INSTRUCTION MANUAL

Energy Storage Inverter ESI-S
Installation, operation and maintenance instructions
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11.4.2 Fault tracing

12 Technical specifications

12.1 What this chapter contains

12.2 Technical specifications
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 ESI-S inverter 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 inverters of the ESI range with ESI-Manager software the following versions or higher.

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

The ratings in the present manual are given in kVA based on a 400V network and are given also in Amps. The current ratings are not changing with the network voltage.

1.4 Configuration of the Energy Storage System

The ESI has been designed to work together with a master controller that is managing the complete system. The master controller is taking care of the communication to the Battery Management System, to the ESI and to the user. The Battery Management System (BMS) is the device ensuring that the battery is used in such a way that the battery is not damaged.

If a direct communication to the BMS is required, please contact your ABB service provider.
1.5 Definition of main functionalities related to energy storage

The use of these functionalities is described in Chapter 9.

- **Islanding**: the islanding mode is a network configuration where some loads and generation devices are disconnected from the main grid and working independently. In this configuration, the Energy Storage System (ESS) is acting as the voltage reference for the complete island. In order to use this feature, an UPS is required, information is given in Chapter 6.

- **Loads**:
  - Three-phase
  - Single-phase

- **Generation**:
  - Wind turbines
  - Solar panels

We distinguish two types of islanding:

- **Intentional**: The BESS receives the order from the main controller/user to disconnect itself (and the loads) from the grid. The system reconnects the island to the grid when it receives the signal from the main controller.

- **Unintentional**: the BESS detects that there is a voltage outage and stops.

- **Black-start (optional)**: this feature allows the ESS to start when the grid is not present. In this case also an UPS is required.

- **Low Voltage Ride Through (LVRT)**: It is required in case of LVRT to remain connected to the grid and to support if possible the fault in order to clear it as fast as possible. In order to use this feature, a UPS is
required. The curve that is followed by the ESI is shown below. A complete description is given in Chapter 9.

Figure 2 LVRT description

- 3ph individual power control (optional):

Once this feature is activated, the inverter is able to receive 6 different power targets. Each phase receives its own active and reactive power targets independently from the 2 other phases. However, this configuration is available only in 4W mode.

1.6 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 ESI-Manager user interface
- Chapter 8: Commissioning instructions
- Chapter 9: Operating instructions
- Chapter 10: Maintenance instructions
- Chapter 11: Troubleshooting guide
- Chapter 12: Technical specifications
2 Safety Instructions

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

After switching off the supply to the ESI-S, always wait for 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 properly connected before applying power to the inverter.

WARNING: There are AC capacitors & DC capacitors connected inside this inverter. Before performing any maintenance work, please short and ground the three line terminals. The DC capacitor needs 25 mins to discharge after disconnection. Please wait for this duration before touching any live parts, even after discharging the AC capacitors, to avoid electrical shock. Never discharge DC capacitors through short circuit. Always use a current limiting resistor of minimum 100Ω.

WARNING: To avoid electrical shock due to residual voltage on the capacitors, the left side cover of the inverter should not be removed once the system is commissioned.
WARNING: If the ground is not done properly, under certain fault conditions in the unit or in the system to which it is connected it can result in full line voltage between chassis and earth ground. Severe injury or death can result if the chassis and earth ground are touched simultaneously.

WARNING: The neutral current in an ESI-S inverter may be as high as 3 times the line current hence do not use a 4 pole breaker to connect this type of inverter 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 ESI-S inverter.

3.2 Delivery inspection
Each ESI-S 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 inverter panels).

3.3 Unpacking instructions

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

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

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

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

Note: you will also receive a separate box containing AC and DC protection devices which should be installed as per instructions provided elsewhere in this document.

3.4 Lifting and transportation guidelines
Please note that inverter equipment weighs approximately 130 kilograms. Care should be taken to ensure that correct handling facilities are used.

In order to transport the equipment use a forklift or similar equipment. ESI-S 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><strong>Temperature</strong></td>
</tr>
<tr>
<td><strong>Relative humidity</strong></td>
</tr>
<tr>
<td><strong>Contamination levels</strong></td>
</tr>
<tr>
<td>(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 3).
- Remove the 4 panel securing screws at the bottom and the top of the enclosure (see Figure 4)

![Figure 4: Locating the 4 panel securing screws](image)

- Remove first the right side of the protective cover and put it aside (see Figure 5).

![Figure 5: Lifting the right protective cover and putting it aside](image)
- Unplug the ESI-Manager from the main system (see Figure 6). Then the protective cover can be safely put aside.

![Unplugging the ESI-Manager from the main system](image)

*Figure 6: Unplugging the ESI-Manager from the main system*

- Remove the two screws fixing the inverter unit to the wooden support (see Figure 7).

![Position of the inverter fixation screws that need to be removed](image)

*Figure 7: Position of the inverter fixation screws that need to be removed*

- Fix the two eyebolts provided with the inverter (see Figure 8).

![Fix the eyebolts before lifting the ESI-S](image)

*Figure 8: Fix the eyebolts before lifting the ESI-S*
- Fix an appropriate lifting device to the eyebolts to lift the inverter from the wooden support. It can then be positioned at the desired location (see Figure 9).

![Figure 9: Lifting an ESI-S unit by using the lifting lugs](image)

### 3.5 Identification tag

Each ESI-S is fitted with nameplates for identification purposes.

The inverter nameplate is located at the top left of the master panel door, at the outside.

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

### 3.6 Storage

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

<table>
<thead>
<tr>
<th>Storage (in the protected package)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
</tr>
<tr>
<td><strong>Relative humidity</strong></td>
</tr>
<tr>
<td><strong>Contamination levels</strong></td>
</tr>
<tr>
<td>(IEC 60721-3-3)</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 ESI-S system and discusses its main components.

4.2 Typical ESI-S inverter panel layout

The ESI-S inverter is basically composed of two parts (Figure 10):

- An inverter controller that is receiving the system information and adapt the current or voltage output based on them. For some features that are described in Chapter 6, measurement of the line currents (network current) through current transformers (CT’s) are required. The CT’s are provided by the customer. The CTs must be connected upstream of the connection point of the inverter and the loads. The user enters his requirements by means of the ESI-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/voltage generator (power unit) that converts the control signals generated by the inverter controller into the inverter current or voltage. The current/voltage generator is connected in parallel with the load(s). Up to four power units may be connected in parallel in one f inverter system. The enclosure(s) containing the inverter GUI controller are referred to as master units. The other enclosures are referred to as the slave units. In an ESI-S system more than one master unit can be present for redundancy purpose.

Figure 10: ESI-S schematic overview with user connections
The user connection description is given in Table 3.

<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>Not 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>PQF-Link – Modbus RTU – Modbus TCP communication connection</td>
<td>Not mandatory</td>
</tr>
<tr>
<td>6</td>
<td>Earth connections from the enclosure to installation earth</td>
<td>Mandatory</td>
</tr>
<tr>
<td>7</td>
<td>Battery connection</td>
<td>Mandatory</td>
</tr>
<tr>
<td>8</td>
<td>Voltage measurement</td>
<td>Not mandatory</td>
</tr>
</tbody>
</table>

Mandatory connections are connections that must be present to make the inverter operational. Connections that are not mandatory can be made to enhance the inverter’s basic functionality.

For more information on cabling the user connections, please refer to Chapter 6.

Figure 11 shows a typical ESI-S master inverter panel.

The input/output connections and protection description is given in Table 4.

<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>
</tbody>
</table>
3 Auxiliary fuse protection

4 ESI-Manager user interface with connection terminals for user I/O (e.g. alarm contact) and communication interfaces

5 Neutral connection

6 Battery connection

Up to 8 ESI-S master panels can be connected in parallel providing full redundancy to the customer.

In addition to using master panels only, ESI-S units can be connected in a master-slave arrangement.

4.3 The ESI current/voltage generator hardware

The power circuit of an ESI-S unit is represented hereafter.

![Power circuit diagram of an ESI-S inverter](image)

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 inverter</td>
</tr>
</tbody>
</table>

Figure 12: Power circuit diagram of an ESI-S inverter

Table 5: Main components of an ESI-S inverter
The current generator is physically organized in power units. Each unit enclosure contains one power unit. An ESI-S inverter 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 must be of the same rating.** Please refer to Chapter 12 for more information on the possible unit ratings.

In Figure 12 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 controller is sent to the IGBTs through one flat cable. At the output of the inverter a voltage waveform is generated which contains the desired spectral components (imposed by the inverter 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 inverter (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).

The battery is connected (9) on the DC capacitors (4) of the inverter. The preload of these DC capacitors is done thanks to the grid. This avoid inrush current coming from the battery.

All units contain a DC capacitors preloading resistor (5) which charges the DC capacitors up to the peak AC voltage once the auxiliary fuse box of the unit(s) is closed. This approach ensures a smooth inverter start-up without excessive inrush currents from the grid. Later in the start-up sequence the IGBT switching pattern will charge more the DC capacitors in order to reach the battery voltage and ensure a connection to the battery without inrush currents.

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

If a master-master configuration of inverter is chosen, all power units incorporate an ESI-Manager display. If a master-slave configuration of inverter is chosen, only the master enclosure contains an ESI-Manager display.

### 4.4 The ESI main controller

The ESI main controller controls the complete inverter 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 user requirements and line current measurements;
- Interfacing to the IGBT-inverters;
- The measurement of system voltages and currents for control, protection and presentation purposes.

Figure 13 depicts the controller interface diagram of the ESI-S inverter.

When the inverter consists of a master unit only, the customer has to:
- Wire the CT signals (on a designated terminal) if required,
- Connect the AC power lines (with or without neutral),
- Connect the DC power line,
- Connect the control of the DC contactor
- Connect the voltage measurement and islanding contactor control if required
- Set up the installation parameters and user’s requirements with the ESI-Manager.

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

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

All units have their own AC-connection and main contactor protection.
All units have their own DC connection and DC contactor.
An ESI-S inverter 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 an ESI-Manager.

### 4.5 The ESI-Manager user interface

All user interaction with the inverter is channeled through the ESI-Manager.

In multi-unit system consisting of only one master, only the master has an ESI-Manager.

In multi-unit system consisting of more than one master, all the master units have an ESI-Manager. However, only the ESI-Manager that is connected to the master unit which has the overall control will be active. The ESI-Manager installed on the units operating as "slaves" are capable of displaying the relevant information about that specific unit only. Certain parameters which are specific to that unit (e.g. related to temperature probes) can be set or changed locally using the ESI-Manager installed on that unit. The ESI-Manager on the master unit has a "unit selection" button which allows the user to select the unit number which he wants to consult. The data then displayed on the master ESI-Manager is specific to that particular unit number. This unit selection button is "deactivated" on the slave Managers. Figure 14 shows the front side of the ESI-Manager.

![Figure 14: Front side of the ESI-Manager](image)

Five main parts can be distinguished (see Table 6)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Menu display</td>
</tr>
<tr>
<td></td>
<td>By navigating through the menus with the , , , and buttons, the inverter can be set-up and controlled. On-line help is available by pressing the button.</td>
</tr>
<tr>
<td>2</td>
<td>Master/ slaves units monitor</td>
</tr>
</tbody>
</table>
When the ESI-Manager closes one of its output relays, the corresponding symbol lights up. The digital outputs of the ESI-Manager are discussed later in this section.

The ESI-Manager also acts as connection point for external user I/O communication. Connections are made at the rear side of the ESI-Manager. **Figure 15** depicts the terminals that are present on the ESI-Manager rear side.

![Figure 15: ESI-Manager rear side terminal designation](image)

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 input 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) and fan outputs</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 ESI-Manager connector)</td>
</tr>
<tr>
<td>7</td>
<td>Power supply terminals (routed to ESI-Manager connector)</td>
</tr>
<tr>
<td>8</td>
<td>Ethernet</td>
</tr>
<tr>
<td>9</td>
<td>USB</td>
</tr>
<tr>
<td>10</td>
<td>Temperature probes</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 inverter settings or auxiliary inverter settings (e.g. different inverter settings for the day and for the night).

The ESI-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 inverter may behave erratically.

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

- $V_{\text{low}}$: 0 Vdc
- $V_{\text{high}}$: 15-24 Vdc
- Driving current: 13 mA @ 24 Vdc ($R_{\text{int}} = 1.88 \, \text{k} \Omega$)

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 ESI-Manager for the input considered, the inverter may behave differently. **Table 8** below gives an overview of the possible settings and the resulting inverter behavior.

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

<table>
<thead>
<tr>
<th>Function</th>
<th>$V_{\text{low}}$ applied to digital input</th>
<th>$V_{\text{high}}$ applied to digital input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote control</td>
<td>inverter off</td>
<td>inverter on</td>
</tr>
<tr>
<td><em>ESI-Manager setup for digital input: Remote ON</em> (a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection of main/auxiliary settings</td>
<td>Auxiliary settings are used</td>
<td>Main settings are used</td>
</tr>
<tr>
<td><em>ESI-Manager setup for digital input: Activ. Main</em> (a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection of main/auxiliary settings</td>
<td>Main settings are used</td>
<td>Auxiliary settings are used</td>
</tr>
</tbody>
</table>
Digital Outputs 1 to 6

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

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

<table>
<thead>
<tr>
<th>ESI-Manager setting for digital output(^{(a)})</th>
<th>Output relay closes when...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxil. ON</td>
<td>The auxiliary power is present in the main inverter enclosure and the main controller is communicating with the ESI-Manager</td>
</tr>
<tr>
<td>ESI running</td>
<td>The inverter is ‘on’ (IGBTs switching) or in ‘standby’ (main contactor closed but IGBTs not switching)</td>
</tr>
<tr>
<td>Full load</td>
<td>The inverter is running under full load condition</td>
</tr>
</tbody>
</table>

Notes:

\(^{(a)}\): In order for this function to be activated, the ESI-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 inverter 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 inverter 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 6.14.

Information on setting up the digital inputs with the ESI-Manager is given in Section 7.9.2.4.

By default, the digital inputs are disabled.

In a master-master inverter 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 inverter system.
24  Hardware description

- **Armed**: The inverter is ON or is in the startup procedure, or it is stopped in fault condition but will restart as soon as the fault has disappeared

- **T limit**: The inverter temperature limit has been reached and the inverter is derating itself to run at a safe temperature

- **In standby**: The inverter is in standby

- **Activ. Main**: The main inverter settings are activated

- **Activ. Aux**: The auxiliary inverter settings are activated

- **Unit miss.**: One of the units in a multi-unit arrangement is not available (e.g. due to a permanent error), or has not yet been commissioned.

- **Pg. alarm 1**: The programmable alarm 1 is activated

- **Pg. alarm 2**: The programmable alarm 2 is activated

- **Pg. alarm 3**: The programmable alarm 3 is activated

- **Warning 1**: The programmable warning 1 is activated

- **Warning 2**: The programmable warning 2 is activated

- **Warning 3**: The programmable warning 3 is activated

- **Battery charging**: The battery is currently charging

- **Connected to grid**: The ESS is connected to grid i.e. not in islanding

**Remarks:**

- In order to set up this function, navigate to [/Welcome/ Settings/ Customer set./ Digital Outputs]

- More information on the standby function is given in Section 7.9.4.1

- Different programmable warnings and alarms can be defined. More information on this subject is given in Section 7.9.2.4.1

Further it should be noted that:

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

- In a master-master inverter 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 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>ESI running</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>
</tbody>
</table>
- The customer can change the default output settings by means of the ESI-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 6.14.
Information on setting up the digital outputs with the ESI-Manager is given in Section 7.9.2.4.3

3 Alarm outputs and fan outputs

Apart from the digital outputs, one potential free relay with a NO and a NC alarm output is available. This relay contact is activated if any error condition is present during a preset time. The relay contact is deactivated if the error condition has disappeared for another preset time. Information on changing the alarm activation/deactivation time is given in Section 7.9.2.4.1.

In a master-master 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 system.

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

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

4 Lock switch

Allows locking the settings of the inverter panel. This switch is documented in Section 7.9.4.5

5 Modbus RTU adapter interface (optional) connection

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

6 CAN bus connection interface

The ESI-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 ESI-Manager connection plug and is subsequently routed to the main control (Cf. Section 4.6.1). It is used for ESI internal communications only.

7 Power supply terminals

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

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

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

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

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

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

4.6 Location of the main ESI-S components

4.6.1 Energy storage inverter components

Figure 16 shows a picture of the ESI-S without cover panel.
The component identification is given in Table 11.

### Table 11: ESI-S 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</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</td>
<td>X21</td>
</tr>
<tr>
<td>5</td>
<td>Preload circuit rESI-Stors</td>
<td>R1, R2</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>ESI 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>PCB EMC neutral</td>
<td>A003</td>
</tr>
<tr>
<td>11</td>
<td>PCB EMC line</td>
<td>A002</td>
</tr>
<tr>
<td>12</td>
<td>PCB output inverter preload</td>
<td>A001</td>
</tr>
<tr>
<td>13</td>
<td>Main power supply terminals (phases) (underneath controller boards)</td>
<td>L1, L2, L3</td>
</tr>
<tr>
<td>14</td>
<td>Main power supply neutral connection (not mandatory) (underneath controller boards)</td>
<td>N</td>
</tr>
<tr>
<td>15</td>
<td>Auxiliary transformer</td>
<td>T001</td>
</tr>
<tr>
<td>16</td>
<td>Fuse preload circuit</td>
<td>PF1, PF2</td>
</tr>
<tr>
<td>17</td>
<td>Measurement board (DC current and AC voltages)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>DC power connection (underneath controller boards)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>DC current measurement</td>
<td></td>
</tr>
</tbody>
</table>
The ESI-S inverters are provided with the preload circuit and the output inverter mounted on a PCB. This design substantially reduces the time needed for replacement of the same. It also gives a more robust design compared to the previous generation of inverters. The power supply to the exhaust fan at the top of the inverter are connected to the terminal block shown which make the replacement of the same easy during periodic maintenance.

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

The preload circuit is shown in Figure 17.

![Figure 17 Preload circuit main components](image)

The component identification is given in Table 12.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Circuit diagram designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuse preload circuit</td>
<td>PF1</td>
</tr>
<tr>
<td>2</td>
<td>Fuse preload circuit</td>
<td>PF2</td>
</tr>
<tr>
<td>3</td>
<td>Preload circuit resistors</td>
<td>R1</td>
</tr>
<tr>
<td>4</td>
<td>Preload circuit resistors</td>
<td>R2</td>
</tr>
<tr>
<td>5</td>
<td>Capacitors</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Terminal block for top fans</td>
<td>P3</td>
</tr>
</tbody>
</table>

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

The main controller board is shown in Figure 18.
The designation of the principal terminals is given in Table 13.
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Circuit diagram designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>System connector: 24 V power supply to control board</td>
<td>P2</td>
</tr>
<tr>
<td>2</td>
<td>CAN bus connection from previous inverter unit</td>
<td>P20</td>
</tr>
<tr>
<td>3</td>
<td>CAN bus connection to next inverter unit</td>
<td>P21</td>
</tr>
<tr>
<td>4</td>
<td>System connector: Power supply and CAN communication to ESI-Manager</td>
<td>P4</td>
</tr>
<tr>
<td>5</td>
<td>System connector: 230 V power supply to control board</td>
<td>P3</td>
</tr>
<tr>
<td>6</td>
<td>System connector: Spare</td>
<td>P19</td>
</tr>
<tr>
<td>7</td>
<td>System connector: Main contactor control</td>
<td>P18</td>
</tr>
<tr>
<td>8</td>
<td>System connector: Spare</td>
<td>P17</td>
</tr>
<tr>
<td>9</td>
<td>System connector: Fan control</td>
<td>P16</td>
</tr>
<tr>
<td>10</td>
<td>System connector: Monitoring temperature of PWM and Line reactors</td>
<td>P25</td>
</tr>
<tr>
<td>11</td>
<td>System connector: Spare</td>
<td>P7</td>
</tr>
<tr>
<td>12</td>
<td>System connector: Coming from CT terminal X21 (internal)</td>
<td>P5</td>
</tr>
<tr>
<td>13</td>
<td>System connector: Supply and DC link voltage measurement</td>
<td>P6</td>
</tr>
<tr>
<td>14-15-16</td>
<td>System connectors: Spare</td>
<td>P9, P10, P11</td>
</tr>
<tr>
<td>17</td>
<td>System connector: control of IGBT-module</td>
<td>P12</td>
</tr>
<tr>
<td>18</td>
<td>Voltage selector DIP-switch : Not used in ESI-S (single voltage)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>System LED’s (top to bottom)</td>
<td></td>
</tr>
<tr>
<td>LED 3: ON: Critical error in inverter unit considered (red LED)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 3: OFF: No critical error in inverter unit considered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 2: ON: ESI unit running or in startup process (Armed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 2: OFF: ESI unit off and not in startup process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 1: Blinking at regular interval (1 s): Microcontroller running properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 1: ON, OFF or blinking irregularly: Microcontroller not running properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>System LED’s (top to bottom)</td>
<td></td>
</tr>
<tr>
<td>LED 5: ON: Inverter unit is acting as the master of the complete system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 5: OFF: Inverter unit is acting as a slave in the inverter system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 4: Blinking at regular interval (1 s): DSP processor running properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED 4: ON, OFF or blinking irregularly: DSP processor not running properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>PQF-Link communication opto-isolated serial link connector</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Inverter unit address selector (3 Left most DIP switches) and CAN bus termination (Right hand DIP switch): Symbols used: L: low – H: high</td>
<td></td>
</tr>
</tbody>
</table>
Address 1: Position of the 3 switches starting from left: L L L
Address 2: Position of the 3 switches starting from left: H L L
Address 3: Position of the 3 switches starting from left: L H L
Address 4: Position of the 3 switches starting from left: H H L
Address 5: Position of the 3 switches starting from left: L L H
Address 6: Position of the 3 switches starting from left: H L H
Address 7: Position of the 3 switches starting from left: L H H
Address 8: Position of the 3 switches starting from left: H H H

Note: In a multi-master arrangement, the master is the unit which is operational and which has the lowest address controls the system.
The default address setting is L L L

CAN bus termination (Right hand DIP switch):
Must be High (H) for the units that are at the extremity of the CAN bus (maximum 2 units in a multi-unit inverters, typically the first one and the last one of the chain). This setting is also applicable to single-unit inverters.
Must be Low (L) for units in the middle of a chain.
The default factory setting is H.

Remarks:
(a) For physical locations of customer CT connection terminals, please refer to Figure 16 item 4.

Table 14: ESI measurement board description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Circuit diagram designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>230V supply of the power supply</td>
<td>P1</td>
</tr>
<tr>
<td>2</td>
<td>Flat cable to Cobo board</td>
<td>FC</td>
</tr>
<tr>
<td>3</td>
<td>15V Power supply</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Voltage measurements (AC and DC)</td>
<td>P4 &amp; P5</td>
</tr>
<tr>
<td>5</td>
<td>Current measurement</td>
<td>P3</td>
</tr>
</tbody>
</table>

4.6.2 ESI inverter cover components
An ESI-S master panel cover (right hand side) contains the ESI-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 about the mechanical design and for the installation of the inverter system.

In case you have a problem, please notify it to our service support mail box: jumet.services@be.abb.com.

5.2 Installation location requirements

The ESI-S 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 15: Ambient operating conditions for ESI-S operation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Altitude</strong></td>
</tr>
<tr>
<td><strong>Minimum temperature</strong></td>
</tr>
<tr>
<td><strong>Maximum temperature</strong></td>
</tr>
<tr>
<td><strong>Maximum average temperature (over 24 h)</strong></td>
</tr>
<tr>
<td><strong>Relative humidity</strong></td>
</tr>
<tr>
<td><strong>Contamination levels</strong></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 inverter 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 inverter is installed in a room where no conductive dust is present.
5.3 Standard enclosure dimensions and clearances

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

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

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

Figure 20 shows a view of a typical ESI-S with characteristic dimensions.

Figure 20: View of a typical ESI-S with characteristic dimensions

If an inverter system consists of more than one 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 21.
5.4 Instructions for mounting the inverter

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

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

- Unpack the inverter as per Section 3.3
- Set the 2 eyebolts on the top of the cubicle. They will be used to lift the inverter properly.
- Pull out the 2 fixation plates (Figure 22)
- 2 bolts M8 are needed to install the inverter on the wall (Figure 23). Use a spirit level to ensure horizontal fixation.
Carefully lift the enclosure and slide it down over the 2 fixation bolts until it is supported by the 2 fixation plates. Screw the 2 bolts to ensure a good fixation of the inverter. Then the lifting tool can be disengaged.

- By means of a lower end fixation screw (not provided) the enclosure can be pushed against the rear support at the bottom also (see Figure 24).

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

## 5.5 Inverter noise level

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

### Table 16: Noise level

<table>
<thead>
<tr>
<th>Unit rating</th>
<th>Power rating (kVA)</th>
<th>Noise (dBA) at one meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>30A - 60A</td>
<td>20-40</td>
<td>65.3 typically</td>
</tr>
<tr>
<td>70A - 100A</td>
<td>50-70</td>
<td>68.4 typically</td>
</tr>
<tr>
<td>120A</td>
<td>85</td>
<td>70.9 typically</td>
</tr>
</tbody>
</table>
5.6 Airflow and cooling requirements

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

Each ESI-S 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 17 gives the airflow requirements for different unit ratings.

Table 17: Airflow requirement

<table>
<thead>
<tr>
<th>Unit rating</th>
<th>Power rating (kVA)</th>
<th>Airflow requirement (m³/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30A - 60A</td>
<td>20-40</td>
<td>520 m³/h</td>
</tr>
<tr>
<td>70A - 100A</td>
<td>50-70</td>
<td>520 m³/h</td>
</tr>
<tr>
<td>120A</td>
<td>85</td>
<td>710 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 25 shows the cooling air flow diagram for a single unit ESI-S.

