

Samsung SDI

# Battery System Installation Manual

E5SU Platform

May 2025\_V01

# Preface

**Read this manual carefully and in its entirety before handling a Samsung SDI ESS battery system. Keep this manual for future reference.**

Copyright © 2025 SAMSUNG SDI Co., Ltd. All rights reserved.

This document contains information that is the asset of Samsung SDI, and is created for the purpose of the installation of ESS products of Samsung SDI. The entire or part of this document may not be reworked, replicated, disclosed, transmitted, posted in a retrieval system, or translated into any human or computer language, in any form, for any purpose, without the prior written consent of Samsung SDI.

Although all information in this document is provided to the best of Samsung SDI's knowledge at the time of completion, Samsung SDI does not warrant that this document will be error-free. Samsung SDI makes no warranty, in any form, of any information presented in this manual, or what can be inferred from this manual.

ESSU is registered as the trademarks of Samsung SDI. All other trademarks herein are the properties of their respective companies.

## 1. Disclaimer

Samsung SDI is given an exemption from warranty for defect and performance in the event of a battery failure for the following reasons, and consequent costs and liabilities are the responsibility of the user.

- 1) Faults resulting from not following the manuals (specifications, Installation Manual, Operation and Maintenance manual, safety checksheet) provided by Samsung SDI
- 2) Battery faults resulting from inadequate storage and transportation
- 3) Battery faults resulting from arbitrary installation without following the Installation Manual
- 4) Direct/indirect battery faults resulting from not following Operation and Maintenance manual
- 5) Battery faults resulting from operation without installation inspection or operation approval of Samsung SDI
- 6) Inadequate battery operation or mishandling
- 7) Operation of the battery system under an inadequate air-conditioning system
- 8) Disassembly or modification of the battery system by an unauthorized engineer
- 9) Product damage caused by unforeseen natural disasters
- 10) Product damage caused by abnormal installation & operating environments including flooding & condensation
- 11) Use the battery system for purposes that have not been discussed in advance
- 12) Distribute the battery system under conditions that have not been discussed in advance

## 2. Recycling & Disposal Guide

- 1) Samsung SDI li-ion batteries are recyclable.
- 2) Do not dispose Samsung batteries with general waste. Please follow the regulations and disposal instructions provided by manufacturers. Please contact the sales for the disposal instructions.
- 3) The customer is responsible for module disposal. Battery shall be disposed through an authorized waste disposal company in accordance with local regulations. In the following situations, do not use the battery and dispose it according to local regulations.
  - Battery is exposed to accidents such as conduction, drop, shock, fire (including high temperature exposure), moisture inflow, etc.

- Battery is damaged or deformed.
- Battery usage is terminated due to customer situation
- Battery status after EOL (SOH70% or less)

If the battery to be disposed is reused (including disassembly and repair), distributed, or arbitrarily disposed without notice, the customer shall take all necessary measures at the request of the SDI and compensate the SDI for all damages caused by the act above.

### 3. Requirements for safe battery use

- 1) The battery system has a risk of serious safety issues caused by moisture, condensation and water leaks. Therefore, the humidity inside the battery room shall be controlled using HVAC at all times. Also, the system should be designed to prevent water leaks and condensation, and have a periodic checkup.
- 2) The difference between the internal and external temperature of the room where the battery system is installed may lead to condensation within the battery modules and electronics. Therefore, the temperature difference shall be managed to prevent condensation.
- 3) Dust may undermine the insulation performance. Therefore, care must be taken to ensure the cleanliness of the inside of the battery room at pollution degree 2 (PD2) or lower (Normally, only nonconductive pollution occurs; Temporary conductivity caused by condensation is to be expected). Periodic inspection and management are required. Dust filters shall be installed in the outside-air pathway to prevent an inflow of foreign substances.
- 4) The battery system shall be installed in high-lying areas to prevent any part of the system from being submerged in case of flooding. There shall also be a drainage near the system.
- 5) The battery room shall be designed and managed to prevent the entry of wild animals.
- 6) The structural materials of the battery room shall be flame-retardant/nonflammable. The battery room shall not contain any high-risk fire objects or direct heat sources.
- 7) It is forbidden to reuse damaged modules and BCUs. Damaged equipment should be immediately moved to and kept in a safe location prior to contacting Samsung SDI for further instructions.
- 8) The battery is sensitive to temperature and humidity; therefore, the battery room's ambient temperature and humidity shall be managed at all times to comply with the conditions that were previously discussed with Samsung SDI. Also, temperature and humidity measuring devices shall be installed in the battery room. The measured data should be saved so that it can be provided to Samsung SDI, if required.
- 9) The upper/lower temperature deviation in any battery string in the room shall be managed within 5°C. Regular inspections are required to prevent hot/cold spots caused by abnormal air convection.
- 10) The battery room shall install a fire suppression system (FSS) dimensioned appropriately for the space. Clean fire extinguishing agents that have no harm to the environment are recommended. Samsung SDI recommends the combination of automatic fire extinguishers and heat/smoke sensors. Heat/smoke sensors shall be placed in appropriate places that allow the monitoring of the entire battery room.
- 11) Check the battery data regularly using an EMS or monitoring devices. The battery data should be stored in storage units that are separately installed from the battery room. Consult Samsung SDI for storage items, cycles and periods.
- 12) Circuit breakers, such as MCCBs, should be installed between the battery system and power converters.
- 13) Like the PCS AC side, the battery DC side also requires the use of an insulation monitoring device. If leakage current is sensed between the high voltage DC terminals and earth ground, the power converters shall immediately disconnect the battery system from the DC bus by opening contactors. Do not close contactors in the battery system until the problem has been fully addressed.
- 14) Like the PCS AC side, the battery DC side also requires the use of a ground fault detection system. If ground is sensed between the high voltage DC terminals and earth ground, the power converters shall immediately disconnect the battery system from the DC bus by opening contactors. Do not close contactors in the battery system until the problem has been fully resolved.
- 15) To prevent the battery damage from experiencing transient voltage surges, protective devices such as a SPD shall be installed on the

DC battery bus. And the protective devices require a regular inspection. If the device starts protection operation, discontinue battery use and inspect the entire system. If no abnormality is found, battery use can be re-continued.

- 16) The battery should operate under a floating condition. Rack frames shall be grounded separately from the PCS.
- 17) After installing the battery system, measure the common mode voltage (CMV) and confirm that the waveforms lie within the range required by Samsung SDI. In addition, it is recommended to measure CMV annually.
- 18) If E-Stop starts in the battery, the PCS shall stop charging/discharging immediately. Inspection on the entire system should be performed according to the procedure discussed in advance.
- 19) Charging/discharging operation patterns discussed in advance shall be complied with. If the patterns change, contact Samsung SDI for instructions. Otherwise, the battery system may be excluded from all product and performance warranties.

## Revision History

Version	Description	Author	Date
1.0	Initial draft	Myungchul Chun	May 21, 2025

## Abbreviations

Abbreviation	Full name	Abbreviation	Full name
BCP	Battery Control Panel	LOTO	LOCK OUT/TAG OUT
BCU	Battery Control Unit	MCCB	Molded Case Circuit Breaker
BMS	Battery Management System	OTP	Over Temperature Protection
BOL	Beginnig of Life	OVP	Over Voltage Protection
CCL	Charge Current Limit	O&M	Operation and Maintenance
DCL	Discharge Current Limit	PCS	Power Conversion System
DMM	Digital Multimeter	PPE	Personal Protective Equipment
D/C	Discount Factor	SMPS	Switched Mode Power Supply
DI	Direct Injection	SOC	State Of Charge
EHS	Environmental Health and Safety	SOH	State Of Health
EMS	Energy Management System	SPD	Surge Protection Device
EOL	End of Life	SW	Switch (DC Contactor)
ESS	Energy Storage System	UTP	Under Temperature Protection
FSS	Fire Suppression System	UVP	Under Voltage Protection

# Table of Contents

<b>Preface .....</b>	<b>2</b>
1. <i>Disclaimer .....</i>	<i>2</i>
2. <i>Recycling &amp; Disposal Guide.....</i>	<i>2</i>
3. <i>Requirements for safe battery use .....</i>	<i>3</i>
<b>Revision History.....</b>	<b>5</b>
<b>Safety Instructions.....</b>	<b>8</b>
1. <i>Safety Signs.....</i>	<i>8</i>
<i>Personnel &amp; Equipment Warnings.....</i>	<i>8</i>
2. <i>Dangerous Voltage .....</i>	<i>9</i>
3. <i>Lock Out / Tag Out .....</i>	<i>10</i>
4. <i>Battery System Handling Instructions .....</i>	<i>10</i>
5. <i>Module Handling Instructions.....</i>	<i>11</i>
▪ <i>Handling Instructions.....</i>	<i>12</i>
▪ <i>Shock Watch .....</i>	<i>12</i>
▪ <i>Storage Instructions .....</i>	<i>13</i>
6. <i>Initial Action Steps .....</i>	<i>14</i>
▪ <i>Battery.....</i>	<i>14</i>
▪ <i>Battery Module Issue.....</i>	<i>15</i>
▪ <i>Access to Battery System.....</i>	<i>16</i>
<b>Description of Major Components.....</b>	<b>17</b>
1. <i>ESS System Overview.....</i>	<i>17</i>
2. <i>Cell .....</i>	<i>17</i>
3. <i>Module.....</i>	<i>17</i>
4. <i>BCU (Battery Control Unit).....</i>	<i>18</i>
5. <i>System BMS.....</i>	<i>19</i>
6. <i>Rack System.....</i>	<i>21</i>
<b>Rack Assembly.....</b>	<b>22</b>

