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 the PQFS-range with PQF-Manager software version v2.3.r0 or higher. 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 PQFI-PQFM-PQFK-PQFS Catalogue [English]
- Power Quality Filter, Active Filtering Guide [English]
- PQF-Link Installation and user’s guide [English]
- PQF Modbus CD [English]
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 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:** Stored energy in capacitors: this equipment contains capacitors. Check for residual DC voltage before working inside the equipment.

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

**WARNING:** If the ground is defeated, certain fault conditions in the unit or in the system to which it is connected can result in full line voltage between chassis and earth ground. Severe injury or death can result if the chassis and earth ground 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.
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 or on the filter panels).

3.3 Unpacking instructions

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

Your filter equipment comes with a package. Verify that all items are present, i.e.:

- this manual;
- the electrical drawing;
- the fixation bar and filter blocking screws;
- the lifting ribbon.
- the rubber seal to cover a knock-out (to be used for multi-unit operation)
- the communication cable needed for multi-unit operation

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

3.4 Lifting and transportation guidelines

Please note that filter equipment weighs approximately 120 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.
Table 1: Maximum allowed ambient conditions during transportation

<table>
<thead>
<tr>
<th>Transportation (in the protected package)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
</tr>
<tr>
<td>Relative humidity</td>
</tr>
<tr>
<td>Contamination levels (IEC 60731-3-3)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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 outer ends of the enclosure (see Figure 2)

Figure 1: Locating the 4 panel securing screws

Figure 2: Locating the 4 panel securing screws
- Lift the filter protective cover and put it at the bottom side of the filter (see Figure 3)

Figure 3: Lifting the protective cover and putting it at the bottom side of the filter

- 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
- Hook the lifting ribbon provided to adequate lifting equipment and lift the filter from the wooden support. It can then be positioned at the desired location (see Figure 6)

![Figure 6: Lifting a single PQFS unit by using the lifting ribbon](image)

### 3.5 Identification tag

Each PQFS is fitted with nameplates for identification purposes.

The filter nameplate is located at the top right of the master panel door, at the outside.

The nameplate information should always remain readable to ensure proper identification during the life of the filter. The main filter nameplate includes the filter type, the nominal voltage range and frequency as well as a serial number and an ABB 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 and 70°C with a maximum relative humidity of 95%, non-condensing.

*Table 2: Maximum allowed ambient conditions for storage*

<table>
<thead>
<tr>
<th>Storage (in the protected package)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
</tr>
<tr>
<td>-25 to 70°C (-13 to 158°F)</td>
</tr>
<tr>
<td><strong>Relative humidity</strong></td>
</tr>
<tr>
<td>Max. 95%</td>
</tr>
<tr>
<td><strong>Contamination levels</strong> (IEC 60721-3-3)</td>
</tr>
<tr>
<td>Chemical class 3C3&lt;sup&gt;(a)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mechanical class 3S3&lt;sup&gt;(b)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Remarks:**

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

<sup>(b)</sup> 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 7):

- 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 four power units may be connected in parallel in one filter unit. The enclosure containing the filter controller is referred to as the master unit. The other enclosures are referred to as the slave units.

Figure 7: PQFS schematic overview with user connections

The user connection description is given in Table 3.
Table 3: User connections for PQFS

<table>
<thead>
<tr>
<th>Item</th>
<th>User connections</th>
<th>Connection requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CT connections</td>
<td>Mandatory</td>
</tr>
<tr>
<td>2</td>
<td>Power cable connection to the supply (including neutral connection if 4-wire operation is desired)</td>
<td>Mandatory</td>
</tr>
<tr>
<td>3</td>
<td>Programmable digital outputs (warnings…)</td>
<td>Not mandatory</td>
</tr>
<tr>
<td>4</td>
<td>Remote control contact connection or/and local on/off buttons or/and main/auxiliary settings control</td>
<td>Not mandatory</td>
</tr>
<tr>
<td>5</td>
<td>Modbus communication connection or serial communication</td>
<td>Not mandatory</td>
</tr>
<tr>
<td>6</td>
<td>Earth connections from the enclosure to installation earth</td>
<td>Mandatory</td>
</tr>
</tbody>
</table>

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 5.

Figure 8 shows a typical PQFS master filter panel.

Figure 8: 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

<table>
<thead>
<tr>
<th>Item</th>
<th>Input/Output connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CT connection terminals</td>
</tr>
<tr>
<td>2</td>
<td>Main power connection</td>
</tr>
<tr>
<td>3</td>
<td>Auxiliary fuse protection</td>
</tr>
<tr>
<td>4</td>
<td>PQF-Manager user interface with connection terminals for user I/O (e.g. alarm contact) and communication interfaces</td>
</tr>
</tbody>
</table>

Up to 4 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.

![Power circuit diagram of a PQFS active filter](image-url)

*Figure 9: Power circuit diagram of a PQFS active filter*
The description of the main components is given in Table 5.

<table>
<thead>
<tr>
<th>Item</th>
<th>Main components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IGBT inverter</td>
</tr>
<tr>
<td>2</td>
<td>DC bus capacitors</td>
</tr>
<tr>
<td>3</td>
<td>PWM reactor</td>
</tr>
<tr>
<td>4</td>
<td>Output filter</td>
</tr>
<tr>
<td>5</td>
<td>Preload resistor</td>
</tr>
<tr>
<td>6</td>
<td>Main contactor</td>
</tr>
<tr>
<td>7</td>
<td>Auxiliary fuses</td>
</tr>
<tr>
<td>8</td>
<td>Neutral cable connection (not mandatory)</td>
</tr>
</tbody>
</table>

The current generator is physically organized in power units. Each filter enclosure contains one power unit. A PQFS filter can contain up to 4 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 of the same rating. Please refer to Chapter 12 for more information on the possible unit ratings.

In Figure 9 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 a 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. The slave enclosures do not have a preload circuit.

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 10 depicts the controller interface diagram of the PQFS active filter.

![Controller interface diagram of the PQFS](image)

Figure 10: Controller interface diagram of the PQFS

When the filter consists of a master unit only, the customer has to:
- Wire the CT signals (on a designated terminal),
- Prepare the filter for networks of nominal voltage 208-240V (if needed),
- Connect the AC power lines (with or without neutral),
- Set up the installation parameters and user’s requirements with the PQF-Manager.

He may also want to wire the communication interface (Modbus or serial communication) 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, e.g. through a daisy chain link.

All units have their own AC-connection and main contactor protection.
A PQFS active filter system consists of up to 4 units of equal rating. 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. Figure 11 shows the front side of the PQF-Manager.

![Figure 11: Front side of the PQF-Manager](image)

Four main parts can be distinguished (see Table 6)

<table>
<thead>
<tr>
<th>Item</th>
<th>Main components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Keypad</td>
</tr>
<tr>
<td></td>
<td>By navigating through the menus with the arrows and the button, the filter can be set-up and controlled (start/stop). On-line help is available by pressing the Help button.</td>
</tr>
<tr>
<td>2</td>
<td>Menu display</td>
</tr>
<tr>
<td>3</td>
<td>Digital output contact monitor</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>Alarm contact indicator</td>
</tr>
</tbody>
</table>

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 12 depicts the terminals that are present on the PQF-Manager rear side.
The terminal designation is given in Table 7.

**Table 7: Terminal designation**

<table>
<thead>
<tr>
<th>Item</th>
<th>Customer terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digital inputs 1 and 2.</td>
</tr>
<tr>
<td>2</td>
<td>Digital outputs 1 to 6 with one common point</td>
</tr>
<tr>
<td>3</td>
<td>Alarm outputs (2 outputs with complementary signals)</td>
</tr>
<tr>
<td>4</td>
<td>Lock switch</td>
</tr>
<tr>
<td>5</td>
<td>Modbus adapter interface (optional) connection</td>
</tr>
<tr>
<td>6</td>
<td>CAN bus connection interface (routed to PQF-Manager connector)</td>
</tr>
<tr>
<td>7</td>
<td>Power supply terminals (routed to PQF-Manager connector)</td>
</tr>
</tbody>
</table>
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

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

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 6.12.

Information on setting up the digital inputs with the PQF-Manager is given in Section 7.7.1.2.

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.
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

<table>
<thead>
<tr>
<th>PQF-Manager setting for digital output&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Output relay closes when…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxil. ON</td>
<td>The auxiliary power is present in the main filter enclosure and the main controller is communicating with the PQF-Manager</td>
</tr>
<tr>
<td>PQF runs</td>
<td>The active filter is ‘on’ (IGBTs switching) or in ‘standby’ (main contactor closed but IGBTs not switching)</td>
</tr>
<tr>
<td>Full load</td>
<td>The active filter is running under full load condition</td>
</tr>
<tr>
<td>Armed</td>
<td>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</td>
</tr>
<tr>
<td>T limit</td>
<td>The filter temperature limit has been reached and the filter is derating itself to run at a safe temperature</td>
</tr>
<tr>
<td>In standby</td>
<td>The filter is in standby&lt;sup&gt;(b)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Activ. Main</td>
<td>The main active filter settings are activated</td>
</tr>
<tr>
<td>Activ. Aux</td>
<td>The auxiliary active filter settings are activated</td>
</tr>
<tr>
<td>Unit miss.</td>
<td>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.</td>
</tr>
<tr>
<td>Pg. alarm 1</td>
<td>The programmable alarm 1 is activated&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pg. alarm 2</td>
<td>The programmable alarm 2 is activated&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pg. alarm 3</td>
<td>The programmable alarm 3 is activated&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Warning 1</td>
<td>The programmable warning 1 is activated&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Warning 2</td>
<td>The programmable warning 2 is activated&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Warning 3</td>
<td>The programmable warning 3 is activated&lt;sup&gt;(c)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Further it should be noted that:

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

- 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

<table>
<thead>
<tr>
<th>Digital output number</th>
<th>Default function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Auxil. ON</td>
</tr>
<tr>
<td>2</td>
<td>PQF Runs</td>
</tr>
<tr>
<td>3</td>
<td>Full Load</td>
</tr>
<tr>
<td>4</td>
<td>Armed</td>
</tr>
<tr>
<td>5</td>
<td>Unit miss.</td>
</tr>
<tr>
<td>6</td>
<td>T Limit</td>
</tr>
</tbody>
</table>

- 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 7.7.1.2

3. Alarm 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 7.7.1.2.

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.

4. Lock switch

Allows locking the settings of the filter panel. This switch is documented in Section 7.4

5. Modbus 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 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.

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 communication interface refer to the dedicated Modbus manual.

4.6 Location of the main PQFS components

4.6.1 Active filter components

Figure 13 shows a picture of the PQFS without cover panel.
The component identification is given in Table 11.

Table 11: PQFS main components description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Circuit diagram designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main contactor (MC) (underneath controller boards)</td>
<td>K01</td>
</tr>
<tr>
<td>2</td>
<td>Fuse holder auxiliaries circuit (6 Amax)</td>
<td>Q02</td>
</tr>
<tr>
<td>3</td>
<td>DC voltage power supply 24V</td>
<td>U002</td>
</tr>
<tr>
<td>4</td>
<td>CT connection terminal (master only)</td>
<td>X21</td>
</tr>
<tr>
<td>5</td>
<td>Preload circuit resistor (master only)</td>
<td>R06</td>
</tr>
<tr>
<td>6</td>
<td>Main earth connection point</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>IGBT inverter with DC capacitors</td>
<td>U01</td>
</tr>
<tr>
<td>8</td>
<td>PQF main controller board</td>
<td>A005</td>
</tr>
<tr>
<td>9</td>
<td>IGBT heat extraction fans</td>
<td>M1, M2</td>
</tr>
<tr>
<td>10</td>
<td>EMC capacitors (underneath controller boards)</td>
<td>C9, C13, C14, C15</td>
</tr>
<tr>
<td>11</td>
<td>Main power supply terminals (phases) (underneath controller boards)</td>
<td>L1, L2, L3</td>
</tr>
<tr>
<td>12</td>
<td>Main power supply neutral connection (not mandatory) (underneath controller boards)</td>
<td>N</td>
</tr>
</tbody>
</table>

The PQF Main controller board terminals are predominantly system terminals. However, it also contains a DIP-switch used to set the identification address of a filter unit in a multi-module filter arrangement.

The main controller board is shown in Figure 14.
The designation of the principal terminals is given in Table 12.
Table 12: PQF main controller board description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Circuit diagram designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAN bus connection from previous filter unit</td>
<td>P20</td>
</tr>
<tr>
<td>2</td>
<td>CAN bus connection to next filter unit</td>
<td>P21</td>
</tr>
<tr>
<td>3</td>
<td>System connector: Power supply and CAN communication to PQF Manager</td>
<td>P4</td>
</tr>
<tr>
<td>4</td>
<td>System connector: 230 V power supply to control board</td>
<td>P3</td>
</tr>
<tr>
<td>5</td>
<td>System connector</td>
<td>P19</td>
</tr>
<tr>
<td>6</td>
<td>System connector: Main contactor control</td>
<td>P18</td>
</tr>
<tr>
<td>7</td>
<td>System connector</td>
<td>P17</td>
</tr>
<tr>
<td>8</td>
<td>System connector</td>
<td>P16</td>
</tr>
<tr>
<td>9</td>
<td>System connector</td>
<td>P25</td>
</tr>
<tr>
<td>10</td>
<td>System connector</td>
<td>P7</td>
</tr>
<tr>
<td>11</td>
<td>System connector: Coming from CT terminal X21 (internal)</td>
<td>P5</td>
</tr>
<tr>
<td>12</td>
<td>System connector: Supply and DC link voltage measurement</td>
<td>P6</td>
</tr>
<tr>
<td>13, 14, 15</td>
<td>System connectors</td>
<td>P9, P10, P11</td>
</tr>
<tr>
<td>16</td>
<td>System connector: control of IGBT-module</td>
<td>P12</td>
</tr>
<tr>
<td>17</td>
<td>Voltage selector DIP-switch</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>System LED’s (top to bottom)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 3: ON: Critical error in filter unit considered (red LED)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 3: OFF: No critical error in filter unit considered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 2: ON: PQF unit running or in startup process (Armed)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 2: OFF: PQF unit off and not in startup process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 1: Blinking at regular interval (1 s): Microcontroller running properly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 1: ON, OFF or blinking irregularly: Microcontroller not running properly</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>System LED’s (top to bottom)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 5: ON: Filter unit is acting as the master of the complete system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 5: OFF: Filter unit is acting as a slave in the filter system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 4: Blinking at regular interval (1 s): DSP processor running properly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LED 4: ON, OFF or blinking irregularly: DSP processor not running properly</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>PQF-Link communication link connector</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Filter unit address selector (3 Left most DIP switches) and CAN bus termination (Right hand DIP switch):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 1: Position of the 3 switches starting from left: L L L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 2: Position of the 3 switches starting from left: L L H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 3: Position of the 3 switches starting from left: L H L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 4: Position of the 3 switches starting from left: L H H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 5: Position of the 3 switches starting from left: H L L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 6: Position of the 3 switches starting from left: H L H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 7: Position of the 3 switches starting from left: H H L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address 8: Position of the 3 switches starting from left: H H H</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note: In a multi-master arrangement, the master which is operational and which has the lowest address controls the system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The default address setting is L L L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAN bus termination (Right hand DIP switch):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Must be Low (L) for units in the middle of a chain.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The default factory setting is H.</td>
<td></td>
</tr>
</tbody>
</table>

Remarks:
(a) For physical locations of customer CT connection terminals, please refer to Figure 13 item 4.
Terminals not explained above are ABB reserved terminals.

4.6.2 Active filter cover components
An active filter master panel cover contains the PQF-Manager user interface. This interface is routed on to the main control board.
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.

5.2 Installation location requirements

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

<table>
<thead>
<tr>
<th>Table 13: Ambient operating conditions for PQFS operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
</tr>
<tr>
<td>Minimum temperature</td>
</tr>
<tr>
<td>Maximum temperature</td>
</tr>
<tr>
<td>Maximum average temperature (over 24 h)</td>
</tr>
<tr>
<td>Relative humidity</td>
</tr>
<tr>
<td>Contamination levels</td>
</tr>
<tr>
<td>(IEC 60721-3-3)</td>
</tr>
</tbody>
</table>

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 3.5% 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 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 **Standard enclosure dimensions and clearances**

Standard PQFS enclosures have dimensions of 585 x 310 x 700 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.

