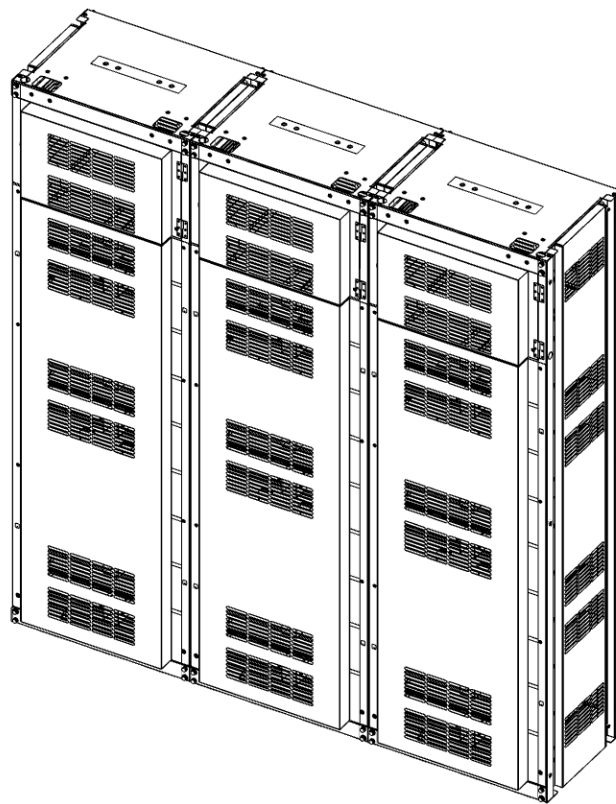


LIB System for UPS – U6A4

Operation and Maintenance Manual



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

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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.

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

General Instructions

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

- Remove watches, rings, and other metallic items.
- Use tools with insulated handles 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 the 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, properly trained and qualified technicians should perform maintenance.
- Only qualified personnel who are familiar with the batteries and safety precautions should install or maintain the battery system.
- Do not allow unauthorized personnel to contact the batteries.

Safety Precautions

The following precautions are general safety guidelines that should be followed when working with or near the Energy Storage System (ESS). The user should develop complete, site-specific safety parameters and procedures.

- 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, properly trained electrical operators should be able to access the system.

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

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 and tag out procedures and related trainings are followed in accordance with local codes and regulations.



WARNING—ARC FLASH HAZARD

All electrical equipment presents an arc flash hazard. There is a serious risk of arc flash relating to any equipment modification, such as opening doors. Serious injuries can occur in arc flash incidents. Appropriate training is required in accordance with local codes and regulations.



WARNING—FIRE HAZARD

Certain faults may cause a fire.

In case of fire involving electrical equipment, use only carbon dioxide fire extinguishers or those approved for use in fighting electrical fires



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 devices 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 Energy Storage System (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 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



Failure to follow all the applicable lock out/tag out (LOTO) procedures at all times may result in serious injury or death.

With power applied to the ESS, hazardous voltages are present on some components. To prevent death or injury, do not touch any components within the enclosure unless 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 the installation manual.

WARNING



Enclosure doors must remain closed except when access to the enclosure interior is required. 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 LOTO procedures must meet or exceed the requirements of all guidelines presented in SAMSUNG SDI safety documentation. Follow these steps before entering potentially hazardous areas or beginning work on the ESS:

- Wear protective clothing and shoes-
- 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.
- Complete the site-specific LOTO procedure and safety checklist before beginning work.

General Warnings



DANGER

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



DANGER

To avoid death, injury, and property damage, follow all safety procedures promulgated by Environmental Health and Safety (EHS) guidelines.



DANGER

To minimize the hazards of electrical shock, death, and injury, approved grounding practices and procedures must be strictly followed.



WARNING

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



WARNING

To avoid personal injury or equipment damage caused by equipment malfunction, only properly and qualified 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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1. About this Manual

This section briefly describes the purpose, audience, organization, revision history, and acronyms and abbreviations used in this document.

1.1 Purpose

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

1.2 Target Audience

This manual is intended for system administrators and operators who install, operate, maintenance and configure the product.

