Generator-ESS for 50kW/369kWh

Australia V1.0

PRANSTEK

2020. 03

CONTENTS

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I Requirements of the Project

1.1 Basic Information

Load: 20~50kW
Peak Load: 60kW for 600s; 30kW for 8 Hours

Generator: 32kW/40kVA

Battery: 368.64kWh

PV: 90.72kW (288 PCS, 315W/PCS, 18S16P)

When will PCS charge and discharge the battery?

---When load power is below 30kW, battery will discharge for 7 to 8 hours;

---When load power is over 30kW, battery and generator will feed the load together;

---When battery discharges from 95% to 15% SoC (can be set), generator will start up to supply the load and charge the battery;

---When load power is over 40kW, battery and generator will feed the load together;

---When battery is below 15% SoC (can be set), PCS will alarm, to remind user of reducing load power, generator will supply the load;

---Generator will stop at night for around 7 hours to avoid noise.

1.2 Operating Mode

Grid Connected:
---When the grid is connected or recovered, PCS will trace the voltage and phase. PCS will transfer to on-grid operation mode when synchronized with the grid.

---When solar power is strong, PV system will support the load first, and the remaining power will charge the battery.

---When solar power is strong and battery is fully charged, PV system will support the load first. If PV system can fully meet all site loads, the remaining power will be paralleled into

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the grid; if PV system can not meet all site loads, the rest power will be supplemented by the battery.

---When solar power is low and the battery is over 50% SOC, solar and battery will support the load together.

---When solar power is low or offline and the battery is between 15% and 50% SoC, The battery will discharge to feed 40% of all site loads, and the rest will be supplemented by the grid.

---When solar power is low or offline, and the battery is below 15% SoC, the system will stop discharge. Then all site loads should be met by the grid.

---During grid failure, a diesel generator needs to be started as a back-up to feed the load.

Off Grid:

---When grid is lost, PCS will transfer to off-grid operation mode.

---When solar power is strong, PV system will support the load first, and the remaining power will charge the battery.

---When solar power is low and the battery is over 50% SoC, solar and battery will support the load together.

---When solar power is low or offline and the battery is between 15% and 50% SoC, PCS will send a dry contact signal to start the generator. PCS and the generator will operate together. The battery will discharge to feed 40% of all site loads.

---When solar power is low or offline, and the battery is below 15% SoC, the system will stop discharge. If the generator can fully meet all site loads, the remaining power will charge the battery until the battery increases to 50% SoC; if not, PCS will stop operating to protect the battery. Simultaneously, if the generator can not afford all site loads, PCS will alarm to remind appropriate load shedding, in order to avoid the case that load power is over the limit of the generator.

---When solar power increases and the battery is over 50% SoC, PCS will send a dry contact signal to stop the generator. PV and battery will support the load together.

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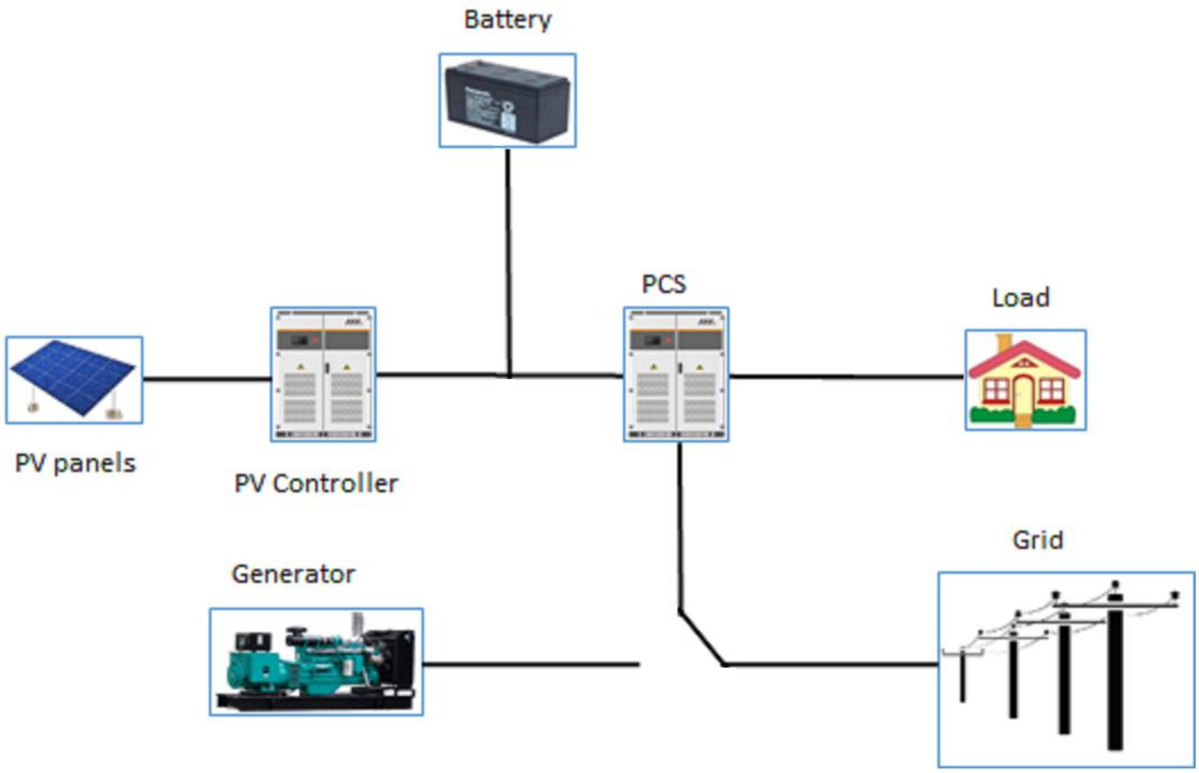
II Topology of the System



