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Battery Module Replacement
&
Manual Charge and Discharge Procedures

Service Manual

SAMSUNG SAMSUNG SDI

Revision Log

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Version	Description	Author	(mm.dd.yyyy)

Contents

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Ⅰ. ESS overview

Ⅱ. Important Safety Precautions

Ⅲ. Work Procedures

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1. Introduction

A Lithium-Ion battery has electrical energy that can cause high voltage and current. Therefore, handling of battery system or components always accompanies a risk of electrical shock and arc flash from high short circuit current. Before performing any activity with the batteries, proper precautions should be taken as the instructions described in the following pages. Personal Protective Equipment (PPE) for each process will be provided in the instructions. Battery modules and cells must not be disposed arbitrarily. Maintenance of battery should be done by certified engineers with proper training of the battery safety and maintenance.

Ⅰ. ESS overview



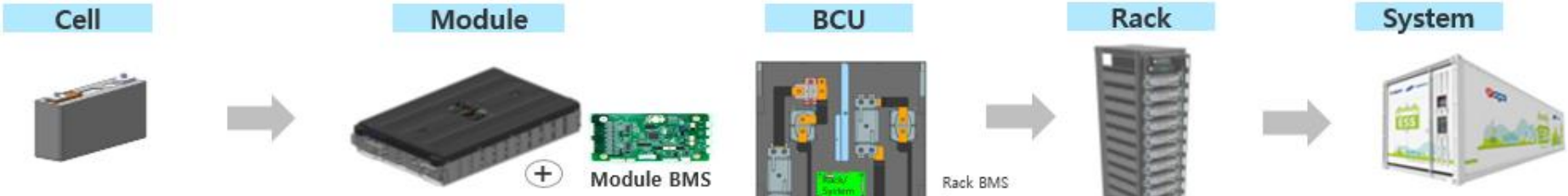
CAUTION

- When access to the battery system is required, only authorized personnel with a good understanding of the entire battery system and safety instructions in this manual and with appropriate PPE should have access
  In any case, repair/replacement is not allowed during the battery operation.
- Do not operate with other components not approved by the ESS systems.
  (Connecting other products in parallel to Samsung SDI's products may result in abnormal operation.)
- The Specifications of the product may be modified without prior notice to improve product quality.
- **Be sure to turn off all powers before parts replacement!**

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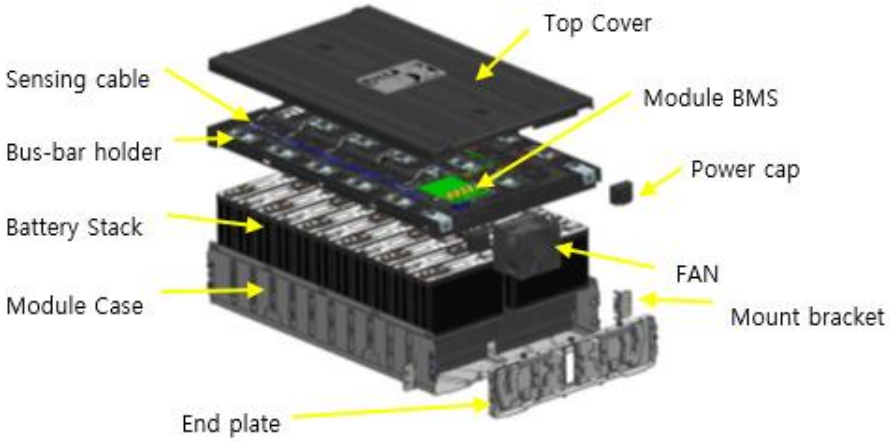
2. Overview of Battery Systems

