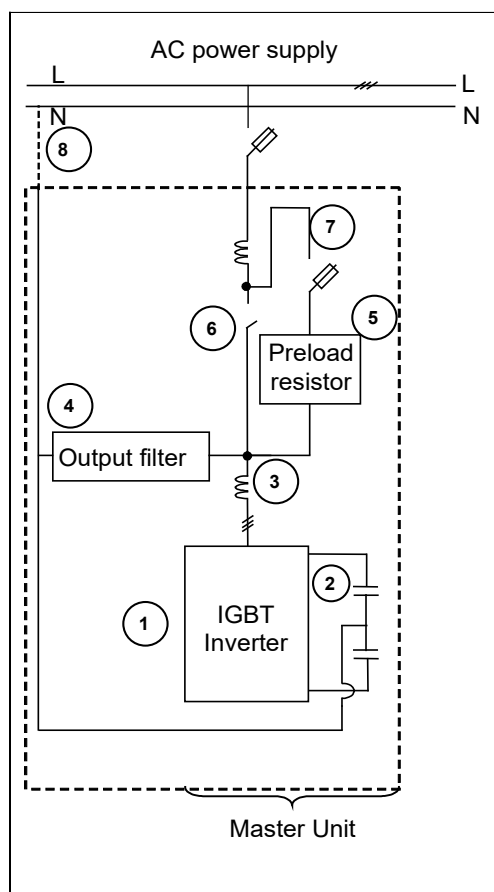


Figure 10: Power circuit diagram of a PQFS active filter

The description of the main components is given in [Table 5](#).

Table 5: Main components of a PQFS active filter

Item	Main components
1	IGBT inverter
2	DC bus capacitors
3	PWM reactor
4	Output filter
5	Preload resistor
6	Main contactor
7	Auxiliary fuses
8	Neutral cable connection (not mandatory)

The current generator is physically organized in power units. Each filter cubicle contains one power unit. A PQFS filter can contain up to 8 power units. Power units can be combined in a master-slave arrangement or in a master-master arrangement, the latter giving full operational redundancy. **The current rating of different units in a filter must be the same.** Please refer to [Chapter 12](#) for more information on the possible unit ratings.

In [Figure 10](#) it may be seen that each current generator consists of an IGBT-inverter bridge (1) that is controlled using PWM-switching technology. Information from the filter controller is sent to the IGBTs through one flat cable. At the output of the inverter a voltage waveform is generated which contains the desired spectral components (imposed by the filter controller) as well as high frequency noise (due to the IGBT switching technology). Coupling impedance consisting of a reactor (3) and a high frequency rejection filter (4) ensures that the useful voltage components are converted into a useful current while the high frequency noise is absorbed. The IGBT-inverter is equipped with DC capacitors that act as energy storage reservoirs (2).

In active filters containing more than one power unit the control information between different units passes through a CAN control cable.

If a master-master configuration of filter is chosen, all power units incorporate a PQF-Manager display. If a master-slave configuration of filter is chosen, only the master enclosure contains a PQF-Manager display. All units contain a DC capacitors preloading resistor (5) which charges the DC capacitors of the filter unit once the auxiliary fuse box of the unit(s) is closed. This approach ensures a smooth filter start-up without excessive inrush currents.

4.4. The PQF main controller

The PQF main controller controls the complete active filter system. Its tasks include:

- Accepting and executing customer requests to stop and start the equipment.
- Calculating and generating IGBT-inverter control references based on the line current measurements and the user requirements.
- Interface to the IGBT-inverters.
- Measurement of system voltages and currents for control, protection and presentation purposes.

[Figure 11](#) depicts the controller interface diagram of the PQFS active filter.

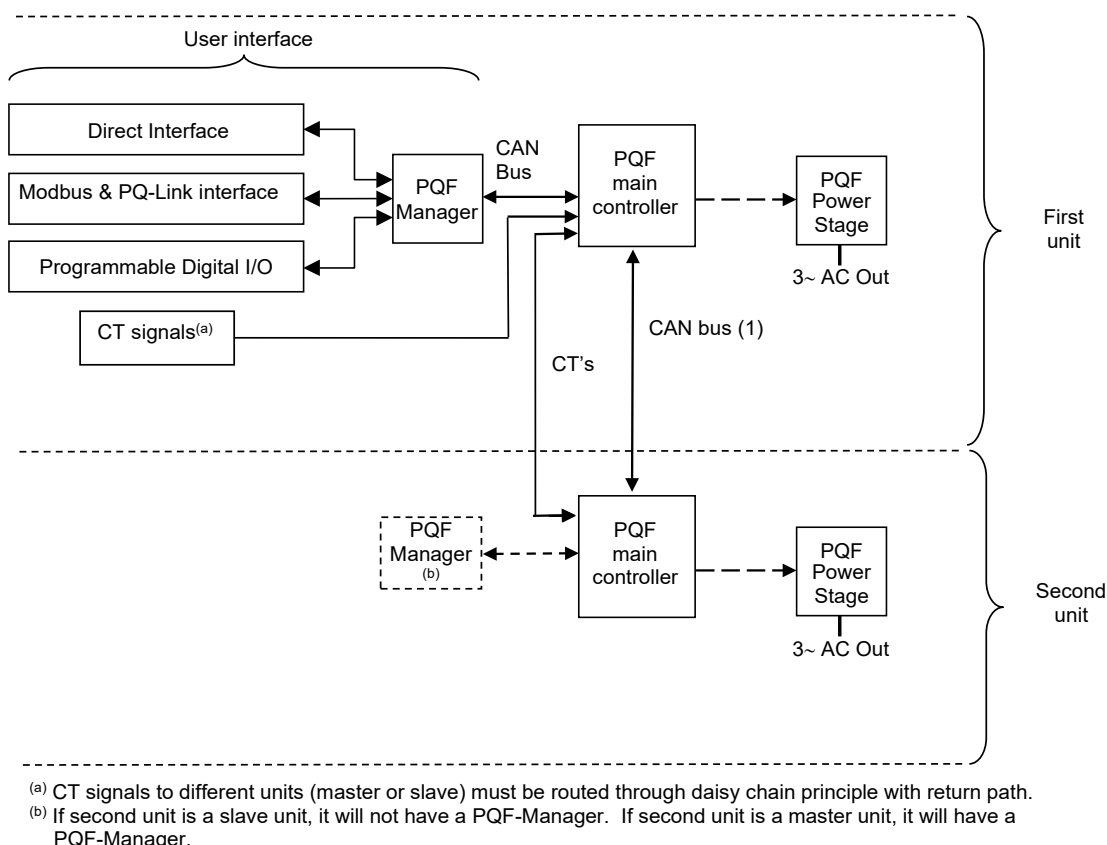


Figure 11: Controller interface diagram of the PQFS active filter

When the filter consists of a master unit only, the customer has to:

- Wire the CT signals (on a designated terminal).
- Connect the AC power lines and earth connection.
- Set up the installation parameters and user's requirements with the PQF-Manager.

He may also want to wire the communication interface (Modbus or Ethernet) and the programmable digital I/O (e.g. alarm contact, remote control).

When a second unit is added, it is connected to the first enclosure by means of a CAN bus communication link (1). In addition, the CT measurements have to be supplied to each unit, i.e. through a daisy chain link with return path.

All units have their own AC-connection and main contactor protection.

A PQFS active filter system consists of up to 8 units. Additional units to the first master unit may be master or slave units. Slave units do not have a PQF-Manager.

4.5. The PQF-Manager user interface

All user interaction with the filter is channeled through the PQF-Manager.

In multi-unit filters consisting of only one master, only the master has a PQF-Manager.

In multi-unit filters consisting of more than one master, all the master units have a PQF-Manager. However, only the PQF-Manager that is connected to the master unit which has the overall control will be active. The PQF-Manager installed on the units operating as "slaves" are capable of displaying the relevant information about that specific unit only. Certain parameters which are specific to that unit (e.g. related to temperature probes) can be set or changed

locally using the PQF-Manager installed on that unit. The PQF-Manager on the master unit has a "unit selection"  button which allows the user to select the unit number which he wants to consult. The data then displayed on the master PQF-Manager is specific to that particular unit number. This unit selection button is "deactivated" on the slave Managers. Figure 12 shows the front side of the PQF-Manager.

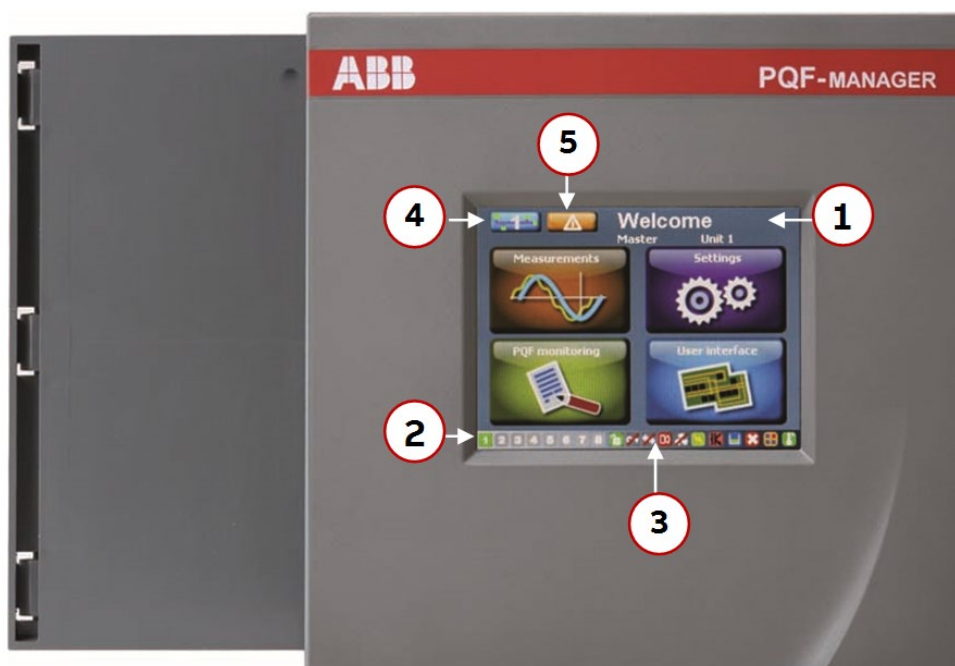


Figure 12: Front side of the PQF-Manager

Five main parts can be distinguished (see Table 6).

Table 6: Front side of the PQF-Manager

Item	Description
1	Menu display By navigating through the menus with the  ,  ,  and  buttons, the filter can be set-up and controlled. On-line help is available by pressing the  button.
2	Master/slaves units monitor 
3	Locking status / Alarm and fan contact indicator / Digital output contact indicator  When the PQF-Manager closes one of its output relays, the corresponding symbol lights up. The digital outputs of the PQF-Manager are discussed later in this section
4	Filter selection
5	Start stop acknowledgment fault

The PQF-Manager also acts as connection point for external user I/O communication. Connections are made at the rear side of the PQF-Manager. Figure 13 depicts the terminals that are present on the PQF-Manager rear side.

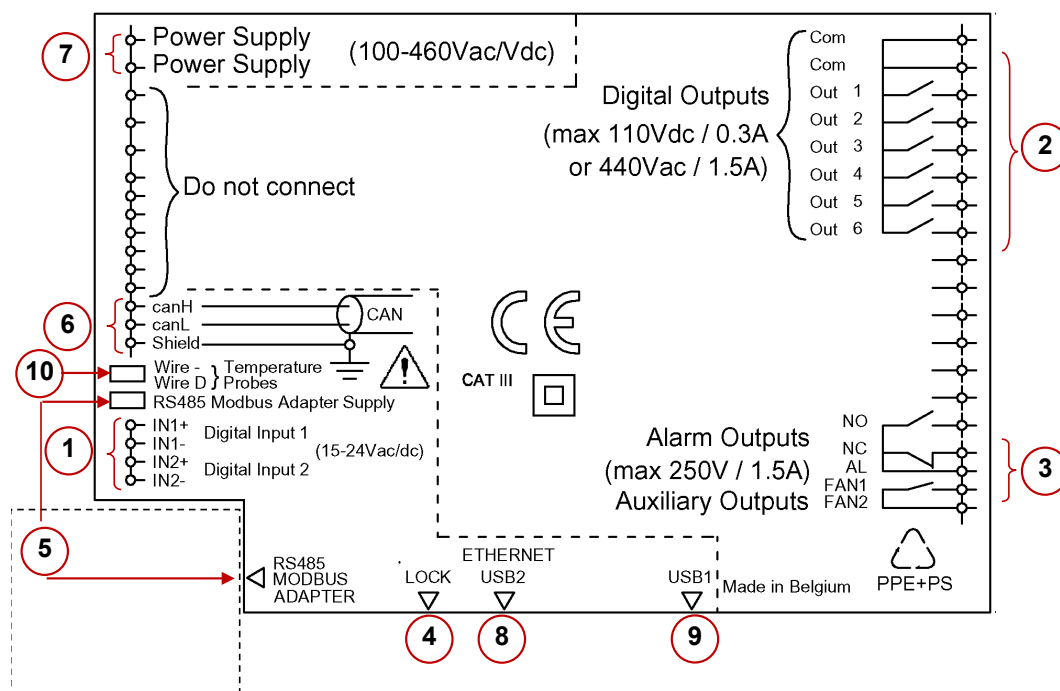


Figure 13: PQF-Manager rear side terminal designation

The terminal designation is given in [Table 7](#).

Table 7: Terminal designation

Item	Customer terminals
1	Digital input 1 and 2
2	Digital outputs 1 to 6 with one common point
3	Alarm outputs (2 outputs with complementary signals) and fan outputs
4	Lock switch
5	Modbus adapter interface (optional) connection
6	CAN bus connection interface (routed to PQF-Manager connector)
7	Power supply terminals (routed to PQF-Manager connector)
8	Ethernet
9	USB
10	Temperature probes

The terminal explanation is given next:

1 Digital input 1 and 2

The digital inputs can be used for three different functions:

- Implementation of remote control functionality;
- Implementation of local on/off buttons (not provided);
- Selection of main filter settings or auxiliary filter settings (e.g. different filter settings for the day and for the night)

The PQF-Manager is used to associate the required functionality with the chosen digital input. The digital inputs can also be disabled.



WARNING: If a function is assigned to a digital input, the same function must never be assigned to the other digital input. Otherwise the filter may behave erratically.

The external voltage source needed to drive the digital inputs has to comply with the following characteristics:

- Vlow: 0 Vdc
- Vhigh: 15-24 Vdc
- Driving current: 13 mA @ 24 Vdc (Rint = 1.88 kΩ)

The digital inputs have free of potential contacts (opto-isolated).

When implementing any of the functions described above, please note that according to the setup done with the PQF-Manager for the input considered, the filter may behave differently. **Table 8** below gives an overview of the possible settings and the resulting filter behavior.

Table 8: Overview of possible digital input settings and resulting filter behavior

Function	Vlow applied to digital input	Vhigh applied to digital input
Remote control <i>PQF-Manager setup for digital input: Remote ON^(a)</i>	Filter off	Filter on
Selection of main/auxiliary settings <i>PQF-Manager setup for digital input: Activ. Main^(a)</i>	Auxiliary settings are used	Main settings are used
Selection of main/auxiliary settings <i>PQF-Manager setup for digital input: Activ. Aux.^(a)</i>	Main settings are used	Auxiliary settings are used
Local ON/OFF buttons <i>PQF-Manager setup for digital input: Edge ON^{(a) (b)}</i>	No effect	Filter starts on rising edge
Local ON/OFF buttons <i>PQF-Manager setup for digital input: Edge OFF^{(a) (b)}</i>	No effect	Filter stops on rising edge
Local ON/OFF buttons <i>PQF-Manager setup for digital input: Edge ON/OFF^{(a) (c)}</i>	No effect	Filter starts on first rising edge, stops on second rising edge etc.

Remarks:

^(a):In order for this function to be activated, the PQF-Manager has to be set up accordingly.

To do this, navigate to [/Welcome/Settings/Customer set./Digital Inputs]

^(b):When using the Edge ON function the filter can only be switched on by applying voltage to the digital input considered. It is therefore recommended in that case to configure and cable the second digital input as Edge OFF.

^(c):When using this function, the filter stop and start can be controlled by one digital input leaving the other one available for an additional remote control or switching between main and auxiliary settings.

Information on cabling the digital input contacts is given in **Section –**.

Information on setting up the digital inputs with the PQF-Manager is given in [Section 7.9.1.4](#).

By default, the digital inputs are disabled.

In a master-master filter arrangement, only the master that has the control over the complete system will monitor its digital outputs. For full redundant functionality, it is recommended to cable the digital inputs of all the units in the filter system.

2

Digital Outputs 1 to 6

With each digital output different filter conditions can be associated. The association between the filter condition and the digital outputs is done with the PQF-Manager. [Table 9](#) gives an overview of the possible PQF-Manager settings for a digital output and the effect on the corresponding digital output relay.

Table 9: Filter conditions that can be related to the digital outputs

PQF-Manager setting for digital output ^(a)	Output relay closes when...
Auxil. ON	The auxiliary power is present in the main filter enclosure and the main controller is communicating with the PQF-Manager
PQF running	The active filter is 'on' (IGBTs switching) or in 'standby' (main contactor closed but IGBTs not switching)
Full load	The active filter is running under full load condition
Armed	The filter is ON or is in the startup procedure, or it is stopped in fault condition but will restart as soon as the fault has disappeared
T limit	The filter temperature limit has been reached and the filter is derating itself to run at a safe temperature
In standby	The filter is in standby ^(b)
Activ. Main	The main active filter settings are activated
Activ. Aux	The auxiliary active filter settings are activated
Unit miss.	One of the filter units in a multi-unit arrangement is not available (e.g. due to a permanent error), or has not yet been commissioned.
Pg. alarm 1	The programmable alarm 1 is activated ^(c)
Pg. alarm 2	The programmable alarm 2 is activated ^(c)
Pg. alarm 3	The programmable alarm 3 is activated ^(c)
Warning 1	The programmable warning 1 is activated ^(c)
Warning 1	The programmable warning 1 is activated ^(c)
Warning 2	The programmable warning 2 is activated ^(c)
Warning 3	The programmable warning 3 is activated ^(c)

Remarks:

(a): In order to set up this function, navigate to [/Welcome/Settings/Customer set./Digital Outputs]

(b): More information on the standby function is given in [Section 7.9.3.1](#)

(c): Different programmable warnings and alarms can be defined. More information on this subject is given in [Section 7.9.1.4.1](#)

Further it should be noted that:

- Whenever a digital output is activated the corresponding icon on the PQF-Manager display will change.

- In a master-master filter arrangement, only the master that has the control over the complete system will activate its digital outputs. For full redundant functionality, it is recommended to monitor the digital outputs of all the units in the filter system.
- The default set-up for the digital contacts is given in [Table 10](#).

Table 10: Default set-up for the digital output contacts

Digital output number	Default function
1	Auxil. ON
2	PQF running
3	Full Load
4	Armed
5	Unit miss.
6	T Limit

- The customer can change the default output settings by means of the PQF-Manager.
- The digital outputs contacts have a common point and are of the NO-type (normal open). The contact ratings are:
 - Maximum continuous ac rating: 440 Vac/1.5 A;
 - Maximum continuous dc rating: 110 Vdc/0.3 A;
 - The common is rated at 9A/terminal, giving a total of 18 A.

Information on cabling the digital output contacts is given in [Section 6.12](#).

Information on setting up the digital outputs with the PQF-Manager is given in [Section 7.9.1.4](#)

3

Alarm outputs and fan outputs

Apart from the digital outputs, one potential free relay with a NO and a NC alarm output is available. This relay contact is activated if any error condition is present during a preset time. The relay contact is deactivated if the error condition has disappeared for another preset time. Information on changing the alarm activation/deactivation time is given in [Section 7.9.1.4.1](#).

In a master-master filter arrangement, only the master that has the control over the complete system will activate its alarm contact. For full redundant functionality, it is recommended to monitor the alarm contacts of all the units in the filter system.

The maximum continuous alarm contact ratings are: 250 Vac/1.5 A.

A fan relay can be activated if a temperature probe detects an overtemperature.

4

Lock switch

Allows locking the settings of the filter panel. This switch is documented in [Section 7.9.3.5](#).

5

Modbus RTU adapter interface (optional) connection

The Modbus adapter interface is connected at this location. The output of the interface is an RS-485 socket. The interface is described in the Modbus RTU interface manual.

6

CAN bus connection interface

The PQF-Manager communicates with the main controller through a CAN bus. This bus consists of three terminals, i.e.:

- Pin H: CAN High signal
- Pin L: CAN Low signal
- Pin Shield: shielding

The CAN bus wiring terminates into the PQF-Manager connection plug and is subsequently routed to the main control (Cf. [Section 4.6.1](#)). It is used for PQF internal communications only.

7 Power supply terminals

The PQF-Manager power supply is provided by the filter itself. The corresponding terminals on the PQF-Manager labeled “Power supply” are connected to the PQF-Manager connection plug.

8 The PQF-Manager communicates with Modbus TCP and PQ-link thanks to the Ethernet connection. For background information on the Modbus RTU and TCP communication interface refer to the dedicated Modbus manual. For background information on the PQ-link communication interface refer to the dedicated PQ-link manual.

9 The PQF-Manager can communicate with PQ-link (PC software) also through USB. . For background information on the PQ-link communication interface refer to the dedicated PQ-link manual.

10 External temperature probes can be added. The PQF-manager can handle until 8 temperature probes connected in a daisy chain way. Please refer to the Temperature probe User’s guide for more information.

For information on how to cable external systems (e.g. remote control, Modbus interface) to the PQF-Manager, refer to [Chapter 6](#). For information on how to use the PQF-Manager, refer to [Chapter 7](#). For background information on the Modbus RTU and TCP communication interface refer to the dedicated Modbus manual. For background information on the PQ-link communication interface refer to the dedicated PQ-link manual.

4.6. Location of the main PQFS components

4.6.1. Active filter components

Figure 14 shows a picture of the PQFS without cover panel.

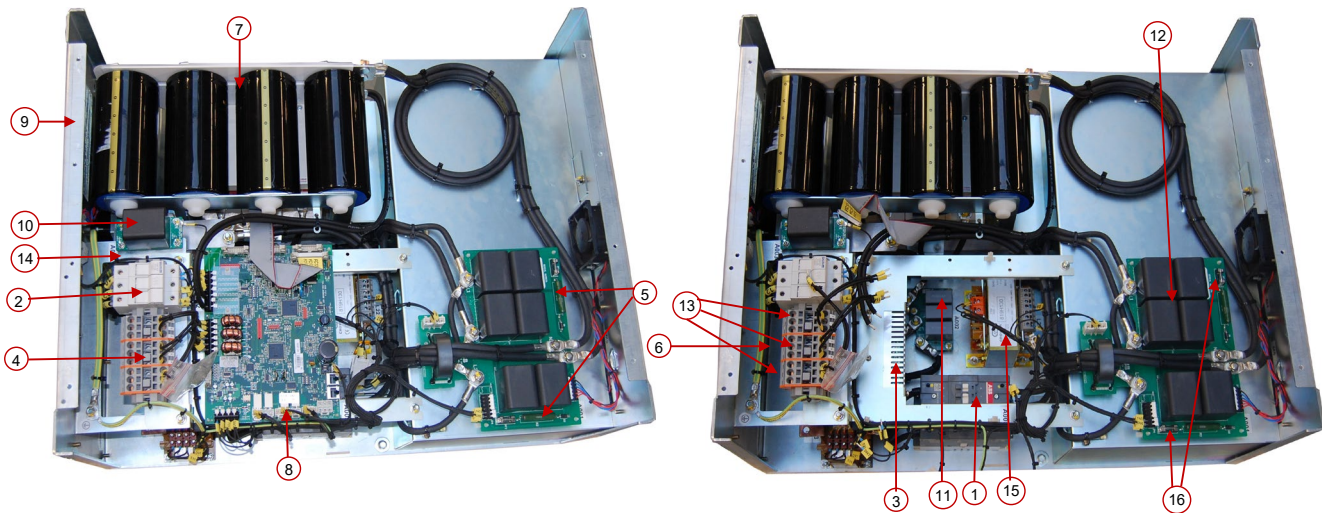


Figure 14: PQFS main components

The component identification is given in [Table 11](#).

Table 11: PQFS main components description

Item	Description	Circuit diagram designation
1	Main contactor (MC)	K01
2	Fuse holder auxiliaries circuit	Q2
3	DC voltage power supply 24V	U002
4	CT connection terminal	X21
5	Preload circuit resistors	R1, R2
6	Main earth connection point	-
7	IGBT inverter with DC capacitors	U01
8	PQF main controller board	A005
9	IGBT heat extraction fan	M1, M2
10	PCB EMC neutral	A003
11	PCB EMC line	A002
12	PCB output filter preload	A001
13	Main power supply terminals (phases) (underneath controller boards)	L1, L2, L3
14	Main power supply neutral connection (not mandatory) (underneath controller boards)	N
15	Auxiliary transformer	T001
16	Fuse preload circuit	PF1, PF2

The PQFS filters are provided with the preload circuit and the output filter mounted on a PCB. This design substantially reduces the time needed for replacement of the same. It also gives a more robust design compared to the previous generation of filters. The power supply to the exhaust fan at the top of the filter are connected to the terminal block shown which make the replacement of the same easy during periodic maintenance.

The fuse on the PCB is of very special characteristics and must be replaced only with the same type. Please refer to our recommended list of spare parts.

The preload circuit is shown in [Figure 15](#).

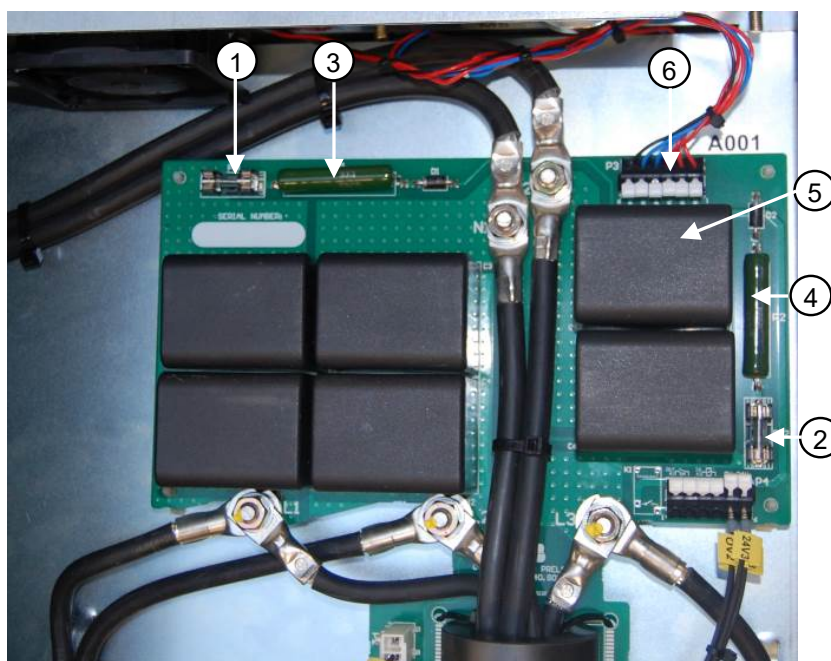


Figure 15 Preload circuit main components

The component identification is given in [Table 12](#).

Table 12: Preload circuit main components description

Item	Description	Circuit diagram designation
1	Fuse preload circuit	PF1
2	Fuse preload circuit	PF2
3	Preload circuit resistors	R1
4	Preload circuit resistors	R2
5	Capacitors	
6	Terminal block for top fans	P3

The PQF Main controller board has connectors which are predominantly pre-wired for use within the filter. However, it also contains a DIP-switch used to set the identification address and CAN bus connectors for use in a multi-module filter arrangements.

The main controller board is shown in [Figure 16](#).

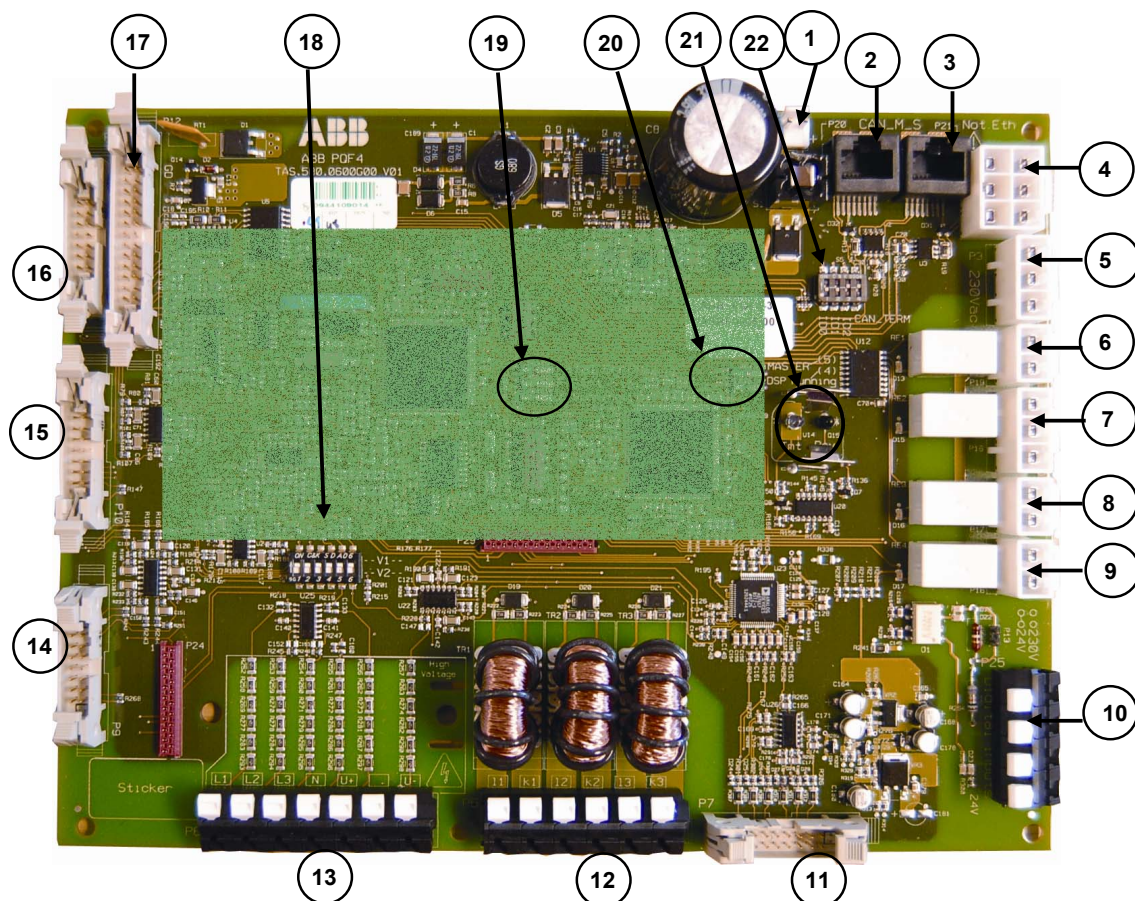


Figure 16: PQF main controller board

The designation of the principal terminals is given in [Table 13](#).

Table 13: PQF main controller board description

Item	Description	Circuit diagram designation
1	System connector: 24 V power supply to control board	P2
2	CAN bus connection from previous filter unit	P20
3	CAN bus connection to next filter unit	P21
4	System connector: Power supply and CAN communication to PQF Manager	P4
5	System connector: 230 V power supply to control board	P3
6	System connector	P19
7	System connector: Main contactor control	P18
8	System connector	P17
9	System connector	P16
10	System connector	P25
11	System connector	P7
12	System connector: Coming from CT terminal X21 (internal)	P5
13	System connector: Supply and DC link voltage measurement	P6
14-15-16	System connectors	P9, P10, P11

Item	Description	Circuit diagram designation
17	System connector: control of IGBT-module	P12
18	Voltage selector DIP-switch	
19	System LED's (top to bottom with ABB Logo at top left side) LED 3: ON: Critical error in filter unit considered (red LED) LED 3: OFF: No critical error in filter unit considered LED 2: ON: PQF unit running or in startup process (Armed) LED 2: OFF: PQF unit off and not in startup process LED 1: Blinking at regular interval (1 s): Microcontroller running properly LED 1: ON, OFF or blinking irregularly: Microcontroller not running properly	
20	System LED's (top to bottom with ABB Logo at top left side) LED 5: ON: Filter unit is acting as the master of the complete system LED 5: OFF: Filter unit is acting as a slave in the filter system LED 4: Blinking at regular interval (1 s): DSP processor running properly LED 4: ON, OFF or blinking irregularly: DSP processor not running properly	
21	PQ-Link communication opto-isolated serial link connector	
22	Filter unit address selector (3 Left most DIP switches with ABB Logo at top left side) and CAN bus termination (Right hand DIP switch): Symbols used: L: low – H: high Address 1: Position of the 3 switches starting from left: L L L Address 2: Position of the 3 switches starting from left: H L L Address 3: Position of the 3 switches starting from left: L H L Address 4: Position of the 3 switches starting from left: H H L Address 5: Position of the 3 switches starting from left: L L H Address 6: Position of the 3 switches starting from left: H L H Address 7: Position of the 3 switches starting from left: L H H Address 8: Position of the 3 switches starting from left: H H H Note: In a multi-master arrangement, the master which is operational and which has the lowest address controls the system. The default address setting is L L L CAN bus termination (Right hand DIP switch): Must be High (H) for the units that are at the extremity of the CAN bus (maximum 2 units in a multi-unit filters, typically the first one and the last one of the chain). This setting is also applicable to single-unit filters. Must be Low (L) for units in the middle of a chain. The default factory setting is H.	

Remark:

^(a) For physical locations of customer CT connection terminals, please refer to **Figure 14**, item 4.

4.6.2. Active filter door components and protective grid

The active filter master panel door contains the PQF-Manager and a protective grid connected to the filter frame. At the bottom of the protective grid a cooling fan is mounted.

5. Mechanical design and installation

5.1. What this chapter contains

This chapter gives the information required for the mechanical design and installation of the filter system.

In case you have a problem, please notify it to our service support mailbox: service.jumet@hitachienergy.com.

5.2. Installation location requirements

The PQFS is suitable for indoor wall-mounted installation, in a well-ventilated area without dust and excessive aggressive gases where the ambient operating conditions do not exceed the following values:

Table 14: Ambient operating conditions for PQFS operation

Altitude	Nominal output at 0 to 1000m (3300ft) above sea level ^(a)
Minimum temperature	-10°C (23°F), non-condensing
Maximum temperature	40°C (104°F) ^(b)
Maximum average temperature (over 24 h)	35°C (95°F)
Relative humidity	Max. 95% non-condensing
Contamination levels (IEC 60721-3-3)	Chemical class 3C2 ^(c) Mechanical class 3S2 ^(d)

Remarks:

(a) At sites over 1000m (3300ft) above sea level, the maximum output current must be derated by 1% every additional 100m (330ft). The derating factor must be entered at commissioning.

(b) Above 40°C (104°F), the maximum output current must be derated by 2% every additional 1°C (1.8°F) up to 50°C (122°F) maximum limit. The derating factor must be entered at commissioning.

(c) Locations with normal levels of contaminants, experienced in urban areas with industrial activities scattered over the whole area, or with heavy traffic.

(d) Locations without special precautions to minimize the presence of sand or dust, but not situated in proximity to sand or dust sources.

The filter installation must be indoor and it should be taken into account that the standard protection class is IP30.



WARNING: Conductive dust may cause damage to this equipment. Ensure that the filter is installed in a room where no conductive dust is present.

5.3. Airflow and cooling requirements

The PQFS dissipates an amount of heat that has to be evacuated out of the room where the filter is located. Otherwise, excessive temperature rise may be experienced. Please note that life of the electrical equipment decreases drastically if the operating temperature exceeds the allowable limit (divided by 2 every 10°C/23°F).

Each PQFS power unit has its own set of cooling fans. The air intakes are located at the bottom of the unit. From the bottom, the air flows through the enclosure and is then routed to the top of the enclosure. For proper cooling, a minimum airflow of cooling air has to be supplied to each unit. [Table 15](#) gives the airflow requirements for different unit ratings.

Table 15: Airflow requirements

Unit rating	Airflow requirement (m³/h)
30A - 60A	520 m³/h
70A - 100A	520 m³/h
120A	710m³/h

Please ensure that the air used for cooling is regularly renewed and does not contain conductive particles, significant amounts of dust, or corrosive or otherwise harmful gases. The cooling air intake temperature must not exceed 40°C under any operating condition. The hot exhaust air also has to be properly ducted away. **Error! Reference source not found.** shows the cooling air flow diagram for a single unit PQFS.

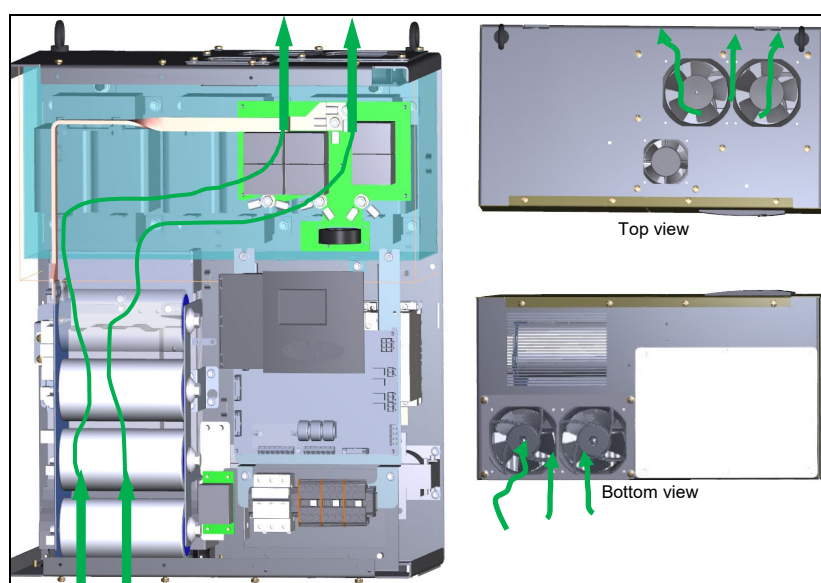


Figure 17: Cooling air flow for a single unit PQFS

When the natural cooling capacity at the location where the filter is installed is not sufficient, air conditioning systems have to be added to the room. In the design of the air conditioning systems, the filter heat losses have to be taken into account. [Table 16](#) gives an overview of the PQFS heat losses for the different power units. For multi-unit filters, the values of [Table 16](#) have to be multiplied by the number of filter units.

Table 16: Filter unit heat losses (maximum values)

Unit rating (Arms)	Heat loss (kW)
30	1.5

Unit rating (Arms)	Heat loss (kW)
45	1.8
60	2.1
70	2.6
80	2.9
90	3.2
100	3.5
120	4.3

5.4. Standard cubicle dimensions, fixing holes and clearances

Standard PQFS enclosures have dimensions of 588 x 326 x 795 mm (width x depth x height). Each enclosure contains one power unit and is fitted with its own main contactor. Power cables with protecting fuses can be connected to each PQFS from the bottom.

A spacing of 30 mm between the filter sides and walls or other enclosures is recommended. However the filter can rest on its back against a wall.

A spacing of 500 mm below the filter bottom and above the filter top is recommended.

Figure 18 shows a view of a typical PQFS with characteristic dimensions.

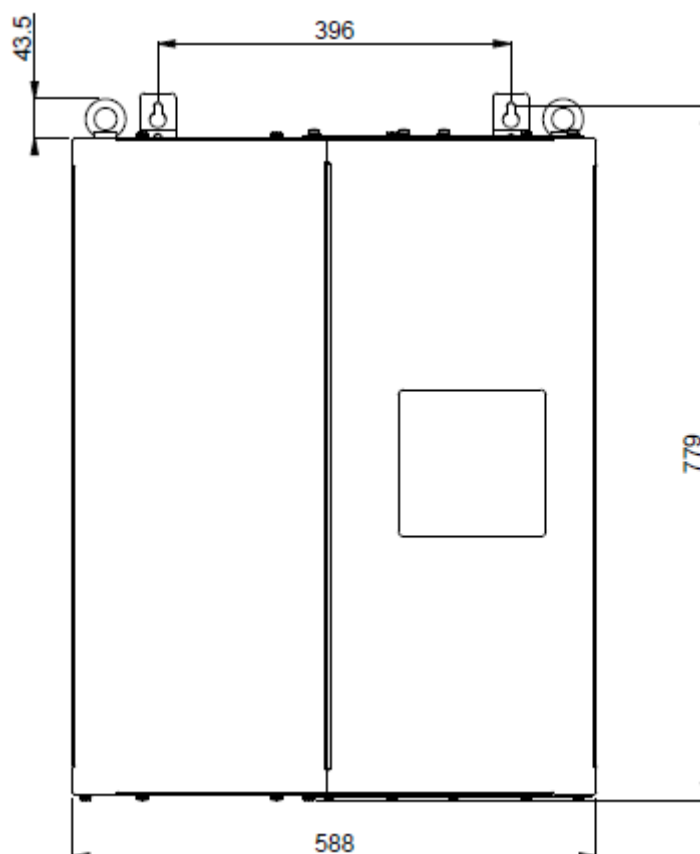


Figure 18: View of a typical PQFS installation with characteristic dimensions

If a filter system consists of more than one filter unit, the units should be installed next to each other. If it is not otherwise possible, additional units can be mounted above the existing unit(s). However, care has to be taken that the hot

air of the bottom unit cannot be sucked in by the fans of the unit mounted above. An example of such an arrangement is given in **Error! Reference source not found.**

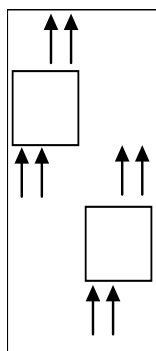


Figure 19: Example of an installation where PQFS units are mounted above each other

5.5. Instructions for mounting the filter

The wall on which the filter unit is mounted must be able to support the weight of the filter, which is about 130 kilograms. Please note that one enclosure contains always one unit.

In order to mount a filter unit on to the wall, follow the steps outlined below:

- Unpack the filter as per [Section 3.3](#)
- Set the 2 eyebolts on the top of the filter cubicle. They will be used to lift the filter properly.
- Pull out the 2 fixation plates ([Figure 20](#))

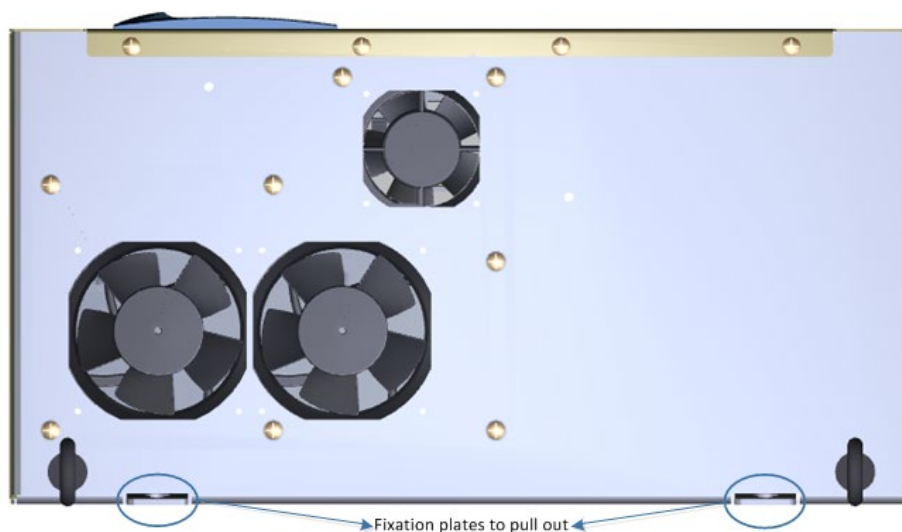


Figure 20: Top view of the PQFS filter with the fixation plates

- 2 bolts M8 are needed to install the filter on the wall ([Figure 21](#)). Use a spirit level to ensure horizontal fixation.

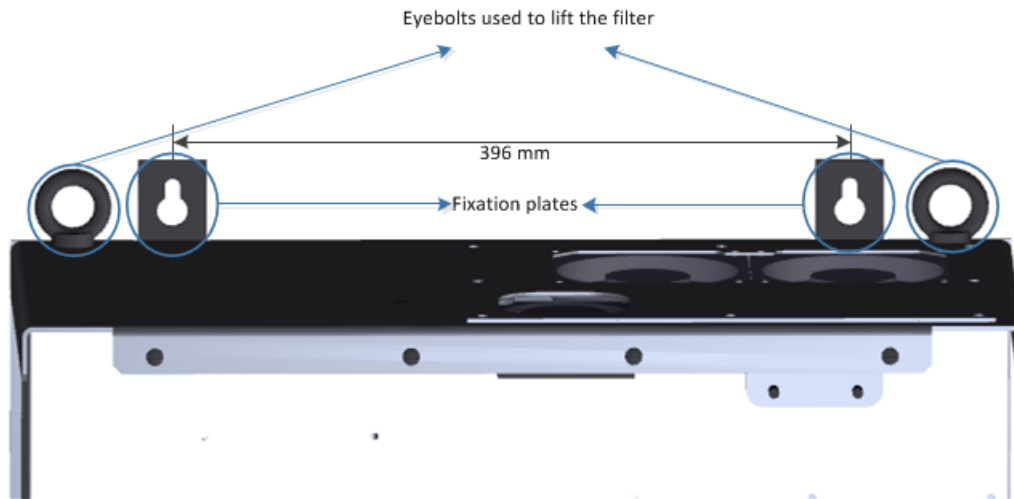


Figure 21: Eyebolts and fixation of PQFS

- Carefully lift the enclosure and slide it down over the 2 fixation bolts until it is supported by the 2 fixation plates. Screw the 2 bolts to ensure a good fixation of the filter. Then the lifting tool can be disengaged.
- By means of a lower end fixation screw (not provided) the enclosure can be pushed against the rear support at the bottom also (see [Figure 22](#)).

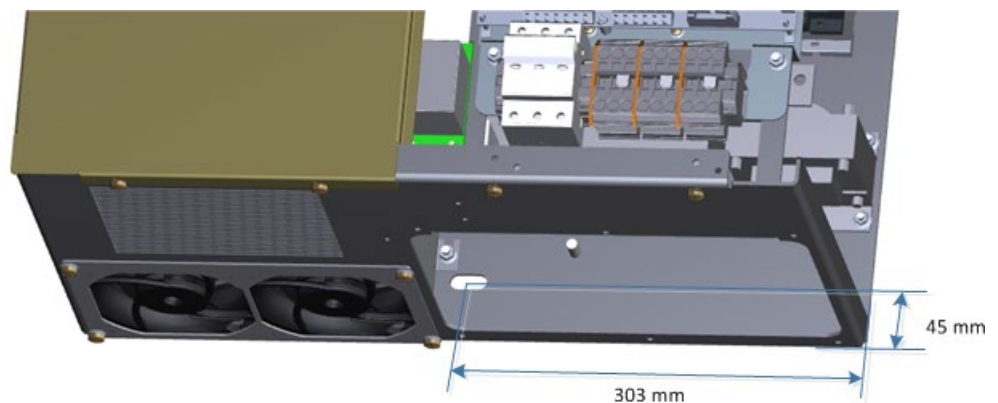


Figure 22: Lower end fixation

For additional units, the same procedure has to be followed.

5.6. Filter noise level

Active filters produce a certain level of noise when they operate. The noise level depends on the operating conditions of the unit and on the rating of the filter. These values should be taken into account when choosing a location for the filter.

Table 17: Noise level

Unit rating	Noise (dBA) at one meter
30A - 60A	65.3 typically
70A - 100A	68.4 typically
120A	70.9 typically

5.7. Instructions for mounting the PQF-Manager in enclosures

The PQF-Manager user interface is mounted on to the front panel. In case it needs to be relocated to another enclosure, follow the guidelines presented next ([Figure 23](#)).