1. Overview .....	22
2. Fastening Module & BCU to Rack frame .....	24
3. System BMS Installation .....	24
4. Power cable / Bus-bar Connection .....	25
▪ Installing Module to Module Bus-bar .....	25
5. Communication Cable Wiring .....	26
6. Rack Grounding .....	27
<b>Connection between Parallel Racks .....</b>	<b>28</b>
1. Communication Cable Wiring (BCU to BCU) .....	28
<b>System Integration .....</b>	<b>29</b>
<b>Appendix. Liquid Cooling System .....</b>	<b>31</b>
1. Liquid cooling condition .....	31
2. Caution for Disassemble .....	32

# Safety Instructions

## 1. Safety Signs

The safety signs below are intended to ensure personal safety and prevent equipment damage. Before installation and operation of SDI battery products, it is the user’s responsibility to read all safety instructions in this document for proper battery installation and operation. Samsung SDI is not responsible for issues resulting from not following this document. Please contact Samsung SDI if you have any questions.



DANGER

Failure to comply with this instruction may result in a serious accident, causing death or a severe injury.




WARNING

Failure to comply with this instruction may result in a serious accident, causing a severe injury.



CAUTION

Failure to comply with this instruction may result in a minor or moderate injury.



NOTICE

This sign is not hazard-related but considered important information requiring your caution. Also, this sign warns against property damage.



Information

This sign indicates the information of maintaining the best conditions for installation and operation of the product.



Personnel who handle ESS need to be aware of the following warning signs and corresponding potential hazards.

**WARNING—SHOCK HAZARD**

Do not come into contact with the system connector or terminal without appropriate PPE. Do not open the enclosure doors if proper LOTO procedures, PPE, related training specified in local rules and regulations are not part of the maintenance plan.

**WARNING—ARC FLASH HAZARD**

There are arc flash hazards related to all electrical equipment. Arc flash hazards may increase with equipment modification (e.g. door opening). Arc flash accidents may lead to a serious injury. Proper PPE and training in accordance with local rules and regulations are required.

**WARNING—FIRE HAZARD**

Some extreme failure conditions such as protection failure, over current, heat generation and combustion may lead to a fire accident, which may generate dangerous gases such as carbon monoxide, carbon dioxide, and various types of hydrocarbon.

**CAUTION— PINCH POINTS**

Multiple pinch points exist in and between the system components. Take caution when working around the equipment enclosure.

**CAUTION—STATIC SENSITIVE**

Electronic devices can be damaged by electrostatic discharge, therefore proper handling procedures are required. Be sure to wear a grounded anti-static wrist trap and discharge static electricity by touching the grounded surface near the equipment before contacting the system component.

## 2. Dangerous Voltage

**DANGER**

The ESS is powered by multiple sources of power. The equipment may be within the dangerous voltage range even when it appears not to work. Please be aware of all the cautions and warnings in this document, otherwise it could result in a severe injury or death. Be sure to follow all the safety instructions provided by the manufacturer.



Electrical equipment has a risk of electric shock and/or arc flash. The following instructions must be observed when working with or near the electrical equipment.

- Remove watches, jewelry, rings and other metal objects.
- Use tools with an insulated handle.
- Wear proper PPE stated in local rules and regulations.

### 3. Lock Out / Tag Out



#### DANGER

Always comply with the applicable lock out/tag out (LOTO) procedure. Failure to comply with proper LOTO procedures may result in a serious injury or death. Because of power applied to the ESS, dangerous voltage may be present in some components. In order to prevent accidental death or injuries, do not touch any components in the enclosure without specific instructions. Make sure that all equipment is properly grounded to reduce the risk of electric shocks.



#### WARNING

The enclosure doors shall remain closed at all times except when access to the enclosure is required. If possible, personnel must keep a safe distance from the enclosure when restarting the equipment. Local, state and national LOTO procedures must always be complied with when working with or around the ESS. The LOTO procedures should meet or exceed all of instructions presented in the SDI safety documents. Before entering potentially dangerous areas or beginning to work with the ESS, complete the following tasks:

- Wear proper personal protective equipment.
- Identify and isolate the stored energy source from the power of the operating rack.
- Apply appropriate LOTO equipment. When applying LOTO to the ESS, do not touch anything inside the enclosure, if it is not specified in the work procedure.
- Complete site-specific LOTO procedures and safety checklists before beginning to work.

### 4. Battery System Handling Instructions



#### DANGER

- When energized, this equipment has a risk of causing electric shocks, death or burns. Only authorized and well-trained personnel with a strong understanding of the equipment shall engage in installation, operation and maintenance.
- Follow all of safety instructions specified in local and/or national EHS (Environment, Health and Safety) guidelines, in order to prevent death, injuries or product damage.
- Approved basic action steps and procedures should be strictly observed, in order to minimize the risk of electric shocks, death or burns.



#### WARNING

- The site protocol concerning working at heights must be complied with, in order to prevent injuries or equipment damage.
- Only personnel who are trained by Samsung SDI are qualified to modify programmable machines, in order to prevent personal injuries or equipment damage resulting from malfunctioning equipment.
- Standards and regulations must always be observed. Only certified equipment should be used as essential parts of the safety system. Do not assume that the safety-critical control loop is closed.

Samsung SDI offers safety instructions as below. As detailed safety items and procedures may differ by the product installation type and product configuration, the customer is responsible for updating the items and procedures applicable to their product, according to their sites.

- Before installing the battery system, read all the safety instructions in this manual.
- Designate a restricted area around the battery system.
- Only authorized personnel wearing uniforms and protective equipment that comply with the PPE regulations are authorized to access and handle the battery system.

**WARNING**

- The battery product should be installed in a restricted area. Only qualified and trained personnel with a strong understanding of the product and the safety instructions in the Operation and Maintenance (O&M) manual should have access. Only authorized and skilled electricians or personnel who have completed proper high voltage training, with appropriate PPE shall be allowed access to the restricted area.
- Methods, capable of controlling access without the approval of the person in charge of the restricted area, such as installing a lock or any method to monitor access should be prepared.
- It is strictly prohibited to disassemble/modify the products without the consent of Samsung SDI.
- It is strictly prohibited to use the battery system for purposes that have not been agreed in advance. Samsung SDI is not responsible for any consequent tangible/intangible losses.

Samsung SDI's battery systems are high voltage systems, so they should be placed in restricted areas that are not accessible to unauthorized individuals. Decide the access qualifications according to the local regulations so that only authorized and trained users with a strong understanding of high voltage battery systems and meet the applicable safety instructions should handle this system. It is strictly prohibited to open the cover, and to modify and disassemble the modules, BCU, and any other parts provided by Samsung SDI without the consent of Samsung SDI. It is also prohibited to use the battery system for purposes other than those agreed before. Failure to comply with above-mentioned instructions may void the product warranty and other agreements.

When handling the battery system, always note that there is a risk of electrical shock resulting from high short-circuit current. All the safety instructions must be observed with extra caution, especially when the system is in operation. Access to the battery system while it is in operation is, in general, prohibited.

- Remove watches, rings or other metal objects.
- Use tools with an insulated handle in order to prevent inadvertent electrical shock or short circuits.
- Do not put tools or metal parts on top of the battery.
- Disconnect the power and charging source before working with high-power cables.
- Use appropriate handling and transport tools when moving the battery system. Wear safety clothing and protective gears that comply with the PPE rules.
- Keep the site as clean and dust-free as possible when installing, servicing, and operating the battery system.
- The battery system must not be disposed arbitrarily. Take extra care when disposing the product due to risk of fire or explosion.
- Do not open or damage (mutilate) the product.
- Installation and maintenance of the battery system must be performed by authorized personnel.
- Unauthorized personnel are not allowed to access or handle the battery system.
- It is recommended to discharge the battery before accessing the site.
- Installation of the battery system involves heavy cargos, follow safe lifting techniques and guidelines.
- The battery system should be directly connected with the ground busbar and should not be connected with the ground wires of other equipment through daisy chains (serial connection).

## 5. Module Handling Instructions

Samsung SDI battery modules store electrical energy even when control power has been removed. High discharge current may occur instantaneously as shown in the table below. Therefore, when handling modules, all personnel shall be aware of the possibility of injuries and product damage resulting from arc flash and shall follow safe handling procedures. In particular, it is strictly prohibited that short circuits occur on the positive and negative terminals of battery modules. Take caution when handling heavy products. In the event of a short circuit, the affected module must be immediately disconnected from the rest of battery modules and kept in a safe place. If the module is dropped, stop using the fallen module at once and keep it in a safe place.