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III Configuration of the System

3.1 Supply Scope

No.	Name	Specifications	Quantity	Unit	Notes
1	Battery System	368.64kWh	1	Set	Contains BMS, Battery Shelf
2	PCS	MEGA0050T, AC Output 415V	1	PCS	Transformer Included, Auto Switch
3	DC/DC Converter	PMDE0100, 100kW DC/DC Converter	1	PCS	
4	Solar Panel	315W	288	PCS	18S16P, 90.72kWh in Total
5	Container	20ft	1	PCS	Optional
6	Generator	40kVA	1	PCS	Optional
7	EMS	MEMS	1	Set	Optional

3.2 System Operation Condition

This system operates according to nominal parameters in the condition with the following environmental factors:

Item	Parameter
Work Temperature	Charge: 0~55℃（No Derating） Discharge: -20~55℃（No Derating）
Humidity	0~95%（No Condensation）
Max Altitude	2000m（No Derating）
Seismic Rating	Uniform Building Code Zone 4
Noise	Less than 65dB at 10 meters from the BESS

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3.3 System Performance

50kW/369kWh ESS Technical Parameters

System Capacity	50kW/369kWh
Available Capacity	368.64kWh
Rated Charging Power	50kW
Rated Discharging Power	50kW
Operating Voltage Range/DC	450~657V
Nominal Voltage/AC	415V (50/60Hz)
Efficiency	≥88%
IP Level	IP55
Cycle Life	≥5000, 0.5C Charging/Discharging
Calendar Life	More than 10 Years

IV Overview of the Products

4.1 LFP Battery

Item	Type	Minimum Voltage (V)	Maximum Voltage (V)	Rated Voltage (V)	Capacity (Ah)	Energy (Wh)	Quantity
Cell	LP27148134	2.5	3.65	3.2	40	128	2880
Battery Module	12S8P	30	43.8	38.4	320	12,288	30
Battery Rack	180S8P	450	657	576	320	184,320	2
BESS	180S16P	450	657	576	640	368,640	1

Table 4.1 LFP Battery Definition and Configuration

4.1.1 Cell

The LP27148134 cell (LFP chemistry) manufactured by Lishen is used for battery modules.

4.1.2 Technical Advantages of the LP27148134 Cell

The Lishen LP27148134 cell has been developed for energy storage system of electric vehicles and photo electrical energy storage systems. It has the following advantages over other cells in ESS:

The LP27148134-40Ah Li-ion cell can be charged and discharged quickly, and responds

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instantly to scheduling commands issued from the BESS, meeting frequency-variable functional requirements of large-scale energy storage battery systems.

The LP27148134 cells allow maximized heat dissipation efficiency within battery module based on the installation clearance among cells.

The shape and size of the battery modules can be customized to meet the volume and exterior requirements of customers. Battery voltage and capacity can be customized based on customer requirements. Batteries can be installed and maintained quickly on site, ensuring stable system operations.

The Lishen Li-ion cells are manufactured based on matured production processes, over 20 years of manufacturing and application experiences.

4.1.3 Advanced Cell Technology

(1) Raw Materials

Lishen has profound expertise in advanced raw materials for Li-ion cells. Lishen has manufactured over 50 million $LiFePO_4$ (LFP) cells based on Aleees materials and Lishen-patented valence materials, with no safety incidents.

LP27148134 cells are made of Aleees positive LFP materials, which feature high specific capacity, good reusability and stable performance. Figure 4.1.3 shows the characteristics of the Aleees positive LFP materials.