A spacing of 500 mm below the filter bottom and above the filter top is recommended. Figure 15 shows a view of a typical PQFS with characteristic dimensions.

![Figure 15: View of a typical PQFS with characteristic dimensions](image)

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 Figure 16.

![Figure 16: Example of an installation where PQFS units are mounted above each other](image)
5.4 **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 120 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**
- Transport the filter to the location of installation as per **Section 3.4**
- Mount the filter fixation bar (Figure 17) on the wall. Use a spirit level to ensure horizontal fixation. Holes in the supporting bar are intended for bolts M8.

![Figure 17: Fixation bar and characteristic dimensions](image)

- Carefully lift the enclosure and slide it down over the fixation bar until it is supported by the fixation bar (Figure 18). Then the lifting tool can be disengaged.
Once the filter is supported by the fixation bar, use the 2 screws provided with the fixation bar to block the filter against the rear support (see Figure 19).

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 20).

Remove the ribbon that has served to lift the filter.

For additional units, the same procedure has to be followed.
5.5 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. The maximum typical noise level is 60dBA for units up to 60A and 67dBA for units with higher ratings. These values should be taken into account when choosing a location for the filter.

5.6 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).

Each PQFS power unit has their own 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 14 gives the airflow requirements for different unit ratings.

<table>
<thead>
<tr>
<th>Unit rating</th>
<th>Airflow requirement (m³/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 60A</td>
<td>400 m³/h</td>
</tr>
<tr>
<td>&gt; 60A</td>
<td>600 m³/h</td>
</tr>
</tbody>
</table>

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. Figure 21 shows the cooling air flow diagram for a single unit PQFS.

Figure 21: 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 installed to the room. In the design of
the air conditioning systems, the filter heat losses have to be taken into account. Table 15 gives an overview of the PQFS heat losses for the different power units. For multi-unit filters, the values of Table 15 have to be multiplied by the number of filter units.

Table 15: Filter unit heat losses (maximum values)

<table>
<thead>
<tr>
<th>Unit rating (Arms)</th>
<th>Heat loss (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1.5</td>
</tr>
<tr>
<td>45</td>
<td>1.8</td>
</tr>
<tr>
<td>60</td>
<td>2.1</td>
</tr>
<tr>
<td>70</td>
<td>2.6</td>
</tr>
<tr>
<td>80</td>
<td>2.9</td>
</tr>
<tr>
<td>90</td>
<td>3.2</td>
</tr>
<tr>
<td>100</td>
<td>3.5</td>
</tr>
</tbody>
</table>

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 22)

Step 1: Make an opening in the new panel of dimensions 138 x 138 mm.
Step 2: Slide the PQF-Manager (1) perpendicularly into the enclosure opening (2).
Step 3: Rotate the PQF-Manager to insert it into the enclosure.
Step 4: Insert the mounting bracket (3) in the corresponding fixation holes (4) of the PQF-Manager.
Step 5: Pull the mounting bracket backwards.
Step 6: Turn the screw (5) into the mounting bracket and tighten until the PQF-Manager is secured in place. Repeat steps 3 to 5 for the bottom-mounting bracket.

Once the PQF-Manager has been installed, it has to be connected electrically (Cf. Section 6.2)
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 ABB.

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 circuit breaker. 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 enclosure);
- 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 circuit breaker;
- 3 CTs (one per phase, to be connected to each filter unit in a filter system through a daisy chain method).

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 minutes 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 800 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 on. 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.

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 23.

![Figure 23: Connection of the PQF-Manager user interface to the PQFS filter hardware](image)

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 the main contactor shorted, and auxiliary circuit open (auxiliary fuses removed).

**WARNING:** Making the test with the auxiliary circuit closed may damage the filter.

Use a measuring voltage of 500 Vdc. The insulation resistance must be higher than 500 kΩ per enclosure with the flat cables from the AC/DC voltage measurement boards (Figure 13, item 5) removed.

6.4 EMC considerations

The active filter complies with the following EMC guidelines:

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

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

6.5 Earthing guidelines

Each PQFS plate has one marked earth points (PE). The earth point is situated at the bottom right side of the filter plate (Figure 24)

![Earth point (PE)](image)

*Figure 24: Identification of the earth point on 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). A copper (Cu) cable of minimum size 16 mm² is recommended 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 enclosures’ PE-point 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. Consequently, there is no need for special screening of the filter connection 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 (Irms).
   
   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 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 mm², the section through which the current flows is only xA mm² (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 (mm²) for the RMS current Irms obtained in 1 above.

   Step 2: Using the cable section A, the cable material and the network frequency as entry points in Table 16, determine the multiplication factor X.
Table 16: Multiplication factors $X$ for different cable sections

<table>
<thead>
<tr>
<th>Cable section [mm²]</th>
<th>Network frequency 50Hz</th>
<th>Network frequency 60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Al-cable</td>
<td>Cu-cable</td>
</tr>
<tr>
<td>16</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
<td>1.01</td>
</tr>
<tr>
<td>35</td>
<td>1.01</td>
<td>1.01</td>
</tr>
<tr>
<td>50</td>
<td>1.01</td>
<td>1.03</td>
</tr>
<tr>
<td>70</td>
<td>1.02</td>
<td>1.05</td>
</tr>
<tr>
<td>95</td>
<td>1.04</td>
<td>1.08</td>
</tr>
<tr>
<td>120</td>
<td>1.05</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Step 3: Determine in a conventional way the cable section $A_2$ (mm²) 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 60 A/50Hz, 3-wire connection, cable material: Cu (copper)

Step 1: $I_N = 60A \Rightarrow$ cable section = 16 [mm²]

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

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

Step 4: $I = 60A \Rightarrow$ 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 17 and Table 18, which show the allowed current for different parameters noting typical cable manufacturer data.
Table 17: Allowed cable current for different cable sections noting the skin effect and typical cable manufacturer data – Network frequency 50Hz

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

Remark: The highlighted values in Table 17 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 18: Allowed cable current for different cable sections noting the skin effect and typical cable manufacturer data – Network frequency 60Hz

<table>
<thead>
<tr>
<th>Cross section [mm²]</th>
<th>Nr of parallel cables</th>
<th>Derating due to paralleling</th>
<th>Copper</th>
<th>Reduction factor</th>
<th>Aluminium</th>
<th>Reduction factor</th>
<th>Rated current [Arms]</th>
<th>Allowed current [Arms]</th>
<th>Reduction factor</th>
<th>Allowed current [Arms]</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>6</td>
<td>1</td>
<td>100</td>
<td>0.996</td>
<td>75</td>
<td>1</td>
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<td>1</td>
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<td>1-1/0</td>
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<td>190</td>
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<td>0.98</td>
<td>143</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>2/0</td>
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<td>230</td>
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<td>180</td>
<td>0.97</td>
<td>175</td>
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<tr>
<td>95</td>
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<td>285</td>
<td>0.911</td>
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<td></td>
</tr>
<tr>
<td>120</td>
<td>4/0</td>
<td>1</td>
<td>325</td>
<td>0.88</td>
<td>250</td>
<td>0.93</td>
<td>233</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>300MCM</td>
<td>1</td>
<td>365</td>
<td>0.85</td>
<td>285</td>
<td>0.91</td>
<td>260</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>185</td>
<td>350MCM</td>
<td>1</td>
<td>415</td>
<td>0.817</td>
<td>325</td>
<td>0.89</td>
<td>288</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>500MCM</td>
<td>1</td>
<td>495</td>
<td>0.775</td>
<td>385</td>
<td>0.85</td>
<td>326</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>600MCM</td>
<td>1</td>
<td>550</td>
<td>0.738</td>
<td>425</td>
<td>0.81</td>
<td>346</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>6</td>
<td>2</td>
<td>160</td>
<td>0.996</td>
<td>120</td>
<td>1</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>2</td>
<td>208</td>
<td>0.99</td>
<td>160</td>
<td>1</td>
<td>160</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>2</td>
<td>2</td>
<td>256</td>
<td>0.981</td>
<td>192</td>
<td>0.99</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1-1/0</td>
<td>2</td>
<td>304</td>
<td>0.965</td>
<td>232</td>
<td>0.98</td>
<td>228</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>2/0</td>
<td>2</td>
<td>368</td>
<td>0.941</td>
<td>288</td>
<td>0.97</td>
<td>280</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>3/0</td>
<td>2</td>
<td>456</td>
<td>0.911</td>
<td>352</td>
<td>0.95</td>
<td>336</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>4/0</td>
<td>2</td>
<td>520</td>
<td>0.88</td>
<td>400</td>
<td>0.93</td>
<td>374</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>300MCM</td>
<td>2</td>
<td>584</td>
<td>0.85</td>
<td>456</td>
<td>0.91</td>
<td>416</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>185</td>
<td>350MCM</td>
<td>2</td>
<td>664</td>
<td>0.817</td>
<td>520</td>
<td>0.89</td>
<td>460</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>500MCM</td>
<td>2</td>
<td>792</td>
<td>0.775</td>
<td>616</td>
<td>0.85</td>
<td>522</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>600MCM</td>
<td>2</td>
<td>880</td>
<td>0.738</td>
<td>680</td>
<td>0.81</td>
<td>553</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remark: The highlighted values in Table 18 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 19.
Table 19: RMS current ratings for protection fuses

<table>
<thead>
<tr>
<th>Filter nominal current rating (Arms)</th>
<th>Minimum fuse protection (Arms)</th>
<th>Maximum fuse protection (Arms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>40</td>
<td>125</td>
</tr>
<tr>
<td>45</td>
<td>63</td>
<td>125</td>
</tr>
<tr>
<td>60</td>
<td>80</td>
<td>125</td>
</tr>
<tr>
<td>70</td>
<td>100</td>
<td>160</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>160</td>
</tr>
<tr>
<td>90</td>
<td>125</td>
<td>160</td>
</tr>
<tr>
<td>100</td>
<td>125</td>
<td>160</td>
</tr>
</tbody>
</table>

Voltage rating of the fuses should be according to the network voltage.

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.

Note: neutral connection only needed for 4-wire connection

Figure 25: 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 UA 50 for units up to 60A and ABB UA 75 for units up to 100A.

The PQFS control circuit and DC bus preload system is protected by a fuse protection scheme, the characteristics of which are given in Table 20.

### Table 20: Control circuit fuse characteristics for PQFS filters

<table>
<thead>
<tr>
<th>Nominal network voltage (Vrms)</th>
<th>Control circuit fuse type</th>
<th>Irms fuse (Arms)</th>
<th>Isc(^{(a)}) fuse (kA) at rated voltage</th>
<th>Rated Voltage (Vrms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>208 ≤ Ue ≤ 415</td>
<td>French Ferrule 10 X 38 gG/gl</td>
<td>6</td>
<td>~ 120</td>
<td>500</td>
</tr>
</tbody>
</table>

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 nor 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 5.4)
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 26)
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 27)
Figure 27: Connecting the three power cables and connecting them 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.

9.1 Preparation of the filter for networks of nominal voltage 380-415V:

When the filter will be installed on a network with nominal voltage 380-415V, no further hardware configuration is needed. The wire ‘N’ is by default connected to the neutral busbar (Cf. Figure 28)

Figure 28: Position of the wire ‘N’ for networks with nominal voltage 380-415V
9.2 Preparation of the filter for networks of nominal voltage 208-240V:

When the filter will be installed on a network with nominal voltage 208-240V, the wire labeled ‘N’ (see Figure 28) has to be disconnected from the neutral busbar and has to be connected to the terminal X02-3 (see Figure 29).

![Figure 29: Position of the wire ‘N’ for networks with nominal voltage 208-240V](image)

Remark: In order to configure the filter for 208-240 V, the ring terminal on the wire ‘N’ has to be replaced by an end terminal of appropriate size.

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 30).

![Figure 30: Connection of the neutral cable when using the PQFS in 4-wire mode](image)

The cable lugs for the neutral cables should comply with:

- 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 31 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 32 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.

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 33. 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 4 filter units) is 5 VA, excluding connecting cables.

• Class 1 accuracy.

• 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 33.

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.
Maximum rms current of the downstream loads (including starting current of DC drives):

\[ X_1 = \ldots \text{ Arms} \]

Multiply \( X_1 \) by 1.6:

\[ X_2 = \ldots \text{ Arms} \]

**NO**

CT cables > 30 meters ?

**YES**

Determine the length of CT cables (meters)

\[ L = \ldots \text{ m} \]

\[ X_3 = (L \times 0.007 \times 25) + 10 \]

Select 3 identical CT's such that:
- rating at primary \( \geq X_2 \)
- rating at secondary: 5A
- Burden \( \geq 15 \text{ VA} \)
- Class 1 accuracy or better

Section of CT cables:

**NO**

2.5 mm²? (recommended)

**YES**

Determine the length (m) and resistance (\( \Omega/m \)) of CT cables (meters)

\[ L = \ldots \text{ m} \]
\[ R = \ldots \Omega/m \]

\[ X_4 = (L \times R \times 25) + 10 \]

Select 3 identical CT's such that:
- rating at primary \( \geq X_2 \)
- rating at secondary: 5A
- Burden \( \geq X_4 \text{ VA} \)
- Class 1 accuracy or better
6.10 Current transformer installation and connection

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 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 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 34):

- 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 X21-3 of the filter.
- The l (S2) terminal of the line 2 CT (L2, Yellow, V) must be connected to terminal X21-4 of the filter.
- The k (S1) terminal of the line 3 CT (L3, Blue, W) must be connected to terminal X21-5 of the filter.
- The l (S2) terminal of the line 3 CT (L3, Blue, W) must be connected to terminal X21-6 of the filter.
- The CT connection terminal X21 is located in the middle of the top plate of the filter (Cf. Figure 35).

![Figure 34: Basic CT connection example for a single unit active filter.](image)

![Figure 35: Location of the CT connection terminal X21 in the PQFS](image)

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 34 above, a 4-wire approach may also be used. This approach is illustrated in Figure 36. 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.
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 7.11.3.

6.11 Electrical interconnection of PQFS enclosures

This section explains how to electrically interconnect different PQFS enclosures. Figure 37 shows schematically which interconnections have to be made between two filter enclosures.
The interconnection description is given in Table 21.

Table 21: Interconnections between two filter units

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control board intercommunication cable through CAN bus (RJ45 cable)</td>
</tr>
<tr>
<td>2</td>
<td>CT interconnection cable</td>
</tr>
</tbody>
</table>

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 preparation of the enclosures

- Remove the knockouts on the appropriate side of the filter cover panels (Cf. Figure 38) where the filter interconnection cables have to be passed through.

![Figure 38: View of knockout on filter sides](image)

- Cover the sharp edges of the knockouts with the rubber seal provided with the slave units.

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. This cable is provided with each unit.

Figure 39: shows the way to interconnect the control boards.

- 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 sever 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 40 for the CT of phase which is
fed to four filter units. The same approach has to be implemented for the other phases too.

![Diagram of CT interconnection circuit for multi-unit filters](image)

*Figure 40: Principle of the CT interconnection circuit for multi-unit filters.*

Note that the overall burden requirement for a complete filter system is maximum 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 filter unit is connected to the same phase for all units. 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 7.7.2.2 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. It is mounted on the filter cover panel. Depending on the user requirements, less or more electrical connections have to be made to it. Figure 41 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.)

![Diagram of 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 4-pole terminal block (bottom right). 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.
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 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 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 41) can be used to cable the remote control functionality. The electrical requirements of the digital inputs are given in Table 60 (Filter characteristics section). Figure 43 gives an example of how to implement the remote control functionality on Digital Input 1.

![Diagram](image)

**Figure 43: 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 43 is closed and the filter will switch off when the switch S is opened. Refer to Section 7.7.1.2 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 Input2.

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 over voltage. 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:

- 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:
  
  o 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.

  o no power is supplied to the filter.

Table 24 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

  o free of potential,

  o 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 22 shows the status of the alarm contacts for different operation modes of the filter.
Table 22: Status of the alarm contacts for different filter operation modes

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

Figure 44 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.