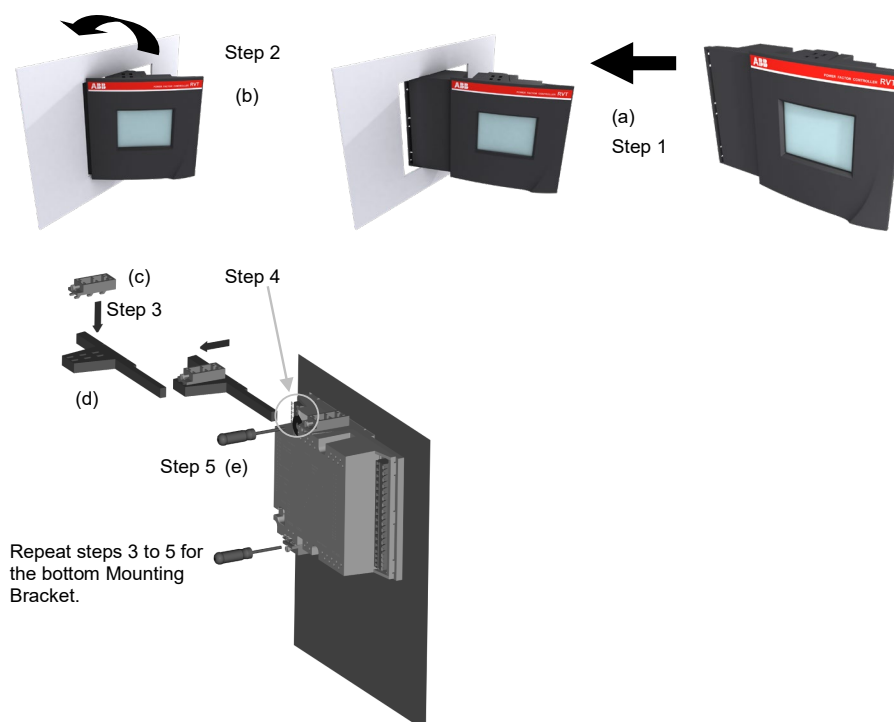


Figure 23: Mechanical installation of the PQF-Manager

Step 1: Slide the PQF-Manager (a) perpendicularly to the filter (b).

Step 2: Rotate the PQF-Manager to insert it into the filter.

Note: cut out dimensions are 138 x 138 mm.

Step 3: Insert the Mounting Bracket (c) in the corresponding Fixation Holes (d) of the PQF-Manager.

Step 4: Pull the Mounting Bracket backwards.

Step 5: Turn the Screw (e) into the Mounting Bracket and tighten until the PQF-Manager is secured in place.

Once the PQF-Manager has been installed, it has to be connected electrically (see [Section 6.2](#)).

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	32/188

6. Electrical design and installation

6.1. What this chapter contains

This chapter gives the data required for integrating the PQFS active filter successfully in an electrical installation. It also gives electrical connection examples for popular filter options.



WARNING: The PQFS is able to operate on networks in a voltage range 208-240 V and 380-415 V with a tolerance range of +/- 10 % (inclusive of harmonics but not transients). Since operation at the upper limits of voltage and temperature may reduce its life expectancy, the PQFS should not be connected to systems for which it is known that over voltages will be sustained indefinitely. Excessive voltage levels may lead to filter damage.

WARNING: The PQFS is not designed to be connected to systems where one phase serves as neutral. Connection of a PQFS to such a system is only authorized after explicit approval by Hitachi Energy.

The active filter must be connected to the network in parallel with the loads.

WARNING: The PQFS does not incorporate protective power line fuses or main contactor. Hence the customer has to ensure that the feeding cables to each filter panel are adequately protected taking into account the filter rating and the cable section used. More information on this topic is presented in **Section 6.7**.

Basic filter functionality can be obtained after connection of:

- Ground (PE) (per cubicle).
- Four power cables including neutral. The neutral connection is not mandatory for filtering three phase loads. The power lines must be protected by appropriately sized fuses or a contactor.
- 3 CTs (one per phase, to be connected to each filter unit in a filter system through a daisy chain method with return path).

More advanced filter features (e.g. external monitoring of the filter status) require some more connections. The connections for these advanced features have to be made on the PQF-Manager.

WARNING: Ensure that the filter supply is isolated upstream during filter installation. If the system has been connected to the supply before, wait for 25 mins after disconnecting the mains power in order to discharge the capacitors. Always verify by measurement that the capacitors have discharged. DC capacitors may be charged to more than 1000 Vdc.

The DC capacitors of PQFS units are automatically charged once the auxiliary circuit is energized, regardless of whether the filter is switched off or not. Do not touch the DC capacitor link when the auxiliary fuse box is closed.

The active filter control board carries dangerous voltages and shall not be touched once the auxiliary circuit is energized, regardless of whether the filter is switched off or on. Once the auxiliary circuit is opened, high voltage levels can still be present on the control board. Respect a delay of 25 minutes after disconnecting the mains power before touching the control board.

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6.2. Instructions for connecting the PQF-Manager to a filter system

PQFS filter master units are by default equipped with the PQF-Manager user interface. In some cases however it may be needed to remove and reconnect the PQF-Manager to the filter.

In order to successfully connect the PQF-Manager to a PQFS filter unit, it suffices to plug the male connector attached to the PQF-Manager into the corresponding female connector attached to the filter hardware. This is illustrated in [Figure 24](#).

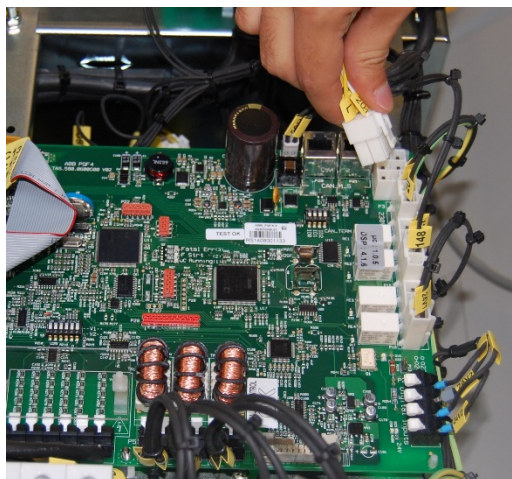


Figure 24: Connection of the PQF-Manager user interface to the PQFS filter hardware

The female connector associated with the filter hardware is situated at the top right side of the control board and becomes visible after removing/lifting slightly the filter protective cover.

Note that the connector incorporates the following signals:

- The 230 V power supply connection
- The internal CAN bus connection

6.3. Checking the insulation of the assembly - earth resistance

WARNING: Follow the procedure outlined below to check the insulation of the filter assembly. Applying other methods may damage the filter.

Every filter has been tested for insulation between the main circuit and the chassis/frame at the factory. Therefore, do not make any voltage tolerance or insulation resistance tests (e.g. hi-pot or megger) on the inverter units. Check the insulation of the assembly by measuring the insulation resistance of the filter between the Protective Earth (PE) and all 3 phases shorted together, with main contactor shorted. The auxiliary fuse box may remain closed, but it is mandatory to disconnect P2 (24V supply), P3 (230Vac in), P4 (PQF-Manager if master), P12 (IGBT) and P20-P21 (to other units) from the main control board (see [Table 13](#)).

WARNING: Making the test without disconnecting the abovementioned connectors may damage the filter.

Use a measuring voltage of 500 Vdc. The insulation resistance must be higher than 500 kΩ per enclosure.

6.4. EMC considerations

The CE version of active filter complies in its standard version with the following EMC guidelines:

- EN/IEC 61000-6-2: Immunity standard for industrial environments, Industrial level.

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- EN/IEC 61000-6-4: Emission standard for industrial environments, Class A.

6.5. Earthing guidelines

Each PQFS plate has one marked earth point (PE). The earth point is situated at the bottom right side of the filter plate (Figure 25).

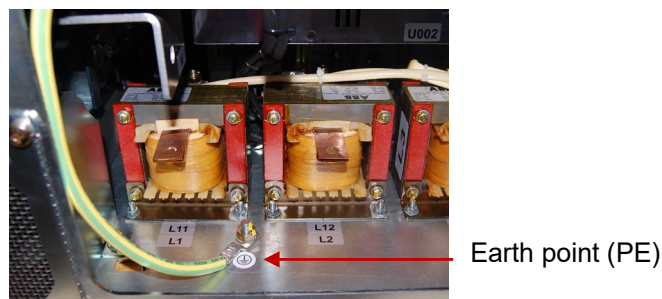


Figure 25: Identification of the earth point in the PQFS hardware

For safety reasons and for proper operation of the filter the earth point of each enclosure must be connected to the installation's earth (PE-point). A copper (Cu) cable of minimum size 16 mm² is required but local regulations should also be taken into account.

Remark: in PEN systems, the earth connection of the filter must be connected to the installation's earth (PE) and not to the N-conductor.

Further, the following rules should be respected:

- When the PQFS consists of only one enclosure, the enclosure's PE-point must be connected directly to the installation's PE-point.
- When the PQFS consists of more than one enclosure, each enclosure's PE-points must be connected directly to the installation's PE-point.

6.6. Selection of the power cable size

Several types of power cable can be used to connect the filter to the network. Local regulations and habits often determine the user's choice. Note however that due to the high frequency output filter of the PQF, there is no radiated emission through the feeding cables.

The following steps have to be followed to determine the section of the power cables feeding the filter:

1. Determine the RMS current rating of the enclosure for which the cable has to be rated (I_{rms}). The rating is marked on the enclosure label.

Each enclosure has to be individually connected to the supply and bottom cable entry has to be used. If required an optional cable connection box can be added to allow for multi-cable termination.

The minimum cable section to be used for the power conductors is 16 mm².

The RMS current for which the cable has to be rated equals the current rating of the unit to be connected to the supply. Note that the neutral connection has to be able to carry three times the unit current rating.

2. Determine the factor X and the cable section required taking into account the skin effect.

The multiplication factor X is a factor that takes into account that the current that will flow through the filter connection cables is predominantly a harmonic current, i.e. a current of which the frequency of the most important components is higher than the network base frequency. Due to the frequency being higher than the network base

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frequency a physical phenomenon called 'skin effect' comes into play. This effect implies that for higher frequencies the current will not flow through the complete cross section of the cable but will have the tendency to flow at the cable surface. The result is that although one may use a cable of $A \text{ mm}^2$, the section through which the current flows is only $X \cdot A \text{ mm}^2$ (with $X < 1$). In order to compensate for this "loss of section", the cable has to be oversized such that the total equivalent section through which the current flows taking into account the skin effect is acceptable.

The multiplication factor X to be used depends on the cable material (e.g. copper [Cu], aluminum [Al]) and on the base frequency of the network on which the filter will be installed. For a given installation its value can be determined using the following process:

Step 1: Determine in a conventional way (e.g. using cable manufacturer's tables) the cable section $A \text{ (mm}^2\text{)}$ for the RMS current I_{rms} obtained in 1 above.

Step 2: Using the cable section A , the cable material and the network frequency as entry points in **Table 18**, determine the multiplication factor X .

Table 18: Multiplication factors X for different cable sections

Cable section [mm ²]	Network frequency 50Hz		Network frequency 60Hz	
	Al-cable	Cu-cable	Al-cable	Cu-cable
16	1.00	1.00	1.00	1.00
25	1.00	1.01	1.00	1.01
35	1.01	1.01	1.01	1.02
50	1.01	1.03	1.02	1.04
70	1.02	1.05	1.03	1.06
95	1.04	1.08	1.05	1.10
120	1.05	1.11	1.07	1.14

Step 3: Determine in a conventional way the cable section $A_2 \text{ (mm}^2\text{)}$ for the current rating found by multiplying I_{rms} by X .

If the new cable section A_2 is equal to the initially found cable section A , the right cable section taking into account the skin effect has been found.

If the new cable section A_2 is bigger than the initially found cable section A , steps 2 and 3 have to be repeated with the new values until the cable section A_2 found is equal to the cable section A .

Remark: During this process it may be found that more than one cable per phase is needed. The process then has to be applied to each cable.

As an illustration of the cable sizing process consider the following example:

PQFS 60A/50Hz, 3-wire connection, cable material: Cu (copper)

Step 1: $I_N = 60\text{A} \rightarrow$ cable section = 16 [mm²]

Step 2: multiplication factor for a 16 [mm²] copper cable at 50 Hz = 1.00

Step 3: $I = I_N \times 1.00 = 60\text{A} \times 1.00 = 60\text{A}$

Step 4: $I = 60\text{A} \rightarrow$ cable section: 16 [mm²]

This section is equal to the section found in the previous step.

Conclusion: one copper cable of 16 [mm²] per phase is sufficient.

Remark: The cable sizing process discussed in point 2 above only takes into account the skin effect. Any further derating due to local standards and/or installation conditions (e.g. distance between cables, number of cables connected in parallel ...) have to be taken into account by the company responsible for the PQF cable connection.

As an example of the cable sizing procedure, consider [Table 19](#) and [Table 20](#), which show the allowed current for different parameters noting typical cable manufacturer data.



WARNING: Consult your cable manufacturer for the applicable cable manufacturer data.

Table 19: Allowed cable current for different cable sections noting the skin effect and typical cable manufacturer data – Network frequency 50Hz

Copper						Aluminum			
Cross section									
[mm²]	[AWG]	Nr of parallel cables	Derating due to paralleling	Rated current [Arms]	Reduction factor	Allowed current [Arms]	Rated current [Arms]	Reduction factor	Allowed current [Arms]
16	6	1	1	100	0.997	100	75	0.999	75
25	4	1	1	130	0.993	125	100	0.997	100
35	2	1	1	160	0.987	158	120	0.994	119
50	1-1/0	1	1	190	0.975	185	145	0.989	142
70	2/0	1	1	230	0.955	220	180	0.98	176
95	3/0	1	1	285	0.93	265	220	0.965	210
120	4/0	1	1	325	0.904	290	250	0.95	238
150	300MCM	1	1	365	0.877	320	285	0.93	265
185	350MCM	1	1	415	0.844	350	325	0.908	295
240	500MCM	1	1	495	0.804	390	385	0.876	335
300	600MCM	1	1	550	0.768	420	425	0.843	358
16	6	2	0.8	160	0.997	159	120	0.999	120
25	4	2	0.8	208	0.993	205	160	0.997	160
35	2	2	0.8	256	0.987	250	192	0.994	190
50	1-1/0	2	0.8	304	0.975	290	232	0.989	229
70	2/0	2	0.8	368	0.955	350	288	0.98	282
95	3/0	2	0.8	456	0.93	420	352	0.965	340
120	4/0	2	0.8	520	0.904	470	400	0.95	380
150	300MCM	2	0.8	584	0.877	510	456	0.93	424
185	350MCM	2	0.8	664	0.844	560	520	0.908	472
240	500MCM	2	0.8	792	0.804	630	616	0.876	540
300	600MCM	2	0.8	880	0.768	675	680	0.843	573

Remark: The highlighted values in [Table 19](#) refer to cable sizes that correspond to typical filter ratings. Note that in 4-wire systems, the neutral may have to carry up to 3 times the line current rating of the filter.

Table 20: Allowed cable current for different cable sections noting the skin effect and typical cable manufacturer data – Network frequency 60Hz

Copper										Aluminum	
Cross section											
[mm²]	[AWG]	Nr of parallel cables	Derating due to paralleling	Rated current [Arms]	Reduction factor	Allowed current [Arms]	Rated current [Arms]	Reduction factor	Allowed current [Arms]		
16	6	1	1	100	0.996	99	75	1	75		
25	4	1	1	130	0.99	128	100	1	100		
35	2	1	1	160	0.981	157	120	0.99	119		
50	1-1/0	1	1	190	0.965	183	145	0.98	143		
70	2/0	1	1	230	0.941	216	180	0.97	175		
95	3/0	1	1	285	0.911	260	220	0.95	210		
120	4/0	1	1	325	0.88	286	250	0.93	233		
150	300MCM	1	1	365	0.85	310	285	0.91	260		
185	350MCM	1	1	415	0.817	339	325	0.89	288		
240	500MCM	1	1	495	0.775	383	385	0.85	326		
300	600MCM	1	1	550	0.738	406	425	0.81	346		
16	6	2	0.8	160	0.996	159	120	1	120		
25	4	2	0.8	208	0.99	205	160	1	160		
35	2	2	0.8	256	0.981	250	192	0.99	190		
50	1-1/0	2	0.8	304	0.965	293	232	0.98	228		
70	2/0	2	0.8	368	0.941	346	288	0.97	280		
95	3/0	2	0.8	456	0.911	415	352	0.95	336		
120	4/0	2	0.8	520	0.88	457	400	0.93	374		
150	300MCM	2	0.8	584	0.85	496	456	0.91	416		
185	350MCM	2	0.8	664	0.817	542	520	0.89	460		
240	500MCM	2	0.8	792	0.775	613	616	0.85	522		
300	600MCM	2	0.8	880	0.738	649	680	0.81	553		

Remark: The highlighted values in [Table 20](#) refer to cable sizes that correspond to typical filter ratings. Note that in 4-wire systems, the neutral may have to carry up to 3 times the line current rating of the filter.

6.7. Selection of the power cable protection/filter input protection scheme

Once the power cables have been selected, a suitable cable and equipment protection has to be selected. The protection only needs to protect the phases and not the neutral. It is recommended to use fuses of type gG/gL with the RMS current ratings given in [Table 21](#).

Table 21: RMS current ratings for protection fuses

Filter nominal current rating (Arms)	Minimum fuse protection (Arms)	Maximum fuse protection (Arms)
30	40	125
45	63	125
60	80	125
70	100	160
80	100	160
90	125	160
100	125	160

Voltage rating and short circuit current handling capability should be in accordance with the network characteristics.

As an alternative to fuse protection, MCCB protection of appropriate sizing can also be used. When the customer protection is in place, the following PQFS input protection will result.

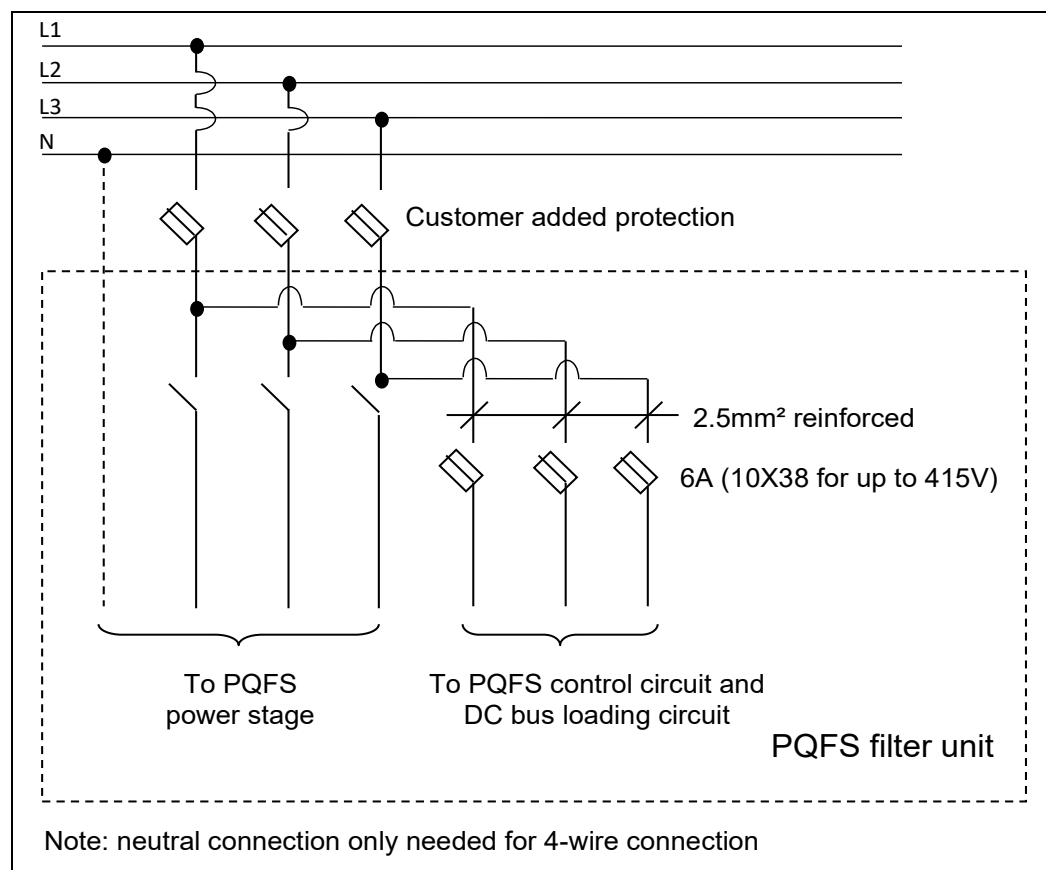


Figure 26: Symbolic representation of the PQFS input protection

The active filter power circuit is internally connected to the network by means of a main contactor of type ABB UA50 or UA95 (depending on the current rating).

The PQFS control circuit and DC bus preload system is protected by a fuse protection scheme, the characteristics of which are given in the table below.

Table 22: Control circuit fuse characteristics for PQFS filters (CE version)

Nominal network voltage (Vrms)	Control circuit fuse type	Irms fuse (Arms)	Isc ^(a) fuse (kA) at rated voltage	Rated Voltage (Vrms)
$208 \leq U_e \leq 415$	French Ferrule 10 X 38 gG/gl	6	~ 120	500

Remark:

(a) fuse short circuit current capability

WARNING: Once the auxiliary fuse box is closed, the DC bus is automatically charged when the upstream network is live. Therefore, close the auxiliary circuit only when the upstream power circuit is not live. Failure to adhere to this guideline may result in injury or death.

6.8. Connection of the PQFS to the network



WARNING: The PQF has to be installed in parallel with the loads, preferably on a free feeder. Local regulations and requirements prevail in determining how the equipment has to be connected to the network. The feeding cables to the filter must be protected by their own cable and equipment protection device (see [Section 6.7](#)).

WARNING: The PQF can operate on networks with nominal voltage in the range 208-240 V and 380-415 V. The unit must be configured for the operation range it will be used on. Follow the guidelines in this section to ensure that the hardware is configured properly. Failure to do so may lead to filter damage.

For applications where predominantly 3 phase loads are present and where there is no need for neutral current filtering nor line to neutral balancing, connect the active filter in 3-Wire mode.

For applications where predominantly single-phase loads are present and where there is a need for neutral current filtering and/or line to neutral balancing, connect the active filter in 4-Wire mode.

NOTE: When installing an active filter in installations containing power factor correction capacitor banks, it is recommended to use detuned capacitor banks and to connect the capacitor banks upstream of the filter measurement CTs.

NOTE: The PQF active filter is not compatible with high impedance devices installed upstream of the filter in the neutral. The PQF may refuse to start or may not function correctly when such a device is present. For best PQF performance, these devices have to be removed or bypassed.

6.8.1. Connection of the PQFS in 3-wire mode

Use the 3-wire connection mode for installations where there is no need for neutral current filtering or line to neutral balancing. In this mode, the active filter can compensate 20 individual harmonic components.

In order to connect the PQFS in 3-wire mode, follow the below guidelines:

1. Fix the filter mechanically to the wall (Cf. [Section 5.7](#))
2. Ensure that an appropriately selected protecting device is connected upstream and that the power supply cables are not live
3. Remove the protective cover present at the bottom right side of the filter (Cf. [Figure 27](#))

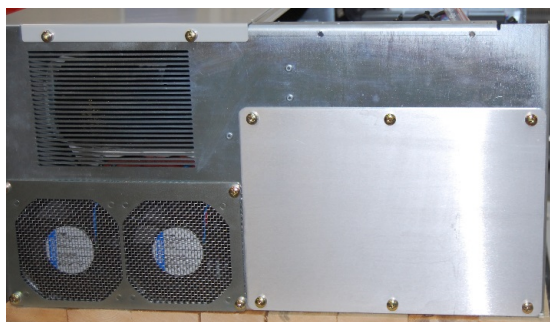


Figure 27: Removing the Aluminum protective cover at the bottom side of the active filter enclosure

4. Make holes in the protective cover of appropriate section corresponding to the power cable section used. Also make holes for the earth cable, the CT wire and any other control wires that may be needed, e.g. for implementing remote control functionality. When finished, slide the cover over the feeding cables and the earth cable.
5. Connect the earth cable (Cf. [Section 6.5](#))
6. Connect the three power cables to the reactor terminals (Cf. [Figure 28](#)).

WARNING: The power cables are directly connected by the customer at the line reactor terminals. In order to safeguard the terminals from mechanical stress, it is recommended that the weight of the power cable is properly supported using a cable tray or a suitable cable connection box.

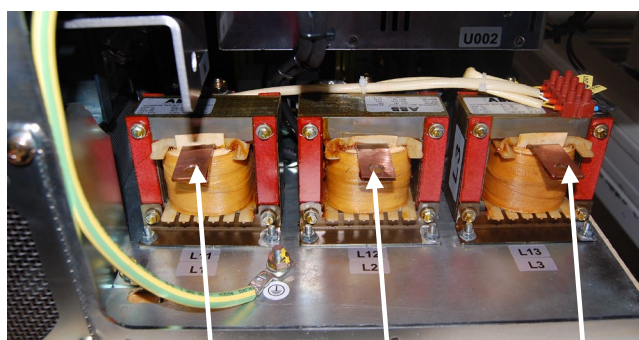


Figure 28: Connecting the three power cables to the filter reactor terminals

Remarks:

- The left reactor terminal corresponds to phase L1 (R, A)
- The middle reactor terminal corresponds to phase L2 (Y, B)
- The right reactor terminal corresponds to phase L3 (B, C)

The cable lugs of the feeding cables should comply with:

- Maximum lug width: in accordance with terminal width
- Minimum lug eye diameter: M8

Appropriate torque (20Nm) must be applied to ensure that cables are properly fixed.

7. Slide the bottom protective cover up and fix it with the screws to seal off the power supply terminals
8. In addition to the power cables and the earth connection cable, the CT connection cable and any other control cables used for enhanced functions can at this stage be passed through the protective cover into the filter panel.
9. Preparation of the filter to match the networks voltages:

The active filter nominal voltage setting must be adapted to the actual network voltage by adjusting the tap setting of the auxiliary transformer. If the tap setting for your network voltage is not available, then choose a tap just above the network voltage present (e.g. for 390V network choose 400V tap setting). The auxiliary transformer is situated at the bottom right side of the filter (Cf. [Figure 14](#) item 15). Ensure that the filter panel is isolated before changing the transformer tap setting.

By default the tap setting of the auxiliary transformer is set at the highest voltage position at the filter production stage.

WARNING: The tap setting of the auxiliary transformer's primary must be adapted according to the network voltage to avoid a too high or too low auxiliary voltage. If the tap setting for your network voltage is not available, then choose a tap just above the network voltage present (e.g. for 390V network choose 400V tap setting). Excessive (auxiliary) voltage levels will lead to filter damage.

6.8.2. Connection of the PQFS in 4-wire mode

Use the 4-wire connecting mode for installations where there is a need for neutral current filtering and/or line to neutral balancing. In this mode, the active filter can compensate 15 individual harmonic components.

In order to connect the PQFS in 4-wire mode, follow the guidelines of [Section 6.8.1](#) with the exception that:

4. Make also a hole for the neutral cable in the protective cover noting the larger section required for the neutral.
6. Connect the three power cables and the neutral cable. Whereas the three power cables can be connected as describes in item 6 of [Section 6.8.1](#), the neutral cable has to be connected to the neutral connection point (Cf. [Figure 29](#)).

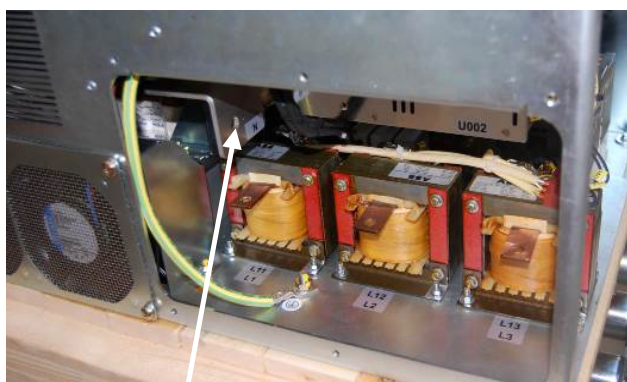


Figure 29: Connection of the neutral cable when using the PQFS in 4-wire mode

The cable lugs for the neutral cables should comply with:

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- Maximum lug width: in accordance with terminal width
- Minimum lug eye diameter: M8

Appropriate torque must be applied to ensure that cables are properly fixed.

Other points in the connection procedure are as per previous Section.

Remarks:

In case of regenerative loads (e.g. loads that may inject active energy to the network, usually called 4Q-loads), it is very important to connect the PQF outside the protection of this load. Indeed, consider [Figure 30](#) where a common protection is installed for both the regenerative load and for the PQF. When the load re-injects energy to the network and the mains protection trips, the whole energy may be pushed into the PQF, which may damage it severely. [Figure 31](#) shows the admitted protection scheme for regenerative loads. In this case, if the breaker of the load trips, the PQF is isolated from the energy fed back by the drive.

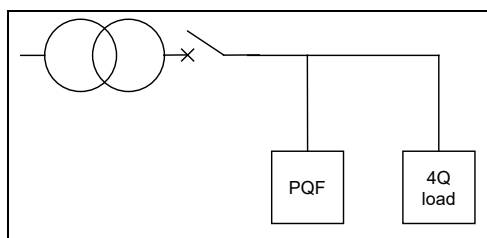


Figure 30: Incorrect connection in the case of 4Q-loads

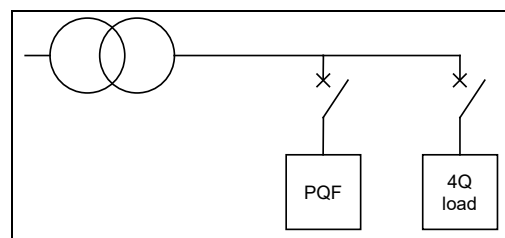


Figure 31: Correct connection in the case of 4Q-loads

6.9. Selection of the current transformers

Each filter unit in a filter system has to monitor the line current in order to determine the harmonic load and function correctly. This is done by three current transformers (CTs). For proper operation of the PQFS standard accuracy CTs with the following minimum specifications have to be used:

- 5 A secondary current rating.
- 15 VA burden for up to 30 meters of 2.5 mm² cable. For longer cables lengths refer to the chart in [Figure 32](#). In case the CTs are shared with other loads, the VA burden shall be adapted accordingly. Note that the burden requirement for a complete filter system (consisting of up to 8 filter units) is 5 VA, excluding connecting cables.
- Class 1 accuracy or better.
- Primary side current rating sufficient to monitor the total line current (including transient phenomena such as drive/motor starts ...).

It is strongly recommended that the three CTs have the same characteristics.



WARNING: The connection of different filter units in a PQFS system, as well as other loads, on the same CT must be in series.

In order to determine the suitable CTs for your application, please refer to the chart in [Figure 32](#).

Remark: In some applications two or more power supplies exist (e.g. a network transformer supply and a generator supply). When the current into both supplies has to be filtered, summing CTs have to be used. All summing CTs must have the same ratio. More information on how to install the summing CTs is given in next section.

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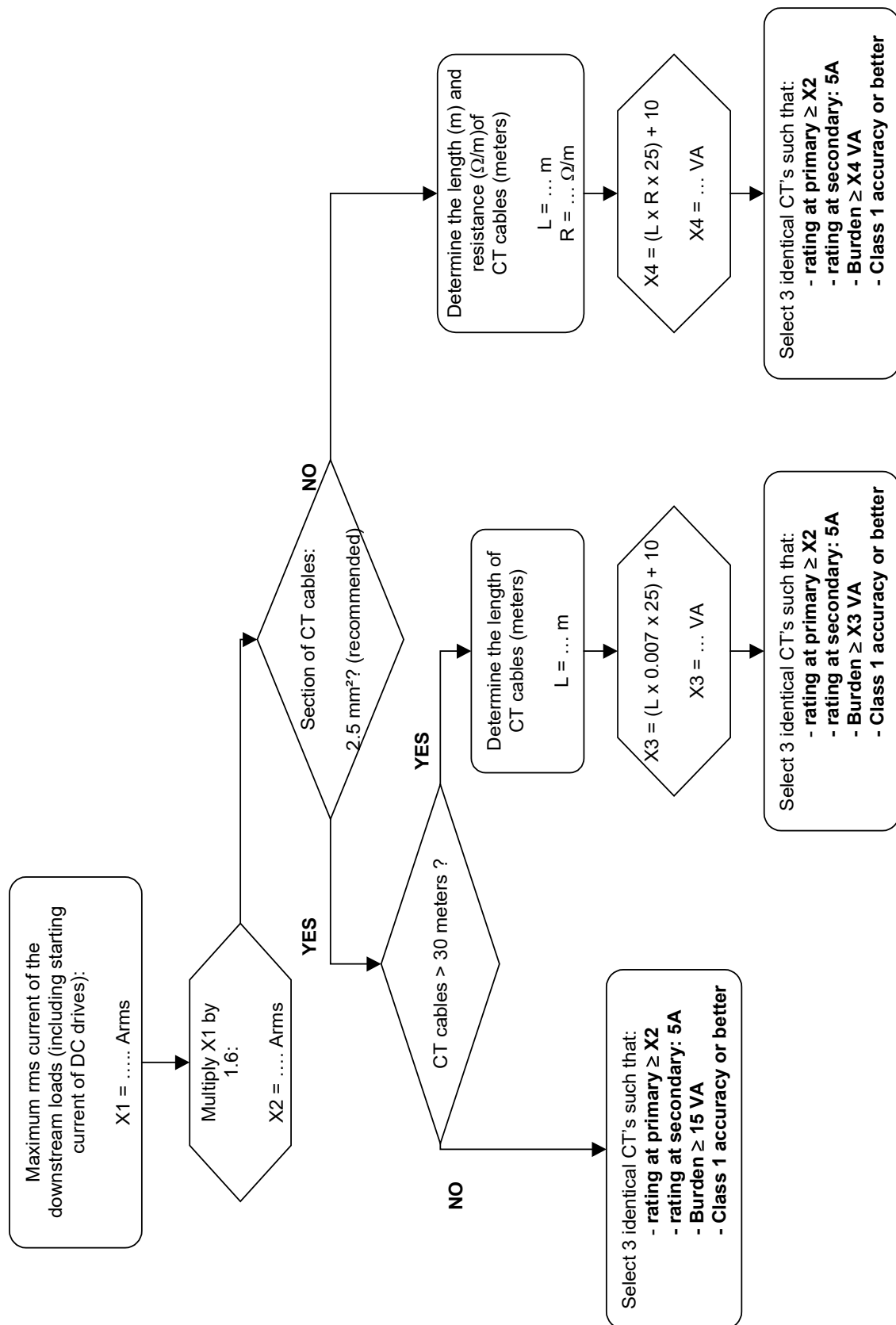


Figure 32: Flow chart for CT determination

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6.10. Current transformer installation

6.10.1. Basic rules for correct CT installation

The location of the CTs is critical to ensure the proper operation of the active filter. The CTs are the “eyes” of the filter and it will react in accordance with the information supplied by them.



WARNING: Special care has to be taken for the connection and location of the CTs: wrong CT installation is the most common source of problems found at the commissioning stage.

WARNING: In a filter system consisting of more than one unit, the CT information has to be supplied to all the units. This must be done through a daisy chain connection with return path configuration.

By default, the PQFS active filter is provided with CT terminals that are not shorted. A set of shorting plugs is provided with the filter. They should always be kept with the filter and be accessible for service engineers.

WARNING: When connecting the CTs of a live system to the PQFS, the secondaries of the CTs have to be shorted. Failure to do so may result in CT explosion and consequent damage to the installation. Once the connections to the filter have been made, the shorting links must be removed.

The basic rules for successful CT installation are given next (Cf. [Figure 33](#)):

- The three filter CTs have to be positioned for closed loop control, i.e. the CT must monitor the load current and the filter current. In some cases, summation CTs may be needed to fulfil the closed loop requirement (Cf. examples further down this section).
- The CTs must be positioned in the correct direction around the power cable: the K (P1) side should be in the direction of the supply and the L (P2) side should be in the direction of the load.
- Each CT must have its own guard circuit, i.e. one terminal of each CTs secondary terminals (k (S1) or l (S2)) should be earthed. Once a terminal is chosen (e.g. k-terminal), the same terminal should be earthed for all the CTs.
- The CT monitoring a phase should be connected to the filter terminal dedicated to the same phase. In practice this means that:
 - The k (S1) terminal of the line 1 CT (L1, Red, U) must be connected to terminal X21-1 of the filter.
 - The l (S2) terminal of the line 1 CT (L1, Red, U) must be connected to terminal X21-2 of the filter.
 - The k (S1) terminal of the line 2 CT (L2, Yellow, V) must be connected to terminal X214 of the filter.
 - The l (S2) terminal of the line 2 CT (L2, Yellow, V) must be connected to terminal X21-5 of the filter.
 - The k (S1) terminal of the line 3 CT (L3, Blue, W) must be connected to terminal X21-7 of the filter.
 - The l (S2) terminal of the line 3 CT (L3, Blue, W) must be connected to terminal X21-8 of the filter.
- The CT connection terminal X21 is located at the middle of the top plate of the filter (Cf. [Figure 34](#)).

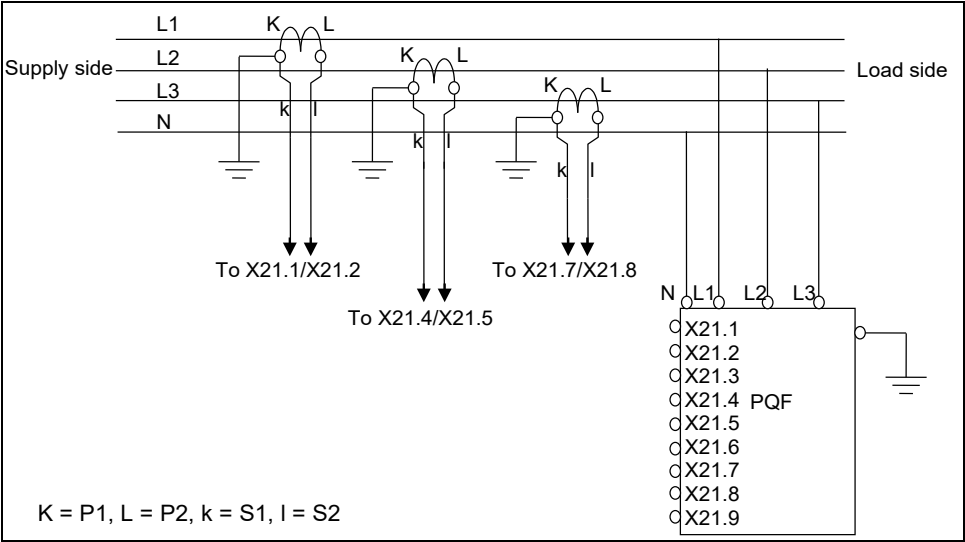


Figure 33: Basic CT connection example for a single unit active filter

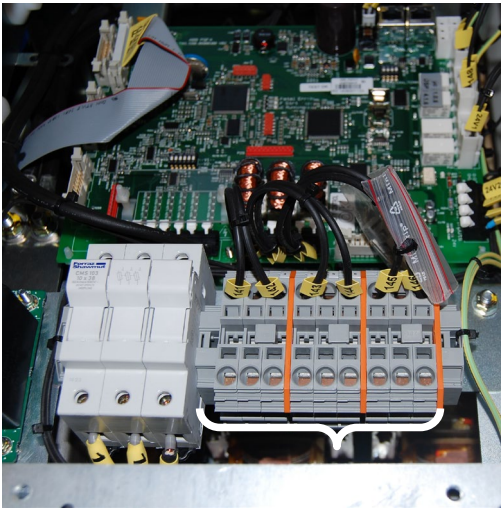


Figure 34: Location of the CT connection terminal X21 in the PQFS

The terminal block X21 can handle control cable wiring with sections from 2.5 mm² to 10 mm².

In addition to the 6-wire CT cabling approach shown in [Figure 33](#) above, a 4-wire approach may also be used. This approach is illustrated in [Figure 35](#). In this case the CT secondary terminal to which the guard circuit is connected is interconnected between the CTs and also on the filter terminal X21. One common cable is used for this terminal. Note that this cable must be able to withstand three times the secondary current rating of the CTs.

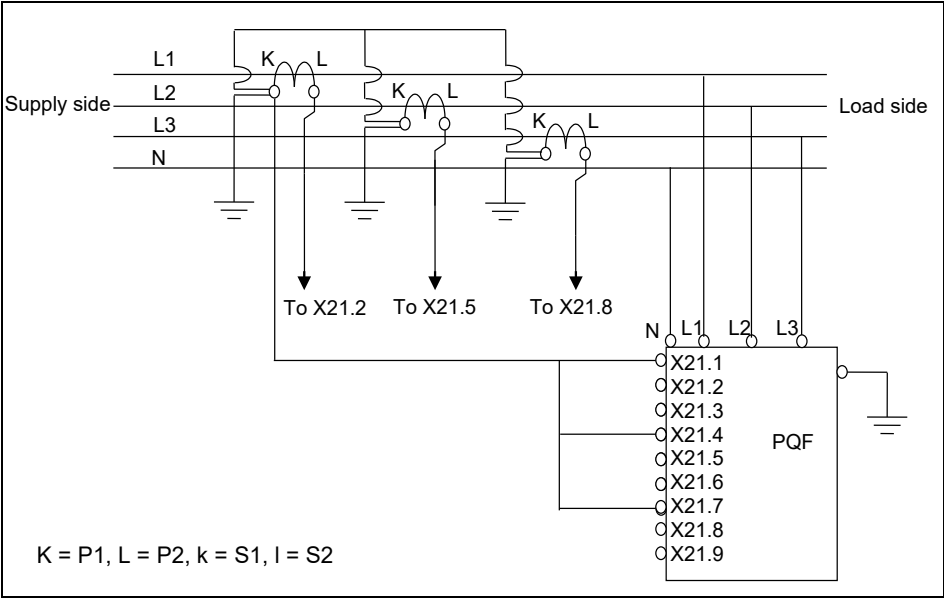


Figure 35: Four wires CT wiring approach that may be used with a single unit PQFS active filter

In case a filter system consists of more than one unit, all units have to be supplied with the CT measurement information. This is done by cabling the CTs in a daisy chain fashion between the different units. This is illustrated in Section 6.11.3.

6.11. Electrical interconnection of PQFS enclosures

This section explains how to electrically interconnect different PQFS enclosures.

Figure 36 shows schematically which interconnections have to be made between two filter enclosures.

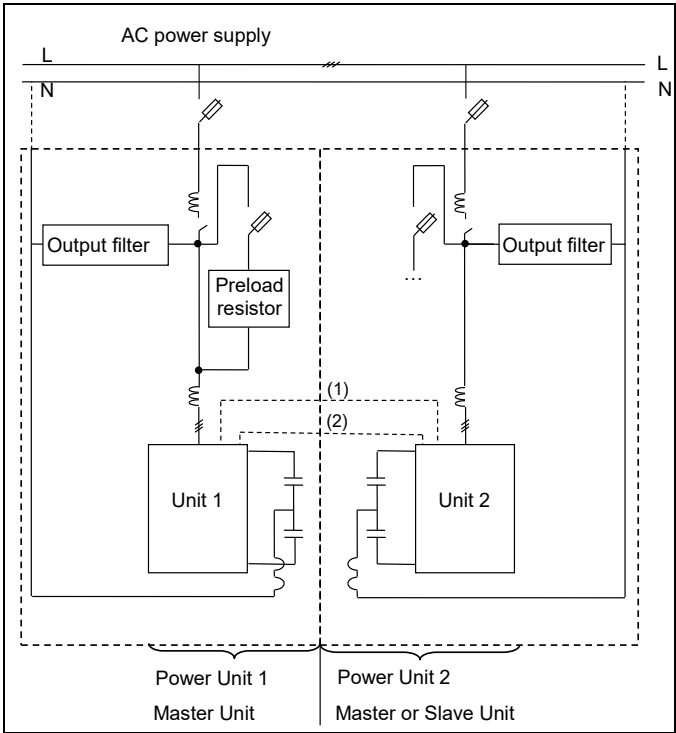


Figure 36: Overview of the connections to be made between two filter enclosures

The interconnection description is given in [Table 23](#).

Table 23: Interconnections between two filter cubicles

Item	Description
1	Control board intercommunication cable through CAN bus (RJ45 cable, straight interconnection)
2	CT interconnection cable (not provided)

Four steps have to be followed to electrically interconnect a new PQFS unit with an existing filter. They are outlined in the next four paragraphs.

6.11.1. Mechanical interconnection of the enclosure

All cables to the PQFS unit such as power cable as well as interconnection cable between modules must pass through the bottom cable entry hole provided in the PQFS box.

6.11.2. Control board cable interconnection



WARNING: Failure to interconnect the control boards in an appropriate way will result in filter malfunctioning and possibly severe damage of the unit.

Interconnect the control boards of a following unit with a previous filter unit by an RJ45-based communication cable (straight interconnection). This cable is provided with each unit.

Figure 37: shows the way to interconnect the control boards.

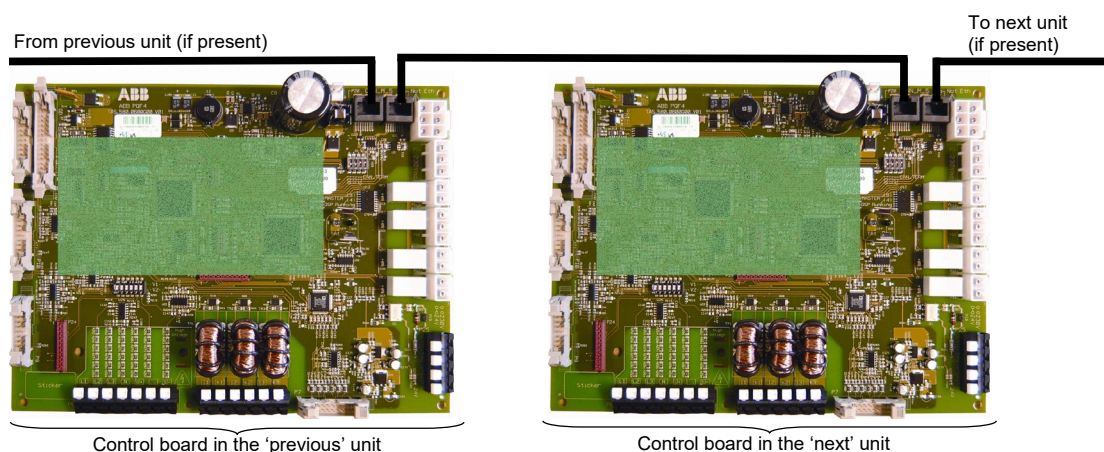


Figure 37: Control board interconnection cable connection method.

- The RJ45 control cable coming from the preceding filter unit is plugged in the left hand side RJ45-socket at the top of the filter control board.

- The RJ45 control cable leaving for the next filter unit is plugged in the right hand side RJ45-socket at the top of the filter control board.
- Repeat the same procedure for any other filters to be connected.

Notes:

- In the first unit of a filter system, the left hand RJ45-socket will always be empty.
- In the last unit of a filter system, the right hand RJ45-socket will always be empty.
- During the commissioning phase, a unique address has to be assigned to each unit in a filter system through dip switch (see [Chapter 8](#)).

6.11.3. CT cable interconnection



WARNING: Failure to connect the CT's to all units in a filter system in an appropriate way will result in filter malfunctioning and possibly severe damage of the unit.

In a multi-unit PQFS-system, all units have to be supplied with the CT –measurement results. In order to do this the CT's have to be cabled to each unit in a daisy chain fashion. The connection principle is shown in [Figure 38](#) for the CT of phase which is fed to four filter units. The same approach has to be implemented for the other phases too. A maximum of 8 filter units can work in parallel in this fashion.

