Read this manual carefully before starting to install the battery system.
Keep these instructions for future reference.
Important Safety Instructions

Read and follow these instructions!

The following precautions are intended to ensure your safety and prevent property damage. Before installing this product, be sure to read all safety instructions in this document for proper installation.

<table>
<thead>
<tr>
<th>Safety Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DANGER</strong></td>
<td>Failure to comply with the instructions with this symbol may result in a serious accident, causing death or a severe injury.</td>
</tr>
<tr>
<td><strong>WARNING</strong></td>
<td>Failure to comply with the instructions with this symbol may result in a serious accident, causing a severe injury.</td>
</tr>
<tr>
<td><strong>CAUTION</strong></td>
<td>Failure to comply with the instructions with this symbol may result in minor or moderate injury.</td>
</tr>
<tr>
<td><strong>NOTICE</strong></td>
<td>Provides information considered important but not hazard-related. The information relates to property damage.</td>
</tr>
</tbody>
</table>

**Important**
Indicates valuable tips for optimal installation and operation of the product.
Important Safety Instructions

General Instructions

Please be aware that a battery presents a risk of electrical shock including high short-circuit current. Follow all safety precautions while operating the batteries.

- Remove watches, rings, and other metallic accessories.
- Use tools with insulated handles in order to avoid inadvertent short circuits.
- Wear rubber gloves and safety boots.
- Do not put tools or any metal parts on the top of the batteries.
- Disconnect charging source and load before connecting or disconnecting terminals.
- Use proper lifting means when moving batteries and wear all appropriate safety clothing and equipment.
- Batteries must be handled, transported and recycled or discarded in accordance with federal, state, and local regulations. Do not dispose of the batteries in a fire because they can explode.
- Do not open or mutilate the batteries.
- Only authorized, trained technicians should perform annual preventive maintenance.
- Only qualified personnel who are familiar with the batteries and safety precautions should perform installation or maintenance of the battery.
- Do not allow unauthorized personnel to contact the batteries.

Safety Precautions

The following precautions provide general safety guidelines that should be followed when working with or near the Energy Storage System (ESS). Complete safety parameters and procedures are site-specific and should be developed by the customer for the installation site.

- Review and refer to all safety warnings and cautions in this manual before installation.
- Build a clear, permanent, restricted access area around the system.
- Only authorized, adequately trained electrical operators should be able to access the system.

The interior design of this equipment must be considered a “no-go area except for non-qualified personnel who are familiar with the batteries and safety precautions,” depending on the location. Consult local codes and applicable rules and regulations to determine permit requirements. If required, mark enclosures appropriately before beginning work.
Important Safety Instructions

Personnel and Equipment Warnings

Personnel in contact with the battery system should be aware of the following hazards:

**WARNING—SHOCK HAZARD**
Do not contact system connectors or terminals. Do not open the enclosure doors unless proper lock out/tag out procedures and related trainings are followed in accordance with the local codes and regulations.

**WARNING—ARC FLASH HAZARD**
There is an arc flash hazard associated with all electrical equipment. There is a serious risk of arc flash relating to any equipment modification (e.g. opening doors). Serious injuries can occur in arc flash incidents. Appropriate training is required in accordance with local codes and regulations.

**WARNING—FIRE HAZARD**
Fire may occur under certain fault conditions.

**CAUTION—PINCH POINTS**
Multiple pinch-points are present in most system components. Be aware that there is a serious risk of injury while working around and in equipment enclosures.

**CAUTION—STATIC SENSITIVE**
Electronic appliances can be damaged by electrostatic discharge. Proper handling procedures are required. Be sure to wear a grounded anti-static wrist strap and to discharge static electricity by touching a grounded surface near the equipment before touching any system components.

Dangerous Voltages

**DANGER**
The ESS is powered by multiple power sources. Hazardous voltages may be present in the equipment even when it does not appear operational. Make sure that you completely understand the cautions and warnings in this installation manual. Failure to do so may result in serious injury or death. Follow all manufacturer-published safety procedures.

Electrical equipment can present a risk of electrical shock and can cause arc flash. The following precautions must be observed when working on or around electrical equipment:

- Remove watches, jewelry, rings, and other metallic objects.
- Use tools with insulated handles.
- Safety clothing and shoes must comply with local codes and regulations.
Lock Out/Tag Out Guidelines

DANGER
Follow all applicable lock out/tag out procedures at all times. Failure to follow proper lock out/tag out procedures may result in serious injury or death.
With power applied to the ESS, hazardous voltages are present on some components. To prevent accidental death or injury, do not touch any components within the enclosure unless you are specifically directed to do so. To reduce the risk of electrical shock, make sure that all equipment is properly grounded. For more information, refer to 3.1 Grounding the Battery System.

WARNING
Enclosure doors must remain closed except when access to the enclosure interior is required. If possible, personnel should keep a safe distance from enclosures whenever the equipment is energized. Always comply with local, state, and national lock out/tag out guidelines when working with or near the ESS. The lock out/tag out procedures must meet or exceed the requirements of all guidelines presented in SAMSUNG SDI safety documentation. Before entering potentially hazardous areas or beginning work on the ESS, complete the following tasks:

- Identify and wear protective clothing and shoes.
- Identify and isolate all power and stored energy sources.
- Apply appropriate lock out/tag out devices. When applying lock out/tag out to the ESS, do not touch anything within the enclosure except as specifically directed in the work procedures.
- Complete the site-specific lock out/tag out procedures and safety checklist before beginning work.

General Warnings

DANGER
When energized, this equipment presents a potential hazard of electric shock, death, and burn. Only authorized personnel who are thoroughly familiar with the equipment and adequately trained should install, operate, or maintain this equipment.

DANGER
To avoid death, personal injury, or damage to the product, follow all safety procedures as regulated by Environmental Health and Safety (EHS) guidelines.

DANGER
To minimize the hazards of electrical shock, death, and burns, approved grounding practices and procedures should be strictly followed.

WARNING
To avoid personal injury and damage to equipment, personnel must adhere to the site protocol concerning working at heights.