When the natural cooling capacity at the location where the inverter is installed is not sufficient, air conditioning systems have to be installed to the room. In the design of the air conditioning systems, the inverter heat losses have to be taken into account. Table 18 gives an overview of the ESI-S heat losses for the different power units. For multi-unit inverters, the values of Table 18 have to be multiplied by the number of units.
### Table 18: Inverter unit heat losses (maximum values)

<table>
<thead>
<tr>
<th>Unit rating (Arms)</th>
<th>Power rating (kVA)</th>
<th>Heat loss (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>20</td>
<td>1.5</td>
</tr>
<tr>
<td>45</td>
<td>30</td>
<td>1.7</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>2.1</td>
</tr>
<tr>
<td>70</td>
<td>50</td>
<td>2.4</td>
</tr>
<tr>
<td>80</td>
<td>55</td>
<td>2.7</td>
</tr>
<tr>
<td>90</td>
<td>60</td>
<td>3.0</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
<td>3.2</td>
</tr>
<tr>
<td>120</td>
<td>85</td>
<td>3.7</td>
</tr>
</tbody>
</table>

#### 5.7 Instructions for mounting the ESI-Manager in enclosures

The ESI-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 26).

![Figure 26: Mechanical installation of the ESI-Manager](image)

**Figure 26: Mechanical installation of the ESI-Manager**

Step 1: Slide the ESI-Manager (a) perpendicularly to the Capacitor Bank Cubicle (b).
Step 2: Rotate the ESI-Manager to insert it into the Capacitor Bank Cubicle.
Note: cut out dimensions are 138 x 138 mm.
Step 3: Insert the Mounting Bracket (c) in the corresponding Fixation Holes (d) of the ESI-Manager.
Step 4: Pull the Mounting Bracket backwards.
Step 5: Turn the Screw (e) into the Mounting Bracket and tighten until the ESI-Manager is secured in place.

Once the ESI-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 ESI-S successfully in an electrical installation. It also gives electrical connection examples for popular energy storage features.

WARNING: The ESI-S 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 ESI-S should not be connected to systems for which it is known that over voltages will be sustained indefinitely. Excessive voltage levels may lead to inverter damage.

WARNING: The ESI-S is not designed to be connected to systems where one phase serves as neutral. Connection of an ESI-S to such a system is only authorized after explicit approval by ABB.

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

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

Basic 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 contactor.
- DC power cables to the Battery
- 3 CTs (one per phase, to be connected to each unit in a system through a daisy chain method with return path)

More advanced features (e.g. external monitoring of the inverter status, islanding, black start…) require some more connections. The connections for these advanced features have to be made on the ESI-Manager and on the network.
WARNING: Ensure that the unit supply is isolated upstream during ESI-S 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 ESI-S units are automatically charged once the auxiliary circuit is energized, regardless of whether the inverter is switched off or on. Do not touch the DC capacitor link when the auxiliary fuse box is closed.

The inverter control board carries dangerous voltages and shall not be touched once the auxiliary circuit is energized, regardless of whether the unit 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 ESI-Manager to a inverter system

ESI-S master units are by default equipped with the ESI-Manager user interface. In some cases however it may be needed to remove and reconnect the ESI-Manager to the control board of the ESI-S.

In order to successfully connect the ESI-Manager to an ESI-S inverter unit, it suffices to plug the male connector attached to the ESI-Manager into the corresponding female connector attached to the inverter hardware. This is illustrated in Figure 27.

![Figure 27: Connection of the ESI-Manager user interface to the ESI-S hardware](image)

The female connector associated with the ESI-S hardware is situated at the top right side of the control board and becomes visible after removing/lifting slightly the inverter 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 inverter assembly. Applying other methods may damage the unit.

Every inverter has been tested for insulation between the main circuit and the chassis/frame at the factory. Therefore, do not make any voltage 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 inverter between the Protective Earth (PE) and all 3 phases shorted together, with main contactor shorted. The auxiliary fuse box may remain closed, but it is mandatory to disconnect P2 (24V supply), P3 (230Vac in), P4 (ESI-Manager if master), P12 (IGBT) and P20-P21 (to other units) from the main control board (see Table 13).

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

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

6.4 EMC considerations

The inverter 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 ESI-S plate has one marked earth points (PE). The earth point is situated at the bottom right side of the inverter plate (Figure 28).

![Earth point (PE)](image)

Figure 28: Identification of the earth point on the ESI-S hardware

For safety reasons and for proper operation of the inverter 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 inverter must be connected to the installation’s earth (PE) and not to the N-conductor.

Further, the following rules should be respected:
- When the ESI-S consists of only one enclosure, the enclosure's PE-point must be connected directly to the installation's PE-point.
- When the ESI-S consists of more than one enclosure, each enclosure's PE-point must be connected directly to the installation's PE-point. Additionally, all cubicles' secondary PE-points must be interconnected. This is illustrated in Figure 29. The interconnection cable should be minimum 16 mm².

![Diagram of Earth connection guidelines for a multi-unit ESI-S](image)

**Figure 29: Earth connection guidelines for a multi-unit ESI-S**

### 6.6 Selection of the power cable size

Several types of power cable can be used to connect the inverter to the network. Local regulations and habits often determine the user’s choice. Note however that due to the high frequency output inverter of the ESI, there is no radiated emission through the feeding cables. Consequently, there is no need for special screening of the inverter connection cables.

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

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 inverter 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 $A \text{ mm}^2$, the section through which the current flows is only $X \times A \text{ m}^2$ (with $X < 1$). In order to compensate for this “loss of section”, the cable has to be oversized such that the total equivalent section through which the current flows taking into account the skin effect is acceptable.

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

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

Step 2: Using the cable section $A$, the cable material and the network frequency as entry points in Table 19, determine the multiplication factor $X$. For the DC current, the multiplication factor $X$ is equal to 1.

Table 19: Multiplication factors $X$ for different cable sections

<table>
<thead>
<tr>
<th>Cable section $[\text{mm}^2]$</th>
<th>Network frequency 50Hz Al-cable</th>
<th>Network frequency 50Hz Cu-cable</th>
<th>Network frequency 60Hz Al-cable</th>
<th>Network frequency 60Hz Cu-cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
<td>1.01</td>
<td>1.00</td>
<td>1.01</td>
</tr>
<tr>
<td>35</td>
<td>1.01</td>
<td>1.01</td>
<td>1.01</td>
<td>1.02</td>
</tr>
<tr>
<td>50</td>
<td>1.01</td>
<td>1.03</td>
<td>1.02</td>
<td>1.04</td>
</tr>
<tr>
<td>70</td>
<td>1.02</td>
<td>1.05</td>
<td>1.03</td>
<td>1.06</td>
</tr>
<tr>
<td>95</td>
<td>1.04</td>
<td>1.08</td>
<td>1.05</td>
<td>1.10</td>
</tr>
<tr>
<td>120</td>
<td>1.05</td>
<td>1.11</td>
<td>1.07</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Step 3: Determine in a conventional way the cable section $A_2 (\text{mm}^2)$ for the current rating found by multiplying $I_{\text{rms}}$ 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:
ESI-S 60 A/50Hz, 3-wire connection, cable material: Cu (copper)

Step 1: \( I_{IN} = 60 \text{A} \) ⇒ cable section = 16 [mm\(^2\)]
Step 2: multiplication factor for a 16 [mm\(^2\)] copper cable at 50 Hz = 1.00
Step 3: \( I = I_{IN} \times 1.00 = 60 \text{A} \times 1.00 = 60 \text{ A} \)
Step 4: \( I = 60 \text{A} \) ⇒ cable section: 16 [mm\(^2\)]

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

Conclusion: one copper cable of 16 [mm\(^2\)] 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 ESI cable connection.

As an example of the cable sizing procedure, consider Table 20 and Table 21, which show the allowed current for different parameters noting typical cable manufacturer data.

\[
\text{WARNING: Consult your cable manufacturer for the applicable cable.}
\]
### Table 20: 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>
<td>100</td>
</tr>
<tr>
<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</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>300MCM</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>350MCM</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>500MCM</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>600MCM</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</td>
<td>1</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>2/0</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</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>
<tr>
<td>150</td>
<td>300MCM</td>
<td>2</td>
<td>584</td>
<td>0.877</td>
<td>510</td>
<td>456</td>
<td>0.93</td>
<td>424</td>
</tr>
<tr>
<td>185</td>
<td>350MCM</td>
<td>2</td>
<td>664</td>
<td>0.844</td>
<td>560</td>
<td>520</td>
<td>0.908</td>
<td>472</td>
</tr>
<tr>
<td>240</td>
<td>500MCM</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>600MCM</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 20 refer to cable sizes that correspond to typical inverter ratings. Note that in 4-wire systems, the neutral may have to carry up to 3 times the line current rating of the inverter.
### Table 21: Allowed cable current for different cable sections noting the skin effect and typical cable manufacturer data – Network frequency 60Hz

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>0.996</td>
<td>99</td>
<td>75</td>
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<td></td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>150</td>
<td>0.99</td>
<td>128</td>
<td>100</td>
<td>1</td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>35</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>160</td>
<td>0.981</td>
<td>157</td>
<td>120</td>
<td>0.99</td>
<td>119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1-1/0</td>
<td>1</td>
<td>1</td>
<td>190</td>
<td>0.965</td>
<td>183</td>
<td>145</td>
<td>0.98</td>
<td>143</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>2/0</td>
<td>1</td>
<td>1</td>
<td>230</td>
<td>0.941</td>
<td>216</td>
<td>180</td>
<td>0.97</td>
<td>175</td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>3/0</td>
<td>1</td>
<td>1</td>
<td>285</td>
<td>0.911</td>
<td>260</td>
<td>220</td>
<td>0.95</td>
<td>210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>4/0</td>
<td>1</td>
<td>1</td>
<td>325</td>
<td>0.88</td>
<td>286</td>
<td>250</td>
<td>0.93</td>
<td>233</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>300MCM</td>
<td>1</td>
<td>1</td>
<td>365</td>
<td>0.85</td>
<td>310</td>
<td>285</td>
<td>0.91</td>
<td>260</td>
<td></td>
<td></td>
</tr>
<tr>
<td>185</td>
<td>350MCM</td>
<td>1</td>
<td>1</td>
<td>415</td>
<td>0.817</td>
<td>339</td>
<td>325</td>
<td>0.89</td>
<td>288</td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
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<td>1</td>
<td>1</td>
<td>495</td>
<td>0.775</td>
<td>383</td>
<td>385</td>
<td>0.85</td>
<td>326</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>600MCM</td>
<td>1</td>
<td>1</td>
<td>550</td>
<td>0.738</td>
<td>406</td>
<td>425</td>
<td>0.81</td>
<td>346</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>6</td>
<td>2</td>
<td>0.8</td>
<td>160</td>
<td>0.996</td>
<td>159</td>
<td>120</td>
<td>1</td>
<td></td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>2</td>
<td>0.8</td>
<td>208</td>
<td>0.99</td>
<td>205</td>
<td>160</td>
<td>1</td>
<td></td>
<td></td>
<td>160</td>
</tr>
<tr>
<td>35</td>
<td>2</td>
<td>2</td>
<td>0.8</td>
<td>256</td>
<td>0.981</td>
<td>250</td>
<td>192</td>
<td>0.99</td>
<td>190</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1-1/0</td>
<td>2</td>
<td>0.8</td>
<td>304</td>
<td>0.965</td>
<td>293</td>
<td>232</td>
<td>0.98</td>
<td>228</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>2/0</td>
<td>2</td>
<td>0.8</td>
<td>368</td>
<td>0.941</td>
<td>346</td>
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<td>0.97</td>
<td>280</td>
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<tr>
<td>95</td>
<td>3/0</td>
<td>2</td>
<td>0.8</td>
<td>456</td>
<td>0.911</td>
<td>415</td>
<td>352</td>
<td>0.95</td>
<td>336</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>4/0</td>
<td>2</td>
<td>0.8</td>
<td>520</td>
<td>0.88</td>
<td>457</td>
<td>400</td>
<td>0.93</td>
<td>374</td>
<td></td>
<td></td>
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<tr>
<td>150</td>
<td>300MCM</td>
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<td>0.8</td>
<td>584</td>
<td>0.85</td>
<td>496</td>
<td>456</td>
<td>0.91</td>
<td>416</td>
<td></td>
<td></td>
</tr>
<tr>
<td>185</td>
<td>350MCM</td>
<td>2</td>
<td>0.8</td>
<td>664</td>
<td>0.817</td>
<td>542</td>
<td>520</td>
<td>0.89</td>
<td>460</td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>500MCM</td>
<td>2</td>
<td>0.8</td>
<td>792</td>
<td>0.775</td>
<td>613</td>
<td>616</td>
<td>0.85</td>
<td>522</td>
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<td></td>
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<tr>
<td>300</td>
<td>600MCM</td>
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<td>880</td>
<td>0.738</td>
<td>649</td>
<td>680</td>
<td>0.81</td>
<td>553</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remark: The highlighted values in Table 21 refer to cable sizes that correspond to typical inverter ratings. Note that in 4-wire systems, the neutral may have to carry up to 3 times the line current rating of the inverter.

### 6.7 Selection of the power cable protection/ inverter 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 22.
Table 22: RMS current ratings for protection fuses

<table>
<thead>
<tr>
<th>Inverter nominal current rating (Arms)</th>
<th>Power rating (kVA)</th>
<th>Minimum fuse protection (Arms)</th>
<th>Maximum fuse protection (Arms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>20</td>
<td>40</td>
<td>125</td>
</tr>
<tr>
<td>45</td>
<td>30</td>
<td>63</td>
<td>125</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>80</td>
<td>125</td>
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<tr>
<td>70</td>
<td>50</td>
<td>100</td>
<td>160</td>
</tr>
<tr>
<td>80</td>
<td>55</td>
<td>100</td>
<td>160</td>
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<td>90</td>
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<tr>
<td>100</td>
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<td>125</td>
<td>160</td>
</tr>
<tr>
<td>120</td>
<td>85</td>
<td>140</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 ESI-S input protection will result.

![Figure 30: Symbolic representation of the ESI-S input protection](image)

The inverter power circuit is internally connected to the network by means of a main contactor of type ABB UA50 or UA95 (depending on the current rating).
The ESI-S control circuit and DC bus preload system is protected by a fuse protection scheme, the characteristics of which are given in Table 23.

**Table 23: Control circuit fuse characteristics for ESI-S inverters**

<table>
<thead>
<tr>
<th>Nominal network voltage (Vrms)</th>
<th>Control circuit fuse type</th>
<th>Irms fuse (Arms)</th>
<th>$I_{SC}$ (kA) at rated voltage</th>
<th>Rated Voltage (Vrms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$208 \leq U_e \leq 415$</td>
<td>French Ferrule 10 X 38 gG/gl</td>
<td>6</td>
<td>$\sim 120$</td>
<td>500</td>
</tr>
</tbody>
</table>

Remark: Fuse short circuit current capability

DC protection (normally a motorized DC breaker) is provided as a loose item together with ESI-S. Installation of the same shall be as per instruction provided with the correct cable size refer to Section 6.6. Depending on the DC voltage level (>750V), a 4 poles or 3 poles breaker will be provided. In a multi units system, each inverter will have its own DC protection.
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 ESI-S to the network

WARNING: The ESI 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 inverter must be protected by their own cable and equipment protection device (see Section 6.7).

WARNING: The ESI 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 inverter 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 inverter 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 inverter in 4-Wire mode.

NOTE: When installing an inverter 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 inverter measurement CTs.

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

6.8.1 Connection of the ESI-S in 3-wire mode

Use the 3-wire connection mode for installations where there is no need for neutral current filtering or line to neutral balancing. In this mode, the minimum DC voltage is lower than in 4 wire (4 wire connection requires 15% of min DC voltage compared to 3 wire mode).
In order to connect the ESI-S in 3-wire mode, follow the below guidelines:

1. Fix the inverter 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 inverter (Cf. Figure 33)

![Figure 33: Removing the Aluminum protective cover at the bottom side of the inverter enclosure](image)

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 34).

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

![Figure 34: Connecting the three power cables to the inverter reactor terminals](image)

**Remarks:**

- The minimum DC voltage for the battery is defined by the following formula:
  \[ U_{DC\, min} = U \cdot \sqrt{2} \] Where U is the phase to phase network voltage.
- 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. Connect the 2 DC cables to the + and – connectors.

8. Slide the bottom protective cover up and fix it with the screws to seal off the power supply terminals

9. In addition to the power cables (AC and DC) 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 inverter panel.

10. Preparation of the inverter to match the networks voltages:
The inverter nominal voltage setting must be adapted to the actual network voltage by adjusting the tap setting of the auxiliary transformer. If the tap setting for your network voltage is not available, then choose a tap just above the network voltage present (e.g. for 390V network choose 400V tap setting). The auxiliary transformer is situated at the bottom right side of the inverter (Cf. Figure 16, item 15). Ensure that the inverter panel is isolated before changing the transformer tap setting.

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

   **WARNING:** The tap setting of the auxiliary transformer’s primary must be adapted according to the network voltage to avoid a too high or too low auxiliary voltage. If the tap setting for your network voltage is not available, then choose a tap just above the network voltage present (e.g. for 390V network choose 400V tap setting). Excessive (auxiliary) voltage levels will lead to inverter damage.
6.8.2 Connection of the ESI-S 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 order to connect the ESI-S 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 36).

![Figure 36: Connection of the neutral cable when using the ESI-S 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.

7. Connect the 2 DC cables to the + and – connectors.

![Figure 37: Connecting the DC power cables to the inverter DC terminals](image)
Remarks:
The minimum DC voltage for the battery is defined by the following formula: \( U_{DC \min} = 2 \cdot V \cdot \sqrt{2} \). Where \( V \) is the phase to neutral network voltage.

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 ESI outside the protection of this load. Indeed, consider **Figure 38** where a common protection is installed for both the regenerative load and for the ESI. When the load re-injects energy to the network and the mains protection trips, the whole energy may be pushed into the ESI, which may damage it severely. **Figure 39** shows the admitted protection scheme for regenerative loads. In this case, if the breaker of the load trips, the ESI is isolated from the energy fed back by the drive.

![Incorrect connection in the case of 4Q-loads](image1)

![Correct connection in the case of 4Q-loads](image2)

**6.9 Connection control the DC switch**

The ESI-S is not connected directly to the battery, a DC switch has to be installed between the ESI-S and the battery. The DC switch is driven by the inverter. The command of the DC switch has to be connected to the X5-1 and X5-2 connectors in the inverter. The output voltage from the inverter for the contactor command is 230V \( V_{ac} \). The table below is giving the max DC current allowed for ESI-S.

<table>
<thead>
<tr>
<th>Inverter nominal AC current rating (Arms)</th>
<th>Power rating (kVA)</th>
<th>Max DC current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>45</td>
<td>30</td>
<td>56</td>
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<td>90</td>
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<td>111</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
<td>123</td>
</tr>
<tr>
<td>120</td>
<td>85</td>
<td>147</td>
</tr>
</tbody>
</table>
6.10 Connection to make to enable the islanding feature and black start

To work properly in islanding mode, a UPS for auxiliaries is required. The minimum rating for the UPS: 600VA.

A NC switch has to be provided (not ABB scope of supply) in order to disconnect the island from the grid in order to avoid any resynchronization issue (Chapter 9). This contactor is driven by the ESI-S and has to be rated according to the loads. The command of the islanding switch has to be connected on the ESI-S on the connectors: X4-1 and X4-2. The output voltage of the command coming from the ESI-S is 230V\textsubscript{ac}.

Also a voltage measurement has to be provided in order to ensure a proper resynchronization when the ESS is leaving the islanding mode. The voltage measurement as to be rightly protected by fuses (current rating: 2A). The measurement has to be connected to X4-3 and X4-4 in the inverter. The voltage measured is the voltage between the upstream point of the islanding contactor on phase 1 and the downstream point of the islanding contactor on phase 1 see Figure 40.

Regarding the black start feature (optional), the external box (to be installed by the customer) has to be supplied by the UPS. The DC bus of the inverter has to be connected on the X3-1 and X3-2 connectors. The command of the black start functionality requires also to be controlled by the inverter. The connectors X2-1, X2-2, X2-3, X2-4 are required to make the system working properly in black start.

![Figure 40: Islanding and black start interface setup](image)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Islanding contactor (NC) (not supplied by ABB)</td>
</tr>
<tr>
<td>2</td>
<td>Resynchronization voltage measurement</td>
</tr>
<tr>
<td>3</td>
<td>Protection fuses for the voltage measurement</td>
</tr>
</tbody>
</table>
### 6.11 Selection of the current transformers

Each invert unit in a system may need to monitor the line current if harmonic mitigation or load balancing are required. This is done by three current transformers (CTs). For proper operation of the ESI-S 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 41. In case the CTs are shared with other loads, the VA burden shall be adapted accordingly. Note that the burden requirement for a complete inverter system (consisting of up to 4 inverter 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]

**WARNING:** The connection of different inverter units in an ESI-S 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 41.

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:

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

Section of CT cables:

- 2.5 mm²? (recommended)

CT cables > 30 meters?

- NO
  - Determine the length (m) and resistance (\( \Omega \)/m) of CT cables (meters)
    - \[ L = \ldots \text{ m} \]
    - \[ R = \ldots \text{ } \Omega/\text{m} \]
    - \[ X_4 = (L \times R \times 25) + 10 \]
    - \[ X_4 = \ldots \text{ VA} \]
  - Select 3 identical CT’s such that:
    - rating at primary ≥ \( X_2 \)
    - rating at secondary: 5A
    - Burden ≥ \( X_3 \) VA
    - Class 1 accuracy or better

- YES
  - Determine the length of CT cables (meters)
    - \[ L = \ldots \text{ m} \]
    - \[ X_3 = (L \times 0.007 \times 25) + 10 \]
    - \[ X_3 = \ldots \text{ VA} \]
  - Select 3 identical CT’s such that:
    - rating at primary ≥ \( X_2 \)
    - rating at secondary: 5A
    - Burden ≥ \( X_3 \) VA
    - Class 1 accuracy or better

Select 3 identical CT’s such that:

- rating at primary ≥ \( X_2 \)
- rating at secondary: 5A
- Burden ≥ \( X_3 \) VA
- Class 1 accuracy or better

Figure 41: Flow chart for CT determination
6.12 Current transformer installation and connection

The location of the CTs is critical to ensure the proper operation of the inverter. The CTs are the “eyes” of the inverter 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 an inverter 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 ESI-S is provided with CT terminals that are not shorted. A set of shorting plugs is provided with the inverter. They should always be kept with the inverter and accessible for service engineers.

**WARNING:** When connecting the CTs of a live system to the ESI-S, 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 inverter have been made, the shorting links must be removed.

The basic rules for successful CT installation are given next (Cf. Figure 42):

- The three inverter CTs have to be positioned for **closed loop control**, i.e. the CT must monitor the load current and the inverter 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 terminal (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 inverter 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 inverter
  - The l (S2) terminal of the line 1 CT (L1, Red, U) must be connected to terminal X21-2 of the inverter
- The k (S1) terminal of the line 2 CT (L2, Yellow, V) must be connected to terminal X21-4 of the inverter.
- The l (S2) terminal of the line 2 CT (L2, Yellow, V) must be connected to terminal X21-5 of the inverter.
- The k (S1) terminal of the line 3 CT (L3, Blue, W) must be connected to terminal X21-7 of the inverter.
- The l (S2) terminal of the line 3 CT (L3, Blue, W) must be connected to terminal X21-8 of the inverter.

  - The CT connection terminal X21 is located in the middle of the top plate of the inverter (Cf. Figure 43).

![Diagram of basic CT connection example](image1)

**Figure 42: Basic CT connection example for a single unit.**

![Diagram of CT connection terminal X21 in the ESI-S](image2)

**Figure 43: Location of the CT connection terminal X21 in the ESI-S**

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 42 above, a 4-wire approach may also be used. This approach is illustrated in Figure 44. In this case the CT secondary terminal to which the guard circuit is connected is interconnected between the CTs and also on the inverter 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 system consists of more than one unit, all units have to be supplied with the CT measurement information. This is done by cabling the CTs in a daisy chain fashion between the different units. This is illustrated in Section 6.13.3.

Note: in case power quality features (harmonics filtering, load balancing and PF correction) are not required above mentioned CT’s are not needed.

6.13 Electrical interconnection of ESI-S enclosures

This section explains how to electrically interconnect different ESI-S enclosures.

Figure 45 shows schematically which interconnections have to be made between two inverter enclosures.
The interconnection description is given in Table 24.

**Table 24: Interconnections between two 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 (RJ 45 cable)</td>
</tr>
<tr>
<td>2</td>
<td>CT interconnection cable</td>
</tr>
<tr>
<td>3</td>
<td>DC power connection to battery DC bus</td>
</tr>
</tbody>
</table>

Four steps have to be followed to electrically interconnect a new ESI-S unit with an existing inverter. They are outlined in the next four paragraphs.

**6.13.1 Mechanical preparation of the enclosures**

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

**6.13.2 Control board cable interconnection**

**WARNING:** Failure to interconnect the control boards in an appropriate way will result in inverter malfunctioning and possibly severe damage of the unit.
Interconnect the control boards of a following unit with a previous unit by an RJ 45-based communication cable. This cable is provided with each unit.

**Figure 46** shows the way to interconnect the control boards.

![Control board interconnection cable connection method](image)

- The RJ 45 control cable coming from the preceding unit is plugged in the left hand side RJ 45-socket at the top of the control board.
- The RJ 45 control cable leaving for the next unit is plugged in the right hand side RJ 45-socket at the top of the control board.
- Repeat the same procedure for any other inverters to be connected.

**Notes:**
- In the first unit of a system, the left hand RJ 45-socket will always be empty.
- In the last unit of a system, the right hand RJ 45-socket will always be empty.
- During the commissioning phase, a unique address has to be assigned to each unit in a system through dip switch (see Chapter 8).

### 6.13.3 CT cable interconnection

**WARNING:** Failure to connect the CT’s to all units in a system in an appropriate way will result in inverter malfunctioning and possibly sever damage of the unit.

In a multi-unit ESI-S-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 47** for the CT of phase which is fed to four units. The same approach has to be implemented for the other phases too.
Figure 47: Principle of the CT interconnection circuit for multi-unit inverters

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

6.13.4 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 units must be adopted. More information on how to connect an ESI-S inverter unit to the power supply can be found in Section 6.8.