	<b>E5SU</b>
Voltage (SOC100%) [V]	157.7
Internal Resistance [mΩ]	9.8
Estimated Fault Current [kA]	16.1
Weight [kg]	215

**WARNING**

- Stop using battery modules that had an external impact immediately and keep them in a safe place; Contact Samsung SDI for further instructions.
- Take caution to prevent modules from having external short circuits.
- Use proper lifting techniques as battery modules weigh over 50kg.
- Unauthorized disassembly/modification of battery modules is strictly prohibited.

### ▪ Handling Instructions

- Do not remove the covers of the modules. Disassembly or modification of modules is strictly prohibited.
- Do not wear or use metal objects that could cause short circuits on the positive and negative terminals.
- Do not permit or allow mechanical shock or trauma to modules.
- Do not drop modules. Discontinue use of dropped modules immediately and store them safely and contact Samsung SDI.
- Do not disassemble or damage modules.
- Do not insert foreign substances into modules.
- Do not remove screws from modules.
- Do not expose modules to water or highly humid environments.
- Do not heat modules. Avoid direct sunlight.
- Do not directly solder to the surfaces of the modules.
- Do not use damaged or deformed modules and discontinue use immediately. Dispose modules according to local regulations.
- Do not damage the sheath of the cables or connectors. Discontinue use of cables that are damaged immediately.
- Do not charge/discharge using inappropriate devices. Always operate the modules within the safe operating window of the BMS.
- Do not smoke within 20 meters of the battery system.
- Do not place anything on top of the battery module and BCU.
- Do not eat or drink near the battery system.
- Use appropriate lifting techniques and procedures when handling battery modules.
- Do not store/install the battery near high fire risk objects, direct heat sources, or flammable materials.

### ▪ Shock Watch

Each BCU is equipped with a non-resettable “shock watch” in order to detect any shock that could occur during handling. Discontinue use of BCUs if the color of the shock watch changed. When receiving the product, check the color of the shock watch. If the sensor turned red, contact Samsung SDI for further instructions. If the color changed after the installation and/or operation of the system without reporting the issue, you may be asked to discontinue use and replace the product. Samsung SDI may not be responsible for compensation for consequent losses.



#### Customer guideline

- When unboxing, users are obliged to check the product before installation.
- If the sensor shows any color change, users must submit a defect report\* that is separately supplied by Samsung SDI upon request. (\* A defect report shall contain ① box serial number, ② product serial number, ③ photo. The defect that is not reported within one week from the date of the finding shall be considered the fault of user.)
  - 1) The subject of responsibility may vary upon the shipping contract.
  - 2) Any defect shall be reported within two months from the date of the delivery.
  - 3) Any defect that is found after installation shall be deemed as the fault of user.
- The product that is determined to be defective shall be sent back to Samsung SDI.

#### BCU



Shock Watch Location

Normal	Damaged
	

Shock Watch Examples

- Discontinue use of the affected BCUs. Contact Samsung SDI for more information.

#### NOTICE



- If the shock watch color changes, contact Samsung SDI for further instructions. Reuse of the affected product is strictly prohibited before following Samsung SDI instructions.
- After receiving the product, need to check whether the shock watch color has changed. If a color change is found after installation or during operation, you may be asked to stop using or replace the product. Samsung SDI is not responsible for compensation for consequent losses.
- Be careful not to touch the shock watch sensor when unpacking, moving or inserting the product into rack frame. If it is discolored due to the customer handling careless, Samsung SDI is not responsible for warranty.

#### Storage Instructions

- When storing or transporting the module in its packaging box, keep the box upright as shown in the figure below. Do not keep the box upside down or on its side.
- Do not stack more than 4 boxes in a row for battery module, 5 boxes for BCU.
- For the long-term storage of modules, SOC should be kept at 15 to 25%. The storage environmental conditions, including temperature and humidity, and maintenance charge frequency as recommended by Samsung SDI shall be followed.
- While keeping battery modules in storage, they are self-discharged. Regular voltage measurements are required to prevent permanent electrical damage resulting from long-term storage. If the voltage of battery modules is SOC 15% or less, must charge the battery to SOC 25%.



Module Storage Method

[Table 1] Storage Environment

Item		Standard	Comment
SOC		10 to 25%	It is essential to check the voltage of battery modules per year. Charging is required according to the following table.
Temp	Module	5 to 28°C	For a convenient battery installation, one of the storage conditions below can be temporarily allowed before installation. The customer should provide Samsung SDI with the records of the storage period and the temperature & humidity management during storage. <ul style="list-style-type: none"> <li>Maximum 6 months: 5 to 28°C</li> <li>Maximum 1 month: -20 to 40°C</li> <li>Maximum 3 months: -20 to 40°C, Mean daily maximum temperature within 30°C.</li> </ul>
	BCU Rack Frame	5 to 40°C	
	Uniformity	Within 5°C	
			If storage is required after installation, the condition of 5 to 28 °C should be maintained for the module. Additional battery degradation (0.1%/Month) may occur depending on the storage period.
Humidity		less than 80%	There must be no condensation.
Altitude		1000m or less	
Pollution Degree		PD2 or PD1	The battery system should be stored under a condition where no foreign substances are generated.

**NOTICE**

Li-ion batteries may experience lifetime degradation or voltage deviation between each battery cells if they are kept for a long time in storage after shipment or are not charging/discharging. This is an electrochemical phenomenon of li-ion batteries, which is not a significant issue. As this may, however, undermine the system performance, it is, therefore, a requirements to perform cell balancing for two to seven days before battery operation. Contact Samsung SDI for details.

## 6. Initial Action Steps

### ■ Battery

Refer to MSDS documents, which were additionally provided, for further information.

#### Organic Solvent Electrolyte

Samsung SDI li-ion battery cells contain organic solvent electrolyte. Damage to the external case may lead to electrolyte leakage. Direct contact with the electrolyte can cause skin irritation. Electrolyte is an acid and smells sour.

In the event of contact with the electrolyte, follow the instructions below to minimize the risk of injuries.

- Flush your eyes immediately with cold running water for at least 15 minutes.
- Rinse your skin immediately with water for at least 15 minutes.
- Remove clothing if they are also affected.
- Seek medical treatment immediately.

## Cell Vent Device

Although the battery system is equipped with multiple safety devices, there is still a possibility of accidents. Misuse, abuse or damage of the battery cell may lead to the opening of the vent located on the top of the cell, in order to prevent severe explosions. In this case, the internal pressure goes down but the electrolyte may leak.

- The opening of the vent could indicate a serious battery issue, which requires extra caution.
- Discontinue use of the battery system by disconnecting all contactors in the battery system. Leave auxiliary power enabled.
- Contact Samsung SDI immediately.
- Check the temperature and voltage of each cell through the external communications interface. Authorized personnel can access and inspect the battery only when the temperature reduces to 40°C or lower. If the temperature and voltage cannot be measured and the cause of the issue cannot be identified, do not attempt to access the system for at least 24 hours.
- Generation and use of any type of spark or flame is strictly banned in order to prevent the ignition of the leaked electrolyte.

## First Aid

The following first aid measures are required only in case of exposure to interior battery components after damage of the external battery casing. Undamaged, closed cells do not represent a danger to the health. Carry out the first-aid steps for your safety in emergency situations. Seek medical treatment and consult with medical professionals, as necessary.

### Eye contact

- In case of contact with substance, immediately flush eyes with running water at least 20 minutes.

### Skin Contact

- In case of contact with substance, immediately flush skin with running water at least 20 minutes.
- Remove and isolate contaminated clothing and shoes.
- Wash contaminated clothing and shoes before reuse.
- Get immediate medical advice/attention.

### Inhalation

- Specific medical treatment is urgent.
- Move victim to fresh air.
- Administer oxygen if breathing is difficult.

### Ingestion

- Do not let him/her eat anything, if unconscious.
- Get immediate medical advice/attention.

## ▪ Battery Module Issue

If defects are found in operation or installation, follow the instructions below.

- Follow the safe handling procedures and wear appropriate PPE before accessing the module.
- Confirm that the contactors are open and no current is flowing before disconnecting power cables.
- At least two people are required for handling modules.
- If the system shows abnormal symptoms such as sparks, smoke or heat generation, do not access the battery system.

Depending on the type of defect, follow the procedures below. Move the defective module to a safe place and contact Samsung SDI immediately.

## Functional Defect

If defects are more related with functionality such as voltage detection, temperature detection or fan malfunction, keep the defective module in a place satisfying the storage conditions of Samsung SDI. Contact Samsung SDI for further instructions.

## Electrical Defect

If mechanical or electrical defects are experienced, such as a dropped module, severe mechanical deformation, residues generated from thermal damage on any module surface, or other abnormal electrical and physical characteristics. Defective modules should be kept in a safe place separated from the battery system. Samsung SDI recommends that the suspect module is kept in a chamber as shown in Figure 4. Contact Samsung SDI immediately for further instructions.



Anti-explosion Chamber

### Severe Defect

If modules have or are likely to have serious safety issues such as flame, vent opening, self-heating or release, the defected modules must be immersed in water. Please follow as below.

Make sure that deal with the defected battery modules only after safety is secured.

- Immerse the defected battery module in water for 5days, for first 24hours in no-salt water, for the rest 96hours with 4% salt water. The module must be fully soaked in water and the distance between the surface of water and the top of the battery is at least 15cm.



Thermal Plastic Box

### Access to Battery System

Samsung SDI recommends that only authorized personnel with a strong understanding of the entire battery system access, install, and commission the system. Access to the system while in operation is not allowed.