![Figure 44: Alarm bulb cabling scheme using the NC alarm contact on the PQF-Manager](image)

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 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 NC alarm contact on each filter.

In the Figure 45, the alarm bulb will be activated when both master units are in alarm.

Figure 46 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.

Figure 46: 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 47 for 2 master filters.
Note: Contacts drawn in non-alarm position

Figure 47: 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 47 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.

• A second method to implement 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. In that case the desired function can be assigned to a programmable alarm which can be monitored be assigned to a digital output.

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 41)

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 23 shows the status of a digital output contact configured as alarm contact for different operation modes of the filter.
Table 23: Status of a digital output contact configured as alarm contact for different filter operation modes

<table>
<thead>
<tr>
<th>Filter state</th>
<th>Normally open digital contact state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disconnected from the supply</td>
<td>Open</td>
</tr>
<tr>
<td>Filter (auxiliaries) connected to the supply, no error present</td>
<td>Open</td>
</tr>
<tr>
<td>Filter (auxiliaries) connected to the supply, predefined error appears</td>
<td>Closes when error present for 3 minutes. Otherwise, contact remains open.</td>
</tr>
<tr>
<td>Filter (auxiliaries) connected to the supply, predefined error disappears</td>
<td>When closed before, opens when error disappears. When opened before, remains open.</td>
</tr>
</tbody>
</table>

The alarm conditions that can be assigned to a digital output are given in Table 24. 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 7.7.1.2 for guidelines on how to navigate to the digital output setup menu.

Table 24: List of possible alarm conditions that may trigger the alarm/digital outputs

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

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 46 and 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 41 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 47.

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 41) 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 25 describes the behavior of the digital output contact configured as warning contact for different filter operating modes.

Table 25: State of a digital output contact configured as warning contact for different filter operation modes

<table>
<thead>
<tr>
<th>Filter state</th>
<th>Normally open digital contact state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disconnected from the supply</td>
<td>Open</td>
</tr>
<tr>
<td>Filter (auxiliaries) connected to the supply, no warning present</td>
<td>Open</td>
</tr>
<tr>
<td>Filter (auxiliaries) connected to the supply, predefined warning present</td>
<td>Closes when warning present for predefined time</td>
</tr>
<tr>
<td></td>
<td>Otherwise, contact remains open</td>
</tr>
<tr>
<td>Filter (auxiliaries) connected to the supply, predefined warning disappears</td>
<td>When closed before and warning disappears for at least the predefined time, contact opens.</td>
</tr>
<tr>
<td></td>
<td>When closed before and warning disappears for a time smaller than predefined time, contact remains closed.</td>
</tr>
<tr>
<td></td>
<td>Otherwise, contact remains open</td>
</tr>
</tbody>
</table>

Table 26 gives a list of the warning conditions that can be assigned to a digital output.

Table 26: List of possible warning conditions that can be assigned to a digital output

<table>
<thead>
<tr>
<th>Warning condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage (RMS) higher than preset value</td>
</tr>
<tr>
<td>Supply voltage (RMS) lower than preset value</td>
</tr>
<tr>
<td>Supply voltage imbalance higher than preset value</td>
</tr>
<tr>
<td>Ground current level higher than preset value</td>
</tr>
<tr>
<td>IGBT Temperature higher than preset value</td>
</tr>
<tr>
<td>Control board temperature higher than preset value</td>
</tr>
<tr>
<td>Remark: All warning levels can be changed by the user.</td>
</tr>
</tbody>
</table>

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 7.7.1.2 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 46 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 47 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 46 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 47 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 41) 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 48 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.
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 27 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 27: Filter behavior as a function of the PQF-Manager settings for main/auxiliary switching

<table>
<thead>
<tr>
<th>PQF-Manager setup for digital input</th>
<th>Vlow applied to digital input</th>
<th>Vhigh applied to digital input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activ. Main</td>
<td>Auxiliary settings are used</td>
<td>Main settings are used</td>
</tr>
<tr>
<td>Activ. Aux.</td>
<td>Main settings are used</td>
<td>Auxiliary settings are used</td>
</tr>
</tbody>
</table>

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 then be restored.
Refer to Section 7.7.1.2 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 28 shows the PQF-Manager setup for the input considered and the resulting effect when applying voltage to this input.

<table>
<thead>
<tr>
<th>PQF-Manager setup for digital input</th>
<th>Vlow applied to digital input</th>
<th>Vhigh applied to digital input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge ON</td>
<td>No effect</td>
<td>Filter starts on rising edge</td>
</tr>
<tr>
<td>Edge OFF</td>
<td>No effect</td>
<td>Filter stops on rising edge</td>
</tr>
</tbody>
</table>

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 7.7.1.2 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 49 shows a cabling diagram for implementing a start function on the first digital input and a stop function on the second digital input.
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 29 shows the PQF-Manager setup for the input considered and the resulting effect when applying voltage to this input.

Table 29: Filter behavior as a function of the PQF-Manager settings for local start/stop and using 1 digital input

<table>
<thead>
<tr>
<th>PQF-Manager setup for digital input</th>
<th>Vlow applied to digital input</th>
<th>Vhigh applied to digital input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge ON/OFF</td>
<td>No effect</td>
<td>Filter starts on first rising edge, stops on second rising edge, etc</td>
</tr>
</tbody>
</table>

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

Refer to Section 7.7.1.2 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 50 shows a cabling diagram for implementing a start function and a stop function on the first digital input.
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.

Remarks:

- The implementation of local start/stop buttons does not inhibit the usage of the start/stop function on the PQF-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 PQF-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 RS-232 cable used for PQF-Link software communication (optional).
- The connection of the Modbus adapter.

The connections of the aforementioned accessories are discussed next.
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 must be 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 lethal injury or death.

6.13.1 Connection of the RS-232 cable used for PQF-Link software communication

When the PQF-Link software is ordered, it comes with a serial communication cable that is used to connect the PC’s serial port to the filter (Figure 51).

![Figure 51: RS-232 serial communication cable for PC-filter interconnection](image)

On the filter side the cable has to be connected to the rear side of the PQF-Manager of the ‘main’ master unit, i.e. the master unit that controls the complete system. This is done by inserting the plug firmly in the dedicated socket. Figure 52 shows the location at the rear of the PQF-Manager where the plug has to be inserted. In order to access the rear side of the PQF-Manager, the filter panel cover has to be removed.

If the connection is only a temporary one (e.g. during commissioning) no special cable pass through hole has to be made in the cable pass through cover present at the bottom right side of the filter panel. The top cover can simply be restored without fixing the screws.

If the connection is a permanent one a cable pass through hole of sufficient diameter has to be made in the cable pass through cover present at the bottom right side of the filter panel and the cable has to be guided through. Note however that in this case the communication may be lost if the ‘main’ master unit goes in error and transfers the main master rights to another master unit in this system. If full redundancy in communication is required, a communication cable has to be connected to each master unit in a filter system.
Figure 52: Location at rear of PQF-Manager where the serial communication cable has to be inserted

The other end of the cable has to be connected to the PC’s serial port.

More information on the PQF-Link software can be found in the ‘PQF-Link installation and user’s guide’.

Note: The PQF Link software gives access to all the parameters of the unit to which the cable is connected, as well as to general network data (e.g. line voltage data, line current data etc.)

6.13.2 Connection of the Modbus adapter
For the connection setup of the Modbus adapter, please refer to the document “2GCS212012A0050-RS-485 Installation and Start-up guide”. 
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 53). 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 the Modbus communication interface.

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 53: Front view of the PQF-Manager user interface](image)

The item description is given in Table 30.

Table 30: Front side of the PQF-Manager

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Keypad</td>
</tr>
<tr>
<td></td>
<td>By navigating through the menus with the arrows and the Help button, the filter can be set-up and controlled (start/stop). On-line help is available by pressing the Help button.</td>
</tr>
<tr>
<td>2</td>
<td>Menu display</td>
</tr>
<tr>
<td>3</td>
<td>Digital output contact monitor</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>Alarm contact indicator</td>
</tr>
</tbody>
</table>
7.2 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 53):

- **Filter starting, filter stopping and acknowledgement of faults:**
  
The PQF-Manager is the default device to be used to start and stop the filter system. Further it is used to acknowledge and reset faults reported by the system.
  
  Refer to Section 7.5 or detailed information on how to start, stop and reset the filter.

- **Measuring, analyzing, logging and printing of characteristic parameters:**
  
The parameters that can be monitored include network voltages, line and filter currents, network power, network power factor and system temperatures.
  
  Refer to the Section 7.6 for detailed information on the monitoring of variables.

- **Setting up the filter:**
  
  Setting up the filter consists of various aspects such as defining the customer’s requirements for harmonic filtration and reactive power but also the configuration of the external I/O and commissioning the filter at the moment of first use.
  
  Refer to Section 7.7 for detailed information on setting up the filter.

- **Monitoring the filter load, event logging and status of individual units:**
  
  The filter load can be monitored to get an idea of its operating point compared to its nominal rating. In addition, logged warnings and faults can be retrieved for troubleshooting the filter operation and any abnormal network conditions.

  For multi-unit filters, the status of each individual unit can be retrieved and individual units can be reset when in error.

  Refer to Section 7.8 for detailed information on the monitoring of the filter load and the analysis of warning and error conditions.

- **Providing filter identification information:**
  
  Filter type information is provided including serial number and firmware versions.

  Refer to Section 0 for detailed information on obtaining filter identification information.

All main functions of the PQF-Manager can be accessed through the main ‘Welcome’ screen. In filter systems consisting of multiple masters, the PQF-Manager on the master controlling the system has full functionality whereas the PQF-Managers on the other masters have limited functionality.
Figure 54 outlines the principle menus that are accessible through the ‘Welcome’ screen.

Figure 54: Principle menus of the PQF-Manager
In addition to the main functions, the PQF-Manager also incorporates:

- A digital output contact monitor located at the top of the screen (Cf. Figure 53 item 3). When the PQF-Manager closes one of its six digital output relays (Cf. Chapter 6) the corresponding symbol lights up. When the relay considered opens again, the symbol disappears.

- An indicator showing when the PQF-Manager’s alarm contact has been activated (Cf. Figure 53, item 4). For the conditions under which the alarm contact is switched on, refer to Table 26 When the alarm condition has disappeared, the indicator switches off.

In order to navigate through the menus of the PQF-Manager, the keypad (Cf. Figure 53 item 1) has to be used. The starting point for the navigation after a power up is the ‘Welcome’ screen. The item selected is highlighted (e.g. the ‘Measurements’ menu in Figure 53). The keypad and its basic functions are shown in Section 6.12.2.

![Figure 55: Keypad of the PQF-Manager](image)

Refer to Table 31 for an explanation on the basic functions of the keypad buttons.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1    | Help key\(^{(a)}\)  
      | Provides on-line help on the highlighted item |
| 2    | Escape key\(^{(b)}\) \(\text{Esc}\)  
      | To go back to the previous window or to leave the current menu or item selection without making changes |
| 3    | Up and down arrows\(^{(c)}\) \(\text{▲} \ \text{▼}\)  
      | To go up or down the item list or to go left \(\text{◀}\) or right \(\text{▶}\) in the item list or to increase or decrease a value |
| 4    | OK key\(^{(b)}\) \(\text{OK}\)  
      | To go to the next submenu or to validate a modification or an operation |

Remark:

\(^{(a)}\) On some items, help is not available. In that case pressing the Help key will have no effect.

\(^{(b)}\) Depending on the menu, this key has a different meaning.

\(^{(c)}\) Depending on the menu, these keys have a different meaning.
Please note that:

- Walking through a list of items happens in a circular manner. When arriving at the last item in a menu and pressing \( \uparrow \), the first item of the menu is highlighted. Similarly, when arriving at the first item in a menu and pressing the \( \downarrow \) key, the last item of the menu is highlighted.

- Sometimes the complete item list in a menu cannot be shown on the display. This is indicated by a small \( \Delta \) and/or \( \nabla \) symbol that appear(s) at the bottom right and/or the top right corner(s) of the display (Cf. Figure 56)

![Figure 56: Illustration of ▲ and ▼ symbols on the PQF-Manager display](image)

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.

- When a ‘right arrow’ symbol is visible next to a menu item, a submenu or sub-item will be opened when pressing the \( \uparrow \) key after highlighting this item. As an example consider the item ‘Main PFC/Bal.’ in Figure 57.

- The ‘Select Unit’-function is accessible at different places in the menu structure and allows to select the measurements and data as reported by different units in a multi-unit filter system.

- When a menu item consists of two fields separated by a space, three possibilities exist:
  1. The first field contains a parameter and the second field contains a parameter value, which can be changed by the user. As an example consider the item ‘Filter mode’ in Figure 57. When this item is highlighted and \( \uparrow \) is pressed, the parameter value can be changed. Validation of the value is done by pressing \( \downarrow \). Leaving the selected item without modification is done by pressing \( \uparrow \).
  2. The first field contains a parameter and the second field contains a parameter value, which cannot be changed by the user. As an example consider any item of Figure 56. Pressing \( \uparrow \) will not have any effect. Pressing \( \downarrow \) will bring up the previous menu.
  3. Same case as 2 above but when pressing \( \uparrow \) on a selected line the whole line starts to blink. By using the arrow keys, the position of the selected item in the list can then be changed. Press \( \downarrow \) when the item is placed at the desired position. The only PQF-Manager menu in which it is possible to change the position of the parameters displayed is the ‘Measurements-overview’ menu.
Pressing successively from any menu will bring up the main ‘Welcome’ screen.

Figure 57: Illustration of different menu item types

The next sections discuss the five 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 successively until the ‘Welcome’ screen is reached.
- Highlighting the ‘Measurements’ menu in the main ‘Welcome’ screen using the arrows
- Pressing the key after which the ‘Measurements’ menu opens
- Highlighting the ‘System values’ menu using the arrows
- Pressing the key will open the menu.

7.3 The PQF-Manager behavior during filter initialization

After a system reset, the filter is initialized. This includes the PQF-Manager. Depending on the type of reset, the initialization process of the PQF-Manager may consist of the first or the first and the second step discussed below.

- Step 1: The PQF-Manager waits for the communication channel to be initialized. This process can be observed when looking closely at the PQF-Manager. During this period the following message will appear on the display (Figure 58)
Step 2: 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. When the PQF-Manager is setting up the user interface, the following message is displayed (Figure 59).

![Figure 58: PQF-Manager display during communication initialization](image)

![Figure 59: PQF-Manager display when the user interface is set up](image)

Table 32 gives an overview of the initialization steps for common reset conditions.

<table>
<thead>
<tr>
<th>Reset condition after...</th>
<th>PQF-Manager initialization steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying power to the filter</td>
<td>Step 1 and Step 2</td>
</tr>
<tr>
<td>Setting up commissioning parameters</td>
<td>Step 1</td>
</tr>
<tr>
<td>Acknowledging fault successfully</td>
<td>Step 1</td>
</tr>
</tbody>
</table>

7.4 The PQF-Manager locking facilities

In order to prevent unauthorized people to modify any of the active filter settings, switch on the hardware lock (Figure 12, 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:

- ![Lock icon](image) will appear in the upper left-hand corner of the graphics display.
- ![Unlock icon](image) will appear next to the menus that are locked. No modification can be made to the settings.
- 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 people to modify 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 software lock is switched on in the menu [/Welcome/Settings/Installation set./Install. Lock].

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 with the \( \text{ and } \text{ } \) keys and then validating with \( \text{ } \text{ } \) . The password can be changed in the menu [/Welcome/Settings/Installation set/Change Password]. Entering the new password is done by choosing the desired value with the \( \text{ and } \text{ } \) keys and then validating with \( \text{ } \text{ } \).

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. In practice, the functions that are not enabled on these units are also locked and a \( \text{ } \) symbol will appear next to them.

7.5 The PQF start, stop and fault acknowledgement menu

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

Refer to Chapter 8 for more information on commissioning the filter.

‘The PQF start, stop and fault acknowledgement’ menu is a one-line menu that can be accessed:

- In the main ‘Welcome’ screen [/Welcome/PQF].
- In the ‘Commissioning’ screen [/Welcome/Settings/Commissioning/PQF]. For more information on the ‘Commissioning’ screen refer to the Section 7.7.