1.3 Organization

This manual is composed of the following chapters:

- Chapter 1, “About this Manual” introduces preliminary description about this document.
- Chapter 2, “Product Description” describes the major components of the product.
- Chapter 3, “Battery System Operation” explains the operation modes of the battery system.
- Chapter 4, “Maintenance Check” lists items to inspect daily, monthly, and annually.
- Chapter 5, “Troubleshooting” guides the reader through clearing protection modes and replacing components.

1.4 Revision History

Rev.	Description	Author	Date
0.0	First Draft (tentative release)		2019.08.20
0.1	Product model number updated (Product Description) Updated 3.3 Operation Status ("Storage humidity" changed to "Humidity") Updated Table 4-1: Maintenance Checklist Template (Added contact resistance readings) Updated Table 5 1: Recommended Tools and Instruments for Repair and Replacement		2020.08.28
0.11	Version for end customers Removed confidential letterhead		2020.08.28

Approved By:		
Name	Signature	Date

Trusted Reviewers		
Name	Signature	Date

1.5 Acronyms and Abbreviations

The following acronyms and abbreviations are used in this manual.

Abbreviations	Full Name
AED	Automated External Defibrillator
BMS	Battery Management System
Comm.	Communication
EHS	Environmental Health and Safety
ESS	Energy Storage System
LOTO	LOCK OUT/TAG OUT
OT	Overtemperature
OVP	Overvoltage Protection
SMPS	Switched Mode Power Supply
SMU	String Management Unit
SOC	State Of Charge
SOH	State Of Health
UT	Undertemperature
UVP	Undervoltage Protection
UPS	Uninterruptible Power Supply

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)
- SMU
- Rack BMS (Embedded in SMU)
- Rack Frame
- SMPS Assembly (Type A / Type B)
- System BMS (Embedded in SMPS Assembly Type A)

Refer to the "Product Specification" document for detailed specifications of the components.

2.1.1 Battery Module (Type A / Type B)

Battery Module is the most basic component of the Battery System and it contains the energy storing battery cells. There is a Module BMS inside each Battery Module. Module BMS checks the status of a Battery Module by measuring its voltage and temperature. It also communicates with the SMU to send all measured voltage and temperature data, and to receive commands to control cell balancing.

There are two types of 8S1P Battery Module depending on the position of terminal's polarity. Type A's plus(+) terminal is on the right side. Type B is on the left.