The battery system contains a high voltage of 1000Vdc or higher, and its resistance is extremely low for battery efficiency, which may generate arc flash when an inadvertent external short circuit event occurs. Therefore, take caution when accessing the battery, and wear appropriate PPE at all times.

Before accessing the battery system, all users must be aware of safety instructions.

Prior to accessing the battery room, confirm that the PCS and the battery have been disconnected. Auxiliary power to the battery system can remain powered.

Samsung SDI recommends wearing the following PPE including long-sleeve shirts and pants, even when accessing the battery system out of operation.

- Safety helmets
- Safety glasses or goggles
- Heavy-duty leather gloves or insulated gloves with leather protectors
- Safety shoes
- Hearing protection
- Face shields for projectile protection

If access to the battery system is required for work, it is allowed only after making sure that the system has been disconnected and personnel are wearing appropriate PPE.



### DANGER

- Access to the system in operation is strictly prohibited.
- If access to the system is required for work, check if the system has entirely stopped. And make sure to fully understand the product characteristics and wear appropriate PPE.



# Description of Major Components

## 1. ESS System Overview

Battery modules, the smallest line replaceable unit in the system, are configured serially and in parallel, so operating voltage and total system capacity are variable. The system is designed to have all installation and maintenance work performed from the front of the rack, making maintenance easy. All of platforms provided by Samsung SDI have a similar design, improving product conformity. Each rack is equipped with a BCU to secure the safety and reliability of serially connected modules. Racks are then electrically connected in parallel to form a battery system, where each battery is equipped with the system BMS responsible for aggregating and transmitting the battery data to the EMS and/or PCS.

## 2. Cell

Reliable, super-long-life, NCM-based prismatic cells manufactured by Samsung SDI are used in the battery system. Cells of different capacity and characteristics are applied to each platform. However, all cells have nearly exactly the same physical size and are covered with a protective, heavy-duty metal case, which is resilient to external shock.

[Table 2] Cell Specification

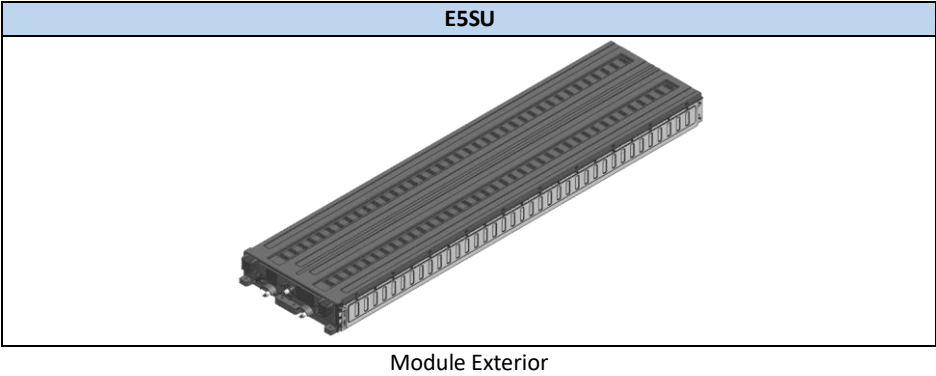
	Cell
Capacity [Ah]	152
Nominal Voltage [V]	3.69
Operating Voltage [V]	3.0 - 4.15
Weight [kg]	Max 2.5
Applied Platform	E5SU
Dimension [mm]	220.08 x 102.22 x 42.74

## 3. Module

The module includes serially-connected/parallel-connected battery cells and the module BMS. The module BMS measures the battery characteristics such as cell voltage and temperature, and monitor the status of each battery. The module BMS digitizes the measured voltage and temperature of each cell, delivers the data to the rack BMS, and receives a command from the rack BMS to control cell balancing. The module BMS communicates with the rack BMS in the BCU via UART interface. What is more, Samsung SDI has applied liquid-cooling system for E5SU platform. There is a cooling plate at the bottom of module and two inlet/outlets are placed in front.

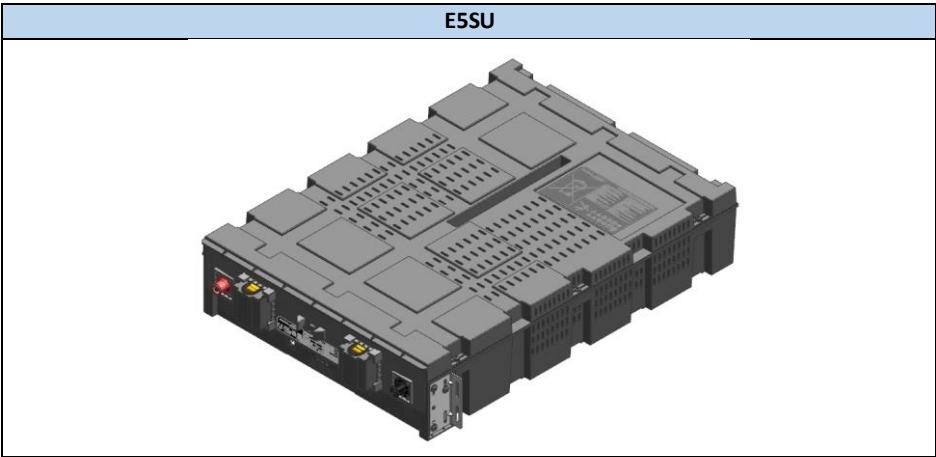
[Table 3] Module Specification

	E5SU
Capacity [Ah]	304
Configuration	2P38S
Nominal Voltage [V]	140.22
Operating Voltage [V]	117.8 – 157.7
Weight [kg]	215
Dimension [mm]	478.2 x 1933.6 x 135



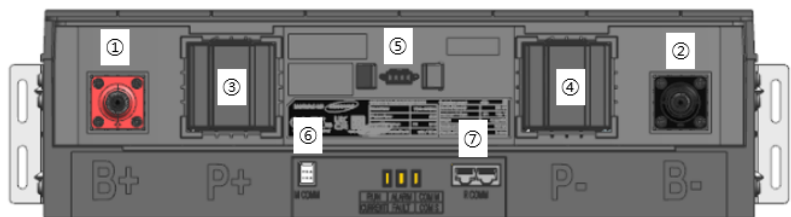
4. BCU (Battery Control Unit)

The BCU is equipped with redundant fuses, one at each terminal, to prevent cell damage resulting from external short circuits. Also, the BCU is equipped with redundant DC contactors, one at each terminal, to control the connection between racks and the main DC bus. The DC contactor status in each BCU is controlled by the rack BMS. The BCU also includes the rack BMS, which collects all of the module BMS data, and delivers this data to the system BMS via internal CAN-Bus interface. The rack BMS calculates the rack SOC and SOH. The BCU requires an externally-provided 24 Vdc power source.



[Table 4] BCU Specification

	E5S
Key Component	DC contactor 2EA, Fuse 2EA, Rack BMS 1EA
Fuse Rating	1500V 300A
Contactor Rating	1500V 600A
Power Consumption [W]	15.6 / 72.8
Weight [kg]	15
Dimension WxLxH [mm]	466 x 680 x 135



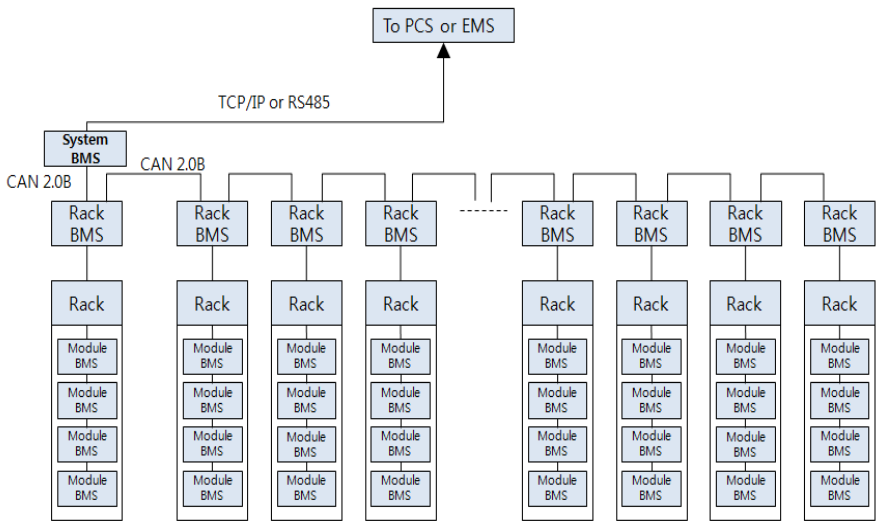
	Function	Pin No	Description		Function	Pin No	Description		
①	B+ : Battery Plus	NA	Connected to the module #n +	⑦	Rack Communication (E6588-015-02-L)	1	CAN High(Rack data)		
②	B- : Battery Minus	NA	Connected to the module #1 -			2	CAN low(Rack data)		
③	P+ : Grid Plus	NA	Connected to PCS + Max cable gauge AWG #1/0, M8/L20 Bolt			3	CAN GND		
④	P- : Grid Minus	NA	Connected to PCS – Max cable gauge AWG #1/0, M8/L20 Bolt			4	NC		
⑤	Aux Power IN (DF63-4EP-3.96C)	1	24V Aux power in GND			5	NC		
		2	24V Aux power in (+)			6	CAN GND		
		3	-			7	Cell CAN Low (Cell data)		
		4	-			8	Cell CAN High (Cell data)		
⑥	Module communication (S06B-J21DK-GGXR)	1A	-			9	CAN High(Rack data)		
		1B	-			10	CAN low(Rack data)		
		2A	-			11	CAN GND		
		2B	-			12	NC		
		3A	IsoSPI (+)			13	NC		
		3B	IsoSPI (-)			14	CAN GND		
						15	Cell CAN low(Cell data)		
						16	Cell CAN High(Cell data)		