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

As can be seen in Table 33, the ‘start, stop and fault acknowledgement’ menu has another function depending on the filter status.
Table 33: ‘Start, stop and fault acknowledgement’ menu functionality according to the filter status

<table>
<thead>
<tr>
<th>Filter status</th>
<th>Menu display</th>
<th>Pushing results in…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter stopped, no critical error present (i.e. ‘normal’ stop condition)</td>
<td>PQF START</td>
<td>Starting the filter unit&lt;sup&gt;(a)(b)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Filter running, no critical error present (i.e. ‘normal’ running condition)</td>
<td>PQF STOP</td>
<td>Stopping the filter unit&lt;sup&gt;(a)(b)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Filter stopped on critical fault</td>
<td>ACK. FAULT</td>
<td>Acknowledging the fault&lt;sup&gt;(a)(b)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Filter controlled by remote control</td>
<td>PQF START or PQF STOP or ACK. FAULT</td>
<td>No action on filter behavior Display shows message that filter is controlled by digital input</td>
</tr>
</tbody>
</table>

Remark:
(a) After pushing , there is always a validation phase.
(b) In multi-master filter units, this function is available on the 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 Units]. 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 7.8.

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].
7.6 The ‘Measurements’ menu

The ‘Measurements’ menu can be accessed in the main ‘Welcome’ screen /Welcome/Measurements.

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.

7.6.1 The ‘Overview’ menu /Welcome/Measurements/Overview

The Overview menu summarizes the following characteristic parameters (Table 34). These parameters are expressed as numerical values in a list.

**Table 34: Summary of parameters displayed in the ‘Overview’ menu**

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
</table>
| 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 |
| 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 |
| 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 |
| F              | Hz   | Network frequency |
| I rms          | 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 |
| I1             | A    | RMS value of the fundamental component of all the line currents |
| THDI           | %    | Total harmonic distortion of all the line currents. |
| PQF I rms      | A    | RMS value of all the filter currents |
| 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  
<pre><code>              |      | Q &lt; 0: Capacitive reactive power |
</code></pre>
<table>
<thead>
<tr>
<th>S</th>
<th>VA, kVA, MVA</th>
<th>Apparent power in the network at the location of the CTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \cos \phi )</td>
<td>-</td>
<td>Displacement power factor: calculation based on the fundamental values of the measurements.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \cos \phi &gt; 0 ): load absorbing active power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \cos \phi &lt; 0 ): load generating active power</td>
</tr>
<tr>
<td>PF</td>
<td>-</td>
<td>Power factor: calculation based on the fundamental and the harmonic values of the measurements. Measurement only valid for quasi-balanced loads.</td>
</tr>
<tr>
<td>T IGBT ( ^\circ C/^\circ F )</td>
<td>IGBT module temperature (hottest module)</td>
<td></td>
</tr>
<tr>
<td>T Control ( ^\circ C/^\circ F )</td>
<td>Main control board temperature</td>
<td></td>
</tr>
<tr>
<td>V dc bus ( \nu )</td>
<td>Active filter DC capacitor voltage</td>
<td></td>
</tr>
</tbody>
</table>

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.
- Press \( \text{ } \). The selected parameter starts flashing.
- Press \( \text{ } \) or \( \text{ } \) to move the selected parameter up or down the list.
- Once the selected parameter is located at the desired position in the list, press \( \text{ } \).

Remark: During the display customization process, the \( \text{ } \) key cannot be used to revert back to the original situation.

### 7.6.2 The ‘System values’ menu

The ‘System values’ menu (Figure 54) gives detailed information on the following parameters:

- **The voltages:** (Refer to Table 34 for an explanation of the symbols).
  - \( \text{Vrms, V1 and THDV in table format.} \)
  - \( \text{The network voltage waveforms for all phases (Figure 60) } \)
    
    All waveforms are synchronized with the rising edge zero crossing of the voltage \( \text{V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).} \)
Figure 60: Time domain waveform of line voltage displayed by the PQF-Manager

(4-W mode example)

- The network voltage spectrum for all phases in chart format (Figure 61)

  The spectral components up to the 50th order are expressed as a % of the fundamental component with absolute values also shown in the top right corner.

Figure 61: Spectrum of the network voltage in chart format displayed by the PQF-Manager

(4-W mode example)

- 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 50th order.
The network frequency
- The network imbalance
- The active filter DC bus voltage

**The line currents:** (refer to Table 34 for an explanation of the symbols)
- Irms, I1 and THDI in table format.
- 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).
- 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)
- 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)

**The filter currents:** (Refer to Table 34 for an explanation of the symbols)
- PQF Irms in table format for the unit selected with the ‘Select Unit’ option.
- 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).
- 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.
- The filter 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) but only absolute current values are shown.

- **The total filter currents:** (Refer to Table 34 for an explanation of the symbols)
  - PQF Irms in table format for the complete filter system.
  - 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).
  - 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.
  - 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 62) 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.

- **The power in the system at the location of the CTs:** (Refer to Table 34 for an explanation of the symbols)
  - Active power P.
  - Reactive power Q.
  - Apparent power S.
  - Displacement power factor \( \cos \varphi \).
  - Power factor PF.

- **Temperatures:** (Refer to Table 34 for an explanation of the symbols)

Temperatures may be expressed in °C and in °F. For changing the temperature unit, go to [Welcome/Settings/Customer set. /Temp unit].

- Temperature of the hottest IGBT (‘T IGBT’) and the hottest phase (‘Hot phase’) of the unit selected by the ‘Select unit’-option. For PQFS filters, the hottest phase function is not available and a default value ‘1’ is shown.
- 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.
7.6.3 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 clearance:

- 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](image)

The parameters that can be used with the logging function are Vrms, THDV, Irms, P, Q, S, f, T IGBT max and Tcontrol max. Refer to Table 34 for an explanation of the symbols. 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 7.4)

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 430 V.

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

7.7 The ‘Settings’ menu

The ‘Settings’ menu has three 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, set up the digital inputs and outputs and define 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 printer/PQF-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.]

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 next to them. These functions are set up in the ‘real’ master and are automatically further dispatched to the other units by the control system.

The three main levels of the ‘Settings’ menu are discussed in more detail in the next sections.

### 7.7.1 The ‘Customer settings’ menu [Welcome/Settings/Customer set.]

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

Refer to Section 7.4 for determining appropriate locking facilities for this menu.

#### 7.7.1.1 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 setting.

- 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.
  
  o 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 35. By default the filter uses the main filter settings.

Table 35: Possible settings for the activate field

<table>
<thead>
<tr>
<th>‘Activate’ field value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>Main window settings are always used</td>
</tr>
<tr>
<td>Auxiliary</td>
<td>Auxiliary window settings are always used</td>
</tr>
<tr>
<td>Ext. input</td>
<td>The filter switches between the main and the auxiliary settings according to a signal applied to the PQF-Manager’s digital input(^{(a)}).</td>
</tr>
</tbody>
</table>

Remark:
\(^{(a)}\) Refer to Section 6.12.5 for cabling instructions for this feature. Refer to Section 7.7.1.2 configuring the digital input for this feature.

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 36 shows the three available modes:

Table 36: Available filter modes

<table>
<thead>
<tr>
<th>Highest priority level</th>
<th>Lowest priority level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td>Filtering to curve</td>
</tr>
<tr>
<td>Mode 2</td>
<td>Filtering to curve</td>
</tr>
<tr>
<td>Mode 3</td>
<td>Filtering to curve</td>
</tr>
</tbody>
</table>
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.

![Diagram of filtering to curve for harmonic order n](image)

**Figure 65: Filtering to curve for harmonic order n**

The default filter mode is Mode 3.

- **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 37**.

  When the PQFS is operating in 4-W mode, 15 harmonics can be selected.

  When the PQFS is operating in 3-W mode, 20 harmonics can be selected.
Table 37: Example of harmonic settings table displayed by PQF-Manager

<table>
<thead>
<tr>
<th>Order</th>
<th>Select(^{(a)})</th>
<th>Curve(^{(b)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>No</td>
<td>0 A</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>10 A</td>
</tr>
<tr>
<td>7</td>
<td>No</td>
<td>0 A</td>
</tr>
<tr>
<td>9</td>
<td>No</td>
<td>0 A</td>
</tr>
</tbody>
</table>

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. The first line will be highlighted.
  - Use 
    and 
    to select the desired order and press 
    to activate the corresponding line. The item in the column ‘Select’ will be highlighted.
  - If the harmonic order of the selected line has to be changed, press 
    to go to the ‘Order’ field. Press 
    and use 
    or 
    to change the order. The PQF-Manager will automatically propose the orders that are not yet in the list. If the desired order is displayed, press 
    Then, press 
    which will highlight the item in the column ‘Select’.
  - Press 
    and then 
    or 
    to select (Yes) or deselect (No) the harmonic. Press 
    to validate the choice made.
  - Use the 
    to switch to the ‘Curve’ level column.
  - Press 
    and then the 
    or 
    to set up the desired curve level in Amps. Press 
    to validate the choice made.
  - Press 
    to highlight the complete line after which the other harmonics can be programmed using the same procedure.
  - Once all the harmonics are programmed, the harmonic selection table can be exit by pressing 

- 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.

- **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 38 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 38 can be accessed in the ‘Main PFC/Bal.’ and ‘Aux. PFC/Bal.’ windows of the PQF-Manager.

*Table 38: Reactive power tasks that the filter can perform*

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

<table>
<thead>
<tr>
<th>Remarks:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(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)</td>
</tr>
<tr>
<td>- ‘Disabled’: No load balancing is done.</td>
</tr>
<tr>
<td>- ‘L-L’: Loads connected between phase only are balanced. Loads connected between phases and neutral are not balanced.</td>
</tr>
<tr>
<td>- ‘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.</td>
</tr>
<tr>
<td>- ‘L-L &amp; 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.</td>
</tr>
<tr>
<td>Note: The modes ‘L-N’ and ‘L-L &amp; L-N’ can be used to minimize the amount of fundamental frequency current flowing in the neutral.</td>
</tr>
<tr>
<td>(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</td>
</tr>
<tr>
<td>© 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</td>
</tr>
</tbody>
</table>

### 7.7.1.2 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.

- **Set up of the digital inputs of the PQF-Manager**

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

  **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.
Table 8 gives an overview of the possible digital input settings and the resulting filter behavior. The settings given in this table can be applied to any of the two digital inputs.

For more information on:
- The remote control functionality, refer to Section 6.12.1
- The main/auxiliary control functionality, refer to Section 6.12.5
- The implementation of local start/stop buttons, refer to Section 6.12.6

The default setting for the digital inputs is ‘Disabled’.

- **Set up of the digital outputs of the PQF-Manager**

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

  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.

  Table 9 gives an overview of the possible filter conditions that can be associated with any of the six digital outputs. When interpreting this table it should be noted that:

  - The ‘In standby’ function refers to a state of the filter in which it is connected to the power supply (i.e. main contactor closed) but the IGBTs are not switching. As a result the filter will have virtually no losses. This mode can be activated when the load requirement is lower than a preset value (e.g. all loads switched off for a long time). For more information on the ‘In standby’ function, refer to Section 7.7.3.2
  - The three programmable alarms and warnings have to be set up before they can be used. This is explained in the next sections. If a programmable alarm has been disabled, the digital output associated with it will never be activated.

  The default settings for the digital outputs are given in Table 10. In order to disable the digital outputs, choose the option ‘Disabled’.

  For more information on cabling the digital output contacts refer to the Sections 6.12.2 and 6.12.4.

  In a master-master configuration, the digital inputs of all masters have to be cabled in case full redundancy is required.

- **Set up of the programmable alarms trip points**

  For setting up the programmable alarms go to [Welcome/Settings/Customer set./Alarms/Prog. Alarms]

  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.
In addition to the alarm contact, which is triggered by any filter fault, three programmable alarms can be defined. They can be associated with a digital output (see preceding paragraph). Table 39 shows the possible alarm conditions that can be associated with each programmable alarm.

**Table 39: Overview of possible programmable alarm settings that can be associated with each digital output**

<table>
<thead>
<tr>
<th>Alarm condition</th>
<th>Setting for programmable alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage (RMS) unacceptably high</td>
<td>Vrms_max</td>
</tr>
<tr>
<td>Supply voltage (RMS) unacceptably low</td>
<td>Vrms_min</td>
</tr>
<tr>
<td>One of the phases of the supply is missing</td>
<td>Phase loss</td>
</tr>
<tr>
<td>Network imbalance unacceptably high</td>
<td>Imbalance</td>
</tr>
<tr>
<td>Frequency variation unacceptably high</td>
<td>Fq change</td>
</tr>
<tr>
<td>PQFS DC bus voltage unacceptably high for each capacitor stack</td>
<td>Vdc_max</td>
</tr>
<tr>
<td>PQFS internal preload error</td>
<td>Prel. Err.</td>
</tr>
<tr>
<td>PQFS over current fault</td>
<td>Overcur.</td>
</tr>
<tr>
<td>PQFS ground fault</td>
<td>Gnd fault</td>
</tr>
<tr>
<td>PQFS IGBT fault</td>
<td>IGBT fault</td>
</tr>
<tr>
<td>PQFS over temperature fault</td>
<td>IGBT temp.</td>
</tr>
<tr>
<td>PQFS control board over temperature fault</td>
<td>T ctrl max</td>
</tr>
<tr>
<td>PQFS control board supply fault</td>
<td>PS fault</td>
</tr>
<tr>
<td>PQFS control board fault</td>
<td>Ctrl board</td>
</tr>
<tr>
<td>Any fault (of the ones listed above)</td>
<td>Any fault</td>
</tr>
</tbody>
</table>

If the alarm condition is met, the programmable alarm will be set and the associated digital output will be activated when the alarm is present for a preset time.

The time during which the alarm condition has to be present has a minimal value of 180 s and can be increased if desired. In order to increase the time during which the alarm has to be present before the digital output is triggered, go to [/Welcome/Settings/Customer set./Alarms/Prog. Alarms/Alarm delay].

Note that the delay programmed here is also applied to the filter alarm contact.

The digital output will be deactivated if the alarm has disappeared for a preset time, which is by default 1 s. In order to change the alarm reset delay, go to [/Welcome/Settings/Customer set./Alarms/Prog. Alarms/Alarm rst. Del.].

When configuring the programmable alarm as ‘Any’ it will trigger the digital output if any of the fault conditions presented in Table 39 is met.

The programmable alarms can be deactivated by setting them to ‘Disabled’. 
Remarks:

- Difference between the alarm contact and the digital output used as alarm contact

  The alarm contact is triggered by any fault that makes the system trip. These faults include the conditions mentioned in Table 39 but includes also all other internal filter faults that may occur. An exhaustive list of faults that may make the filter trip and thus trigger the alarm contact is given in Table 46 and Table 47. Use the digital outputs as alarm contact if the aim is to find the exact cause of the filter trip without having to analyze the event-logging window.

- Set up of the programmable warnings

  For setting up the programmable warnings go to [Welcome/Settings/Customer set./Warnings/Prog. Warnings]

  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.

  Three programmable warnings can be defined. Similar to the programmable alarms, they can be associated with a digital output. Table 40 shows the possible warning conditions that can be associated with each programmable warning.

  Unlike alarms that cause a filter trip, warnings only activate the digital output contact.

  Table 40: Overview of possible programmable warning settings that can be associated with each digital output

<table>
<thead>
<tr>
<th>Warning condition</th>
<th>Setting for programmable warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage (RMS) higher than preset value V.max.warn.</td>
<td></td>
</tr>
<tr>
<td>Supply voltage (RMS) lower than preset value V.min.warn.</td>
<td></td>
</tr>
<tr>
<td>Supply voltage imbalance higher than preset value Imbalance</td>
<td></td>
</tr>
<tr>
<td>PQFS ground current level higher than preset value Ground Fault</td>
<td></td>
</tr>
<tr>
<td>PQFS IGBT Temperature higher than preset value T IGBT warn.</td>
<td></td>
</tr>
<tr>
<td>PQFS control board temperature higher than preset value T ctrl warn.</td>
<td></td>
</tr>
</tbody>
</table>

If the warning condition is met, the programmable warning will be set and the associated digital output will be activated when the warning is present for a preset time. This time has a minimal value of 1 s and can be increased if desired. In order to increase the time during which the warning has to be present before the digital output is triggered, go to [Welcome/Settings/Customer set./Warnings/Prog. Warnings/Warning delay].