Type A: EM2031AE003A

Type B: EM2031AE004A

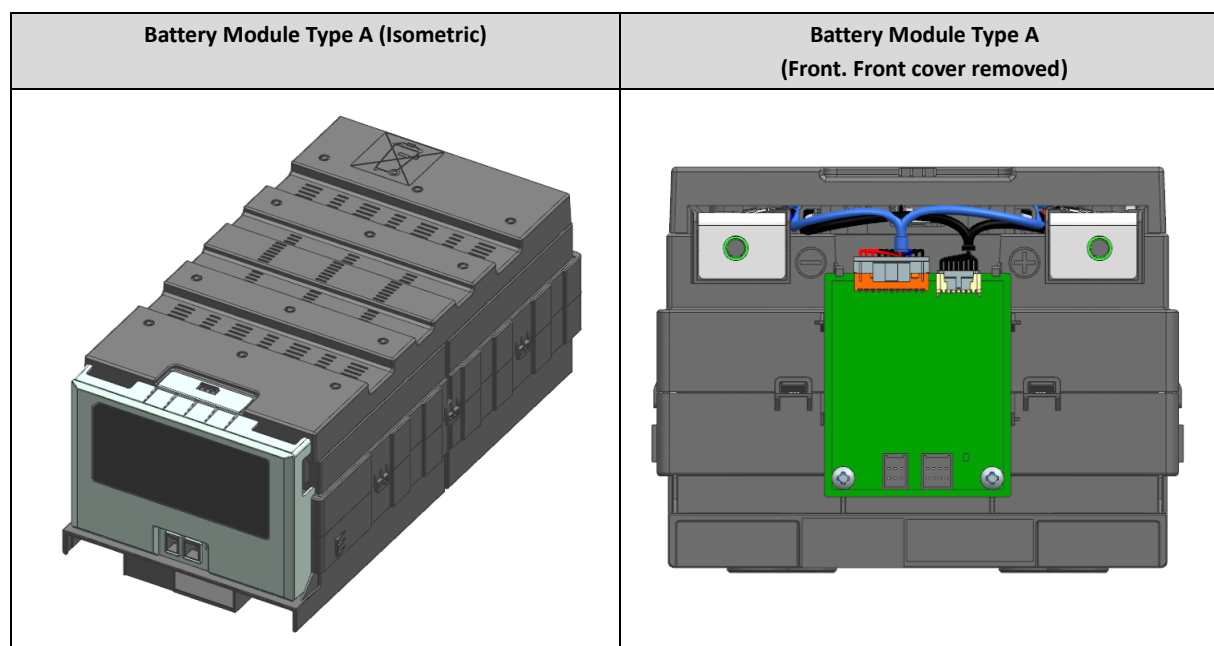


Figure 2-1: Battery Module Type A

2. Product Description

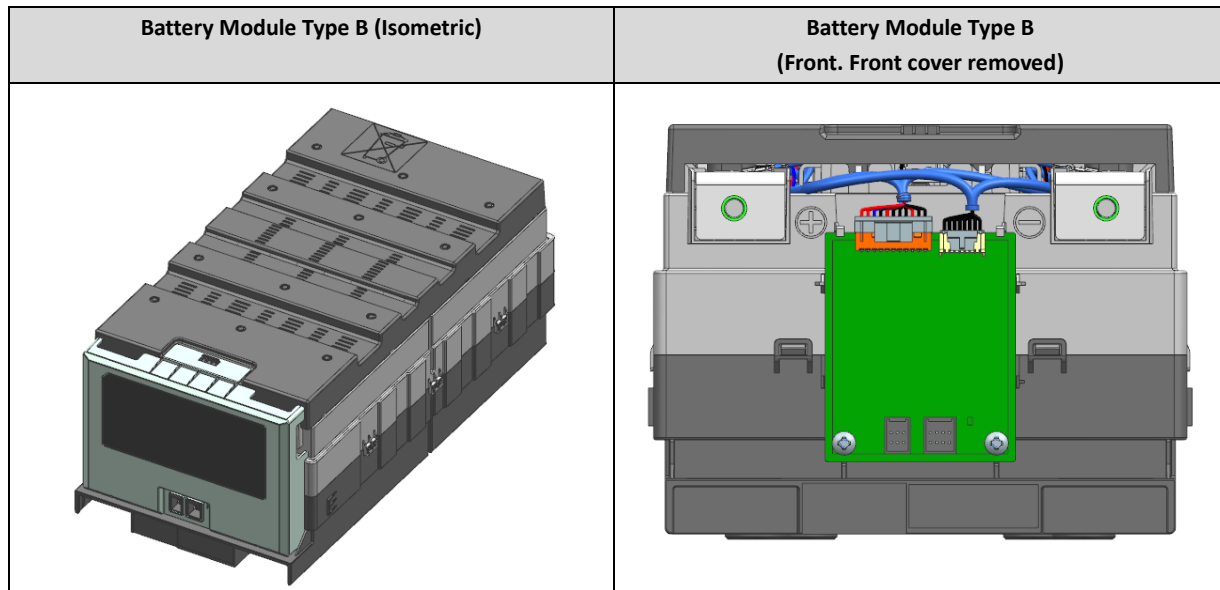


Figure 2-2: Battery Module Type B

2.1.2 SMU (String Management Unit)

SMU collects all information about the battery system and controls the battery system by switching the main power line and controls each Battery Module by cell balancing. SMU calculates the state-of-charge (SOC) and state-of-health (SOH) of the battery system. Key components in the SMU are Rack BMS, MCCB, and shunt resistor. Rack BMS is the main controller that takes all data from the Module BMS, measures the string voltage and current, determines the state of the battery and controls the MCCB accordingly.