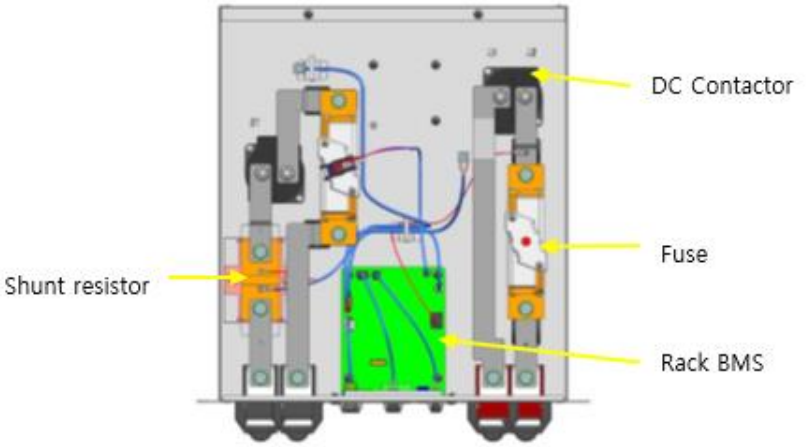
☐ **Battery System:** Cell, Module, BCU and System BMS



[Terminology]
- **BMS** (Battery Management System) : Cell state monitoring and protecting circuit board
- **BCU** (Battery Control Unit) : Rack level Charging/Discharging control and Protection
- **Rack** : Multiple module in series with BCU assembly

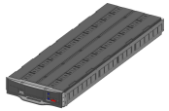
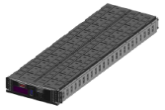
☐ **Internal Structure**





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3. Current Project Line Up

Classification	Energy				Power		
	E2	E2D	E3D	E4D	Mega 3.3	P2	P3
Image							
Configuration	1P22S	2P22S	2P24S	2P24S	1P16S	1P22S	1P22S
Cell Capacity[Ah]	94	94	100	112	68	68	78
Design Energy [kWh]	7.61	15.2	17.7	19.5	3.97	5.46	6.34
Operating Voltage[V]	70.4~91.3	70.4~91.3	76.8~99.6	76.8~98.4	49.6~65.6	68.2~90.2	68.2~90.2
Weight[kg]	<52.5	<120	<126	<120	<50	<49	<54
Dimension[mm]	370X588X160	394X1220X160	377X1,281x158	377X1,281x158	488X510X161	370X650X160	370X650X160

Ⅱ. Important Safety Precautions

1. Introduction

- The following precautions are intended to ensure your safety and prevent property damage.

Before performing any work, please read carefully and follow these instructions

	**DANGER** Failure to comply with the instruction with this symbol may result in a serious accident, causing death or a severe injury.
	**WARNING** Failure to comply with the instruction with this symbol may result in a serious accident, causing a severe injury.
	**CAUTION** Failure to comply with the instruction with this symbol may result in minor or moderate injury.
	***NOTICE*** Provide information considered important but not hazard-related. The information relates to property damage.
	**Important** Indicate valuable tips for optimum installation and operation of the product.

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2. Safety Precautions

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

Review and refer to all safety warnings & cautions in this manual before beginning work.

Build a clear, permanent, restricted access area around the system.

Only authorized, adequately trained electrical operators with proper Personal Protective Equipment (PPE) should be able to access the system.

Depending on the location, the interior of this equipment could be considered a Confined Space. Review local codes and regulations to make this determination. If required, mark enclosures appropriately before beginning work.

3. Personnel & Equipment Warnings

Persons who are manipulating the ESS shall be aware of the following potential hazards



WARNING—SHOCK HAZARD

Do not come into contact with system connectors or terminals. Do not open the enclosure doors unless appropriate LOTO procedures, PPE, and related training as required by local codes and regulations are part of the maintenance plan.



WARNING—ARC FLASH HAZARD

There is an arc flash hazard associated with all electrical equipment. There is an increased risk of an arc flash with any equipment modification (e.g. opening doors). Serious injuries can occur in arc flash incidents. Appropriate PPE and training is required per local codes and regulations.