Regarding the power DC connection, each unit has its own connection to the battery with its own DC switch.

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

WARNING: Connect the correct polarity of the battery to the ESI. Wrong polarity of battery may result in severe damage to the inverter and/ or battery.

WARNING: Once a new unit has been added to a system, this unit has to be given a unique address (through DIP switch setting on its control board). In addition, the 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 inverter controller unit settings can be found in Section 7.9.3.2 and Section 8.5.

After making and verification of all the electrical connections:
- Set a unique address on each unit control board
- Close the auxiliary fuse box of the units
- Restore the top cover(s) of the units

### 6.14 Electrical connections to the ESI-Manager user interface

The ESI-Manager is the user interface between the outside world and the controller. It is mounted on the inverter cover panel. Depending on the user requirements, less or more electrical connections have to be made to it. Figure 48 shows the rear side layout of the ESI-Manager. In order to get access to the rear side of the ESI-Manager, remove the ESI-S top cover (Cf. guidelines in Section 3.4.)

When looking at the ESI-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 5-pole terminal block (bottom right). Intermediate contacts are not used. In order to make control connections to any of these terminals, the following procedure has to be applied:

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

![Figure 48: Rear side layout of the ESI-Manager user interface](image-url)
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 Inverter 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 ESI-S, a connector approach is used such as is the case for the internal communication and ESI-Manager power supply.

WARNING: Before cabling any of the circuits discussed below, switch off the power supply to the inverter. When the inverter has already been installed on site, this is done by opening the protection system located just upstream of the inverter and opening the auxiliary fuse box present in the inverter. Wait for at least 25 minutes to allow for the DC capacitors to discharge when the inverter 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 inverter units starting from the last slave and ending with the master unit
- Restore the top cover(s) of the units including the connection of the ESI-Manager to the master unit
- The power to the inverter may then be restored
6.14.1 Cabling of remote control functionality

The ESI-S 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 inverter. When the drive is then stopped, the drive sends automatically a stop command to the inverter too. This section gives an example of how the cabling has to be done on the inverter side.

Any of the two digital inputs on the ESI-Manager (Cf. Figure 48) can be used to cable the remote control functionality. The electrical requirements of the digital inputs are given in Table 64 (inverter characteristics section). Figure 50 gives an example of how to implement the remote control functionality on Digital Input 1.

![Figure 50: Implementation of remote control functionality on Digital Input 1 of the ESI-Manager](image)

**Remarks:**
- (a) Left hand terminal block when looking from rear, counting from top to bottom
- (b) Acceptable power supply range: 15Vdc-24 Vdc, driving current 13mA@24Vdc

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

Once the cabling has been finished,
- The auxiliary fuse box may be closed
- The inverter top cover may be replaced including the connection of the ESI-Manager to the master unit
- The power to the inverter may then be restored

Then, the ESI-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 inverter will switch on when the switch S shown in Figure 50 is closed and the inverter will switch off when the switch S is opened. Refer to Section 7.9.2.4.2 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 inverters 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 ESI-Manager to the digital input setup menu and setting the digital input considered to ‘Disabled’.
- The remote control functionality can also be implemented on the Digital Input 2.

6.14.2 Cabling of alarm functionality

An alarm represents an error condition that makes the inverter trip.

Two types of error conditions exist:

1. External error condition: These are conditions that are imposed on the inverter from the outside world. Consider the example of the network voltage that increases well above the inverter safe operation level for a certain time. In that case the inverter will disconnect from the network reporting a network over voltage. When the network voltage returns to a normal level however, the inverter will reconnect to the network and continue filtering providing that the same problem does not occur systematically.

2. Internal error conditions: These are error conditions that are reported by internal controls of the inverter itself. They may indicate an internal inverter problem.

Two ways to cable the alarm functionality exist:

1. The ESI-Manager alarm outputs located at the bottom right side (when looking at the ESI-Manager from the rear) are triggered (return to default position) whenever:
   - A permanent internal or external error condition is present. In order to avoid transient switching of the contacts, the error has to be present for 3 minutes before the alarm relays are activated.
   - No power is supplied to the inverter

Table 27 further down this section gives an overview of all the error conditions that lead to the alarm contact being triggered. Two alarm contacts exist, one being of type ‘normally open’ (NO) and the other of type ‘normally closed’ (NC).

The alarm contacts are
- Free of potential
- Rated for a maximum of 250 Vac/1.5 A or 30 Vdc/5 A. When using a 24 Vdc power supply, a minimum current of 25 mA should be drawn by the circuit connected to the alarm contact.
Table 25 shows the status of the alarm contacts for different operation modes of the inverter.

Table 25: Status of the alarm contacts for different inverter operation modes

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

Figure 51 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 inverter is interrupted or the inverter trips due to an error. Otherwise the bulb will be off.

![Diagram of alarm contact-cabling scheme using the NC alarm contact on the ESI-Manager](image)

Remark:

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

Figure 51: Alarm bulb cabling scheme using the NC alarm contact on the ESI-Manager

When the inverter 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 52 for 2 master inverters.
Figure 52: Cabling of the alarm status of a multi-unit inverter consisting of masters only, using the NC alarm contact on each inverter.

In the Figure 52, the alarm bulb will be activated when both master units are in alarm. Figure 53 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 inverter. In this case the voltage applied to the digital input will be low when:

- the inverter is disconnected from the supply OR
- the inverter 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 inverter is connected to the supply and is not in error AND
- the external 24 Vdc power supply is in working order

Figure 53: Alarm cabling example using NO alarm contact and external digital input

When the inverter 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 54 for 2 master inverters.
In the Figure 54 above, the external input will be low if:

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

2. A second method to implement alarm functionality is to use the ESI-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 inverter trips due to an unacceptably high network voltage or when the inverter 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 ESI-Manager from the rear (Cf. Figure 48)

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 26 shows the status of a digital output contact configured as alarm contact for different operation modes of the inverter.

<table>
<thead>
<tr>
<th>Inverter 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>Inverter (auxiliaries) connected to the supply, no error present</td>
<td>Open</td>
</tr>
</tbody>
</table>

Table 26: Status of a digital output contact configured as alarm contact for different inverter operation modes
The alarm conditions that can be assigned to a digital output are given in Table 27. The assignment must be made with the ESI-Manager. Any of the six digital outputs can be used to cable an alarm. A maximum of 3 alarms can be assigned to the digital outputs. Note however that by default the digital outputs have been set up for monitoring other functions than alarms (cf. Table 10) Refer to Section 7.9.2.4.3 for guidelines on how to navigate to the digital output setup menu.

**Table 27: 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>ESI-S DC bus voltage unacceptably high</td>
<td>$V_{dc} &gt; 105% V_{dc_max_allowed_for_each_capacitor_stack}$</td>
</tr>
<tr>
<td>ESI-S 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>ESI-S over current fault</td>
<td>Internal current higher than allowed</td>
</tr>
<tr>
<td>ESI-S IGBT fault</td>
<td>IGBT hardware reports internal permanent error</td>
</tr>
<tr>
<td>ESI-S IGBT over temperature</td>
<td>IGBT hardware reports internal over temperature</td>
</tr>
<tr>
<td>Control board temperature too high</td>
<td>Internal control board temperature probe reports too high temperature</td>
</tr>
<tr>
<td>ESI-S internal power supply fault</td>
<td>Internal control voltage too low or not present</td>
</tr>
<tr>
<td>ESI-S control board fault</td>
<td>Internal control board reports an error</td>
</tr>
<tr>
<td>ESI-S 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 53 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 inverter 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 ESI-Manager (rear view, counting from top to bottom). This is clearly indicated in Figure 48 above.

A second use of the digital outputs is to monitor the status of individual master units in a multi-inverter 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 inverter system is not operational due to error.

In order to obtain full redundancy with inverters 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 54.

Once the cabling has been finished,
- The auxiliary fuse box may be closed
- The inverter top cover may be replaced including the connection of the ESI-Manager to the master unit
- The power to the inverter may then be restored

### 6.14.3 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 ESI-Manager user interface (Cf. Figure 48) 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 inverter 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 inverter trip. It only has a monitoring function. Table 28 describes the behavior of the digital output contact configured as warning contact for different inverter operating modes.
Table 28: State of a digital output contact configured as warning contact for different inverter operation modes

<table>
<thead>
<tr>
<th>Inverter 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>Inverter (auxiliaries) connected to the supply, no warning present</td>
<td>Open</td>
</tr>
<tr>
<td>Inverter (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>Inverter (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 29 gives a list of the warning conditions that can be assigned to a digital output.

Table 29: 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 ESI-Manager have been set up for monitoring other functions than warnings (cf. Table 10) Refer to Section 7.9.2.4.1 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 53 can be adopted. The electrical characteristics of the digital output contacts and the points to pay attention to are discussed in Section 6.14.2.

In order to obtain full redundancy with inverters 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 54 can be used to implement the monitoring of the warnings in multi-master units.
6.14.4 Cabling of the digital output contacts to monitor other inverter 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 inverter operation, the same approach as shown in Figure 53 can be adopted. The electrical characteristics of the digital output contacts and the points to pay attention to are discussed in Section 6.14.2.

In order to obtain full redundancy with inverters 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 54 can be used to implement the monitoring of these functions in multi-master units.

6.14.5 Cabling of main/auxiliary control functionality

The active inverter 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 ESI-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 ESI-Manager (Cf. Figure 48). 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 inverter 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 55 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.
Remark:
(a) Left hand terminal block when looking from rear, counting from top to bottom

Figure 55: Example of how to cable the 2nd digital input of the ESI-Manager for main/auxiliary control switching functionality

When implementing the function described above, please note that according to the setup done with the ESI-Manager for the input considered, the inverter may behave differently. Table 30 shows the inverter behavior as a function of the ESI-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 inverter may behave erratically.

<table>
<thead>
<tr>
<th>ESI-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 inverters 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 ESI-Managers have to be set up accordingly.

Once the cabling has been finished,

- The auxiliary fuse box may be closed
The inverter top cover may be replaced including the connection of the ESI-Manager to the master unit

The power to the inverter may be restored

Refer to Section 7.9.2.4.2 for guidelines on how to set up the digital inputs according to the function required.

### 6.14.6 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 inverter may behave erratically.

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

Note that in a multi-unit inverter 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 31* shows the ESI-Manager setup for the input considered and the resulting effect when applying voltage to this input.

  *Table 31: Inverter behavior as a function of the ESI-Manager settings for local start/stop and using 2 digital inputs*

<table>
<thead>
<tr>
<th>ESI-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>Inverter starts on rising edge</td>
</tr>
<tr>
<td>Edge OFF</td>
<td>No effect</td>
<td>Inverter stops on rising edge</td>
</tr>
</tbody>
</table>

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

When using the Edge ON function the inverter can only be switched on by applying voltage to the digital input considered. It is therefore recommended in that case to configure and cable the second digital input as Edge OFF. Refer to Section 7.9.2.4.2 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 56 shows a cabling diagram for implementing a start function on the first digital input and a stop function on the second digital input.

![Cabling diagram for implementing start on digital input 1 and stop on digital input 2](image)

**Remark:**

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

*Figure 56: Cabling diagram for implementing start on digital input 1 and stop on digital input 2*

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

Table 32 shows the ESI-Manager setup for the input considered and the resulting effect when applying voltage to this input.

**Table 32: Inverter behavior as a function of the ESI-Manager settings for local start/stop and using 1 digital input**

<table>
<thead>
<tr>
<th>ESI-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>Inverter starts on first rising edge, stops on second rising edge, etc</td>
</tr>
<tr>
<td>Remark: Vlow = 0 Vdc, Vhigh = 15-24 Vdc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Refer to Section 7.9.2.4.2 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 57 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 inverter top cover may be replaced including the connection of the ESI-Manager to the master unit
- The power to the inverter may be restored

Remarks:

- The implementation of local start/stop buttons does not inhibit the usage of the start/stop function on the ESI-Manager.
- When remote control functionality is implemented (cf. Section 6.14.1) 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 ESI-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 inverter 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.

### 6.15 Electrical connections of inverter options and accessories

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

- The connection of the USB or Ethernet cable used for PQF-Link software communication (optional)
The connection of the Ethernet cable used for Modbus TCP communication (optional)

The connection of the RS485 Modbus RTU adapter (optional)

The connections of the aforementioned accessories are discussed next.

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

### 6.15.1 External communication with ESI

The ESI Inverter communicates with a computer in three possible ways:

- Using our in-house communication software called PQF-Link (rs232)
- Using any communication system supporting the Modbus TCP protocol
- Using any communication system supporting the Modbus RTU protocol

For communication over Modbus TCP, the computer can be connected through the Ethernet port using standard cable (RJ 45).

For communication over Modbus RTU, we need a RS485 Modbus adapter (as shown in Figure 67). This adapter has to be connected to the rear side of the ESI-Manager. This is done by inserting the adapter plug firmly in the dedicated socket. Figure 67 shows the location at the rear of the ESI-Manager where the plug has to be inserted. The user can use custom software where the standard Modbus RTU protocol is implemented or any other standard software (OPC server, SCADA ...).

![Figure 58: Location at rear of ESI-Manager where the serial communication cable has to be inserted](image)

More information on the PQF-Link software or Modbus communication can be found in the ‘PQF-Link installation and user’s guide’ and ‘2GCS239011A0070_ESI-Manager communication with Modbus RTU, Modbus TCP and PQF-Link protocols’.
6.15.2 Connection of the Modbus adapter

For the connection setup of the Modbus adapter, please refer to the document “2GCS212013A0050-RS-485 Installation and Start-up guide”.

7 The ESI-Manager user interface

7.1 What this chapter contains

This chapter presents the features and operating instructions for the ESI-Manager user interface (Figure 59). Use the contents of this chapter as background information for the next chapters, which explain how to commission, operate and troubleshoot the inverter and how to set up various communication interfaces based on RS485 or Ethernet.

Some of the functions discussed in this chapter require cabling of external I/O to the connection terminals at the rear of the ESI-Manager. Refer to Section 6.14 for guidelines on how to do this.

Figure 59: Front view of the ESI-Manager user interface

7.2 ESI-Manager user interface description

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

The main screen of the ESI-Manager is given in Figure 60.
7.3 ESI-Manager overview and navigation

All user inter-action with the inverter is channeled through the ESI-Manager. It provides for the following main functions (Cf. Figure 59):

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

Figure 61 outlines the principle menus that are accessible through the ‘Welcome’ screen.

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

7.4 Icons and main screen

Following icons and menu are present on the main screen:

Table 33 Inverter status icons

<table>
<thead>
<tr>
<th>Inverter status</th>
<th>Menu display</th>
<th>Touching the button results in ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter stopped, no critical error present (i.e. ‘normal’ stop condition)</td>
<td>ESI START</td>
<td>Starting the inverter unit</td>
</tr>
<tr>
<td>Inverter running, no critical error present (i.e. ‘normal’ running condition)</td>
<td>ESI STOP</td>
<td>Stopping the inverter unit</td>
</tr>
<tr>
<td>Inverter stopped on critical fault</td>
<td>ACK. FAULT</td>
<td>Acknowledging the fault</td>
</tr>
</tbody>
</table>
The module status indicator: there are 8 numbered icons present on the left bottom of the screen, each representing a power module. The active modules are displayed in blue color; the faulty ones in red and those modules which are not present are greyed.

*Table 34 Module status icons*

<table>
<thead>
<tr>
<th>Icons</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><strong>Ready</strong>: the unit considered does not have a fault and can run normally</td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td><strong>Fault</strong>: 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 inverter 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 inverter system will be shut down. The inverter can be restarted after the fault clearing process has ended.</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td><strong>Not present</strong>: the unit considered has been excluded of the normal inverter operation due to either fault or the unit is not present</td>
</tr>
<tr>
<td><img src="image4.png" alt="Image" /></td>
<td><strong>Master</strong></td>
</tr>
</tbody>
</table>

An alarm icon showing when the ESI-Manager’s alarm contact has been activated (Cf. Figure 59) changes its appearance when the alarm condition exists. When the alarm condition has disappeared, the respective alarm icon takes back the normal appearance. The status of protection (locked/unlocked) is also displayed by a dedicated icon. Hardware lock and software locks have separate icons.

*Table 35 Alarm/lock status icons*

<table>
<thead>
<tr>
<th>Icons</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td><strong>Software lock</strong></td>
</tr>
<tr>
<td><img src="image6.png" alt="Image" /></td>
<td><strong>Software unlock</strong></td>
</tr>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td><strong>Hardware lock</strong></td>
</tr>
<tr>
<td><img src="image8.png" alt="Image" /></td>
<td><strong>Hardware unlock</strong></td>
</tr>
<tr>
<td><img src="image9.png" alt="Image" /></td>
<td><strong>Communication lock status</strong></td>
</tr>
<tr>
<td><img src="image10.png" alt="Image" /></td>
<td><strong>Communication unlock status</strong></td>
</tr>
<tr>
<td><img src="image11.png" alt="Image" /></td>
<td><strong>Alarm status</strong></td>
</tr>
<tr>
<td><img src="image12.png" alt="Image" /></td>
<td><strong>Fan status</strong></td>
</tr>
</tbody>
</table>

**Alarms**

Programmed alarm can:
- activate any digital output relay 1-6 if selected
- activate global alarm NO/ NC relay
Tprobe alarm 1 to 8 can activate global alarm NO/NC relay

**Warnings**

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

Tprobe warning 1 to 8 can activate global fan NO relay

Digital output contact icons are located at the bottom of the screen (Cf. Figure 60). These icons are numbered 1 to 6 when they are disabled. If these output contacts are programmed, the corresponding icon changes. When the ESI-Manager closes one of its six digital output relays (Cf. Chapter 6) the corresponding symbol changes its appearance as described in the Table 36. When the relay considered opens again, the symbol takes back the original appearance.

If a digital output is ‘Disabled’ the default icon is shown. Example:

---

**Table 36 Digital outputs status icons**

<table>
<thead>
<tr>
<th>Icons</th>
<th>ESI-Manager setting for digital output</th>
<th>Output relay closes when...</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Auxiliary Power" /></td>
<td>Auxil. ON</td>
<td>The auxiliary power is present in the main inverter enclosure and the main controller is communicating with the ESI-Manager</td>
</tr>
<tr>
<td><img src="image" alt="Auxiliary Power" /></td>
<td>Auxil. OFF</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="ESI Running" /></td>
<td>ESI running</td>
<td>The active inverter is ‘on’ (IGBTs switching) or in ‘standby’ (main contactor closed but IGBTs not switching)</td>
</tr>
<tr>
<td><img src="image" alt="ESI Not Running" /></td>
<td>ESI not running</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Not Full Load" /></td>
<td>Not full load</td>
<td>The active inverter is running under full load condition</td>
</tr>
<tr>
<td><img src="image" alt="Full Load" /></td>
<td>Full load</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Armed" /></td>
<td>Armed</td>
<td>The inverter is ON or is in the start-up procedure, or it is stopped in fault condition but will restart as soon as the fault has disappeared</td>
</tr>
<tr>
<td><img src="image" alt="Not Armed" /></td>
<td>Not armed</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Within T Limit" /></td>
<td>Within T limit</td>
<td>The inverter temperature limit has been reached and the inverter is derating itself to run at a safe temperature</td>
</tr>
<tr>
<td><img src="image" alt="T Limit Reached" /></td>
<td>T limit reached</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="In Standby" /></td>
<td>In standby</td>
<td>The inverter is in standby</td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Activ. Main</td>
<td>The main active inverter settings are activated</td>
<td></td>
</tr>
<tr>
<td>Activ. Aux</td>
<td>The auxiliary active inverter settings are activated</td>
<td></td>
</tr>
<tr>
<td>Unit miss.</td>
<td>One of the inverter units in a multi-unit arrangement is not available (e.g. due to a permanent error), or has not yet been commissioned.</td>
<td></td>
</tr>
<tr>
<td>Pg. alarm 1</td>
<td>The programmable alarm 1 is activated</td>
<td></td>
</tr>
<tr>
<td>Pg. alarm 2</td>
<td>The programmable alarm 2 is activated</td>
<td></td>
</tr>
<tr>
<td>Pg. alarm 3</td>
<td>The programmable alarm 3 is activated</td>
<td></td>
</tr>
<tr>
<td>Warning 1</td>
<td>The programmable warning 1 is activated (c)</td>
<td></td>
</tr>
<tr>
<td>Warning 2</td>
<td>The programmable warning 2 is activated (c)</td>
<td></td>
</tr>
<tr>
<td>Warning 3</td>
<td>The programmable warning 3 is activated (c)</td>
<td></td>
</tr>
<tr>
<td>Battery charging</td>
<td>The ESS is discharging or charging the battery</td>
<td></td>
</tr>
<tr>
<td>Connected to grid</td>
<td>The ESS is connected to grid or islanded</td>
<td></td>
</tr>
</tbody>
</table>

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

**Table 37 Main screen**

<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>ESI Running</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>
### Measurements

<table>
<thead>
<tr>
<th>Overview</th>
<th>Measurements</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vrms</td>
<td>THDV</td>
<td>V1</td>
</tr>
<tr>
<td>Irms</td>
<td>THDI</td>
<td>E1</td>
</tr>
<tr>
<td>Q</td>
<td>S</td>
<td>P</td>
</tr>
<tr>
<td>T Control max</td>
<td>T IGBT</td>
<td>State of charge</td>
</tr>
<tr>
<td>Max cell voltage</td>
<td>Battery current</td>
<td>Battery voltage</td>
</tr>
<tr>
<td>Max cell temp.</td>
<td>Min cell voltage</td>
<td>Average cell temp.</td>
</tr>
<tr>
<td>ESI  Q</td>
<td>ESI S</td>
<td>ESI P</td>
</tr>
</tbody>
</table>

### System values

<table>
<thead>
<tr>
<th>Voltages</th>
<th>Global Values</th>
<th>Waveforms</th>
<th>Spectrum</th>
<th>Harm. Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line currents</td>
<td>Global Values</td>
<td>Waveforms</td>
<td>Spectrum</td>
<td>Harm. Table</td>
</tr>
<tr>
<td>Inverter currents</td>
<td>Waveforms</td>
<td>Spectrum</td>
<td>Harm. Table</td>
<td></td>
</tr>
<tr>
<td>Total Inverter curr.</td>
<td>Waveforms</td>
<td>Spectrum</td>
<td>Harm. Table</td>
<td></td>
</tr>
<tr>
<td>Powers</td>
<td>P</td>
<td>Q</td>
<td>S</td>
<td>PF</td>
</tr>
<tr>
<td>ESI  P</td>
<td>ESI Q</td>
<td>ESI S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESI P1</td>
<td>ESI P2</td>
<td>ESI P3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESI Q2</td>
<td>ESI Q3</td>
<td>ESI S1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESI S3</td>
<td></td>
<td>ESI S2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperatures</th>
<th>T Control</th>
<th>T Control Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>T ESI Manager</td>
<td>T Probe (1...8)</td>
<td>T IGBT</td>
</tr>
<tr>
<td>T IGBT Max</td>
<td>T IGBT</td>
<td>T IGBT Max</td>
</tr>
</tbody>
</table>

### Battery information

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Battery voltage</th>
<th>Max cell voltage</th>
<th>Min cell voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>Battery ambient temp.</td>
<td>Average cell temp.</td>
<td>Max cell temperature</td>
</tr>
<tr>
<td>Min cell temperature</td>
<td>Max charge current</td>
<td>Max discharge current</td>
<td></td>
</tr>
<tr>
<td>ESI user</td>
<td>Battery voltage</td>
<td>Max cell voltage</td>
<td>Min cell voltage</td>
</tr>
<tr>
<td>Battery current</td>
<td>Battery ambient temp.</td>
<td>Average cell temp.</td>
<td>Max cell temperature</td>
</tr>
<tr>
<td>Min cell temperature</td>
<td>Max charge current</td>
<td>Max discharge current</td>
<td></td>
</tr>
<tr>
<td>Batt. Voltage @VC-Chg</td>
<td>Min. charge current @VC</td>
<td>Min. discharge current @VC</td>
<td>Max battery voltage</td>
</tr>
<tr>
<td>Min battery voltage</td>
<td>Max cell voltage</td>
<td>Min cell voltage</td>
<td>Max cell temperature</td>
</tr>
<tr>
<td>Min cell temperature</td>
<td>Max state of charge</td>
<td>Min state of charge</td>
<td>AC/DC P Control</td>
</tr>
<tr>
<td>Q External Control</td>
<td>Blackstart</td>
<td>Enable Low Volt. Ride Thr.</td>
<td>Vac Min1</td>
</tr>
<tr>
<td>Vac Min2</td>
<td>Time Min1</td>
<td>Time Min2</td>
<td>P ramping rate</td>
</tr>
<tr>
<td>P set point</td>
<td>Q set point</td>
<td>Islanding</td>
<td></td>
</tr>
</tbody>
</table>

### Min-Max logging

<table>
<thead>
<tr>
<th>Voltages</th>
<th>Line currents</th>
<th>Power</th>
<th>Frequency</th>
<th>Temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line currents</td>
<td>Power</td>
<td>Frequency</td>
<td>Temperatures</td>
<td></td>
</tr>
</tbody>
</table>

### ESI monitoring

<table>
<thead>
<tr>
<th>Status of module</th>
<th>Inverter load</th>
<th>Event logging</th>
<th>Active warn.</th>
<th>Number of errors</th>
<th>ESI operation</th>
</tr>
</thead>
</table>

**Figure 61: Principle menus of the ESI-Manager - part 1**
Figure 62: Principle menus of the ESI-Manager – part 2
In order to navigate through the menus of the ESI-Manager, the touch screen (see Figure 59) has to be used. The starting point for the navigation after a power up is the ‘Welcome’ screen. The item selected is activated and its submenu appears on the screen (e.g. the ‘Measurements’ menu in Figure 59). The name of the parent menu is displayed at the top of the screen.

![Figure 63: Sub-menu Measurements](image)

Please note that:

- Sometimes the complete item list in a menu cannot be shown on the display. This is indicated by a small symbol that appear(s) at the bottom right (see Figure 64). Pressing this button takes the menu to the next screen where more items are available to choose from.