BCU Pin Description

5. System BMS

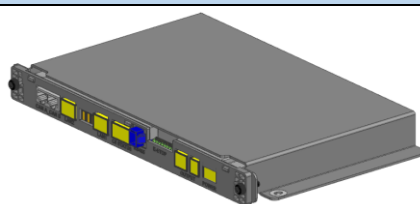
The system BMS assembly can control and monitor up to 128 racks and communicates with the PCS (or EMS) via MODBUS TCP/IP or MODBUS RTU. The system BMS is mounted on the first or last rack in the battery bank and is mounted to the rack frame. The system BMS communicates with the BCUs (rack BMS), connected through a daisy chained CAN communication (CAN 2.0B). In case 40 or more racks are connected in parallel, or the battery racks are installed in different places in the same BUS due to physical constraints, CAN repeaters must be installed by customers for seamless communication.

- Dimension [mm]: 198 x 317 x 30

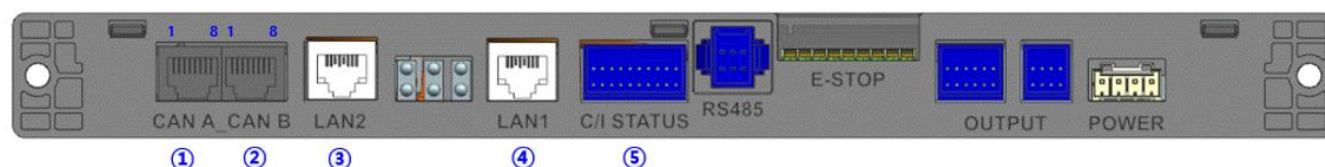


Communication Block Diagram

## E5SU



System BMS Exterior



## ① CAN A

Pin No.	Pin Name	Function
1	CAN 1_HIGH	CAN A is for communication, must connect with BCU(R-BMS).
2	CAN 1_LOW	
3	CAN_GND	
4	CAN 3_LOW	
5	CAN 3_HIGH	
6	CAN 3_GND	
7	CAN 2_LOW	
8	CAN 2_HIGH	

## ② CAN B

Pin No.	Pin Name	Function
1	CAN 2_HIGH	CAN B is for maintenance
2	CAN 2_LOW	
3	CAN 2_GND	
4	N.C	
5	N.C	
6	N.C	
7	N.C	
8	N.C	

## ③ LAN 2

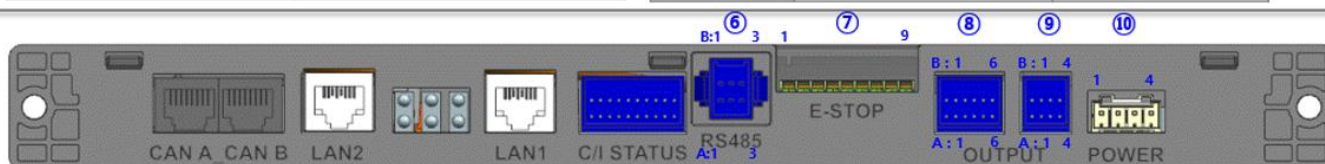
Pin No.	Pin Name	Function
1	Ethernet_TX_P	Ethernet communication between System BMS and PCS
2	Ethernet_TX_N	
3	Ethernet_RX_P	
6	Ethernet_RX_N	5 ports available (502, 602, 702, 802, 902)
4,5,7,8	N.C	

## ④ LAN 1

Pin No.	Pin Name	Function
1	Ethernet_TX_P	Ethernet communication between System BMS and PCS
2	Ethernet_TX_N	
3	Ethernet_RX_P	
6	Ethernet_RX_N	3 ports available (502, 602, 702)
4,5,7,8	N.C	

## ⑤ Digital Input

Pin No.	Pin Name	Function
B1	INPUT_1	Dry Input
B2	INPUT_2	Dry Input
B3	INPUT_3	Dry Input
B4	INPUT_4	Dry Input
B5	INPUT_5	Dry Input
B6	INPUT_6	Dry Input
B7	INPUT_7	Dry Input
B8	INPUT_8	Dry Input
B9	INPUT_9	Dry Input
B10	INPUT_10	Dry Input
A1,A2,A3,A4,A5,A6,A7,A8,A9,A10	GND_SMPS_IN	Ground



## ⑥ RS485

Pin No.	Pin Name	Function
B1	RS485_P	RS485 communication between System BMS and PCS
B2	RS485_N	
B3	RS485_GND	
A1,2,3	N.C	

## ⑧ Dry Contact out

Pin No.	Pin Name	Function
B1	DRY1_STATE_COM	Dry Contact output 3ch
B2	DRY1_STATE_NO	
B3	DRY2_STATE_NC	
B4	DRY3_STATE_COM	
B5	DRY3_STATE_NO	
A1	DRY1_STATE_NC	
A2	DRY2_STATE_COM	
A3	DRY2_STATE_NO	
A4	DRY3_STATE_NC	* Contact Rating : 30Vdc, 1A : 125Vac, 0.3A
A5,B5,A6	N.C	

## ⑦ E-stop

Pin No.	Pin Name	Function
1,2,3	1 : N.C , 2 : COM , 3 : N.O	PCS E-Stop port
4,5	-	External port 1
6,7	-	External port 2
8,9	-	External port 3

## ⑨ 24V out

Pin No.	Pin Name	Function
B1,B2,B3,B4	GND_SMPS_IN	24Vdc output 4ch
A1	24V out 0	
A2	24V out 1	
A3	24V out 2	
A4	24V out 3	* Rated Voltage : 24Vdc * Max Current : Under 2A

## ⑩ Power

Pin No.	Pin Name	Function
1	GND_SMPS_IN	24Vdc input
2	24V+	
3	N.C	
4	N.C	

System BMS Pin Description for DI system platform

## 6. Rack System

The battery rack system is configured as below. Refer to Table below.

[Table 5] Rack System Configuration for E5SU

Configuration	2P342S
Model Name	PHR3836-001A
Nominal Energy [kWh]	383.642
Nominal Voltage [Vdc]	1262.0
Capacity [Ah]	304
Recommended CC [A]	60.8
Recommended CV [V]	1419.3
End Charge Current[A]	15.2
Module Number [EA]	9

# Rack Assembly

## 1. Overview

**[Work explanation]**

Put modules, BCUs and system BMS in the rack frames and connect with power cables(or bus-bars) and communication cables.

**[PPE for installation]**

- Do not wear watches, rings, jewelry, or any other metal objects.
- Do wear gloves, PPE, steel-toed shoes, safety helmet, safety glasses, ear protection, and any other required safety equipment

**[Cautions]**

The following safety labels are located on the battery modules and BCUs, it is the user’s responsibility to ensure that all warnings are properly observed.



During the installation, fastening torques must be followed as below table, only except for installing modules.

Screw Spec	Fastening torque(kgf·cm)
M4	18~24 kgfcm / 1.8~2.3 Nm
M5	28~32 kgfcm / 2.8~3.2 Nm
M6	50~60 kgfcm / 4.9~5.9 Nm
M8	152.9 kgfcm / 15 Nm
M10	170~180 kgfcm / 16.7~17.7 Nm
M12	400~410 kgfcm / 39.2~40.2 Nm
M16	890~900 kgfcm / 87.3~88.2 Nm

[Table 6] Fastening torque per screw

- Move modules, BCUs and System BMS to the installation place**
  - Use appropriate method to move considering the weight of module, strapping or banding can be helpful as necessary to prevent from drops.
  - In case of moving the modules by human force, follow safe lifting techniques and guidelines
- Install modules in rack frames**
  - Install battery modules from bottom slots of rack frame to top.
  - Follow safe lifting techniques and guidelines. The number of workers should be more than two and they must fully understand safety regulations and handling instructions of the battery modules.
  - Power terminal caps must not be removed at all time.
  - Do NOT push, pull or shock to coolant inlet/outlet on the exterior of module. Any harm, damager and/or bent can lead to leakage.
  - Rubber dust cap of coolant inlet/outlet must be removed only right before connecting branch tubes.