UL: V049-0011AA

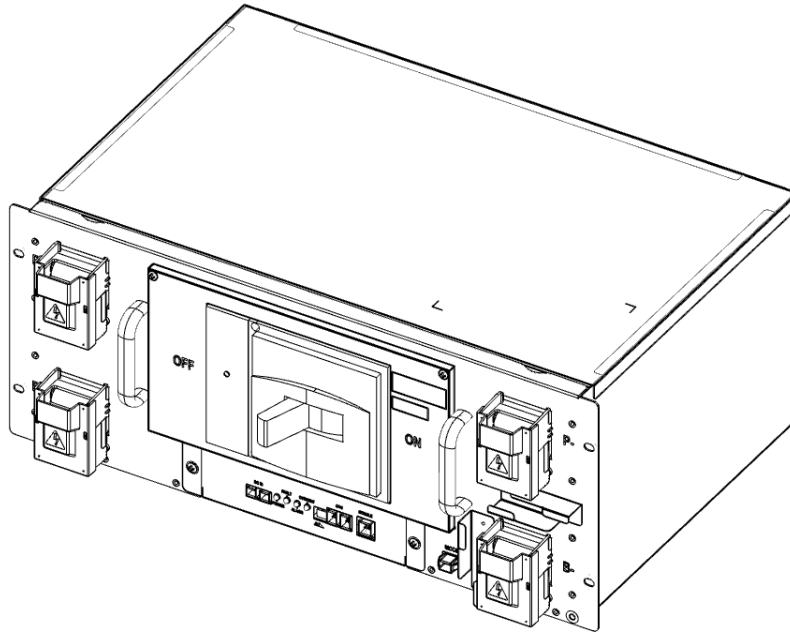


Figure 2-3: SMU

2. Product Description

2.1.3 SMPS Assembly (Type A / Type B)

3-Phase Type A (with System BMS): V044-0006AA

3-Phase Type B (without System BMS): SJ94-00238B

1-Phase Type A (with System BMS): V044-0004AA

1-Phase Type B (without System BMS): V044-0005AA

SMPS Assembly houses the System BMS and SMPS, which provides power to the System BMS and SMU. Two options are available for the SMPS depending on the AC input range and cabling: 3 phase and 1 phase. The System BMS assembly provides data to the external systems (i.e. building management system, UPS, etc.) while controlling and monitoring all connected Rack BMS.

There are two types of SMPS Assembly: Type A is with System BMS and Type B is without System BMS.

