1. Technical Specification of Battery System Components

1.1 Battery Cell (94Ah)

Samsung SDI's lithium ion energy storage system relies on advanced nickel cobalt manganese chemistry to provide a combination of high energy density, low cost, and industry leading safety. Since its entry into lithium ion battery production in 2000, SDI has maintained a zero-recall rate of its battery products. Configurable to serve the application at hand, 94 Ah prismatic cells form the core of SDI's energy storage solution.

Employing a state of the art Manufacturing Execution System (MES) tracking hundreds of factors across each stage of the manufacturing process, Samsung SDI is committed to delivering consistent, quality products. To ensure safety, each energy storage system contains redundant levels of both mechanical and software based safety systems to guard against potentially harmful situations. This commitment to safety starts at the battery cell level.

1.1.1 Specification

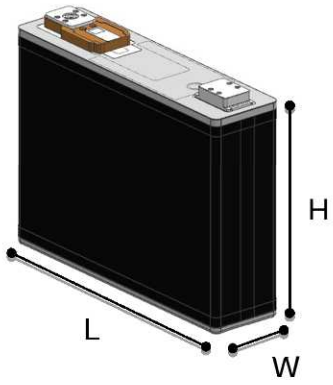
Battery Cell	Parameters	Spec
CAN Type LIB 	Shape	Prismatic
	Battery chemistry	NCM
	Dimension (L x W x H mm)	173.9 × 45.6 × 125.7
	Weight	2.090 kg
	Nominal capacity	94 Ah
	Nominal voltage (V)	3.68
	Nominal energy, Wh	345.9
	Operational voltage (V)	3.20 ~ 4.15
	Charging method	CC-CV

Table 5 94Ah Cell Specification

1.1.2 Safety Design in Cell

- Safety Function Layer : Maintain electrical separation even after polymer separator damage
- Positive polarity Aluminum CAN: Prevent surface corrosion resulting no electrolyte leakage even after long-term usage
- Overcharge Safety Device: Prevent current flow after activation of OSD
- Vent: Emit the generated gas effectively if the inside pressure goes abnormally high in abuse conditions
- Fuse: Cut the current path when abnormally high current flows

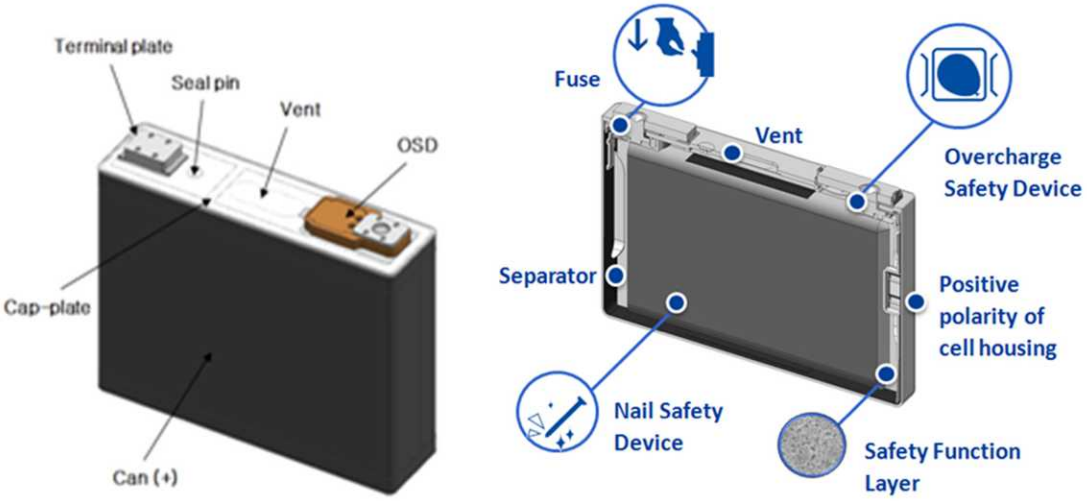


Figure 1 Safety Design of 94Ah Cell

1.2 Battery Module

Samsung SDI's energy storage systems employ a hierarchical modular design which allows for customized configurations, ease of maintenance, and future expansion capability. Modules, the basic building block of Samsung SDI ESS, are formed by configuring 22 of SDI's NCM cells in series. Module is connected with a battery management system (BMS) to form a rack mountable module assembly. Multiple module assemblies are then combined into a rack. Each rack contains rack-level BMS.