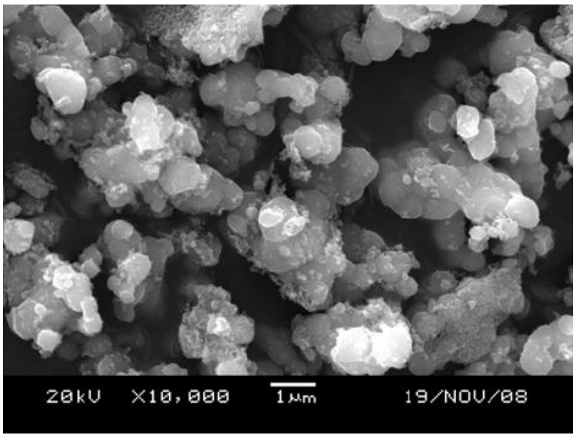

Figure 4.1.3.1 Characteristics of Aleees Positive LFP Materials

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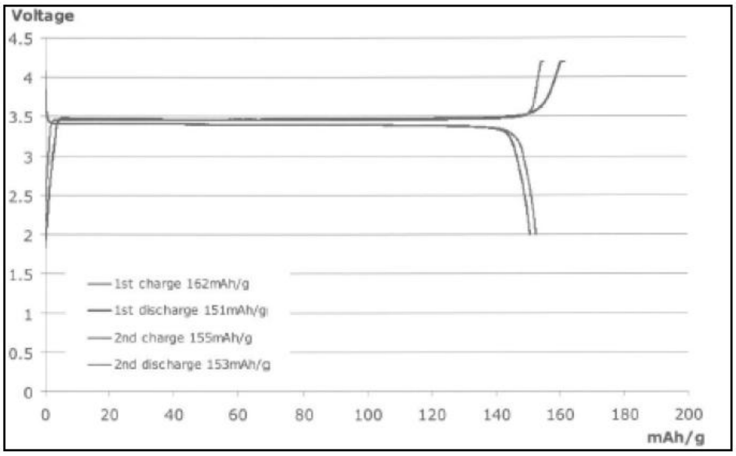

Figure 4.1.3.2 Charging and Discharging Curves (Button Cell)

The negative electrode of the LP27148134 cells are made of the MeSoCarbon Microbeads (MCMB) material. The MCMB material provides high specific capacity (~330mAh/g) and low irreversible specific capacity (~20mAh/g).

(2) Cell Structural Design

Multiple electrodes are connected in parallel to provide high specific energy and high specific power. The thin-electrode coating and laminating technology is adopted to meet the requirements for specific energy and specific power. Aluminum housing stretched for multiple times is used. Compared with steel housing, aluminum housing is lighter and involves less risk when welding. Compared with aluminum-plastic film housing, aluminum housing provides higher strength and longer service life. Compared with plastic housing, aluminum housing provides a longer service life as plastic ages more easily.

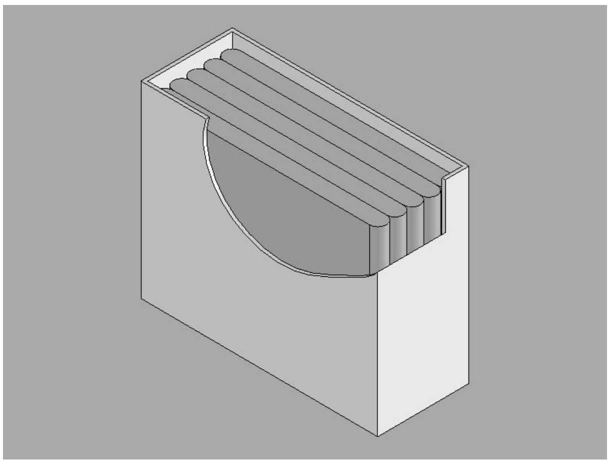

Figure 4.1.3.3 Inner structure of LP27148134 cell

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LP27148134 cells are welded together and the welding tension can reach 200N. This greatly reduces the contact impedance of the battery system.

(3) Cell Safety Design

Robust cell chemistry with stable $LiFePO_4$ (LFP) material, cell structural design, and cell manufacturing technology are critical to the safety and reliability of BESS based on Li-ion cells. In addition to the stable LFP material, the following measures are taken to ensure the safety of Li-ion cells manufactured by Lishen:

A. Advanced lamination technology

B. Anti-overcharge mechanism and flame-retardant electrolyte

C. Anti-explosion design of valves

D. Heat-resistant film specific for Li-ion cells with high power capability

E. Extruding and coating technology for positive electrodes

F. Hot-pressing technology for laminating electrodes

G. Advanced automatic manufacturing processes and controls to ensure cell consistence:

---Precision control for mixing active electrode materials

---Control of electrode coating uniformity

---Winding precision control

---Control of electrolyte weight

---Automatic sorting after cell aging

(4) Charging Method (★)

Cells are charged with Constant Current and Constant Voltage (CC/CV) method at ambient temperature. The CC is 40A and the CV is 3.65V. Charge shall be terminated when the CC has tapered to 2A, then store cells for 1h.

(5) Superior Cell Performance

Lishen LP27148134-40Ah Li-ion cell provides high specific energy, long cycle life, low self-discharge rate, safe performance. Table 4.1.3.1 summarizes the cell performance characteristics; while Table 4.1.3.2 summarizes the LP27148134 cell safety performance.