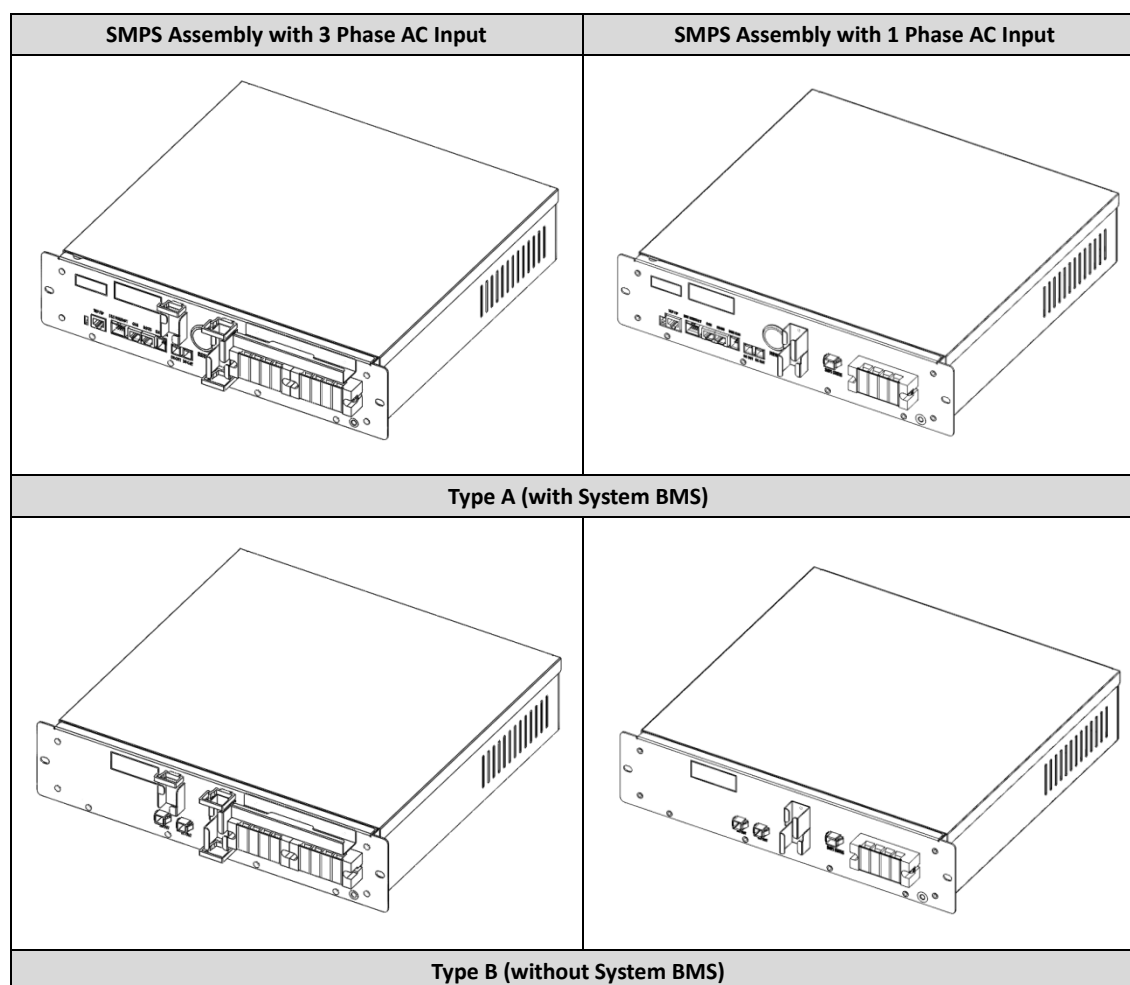


Figure 2-4: SMPS Assembly

2.1.4 Rack Frame

Black: V808-00068A

The Rack Frame is used to mount the modules, SMU and SMPS assembly and provides ground connections for SMU and SMPS Assembly.

(Grounding cable/busbar for the rack frame is necessary for the SMU and SMPS Assembly as 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).

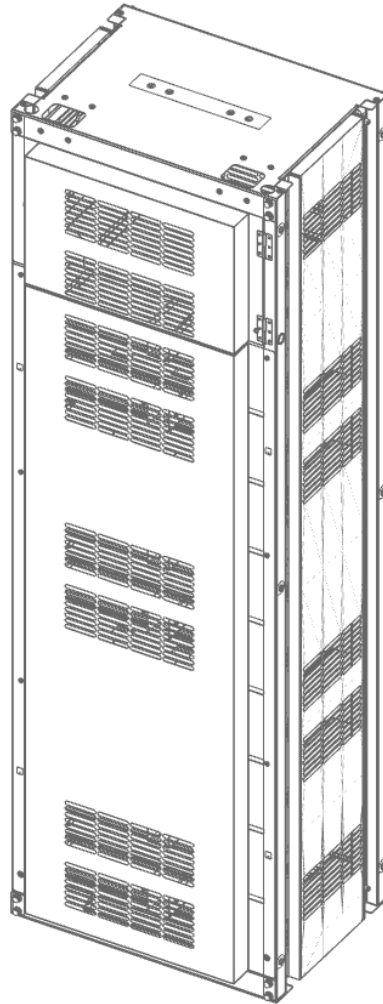


Figure 2-5: Rack Frame

3. Battery System Operation

The battery system for a UPS is designed to be always on. The UPS and the critical load must be set up so that the battery system's maximum allowable voltage and current are not exceeded.

3.1 Indicator LED

Four indicator LED's on the front of the SMU in each rack displays the status of the battery system per string. Table 3-1 shows each LED's color and the battery status indicated.

Table 3-1: Indicator LED Status

Items	POWER(Green)	FAULT(Red)	ALARM(Yellow)	CURRENT(Green)
Location				
Status	On : MCCB Off Off : Power Off Blink : MCCB On	On : N/A Off : No Major Protection Blink : Major Protection	On : N/A Off : No Minor Protection Blink : Minor Protection	On : Discharge Off : Idle Blink : Charge

Depending on the battery system's operating conditions, each indicator LED may be on, blinking or off. Table 3-2 shows the LED indication for the battery status.

Table 3-2: Indicated Codes

LED Status	Battery Status	Remarks
<p>POWER FAULT ALARM CURRENT</p> <p>All LED's Off</p>	BMS Power Off	MCCB Off
<p>POWER FAULT ALARM CURRENT</p> <p>POWER LED Steady</p>	Normal	MCCB Off
<p>POWER FAULT ALARM CURRENT</p> <p>POWER LED Flashing</p>	Normal	MCCB On
<p>POWER FAULT ALARM CURRENT</p> <p>POWER LED Flashing CURRENT LED Steady</p>	Normal	Discharge
<p>POWER FAULT ALARM CURRENT</p> <p>POWER LED Flashing CURRENT LED Flashing</p>	Normal	Charge
<p>POWER FAULT ALARM CURRENT</p> <p>POWER LED Steady FAULT LED Flashing</p>	Major Protection MCCB Tripped	Overvoltage Protection Undervoltage Protection Overtemperature Protection Overcurrent Protection
<p>POWER FAULT ALARM CURRENT</p> <p>POWER LED Flashing ALARM LED Flashing</p>	Minor Protection MCCB On	Voltage Imbalance Error Voltage Sensing Error Undertemperature Protection Temperature Imbalance Error

3.2 Dry Contact Signals

This section has been removed from the customer facing copy of the operation and maintenance manual.