Module	Parameters	Specification
	Configuration	22S 1P
	Key component	22 cells, 1 Module BMS
	Dimension (L×W×H)	370 × 588 × 160 mm
	Weight	< 52.5 kg
	Nominal capacity	94 Ah
	Nominal energy	7.61 kWh (1/3C Rating)
	Nominal voltage	80.96 V
	Operating voltage	70.4 – 91.3 V
	Charging method (CC-CV)	4.15V/Cell, 31A, 3A cut off

Table 6 Module Specification

1.3 Switch Gear with Rack BMS (S/G)

Rack BMS has full function of measuring whole voltages and current for all cells in the RACK. It can protect batteries according to its own algorithm. Rack SOC and SOH are also automatically calculated and updated very precisely by Rack BMS.

Among many functions, (+) and (-) poles are controlled separately with 2 switches. For safety, each string has serially connected fuse, which has enough margin over operating range and fast fusing characteristic for safety. Automatic rack balancing function allows convenience of maintenance. This function is different from pre-charge function for charging up capacitors in PCS.

1.3.1 Specification

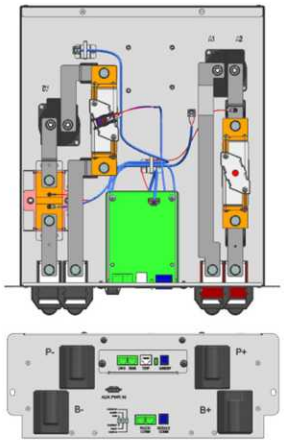
Switch Gear	Parameters	Specification
	Key component	Rack BMS DC contactor (2EA) DC Fuse 200A (2EA) Voltage & Current sensing device
	Dimension (L x W x H mm)	370 X 418 X 160
	Aux Power IN (TBD)	24Vdc Aux input (Total 38W) - For DC Contactor Switch (2EA) (Max 29W, TYP 7W) - For Rack BMS (Max 6W, TYP 5W) - For System BMS(Max 3W, TYP 2.5W)
	Communication	UART up to 1.0Mbps (For Module BMS)
	Communication	CAN 2.0B 500kbps (For parallel Rack & System BMS)

Table 7 Switch Gear Specification

1.3.2 Mechanical Drawing

One string is combination of maximum 12 modules connected in serial to achieve high voltages

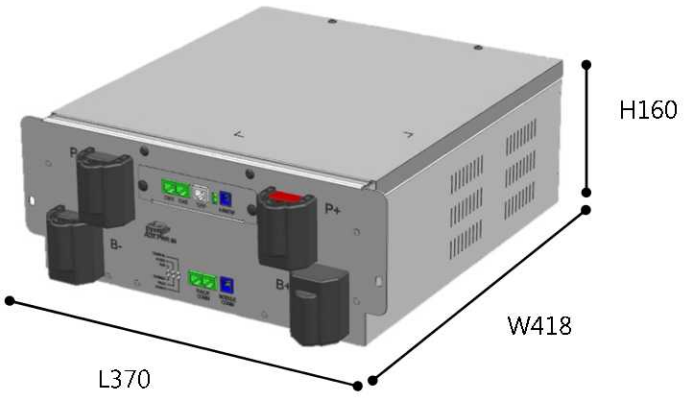


Figure 2 Switch Gear Drawing

1.4 System BMS

1.4.1 Specification

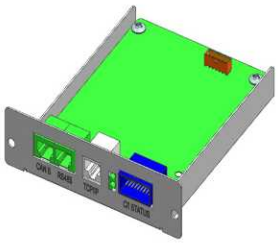
System BMS		Specification	Remark
	Key component	System BMS	mounted into switchgear assembly
	Communication	CAN 2.0B 500kbps	For Rack communication
	Communication	MODBUS RTU (RJ45) MODBUS TCP/IP (RJ45)	For PCS or EMS communication