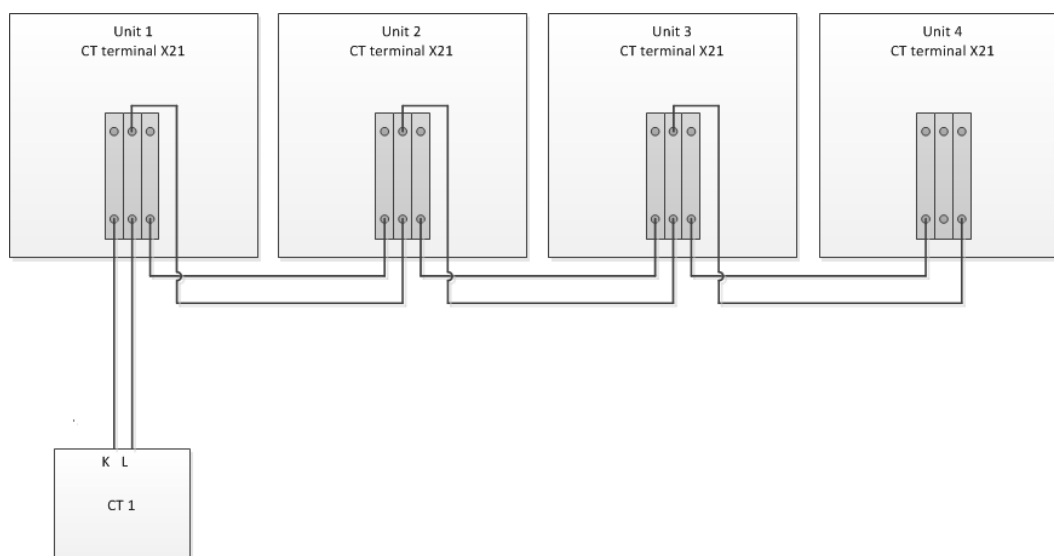


Figure 38: Principle of the CT interconnection circuit for multi-unit filters.

Note that the overall burden requirement for a complete filter system is 5 VA. To this value has to be added the burden requirement of the interconnection cables to obtain the total burden requirement of the CT's to be used.

6.11.4. Connection of the power stage to the supply

As a final step in the interconnection process, the power stage of the new unit has to be connected to the supply. The same connection approach as used for the other filter units must be adopted. More information on how to connect a PQFS filter unit to the power supply can be found in [Section 6.8](#).



WARNING: Make sure that the phase rotation of the power cable connection is clockwise at the filter terminals and that the L1, L2 and L3 terminal in each cubicle is connected to the same phase for all cubicles. Failure to do so may lead to the filter being damaged upon startup.

WARNING: Once a new filter unit has been added to a filter system, this unit has to be given a unique address (through DIP switch setting on its control board). In addition, the filter unit has to be recommissioned.

If more than one unit is added, it is recommended to first finish the hardware modifications and then set up the controller accordingly. More information on how to change the filter controller unit settings can be found in [Section 7.9.2.2](#) and [Section 8.5](#).

After making and verification of all the electrical connections:

- Set a unique address on each filter unit control board
- Close the auxiliary fuse box of the filter units
- Restore the top cover(s) of the filter units

6.12. Electrical connections to the PQF-Manager user interface

The PQF-Manager is the user interface between the outside world and the filter controller. Depending on the user requirements, less or more electrical connections have to be made to it. [Figure 39](#) shows the rear side layout of the PQF-Manager. In order to get access to the rear side of the PQF-Manager, remove the PQFS top cover (Cf. guidelines in [Section 3.4](#).)

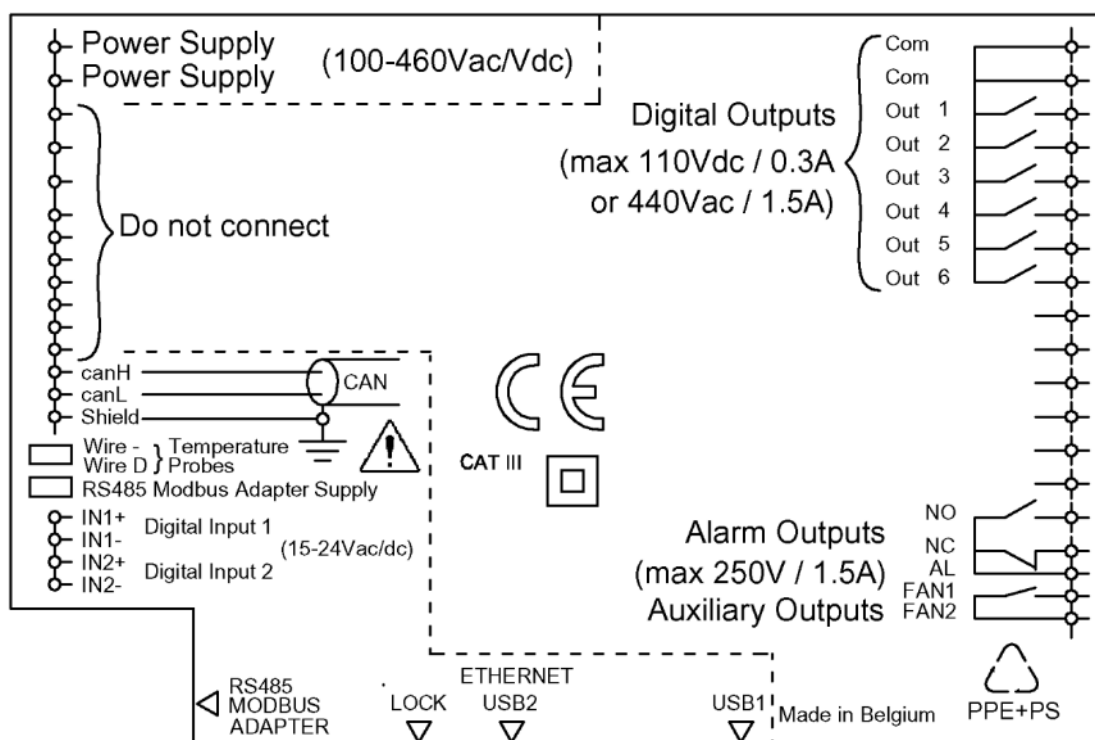


Figure 39: Rear side layout of the PQF-Manager user interface

When looking at the PQF-Manager from the rear, on the left side can be found a 15-pole terminal block and on the right side an 8 pole terminal block (top-right) and a 45-pole terminal block (bottom right). Intermediate contacts are not used. In order to make control connections to any of these terminals, the following procedure has to be applied:

1. Push the lever of the connector backwards with a screwdriver.
2. Insert the control wires (from 0.75 mm² to 2.5 mm² single core without cable shoe or max. 1.5 mm² for multi-strand wire) in the corresponding connection hole while keeping the pressure on the lever.
3. Release the screwdriver.
4. The wire is then properly connected.

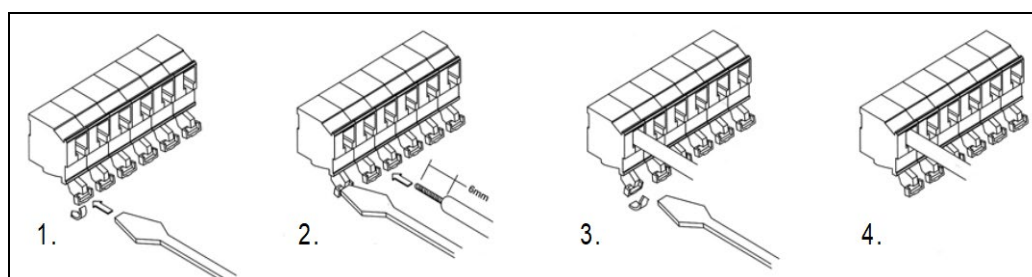


Figure 40: PQF-Manager lead connections

The remainder of this section gives examples of how to cable different functions, i.e.

Case 1: Cabling of remote control functionality.

Case 2: Cabling of alarm functionality.

Case 3: Cabling of warning functionality.

Case 4: Cabling of the digital output contacts to monitor other filter operation modes than warnings and alarms.

Case 5: Cabling of main/auxiliary control functionality.

Case 6: Implementation of local start/stop buttons.

It is recommended that for additional functions that are cabled to the PQFS, a connector approach is used such as is the case for the internal communication and PQF-Manager power supply.



WARNING: Before cabling any of the circuits discussed below, switch off the power supply to the filter. When the filter has already been installed on site, this is done by opening the protection located just upstream of the filter and opening the auxiliary fuse box present in the filter. Wait at least 25 minutes to allow for the DC capacitors to discharge when the filter has been connected to the network before. Failure to do so may result in the lethal injury or death

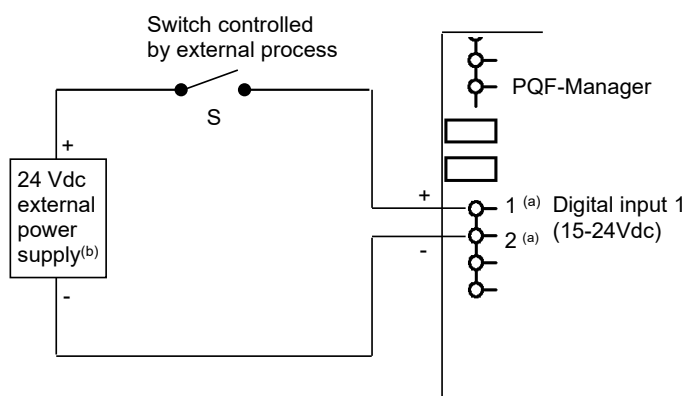
After making and verification of all the electrical connections

- Close the auxiliary fuse box of the filter units starting from the last slave and ending with the master unit.
- Restore the top cover(s) of the filter units including the connection of the PQF-Manager to the master unit
- The power to the filter may then be restored.

6.12.1. Cabling of remote control functionality

The PQFS has the possibility to be controlled by remote control. An example of this approach is a drive that is switched on at a location and which automatically gives a start command to the filter. When the drive is then stopped, the drive sends automatically a stop command to the filter too. This section gives an example of how the cabling has to be done on the filter side.

Any of the two digital inputs on the PQF-Manager (Cf. Figure 39) can be used to cable the remote control functionality. The electrical requirements of the digital inputs are given in Table 66 (Filter characteristics section). Figure 41 gives an example of how to implement the remote control functionality on Digital Input 1.



Remarks:

(a) Left hand terminal block when looking from rear, counting from top to bottom

(b) Acceptable power supply range: 15Vdc-24 Vdc, driving current 13mA@24Vdc

Figure 41: Implementation of remote control functionality on Digital Input 1 of the PQF-Manager



WARNING: If a function is assigned to a digital input, the same function must never be assigned to the other digital input. Otherwise the filter may behave erratically.

Once the cabling has been finished:

- The auxiliary fuse box may be closed
- The filter top cover may be replaced including the connection of the PQF-Manager to the master unit
- The power to the filter may then be restored

Then, the PQF-Manager has to be used to associate the remote control functionality with Digital Input 1. This is done by going to the digital input setup menu and selecting 'Remote ON' for digital input 1. When this is done the filter will switch on when the switch S shown in [Figure 41](#) is closed and the filter will switch off when the switch S is opened. Refer to [Section 7.9.1.4](#) for guidelines on how to navigate to the digital input setup menu.

In a multi-master arrangement, the master that has the control over the system (i.e. the master which is operational and which has the lowest address) will monitor the digital inputs. Therefore, in order to obtain full redundancy with filters consisting of more than one master unit, the digital inputs of all the units in a multi-master arrangement have to be set up and cabled in the same way.

Remarks:

- When the remote control functionality has been activated this function has priority over a local start/stop command. When the local command has to be given, deactivate first the remote control functionality by navigating with the PQF-Manager to the digital input setup menu and setting the digital input considered to 'Disabled'.
- The remote control functionality can also be implemented on the Digital Input 2.

6.12.2. Cabling of alarm functionality

An alarm represents an error condition that makes the filter trip. Two types of error conditions exist:

- External error condition: These are conditions that are imposed on to the filter from the outside world. Consider the example of the network voltage that increases well above the filter safe operation level for a certain time. In that case the filter will disconnect from the network reporting a network overvoltage. When the network voltage returns to a normal level however, the filter will reconnect to the network and continue filtering providing that the same problem does not occur systematically.
- Internal error conditions: These are error conditions that are reported by internal controls of the filter itself. They may indicate an internal filter problem.

Two ways to cable the alarm functionality exist:

6.12.2.1. Alarm outputs

The PQF-Manager alarm outputs located at the bottom right side (when looking at the PQF-Manager from the rear) are triggered (return to default position) whenever:

- A permanent internal or external error condition is present. In order to avoid transient switching of the contacts, the error has to be present for 3 minutes before the alarm relays are activated.

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- No power is supplied to the filter.

Table 26 further down this section gives an overview of all the error conditions that lead to the alarm contact being triggered. Two alarm contacts exist, one being of type 'normally open' (NO) and the other of type 'normally closed' (NC).

The alarm contacts are:

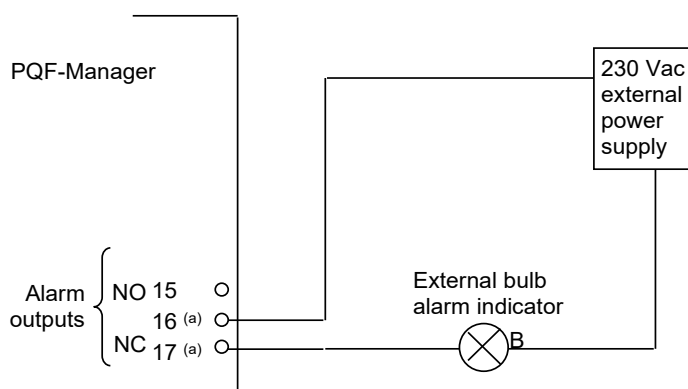
- Free of potential.
- Rated for a maximum of 250 Vac/1.5 A or 30 Vdc/5 A. When using a 24 Vdc power supply, a minimum current of 25 mA should be drawn by the circuit connected to the alarm contact.

Table 24 shows the status of the alarm contacts for different operation modes of the filter.

Table 24: Status of the alarm contacts for different filter operation modes

Filter state	Normally open alarm contact state	Normally closed alarm contact state
Disconnected from the supply	Open	Closed
Filter (auxiliaries) connected to the supply, no error present	Closed	Open
Filter (auxiliaries) connected to the supply, error appears	Opens when error present for 3 minutes Otherwise, remains closed	Closes when error present for 3 minutes Otherwise, remains open
Filter (auxiliaries) connected to the supply, error disappears	When open before, closes when error disappears When closed before, remains closed	When closed before, opens when error disappears When open before, remains open

Figure 42 shows an example of an alarm contact cabling scheme using the NC alarm contact. Using this scheme the bulb B will be on when the power supply to the filter is interrupted or the filter trips due to an error. Otherwise the bulb will be off.

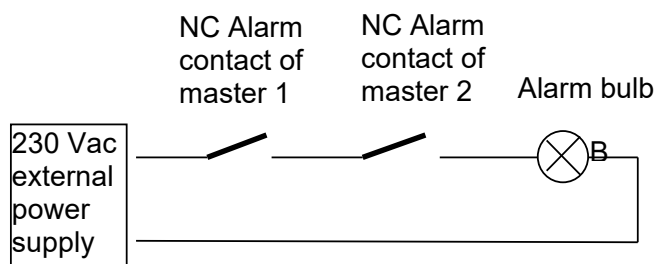


Remark:

^(a) Right hand terminal block when looking from rear, counting from top to

Figure 42: Alarm bulb cabling scheme using the NC alarm contact on the PQF-Manager

When the filter system consists of multiple master-units and an alarm contact is needed to signal when the complete system is off, then the NC alarm contacts of all the master units have to be cabled in series. An example is given in **Figure 43** for 2 master filters.



Note: Contacts drawn in non-alarm position

Figure 43: Cabling of the alarm status of a multi-unit filter consisting of masters only, using the NC alarm contact on each filter.

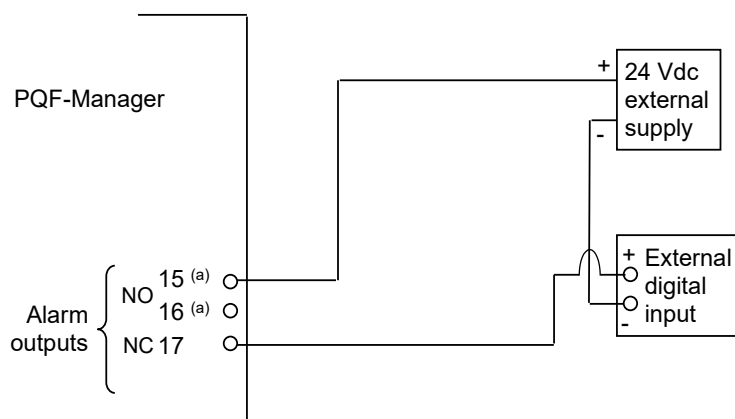
In the **Figure 43**, the alarm bulb will be activated when both master units are in alarm.

Figure 44 shows a cabling scheme using a 24 Vdc supply in conjunction with the NO alarm contact. The scheme assumes that an external digital input monitors the alarm contact of the filter. In this case the voltage applied to the digital input will be low when:

- The filter is disconnected from the supply OR.
- The filter trips due to an error OR.
- The external 24 Vdc power supply fails.

The voltage applied to the external digital input is high when:

- The filter is connected to the supply and is not in error AND
- The external 24 Vdc power supply is in working order.

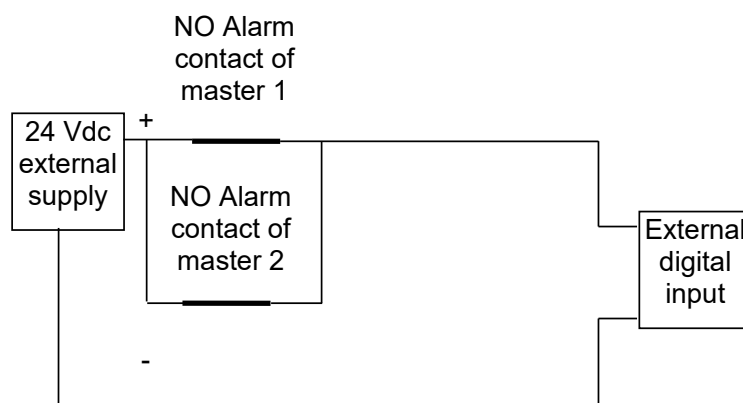


Remark:

^(a) Right hand terminal block when looking from rear, counting from top to

Figure 44: Alarm cabling example using NO alarm contact and external digital input

When the filter system consists of multiple master-units and an alarm contact is needed to signal when the complete system is off, then the NO alarm contacts of all the master units have to be cabled in parallel. An example is given in **Figure 45** for 2 master filters.



Note: Contacts drawn in non-alarm position

Figure 45: Cabling of the alarm status of a multi-unit filter consisting of masters only, using the NO alarm contact on each filter.

In the [Figure 45](#) above, the external input will be low if:

- Both master units are in alarm OR
- The external 24 V power supply fails OR
- Both filter units are disconnected from the supply.

6.12.2.2. Digital outputs

A second method to implement the alarm functionality is to use the PQF-Manager's programmable digital output contacts. Use this approach when the condition for alarm is uniquely defined, e.g. an alarm has to be given only when the filter trips due to an unacceptably high network voltage or when the filter trips due to a well-defined internal error. This type of alarm has to be cabled on the 8 pin terminal block situated at the top right corner when looking at the PQF-Manager from the rear (Cf. [Figure 39](#)).

The digital output contacts have a common point (cabled on contacts 1 and 2) and are of the NO-type (normally open). The contact ratings are:

- Maximum continuous ac rating: 440 Vac/1.5 A.
- Maximum continuous dc rating: 110 Vdc/0.3A.
- The common is rated at 9 A/terminal, giving a total of 18 A.
- When using a power supply of 24Vdc, a minimum current of 10 mA should be drawn by the circuit connected to the digital output contact.

[Table 25](#) shows the status of a digital output contact configured as alarm contact for different operation modes of the filter.

Table 25: Status of a digital output contact configured as alarm contact for different filter operation modes

Filter state	Normally open digital contact state
Disconnected from the supply	Open
Filter (auxiliaries) connected to the supply, no error present	Open

Filter state	Normally open digital contact state
Filter (auxiliaries) connected to the supply, predefined error appears	Closes when error present for 3 minutes. Otherwise, contact remains open.
Filter (auxiliaries) connected to the supply, predefined error disappears	When closed before, opens when error disappears. When opened before, remains open.

The alarm conditions that can be assigned to a digital output are given in [Table 26](#). The assignment must be made with the PQF-Manager. Any of the six digital outputs can be used to cable an alarm. A maximum of 3 alarms can be assigned to the digital outputs. Note however that by default the digital outputs have been set up for monitoring other functions than alarms (cf. [Table 10](#)) Refer to [Section 7.9.1.4](#) for guidelines on how to navigate to the digital output setup menu.

Table 26: List of possible alarm conditions that may trigger the alarm/digital outputs

Alarm condition	Criteria to be fulfilled before contact is activated
Supply voltage (RMS) unacceptably high	$V_{rms_max} > 110\% V_{nominal}$
Supply voltage (RMS) unacceptably low	$V_{rms_min} < 90\% V_{nominal}$
One of the phases of the supply is missing	$V_{rms_min} < 60\% V_{nominal}$
Network imbalance unacceptably high	$V_{imbalance} > 2\%$
Frequency variation unacceptably high	Frequency variation $> 20\%/s$
PQFS DC bus voltage unacceptably high	$V_{dc} > 105\% V_{dc_max_allowed}$
PQFS internal preload error	DC capacitor voltage rise too low in preload phase or the DC capacitors could not be preloaded in an acceptable time.
PQFS overcurrent fault	Internal current higher than allowed.
PQFS ground fault	Internal ground current higher than allowed.
PQFS IGBT fault	IGBT hardware reports internal permanent error.
PQFS IGBT overtemperature	IGBT hardware reports internal overtemperature.
Control board temperature too high	Internal control board temperature probe reports too high temperature.
PQFS internal power supply fault	Internal control voltage too low or not present.
PQFS control board fault	Internal control board reports an error.
PQFS unit down (i.e. not operational due to error)	Any of the units in a multi-unit arrangement is not running although the start-command has been given.

Remark: the alarm trigger levels cannot be changed by the user.

For cabling the digital output contacts as alarm contact, the same approach as shown in [Figure 44](#) can be adopted. Note however that the following behavior will result:

- The voltage applied to the external monitoring device will be low when:
 - The filter is disconnected from the supply or when there is no error.
- The voltage applied to the external monitoring device will be high when:
 - The predefined error is present for the predefined time (minimum 180s) AND
 - The external 24 Vdc power supply is in working order.

The different electrical characteristics of the digital output contacts compared to the alarm contact characteristics must be respected. Note also that all digital outputs have the same common which is located at the pins 1 and 2 of the right hand terminal of the PQF-Manager (rear view, counting from top to bottom). This is clearly indicated in [Figure 39](#) above.

A second use of the digital outputs is to monitor the status of individual master units in a multi-filter system. This can be done by assigning the function 'Unit missing' ('Unit miss.') to a digital output. In that case the digital output of the master controlling the complete system will activate the digital output considered when one of the units in a filter system is not operational due to error.

In order to obtain full redundancy with filters consisting of more than one master unit, the digital outputs of all the units in a multi-master arrangement have to set up and cabled in the same way. The cabling scheme is given in [Figure 45](#).

Once the cabling has been finished:

- The auxiliary fuse box may be closed
- The filter top cover may be replaced including the connection of the PQF-Manager to the master unit
- The power to the filter may then be restored

6.12.3. Cabling of warning functionality

A warning condition is a condition that can be set up by the user in such a way that if the condition is met, a digital output contact of the PQF-Manager user interface (Cf. [Figure 39](#)) is closed. As an example consider a case where the user has set up an upper warning level for the network voltage. If the level measured by the filter becomes higher than the predefined warning level and this condition remains valid for a preset time, the associated digital output will be closed. By monitoring the digital output, the customer will then know when the network voltage becomes too high and subsequently he can take appropriate action.

Note that the warning functionality is not associated with a filter trip. It only has a monitoring function. [Table 27](#) describes the behavior of the digital output contact configured as warning contact for different filter operating modes.

Table 27: State of a digital output contact configured as warning contact for different filter operation modes

Filter state	Normally open digital contact state
Disconnected from the supply	Open
Filter (auxiliaries) connected to the supply, no warning present	Open
Filter (auxiliaries) connected to the supply, predefined warning present	Closes when warning present for pre-defined time. Otherwise, contact remains open.
Filter (auxiliaries) connected to the supply, predefined warning disappears	When closed before and warning disappears for at least the predefined time, contact opens. When closed before and warning disappears for a time smaller than predefined time, contact remains closed. Otherwise, contact remains open

[Table 28](#) gives a list of the warning conditions that can be assigned to a digital output.

Table 28: List of possible warning conditions that can be assigned to a digital output

Warning condition
Supply voltage (RMS) higher than preset value.
Supply voltage (RMS) lower than preset value.
Supply voltage imbalance higher than preset value.
Ground current level higher than preset value.
IGBT Temperature higher than preset value.
Control board temperature higher than preset value.
Remark: All warning levels can be changed by the user.

Any of the six digital outputs can be used to cable warning functionality. A maximum of 3 warnings can be assigned to the digital outputs. However, by default the digital outputs of the PQF-Manager have been set up for monitoring other functions than warnings (cf. [Table 10](#)) Refer to [Section 7.9.1.4](#) for guidelines on how to set up warning conditions and how to associate them with digital output contacts.

For cabling the digital output contacts as warning contact, the same approach as shown in [Figure 44](#) can be adopted. The electrical characteristics of the digital output contacts and the points to pay attention to are discussed in [Section 6.12.2](#).

In order to obtain full redundancy with filters consisting of more than one master unit, the digital outputs of all the units in a multi-master arrangement have to be set up and cabled in the same way. The wiring diagram given in [Figure 45](#) can be used to implement the monitoring of the warnings in multi-master units.

6.12.4. Cabling of the digital output contacts to monitor other filter operation modes than warnings and alarms

[Table 9](#) gives an overview of the other functions that can be monitored with the digital outputs in addition to the already discussed warnings and alarms.

For cabling the digital output contacts to monitor other filter operation, the same approach as shown in [Figure 44](#) can be adopted. The electrical characteristics of the digital output contacts and the points to pay attention to are discussed in [Section 6.12.2](#).

In order to obtain full redundancy with filters consisting of more than one master unit, the digital outputs of all the units in a multi-master arrangement have to be set up and cabled in the same way. The wiring diagram given in [Figure 45](#) can be used to implement the monitoring of these functions in multi-master units.

6.12.5. Cabling of main/auxiliary control functionality

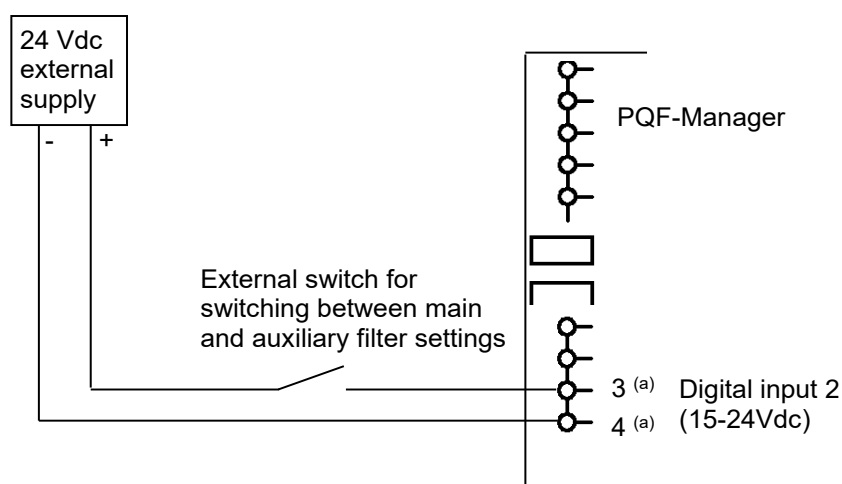
The active filter features main and auxiliary control setup modes. This implies that two different compensation characteristics can be defined, e.g. one for the day and one for the night or one for normal network operation and one for backup generator operation. With the PQF-Manager a set up can be made to either use always the main or the auxiliary settings. In addition, the possibility exists to switch between main and auxiliary settings 'automatically' according to a signal applied to a digital input of the PQF-Manager (Cf. [Figure 39](#)). Any digital input can be configured to act as the deciding factor for switching between the main and auxiliary settings. Moreover, both normal and inverse logic can be used to drive the digital inputs.

Note that in a multi-unit filter system in which more than one master system is present, the digital inputs of all masters have to be set up and cabled in the same way to obtain full redundancy.

The electrical requirements of the digital inputs are as discussed in [Chapter 12](#).

[Figure 46](#) gives an example of how to implement the main/auxiliary control switching functionality on Digital Input 2. It is assumed that normal control logic is used.

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Remark:

(a) Left hand terminal block when looking from rear, counting from top to bottom

Figure 46: Example of how to cable the 2nd digital input of the PQF-Manager for main/auxiliary control switching functionality

When implementing the function described above, please note that according to the setup done with the PQF-Manager for the input considered, the filter may behave differently. Table 29 shows the filter behavior as a function of the PQF-Manager settings.



WARNING: If a function is assigned to a digital input, the same function must never be assigned to the other digital input. Otherwise the filter may behave erratically.

Table 29: Filter behavior as a function of the PQF-Manager settings for main/auxiliary switching

PQF-Manager setup for digital input	Vlow applied to digital input	Vhigh applied to digital input
Activ. Main	Auxiliary settings are used	Main settings are used
Activ. Aux.	Main settings are used	Auxiliary settings are used

Remark: Vlow = 0 Vdc, Vhigh = 15-24 Vdc

In order to obtain full redundancy with filters consisting of more than one master unit, the digital inputs of all the units in a multi-master arrangement have to be set up and cabled in the same way and the individual PQF-Managers have to be set up accordingly.

Once the cabling has been finished:

- The auxiliary fuse box may be closed
- The filter top cover may be replaced including the connection of the PQF-Manager to the master unit
- The power to the filter may be restored

Refer to Section 7.9.1.4 for guidelines on how to set up the digital inputs according to the function required.

6.12.6. Implementation of local start/stop buttons



WARNING: If a function is assigned to a digital input, the same function must never be assigned to the other digital input. Otherwise the filter may behave erratically.

The PQFS active filter is equipped with a start/stop function integrated in the PQF-Manager user interface. If the customer desires this however, he can add extra start/stop buttons (not provided) to the filter system. The start and stop button has to be connected to the PQF-Manager's digital inputs and the PQF-Manager has to be set up accordingly.

Note that in a multi-unit filter system in which more than one master system is present, the digital inputs of all masters have to be set up and cabled in the same way to obtain full redundancy.

Two connection approaches exist:

- The first approach is to use one digital input for the start function and the second digital input for the stop function. **Table 30** shows the PQF-Manager setup for the input considered and the resulting effect when applying voltage to this input.

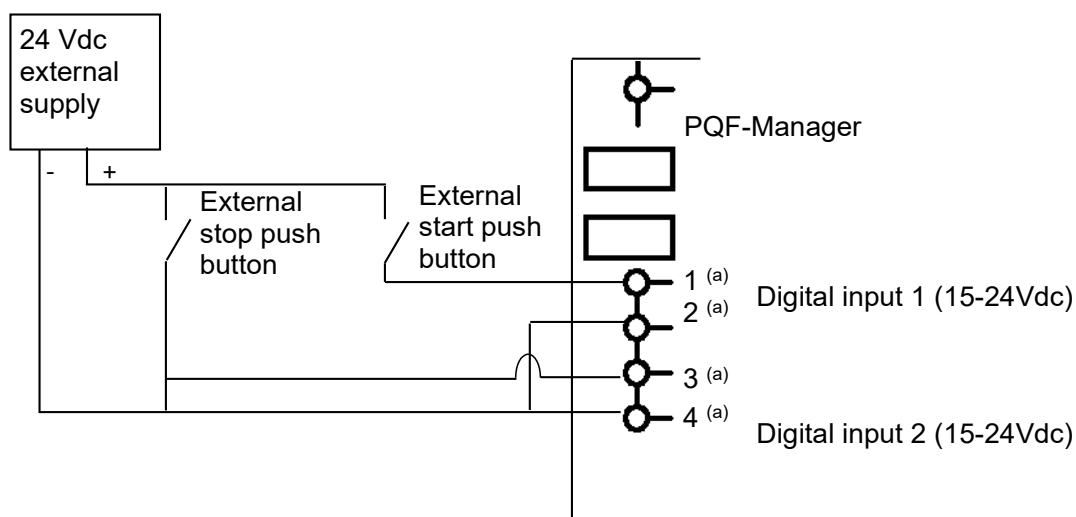
Table 30: Filter behavior as a function of the PQF-Manager settings for local start/stop and using 2 digital inputs

PQF-Manager setup for digital input	Vlow applied to digital input	Vhigh applied to digital input
Edge ON	No effect	Filter starts on rising edge
Edge OFF	No effect	Filter stops on rising edge

Remark: Vlow = 0 Vdc, Vhigh = 15-24 Vdc

When using the Edge ON function the filter can only be switched on by applying voltage to the digital input considered. It is therefore recommended in that case to configure and cable the second digital input as Edge OFF. Refer to **Section 7.9.1.4** for guidelines on how to set up the digital inputs according to the function required.

The electrical requirements of the digital inputs are as discussed in **Section 4.5**. **Figure 47** shows a cabling diagram for implementing a start function on the first digital input and a stop function on the second digital input.



Remark:

(a) Left hand terminal block when looking from rear, counting from top to bottom

Figure 47: Cabling diagram for implementing start on digital input 1 and stop on digital input 2

- The second approach is to use one digital input for both the start function and the stop function. This leaves the other digital input available for the implementation of other functions.

Table 31 shows the PQF-Manager setup for the input considered and the resulting effect when applying voltage to this input.

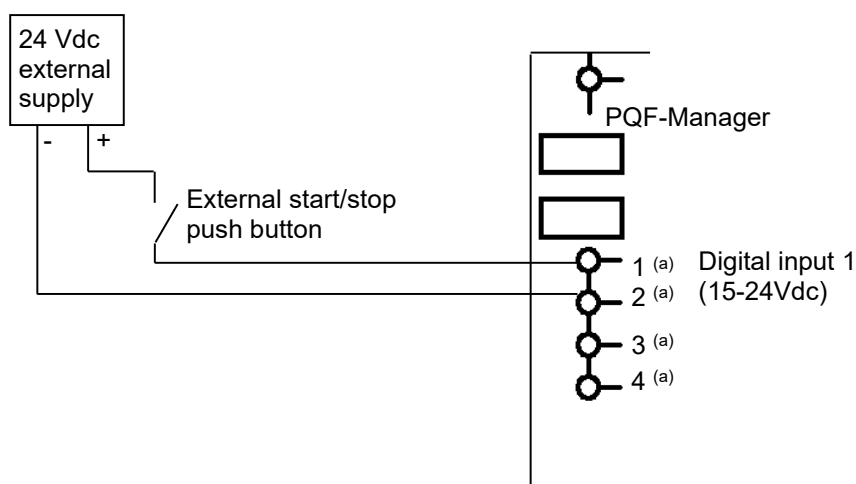
Table 31: Filter behavior as a function of the PQF-Manager settings for local start/stop and using 1 digital input

PQF-Manager setup for digital input	Vlow applied to digital input	Vhigh applied to digital input
Edge ON/OFF	No effect	Filter starts on first rising edge, stops on second rising edge, etc

Remark: Vlow = 0 Vdc, Vhigh = 15-24 Vdc

Refer to **Section 7.9.1.4** for guidelines on how to set up the digital inputs according to the function required.

The electrical requirements of the digital inputs are as discussed in **Section 4.5**. **Figure 48** shows a cabling diagram for implementing a start function and a stop function on the first digital input.



Remark:

(a) Left hand terminal block when looking from rear, counting from top to bottom

Figure 48: Cabling diagram for implementing start and stop on digital input 1

Once the cabling has been finished:

- The auxiliary fuse box may be closed
- The filter top cover may be replaced including the connection of the POF-Manager to the master unit
- The power to the filter may be restored

Remarks:

- The implementation of local start/stop buttons does not inhibit the usage of the start/stop function on the POF-Manager.
- When remote control functionality is implemented (cf. [Section 6.12.1](#)) at the same time as local start/stop buttons, the remote control has priority over the local start/stop buttons. When the local start/stop command has to be given, deactivate first the remote control functionality by navigating with the POF-Manager to the digital input setup menu and setting the digital input associated with the remote control to 'Disabled'.
- Note that in a multi-unit filter system in which more than one master system is present, the digital inputs of all masters have to be set up and cabled in the same way to obtain full redundancy.

6.13. Electrical connections of filter options and accessories

Filter options must be ordered in advance and are cabled in the factory. For these options, refer to the wiring diagram provided with your filter to identify the electrical connections if desired. For some accessories however, the customer may have to do the cabling on site. These accessories include:

- The connection of the USB or Ethernet cable used for PQ-Link software communication (optional)
- The connection of the Ethernet cable used for Modbus TCP communication (optional)
- The connection of the RS485 Modbus RTU adapter (optional)

The connections of the aforementioned accessories are discussed next.

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WARNING: Before cabling any of the circuits discussed below, switch off the power supply to the filter. When the filter has already been installed on site, this is preferably done by opening the protection system located just upstream of the filter and opening the auxiliary fuse box present in the filter. Wait at least 25 minutes to allow for the DC capacitors to discharge when the filter has been connected to the network before. Failure to do so may result in the lethal injury or death.

6.13.1. External communication with PQF

The PQF Filter communicates with a computer in three possible ways:

- Using our in-house communication software called PQ-Link (TCP/IP-USB)
- Using any communication system supporting the Modbus TCP protocol
- Using any communication system supporting the Modbus RTU protocol

While using the PQ-Link software, the computer can be connected either through the Ethernet port using standard cable (RJ45) or through the USB port using standard USB cable.



Figure 49: Ethernet cable & USB cable for PC-filter interconnection

For communication over Modbus TCP, the computer can be connected through the Ethernet port using standard cable (RJ45).

For communication over Modbus RTU, we need a RS485 Modbus adapter (as shown in [Figure 50](#)). This adapter has to be connected to the rear side of the PQF-Manager. This is done by inserting the adapter plug firmly in the dedicated socket. [Figure 50](#) shows the location at the rear of the PQF-Manager where the plug has to be inserted. The user can use custom software where the standard Modbus RTU protocol is implemented or any other standard software (OPC server, SCADA ...).

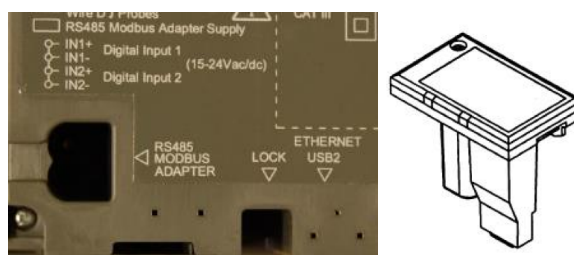


Figure 50: Location at rear of PQF-Manager where the serial communication cable has to be inserted

More information on the PQ-Link software or Modbus communication can be found in the 'PQ-Link installation and user's guide' and 9AKK106713A9759_PQF-Manager communication with Modbus RTU, Modbus TCP and PQ-Link protocols.

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6.13.2. Connection of the Modbus adapter

For the connection setup of the Modbus adapter, please refer to the document “9AKK107045A9895-RS-485 Installation and Start-up guide”.

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7. The PQF-Manager user interface

7.1. What this chapter contains

This chapter presents the features and operating instructions for the PQF-Manager user interface (Figure 51). Use the contents of this chapter as background information for the next chapters, which explain how to commission, operate and troubleshoot the active filter and how to set up various communication interfaces based on RS485 or Ethernet.

Some of the functions discussed in this chapter require cabling of external I/O to the connection terminals at the rear of the PQF-Manager. Refer to Section 6.12 for guidelines on how to do this.



Figure 51: Front view of the PQF-Manager user interface

7.2. PQF-Manager user interface description

The PQF-Manager is based on a touch screen user interface hence there are no hardware buttons used. All user actions like moving from one to another menu or data entry are done directly by touching the soft buttons or icons on the “touch sensitive” screen. The screen is made of high quality scratch resistance glass. The screen is “resistive touch screen” and hence the user may use any object such as finger or any blunt object like a pen, screw driver etc. Care must be taken not to damage the screen by accidental hard tapping by a sharp object.

The main screen of the PQF-Manager is given in Figure 52.

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Figure 52 Main screen of the PQF-Manager

7.3. PQF-Manager overview and navigation

All user inter-action with the filter is channeled through the PQF-Manager. It provides for the following main functions (Cf. Figure 51):

- Filter starting, filter stopping and acknowledgement of faults
- Selection of power module for which the relevant data is displayed
- Measuring, analyzing, logging
- Setting up the filter
- Monitoring the filter load, event logging and status of individual units
- Providing filter identification information

Figure 53 outlines the principle menus that are accessible through the 'Welcome' screen.

In a multi master configuration (several master units in parallel in a single filter), the PQF-Manager on the "Master" unit has all the menus and options active. The PQF-Manager(s) on the "Slave" unit(s) have different screens in the sense that certain items (menu, buttons etc.) are "non-active" and may appear "greyed". In case the maser unit fails and the next unit in the order takes over as new master (due to redundancy feature of PQF), the menu of the new master automatically adapts to this new situation.

7.4. Icons and main screen

Following icons and menu are present on the main screen:

Table 32 Filter status icons

Filter status	Menu display	Touching the button results in ...
Filter stopped, no critical error present (i.e. 'normal' stop condition)	PQF START 	Starting the filter unit
Filter running, no critical error present (i.e. 'normal' running condition)	PQF STOP 	Stopping the filter unit
Filter stopped on critical fault	ACK. FAULT 	Filter stopped on critical fault

The module status indicator: there are 8 numbered icons present on the left bottom of the screen, each representing a power module. The active modules are displayed in blue color; the faulty ones in red and those modules which are not present are greyed.

Table 33 Module status icons

Icons	Status
	Ready: the unit considered does not have a fault and can run normally
	Fault: the unit considered has been stopped due to an error. By pressing Ack. Fault, the reason for the fault will be displayed and an attempt will be made to clear the fault. When doing this, the complete filter system will be shut down. If the fault could be cleared, the unit status will become 'ready'. If the fault could not be cleared, the unit status will remain 'Ack. Fault'. In the fault clearing process, the complete filter system will be shut down. The filter can be restarted after the fault clearing process has ended.
	Not present: the unit considered has been excluded of the normal filter operation due to either fault or the unit is not present
	Master

An alarm icon showing when the PQF-Manager's alarm contact has been activated (Cf. [Figure 51](#)) changes its appearance when the alarm condition exists. When the alarm condition has disappeared, the respective alarm icon takes back the normal appearance. The status of protection (locked/unlocked) is also displayed by a dedicated icon. Hardware lock and software locks have separate icons.

Table 34 Alarm/lock status icons

Icons	Status
	Software lock
	Software unlock
	Hardware lock
	Hardware unlock
	Communication lock status
	Communication unlock status
 	Alarm status
 	Fan status

Alarms

Programmed alarm can:

- activate any digital output relay 1-6 if selected
- activate global alarm NO/NC relay

Tprobe alarm 1 to 8 can activate global alarm NO/NC relay.

Warnings

Programmed warning can activate any digital output relay 1-6 if selected.

Tprobe warning 1 to 8 can activate global fan NO relay.



Digital output contact icons are located at the bottom of the screen (Cf. [Figure 52](#)). These icons are numbered 1 to 6 when they are disabled. If these output contacts are programmed, the corresponding icon changes. When the PQF-Manager closes one of its six digital output relays (Cf. [Chapter 6](#)) the corresponding symbol changes its appearance as described in the [Table 35](#). When the relay considered opens again, the symbol takes back the original appearance. If a digital output is 'Disabled' the default icon is shown. Example:

Table 35 Digital outputs status icons

Icons	PQF-Manager setting for digital output	Output relay closes when...
	Auxil. ON	The auxiliary power is present in the main filter enclosure and the main controller is communicating with the PQF-Manager
	Auxil. OFF	
	PQF running	The active filter is 'on' (IGBTs switching) or in 'standby' (main contactor closed but IGBTs not switching)
	PQF not running	
	Not full load	The active filter is running under full load condition
	Full load	
	Armed	The filter is ON or is in the start-up procedure, or it is stopped in fault condition but will restart as soon as the fault has disappeared
	Not armed	
	Within T limit	The filter temperature limit has been reached and the filter is derating itself to run at a safe temperature
	T limit reached	
	In standby	The filter is in standby

Icons	PQF-Manager setting for digital output	Output relay closes when...
	Activ. Main	The main active filter settings are activated
	Activ. Aux	The auxiliary active filter settings are activated
 	Unit miss.	One of the filter units in a multi-unit arrangement is not available (e.g. due to a permanent error), or has not yet been commissioned.
 	Pg. alarm 1	The programmable alarm 1 is activated
 	Pg. alarm 2	The programmable alarm 2 is activated
 	Pg. alarm 3	The programmable alarm 3 is activated
 	Warning 1	The programmable warning 1 is activated(c)
 	Warning 2	The programmable warning 2 is activated(c)
 	Warning 3	The programmable warning 3 is activated(c)

Following are the default functions set for the six digital output contacts:

Table 36 Main screen

Digital output number	Default function
1	Auxil. ON
2	PQF Running
3	Full Load
4	Armed
5	Unit miss.
6	T Limit

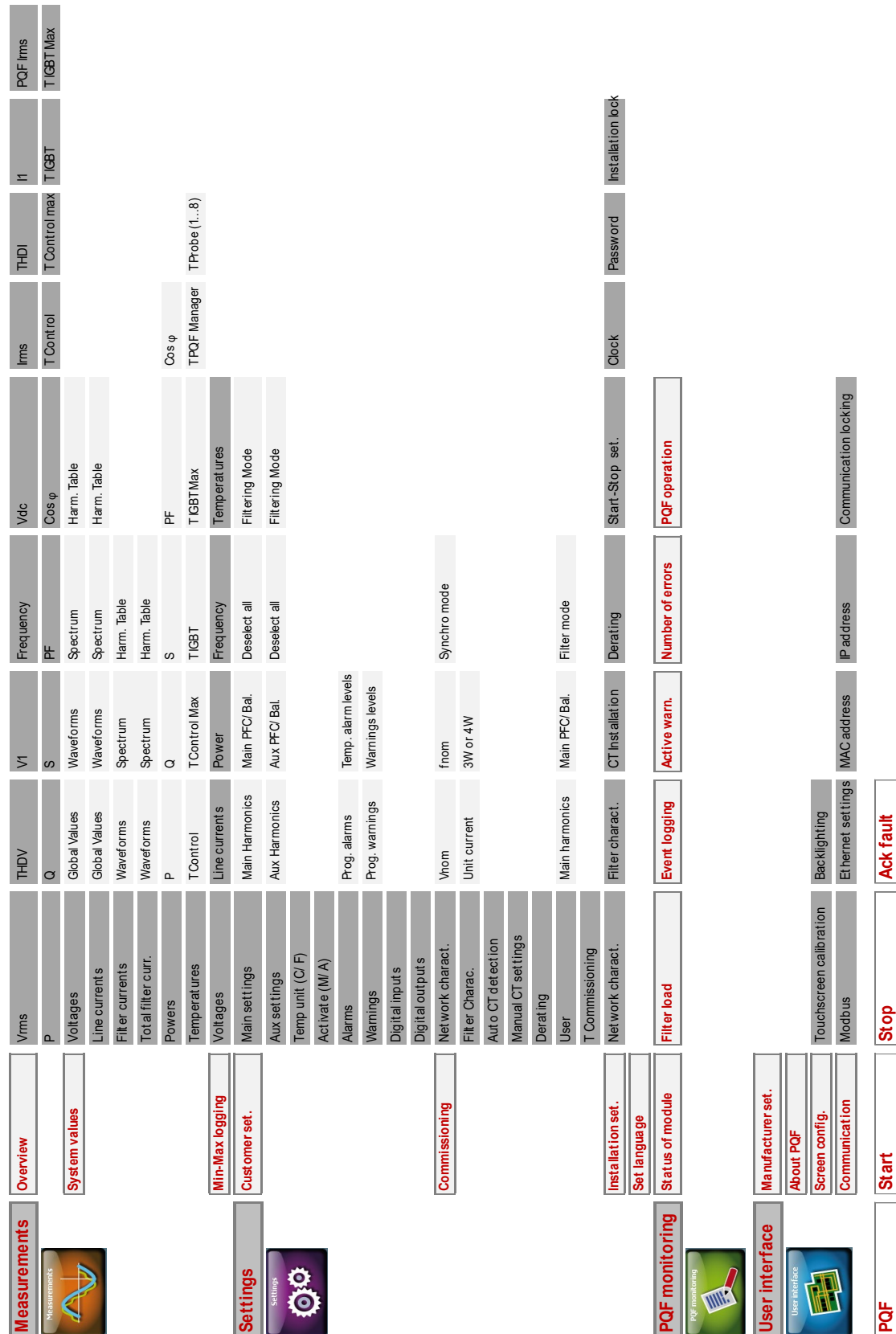


Figure 53: Principle menus of the PQF-Manager

In order to navigate through the menus of the PQF-Manager, the touch screen (Cf. Figure 51) has to be used. The starting point for the navigation after a power up is the 'Welcome' screen. The item selected is activated and its sub-menu appears on the screen (e.g. the 'Measurements' menu in Figure 51). The name of the parent menu is displayed at the top of the screen.