WARNING
To avoid personal injury or equipment damage caused by equipment malfunction, only adequately trained personnel should modify any programmable machine.

WARNING
Always ensure that applicable standards and regulations are followed and only properly certified equipment is used as a critical component of a safety system. Never assume that a safety-critical control loop is functioning correctly.
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- Safety Precautions
- Personnel and Equipment Warnings
- Dangerous Voltages
- Lock Out/Tag Out Guidelines
- General Warnings

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1.2 Target Audience
1.3 Organization
1.4 Revision History
1.5 Acronyms and Abbreviations

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1. About this Manual

To make sure that you understand the proper procedures for safe operation, this section briefly describes the purpose, audience, organization, revision history, and acronyms and abbreviations.

1.1 Purpose

The purpose of this manual is to provide information for the safe and successful assembly of the product.

This product requires configuration by a factory trained service.

The instructions in this manual are based on assembly of a three-cabinet system. Other configurations are possible and these instructions can be reduced or expanded to accommodate installation of those systems.

1.2 Target Audience

This installation manual is intended for trades suitable for assembling electrical and electronic assemblies.

1.3 Organization

This manual is composed of the following chapters:

- Chapter 1 “About this Manual” outlines this document.
- Chapter 2 “Product Description” describes the major components of the product.
- Chapter 3 “Assembling the Product” explains how to install the product.
1.4 Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Description</th>
<th>Author</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>First Release (customer facing)</td>
<td></td>
<td>2018.04.08</td>
</tr>
</tbody>
</table>

1.5 Acronyms and Abbreviations

The following acronyms and abbreviations are used in this manual.

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AED</td>
<td>Automated External Defibrillator</td>
</tr>
<tr>
<td>BMS</td>
<td>Battery Management System</td>
</tr>
<tr>
<td>EHS</td>
<td>Environmental Health and Safety</td>
</tr>
<tr>
<td>ESS</td>
<td>Energy Storage System</td>
</tr>
<tr>
<td>LOTO</td>
<td>LOCK OUT/TAG OUT</td>
</tr>
<tr>
<td>OT</td>
<td>Overtemperature</td>
</tr>
<tr>
<td>OVP</td>
<td>Overvoltage Protection</td>
</tr>
<tr>
<td>PCS</td>
<td>Power Conversion System</td>
</tr>
<tr>
<td>SMPS</td>
<td>Switched Mode Power Supply</td>
</tr>
<tr>
<td>SOC</td>
<td>State Of Charge</td>
</tr>
<tr>
<td>SOH</td>
<td>State Of Health</td>
</tr>
<tr>
<td>SG</td>
<td>Switchgear</td>
</tr>
<tr>
<td>UT</td>
<td>Undertemperature</td>
</tr>
<tr>
<td>UVP</td>
<td>Undervoltage Protection</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterruptible Power Supply</td>
</tr>
</tbody>
</table>
2. Product Description

Before operating the battery system, users must be familiar with its components.

2.1 Major Components

Samsung SDI’s Lithium Ion Battery System has the following components:

- Battery Module (Type A / Type B)
- Switchgear Assembly
- SMPS Assembly (Type A / Type B)
- Rack Frame
2.1.1 **Battery Module (Type A / Type B)**

The battery module consists of battery cells. Each battery module has a module BMS (Battery Management System).

There are two types of Battery Modules. The model number for each type is determined by the position of polarity. Type A’s positive (+) terminal is on the right side viewed from the front. The positive terminal for Type B is on the left.

Following are front and rear views of module assemblies.

![Battery Module Type A (Front)](image1)

![Battery Module Type B (Front)](image2)

*Figure 2-1: Battery Modules (Type A and Type B)*
2.1.2 Switchgear Assembly

The Switchgear Assembly consists of a protective circuit and a rack BMS. It is connected to the UPS using the positive and negative power terminals on the front of switchgear.

![Figure 2-2: Switchgear Assembly](image)

The switchgear provides an auxiliary breaker switch that can be connected to an external building monitoring system.

![Figure 2-3: Front View of the Switchgear Assembly](image)
2.1.3 SMPS Assembly (Type A / Type B)

The SMPS Assembly provides data to the external systems (i.e., building management system, UPS, etc.) while controlling and monitoring all connected Rack BMS’s.

There are two types of SMPS Assemblies: Type A has a System BMS; Type B does not.

The SMPS Assembly provides these communication protocols: RS485, TCP/IP and dry contact.
2.1.4 Rack Frame

The Rack Frame is used to mount the Battery Modules, Switchgear Assembly and SMPS Assembly. It facilitates grounding of the installed components. Grounding cable/busbar for the rack frame is necessary for the Switchgear and SMPS Assemblies because they are grounded to the rack frame when installed. An equipment grounding conductor is required to ground the rack frames together and to the UPS module.

Figure 2-5: Rack Frame
3. Assembling the Product

Because this product has a battery with more than 300V present when fully assembled, you must follow the general safety Instructions. This system must be installed by qualified, trained workers familiar with the required instruments. Use appropriate lifting methods when moving the batteries.

**WARNING**
- The power terminal cap must be left in place on the power terminal of the tray for insulation.
- Be sure to use insulated tools (torque wrench, extension, socket, etc.).
- All the instruments must be insulated and no metal articles (e.g. watch, ring) should be present in the installation area.
- All power switches must be turned off in advance.
- Prepare a CO₂ fire extinguisher, a first aid kit, and an AED (automated external defibrillator) before installation.

**CAUTION**
- If available, use a mechanical lift for lifting heavy (22 kg [50 lb.]) components. If there is no lift, two or three workers must move items weighing more than 22 kg (50 lb.).
- The ambient temperature range must be 23°C ±5°C during installation.

### 3.1 Grounding the Battery System

**WARNING—SHOCK HAZARD**
Verify with a voltmeter that no power is present on the system before beginning work on the battery system or other part of the UPS system. Use lock out/tag out procedures to secure the UPS and batteries. Do not contact system connectors or terminals. Follow all applicable safety measures.

Follow all local and national codes and regulations.

Grounding methods and wiring must comply with NEC Article 250.