![Figure 64: Illustration of arrow symbol on the ESI-Manager display](image)

- Sometimes, when the number of items or variables exceeds the limit of full screen size, a sliding bar appears on the side of the screen. Sliding down (up) this bar displays the remaining (previous) items as shown below:
When any of these symbols is visible, the user can scroll down/up beyond the limit of the screen. The item list will be adjusted accordingly.

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

- When a menu button is selected, any submenu under it appears in the screen.

- The ‘Select Unit’-function \[ \text{is accessible at different places in the menu structure and allows selecting the measurements and data as reported by different units in a multi-unit inverter system.} \]

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

Remark:

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

The main ‘Welcome’ screen is referenced as \[/Welcome\].

Example: \[/Welcome/Measurements/System values\] indicates that the ‘System values’ menu can be accessed by:

- Press \[ \text{button (on the top right corner of any screen)} \text{successively until the ‘Welcome’ screen is reached} \]

- Press the ‘Measurements’ menu in the main ‘Welcome’ screen which opens the ‘Measurements’ menu

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

![Image](image_url)

7.5 **The ESI-Manager behavior during inverter initialization**

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

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

- **Step 1**

![Figure 67: ESI-Manager display during communication initialization](image_url)

- **Step 2**
Once the communication channel has been initialized, the user interface is set up. During this process the ESI-Manager retrieves the data structure to be displayed from the ESI main controller.

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

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

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

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

- “Please wait…..”
- “Resetting system…..”

Table 38 gives an overview of the initialization steps for common reset conditions.

<table>
<thead>
<tr>
<th>Reset condition after...</th>
<th>ESI-Manager initialization steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying power to the inverter first time or after a complete isolation of inverter</td>
<td>Case 1</td>
</tr>
<tr>
<td>Resetting power only to the main controller</td>
<td>Case 2</td>
</tr>
<tr>
<td>Setting up commissioning parameters</td>
<td>Case 3</td>
</tr>
<tr>
<td>Acknowledging fault successfully</td>
<td>Case 3</td>
</tr>
</tbody>
</table>

### 7.6 The ESI-Manager locking facilities

In order to prevent unauthorized modification of any of the active inverter settings, switch on the hardware lock (Figure 15 item 4).

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

- ![Lock icon] will appear bottom portion of the graphics display
Most setting values can be consulted

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

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

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

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

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

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

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

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

1234

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

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

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

### 7.7 The ESI start, stop and fault acknowledgement menu

**WARNING:** The active inverter 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 inverter and void warranty.

Refer to Chapter 8 for more information on commissioning the inverter.
‘The ESI start, stop and fault acknowledgement’ menu can only be accessed in the main ‘Welcome’ screen [/Welcome/ESI].

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

As can be seen in Table 39 the ‘start, stop and fault acknowledgement’ menu behaves differently depending on the inverter status.

Table 39: ‘Start, stop and fault acknowledgement’ menu functionality according to the inverter status

<table>
<thead>
<tr>
<th>Inverter status</th>
<th>Menu display</th>
<th>Pushing OK results in...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter stopped, no critical error present (i.e. ‘normal’ stop condition)</td>
<td>ESI START</td>
<td>Starting the inverter^{(a)(b)}</td>
</tr>
<tr>
<td>Inverter running, no critical error present (i.e. ‘normal’ running condition)</td>
<td>ESI STOP</td>
<td>Stopping the inverter^{(a)(b)}</td>
</tr>
<tr>
<td>Inverter stopped on critical fault</td>
<td>ACK. FAULT</td>
<td>Acknowledging the fault^{(a)(b)}</td>
</tr>
<tr>
<td>Inverter controlled by remote control</td>
<td>ESI START or</td>
<td>No action on inverter behavior</td>
</tr>
<tr>
<td></td>
<td>ESI STOP or</td>
<td>Display shows message that inverter is controlled by digital input</td>
</tr>
<tr>
<td></td>
<td>ACK. FAULT</td>
<td></td>
</tr>
</tbody>
</table>

Remark:

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

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

In a multi-unit system, the ESI start, stop and fault acknowledgement menu will only switch to the ACK. FAULT message when the complete inverter 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 ESI Monitoring menu [/Welcome/ESI Monitoring/Status of module]). Note that in the reset process the whole system will be shut down. If the fault of the unit cannot be reset, the ACK. FAULT message will be displayed again for the unit considered. The inverter 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 inverter 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 inverter can be restarted.

- If the fault is not present anymore when the ‘ACK. FAULT’ command is given, the menu will change into ‘ESI START’ to indicate that the inverter can be restarted.
Fault analysis can be done by consulting the ‘ESI Monitoring’ menu [/Welcome/ESI Monitoring]. For more information on the ‘ESI monitoring’ menu, refer to Section 7.10.

If the inverter is set up for remote control operation, the local start/stop command has no effect.

Disable the digital inputs to override the remote control [/Welcome/Settings/Customer set./Digital inputs].

### 7.8 The ‘Measurements’ menu

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

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

#### 7.8.1 The ‘Overview’ menu

The Overview menu summarizes the following characteristic parameters (Table 40). These parameters are expressed as numerical values in a list.
<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vrms</td>
<td>V</td>
<td>4-wire mode: RMS value of all the line-to-neutral voltages 3-wire mode: RMS value of all the line-to-line voltages</td>
</tr>
<tr>
<td>THDV</td>
<td>%</td>
<td>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</td>
</tr>
<tr>
<td>V1</td>
<td>V</td>
<td>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</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>Network frequency</td>
</tr>
<tr>
<td>V dc bus</td>
<td>V</td>
<td>Inverter DC capacitor voltage</td>
</tr>
<tr>
<td>Imbalance</td>
<td>%</td>
<td>Indicates the imbalance in supply voltage (%value)</td>
</tr>
<tr>
<td>Irms</td>
<td>A</td>
<td>4-wire mode: RMS value of all the line currents and the neutral current 3-wire mode: RMS value of all the line currents</td>
</tr>
<tr>
<td>THDI</td>
<td>%</td>
<td>Total harmonic distortion of all the line currents.</td>
</tr>
<tr>
<td>I1</td>
<td>A</td>
<td>RMS value of the fundamental component of all the line currents</td>
</tr>
<tr>
<td>ESI Irms</td>
<td>A</td>
<td>RMS value of all the inverter currents, including neutral current for 4-wire configuration</td>
</tr>
</tbody>
</table>
| P              | W, kW, MW | Active power in the network at the location of the CTs  

\[
\begin{align*}
P > 0 & : \text{Load absorbing active power} \\
P < 0 & : \text{Load generating active power}
\end{align*}
\]

| Q              | var, kvar, Mvar | Reactive power in the network at the location of the CTs  

\[
\begin{align*}
Q > 0 & : \text{Inductive reactive power} \\
Q < 0 & : \text{Capacitive reactive power}
\end{align*}
\]

<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>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>
</tbody>
</table>
| \( \cos \phi \) | -           | Displacement power factor: calculation based on the fundamental values of the measurements.  

\[
\begin{align*}
\cos \phi > 0 & : \text{System has inductive behavior} \\
\cos \phi < 0 & : \text{System has capacitive behavior}
\end{align*}
\]

<table>
<thead>
<tr>
<th>T Control</th>
<th>°C/°F</th>
<th>Main control board temperature of the selected module</th>
</tr>
</thead>
<tbody>
<tr>
<td>T Control max</td>
<td>°C/°F</td>
<td>Main control board temperature of the hottest module in the group</td>
</tr>
<tr>
<td>Parameter</td>
<td>Unit</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>T IGBT</td>
<td>°C/°F</td>
<td>IGBT module temperature of the selected module</td>
</tr>
<tr>
<td>T IGBT max</td>
<td>°C/°F</td>
<td>IGBT module temperature of the hottest module in the group</td>
</tr>
<tr>
<td>State of Charge</td>
<td>%</td>
<td>State of charge of the battery (100% means fully charged, 0% means fully discharged)</td>
</tr>
<tr>
<td>Battery voltage</td>
<td>V</td>
<td>Battery voltage</td>
</tr>
<tr>
<td>Cell temperature</td>
<td>°C/°F</td>
<td>Minimum, average and maximum cell voltage reported by BMS</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>°C/°F</td>
<td>Ambient temperature reported by BMS</td>
</tr>
<tr>
<td>Cell voltage</td>
<td>V</td>
<td>Minimum and maximum cell voltage reported by the BMS</td>
</tr>
<tr>
<td>Maximum battery current</td>
<td>A</td>
<td>Maximum charge and discharge currents allowed by the BMS</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. The selected parameter gets highlighted in green color background.
- Select a new location for this parameter by touching the preferred location on the list of parameters
- The selected parameter relocates to the new place

### 7.8.2 The ‘System values’ menu

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

#### 7.8.2.1 Voltages
Refer to Table 40 for an explanation of the parameters.

7.8.2.1.1 Global values
Vrms, V1 and THDV in table format.

7.8.2.1.2 Waveforms
The network voltage waveforms for all phases (Figure 69). All waveforms are synchronized with the rising edge zero crossing of the voltage V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).

7.8.2.1.3 Spectrum
The network voltage spectrum for all phases in chart format (Figure 70). The spectral components up to the 49th order are expressed as a % of the fundamental component with absolute values also shown in the top right corner. The two buttons with “+” and “-“mark help changing the voltage level resolution (i.e. Y-axis value in the chart).
7.8.2.14 Harmonic table
The network voltage spectrum for all phases in table format (Figure 71). Both the absolute values and the % of the fundamental component values are shown for each spectral component up to the 49th rank.

Figure 71: Spectrum of the network voltage in table format displayed by the ESI-Manager (4-W mode example)

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

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

7.8.2.2 Line currents
Refer to Table 40 for an explanation of the parameters.

7.8.2.2.1 Global values

I rms, I 1 and THDI are displayed in table format. These measurements are based on CT’s that may not be connected if power quality features are not required.

7.8.2.2.2 Waveforms

The line current waveforms for all phases (3-W mode) and the neutral current waveform (4-W mode). The graph layout is similar to the one of the voltages (Figure 69). All waveforms are synchronized with the rising edge zero crossing of the voltage V (L1-N) (4-W mode) or V (L1-L2) (3-W mode).

7.8.2.2.3 Spectrum

The line current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in chart format. The chart layout is similar to the one of the voltages (Figure 70).

7.8.2.2.4 Harmonic table

The line current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in table format. The table layout is similar to the one of the voltages (Figure 71).

7.8.2.3 Inverter currents

Refer to Table 40 for an explanation of the parameters.

ESI I rms in table format for the unit selected with the ‘Select Unit’ option.
7.8.2.3.1 Waveforms
The inverter 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 69). All waveforms are synchronized with the rising edge zero crossing of the voltage \( V \) (L1-N) (4-W mode) or \( V \) (L1-L2) (3-W mode).

7.8.2.3.2 Spectrum
The inverter 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 70) but the values are expressed in absolute terms.

7.8.2.3.3 Harmonic table
The inverter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in table format for the unit selected with the ‘Select unit’ option. The table layout is similar to the one of the voltages (Figure 71) but only absolute current values are shown.

7.8.2.4 Total inverter currents
Refer to Table 40 for an explanation of the parameters.
ESI Irms in table format for the complete inverter system.

7.8.2.4.1 Waveforms
The inverter current waveforms for all phases for the complete inverter system. The graph layout is similar to the one of the voltages (Figure 69). All waveforms are synchronized with the rising edge zero crossing of the voltage \( V \) (L1-N) (4-W mode) or \( V \) (L1-L2) (3-W mode).

7.8.2.4.2 Spectrum
The inverter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in chart format for the complete inverter system. The chart layout is similar to the one of the voltages (Figure 70) but the values are expressed in absolute terms.
7.8.2.4.3 Harmonic table
The inverter current spectrum for all phases (3-W mode) and the neutral current spectrum (4-W mode) in table format for the complete inverter system. The table layout is similar to the one of the voltages (Figure 71) but only absolute current values are shown.

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

7.8.2.5 Powers

**The power in the system at the location of the CTs:** (Refer to Table 40 for an explanation of the parameters).

- Active power $P$
- Reactive power $Q$
- Apparent power $S$
- Power factor $PF$

Displacement power factor $\cos \varphi$

**The power in the system at the location of the IGBT’s (inverter unit measurements):** (Refer to Table 40 for an explanation of the parameters).

- Active power ESI $P$
- Reactive power ESI $Q$
- Apparent power ESI $S$
- Active power $P$ per phase (ESI P1, ESI P2, ESI P3)
- Reactive power $Q$ per phase (ESI Q1, ESI Q2, ESI Q3)
- Apparent power $S$ per phase (ESI S1, ESI S2, ESI S3)

7.8.2.6 Temperatures
Refer to Table 40 for an explanation of the parameters.

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’) of the unit selected by the ‘Select unit’-option. Temperature of the hottest IGBT (T IGBT max) in a multi-unit system
- Temperature of the control board (‘T Control’) of the unit selected by the ‘Select unit’-option
- Temperature of the hottest control board (‘T control max’) in a multi-unit system
- Temperature recorded by the optional temperature probes (up to 8 probes can be connected on each ESI-Manager)

7.8.2.7 Battery information

The battery information reported by the BMS. (Refer to Table 40 for an explanation of the parameters).

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

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

**Once a threshold has been set the ESI-Manager starts recording the maximum (or minimum) value automatically as well as the total duration until a reset is performed.** Figure 72 illustrates this.

*Figure 72: Illustration of the threshold and the maximum recorded value used in the Min/Max logging function*

The parameters that can be used with the logging function are voltages (V<sub>rms</sub>, THDV), currents (I<sub>rms</sub>), Power (P, Q, S), frequency and temperature (T<sub>IGBT</sub> and T<sub>control</sub>) along with temperatures recorded by the probes (max. 8 probes possible). All information about temperature are specific to the probe connected to the ESI-Manager where the probe is connected. Refer to Table 40 for an explanation of the parameters. For the frequency, minimum values and duration below a threshold can also be recorded.

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

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

**Figure 73** shows an example in which the network voltage between L1 and L2 is monitored. The nominal network voltage is assumed to be 400 V. The threshold was initially set at 1000 V and is changed to 420 V.
The ‘Settings’ menu has four main levels:

- The **customer level** which allows the user to set up the typical user requirements such as the active and reactive power set points, harmonic filtration settings, sets up the digital inputs and outputs and defines the programmable warnings and alarms. At this level, the user can also change the temperature unit used by the system. The customer level is accessed through [/Welcome/Settings/Customer set.]

- The **commissioning level** which allows the commissioning engineer to set up the equipment according to the customer's installation. Typical parameters that need to be entered are the network voltage and frequency, the CT parameters and a derating factor that needs to be applied when the installation is at great height above sea level or in conditions where excessive ambient temperatures are present. At the commissioning level the possibility also exists to set up the user's requirements for the power control (AC or DC target), set up the LVRT settings, 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 inverter auto restart and standby
functions, the clock, the communication of Modbus and 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 inverter unit(s), the CT parameters and the derating factor that has been set-up at the commissioning level. The installation settings level is accessed through [/Welcome/ Settings/ Installation set.]

- Apart from above three, the fourth button allows the language setting. The ESI-Manager supports six languages: English, French,

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

All functions and measurements (e.g. digital I/O, temperature) which are “hardwired” to an ESI-Manager provide data/control only for that specific inverter unit.

7.9.1 The ‘Battery operation’ menu

This menu allows the user to set the active and reactive power set points and also to switch the system into islanding mode.
7.9.1.1 Set active and reactive power set points

The powers P1, P2, P3 and Q1, Q2, Q3 are available only if the individual phase control is enabled (optional).

The customer is able to set the power set points in kW and kvar. The set points will be applied soon as the button “OK” is hit.

An internal reactive power control is available in [/Welcome/Settings/Customer set./Main settings]. This control requires external CT’s in order to measure the reactive power and correct the cos φ accordingly.

7.9.2 The ‘Customer settings’ menu

The customer settings menu is intended to be used by people that are authorized to change the inverter operation settings.
Refer to Section 7.6 for determining appropriate locking facilities for this menu.

7.9.2.1 Settings up harmonics, reactive power and filter mode

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

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

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

The inverter 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 41. By default the inverter uses the main inverter settings.

Table 41: 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 inverter switches between the main and the auxiliary settings according to a signal applied to the ESI-Manager’s digital input (a).</td>
</tr>
</tbody>
</table>

Remark:
Manual Energy Storage Inverter ESI-S

7.9.2.1.1 Setting up the filter mode

For setting up the inverter’s main inverter mode go to [/Welcome/Settings/Customer set./Main settings/Inverter mode].

For setting up the inverter’s auxiliary inverter mode go to [/Welcome/Settings/Customer set./Auxiliary settings/Inverter mode].

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

- Inverter the selected harmonics until their magnitudes are close to zero (Maximum filtering)
- Inverter 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 42 shows the three available modes:

<table>
<thead>
<tr>
<th>Mode 1</th>
<th>Active power set point</th>
<th>filtering to curve</th>
<th>Maximum filtering</th>
<th>Reactive compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 2</td>
<td>Active power set point</td>
<td>filtering to curve</td>
<td>Reactive compensation</td>
<td>Maximum filtering</td>
</tr>
<tr>
<td>Mode 3</td>
<td>Active power set point</td>
<td>filtering to curve</td>
<td>Reactive compensation</td>
<td>-</td>
</tr>
</tbody>
</table>

In Mode 1, the inverter will first generate the active power target. Then it will 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 active power set point and 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 inverter will first ensure that active power set point and the harmonic curve specification is fulfilled. If then there are still resources available, the inverter will do reactive power compensation and load balancing if requested by the user.

Figure 74 illustrates the principle of filtering to curve for one particular harmonic order. The flexibility of the ESI control is such that a specific curve level may be defined for each selected harmonic.

![Figure 74: Invertering to curve for harmonic order n](image)

The default inverter mode is Mode 3.

### 7.9.2.1.2 Selecting the harmonics with setting of curve levels

For setting up the inverter’s main harmonics selection go to

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

For setting up the inverter’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 Table 43.

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

When the ESI is operating in 3-W mode, 20 harmonics can be selected.
Table 43: Example of harmonic settings table displayed by ESI-Manager

<table>
<thead>
<tr>
<th>Order</th>
<th>Select(a)</th>
<th>Curve(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Yes</td>
<td>0 A</td>
</tr>
<tr>
<td>5</td>
<td>Yes</td>
<td>10 A</td>
</tr>
<tr>
<td>7</td>
<td>Yes</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 filtering
   - S: Harmonic selected by user but put in ‘standby’ by the inverter. Refer to Section 8.10 for more information on the “harmonic standby” mode.

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

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

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

For deselecting all harmonics of the main window at once go to
[/Welcome/Settings/Customer set./Main settings/Deselect all]

For deselecting all harmonics of the auxiliary window at once go to
[/Welcome/Settings/Customer set./Auxiliary settings/Deselect all]

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

7.9.2.14 Selecting the reactive power compensation and balancing options

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

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

The active inverter can perform different reactive power tasks based on CT’s measurements including balancing, each of which require the appropriate setup. Table 44 shows an overview of the possible tasks and shows how the inverter set up should be done to implement this task. The parameters (italic print) referred to in Table 44 can be accessed in the ‘Main PFC/ Bal.’ and ‘Aux. PFC/ Bal.’ windows of the ESI-Manager.
### Table 44: Reactive power tasks that the inverter can perform

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

**Remarks:**

(a) When load balancing is required, set the ‘Balance load’ flag to the desired mode. The following modes are available depending on the way the inverter is connected (3-W or 4-W):
- ‘Disabled’: No load balancing is done.
- ‘L-L’: Loads connected between phases only are balanced. Loads connected between phases and neutral are not balanced.
- ‘L-N’: Loads connected between phase and neutral are balanced. Loads connected between phases are not balanced. This mode is only available when the inverter is connected in 4-W mode.
- ‘L-L & L-N’: Both loads connected between phase and neutral as well as loads connected between phases are balanced. This mode is only available when the inverter is connected in 4-W mode.

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

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

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

7.9.2.2 Temp unit

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

7.9.2.3 Activate menu

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

The ESI-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 inverter (e.g. remote control signals) and get data out of the inverter (e.g. inverter status information, alarm information etc.). This section discusses the ESI-Manager setup for controlling all the digital I/ O and creating warnings and alarms.

7.9.2.4.1 Alarms and warnings

- Programmable alarms and warnings
7.9.2.4.2 Set up of the digital inputs of the ESI-Manager

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

7.9.2.4.3 Set up of the digital outputs of the ESI-Manager

For setting up the digital output go to [/Welcome/Settings/Customer set./Digital outputs]
ESI-Manager has six programmable digital output contacts. Each of them can be programmed from a set of possible inverter condition. If the selected condition is attained, that specific output contact closes.

**WARNING:** If a function is assigned to a digital input, the same function must never be assigned to the other digital input. Otherwise the inverter may behave erratically. For full redundancy with multi-master inverters, these functions need to be set up in each master unit of the inverter system and the functions should be cabled accordingly.

### 7.9.3 The ‘Commissioning’ menu

**WARNING:** The commissioning menu is intended to be used by qualified commissioning engineers that are authorized to change the inverter'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 an inverter is (re)-installed or when a unit is added to the existing inverter. During the commissioning procedure, the user settings will be lost, so note them down prior to starting the commissioning procedure.

Refer to Section 7.6 for determining appropriate locking facilities for this menu.

For an overview of the main items of the commissioning window, refer to Figure 61. These items are discussed next.
For commissioning the inverter follow the commissioning procedure presented in Chapter 8.

Remarks:
- The commissioning window incorporates the start, stop and fault acknowledgement menu (Cf. Section 7.7)
- For advanced inverter setup (auto restart function, standby function, system clock setup, external communication setup, system lock activation and password setup) refer to Section 7.9.4.

7.9.3.1 Setting up the network characteristics and the inverter synchro mode

For modifying the network characteristics and the inverter 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.

\[\text{WARNING: For ESI-S inverter, the hardware is by default set for operation at voltages in the range 380-415V. When the inverter is used in networks with voltages in the range 208-240V, its hardware configuration needs to be changed. Refer to Section 6.7. for guidelines on how this needs to be done. Failure to adapt the inverter hardware to the right network voltage range may result in hardware failure.}\]
- The nominal value of the network frequency: This value has to be set up according to the nominal value of the network frequency.
WARNING: If the inverter nominal frequency is changed to the wrong value, the inverter will refuse to start indicating a frequency error in the event logging window.

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

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

Remarks:

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

7.9.3.2 Setting up the inverter characteristics

Except for ESI-S inverter, other inverters (ESII and ESIM) are always connected in 3-ph, 3-wire mode i.e. no neutral connected is needed. The ESI-S inverter can be configured as a 3-Ph, 3-wire or 3-Ph, 4-wire device.

For modifying the inverter characteristics (3-wire or 4-wire connection mode) and number of units/unit ratings, go to [/Welcome/Settings/Commissioning/Inverter charact.]
In the main screen of inverter characteristic setting, a warning message appears and by following the button, the set-up screen appears. The warning states that if there is a mismatch between the selection of inverter connection type (3 or 4-wire) and the actual cable connection to the ESI-S (neutral cable not connected or otherwise) the inverter may refuse to start. Following a choice is made by the user; the inverter makes a “reset” of the system.

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

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

When entering the ‘Inverter 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 inverter can invert harmonics that are flowing between phases and make phase to phase balancing but cannot invert 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 inverter can invert 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 inverter arrangement must have the same rating in ESI-S range. Combining hardware units of different ratings in the same inverter panel will lead to hardware failure and/or inability for the inverter to start up.

In the same screen, the user needs to enter the rating of each inverter units connected together. For ESI-S range, the unit rating needs to be identical whereas for ESI-M and ESI-I range, unequal rated inverter units can operate together as well.

Remarks:
The inverter needs to be stopped before the unit ratings menu can be accessed. Attempting to access the menu while the inverter is running will result in a fault message being displayed.

Pressing the button in the unit ratings setup menu will result into jumping to the next step in the menu without the values entered being taken into account. When involuntarily entering the menu, walk through the menu. This way the menu can be quit without modifying any values.

7.9.3.3 Setting up the current transformer ratios and position
The ratio of the current transformers connected to the inverter (units) has to be entered into the inverter system.

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

Two methods can be used to do this.

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

These approaches are discussed next.

7.9.3.3.1 Automatic detection of the CT positions and ratio’s
For detecting the CT-settings automatically, go to
[/ Welcome/ Settings/ Commissioning/ Auto CT detection]

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

When engaging the automatic CT detection procedure the inverter 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
- Close the DC contactor
- Inject a small current into the supply
- Record the current measured by the CTs and calculate the inverter CT ratios and positions
Display a message indicating whether the CT identification ended successfully or not.

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

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

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

- Showing the CT positions found. This is done in a table format as given in Table 45

**Table 45: Automatic CT detection position-results presentation**

<table>
<thead>
<tr>
<th>Inverter connection CT terminal(a)</th>
<th>Physical CT location and orientation(b)</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:

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

  - Input 1: inverter input X21/1-2 (L1, R, U)
  - Input 2: inverter input X21/4-5 (L2, S, V)
  - Input 3: inverter input X21/7-8 (L3, T, W)

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

  - Line 1: CT connected in phase 1 (L1, R, U) with correct orientation
  - 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 ESI-Manager should display the results as in Table 45.

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 inverter 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 inverter and vice versa).

After showing the CT positions found, the customer is asked to either acknowledge the results found (by pressing **OK**) or either not to accept them by pressing any other key. If any other key than **OK** is pressed, the automatic CT
The ESI-Manager user interface

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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 inverter 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 inverter has to be adapted accordingly.