Figure 54: Sub-menu Measurements

Please note that:

- Sometimes the complete item list in a menu cannot be shown on the display. This is indicated by a small  symbol that appear(s) at the bottom right (Cf. Figure 55). Pressing this button takes the menu to the next screen where more items are available to choose from.

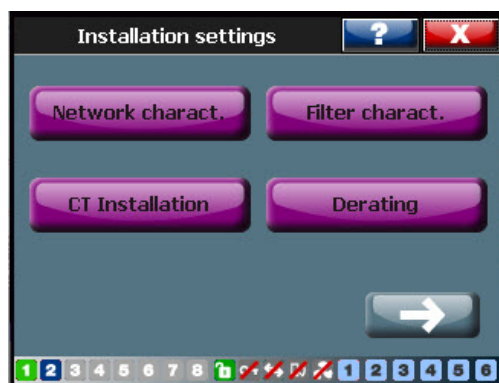


Figure 55: Illustration of arrow symbol on the PQF-Manager display

- Sometimes, when the number of items or variables exceeds the limit of full screen size, a sliding bar appears on the side of the screen. Sliding down (up) this bar displays the remaining (previous) items as shown below:



Figure 56: Illustration of sliding bar on the PQF-Manager display

When any of these symbols is visible, the user can scroll down/up beyond the limit of the screen. The item list will be adjusted accordingly.

To come back (up) in the menu ladder or to quit any screen, the  button available in each screen (top right corner) should be used.

- When a menu button is selected, any submenu under it appears in the screen.
- The 'Select Unit'-function  is accessible at different places in the menu structure and allows selecting the measurements and data as reported by different units in a multi-unit filter system.

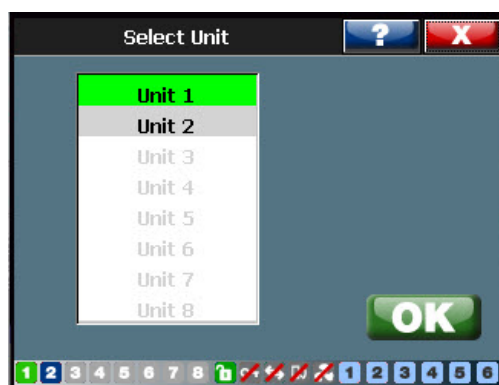


Figure 57: Illustration of different menu item types

The next sections discuss the four main submenus of the 'Welcome' screen.

Remark:

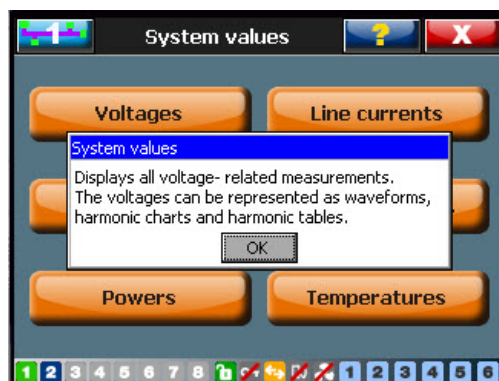
This manual uses a directory structure convention to indicate a submenu.

The main 'Welcome' screen is referenced as [/Welcome].

Example: **[/Welcome/Measurements/System values]** indicates that the 'System values' menu can be accessed by:

- Press  button (on the top right corner of any screen) successively until the 'Welcome' screen is reached
- Press the 'Measurements' menu in the main 'Welcome' screen which opens the 'Measurements' menu.
- Similarly, other submenus can be opened by pressing the respective button.

In all menus as well as sub menu, the help symbol  is present which offers a user friendly contextual help. If this icon is touched, its color changes to yellow  and the user is then expected to touch any button for which a help is required. A new window pops-up with a brief explanation about that button which was touched by the user. For example, is a help on the "Voltage" button is requested in the menu "System Values", following help will appear:



7.5. The PQF-Manager behavior during filter initialization

During powering up the filter or after a system reset, the filter is initialized. This includes initialization of the PQF-Manager also. Depending on the type of reset, the initialization process of the PQF-Manager results in following message displayed on the screen:

Case 1: If a filter is powered up first time or after a complete power shut down, following screens with ABB logo appear:

- Step 1

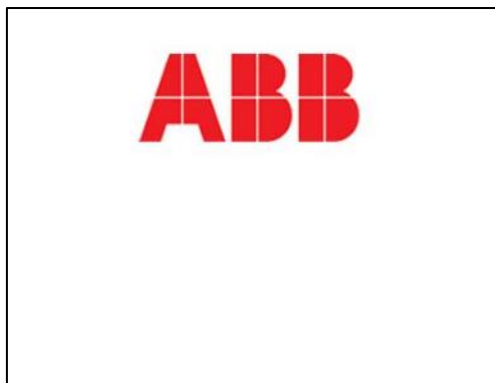


Figure 58: PQF-Manager display during communication initialization

- Step 2



Figure 59: PQF-Manager display when the user interface is set up

Once the communication channel has been initialized, the user interface is set up. During this process the PQF-Manager retrieves the data structure to be displayed from the PQF main controller.

Case 2: If a system reset is done while the PQF-Manager is still powered (example the power to the main controller is reset), the initialization process takes place without the ABB logo appearing on the screen. During this process, following two messages appear one after another:

- “Initializing communication, please wait” followed by:
- “Setting up user interface, please wait”.

Above messages can be observed when looking closely at the PQF-Manager.

Case 3: When the commissioning parameters are changed or a fault is acknowledged by the user, the filter resets and the following messages are displayed on the screen

- “Please wait....”

- “Resetting system....”

Table 37 gives an overview of the initialization steps for common reset conditions.

Table 37: Overview of common reset conditions and corresponding PQF-Manager initialization steps

Reset condition after...	PQF-Manager initialization steps
Applying power to the filter first time or after a complete isolation of filter	Case 1
Resetting power only to the main controller	Case 2
Setting up commissioning parameters	Case 3
Acknowledging fault successfully	Case 3

7.6. The PQF-Manager locking facilities

In order to prevent unauthorized modification of any of the active filter settings, switch on the hardware lock (Figure 13 item 4).

The hardware lock is switched on by pushing the blue button located at the bottom rear side of the PQF-Manager with a pointed object (e.g. pencil). When the lock is set:

-  will appear bottom portion of the graphics display
- Most setting values can be consulted

Once the PQF-Manager is locked, it can be unlocked by pushing the blue button again.

In order to prevent unauthorized modification of the core installation settings of the active filter but still giving them access to typical user settings (e.g. harmonics selection, programming digital outputs, ...), switch on the software lock.

The communication lock is applied when the corresponding parameter is set through the menu interface. When the lock is set:

-  will appear when the settings can be changed only through the communication

The software lock is applied when the corresponding parameter is set through the menu interface. When the lock is set:

-  will appear. No modification can be made to the settings

The software lock is switched on in the menu [/Welcome/Settings/Installation set./Password].

In order to unlock the system go to the same menu. After giving the appropriate password, the system will be unlocked. The password is a four-digit number, which is set by default to:

1234

Entering the password is done by choosing the right value numeric keyboard which appears on the screen. The password can be changed in the menu [/Welcome/Settings/Installation set/Change Password]. Entering the new password is done the same way and confirming the password by re-entering the same.

If hardware and software lock are combined, the hardware lock has priority over the software lock.

Note: In active filter systems consisting of more than one master, the PQF-Manager of the master that has the control over the system has full functionality and the PQF-Managers of the other master units have limited functionality. The hardware lock in the master has no effect on access level of parameters in the slave modules like warning (alarm ...). To disable these settings the hardware lock of each PQF-Manager must be engaged.

7.7. The PQF start, stop and fault acknowledgement menu



WARNING: The active filter should only be started when it has been installed and commissioned according to the guidelines of this manual. Failure to adhere to this guideline may damage the filter and void warranty.

Refer to [Chapter 8](#) for more information on commissioning the filter.

'The PQF start, stop and fault acknowledgement' menu can only be accessed in the main 'Welcome' screen [/Welcome/PQF]

'The start, stop and fault acknowledgement' menu is the default menu for starting, stopping and resetting the filter.

As can be seen in [Table 38](#) the 'start, stop and fault acknowledgement' menu behaves differently depending on the filter status.

Table 38: 'Start, stop and fault acknowledgement' menu functionality according to the filter status

Filter status	Menu display	Pushing  results in...
Filter stopped, no critical error present (i.e. 'normal' stop condition)	PQF START	Starting the filter ^(a) ^(b)
Filter running, no critical error present (i.e. 'normal' running condition)	PQF STOP	Stopping the filter ^(a) ^(b)
Filter stopped on critical fault	ACK. FAULT	Acknowledging the fault ^(a) ^(b)
Filter controlled by remote control	PQF START or PQF STOP or ACK. FAULT	No action on filter behavior Display shows message that filter is controlled by digital input

Remark:

^(a) After pushing this button, there is always a validation phase.

^(b) In multi-master filter units, this function is available on the master unit that has the control over the system.

In a multi-unit system, the PQF start, stop and fault acknowledgement menu will only switch to the ACK. FAULT message when the complete filter system is shut down.

If one of the units of a multi-unit system is shut down due to a fault, this fault can be acknowledged and reset in the PQF Monitoring menu [/Welcome/PQF Monitoring/Status of module]). Note that in the reset process the whole system will be shut down. If the fault of the unit cannot be reset, the ACK. FAULT message will be displayed again for the unit considered. The filter system can be restarted at any time and the units that are available will operate normally.

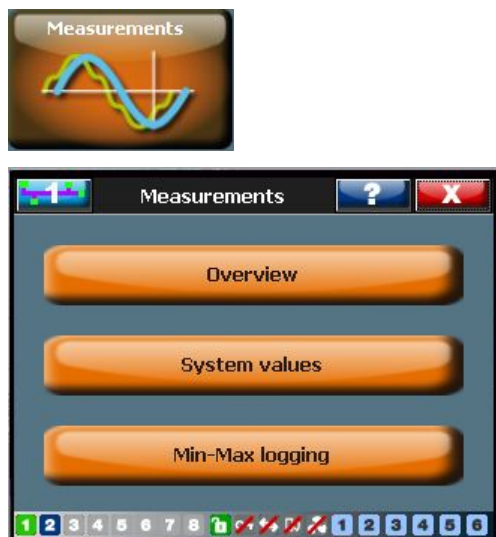
Acknowledging of a fault which resulted in a complete filter system shut down has two possible consequences:

- If the fault is permanent (e.g. permanent network under voltage due to phase loss), it cannot be cleared and the message 'ACK. FAULT' will remain on the display. In this case the cause of the problem has to be identified and removed before the filter can be restarted.
- If the fault is not present anymore when the 'ACK. FAULT' command is given, the menu will change into 'PQF START' to indicate that the filter can be restarted.

Fault analysis can be done by consulting the 'PQF Monitoring' menu [/Welcome/PQF Monitoring]. For more information on the 'PQF monitoring' menu, refer to [Section 7.10](#).

If the filter is set up for remote control operation, the local start/stop command has no effect. Disable the digital inputs to override the remote control [/Welcome/Settings/Customer set./Digital inputs].

7.8. The 'Measurements' menu



This menu allows monitoring a variety of variables (e.g. voltage, current ...) in a variety of formats (e.g. RMS-values, spectra, time domain waveforms). Its submenus are discussed next.

In multi-unit filters, several parameters are measured by the individual units. In order to consult measurements from a specific unit, select the unit with the 'Select Unit' option (where available). The order of the unit is determined by the DIP switch unit identification setting at the moment of commissioning.

7.8.1. The 'Overview' menu



The Overview menu summarizes the following characteristic parameters ([Table 39](#)). These parameters are expressed as numerical values in a list.

Table 39: Summary of parameters displayed in the 'Overview' menu

Parameter name	Unit	Description
Vrms	V	4-wire mode: RMS value of all the line-to-neutral voltages 3-wire mode: RMS value of all the line-to-line voltages
THDV	%	4-wire mode: Total harmonic distortion of all the line-to-neutral voltages 3-wire mode: Total harmonic distortion of all the line-to-line voltages
V1	V	4-wire mode: RMS value of the fundamental component of all the line-to-neutral voltages 3-wire mode: RMS value of the fundamental component of all the line-to-line voltages
Frequency	Hz	Network frequency
V dc bus	V	Active filter DC capacitor voltage
Imbalance	%	Indicates the imbalance in supply voltage (%value)
Irms	A	4-wire mode: RMS value of all the line currents and the neutral current 3-wire mode: RMS value of all the line currents
THDI	%	Total harmonic distortion of all the line currents.
I1	A	RMS value of the fundamental component of all the line currents
PQF Irms	A	RMS value of all the filter currents, including neutral current for 4-wire configuration
P	W, kW, MW	Active power in the network at the location of the CTs P > 0: Load absorbing active power P < 0: Load generating active power
Q	var, kvar Mvar	Reactive power in the network at the location of the CTs Q > 0: Inductive reactive power Q < 0: Capacitive reactive power
S	VA, kVA, MVA	Apparent power in the network at the location of the CTs
PF	-	Power factor: calculation based on the fundamental and the harmonic values of the measurements. Measurement only valid for quasi-balanced loads.
cos φ	-	Displacement power factor: calculation based on the fundamental values of the measurements.  : System has inductive behavior  : System has capacitive behavior cos φ > 0: load absorbing active power cos φ < 0: load generating active power
T Control	°C/°F	Main control board temperature of the selected module
T Control max	°C/°F	Main control board temperature of the hottest module in the group
T IGBT	°C/°F	IGBT module temperature of the selected module
T IGBT max	°C/°F	IGBT module temperature of the hottest module in the group

On the display, the parameters are organized in such a way that a maximum of information is obtained without having to scroll down. The user may customize the display to his particular needs. To do this, follow the steps given below:

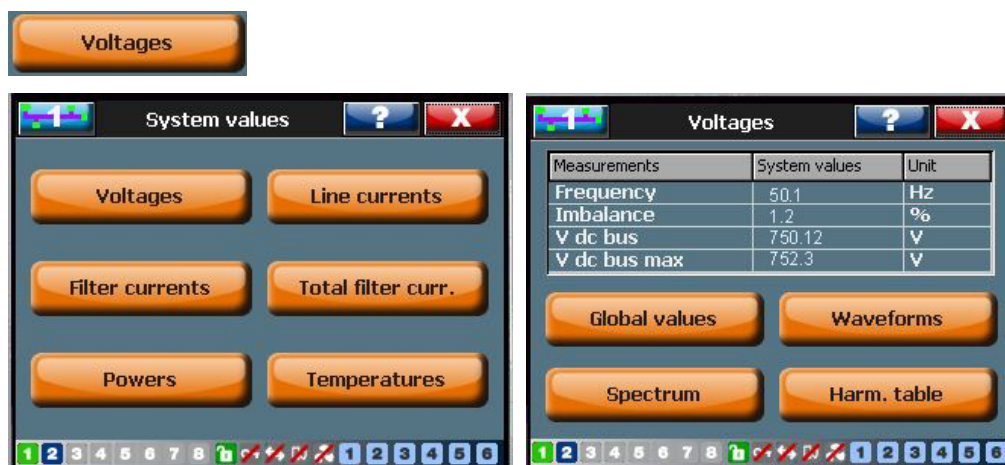
- Select the measured parameter that has to be moved. The selected parameter gets highlighted in green color background.
- Select a new location for this parameter by touching the preferred location on the list of parameters.
- The selected parameter relocates to the new place.

7.8.2. The 'System values' menu



The 'System values' menu gives detailed information on the following parameters.

7.8.2.1. Voltages



Refer to [Table 39](#) for an explanation of the parameters.

7.8.2.1.1. Global values

Vrms, V1 and THDV in table format.



Measurements	System values	Unit
Vrms (L1-L2)	414.0	V
Vrms (L2-L3)	415.0	V
Vrms (L3-L1)	416.0	V
THDV (L1-L2)	3.2	%
THDV (L2-L3)	3.3	%
THDV (L3-L1)	3.4	%
V1 (L1-L2)	413.8	V
V1 (L2-L3)	414.6	V
V1 (L3-L1)	415.4	V

7.8.2.1.2. Waveforms

The network voltage waveforms for all phases (Figure 60). All waveforms are synchronized with the rising edge zero crossing of the voltage V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).

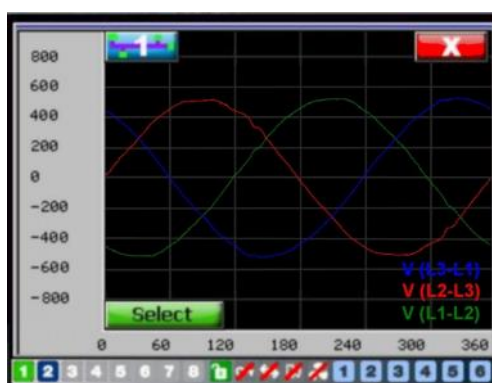


Figure 60: Time domain waveform of line voltage displayed by the PQF-Manager (3-W mode example)

7.8.2.1.3. Spectrum

The network voltage spectrum for all phases in chart format (Figure 61). The spectral components up to the 49th order are expressed as a % of the fundamental component with absolute values also shown in the top right corner. The two buttons with “+” and “-” mark help changing the voltage level resolution (i.e. Y-axis value in the chart).

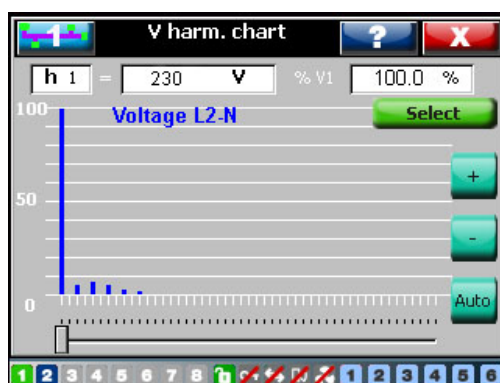


Figure 61: Spectrum of the network voltage in chart format displayed by the PQF-Manager (4-W mode example)

7.8.2.1.4. Harmonic table

The network voltage spectrum for all phases in table format (Figure 62). Both the absolute values and the % of the fundamental component values are shown for each spectral component up to the 49th rank.

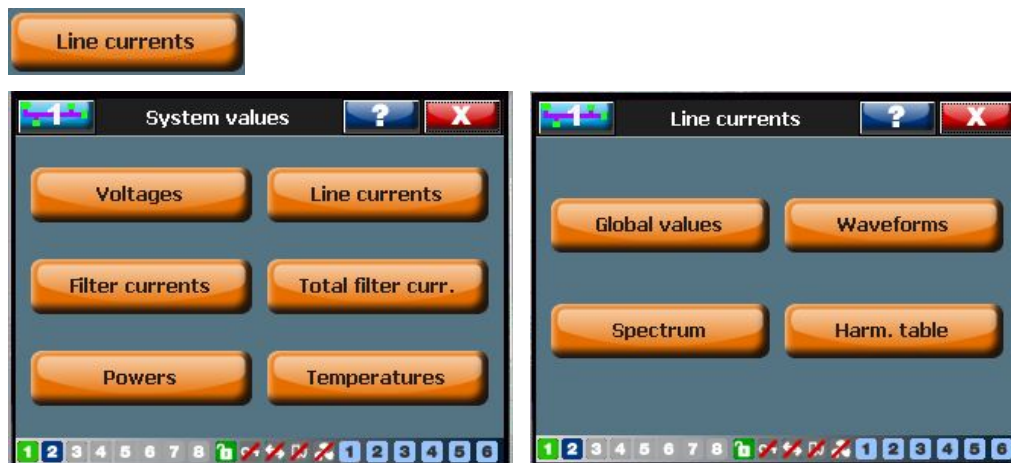
Rank	%	V
1	100.0	235.97
2	0.0	0.00
3	0.2	0.47
4	0.0	0.00
5	0.7	1.65
6	0.0	0.00
7	0.5	1.40
8	0.0	0.00
9	0.2	0.47

Figure 62: Spectrum of the network voltage in table format displayed by the PQF-Manager (4-W mode example)

Following parameters are displayed in the sub-menu “Voltages” itself in a tabular form.

- The network frequency
- The network imbalance
- The active filter DC bus voltage of the selected unit
- The active filter DC bus voltage (max.)

7.8.2.2. Line currents



Refer to [Table 39](#) for an explanation of the parameters.

7.8.2.2.1. Global values

Measurements	System values	Unit
Irms (L1)	275.3	A
Irms (L2)	285.4	A
Irms (L3)	283.1	A
Irms (N)	63.2	A
THDI (L1)	23.1	%
THDI (L2)	26.2	%
THDI (L3)	22.8	%
I1 (L1)	270.2	A
I1 (L2)	272.1	A
I1 (L3)	271.6	A

Irms, I1 and THDI are displayed in table format.

7.8.2.2.2. Waveforms

The line current waveforms for all phases (3-W mode) and the neutral current waveform (4-W mode). The graph layout is similar to the one of the voltages (Figure 60). All waveforms are synchronized with the rising edge zero crossing of the voltage V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).

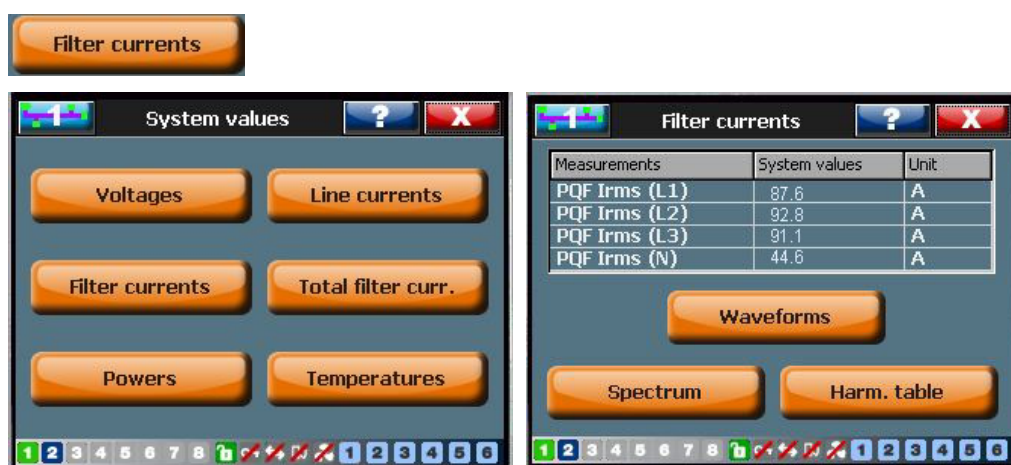
7.8.2.2.3. Spectrum

The line current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in chart format. The chart layout is similar to the one of the voltages (Figure 61).

7.8.2.2.4. Harmonic table

The line current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in table format. The table layout is similar to the one of the voltages (Figure 62).

7.8.2.3. Filter currents



Refer to Table 39 for an explanation of the parameters.

PQF Irms in table format for the unit selected with the 'Select Unit' option.

7.8.2.3.1. Waveforms

The filter current waveforms for all phases for the unit selected with the 'Select unit' option. The graph layout is similar to the one of the voltages (Figure 60). All waveforms are synchronized with the rising edge zero crossing of the voltage V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).

7.8.2.3.2. Spectrum

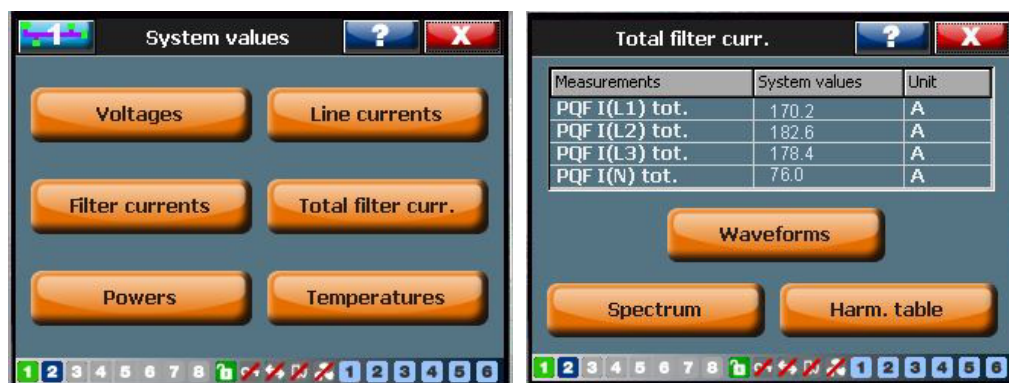
The filter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in chart format for the unit selected with the 'Select unit' option. The chart layout is similar to the one of the voltages (Figure 61) but the values are expressed in absolute terms.

7.8.2.3.3. Harmonic table

The filter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in table format for the unit selected with the 'Select unit' option. The table layout is similar to the one of the voltages (Figure 46) but only absolute current values are shown.

7.8.2.4. Total filter currents





Refer to [Table 39](#) for an explanation of the parameters.

PQF Irms in table format for the complete filter system.

7.8.2.4.1. Waveforms

The filter current waveforms for all phases for the complete filter system. The graph layout is similar to the one of the voltages ([Figure 60](#)). All waveforms are synchronized with the rising edge zero crossing of the voltage V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).

7.8.2.4.2. Spectrum

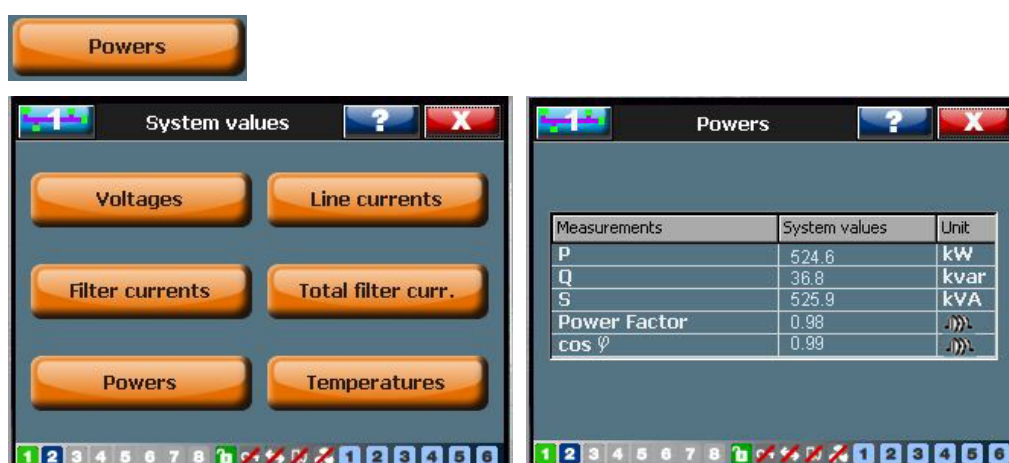
The filter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in chart format for the complete filter system. The chart layout is similar to the one of the voltages ([Figure 61](#)) but the values are expressed in absolute terms.

7.8.2.4.3. Harmonic table

The filter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in table format for the complete filter system. The table layout is similar to the one of the voltages ([Figure 46](#)) but only absolute current values are shown.

Note: For a multi-unit filter system, the total filter current is an approximate value. More detailed values for the individual units can be obtained in the 'Filter currents'-menu.

7.8.2.5. Powers

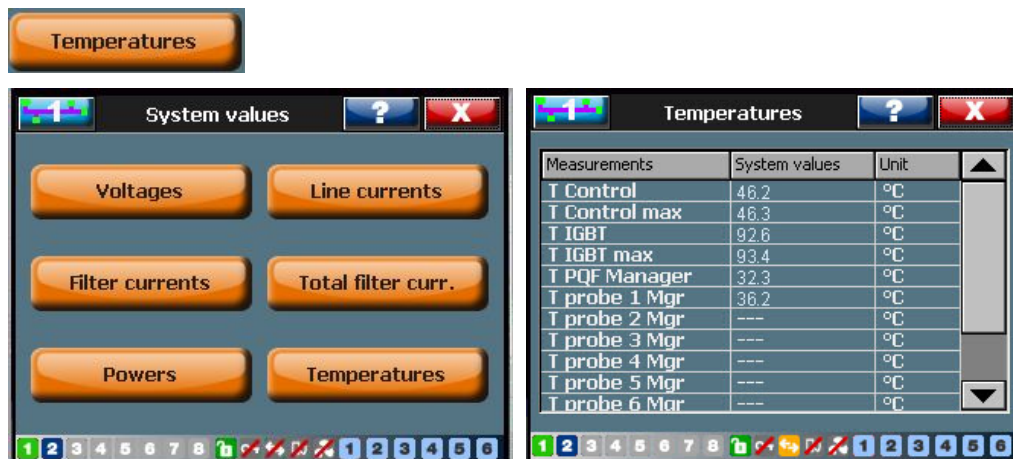


The power in the system at the location of the CTs: (Refer [Table 39](#) for an explanation of the parameters).

- Active power P
- Reactive power Q

- Apparent power S
- Power factor PF
- Displacement power factor $\cos \varphi$

7.8.2.6. Temperatures



Refer to Table 39 for an explanation of the parameters.

- Temperatures may be expressed in °C and in °F. For changing the temperature unit, go to [Welcome/Setttings/Customer set. /Temp unit].
- Temperature of the hottest IGBT ('T IGBT') of the unit selected by the 'Select unit'-option. Temperature of the hottest IGBT (T IGBT max) in a multi-unit system
- Temperature of the control board ('T Control') of the unit selected by the 'Select unit'-option
- Temperature of the hottest control board ('T control max') in a multi-unit system
- Temperature recorded by the optional temperature probes (up to 8 probes can be connected on each PQF-Manager)

7.8.3. The 'Min-Max logging' menu



The 'Min-Max logging' function allows for the user to log for each significant measured item and since the last reset:

- The maximum (or minimum) value
- The duration above (or below) the threshold

Once a threshold has been set the PQF-Manager starts recording the maximum (or minimum) value automatically as well as the total duration until a reset is performed. Figure 63 illustrates this.

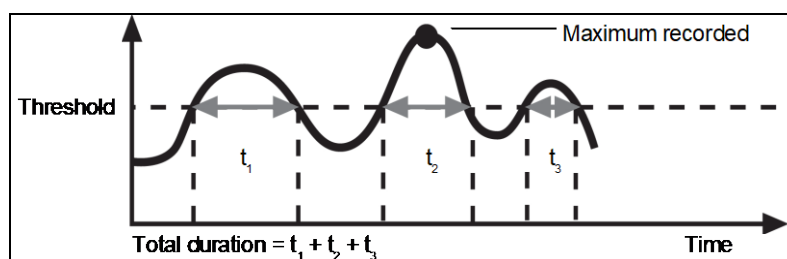


Figure 63: Illustration of the threshold and the maximum recorded value used in the Min/Max logging function

The parameters that can be used with the logging function are voltages (Vrms, THDV), currents (Irms), Power (P, Q, S), frequency and temperature (T IGBT and Tcontrol) along with temperatures recorded by the probes (max. 8 probes possible). All information about temperature are specific to the probe connected to the PQF-Manager where the probe is connected. Refer to Table 39 for an explanation of the parameters. For the frequency, minimum values and duration below a threshold can also be recorded.

The recorded information may be cleared by selecting and validating the 'Reset' item.

If the hardware lock is engaged, the logging function cannot be started nor reset (Cf. Section 7.6)

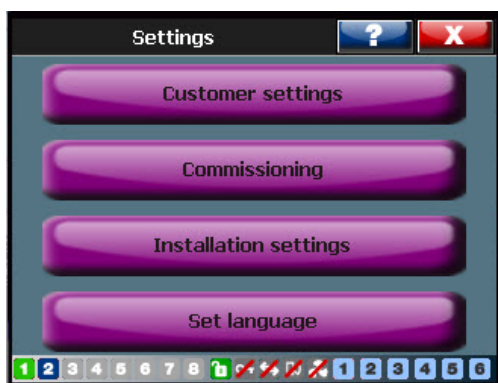
Figure 64 shows an example in which the network voltage between L1 and L2 is monitored. The nominal network voltage is assumed to be 400 V. The threshold was initially set at 1000 V and is changed to 420 V.



Figure 64: Example of the Min/Max logging function (4-W mode)

7.9. The 'Settings' menu





The 'Settings' menu [/Welcome/Settings] has four main levels:

- The **customer level** which allows the user to set up the typical user requirements such as harmonic filtration settings, the reactive power settings, sets up the digital inputs and outputs and defines the programmable warnings and alarms. At this level, the user can also change the temperature unit used by the system. The customer level is accessed through [/Welcome/Settings/Customer set.]
- The **commissioning level** which allows the commissioning engineer to set up the equipment according to the customer's installation. Typical parameters that need to be entered are the network voltage and frequency, the CT parameters and a derating factor that needs to be applied when the installation is at great height above sea level or in conditions where excessive ambient temperatures are present. At the commissioning level the possibility also exists to set up the user's requirements for harmonic filtration and reactive power compensation. The commissioning level is accessed through [/Welcome/Settings/Commissioning].
- The **installation settings level** allows for the commissioning engineer to set up advanced system functions such as the filter auto restart and standby functions, the clock, the communication of Modbus and PQ-Link and the setting of a system lock with password.

For information purposes the installation settings level also shows the settings for the network voltage and frequency, the rating of the filter unit(s), the CT parameters and the derating factor that has been set-up at the commissioning level. The installation settings level is accessed through [/Welcome/Settings/Installation set.]

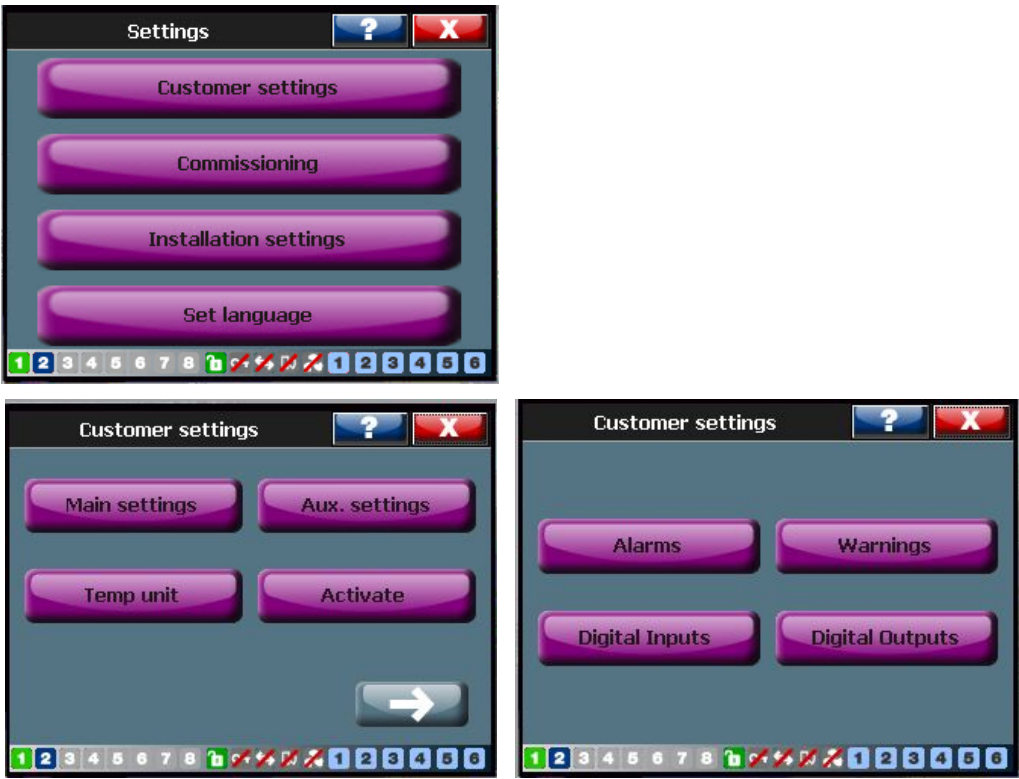
- Apart from above three, the fourth button allows the language setting. The PQF-Manager supports six languages: English, French, German, Spanish, Chinese (simplified) and Korean.

Note: In active filter systems consisting of more than one master, the PQF-Manager of the master that has the control over the system has full functionality and the PQF-Managers of the other master units have limited functionality. In practice, the functions that are not enabled on these units are locked and a  symbol will appear. These functions are set up in the 'real' master and are automatically further dispatched to the other units by the control system.

All functions and measurements (e.g. digital I/O, temperature) which are "hardwired" to a PQF-Manager provide data/control only for that specific filter unit.

7.9.1. The 'Customer settings' menu





The customer settings menu is intended to be used by people that are authorized to change the filter operation settings.

Refer to [Section 7.6](#) for determining appropriate locking facilities for this menu.

7.9.1.1. Settings up harmonics, reactive power and filter mode



In multi-master units these functions need to be set up only in the master with the lowest hardware ID (0001 in case of single module and 0000 in case of multiple units) setting in the DIP switch.

Setting up harmonics, reactive power and filter mode can be done in a main window [/Welcome/Settings/Customer set./Main settings] and in an auxiliary window [/Welcome/Settings/Customer set./Auxiliary settings]. By having two windows, the customer can set two sets of different settings, e.g. one set for mains operation and one set for generator operation, or one set for day settings and one set for night settings. Both main and auxiliary settings windows have the same setup possibilities, i.e.

- Definition of the filter mode

- Selection of the harmonics with setting of curve levels
- Selection of reactive power compensation with balancing functionality
- Deselection of all harmonics

The filter has to be informed about whether the main window settings or the auxiliary window settings must be used. This is done by the 'Activate' flag [/Welcome/Settings/Customer set/Activate]. Possible values for this flag are given in [Table 40](#). By default the filter uses the main filter settings.

Table 40: Possible settings for the activate field

'Activate' field value	Description
Main	Main window settings are always used
Auxiliary	Auxiliary window settings are always used
Ext. input	The filter switches between the main and the auxiliary settings according to a signal applied to the PQF-Manager's digital input ^(a) .

Remark:

(a) Refer to detailed manuals for cabling instructions for this feature. Refer to [Section 7.9.1.4](#) configuring the digital input for this feature. The external input must be provided to the PQF-Manager which acts like the "master" unit.

7.9.1.1.1. Setting up the filter mode



For setting up the filter's main filter mode go to [/Welcome/Settings/Customer set./Main settings/Filter mode].

For setting up the filter's auxiliary filter mode go to [/Welcome/Settings/Customer set./Auxiliary settings/Filter mode].

The filter can have three types of effect on the network:

- Filter the selected harmonics until their magnitudes are close to zero (Maximum Filtering)
- Filter the selected harmonics until their magnitudes reach the residual level permitted by the user (Filtering to Curve)
- Produce or absorb reactive power including load balancing

The user can put the emphasis on one of the above effects by selecting the filtering mode.

[Table 41](#) shows the three available modes:

Table 41: Available filter modes

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	88/188

	Highest priority level	←————→	Lowest priority level
Mode 1	Filtering to curve	Maximum filtering	Reactive compensation
Mode 2	Filtering to curve	Reactive compensation	Maximum filtering
Mode 3	Filtering to curve	Reactive compensation	-

In Mode 1, the filter will first filter to the pre-programmed curve. Once the requirements are fulfilled, the remaining resources will be allocated to reducing the selected harmonics as close as possible to zero. If further resources are then available, reactive power compensation and load balancing will be performed as required.

In Mode 2, the second priority after filtering to the curve is reactive power compensation and load balancing. Maximum filtering comes in third place and will be done if both the curve specification and the reactive power requirements including balancing are fulfilled.

In Mode 3, the filter will first ensure that the harmonic curve specification is fulfilled. If then there are still resources available, the filter will do reactive power compensation and load balancing if requested by the user.

Figure 65 illustrates the principle of filtering to curve for one particular harmonic order. The flexibility of the PQF control is such that a specific curve level may be defined for each selected harmonic.

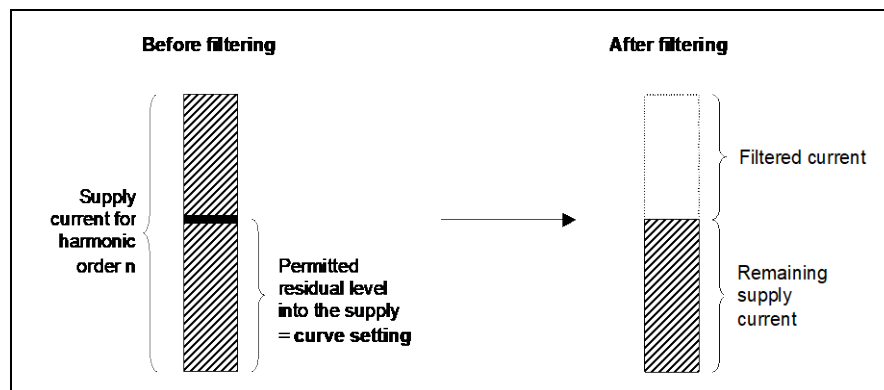
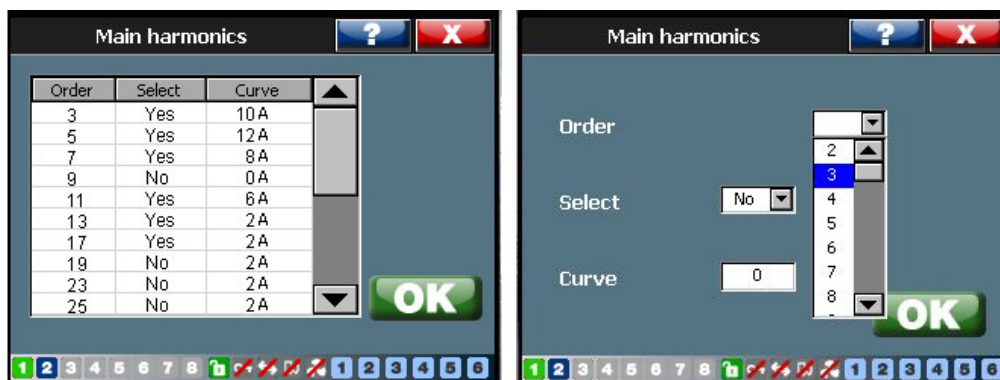


Figure 65: Filtering to curve for harmonic order n

The default filter mode is Mode 3.

7.9.1.1.2. Selecting the harmonics with setting of curve levels



For setting up the filter's main harmonics selection go to

[/Welcome/Settings/Customer set./Main settings/Main harmonics]

For setting up the filter's auxiliary harmonics selection go to

[/Welcome/Settings/Customer set./Auxiliary settings/Aux. harmonics]

The harmonics that can be selected are presented in a table such as presented in [Table 42](#). When the PQF is operating in 4-W mode, 15 harmonics can be selected. When the PQF is operating in 3-W mode, 20 harmonics can be selected.

Table 42: Example of harmonic settings table displayed by PQF-Manager

Order	Select ^(a)	Curve ^(b)
3	Yes	0 A
5	Yes	10 A
7	Yes	0 A
9	No	0 A

Remarks:

(a) The 'Select' column may have three values:

No: Harmonic not selected by user

Yes: Harmonic selected by user and being filtered

S: Harmonic selected by user but put in 'standby' by the filter. Refer to [Section 8.10](#) for more information on the "harmonic standby" mode.

(b) Curve settings for allowed current into the network are expressed in Amps

In order to select the harmonics and set up a curve level (if desired)

- Open the harmonic table by selecting the "Main harmonics". The table has a default factory setting.
- Select any row by touching it, a new window opens up with two drop down menu (one for harmonic order and another for select option) and a third one to enter the "curve" value. In the harmonic order all harmonics from 2nd to 49th order are listed but, only those harmonics which are not already chosen appears selectable and those which are already in the pre-selected list appear "greyed". Once a new harmonic order is selected, the table automatically gets sorted in ascending order. In order to remove any harmonic order from this list, one has to touch that row and then from the dropdown menu, replace that harmonic order by any other harmonic of choice.
- Note: Above procedure is only to include (or exclude) any harmonic order in the list. Further to that, the user must select specific harmonics by choosing Yes or No from the other dropdown menu for the filter to consider them for filtering
- To set the curve value, the "curve" data entry window needs to be selected. As soon the window is touched, the numeric keypad appears allowing the user to set a desired curve level (in terms of Amp). Fractional values are not accepted and are rounded off to the nearest integer. Once all the harmonics are programmed, the harmonic selection table can be exit by pressing. The  button at the top right corner.

7.9.1.1.3. Deselect all harmonics



For deselecting all harmonics of the main window at once go to

[/Welcome/Settings/Customer set./Main settings/Deselect all]

For deselecting all harmonics of the auxiliary window at once go to

[/Welcome/Settings/Customer set./Auxiliary settings/Deselect all]

This function allows for the customer to quickly deselect all harmonics in the main or the auxiliary window. This may be useful e.g. when the commissioning engineer realizes that the CTs have been installed wrong and an intervention is required to correct the problem.

7.9.1.1.4. Selecting the reactive power compensation and balancing options



For setting up the filter's main reactive power and balancing mode go to [/Welcome/Settings/Customer set./Main settings/Main PFC/Bal.]

For setting up the filter's auxiliary reactive power and balancing mode go to [/Welcome/Settings/Customer set./Auxiliary settings/Aux. PFC/Bal.]

The active filter can perform different reactive power tasks including balancing, each of which require the appropriate setup. **Table 43** shows an overview of the possible tasks and shows how the filter set up should be done to implement this task. The parameters (italic print) referred to in **Table 43** can be accessed in the 'Main PFC/Bal.' and 'Aux. PFC/Bal.' windows of the PQF-Manager.

Table 43: Reactive power tasks that the filter can perform

Reactive power task requirement	Description and filter set-up to be made
No requirements	<i>PFC type:</i> Disabled Balance load: Disabled The filter will not do any reactive power task, regardless of the values set for $\cos \varphi$ or static reactive power
Power factor compensation with inductive power factor set point, no load balancing required ^(a)	<i>PFC type:</i> Dyn. Ind. Target $\cos \varphi$: Desired power factor between 0.6 and 1.0 The filter will do power factor compensation up to the $\cos \varphi$ set point, regardless of the value set for static reactive power^(b)
Power factor compensation with capacitive power factor set point, no load balancing required ^(a)	<i>PFC type:</i> Dyn. Cap. Target $\cos \varphi$: Desired power factor between 0.6 and 1.0 The filter will do power factor compensation up to the $\cos \varphi$ set point, regardless of the value set for static reactive power^(b)
Fixed capacitive power step with a rating of x kvar, no load balancing required ^(a)	<i>PFC type:</i> Static cap. <i>Q static:</i> x kvar The filter will generate x kvar reactive capacitive power, regardless of the value set for the target $\cos \varphi$
Fixed inductive power step with a rating of x kvar, no load balancing required ^(a)	<i>PFC type:</i> Static ind. <i>Q static:</i> x kvar The filter will absorb x kvar reactive inductive power, regardless of the value set for the target $\cos \varphi$

Remarks:

^(a) When load balancing is required, set the '*Balance load*' flag to the desired mode. The following modes are available depending on the way the filter is connected (3-W or 4-W)

- 'Disabled': No load balancing is done.
- 'L-L': Loads connected between phases only are balanced. Loads connected between phases and neutral are not balanced.
- 'L-N': Loads connected between phase and neutral are balanced. Loads connected between phases are not balanced. This mode is only available when the filter is connected in 4-W mode.
- 'L-L & L-N': Both loads connected between phase and neutral as well as loads connected between phases are balanced. This mode is only available when the filter is connected in 4-W mode.