Grounding is required to prevent electric shock hazards and reduce or eliminate damage caused by electrical noise. Ground connections and ground wire routing vary significantly depending on system configuration and equipment layout. Samsung provides two grounding strips on each rack, one on top of the rack and the other on the bottom of the rack. See Figure 3-109: Grounding Points (2 EA).
3.2 Installation and Assembly Procedure

This product must be installed and assembled by following the procedure below:

- **Preparation Stage**
  - Procedure
  - Unpacking
  - Ground wire and tools
  - Recommended tools and instruments
  - Appearance inspection

- **Rack Anchoring Stage**
  - Transport the rack frame to the installation location after unpacking
  - Arrange the rack frame after checking the positions of holes in the frame and anchoring points
  - Perform the anchoring and ground connections

- **Rack Installation Stage**
  - Transport the battery modules to the installation location
  - Place the battery modules in the rack frame
  - Insert the Switchgear assembly in the rack frame
  - Insert the SMPS assembly in the rack frame
  - After all subassemblies are inserted in the rack frame, attach the subassemblies to the rack frame
  - Connect the busbars
  - Connect the signal cables from switchgear to module, and module to module
  - Connect the signal cables from switchgear to switchgear

- **System Installation Stage**
  - Connect the SMPS assembly
  - Perform installation checks
  - Prepare the items for BMS configuration
  - Configure the BMS EEPROM settings
3. Assembling the Product

3.3 Preparation Stage—Procedure

For the preparation stage, perform the following steps:

1. Create the installation plan and check the equipment and instruments for installation.
2. Check the arrival schedule of the parts required.
3. Unpack the equipment.
4. Inspect the equipment.

**WARNING**
- Do not wear watches, rings, jewelry, or any other metal objects.
- Wear electrically insulated gloves and safety shoes.

**CAUTION**
- Store the product in a dust-free place with the moisture level of below 60% and the temperature level of 23°C ±5°C.
- Keep components out of direct sunlight.
3.4 Preparation Stage - Unpacking

Check the parts during unpacking:

3.5 Preparation Stage - Ground Wire and Tools

Ground wires for the racks must be provided by the installer. Installer-supplied ground wires must meet the specifications below.

3.5.1 Ground Wires

Use ground wire that is #1AWG. The ground wire specifications are:

Table 3-1: Ground Wire Specifications

<table>
<thead>
<tr>
<th>Wire No.</th>
<th>Terminal Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1AWG or thicker</td>
<td>M12 2 Hole Ring Terminal</td>
</tr>
</tbody>
</table>

3.5.2 Ground Wire Fasteners

Specifications for the ground wire fastening screws are:

Table 3-2: Ground Wire Fastener Specification

<table>
<thead>
<tr>
<th>Size</th>
<th>Hardness</th>
<th>Thread Pitch</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12–30mm</td>
<td>70 (Grade 7)</td>
<td>1.25 mm (0.05 in)</td>
<td>SS304</td>
</tr>
</tbody>
</table>

3.5.3 Rack Fasteners (Anchors)

Specifications for the rack fastener screws for anchoring the rack frame to the floor are:

Table 3-3: Rack Fastener Specifications

<table>
<thead>
<tr>
<th>Size</th>
<th>Hardness</th>
<th>Thread Pitch</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>M16–L (Bottom Anchor)</td>
<td>70 (Grade 7)</td>
<td>2.0 mm (0.08 in)</td>
<td>SS304</td>
</tr>
</tbody>
</table>

3.5.4 Multiple Rack Fasteners

Specifications for the rack fastener screws for installing multiple rack frames side-by-side are:

Table 3-4: Rack Fastener Specifications (Side by side)

<table>
<thead>
<tr>
<th>Size</th>
<th>Hardness</th>
<th>Thread Pitch</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>M10–25mm (Side)</td>
<td>70 (Grade 7)</td>
<td>1.5 mm (0.06 in)</td>
<td>SS304</td>
</tr>
</tbody>
</table>

1 Not provided. Must be provided by the installer or customer.
2 Not provided. Must be provided by the installer or customer.
3 Not provided. Must be provided by the installer or customer.
## 3.6 Preparation Stage—Recommended Tools/Instruments

Installers must provide these tools for installing the battery:

**Table 3-5: Recommended Tools and Instruments**

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
<th>Usage</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power Screwdriver/Drill (Max torque: 26Nm/270 kgf/cm)</td>
<td>To fasten switchgear and SMPS assemblies to the rack frames (5.1–6.1Nm/50–60 kgf/cm)</td>
<td><img src="image1" alt="Image" /></td>
</tr>
<tr>
<td>2</td>
<td>Torque Limiter</td>
<td>For use with torque wrench</td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>3</td>
<td>Phillips Screwdriver or Bit</td>
<td>To fasten switchgear and SMPS assemblies to the rack frames (M5 Tip)</td>
<td><img src="image3" alt="Image" /></td>
</tr>
<tr>
<td>4</td>
<td>Box Cutter</td>
<td>Opening boxes</td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td>5</td>
<td>Forklift</td>
<td>Moving rack frames and pallets containing modules and switchgear</td>
<td><img src="image5" alt="Image" /></td>
</tr>
<tr>
<td>6</td>
<td>Insulated Torque Wrench</td>
<td>Installing a high-current cable 8.16–30 Nm (72–265 in lbs)</td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td>7</td>
<td>Insulated Sockets (13 mm, 17mm and 19mm)</td>
<td>Installing power cables and busbars</td>
<td><img src="image7" alt="Image" /></td>
</tr>
<tr>
<td>8</td>
<td>Insulated Extension for Socket</td>
<td>Installing a power cable</td>
<td><img src="image8" alt="Image" /></td>
</tr>
<tr>
<td>9</td>
<td>Inclinometer/Level</td>
<td>Installing a rack frame</td>
<td><img src="image9" alt="Image" /></td>
</tr>
</tbody>
</table>
### 3. Assembling the Product

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
<th>Usage</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Battery Tester</td>
<td>Measure battery module’s voltage and internal impedance</td>
<td><img src="image" alt="Battery Tester" /></td>
</tr>
</tbody>
</table>
3.7 Preparation Stage - Visual Inspection

During visual inspection, the inspector should check for:

![Image of faulty cases]

**CAUTION**
- If any defects are found during the inspection, contact the SAMSUNG SDI customer service department.

### 3.7.1 Inspecting the Rack Frame

After transporting the rack frame to the installation location, check for:

- Structural damage
- Paint peeling
- Damaged or protruding screws.