- When the CT positions have been acknowledged the inverter will carry on by showing the CT ratio found phase per phase. The values shown are indicative only and always have to be verified by the commissioning engineer. He can change the values by entering the right CT ratio. In order to approve the value entered has to be pressed. Table 46 explains the meaning of the text that appears on the display:

<table>
<thead>
<tr>
<th>Text on ESI-Manager display</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio found</td>
<td>Ratio found for the CT in the considered phase</td>
</tr>
<tr>
<td></td>
<td>E.g. 200 means a CT of 1000/5</td>
</tr>
<tr>
<td>CT Ratio L1&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>Ratio that will be used by the inverter for the CT physically connected in phase 1 (L1, R, U) of the installation</td>
</tr>
<tr>
<td>CT Ratio L2&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>Ratio that will be used by the inverter for the CT physically connected in phase 2 (L2, S, V) of the installation</td>
</tr>
<tr>
<td>CT Ratio L3&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>Ratio that will be used by the inverter 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 OK, the inverter will automatically reset and the new values will be taken into account. Pressing X at any time will interrupt the automatic CT detection process. In single unit inverters, original CT-values and positions existing prior to the start of the procedure will be restored. In multi-unit inverters, 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 inverter displays an error message indicating the reason for the problem.

Table 47 gives a list of the possible error messages.
Table 47: Possible error messages during automatic CT identification

<table>
<thead>
<tr>
<th>ESI-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 inverter connection although the CTs have been correctly installed upstream of the inverter connection. This will result in wrong CT ratio’s being found. In that case the commissioning engineer can easily correct the CT ratio’s found.
- The use of complex CT arrangements including summing CTs.

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

7.9.3.3.2 Manual set up of the CT positions and ratio’s
For detecting the CT-settings manually, go to

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

For multi-unit inverters 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 inverter unit of an inverter system:

- **for the CT connected to the inverter 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 inverter CT terminals X21/4-5 (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 inverter CT terminals X21/7-8 (Input 3):**
  - in which line (phase) is it installed (Line 1, Line 2, Line 3)
  - does the CT (cabling) have the good orientation (Line x) or not (-Line x)
    
    **Remark:**
    
    If the CT installation is correct, enter ‘Line 3’.
    
    If the CT is installed in the right phase but inversed, enter ‘-Line 3’.

- **for the CT physically installed in Line 1 (L1, R, U):**
  
  - the CT ratio, which is always positive; e.g. a CT of 5000/5 has a ratio 1000

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

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

Remarks:
- Pressing button during the manual CT setup procedure will result in:
  - For single unit inverters, the original CT-values and positions existing prior to the start of the procedure being restored.
  - For multi-unit inverters, 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 6.12 for more information on the selection and the installation of the current transformers.

7.9.3.4 Setting up the inverter rating parameter

ESI-battery menu allows the customer to set the type of active power control (AC or DC), the ramping needed when a new set point is chosen and also select where the harmonics have to be compensated (on the inverter current in order to ensure a clean waveform or on the CT’s measurements). It allows also to set the battery limitations to ensure that the battery stays always in safe state; set the LVRT limits and finally to enable the Black Start if available (optional feature). If the black Start is not available the button will be grey as shown on the picture, if it is available it will be purple.
7.9.3.5 Setting up the inverter rating parameter

For entering the rating parameter, go to

[/Welcome/Settings/Commissioning/Derating]

The permissible ambient conditions for ESI operation are laid out in Table 15. If the inverter is installed at locations higher than 1000 m (3300 ft) above sea level, the maximum inverter output current must be derated by 1% every additional 100 m (330 ft).
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 ESI-Manager rating menu shows the inverter nominal rating, which is by default 100%. The new value to be set when derating is required is 100% - (total required derating %).

After approving the new rating value (OK), the inverter 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 inverter nominal current times the entered rating factor. E.g. a rating factor of 50% implies that the maximum RMS inverter current is half the nominal inverter current.

Pressing [X] will result in the original value being restored and the inverter rating menu being quit.

7.9.3.6 Setting up the user’s requirements

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

At the commissioning level, a shortcut exists to the principal user set up menus. These consist of:
- Setting up the inverter mode for the main settings. After selecting the desired value, press **OK** to go to the next step.

- Setting up the harmonic selection table for the main settings. After entering the desired values (cf. Section 7.9.2.1), press **OK** repeatedly until the next step is displayed.

- Setting up the reactive power requirements including balancing for the main settings. After selecting the desired values, press **OK** to go to the next step.

- After entering the data, the main settings can be copied on to the auxiliary settings (if desired) by pressing **OK**. Pressing any other key will omit this step.

- The set-up ends by displaying the main commissioning menu.

Remarks:

- Refer to Section 7.9.2.1 for more explanation on the main and auxiliary inverter settings, the inverter mode, the harmonics selection table and reactive power setup possibilities.

- A more complete user set up process can be done at the customer settings level (cf. Section 7.9.2).

- In order to interrupt the set up process, press **X** 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 inverter’s memory. Re-enter the user set up to change the values again if desired.

### 7.9.3.7 Commissioning of temperature probes

For commissioning the temperature probe(s), go to

[/ Welcome/ Settings/ Commissioning/ T Commissioning]

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

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

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

142 85 0 25 12 1 12 156

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

7.9.4 The ‘Installation settings’ menu

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

The inverter's advanced settings include:
- Setting up the ‘standby’ function
- Setting up the ‘auto restart’ function
- Setting up the system clock
- Setting Password
The aforementioned functions are discussed more in detail later in this section.

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

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

![Network character](image)

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

![Inverter character](image)

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

![CT Installation](image)

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

![Derating](image)
Where applicable the settings for individual units in an inverter system can be reviewed by selecting the appropriate unit.

Note that the settings of the above-mentioned parameters can only be changed at the commissioning level (Cf. Section 7.9.3).

7.9.4.1 Setting up the ‘standby’ function

For setting up the ‘standby’ function, go to

[/ Welcome/ Settings/ Installation set./ Start-Stop set.]

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

The ‘standby’ function when enabled puts the inverter in standby, a preset time after the load requirement disappears. In this condition, the IGBTs stop switching while the main contactor remains closed (inverter remains connected to the network). This way the inverter losses become virtually zero. The inverter 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.
7.9.4.2 Setting up the ‘auto restart’ function

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

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

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

- To enable/disable the ‘auto restart’ function, go to
  [Welcome/Settings/Installation set./Start-Stop set./] and enable the auto start option.

- To program the delay after which the inverter has restart once the power returns, in the same menu specify the desired delay. This delay is available from the “drop-down” menu, in “seconds”.

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

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

7.9.4.4 Setting Password

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

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

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

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

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

### 7.9.5 Set Language

This menu allows the user to choose one of the two languages (English, French) available in the ESI-Manager. The default setting is English.
7.10 The ‘ESI monitoring’ menu

The ‘ESI monitoring’ menu can be accessed in the main Welcome screen [/Welcome/ ESI monitoring].

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

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

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

The items of the ‘ESI Monitoring’ menu are discussed next.

7.10.1 The ‘Status of module’ menu

This menu shows for each unit of an inverter 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 inverter 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 inverter system will be shut down. The inverter can be restarted after the fault clearing process has ended.

- Not present: The unit considered has been excluded of the normal inverter operation due to either:
  - The unit is physically not present
  - The unit is physically present but the control board power is not present

### 7.10.2 The ‘Inverter load’ menu

The inverter load menu shows bar graphs expressed in % indicating the inverter 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 inverters, this data can be obtained for each individual unit.

### 7.10.3 The ‘Event logging’ menu

![Event logging menu]

The inverter load menu shows bar graphs expressed in % indicating the inverter load with respect to the nominal rating of the following parameters:
The ‘event logging’ window stores the events that are recorded by the inverter controllers. The event buffer stores the 200 most recent events. Figure 75 gives an example of the event window. Two buttons are available on this screen, one scrolls to the next 10 events and the other the previous 10 events at a time.

![Figure 75: Example of an event window](image)

The explanation of the different items is given in Table 48.

**Table 48: 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 49 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 50 and Table 51 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 49: 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 inverter controller has been reset</td>
</tr>
<tr>
<td>Start request</td>
<td>An inverter start has been requested</td>
</tr>
<tr>
<td>Stop request</td>
<td>An inverter stop has been requested</td>
</tr>
<tr>
<td>Fault (DSP)</td>
<td>The DSP controller has reported a fault</td>
</tr>
<tr>
<td>Fault (μC)</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 ESI-Manager)</td>
</tr>
<tr>
<td>No more fault</td>
<td>The system detects no more faults</td>
</tr>
<tr>
<td>Power outage</td>
<td>The system has detected a power outage</td>
</tr>
<tr>
<td>Download DSP</td>
<td>A DSP controller firmware upgrade (attempt) has been recorded</td>
</tr>
<tr>
<td>DSP stop</td>
<td>An internal stop command coming from the DSP controller has been recorded</td>
</tr>
</tbody>
</table>

From Table 49 it can be seen that both the DSP controller 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 DSP relate predominantly to the inverter interacting with the installation. Table 50 gives an overview of the faults that can be reported by the DSP controller. The list is in alphabetical order.

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

<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. the detailed manuals 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>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>Controller fault message</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</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>
<tr>
<td>Over volt. Transient (SW)</td>
<td>The software transient over voltage protection has been triggered.</td>
</tr>
<tr>
<td>Over current RMS</td>
<td>The system has detected RMS over current.</td>
</tr>
<tr>
<td>Over current peak (SW)</td>
<td>The software peak current protection has been triggered.</td>
</tr>
<tr>
<td>Preload problem</td>
<td>The DC capacitors could not be preloaded. The voltage increase on the DC capacitors during the preload phase is not high enough.</td>
</tr>
<tr>
<td>Unbalanced supply</td>
<td>The supply imbalance is out of range.</td>
</tr>
<tr>
<td>Under voltage RMS</td>
<td>The RMS value of the supply voltage is lower than the acceptable minimum value.</td>
</tr>
<tr>
<td>Unstable mains frequ.</td>
<td>The network frequency is varying too fast.</td>
</tr>
<tr>
<td>Wrong phase rotation</td>
<td>The inverter is fed by a supply system, which has the wrong phase rotation.</td>
</tr>
<tr>
<td>SPI Timeout</td>
<td>Internal system error</td>
</tr>
<tr>
<td>Global BESS fault</td>
<td>The system encountered an issue during a BESS application (islanding)</td>
</tr>
<tr>
<td>Mismatch between units</td>
<td>Different units in an inverter system have different settings (e.g. 3-wire and 4-wire setting) or are connected in a different way.</td>
</tr>
</tbody>
</table>

Remark: Maximum limits for certain parameters are given in the detailed manuals.

Table 51 gives an overview of the faults that can be reported by the µcontroller.

**Table 51: Overview of the faults that can be reported by the µcontroller**

<table>
<thead>
<tr>
<th>Controller 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 inverter 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>Condition</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------</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 SS dip switches)</td>
</tr>
<tr>
<td>Different firmwares</td>
<td>Different units in a inverter system have different control firmwares</td>
</tr>
<tr>
<td>Int. BMS fault</td>
<td>Fault coming from Battery Monitoring System</td>
</tr>
<tr>
<td>BMS com. watchdog</td>
<td>If the setup where the inverter is communicating with the BMS is chosen,</td>
</tr>
<tr>
<td></td>
<td>the watchdog error can triggered if the communication with the BMS is lost</td>
</tr>
<tr>
<td>BMS not ready</td>
<td>If the setup where the inverter is communicating with the BMS is chosen,</td>
</tr>
<tr>
<td></td>
<td>this error is triggered if the BMS is not answering at the startup of the</td>
</tr>
<tr>
<td></td>
<td>system (power is supplied to the control)</td>
</tr>
<tr>
<td>BMS cont. trip</td>
<td>Trip of the DC contactor</td>
</tr>
</tbody>
</table>

For guidelines on how to troubleshoot and solve the reported problems, refer to Chapter 11.

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

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

In that case, check the cooling of the system (fans, inverters) 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 inverter. Only when an error becomes ‘critical’, a problem may exist.

A fault is considered critical if after occurrence, it cannot be successfully automatically cleared by the system within a reasonable time. The time frame considered depends on the error type.
In practice the word ‘Critical’ will appear in the ‘Event logging’ window if the system has detected a critical error. The user can then backtrack in the logging window to see which errors were already present in the previous events, to know which is/are the critical error(s).

7.10.4 The ‘Active warnings’ menu

The ‘Active warnings’ menu is constantly updated by the system. It shows at any time the warning conditions set up by the customer that are met. For more information on setting up the programmable warnings, refer to Section 7.9.2.4 and the list of possible warning in the detailed manuals.

Table 52 shows an overview of the warning messages that will be displayed and the corresponding warning condition.

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

Table 52: Warning messages that can be displayed by the ESI-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>
<tr>
<td>ESI IGBT temperature higher than preset value</td>
<td>IGBT temperature</td>
</tr>
<tr>
<td>ESI control board temperature higher than preset value</td>
<td>Ctrl over temperature</td>
</tr>
</tbody>
</table>
7.10.5 The ‘Number of errors’ menu

The ‘Number of errors’ menu keeps track of all the errors that have been recorded since the controller system has been initialized at the production stage. The errors that have occurred the most are listed first. Errors that have not occurred are not listed. For an explanation on the errors listed, refer to the Table 50 and Table 51.

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

7.10.6 The ‘ESI operation’

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

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

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

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

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

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

7.11.1 Manufacturer setting

This menu gives basic data on the inverter.

Basic manufacturer settings such as inverter type, maximum voltage rating and inverter serial number. These settings can be accessed in [/Welcome/User Interface/ /Manufacturer set.].

7.11.2 About ESI
These settings can be accessed in [/Welcome/User Interface/About ESI.]

This menu gives basic data on the inverter’s following

Firmware version numbers for the ESI-Manager, the µcontroller and the DSP controller.

**WARNING:** When communicating with your ABB representative on a specific inverter, please provide always the data shown in the ‘About ESI’ menu.

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

### 7.11.3 Screen configuration

These settings can be accessed in [/Welcome/User Interface/Screen Config.]

Two main buttons “Touch Screen Cal” and “Backlighting” allows the user to calibrate the touch screen and adjust the backlighting to the optimal level.

The touch screen calibration is normally not needed in a reasonable use of the screen and in standard environmental conditions.

To prevent loss of the touch screen interface, the possibility is meanwhile given to the user to manually calibrate the XY coordinates necessary to detect button activation.

**Warning:** Touch screen calibration has to be done carefully with a pen or a stylus in order to accurately mark and detect the calibration points!
The backlight adjustment menu sets the default backlight intensity when the touch screen is used. After 10 minutes of touch screen inactivity, the backlight intensity returns to 10%.

7.11.4 Communication

The ESI-Manager provides a variety of communications methods. In this main menu, it includes the settings for Modbus and Ethernet and the MAC and IP addresses. More information regarding the Modbus, USB and TCP/IP protocol and programming, please refer to manual: 2GCS239011A0070_ESI-Manager communication with Modbus RTU, Modbus TCP and PQF-Link protocols.

When the communication is unlocked (see Figure 76), the user can change parameter/setting of the inverter using the ESI-Manager as well as a communication link (e.g. Modbus or TCP/IP based with help of PQF-Link software).
When the communication lock is "checked" (see Figure 77), any change in the inverter parameter or setting is possible ONLY using a communication link (e.g. Modbus or TCP/IP based with help of PQF-Link software). In other words, locking the communication is equivalent to using the hardware lock in the back side of the ESI-Manager.

7.11.4.1 Modbus (RTU)

The slave address is the one used by the Modbus master to address the ESI through Modbus.

Baud rate, Parity, Stop bit shall match exactly the communication settings of the Modbus master which controls the RS485 / Modbus network.
RS485 / Modbus Adapter

The Modbus adapter is an optional device for the inverters which enables the connection of the ESI-Manager to a RS485 Modbus system. The controller is considered as a slave unit in the Modbus network.

Refer to the 2GCS214013A0050 - RS485 adapter- User guide for more information on the RS485 Modbus Adapter.

7.11.4.2 MAC address
This menu displays the ESI physical MAC address.

### 7.11.4.3 Ethernet settings

This menu displays the actual ESI IP address, mask address and gateway IP address. Depending on the DHCP status, the displayed data may be different.

The below screens give the result for the above Example 1 and 2:

**Example 1:** The below screen shows the actual IP address fixed with DHCP disabled.

**Example 2:** The below screen shows the actual settings resulting from the automatic IP address resolution with DHCP enabled.
The ESI-Manager needs an IP address to be connected directly to a PC or to an Ethernet network.

This IP address may be fixed and entered manually if DHCP is disabled. The default address is 192.168.1.40.

In case the IP address is given automatically by a gateway or Ethernet LAN, set DHCP to enable.

Some examples are given below:

Example 1: The below screen shows the default settings to connect directly to a PC (note that the PC need to be configured accordingly with a fixed IP address of 192.168.1.40, Subnet mask of 255.255.255.0, DHCP disabled)

Example 2: The below screen shows the default settings to connect to an Ethernet network (note that the PC which is also connected to the LAN has its own IP address given by the network with DHCP enabled)
Details about the communication settings can be found in the manual: 2GCS239011A0070_ESI-Manager communication with Modbus RTU, Modbus TCP and PQF-Link protocols.

Reboot the ESI-Manager to initialize it with these parameters.

**Ethernet / TCP/IP**

TCP/IP connections can be indifferently initiated locally or remotely.

The TCP port used by default is 4250.

The connection to the ESI-Manager is an RJ 45 Cat5e Ethernet cable.

The ESI-Manager can be connected directly to a LAN or through Internet.

**USB**

The USB interface is used to present the ESI-Manager as a serial interface on its USB port.

The computer is connected through a USB-A male to USB-Mini B male.
Caution: The USB connection to the ESI-Manager is not isolated. It is mandatory to connect the protective EARTH connection when using the USB.

7.11.4.4 IP address
The IP address displayed in Figure 79 indicates the actual (current) IP address prevailing for the ESI-Manager. For example, the factory default setting of the ESI-Manager IP address is 192.168.1.40 which appears in the screen under the menu "IP address". Using the Menu "Ethernet Setting", the user can change this address and when the inverter is reset, the new IP address is copied in the window under menu "IP address".

If the DHCP client is enabled (see Figure 79), the customer's system automatically assigns an IP address to the ESI-Manager, which is visible in the window under menu "IP address". In this case, the IP address in the window under Menu "Ethernet Setting" Menu still remains what the user has set or the factory default value, but has no influence in the communication as the ESI-Manager's IP address is dynamically controlled by customer's communication network.
8 Commissioning instructions

8.1 What this chapter contains

This chapter presents the steps to follow to commission the inverter. The commissioning of your ESI should be conducted in strict accordance with this procedure.

Before applying the commissioning procedure, make sure that you are familiar with:

- The inverter hardware (discussed in Chapter 4)
- The mechanical installation requirements (discussed in Chapter 5)
- The electrical installation requirements (discussed in Chapter 6)
- The ESI programming interface ESI-Manager (discussed in Chapter 7)
- If the Modbus option has been installed, please refer to the document “2GCS212013A0050-RS-485 Installation and Start-up guide” for more information on this item.

The commissioning procedure consists of 9 steps that should be strictly followed.

Table 53: Steps to follow to commission the inverter

<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 inverter 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</td>
</tr>
<tr>
<td>Step 5</td>
<td>Automatic and manual CT detection procedure if CT are connected</td>
</tr>
<tr>
<td>Step 6</td>
<td>Before starting the inverter</td>
</tr>
<tr>
<td>Step 7</td>
<td>Start the inverter</td>
</tr>
<tr>
<td>Step 8</td>
<td>Generate inverter load</td>
</tr>
<tr>
<td>Step 9</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 inverter.
8.2 Step 1: Visual and installation check

**WARNING:** Make sure that the inverter supply is isolated during the visual and installation check. For safety reasons, this must be done upstream of the inverters and before removing the right protective cover. In multi-unit inverters, ensure that all units are disconnected from the supply.

In order to perform a successful installation and commissioning, only the right side of the protective cover of the inverter needs to be removed.

**WARNING:** The left side of the protective cover should not be removed because there are live parts underneath. When the right side of the protective cover is removed, open the auxiliary power fuse holder. Failure to adhere to these guidelines may result in lethal electric shock and/or inverter damage.

**WARNING:** Connect the correct polarity of the battery to the ESI. Wrong polarity of battery may result in severe damage to the inverter and/or battery.

**WARNING:** Make sure that the inverter is installed at a location where no conductive dust is present. Conductive dust when distributed in the inverter panel may lead to equipment failure.

- Check that the mechanical and electrical installation fulfils the requirements described in Chapter 5 and Chapter 6 of this manual.
- Pay attention to the ambient temperature noting the inverter cooling requirements.
- Check visually the condition of the inverter (e.g. for transportation damage).
- Remove the anti-corrosion capsules which are affixed at the inside of the inverter, 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 ESI-Manager and the control board connections inside the inverter.
- Ensure that the feeding cable protection devices are rated appropriately (see Table 22).

8.3 Step 2: Setting the address of each unit in a multi-unit inverter and terminate the CAN bus

Each inverter is defined by an inverter address. This address is by default set to 1.
In a multi-inverter arrangement, the address of each unit has to be set to a unique value. Setting two units in the same system to the same address will lead to a conflict and will inhibit the system from running.

In a system consisting of more than one unit, the inverter with the lowest address will be considered as the first unit in the chain. The inverter with the highest address will be considered as the last unit in the chain:

- In master-slave inverter 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 system, the DIP switch module on the control board has to be set accordingly. Figure 80 shows the location of the DIP switch on the control board (Item 22 in the figure).

The inverter identification DIP switch consists of 4 switches that can be put in low or high position (facing the board with the ABB logo at the top left side). The three left hand DIP switches determine the unit address. Table 54 shows the unit addresses that can be chosen and the corresponding configuration to be set.
Table 54: Possible inverter unit addresses and corresponding DIP switch settings (facing the board with ABB logo at the top), counting low to high.

<table>
<thead>
<tr>
<th>Inverter address</th>
<th>DIP switch 1 setting (ID0)</th>
<th>DIP switch 2 setting (ID1)</th>
<th>DIP switch 3 setting (ID2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>High</td>
<td>Low</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 units in one system will lead to the system not being able to start up and go in error (Bad Ratings)

When a system 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 81 by the black lines interconnecting the different units.

In order to terminate the bus correctly, the fourth switch (counting from left to right) from DIP switch 22 (Cf. Figure 80) has to be set as follows:
- High: For the first unit in a system (single unit or first physical unit of a multi-unit inverter)
- High: For the last physical unit of a multi-unit inverter
- Low: For all the other units

![Communication bus between different units](image-url)
8.4 Step 3: Voltage rating check/adaptation and phase rotation check

- The inverter nominal voltage setting must be adapted to the actual network voltage by adjusting the tab of the auxiliary transformer. Ensure that the inverter panel is isolated upstream before changing the tab of the aux. transformer.

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

Note that in addition to configuring the unit hardware for a certain voltage range, the network voltage also has to be set up in the inverter controller software (commissioning window).

**WARNING:** Applying voltage to the inverter to check the phase rotation may only be done after ensuring that the network voltage level is acceptable for the inverter operation and after it has been found that the inverter is not mechanically nor electrically damaged.

When power is supplied to the inverter terminals, the unit will automatically do a phase rotation check in the master unit. If the phase rotation is wrong the inverter will show the message ‘ACK. FAULT’ on the ESI-Manager ‘Welcome’ screen. The unit will refuse to start and a message indicating wrong phase rotation will be stored in the inverter event log (Cf. Section 7.10.3)

**WARNING:** For safety reasons, when using a phase rotation meter, the phase rotation must be measured at the upstream protection level and not in the inverter 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 inverter arrangement, care must be taken to connect all units to the power supply in an identical way as the master unit (individual phases and phase rotation). Otherwise, the equipment may be damaged upon energization and/or may function incorrectly.

Before going to the next step, it is recommended at this stage to first install the other I/O cabling if required.

Once all the hardware has been cabled,
- Close the auxiliary circuit fuse box
- Refit the unit protective cover including ESI-Manager and its connections
- Close the inverter upstream protection

When the power is applied to the inverter:
- The DC capacitors will be charged
- The ESI-Manager will initialize and show the ‘Welcome’ screen (Cf. Figure 59), or will show a screen indicating that it is in slave mode

If the voltage level or phase rotation is incorrect, the installation should be corrected before applying power to the inverter to avoid potential inverter malfunctioning and/or damage.

### 8.5 Step 4: Basic commissioning parameters set up (using ESI-Manager)

In order to set up the basic commissioning parameters with the ESI-Manager, navigate to [/Welcome/Settings/Commissioning] (Cf. Section 7.9.3). An overview of the main menus of the ESI-Manager is given in Figure 61.

The complete commissioning must be done at the first installation of a system and each time a unit is added to an existing system.

If the window or some of its items are locked (i.e. a small 🗝️ symbol or 🔒 symbol is present on the screen), the hardware and/or software lock has been engaged. Refer to Section 7.6 for more information on these features and for guidelines on how to unlock the unit setting menus.

Note: In systems consisting of more than one master, the ESI-Manager of the master that has the control over the system has full functionality and the ESI-Managers of the other master units have limited functionality. In practice, the functions that are not enabled on these units are also locked.

In the commissioning window, the following basic parameters have to be specified:
- The network characteristics (Cf. Section 7.9.3.1):
The parameters to enter are the nominal network voltage, network frequency and inverter synchronization mode. The inverter synchronization mode shall normally not be changed unless specifically instructed by the ABB service provider.

- The inverter characteristics (Cf. Section 7.9.3.2):

This consists of setting up the inverter 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 inverter, the unit will trip out when started. A ‘Bad Parameters’ fault will be reported in the inverter 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 inverter is installed at locations higher than 1000m / 3300ft or is running under ambient temperature conditions higher than 40°C/104°F, the inverter has to be derated. For more information on how to calculate the derating required and how to enter the derating value, refer to Section 7.9.3.5.

- The battery limitations

According to the specification of the battery, limitations can be set in the inverter control. These limitations are concerning the voltage (battery and cell), temperature (battery and cell) and current (battery).