The digital output will be deactivated if the warning has disappeared for a preset time, which is by default 1 s. In order to change the warning reset
The warning levels can be changed by the user. In order to do this, go to [/Welcome/Settings/Customer set./Warnings/Prog. Warnings/Warn. Rst del.]

7.7.1.3 Setting up the unit for temperature measurements

For changing the default unit for the temperature measurements, go to [/Welcome/Settings/Customer set./Temp unit]

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

The temperature unit can either be °C or °F.

7.7.2 The ‘Commissioning’ menu [/Welcome/Settings/Commissioning]

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 7.4 for determining appropriate locking facilities for this menu.

For an overview of the main items of the commissioning window, refer to Section 7.5. 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 7.5)
- For advanced filter setup (auto restart function, standby function, system clock setup, external communication setup, system lock activation and password setup) refer to Section 7.7.3.
7.7.2.1 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.

\[\text{WARNING: The filter hardware is by default set for operation at voltages in the range 380-415V. When the filter is used in networks with voltages in the range 208-240V, its hardware configuration needs to be changed. Refer to Section Error! Reference source not found. For guidelines on how this needs to be done. Failure to adapt the filter hardware to the right network voltage range may result in hardware failure.}\]

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

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

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

\[\text{WARNING: This parameter shall only be changed by experienced commissioning engineers or after advice from the ABB service provider. Using the wrong synchro mode will lead to filter malfunctioning.}\]
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.
- Pressing \( \text{on} \) in the network characteristics 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 by pressing \( \text{on} \) or \( \text{on} \) repeatedly. This way the menu can be quit without modifying any values.

### 7.7.2.2 Setting up the filter characteristics

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.]

The 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 of the same rating. 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 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. 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.
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 \( \uparrow \) in the unit ratings setup menu will result in 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 by pressing \( \uparrow \) or \( \downarrow \) repeatedly. This way the menu can be quit without modifying any values.

7.7.2.3 Setting up the current transformer ratios and position

The current transformers connected to the filter (units) have 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.

- Detection of the CT positions and ratio’s using the automatic CT detection feature:

  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 filter. 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.

**NOTES:**

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 41**.

**Table 41: Automatic CT detection position-results presentation**

<table>
<thead>
<tr>
<th>Filter connection CT terminal&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Physical CT location and orientation&lt;sup&gt;(b)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input 1</td>
<td>Line 1</td>
</tr>
<tr>
<td>Input 2</td>
<td>Line 2</td>
</tr>
<tr>
<td>Input 3</td>
<td>Line 3</td>
</tr>
</tbody>
</table>

**Remarks:**

<sup>(a)</sup> This column refers to the filter terminal X21 located in the filter unit.
- 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)

<sup>(b)</sup> 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
- Line 1: 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 41**. 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 with the and if desired. In order to approve the value entered has to be pressed. Table 42 explains the meaning of the text that appears on the display:

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

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 43 gives a list of the possible error messages.
Table 43: Possible error messages during automatic CT identification

<table>
<thead>
<tr>
<th>PQF-Manager error messages during automatic CT identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>The CT identification found inconsistent CT positions.</td>
</tr>
<tr>
<td>The CT identification did not end within an appropriate time frame.</td>
</tr>
<tr>
<td>The CT identification required an abnormally high DC voltage.</td>
</tr>
</tbody>
</table>

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.

• Setting up the CT positions and ratio’s using the manual setup procedure:

For entering 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 abovementioned values, the filter resets and the settings are taken into account.

Remarks:

- Pressing during the manual CT setup procedure will result in:
  - For single unit filters, the original CT-values and positions existing prior to the start of the procedure be 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 6.9 and Section 6.10 for more information on the selection and the installation of the current transformers.

### 7.7.2.4 Setting up the filter rating parameter

For entering the derating parameter, go to 

```
/Welcome/Settings/Commissioning/Derating
```

The permissible ambient conditions for PQFS operation are laid out in Table 13.

- 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 (anneer), 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  will result in the original value being restored and the filter rating menu being quit.

### 7.7.2.5 Setting up the users 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  to go to the next step.
- Setting up the harmonic selection table for the main settings. After entering the desired values (cf. Section 7.7.1.1), press  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  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 . Pressing any other key will omit this step.
- The set-up ends by displaying the main commissioning menu.
Remarks:

- Refer to Section 7.7.1.1 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 7.7.1)
- 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.

7.7.3 The ‘Installation settings’ menu [/Welcome/Settings/Installation set.]

![Warning]

**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:

- the auto restart function
- the standby function
- the system clock setup
- the external communication setup
- the software lock activation and password setup

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 charact.]);
- 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 7.7.2)
7.7.3.1 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./Auto start].
- To program the delay after which the filter has restart once the power returns, go to [/Welcome/Settings/Installation set./Start-Stop set./Auto st. del].

Remark:
By default the ‘auto restart’ function is enabled and the delay time is set at 5s.

7.7.3.2 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 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.

- ‘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.

The filter standby parameters are illustrated in Figure 66.

![Figure 66: Illustration of the filter standby parameters](image)

Remarks:

- The filter load requirement is determined from the user settings for harmonic filtration, reactive power compensation and balancing.
- It is recommended to put the lower threshold (i.e. [Standby level – Standby hyst.] \% of the standby function at least to 15%.

### 7.7.3.3 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. Both the date and the hour can be changed. The hour is presented in 24-hour format and is set up for the time zone GMT +1.
7.7.3.4 Setting up the external communication parameters

For setting up the external communication parameters, go to [Welcome/Settings/Installation set./Communication]

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

Two communication protocols can be selected for the external communication:

- **PC:**
  Choose this setting if a PC running the PQF-Link software (optional) will be connected to the PQF-Manager. When choosing this protocol, no other communication parameters have to be set-up on the filter side. For more information on how to connect the PQF-Link software, refer to the PQF-Link manual.

- **Modbus protocol:**
  Choose this setting if the filter will be connected to a Modbus network. When the Modbus protocol is used, some more parameters have to be configured. To do this, go to [Welcome/Settings/Installation set./Communication/Modbus]. The parameters to be set include:
  o Baud rate, parity and number of stop bits for the communication
  o The PQF address in the Modbus network
  o The Modbus lock which when activated ensures that the PQF parameters can only be changed from the Modbus network.

  For more information on the Modbus communication system, refer to the “2GCS212012A0050-RS-485 Installation and Start-up guide”

7.7.3.5 Setting up the software lock and password

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

The settings section of the PQF-Manager can be protected by software and hardware lock. More information on these locks is given in Section 7.4.

7.8 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.

7.8.1 The ‘Status of units’ 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.

7.8.2 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.

7.8.3 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 67 gives an example of the event window.
The explanation of the different items is given in Table 44.

**Table 44: Item explanation of the event window**

<table>
<thead>
<tr>
<th>Item</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| 1    | Event number (0-199)  
The smaller the number, the more recent the event |
| 2    | Event type  
Table 45 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 46 and Table 47 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 45: Overview of the events that can be recorded**

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No event</td>
<td>No storable event has occurred yet</td>
</tr>
<tr>
<td>Energization</td>
<td>The power has been switched on</td>
</tr>
<tr>
<td>System reset</td>
<td>The filter controller has been reset</td>
</tr>
<tr>
<td>Start request</td>
<td>A filter start has been requested</td>
</tr>
<tr>
<td>Stop request</td>
<td>A filter stop has been requested</td>
</tr>
<tr>
<td>Fault (DSP)</td>
<td>The DSP controllers have reported a fault</td>
</tr>
<tr>
<td>Fault (uC)</td>
<td>The µcontroller has reported a fault</td>
</tr>
<tr>
<td>Fault cleared</td>
<td>A user attempt to clear a fault has been recorded (by validating the ‘ACK. FAULT’ option on the PQF-Manager)</td>
</tr>
<tr>
<td>No more fault</td>
<td>The system detects no more faults</td>
</tr>
</tbody>
</table>
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 controllers has been recorded

From Table 45 it can be seen that both the DSP controllers and the μcontroller can record faults. Where the faults reported by the μcontroller are predominantly relating to a control board failure, the faults reported by the DSPs relate predominantly to the filter interacting with the installation. Table 46 gives an overview of the faults that can be reported by the DSP controllers. The list is in alphabetical order.

Table 46: Overview of the faults that can be reported by the DSP controllers

<table>
<thead>
<tr>
<th>DSP fault message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad CT connection</td>
<td>The automatic CT detection procedure has encountered a problem during the identification process.</td>
</tr>
<tr>
<td>Bad Ratings</td>
<td>The DSP has detected an inconsistent set of commissioning parameters</td>
</tr>
<tr>
<td>DC over voltage (SW)</td>
<td>The DC software over voltage protection has been triggered (Cf. Table 24 for limit values).</td>
</tr>
<tr>
<td>DC over voltage (HW)</td>
<td>The DC hardware over voltage protection has been triggered.</td>
</tr>
<tr>
<td>DC Top over voltage</td>
<td>The DC over voltage protection of the capacitors in the positive stack has been triggered.</td>
</tr>
<tr>
<td>DC Bot over voltage</td>
<td>The DC over voltage protection of the capacitors in the negative stack has been triggered.</td>
</tr>
<tr>
<td>DC under voltage (SW)</td>
<td>The DC software under voltage protection has been triggered.</td>
</tr>
<tr>
<td>Ground fault</td>
<td>A ground fault has been detected.</td>
</tr>
<tr>
<td>IGBT check cooling</td>
<td>The software IGBT temperature protection has been triggered.</td>
</tr>
<tr>
<td>IGBT permanent</td>
<td>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.</td>
</tr>
<tr>
<td>IGBT temporary</td>
<td>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.</td>
</tr>
<tr>
<td>Loss of phase</td>
<td>The system has detected a loss of supply on at least one phase.</td>
</tr>
<tr>
<td>No synchronization</td>
<td>The system cannot synchronize on to the network.</td>
</tr>
<tr>
<td>SPI Error</td>
<td>The DSP has received no response after its request on the SPI port.</td>
</tr>
<tr>
<td>Bad Sequence</td>
<td>The DSP has detected an inadequate behaviour in the sequence.</td>
</tr>
<tr>
<td>Out of mains freq. Limit</td>
<td>The system has detected that the network frequency is out of range.</td>
</tr>
<tr>
<td>Over voltage RMS</td>
<td>The RMS value of the supply voltage is higher than the acceptable maximum value.</td>
</tr>
</tbody>
</table>
Over volt. Transient (SW)  The software transient over voltage protection has been triggered.

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 Table 24

**Table 47** gives an overview of the faults that can be reported by the µcontroller.

**Table 47: Overview of the faults that can be reported by the µcontroller**

<table>
<thead>
<tr>
<th>µcontroller fault message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Com. Problem 1 (CAN bus)</td>
<td>Communication problem between different units in a multi-unit filter arrangement</td>
</tr>
<tr>
<td>Com. Problem (RS-232)</td>
<td>Serial communication problem between the main controller board and an external PC</td>
</tr>
<tr>
<td>Corrupted DSP code</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Corrupted uC code</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Internal uC fault</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Ctrl over temperature</td>
<td>The system detected an over temperature of the main controller board</td>
</tr>
<tr>
<td>DSP watchdog</td>
<td>Internal system error</td>
</tr>
<tr>
<td>µController watchdog</td>
<td>Internal system error</td>
</tr>
<tr>
<td>SPI Time out</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Flash memory corrupted</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Power supply fault</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Preload time-out</td>
<td>The DC capacitors could not be preloaded in an acceptable time</td>
</tr>
<tr>
<td>Real time clock problem</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Several units same id</td>
<td>Two or more units have the same CAN_ID (settings of the S5 dip switches (1 tot 3) on the control board</td>
</tr>
<tr>
<td>Different firmwares</td>
<td>Different units in a filter system have different control firmwares (DSP and/or microcontroller)</td>
</tr>
</tbody>
</table>
For guidelines on how to troubleshoot and solve the reported problems, refer to Chapter 11.

Remarks:

- 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’ appear, 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).

7.8.4 The ‘Active warnings’ menu [Welcome/PQF monitoring/Active warn.]

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 7.7.1.2 and Table 26.

Table 48 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 48: Warning messages that can be displayed by the PQF-Manager and corresponding warning conditions

<table>
<thead>
<tr>
<th>Warning condition</th>
<th>Warning message displayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage (RMS) higher than preset value</td>
<td>Over voltage RMS</td>
</tr>
<tr>
<td>Supply voltage (RMS) lower than preset value</td>
<td>Under voltage RMS</td>
</tr>
<tr>
<td>Supply voltage imbalance higher than preset value</td>
<td>Unbalanced supply</td>
</tr>
</tbody>
</table>
PQFS ground current level higher than preset value | Ground fault
---|---
PQFS IGBT temperature higher than preset value | IGBT temperature
PQFS control board temperature higher than preset value | Ctrl over temperature

7.8.5 The ‘Total number of errors’ menu
The ‘Total 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 46 and Table 47.

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

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

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

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

7.8.7 The ‘Trip. Phase’ parameter
The value shown in the menu is by default 0. If a trip due to an overtemperature occurs, the value will become 1 for the unit in which the problem occurred.

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.

7.9 The ‘About PQF’ menu
The ‘About PQF’ menu can be accessed in the main Welcome screen ([/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/About PQF/Manufacturer set.]
- Firmware version numbers for the PQF-Manager, the \mu controller and the DSP controllers.

**WARNING:** When communicating with your ABB 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.
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 “2GCS212012A0050-RS-485 Installation and Start-up guide” for more information on this item.

The commissioning procedure consists of 8 steps that should be strictly followed.

Table 49: Steps to follow to commission the active filter

<table>
<thead>
<tr>
<th>Steps</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Visual and installation check</td>
</tr>
<tr>
<td>Step 2</td>
<td>Setting the address of each unit in a multi-unit filter and terminate the CAN bus</td>
</tr>
<tr>
<td>Step 3</td>
<td>Voltage rating and phase rotation check</td>
</tr>
<tr>
<td>Step 4</td>
<td>Basic commissioning parameters setup (including CT setup)</td>
</tr>
<tr>
<td>Step 5</td>
<td>Before starting the filter</td>
</tr>
<tr>
<td>Step 6</td>
<td>Start the filter</td>
</tr>
<tr>
<td>Step 7</td>
<td>Generate filter load</td>
</tr>
<tr>
<td>Step 8</td>
<td>Set up the user requirements</td>
</tr>
</tbody>
</table>

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 must be done upstream of the active filter and before removing the protective cover. In multi-unit filters, ensure that all units are disconnected from the supply.

In order to perform a successful installation and commissioning, the filter protective cover must be removed.

**WARNING:** When the protective cover is removed, open the auxiliary power fuse holder. Verify that the filter DC capacitors are discharged before touching them. 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 fulfills 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 capsules 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 section and tightness, 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 (Cf. Table 19)

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 68 shows the location of the DIP switch on the control board (Item 21 in the Figure).

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). The three left hand DIP switches determine the filter unit address. Table 50 shows the filter unit addresses that can be chosen and the corresponding configuration to be set.
Table 50: Possible filter unit addresses and corresponding DIP switch settings (facing the board with ABB logo at the top), counting left to right.

<table>
<thead>
<tr>
<th>Filter address</th>
<th>DIP switch 1 setting</th>
<th>DIP switch 2 setting</th>
<th>DIP switch 3 setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>8</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Notes:
- 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 the below Figure 69 by the black lines interconnecting the different units.

Figure 69: Communication bus between different filter units

In order to terminate the bus correctly, the fourth switch (counting from left to right) from DIP switch 21 (Cf. Figure 68) 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 13, wire 'N'). Ensure that the filter panel is isolated upstream before changing the power supply connection of the control voltage.

By default the power supply connection of the control voltage is configured for networks in the voltage range 380-415 V (Cf. Figure 28). For networks in the voltage range 208-240 V, use the connection given in Figure 29.

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).

**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 7.8.3)
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 slaves 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 53), or will show a screen indicating that they are 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 7.7.2). An overview of the main menus of the PQF-Manager is given in Figure 54.