WARNING—FIRE HAZARD

Fire may result under certain, extreme fault conditions.



CAUTION—PINCH POINTS

Multiple pinch-points are present within and between system components. Be cautioned when working around 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 you touch any system component.

Handling of High Voltage Equipment



DANGER:

The ESS is energized by multiple power sources. Hazardous voltages can be present within this equipment even when it does not appear to be operational. Observe all cautions and warnings in this document. 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 arc flash. The following precautions must be observed when working on or around electrical equipment:

- Remove watches, jewelry, rings, and other metallic objects.
- Use the tools with insulated handles.
- Wear appropriate PPE as defined by local codes and regulations.

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3. Personnel & Equipment Warnings

Lock Out Tag Out Guidelines



DANGER

Follow all applicable Lock Out/Tag Out (LOTO) procedures at all times. If proper LOTO procedures are not followed, serious injury or death may result.
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, verify that all equipment is properly grounded.



WARNING

Enclosure doors shall 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 re-energized. Always follow local, state, and national Lock Out/Tag Out (LOTO) guidelines when working with or near the ESS. LOTO procedures should meet or exceed all guidelines presented in SDI safety documentation. Before entering potentially hazardous areas or beginning work on the ESS, complete the following tasks:

- Identify and wear appropriate PPE.
- Identify and isolate all power and stored energy sources.
- Apply appropriate LOTO devices. When applying LOTO to the ESS, do not touch anything within the enclosure except as specifically directed in the work procedures.

General Warnings



DANGER

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



DANGER

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



DANGER

To minimize hazard of electrical shock, death, or burn, approved grounding practices and procedures shall be strictly followed.



WARNING

To prevent personal injury or damage to equipment, personnel shall adhere to the site protocol in regard to working at heights.



WARNING

To prevent 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 closed.

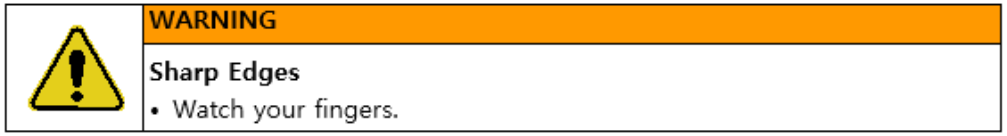
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1. Safety Requirements

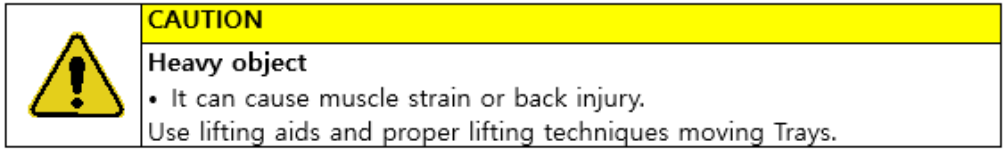
Personal Protective Equipment (PPE) category required for this process is level 2.
All PPE requirements must contain at least the minimum arc energy rated at 13 cal/cm²
The following are the list of the PPEs to be worn:
Arc-Rated Long Sleeve Shirt, Pants, Face Shield and Safety Gloves
Hard Hat, Safety Glasses, Mask and Safety Shoes











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2. Recommended Tools and Device list for replacement

No	Name of Tool	Use / Recommended Tool	Shape
1	**Battery Charger (Power Supply)**	**For Battery Charging** [Recommended] Kikusui PWR1201MH / 1200W , 240V, 15A) or Similar	
2	**Power Loader (Discharger)**	**For Battery Discharging** (Kikusui PLZ1205W / 1200W , 150V, 240A) or Similar with voltage higher than target module with CC-CV mode	
3	**DC Circuit Breaker**	**For Safety Precaution before and after battery charge and discharge** 1) Current Specification: To 2 times bigger than allowed current limit For example: If charger's current limit is 15A, circuit breaker to allow > 30A 2) Voltage Specification: Greater than 120V per module	
4	**Charging/Discharging Power Cables**	For 0.5C charge, use AWG4 with current limit greater than 100A	