After completion, install or package the rack for protection during storage.
3.7.2 Visual Inspection of the Modules

After transporting the modules to the installation location, check for:

• Physical damage to the exterior
• Damaged or protruding screws
• Proper voltage and internal impedance of the battery modules using the battery tester.

Table 3-6: Module Voltage and Internal Impedance

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Voltage Check</td>
<td>28.712 ~ 29.104V</td>
</tr>
<tr>
<td>2</td>
<td>Internal Impedance Check</td>
<td>3.0 ~ 4.3 mΩ</td>
</tr>
</tbody>
</table>

After completion, install the battery module in the previously installed rack or return the battery module to its original packing for protection during storage.

3.7.3 Inspecting the Switchgear

After transporting the Switchgear to its installation location, check for:

• Physical damage
• Paint peeling
• Damaged or protruding screws.

After completion, install the switchgear in the previously installed rack or return the switchgear to its original packing for protection during storage.

3.7.4 Inspecting the SMPS assembly

After transporting the SMPS Assembly to its installation location, check for:

• Physical damage
• Paint peeling
• Damaged or protruding screws.

After completion, install the SMPS in the previously installed rack or return the SMPS to its original packing for protection during storage.
3.8 Rack Anchoring Stage

Install the rack frame on a flat, level surface.

- To attach the rack and perform the related works

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Use a proper transportation method considering the weight of the rack frame.</td>
</tr>
<tr>
<td>• Ensure that the safety of the working place is maintained.</td>
</tr>
<tr>
<td>• When using a forklift, lift the rack frame from the front.</td>
</tr>
<tr>
<td>• When a forklift cannot be used, use a mechanical lift or move it by hand with three or more people.</td>
</tr>
<tr>
<td>• Use lock washers to prevent bolts from loosening.</td>
</tr>
<tr>
<td>• Use an inclinometer or carpenter’s level to ensure that the rack frame is plumb.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NOTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Battery rack type A will be used for SMPS type A. External communications will connect to the SMPS in this rack.</td>
</tr>
<tr>
<td>• Failure to anchor the rack frame on a flat and level surface may distort the rack frame after installing the racks side-by-side.</td>
</tr>
<tr>
<td>• Frame distortion may make the rack doors difficult or impossible to open.</td>
</tr>
</tbody>
</table>

In order to anchor the racks in all four points, racks are recommended to be placed according to the clearance distances listed in the figures below. In seismically active areas, all four anchor points of the rack must be installed.

To reduce the product footprint, the racks can be installed side-by-side and rear-to-rear against a wall or next to another rack. In this case, only two anchor points on the front side of each rack can be installed. Proper cooling and ventilation of the installed area is recommended for racks installed with no side and rear clearance. Front side of the rack must be cleared for installation, maintenance, service access, and ventilation and cooling.

Clearance from the top of the rack frame is not required and the top of the rack frame can be covered to prevent any foreign objects from falling into the battery rack frame.

### Table 3-7: Rack Clearance Distances

| Configuration | Anchor points per rack | Clearance Distance (mm) |
| --- | --- | --- | | | | Side (end) | Side (adjacent) | Rear | Front |
| Single Rack | 2 (Front) not rated for seismic event | 0 | n/a | 0 | 1000 |
| | 4 (All) – Telcordia Zone 3 | 800 | n/a | 800 | 1000 |
| Multiple Racks (Side-to-Side) | 2 (Front) not rated for seismic event | 0 | 0 | 0 | 1000 |
| | 4 (All) – Telcordia Zone 3 | 800 | 0 | 800 | 1000 |
| Multiple Racks (Side-to-Side and Rear-to-Rear) | 2 (Front) not rated for seismic event | 0 | 0 | 0 | 1000 |
| | 4 (All) – Telcordia Zone 3 | 800 | 0 | 800 | 1000 |
Two anchor points (not rated for seismic event)

Four anchor points (Telcordia Zone 3)

Figure 3-3: Clearance Distance for Single Rack Frame

Two anchor points (not rated for seismic event)

Four anchor points (Telcordia Zone 3)

Figure 3-4: Clearance Distance for Multiple Rack Frames
3. Assembling the Product

Two anchor points (not rated for seismic event)

Four anchor points (Telcordia Zone 3)

1. After unpacking the rack frame, transport it to its installation location.
2. Arrange the rack frame after verifying that the holes in the frame and anchoring points are aligned.
3. Remove the side panels for cabinets attached side by side. Remove rear covers when rear service access is provided.
4. Connect four anchoring points on the bottom of the rack.

**NOTICE**

- Anchor the frame with M16 bolts and nuts.
- The fastening torque should be 140Nm / 100ft lbs.
- Check the rack and other parts for distortion caused by unpacking.
5. Connect the racks, using M10 hardware through holes in the sides (“SCREW M10 X 25mm,” “M10 FLAT WASHER” and “NUT M10”). Torque the bolts to 30Nm (22 ft lbs).

6. After all the rack frames are anchored, reattach the side panels to the outermost rack frames using four M5 Screws (“SCREW M5 X 10 mm”) for each side panel. Fasten the screws using torque of 5.1–6.1 Nm (45–54 in lbs).
7. If removed reattach the rear panels to the rack frames using four M5 Screws "SCREW M5 X 10 mm" for each rear panel. Fasten the screws using torque of 5.1–6.1 Nm (45–54 in lbs).
### 3.9 Rack Installation Stage

<table>
<thead>
<tr>
<th>WARNING</th>
<th>Arc Flash and Shock Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insulated tools are required for any work on this energized equipment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WARNING</th>
<th>Sharp Edges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wear gloves and other protective gear to prevent injury.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WARNING</th>
<th>Pinch Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use caution when working in the enclosure to prevent injury.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAUTION</th>
<th>Heavy Object</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Can cause muscle strain or back injury. Use lifting aids and proper lifting techniques when moving trays, batteries and other heavy objects.</td>
</tr>
</tbody>
</table>
3.9.1 Switchgear and SMPS Assembly Installation

Figures may show other assemblies to indicate relative position. Those assemblies will be installed at a later time.