- Install BCUs in rack frames

Place BCUs in the designated rack location  
Follow safe lifting techniques and guidelines

- Install system BMS

Place system BMS near BCU

**NOTICE**

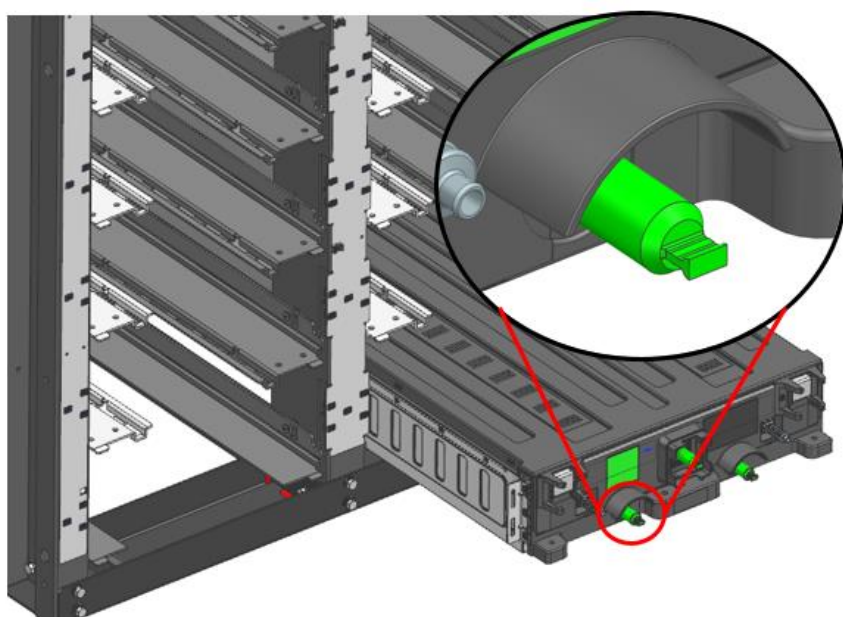
- When installing modules, Do NOT push the front cover.
- Be careful with coolant inlet/outlet in front of module.
- Do NOT push, pull or shock to the inlet/outlet. No damage or bent is critical.

When putting module into rack frame, extra care is essential for coolant inlet/outlet on the exterior of module in front.

Do NOT push, pull or shock to the inlet/outlet. No damage or bent is critical. Otherwise, leakage may occur.

Rubber dust cap of coolant inlet/outlet must be removed only right before connecting branch tubes.

Furthermore, when installing modules, do not push the front cover.



When putting modules in rack frame, it is recommended to use proper tools such as a movable lift or roller conveyor.

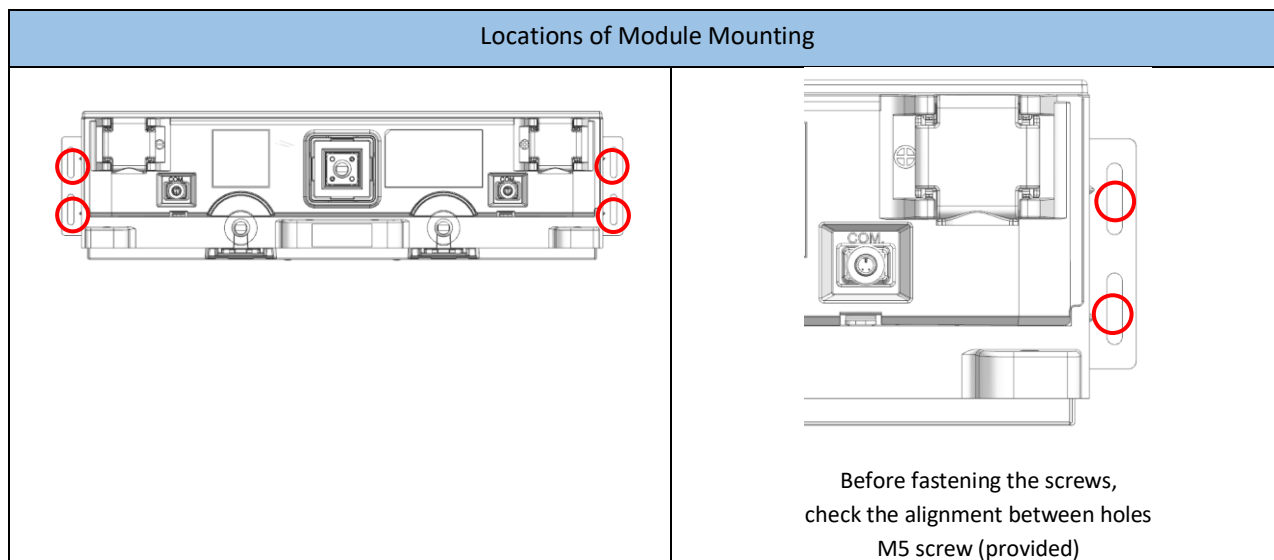




## 2. Fastening Module & BCU to Rack frame

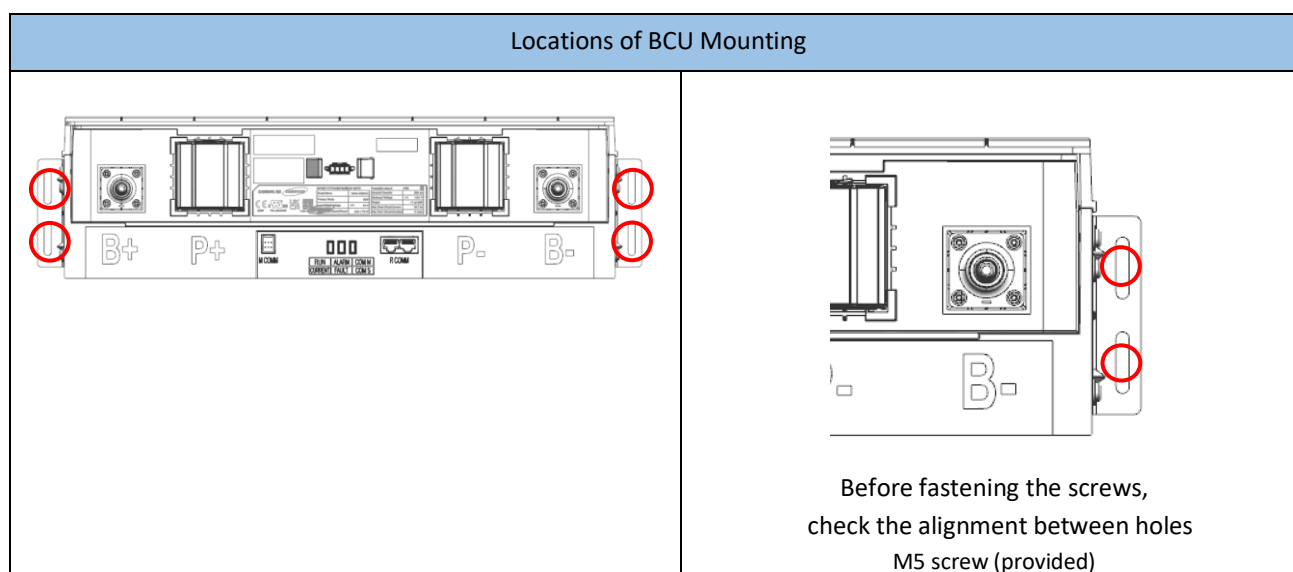
- After placing all modules and BCUs in rack frame, secure the units by bolting them to the rack frames
- There are 4 mounting points each for a module and a BCU
- Before fastening M5 bolts, check the alignment between holes on module/BCU and the holes on the rack frame
- Fasten with M5 screw
- It is strongly recommended to scan and map QR codes of all modules and BCUs after installation into the racks so that in the rare event of a product recall, the target units can be replaced with as minimal of an operational impact to the system as possible.

### Locations of Module Mounting



Locations of Module Mounting

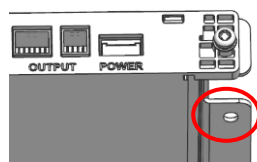
### Locations of BCU Mounting



Locations of BCU Mounting

## 3. System BMS Installation

- System BMS has 2 mounting holes.
- Before fastening screws, check the alignment.
- Use M5 screws.





## 4. Power cable / Bus-bar Connection



**Verify for zero energy state or isolation between strings!**

**Make sure that PCS interface is LOTO'ed!**



### CAUTION

- Follow these instruction steps to protect BMS against damage.
- Must check whether all communication cables are connected.
- Important: DO NOT deviate from the sequence of steps below.



### NOTICE

- Must use provided M8 screws with washer in it.
- The fastening torque must be 15 Nm or 152.9 kgfcm.
- Check the direction of bus-bar, then connect between modules
- Use an insulated extension torque wrench with a 12 mm socket.



### Important

- Power terminals, such as "B+", "B-", "P+", and "P-", on a module or BCU are protected with a power terminal cover.
- The purpose of the power terminal cover is to prevent a short circuit.
- At each step in this process, remove the cover prior to connecting power cable and re-cover immediately after connecting and securing the power cable/busbar.
- The figures below are provided as examples. Other configurations will change the connection method.

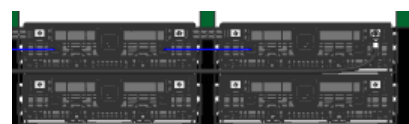
### ■ Installing Module to Module Bus-bar

- Remove the terminal cap ONE by ONE (MUST NOT remove all at once, BUT be sure to cover the cap right after retightening)
- Must use provided M8 screws.
- The fastening torque must be 15 Nm or 152.9 kgfcm.