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Item	Test Profile	Phenomenon/Results
Appearance and Dimension	Eyeballing; Test Cells' Dimension with Slide Caliper	No Deep Scratch, No Transformation, No Leakage
Weight	Electronic Scale	1050±30g
Open Circuit Voltage	Charged as ★, within 1 Hour	≥3.35V
Nominal Discharge Capacity	Charged as ★, Discharge Cells at 40A to 2V within 1 Hour, 5 Times,	1 C Capacity ≥ Nominal Capacity
Maximum Charge Current	Continuous: Charged as ★, Discharge to 2V at 40A, Record the Capacity; Charge to 3.65V at n*40A, and then charge at 3.65V until current has tapered to 2A; 50% SoC: Discharge Cells 0.5h at 40A, Charge 30s at n*40A, and the Cut-off Voltage is 3.65V.	240A (Continuous); 400A (30s, 50% SoC)
Maximum Discharge Current	Continuous: Charged as ★, Discharge to 2V at 40A, Record the Capacity; Discharge in n*40A to 2V; 50% SoC: Discharge at 40A for 0.5h; Discharge 30s at n*40A and the Cut-off Voltage is 2V.	240A (Continuous); 400A (30s, 50% SoC)
Cycle Life	Charged as ★, Discharge to 2V at 40A, 100% DoD. Rest 10mins before Recharge. Measured for 5000 Cycles.	Discharge Capacity (5000th Cycle) ≥ 80% Initial Capacity
Capacity Retention at Ambient Temperature	Charged as ★, Stored for 28 Days at Ambient Temperature, then Discharge to 2V at 40A. Record the Residual Capacity; Charged as ★, Discharge to 2V at 40A. Record the Recovery Capacity.	Residual Capacity ≥ 90% of Initial Capacity; Recovery Capacity ≥ 93% of Initial Capacity
Capacity Retention at High Temperature	Charged as ★, Stored for 7 Days at (60±2)℃ , then Discharge to 2V at 40A. Record the Residual Capacity; Charged as ★, Discharge to 2V at 40A. Record the Recovery Capacity.	Residual Capacity ≥ 90% of Initial Capacity; Recovery Capacity ≥ 93% of Initial Capacity
Characteristics at High Temperature	Charged as ★, Stored for 5h at (60±2)℃, then Discharge to 2V at 40A. Record the Capacity.	Residual Capacity ≥ 95% of Initial Capacity
Characteristics at Low Temperature	Charged as ★, Stored for 24h at (-20±2)℃, then Discharge to 2V at 40A. Record the Capacity.	Residual Capacity ≥ 75% of Initial Capacity

Table 4.1.3.1 Performance Characteristics of LP27148134 Cell

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Item	Test Criterion	Cell Maximum Temperature (°C)	Phenomenon	Result
Low Pressure	Charged as ★, Stored for 6 Hours at 11kPa in Low Pressure Test Chamber	Ambient Temperature	No Phenomenon	Pass
Short-Circuit	Charged as ★, 10 mins, R External Line，<5mΩ	58	No Phenomenon	Pass
Over-Charge	1.5 Times of Cut-off Voltage, 1C or Charge for 1 Hour	43	Cell Inflation	Pass
Over-Discharge	Charged as ★, 1C, Discharge for 90min	42	No Phenomenon	Pass
Nail-Penetration	Charged as ★, Nail Size: Φ5mm~Φ8mm，Speed: (25±5)mm/s	125	No Fire No Explosion Cell Can Break	Pass
Crush	Charged as ★, Speed: (5±1)mm/s, up to 0V or 30% Deformation or the Force to 200kN	Ambient Temperature	No Fire No Explosion	Pass
Hot-Oven	Charged as ★, Speed: 5°C/min, Temperature: 130±2°C，Maintain: 30 mins	118	No Phenomenon	Pass
Drop	Charged as ★, from 1.5m to Concrete Ground	Ambient Temperature	No Phenomenon	Pass
Seawater Immersion	Charged as ★, Immerged in NaCl Solution with Concentration of 3.5%, 2 Hours	Ambient Temperature	No Fire No Explosion	Pass

Table 4.1.3.2 Safety Performance Data of LP27148134 Cell

4.2 Battery Module

Each battery module contains 96 cells in a 12S8P configuration. The battery module is the smallest replaceable storage unit, including Li-ion cells and battery management system. Each module has two power terminals (+/-) and a communication terminal, via which communication with the higher-level controller takes place. Table 4.2 summarizes the key characteristics of the battery module.

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Table 4.2 Key Characteristics of the Battery Module

No.	Item	Specification	Unit	Remark
1	Rated Energy	12.288	kWh	
2	Rated Voltage	38.4	V	
3	Operational Voltage	30~43.8	V	Operational Range @1C
4	Calendar Life Time	10	year	
5	Capacity (0.5C)	320	Ah	Standard Charging and Discharging
6	Self-discharge (% per month)	≤2.5% per month @100% SoC, 25°C, 30 Days Storage	%	25±3°C
7	DC-Internal Resistance	10	mΩ	Initial
8	Temperature Range Transport/Storage	-20～50	°C	
9	Charging Temperature Range	0～45	°C	
10	Discharging Temperature Range	-20～50	°C	
11	Communication Interface and Protocol	CAN		CAN-Bus
12	Module Weight	130±2.0	kg	
13	Dimension (w*d*h)	600*1032*172 (±3)	mm	

4.3 Battery Rack

14 standard LFP battery modules are connected in series through connectors to form a battery cluster. Within a battery cluster, a battery cluster management system (BCMU) is deployed to detect and manage cell voltage and temperature inside the battery modules. The BCMU monitors the data values detected by the BLMU and sends a warning signal to the battery array management system (BAMS) if any detected data value exceeds the preset threshold. The BCMU also detects the operating current of battery modules and works with the HVCU to protect battery modules. Table 4.3 summarizes the key characteristics of the battery rack.