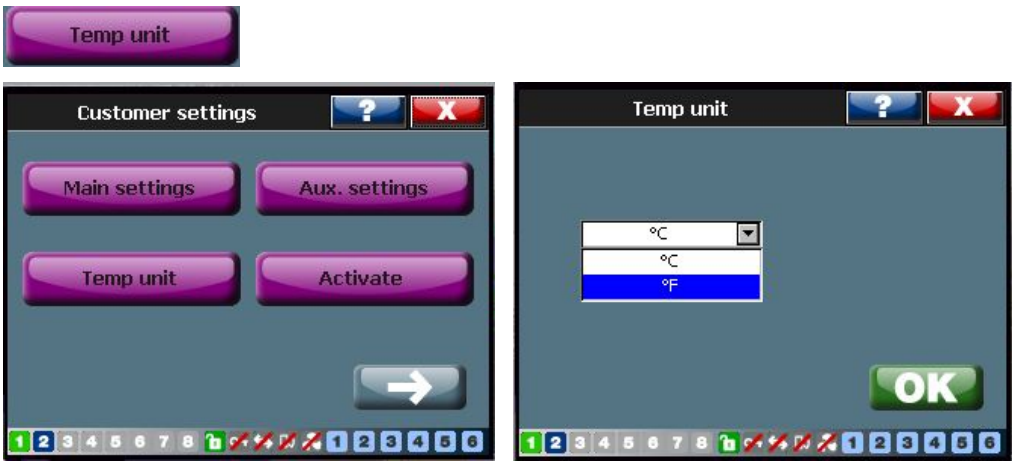
Note: The modes 'L-N' and 'L-L & L-N' can be used to minimize the amount of fundamental frequency current flowing in the neutral.

^(b) If the measured $\cos \varphi$ is higher than the set point and is inductive (e.g. measured 0.97 inductive and set point 0.92 inductive, then the filter will not make any correction. If the measured $\cos \varphi$ is capacitive, the filter will correct the power factor to 1.0

^(c) If the measured $\cos \varphi$ is higher than the set point and is capacitive (e.g. measured 0.97 capacitive and set point 0.92 capacitive, then the filter will not make any correction. If the measured $\cos \varphi$ is inductive, the filter will correct the power factor to 1.0

Note: In the Main PFC/Balancing window, there is a “Sliding bar” which can also be used to set the target PF in case of dynamic compensation.

7.9.1.2. Temp unit



This menu provides two temperature units: Celsius and Fahrenheit.
User can choose the unit (Celsius or Fahrenheit) for all temperature measurements or settings.

7.9.1.3. Activate menu



The “Activate” function is used to select the setting (Main or Aux.) with respect to harmonics & PF/Load balancing. If the “main” is selected by the user in this menu, the filter operated as per the data provided by the user in the “main” setting. Same applies if “Auxiliary” is selected here. If “Ext. Input” is selected, the filter changes its operation based on the “Digital Input” selection [Welcome/Setting/Customer Setting/Digital Inputs] chosen by the user.

7.9.1.4. Setting up alarms, warnings and digital inputs and outputs (D I/O)



The PQF-Manager contains 2 digital inputs, 6 digital outputs and 1 alarm contact (with two complementary outputs). These contacts can be used to provide data to the filter (e.g. remote control signals) and get data out of the filter (e.g. filter status information, alarm information etc.). This section discusses the PQF-Manager setup for controlling all the digital I/O and creating warnings and alarms.

7.9.1.4.1. Alarms and warnings



– Programmable alarms and warnings



– Temperature alarm and warnings levels

Temp. alarm levels

T probe 1 Mgr

40.0

°C

T probe 5 Mgr

40.0

°C

T probe 2 Mgr

40.0

°C

T probe 6 Mgr

40.0

°C

T probe 3 Mgr

40.0

°C

T probe 7 Mgr

40.0

°C

T probe 4 Mgr

40.0

°C

T probe 8 Mgr

40.0

°C

OK

Warning levels

V. min. warn.

360.0

V

V. max. warn.

440.0

V

Imbalance

3.0

%

Ground fault

90

%

T IGBT warn.

95

°C

T ctrl warn.

50

°C

→

OK

7.9.1.4.2. Set up of the digital inputs of the PQF-Manager

Digital Inputs

Dig. In 1

Disabled

Dig. In 2

Disabled

Edge ON

Edge OFF

Edge ON/OFF

Remote ON

Activ. main

OK

For setting up the digital inputs go to [/Welcome/Settings/Customer set./Digital Inputs]



7.9.1.4.3. Set up of the digital outputs of the PQF-Manager

Digital Outputs

Dig. Out 1

Auxil. ON

Dig. Out 2

Disabled

Dig. Out 3

Auxil. ON

Dig. Out 4

PQF running

Dig. Out 5

Full load

Dig. Out 6

T limit

In standby

Activ. main

Activ. aux.

Armed

OK

For setting up the digital output go to [/Welcome/Settings/Customer set./Digital outputs].

PQF-Manager has six programmable digital output contacts. Each of them can be programmed from a set of possible filter condition. If the selected condition is attained, that specific output contact closes.

WARNING: If a function is assigned to a digital input, the same function must never be assigned to the other digital input. Otherwise the filter may behave erratically.

For full redundancy with multi-master filters, these functions need to be set up in each master unit of the filter system and the functions should be cabled accordingly.

7.9.2. The 'Commissioning' menu



WARNING: The commissioning menu is intended to be used by qualified commissioning engineers that are authorized to change the filter's core installation settings and to set up the user's requirements.

In multi-master units these functions need to be set up only in the master with the lowest hardware ID setting.

The complete commissioning procedure must be executed each time a filter is (re)-installed or when a unit is added to the existing filter. During the commissioning procedure, the user settings will be lost, so note them down prior to starting the commissioning procedure.

Refer to [Section 7.6](#) for determining appropriate locking facilities for this menu.

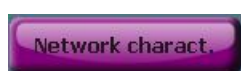
For an overview of the main items of the commissioning window, refer to [Figure 53](#). These items are discussed next.

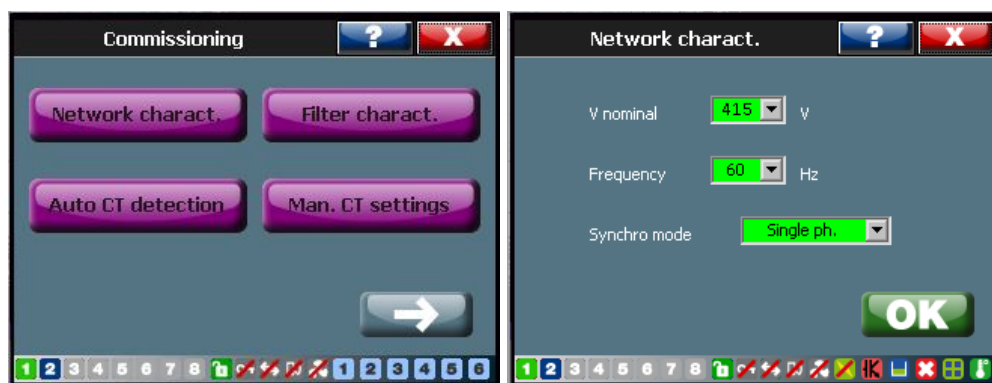
For commissioning the active filter follow the commissioning procedure presented in [Chapter 8](#).

Remarks:

- The commissioning window incorporates the start, stop and fault acknowledgement menu (Cf. [Section 7.7](#))
- For advanced filter setup (auto restart function, standby function, system clock setup, external communication setup, system lock activation and password setup) refer to [Section 7.9.3](#)

7.9.2.1. Setting up the network characteristics and the filter synchro mode





For modifying the network characteristics and the filter synchro mode, go to
[Welcome/Settings/Commissioning/Network charact.]

The network characteristics include:

- The nominal supply voltage: This value has to be set up according to the nominal value of the grid voltage.



WARNING: For PQFS filter, the hardware is by default set for operation at voltages in the range 380-415V. When the filter is used in networks with voltages in the range 208-240V, its hardware configuration needs to be changed. Refer to **Section 6.7.** for guidelines on how this needs to be done. Failure to adapt the filter hardware to the right network voltage range may result in hardware failure.

- The nominal value of the network frequency: This value has to be set up according to the nominal value of the network frequency.



WARNING: If the filter nominal frequency is changed to the wrong value, the filter will refuse to start indicating a frequency error in the event logging window.

- The active filter synchronization mode (Synchro Mode): by default single phase synchronization is used (Single ph.). In exceptional circumstances this may not be adequate. In that case choose three phase synchronization (Three ph.).



WARNING: This parameter shall only be changed by experienced commissioning engineers or after advice from the HITACHI service provider. Using the wrong synchro mode will lead to filter malfunctioning.

Remarks:

- After going through the network characteristics menu, the filter system will be automatically reset after which the new values will be taken into account.
- The filter needs to be stopped before the network characteristics menu can be accessed. Attempting to access the menu while the filter is running will result in a fault message being displayed.
- When involuntarily entering the menu, walk through the menu by pressing the  button or following the complete menu. This way the menu can be quit without modifying any values.

7.9.2.2. Setting up the filter characteristics



Except for PQFS filter, other filters (PQFS and PQFS) are always connected in 3-ph, 3-wire mode i.e. no neutral connected is needed. The PQFS filter can be configured as a 3-Ph, 3-wire or 3-Ph, 4-wire device.

For modifying the filter characteristics (3-wire or 4-wire connection mode) and number of units/unit ratings, go to [Welcome/Settings/Commissioning/Filter charact.]

In the main screen of filter characteristic setting, a warning message appears and by following the  button, the set-up screen appears. The warning states that if there is a mismatch between the selection of filter connection type (3 or 4-wire) and the actual cable connection to the PQFS (neutral cable not connected or otherwise) the filter may refuse to start. Following a choice is made by the user; the filter makes a “reset” of the system.

The PQFS filter may be connected in 3-wire mode (only phases connected) or in 4-wire mode (both phases and the neutral connected). Also the filter may consist of up to 4 parallel hardware units (8 for the PQFI and PQFS range) of the same rating. For PQFI & PQFS filters, unequal ratings are also allowed, please refer to the respective filter's detailed manual. The filter connection mode must be adapted in software to the on-site configuration. In addition, when the filter configuration is changed on site (e.g. going from one connection mode to another); the filter setup has to be adapted accordingly.



WARNING: Setting up a wrong filter configuration (possible in case of PQFS range) may lead to filter malfunction. This should only be done by experienced commissioning engineers.

When entering the 'Filter characteristics' window, first the connection mode has to be defined:

- 3-W: choose this mode when only the phases are connected. In this case, the filter can filter harmonics that are flowing between phases and make phase to phase balancing but cannot filter harmonics in the neutral nor make line to neutral balancing.
- 4-W: choose this mode when both the phases and the neutral are connected. In this case, the filter can filter harmonics between phases as well as harmonics in the neutral, and can perform balancing of loads connected between phases as well as connected phase to neutral.

Further note that:

WARNING: All hardware units in a master-slave filter arrangement must have the same rating in PQFS range. Combining hardware units of different ratings in the same filter panel will lead to hardware failure and/or inability for the filter to start up.

In the same screen, the user needs to enter the rating of each filter units connected together. For PQFS range, the unit rating needs to be identical whereas for PQFS and PQFI range, unequal rated filter units can operate together as well.

Remarks:

- The filter needs to be stopped before the unit ratings menu can be accessed. Attempting to access the menu while the filter is running will result in a fault message being displayed.
- Pressing the  button in the unit ratings setup menu will result into jumping to the next step in the menu without the values entered being taken into account. When involuntarily entering the menu, walk through the menu. This way the menu can be quit without modifying any values.

7.9.2.3. Setting up the current transformer ratios and position

The ratio of the current transformers connected to the filter (units) has to be entered into the filter system.

- For single master units, this has to be done only for that master
- For filter systems consisting of more than one unit, this has to be done for all the units of the system

Two methods can be used to do this.

- Using the automatic CT detection feature
- Entering the CT ratios and positions manually

These approaches are discussed next.

7.9.2.3.1. Automatic detection of the CT positions and ratio's



STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	99/188



For detecting the CT-settings automatically, go to
 [/Welcome/Settings/Commissioning/Auto CT detection]



WARNING: When launching the automatic CT detection procedure, the filter will connect to the network automatically. This may take several minutes in the case of large multi-unit filters. During this operation (high) operating voltages will be present in the filter unit. For personal safety reasons, close the filter cover before launching the CT detection procedure. Also ensure that the filter CT terminals (X21) are not shorted.

When engaging the automatic CT detection procedure the filter will execute the following steps:

- Deselect harmonics and reactive power/balancing settings previously entered by the customer
- Display a warning message to wait for the identification procedure to end
- Check the voltage level of the DC capacitors, close the main contactor and start the IGBTs
- Inject a small current into the supply
- Record the current measured by the CTs and calculate the filter CT ratios and positions
- Display a message indicating whether the CT identification ended successfully or not

NOTE: The automatic CT detection is repeated automatically for all the units present in a multi-unit filter system.

After the CT detection procedure has finished, the user has to reprogram the filter settings that were automatically deselected.

If the CT identification ended successfully, the filter carries on by:

- Showing the CT positions found. This is done in a table format as given in [Table 44](#)

Table 44: Automatic CT detection position-results presentation

Filter connection CT terminal ^(a)	Physical CT location and orientation ^(b)
Input 1	Line 1
Input 2	Line 2
Input 3	Line 3

Remarks:

^(a)This column refers to the filter terminal X21 located in the filter cubicle.

Input 1: filter input X21/1-2 (L1, R, U)

Input 2: filter input X21/3-4 (L2, S, V)

Input 3: filter input X21/5-6 (L3, T, W)

^(b)This column refers to the physical location of the CT connected to the input shown in the first column.

Line 1: CT connected in phase 1 (L1, R, U) with correct orientation

-Line1: CT connected in phase 1 (L1, R, U) with inversed orientation

Line 2: CT connected in phase 2 (L2, S, V) with correct orientation

-Line 2: CT connected in phase 2 (L2, S, V) with inversed orientation

Line 3: CT connected in phase 3 (L3, T, W) with correct orientation

-Line 3: CT connected in phase 3 (L3, T, W) with inversed orientation

When all CTs have been correctly installed, the PQF-Manager should display the results as in [Table 44](#). If the CTs have been connected wrongly, the corresponding line will read e.g.

Input 1 -Line 3 ...

In the example above, the CT connected physically in phase 3 (L3, T, W) has been routed to the filter terminal for phase 1 (L1, R, U). Further the CT orientation or the cabling has been inversed (k terminal of CT connected to l terminal of filter and vice versa).

- After showing the CT positions found, the customer is asked to either acknowledge the results found (by pressing ) or either not to accept them by pressing any other key. If any other key than  is pressed, the automatic CT detection program will be quit. The CT parameters existing before the automatic CT detection program was started will be restored.

If the CTs have been wrongly connected and the results are acknowledged by the commissioning engineer, the filter controller will automatically take into account the wrong positions and correct them internally. Hence, there is no need to correct the CT connections manually. However, in line with proper installation guidelines, it may be recommended to correct physically the CT installation. In that case, the CT setup of the filter has to be adapted accordingly.

- When the CT positions have been acknowledged the filter will carry on by showing the CT ratio found phase per phase. The values shown are indicative only and always have to be verified by the commissioning engineer. He can change the values by entering the right CT ratio. In order to approve the value entered  has to be pressed. [Table 45](#) explains the meaning of the text that appears on the display:

Table 45: Automatic CT detection ratio-results presentation

Text on PQF-Manager display	Meaning
Ratio found	Ratio found for the CT in the considered phase E.g. 200 means a CT of 1000/5
CT Ratio L1 ^(a)	Ratio that will be used by the filter for the CT physically connected in phase 1 (L1, R, U) of the installation
CT Ratio L2 ^(a)	Ratio that will be used by the filter for the CT physically connected in phase 2 (L2, S, V) of the installation
CT Ratio L3 ^(a)	Ratio that will be used by the filter for the CT physically connected in phase 3 (L3, T, W) of the installation

Remark:

- ^(a) The first phase has to be acknowledged before the second phase is displayed...

After acknowledging the last phase with , the filter will automatically reset and the new values will be taken into account. Pressing  at any time will interrupt the automatic CT detection process. In single unit filters, original CT-values and positions existing prior to the start of the procedure will be restored. In multi-unit filters, the new values will be stored in the units for which the CT setting were already accepted, and will be restored to the initial value in the other units.

If the CT identification ended unsuccessfully:

- The filter displays an error message indicating the reason for the problem. [Table 46](#) gives a list of the possible error messages.

Table 46: Possible error messages during automatic CT identification

PQF-Manager error messages during automatic CT identification

The CT identification found inconsistent CT positions.

The CT identification did not end within an appropriate time frame.

The CT identification required an abnormally high DC voltage.

The most common causes for these messages are:

- CTs not connected or shorted
 - CTs connected in open loop configuration
 - Usage of an excessive CT ratio (including summation CTs). The CT ratio limit is set at 20000/5.
- After acknowledging the error message, the CT values existing before the start of the process will be restored and the automatic CT detection procedure will be ended. The unsuccessful CT detection attempt is recorded in the event logging window.

Conditions under which the automatic CT identification process may give unsatisfactory results include:

- The use of CTs with extremely high ratio's (> 20000/5). This will result in an error message indicating inconsistent CT positions. In this, the ratio of the summation CTs that may be present should be included.
- The presence of a low impedance directly downstream of the filter connection although the CTs have been correctly installed upstream of the filter connection. This will result in wrong CT ratio's being found. In that case the commissioning engineer can easily correct the CT ratio's found.
- The use of complex CT arrangements including summing CTs.

It is recommended that the results obtained with the automatic CT detection procedure be crosschecked with a visual inspection of the installation.

7.9.2.3.2. Manual set up of the CT positions and ratio's



For detecting the CT-settings manually, go to

[/Welcome/Settings/Commissioning/Man. CT settings]

For multi-unit filters the CT data for each unit has to be entered.

When entering the manual CT setup menu the user is subsequently prompted to define for the selected filter unit of a filter system:

- for the CT connected to the filter CT terminals X21/1-2 (Input 1):
 - in which line (phase) is it installed (Line 1, Line 2, Line 3)
 - does the CT (cabling) have the good orientation (Line x) or not (-Line x)

Remark: If the CT installation is correct, enter 'Line 1'.

If the CT is installed in the right phase but inversed, enter '-Line 1'.

- for the CT connected to the filter CT terminals X21/3-4 (Input 2):
 - in which line (phase) is it installed (Line 1, Line 2, Line 3)
 - does the CT (cabling) have the good orientation (Line x) or not (-Line x)

Remark: If the CT installation is correct, enter 'Line 2'.

If the CT is installed in the right phase but inversed, enter '-Line 2'.

- for the CT connected to the filter CT terminals X21/5-6 (Input 3):
 - in which line (phase) is it installed (Line 1, Line 2, Line 3)
 - does the CT (cabling) have the good orientation (Line x) or not (-Line x)

Remark: If the CT installation is correct, enter 'Line 3'.

If the CT is installed in the right phase but inversed, enter '-Line 3'.

- for the CT physically installed in Line 1 (L1, R, U):
 - the CT ratio, which is always positive; e.g. a CT of 5000/5 has a ratio 1000
- for the CT physically installed in Line 2 (L2, S, V):
 - the CT ratio, which is always positive; e.g. a CT of 5000/5 has a ratio 1000
- for the CT physically installed in Line 3 (L3, T, W):
 - the CT ratio, which is always positive; e.g. a CT of 5000/5 has a ratio 1000

After entering all the above mentioned values, the filter resets and the settings are taken into account.

Remarks:

- Pressing  button during the manual CT setup procedure will result in:

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	104/188

- For single unit filters, the original CT-values and positions existing prior to the start of the procedure being restored.
- For multi-unit filters, the new values will be stored in the units for which the CT setting were already accepted, and will be restored to the initial values in the other units.
- **Section 8.6** gives guidelines on how to identify the position of the CTs in case the automatic CT detection procedure cannot be used or is unsuccessful.
- Refer to **Section 6.8.1** and **Section 6.10** for more information on the selection and the installation of the current transformers.

7.9.2.4. Setting up the filter rating parameter



For entering the rating parameter, go to

[/Welcome/Settings/Commissioning/Derating]

The permissible ambient conditions for PQF operation are laid out **Table 14**. If the filter is installed at locations higher than 1000 m (3300 ft) above sea level, the maximum filter output current must be derated by 1% every additional 100m (330ft).

- Above 40°C (104°F), the maximum output current must be derated by 3.5% every additional 1°C (1.8°F) up to 50°C (122°F) maximum limit.

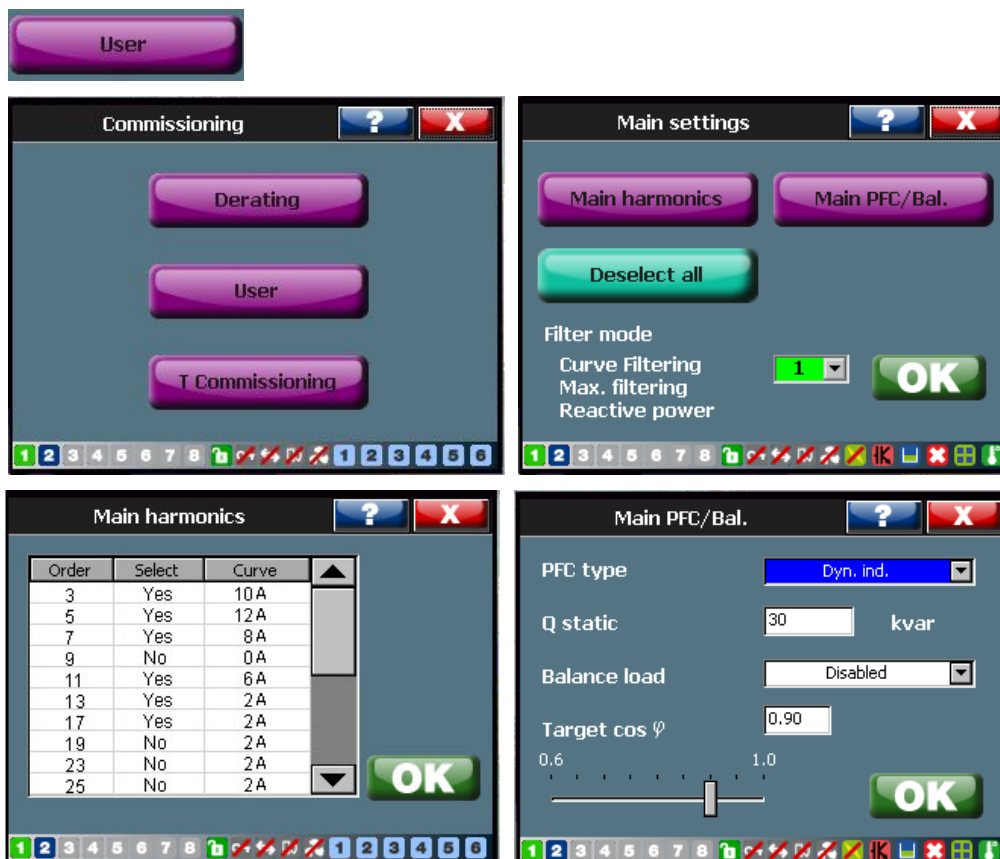
The total required derating is the sum of all the deratings taking into account the installation height and the ambient temperature.

The PQF-Manager rating menu shows the filter nominal rating, which is by default 100%. The new value to be set when derating is required is 100% - (total required derating %).

After approving the new rating value (**OK**), the filter will reset and the new value will be taken into account. In practice, this implies that the output current of the unit will be limited to the filter nominal current times the entered rating factor. E.g. a rating factor of 50% implies that the maximum RMS filter current is half the nominal filter current.

Pressing **X** will result in the original value being restored and the filter rating menu being quit.

7.9.2.5. Setting up the user's requirements



For entering the user's requirements at the commissioning level, go to [Welcome/Settings/Commissioning/User]

At the commissioning level, a shortcut exists to the principal user set up menus. These consist of:

- Setting up the filter mode for the main settings. After selecting the desired value, press **OK** to go to the next step.
- Setting up the harmonic selection table for the main settings. After entering the desired values (cf. [Section 7.9.1.1](#)), press **OK** repeatedly until the next step is displayed.
- Setting up the reactive power requirements including balancing for the main settings. After selecting the desired values, press **OK** to go to the next step.
- After entering the data, the main settings can be copied on to the auxiliary settings (if desired) by pressing **OK**. Pressing any other key will omit this step.
- The set-up ends by displaying the main commissioning menu.

Remarks:

- Refer to **Section 7.9.1.1** for more explanation on the main and auxiliary filter settings, the filter mode, the harmonics selection table and reactive power setup possibilities.
- A more complete user set up process can be done at the customer settings level (cf. **Section 7.9.1**).
- In order to interrupt the set up process, press  repeatedly until the stop message appears. It should be noted that any parameters entered before the procedure is stopped, will have been recorded in the filter's memory. Re-enter the user set up to change the values again if desired.

7.9.2.6. Commissioning of temperature probes



For commissioning the temperature probe(s), go to

[/Welcome/Settings/Commissioning/T Commissioning]

User can connect up to eight temperature probes in a daisy chain to the PQF-Manager. Each probe needs to be commissioned as following procedures before it can be used. Each probe has to be recognized one by one:

- Connect the probe to the temperature probe input (one probe only)
- Click on a row to assign a probe number
- click on the “Start” button
- The PQF-Manager recognize automatically the probe address
- Restart the same procedure for each probe

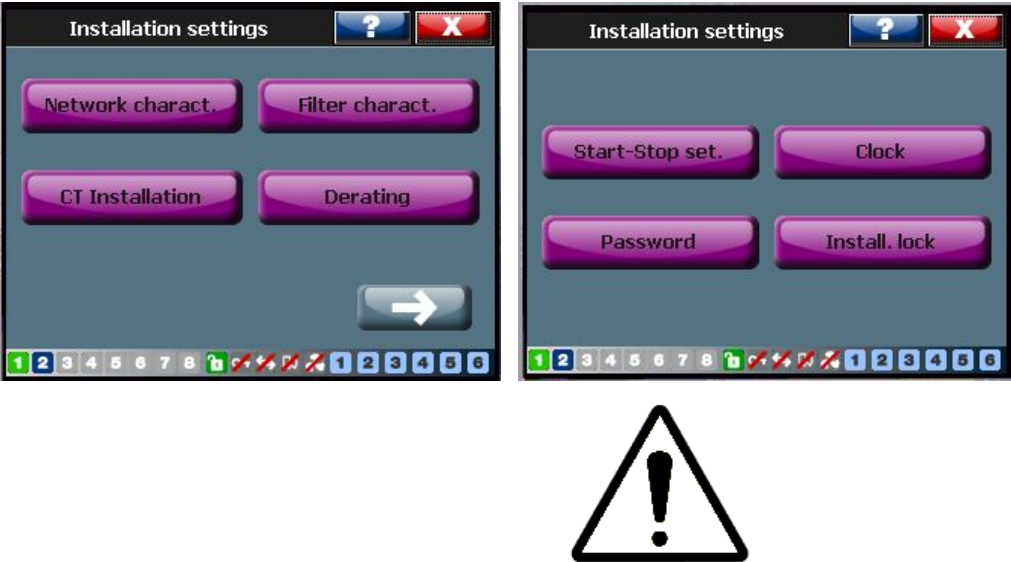
When one of the probes has a problem, it can be cleared by selecting that row and clicking the “Clear” button. A unique address will be assigned to each activated probe after the recognition completes. This unique address is a set of eight groups of numbers like:

142 85 0 25 12 1 12 156

Note: In a multiple “Master” filter situation, it is recommended that all the temperature probes are connected to the PQF-Manager installed on the unit assigned the “Master” status. In case of failure of Master unit, the next unit assumes the role of Master, however, the temperature probe connection needs to be physically shifted to the new Master unit and commissioning of probes be redone on the new PQF-Manager for the probes to function properly.

7.9.3. The ‘Installation settings’ menu





WARNING: The installation settings menu is intended to be used by qualified commissioning engineers that are authorized to change the filter’s advanced settings.

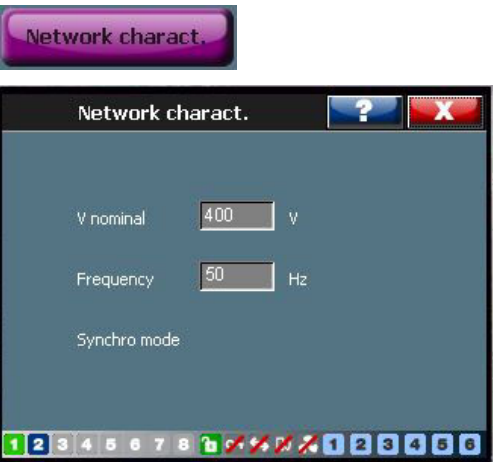
The filter’s advanced settings include:

- Setting up the ‘auto restart’ function
- Setting up the ‘auto restart’ function
- Setting up the system clock
- Setting Password

The aforementioned functions are discussed more in detail later in this section.

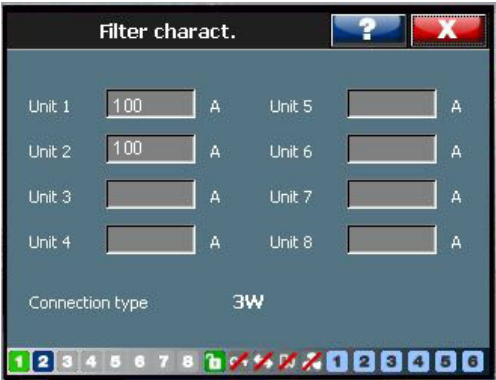
For convenience, the installation settings menu also gives an overview of the installation settings. More specifically, the following settings can be read:

- Settings for the nominal voltage, frequency and synchro mode ([/Welcome/Settings/Installation set./Network char-act.])



- Filter characteristics ([/Welcome/Settings/Installation set./Filter charact.])

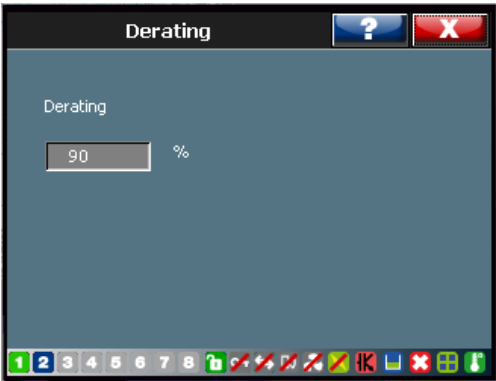
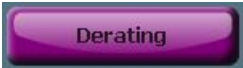




– CT installation settings ([/Welcome/Settings/Installation set./CT Installation])



– % Rating setting ([/Welcome/Settings/Installation set./Rating])



Where applicable the settings for individual units in a filter system can be reviewed by selecting the appropriate unit.
Note that the settings of the above-mentioned parameters can only be changed at the commissioning level (Cf. [Section 7.9.2](#)).

7.9.3.1. Setting up the ‘standby’ function



For setting up the ‘standby’ function, go to [/Welcome/Settings/Installation set./Start-Stop set.]

In multi-master units these functions need to be set up in each master-unit in order to obtain full redundancy.

The 'standby' function when enabled puts the filter in standby, a preset time after the load requirement disappears. In this condition, the IGBTs stop switching while the main contactor remains closed (filter remains connected to the network). This way the filter losses become virtually zero. The filter will resume normal operation a preset time after the load requirement comes back. The standby function is particularly interesting for applications where the load is present for a long time and subsequently switches off for another long time.

In order to set-up the standby function, five parameters have to be defined:



– 'Stdby status':

When enabled, the 'standby' function is activated.

When disabled, the 'standby' function is deactivated.

– 'Standby level' and 'Standby hyst':

Define the filter load level in % on which the filter goes in standby and comes out of standby.

– 'Stdby del on':

Defines the time during which the filter load level has to be higher than the upper threshold level before the filter comes out of standby.

– 'Stdby del off':

Defines the time during which the filter load level has to be smaller than the lower threshold level before the filter is put in standby.

7.9.3.2. Setting up the 'auto restart' function



For setting up the 'auto restart' function, go to [/Welcome/Settings/Installation set./Start-Stop set.].

In multi-master units these functions need to be set up in each master-unit in order to obtain full redundancy.

The 'auto restart' function when enabled ensures that the filter restarts automatically after a power outage if the filter was on before the power outage occurs. A time delay can be programmed to define how long after the power returns, the filter will restart. When the 'auto restart' function is disabled, the filter will not restart automatically after a power outage.

- To enable/disable the 'auto restart' function, go to [/Welcome/Settings/Installation set./Start-Stop set./] and enable the auto start option.
- To program the delay after which the filter has restart once the power returns, in the same menu specify the desired delay. This delay is available from the "drop –down" menu, in "seconds".

Remark: By default the 'auto restart' function is enabled and the delay time is set at 15s.

7.9.3.3. Setting up the system clock



For setting up the system clock, go to [/Welcome/Settings/Installation set./Clock]

In multi-master units these functions need to be set up in each master-unit in order to obtain full redundancy.

The PQF is equipped with a system clock, which can be modified by the user. The date and the time (Hr, Min. Sec) can be changed. The hour is presented in 24-hour format and is set up for the time zone GMT +1.

7.9.3.4. Setting Password



For setting up the password, go to [/Welcome/Settings/Installation set./Password]

A password setting allows the user to set a software lock of the settings. Once set and the installation are locked, the crucial parameters cannot be changed unless the software lock is removed.

A customer can choose a 4 digit password of his choice to activate the software lock. During selection, first the old password (default: 1234) needs to be entered followed by a new password. The new password needs to be confirmed. Now pressing the **OK** button saves the new password.

7.9.3.5. Installation Locking



For Installation locking, go to [/Welcome/Settings/Installation set./Install Lock]

In order to enable the software lock, one needs to enter the password first. With correct password entered, the installation gets a software lock and changing of key parameters is prohibited. The software lock can be disabled after checking the "Installation Unlocked" check box. This checkbox can be used only after entering the right password.

7.9.4. Set Language



This menu allows the user to choose one of the six languages (English, French, German, Spanish, Chinese and Korean) available in the PQF-Manager. The default setting is English.

7.10. The 'PQF monitoring' menu





The 'PQF monitoring' menu can be accessed in the main Welcome screen [/Welcome/PQF monitoring].

This menu allows to monitor the filter load and to get an idea of its operating point compared to the nominal rating of the filter. In addition, logged warnings and faults can be retrieved for troubleshooting the filter operation and any abnormal network conditions.

Where applicable the different units in a filter system can be selected to get more detailed information on parameters of the individual unit.

The PQF monitoring menu can also be used to check the status of individual units of a multi-filter system. If required, errors in individual units can be reset.

The items of the 'PQF Monitoring' menu are discussed next.

7.10.1. The 'Status of module' menu



This menu shows for each unit of a filter system its status and allows resetting the 'fault' status of individual units.

Three possible status indications exist:

- Ready: The unit considered does not have a fault and can run normally.
- Ack. Fault: The unit considered has been stopped due to an error. By pressing Ack. Fault, the reason for the fault will be displayed and an attempt will be made to clear the fault. When doing this, the complete filter system will be shut down. If the fault could be cleared, the unit status will become 'Ready'. If the fault could not be cleared, the unit status will remain 'Ack. Fault'. In the fault clearing process, the complete filter system will be shut down. The filter can be restarted after the fault clearing process has ended.
- Not present: The unit considered has been excluded of the normal filter operation due to either:
 - The unit is physically not present
 - The unit is physically present but the control board power is not present

7.10.2. The ‘Filter load’ menu



The filter load menu shows bar graphs expressed in % indicating the filter load with respect to the nominal rating of the following parameters:

- Inverter DC bus voltage: ‘Udc’ graph
- Peak current of the IGBT-modules: ‘Ipeak’ graph
- RMS current of the IGBT-modules: ‘Irms’ graph
- IGBT-temperature: ‘Temp’ graph

For multi-unit filters, this data can be obtained for each individual unit.

7.10.3. The ‘Event logging’ menu



The ‘event logging’ window stores the events that are recorded by the filter controllers. The event buffer stores the 200 most recent events. **Figure 66** gives an example of the event window. Two buttons are available on this screen, one scrolls to the next 10 events and the other the previous 10 events at a time.



Figure 66: Example of an event window

The explanation of the different items is given in [Table 47](#).

Table 47: Item explanation of the event window

Item	Explanation
1	Event number (0-199) The smaller the number, the more recent the event
2	Event type Table 48 gives an overview of the possible event types
3	Date and time at which the event occurred
4	If the event reported is a fault, which is considered critical by the system, a 'Critical' indication will appear on the screen.
5	Fault description list if the event was a fault. Table 49 and Table 50 give an overview of the possible faults that can be reported.

When entering the 'Event logging' window, the most recent event is always displayed. Use the arrow keys to scroll through the event list. Use any other key to quit the menu.

Table 48: Overview of the events that can be recorded

Event	Description
No event	No storable event has occurred yet
Energization	The power has been switched on
System reset	The filter controller has been reset
Start request	A filter start has been requested
Stop request	A filter stop has been requested
Fault (DSP)	The DSP controller has reported a fault
Fault (uC)	The μ controller has reported a fault
Fault cleared	A user attempt to clear a fault has been recorded (by validating the 'ACK. FAULT' option on the PQF-Manager)

Event	Description
No more fault	The system detects no more faults
Power outage	The system has detected a power outage
Download DSP	A DSP controller firmware upgrade (attempt) has been recorded
DSP stop	An internal stop command coming from the DSP controller has been recorded

From **Table 48** it can be seen that both the DSP controller and the μ controller can record faults. Where the faults reported by the μ controller are predominantly relating to a control board failure, the faults reported by the DSP relate predominantly to the filter interacting with the installation. **Table 49** gives an overview of the faults that can be reported by the DSP controller. The list is in alphabetical order.

Table 49: Overview of the faults that can be reported by the DSP controller

DSP fault message	Description
Bad CT connection	The automatic CT detection procedure has encountered a problem during the identification process.
Bad Ratings	The DSP has detected an inconsistent set of commissioning parameters
DC over voltage (SW)	The DC software over voltage protection has been triggered (Cf. the detailed manuals for limit values).
DC over voltage (HW)	The DC hardware over voltage protection has been triggered.
DC Top over voltage	The DC over voltage protection of the capacitors in the positive stack has been triggered.
DC Bot over voltage	The DC over voltage protection of the capacitors in the negative stack has been triggered.
DC under voltage (SW)	The DC software under voltage protection has been triggered.
IGBT check cooling	The software IGBT temperature protection has been triggered.
IGBT permanent	The IGBT modules report an error that cannot be cleared by the system. This error can be due to peak over current or too low control voltage for the IGBT drivers.
IGBT temporary	The IGBT modules report a transient error that could be cleared by the system. This error can be due to peak over current or too low control voltage for the IGBT drivers.
Loss of phase	The system has detected a loss of supply on at least one phase.
No synchronization	The system cannot synchronize on to the network.
SPI Error	The DSP has received no response after its request on the SPI port.
Bad Sequence	The DSP has detected an inadequate behavior in the sequence.
Out of mains freq. Limit	The system has detected that the network frequency is out of range.
Over voltage RMS	The RMS value of the supply voltage is higher than the acceptable maximum value.
Over volt. Transient (SW)	The software transient over voltage protection has been triggered.

DSP fault message	Description
Over current RMS	The system has detected RMS over current.
Over current peak (SW)	The software peak current protection has been triggered.
Preload problem	The DC capacitors could not be preloaded. The voltage increase on the DC capacitors during the preload phase is not high enough.
Unbalanced supply	The supply imbalance is out of range.
Under voltage RMS	The RMS value of the supply voltage is lower than the acceptable minimum value.
Unstable mains frequ.	The network frequency is varying too fast.
Wrong phase rotation	The filter is fed by a supply system, which has the wrong phase rotation.
SPI Timeout	Internal system error
Mismatch between units	Different units in a filter system have different settings (e.g. 3-wire and 4-wire setting) or are connected in a different way.
Remark: Maximum limits for certain parameters are given in the detailed manuals	

Table 50 gives an overview of the faults that can be reported by the μ controller.

Table 50: Overview of the faults that can be reported by the μ controller

μ controller fault message	Description
Com. Problem 1 (CAN bus)	Communication problem between different units in a multi-unit filter arrangement
Corrupted DSP code	Internal system error
Corrupted uC code	Internal system error
Internal uC fault	Internal system error
Ctrl over temperature	The system detected an over temperature of the main controller board
DSP watchdog	Internal system error
μ Controller watchdog	Internal system error
SPI Time out	Internal system error
Flash memory corrupted	Internal system error
Power supply fault	Internal system error
Preload time-out	The DC capacitors could not be preloaded in an acceptable time
Real time clock problem	Internal system error
Several units same id	Two or more units have the same CAN_ID (settings of the S5 dip switches (1 to 3) on the control board

µcontroller fault message	Description
Different firmwares	Different units in a filter system have different control firmwares (DSP) Important Note : In case of different DSP firmware between master and one or more slave(s), the newest version will be automatically downloaded into filters equipped with an older version. A dedicate PQF Manager menu will guide the user through the different steps of the software upgrade

For guidelines on how to troubleshoot and solve the reported problems, refer to [Chapter 11](#).

- For multi-unit filters, this data can be obtained for each individual unit.
- Internal system errors are most likely due to faulty hardware and thus the only solution may be to exchange the controller cards.



- If the message 'IGBT check cooling' appears, this implies that the system is stopped due to an over temperature problem.

In that case, check the cooling of the system (fans, filters) and of the switchgear room (air conditioning system etc.)

After the problem is solved the system has to be manually reset (fault acknowledgement) before normal operation can be resumed.

- In general the occurrence of transient faults is no problem for the proper operation of the active filter. Only when an error becomes 'critical', a problem may exist.

A fault is considered critical if after occurrence, it cannot be successfully automatically cleared by the system within a reasonable time. The time frame considered depends on the error type.

In practice the word 'Critical' will appear in the 'Event logging' window if the system has detected a critical error. The user can then backtrack in the logging window to see which errors were already present in the previous events, to know which is/are the critical error(s).

7.10.4. The 'Active warnings' menu



STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	118/188



The 'Active warnings' menu is constantly updated by the system. It shows at any time the warning conditions set up by the customer that are met. For more information on setting up the programmable warnings, refer to [Section 7.9.1.4](#) and the list of possible warning in the detailed manuals.

Table 51 shows an overview of the warning messages that will be displayed and the corresponding warning condition.

For multi-master filters, this data can be obtained for each individual unit.

Table 51: Warning messages that can be displayed by the PQF-Manager and corresponding warning conditions

Warning condition	Warning message displayed
Supply voltage (RMS) higher than preset value	Over voltage RMS
Supply voltage (RMS) lower than preset value	Under voltage RMS
Supply voltage imbalance higher than preset value	Unbalanced supply
PQF IGBT temperature higher than preset value	IGBT temperature
PQF control board temperature higher than preset value	Ctrl over temperature

7.10.5. The 'Number of errors' menu



The 'Number of errors' menu keeps track of all the errors that have been recorded since the controller system has been initialized at the production stage. The errors that have occurred the most are listed first. Errors that have not occurred are not listed. For an explanation on the errors listed, refer to the [Table 49](#) and [Table 50](#).

For multi-master filters, this data can be obtained for each individual unit.

7.10.6. The ‘PQF operation’



The ‘PQF operation’ ([/Welcome/PQF monitoring/PQF Operation]) parameter indicates the total operating time of the filter (filter ‘on’).

The ‘Fan operation’ parameter indicates the total operating time of the fans cooling the filter. The reset fan operation button resets the number of fan operation and should be used after a fan is replaced.

For multi-master filters, this data can be obtained for each individual unit.

If a problem exists, an external intervention is required to solve the problem after which the unit has to be reset by acknowledging the fault for the unit considered. After this, the parameter value will be reset to 0.

Note: the reset of fan operation is protected by a password (default password is 1234). If the user changes the password in [/Welcome/Settings/Installation settings/Password], the “Reset Fan operation” password is changed as well.

7.11. The ‘User Interface menu



This menu gives basic data on the filter, allows the touch screen to be configured and Communication setting to be performed.

7.11.1. Manufacturer setting

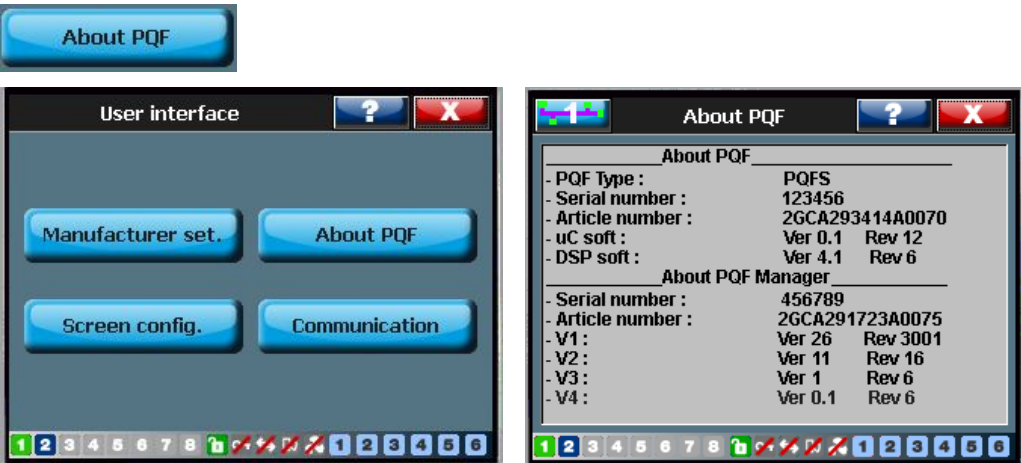




This menu gives basic data on the filter.

Basic manufacturer settings such as filter type, maximum voltage rating and filter serial number. These settings can be accessed in [/Welcome/User Interface/ /Manufacturer set.].

7.11.2. About PQF



These settings can be accessed in [/Welcome/User Interface/ About PQF.]

This menu gives basic data on the filter’s following

Firmware version numbers for the PQF-Manager, the μ controller and the DSP controller.



WARNING: When communicating with your HITACHI representative on a specific filter, please provide always the data shown in the ‘About PQF’ menu.

For multi-master filters, this data can be obtained for each individual unit.

7.11.3. Screen configuration





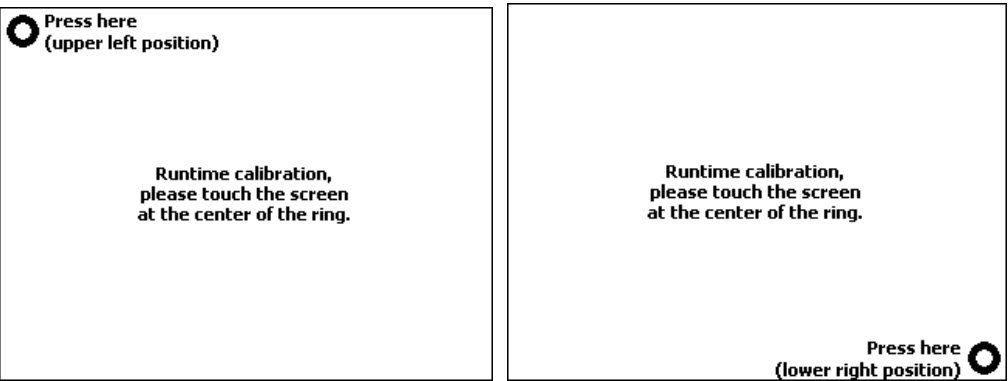
These settings can be accessed in [/Welcome/User Interface/ Screen Config.]

Two main buttons “Touch Screen Cal” and “Backlighting” allows the user to calibrate the touch screen and adjust the backlighting to the optimal level.

The touch screen calibration is normally not needed in a reasonable use of the screen and in standard environmental conditions.

To prevent loss of the touch screen interface, the possibility is meanwhile given to the user to manually calibrate the XY coordinates necessary to detect button activation.