3.3 Operation Status

Refer to the table below for typical and maximum state of charge and discharge conditions to keep the battery system in normal operation.

Table 3-3: Range of Operation (136S Configuration)

No.	Item	Specification	Remarks
1	Nominal Capacity	34.6kWh	1/3C@R.T
2	Nominal Voltage ¹	516.8V DC	3.8V/cell
3	Maximum Voltage ¹	571.2V DC	4.2V/cell
4	Discharging Method	Constant Power	
	End of Discharge Voltage ¹	408V DC	3.0V/cell
	Recommended End of Discharge Voltage ¹	435.2V DC	3.2V/cell
	Standard Discharging Current	22.3A	1/3C@R.T
	Maximum Continuous Discharge Power	183.6kW	Peak 450A @ EODV
5	Charging Method	CC-CV, Floating	
	Floating Charge Voltage ¹	571.2V DC	4.2V/cell
	Standard Charge Current	22.3A	1/3C
	Maximum Peak Charge Current	250A	2 second pulse
	Maximum Continuous Charging Current	67A	1C
6	Recommended Operation Temperature	23±5°C	
7	Storage Temperature	0 ~ 40°C	
8	Humidity	Less than 90 % RH	Noncondensing
9	Recommended Humidity	Less than 60 % RH	Noncondensing
10	Storage Period ²	Less than 6 months	

¹ Specified voltage must be satisfied in all load and charging conditions.

² Capacity degradation will occur depending on storage time. To minimize capacity degradation, storage temperature of less than 10°C and 3.630V per cell is recommended.

3. Battery System Operation

Table 3-4: Range of Operation (128S Configuration)

No.	Item	Specification	Remarks
1	Nominal Capacity	32.6kWh	1/3C@R.T
2	Nominal Voltage ¹	486.4V DC	3.8V/cell
3	Maximum Voltage ¹	537.6V DC	4.2V/cell
4	Discharging Method	Constant Power	
	End of Discharge Voltage ¹	384V DC	3.0V/cell
	Recommended End of Discharge Voltage ¹	409.6V DC	3.2V/cell
	Standard Discharging Current	22.3A	1/3C@R.T
	Maximum Continuous Discharge Power	173kW	Peak 450A @ EODV
5	Charging Method	CC-CV, Floating	
	Floating Charge Voltage ¹	537.6V DC	4.2V/cell
	Standard Charge Current	22.3A	1/3C
	Maximum Peak Charge Current	250A	2 second pulse
	Maximum Continuous Charging Current	67A	1C
6	Recommended Operation Temperature	23±5°C	
7	Storage Temperature	0 ~ 40°C	
8	Humidity	Less than 90 % RH	Noncondensing
9	Recommended Humidity	Less than 60 % RH	Noncondensing
10	Storage Period ²	Less than 6 months	

¹ Specified voltage must be satisfied in all load and charging conditions.

² Capacity degradation will occur depending on storage time. To minimize capacity degradation, storage temperature of less than 10°C and 3.630V per cell is recommended.

Table 3-5: Range of Operation (112S Configuration)

No.	Item	Specification	Remarks
1	Nominal Capacity	28.5kWh	1/3C@R.T
2	Nominal Voltage ¹	425.6V DC	3.8V/cell
3	Maximum Voltage ¹	470.4V DC	4.2V/cell
4	Discharging Method	Constant Power	
	End of Discharge Voltage ¹	336V DC	3.0V/cell
	Recommended End of Discharge Voltage ¹	358.4V DC	3.2V/cell
	Standard Discharging Current	22.3A	1/3C@R.T
	Maximum Continuous Discharge Power	151kW	Peak 450A @ EODV
5	Charging Method	CC-CV, Floating	
	Floating Charge Voltage ¹	470.4V DC	4.2V/cell
	Standard Charge Current	22.3A	1/3C
	Maximum Peak Charge Current	250A	2 second pulse
	Maximum Continuous Charging Current	67A	1C
6	Recommended Operation Temperature	23±5°C	
7	Storage Temperature	0 ~ 40°C	
8	Humidity	Less than 90 % RH	Noncondensing
9	Recommended Humidity	Less than 60 % RH	Noncondensing
10	Storage Period ²	Less than 6 months	

¹ Specified voltage must be satisfied in all load and charging conditions.