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Table 4.3 Data Sheet of the Battery Rack

No.	Item	Specification	Unit	Remark
1	Maximal Voltage	657	V dc	
2	Nominal Voltage	576	V dc	
3	Minimal Voltage	450	V dc	
4	Nominal Capacity	320	Ah	0.5C
5	Nominal Energy	184.32	kWh	
6	Internal Resistance DC	150	mΩ	Initial
7	Prospective Value of Short-circuit Current	4.38	kA	Without Protection Device
8	Admitted Short-circuit Current Inside Rack	3.84	kA	Relevant for Rack-paralleling or Internal Power Wiring, Short-circuit Proof
9	Cell Series/Parallel Configuration	180S8P		
10	Battery Management System (BMS)	1 2 30	Set Set Set	BAMS: 1 BCMU: 2 BLMU: 30
11	DC Protection	Circuit Switch, Fuse, Contactor, Relay	Set	
12	Communication Interface and Protocol	CAN/RS485/Ethernet		
13	Rack Weight	160±2.0	kg	
14	Dimension (w*d*h)	1170*1050*2378 (±5)	mm	

4.4 Battery Protection Unit (BPU)

The battery protection unit (BPU) contains the high voltage device and the second level management unit of the battery management system. The high voltage devices include: fuses, relays, pre-charging resistors, etc. The fuse will protect the system when a short circuit occurs between the DC Control Cabinet A1 and the BPU. Relay is mainly used to control battery

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main circuit cut and close.

The second level management unit in BMS includes: battery cluster management unit (BCMU) and high voltage control unit (HVCU). The 24V DC power supply bus (provided by the DC Control Cabinet A1) supplies power to the second stage battery management unit in BPU through the connector on the front panel of the BPU. The BCMU communication with the first stage management unit (BLMU) is also communicated by the CAN on the front panel of the BPU. BCMU controls the opening signal of BLMU, and controls relays in the BPU, which is connected with the Ethernet switch in the DC control cabinet A1 by RJ45, and the third level management system (BAMS) is communicated through the switch.

The internal and external schematics of the BPU are illustrated as follows:

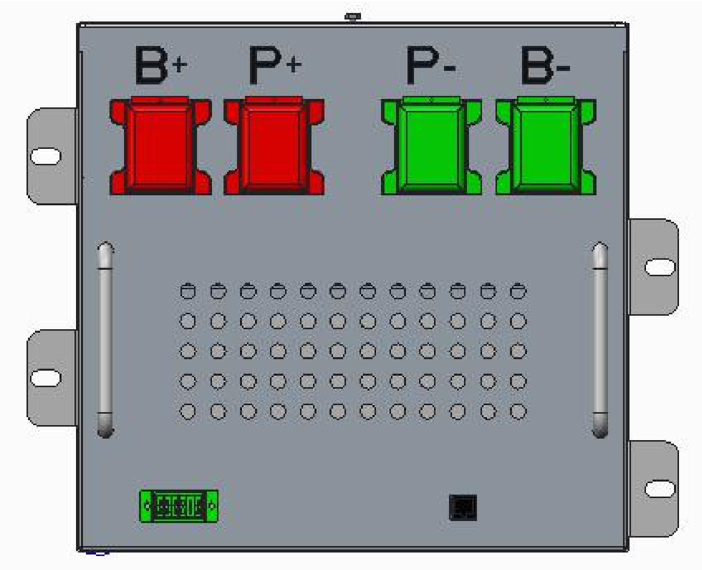

Figure 4.4.1 BPU Diagram (Front View)

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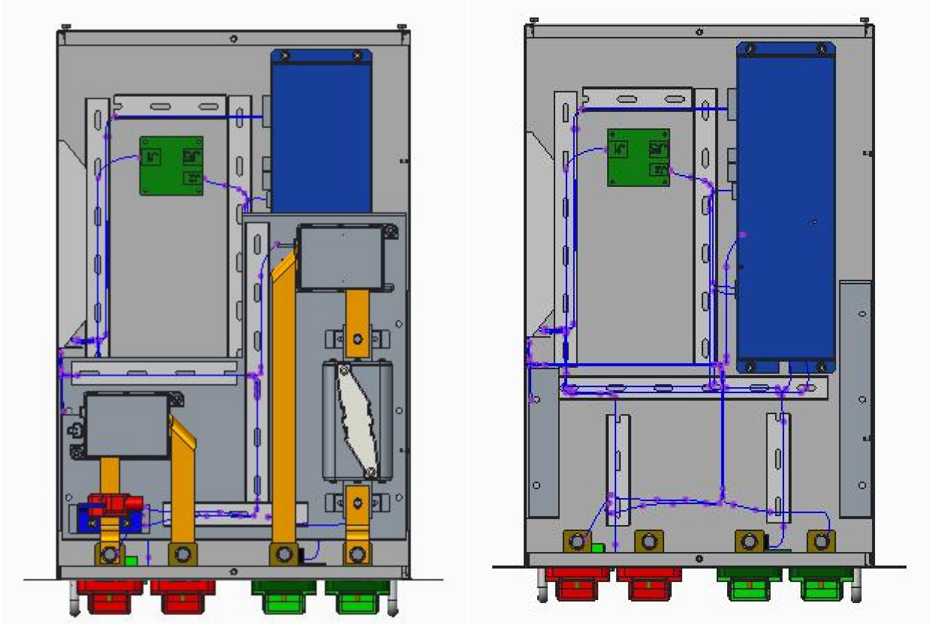