**Important**
- Attach each Switchgear to its rack frame with four M5 x 10 mm screws. (Torque: 5.1–6.1 Nm [45–54 in lbs])
- Verify that the torque setting is correct.

1. Insert the Switchgear Assembly through the front of the rack as shown in Figure 3-10: Inserting Switchgear

![Figure 3-10: Inserting Switchgear](image)

2. After all Switchgear Assemblies are inserted in the rack frames, attach each to the rack frame with four M5 x 10 mm bolts. (Torque: 5.1–6.1 Nm [45–54 in lbs])

![Figure 3-11: Attaching a Switchgear Assembly to a Rack Frame](image)
3. After each Switchgear Assembly is inserted into the rack frame, connect the ground cable (Wire Assembly Earth).

**NOTICE**

Connect a ground cable between the Switchgear Assembly and the Rack Frame (SCREW M5 x 10 mm). (Torque: 5.1–6.1 Nm [45–54 in lbs])

- Verify that the torque setting is correct.

Figure 3-12: Ground Cable Connection to the Switchgear Assembly
3. Assembling the Product

4. Insert SMPS Assembly into the rack frames designated for SMPS Assembly as shown in Figure 3-13: Inserting SMPS Assembly

<table>
<thead>
<tr>
<th>Important</th>
</tr>
</thead>
</table>
| ▪ Attach the inserted SMPS Assemblies to the rack frames by fastening each with four M5 x 10 mm screws  
| ▪ (Torque: 5.1–6.1 Nm [45–54 in lbs])  
| ▪ Verify that the torque setting is correct. |

5. Slide the SMPS Assembly into the rack frame on the shelf designated for the SMPS Assembly as shown below.

![Figure 3-13: Inserting SMPS Assembly](image)

6. After all SMPS Assemblies are inserted into the rack frames, attach them to the Rack with screws (Torque: 5.1–6.1 Nm [45–54 in lbs])

![Figure 3-14: Attaching the SMPS Assembly](image)

7. After each SMPS Assembly is attached to the rack frames, connect the ground cable (Wire Assembly Earth).
Notice

- Connect a ground cable between the SMPS Assembly and the Rack Frame with an M5 x 10 mm screw. (Torque: 5.1–6.1 Nm [45–54 in lbs])
- Verify that the torque setting is correct.

Figure 3-15: Ground Cable Connection to the SMPS Assembly
3.9.2 Battery Module Installation

1. Measure the voltage and internal impedance of each module. All modules in one rack frame must be near the same state of charge. Refer to Table 3-6: Module Voltage and Internal Impedance.

2. Place the battery modules in the rack frame.

<table>
<thead>
<tr>
<th>Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Install Battery Modules in the upper shelves first and proceeding to the bottom. (Two Type B battery modules are inserted in the ninth shelf from the bottom.)</td>
</tr>
<tr>
<td>- Seventeen battery modules can be inserted into a rack frame as shown in Figure 3-18.</td>
</tr>
</tbody>
</table>

Two Type B Battery Modules

Figure 3-16: Insertion of Modules on the Ninth Shelf from the Bottom
3. Assembling the Product

Figure 3-17: Battery Module Arrangement on Eighth and Ninth Shelves

Figure 3-18: Battery Module Arrangement
3. Assembling the Product

Figure 3-19: Module Number

<table>
<thead>
<tr>
<th>Module #17</th>
<th>Module #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module #16</td>
<td>Module #2</td>
</tr>
<tr>
<td>Module #15</td>
<td>Module #3</td>
</tr>
<tr>
<td>Module #14</td>
<td>Module #4</td>
</tr>
<tr>
<td>Module #13</td>
<td>Module #5</td>
</tr>
<tr>
<td>Module #12</td>
<td>Module #6</td>
</tr>
<tr>
<td>Module #11</td>
<td>Module #7</td>
</tr>
<tr>
<td>Module #10</td>
<td>Module #8</td>
</tr>
<tr>
<td>Module #9</td>
<td></td>
</tr>
</tbody>
</table>

**Important**

- The bottom shelf (#1) has one Type B module in the left slot, as shown in Figure 3-20.

Figure 3-20: Insertion of modules on 1st shelf
### 3.9.3 Busbar Installation

Connect the power busbars between modules

> **Verify with a voltmeter that no power is present on the system. Use lock out/tag out procedures to secure the UPS and batteries.**

**CAUTION**

- Please follow the instructions to protect the module BMS against damage.
- Important: DO NOT deviate from the sequence of steps below.
- The system’s voltage will increase proportionally as battery modules are connected. Exercise extreme caution prevent the terminals from contacting anything except their intended mounting points.
- Terminals and their connected wires have either positive or negative polarity (Positive: B+, P+; Negative: B-, P-). The polarity of a terminal or a wire connected to the terminal is on the front of each module and switchgear. Exercise extreme caution to prevent the terminals and/or wires with opposite polarity from contacting with each other.
- It is recommended not to touch the battery positive (+) or negative (-) terminal for the batteries with rack frame. There is no evidence of dielectric breakdown because of electrical isolation between the battery positive (+) or negative (-) terminals and rack frame. However, it is recommended not to touch them for safety because it is possible to touch between battery positive (+) and negative (-) through the rack frame.

**NOTICE**

- Connect the power busbar with an M8 screw for battery module terminals
- **When tightening the screws, make sure they are at a straight angle from the battery module terminals to avoid damage to the nuts inside.**
- First, assemble the screws using a Phillips-head tip screwdriver using fastening torque of less than 5.1 Nm (45 in lbs).
- Then, use an insulated torque wrench extension with a 13 mm socket. Use fastening torque of 8.16–11.94 Nm (72–105 in lbs).