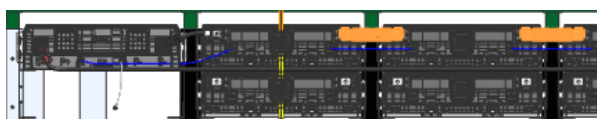
1. Connect (-) power cable between BCU and module #1.



.....



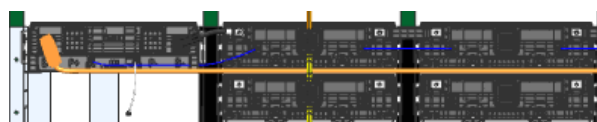
2. Connect bus-bars between modules in order. (#1 to #9)



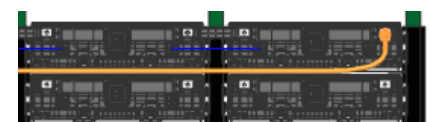
.....



3. Connect a (+) power cable between BCU and module #9.

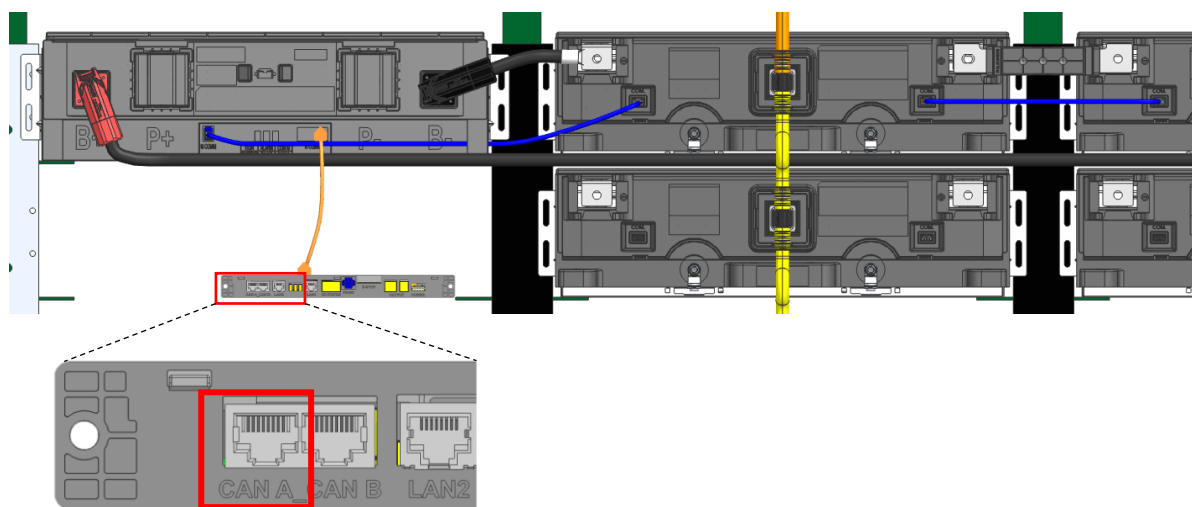


.....

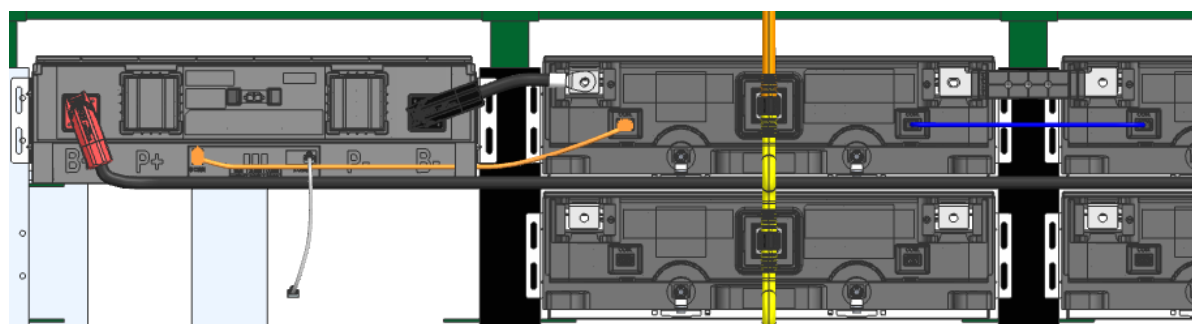


## 5. Communication Cable Wiring

- Connect S to R communication cable between S-BMS and BCU.



- Connect R to M communication cable between BCU and module placed right next to the BCU.



- Connect M to M cables for the rest of modules in order.



### NOTICE

Use the communication cables as indicated in procedure below. They are designed to have optimized lengths at each step.



### WARNING

#### BMS Damage

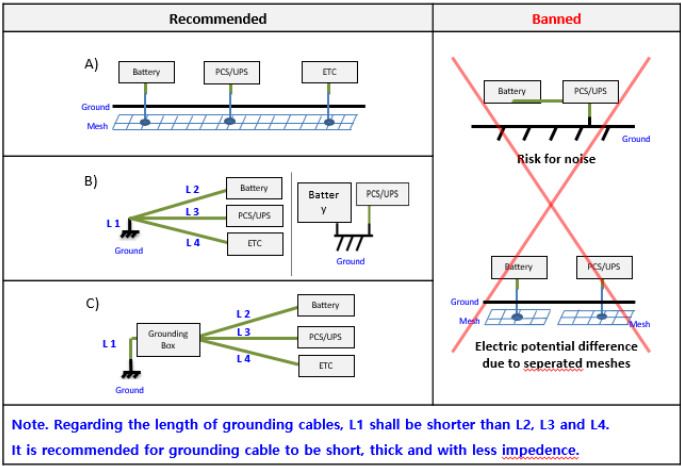
- Do not plug the same communications cable into both the input and output ports on the same module.
- All communication cables must be done installation before connecting power cables and busbars.
- Installing/Uninstalling order must be followed as below.
  - . Installing : Power cables/bus-bars → Communication cables → 24Vdc cables
  - . Uninstalling : 24Vdc cables → Communication cables → Power cables/bus-bars

## 6. Rack Grounding

Each rack shall be individually grounded according to local codes and regulations. Samsung SDI recommends to use at least 25 mm<sup>2</sup> cable for rack frame grounding.

- Bolts, ground wires, and other components used for rack frame grounding are not included in Samsung SDI’s scope of supply.
- Grounding of rack frames can be connected in series, but directly connecting with PCS grounding is strictly prohibited as shown below.

[Reference. Grounding Specifications recommended by Samsung SDI]

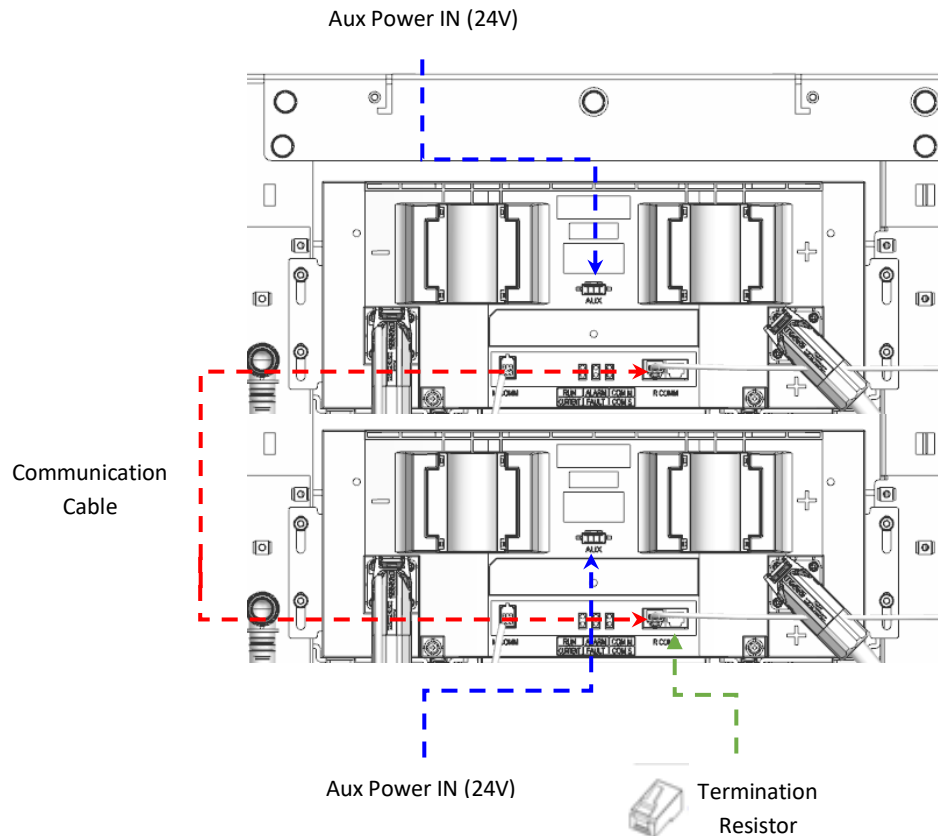


Grounding Specifications recommended by Samsung SDI

# Connection between Parallel Racks

## 1. Communication Cable Wiring (BCU to BCU)

- Connect the communication cable between BCUs as shown below
- Connect the 24Vdc Aux Power IN cable to each BCU
- Supply 24Vdc aux power to each BCU
- Insert the termination resistor (p/n: 4719-002545) to the last installed BCU CAN B connector.