Figure 4.4.2 BPU Internal Schematic Diagram (Top View Level 1, Top View Level 2)

DC Control Cabinet A1

The upper panel of the DC control cabinet A1 consists of several parts: AC/DC power supply bus control section, Ethernet communication extension section and BAMS. It mainly consists of 24V DC power supply bus and control parts, the third level management system man-machine interface (BAMS), and Intranet-Ethernet switch. The 24V DC power supply bus of each module and BPU is provided by the DC control cabinet A1. The outer network CAN bus and Ethernet communication line of the BPU are integrated in the DC control cabinet A1.

The bottom panel of the DC control cabinet A1 consists of several parts: load break switch and copper bar. Each load break switch is connected with the BPU by the power cable, the copper bar of total positive and total negative in DC control cabinet A1 will be connected with the PCS.

4.5 Battery Management System

Based on the features of large-scale energy storage battery arrays using LFP batteries as energy storage units, LSESS BMS is deployed to monitor and protect battery arrays when protection conditions are met. A reliable and effective BMS can protect the ESS battery life.

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4.5.1 Advantages of LSESS BMS

(1) High Accuracy

Cell Voltage Accuracy$\leqslant \pm 3mV$

Temperature Accuracy$\leqslant \pm 1$℃

Current Measure Accuracy$\leqslant 0.5\%$FSR

(2) Precise SoC and SoH Calculation

A precise and comprehensive method is used to calculate battery's state of charge (SoC) and state of health (SoH) through the battery performance detection and combining the battery state and system parameters. A precise SoC and SoH provide the battery status to the system and help to transmit a warning signal to the upper management. Accuracy of insulation resistance is less than 5%.

(3) Low Power Consumption

LSESS BMS incorporates advanced technologies such as big-league integrated circuit, filtering technology, high level voltage insulation, etc. These advanced technologies provide low power consumption BMS.

(4) Powerful Communication

LSESS BMS uses CAN 2.0 and Ethernet to communicate with battery modules, and uses Ethernet to communicate with PCS and SCADA. Efficient communication can guarantee system safety.

(5) Advanced Battery Balance Approach

LSESS BMS uses an intelligent non-destructive initiative balance that is devised by Lishen according to the cell voltage to charge or discharge the cell. The average balance current is 100mA. The initiative balance approach is more efficient with lower quantity of heat and has little thermal influence on battery.

(6) Advanced Thermal Design

LSESS BMS has an efficient thermal management system, according to the features of battery and battery temperature, to control the temperature management device. Therefore, battery can work in a suitable environment with a longer service life.

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(7) **Safe HV Control Design**

LSESS BMS has a reliable control solution. First, it has a pre-charging circuit in the main loop. Then it has a redundant and isolated solution. All of these can enhance the BESS safety.

(8) **Online Self-detection and Diagnosis**

Online self-detection can accomplish fault detection and diagnosis. This method can estimate any fault that system may occur and find the fault type and location, so it reduces system repair time. Fault detection will result in a manual overwrite on alarm.

(9) **Efficient and Humanistic Graphical User Interface (GUI)**

LSESS BMS has efficient and humanistic software which enables monitoring, recording, displaying and analyzing the battery status online.

(10) **Robust Structure Design**

LSESS uses multiple protection design, such as waterproof, dust-proof, tamper-proof, etc. From the early stages of system design to mass production, the BESS will be strictly inspected with findings documented to ensure product quality. LSESS BMS conforms to the EMC standards and can work under some severe conditions.

4.5.2 BESS Unit BMS Structure

The BESS requires 1 set of LSESS BMS. This document is an introduction of the LSESS BMS. It contains 1 Battery Array Management System (BAMS), 2 Battery Cluster Management Units (BCMU) and 30 Battery Local Management Units (BLMU). LSESS BMS uses 1 BAMS to communicate with PCS and SCADA, and the BAMS communicates with all the BCMU at the same time through TCP/IP. Each BCMU includes a High Voltage Control Unit (HVCU) and manages 15 BLMU. 1 BLMU monitors 1 battery module. Figure 4.5.2 shows the major component blocks of this battery management system.