² Capacity degradation will occur depending on storage time. To minimize capacity degradation, storage temperature of less than 10°C and 3.630V per cell is recommended.

3. Battery System Operation

Table 3-6: Range of Operation (104S Configuration)

No.	Item	Specification	Remarks
1	Nominal Capacity	26.5kWh	1/3C@R.T
2	Nominal Voltage ¹	395.2V DC	3.8V/cell
3	Maximum Voltage ¹	436.8V DC	4.2V/cell
4	Discharging Method	Constant Power	
	End of Discharge Voltage ¹	312V DC	3.0V/cell
	Recommended End of Discharge Voltage ¹	332.8V DC	3.2V/cell
	Standard Discharging Current	22.3A	1/3C@R.T
	Maximum Continuous Discharge Power	140kW	Peak 450A @ EODV
5	Charging Method	CC-CV, Floating	
	Floating Charge Voltage ¹	436.8V DC	4.2V/cell
	Standard Charge Current	22.3A	1/3C
	Maximum Peak Charge Current	250A	2 second pulse
	Maximum Continuous Charging Current	67A	1C
6	Recommended Operation Temperature	23±5°C	
7	Storage Temperature	0 ~ 40°C	
8	Humidity	Less than 90 % RH	Noncondensing
9	Recommended Humidity	Less than 60 % RH	Noncondensing
10	Storage Period ²	Less than 6 months	

¹ Specified voltage must be satisfied in all load and charging conditions.

² Capacity degradation will occur depending on storage time. To minimize capacity degradation, storage temperature of less than 10°C and 3.630V per cell is recommended.

Table 3-7: Range of Operation (80S Configuration)

No.	Item	Specification	Remarks
1	Nominal Capacity	20.4kWh	1/3C@R.T
2	Nominal Voltage ¹	304V DC	3.8V/cell
3	Maximum Voltage ¹	336V DC	4.2V/cell
4	Discharging Method	Constant Power	
	End of Discharge Voltage ¹	240V DC	3.0V/cell
	Recommended End of Discharge Voltage ¹	256V DC	3.2V/cell
	Standard Discharging Current	22.3A	1/3C@R.T
	Maximum Continuous Discharge Power	108kW	Peak 450A @ EODV
5	Charging Method	CC-CV, Floating	
	Floating Charge Voltage ¹	336V DC	4.2V/cell
	Standard Charge Current	22.3A	1/3C
	Maximum Peak Charge Current	250A	2 second pulse
	Maximum Continuous Charging Current	67A	1C
6	Recommended Operation Temperature	23±5°C	
7	Storage Temperature	0 ~ 40°C	
8	Humidity	Less than 90 % RH	Noncondensing
9	Recommended Humidity	Less than 60 % RH	Noncondensing
10	Storage Period ²	Less than 6 months	

¹ Specified voltage must be satisfied in all load and charging conditions.

² Capacity degradation will occur depending on storage time. To minimize capacity degradation, storage temperature of less than 10°C and 3.630V per cell is recommended.

3.3.1 Normal Status

In normal status, the battery system is available for charge or discharge. The system operator must follow the guidelines below to ensure safe and optimal performance from the battery.

- The battery must be fully charged to power the critical load for the duration of the backup time.
- After a full discharge at maximum continuous power, cool the battery for at least 12 hours before another discharge in order to avoid over-temperature protection. For optimal performance, wait until the battery temperature returns to at least $\pm 3^{\circ}\text{C}$ within the room temperature.
- Immediate recharging after a full discharge at maximum continuous power may degrade the battery performance.

3.3.2 Minor Protection Status (Alarm)

When a minor protection (alarm status) occurs, the battery system will send a message to the UPS or other systems and request that all charge or discharge operation be stopped until the problem is corrected. Battery system will not be disconnected in minor protection status to maximize the battery's availability. Refer to Section 5 "Troubleshooting" for solutions to minor protection status.