Remarks:

- Although the user requirements can be set up from the commissioning window this should not be done before the system 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 ESI-Manager, the appropriate software settings have to be made. This has to be done in the ‘Customer settings’ menu ([/Welcome/Settings/Customer set.]). Refer to Section 7.9.2.4 for detailed information on how to set up digital I/O, alarms and warnings. In order to achieve full redundancy with master-master inverters, the digital I/O have to be cabled to all master units and all the ESI-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 inverter functions such as the autorestart feature (after power outage), the inverter standby feature (which stops the IGBTs when the load requirement is low), the system clock, the external communication protocol (Modbus or PC) and the software lock, refer to Section 7.9.4. In order to achieve
full redundancy for the communication features in master-master inverters, this
function has to be cabled to all master units and all the ESI-Managers have to be
set up accordingly.

If the CTs have been set up correctly at this stage or if CTs are not required, 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 (if
required)

WARNING: Do not inverter 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 inverter operation.

Refer to Section 6.9 and Section 6.12 for the CT selection and installation guidelines.

WARNING: Before programming or detecting the CTs, make sure that:
- The CTs have been connected to the inverter CT terminal X21. For multi-units
  configurations all the units of a system have to be supplied with the same CT
  information (daisy chain principle with return path as shown in Figure 47)
- All shorting links in the CT path have been removed (i.e. on the CTs, on the inverter
  CT terminal X21 ...)

CT shorting links are provided with the ESI-S 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 7.9.3.3.

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 inverter 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 inverter.

### 8.6.2 Manual CT detection procedure

Refer to Section 7.9.3.3 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 ESI-S 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 ESI connection diagram

Figure 82 shows the standard connection diagram for the ESI (Cf. Section 7.9.2). It must be noted that:

- L1, L2 and L3 rotation must be clockwise
- The CTs must be on the supply (line) side of the ESI
- The CT monitoring a phase must be connected to the inverter CT terminal dedicated to the same phase
- One secondary terminal of the CT must be earthed

![Figure 82: 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 X21.4 and X21.5 are related to the CT located in phase L2 and terminal X21.7 and X21.8 are related to the CT located in phase L3.
8.6.2.2 Material needed and hypotheses for correct measurements
A two-channel scopemeter with one voltage input and one current input is needed. Adequate probes are also needed. A power analyzer like the Fluke 41B can also be used.

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 ways to check the CT installation manually is to use the waveform displays of the ESI-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 ESI

8.6.2.3.1 Measurement of the CT in phase L1 (Figure 84)
- 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 ESI. 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 85).

Remark: If the earthing of the system is bad, the phase to ground voltage may appear like a much distorted waveform. In this case, it is better to measure the phase-to-phase voltage (move the black clamp to the phase L2) and subtract 30° on the measured phase shift.

![Figure 84: Connection of the scopemeter for checking the CT in phase L1](image)

From the fundamental component of both signals, the phase shift must then be evaluated (Figure 86). The time \( \Delta T \) between zero crossing of the rising (falling) edge of both traces must be measured and converted to a phase shift \( \varphi \) by the following formula:

\[
\varphi = \frac{\Delta T}{T_1} \times 360^\circ
\]

where \( T_1 \) is the fundamental period duration.
For an inductive and non-regenerative load, the current signal should lag the voltage by a phase shift lower than 90°.

![Figure 86: Phase shift evaluation between two waveforms](image)

8.6.2.3.2 Measurement of the CT in phase L2 and L3 (Figure 87 and Figure 88)
The same operations as those described in the previous paragraph must be repeated with the phase L2 (Figure 87) and phase L3 (Figure 88).

For a balanced load (which is usually the case in most of the three phase systems), the phase shift should be approximately the same for all the three phases.

![Figure 87: Connection of the scopemeter for checking CT in phase L2](image)
8.6.2.3.3 Checking the correct connection of the CTs with two current probes

If the main bus bar is available and all security rules are taken, it is possible to use the two-channel scopemeter in order to see if the current measured through the CT is matching the real current in the bus. Connect the current probes as shown on Figure 89. 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 84, Figure 87 and Figure 88.

8.7 Step 6: Before starting the inverter

Before switching the system ON, ensure that:

- The inverter is communicating well with the different components of the system such as the Master Controller System. Verify that all battery information is received by the inverter.
- The battery voltage reported on the ESI-Manager (information coming from the master controller) is matching the real battery voltage
- The protection of the battery is closed
- The battery is ready to start

Before switching the inverter ON, ensure that all features have been deselected.

- For deselecting the active power target, set the target back to zero. [/Welcome/Settings/BESS operation]
- For deselecting all harmonics of the main inverter settings at once go to [/Welcome/Settings/Customer set./Main settings/Deselect all]
- For deselecting all harmonics of the auxiliary inverter settings at once go to [/Welcome/Settings/Customer set./Auxiliary settings/Deselect all]
- For deselecting the reactive power compensation option of the main inverter 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 inverter 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 inverter 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 inverter settings disable the option ‘Balance load’ in
  [Welcome/Settings/Customer set./Auxiliary settings/Aux. PFC/Bal.]

For more information on the main and auxiliary settings concept, refer to Section 7.9.2.1.

In multi-unit system consisting of only masters, the master unit with the lowest address has to be used to control the complete system.

8.8 Step 7: Start the system

Fit the inverter top cover before starting the system.

The ESI-S contains a main contactor that is controlled by the inverter controller.

WARNING: Under no circumstances close the main contactor manually. Failure to adhere to this guideline may result in physical danger and in inverter damage.

In order to start it with the ESI-Manager:

- Press \[x\] repeatedly until the ‘Welcome’ screen is displayed
- Highlight the inverter start/stop menu (‘ESI’ item in the list). In this menu, the ‘START’ indication should be present.
- Press \[\text{OK}\]. The inverter will ask confirmation and then it will start. The main contactor should close within 30 seconds. One second after closing, the IGBTs will start and the inverter will charge the DC capacitors in order to reach the battery voltage. Once it reach it, the inverter will close the DC contactor and will be connected to the battery without power flow.
- The ‘START’ indication in the start/stop menu changes in a ‘STOP’ indication once the inverter is running

Detailed information on the inverter start/stop menu can be found in Section 7.7.

Remarks:

- If the start/stop menu reads ‘ACK. FAULT’ (i.e. ‘acknowledge fault’), the inverter has encountered a fault that needs to be corrected before the inverter can be started. Refer to Chapter 11 for troubleshooting the problem.
- If the inverter when activating the start menu displays a message to indicate that it is remote control mode, the inverter 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 6.14.1 and Section 7.9.2.4.
- If one of the units in a multi-unit inverter system does not switch on, the unit considered is in error. Refer to [/Welcome/ESI Monitoring/Status of modules]) to find out about the problem.
8.9 Step 8: Generate inverter load

Once the system is connected to the supply and is running, the system can start to charge or discharge the battery. Initially a low value can be set which can then be gradually increased to the nominal inverter rating. When power quality features are required, and if 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 inverter’s main harmonics selection go to 
  [Welcome/ Settings/ Customer set./ Main settings/ Main harmonics]
- For setting up the inverter’s auxiliary harmonics selection go to 
  [Welcome/ Settings/ Customer set./ Auxiliary settings/ Aux. Harmonics]

For more information on the main and auxiliary settings concept and on the setting up of harmonics, refer to Section 7.9.2.1.

Once the harmonic is selected, analyze the spectrum of the line currents to see if the selected harmonic is filtered. Refer to Section 7.8.2 for more information on displaying measurement results. If the harmonic is not filtered properly (e.g. if it is amplified), deselect the harmonic and refer to Chapter 11 for troubleshooting the problem.

When harmonic load is not present, the inverter can be tested by generating static reactive power. Initially a low value can be set which can then be gradually increased to the nominal inverter rating.

- For setting up the inverter’s main reactive power feature go to 
  [Welcome/ Settings/ Customer set./ Main settings/ Main PFC/ Bal.]
- For setting up the inverter’s auxiliary harmonics selection go to 
  [Welcome/ Settings/ Customer set./ Auxiliary settings/ Aux. PFC/ Bal.]

Set the ‘PFC Type’ item to ‘Static cap.’ and choose the desired value for the item ‘Q static’.

For more information on the main and auxiliary settings concept, refer to Section 7.9.2.1.

Once the reactive power is selected, analyze the inverter current. Refer to Section 7.8.2 for more information on displaying measurement results. Refer to Chapter 11 in case of problems. Disable the reactive power setting after the test if it is not required by the user.

8.10 Step 9: Set up the user requirements

If everything goes well at this stage, the user requirements for harmonic filtration and reactive power compensation/balancing, if required, can now be set up. Both main and auxiliary settings can be programmed if desired.

By default the inverter is set up to take into consideration the main settings only.

- Select the desired inverter mode
- Select the harmonics and the curve level
- Select the reactive power and balancing settings
Background information on all the items discussed above is given in Section 7.9.2.1.

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

- Inverter running at 100% load while RMS current rating is not attained

Under exceptional conditions it is possible that the inverter is showing a 100% load indication whereas its nominal RMS current rating is not yet attained. This is because the inverter has reached an operating limit other than the RMS current limit. Possible other limits are:

  - Temperature limit due to a too high ambient temperature or a failing cooling system
  - Peak current limit due to an a-typical peak current requirement of the load
  - Peak voltage limit due to an a-typical DC-link voltage requirement of the load or due to a high network voltage

Under all these conditions, the inverter will run in limited mode and may not attain 100% of its nominal current rating.

- Harmonics put in ‘standby’ by the system:

  When selecting a harmonic that has not been selected before, the inverter will identify the network characteristics for this harmonic. After this process, the inverter 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 filtering 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 ESI-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 inverter 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 filtering when the network conditions allow for this.

- If plain capacitors (i.e. capacitor banks not incorporating detuning reactors) are present in the network it is recommended to switch them off or change them into detuned banks. Sometimes, the commissioning engineer is faced with an installation where both an active inverter 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 system should aim to give an optimal performance. For this reason the control software of the inverter incorporates a Stability Detection Program (SDP) that aims to increase the inverter 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 inverter CT measurement location
- Set the inverter 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 55 indicates the harmonics recommended to be deselected for different types of detuned banks.

**Table 55: 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 inverter or inverter but connected downstream of the inverter CTs, inverter resources will be lost. To overcome this, it is recommended to either connect the detuned capacitor bank upstream of the inverter CTs or to use the CT connection approach shown in Figure 90.

![Figure 90: Connection approach for installations where detuned capacitor banks are installed adjacent to the inverter but downstream to the ESI CTs (background distortion present)](image-url)
In installations where active inverters and passive inverters are present, the active inverters must be installed downstream of the passive inverter. If this is not possible, the CT connection scheme of Figure 91 shall be used.

![Diagram](image)

**Figure 91: CT connection guidelines for the case that a passive inverter is installed downstream of the inverter**

Further, when a passive inverter and an active inverter/ESS system are installed on the same bus, it is not recommended to select on the active inverter the harmonics at or below the tuning frequency of the passive inverter. If these harmonics are selected, the SDP function may stop filtering these harmonics temporarily resulting in a reduced overall filtering performance.

In installations where 2 non-compatible masters are connected to the same CT, respect the following guidelines for best performance:

1. Select different harmonics on both units
2. If 1 above is not possible, put one inverter in Mode 1 and the other inverter in Mode 3

Note: ‘Non-compatible” master units are master units that cannot or are not interconnected with the RJ45-communication cable.

Please do not forget to fill in the commissioning report for future reference.

### 8.11 Commissioning report

The commissioning report is designed to help the person in charge of the commissioning.

Before installation and operation of the ESI, read the relevant sections of the Instruction Manual.
### 8.11.1 Inverter identification

<table>
<thead>
<tr>
<th>Inverter type&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Global ratings&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum voltage (V)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total current (A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power rating (kVA)</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>
</tr>
<tr>
<td>Inverter connection mode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3-W or 4-W)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit ratings/ serial number&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rating (A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Article code&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 1 (M)</td>
<td></td>
<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>
</tr>
<tr>
<td>Unit 3 (M/ S)&lt;sup&gt;(d)&lt;/sup&gt;</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>
</tr>
<tr>
<td>Software version&lt;sup&gt;(c)&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESI-Manager software</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>µcontroller software</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSP software</td>
<td></td>
<td></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.

<sup>(c)</sup> After the inverter has been commissioned, navigate with the ESI-Manager to [/Welcome/User interface/About ESI].

<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 inverter after installation

**Ambient conditions**
- Check the ambient temperature (<40°C/104°F) (if >40°C/104°F, derating is required)
- Check the installation altitude (<1000m/3300ft) (if >1000m/3300ft, derating is required)
- Check the ventilation (room and enclosure)
- Ensure that no sources of conductive dust are present

| OK/NOK |
|------------------|---|
| Ambient conditions | |

**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.
- Earth interconnection between the different units installed
- Check cross-section of DC power supply cables
- Check the setting and operation of the protective apparatus
- ESI-S neutral current can be up to 3 times the ESI-S 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 inverter from the supply (disconnection recommended by upstream protection)
- If inverter connected to the supply before, wait for 25 minutes to discharge DC capacitors
- Remove the right side of the protective cover of the inverter. Ensure that the left side of the protective cover is in place. Disconnect ESI-Manager if required.
- Open auxiliary circuit fuse protection box
- DC capacitor voltage low enough to operate safely (DC voltage measurement)
- Change auxiliary transformer primary tap setting to correspond to network nominal voltage rating(b)
- Wiring of main and auxiliary circuit
- Tightness of all electrical connections
- Connectors properly plugged in
- Fixation of components
- Remove anti-corrosion capsules installed at the inside bottom of the inverter (if still present)
- Clearances
- Address of each inverter unit in a multi-unit system set to a different value and ‘main’ master has the lowest address(c)
- CAN bus terminated properly on each unit of a multi-unit system(c)
- CAN bus communication cable between the different units properly installed(c)

**Installation**
- Check the cabling of the digital I/O (if present)
- Check the voltage in accordance with the specification
- Check the phase rotation order (with inverter auxiliaries off) (clockwise)(b)
- Check the polarity of the DC cables
- For multi-unit system, check that the same phases are connected to the same inverter power terminals for the individual units
8.1 Commissioning instructions

- Check visually the current transformers (if installed)
  - Ratio
  - Installed at the right side (feeding-side of the system)
- For multi-unit system, check that the CTs of all units are cabled in a daisy chain fashion with return path
- Remove all jumpers of all current transformers (CTs and SCTs)
- Remove all jumpers of the CT connection terminal(s) X21

Remarks:
(a) Refer to Section 8.2 of the manual for more information on this topic.
(b) Refer to Section 8.4 of the manual for more information on this topic.
(c) Refer to Section 8.3 of the manual for more information on this topic.
(d) Refer to Section 8.6.2.1 of the manual for more information on this topic.

8.11.3 Programming

**Apply voltage to the inverter**
- Close the auxiliary circuit fuse box
- Refit the inverter protective cover including ESI-Manager connection
- Apply voltage to the inverter (restore upstream protection)
- ESI-Manager booting and showing ‘Welcome’ screen (or standby screen on master units running as slave)

**Program equipment**
- Network characteristics
  - Supply voltage (V)
  - Supply frequency (Hz)
  - Synchro mode (should normally not be changed, default value is Single ph.)
- Inverter ratings
  - Connection mode (3-wire or 4-wire)
  - Battery limitations are set according to the battery specification
- CT position and ratio (for first unit)
  - Automatic detection feature used YES/NO
  - Inverter terminal ‘Input 1’ is connected to the CT (including sign)
  - Inverter terminal ‘Input 2’ is connected to the CT (including sign)
  - Inverter terminal ‘Input 3’ is connected to the CT (including sign)
  - Ratio of CT installed in line L1 (R, U)
  - Ratio of CT installed in line L2 (Y, V)
  - Ratio of CT installed in line L3 (B, W)
- CT position and ratio for other units of a multi-unit system is ok?
- Rating factor (temp > 40°C/104°F or altitude > 1000m/3300ft or...)
  - Rating (%)
- Configure digital inputs if applicable
  - For full redundancy, configure/ cable digital inputs on all masters of a multi-master system
- Configure digital outputs if applicable
  - For full redundancy, configure/ cable digital outputs on all masters of a multi-master system
- Configure programmable warnings if applicable
  - For full redundancy, configure programmable warnings on all masters of a multi-master system
8.11.4 Testing (with load)

Before starting the inverter

- Set the power target to zero
- Deselect all harmonics and reactive power/ balancing

Start the inverter

- Fans start running

While the inverter is running

- Charge and discharge the battery
- If harmonic load is present, select for example the 11th harmonic
- Check the line current (Irms, 11th harmonic level and waveforms)
- If harmonic load is not present, generate static capacitive power (first select H3)
- Check the inverter currents (fundamental current level)

Set up the user requirements for harmonics and reactive power/ balancing

- Check the line currents (Irms, THDI and waveforms)
- Check the line voltage (Vrms, THDV and waveforms)

Remarks:

(a) Refer to Section 8.7 of the manual for more information on this topic.
(b) Refer to Section 8.8 of the manual for more information on this topic.
(c) Refer to Section 8.9 of the manual for more information on this topic.
(d) Refer to Section 8.10 of the manual for more information on this topic.
### 8.11.5 Programmed parameters

#### Activate
- Main
- Auxiliary
- Ext. Input

#### ESS functions
- Islanding mode
- Black start
- 3ph individual control

#### Inverter mode
- Main settings: 1 2 3
- Auxiliary settings: 1 2 3

#### Reactive power compensation

<table>
<thead>
<tr>
<th>Main settings (Main PFC/Bal.)</th>
<th>Auxiliary settings (Aux. PFC/Bal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFC type</td>
<td>PFC type</td>
</tr>
<tr>
<td>Disabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>Static ind.</td>
<td>Static ind.</td>
</tr>
<tr>
<td>Q static (kvar)</td>
<td>Q static (kvar)</td>
</tr>
<tr>
<td>Static cap.</td>
<td>Static cap.</td>
</tr>
<tr>
<td>Q static (kvar)</td>
<td>Q static (kvar)</td>
</tr>
<tr>
<td>Target cos φ</td>
<td>Target cos φ</td>
</tr>
<tr>
<td>Target cos φ</td>
<td>Target cos φ</td>
</tr>
<tr>
<td>Balance load</td>
<td>Balance load</td>
</tr>
<tr>
<td>Disabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>L-L</td>
<td>L-L</td>
</tr>
</tbody>
</table>

#### Harmonics

<table>
<thead>
<tr>
<th>Main settings (Main PFC/Bal.)</th>
<th>Auxiliary settings (Aux. PFC/Bal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. Order</td>
<td>Selected</td>
</tr>
<tr>
<td>1</td>
<td>YES</td>
</tr>
<tr>
<td>2</td>
<td>YES</td>
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<td>3</td>
<td>YES</td>
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<td>4</td>
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<td>5</td>
<td>YES</td>
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<td>6</td>
<td>YES</td>
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<td>7</td>
<td>YES</td>
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<td>8</td>
<td>YES</td>
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<tr>
<td>9</td>
<td>YES</td>
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<td>10</td>
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<tr>
<td>14</td>
<td>YES</td>
</tr>
<tr>
<td>15</td>
<td>YES</td>
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</tbody>
</table>
## Alarms

<table>
<thead>
<tr>
<th>Prog. alarms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prog. alarm 1</td>
<td></td>
</tr>
<tr>
<td>Prog. alarm 2</td>
<td></td>
</tr>
<tr>
<td>Prog. alarm 3</td>
<td></td>
</tr>
<tr>
<td>Alarm delay</td>
<td></td>
</tr>
<tr>
<td>Alarm rst del.</td>
<td></td>
</tr>
</tbody>
</table>

## Warnings

<table>
<thead>
<tr>
<th>Warning levels</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T IGBT warn.</td>
<td></td>
</tr>
<tr>
<td>T ctrl war.</td>
<td></td>
</tr>
<tr>
<td>V. min. warn.</td>
<td></td>
</tr>
<tr>
<td>V. max. warn.</td>
<td></td>
</tr>
<tr>
<td>Imbalance</td>
<td></td>
</tr>
<tr>
<td>Ground fault</td>
<td></td>
</tr>
</tbody>
</table>

## Prog. warnings

| Prog. warn. 1 |  |
| Prog. warn. 2 |  |
| Prog. warn. 3 |  |
| Warning delay |  |
| Warn. rst del.|  |

## Digital Inputs

| Dig. In 1 |  |
| Dig. In 2 |  |

## Digital Outputs

| Dig. Out 1 |  |
| Dig. Out 2 |  |
| Dig. Out 3 |  |
| Dig. Out 4 |  |
| Dig. Out 5 |  |
| Dig. Out 6 |  |

## Start-Stop set.

| Stdby status |  |
| Standby level |  |
| Stdby del off |  |
| Standby hyst |  |
| Stdby del con |  |
| Auto start |  |
| Auto st. del. |  |

## Communication

| Protocol |  |
| Modbus   |  |
| Baud rate |  |
| Parity   |  |
| Stop bit |  |
| Slave Address |  |
| Modbus lock |  |
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 energy storage inverter. It is assumed that the inverter has been installed and commissioned correctly (cf. previous chapters). The following operations are discussed:

- Starting and stopping the inverter
- Description of the different features:
  - Active and reactive power target
  - Low Voltage Ride Through
  - Islanding
  - Black start (optional)
  - Individual power control (optional)
- Modifying the user requirements
- Changing the system temperature unit
- Consulting inverter measurements
- Consulting inverter statistics and manufacturer data
- Inverter behavior on faults – retrieving error information

Note that in the context of this manual, the ESI-Manager is used to operate the inverter. Background information on the ESI-Manager can be found in Chapter 7.

Alternative ways to operate the inverter are:

- Using the optional PQF-Link software. Refer to the ‘PQF-Link installation and user’s guide’ for more information on this subject
- Using Modbus RTU or TCP-IP communication. Refer to document “2GCS212013A0050-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 inverter enclosure. Do not operate the unit with the protective panels removed. Do not touch any inverter parts unless you have ascertained that they do not carry dangerous voltage levels.
9.2 Starting and stopping the inverter

The ESI-S contains a main AC contactor and a DC contactor that are controlled by the inverter controller. These contactors should never be activated manually for normal inverter operation.

**WARNING:** Under no circumstances close the AC and DC contactor manually. Failure to adhere to this guideline may result in physical injury and/or in inverter damage.

Normally, the commissioning engineer has set up the inverter and the desired inverter requirements. As a result, the user only has to start and stop the inverter. Detailed information on the inverter start/stop menu can be found in Section 7.7.

9.2.1 Starting the inverter with the ESI-Manager

In order to start the inverter with the ESI-Manager follows the instructions given below:

- Ensure that power is supplied to the system and that the inverter auxiliaries are ‘on’ (auxiliary fuse holder contains good fuses and is closed)
- Press on the ESI-Manager repeatedly until the ‘Welcome’ screen is displayed
- Highlight the inverter ‘start/stop’ menu (‘ESI’ item in the list). In this menu, the ‘START’ indication should be visible.
- Press . The system will ask confirmation and then it will start. The main AC contactor should close within 30 seconds and one second after closing, the IGBTs will start. The inverter will increase its DC voltage in order to reach the battery voltage then it will close the DC contactor. This operation may take up to 30 sec. After this operation the system is ready to charge or discharge the battery.
- The ‘START’ indication in the ‘start/stop’ menu changes in a ‘STOP’ indication once the inverter is running

Remarks:

- If the ‘start/stop’ menu reads ‘ACK. FAULT’ (i.e. ‘acknowledge fault’), the inverter has encountered a fault that needs to be corrected before the system can be started. Refer to Chapter 11 for troubleshooting the problem. In systems consisting of more than one unit, an ACK. FAULT message will only occurs when all the masters in the system have failed.
- In systems consisting of more than one master, one master unit is the main one and the other units behave as slaves. The ESI-Manager of the main master unit has full functionality and can be used to control the complete system. If the main master unit fails, then another master unit will assume the role of main master...
unit. The order in which master units assume control has been determined at the moment of commissioning.

- If some units of a multi-unit system do not start, this implies that the units concerned are in error. Refer to [Welcome/ ESI Monitoring/ Status of module] to identify the unit that is at fault and for which reason. Refer to Chapter 11 for troubleshooting the problem.

- If the inverter when activating the start menu displays a message to indicate that it is remote control mode, the inverter 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 6.14.1 and Section 7.9.2.4.

- If the hardware lock and/or the Communication lock has/have been engaged, the inverter cannot be started nor stopped. In order to see which lock(s) has/have been engaged push the button 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 ESI-Manager. More information on the inverter menu locking facilities is given in Section 7.6.

  - The Communication lock can be engaged in the menu [/Welcome/ User interface/ Communication] by ticking the “check box”. More information on the Communication lock is available in the document “2GCS212013A0050-RS-485 Installation and Start-up guide”.

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

Controller running, DC capacitors charging

Start the system

DC capacitors preload check

Close the AC contactor, fans are running

Start IGBT's

Charge DC capacitors to battery voltage

DC voltage = battery voltage?

Y

Close DC contactor

System in idle

N

Figure 92: inverter start-up sequence when power is applied and the start command is given

In Figure 92 it may be seen that:

- The DC capacitors charge as soon as the auxiliary circuit power is switched on.
- The start-up sequence consists of the DC capacitors voltage check, the closure of the inverter AC contactor, the start of fan and the starting of the IGBTs.
- If harmonics mitigation feature is activated, the 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 inverter was removed before or when new harmonic components have been selected. The network identification may also be done automatically during normal inverter operation if the inverter controller has noted a big change of network impedance.
- At the end of the start-up procedure, the inverter will work as programmed.

Remark: if power quality features are enabled and the inverter running at 100% load while RMS current rating is not attained.
Under exceptional conditions it is possible that the inverter is showing a 100% load indication whereas its nominal RMS current rating is not yet attained. This is because the inverter has reached an operating limit other than the RMS current limit. Possible other limits are:

- Temperature limit due to a too high ambient temperature or a failing cooling system
- Peak current limit due to an a-typical peak current requirement of the load
- Peak voltage limit due to an a-typical DC-link voltage requirement of the load or due to a high network voltage

Under all these conditions, the inverter will run in limited mode and may not attain 100% of its nominal current rating.