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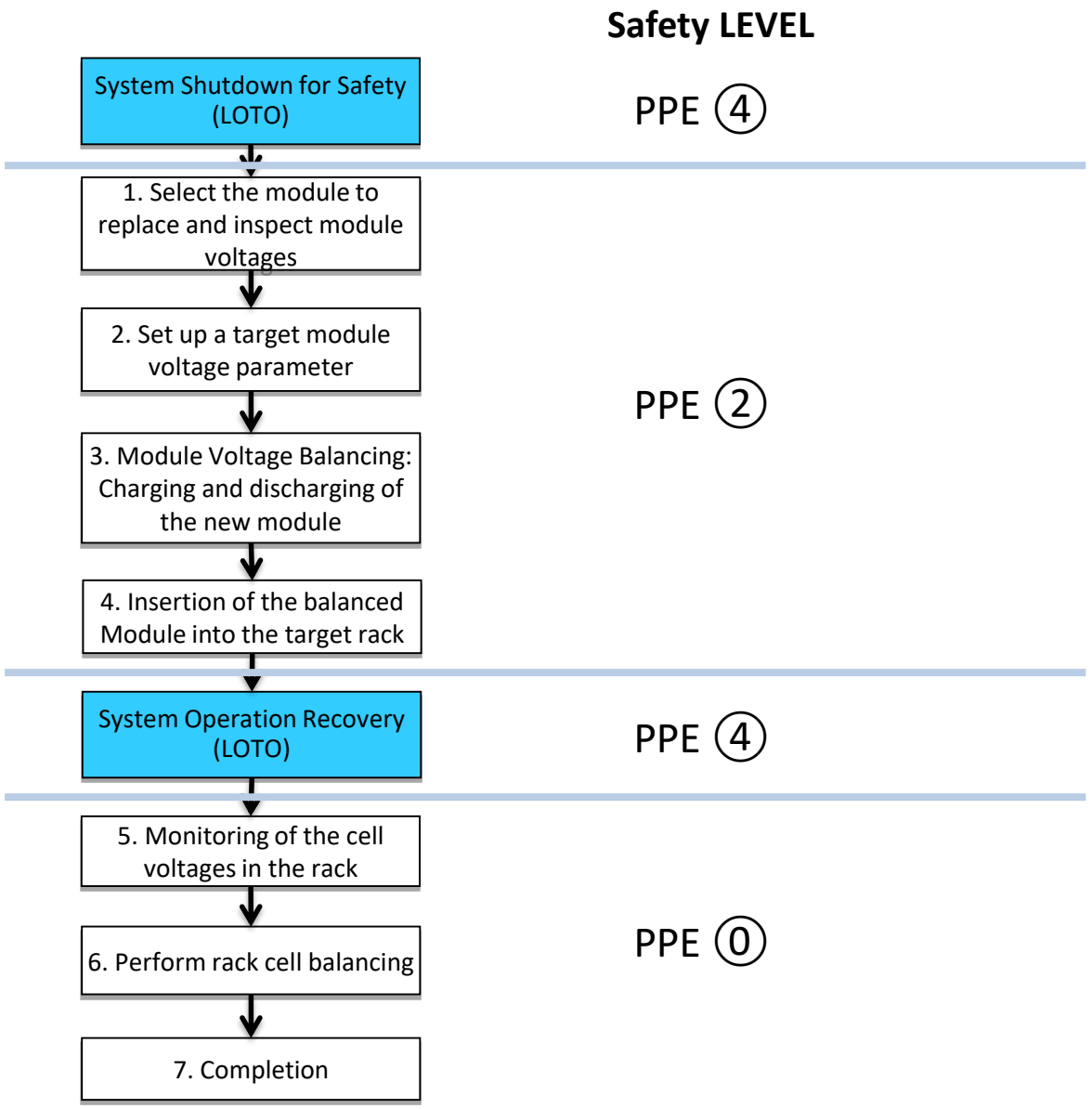
2. Recommended Tools and Device list for replacement