Warning: Touch screen calibration has to be done carefully with a pen or a stylus in order to accurately mark and detect the calibration points!



The backlight adjustment menu set the default backlight intensity when the touch screen is used. After 10 minutes of touch screen inactivity, the backlight intensity returns to 10%.



7.11.4. Communication





The PQF-Manager provides a variety of communications methods. In this main menu, it includes the settings for Modbus and Ethernet and the MAC and IP addresses. More information regarding the Modbus, USB and TCP/IP protocol and programming, please refer to manual: 9AKK106713A9759_PQF-Manager communication with Modbus RTU, Modbus TCP and PQ-Link protocols.

When the communication is unlocked (see Figure 67), the user can change parameter/setting of the filter using the PQF-Manager as well as a communication link (e.g. Modbus or TCP/IP based with help of PQ-Link software).



Figure 67 Communication unlocked

When the communication lock is "checked" (see Figure 68), any change in the filter parameter or setting is possible ONLY using a communication link (e.g. Modbus or TCP/IP based with help of PQ-Link software). In other words, locking the communication is equivalent to using the hardware lock in the back side of the PQF-Manager.

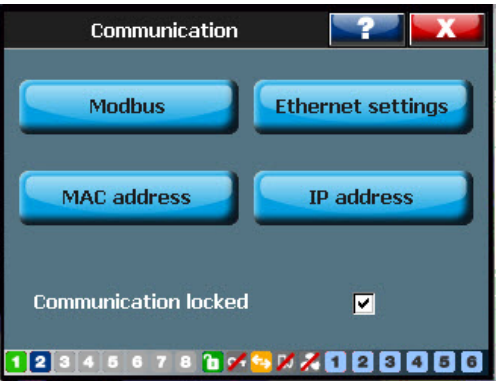


Figure 68 Communication locked

7.11.4.1. Modbus RTU





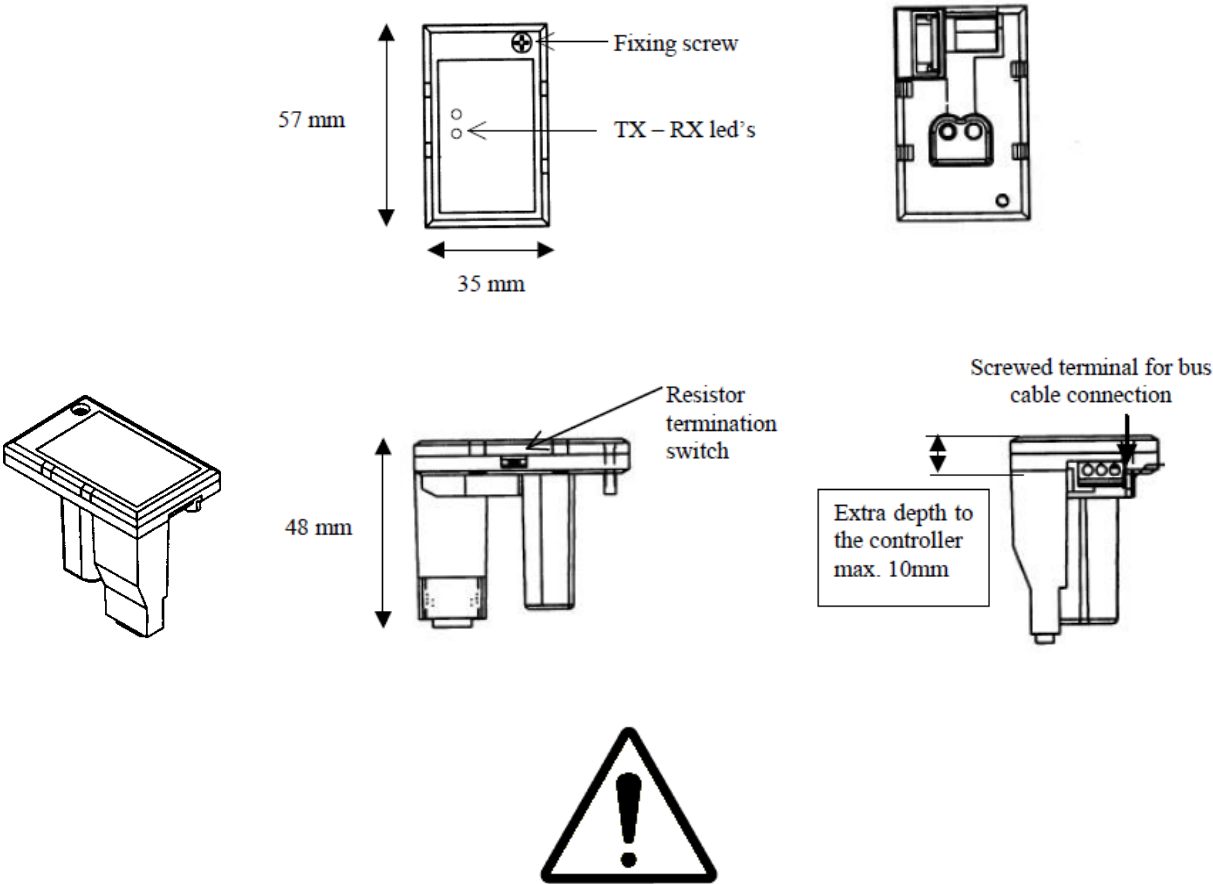
The slave address is the one used by the Modbus master to address the PQF through Modbus.

Baud rate, Parity, Stop bit shall match exactly the communication settings of the Modbus master which controls the RS485 / Modbus network.

RS485 / Modbus Adapter

The Modbus adapter is an optional device for the Active Filters which enables the connection of the PQF-Manager to a RS485 Modbus system. The controller is considered as a slave unit in the Modbus network.

Refer to the 9AKK107045A9896- RS485 adapter- User guide for more information on the RS485 Modbus Adapter.



Be careful that the RS485 MODBUS ADAPTER is the one with a **GREEN** text color (3.3V power supply).

The one with a **WHITE** text color is reserved for the old model (5V power supply).

That means: the new Modbus adapter is not compatible to the old PQF-Manager; and the old Modbus adapter cannot be connected to the new PQF-Manager (with touch screen).



7.11.4.2. MAC address



This menu displays the PQF physical MAC address.

7.11.4.3. Ethernet settings



This menu displays the actual PQF IP address, mask address and gateway IP address.

Depending on the DHCP status, the displayed data may be different.

The below screens give the result for the above Example 1 and 2:

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Example 1: The below screen shows the actual IP address fixed with DHCP disabled.

The screenshot shows the 'Ethernet settings' window. It has a title bar with a question mark and a close button. The 'Static IP address' field is set to 192.168.1.40. The 'Static IP Mask' field is set to 255.255.255.0. The 'Static GW IP' field is set to 0.0.0.0. The 'DHCP Client' status is 'Disabled' with an unchecked checkbox. There is an 'OK' button at the bottom right. At the bottom of the window is a status bar with various icons and numbers.

Example 2: The below screen shows the actual settings resulting from the automatic IP address resolution with DHCP enabled.

The screenshot shows the 'Ethernet settings' window. It has a title bar with a question mark and a close button. The 'Static IP address' field is set to 10.32.20.134. The 'Static IP Mask' field is set to 255.255.255.0. The 'Static GW IP' field is set to 10.32.20.1. The 'DHCP Client' status is 'Enabled' with a checked checkbox. There is an 'OK' button at the bottom right. At the bottom of the window is a status bar with various icons and numbers.

The PQF-Manager needs an IP address to be connected directly to a PC or to an Ethernet network.

This IP address may be fixed and entered manually if DHCP is disabled. The default address is 192.168.1.40.

In case the IP address is given automatically by a gateway or Ethernet LAN, set DHCP to enable.

Some examples are given below:

Example 1: The below screen shows the default settings to connect directly to a PC (note that the PC need to be configured accordingly with a fixed IP address of 192.168.1.40, Subnet mask of 255.255.255.0, DHCP disabled)

The screenshot shows the 'Ethernet settings' window. It has a title bar with a question mark and a close button. The 'Static IP address' field is set to 192.168.1.40. The 'Static IP Mask' field is set to 255.255.255.0. The 'Static GW IP' field is set to 0.0.0.0. The 'DHCP Client' status is 'Disabled' with an unchecked checkbox. There is an 'OK' button at the bottom right. At the bottom of the window is a status bar with various icons and numbers.

Figure 69: PQF TCP/IP protocol setting

Example 2: The below screen shows the default settings to connect to an Ethernet network (note that the PC which is also connected to the LAN has its own IP address given by the network with DHCP enabled)



Details about the communication settings can be found in the manual: 9AKK106713A9759_PQF-Manager communication with Modbus RTU, Modbus TCP and PQ-Link protocols.

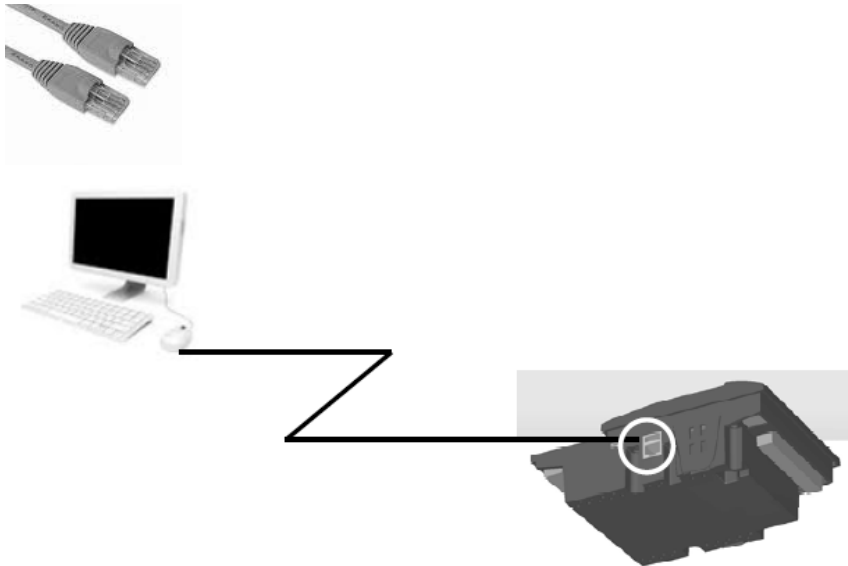
Reboot the PQF-Manager to initialize it with these parameters.

Ethernet / TCP/IP

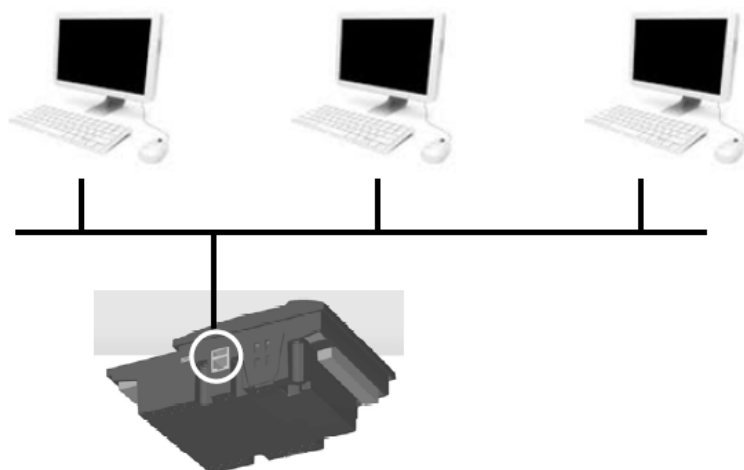
TCP/IP connections can be indifferently initiated locally or remotely.

The TCP port used by default is 4250.

The connection to the PQF-Manager is an RJ45 Cat5e Ethernet cable.



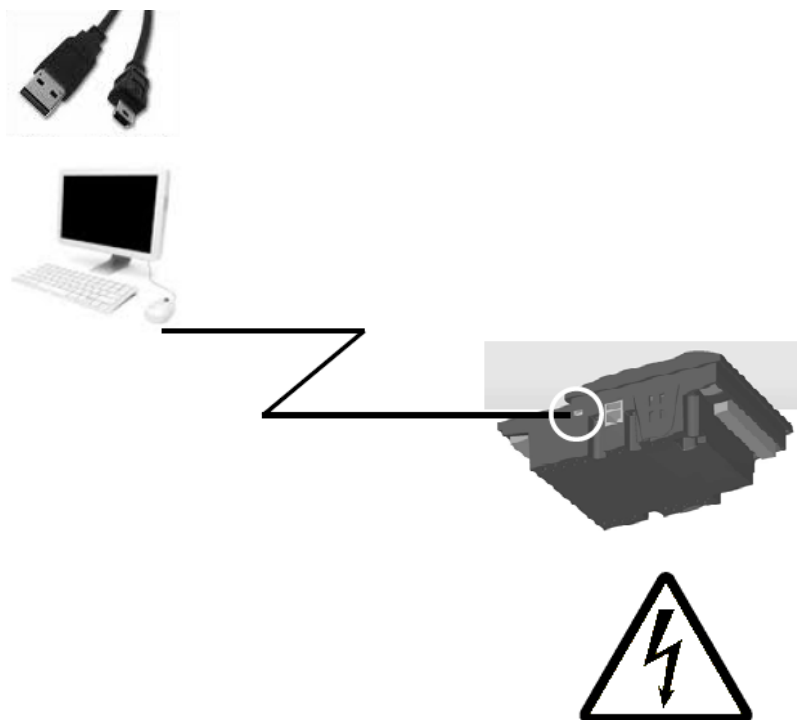
The PQF-Manager can be connected directly to a LAN or through Internet.



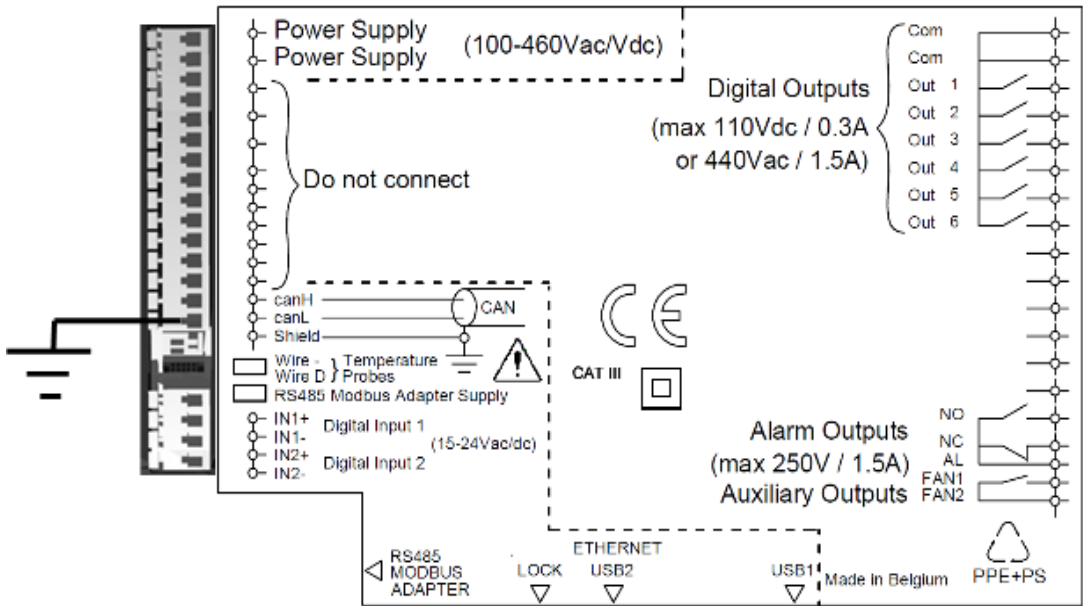
USB

The USB interface is used to present the PQF-Manager as a serial interface on its USB port.

The computer is connected through a USB-A male to USB-Mini B male.



Caution: The USB connection to the PQF-Manager is not isolated. It is mandatory to connect the protective EARTH connection when using the USB.



7.11.4.4. IP address



The IP address displayed in [Figure 70](#) indicates the actual (current) IP address prevailing for the PQF-Manager. For example, the factory default setting of the PQF-Manager IP address is 192.168.1.40 which appears in the screen under the menu "IP address". Using the Menu "Ethernet Setting", the user can change this address and when the filter is reset, the new IP address is copied in the window under menu "IP address".

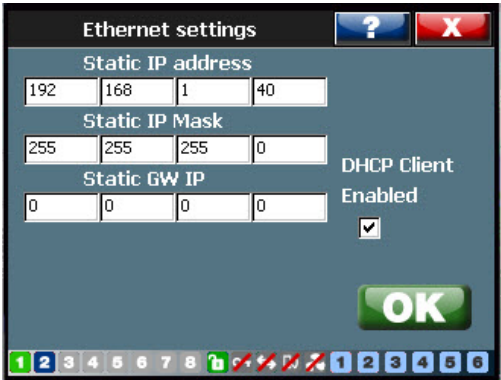


Figure 70 Ethernet settings

If the DHCP client is enabled (see [Figure 70](#)), the customer's system automatically assigns an IP address to the PQF-Manager, which is visible in the window under menu "IP address". In this case, the IP address in the window under Menu "Ethernet Setting" Menu still remains what the user has set or the factory default value, but has no influence in the communication as the PQF-Manager's IP address is dynamically controlled by customer's communication network.

The screenshot shows a software window titled "IP address". Inside, there are three groups of input fields:

- Static IP address:** Four fields containing the values 10, 32, 20, and 87.
- Static IP Mask:** Four fields containing the values 255, 255, 255, and 0.
- Static GW IP:** Four fields containing the values 0, 0, 0, and 0.

At the bottom of the window is a toolbar with various icons, including a green checkmark, a red X, and a numeric keypad with digits 1 through 6.

8. Commissioning instructions

8.1. What this chapter contains

This chapter presents the steps to follow to commission the active filter. The commissioning of your PQF should be conducted in strict accordance with this procedure.



Before applying the commissioning procedure, make sure that you are familiar with:

- The filter hardware (discussed in [Chapter 4](#)).
- The mechanical installation requirements (discussed in [Chapter 5](#)).
- The electrical installation requirements (discussed in [Chapter 6](#)).
- The PQF programming interface PQF-Manager (discussed in [Chapter 7](#)).
- If the Modbus option has been installed, please refer to the document “9AKK107045A9896-RS-485 Installation and Start-up guide” for more information on this item.

The commissioning procedure consists of 9 steps that should be strictly followed.

Table 52: Steps to follow to commission the active filter

Steps	Actions
Step 1	Visual and installation check
Step 2	Setting the address of each unit in a multi-unit filter and terminate the CAN bus
Step 3	Voltage rating and phase rotation check
Step 4	Basic commissioning parameters setup
Step 5	Automatic and manual CT detection procedure
Step 6	Before starting the filter
Step 7	Start the filter
Step 8	Generate filter load
Step 9	Set up the user requirements

[Section 8.11](#) presents the commissioning report to be filled in when commissioning the filter.

8.2. Step 1: Visual and installation check



WARNING: Make sure that the filter supply is isolated during the visual and installation check. For safety reasons, this should be done upstream of the active filter and before removing the right protective cover. In multi-unit filters, ensure that all units are disconnected from the supply

In order to perform a successful installation and commissioning, only the right side of the protective cover of the filter needs to be removed.

WARNING: The left side of the protective cover should not be removed because there are live parts underneath. When the right side of the protective cover is removed, open the auxiliary power fuse holder. Failure to adhere to these guidelines may result in lethal electric shock and/or filter damage.

WARNING: Make sure that the filter is installed at a location where no conductive dust is present. Conductive dust when distributed in the filter panel may lead to equipment failure.

- Check that the mechanical and electrical installation fulfils the requirements described in [Chapter 5](#) and [Chapter 6](#) of this manual. Remove the filter lifting ribbon if it is still present.
- Pay attention to the ambient temperature noting the filter cooling requirements.
- Check visually the condition of the filter (e.g. for transportation damage).
- Remove the anti-corrosion modules which are affixed at the inside of the filter, at the bottom (next to the fan and IGBT assembly).
- Check the tightness of all connections including power cable connections, CT connections, digital I/O connections on the PQF-Manager and the control board connections inside the filter.
- Ensure that the feeding cable protection devices are rated appropriately (see [Table 21](#)).

8.3. Step 2: Setting the address of each unit in a multi-unit filter and terminate the CAN bus

Each filter is defined by a filter address. This address is by default set to 1.

In a multi-filter arrangement, the address of each unit has to be set to a unique value. Setting two filter units in the same system to the same address will lead to a conflict and will inhibit the filter from running.

In a filter system consisting of more than one unit, the filter with the lowest address will be considered as the first unit in the chain. The filter with the highest address will be considered as the last unit in the chain:

- In master-slave filter arrangements, it is recommended to assign the lowest address to the master unit and increment the address by 1 for the next slave etc.
- In master-master arrangements, the lowest address must be assigned to the master unit that is considered as the main controlling unit. When the main master unit is faulty, the master unit with the next lowest address will become the main controlling unit.

In order to set the address of each unit in a filter system, the DIP switch module on the control board has to be set accordingly. [Figure 71](#) shows the location of the DIP switch on the control board (Item 22 in the Figure).

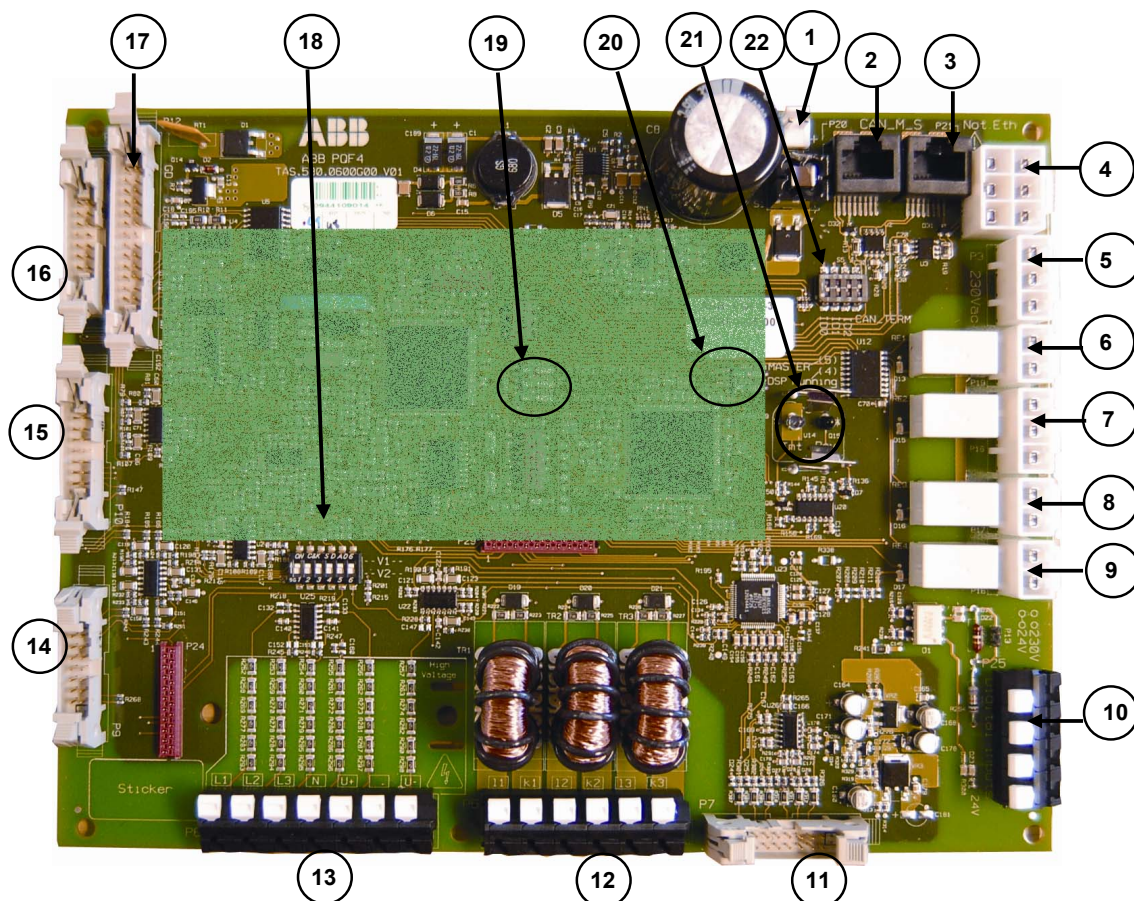


Figure 71: Location of the filter identification DIP switch on the control board (Item 22)

The filter identification DIP switch consists of 4 switches that can be put in low or high position (facing the board with the ABB logo at the top left side). **The three left DIP switches determine the filter unit address.**

Table 56 shows the filter unit addresses that can be chosen and the corresponding configuration to be set.

Table 53: Possible filter unit addresses and corresponding DIP switch settings (facing the board with ABB logo at the left hand side), counting from bottom to top

Filter address	DIP switch 1 setting (ID0)	DIP switch 2 setting (ID1)	DIP switch 3 setting (ID2)
1	Low	Low	Low
2	High	Low	Low
3	Low	High	Low
4	High	High	Low
5	Low	Low	High
6	High	Low	High
7	Low	High	High
8	High	High	High

Notes:

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- Do not use other settings than the ones mentioned in the table.
- It is recommended to assign increasing addresses starting from the main master at the left and moving right.
- Assigning the same address to different filter units in one filter system will lead to the filter not being able to start up and go in error (Bad Ratings).

When a filter consists of more than one unit, attention has to be paid to the proper termination of the communication bus between the different units. This communication bus is depicted in **Figure 72** by the black lines interconnecting the different units.

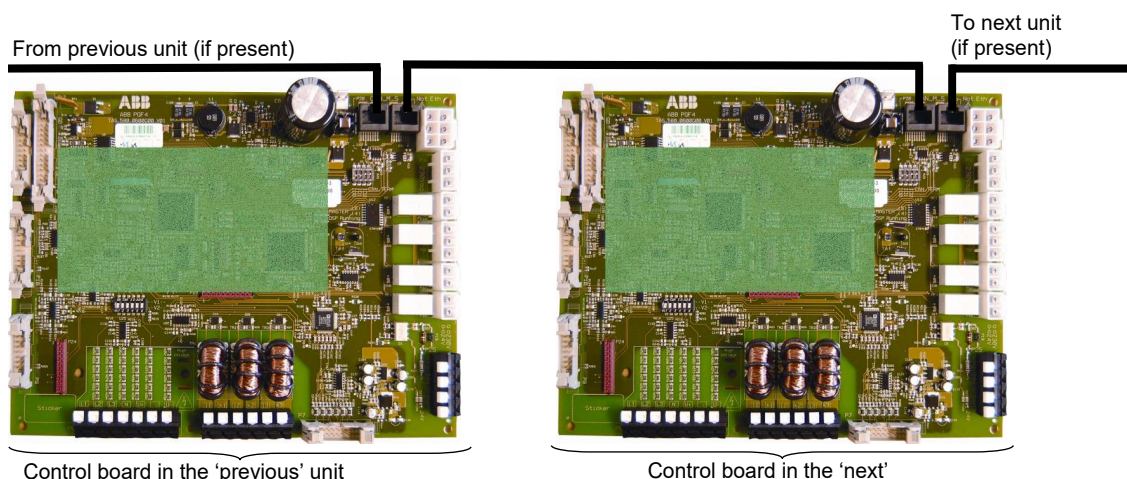


Figure 72: Communication bus between different filter units

In order to terminate the bus correctly, the fourth switch (counting from left to right) from DIP switch 22 (Cf. **Figure 71**) has to be set as follows:

- High: For the first unit in a filter system (single unit filter or first physical unit of a multi-unit filter).
- High: For the last physical unit of a multi-unit filter.
- Low: For all the other units.

WARNING: Failing to terminate the communication bus properly will lead to equipment malfunction and equipment damage.

8.4. Step 3: Voltage rating check/adaptation and phase rotation check

- The active filter nominal voltage setting must be adapted to the actual network voltage by adjusting the power supply connection of the control voltage (Cf. **Figure 14**, wire 'N'). Ensure that the filter panel is isolated upstream before changing the power supply connection of the control voltage.

WARNING: The tap setting of the auxiliary transformer's primary must be adapted according to the network voltage to avoid a too high or too low auxiliary voltage. If the tap setting for your network voltage is not available, then choose a tap just above the network voltage present (e.g. for 390V network choose 400V tap setting). Excessive (auxiliary) voltage levels will lead to filter damage.

Note that in addition to configuring the unit hardware for a certain voltage range, the network voltage also has to be set up in the filter controller software (commissioning window).

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WARNING: The PQFS is able to operate on networks where the supply voltage is up to 10% higher (inclusive of harmonics but not transients) or lower than the voltage range it is set up for. Since operation at the upper limits of voltage and temperature may reduce its life expectancy, the PQFS should not be connected to systems for which it is known that the overvoltage will be sustained indefinitely.

- The voltage phase rotation at the active filter incoming power supply terminals must be clockwise (L1 (R,U) -> L2 (Y,V) -> L3 (B,W) -> L1 (R,U)).

WARNING: Applying voltage to the filter to check the phase rotation may only be done after ensuring that the network voltage level is acceptable for the filter operation and after it has been found that the filter is not mechanically nor electrically damaged.

When power is supplied to the active filter terminals, the unit will automatically do a phase rotation check in the master unit. If the phase rotation is wrong the filter will show the message 'ACK. FAULT' on the PQF-Manager 'Welcome' screen. The filter will refuse to start and a message indicating wrong phase rotation will be stored in the filter event log (Cf. [Section 7.10.3](#))

WARNING: For safety reasons, when using a phase rotation meter, the phase rotation must be measured at the upstream protection level and not in the filter panel itself.

When checking the phase rotation with a phase rotation meter, ensure that the auxiliary fuse box is open during the measurement process.

WARNING: In a multi-unit filter arrangement, care must be taken to connect all units to the power supply in an identical way as the master unit (individual phases and phase rotation). Otherwise, the equipment may be damaged upon energization and/or may function incorrectly.

Before going to the next step, it is recommended at this stage to first install the other I/O cabling if required.

Once all the hardware has been cabled,

- Close the auxiliary circuit fuse box
- Refit the filter protective cover including PQF-Manager and its connections
- Close the filter upstream protection

When the power is applied to the active filter:

- The active filter fans will start running
- The DC capacitors will be charged
- The PQF-Manager will initialize and show the 'Welcome' screen (Cf. [Figure 51](#)), or will show a screen indicating that it is in slave mode

If the voltage level or phase rotation is incorrect, the installation should be corrected before applying power to the filter to avoid potential filter malfunctioning and/or damage.

8.5. Step 4: Basic commissioning parameters set up (using PQF-Manager)

In order to set up the basic commissioning parameters with the PQF-Manager, navigate to [/Welcome/Settings/Commissioning] (Cf. [Section 7.9.2](#)). An overview of the main menus of the PQF-Manager is given in [Figure 53](#).

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The complete commissioning must be done at the first installation of a filter system and each time a filter unit is added to an existing filter system.

If the window or some of its items are locked (i.e. a small  symbol or  symbol is present on the screen), the hardware and/or software lock has been engaged. Refer to [Section 7.6](#) for more information on these features and for guidelines on how to unlock the filter setting menus.

Note: In active filter systems consisting of more than one master, the PQF-Manager of the master that has the control over the system has full functionality and the PQF-Managers of the other master units have limited functionality. In practice, the functions that are not enabled on these units are also locked.

In the commissioning window, the following basic parameters have to be specified:

- The network characteristics (Cf. [Section 7.9.2.1](#)):

The parameters to enter are the nominal network voltage, network frequency and filter synchronization mode. The filter synchronization mode shall normally not be changed unless specifically instructed by the HITACHI ENERGY service provider.

- The filter characteristics (Cf. [Section 7.9.2.2](#)):

This consists of setting up the filter connection mode: 3-wire (no neutral connected) or 4-wire (neutral connected).

When the connection mode selected in the commissioning menu does not correspond to the hardware set-up detected by the filter, the filter will trip out when started. A 'Bad Parameters' fault will be reported in the filter event log. Correct the problem before proceeding.

- The CT settings:

The CT settings can in many cases be automatically detected or can be entered manually. [Section 8.6](#) discusses the automatic and manual CT detection procedure.

- The Rating parameter:

If the filter is installed at locations higher than 1000m /3300ft or is running under ambient temperature conditions higher than 40°C/104°F, the filter has to be derated. For more information on how to calculate the derating required and how to enter the rating value, refer to [Section 7.9.2.4](#).

Remarks:

- Although the user requirements for harmonic filtering and reactive power compensation/balancing can be set up from the commissioning window this should not be done before the filter has been started successfully for the first time (Cf. [Section 8.7](#)).
- If digital I/O and/or the alarm contact have been cabled on the PQF-Manager, the appropriate software settings have to be made. This has to be done in the 'Customer settings' menu ([/Welcome/Settings/Customer set.]). Refer to [Section 7.9.1.4](#) for detailed information on how to set up digital I/O, alarms and warnings. In order to achieve full redundancy with master-master filters, the digital I/O have to be cabled to all master units and all the PQF-Managers have to be set up accordingly.
- In order to change the temperature unit used by the system, go to [/Welcome/Settings/Customer set./Temp unit].
- For setting up advanced filter functions such as the auto restart feature (after power outage), the filter standby feature (which stops the IGBTs when the load requirement is low), the system clock, the external communication protocol (Modbus or PC) and the software lock, refer to [Section 7.9.3](#). In order to achieve full redundancy for the communication features in master-master filters, this function has to be cabled to all master units and all the PQF-Managers have to be set up accordingly.

If the CTs have been set up correctly at this stage, go to step 6 ([Section 8.7](#)).

Otherwise, consult go to step 5 for background information on the automatic and manual CT detection procedure.

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8.6. Step 5: Automatic and manual CT detection procedure



WARNING: Do not filter harmonics or do reactive power compensation/balancing when the CTs have not been set up correctly. Failure to adhere to this guideline will result in erratic filter operation.

Refer to [Section 6.8.1](#) and [Section 6.10](#) for the CT selection and installation guidelines.

WARNING: Before programming or detecting the CTs, make sure that:

- The CTs have been connected to the filter CT terminal X21. For multi-filter configurations all the units of a filter system have to be supplied with the same CT information (daisy chain principle with return path as shown in [Figure 38](#)).
- All shorting links in the CT path have been removed (i.e. on the CTs, on the filter CT terminal X21 ...).

CT shorting links are provided with the filter for servicing purposes, but they are not installed by default on the X21 terminal.

The CT settings can be detected with the automatic CT detection feature or in a conventional way. The automatic CT detection approach allows compensating for physical connection errors in software. For multi-unit filters, the automatic CT detection feature will automatically try and detect the CT-connections for the different units.

8.6.1. Automatic CT detection procedure

The automatic CT detection procedure and the precautions to take when using it are explained in detail in [Section 7.9.2.3](#).

[Section 8.6.2](#) discusses a way to check the CT installation if the automatic CT detection procedure is not used or does not find the correct results.

NOTE: When the automatic CT detection procedure is started, the filter will automatically deactivate all user requirements for filtering, reactive power compensation and balancing. After the procedure has finished, the user has to reprogram these parameters into the filter.

8.6.2. Manual CT detection procedure

Refer to [Section 7.9.2.3](#) for guidelines on how to enter data when using the manual CT setup.

The following procedure will allow you to check the CT connection. This step only has to be executed if the CT setup could not be detected automatically. For filters consisting of more than one unit, it is necessary to check the CT connections for each individual unit.



WARNING: The secondary circuit of a loaded CT must never be opened. Otherwise extremely high voltages may appear at its terminals which can lead to physical danger or destruction of the CT.

8.6.2.1. PQF connection diagram

Figure 73 shows the standard connection diagram for the PQF (Cf. Section 7.9.1). It must be noted that:

- L1, L2 and L3 rotation must be clockwise.
- The CTs must be on the supply (line) side of the PQF.
- The CT monitoring a phase must be connected to the filter CT terminal dedicated to the same phase.
- One secondary terminal of the CT must be earthed.

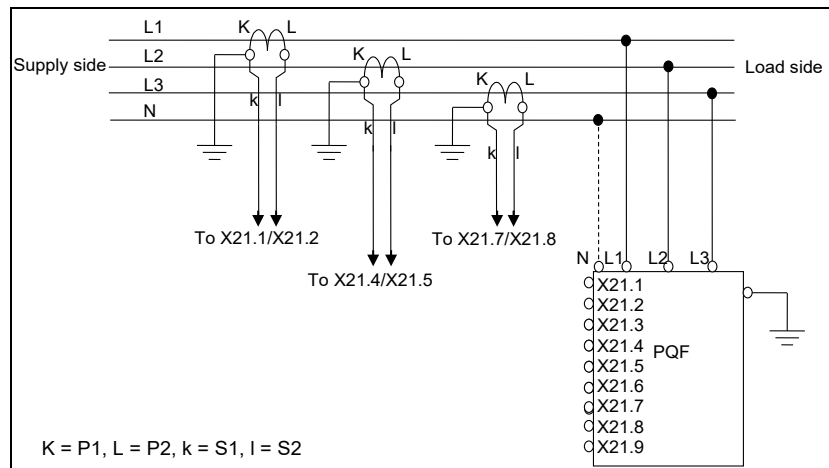


Figure 73: Basic CT connection diagram

It is also seen that terminal X21.1 and X21.2 are related to the CT located in phase L1, terminal X21.4 and X21.5 are related to the CT located in phase L2 and terminal X21.7 and X21.8 are related to the CT located in phase L3.

For multi-unit filters, the following diagram is applicable:

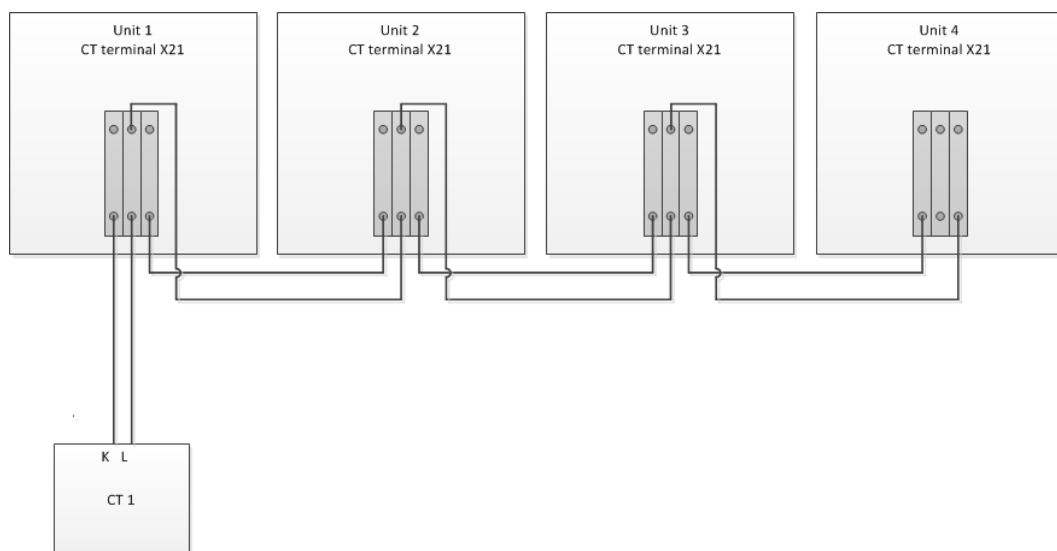


Figure 74: Basic CT configuration in the case of a multi-unit filter arrangement
(only shown for one phase)

8.6.2.2. Material needed and hypotheses for correct measurements

A two-channel scopemeter with one voltage input and one current input is needed. Adequate probes are also needed. A power analyzer like the Fluke 41B can also be used.

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Some minor knowledge of the load is also required. For instance, the method explained below is based on the fact that the load is inductive and not regenerative (i.e. the load current lags by less than 90° the phase voltage). If a capacitor bank is present, it is better to disconnect it before making measurements in order to ensure an inductive behavior of the load. It is also assumed that the load is approximately balanced.

Remark: Other way to check the CT installation manually is to use the waveform displays of the PQF-Manager. In this it should be noted that all waveforms displayed are synchronized on the rising edge zero crossing of the voltage V (L1-L2). Note however that this approach requires some experience.

8.6.2.3. Checking the correct connection of the CTs with a two-channel scopemeter

- The first channel of the scopemeter must be connected to the phase voltage referenced to the neutral or to the ground if the neutral is not accessible
- The second channel must measure the associated current flowing from the network to the load as seen by the CT input of the PQF

8.6.2.3.1. Measurement of the CT in phase L1 (Figure 75)

- For the voltage measurement (channel 1), the positive (red) clamp must be connected to the phase L1 and the negative clamp (black) must be connected to the neutral (ground)
- For the current measurement (channel 2), the clamp should be inserted into the wire connected on terminal X21.1 and the arrow indicating positive direction of the current should point towards the PQF. Do not forget to remove the shorts on the CT secondary (if present) before making the measurement.

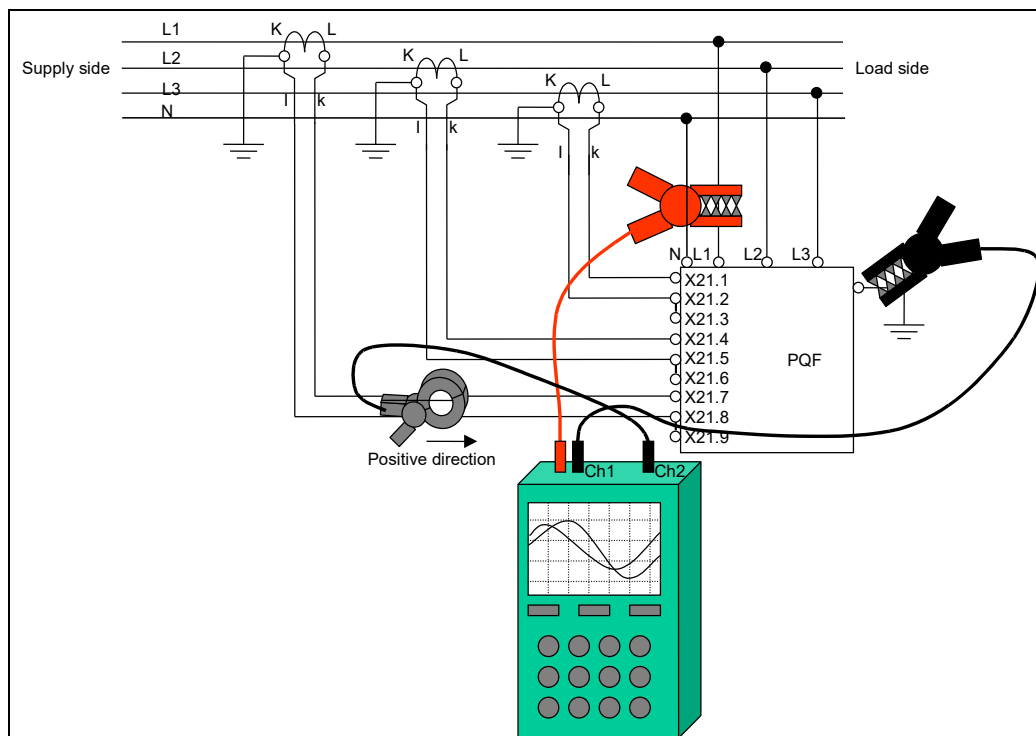


Figure 75: Connection of the scopemeter for checking the CT in phase L1

On the scopemeter screen, two waveforms should appear. The voltage waveform should be approximately a sine wave and the current waveform would normally be a well-distorted wave because of harmonic distortion. Usually, it is quite easy to extrapolate the fundamental component as it is the most important one (Figure 76).

Remark: If the earthing of the system is bad, the phase to ground voltage may appear like a much distorted waveform. In this case, it is better to measure the phase-to-phase voltage (move the black clamp to the phase L2) and subtract 30° on the measured phase shift.

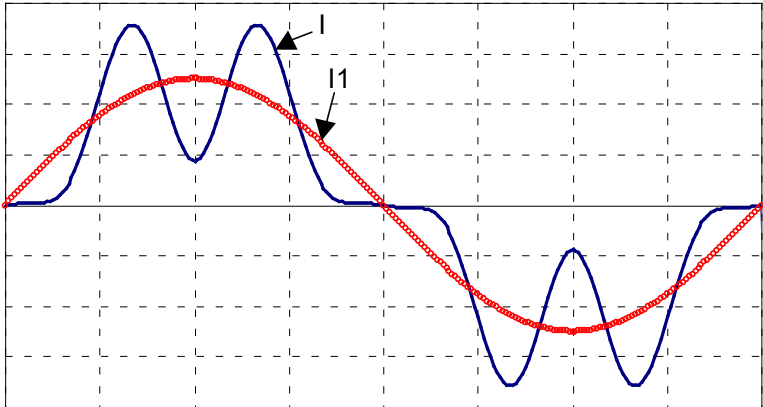


Figure 76: Extrapolation of the fundamental component from a distorted waveform

From the fundamental component of both signals, the phase shift must then be evaluated (Figure 77). The time ΔT between zero crossing of the rising (falling) edge of both traces must be measured and converted to a phase shift φ by the following formula:

$$\varphi = \frac{\Delta T}{T_1} * 360^\circ$$

where T1 is the fundamental period duration.

For an inductive and non-regenerative load, the current signal should lag the voltage by a phase shift lower than 90°.

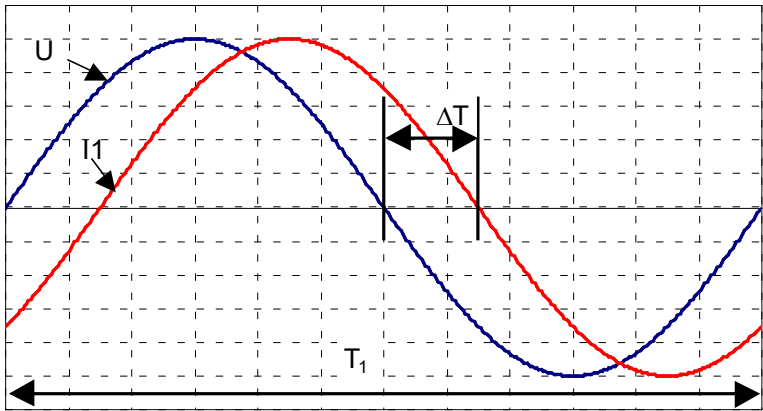


Figure 77: Phase shift evaluation between two waveforms

8.6.2.3.2. Measurement of the CT in phase L2 and L3 (Figure 78 and Figure 79)

The same operations as those described in the previous paragraph must be repeated with the phase L2 (Figure 78) and phase L3 (Figure 79).

For a balanced load (which is usually the case in most of the three phase systems), the phase shift should be approximately the same for all the three phases.