9.2.2 Stopping the inverter with the ESI-Manager

In order to stop the system with the ESI-Manager follows the instructions given below:

- Press \[ \text{X} \] on the ESI-Manager repeatedly until the ‘Welcome’ screen is displayed
- Highlight the inverter ‘start/stop’ menu (‘ESI’ item in the list). In this menu, the ‘STOP’ indication should be present.
- Press \[ \text{OK} \]. The inverter will ask confirmation and then it will stop. The main contactor will open.
- The ‘STOP’ indication in the start/stop menu changes in a ‘START’ indication once the inverter is stopped

Remarks:

- If the ‘start/stop’ menu reads ‘ACK. FAULT’ (i.e. ‘acknowledge fault’), the inverter has encountered a fault. Refer to Section 9.8 and Chapter 11 for troubleshooting the problem.

**WARNING:** In case the inverter 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 inverter.

- If the inverter when activating the stop menu displays a message to indicate that it is remote control mode, the inverter 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 6.14.1 and Section 7.9.2.4.
If the hardware lock and/or the Communication lock has/have been engaged, the inverter 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 \[\text{OK}\] 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 ESI-Manager. More information on the inverter menu locking facilities is given in Section 7.6.
- The Communication lock can be engaged in the menu [/Welcome/ User interface/ Communication] by ticking the “check box”. More information on the Communication lock is available in the document “2GCS212013A0050-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]

*Figure 93: inverter operation sequence when no fault is present*

The DC bus incorporates discharge resistors that can discharge the DC bus in 25 minutes once the supply is open.

### 9.3 Modifying the user requirements

#### 9.3.1 Active and reactive power targets

Power targets (P and Q) can set soon as the system is connected to the battery. The sign convention is described in the table below. Since the inverter is defined in kVA, both
active and reactive powers can be set together, the PQ diagram is shown in Figure 94. The variation (3 circles) is explained by the tolerance on the network voltage.

If the individual power control is enabled (optional), the different set points can be applied independently on each phase. However, the inverter has to be set in 4W mode.

<table>
<thead>
<tr>
<th>Active power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge</td>
</tr>
<tr>
<td>Discharge</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reactive power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductive</td>
</tr>
<tr>
<td>Capacitive</td>
</tr>
</tbody>
</table>

![Figure 94 PQ diagram]

As shown in Chapter 8 the target of the active power can be or in kW on the AC side or in kW on the DC side.

To set the active power target on the ESI-manager:

- Press \[ \text{on the ESI-Manager repeatedly until the 'Welcome' screen is displayed} \]
- Press the inverter ‘Settings’ menu .In this menu press on ‘Battery operation’
- In this menu, the window shows 1 empty box where the set point in kW
- If the individual power control is enabled, 3 different set points can be set

**9.3.2 Low Voltage Ride Through (LVRT)**

The curve that applies for the ESI-S is described in the Figure 2.

Different parameters can be set on the ESI-Manager (see Chapter 7). For this functionality an UPS is required.
9.3.3 Islanding

The islanding is the capability for the ESS to work as the voltage generator for the loads on the island. 3 different phases are defining this feature: going to the islanding mode, working in islanding and resynchronize the island on the network voltage.

9.3.3.1 Description of island setup

The island is constituted by a voltage and by loads and power generators such as wind turbines, solar panels... as shown on Figure 95. The island is physically disconnected thanks to a switch from the supply. This avoid any issue when the supply is back because both voltages are not synchronized.

![Figure 95 Island setup](image)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC voltage measurement</td>
</tr>
<tr>
<td>2</td>
<td>Islanding contactor/switch (not provided)</td>
</tr>
</tbody>
</table>

The inverter ESI-S has to be correctly connected to work in islanding: the islanding contactor has to be driven by the ESI and the grid voltage has to be rightly measured by the inverter (see Chapter 6).
9.3.3.2 Going to the islanding mode

When the unit connected to the network grid, the ESS is charging or discharging the battery based on the request. If the user requests to switch to the islanding mode, it can be done on the ESI-Manager:

- Press \( \text{on the ESI-Manager} \) repeatedly until the ‘Welcome’ screen is displayed.
- Press the inverter ‘Settings’ menu. In this menu press on ‘BESS operation’.
- In this menu, the window shows the status of the system: ‘Unit connected to grid’. Press on \( \text{Go to islanding state} \) to switch to the Islanding mode.
- Once the system is in islanding the system status is: ‘Islanding: Unit is in islanding state’.
In case of voltage outage, the inverter will detect it and stop for safety reason. The user or the main controller as to command the inverter to switch into islanding mode.

9.3.3.3 Working in islanding mode
When the inverter is in islanding mode, it is working as a voltage generator. The voltage controls the magnitude of each phase separately. The current is generated as requested by the loads/generation plants.

Active protections in islanding:
- Linked to inverter:
  - Max. AC current: if the inverter reach a higher current than the nominal value, the system stops.
  - Max THDV: if it is higher than 20% (at the inverter connection), the system stops.
- Linked to battery:
  - Max DC current: if the current flowing in the battery is higher than the current allowed by the Battery Management System, the system stops.
  - Max/ min State Of Charge (SOC): if the battery reach the limit max SOC and the min SOC set during the commissioning, the system stops
  - Max/ min voltages (battery and cell): if the battery reach the limits set during the commissioning the system stops.
  - Max/ min temperatures (battery and cell): if the battery reach the limits set during the commissioning the system stops.

9.3.3.4 Resynchronization of the island
If the user or the main controller system is requesting to leave the islanding mode, the inverter will resynchronize the island on the network voltage thanks to the voltage measurement (see 1 on Figure 95). The resynchronization may take up to 20 sec.

Once the voltage is synchronized, the inverter closes the islanding contactor/switch and active the power control.

If the user requests to leave to the islanding mode, it can be done on the ESI-Manager:
- Press \[X\] on the ESI-Manager repeatedly until the ‘Welcome’ screen is displayed
- Press the inverter ‘Settings’ menu. In this menu press on ‘BESS operation’
- In this menu, the window shows the status of the system: ‘Unit in islanding. Press \[Go to islanding state\] to switch to the Islanding mode.
- Once the system is in islanding the system status is: ‘Unit connected to grid’
9.3.4 Black Start (optional):
Black start is the functionality that allows the system to start when network voltage is not present. As described in Section 6.10 an UPS (Uninterruptible power supply) is required to supply the auxiliaries.

The system will be ready to start if the black start functionality is activated in settings menu:

- Press on the ESI-Manager repeatedly until the ‘Welcome’ screen is displayed
- Press the inverter ‘Settings’ menu. In this menu press on ‘BESS operation’
- Hit the radio button to activate the black start functionality.

If the black start functionality is activated, the system will start on request from the user, as for the normal start, the following steps have to be followed on the ESI-Manager:

- Press on the ESI-Manager repeatedly until the ‘Welcome’ screen is displayed
- Highlight the inverter ‘start/stop’ menu (‘ESI’ item in the list). In this menu, the ‘START’ indication should be visible.
- Press . The system will ask confirmation and then it will start. The main AC contactor should close within 30 seconds and one second after closing, the IGBTs will start. The inverter will increase its DC voltage in order to reach the battery voltage then it will close the DC contactor. This operation may take up to 30 sec. After this operation the system is ready to charge or discharge the battery.
- The ‘START’ indication in the ‘start/stop’ menu changes in a ‘STOP’ indication once the inverter is running.

The system will start by charging the DC capacitors up to the battery voltage thanks to the additional box. Then it will close the DC switch and start the IGBT’s. Once the right network voltage is generated by the inverter, the ESI-S close its AC contactor and supply the island.

Once the system is generating the network voltage, it will work as in islanding.

9.3.5 Individual power control (optional):
The individual power control consists to have specific set points (active power and reactive power) per phase. This functionality is only working in 4W connection (cf Sections 6.8.1 and 6.8.2).

Once the system is started, the set points can be set by the ESI-Manager:

- Press on the ESI-Manager repeatedly until the ‘Welcome’ screen is displayed
- Press the inverter ‘Settings’ menu. In this menu press on ‘BESS operation’
In this menu, the window shows 6 empty box where the set points in kW and kVar can be set per phases.

9.4 Modifying the user requirements

Providing that the inverter locks have not been engaged, the user can change the customer settings to better suit his needs. These settings can be accessed in the ESI-Manager menu [/Welcome/ Settings/ Customer set.].

The user requirements can be divided into the following categories:

- Setting up the inverter mode, the harmonic requirements and the reactive power and balancing requirements. Refer to Section 7.9.2.1 for detailed information on these topics.
- Setting up alarms, warnings and digital I/O. The digital I/O allows configuration of the inverter to operate in remote control mode etc. Refer to Section 7.9.2.4 for detailed information on these topics.

Advanced user requirements have to be set up in the ‘installation settings’ menu (/Welcome/ Settings/ Installation set.). These advanced functions include:

- the autorestart function (after power outage)
- the standby function to switch off the IGBTs when the load requirement is low
- the system clock setup
- the software lock activation and password setup for inverter protection purposes

Refers to Section 7.9.4 for detailed information on these topics.

It is recommended that the advanced functions be set up by a skilled commissioning engineer.

9.5 Changing the system temperature unit and ESI-Manager backlighting

If desired the system temperature unit can be changed from °C to °F or vice versa. This is done in [/Welcome/ Settings/ Customer set./ Temp unit].

In addition, the ESI-Manager backlighting can be changed in [/Welcome/ User interface/ Screen config./ Backlighting]. Calibration of touch screen can also be done here.

In systems consisting of more than one master, this needs to be done in all the ESI-Managers.

9.6 Consulting inverter measurements

In order to consult the measurements done by the inverter system, go to [/Welcome/ Measurements].

The complete list of measured items is discussed in Section 7.8.
9.7 Consulting inverter statistics and manufacturer data

In order to consult the inverter statistics, go to [/Welcome/ESI Monitoring]. This menu allows to monitor the inverter load and to get an idea of its operating point compared to the nominal rating of the inverter. In addition, logged warnings, faults and events can be retrieved for troubleshooting the inverter operation and any abnormal network conditions. Also, an indication is given of fan running hours and inverter running hours.

The ‘ESI Monitoring’ menu can also be used to verify the status of the individual units in a multi-master units system.

The ‘ESI Monitoring’ menu is discussed in depth in Section 7.10.

In order to obtain background manufacturer data on your ESI, go to [/Welcome/User interface/About ESI]. This menu gives basic data on the inverter. This data includes:

- Basic manufacturer settings such as inverter type, maximum voltage rating and ESI-S serial number. These settings can be accessed in [/Welcome/User interface/About ESI]
- Firmware version numbers for the ESI-Manager, the µcontroller and the DSP controller

When communicating with your ABB representative on a specific inverter, please provide always the data shown in the ‘About ESI’ menu.

9.8 Inverter behavior on fault - retrieving error information

Under normal conditions the inverter is either running or stopped and the ESI-item in the ESI-Manager ‘Welcome’ screen shows the message ‘START’ or ‘STOP’. In this case, if the inverter 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/ESI 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 inverter 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 inverter 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 ESI-item in the ESI-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 inverter, when running, may either:
- Stop (open the main contactors (AC and DC)) and await user intervention. In this condition the alarm contact of the ESI-Manager will switch on after a programmable delay and the ‘Armed’ indicator will be OFF. The green LED on the main controller board (Cf. Table 13 item 18, LED 2) will be off and the red LED on (Cf. Table 13 item 18, LED 3). The user has to acknowledge the fault (with the ESI-Manager via Modbus or PQF-link or via remote control) before the inverter can be restarted.

- By default, the ‘Armed’ indicator is associated with the fourth digital output contact (cf. Table 9 and Table 10) The digital output contact monitor at the top of the ESI-Manager display (Cf. Figure 68 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 6.14.4).

- Stop (open the main contactor) and restart automatically if the fault disappears. If stopped, the alarm contact of the ESI-Manager will switch on after a programmable delay and the ‘Armed’ indicator will be ON. The green LED on the main controller board (Cf. Table 13 item 18, LED 2) will be ON and the red LED will be OFF (Cf. Table 13 item 18, LED 3). If it takes a long time before the fault disappears, the user may decide to give an inverter stop command. This is done by highlighting the ‘ESI ACK. FAULT’ item in the ‘Welcome’ menu and selecting . After this, the ‘Armed’ indicator will be OFF. The green and red LED on the main controller board (Cf. Table 13 item 18, LEDs 2 and 3) will be OFF too.

- Stop briefly without opening the main contactor and continue to run 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 inverter 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 inverter will refuse to start; The ‘Armed’ indicator on the ESI-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 inverter. Only when an error becomes ‘critical’, a problem may exist.

If ‘ACK. FAULT’ is present on the ESI-Manager display, look at the ‘Armed’ indicator (By default mapped to the 4th digital output of the ESI-Manager) to know whether the inverter will restart automatically after clearance of the problem or not.

- ‘Armed’ indicator ON: The inverter waits for the problem to disappear and then restarts automatically (unless the user acknowledges the fault).
- ‘Armed’ indicator OFF: The inverter is permanently stopped and the customer has to solve the problem, acknowledge the fault and restart the system manually.

If the inverter is in remote control operation and the message ‘ACK. FAULT’ is present on the ESI-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 inverter.
10 Maintenance instructions

10.1 What this chapter contains

This chapter contains the maintenance instructions for the inverter. Although your ESI-S 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 inverter panel. Do not touch any inverter parts unless you have ascertained that they do not carry dangerous voltage levels.

**WARNING:** Under no circumstances close the DC and AC contactor manually. Failure to adhere to this guideline may result in physical injury and/or in inverter damage.

10.2 Maintenance intervals

Table 56 lists the routine maintenance intervals. Depending on the operating and ambient conditions, the intervals of Table 56 may have to be reduced. Announced intervals assume that the equipment is operating under ABB approved operating conditions (Cf. Chapter 12).

*Table 56: inverter maintenance intervals*

<table>
<thead>
<tr>
<th>Maintenance Procedure</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 years for the “fan in” (35000 hours)</td>
<td>Section 10.4</td>
</tr>
<tr>
<td></td>
<td>Every 3 years for the “fan out” (27000 hours)</td>
<td></td>
</tr>
<tr>
<td>DC capacitor change</td>
<td>Every 8 years for 3-wire connection.</td>
<td>Section 10.5</td>
</tr>
<tr>
<td></td>
<td>Every 5 years for 4-wire connection.</td>
<td></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 inverter 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 inverter derating factor (Welcome/Settings/Installation set./Rating) corresponds to the ambient conditions observed. If the ambient temperature is higher than 40°C/104°F, the ESI-S should be derated (Cf. Section 5.2).

10.3.2 Step 2: Record the inverter operating status
- With the inverter running, check and note the inverter load graphs (Welcome/ESI Monitoring/unit 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 inverter 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 ESI-Manager screen will be on if the inverter is limiting its output current due to temperature problems. By default, the ‘T Limit’ indicator is assigned to digital output 6 of the ESI-Manager.
- Make a note of the ESI-operation hours (Welcome/ESI monitoring/ESI operation) and the fan-operation hours (Welcome/ESI Monitoring/Fan operation)). For units up to 60A, if the fan operation indicator shows a multiple of 40000 hours, it is recommended that the fan be replaced. For units with higher ratings than 60A, if the fan operation indicator shows a multiple of 35000 hours (for “fan in”) or 27000 hours (for “fan out”), it is recommended that the fan be replaced (Cf. Section 10.4). Pay attention to any noise that could indicate fan failure.
- Browse the ‘event logging’ menu (Welcome/ESI 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/ESI monitoring/Number of errors)]
- Inspect the inverter visually for any condition that could indicate an abnormal inverter stress (e.g. abnormal noises, abnormal appearance/colour or components and cables)
- Note: In systems consisting of more than one master, the above parameters can be reviewed for the different units.

10.3.3 Step 3: Shut the system down
- Switch the inverter off and remove the power supply to the system.
- Wait for at least 25 minutes to allow for the DC capacitors to discharge.
- Remove the inverter cover panel (right hand side). Pay attention to the ESI-Manager connections.
10.3.4 Step 4: Inspect and clean the inverter
- Inspect the inverter visually for any condition that could indicate an abnormal inverter stress (e.g. abnormal appearance/colour of components and wires)
- Remove all dust deposits in and around the unit. Pay special attention to the fan and the heatsink. Indeed, the heatsink picks up dust from the cooling air and the ESI might run into overtemperature faults if the heatsink is not cleaned regularly. Pay special attention to this item if the inverter 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 card is free of dust. If necessary remove dust from it with a soft brush.

10.3.5 Step 5: Check the condition of the unit contactors and fuses
- Ensure that the AC and DC 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 unit.

10.3.8 Step 8: Restart the system
- Reclose the auxiliary circuit fuse box.
- Refit the inverter protective cover and reconnect the ESI-Manager if necessary.
- Reapply power to the system upstream. Verify that the ESI-Manager is booting.
- Restart the inverter, verify that the fan starts running. If major servicing work has been done it is recommended to follow the commissioning instructions (cf. Chapter 8) for restarting the inverter.
- Verify the inverter performance.
10.4 Fan replacement

There are different types of fans present in your ESI-S unit, depending on the inverter rating. The cooling fan lifespan is between 3 and 6 years typically, depending on the usage and ambient temperature. Check the actual fan operating hours with the ESI-Manager (welcomes/ESI monitoring/ESI 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 cooling fans, follow the instructions below (Cf. Figure 96):

- Ensure that the power to the inverter is switched off (upstream).
- Wait for at least 25 minutes to allow for the DC capacitors to discharge.
- Remove the cover on the right hand side of the ESI-S and disconnect the fan terminals (at the bottom of the inverter next to the IGBT bridge for the “fan in” and on the top right of the PCB for the “fan out”).
- Remove the screws that fix the fan set to the inverter enclosure (4 screws on the bottom left side of the ESI-S for the “fan in” and 8 screws on the top right side for the “fan out”).
- Remove the fan assembly from the enclosure.
- Refit the assembly in the unit. Ensure proper fixation by the screws.
- Reconnect the fan wires to the terminal block.
- Reclose the inverter cover.

![Figure 96: Overview of cooling fan in](image)

![Figure 97: Overview of cooling fan out](image)

The components description is given in Table 57.
10.5 DC capacitor change

The inverter DC link contains electrolytic DC capacitors. Their lifespan is up to 8 years when the inverter option ‘line to neutral balancing’ is not used and up to 5.5 years when the full capacity of the inverter is used for line to neutral balancing. This data assumes that the inverter 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 inverter has been non-operational for more than one year, the DC capacitors must be reforming (re-aged) before use. Without reforming, the DC capacitors may be damaged at start-up.

Stocked or non-operational units should be reforming once a year. The method described here assumes that the inverter is stocked in a clean and dry environment.

To reform the capacitors,

- Switch on the power supply to the inverter without starting the inverter for about 2 hours. Verify with the ESI-Manager the DC capacitor voltage and ensure that it is charged to a couple of hundred volts.
- Then, with all features deselected, start the system and leave it running for one hour
- The inverter is now ready for normal operation

If the inverter 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 system.
### 10.7.1 Inverter identification

<table>
<thead>
<tr>
<th>Inverter type&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global ratings&lt;sup&gt;(a)&lt;/sup&gt;</strong></td>
<td></td>
</tr>
<tr>
<td>Maximum voltage (V)</td>
<td></td>
</tr>
<tr>
<td>Total current (A)</td>
<td></td>
</tr>
<tr>
<td>Power rating (kVA)</td>
<td></td>
</tr>
<tr>
<td><strong>System serial number&lt;sup&gt;(a)&lt;/sup&gt;</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Inverter connection mode</strong></td>
<td>(3-W or 4-W)</td>
</tr>
<tr>
<td><strong>Unit ratings/ serial number&lt;sup&gt;(b)&lt;/sup&gt;</strong></td>
<td>Rating (A)</td>
</tr>
<tr>
<td>Unit 1 (M)</td>
<td></td>
</tr>
<tr>
<td>Unit 2 (M/ S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Unit 3 (M/ S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Unit 4 (M/ S)&lt;sup&gt;(d)&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>Software version&lt;sup&gt;(c)&lt;/sup&gt;</strong></td>
<td>ESI-Manager software</td>
</tr>
<tr>
<td></td>
<td>µcontroller software</td>
</tr>
<tr>
<td></td>
<td>DSP software</td>
</tr>
<tr>
<td><strong>Installation location</strong></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 inverter has been commissioned, navigate with the ESI-Manager to [/Welcome/User interface/ About ESI].

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

### Ambient conditions and derating condition (inverter running)

- Check the ambient temperature (< 40°C/104°F) (if > 40°C/104°F, derating is required)
- Check the installation altitude (< 1000m/3300ft) (if > 1000m/3300ft, derating is required)
- Check the ventilation (room and enclosure)
- Ensure that no conductive dust is present in and around the inverter enclosure
- Rating factor (temperature >40°C/ 104°F or altitude >1000m/3300ft)
  - Rating (%)

### Inverter operating status record (inverter running)

- Inverter load graphs
  - Vdc load (%)
  - Ipeak load (%)
  - Irms load (%)
  - Temp (%)
- Inverter 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 inverter cooling.

- ESI operation hours
- Fan operation hours
  - If fan operation hours are multiple of 40000 hrs for units up to 60A and of 35000 hrs / 27000 hrs for units with higher ratings, exchange fan.
- Event logging window
  - Abnormal events present? (Y/ N)
  - If ‘Y’, describe them in the ‘comments’ section of this report.
- Total number of faults recorded by the system
  - Describe them in the ‘comments’ section of this report.

### Shut down the inverter, remove supply to the unit

Wait for 25 minutes for DC capacitors to discharge

Remove the inverter protective cover (right hand side) and open the auxiliary fuse box

- Ensure that components do not carry dangerous voltage levels anymore.

### Inspect and clean the inverter

- 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 inverter (fans, heatsinks, control board, …)
- Remove loose components if present in enclosure
### Condition of inverter contactors and fuses
- DC and AC contactors can move freely? (Y/N)
- Fuses are OK? (Y/N)

If 'N', describe the problems in the ‘comments’ section of this report.

### Tightness of electrical and mechanical connections
- Check tightness of all electrical connections
- Check the mechanical fixation of all components
- Retighten connections/fixations if necessary

### Correct the outstanding problems

**Reclose the auxiliary fuse box and refit the inverter protective cover**

**Reclose the inverter upstream protection**

**Restart the system**
- ESI-Manager booting
- DC capacitors charging

**Start the inverter**
- Fan(s) start(s) running

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

### 10.7.3 Special service actions

**Fan replacement**
- Fan operating hours?

**DC capacitor replacement**
- Inverter operating hours?
- Ambient inverter conditions?
- Describe in the ‘comments’ section of this report.

**DC capacitor reforming**
- Inverter storage time?
- Reforming time?
- Describe in the ‘comments’ section of this report.
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 inverter. The 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 inverter enclosure. Do not open the panel and touch any inverter parts unless you have ascertained that they do not carry dangerous voltage levels.

WARNING: Under no circumstances close the DC and AC contactors manually. Failure to adhere to this guideline may result in physical injury and/or in inverter damage.

WARNING: Some checks may have to be made with the supply on and the inverter 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 inverter event log and are analyzed by the inverter controller. The event log is of the circular type and can store up to 200 events. It can be accessed through [/Welcome/ESI Monitoring/Event logging]. Background information on the event logging display is given in Section 7.10.3.

A fault can either be non-critical or critical.

- A non-critical fault is a transient fault (e.g. a voltage spike). When a non-critical fault occurs the inverter 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 inverter 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 ESI item in the ESI-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 inverter, when running, may either:

- Stop (open the DC and AC contactors) and await user intervention. In this condition the alarm contact of the ESI-Manager will switch on after a programmable delay and the ‘Armed’ indicator will be OFF. The user has to acknowledge the fault (with the ESI-Manager, via Modbus via PQF-link or via remote control) before the inverter can be restarted.

- By default, the ‘Armed’ indicator is associated with the fourth digital output contact (cf. Table 9 and Table 10) The digital output contact monitor at the top of the ESI-Manager display (Cf. Figure 59 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 6.14.4)

- Stop (open the main contactor) and restart automatically if the fault disappears. In this condition the alarm contact of the ESI-Manager will switch on after a programmable delay and the ‘Armed’ indicator will be ON. If it takes a long time before the fault disappears, the user may decide to give a inverter stop command. This is done by highlighting the ‘ESI ACK. FAULT’ item in the ‘Welcome’ menu and selecting . After this, the ‘Armed’ indicator will be OFF.

- Stop briefly without opening the contactors and continue running 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 inverter 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 inverter will refuse to start. The ‘Armed’ indicator on the ESI-Manager will be OFF.

When pressing ‘ACK. FAULT’ the inverter will display a message relevant to the problem. It also shows a list of the most recent critical faults that have been recorded.

Remark: If the inverter is in remote control operation and the message ‘ACK. FAULT’ is present on the ESI-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 98 shows the error treatment procedure in flowchart format.
Critical fault?

YES

Display ‘ACK_FAULT’ on PQF-Manager

NO

- Stop and restart IGBTs (fast)
- Reinitialize controller
- Carry on as before

Number of critical errors acceptable?

YES

Filter stop awaiting manual fault clearance
- Switch on alarm (after programmable delay)
- Keep on ‘Armed’-indicator and
  green LED

NO

- 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?

NO

Switch off alarm
(after programmable delay)

‘Armed’-indicator on?

YES

NO

Fault disappeared?

YES

Switch off ‘Armed’-indicator

NO

‘Armed’-indicator on?

NO

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 LED2 on the main controller board and is ‘Armed’-indicator on PQF-Manager
- Red LED is LED3 on the main controller board
In general the occurrence of transient faults is no problem for the proper operation of the energy storage inverter. Only when an error becomes ‘critical’, a problem may exist.

If ‘ACK. FAULT’ is present on the ESI-Manager display, look at the ‘Armed’ indicator (By default mapped to the 4th digital output of the ESI-Manager) to know whether the inverter will restart automatically after clearance of the problem or not.

‘Armed’ indicator ON: The inverter waits for the problem to disappear and then restarts automatically (unless the user acknowledges the fault).

‘Armed’ indicator OFF: The inverter is permanently stopped and the customer has to solve the problem, acknowledge the fault and restart the inverter manually.

### 11.3 Spare part list for normal and dedicated inverter servicing

A standard set of spare parts for the ESI-S inverter is shown in Table 58.