Table 8 System BMS Specification

1.4.2 Mechanical Drawing

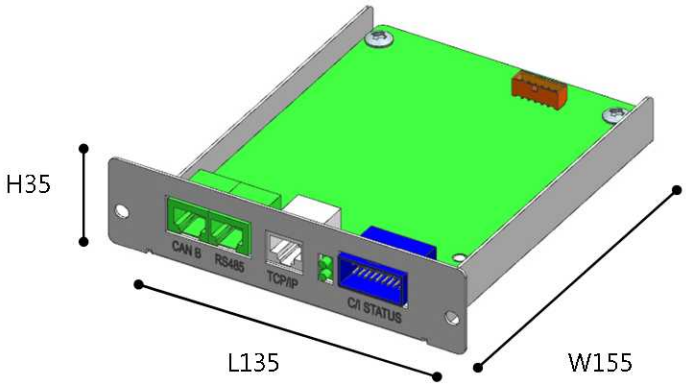


Figure 5 System BMS

1.5 Rack Frame

1.5.1 Specification

Samsung SDI's unit rack frame has maximum 10 slots to accommodate maximum 9 modules and 1 switchgear. Racks are connected in parallel and paired with a system BMS to meet the power and energy requirements of the application at hand. All wire connections are placed on the front side of the rack, with the exception of the power output to the inverter, to allow for easy installation and maintenance.

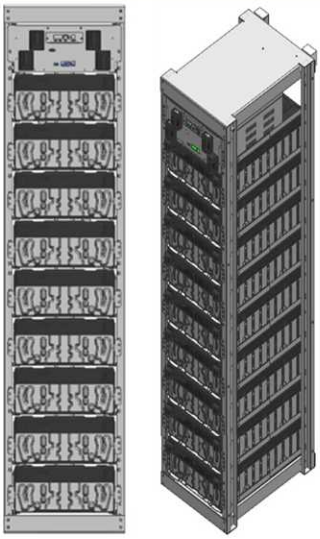
Rack	Parameters	Specification
	Configuration	198S 1P
	Key component	9 Modules, 1 Switch Gear
	Dimension (L x W x H)	442 x 702 x 1792 mm
	Weight	~ 590 kg
	Nominal Capacity	94Ah
	Nominal energy	68.49kWh (1/3C Rating)
	Nominal voltage	728.64V
	Operating voltage	633.6V ~ 821.7V
	Power Continuous	34.2 (0.5C rating)
	Frame Material	SGHC (Non coating, HGI)

Table 9 Rack Frame Specification

TÜVRheinland®
Genau. Richtig.

Date : 24.01.2017

TUV Rheinland Korea Ltd.
E&C Venture Dream Tower 6
197-28, Guro-dong, Guro-gu
Seoul 152-719
Rep. of Korea
Attn: Mr. HwangHyun No Products/Electrical/BATT

Re. : TU TUV Rheinland US Mark

Type of Equipment : Secondary System, LiNiMnCoO2, as page 01
Model Designation : See Certificate
Certificate No. : TU 50343703 0003
File No. : 50041408 003
Engineer/Contact : Hwang-Hyun No
Standard(s) : UL 1973:2013

Dear Madame or Sir,

Please find enclosed certification documents as specified above.

Please forward these originals to the certificate holder.

If you contact our office, please quote our reference above.

We thank you for your cooperation.

If we can be of any further assistance to you,
please do not hesitate to contact us.

Sincerely yours,
Certification Body

Dipl.-Ing. (FH) M. Geiser

Enclosure

TÜV Rheinland Japan Ltd.
Global Technology Assessment Center
4-25-2 Kita-Yamata
Tsuzuki-ku
Yokohama 224-0021, Japan

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テュフ ラインランド ジャパン株式会社
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www.jpn.tuv.com

TÜVRheinland®
Genau. Richtig.

Date : 24.01.2017

LG Chem, Ltd.
128, Yeoui-daero,
Yeongdeungpo-gu, Seoul 150-721
Rep. of Korea

Attn: Mr. Jaeseung Lee Quality Management Dept.

Re. : TU TUV Rheinland US Mark

Type of Equipment : Secondary System, LiNiMnCoO2, as page 01
Model Designation : See Certificate
Certificate No. : TU 50343703 0003
File No. : 50041408 003
Engineer/Contact : Hwang-Hyun No
Standard(s) : UL 1973:2013

Dear Madame or Sir,

The above specified technical equipment has been tested and found to be in accordance with the relevant requirements.

Please find enclosed your certificate.