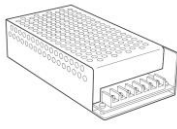
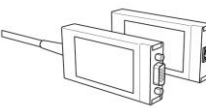

Communication Cable / Aux Power IN (24V) / Termination Resistor

# System Integration

Regarding System Integration, please refer to BATTINS Manual.

The following table shows the required tools for System Integration. The items are not included in Samsung SDI scope of supply.

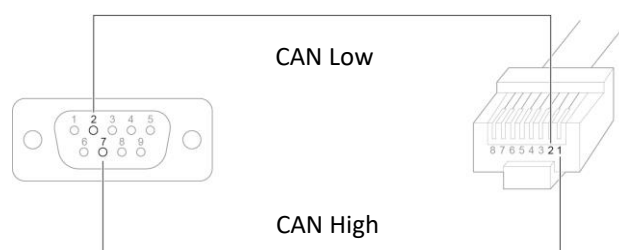
[Table 7] Required Tools for System Integration

No.	Items	Shape	Comments
1	<b>Power Supply cable to BCU &amp; System BMS</b> (Connector: Connect to the 24Vdc SMPS supply)		BCU Power Supply - Connector (DF63-4S-3.96C, Hirose)- Receptacle (DF63-1618SCF, Hirose)
2	<b>ID Writing Cable</b> Connect between BCU and IXXAT (must be made by the customer)		RJ45 (8 pin) and D-SUB female (9 pin), see Fig 41 and Table 14 for more details
3	<b>24Vdc SMPS (Power Supply)</b> (must be sourced by the customer)		Output 24 Vdc, 150 W, 6.3 A (max current)
4	<b>IXXAT</b> (must be sourced by the customer)		USB-to-CAN V2 (IXXAT)
5	<b>Notebook PC</b> English Language Window 7 or later recommended with Samsung SDI BATTMON program installed (must be sourced by the customer)		Minimum hardware requirements <ul style="list-style-type: none"> <li>• 1 GHz or faster processor</li> <li>• 1 GB RAM (32-bit) or 2 GB RAM (64-bit)</li> <li>• 16 GB available hard disk (32-bit) or 20 GB (64-bit)</li> </ul>



## NOTICE

- The ID writing cable must be prepared by the customer according to the following PIN map.



Pin map for ID writing cable

[Table 8] Pins for ID writing cable

Connector A	Pin No.	Connector B	Pin No.	Remarks
D-SUB (female)	2	RJ45	2	CAN Low
	7		1	CAN High

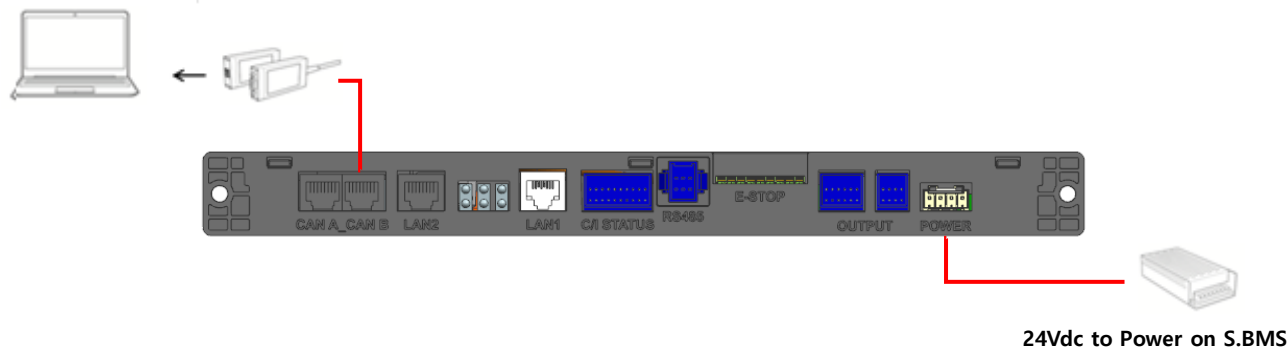


**NOTICE**

- A 120  $\Omega$  termination resistor shall be inserted between the pins 2 and 7 in the D-SUB (Female) connector.

Connection for System Integration


- Using the ID writing cable listed in Table 23, connect to the “CAN B” port on the system BMS and the IXXAT unit.



# Appendix. Liquid Cooling System

## 1. Liquid cooling condition

It is required to keep the condition below for liquid cooling.

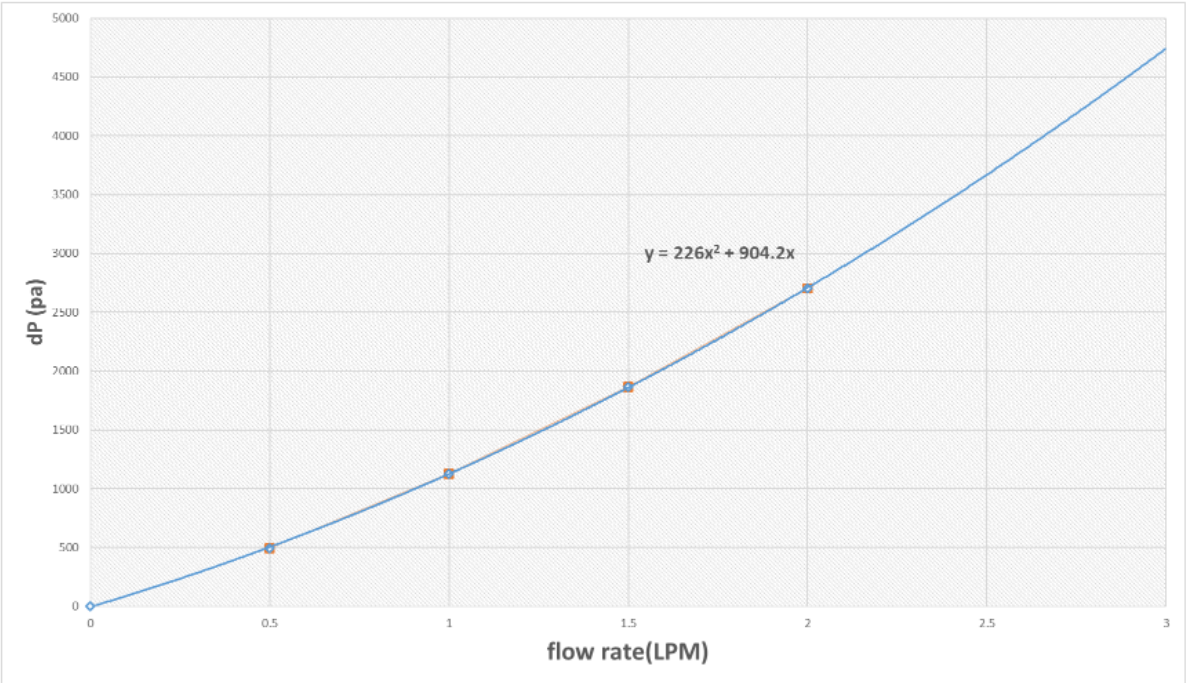


NOTICE

- Coolant working pressure in module is no more than 3bar.
- Coolant must be flowed at least 1.0LPM in every single module so chiller shall be set exceeding 1.0LPM per module.
- The type of coolant is BSC-2 (EG 50 : Water 50).
- Coolant temperature shall be set 23±1°C.
- Coolant must be replaced in 10years.

Items	Specification
Working pressure	≤ 3 bar
Coolant Flow rate	≥ 1.0 L/min per module
Coolant	BSC-2 (EG 50 : Water 50)
Coolant Temperature	23°C ± 1°C

Pressure drop per module is provided as below.



## 2. Caution for Disassemble

In case of disassemble of liquid cooling system, draing the coolant must be done at first. No matter how perfectly drained, there will be some coolant left in modules, manifolds and/or branch tubes. Therefore, the disassembling must be started with a module at the bottom after draining. Before disassembling the branch tubes, the busbars must be removed and put the module terminal covers back. After disassembling, cover the inlet/outlet of module with rubber dust cap. Then, pay attention to check other modules around. Make sure that there is no sign of coolant on any components of near modules, especially modules located in upper & below and on left & right from the one disassembled. If the coolant is stained on module front cover, terminal cover or metal housing body, then it can be used again only after wiping off or cleaning. However, if it is stained on module terminal, busbars or BMS connector, the component cannot be used again so must be replaced. That's why you must be careful when disassembling.



NOTICE	
	▪ Before disassemble any of liquid cooling components, drain the coolant first.
	▪ Disassembling must be started with a module at the bottom.
	▪ Before disassembling branch tube, busbars must be removed and put module terminal covers back.
	▪ After disassembling, cover the inlet/outlet of module with rubber dust cap.
	▪ Make sure that there is no sign of coolant on any components of near modules, especially modules located in upper & below and on left & right from the one disassembled..
	▪ If the coolant is stained on module front cover, terminal cover or metal housing body, then it can be used again only after wiping off or cleaning.
	▪ If it is stained on module terminal, busbars or BMS connectors, the component cannot be used again so must be replaced.