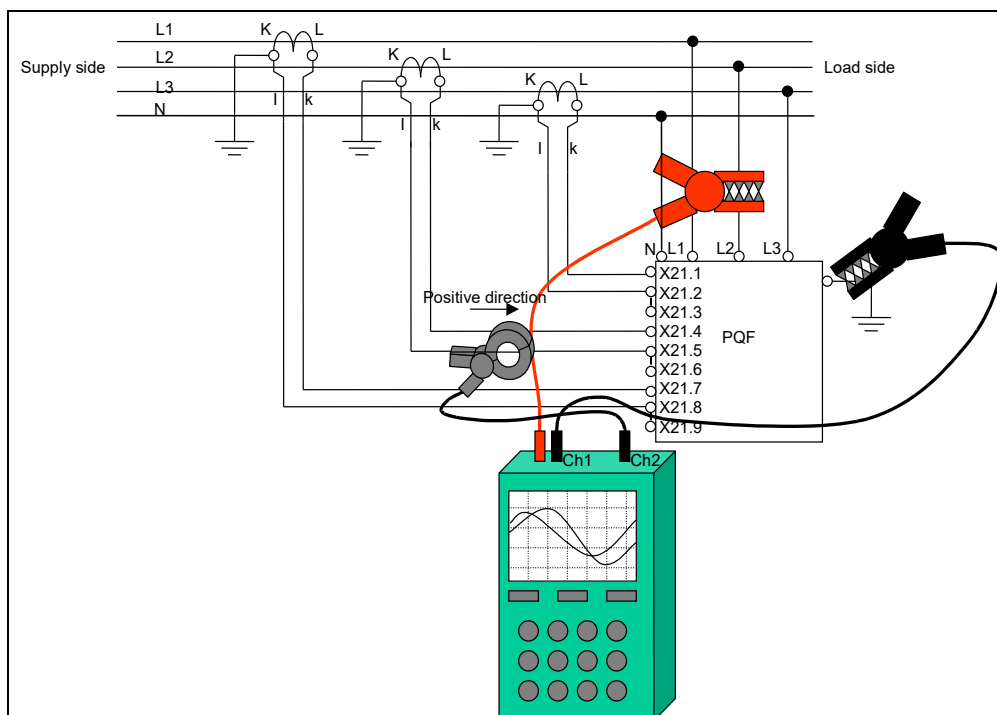


Figure 78: Connection of the scopemeter for checking CT in phase L2

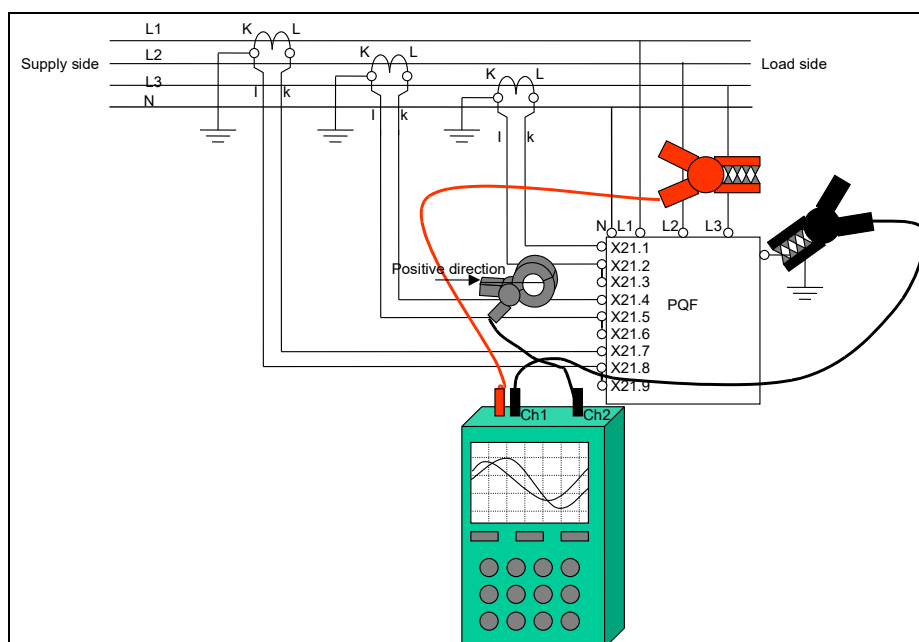


Figure 79: Connection of the scopemeter for checking CT in phase L3

8.6.2.3.3. Checking the correct connection of the CTs with two current probes

If the main bus bar is available and all security rules are taken, it is possible to use the two-channel scopemeter in order to see if the current measured through the CT is matching the real current in the bus. Connect the current probes as shown on **Figure 80**. The two traces must be in phase and of the same shape (the magnitude could be different as the gains are different) if the wiring is correct.

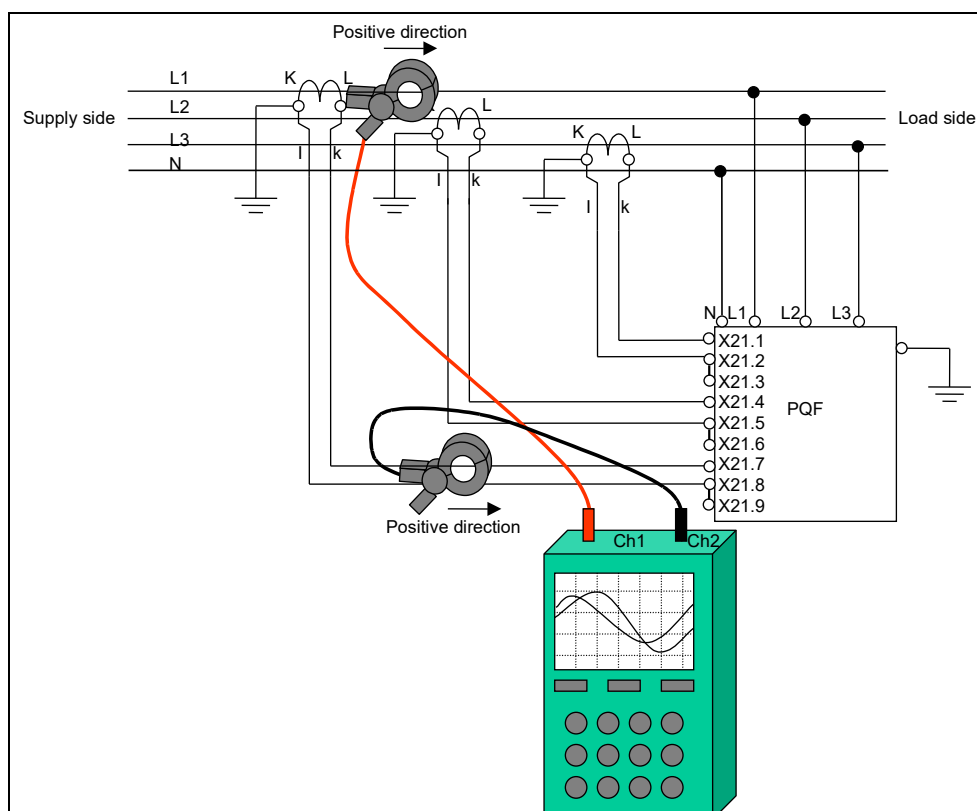


Figure 80: Connection of the scopemeter for checking the CT in phase L1 by comparing the currents

This operation has to be repeated for the remaining two phases for a complete check. The current probes have to be changed accordingly.

8.6.2.4. Checking the correct connection of the CTs with a Fluke 41B or similar equipment

The Fluke 41B is a power analyzer that allows measurements of one voltage and one current wave. Unfortunately, the device does not allow simultaneous display of both waveforms on the screen. However, it is possible to synchronize the triggering on either the voltage or on the current. All phase shift measurements are then referenced to the chosen origin. To read directly the phase shift between the fundamental components, just select the spectrum window of the signal which is not chosen as the origin.

The instrument must be configured for single-phase measurements.

The probes must be connected as shown in [Figure 75](#), [Figure 78](#) and [Figure 79](#).

8.7. Step 6: Before starting the filter

Before switching the filter ON, ensure that all harmonics and reactive power compensation/balancing options have been deselected.

- For deselecting all harmonics of the main filter settings at once go to [Welcome/Settings/Customer set./Main settings/Deselect all].
- For deselecting all harmonics of the auxiliary filter settings at once go to [Welcome/Settings/Customer set./Auxiliary settings/Deselect all].
- For deselecting the reactive power compensation option of the main filter settings disable the option 'PFC type' in [Welcome/Settings/Customer set./Main settings/Main PFC/Bal.].

- For deselecting the load balancing option of the main filter settings disable the option 'Balance load' in [/Welcome/Settings/Customer set./Main settings/Main PFC/Bal.].
- For deselecting the reactive power compensation option of the auxiliary filter settings disable the option 'PFC type' in [/Welcome/Settings/Customer set./Auxiliary settings/Aux. PFC/Bal.].
- For deselecting the load balancing option of the auxiliary filter settings disable the option 'Balance load' in [/Welcome/Settings/Customer set./Auxiliary settings/Aux. PFC/Bal.].

For more information on the main and auxiliary settings concept, refer to [Section 7.9.1.1](#).

In multi-unit filters consisting of only masters, the master unit with the lowest address has to be used to control the complete filter system.

8.8. Step 7: Start the filter

Fit the filter top cover before starting the filter. The PQFS contains a main contactor that is controlled by the filter controller.



WARNING: Under no circumstances close the main contactor manually. Failure to adhere to this guideline may result in physical danger and in filter damage.

With all harmonics and reactive power compensation/balancing deselected, you can start the filter.

In order to do this with the PQF-Manager:

- Press  repeatedly until the 'Welcome' screen is displayed.
- Highlight the filter start/stop menu ('PQF' item in the list). In this menu, the 'START' indication should be present.
- Press . The filter will ask confirmation and then it will start. The main breaker should close within 30 seconds. One second after closing, the IGBTs will start and the filter will work under no load condition.
- The 'START' indication in the start/stop menu changes in a 'STOP' indication once the filter is running.

Detailed information on the filter start/stop menu can be found in [Section 7.7](#).

Remarks:

- If the start/stop menu reads 'ACK. FAULT' (i.e. 'acknowledge fault'), the filter has encountered a fault that needs to be corrected before the filter can be started. Refer to [Chapter 11](#) for troubleshooting the problem.
- If the filter when activating the start menu displays a message to indicate that it is remote control mode, the filter either has to be started by remote control or the remote control mode has to be deactivated. More information about the remote control functionality is given in [Section 6.12.1](#) and [Section 7.9.1.4](#).
- If one of the units in a multi-unit filter system does not switch on, the unit considered is in error. Refer to [/Welcome/PQF Monitoring/Status of modules]) to find out about the problem.

8.9. Step 8: Generate filter load

Once the filter is connected to the supply and is running, some filter load can be generated to verify if the filtering is performing well.

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When a harmonic load is present, the filtering performance can be tested by selecting a harmonic, e.g. of order 11, and verifying if it is filtered properly.

- For setting up the filter's main harmonics selection go to [/Welcome/Settings/Customer set./Main settings/Main harmonics].
- For setting up the filter's auxiliary harmonics selection go to [/Welcome/Settings/Customer set./Auxiliary settings/Aux. Harmonics].

For more information on the main and auxiliary settings concept and on the setting up of harmonics, refer to [Section 7.9.1.1](#).

Once the harmonic is selected, analyze the spectrum of the line currents to see if the selected harmonic is filtered. Refer to [Section 7.8.2](#) for more information on displaying measurement results. If the harmonic is not filtered properly (e.g. if it is amplified), deselect the harmonic and refer to [Chapter 11](#) for troubleshooting the problem.

When harmonic load is not present, the filter can be tested by generating static reactive power. Initially a low value can be set which can then be gradually increased to the nominal filter rating.

- For setting up the filter's main reactive power feature go to [/Welcome/Settings/Customer set./Main settings/Main PFC/Bal.].
- For setting up the filter's auxiliary harmonics selection go to [/Welcome/Settings/Customer set./Auxiliary settings/Aux. PFC/Bal.].

Set the 'PFC Type' item to 'Static cap.' and choose the desired value for the item 'Q static'.

For more information on the main and auxiliary settings concept, refer to [Section 7.9.1.1](#).

Once the reactive power is selected, analyze the filter current. Refer to [Section 7.8.2](#) for more information on displaying measurement results. Refer to [Chapter 11](#) in case of problems. Disable the reactive power setting after the test if it is not required by the user.

8.10. Step 9: Set up the user requirements

If everything goes well at this stage, the user requirements for harmonic filtration and reactive power compensation/balancing can be set up. Both main and auxiliary settings can be programmed if desired.

By default the filter is set up to take into consideration the main settings only.

- Select the desired filter mode.
- Select the harmonics and the curve level.
- Select the reactive power and balancing settings.

Background information on all the items discussed above is given in [Section 7.9.1.1](#)

At this stage, verify the functioning of the settings made for the digital I/O if possible (e.g. remote control, local start/stop buttons).

Remarks:

- Refer to [Chapter 11](#) for troubleshooting problems.
- Filter running at 100% load while RMS current rating is not attained.

Under exceptional conditions it is possible that the active filter is showing a 100% load indication whereas its nominal RMS current rating is not yet attained. This is because the filter has reached an operating limit other than the RMS current limit. Possible other limits are:

- Temperature limit due to a too high ambient temperature or a failing cooling system.

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- Peak current limit due to an atypical peak current requirement of the load.
- Peak voltage limit due to an atypical DC-link voltage requirement of the load or due to a high network voltage.

Under all these conditions, the filter will run in limited mode and may not attain 100% of its nominal current rating.

- Harmonics put in 'standby' by the filter system:

When selecting a harmonic that has not been selected before, the filter will identify the network characteristics for this harmonic. After this process, the filter will launch the filtering process for the component considered. If during the network identification process for a given harmonic a special (problematic) condition is encountered, the system puts the component in 'standby'. In that case the harmonic selected is not filtered for the time being. Special network conditions include extremely high impedance of the supply network or extremely low impedance towards the load. When consulting the harmonic selection table of the PQF-Manager, harmonics put in 'standby' can be recognized by the label 'S' that is displayed in the harmonic selection column (which reads otherwise either 'Y' or 'N'). The following possibilities exist to bring a harmonic out of standby:

- The user restarts a network identification process by changing the 'S' indication into a 'Y' indication in the harmonic selection table.
 - The filter automatically restarts an identification process on all harmonics that were put in standby previously when a successful identification of another harmonic is made. As a result, the harmonic considered will be automatically filtered when the network conditions allow for this.
- If plain capacitors (i.e. capacitor banks not incorporating detuning reactors) are present in the network it is recommended to switch them off or change them into detuned banks. Sometimes, the commissioning engineer is faced with an installation where both an active filter and plain capacitors are present however. While this is an ill-advised and a technically unsound situation, HITACHI has acknowledged that in this case also the active filter should aim to give an optimal performance. For this reason the control software of the filter incorporates a Stability Detection Program (SDP) that aims to increase the filter performance in this type of applications.

In installations where plain capacitors are present and cannot be switched off or changed to detuned capacitor banks, adhere to the recommendations below for optimal results.

- Install the capacitor banks upstream of the active filter CT measurement location
 - Set the filter in Mode 3
- In installations where detuned banks are present, it is recommended not to select harmonic orders below the tuning frequency of the detuned banks. **Table 54** indicates the harmonics recommended to be deselected for different types of detuned banks.

Table 54: Recommended harmonics to be deselected for different detuned bank types

Detuned bank type	Harmonics recommended to be deselected
5.67 %	2, 3, 4
6 %	2, 3, 4
7 %	2, 3
14 %	2

For other types of detuned bank please contact your HITACHI Service provider to evaluate the resonance frequency and the harmonics that are recommended to be deselected.

When background distortion is present on the network and detuned capacitor banks are installed adjacent to the active filter but connected downstream of the filter CTs, filter resources will be lost. To overcome this, it is recommended

to either connect the detuned capacitor bank upstream of the filter CTs or to use the CT connection approach shown in **Figure 81**.

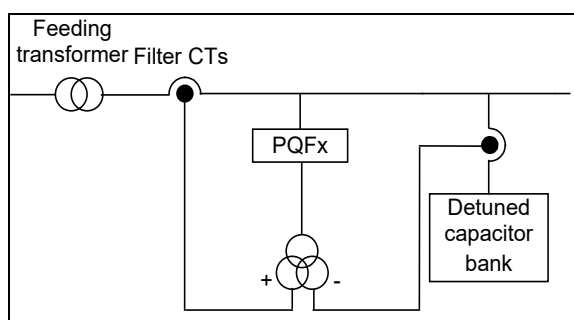


Figure 81: Connection approach for installations where detuned capacitor banks are installed adjacent to the active filter but downstream to the active filter CTs (background distortion present)

- In installations where active filters and passive filters are present, the active filters must be installed downstream of the passive filter. If this is not possible, the CT connection scheme of **Figure 82** shall be used.

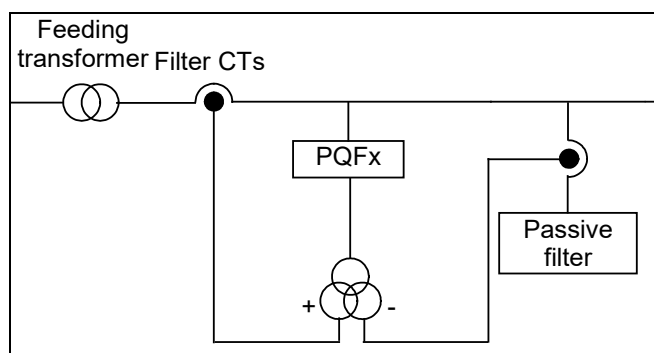


Figure 82: CT connection guidelines for the case that a passive filter is installed downstream of the active filter

Further, when a passive filter and an active filter are installed on the same bus, it is not recommended to select on the active filter the harmonics at or below the tuning frequency of the passive filter. If these harmonics are selected, the SDP function may stop filtering these harmonics temporarily resulting in a reduced overall filtering performance.

- In installations where 2 non-compatible masters are connected to the same CT, respect the following guidelines for best performance:
 1. Select different harmonics on both units
 2. If 1 above is not possible, put one filter in Mode 1 and the other filter in Mode 3

Note: 'Non-compatible' master units are master units that cannot or are not interconnected with the RJ45-communication cable.

Please do not forget to fill in the commissioning report for future reference.

8.11. Commissioning report

The commissioning report is designed to help the person in charge of the commissioning.

Before installation and operation of the PQF, read the relevant sections of the Instruction Manual.

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8.11.1. Filter identification

Active filter type^(a)

Global ratings^(a) Maximum voltage (V)

Total current (A)

System serial number^(a)

Filter connection mode 3-W / 4W

Unit ratings/serial number^(b) Rating (A) Serial number Article code^(b)

Unit 1 (M)

Unit 2 (M/S)^(d)

Unit 3(M/S)^(d)

Unit 4(M/S)^(d)

Unit 5(M/S)^(d)

Unit 6(M/S)^(d)

Unit 7(M/S)^(d)

Unit 8(M/S)^(d)

Software version^(c) PQF-Manager software

μcontroller software

DSP software

Installation location

Remarks:

^(a) Read from main identification tag located on the master cubicle door.

^(b) Read on identification tag located at the outside of each cubicle door.

^(c) After the filter has been commissioned, navigate with the PQF-Manager to [/Welcome/User interface/About PQF].

^(d) Select whether this unit is a master (M) or a slave (S) unit.

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8.11.2. Inspection on site – verification of the active filter after installation

Ambient conditions	OK/NOK
Check the ambient temperature (< 40°C/104°F) (if > 40°C/104°F, derating is required)	
Check the installation altitude (< 1000m/3300ft) (if > 1000m/3300ft, derating is required)	
Check the ventilation (room and enclosure)	
Ensure that no sources of conductive dust are present	
Upstream cabling and protection	
Upstream protection installed	
Check cross-section of power supply cables (L1-L2-L3) and neutral (if connected)	
Check cross-section of protective conductors (PE) (/ 16 mm ²) connected to each enclosure.	
Earth interconnection between the different units installed	
Check the setting and operation of the protective apparatus PQFS neutral current can be up to 3 times the PQFS phase current!	
Check rated current of the power supply cable fuses (if applicable)	
Check tightness of conductor fixations	
The material of busbars, terminals and conductors must be compatible (corrosion)	
Internal connections^(a)	
Disconnect the filter from the supply (disconnection recommended by upstream protection)	
If filter connected to the supply before, wait for 25 minutes to discharge DC capacitors	
Remove the right side of the protective cover of the filter. Ensure that the left side of the protective cover is in place. Disconnect PQF-Manager if required.	
Open auxiliary circuit fuse protection box	
DC capacitor voltage low enough to operate safely (DC voltage measurement)	
Change auxiliary transformer primary tap setting to correspond to network nominal voltage rating ^(b)	
Wiring of main and auxiliary circuit	
Tightness of all electrical connections	
Connectors properly plugged in	
Fixation of components	
Remove anti-corrosion capsules installed at the inside bottom of the filter (if still present)	
Clearances	
Address of each filter unit in a multi-unit system set to a different value and 'main' master has the lowest address ^(c)	
CAN bus terminated properly on each unit of a multi-unit system ^(c)	
CAN bus communication cable between the different units properly installed ^(c)	

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Installation ^(a)	OK/NOK
Check the cabling of the digital I/O (if present)	
Check the voltage in accordance with the specification	
Check the phase rotation order (with filter auxiliaries off) (clockwise) ^(b)	
For multi-unit filters, check that the same phases are connected to the same filter power terminals for the individual units	
Check visually the current transformers	
- Ratio	
- Installed at the right side (feeding-side of the active filter)	
For multi-unit filters, check that the CTs of all units are cabled in a daisy chain fashion with return path ^(d)	
Remove all jumpers of all current transformers (CTs and SCTs)	
Remove all jumpers of the CT connection terminal(s) X21	

Remarks:

(a) Refer to [Section 8.2](#) of the manual for more information on this topic.

(b) Refer to [Section 8.4](#) of the manual for more information on this topic.

(c) Refer to [Section 8.3](#) of the manual for more information on this topic.

(d) Refer to [Section 8.6.2.1](#) of the manual for more information on this topic.

8.11.3. Programming

Apply voltage to the filter ^(a)	OK/NOK
Close the auxiliary circuit fuse box	
Refit the filter protective cover including PQF-Manager connection	
Apply voltage to the active filter (restore upstream protection)	
PQF-Manager booting and showing 'Welcome' screen (or standby screen on master units running as slave)	
Fans start running	
Program equipment^(b)	
Network characteristics	
- Supply voltage (V)	
- Supply frequency (Hz)	
- Synchro mode (should normally not be changed, default value is Three ph.)	
Filter ratings	
- Connection mode (3-wire or 4-wire)	
CT position and ratio (for first unit)	
- Automatic detection feature used	YES/NO
- Filter terminal 'Input 1' is connected to the CT (including sign) ^(c)	Line 1, 2, 3, -1, -2, -3

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- Filter terminal 'Input 2' is connected to the CT (including sign) ^(c)	Line 1, 2, 3, -1, -2, -3
- Filter terminal 'Input 3' is connected to the CT (including sign) ^(c)	Line 1, 2, 3, -1, -2, -3
- Ratio of CT installed in line L1 (R, U)	
- Ratio of CT installed in line L2 (Y, V)	
- Ratio of CT installed in line L3 (B, W)	
CT position and ratio for other units of a multi-unit filter system is ok?	
Rating factor (temp > 40°C/104°F or altitude > 1000m/3300ft or...)	
- Rating (%)	
Configure digital inputs if applicable ^(d)	
For full redundancy, configure/cable digital inputs on all masters of a multi-master system ^(d)	
Configure digital outputs if applicable ^(e)	
For full redundancy, configure/cable digital outputs on all masters of a multi-master system ^(e)	
Configure programmable warnings if applicable ^(f)	
For full redundancy, configure programmable warnings on all masters of a multi-master system ^(f)	
Configure programmable alarms if applicable ^(g)	
For full redundancy, configure programmable alarms on all masters of a multi-master system ^(g)	

Remarks:

(a) Refer to **Sections 8.5.** and **8.6** of the manual for more information on this topic.

(b) Navigate with the PQF-Manager to [/Welcome/Settings/Commissioning].

(c) Encircle the correct setting. Negative values imply inversed CT orientation or cabling.

(d) Navigate with the PQF-Manager to [/Welcome/Settings/Customer set./Digital inputs].

(e) Navigate with the PQF-Manager to [/Welcome/Settings/Customer set./Digital outputs].

(f) Navigate with the PQF-Manager to [/Welcome/Settings/Customer set./Warnings].

(g) Navigate with the PQF-Manager to [/Welcome/Settings/Customer set./Alarms].

8.11.4. Testing (with load)

Before starting the filter	OK/NOK
Deselect all harmonics and reactive power/balancing ^(a)	
Start the filter^(b)	
While the filter is running^(c)	
If harmonic load is present, select for example the 11 th harmonic	
Check the line current (I _{rms} , 11 th harmonic level and waveforms)	

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If harmonic load is not present, generate static capacitive power (first select H3)	
Check the filter currents (fundamental current level)	
Set up the user requirements for harmonics and reactive power/balancing^(d)	
Check the line currents (Irms, THDI and waveforms)	
Check the line voltage (Vrms, THDV and waveforms)	

Remarks:

- (a) Refer to [Section 8.7](#) of the manual for more information on this topic.
- (b) Refer to [Section 8.8](#) of the manual for more information on this topic.
- (c) Refer to [Section 8.9](#) of the manual for more information on this topic.
- (d) Refer to [Section 8.10](#) of the manual for more information on this topic.

8.11.5. Programmed parameters

Activate			
Main	☐		
Auxiliary	☐		
Ext. Input	☐		
Filter mode			
Main settings	1 ☐	2 ☐	3 ☐
Auxiliary settings	1 ☐	2 ☐	3 ☐
Reactive power compensation			
Main settings (Main PFC/Bal.)		Auxiliary settings (Aux. PFC/Bal.)	
PFC type Disabled ☐ Static ind. ☐ Q static (kvar) Static cap. ☐ Q static (kvar) Dyn. ind. ☐ Target cos ϕ Dyn. cap. ☐ Target cos ϕ Balance load ☐ Disabled ☐ L-L ☐		PFC type Disabled ☐ Static ind. ☐ Q static (kvar) Static cap. ☐ Q static (kvar) Dyn. ind. ☐ Target cos ϕ Dyn. cap. ☐ Target cos ϕ Balance load ☐ Disabled ☐ L-L ☐	

Harmonics									
Main settings (Main PFC/Bal.)					Auxiliary settings (Aux. PFC/Bal.)				
	H. Order	Selected		Curve (A)		H. Order	Selected		Curve (A)
		YES	NO				YES	NO	
1	3				1	3			
2	5				2	5			
3	7				3	7			
4	11				4	11			
5	13				5	13			
6	17				6	17			
7	19				7	19			
8	23				8	23			
9	25				9	25			
10	29				10	29			
11	31				11	31			
12	35				12	35			
13	37				13	37			
14	41				14	41			
15	43				15	43			
16	47				16	47			
17	49				17	49			
18	9				18	9			
19	15				19	15			
20	21				20	21			

Alarms			Warnings																																						
Prog. alarms <table><tr><td>Prog. alarm 1</td><td></td></tr><tr><td>Prog. alarm 2</td><td></td></tr><tr><td>Prog. alarm 3</td><td></td></tr><tr><td>Alarm delay</td><td></td></tr><tr><td>Alarm rst del.</td><td></td></tr></table>			Prog. alarm 1		Prog. alarm 2		Prog. alarm 3		Alarm delay		Alarm rst del.		Warning levels <table><tr><td>T IGBT warn.</td><td></td></tr><tr><td>T ctrl war.</td><td></td></tr><tr><td>V. min. warn.</td><td></td></tr><tr><td>V. max. warn.</td><td></td></tr><tr><td>Imbalance</td><td></td></tr><tr><td>Ground fault</td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table> Prog. warnings <table><tr><td>Prog. warn. 1</td><td></td></tr><tr><td>Prog. warn. 2</td><td></td></tr><tr><td>Prog. warn. 3</td><td></td></tr><tr><td>Warning delay</td><td></td></tr><tr><td>Warn. rst del.</td><td></td></tr></table>			T IGBT warn.		T ctrl war.		V. min. warn.		V. max. warn.		Imbalance		Ground fault						Prog. warn. 1		Prog. warn. 2		Prog. warn. 3		Warning delay		Warn. rst del.	
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Start-Stop set.			Communication																																						
<table><tr><td>Stdbby status</td><td></td></tr><tr><td>Standby level</td><td></td></tr><tr><td>Stdbby del off</td><td></td></tr><tr><td>Standby hyst</td><td></td></tr><tr><td>Stdbby del con</td><td></td></tr><tr><td>Auto start</td><td></td></tr><tr><td>Auto st. del.</td><td></td></tr></table>			Stdbby status		Standby level		Stdbby del off		Standby hyst		Stdbby del con		Auto start		Auto st. del.		<table><tr><td>Protocol</td><td></td></tr><tr><td>Modbus</td><td></td></tr><tr><td>Baud rate</td><td></td></tr><tr><td>Parity</td><td></td></tr><tr><td>Stop bit</td><td></td></tr><tr><td>Slave Address</td><td></td></tr><tr><td>Modbus lock</td><td></td></tr></table>			Protocol		Modbus		Baud rate		Parity		Stop bit		Slave Address		Modbus lock									
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Modbus lock																																									

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8.11.6. Comments

	Commissioning Engineer	Customer's representative
Name		
Signature		
Date		

9. Operating instructions

9.1. What this chapter contains

This chapter contains the user operating instructions for the active filter. It is assumed that the filter has been installed and commissioned correctly (cf. previous chapters). The following operations are discussed:

- Starting and stopping the filter
- Modifying the user requirements
- Changing the system temperature unit and PQF-Manager contrast
- Consulting filter measurements
- Consulting filter statistics and manufacturer data
- Filter behavior on faults – retrieving error information

Note that in the context of this manual, the PQF-Manager is used to operate the filter. Background information on the PQF-Manager can be found in [Chapter 7](#).

Alternative ways to operate the filter are:

- Using the optional PQ-Link software. Refer to the 'PQ-Link installation and user's guide' for more information on this subject
- Using Modbus RTU communication. Refer to document "9AKK107045A9895-RS-485 Installation and Start-up guide" for more background information on this subject and to the information provided by your system integrator.



WARNING: High AC and DC voltage may be present in the filter enclosure. Do not operate the unit with the protective panels removed. Do not touch any filter parts unless you have ascertained that they do not carry dangerous voltage levels.

9.2. Starting and stopping the filter

The PQFS contains a main contactor that is controlled by the filter controller. The main contactor should never be activated manually for normal filter operation.



WARNING: Under no circumstances close the main contactor manually. Failure to adhere to this guideline may result in physical injury and/or in filter damage.

Normally, the commissioning engineer has set up the filter and the desired filter requirements. As a result, the user only has to start and stop the filter. Detailed information on the filter start/stop menu can be found in [Section 7.7](#).

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9.2.1. Starting the filter with the PQF-Manager

In order to start the filter with the PQF-Manager follow the instructions given below:

- Ensure that power is supplied to the filter and that the filter auxiliaries are 'on' (auxiliary fuse holder contains good fuses and is closed).
- Press  on the PQF-Manager repeatedly until the 'Welcome' screen is displayed.
- Highlight the filter 'start/stop' menu ('PQF' item in the list). In this menu, the 'START' indication should be visible.
- Press . The filter will ask confirmation and then it will start. The main breaker should close within 30 seconds. One second after closing, the IGBTs will start and the filter will work under no load condition.
- The 'START' indication in the 'start/stop' menu changes in a 'STOP' indication once the filter is running.

Remarks:

- If the 'start/stop' menu reads 'ACK. FAULT' (i.e. 'acknowledge fault'), the filter has encountered a fault that needs to be corrected before the filter can be started. Refer to [Chapter 11](#) for troubleshooting the problem. In filter systems consisting of more than one unit, an ACK. FAULT message will only occurs when all the masters in the system have failed.
- In filter systems consisting of more than one master, one master unit is the main one and the other units behave as slaves. The PQF-Manager of the main master unit has full functionality and can be used to control the complete system. If the main master unit fails, then another master unit will assume the role of main master unit. The order in which master units assume control has been determined at the moment of commissioning.
- If some units of a multi-unit filter system do not start, this implies that the units concerned are in error. Refer to [Welcome/PQF Monitoring/Status of units] to identify the unit that is at fault and for which reason. Refer to [Chapter 11](#) for troubleshooting the problem.
- If the filter when activating the start menu displays a message to indicate that it is remote control mode, the filter either has to be started by remote control or the remote control mode has to be deactivated. More information about the remote control functionality is given in [Section 6.12.1](#) and [Section 7.9.1.4](#).
- If the hardware lock and/or the Communication lock has/have been engaged, the filter cannot be started nor stopped. In order to see which lock(s) has/have been engaged push  when the 'start/stop' menu is highlighted. A message will appear to indicate which lock(s) has/have to be disengaged. If authorized, disengage the relevant lock.
 - The hardware lock can be disengaged by pushing the blue button present at the bottom rear of the PQF-Manager. More information on the filter menu locking facilities is given in [Section 7.6](#).
 - The Communication lock can be engaged in the menu [/Welcome/User interface/Communication] by ticking the "check box". More information on the Communication lock is available in the document "9AKK107045A9896-RS-485 Installation and Start-up guide".

When power is applied to the filter and it is started, the following startup sequence is conducted:

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	155/188

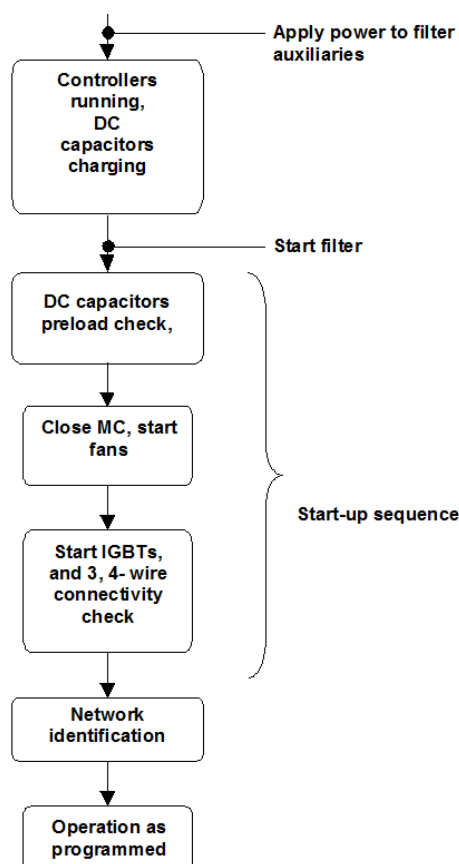


Figure 83: Filter start-up sequence when power is applied and the start command is given

In **Figure 83** it may be seen that:

- The DC capacitors charge as soon as the auxiliary circuit power is switched on.
- The start-up sequence consists of the DC capacitors voltage check, the closure of the filter main contactor and the starting of the IGBTs.
- Network identification may be done after the start-up sequence has finished. This network identification will always be done when harmonic components were selected and the filter was powered down before or when new harmonic components have been selected. The network identification may also be done automatically during normal filter operation if the filter controller has noted a big change of network impedance.
- At the end of the start-up procedure, the filter will work as programmed.

Remark: Filter running at 100% load while RMS current rating is not attained.

Under exceptional conditions it is possible that the active filter is showing a 100% load indication whereas its nominal RMS current rating is not yet attained. This is because the filter has reached an operating limit other than the RMS current limit. Possible other limits are:

- Temperature limit due to a too high ambient temperature or a failing cooling system.
- Peak current limit due to an atypical peak current requirement of the load.
- Peak voltage limit due to an atypical DC-link voltage requirement of the load or due to a high network voltage.

Under all these conditions, the filter will run in limited mode and may not attain 100% of its nominal current rating.

9.2.2. Stopping the filter with the PQF-Manager

In order to stop the filter with the PQF-Manager follow the instructions given below:

- Press  on the PQF-Manager repeatedly until the 'Welcome' screen is displayed.
- Highlight the filter 'start/stop' menu ('PQF' item in the list). In this menu, the 'STOP' indication should be present.
- Press . The filter will ask confirmation and then it will stop. The main contactor will open.
- The 'STOP' indication in the start/stop menu changes in a 'START' indication once the filter is stopped.

Remarks:

- If the 'start/stop' menu reads 'ACK. FAULT' (i.e. 'acknowledge fault'), the filter has encountered a fault. Refer to [Section 9.7](#) and [Chapter 11](#) for troubleshooting the problem.



WARNING: In case the filter stops operating due to a fault, very high voltages may be present on the DC capacitors for a long time. Do not touch any live parts unless you have ascertained that no dangerous voltage levels exist in the filter.

- If the filter when activating the stop menu displays a message to indicate that it is remote control mode, the filter either has to be stopped by remote control or the remote control mode has to be deactivated. More information about the remote control functionality is given in [Section 6.12.1](#) and [Section 7.9.1.4](#).
- If the hardware lock and/or the Communication lock has/have been engaged, the filter cannot be started nor stopped neither by the local button nor by remote control. In order to see which lock(s) has/have been engaged push  when the 'start/stop' menu is highlighted. A message will appear to indicate which lock(s) has/have to be disengaged. If authorized, disengage the relevant lock.
 - The hardware lock can be disengaged by pushing the blue button present at the bottom rear of the PQF-Manager. More information on the filter menu locking facilities is given in [Section 7.6](#).
 - The Communication lock can be engaged in the menu [/Welcome/User interface/Communication] by ticking the "check box". More information on the Communication lock is available in the document "9AKK107045A9896-RS-485 Installation and Start-up guide".

The stop sequence conducted when a stop command is given can be derived from the following flow chart.

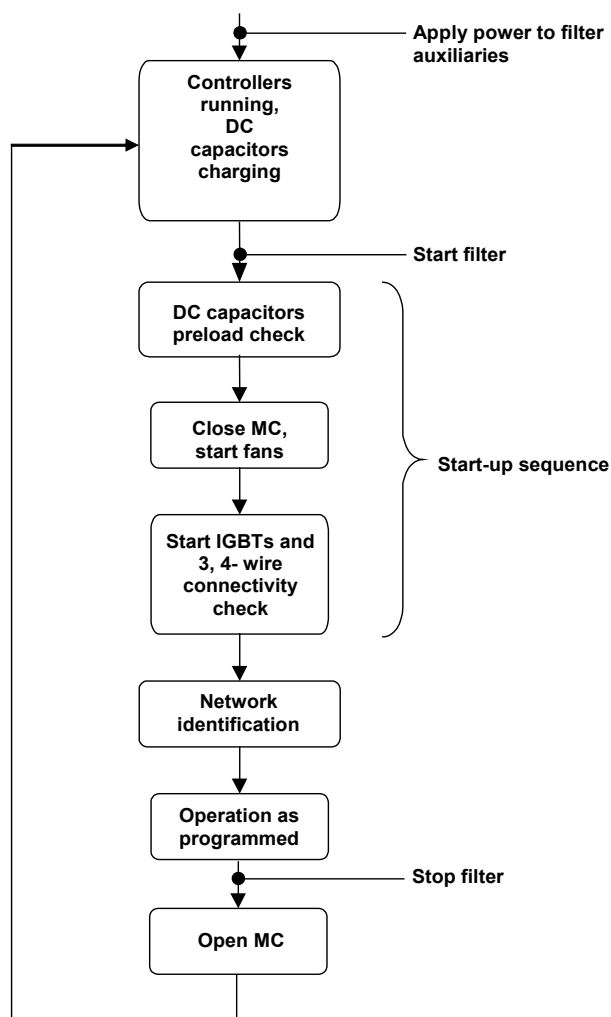


Figure 84: Filter operation sequence when no fault is present

The DC bus also incorporates discharge resistors that can discharge the DC bus in 25 minutes..

9.3. Modifying the user requirements

Providing that the filter locks have not been engaged, the user can change the customer settings to better suit his needs. These settings can be accessed in the PQF-Manager menu [/Welcome/Settings/Customer set.].

The user requirements can be divided into the following categories:

- Setting up the filter mode, the harmonic requirements and the reactive power requirements. Refer to [Section 7.9.1.1](#) for detailed information on these topics.
- Setting up alarms, warnings and digital I/O. The digital I/O allows configuration of the filter to operate in remote control mode etc. Refer to [Section 7.9.1.4](#) for detailed information on these topics.

Advanced user requirements have to be set up in the 'installation settings' menu ([/Welcome/Settings/Installation set.]). These advanced functions include:

- The autorestart function (after power outage).
- The standby function to switch off the IGBTs when the load requirement is low.
- The system clock setup.

- The software lock activation and password setup for filter protection purposes.

Refer to [Section 7.9.3](#) for detailed information on these topics.

It is recommended that the advanced functions be set up by a skilled commissioning engineer.

9.4. Changing the system temperature unit and PQF-Manager backlighting

If desired the system temperature unit can be changed from °C to °F or vice versa. This is done in [/Welcome/Settings/Customer set./Temp unit].

In addition, the PQF-Manager backlighting can be changed in [/Welcome/User interface/Screen config./Backlighting]. Calibration of touch screen can also be done here.

In systems consisting of more than one master, this needs to be done in all the PQF-Managers.

9.5. Consulting filter measurements

In order to consult the measurements done by the filter system, go to [/Welcome/Measurements].

The complete list of measured items is discussed in [Section 7.8](#).

9.6. Consulting filter statistics and manufacturer data

In order to consult the filter statistics, go to [/Welcome/PQF Monitoring]. This menu allows to monitor the filter load and to get an idea of its operating point compared to the nominal rating of the filter. In addition, logged warnings, faults and events can be retrieved for troubleshooting the filter operation and any abnormal network conditions. Also, an indication is given of fan running hours and filter running hours.

The 'PQF Monitoring' menu can also be used to verify the status of the individual units in a multi-master filter system.

The 'PQF Monitoring' menu is discussed in depth in [Section 7.10](#).

In order to obtain background manufacturer data on your PQF, go to [/Welcome/About PQF]. This menu gives basic data on the filter. This data includes:

- Basic manufacturer settings such as filter type, maximum voltage rating and filter serial number. These settings can be accessed in [/Welcome/User interface/About PQF].
- Firmware version numbers for the PQF-Manager, the μ controller and the DSP controller.

When communicating with your HITACHI representative on a specific filter, please provide always the data shown in the 'About PQF' menu.

9.7. Filter behavior on fault – retrieving error information

Under normal conditions the filter is either running or stopped and the PQF-item in the PQF-Manager 'Welcome' screen shows the message 'START' or 'STOP'. In this case, if the filter is stopped it can be started and if it is running it can be stopped. The start and stop commands will be stored in the event log accessible in [/Welcome/PQF Monitoring/Event logging].

All faults that occur are stored in the same event log. A fault can either be non-critical or critical.

- A non-critical fault is a transient fault (e.g. a voltage spike). When a non-critical fault occurs the filter may stop the switching of the IGBTs momentarily (< 40 ms) but they will automatically restart. The only way to pick up this type of fault is to analyze the event log. Given the transient/random character of this type of fault, the filter performance will hardly deteriorate when it occurs.

- A critical fault is a fault that after occurrence cannot be successfully automatically cleared by the system within a reasonable time. The time frame considered depends on the error type. If the fault is considered critical by the system, the label 'Critical' will be shown in the event logging window. In addition, the PQF-item in the PQF-Manager 'Welcome' screen will show the label 'ACK. FAULT'. Note however that if the fault disappears fast, this label disappears too. Depending on the type of critical fault and the number of occurrences, the filter, when running, may either:

- Stop (open the main contactor) and await user intervention. In this condition the alarm contact of the PQF-Manager will switch on after a programmable delay and the 'Armed' indicator will be OFF. The green LED on the main controller board (Cf. [Table 13](#) item 18, LED 2) will be off and the red LED on (Cf. [Table 13](#) item 18, LED 3). The user has to acknowledge the fault (with the PQF-Manager via Modbus or PQ-Link or via remote control) before the filter can be restarted.

By default, the 'Armed' indicator is associated with the fourth digital output contact (cf. [Table 9](#) and [Table 10](#)). The digital output contact monitor at the top of the PQF-Manager display (Cf. [Figure 51](#) item 3) can be used to check the status of the digital output. Alternatively, the digital output considered can be wired to monitor the 'Armed' indicator by distance (cf. [Section 6.12.4](#)).

- Stop (open the main contactor) and restart automatically if the fault disappears. If stopped, the alarm contact of the PQF-Manager will switch on after a programmable delay and the 'Armed' indicator will be ON. The green LED on the main controller board (Cf. [Table 13](#) item 18, LED 2) will be ON and the red LED will be OFF (Cf. [Table 13](#) item 18, LED 3). If it takes a long time before the fault disappears, the user may decide to give a filter stop command. This is done by highlighting the 'PQF ACK. FAULT' item in the 'Welcome' menu and selecting . After this, the 'Armed' indicator will be OFF. The green and red LED on the main controller board (Cf. [Table 13](#) item 18, LEDs 2 and 3) will be OFF too.
- Stop briefly without opening the contactor and continue filtering when the error has disappeared. This is essentially the same case as the one described above but the error phenomenon disappears faster than the time required to generate a contactor opening command.

If the filter is OFF and an external critical error occurs, these errors are also reported in the event log. As long as a critical fault condition exists (e.g. permanent undervoltage on one phase) the display will show the message 'ACK. FAULT' and the filter will refuse to start; The 'Armed' indicator on the PQF-Manager will be OFF and both the green and red main controller LEDs will be OFF too.

In general the occurrence of transient faults is no problem for the proper operation of the active filter. Only when an error becomes 'critical', a problem may exist.

If 'ACK. FAULT' is present on the PQF-Manager display, look at the 'Armed' indicator (By default mapped to the 4th digital output of the PQF-Manager) to know whether the filter will restart automatically after clearance of the problem or not.

- 'Armed' indicator ON: The filter waits for the problem to disappear and then restarts automatically (unless the user acknowledges the fault).

- 'Armed' indicator OFF: The filter is permanently stopped and the customer has to solve the problem, acknowledge the fault and restart the filter manually.

If the filter is in remote control operation and the message 'ACK. FAULT' is present on the PQF-Manager, the fault can be acknowledged by sending a 'STOP' command by remote control (low signal). Alternatively, the remote control functionality can be disabled by disabling the corresponding digital input functionality. Then, the fault can be acknowledged locally.

Refer to [Chapter 11](#) for advanced troubleshooting of the filter.

10. Maintenance instructions

10.1. What this chapter contains

This chapter contains the maintenance instructions for the active filter. Although your PQF has been designed for minimum maintenance, the following procedure should be carefully followed to ensure the longest possible lifetime of your investment.



WARNING: All maintenance work described in this chapter should only be undertaken by a qualified electrician. The safety instructions presented in **Chapter 2** of this manual must be strictly adhered to.

WARNING: High AC and DC voltages may be present in the filter panel. Do not touch any filter parts unless you have ascertained that they do not carry dangerous voltage levels.

WARNING: Under no circumstances close the main contactor manually. Failure to adhere to this guideline may result in physical injury and/or in filter damage.

10.2. Maintenance intervals

Table 55 lists the routine maintenance intervals recommended by HITACHI. Depending on the operating and ambient conditions, the intervals of **Table 55** may have to be reduced. Announced intervals assume that the equipment is operating under HITACHI approved operating conditions (Cf. **Chapter 12**).

Table 55: Filter maintenance intervals recommended by HITACHI

Maintenance	Intervals	Instructions
Standard maintenance procedure	Depending on the dustiness/dirtiness of the environment, at least once per year.	Section 10.3
Cooling fan(s) change	Every 4 years for the “fan in”(35000 hours) Every 3 years for the “fan out”(27000 hours)	Section 10.4
DC capacitor change	Every 8 years for 3-wire connection Every 5 years for 4-wire connection	Section 10.5
Output filter board change	Every 5 years	Section 10.8

For convenience **Section 10.6** presents a maintenance template that can be used by the maintenance engineer.

10.3. Standard maintenance procedure

10.3.1. Step 1: Check the ambient temperature conditions

With the filter running, check the ambient temperature conditions and make sure that they are similar to the conditions at the commissioning stage. If higher temperatures are present, this may indicate a problem with the switch room cooling/ventilation system. Ensure that the filter derating factor ([/Welcome/Settings/Installation set./Rating])

corresponds to the ambient conditions observed. If the ambient temperature is higher than 40°C/104°F, the filter should be derated (Cf. [Section 5.2](#)).

10.3.2. Step 2: Record the filter operating status

- With the filter running, check and note the filter load graphs ([/Welcome/PQF Monitoring/Filter load]). Pay special attention to the temperature graph. If this one is around 100% and the other load indicators are relatively low, this could indicate that the filter is limiting its output because it is experiencing a cooling (fan) problem. If in doubt, assign the 'T Limit' indicator to a spare digital output ([/Welcome/Settings/Customer set./Digital Outputs]). This way, the digital output monitor at the top of the PQF-Manager screen will be on if the filter is limiting its output current due to temperature problems. By default, the 'T Limit' indicator is assigned to digital output 6 of the PQF-Manager.
- Make a note of the PQF-operation hours ([/Welcome/PQF monitoring/PQF operation]) and the fan-operation hours ([/Welcome/PQF Monitoring/Fan operation]). For units up to 60A, if the fan operation indicator shows a multiple of 40000 hours, it is recommended that the fan be replaced. For units with higher ratings than 60A, if the fan operation indicator shows a multiple of 35000 hours (for "fan in") or 27000 hours (for "fan out"), it is recommended that the fan be replaced (Cf. [Section 10.4](#)). Pay attention to any noise that could indicate fan failure.
- Browse the 'event logging' menu ([/Welcome/PQF monitoring/Event logging]) to spot any abnormal events that may have occurred.
- Make a note of the total number of faults that the system has recorded over time ([/Welcome/PQF monitoring/Number of errors]).
- Inspect the filter visually for any condition that could indicate an abnormal filter stress (e.g. abnormal noises, abnormal appearance/colour or components and cables).