As the photo documentation is the evidence of certification, you need to keep the authorized copy for reference purposes as long as your certificate remains valid and the products are being sold.

If cancellation of the certificate is submitted by 15 November in a given year, no fee will be charged for the following year.

We appreciate your support and would like to offer our assistance in the approval of your future products through our extensive range of technical services. Please feel free to contact us whatever your requirements may be.

If we can be of any further assistance to you,
please do not hesitate to contact us.

Sincerely yours,
Certification Body

Dipl.-Ing. (FH) M. Geiser

Enclosure

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e-mail: info@jpn.tuv.com
www.jpn.tuv.com

Certificate

TÜVRheinland®

Certificate no. TU 50343703 03

License Holder:
LG Chem, Ltd.
128, Yeoui-daero,
Yeongdeungpo-gu, Seoul 150-721
Rep. of Korea

Manufacturing Plant:
LG Chem, Ltd. Ochang Plant1
29, Gwahaksaneop-3-ro, Oksan-Myeon,
Heungdeok-gu, Cheongju-si,
Chungcheongbuk-do, 363-911
Rep. of Korea

Test report no.: USA-HHN 50041408 003 **Client Reference:** 386141

Tested to: UL 1973:2013

Certified Product: Secondary System, LiNiMnCoO2, as page 01 **License Fee - Units**

Addition

Type Designations: (1) SR22F215F_G16D1 1
(2) SR19F211F_G16D1 1
System Configuration:
(1) [1P_15S Modules]; (2) [1P_11S Modules]
(For one module: 2P_14S Cells)

Nominal Voltage: (1) 777.0V; (2) 569.8V
Nominal Charging Voltage: (1) 882V; (2) 646.8V
Watt-hour Rating: (1) 97.860kWh; (2) 71.764kWh

2

Appendix: 1.1

Licensed Test mark:

TUV Rheinland of North America, Inc. US

Date of Issue (day/mo/yr)
24/01/2017

CERTIFICATE OF COMPLIANCE

Certificate Number	20171121-MH49407
Report Reference	MH49407-20160928
Issue Date	2017-NOVEMBER-21
Issued to:	SAMSUNG SDI CO LTD 428-5 GONGSE-DONG GIHEUNG-GU YONGIN-SI GYEONGGI-DO 446-577 KOREA
This is to certify that representative samples of	COMPONENT - BATTERIES FOR USE IN LIGHT ELECTRIC RAIL AND STATIONARY APPLICATIONS See Addendum Page
	Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	Standard for Safety for Batteries For Use In Light Electric Rail (LER) Applications And Stationary Applications, UL 1973
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

The UL Recognized Component Mark generally consists of the manufacturer's identification and catalog number, model number or other product designation as specified under "Marking" for the particular Recognition as published in the appropriate UL Directory. As a supplementary means of identifying products that have been produced under UL's Component Recognition Program, UL's Recognized Component Mark: , may be used in conjunction with the required Recognized Marks. The Recognized Component Mark is required when specified in the UL Directory preceding the recognitions or under "Markings" for the individual recognitions.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

Look for the UL Certification Mark on the product.

Bruce Mahrenholz, Director North American Certification Program

UL LLC

CERTIFICATE OF COMPLIANCE

Certificate Number	20171121-MH49407
Report Reference	MH49407-20160928
Issue Date	2017-NOVEMBER-21

This is to certify that representative samples of the product as specified on this certificate were tested according to the current UL requirements.

USR – Components - Batteries for Use in Stationary Applications

Models Battery module;
Model: ELPM762-00001, ELPM762-00002, ELPM762-00003, ELPM762-00004, ELPM762-00005, ELPM762-00006, ELPM762-00007, ELPM762-00014, ELPM762-00015, ELPM762-00016, ELPM762-00018,ELPM762-00020 and ELPM762-00023

Switchgear box;
Model: ELPJ112-00006, ELPJ112-00015, ELPJ112-00016, ELPJ112-00017, ELPJ112-00028, ELPJ122-00011, ELPJ122-00025, ELPJ104-00009 and ELPJ114-00003

CNR – Components - Batteries for Use in Stationary Applications Certified for Canada,

Models Battery module;
Model: ELPM762-00014 and ELPM762-00015

Switchgear box;
Model: ELPJ122-00011

Bruce Mahrenholz, Director North American Certification Program

UL LLC