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 unlock symbol or lock symbol is present on the screen), the hardware and/or software lock has been engaged. Refer to Section 7.4 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 and a lock symbol will appear next to them.
In the commissioning window, the following basic parameters have to be specified:

- **The network characteristics (Cf. Section 7.7.2.1):**
  
  The parameters to enter are the nominal network voltage, network frequency and filter synchronisation mode. The filter synchronisation mode shall normally not be changed unless specifically instructed by the ABB service provider.

- **The filter characteristics (Cf. Section 7.7.2.2):**
  
  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 1000 m or is running under ambient temperature conditions higher than 40°C, the filter has to be derated. For more information on how to calculate the derating required and how to enter the derating value, refer to Section 7.7.2.4.

**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 7.7.1.2 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 autorestart 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) and the software lock, refer to Section 7.7.3 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)
If there is a need to do a manual check of the CT connections, go to step 5 (Section 8.6)

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 6.9 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 as shown in Figure 40)
- 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 functions, 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 7.7.2.3.

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 7.7.2.3 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 70 shows the standard connection diagram for the PQF (Cf. Section 7.7.1). 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.

![Basic CT connection diagram](image)

It is also seen that terminal X21.1 and X21.2 are related to the CT located in phase L1, terminal X21.3 and X21.4 are related to the CT located in phase L2 and terminal X21.5 and X21.6 are related to the CT located in phase L3.

For multi-unit filters, the following diagram is applicable:
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 sensors are also needed. A power analyzer like the Fluke 41B can also be used.

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: Another 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-N). 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 72)

- 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.
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 73).

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.

From the fundamental component of both signals, the phase shift must then be evaluated (Figure 74). 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:

$$\phi = \frac{\Delta T}{T1} \times 360^\circ$$

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°.

8.6.2.3.2 Measurement of the CT in phase L2 and L3 (Figure 75 and Figure 76)
The same operations as those described in the previous paragraph must be repeated with the phase L2 (Figure 75) and phase L3 (Figure 76).

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.
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. Connecting the current probes as shown on Figure 77. 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.
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 72, Figure 75 and Figure 76.

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 7.7.1.1.

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 contactor should close within 240 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 7.5.

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 7.7.1.2.
- 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 units] 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.

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 7.7.1.1.
Once the harmonic is selected, analyze the spectrum of the line currents to see if the selected harmonic is filtered. Refer to Section 7.6.2 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 7.7.1.1.

Once the reactive power is selected, analyze the filter current. Refer to Section 7.6.2 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 7.7.1.1.

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.
- 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 incorporated 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, ABB acknowledges 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 51 indicates the harmonics recommended to be deselected for different types of detuned banks.

Table 51: Recommended harmonics to be deselected for different detuned bank types

<table>
<thead>
<tr>
<th>Detuned bank type</th>
<th>Harmonics recommended to be deselected</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.67 %</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>6 %</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>7 %</td>
<td>2, 3</td>
</tr>
<tr>
<td>14 %</td>
<td>2</td>
</tr>
</tbody>
</table>

For other types of detuned bank please contact your ABB 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 78.

![Figure 78: 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)](image)

- 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 79 shall be used.

![Figure 79: CT connection guidelines for the case that a passive filter is installed downstream of the active filter](image)

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.

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.
### 8.11.1 Filter identification

<table>
<thead>
<tr>
<th>Active filter type&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Voltage (V)</th>
<th>Total current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global ratings&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System serial number&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter connection mode (3-W or 4-W)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit ratings/serial number&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>Rating (A)</td>
<td>Serial number</td>
</tr>
<tr>
<td>Unit 1 (M)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 2 (M/S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 3 (M/S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 4 (M/S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software version ©</td>
<td>PQF-Manager software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>µcontroller software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSP software</td>
<td></td>
</tr>
</tbody>
</table>

**Installation location**

**Remarks:**

<sup>(a)</sup> Read from main identification tag located on the master enclosure.

<sup>(b)</sup> Read on identification tag located at the outside of each enclosure.

© After the filter has been commissioned, navigate with the PQF-Manager to [Welcome/About PQF].

<sup>(d)</sup> Select whether this unit is a master (M) or a slave (S) unit.
### 8.11.2 Inspection on site – verification of the active filter after installation

<table>
<thead>
<tr>
<th>Ambient conditions</th>
<th>OK/NOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Check the ambient temperature (&lt; 40°C) (if &gt; 40°C, derating is required)</td>
<td></td>
</tr>
<tr>
<td>• Check the installation altitude (&lt; 1000 m) (if &gt; 1000 m, derating is required)</td>
<td></td>
</tr>
<tr>
<td>• Check the ventilation (room and enclosure)</td>
<td></td>
</tr>
<tr>
<td>• Ensure that no sources of conductive dust are present</td>
<td></td>
</tr>
</tbody>
</table>

**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 mm²) connected to each enclosure |        |
| • 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**

| • Disconnect the filter from the supply (disconnection by upstream protection) |        |
| • If filter connected to the supply before, wait 25 minutes to discharge DC capacitors |        |
| • Remove the filter protective cover, disconnect PQF-Manager if required |        |
| • Open auxiliary circuit fuse protection box |        |
| • DC capacitor voltage low enough to operate safely (DC voltage measurement) |        |
| • Filter hardware configured for the desired network voltage (208-240 V or 380-415 V) |        |
| • Wiring of main and auxiliary circuit |        |
| • Tightness of all electrical connections |        |
| • Connectors properly plugged in |        |
| • Fixation of components |        |
| • Remove anti-corrosion capsules installed at 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 |        |
| • CAN bus terminated properly on each unit of a multi-unit system |        |
| • CAN bus communication cable between the different units properly installed |        |

**Installation**

<p>| • 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) |        |
| • 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 |        |</p>
<table>
<thead>
<tr>
<th>ABB</th>
<th>Project:</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV Active Filters PQF</td>
<td>Issued by:</td>
</tr>
<tr>
<td>Commissioning report</td>
<td>Date:</td>
</tr>
</tbody>
</table>

- Remove all jumpers of all current transformers (CTs and SCTs)
### 8.11.3 Programming

**Apply voltage to the filter**(a)
- 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)
- Fan starts running

**Program equipment**(b)

<table>
<thead>
<tr>
<th>Network characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Supply voltage (V)</td>
</tr>
<tr>
<td>- Supply frequency (Hz)</td>
</tr>
<tr>
<td>- Synchro mode (should normally not be changed, default value is Three ph.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Connection mode (3-wire or 4-wire)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT position and ratio (for first unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Automatic detection feature used</td>
</tr>
<tr>
<td>- Filter terminal ‘Input 1’ is connected to the CT (including sign)</td>
</tr>
<tr>
<td>- Filter terminal ‘Input 2’ is connected to the CT (including sign)</td>
</tr>
<tr>
<td>- Filter terminal ‘Input 3’ is connected to the CT (including sign)</td>
</tr>
<tr>
<td>- Ratio of CT installed in line L1 (R, U)</td>
</tr>
<tr>
<td>- Ratio of CT installed in line L2 (Y, V)</td>
</tr>
<tr>
<td>- Ratio of CT installed in line L3 (B, W)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CT position and ration for other units of a multi-unit filter system is ok?</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Rating factor (temp &gt; 40°C or altitude &gt; 1000 m or...)</td>
</tr>
<tr>
<td>- Rating (%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configure digital inputs if applicable**(d)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>- For full redundancy, configure/cable digital inputs on all masters of a multi-master system**(d)**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configure digital outputs if applicable**(e)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>- For full redundancy, configure/cable digital outputs on all masters of a multi-master system**(e)**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Configure programmable warnings if applicable**(f)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>- For full redundancy, configure programmable warnings on all masters of a multi-master system**(f)**</td>
</tr>
</tbody>
</table>
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] or use PQF-Link.

\(^{(c)}\) 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)

<table>
<thead>
<tr>
<th>Before starting the filter</th>
<th>OK/NOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Deselect all harmonics and reactive power/balancing(^{(a)})</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start the filter(^{(b)})</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>While the filter is running(^{c})</th>
</tr>
</thead>
<tbody>
<tr>
<td>• If harmonic load is present, select for example the 11(^{th}) harmonic</td>
</tr>
<tr>
<td>• Check the line current (Irms, 11(^{th}) harmonic level and waveforms)</td>
</tr>
<tr>
<td>• If harmonic load is not present, generated static capacitive power (first select H3)</td>
</tr>
<tr>
<td>• Check the filter currents (fundamental current level)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set up the user requirements for harmonics and reactive power/balancing(^{(d)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Check the line currents (Irms, THDI and waveforms)</td>
</tr>
<tr>
<td>• Check the line voltage (Vrms, THDV and waveforms)</td>
</tr>
</tbody>
</table>

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

#### Filter connection mode

<table>
<thead>
<tr>
<th>Mode</th>
<th>3 Wire</th>
<th>4 Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activate</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

#### Filter mode

<table>
<thead>
<tr>
<th>Mode</th>
<th>Main settings</th>
<th>Auxiliary settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main settings</td>
<td>1 2 3</td>
<td></td>
</tr>
<tr>
<td>Auxiliary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Reactive power compensation

#### Main settings (Main PFC/Bal.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Disabled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Auxiliary settings (Aux. PFC/Bal.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Disabled</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Harmonics

#### Main settings (Main PFC/Bal.)

<table>
<thead>
<tr>
<th>H. Order</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
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<tbody>
<tr>
<td>Selected</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

#### Auxiliary settings (Aux. PFC/Bal.)

<table>
<thead>
<tr>
<th>H. Order</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

#### Curve (A)

<table>
<thead>
<tr>
<th>H. Order</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curve (A)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
### Alarms

<table>
<thead>
<tr>
<th>Prog. alarms</th>
<th>Warning levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prog. alarm 1</td>
<td>T IGBT warn.</td>
</tr>
<tr>
<td>Prog. alarm 2</td>
<td>T ctrl war.</td>
</tr>
<tr>
<td>Prog. alarm 3</td>
<td>V. min. warn.</td>
</tr>
<tr>
<td>Alarm delay</td>
<td>V. max. warn.</td>
</tr>
<tr>
<td>Alarm rst del.</td>
<td>Imbalance</td>
</tr>
</tbody>
</table>

### Warnings

<table>
<thead>
<tr>
<th>Prog. warnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prog. warn. 1</td>
</tr>
<tr>
<td>Prog. warn. 2</td>
</tr>
<tr>
<td>Prog. warn. 3</td>
</tr>
<tr>
<td>Warning delay</td>
</tr>
<tr>
<td>Warn. rst del.</td>
</tr>
</tbody>
</table>

### Digital Inputs

<table>
<thead>
<tr>
<th>Digital Inputs</th>
<th>Digital Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dg. In 1</td>
<td>Dg. Out 1</td>
</tr>
<tr>
<td>Dg. In 2</td>
<td>Dg. Out 2</td>
</tr>
</tbody>
</table>

### Digital Outputs

<table>
<thead>
<tr>
<th>Digital Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dg. Out 3</td>
</tr>
<tr>
<td>Dg. Out 4</td>
</tr>
<tr>
<td>Dg. Out 5</td>
</tr>
<tr>
<td>Dg. Out 6</td>
</tr>
</tbody>
</table>

### Start-Stop set.

<table>
<thead>
<tr>
<th>Start-Stop set.</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stdby status</td>
<td>Protocol</td>
</tr>
<tr>
<td>Standby level</td>
<td>Modbus</td>
</tr>
<tr>
<td>Stdby del off</td>
<td>Baud rate</td>
</tr>
<tr>
<td>Standby hyst</td>
<td>Parity</td>
</tr>
<tr>
<td>Stdby del con</td>
<td>Stop bit</td>
</tr>
<tr>
<td>Auto start</td>
<td>Slave Address</td>
</tr>
<tr>
<td>Auto st. del.</td>
<td>Modbus lock</td>
</tr>
</tbody>
</table>
8.11.6 Comments

<table>
<thead>
<tr>
<th>Commissioning Engineer</th>
<th>Customer's representative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
</tbody>
</table>
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 behaviour 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.

An alternative way to operate the filter is using Modbus communication. Refer to document “2GCS212012A0050-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 7.5.
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 \( \textcircled{\text{on}} \) 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 \( \textcircled{\text{on}} \). The filter will ask confirmation and then it will start. The main contactor closes and 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 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 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 7.7.1.2.

- If the hardware lock and/or the Modbus lock has/have been engaged, the filter cannot be started nor stopped. In order to see which lock(s) has/have been engaged push \( \textcircled{\text{on}} \) 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 7.4.

- The Modbus lock can be disengaged in the menu [Welcome/Settings/Installation set./Communication/Modbus/Modbus lock]. More information on the Modbus lock is available in the document “2GCS212012A0050-RS-485 Installation and Start-up guide”
• 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 occur when all the masters in the system have failed.

• 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.

When power is applied to the filter and it is started, the following startup sequence is conducted:

![Filter start-up sequence](image)

*Figure 80: Filter start-up sequence when power is applied and the start command is given*

In Figure 80 it may be seen that:

• The fan starts running as soon as the auxiliary circuit power is switched on.
• The DC capacitors will be charged.
• The start-up sequence consists of checking whether the charging of the DC capacitors has been successful, 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 supply to the filter was removed 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.

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 \( \text{on the PQF-Manager repeatedly until the 'Welcome' screen is displayed.} \)

• Highlight the filter ‘start/stop’ menu (‘PQF’ item in the list). In this menu, the ‘STOP’ indication should be present.

• Press \( \text{The filter will ask confirmation and then it will stop. The main contactor will open. The DC capacitors will remain charged.} \)

• 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 7.7.1.2.

• If the hardware lock and/or the Modbus 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 \( \text{when the ‘start/stop’ menu is highlighted. A message will appear to indicate which lock(s) has/have to be disengaged. If authorized, disengage the relevant lock.} \)

  o 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 7.4.
The Modbus lock can be disengaged in the menu 
[/Welcome/Settings/Installation set./Communication/Modbus/Modbus lock]. More information on the Modbus lock is available in the document “2GCS212012A0050-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.

![Flow chart showing the stop sequence](image)

*Figure 81: Filter operation sequence when no fault is present*

The DC bus 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 and balancing requirements. Refer to Section 7.7.1.1 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 7.7.1.2 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 external communication setup for Modbus.
• the software lock activation and password setup for filter protection purposes.

Refer to Section 7.7.3 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 contrast

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 contrast can be changed in

[/Welcome/Settings/Customer set./Contrast].

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 7.6.

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 7.8.
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/About PQF/Manufacturer set.]

- Firmware version numbers for the PQF-Manager, the µcontroller and the DSP controllers.

When communicating with your ABB 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:
  o 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 (a) will be OFF. The green LED on the main controller board (Cf. Table 12 item 18, LED 2) will be off and the red LED on (Cf. Table 12 item 18, LED 3). The user has to acknowledge the fault (with the PQF-Manager via Modbus or via remote control) before the filter can be restarted.
  o 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 (a) will be ON. The green LED on the main controller board (Cf. Table 12 item 18, LED 2) will be ON and the red LED will be OFF (Cf. Table 12 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 \(^{(a)}\) will be OFF. The green and red LED on the main controller board (Cf. Table 12 item 18, LEDs 2 and 3) will be OFF too.

- 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 main 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.