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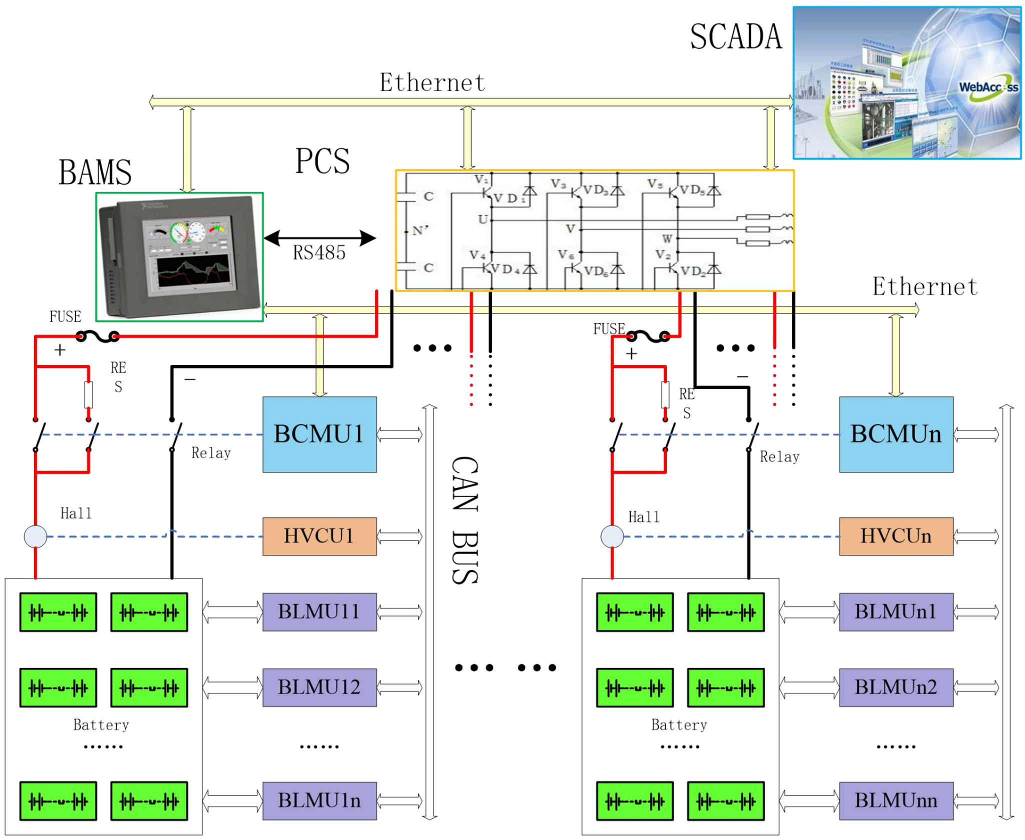

Figure 4.5.2 BESS Framework

4.6 Battery Array Management System (BAMS)

4.6.1 BAMS Function and Specification

The BAMS manages all the BCMUs under 1 co-operating PCS. Besides, it can communicate with PCS and SCADA, so that BAMS can request PCS to change operating status according to the battery status in time.

Function Description of BAMS:

(1) Data Recording

A. Receive data from BCMUs, such as battery rack voltage, current, SoC, temperature, etc. Record the received data and other data such as the numbers of battery strings, time of charge and discharge. The record file will be distinguished according to date;

B. Receive all warning and protection events of BCMUs and save them as a document in

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local memory.

(2) Calculate SoC and SoH of battery array.

(3) Receive protection and warning signals of BCMU; set parameters of BCMU and BLMU; communicate with PCS and SCADA.

(4) Receive commands from PCS and SCADA, and transmit commands to BCMU and BLMU.

(5) Communicate with PCS and SCADA to achieve below functions:

A. Transmit protection or warning signals of BCMU and upload these signals to PCS and SCADA;

B. Transmit protection and warning signals found in BMS self-checking to PCS and SCADA;

C. Upload battery array data to PCS and SCADA, such as total voltage, present current, etc;

D. Upload event log;

E. Provide a human-computer interaction function for local and remote operation, such as communication interface, permission management, parameter setting, etc.

4.6.2 BAMS Interface Definition

Interface	Description	Functions	Harness Definition
Ethernet	RJ45, 10/100/1000 Mbps	1, External Interface： Communicate with PCS and SCADA 2, Internal Interface： Communicate with BCMU	Shielded Twisted-pair Cable, Super Five Categories
USB	USB 2.0	Record Local Data	
RS485	9.6~115.2 Kbps Communication Rate， 1500V Isolation	Communicate with PCS	Shielded Difference Twisted-pair, 1500V Insulation Voltage

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4.7 Battery Cluster Management Unit (BCMU)

4.7.1 BCMU Appearance

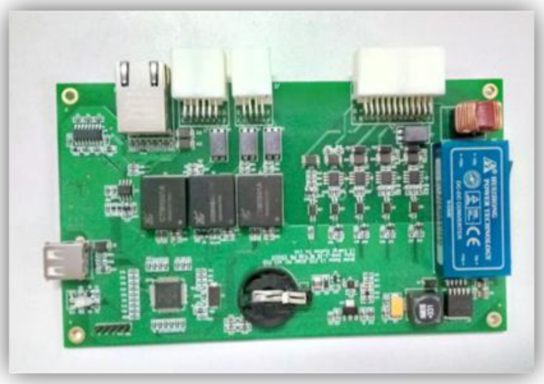

Figure 4.7.1 BCMU Appearance

4.7.2 Functional Description of BCMU

(1) Manage a single battery rack;

(2) Each BCMU manages 15 BLMU, gathers the information of battery voltage, temperature, etc and reports to BAMS;

(3) Short-circuit protection. If short circuit occurs, BCMU will break the main loop immediately;

(4) Analyze warning and protection status. If a battery rack detects any abnormal status, BCMU will transmit protection or warning signals to BAMS and be ready to receive commands;

(5) Control circuit switch, contactors, relays and other components to ensure the battery safety.