3.3.3 Major Protection Status (Fault)

If the system detects a major protection (fault status), it will trip the MCCB to disconnect the battery system from the UPS to prevent damage to the battery. Measures must be taken to clear the major protection status and return the battery system to normal status. Personnel must be on-site to return the MCCB from "trip" to "on" position after returning the system status to normal. Refer to Section 5 "Troubleshooting" for details on solutions to major protection status.

4. Maintenance Checks

The battery system components are designed to be free of regular maintenance. Regular inspection of components and power connections are recommended to ensure proper performance. Scheduled checks of the battery system are recommended but not mandatory for optimal performance. Refer to 3.3 Operation Status for the battery system's operating conditions.

4.1 Daily Checks

Following is a list of items to be checked daily.

- Rack voltage should be in its floating charge voltage.
- Cell voltage range should be within 300mV.
- MCCB must be on for all racks.
- There must be no alarms or faults.
- Maintaining room temperature and humidity according to the range of operation.

4.2 Monthly Checks

Personnel should visually inspect the battery system monthly and review log data about the battery and its operating environment.

- Battery should have no visible damage (rust, bent structure, damaged or missing cables or busbars, etc.)
- Check the recorded data of the battery system for the voltage and current readings.
- Check the date and time of charge and discharge cycles.
- Check whether any alarms or faults have been triggered.

4.3 Annual Check

A trend analysis of the recorded data (battery and environment) is recommended.

4.4 Maintenance Checklist

Refer to the following checklist template for scheduled checks. Detailed recordings may be necessary depending on the level of maintenance required by the user. Use Table 3-3: Range of Operation to check the criteria for each item. Refer to the product specification and installation manual for more details.

Table 4-1: Maintenance Checklist Template


Items	Criteria	Location	Schedule	Result
Battery Status	1. Battery voltage a) Rack voltage check b) Cell voltage check (max/min difference) 2. Alarm or faults: No alarms or faults set 3. MCCB status: All on	Control room	Daily	
	1. Alarm or protection: No alarms or protections set Check the indicator LED's in each rack 2. MCCB status: All on Check the position of the MCCB handle	On-Site	Weekly	
	1. Visual Inspection: check for physical damages (rust, bent structure, damaged or missing cables, etc.)	On-Site	Monthly	
	1. Contact resistance of battery terminal and busbar	On-Site	Semi-annual	
Environment	Temperature (measured from facility's HVAC unit or other measurement devices)	Control Room or On-Site	Daily	
	Humidity (measured from facility's HVAC unit or other measurement device)		Daily	
Recorded Data	1. Recorded voltage and current 2. Date and time of charge and discharge cycles 3. Number of alarms and faults recorded	Control Room	Monthly	
	1. Recorded voltage and current 2. Date and time of charge and discharge cycles 3. Number of alarms and faults recorded 4. Record of temperature and humidity (measured from facility's HVAC unit or other measurement device)	Control Room	Annual	

5. Troubleshooting, Repair and Replacement

Users must operate the battery system within its specified range of operating conditions. Refer to the “Product Specification” for details.

If the battery system is not operated under the specified conditions, it may display protective modes depending on conditions. Users should familiarize themselves with the types of protective modes and the battery system’s behavior during these modes. Dry contact signals from the System BMS and indicator LED’s on the front of each SMU displays the status of the battery system. Users can quickly and easily determine the battery system’s status from a centralized monitoring location using the dry contact signals or perform an on-site examination using the indicator LED’s. Detailed status of the battery system can be examined by using additional monitoring software.

If repair or replacement is required, refer to the installation manual for safety guidelines and basic information on disassembly and reassembly of components.

	<p>DANGER</p> <p>Repair of the battery system should only be attempted by factory trained service engineers.</p>
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This section has been removed from the customer facing copy of the operation and maintenance manual.

6. Appendix

6.1 Disposal and Recycling

For recycling, contact the manufacturer.

Contaminated packaging must be disposed in accordance with local regulations.

[illegible]

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

For more information and pricing contact:

Thad Everson

(608)999-0039

teverson@facilitygateway.com

Frank Horner

(608)692-9236

fhorner@facilitygateway.com

www.SamsungSDI.com