Remark:

- \(^{(a)}\)By default, the ‘Armed’ indicator is associated with the fourth digital output contact (cf. Table 10) The digital output contact monitor at the top of the PQF-Manager display (Cf. Figure 53 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)

<table>
<thead>
<tr>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>- ‘Armed’ indicator ON: The filter waits for the problem to disappear and then restarts automatically (unless the user acknowledges the fault).</td>
</tr>
<tr>
<td>- ‘Armed’ indicator OFF: The filter is permanently stopped and the customer has to solve the problem, acknowledge the fault and restart the filter manually.</td>
</tr>
</tbody>
</table>

- 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 52 lists the routine maintenance intervals recommended by ABB. Depending on the operating and ambient conditions, the intervals of Table 52 may have to be reduced. Announced intervals assume that the equipment is operating under ABB approved operating conditions (Cf. Chapter 12)

Table 52: Filter maintenance intervals recommended by ABB

<table>
<thead>
<tr>
<th>Maintenance</th>
<th>Intervals</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard maintenance procedure</td>
<td>Depending on the dustiness/dirtiness of the environment, every 12 to 24 months.</td>
<td>Section 10.3</td>
</tr>
<tr>
<td>Cooling fan change</td>
<td>Every 4.5 years (40000 hours)</td>
<td>Section 10.4</td>
</tr>
<tr>
<td>For units up to 60A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling fan change</td>
<td>Every 4 years (35000 hours)</td>
<td>Section 10.4</td>
</tr>
<tr>
<td>For units with higher ratings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC capacitor change</td>
<td>Every 8 years when not using line to neutral balancing option. Every 5.5 years when using full capacity for line to neutral balancing. Every 5.5 years for PQFS 100A in case of compensation of 3rd harmonic in single-phase applications.</td>
<td>Section 10.5</td>
</tr>
</tbody>
</table>

For convenience Section 10.7 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, 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 5 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, 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 to allow for the DC capacitors to discharge.
- Remove the filter cover panel. 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 unit that could cause consequential damage.
- Ensure that the control cards are free of dust. If necessary remove dust from them with a soft brush.

10.3.5 Step 5: Check the condition of the filter contactors and fuses
- Ensure that the main contactor can move freely.
- If bad fuses are found (upstream or in the unit), 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 and in Chapter 12.

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 fan starts running and that the PQF-Manager is booting.
- Restart the filter. If major servicing work has been done it is recommended to follow the commissioning instructions (cf. Chapter 12) for restarting the filter.
- Verify the filter performance.

10.4 Fan replacement
The cooling fan lifespan is between 4 and 6 years typically, depending on the usage and ambient temperature. Check the actual fan operating hours with the PQF-Manager ([Welcome/PQF monitoring/Fan 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 ABB service provider for replacement fans for your system.

In order to exchange the main IGBT cooling fan, follow the instructions below (Cf. Figure 82):

- Ensure that the power to the filter is switched off (upstream).
- Wait at least 25 minutes to allow for the DC capacitors to discharge.
- Open the filter front and disconnect the fan terminals (at the bottom of the filter next to the IGBT bridge)
- Remove the 4 screws that fix the fan set to the filter enclosure (bottom left side of the filter).
- Remove the fan assembly from the enclosure.
- Remove the fans from their holder and replace by new ones.
- Refit the assembly in the unit. Ensure proper fixation by the screws.
- Reconnect the fan wires to the terminal block
- Reclose the filter cover

Figure 82: Overview of IGBT cooling fan for units

The components description is given in Table 53.

Table 53: IGBT cooling fan related items description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cooling fans</td>
</tr>
<tr>
<td>2</td>
<td>Fan assembly fixation holes</td>
</tr>
<tr>
<td>3</td>
<td>Fan electrical connections</td>
</tr>
</tbody>
</table>
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 ABB approved technical specifications (Cf. Chapter 12.)

It is not possible to predict a capacitor failure. Contact your ABB service provider if capacitor failure is suspected. Replacement kits are available from ABB. Do not use other than ABB-specified spare parts.

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,

- 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 charged 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 ABB service provider.

10.7 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.
### Filter identification

<table>
<thead>
<tr>
<th>Active filter type&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Global ratings&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>System serial number&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Filter connection mode (3-W or 4-W)</th>
<th>Unit ratings/serial number&lt;sup&gt;(b)&lt;/sup&gt;</th>
<th>Rating (A)</th>
<th>Serial number</th>
<th>Article code&lt;sup&gt;(b)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Voltage (V)</td>
<td>Total current (A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System serial number&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter connection mode (3-W or 4-W)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit ratings/serial number&lt;sup&gt;(b)&lt;/sup&gt;</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Unit 1 (M)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Unit 2 (M/S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 3 (M/S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 4 (M/S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software version&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>PQF-Manager software</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>µcontroller software</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>DSP software</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks:

<sup>(a)</sup> Read from main identification tag located on the master enclosure.

<sup>(b)</sup> Read on identification tag located at the outside of each enclosure.

<sup>(c)</sup> After the filter has been commissioned, navigate with the PQF-Manager to [/Welcome/About PQF].

<sup>(d)</sup> Select whether this unit is a master (M) or a slave (S) unit.
### 10.7.2 Standard maintenance procedure

**Ambient conditions**
- Check the ambient temperature (< 40°C) (if > 40°C, derating is required)
- Check the installation altitude (< 1000 m) (if > 1000 m, derating is required)
- Check the ventilation (room and enclosure)
- Ensure that no conductive dust is present in and around the filter enclosure
- Rating factor (temperature > 40°C or altitude > 1000 m)
  - 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 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 25 minutes for DC capacitors to discharge
- Remove the filter protective cover 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, …)
- Remove loose components if present in enclosure

**Condition of filter main contactor and fuses**
- Main contactor 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 fuse box and refit the filter protective cover
Reclose the filter upstream protection

Restart the filter
- PQF-Manager booting
- Fan(s) start(s) running
- DC capacitors charging

Start the filter
If major servicing work has been done, follow the commissioning instructions to start the filter.

10.7.3 Special service actions

<table>
<thead>
<tr>
<th>Fan replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fan operation hours?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DC capacitor replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Filter operating hours?</td>
</tr>
<tr>
<td>- Ambient filter conditions?</td>
</tr>
<tr>
<td>Describe in the ‘comments’ section of this report.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DC capacitor reforming</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Filter storage time?</td>
</tr>
<tr>
<td>- Reforming time?</td>
</tr>
</tbody>
</table>
10.7.4 Comments

<table>
<thead>
<tr>
<th>Service Engineer</th>
<th>Customer's representative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
</tbody>
</table>
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 enclosure. Do not open the panel and 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 protective cover removed. 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 7.8.3.

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 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 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:

- 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\(^{(a)}\) 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.

- 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\(^{(a)}\) 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 \(\text{STOP}\). 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 main contactor 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.

Remark:

- \(^{(a)}\)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 53 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)

- 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 83 shows the error treatment procedure in flowchart format.
Figure 83: PQF error treatment procedure in flowchart format

Fault occurrence

- Store fault in event log
- Critical fault?
  - YES: Display 'ACK, FAULT' on PQF-Manager
  - NO: No action required

Critical fault?

- YES: Display 'ACK, FAULT' on PQF-Manager
- NO: No action required

Number of critical errors acceptable?

- YES: Filter stops awaiting automatic fault clearance (***)
  - Switch on alarm (after programmable delay)
  - Switch off 'Armed'-indicator and green LED (***)
  - Switch on red LED
- NO: No action required

Stop filter awaiting manual fault clearance (***)

- Switch on alarm (after programmable delay)
- Switch off 'Armed'-indicator and green LED (***)
- Switch on red LED

'Armed'-indicator on?

- YES: User acknowledges fault?
  - YES: Switch off 'Armed'-indicator
  - NO: Fault disappeared?
    - YES: Switch off alarm (after programmable delay)
    - NO: 'Armed'-indicator on?
      - YES: Filter remains stopped.
        - 'ACK, FAULT' changes in 'START'
      - NO: Filter restarts automatically.
        - 'ACK, FAULT' changes in 'STOP'
    - NO: Fault has cleared and filter has been stopped by the customer.
      - Filter to be restarted manually.
      - Customer has to do nothing.

Filter rides through fault.
Customer has to do nothing.

Filter has stopped.
Customer has to:
- Analyze and solve the problem.
- Acknowledge the fault.
- Restart the filter manually.

Filter waits for fault to clear automatically.
If this takes too long, customer has to analyze and solve the problem.

Remarks:

*** If the filter is not running, this step is omitted.
**** If the filter is running and the fault clearance happens fast, the main breaker is not opened otherwise it is opened.

Green LED is LED DL5 on the main controller board and is 'Armed'-indicator on PQF-Manager.
Red LED is LED DL6 on the main controller board.
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 4\textsuperscript{th} 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 54.

Table 54: Standard set of spare parts for normal and dedicated filter servicing

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Order code</th>
<th>Recommended quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spare fuses for auxiliary circuit</td>
<td>2GCA100465A0420</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Fan kit for units ≤ 60A</td>
<td>2GCA288044A0075</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Fan kit for units &gt; 60A</td>
<td>2GCA291064A0075</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>PQF-Manager filter controller</td>
<td>2GCA291950A0075</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>PQF control board</td>
<td>2GCA111393A0580</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Kit flat cable</td>
<td>2GCA291951A0075</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Power supply 24V 100W</td>
<td>2GCA109046A0530</td>
<td>1</td>
</tr>
</tbody>
</table>

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 of 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 57 and Table 58 for an overview of the possible messages and the corresponding troubleshooting tips. Note that for troubleshooting it may be necessary to remove the filter protective cover. Always remove power to the units and allow time for the DC capacitors to discharge (min. 25 mins) before removing the filter cover.

When the filter 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 14 (items 18 and 19) can be used to locate the main controller board LEDs.

Table 12 (items 18 and 19) explains the meaning of the LEDs and their status for normal operation.

**WARNING:** Only apply power to a filter without 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 ABB service provider when discussing a potential filter problem.

### 11.4.2 Fault tracing

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>No display on PQF-Manager. Fan(s) not running. All the indicator LEDs on the electronic cards (LEDs) remain OFF.</td>
<td>The active filter (auxiliaries) is/are not energized or no power supplied to the filter.</td>
<td>• Check if the protection (fuses, disconnector …) feeding the active filter are OK. • Check if the auxiliary fuse box is closed and the fuses are OK. • Check if the DC power supply fuse is OK. • Check the mains and auxiliary supply voltages.</td>
</tr>
<tr>
<td>No display on PQF-Manager. Fans are running. All the indicator LEDs on the electronic cards (LEDs) are functioning properly.</td>
<td>The filter is wired for operation at 400 V but is supplied with 230 V.</td>
<td>• Check that the filter is wired for 208-240 V operation. • Check the supply voltage to see that it is within the tolerance range of the nominal filter settings.</td>
</tr>
<tr>
<td>After applying the auxiliary power to the system, the filter fans do not run and the PQF-Manager cannot finish the boot process. The controller board LEDs are not functioning.</td>
<td>The 24 Vdc power supply feeding the controller boards has failed.</td>
<td>• Check the 24 V power supply feeding the control boards. • 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.</td>
</tr>
<tr>
<td>After applying auxiliary power to the system, the fan is running, the PQF-Manager shows the message ‘Initializing communication. Please wait… none of the LEDs of the main controller board is functioning.</td>
<td>No power supply to the main controller board or main controller board faulty.</td>
<td>• Check the 24 V power supply connection between the 24 V power supply and the main controller board.</td>
</tr>
</tbody>
</table>
### Table 56: Abnormal states of the controller board LEDs (after auxiliary power is applied to the system)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>The two green main controller board LEDs are blinking but the DSP controller LED (4) is blinking twice as slow as the µcontroller LED (1). The PQF-Manager shows ‘ACK. FAULT’ and gives error message ‘Bad parameters’.</td>
<td>The filter parameters entered by the commissioning engineer are not consistent with the filter configuration reported by the controllers.</td>
<td>• Check the commissioning parameters and correct where necessary. (Cf. Chapter 8).</td>
</tr>
</tbody>
</table>
| 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 57 to know what to do in order to solve the problem reported.  
• After resolving the problem, the fault has to be acknowledged and the filter has to be restarted 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 57 to know what to do in order to solve the problem reported.  
• After changing the main controller board, the filter has to be recommissioned. |

### Table 57: Fault messages reported by the DSP controllers of the filter and troubleshooting tips

<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad parameters</td>
<td>The filter parameters entered by the commissioning engineer are not consistent with the filter configuration reported by the controllers.</td>
<td>• Check the commissioning parameters and correct where necessary. (Cf. Chapter 8)</td>
</tr>
</tbody>
</table>
| Mismatch between units | In a multi-unit filter, incompatible units or incompatible unit settings are used.                               | • Ensure that all filters have the same rating.  
• Check that all units have the same setup for the connection method (hardware/software).  
• Recommission the units. |
<p>| Bad message sequence | Internal system error                                                                                           | • Contact your ABB service provider. Most likely the controller software has to be upgraded or the main controller card replaced. |</p>
<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad CT connection</td>
<td>The automatic CT detection procedure has encountered a problem during the CT identification process.</td>
<td>• 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 15000/5. • Set up the CTs manually (Cf. Section 8.6)</td>
</tr>
<tr>
<td>DC overvoltage (SW)</td>
<td>The DC software overvoltage protection has been triggered.</td>
<td>• 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.</td>
</tr>
<tr>
<td>DC Top overvoltage</td>
<td>The DC overvoltage protection of the capacitors in the positive stack has been triggered.</td>
<td>• Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors, as well as the Neutral voltage measurement connector (P6-4) and the Neutral conductor. • Check flat cable connections between the Control Board and the IGBT module. • Check integrity of the DC capacitor stack and the balancing/discharge resistors. • Analyze network voltage stability (amplitude and phase). • Disable reactive power compensation and balancing options to see if the problem persists.</td>
</tr>
<tr>
<td>Fault message</td>
<td>Cause</td>
<td>What to do</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| DC Bot overvoltage    | The DC overvoltage protection of the capacitors in the negative stack has been triggered. | • Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors, as well as the Neutral voltage measurement connector (P6-4) and the Neutral conductor.  
  • Check flat cable connections between the Control Board and the IGBT module.  
  • Check integrity of the DC capacitor stack and the balancing/discharge resistors.  
  • Analyze network voltage stability (amplitude and phase).  
  • Disable reactive power compensation and balancing options 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. |
| 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. |
<p>| Ground fault          | A ground fault has been detected.                                    | • Check the equipment for possible connections to earth.                                      |</p>
<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGBT check cooling</td>
<td>The software IGBT temperature protection has been triggered.</td>
<td>• Check the cooling of the filter system (fans and air flow, heatsink).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check the cooling of the location where the filter is installed (air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>conditioning system etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure that the correct derating factor is applied noting the ambient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>temperature and altitude.</td>
</tr>
<tr>
<td>IGBT permanent</td>
<td>The IGBT module reports an error that cannot be cleared by the system.</td>
<td>• Identify unit for which the red LED (3) is on.</td>
</tr>
<tr>
<td></td>
<td>This error can be due to peak overcurrent, too low control voltage</td>
<td>• Inspect the corresponding IGBT module (bridge and DC capacitors) for</td>
</tr>
<tr>
<td></td>
<td>for the IGBT drivers or IGBT module failure.</td>
<td>visual traces of damage. If they are present, exchange the IGBT module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Verify flat cable connection between the Control board and the IGBTs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure that the Control board power supply is around 24 V. If</td>
</tr>
<tr>
<td></td>
<td></td>
<td>significantly lower, check the 24 V power supply and the wiring between</td>
</tr>
<tr>
<td></td>
<td></td>
<td>this supply and the Control board.</td>
</tr>
<tr>
<td>IGBT temporary</td>
<td>The IGBT modules report a transient error that could be automatically</td>
<td>If the errors occur sporadically and the system rides through, nothing</td>
</tr>
<tr>
<td></td>
<td>cleared by the system. This error can be due to peak overcurrent or a</td>
<td>has to be done. If the system does not ride through (too many transient</td>
</tr>
<tr>
<td></td>
<td>too low control voltage for the IGBT drivers.</td>
<td>errors in a short time):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Verify that the filter CTs are properly installed and are not shorted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Verify that the unit current ratings and order programmed at the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>commissioning stage corresponds to the rating and order physically</td>
</tr>
<tr>
<td></td>
<td></td>
<td>present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Verify the filter cooling system and check the IGBT-temperature using</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the PQF-Manager.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Desactivate harmonic and reactive power requirements and see if the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>problem persists.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Inspect the items discussed for the ‘IGBT permanent’ message.</td>
</tr>
<tr>
<td>Fault message</td>
<td>Cause</td>
<td>What to do</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 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 PQF-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). |
| 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. |
<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
</table>
| Overvolt. Transient (SW) | The software transient network overvoltage protection has been triggered. | 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):  
   • 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 PQF-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. |
<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preload problem</td>
<td>The DC capacitors could not be preloaded at startup. The voltage increase on the DC capacitors during the preload phase is not high enough.</td>
<td>Measure the three line voltages and check if they are within limits. Verify the preload circuit and its resistor R06. 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.</td>
</tr>
<tr>
<td>Unbalanced supply</td>
<td>The supply network imbalance is out of range.</td>
<td>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 PQF-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.</td>
</tr>
<tr>
<td>Undervoltage RMS</td>
<td>The RMS value of the supply voltage measured with the AC voltage measurement board is lower than the acceptable maximum value.</td>
<td>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 PQF-Link). Ensure that the AC voltage is properly measured. Do the checks discussed for the ‘Loss of phase’ fault.</td>
</tr>
<tr>
<td>Unstable mains frequ.</td>
<td>The network frequency is varying too fast.</td>
<td>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.</td>
</tr>
<tr>
<td>Fault message</td>
<td>Cause</td>
<td>What to do</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Wrong phase rotation</td>
<td>The supply network feeding the filter has the wrong phase rotation.</td>
<td>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 PQF-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).</td>
</tr>
<tr>
<td>Mismatch between units</td>
<td>Different units in a filter system have different ratings or different connections (e.g. 3-wire and 4-wire).</td>
<td>Recommission the filters If recommissioning does not solve the problem, contact your ABB service provider.</td>
</tr>
</tbody>
</table>