**NOTICE**

- Connect the power bus-bar with an M12 screw for switchgear terminals
- **When tightening the screws, make sure they are at a straight angle from the switchgear terminals to avoid damage to the nuts inside.**
- The fastening torque should be 30 Nm (265 in lbs)
- Use an insulated torque wrench extension with a 19 mm socket.

**Important**

- The power terminals, such as “B+,” “B-,” “P+,” and “P-,” of the module and Switchgear are covered with the power terminal cover to guard against a short circuit.
- At each step in this process, you must remove the cover prior to connecting a power busbar and reattach the cover immediately after connecting the power busbars.
3. Assembling the Product

1. Remove Battery Module #1’s front cover and the Switchgear B- terminal cover.

![Figure 3-21: Removing the Module #1’s Cover and Switchgear B- Terminal Cover](image)

2. Connect Switchgear B- and Module #1 B- using “BUSBAR_BUSBAR M TO SG.” Switchgear B- terminal is connected using an M12 screw and Battery Module #1 B- terminal is connected using an M8 screw.

![Figure 3-22: Connect Switchgear B- and Module #1 B-](image)
3. Reattach Switchgear’s B- terminal cover.

4. Remove Battery Module #2’s front cover.
3. Assembling the Product

5. Connect Battery Module #1 B+ and Module #2 B- using “BUS-BAR MAIN.” Connect using an M8 screw.

Figure 3-25: Connect Battery Module #1 B+ and Battery Module #2 B-.
6. Reattach Battery Module #1's front cover and remove Battery Module #3's front cover.

Figure 3-26: Reattach Battery Module #1's Front Cover

Figure 3-27: Remove Battery Module #2's Front Cover
7. Connect Battery Module #2 B+ and Battery Module #3 B- using “BUS-BAR MAIN.” Connect using an M8 screw.

Figure 3-28: Connect Battery Module #2 B+ and Battery Module #3 B-.
8. Reattach Battery Module #2’s front cover and remove Battery Module #4’s front cover.

Figure 3-31: Connect Battery Module #3 B+ and Module #4 B-.
10. Reattach Battery Module #3’s front cover and remove Battery Module #5’s front cover.
11. Connect Battery Module #4 B+ and Battery Module #5 B- using “BUS-BAR MAIN.” Connect using an M8 screw.

Figure 3-34: Connect Battery Module #4 B+ and Battery Module #5 B-.
12. Reattach Battery Module #4’s front cover and remove Battery Module #6’s front cover.

Figure 3-35: Reattach Battery Module #4’s Front Cover

Figure 3-36: Remove Battery Module #6’s Front Cover
13. Connect Battery Module #5 B+ and Battery Module #6 B- using “BUS-BAR MAIN.” Connect using an M8 screw.

Figure 3-37: Connect Battery Module #5 B+ and Battery Module #6 B-.
14. Reattach Battery Module #5's front cover and remove Battery Module #7's front cover.

Figure 3-38: Reattach Battery Module #5's Front Cover

Figure 3-39: Remove Battery Module #7's Front Cover
15. Connect Battery Module #6 B+ and Battery Module #7 B- using "BUS-BAR MAIN." Connect using an M8 screw.
16. Reattach Battery Module #6’s front cover and remove Battery Module #8’s front cover.

Figure 3-41: Reattach Battery Module #6’s Front Cover

Figure 3-42: Remove Battery Module #8’s Front Cover
17. Connect Battery Module #7 B+ and Battery Module #8 B- using “BUS-BAR MAIN.” Connect using an M8 screw.

Figure 3-43: Connect Battery Module #7 B+ and Battery Module #8 B-

Connecting Battery Modules #8 and #9 will be done in 3.9.8 Rack Fuse and Additional Module Signal Cable Connection.
18. Reattach the front covers to Battery Modules #7 and #8 and remove the front covers from Battery Modules #9 and #10.

Figure 3-44: Reattach Battery Modules #7 and #8’s Front Covers

Figure 3-45: Remove Front Covers from Battery Modules #9 and #10

Figure 3-46: Connect Battery Module #9 B+ and Battery Module #10 B-.
20. Reattach Battery Module #9’s front cover and remove Battery Module #11’s front cover.

Figure 3-47: Reattach Battery Module #9’s Front Cover

Figure 3-48: Remove Battery Module #11’s Front Cover
22. Reattach Battery Module #10’s front cover and remove Module #12’s front cover.

![Figure 3-50: Reattach Battery Module #10’s Front Cover](image1)

![Figure 3-51: Remove Battery Module #12’s Front Cover](image2)
23. Connect Battery Module #11 B+ and Battery Module #12 B- using "BUS-BAR MAIN." Connect using an M8 screw.

Figure 3-52: Connect Battery Module #11 B+ and Battery Module #12 B-.
24. Reattach Battery Module #11’s front cover and remove Battery Module #13’s front cover.

Figure 3-53: Assemble Module #11’s Front Cover

Figure 3-54: Remove Module #13’s Front Cover

Figure 3-55: Connect Battery Module #12B+ and Battery Module #13 B-.
26. Reattach Battery Module #12’s front cover and remove Battery Module #14’s front cover.

Figure 3-56: Assemble Module #12’s Front Cover

Figure 3-57: Remove Battery Module #14’s Front Cover
27. Connect Battery Module #13 B+ and Battery Module #14 B- using “BUS-BAR MAIN.” Connect using an M8 screw.

Figure 3-58: Connect Battery Module #13 B+ and Battery Module #14 B-.
28. Reattach Battery Module #13’s front cover and remove Battery Module #15’s front cover.

Figure 3-59: Reattach Battery Module #13’s Front Cover

Figure 3-60: Remove Battery Module #15’s Front Cover

Figure 3-61: Connect Battery Module #14 B+ and Battery Module #15 B-.
30. Reattach Battery Module #14’s front cover and remove Battery Module #16’s front cover.

Figure 3-62: Assemble Battery Module #14’s Front Cover

Figure 3-63: Remove Battery Module #16’s Front Cover
31. Connect Battery Module #15 B+ and Battery Module #16 B- using "BUS-BAR MAIN." Connect using an M8 screw.