Note: In filters consisting of more than one master, the above parameters can be reviewed for the different units.

10.3.3. Step 3: Shut the filter down

- Switch the filter off and remove the power supply to the filter.
- Wait at least 25 minutes for the discharge of the DC capacitors.
- Remove the filter cover panel (right hand side). Pay attention to the PQF-Manager connections.
- Open the auxiliary circuit fuse box.
- Ensure that the DC capacitors have completely discharged before going to step 4

10.3.4. Step 4: Inspect and clean the filter

- Inspect the filter visually for any condition that could indicate an abnormal filter stress (e.g. abnormal appearance/colour of components and wires).
- Remove all dust deposits in and around the filter. Pay special attention to the fan and the heatsink. Indeed, the heatsink picks up dust from the cooling air and the PQF might run into overtemperature faults if the heatsink is not cleaned regularly. Pay special attention to this item if the filter has experienced shut downs due to over temperature in the past.
- Ensure that no loose particles are left in the fan that could obstruct their free rotation.
- Ensure that the control cards are free of dust. If necessary remove dust from them with a soft brush or vacuum cleaner.

10.3.5. Step 5: Check the condition of the filter breakers, contactors and fuses

- Ensure that the main contactor can move freely.

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- If bad fuses are found, replace them. If the fuse in one phase is bad, it is good practice to change the fuses of all phases. More information on the fuses to use is given in [Section 6.7](#). The active filter power circuit is internally connected to the network by means of a main contactor of type ABB UA50 or UA95 (depending on the current rating).

The PQFS control circuit and DC bus preload system is protected by a fuse protection scheme, the characteristics of which are given in the table below.

- Table 22.

10.3.6. Step 6: Check the tightness of the electrical and mechanical connections

- Ensure that all electrical connections are properly fixed and that connectors are properly plugged in. Remove oxidation traces of pin connectors if present. To this effect a small stiff brush can be used.
- Check the mechanical fixation of all components and retighten if necessary

10.3.7. Step 7: Correct any abnormal conditions found

If required, refer to [Chapter 11](#) for advice on troubleshooting the filter.

10.3.8. Step 8: Restart the filter

- Reclose the auxiliary circuit fuse box.
- Refit the filter protective cover and reconnect the PQF-Manager if necessary.
- Reapply power to the filter upstream. Verify that the PQF-Manager is booting.
- Restart the filter, verify that the fan starts running. If major servicing work has been done it is recommended to follow the commissioning instructions (cf. [Chapter 8](#)) for restarting the filter.
- Verify the filter performance.

10.4. Fan replacement

There are different types of fans present in your PQFS unit, depending on the filter rating. The cooling fan lifespan is between 3 and 6 years typically, depending on the usage and ambient temperature. Check the actual fan operating hours with the PQF-Manager ([/Welcome/PQF monitoring/PQF operation]).

Fan failure is often preceded by increasing noise from the bearings and rise of the heatsink temperature despite cleaning. It is recommended to replace the fan once these symptoms appear. Contact your HITACHI service provider for replacement fans for your system.

In order to exchange the cooling fans, follow the instructions below (Cf. [Figure 85](#)):

- Ensure that the power to the filter is switched off (upstream).
- Wait for at least 25 minutes to allow for the DC capacitors to discharge.
- Remove the cover on the right hand side of the filter and disconnect the fan terminals (at the bottom of the filter next to the IGBT bridge for the “fan in” and on the top right of the PCB for the “fan out”).
- Remove the screws that fix the fan set to the filter enclosure (4 screws on the bottom left side of the filter for the “fan in” and 8 screws on the top right side for the “fan out”).
- Remove the fan assembly from the enclosure.
- Refit the assembly in the unit. Ensure proper fixation by the screws.
- Reconnect the fan wires to the terminal block.

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- Reclose the filter cover.

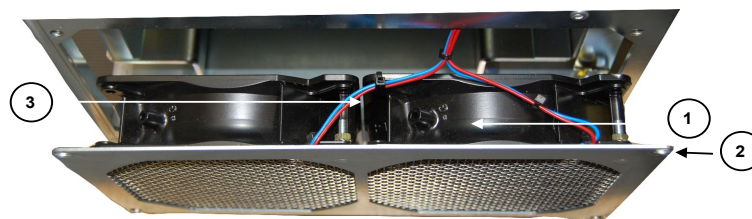


Figure 85: Overview of cooling fan in

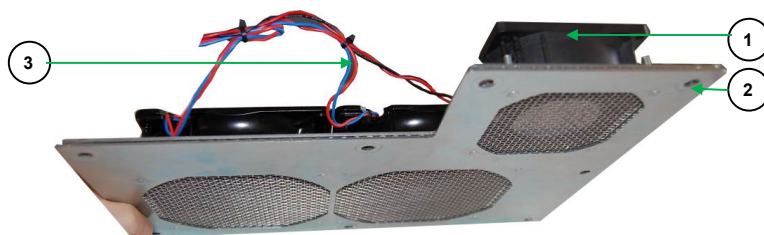


Figure 86: Overview of cooling fan out

The components description is given in [Table 56](#).

Table 56: IGBT cooling fan related items description

Item	Description
1	Cooling fan
2	Fan assembly fixation holes
3	Fan electrical connections

10.5. DC capacitor change

The active filter DC link contains electrolytic DC capacitors. Their lifespan is up to 8 years when the filter option 'line to neutral balancing' is not used and up to 5.5 years when the full capacity of the filter is used for line to neutral balancing. This data assumes that the filter is used within the HITACHI approved technical specifications (Cf. [Chapter 12](#)).

It is not possible to predict a capacitor failure. Contact your HITACHI service provider if capacitor failure is suspected. Replacement kits are available from HITACHI. Do not use other than HITACHI-specified spare parts.

Please refer to "9AKK107992A0402- Replacement of DC Capacitors in PQFS - After June 2010" specific detailed procedure for the change of the DC capacitors

Important note: for PQFS older than June 2010, please refer to below specific procedure:

Please refer to "9AKK107992A0401- Replacement of DC Capacitors in PQFS - Before June 2010" specific detailed procedure for the change of the DC capacitors for PQFS older than June 2010.

10.6. DC capacitor reforming

If the filter has been non-operational for more than one year, the DC capacitors must be reformed (re-aged) before use. Without reforming, the DC capacitors may be damaged at start-up.

Stocked or non-operational filters should be reformed once a year. The method described here assumes that the filter is stocked in a clean and dry environment.

To reform the capacitors,

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- Switch on the power supply to the filter without starting the filter for about 2 hours. Verify with the PQF-Manager the DC capacitor voltage and ensure that it is charges to a couple of hundred volts.
- Then, with all harmonics and reactive power and balancing functionality deselected, start the active filter and leave it running for one hour.
- The filter is now ready for normal operation

If the filter has been left more than 2 years without operation, please contact your HITACHI service provider.

10.7. Output filter board change

PQFS filters are equipped with output filter board which has 6 capacitors (2 per phase) and pre-load circuit in built. Capacitor lifespan is up to 5 years. This data assumes that the filter is used within the HITACHI approved technical specifications (Cf. [Chapter 12](#)).

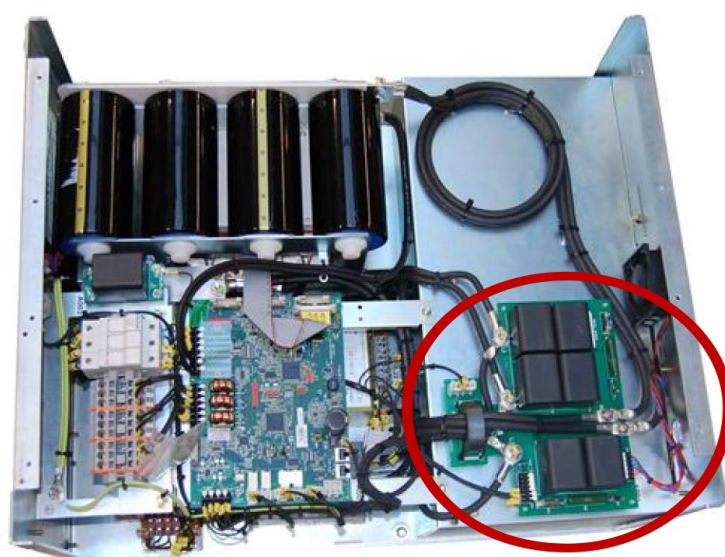


Figure 87 Output filter board location in PQFS

Please refer to “9AKK107992A0162- Replacement of output filter board in PQFS – After October 2014” specific detailed procedure for the change of the output filter board.

IMPORTANT NOTE: For PQFS filter older than October 2014, the design was different and the output filters capacitors must also be changed after 5 years.

Please refer to “9AKK107992A0175- Replacement of output filter board in PQFS – Before October 2014” specific detailed procedure for the change of the output filter capacitors for PQFS older than Oct 2014.

10.8. Servicing report

The Servicing report is designed to help the person in charge of servicing.

The report can be used for each individual unit of a multi-unit filter.

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
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	Project:
LV Active Filters PQF	Issued by:
Servicing report	Date:

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10.8.1. Filter identification

Active filter type^(a)

Global ratings^(a) Maximum voltage (V)

Total current (A)

System serial number^(a)

Filter connection mode 3-W / 4-W

Unit ratings/serial number^(b)	Rating (A)	Serial number	Article code ^(b)
---	------------	---------------	-----------------------------

Unit 1 (M)

Unit 2 (M/S)^(d)

Unit 3(M/S)^(d)

Unit 4(M/S)^(d)

Unit 5(M/S)^(d)

Unit 6(M/S)^(d)

Unit 7(M/S)^(d)

Unit 8(M/S)^(d)

Software version^(c) PQF-Manager software

µcontroller software

DSP software

Installation location

Remarks:

^(a) Read from main identification tag located on the master cubicle door.

^(b) Read on identification tag located at the outside of each cubicle door.

^(c) After the filter has been commissioned, navigate with the PQF-Manager to to [\[/Welcome/User interface/About PQF\]](#).

^(d) Select whether this unit is a master (M) or a slave (S) unit.

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LV Active Filters PQF	Issued by:
Servicing report	Date:

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10.8.2. Standard maintenance procedure

Ambient conditions and derating condition (filter running)	OK/NOK
Check the ambient temperature (< 40°C/104°F) (if > 40°C/104°F, derating is required)	
Check the installation altitude (< 1000m/3300ft) (if > 1000m/3300ft, derating is required)	
Check the ventilation (room and enclosure)	
Ensure that no conductive dust is present in and around the filter panel	
Rating factor (temperature > 40°C/104°F or altitude > 1000m/3300ft)	
- Rating (%)	
Filter operating status record (filter running)	
Filter load graphs	
- Vdc load (%)	
- Ipeak load (%)	
- Irms load (%)	
- Temp (%)	
Filter running in derated mode due to temperature limitation?	
- Temp-load around 100% and other load indicators low? (Y/N)	
- 'T-Limit' indicator on digital output monitor on? (digital output 6 by default) (Y/N)	
If answer if 'Y' to any of the two questions above, check filter cooling.	
- PQF operation hours	
- Fan operation hours	
If fan operation hours are multiple of 40000 hrs for units up to 60A and of 35000 hrs / 27000 hrs for units with higher ratings, exchange fan.	
- Event logging window	
Abnormal events present? (Y/N)	
If 'Y', describe them in the 'comments' section of this report.	
- Total number of faults recorded by the system	
Describe them in the 'comments' section of this report.	
Shut down the filter, remove supply to the unit	
Wait for 25 minutes for DC capacitors to discharge	
Remove the filter protective cover (right hand side) and open the auxiliary fuse box	
Ensure that components do not carry dangerous voltage levels anymore.	
Inspect and clean the filter	
- All components/cabling looks OK? (Y/N)	
If 'N', describe the problems in the 'comments' section of this report.	
- Remove all dust deposits in and around the filter (fans, heatsinks, control board, ...)	

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LV Active Filters PQF	Issued by:
Servicing report	Date:

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Remove loose components if present in enclosure	OK/NOK
Condition of filter main contactor, contactors and fuses	
Contactors can move freely? (Y/N)	
Fuses are OK? (Y/N)	
If 'N', describe the problems in the 'comments' section of this report.	
Tightness of electrical and mechanical connections	
Check tightness of all electrical connections	
Check the mechanical fixation of all components	
Retighten connections/fixations if necessary	
Correct the outstanding problems	
Reclose the auxiliary circuit fuse box and refit the filter protective cover	
Restart the filter upstream protection and restart the filter	
- PQF-Manager booting	
- DC capacitors charging	
Start the filter	
- Fan(s) start(s) running	-
If major servicing work has been done, follow the commissioning instructions to start the filter.	

10.8.3. Special service actions

Fan replacement	OK/NOK
Fan operating hours?	
DC capacitor replacement	
Filter operating hours/years?	
Ambient filter conditions?	
Describe / follow the procedure 9AKK107992A0401 or 9AKK107992A0402	
DC capacitor reforming (CE versions only)	
Filter storage time?	
Reforming time?	
Describe in the 'comments' section of this report.	
Output filter board change	
Filter operating hours / years?	
Describe / follow the procedure 9AKK107992A0162 or 9AKK107992A0175	

	Project:
LV Active Filters PQF	Issued by:
Servicing report	Date:

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10.8.4. Comments

	Servicing Engineer	Customer's representative
Name		
Signature		
Date		

11. Troubleshooting guide

11.1. What this chapter contains

This chapter presents the troubleshooting guide for the active filter. The filter fault treatment procedure is described. Also, an overview of possible errors is given. Finally, recommendations are made on how problems may be resolved.



WARNING: All troubleshooting and repair work described in this chapter should only be undertaken by a qualified electrician. The safety instructions presented in **Chapter 2** of this manual must be strictly adhered to.

WARNING: High AC and DC voltages may be present in the filter panel. Do not touch any filter parts unless you have ascertained that they do not carry dangerous voltage levels.

WARNING: Under no circumstances close the main contactor manually. Failure to adhere to this guideline may result in physical injury and/or in filter damage.

WARNING: Some checks may have to be made with the supply on and the filter doors opened. These tests must be carried out only by authorized and qualified personnel, in accordance with the local regulations. Apply the safety guidelines that are presented in **Chapter 2**. Failure to adhere with the safety guidelines may result in lethal physical injury.

11.2. Fault treatment procedure

All faults that occur are stored in the filter event log and are analyzed by the filter controller. The event log is of the circular type and can store up to 200 events. It can be accessed through [/Welcome/PQF Monitoring/Event logging]. Background information on the event logging display is given in **Section 7.10.3**.

A fault can either be non-critical or critical.

- A non-critical fault is a transient fault (e.g. a voltage spike). When a non-critical fault occurs the filter may stop the switching of the IGBTs momentarily (< 40 ms) but they will automatically restart. The only way to pick up this type of fault is to analyse the event log. Given the transient/random character of this type of fault, the filter performance will hardly deteriorate when it occurs.
- A critical fault is a fault that after occurrence cannot be successfully automatically cleared by the system within a reasonable time. The time frame considered depends on the error type. If the fault is considered critical by the system, the label 'Critical' will be shown in the event logging window. In addition, the PQF item in the PQF-Manager 'Welcome' screen will display the label 'ACK. FAULT'. Note however that if the fault disappears fast, this label disappears too.

Depending on the type of critical fault and the number of occurrences, the filter, when running, may either:

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	170/188

- Stop (open the main contactor) and await user intervention. In this condition the alarm contact of the PQF-Manager will switch on after a programmable delay and the 'Armed' indicator will be OFF. The user has to acknowledge the fault (with the PQF-Manager via Modbus or via remote control) before the filter can be restarted.
- By default, the 'Armed' indicator is associated with the fourth digital output contact (cf. Table 9 and Table 10). The digital output contact monitor at the top of the PQF-Manager display (Cf. Figure 51 item 3) can be used to check the status of the digital output. Alternatively, the digital output considered can be wired to monitor the 'Armed' indicator by distance (cf. Section 6.12.4)
- Stop (open the main contactor) and restart automatically if the fault disappears. In this condition the alarm contact of the PQF-Manager will switch on after a programmable delay and the 'Armed' indicator will be ON. If it takes a long time before the fault disappears, the user may decide to give a filter stop command. This is done by highlighting the 'PQF ACK. FAULT' item in the 'Welcome' menu and selecting . After this, the 'Armed' indicator (a) will be OFF.
- Stop briefly without opening the main contactor and continue filtering when the error has disappeared. This is essentially the same case as the one described above but the error phenomenon disappears faster than the time required to generate a breaker opening command.

If the filter is OFF and a critical error occurs (e.g. network undervoltage), the errors will also be reported in the event log. As long as a critical fault condition exists (e.g. permanent undervoltage on one phase) the display will show the message 'ACK. FAULT' and the filter will refuse to start. The 'Armed' indicator on the PQF-Manager will be OFF.

When pressing 'ACK. FAULT' the filter will display a message relevant to the problem. It also shows a list of the most recent critical faults that have been recorded.

If the filter is in remote control operation and the message 'ACK. FAULT' is present on the PQF-Manager, the fault can be acknowledged by sending a 'STOP' command by remote control (low signal). Alternatively, the remote control functionality can be disabled by disabling the corresponding digital input functionality. Then, the fault can be acknowledged locally.

Figure 88 shows the error treatment procedure in flowchart format.

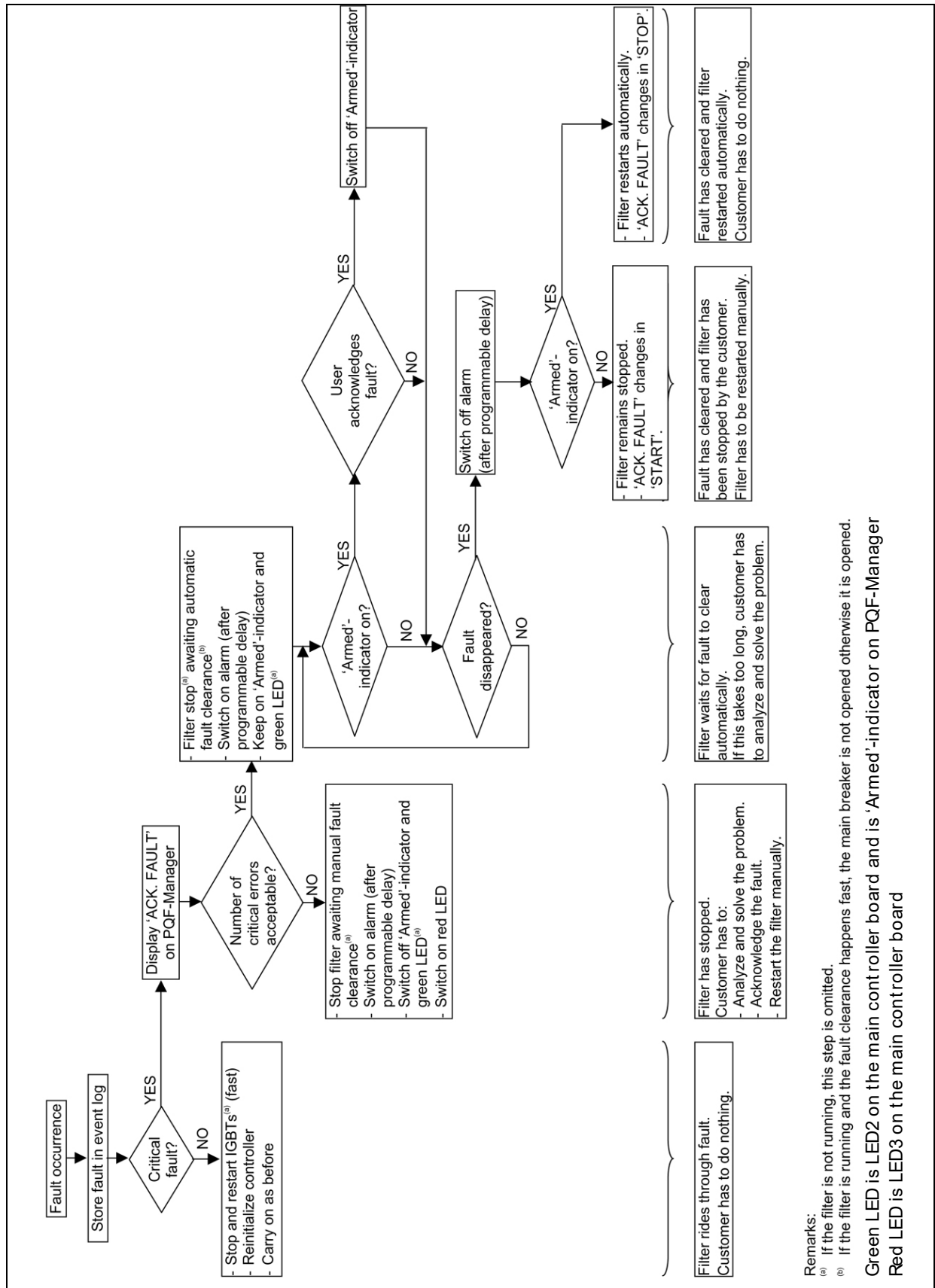


Figure 88: PQF error treatment procedure in flowchart format

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	172/188

In general the occurrence of transient faults is no problem for the proper operation of the active filter. Only when an error becomes 'critical', a problem may exist.

If 'ACK. FAULT' is present on the PQF-Manager display, look at the 'Armed' indicator (By default mapped to the 4th digital output of the PQF-Manager) to know whether the filter will restart automatically after clearance of the problem or not.

'Armed' indicator ON: The filter waits for the problem to disappear and then restarts automatically (unless the user acknowledges the fault).

'Armed' indicator OFF: The filter is permanently stopped, and the customer has to solve the problem, acknowledge the fault and restart the filter manually.

11.3. Spare part list for normal and dedicated filter servicing

A standard set of spare parts for the PQFS filter is shown in [Table 57](#).

Table 57: Standard set of spare parts for normal and dedicated filter servicing

Ref.	Description	Order code	Recommended quantity
1	Spare fuses for auxiliary circuit	2GCA100465A0420	3
2	Spare fuses for preload circuit	2GCA113178A0420	2
3	PQF-Manager filter controller (touchscreen)	2GCA291723A0075	1
4	Assy cooling "fan in" PQFS (30-100A)	2GCA294292A0075	1
5	Assy cooling "fan in" PQFS (120 A)	2GCA294290A0075	1
6	Assy cooling "fan out" PQFS (30-60A)	2GCA294800A0075	1
7	Assy cooling "fan out" PQFS (70-120A)	2GCA293805A0075	1
8	Control board Master ¹	2GCA292552A0079	1
	Control board Slave ¹	2GCA292553A0079	
9	DC Power Supply ²	2GCA116277A0530	1
10	DC power Supply + Metallic support ³	2GCA291036A0075	1
11	EMC Line + EMC Neutral + Output Filter Boards ⁴	2GHV856581-0001	1

1 Serial number including DSP and uC software versions of existing PQFS must be communicated for suitable programming.

2 For PQFS manufactured after Jan 1st, 2021.

3 For PQFS manufactured before 2021.

4 This item contains the 3 individual boards (2GCA112522A0580- 2GCA113067A0580-2GCA113068A0580).

11.4. Troubleshooting guide

11.4.1. Verification of the PQF-Manager status and the system LEDs

As a first phase of troubleshooting make a record of the information provided by the PQF-Manager:

- 'ACK. FAULT' message present or not.
- Filter event log information messages.
- Alarm horn on or not?

- Status of the digital output contact monitor.

The most recent messages are shown first in the event log.

Refer to **Table 60** and **Table 61** for an overview of the possible messages and the corresponding troubleshooting tips. Note that for troubleshooting it may be necessary to open the filter door. Always remove power to the units and allow time for the DC capacitors to discharge (min. 25 mins) before opening the filter cover.

When the filter right cover is removed and power is supplied again to the filter, the status of the control card LEDs can be monitored.

- Main controller board LEDs:

Figure 16 (items 18 and 19) can be used to locate the main controller board LEDs.

Table 13 (items 18 and 19) explains the meaning of the LEDs and their status for normal operation.

WARNING: Only apply power to a filter with protective cover if there is no physical damage in the filter panel. Failure to adhere to this guideline may result in physical injury or death.

Provide the data provided by the PQF-Manager and the LED status information to the HITACHI service provider when discussing a potential filter problem.

STATUS	SECURITY LEVEL	DOCUMENT ID	REV.	LANG.	PAGE
Released	External	9AKK107045A4706	C	en	174/188

11.4.2. Fault tracing

Table 58: Power supply problems

Symptom	Cause	What to do
No display on PQF-Manager. All the indicator LEDs on the electronic card (LEDs) remain OFF.	The active filter (auxiliaries) is/ (are) not energized or no power supplied to the filter.	- Check if the protection (fuses, disconnecter ...) feeding the active filter are OK. - Check if the auxiliary fuse box is closed and the fuses are OK. - Check the mains and auxiliary supply voltages.
No display on PQF-Manager. All the indicator LEDs on the electronic cards (LEDs) are functioning properly.	The auxiliary transformer is not set according to the network voltage.	- Check the selection of the tap on the auxiliary transformer. - Check the supply voltage to see that it is within the tolerance range of the nominal filter settings.
After applying auxiliary power to the system, the PQF-Manager shows the message 'Initializing communication. Please wait... none of the LEDs of the main controller board is functioning.	The 24 Vdc power supply feeding the controller board has failed or the cabling between the power supply and main controller is loose or main controller board faulty.	- Check the 24 V power supply feeding the control board. - Check the feeding cable between the main power and the 24 V power supply. - Check the feeding cable between the control boards and the 24 V power supply.

Table 59: Abnormal states of the controller board LEDs (after auxiliary power is applied to the system)

Symptom	Cause	What to do
The two green main controller board LEDs are blinking but the DSP controller LED (4) is blinking twice as slow as the μ controller LED (1). The PQF-Manager shows 'ACK. FAULT' and gives error message 'Bad parameters'.	The filter parameters entered by the commissioning engineer are not consistent with the filter configuration reported by the controller.	- Check the commissioning parameters and correct where necessary. (Cf. Chapter 8).
The red LED (3) on the main controller board is on.	The filter is stopped due to an unacceptably high number of critical errors.	- Check the filter event log to analyze the critical errors. Refer to Table 60 to know what to do to solve the problem reported. - After resolving the problem, the fault must be acknowledged, and the filter has to be re-started manually.
One of the two controller LEDs (1-4) on the main controller board is not blinking while the other one is.	One of the controllers is not starting up properly. Eventually the red LED (3) will switch on.	- Check the filter event log to analyze the critical errors. Refer to Table 60 to know what to do to solve the problem reported. Most likely the controller board must be replaced. - After changing the main controller board, the filter must be recommissioned.

Table 60: Fault messages reported by the DSP controller of the filter and troubleshooting tips

Fault message	Cause	What to do
Bad parameters	The filter parameters entered by the commissioning engineer are not consistent with the filter configuration reported by the controller.	- Check the commissioning parameters and correct where necessary. (Cf. Chapter 8)
Bad message sequence	Internal system error	- Contact your HITACHI service provider. Most likely the controller software has to be upgraded or the main controller card replaced.
Bad CT connection	The automatic CT detection procedure has encountered a problem during the CT identification process.	- Check that the CTs are installed on the supply side of the filter. - Check that the CTs are not shorted. - Check that the overall CT ratio (including summing CTs) is smaller than 20000/5. - Set up the CTs manually (Cf. Section 8.6)
DC overvoltage (SW)	The DC software overvoltage protection has been triggered.	- Check the connection between the DC voltage measurement connector (P6-5 and P6-7) and the DC capacitors. - Check flat cable connections between the Control Board and the IGBT module. - Analyze network voltage stability (amplitude and phase). - Disable reactive power compensation and balancing options to see if the problem persists. - Deselect the high frequency components to free DC bus resources and to see if the problem persists.
DC overvoltage (HW)	The DC hardware overvoltage protection has been triggered.	- Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors. - Check flat cable connections between the Control Board and the IGBT module. - Analyze network voltage stability (amplitude and phase). - Disable reactive power compensation and balancing options to see if the problem persists. - Deselect the high frequency components to free DC bus resources and to see if the problem persists.

Fault message	Cause	What to do
DC undervoltage (SW)	The DC software undervoltage protection has been triggered.	- Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors. - Check flat cable connections between the Control Board and the IGBT module. - Analyze network voltage stability (amplitude and phase). - Disable reactive power compensation and balancing options to see if the problem persists. - Check the main contactor and its control signal.
IGBT check cooling	The software IGBT temperature protection has been triggered.	- Check the cooling of the filter system (fans and air flow, heatsink). - Check the cooling of the location where the filter is installed (air conditioning system etc.) - Ensure that the correct derating factor is applied noting the ambient temperature and altitude.
IGBT permanent	The IGBT module reports an error that cannot be cleared by the system. This error can be due to peak overcurrent, too low control voltage for the IGBT drivers or IGBT module failure.	- Identify unit for which the red LED (3) is on. - Inspect the corresponding IGBT module (bridge and DC capacitors) for visual traces of damage. If they are present, exchange the IGBT module. - Verify flat cable connection between the Control board and the IGBTs. - Ensure that the Control board power supply is around 24 V. If significantly lower, check the 24 V power supply and the wiring between this supply and the control board.
IGBT temporary	The IGBT modules report a transient error that could be automatically cleared by the system. This error can be due to peak overcurrent or a too low control voltage for the IGBT drivers.	If the errors occur sporadically and the system rides through, nothing has to be done. If the system does not ride through (too many transient errors in a short time): - Verify that the filter CTs are properly installed and are not shorted. - Verify that the unit current ratings and order programmed at the commissioning stage corresponds to the rating and order physically present. - Verify the filter cooling system and check the IGBT-temperature using the PQF-Manager. - Deactivate harmonic and reactive power requirements and see if the problem persists. - Inspect the items discussed for the 'IGBT permanent' message.

Fault message	Cause	What to do
Loss of phase	The system has detected a loss of supply on at least one phase.	- Measure the three-line voltages and check if they are within limits. - Measure the line voltages (e.g., voltmeter) and compare them with the line voltages given by the filter (PQF-Manager or PQ-Link). - Check the AC voltage measurement connectors (P6-1 to and P6-4) for loose connections and component damage. - Check the connections between the auxiliary fuses and the AC voltage measurement connectors (P6-1 to and P6-4). - Check the filter parameters (Cf. Chapter 8).
Mismatch between units	In a multi-unit filter, incompatible units or incompatible unit settings are used.	- Ensure that all filters have a compatible setting. - Recommission the units.
No synchronization	The system cannot synchronize on to the network. The supply frequency has changed too much or too fast. No/low voltage measured during filter initialization. Wrong frequency set up	- Measure the network frequency and its variation, and check if they are within limits. - Check the phase rotation (only in case of modification at the installation). - Ensure that the AC voltage is properly measured. Do the checks discussed for the 'Loss of phase' fault. - Verify that the frequency set up at the commissioning stage corresponds to the frequency of the network. (Cf. Chapter 8). - Reset the system by powering off and on again.
Out of mains freq. Limit	The system has detected that the network frequency is out of range.	- Measure the network frequency and check if it is within limits. - Check the phase rotation (only in case of modification at the installation). - Ensure that the AC voltage is properly measured. Do the checks discussed for the 'Loss of phase' fault.

Fault message	Cause	What to do
Overvolt. Transient (SW)	The software transient network overvoltage protection has been triggered.	If the errors occur sporadically and the system rides through, nothing must be done. If the system does not ride through (too many transient errors in a short time): - Measure the line voltages with a device capable of measuring the peak voltage (e.g., scopemeter) and verify that this value is within acceptable limits. - Measure the RMS value of the network voltage and compare with the line voltages given by the filter (PQF-Manager or PQ-Link). - Ensure that the AC voltage is properly measured. Do the checks discussed for the 'Loss of phase' fault. - Check the earthing of the unit.
Overcurrent RMS	The system has detected RMS overcurrent in the filter.	- Verify that the filter CTs are properly installed and are not shorted. - Verify that the unit current ratings and order programmed at the commissioning stage corresponds to the rating and order physically present. - Verify the filter cooling system and check the IGBT temperature using the PQF-Manager. - Deactivate harmonic and reactive power requirements and see if the problem persists.
Overcurrent peak (SW)	The software peak current protection has been triggered.	- Verify that the filter CTs are properly installed and are not shorted. - Verify that the unit current ratings and order programmed at the commissioning stage corresponds to the rating and order physically present. - Verify the filter cooling system and check the IGBT temperature using the PQF-Manager. - Deactivate harmonic and reactive power requirements and see if the problem persists.
Overvoltage RMS	The RMS value of the supply voltage measured with the AC voltage measurement board is higher than the acceptable maximum value.	- Measure the three-line voltages and check if they are within limits. - Measure the line voltages (e.g., voltmeter) and compare them with the line voltages given by the filter (PQF-Manager or PQ-Link). - Ensure that the AC voltage is properly measured.

Fault message	Cause	What to do
Preload problem	The DC capacitors could not be preloaded at startup. The voltage increase on the DC capacitors during the preload phase is not high enough.	- Measure the three-line voltages and check if they are within limits. - Verify the fuses (PF1 and PF2) and the resistors (R1 and R2) of the preload circuit (A001). - Inspect the DC-bus for traces of damage that may have caused a short circuit on the DC side of the IGBT module or on the DC voltage measurement board.
Unbalanced supply	The supply network imbalance is out of range.	- Measure the three-line voltages and check if they are within limits including the imbalance limit. - Measure the line voltages (e.g., voltmeter) and compare them with the line voltages given by the filter (PQF-Manager or PQ-Link). - Ensure that the AC voltage is properly measured. Do the checks discussed for the 'Loss of phase' fault. - Check the earth of the unit.
Undervoltage RMS	The RMS value of the supply voltage measured with the AC voltage measurement board is lower than the acceptable maximum value.	- Measure the three-line voltages and check if they are within limits. - Measure the line voltages (e.g., voltmeter) and compare them with the line voltages given by the filter (PQF-Manager or PQ-Link). - Ensure that the AC voltage is properly measured. Do the checks discussed for the 'Loss of phase' fault.
Unstable mains frequ.	The network frequency is varying too fast.	- Measure the network frequency and its variation, and check if they are within limits. - Check the phase rotation (only in case of modification at the installation). - Ensure that the AC voltage is properly measured. Do the checks discussed for the 'Loss of phase' fault.
Wrong phase rotation	The supply network feeding the filter has the wrong phase rotation.	- Check the phase rotation of the filter supply. - Measure the three-line voltages and check if they are within limits. - Measure the line voltages (e.g., voltmeter) and compare them with the line voltages given by the filter (PQF-Manager or PQ-Link). - Check the AC voltage measurement connectors (P6-1 to and P6-4) for loose connections and component damage. - Check the connections between the auxiliary fuses and the AC voltage measurement connectors (P6-1 to and P6-4).

Remark:

If the problem persists, contact your HITACHI service provider. Provide him with all the relevant information, i.e. Filter serial number and type, status of the control LEDs, Error messages displayed and filter behavior.

Table 61: Fault messages reported by the μ controller of the filter and troubleshooting tips

Fault message	Cause	What to do
Com. Problem (RS-232)	Communication problem between the main controller board and the external PC	- Ensure that the PQ-Link cable is properly connected.
Ctrl overtemperature	The system detected an overtemperature of the main controller board.	- Verify the ambient temperature and the cooling of the filter (dust filters, fans, heatsinks ...). - If the ambient conditions and the filter cooling is ok, the main control board is suspect. Contact your HITACHI service provider. The main control board may have to be replaced.
Reactor overtemperature	Line reactor thermal switch has open	- Check the status of the reactors and the PCB output filter
PWM check cooling	The thermal switch in the PWM reactor has open	- Check the "fan out" status
DSP watchdog	Internal system error.	- Reset the filter by switching off and on the power. If the problem persists, contact your HITACHI representative. The controller card must probably be replaced, or the controller software upgraded.
SPI Timeout Power supply fault	Internal system error.	- Reset the filter by switching off and on the power. If the problem persists, contact your HITACHI representative. The controller card must probably be replaced.
Preload time-out	The DC capacitors could not be charged.	- Measure the three-line voltages and check if they are within limits. - Verify the fuses (PF1 and PF2) and the resistors (R1 and R2) of the preload circuit (A001). - Inspect the DC-bus for traces of damage that may have caused a short circuit on the DC-side of the IGBT-module or on the DC voltage measurement board.
Several units same id	Two or more units in a filter system have the same CAN_ID.	- Check the CAN_ID of the different units in the set of filters: each unit has to have one unique CAN_ID on the DIP switch S5-1 to S5-3. - Reset the filter by switching off and on the power. If the problem persists, contact your HITACHI representative. The controller card must probably be replaced.
Com. Problem (CAN Bus)	The communication through the CAN bus between units is not working properly.	- Check the RJ-45 cables between modules. - Check the termination for the CAN bus: both (and only) the ends of the bus must have the DIP switch S5-4 in the "set" status. - Reset the filter by switching off and on the power. If the problem persists, contact your HITACHI representative. The controller card must probably be replaced.

Fault message	Cause	What to do
- Real time clock problem - Watchdog fault - Internal µC fault - Corrupted DSP code - Corrupted µC code	Internal system error	Reset the filter by switching off and on the power. If the problem persists, contact your HITACHI representative. The controller card must probably be replaced.
Different firmwares	Different units in a filter system have different firmware version (DSP or microcontroller)	Upgrade all the units with the same (most recent) firmware.

Remark:

If the problem persists, contact your HITACHI service provider. Provide him with all the relevant information, i.e., Filter serial number and type, status of the control LEDs, Error messages displayed and filter behavior.

Table 62: Other filter indications and behavior with corresponding troubleshooting tips

Symptom	Cause / State	What to do
The filter is working at 100% of its nominal capacity because the load requirement is asking this.	The harmonic stress on the network is still too high.	Install additional filter units to reduce the stress further.
	The harmonic stress on the network is sufficiently low. The load requirement is only a fraction of the filter size.	The filter can be kept running in this condition.
The filter is working at 100% of its nominal capacity while the load is only at a fraction of the filter rating.	There is a problem in the CT connections or a hardware problem.	- Check the CT installation (CT location, CT shorts, ...) - Check the connection between the CT terminal block X21 and the main controller terminals P5-1...P5-6. - Measure the line currents (e.g., ammeter) and compare them with the line currents given by the filter (PQF-Manager or PQ-Link).
	There is a software problem.	- Stop the filter, switch off the power of the auxiliaries and switch it on again. Restart the filter and see if the problem is solved. - If the problem persists, contact your HITACHI service provider.
	The filter has been asked to generate static reactive power.	- Verify the reactive power settings of the filter.
The filter is running but it is unstable (oscillating behavior).	There is a problem in the CT connections or a hardware problem.	- Check the CT installation (CT location, CT shorts ...). - Check the connection between the CT terminal block X21 and the main controller terminals P5-1...P5-6. - Measure the line currents (e.g., ammeter) and compare them with the line currents given by the filter (PQF-Manager or PQ-Link).

Symptom	Cause / State	What to do
	Presence of (detuned) power capacitor banks or plain capacitors (LV or MV).	- Refer to Section 8.10 for precautions to take when plain capacitors are present in the network.
	The filter is installed on a very weak network.	- Make sure that the filter is operating in Mode 3. - If the problem persists, contact your HITACHI representative.
	Two master units are fed from the same CTs. The setup guidelines for this installation setup have not been implemented.	Interconnect the units with an RJ-45 cable. If this is not possible: - Select different harmonics on both filters. - If not possible, ensure that one filter is operating in Mode 1 and the other filter is operating in Mode 3.
The filter is running with low load indication and the load harmonics are not filtered.	The harmonics are not selected, the curve setting is very high, or the harmonics are put in standby by the system.	- (Re)select the harmonics, check the curve levels, and ensure that the correct settings are active (Main/Auxiliary).
	The line currents measured by the filter via the CTs are lower than the real load currents.	- Check the CT cabling for problems (CT-installation, CT-shorts ...). - Check the CT settings set up in the PQF-Manager.
	The filter is in standby mode, the IGBTs are not switching.	- Check the standby mode settings to ensure that they represent realistic values.
	The filter (CTs) is/are not installed in a central position and therefore the filter does not eliminate the harmonics of all the loads.	- Check that the CTs are installed at the desired location.
When selecting a harmonic, the filter attempts to identify it but after a while it is put in standby. The letter 'S' appears in the harmonic's selection list. The harmonic is not filtered.	The network conditions do not allow for the harmonic to be filtered at present or there is a CT-problem.	- Check the CT-setup. - Reselect the harmonic to see if the problem persists. - Leave the harmonic in standby. The filter will automatically restart identifying/filtering it when another harmonic component is successfully (re)identified.
The 'ACK. FAULT'-message is present on the PQF-Manager. The alarm contact switches on after some delay.	The filter has stopped due to an error.	- Acknowledge the fault to see a list of most recent critical errors. - Look in the filter event log for more information on which errors have occurred. - Refer to the Table 60 and Table 61 for more information on these errors and for guidelines on how to troubleshoot them.

12. Technical specifications

12.1. What this chapter contains

This chapter contains the technical specifications of the active filter PQFS.

12.2. Technical specifications

The PQFS is an active filter for three phase networks with or without neutral for filtering of non-zero sequence harmonics and reactive power compensation including balancing between phases.

Table 63: Technical Specifications

Installation location	
Indoor installation on firm foundation in a clean environment	
Altitude	Nominal output at 0 to 1000m (3300ft) above sea level (for derating refer to Table 14)
Minimum temperature	-10°C (23°F) non condensing
Maximum temperature	40°C (104°F) (for derating refer to Table 14)
Recommended maximum average temperature (over 24 h)	35°C (95°F)
Relative humidity	Max. 95% non-condensing during operation. Max. 85% non-condensing during storage.
Contamination levels (IEC 60721-3-3)	Chemical class 3C2 (for more information refer to Table 14) Mechanical class 3S2 (for more information refer to Table 14)
Vibration (IEC 60068-2-6)	Max. 0.3mm (2-9Hz) Max. 1m/s ² (9-200Hz)
Shock (IEC 60068-2-27)	Max. 40m/s ² - 22ms
Filter installation information	
Degree of protection	IP30
Dimensions per power unit (appr.)	W x D x H: 588 x 326 x 752 mm W x D x H: 588 x 326 x 795 mm (including fixations)
Weight per power unit cubicle (unpacked)	130 kgs
Color	RAL 7035 (light gray)
Mechanical installation	Wall mounted (fixation plates included)
Cable entry method	Bottom cable entry
CT requirements	3 CTs are required (Class 1.0 or better) Filter burden: 5 VA for upto 8 units 15 VA burden for up to 30 m of 2.5 mm ² cable 5 A secondary rating CTs must be installed in closed loop configuration CTs must be cabled to master and slave units through daisy chain principle

Airflow requirements	A minimum airflow of cooling air has to be supplied to each cubicle: 30A - 60A: 520 m³/h 70A - 100A: 520 m³/h 120A : 710 m³/h.
Network voltage characteristics	
Network voltage ratings	208 V-240 V or 380 V-415 V between phases
Network voltage tolerance	+/- 10 %
Network frequency	50 Hz or 60 Hz
Network frequency tolerance	+/- 5 %
Maximum rate of frequency variation	20%/s
Maximum phase jump of network voltage	30°
Network voltage distortion	Maximum 20% phase to phase
Minimum network fault level	1 MVA
Voltage notch limits	No voltage notches allowed
Line voltage imbalance	Maximum 5% of phase to phase voltage
Insulation voltage (Ui)	415V
Network voltage: 208 V ≤ Ue ≤ 480 V (Voltage group V1)	480V
Auxiliary circuit voltage	230 Vrms
Neutral connection systems (if any)	IT, TT, TNC and TNS. Earth current protection type and sensitivity must be chosen appropriately.
EMC-Environment class (according to IEC 60439-1)	2
Compliance with standards	
General construction aspects	EN-61439-1 (2011)
EMC immunity	EN/IEC 61000-6-2, Industrial level
EMC emissions	EN/IEC 61000-6-4
Filter characteristics	
RMS output current per power unit type ^(a) (50Hz or 60Hz network).	
Current ratings	Unit type 1: 30 A Unit type 2: 45 A Unit type 3: 60 A Unit type 4: 70 A Unit type 5: 80 A Unit type 6: 90 A Unit type 7: 100 A Unit type 8: 120 A
Network current ratings	3 times the current ratings limited to 300A for PQFS 120 A
Modularity	Up to 8 power units/filter (power units must have same rating). One power unit per enclosure. Power units can be master or slave type.

Redundancy	For full redundancy combine master units of same rating. If any unit in a master-master filter system fails, the other units can keep running. For limited redundancy combine master with slave units of the same rating. If any slave unit in a master-slave filter system fails, the other units can keep running. If the master in a master-slave filter system fails, the complete system stops running.	
Harmonics that can be filtered	15 harmonics individually selectable in the range 2nd – 50th harmonic order if the neutral is connected. 20 harmonics individually selectable in the range 2nd – 50th harmonic order if the neutral is not connected.	
Degree of filtering	Programmable per harmonic in absolute terms	
Filtering efficiency	Better than 97% of filter rating typically	
Response time	40 ms typically (10% - 90% filtering)	
Reactive power	Static/dynamic Power factor programmable from 0.6 (inductive) to 0.6 (capacitive)	
Load balancing	Off Phase to phase, phase to neutral (if neutral present), both (if neutral present)	
Setting possibilities	Main and auxiliary settings functionality. Three possible filter modes that allow to set different priorities	
Start and stop settings	Local/remote control functionality. Filter standby functionality. Auto restart after power outage functionality.	
Digital inputs	2 multipurpose digital inputs on PQF-Manager. Vlow: 0 Vdc, Vhigh: 15-24 Vdc, driving current: 13 mA@ 24Vdc (Rint = 1.88 kΩ). Can be used to implement remote control functionality, start/stop buttons and switching between main and auxiliary settings.	
Digital outputs	6 multipurpose (NO) digital outputs on PQF-Manager. Maximum continuous ac rating: 440 Vac/1.5 A Maximum continuous dc rating: 110 Vdc/0.3 A Common rating: 9A/terminal, totaling 18 A Can be used to monitor the filter state (e.g. filter on/off or specific filter warnings/alarms) and the network state.	
Alarm contact	1 universal alarm contact with two complimentary outputs (NO/NC) on PQF-Manager. Triggered by any fault. Maximum continuous rating: 250 Vac/1.5 A	
Filter losses	Typical values	Maximum values
Unit rating: 30 A	0.7 kW	≤ 1.5 kW
Unit rating: 45 A	1 kW	≤ 1.8 kW
Unit rating: 60 A	1.3 kW	≤ 2.1 kW
Unit rating: 70 A	1.8 kW	≤ 2.6 kW
Unit rating: 80 A	2.1 kW	≤ 2.9 kW
Unit rating: 90 A	2.4 kW	≤ 3.2 kW

Unit rating: 100 A	2.7 kW	≤ 3.5 kW
Unit rating: 120 A	3.5 kW	≤ 4.3 kW
Phase to earth resistance	1.67 M Ω /filter unit	
Noise intensity	30A - 60A: 65.3 dBA typically 70A - 100A: 68.4 dBA typically 120A : 70.9 dBA typically	
Communication	Through PQF-Manager display. Through Modbus RTU (with optional RS485 Modbus Adapter). Through Modbus TCP (with Ethernet). Through dedicated optional software PQ-link (with USB-Ethernet).	
Programming	Through PQF-Manager display. Through USB-Ethernet with dedicated optional software (PQ-Link).	

Fuse information

Main circuit fuses	Not included
Auxiliary circuit fuses	French Ferrule 10 x 38 gG/gI, 6A, 500V, I _{sc} ~120kA

Main options

PQ-Link software
Modbus kit (RS-485 based)
Easy connection box for power cables
Cable extension kit for PQF-Manager

Remark:

^(a) Under exceptional circumstances other limits may be reached before the RMS current limit (e.g. temperature limit, peak current limit, peak voltage limit).

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Additional information

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