Remark:
If the problem persists, contact your ABB 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 58: Fault messages reported by the µcontroller of the filter and troubleshooting tips

<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Com. Problem (RS-232)</td>
<td>Communication problem between the main controller board and the external PC</td>
<td>• Ensure that the PQF-Link cable is properly connected. • Contact your ABB service provider.</td>
</tr>
<tr>
<td>Ctrl overtemperature</td>
<td>The system detected an overtemperature of the main controller board.</td>
<td>• 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 ABB service provider. The main control board may have to be replaced.</td>
</tr>
<tr>
<td>DSP watchdog</td>
<td>Internal system error</td>
<td>• Reset the filter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced or the controller software upgraded.</td>
</tr>
<tr>
<td>• Flash memory corrupted • SPI Timeout • Power supply fault</td>
<td>Internal system error</td>
<td>• Reset the filter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced.</td>
</tr>
<tr>
<td>Fault message</td>
<td>Cause</td>
<td>What to do</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Preload time-out</td>
<td>The DC capacitors could not be charged.</td>
<td>• Measure the three line voltages and check if they are within limits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Verify the preload circuit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 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.</td>
</tr>
<tr>
<td>Several units same id</td>
<td>Two or more units in a filter system have the same CAN_ID.</td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reset the filter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced.</td>
</tr>
<tr>
<td>Com. Problem (CAN Bus)</td>
<td>The communication through the CAN bus between units is not working properly.</td>
<td>• Check the RJ-45 cables between modules.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Check the termination for the CAN bus: both (and only) extremity of the the bus must have the DIP switch S5-4 in the “set” status.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reset the filter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced.</td>
</tr>
<tr>
<td></td>
<td>Internal system error</td>
<td>• Reset the filter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced.</td>
</tr>
<tr>
<td></td>
<td>Different firmwares</td>
<td>• Upgrade all the units with the same (most recent) firmware.</td>
</tr>
<tr>
<td>Real time clock problem</td>
<td>• µC Watchdog fault</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Internal µC fault</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Corrupted DSP code</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Corrupted µC code</td>
<td></td>
</tr>
<tr>
<td>Different firmwares</td>
<td>Different units in a filter system have different firmware version (DSP or microcontroller)</td>
<td></td>
</tr>
</tbody>
</table>

Remark:

If the problem persists, contact your ABB 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>
<thead>
<tr>
<th>Symptom</th>
<th>Cause / State</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>The harmonic stress on the network is still too high.</td>
<td>• Install additional filter units to reduce the stress further.</td>
<td></td>
</tr>
<tr>
<td>The harmonic stress on the network is sufficiently low. The load requirement is only a fraction of the filter size.</td>
<td>• The filter can be kept running in this condition.</td>
<td></td>
</tr>
<tr>
<td>The filter is working at 100% of its nominal capacity because the load requirement is asking this.</td>
<td>• Check the CT installation (CT location, CT shorts, …)</td>
<td>• Check the connection between the CT terminal block X21 and the main controller terminals X4..X9.</td>
</tr>
<tr>
<td></td>
<td>• Measure the line currents (e.g. ammeter) and compare them with the line currents given by the filter (PQF-Manager or PQF-Link).</td>
<td></td>
</tr>
<tr>
<td>There is a problem in the CT connections or a hardware problem.</td>
<td>• 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.</td>
<td>• If the problem persists, contact your ABB service provider.</td>
</tr>
<tr>
<td>There is a software problem.</td>
<td>• Verify the reactive power settings of the filter.</td>
<td></td>
</tr>
<tr>
<td>The filter has been asked to generate static reactive power.</td>
<td>• Check the CT installation (CT location, CT shorts, …)</td>
<td>• Check the connection between the CT terminal block X21 and the main controller terminals X4..X9.</td>
</tr>
<tr>
<td></td>
<td>• Measure the line currents (e.g. ammeter) and compare them with the line currents given by the filter (PQF-Manager or PQF-Link).</td>
<td></td>
</tr>
<tr>
<td>Presence of (detuned) power capacitor banks or plain capacitors (LV or MV).</td>
<td>• Refer to Section 8.10 for precautions to take when plain capacitors are present in the network.</td>
<td></td>
</tr>
<tr>
<td>The filter is installed on a very weak network.</td>
<td>• Make sure that the filter is operating in Mode 3.</td>
<td>• If the problem persists, contact your ABB representative.</td>
</tr>
<tr>
<td>Two master units are fed from the same CTs. The setup guidelines for this installation setup have not been implemented.</td>
<td>• Select different harmonics on both filters.</td>
<td>• If the above is not possible, ensure that one filter is operating in Mode 1 and the other filter is operating in Mode 3.</td>
</tr>
<tr>
<td>Symptom</td>
<td>Cause / State</td>
<td>What to do</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>The filter is running with low load indication and the load harmonics are not filtered.</td>
<td>The harmonics are not selected, the curve setting is very high or the harmonics are put in 'filter-standby' by the system.</td>
<td>(Re)select the harmonics, check the curve levels and ensure that the correct settings are active (Main/Auxiliary)</td>
</tr>
<tr>
<td>The line currents measured by the filter via the CTs are lower than the real load currents.</td>
<td></td>
<td>Check the CT cabling for problems (CT-installation, CT-shorts, …) Check the CT settings set up in the PQF-Manager</td>
</tr>
<tr>
<td>The filter is in standby-mode, the IGBTs are not switching.</td>
<td></td>
<td>Check the standby mode settings to ensure that they represent realistic values.</td>
</tr>
<tr>
<td>The filter (CTs) is/are not installed in a central position and therefore the filter does not eliminate the harmonics of all the loads.</td>
<td></td>
<td>Check that the CTs are installed at the desired location.</td>
</tr>
<tr>
<td>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 harmonics selection list. The harmonic is not filtered.</td>
<td>The network conditions do not allow for the harmonic to be filtered at present or there is a CT-problem.</td>
<td>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.</td>
</tr>
<tr>
<td>The ‘ACK. FAULT’-message is present on the PQF-Manager. The alarm contact switches on after some delay.</td>
<td>The filter has stopped due to an error.</td>
<td>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 57 and Table 58 for more information on these errors and for guidelines on how to troubleshoot them.</td>
</tr>
</tbody>
</table>

Remark:
If the problems persist, contact your ABB 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.
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 and zero-sequence harmonics and reactive power compensation including balancing between phases.

*Table 60: Technical Specifications*

<table>
<thead>
<tr>
<th>Installation location</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor installation on firm foundation mounted in a clean environment</td>
<td></td>
</tr>
<tr>
<td>Altitude</td>
<td>Nominal output at 0 to 1000m (3300ft) above sea level (for derating refer to Table 13)</td>
</tr>
<tr>
<td>Minimum temperature</td>
<td>-10°C (23°F) non condensing</td>
</tr>
<tr>
<td>Maximum temperature</td>
<td>40°C (104°F) (for derating refer to Table 13)</td>
</tr>
<tr>
<td>Recommended maximum average temperature (over 24 h)</td>
<td>35°C (95°F)</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>Max. 95% non condensing</td>
</tr>
<tr>
<td>Contamination levels (IEC 60721-3-3)</td>
<td>Chemical class 3C2 (for more information refer to Table 13) Mechanical class 3S2 (for more information refer to Table 13)</td>
</tr>
<tr>
<td>Vibration (IEC 60068-2-6)</td>
<td>Max. 0.3mm (2-9Hz) Max. 1m/s² (9-200Hz)</td>
</tr>
<tr>
<td>Shock (IEC 60068-2-27)</td>
<td>Max. 40m/s² - 22ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filter installation information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of protection</td>
<td>IP30</td>
</tr>
<tr>
<td>Dimensions per power unit enclosure (appr.)</td>
<td>W x D x H: 585 x 310 x 700 mm</td>
</tr>
<tr>
<td>Weight per power unit enclosure (unpacked)</td>
<td>120 kgs</td>
</tr>
<tr>
<td>Color</td>
<td>RAL 7035 (light gray). Other colors on request.</td>
</tr>
<tr>
<td>Mechanical installation</td>
<td>Wall mounted (rail provided)</td>
</tr>
<tr>
<td>Cable entry method</td>
<td>Bottom cable entry</td>
</tr>
<tr>
<td>CT requirements</td>
<td>3 CTs are required (Class 1.0 or better) Filter burden: 5 VA 15 VA burden for up to 30 m of standard size cable 5 A secondary rating CTs must be installed in closed loop configuration</td>
</tr>
<tr>
<td>Airflow requirements</td>
<td>A minimum of 600 m³/h cooling air has to be supplied to each cubicle.</td>
</tr>
<tr>
<td><strong>Network characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Network voltage ratings</td>
<td>208 V-240 V or 380 V-415 V between phases</td>
</tr>
<tr>
<td>Network voltage tolerance</td>
<td>+/- 10%</td>
</tr>
<tr>
<td>Network frequency</td>
<td>50 Hz or 60 Hz</td>
</tr>
<tr>
<td>Network frequency tolerance</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>Maximum rate of frequency variation</td>
<td>20%/s</td>
</tr>
<tr>
<td>Maximum phase jump of network voltage</td>
<td>30°</td>
</tr>
<tr>
<td>Network voltage distortion</td>
<td>Maximum 20% phase to phase</td>
</tr>
<tr>
<td>Minimum network fault level</td>
<td>1 MVA</td>
</tr>
<tr>
<td>Voltage notch limits</td>
<td>No voltage notches allowed.</td>
</tr>
<tr>
<td>Line voltage imbalance</td>
<td>Maximum 5% of phase to phase voltage</td>
</tr>
<tr>
<td>Insulation voltage (Ui)</td>
<td>690V</td>
</tr>
<tr>
<td>Auxiliary circuit voltage</td>
<td>230 Vrms</td>
</tr>
<tr>
<td>Neutral connection systems (if any)</td>
<td>IT, TT, TNC and TNS. Earth current protection type and sensitivity must be chosen appropriately.</td>
</tr>
<tr>
<td>Environment class</td>
<td>2</td>
</tr>
</tbody>
</table>

**Compliance with standards**

- General construction aspects: EN-60439-1 (1999)
- EMC immunity: EN/IEC 61000-6-2
- 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
  - 3 times the current ratings limited to 270A

- **Neutral current ratings**

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.
<table>
<thead>
<tr>
<th>Modularity</th>
<th>Up to 4 power units/filter (power units must have same rating). One power unit per enclosure. Power units can be master or slave type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonics that can be filtered</td>
<td>15 harmonics individually selectable in the range 2(^{\text{nd}}) – 50(^{\text{th}}) harmonic order if the neutral is connected. 20 harmonics individually selectable in the range 2(^{\text{nd}}) – 50(^{\text{th}}) harmonic order if the neutral is not connected.</td>
</tr>
<tr>
<td>Degree of filtering</td>
<td>Programmable per harmonic in absolute terms</td>
</tr>
<tr>
<td>Filtering efficiency</td>
<td>Better than 97% of filter rating typically</td>
</tr>
<tr>
<td>Response time</td>
<td>40 ms typically (10% - 90% filtering)</td>
</tr>
<tr>
<td>Reactive power</td>
<td>Static/dynamic</td>
</tr>
<tr>
<td></td>
<td>Power factor programmable from 0.6 (inductive) to 0.6 (capacitive)</td>
</tr>
<tr>
<td>Load balancing</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>Phase to phase, phase to neutral (if neutral present), both (if neutral present)</td>
</tr>
<tr>
<td>Setting possibilities</td>
<td>Main and auxiliary settings functionality. Three possible filter modes that allow to set different priorities</td>
</tr>
<tr>
<td>Start and stop settings</td>
<td>Local/remote control functionality. Filter standby functionality. Auto restart after power outage functionality.</td>
</tr>
<tr>
<td>Digital inputs</td>
<td>2 multi purpose digital inputs on PQF-Manager.</td>
</tr>
<tr>
<td></td>
<td>Vlow: 0 Vdc, Vhigh: 15-24 Vdc, driving current: 13 mA@ 24Vdc (R\text{int} = 1.88 k\Omega).</td>
</tr>
<tr>
<td></td>
<td>Can be used to implement remote control functionality, start/stop buttons and switching between main and auxiliary settings.</td>
</tr>
<tr>
<td>Digital outputs</td>
<td>6 multi purpose (NO) digital outputs on PQF-Manager.</td>
</tr>
<tr>
<td></td>
<td>Maximum continuous ac rating: 440 Vac/1.5 A</td>
</tr>
<tr>
<td></td>
<td>Maximum continuous dc rating: 110 Vdc/0.3 A</td>
</tr>
<tr>
<td></td>
<td>Common rating: 9A/terminal, totaling 18 A</td>
</tr>
<tr>
<td></td>
<td>Can be used to monitor the filter state (e.g. filter on/off or specific filter warnings/alarms) and the network state.</td>
</tr>
<tr>
<td>Alarm contact</td>
<td>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</td>
</tr>
<tr>
<td>Filter losses (maximum values)</td>
<td></td>
</tr>
<tr>
<td>- Unit rating: 30 A</td>
<td>(\leq 1.5 \text{ kW})</td>
</tr>
<tr>
<td>- Unit rating: 45 A</td>
<td>(\leq 1.8 \text{ kW})</td>
</tr>
<tr>
<td>- Unit rating: 60 A</td>
<td>(\leq 2.1 \text{ kW})</td>
</tr>
<tr>
<td>Unit rating</td>
<td>Power Limit</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>70 A</td>
<td>≤ 2.6 kW</td>
</tr>
<tr>
<td>80 A</td>
<td>≤ 2.9 kW</td>
</tr>
<tr>
<td>90 A</td>
<td>≤ 3.2 kW</td>
</tr>
<tr>
<td>100 A</td>
<td>≤ 3.5 kW</td>
</tr>
</tbody>
</table>

**Noise intensity**

<table>
<thead>
<tr>
<th>Unit rating</th>
<th>Noise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 A</td>
<td>60 dBA typically</td>
</tr>
<tr>
<td>45 A</td>
<td>60 dBA typically</td>
</tr>
<tr>
<td>60 A</td>
<td>60 dBA typically</td>
</tr>
<tr>
<td>70 A</td>
<td>67 dBA typically</td>
</tr>
<tr>
<td>80 A</td>
<td>67 dBA typically</td>
</tr>
<tr>
<td>90 A</td>
<td>67 dBA typically</td>
</tr>
<tr>
<td>100 A</td>
<td>67 dBA typically</td>
</tr>
</tbody>
</table>

**Communication**

- Through PQF-Manager display.
- Through Modbus RTU (with optional adapter).
- Through RS-232 port with dedicated optional software (PQF-Link).

**Programming**

- Through PQF-Manager display.
- Through RS-232 port with dedicated optional software (PQF-Link).

**Fuse information**

- Main circuit fuses: Not included
- Auxiliary circuit fuses: French Ferrule 10 x 38 gG/gl, 6A, 500V, Isc ~120kA

**Options**

- PQF-Link software
- RS-485 Modbus adapter
- 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).
13 Contact information

ABB n.v.

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