Figure 3-64: Connect Battery Module #15 B+ and Battery Module #16 B-.
32. Reattach Battery Module #15’s front cover and remove Battery Module #17’s front cover.

Figure 3-65: Reattach Battery Module #15’s Front Cover

Figure 3-66: Remove Battery Module #17’s Front Cover
33. Connect Battery Module #16 B+ and Battery Module #17 B- using “BUS-BAR MAIN”. Connect using M8 screw.

Figure 3-67: Connect Battery Module #15 B+ and Battery Module #16 B-.
34. Reattach Battery Module #16’s front cover and remove Switchgear’s B+ terminal cover.

Figure 3-68: Reattach Battery Module #15’s Front Cover

Figure 3-69: Remove Switchgear B+ Terminal Cover
35. Connect Switchgear B+ and Battery Module #17 B+ using “BUSBAR_BUSBAR M TO SG.” Switchgear B+ terminal is connected using an M12 screw and Module #17 B+ terminal is connected using an M8 screw.

36. Reattach Battery Module #17’s front cover and Switchgear B+ terminal cover.
3.9.4 Module and Switchgear Signal Cable Connection

Connect the signal cables for Switchgear and Module BMS’s for each module.

**NOTICE**

- Use the proper signal cables as specified by the part numbers below.

**WARNING**

**Rack BMS / Module BMS Damage**

Do not insert both ends of the signal cable WIRE ASSY MODULE TO MODULE #1 or WIRE ASSY MODULE TO MODULE #2 into the same Battery Module.

1. Connect the signal cable “WIRE ASSY RACK TO MODULE SHIELDING” between the switchgear “MODULE” connector and Module #1 “OUT” connector. Pass the cable through the opening above Module #1.

*Figure 3-72: Rack BMS to Module #1 OUT Signal Cable*
2. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #1 “IN” to Module #2 “OUT.”

Figure 3-73: Opening for Cable Installation

Figure 3-74: Module #1 to Module #2 Signal Cabling
3. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #2 “IN” to Module #3 “OUT.”

Figure 3-75: Module #2 to Module #3 Signal Cabling

4. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #3 “IN” to Module #4 “OUT.”

Figure 3-76: Module #3 to Module #4 Signal Cabling
5. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #4 “IN” to Module #5 “OUT.”

![Figure 3-77: Module #4 to Module #5 Signal Cabling](image)

6. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #5 “IN” to Module #6 “OUT.”

![Figure 3-78: Module #5 to Module #6 Signal Cabling](image)
7. Connect the signal cable "WIRE ASSY MODULE TO MODULE #1" from Module #6 "IN" to Module #7 "OUT."

Signal cables connecting Module #7 to #8, #8 to #9 and #9 to #10 will be installed in 3.9.8 Rack Fuse and Additional Module Signal Cable Connection.

8. Connect the signal cable "WIRE ASSY MODULE TO MODULE #1" from Module #10 "IN" to Module #11 "OUT."
9. Connect the signal cable "WIRE ASSY MODULE TO MODULE #1" from Module #11 "IN" to Module #12 "OUT."

Figure 3-81: Module #11 to Module #12 Signal Cabling

10. Connect the signal cable "WIRE ASSY MODULE TO MODULE #1" from Module #12 "IN" to Module #13 "OUT."

Figure 3-82: Module #12 to Module #13 Signal Cabling
11. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #13 “IN” to Module #14 “OUT.”

![Figure 3-83: Module #13 to Module #14 Signal Cabling](image)

12. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #14 “IN” to Module #15 “OUT.”

![Figure 3-84: Module #14 to Module #15 Signal Cabling](image)
13. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #15 “IN” to Module #16 “OUT.”

![Figure 3-85: Module #15 to Module #16 Signal Cabling](image)

14. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #16 “IN” to Module #17 “OUT.”

![Figure 3-86: Module #16 to Module #17 Signal Cabling](image)
15. Connect the signal cable “WIRE ASSY MODULE TO MODULE #1” from Module #15 “IN” to Module #16 “OUT.”

Figure 3-87: Module #15 to Module #16 Signal Cabling
3. Assembling the Product

16. For a multiple rack system, connect the signal cables “WIRE ASSY RACK TO RACK #2” between each rack’s Switchgear. Push the pre-punched hole to pass the cable through a circular hole in the side of the rack frame and through the opening above Module #1 and Module #16.

17. Connect the signal cable from the left port of Switchgear #1 CAN to the right port of Switchgear #2 CAN.

18. Repeat for the remaining Switchgear Assemblies.

19. Slide the switch to the “ON” position for the last Switchgear.

![Figure 3-88: Pre-Punched Hole for Signal Cable](image)

Signal Cabling Examples of Left Alignment of Trays
20. Turn the termination resistor switch on for the last Switchgear in the CANbus loop.
3. Assembling the Product

**NOTICE**

- Factory-provided cables are adequate for systems with Rack Frames bolted together. Different configurations may require cable modification.
3.9.5 SMPS Assembly and Switchgear Power Cable Connection

Connect the Switchgear DC power cables.

Figure 3-92: DC Power Cables from SMPS Assembly Type A to Switchgear

Figure 3-93: DC Power Cables from SMPS Assembly Type B to Switchgear
3. Assembling the Product

3.9.6 SMPS Assembly and Switchgear Signal Cable Connection

The following steps are only for an SMPS Assembly Type A.

37. Connect the signal cable from the SMPS Assembly to Switchgear “WIRE ASSY RACK TO SYSTEM.”

![Figure 3-94: CAN Signal Cable Connection from SMPS Assembly to Switchgear](image)

2. Connect the SMPS Assembly TCP/IP Cable\(^4\) to the SMPS Assembly.

![Figure 3-95: TCP/IP Cable Connection to SMPS Assembly](image)

---

\(^4\) Not factory-provided. Must be provided by the installer or customer.
3. Connect the SMPS Assembly Dry Contact Cable.