**Table 58: Standard set of spare parts for normal and dedicated inverter 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>Spare fuses for pre load circuit</td>
<td>2GCA113178A0420</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>ESI-Manager controller</td>
<td>2GCA294781A0079</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Assy cooling “fan in” ESI-S (30-100A)</td>
<td>2GCA294292A0075</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Assy cooling “fan in” ESI-S (120 A)</td>
<td>2GCA294290A0075</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Assy cooling “fan out” ESI-S (30-60A)</td>
<td>2GCA294201A0075</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Assy cooling “fan out” ESI-S (70-120A)</td>
<td>2GCA293805A0075</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Control board</td>
<td>2GCA292310A0075</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Power supply V24 I8.4 SP-200-24 ESI-S</td>
<td>2GCA112450A0530</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>PCB EMC - OUTPUT INVERTER ESI-S</td>
<td>2GCA112522A0580</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>PCB EMC LINE ESI-S</td>
<td>2GCA113067A0580</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>PCB EMC NEUTRAL ESI-S</td>
<td>2GCA113068A0580</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>PCB EMC NEUTRAL LINE OUT FILT PRÉL ESI-S</td>
<td>2GCA113070A0580</td>
<td>1</td>
</tr>
</tbody>
</table>

### 11.4 Troubleshooting guide

#### 11.4.1 Verification of the ESI-Manager status and the system LEDs

As a first phase of troubleshooting make a record of the information provided by the ESI-Manager:

- ‘ACK. FAULT’ message present of not
- Inverter 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 61 and Table 62 for an overview of the possible messages and the corresponding troubleshooting tips. Note that for troubleshooting it may be necessary to remove the inverter right protective cover. Always remove power to the units and allow time for the DC capacitors to discharge (min. 25 minutes) before removing the inverter cover.

When the inverter right cover is removed and power is supplied again to the inverter, the status of the control card LEDs can be monitored.

- Main controller board LEDs:

  Figure 18 (items 18 and 19) can be used to locate the main controller board LEDs
  Table 13 (items 18 and 19) explains the meaning of the LEDs and their status for normal operation

**WARNING:** Only apply power to an inverter without protective cover if there is no physical damage in the inverter panel. Failure to adhere to this guideline may result in physical injury or death.

Provide the data provided by the ESI-Manager and the LED status information to the ABB service provider when discussing a potential inverter problem.

### 11.4.2 Fault tracing

*Table 59: Power supply problems*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>No display on ESI-Manager. All the indicator LEDs on the electronic</td>
<td>The inverter (auxiliaries) is/ are not energized or no power supplied</td>
<td>– Check if the protection (fuses, disconnector ...) feeding the inverter</td>
</tr>
<tr>
<td>cards (LEDs) remain OFF.</td>
<td>to the inverter.</td>
<td>are OK.</td>
</tr>
<tr>
<td></td>
<td>– Check if the auxiliary fuse box is closed and the fuses are OK.</td>
<td>– Check the mains and auxiliary supply voltages.</td>
</tr>
<tr>
<td></td>
<td>– Check the mains and auxiliary supply voltages.</td>
<td></td>
</tr>
<tr>
<td>No display on ESI-Manager. All the indicator LEDs on the electronic</td>
<td>The auxiliary transformer is not set according to the network voltage.</td>
<td>– Check the selection of the tap on the auxiliary transformer.</td>
</tr>
<tr>
<td>cards (LEDs) are functioning properly.</td>
<td></td>
<td>– Check the supply voltage to see that it is within the tolerance range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of the nominal inverter settings.</td>
</tr>
<tr>
<td>After applying auxiliary power to the system, the ESI-Manager shows</td>
<td>The 24 Vdc power supply feeding the controller board has failed or the</td>
<td>– Check the 24 V power supply feeding the control boards.</td>
</tr>
<tr>
<td>the message ‘Initializing communication. Please wait... none of the</td>
<td>cabling between the power supply and main controller is loose or main</td>
<td>– Check the feeding cable between the main power and the 24 V power</td>
</tr>
<tr>
<td>LEDs of the main controller board is functioning.</td>
<td>controller board faulty.</td>
<td>supply.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Check the feeding cable between the control boards and the 24 V power</td>
</tr>
<tr>
<td></td>
<td></td>
<td>supply.</td>
</tr>
</tbody>
</table>
### Table 60: 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 ESI-Manager shows ‘ACK, FAULT’ and gives error message ‘Bad parameters’.</td>
<td>The inverter parameters entered by the commissioning engineer are not consistent with the inverter configuration reported by the controller.</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 inverter is stopped due to an unacceptably high number of critical errors. | - Check the inverter event log to analyze the critical errors. Refer to Table 61 to know what to do in order to solve the problem reported.  
  - After resolving the problem, the fault has to be acknowledged and the inverter 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 inverter event log to analyze the critical errors. Refer to Table 61 to know what to do in order to solve the problem reported. Most likely the controller board has to be replaced.  
  - After changing the main controller board, the inverter has to be recommissioned. |

### Table 61: Fault messages reported by the DSP controller of the inverter 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 inverter parameters entered by the commissioning engineer are not consistent with the inverter configuration reported by the controller.</td>
<td>Check the commissioning parameters and correct where necessary. (Cf. Chapter 8)</td>
</tr>
<tr>
<td>Bad message sequence</td>
<td>Internal system error</td>
<td>Contact your ABB service provider. Most likely the controller software has to be upgraded or the main controller card 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>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 inverter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check that the CTs are not shorted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check that the overall CT ratio (including summing CTs) is smaller than 20000/5.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check flat cable connections between the Control Board and the IGBT module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Analyze network voltage stability (amplitude and phase).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Disable all features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Deselect the high frequency components to free DC bus resources and to see if the problem persists.</td>
</tr>
<tr>
<td>DC overvoltage (HW)</td>
<td>The DC hardware overvoltage protection has been triggered.</td>
<td>- Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check flat cable connections between the Control Board and the IGBT module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Analyze network voltage stability (amplitude and phase).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Disable all features</td>
</tr>
<tr>
<td>DC undervoltage (SW)</td>
<td>The DC software undervoltage protection has been triggered.</td>
<td>- Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check flat cable connections between the Control Board and the IGBT module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Analyze network voltage stability (amplitude and phase).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Disable all features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the main contactor and its control signal.</td>
</tr>
<tr>
<td>DC undervoltage (HW)</td>
<td>The DC hardware undervoltage protection has been triggered.</td>
<td>- Check the connection between the DC voltage measurement connectors (P6-5 and P6-7) and the DC capacitors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check flat cable connections between the Control Board and the IGBT module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Analyze network voltage stability (amplitude and phase).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Disable all features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the main contactor and its control signal.</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>IGBT check cooling</td>
<td>The software IGBT temperature protection has been triggered.</td>
<td>- Check the cooling of the inverter system (fans and air flow, heatsink).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the cooling of the location where the inverter is installed (air conditioning system etc.).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ensure that the correct derating factor is applied noting the ambient temperature and altitude.</td>
</tr>
<tr>
<td>IGBT permanent</td>
<td>The IGBT module reports an error that cannot be cleared by the system. The error can be due to peak overcurrent, too low control voltage for the IGBT drivers or IGBT module failure.</td>
<td>- Identify unit for which the red LED (3) is on.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Inspect the corresponding IGBT module (bridge and DC capacitors) for 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 significantly lower, check the 24 V power supply and the wiring between 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 cleared by the system. The error can be due to peak overcurrent or a too low control voltage for the IGBT drivers.</td>
<td>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):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Verify that the inverter 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 commissioning stage corresponds to the rating and order physically present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Verify the inverter cooling system and check the IGBT-temperature using the ESI-Manager.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Desactivate All features</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>
<tr>
<td>Loss of phase</td>
<td>The system has detected a loss of supply on at least one phase.</td>
<td>- Measure the three line voltages and check if they are within limits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Measure the line voltages (e.g. voltmeter) and compare them with the line voltages given by the inverter (ESI-Manager or PQF-Link).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the AC voltage measurement connectors (P6-1to and P6-4) for loose connections and component damage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the connections between the auxiliary fuses and the AC voltage measurement connectors (P6-1to and P6-4).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the inverter parameters (Cf. Chapter 8).</td>
</tr>
<tr>
<td>Mismatch between units</td>
<td>Different units in an inverter system have different ratings or different connections (e.g. 3-wire and 4-wire).</td>
<td>- Recommission the inverters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- If recommissioning does not solve the problem, contact your ABB service provider.</td>
</tr>
<tr>
<td>No synchronization</td>
<td>The system cannot synchronize on to the network.</td>
<td>- Measure the network frequency and its variation, and check if they are within limits.</td>
</tr>
<tr>
<td></td>
<td>The supply frequency has changed too much or too fast.</td>
<td>- Check the phase rotation (only in case of modification at the installation).</td>
</tr>
<tr>
<td></td>
<td>No/low voltage measured during inverter initialization.</td>
<td>- Ensure that the AC voltage is properly measured. Do the checks discussed for the ‘Loss of phase’ fault.</td>
</tr>
<tr>
<td></td>
<td>Wrong frequency set up</td>
<td>- Verify that the frequency set up at the commissioning stage corresponds to the frequency of the network. (Cf. Chapter 8).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Reset the system by powering off and on again.</td>
</tr>
<tr>
<td>Out of mains freq.</td>
<td>The system has detected that the network frequency is out of range.</td>
<td>- Measure the network frequency and check if it is within limits.</td>
</tr>
<tr>
<td>Limit</td>
<td></td>
<td>- Check the phase rotation (only in case of modification at the installation).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 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>Overvolt. Transient</td>
<td>The software transient network overvoltage protection has been</td>
<td>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):</td>
</tr>
<tr>
<td>(SW)</td>
<td>triggered.</td>
<td>- 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Measure the RMS value of the network voltage and compare with the line voltages given by the inverter (ESI-Manager or PQF-Link).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ensure that the AC voltage is properly measured. Do the checks discussed for the ‘Loss of phase’ fault.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check the earthing of the unit.</td>
</tr>
<tr>
<td>Overcurrent RMS</td>
<td>The system has detected RMS overcurrent in the inverter.</td>
<td>- Verify that the inverter 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 commissioning stage corresponds to the rating and order physically present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Verify the inverter cooling system and check the IGBT temperature using the ESI-Manager.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Deactivate all features</td>
</tr>
<tr>
<td>Overcurrent peak</td>
<td>The software peak current protection has been triggered.</td>
<td>- Verify that the inverter CTs are properly installed and are not shorted.</td>
</tr>
<tr>
<td>(SW)</td>
<td></td>
<td>- Verify that the unit current ratings and order programmed at the commissioning stage corresponds to the rating and order physically present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Verify the inverter cooling system and check the IGBT temperature using the ESI-Manager.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Deactivate all features</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>Overvoltage RMS</td>
<td>The RMS value of the supply voltage measured with the AC voltage measurement board is higher than the acceptable maximum value.</td>
<td>– Measure the three line voltages and check if they are within limits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Measure the line voltages (e.g. voltmeter) and compare them with the line voltages given by the inverter (ESI-Manager or PQF-Link).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Ensure that the AC voltage is properly measured.</td>
</tr>
<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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Verify the fuses (PF1 and PF2) and the rESI-Stors (R1 and R2) of the preload circuit (A001).</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>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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Measure the line voltages (e.g. voltmeter) and compare them with the line voltages given by the inverter (ESI-Manager or PQF-Link).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Ensure that the AC voltage is properly measured. Do the checks discussed for the ‘Loss of phase’ fault.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Measure the line voltages (e.g. voltmeter) and compare them with the line voltages given by the inverter (ESI-Manager or PQF-Link).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Check the phase rotation (only in case of modification at the installation).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– 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>
</tbody>
</table>
| Wrong phase rotation  | The supply network feeding the inverter has the wrong phase rotation. | – Check the phase rotation of the inverter 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 inverter (ESI-Manager or PQF-Link).  
– Check the AC voltage measurement connectors (P6-1to and P6-4) for loose connections and component damage.  
– Check the connections between the auxiliary fuses and the AC voltage measurement connectors (P6-1to and P6-4). |
| Global BESS fault     | An error appeared during a BESS application (islanding)            | A limit on the battery or on the inverter has been reached. Since the system is in islanding, it stopped. The limitation can be on the battery current, cell voltage, cell temperature or on the inverter current. |

Remark:
If the problem persists, contact your ABB service provider. Provide him with all the relevant information, i.e. Inverter serial number and type, status of the control LEDs, Error messages displayed and inverter behavior.

Table 62: Fault messages reported by the μcontroller of the inverter and troubleshooting tips

<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
</table>
| Com. Problem (RS-232) | Communication problem between the main controller board and the external PC | – Ensure that the PQF-Link cable is properly connected.  
– Contact your ABB service provider. |
| Ctrl overtemperature  | The system detected an overtemperature of the main controller board. | – Verify the ambient temperature and the cooling of the inverter (dust inverters, fans, heatsinks, ...)  
– If the ambient conditions and the inverter cooling are ok, the main control board is suspect. Contact your ABB service provider. The main control board may have to be replaced. |
<p>| Reactor overtemperature| Line reactor thermal switch has open                                 | Check the status of the reactors and the PCB output inverter                                                                                                                                               |
| PWM check cooling     | The thermal switch in the PWM reactor has open                       | Check the “fan out” status                                                                                                                                                                                 |</p>
<table>
<thead>
<tr>
<th>Fault message</th>
<th>Cause</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSP watchdog</td>
<td>Internal system error</td>
<td>Reset the inverter 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>SPI Timeout</td>
<td>Internal system error</td>
<td>Reset the inverter 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>Power supply fault</td>
<td>Internal system error</td>
<td>Reset the inverter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced.</td>
</tr>
</tbody>
</table>
| Preload time-out               | The DC capacitors could not be charged. | – Measure the three line voltages and check if they are within limits.  
- Verify the fuses (PF1 and PF2) and the resistors (R1 and R2) of the preload circuit (A001).  
- Inspect the DC-bus for traces of damage that may have caused a short circuit on the DC-side of the IGBT-module or on the DC voltage measurement board. |
| Several units same id          | Two or more units in an inverter system have the same CAN_ID. | – Check the CAN_ID of the different units in the set of inverters: each unit has to have one unique CAN_ID on the DIP switch S5-1 to S5-3.  
- Reset the inverter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced. |
| Com. Problem (CAN Bus)         | The communication through the CAN bus between units is not working properly. | – Check the RJ-45 cables between modules.  
- Check the termination for the CAN bus: both (and only) the ends of the bus must have the DIP switch S5-4 in the “set” status.  
- Reset the inverter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced. |
| Real time clock problem        | Internal system error        | Reset the inverter by switching off and on the power. If the problem persists, contact your ABB representative. The controller card must probably be replaced. |
| Watchdog fault                 |                              |                                                                            |
| Internal µC fault              |                              |                                                                            |
| Corrupted DSP code             |                              |                                                                            |
| Corrupted µC code              |                              |                                                                            |
### Fault message

<table>
<thead>
<tr>
<th>Different firmwares</th>
<th>Different units in an inverter system have different firmware version (DSP or microcontroller)</th>
<th>Upgrade all the units with the same (most recent) firmware. In the ESI-Manager menu, go to “About ESI\Code update” item.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int. BMS fault</td>
<td>Fault coming from Battery Monitoring System</td>
<td></td>
</tr>
<tr>
<td>BMS com. watchdog</td>
<td>If the setup where the inverter is communicating with the BMS is chosen, the watchdog error can triggered if the communication with the BMS is lost</td>
<td>Check if the BMS is supplied</td>
</tr>
<tr>
<td>BMS not ready</td>
<td>If the setup where the inverter is communicating with the BMS is chosen, this error is triggered if the BMS is not answering at the startup of the system (power is supplied to the control)</td>
<td>Check if the BMS is supplied</td>
</tr>
<tr>
<td>BMS cont. trip</td>
<td>Trip of the DC contactor</td>
<td>Check if DC contactor/switch is fine (control and main contact)</td>
</tr>
</tbody>
</table>

**Remark:**
If the problem persists, contact your ABB service provider. Provide him with all the relevant information, i.e. Inverter serial number and type, status of the control LEDs, Error messages displayed and inverter behavior.

*Table 63: Other inverter indications and behavior with corresponding troubleshooting tips*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause / State</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>The inverter is working at 100% of its nominal capacity in harmonics filtering because the load requirement is asking this.</td>
<td>The harmonic stress on the network is still too high. The harmonic stress on the network is sufficiently low. The load requirement is only a fraction of the inverter size.</td>
<td>Install additional inverter units to reduce the stress further. The inverter can be kept running in this condition.</td>
</tr>
<tr>
<td>The inverter is working at 100% of its nominal capacity in harmonics filtering while the load is only at a fraction of the inverter rating.</td>
<td>There is a problem in the CT connections or a hardware problem.</td>
<td>Check the CT installation (CT location, CT shorts, …) Check the connection between the CT terminal block X21 and the main controller terminals P5-1..P5-6. Measure the line currents (e.g. ammeter) and compare them with the line currents given by the inverter (ESI-Manager or PQF-Link).</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>There is a software problem.</td>
<td>Stop the inverter, switch off the power of the auxiliaries and switch it on again. Restart the inverter and see if the problem is solved. If the problem persists, contact your ABB service provider.</td>
<td></td>
</tr>
<tr>
<td>The inverter is running but it is unstable (oscillating behavior)</td>
<td>There is a problem in the CT connections or a hardware problem</td>
<td>– Check the CT installation (CT location, CT shorts, ...)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Check the connection between the CT terminal block X21 and the main controller terminals P5-1...P5-6.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Measure the line currents (e.g. ammeter) and compare them with the line currents given by the inverter (ESI-Manager or PQF-Link).</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 inverter is installed on a very weak network.</td>
<td>Make sure that the inverter 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>Interconnect the units with an RJ-45 cable. If this is not possible:</td>
<td>– Select different harmonics on both inverters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– If not possible, ensure that one inverter is operating in Mode 1 and the other inverter is operating in Mode 3.</td>
</tr>
<tr>
<td>When selecting a harmonic, the inverter 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Reselect the harmonic to see if the problem persists.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Leave the harmonic in standby. The inverter will automatically restart identifying/filtered it when another harmonic component is successfully (re)identified.</td>
</tr>
<tr>
<td>The ‘ACK. FAULT’-message is present on the ESI-Manager and inverter working in blackstart</td>
<td>Blackstart option is not selected</td>
<td>Follow instructions to setup the inverter to operate in blackstart mode before starting the inverter.</td>
</tr>
</tbody>
</table>
## Symptom

The ‘ACK. FAULT’-message is present on the ESI-Manager. The alarm contact switches on after some delay.

## Cause / State

The inverter has stopped due to an error.

## What to do

- Acknowledge the fault to see a list of most recent critical errors.
- Look in the inverter event log for more information on which errors have occurred.
- Refer to the Table 61 and Table 62 for more information on these errors and for guidelines on how to troubleshoot them.

### Remark:

If the problems persist, contact your ABB service provider. Provide him with all the relevant information, i.e. inverter serial number and type, status of the control LEDs, error messages displayed and inverter behavior.
12 Technical specifications

12.1 What this chapter contains

This chapter contains the technical specifications of the inverter ESI-S.

12.2 Technical specifications

The ESI-S is an inverter 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 64: Technical Specifications

<table>
<thead>
<tr>
<th>Installation location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indoor installation on firm foundation mounted in a clean environment</strong></td>
</tr>
<tr>
<td>Altitude</td>
</tr>
<tr>
<td>Minimum temperature</td>
</tr>
<tr>
<td>Maximum temperature</td>
</tr>
<tr>
<td>Recommended maximum average temperature (over 24 h)</td>
</tr>
<tr>
<td>Relative humidity</td>
</tr>
<tr>
<td>Contamination levels (IEC 60721-3-3)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Vibration (IEC 60068-2-6)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Shock (IEC 60068-2-27)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inverter installation information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of protection</td>
</tr>
<tr>
<td>Dimensions per power unit enclosure (appr.)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Weight per power unit enclosure (unpacked)</td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Mechanical installation</td>
</tr>
<tr>
<td>Cable entry method</td>
</tr>
<tr>
<td>CT requirements</td>
</tr>
<tr>
<td>Airflow requirements</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Network characteristics

Battery voltage range
- 585-830 V\(_{DC}\) at 400 V\(_{AC}\) (3-phase)
- 120-830 V\(_{DC}\) at 240 V\(_{AC}\) (single-phase)

Network voltage range
- 208 V-240 V or 380 V-415 V between phases

Network voltage tolerance
- +/- 10 %

Network frequency
- 50 Hz or 60 Hz

Network frequency tolerance
- +/- 5 %

Maximum rate of frequency variation
- 20%/s

Maximum phase jump of network voltage
- 30°

Network voltage distortion
- Maximum 20% phase to phase

Minimum network fault level
- 1 MVA

Voltage notch limits
- No voltage notches allowed.

Line voltage imbalance
- Maximum 5% of phase to phase voltage

Insulation voltage (U\(_i\))
- 415 V

Auxiliary circuit voltage
- 230 Vrms

Neutral connection systems (if any)
- IT, TT, TNC and TNS. Earth current protection type and sensitivity must be chosen appropriately.

Environment class
- 2

Compliance with standards

IEEE 1547 (pending)

General construction aspects
- EN-61439-1 (ed. 2.0)

EMC immunity
- EN/IEC 61000-6-2, Industrial level

EMC emissions
- EN/IEC 61000-6-4

Inverter characteristics

RMS output current per power unit type\(^{(a)}\) (50Hz or 60Hz network).

\(\bar{n}\) Power ratings at 400Vac
- Unit type 1: 20 kW
- Unit type 2: 30 kW
- Unit type 3: 40 kW
- Unit type 4: 50 kW
- Unit type 5: 55 kW
- Unit type 6: 60 kW
- Unit type 7: 70 kW
- Unit type 8: 85 kW

\(\bar{n}\) Neutral current ratings
- 3 times the current ratings limited to 300 A for ESI-S 120 A

Equipment losses
- 3% of the equipment rated power typically

Modularity
- Up to 4 power units/inverter (power units must have same rating).
- One power unit per enclosure.
| **Redundancy** | Power units can be master or slave type  
For full redundancy combine master units of same rating.  
If any unit in a master-master inverter 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 inverter system fails, the other units can keep running.  
If the master in a master-slave inverter system fails, the complete system stops running. |
|---|---|
| **Harmonics that can be filtered** | 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. |
| **Degree of filtered efficiency** | Harmonics that can be filtered  
Programmable per harmonic in absolute terms  
Better than 97% of inverter rating typically |
| **Reaction time** | <500 μs |
| **Response time** | P and Q: 200-500 ms  
40 ms typically (10% - 90% filtered) |
| **Reactive power** | Static/ dynamic  
Power factor programmable from 0.6 (inductive) to 0.6 (capacitive) |
| **Load balancing** | Off  
Phase to phase, phase to neutral (if neutral present), both (if neutral present) |
| **Setting possibilities** | Main and auxiliary settings functionality.  
Three possible inverter modes that allow to set different priorities |
| **Start and stop settings** | Local/ remote control functionality.  
Inverter standby functionality.  
Auto restart after power outage functionality |
| **Digital inputs** | 2 multipurpose digital inputs on ESI-Manager.  
Vlow: 0 Vdc, Vhigh: 15-24 Vdc, driving current: 13 mA@24Vdc (Rint =1.88 kΩ).  
Can be used to implement remote control functionality, start/ stop buttons and switching between main and auxiliary settings. |
| **Digital outputs** | 6 multipurpose (NO) digital outputs on ESI-Manager.  
Maximum continuous ac rating: 440 Vac/ 1.5 A  
Maximum continuous dc rating: 110 Vdc/ 0.3 A  
Common rating: 9A/ terminal, totaling 18 A |
Can be used to monitor the inverter state (e.g. inverter on/off or specific inverter warnings/alarms) and the network state.

**Alarm contact**

A universal alarm contact with two complimentary outputs (NO/NC) on ESI-Manager. Triggered by any fault. Maximum continuous rating: 250 Vac/ 1.5 A

<table>
<thead>
<tr>
<th><strong>Inverter losses</strong></th>
<th><strong>Typical values</strong></th>
<th><strong>Maximum values</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>n Unit rating: 30 A</td>
<td>1.2 kW</td>
<td>1.5 kW</td>
</tr>
<tr>
<td>n Unit rating: 45 A</td>
<td>1.5 kW</td>
<td>1.7 kW</td>
</tr>
<tr>
<td>n Unit rating: 60 A</td>
<td>1.9 kW</td>
<td>2.1 kW</td>
</tr>
<tr>
<td>n Unit rating: 70 A</td>
<td>2.2 kW</td>
<td>2.4 kW</td>
</tr>
<tr>
<td>n Unit rating: 80 A</td>
<td>2.3 kW</td>
<td>2.7 kW</td>
</tr>
<tr>
<td>n Unit rating: 90 A</td>
<td>2.5 kW</td>
<td>3.0 kW</td>
</tr>
<tr>
<td>n Unit rating: 100 A</td>
<td>2.7 kW</td>
<td>3.2 kW</td>
</tr>
<tr>
<td>n Unit rating: 120 A</td>
<td>3 kW</td>
<td>3.7 kW</td>
</tr>
</tbody>
</table>

**Phase to earth resistance**

> 1 MΩ/inverter unit

**Noise intensity at one meter**

- 30A - 60A: 65.3 dBA typically
- 70A - 100A: 68.4 dBA typically
- 120A: 70.9 dBA typically

**Communication**

Through ESI-Manager display.
Through Modbus RTU (with optional RS485 Modbus Adapter).
Through Modbus TCP (with Ethernet).
Through dedicated optional software PQF-link (with USB-Ethernet)

**Programming**

Through ESI-Manager display.
Through USB-Ethernet 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

**Main options**

- PQF-Link software
- RS 485 Modbus adapter
- Easy connection box for power cables
- Cable extension kit for ESI-Manager

**Remark:**

(a) Under exceptional circumstances other limits may be reached before the RMS current limit (e.g. temperature limit, peak current limit, peak voltage limit).
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