No	Name of Tool	Use / Recommended Tool	Shape
5	**Power Tool – Electrical Screwdriver (Max torque : 27N.m/270kgf.cm)**	Disassemble module and BCU – Rack Hold module and BCU – Rack (5~6N.m / 50~60kgf.cm)	
6	**Insulated Nipper**	Cutting the Cable Tie	
7	**Hexagon Tip**	Hold / Disjoint Module-Rack (4mm Tip)	
8	**Insulated Torque wrench**	Use to install high current cable Cementex: 40200TW38I	
9	**Insulated socket**	Use to install high current cable (Use 13mm socket)	
10	**Insulated Tapes**	To insulate power cable terminals	

Ⅲ. Work Procedures

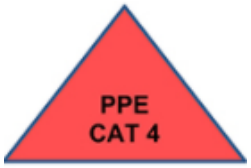
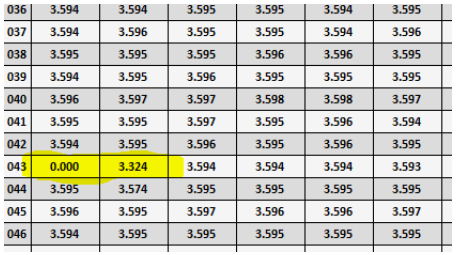
3. Battery Replacement Procedure

- Process Flow Chart



Ⅲ. Work Procedures

- Standard operating procedure

No	Process	Work method	
0	Preparation – LOTO 	Stop the PCS operation Isolate the BCP's main DC disconnect Check if all BCU DC contactors are OFF. Connect the differential probe in the two channels of the Oscilloscope	
1	Set up a target module voltage parameter 	Locate the position of defective module using EMS or Samsung monitoring program Measure the real cell voltage	 036 3.594 3.594 3.595 3.595 3.594 3.595 037 3.594 3.596 3.595 3.595 3.594 3.596 038 3.595 3.595 3.595 3.596 3.596 3.595 039 3.594 3.595 3.596 3.595 3.595 3.595 040 3.596 3.597 3.597 3.598 3.598 3.597 041 3.595 3.595 3.597 3.595 3.596 3.594 042 3.594 3.595 3.596 3.595 3.596 3.595 043 0.000 3.324 3.594 3.594 3.594 3.593 044 3.595 3.574 3.595 3.595 3.595 3.595 045 3.596 3.595 3.597 3.596 3.596 3.597 046 3.594 3.595 3.595 3.595 3.595 3.595 
2	Selection of module for replacement 	- To select the module with the same part number and prepare for replacement	

Ⅲ. Work Procedures

<table>
<tr><th>No</th><th>Process</th><th>Work method</th></tr>
<tr><td>3</td><td>New module voltage balancing



Setting up module voltage target before charging and discharging

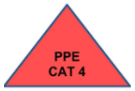
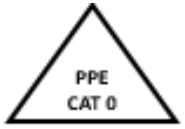
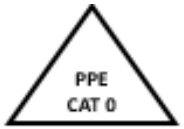
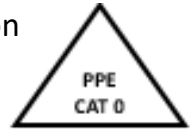

</td><td>In a rack of modules in series, maintaining the max and min cell voltage difference level to its minimum is critical for operation to avoid any voltage imbalance issues.
Recommended difference between maximum and minimum cell voltage difference is 20mV in order to operate the system in a stable state for long time period with continuous monitoring.