Figure 3-96: Dry Contact Cable Connection to SMPS Assembly

4. Connect the Switchgear MCCB Cable.

Figure 3-97: MCCB Extra Auxiliary Connection
3.9.7 SMPS Assembly AC Input Connection

1. Remove the protective covers from the AC input terminals.

![Figure 3-98: AC Input Terminals](image)

2. Connect each AC input in the SMPS Assembly. Make sure the AC cables are not energized.\(^5\)

![Figure 3-99: AC Input Terminals with Cables Attached](image)

\(^5\) AC Cables are not factory-provided. They must be provided by the installer or customer.
3. Reattach the protective covers to the AC input.

Figure 3-100: AC Input Terminals Protective Covers
3.9.8 Rack Fuse and Additional Module Signal Cable Connection

**NOTICE**

The rack fuse cover must be installed over the fuse to prevent the exposure of live electrical parts.

4. Remove the front covers from Battery Modules #8 and #9.

Figure 3-101: Remove Front Covers from Battery Modules #8 and #9
5. Assemble the Rack fuse Bus-bar assembly. Rack fuse bus-bar assembly is comprised of one "RACKFUSE BUSBAR_R_136S", one "RACKFUSE BUSBAR_L_136S", two "SCREW M12 X 16" and one "FUSE"

**NOTICE**

Rack Fuse Busbar Assembly is assembled at the installation location. M12 X 16L screws are used to assemble the busbars and fuse. The fastening torque should be 30 Nm (300 kgf/cm).

---

Figure 3-102: Rack Fuse Busbar Assembly.
6. Assemble Rack Fuse Cover “FUSE COVER.”

![Figure 3-103: Rack Fuse Cover](image)

![Figure 3-104: Rack Fuse Cover (Fully Assembled; Front View)](image)
7. Reattach the front covers to Battery Modules #8 and #9.

8. Connect the signal cable "WIRE ASSY MODULE TO MODULE #1" from Battery Module #7 "IN" to Battery Module #8 "OUT."

Figure 3-105: Reattach Front Covers to Battery Modules #8 and #9

Figure 3-106: Battery Module #7 to Battery Module #8 Signal Cabling
9. Connect the signal cable "WIRE ASSY MODULE TO MODULE #2" from Battery Module #8 "IN" to Battery Module #9 "OUT."

Figure 3-107: Battery Module #8 to Battery Module #9 Signal Cabling (WIRE ASSY MODULE TO MODULE #2)

10. Connect the signal cable "WIRE ASSY MODULE TO MODULE #1" from Battery Module #9 "IN" to Battery Module #10 "OUT."

Figure 3-108: Battery Module #9 to Battery Module #10 Signal Cabling
3.9.9 DC Link Cable Connection

1. Connect the ground cables.

![Diagram of grounding points](image)

Figure 3-109: Grounding Points (2 EA)

Ground connections are provided on the bottom and on the top of the rack. Either may be used for grounding.

**NOTICE**

- Connect the rack ground wire with an M12 x 30 mm screw. Rack ground screws are not factory-provided and must be provided by the installer or customer.
- The fastening torque should be 30Nm (265 in lbs).
3. Assembling the Product

2. Connect the DC link high-voltage cables from the UPS.

<table>
<thead>
<tr>
<th>CAUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Verify with a voltmeter that no power is present on the system. Disconnect all input power supplies. Use lock out/tag out procedures to secure the UPS and battery system before beginning this step.</td>
</tr>
<tr>
<td>• In this step, the battery and UPS are isolated by the Switchgear because the circuit breaker in the switchgear is opened.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NOTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Connect the high-voltage cables using an M12 bolt.</td>
</tr>
<tr>
<td>• The fastening torque should be 30 Nm (265 in lbs).</td>
</tr>
</tbody>
</table>

Figure 3-110: Connecting the DC Link High Current Cables

After installation is complete, check the following:

• Bolt fastening condition
• Screw fastening torque by sampling
• High-voltage cable connection
• Module connections
• Switchgear connections

3.9.10 AC Input Commissioning

When the installation and assembly of the battery system is complete, notify the system supplier for system commissioning. Special tools and training are required for commissioning.

**CAUTION**

• Do not energize the input or control power prior to commissioning.
4. Performance

4.1 Operating Conditions

For operating conditions, consult your supplier.

4.2 Control Power Requirements

The control power table is based on nominal operating conditions. For other operating conditions consult your supplier.
Control power must be continuously maintained for the ESS to remain on-line. Loss of control power will result in the automatic isolation of the ESS from the UPS.

Table 4-1: Control Power Range of Operation

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nominal Voltage</td>
<td>480VAC</td>
<td>3 phase &amp; gnd</td>
</tr>
<tr>
<td>2</td>
<td>Nominal Current</td>
<td>0.1A</td>
<td>Operating</td>
</tr>
<tr>
<td>3</td>
<td>Inrush Current</td>
<td>15A</td>
<td>Sub-cycle</td>
</tr>
<tr>
<td>4</td>
<td>Control Power Circuits</td>
<td>2</td>
<td>Redundant</td>
</tr>
<tr>
<td>5</td>
<td>Control Power Source</td>
<td>Uninterrupted</td>
<td>During battery discharge</td>
</tr>
</tbody>
</table>

4.3 Hardware

The use of proper hardware is critical to the assembly of the ESS. Should the supplied hardware be lost or damaged replacement hardware must meet the following description.

Table 4-2: Hardware Description

<table>
<thead>
<tr>
<th>Item</th>
<th>Pitch</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw M5 x 10 mm</td>
<td>0.8 mm</td>
<td>70 (Grade 7)</td>
</tr>
<tr>
<td>Screw M8 x 16 mm</td>
<td>1.25 mm</td>
<td>70 (Grade 7)</td>
</tr>
<tr>
<td>Screw M10 x 25 mm</td>
<td>1.5 mm</td>
<td>70 (Grade 7)</td>
</tr>
<tr>
<td>Screw M12 x 16 mm</td>
<td>1.25 mm</td>
<td>70 (Grade 7)</td>
</tr>
<tr>
<td>Screw M12 x 25 mm</td>
<td>1.25 mm</td>
<td>70 (Grade 7)</td>
</tr>
<tr>
<td>Screw M12 x 30 mm</td>
<td>1.25 mm</td>
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</tr>
</tbody>
</table>