If any module cell voltage issue found, new module as to be inserted. As the modules are In series in rack, target module that requires charging and discharging are need to be matched to the following

<table><tr><th>Platforms</th><th>Max. Module Voltage Difference allowed
To reference target voltage</th></tr><tr><td>16 Cell Module
Mega 3.3</td><td>△V = 0.0 to 0.2V (300mV)
lower than the reference</td></tr><tr><td>22 Cell Module
Mega E2, P2, P3 or similar</td><td>△V = 0.0 to 0.3V (300mV)
lower than the reference</td></tr></table>
- If there is only one reference voltage module (when all module voltages are equal), balance the module voltage to the upper voltage range difference. For example: if module voltage reference is 78.1V in a 22 cell module, you can match from 78.1 to 78.4. Always the best option is to match 100%.
- If there are maximum and minimum voltage modules values, balance the module voltage value to closest value in between. For example: if max and min value is 78.4 and 78.5 in a 22cell, it can between to 78.5 to 78.7V

For details of manual charge and discharge procedure, please go to page #17</td></tr>
</table>

Ⅲ. Work Procedures

No	Process	Work method	
4	Insertion of the balanced module into the target rack 	To insert the module into the rack based on installation and O&M or SOP procedures	
5	Re-Energizing the System 	LOTO -deactivation. Reconnect All DC and AC disconnects and circuit breakers	
6	Monitoring of cell voltages in the rack 	To check rack's cell voltage conditions and make sure that maximum and minimum cell voltage difference is less than 20mV	
7	Rack cell balancing after the replacement 	- To perform rack voltage balancing to achieve the recommended maximum and minimum cell voltage difference to be less than 20mV	
8	Completion 	- To perform normal battery charge and discharge operation	

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4. Battery Charging Procedures

- Standard operating procedure

→ **Before starting any operation, proper PPE must be worn (Page #10 Safety Requirements)**

No	Process	Work method	
1	Setting up for the battery charging station (Everything must be turned off) 	- Make sure that everything is powered off, all cables are wired and DC Breaker is open	
2	Setting up for the battery charging station (Everything must be turned off) 	Turn on the power supply (Charger) and - Set up the mode to CC-CV mode ONLY - Set up the Max C-Rate (Specification: Up to 0.5C rate or up to 15A for PWR1201MH) - Set up the target voltage	

Ⅲ. Work Procedures

- Standard operating procedure

No	Process	Work method	
3	Starting the charging process 	Close the DC Breaker and press OUTPUT button in the charger to start with the charging process.	
4	Charging Completion 	When the charger shows that it reached the target voltage, stop the charging process by pressing OUTPUT button (Measurement of real voltages and the charger's voltage value required to make sure that there are no variations. If there is any variation, then it must be adjusted accordingly)	

Ⅲ. Work Procedures

- Standard operating procedure

No	Process	Work method	
5	Finalizing Charging Process 	Open the DC Breakers Disconnect all the wires Verify the voltage of the module	

5. Battery Discharging Procedures

- Standard operating procedure

→ **Before starting any operation, proper PPE must be worn (Page #10 Safety Requirements)**

No	Process	Work method	
1	Setting up for the battery discharging station (Everything must be turned off) 	- Make sure that everything is powered off, all cables are wired and DC Breaker is open	
2	Setting up for the battery discharging station (Everything must be turned off) 	Turn on the Power Loader and: - Set up the mode to CC-CV mode (Do not set up as CC mode only) - Set up the Max C-Rate (Specification: Up to 0.5C rate) - Set up the target voltage	

Ⅲ. Work Procedures

- Standard operating procedure

No	Process	Work method	
3	Starting the discharging process 	Close the DC Breaker and press OUTPUT button in the charger to start with the charging process.	
4	Charging Completion 	When the power loader shows that it reached the target voltage, stop the charging process by pressing OUTPUT button (Measurement of real voltages and the charger's voltage value required to make sure that there are no variations. If there is any variation, then it must be adjusted accordingly)	

Ⅲ. Work Procedures

- Standard operating procedure

No	Process	Work method	
5	Finalizing Discharging Process 	Open the DC Breakers Disconnect all the wires Verify the voltage of the module	