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4.7.3 BCMU Technical Specification

BCMU Type	LS_ESS_BCMU_A1 PCBA
Manage BLMU Max Number	30
Power Supply	12~24V DC
Power Consumption	<200mA
Communication Interface	CAN, Ethernet
Display Type (Optional)	SDW8060-080-TJ20W
Screen Resolution	800*600
Display Size	162*122mm
Display Power Consumption	<2.8W

4.7.4 BCMU Communication Interface

Interface	Description	Functions	Harness Definition
Ethernet	RJ45, 100 Mbps	Communicate with BAMS	Shielded Twisted-pair Cable, Super Five Categories
CAN	250 Kbps	Collect Battery System Information and Communicate with BLMU through CAN Bus	Shielded Difference Twisted-pair Cable, 1000V Insulation Voltage
Power Wire of BCMU	2 Core Wire，24V DC Power	Provide BCMU Power Supply	Min Size of Copper Cable is $1mm^2$; 1000V Insulation Voltage

4.8 Main Loop Component (MLC)

MLC includes relays, fuses, pre-charging resistors (LaiFu, RXLG), HALL elements, etc.

(1) Relay connects or breaks main loop. BCMU controls relays;

(2) Fuses are used in short circuit protection. Fuses break down immediately;

(3) Pre-charging resistor can reduce the influx rush current. BCMU commands pre-charging relay to release pre-charging resistor into main loop;

(4) HALL element is used to measure current. HVCU measures HALL element voltage.

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4.9 High Voltage Control Unit (HVCU)

4.9.1 HVCU Appearance

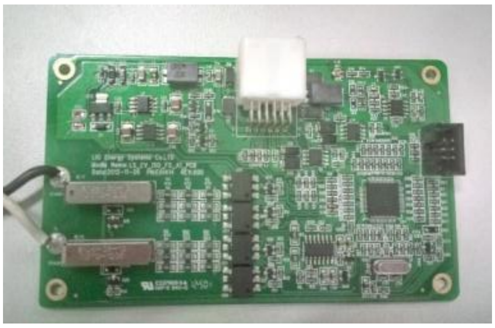

Figure 4.9 HVCU Appearance

4.9.2 HVCU Technical Specification

Voltage Range	>2500V
Accuracy of Insulation Resistance	5%
Power Consumption	<50mA
Current Sample Range	0~350A
Current Measure Accuracy	≤0.5% FSR

4.10 Battery Local Management Unit (BLMU)

Each BLMU monitors 1 battery module, it can upload the module information, such as voltage, temperature, protection and warning status, and other parameters to BCMU.

4.10.1 BLMU Appearance

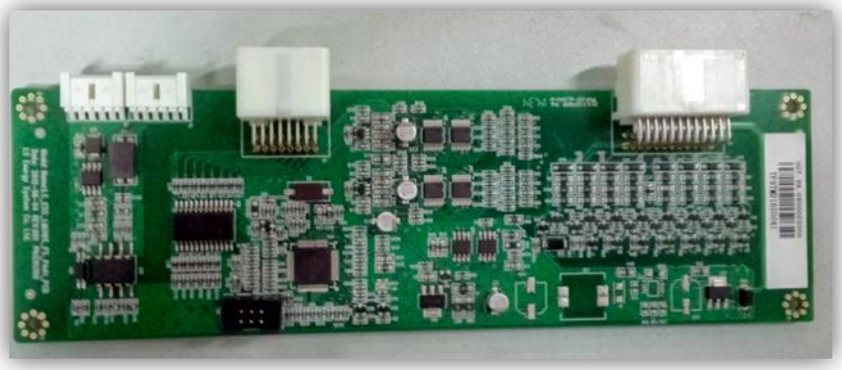

Figure 4.10.1 BLMU

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4.10.2 Functional Description of BLMU

(1) Every BLMU monitors all battery cells in 1 battery module;

(2) Measures the battery voltage, temperature and reports to BCMU;

(3) Battery balance function;

(4) Isolated CAN communication function.

4.10.3 BLMU Technical Specification

BLMU Module Type	LS_ESS_LMU16_FS_AWD2
Power Supply	12~24V DC
Busy Power Consumption	<50mA
Free Power Consumption	<1mA
Measurable Voltage Scope	0.5~5V
Cell Voltage Accuracy	≤±3mV
Cell Temperature Measurement Range	-30~105℃
Temperature Accuracy	≤±1℃
Communication Interface	CAN 2.0*2
Balance Approach	Intelligent Non-destructive Balance

4.10.4 BLMU Interface and Wiring Definition

Interface	Description	Function	Wiring Definition
CAN	250 Kbps	Communicate with BCMU through CAN Bus	Shielded Difference Twisted-pair Cable, 1500V Insulation Voltage
Power Wire of BLMU	2 Core Wire, 24V DC Power	Provide BLMU Power Supply	Min Size of Copper Cable is 1mm², 1500V Insulation Voltage
Voltage Sampling of Harness	10 Pieces Harness	Sample Cell (Series Connection) Voltage	High Temperature Wire 2.5mm²
Temperature Sampling of Harness	8*2*2 Pieces of Harness	Sample 8 Temperature Points	

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4.11 Thermal Management System

Thermal Power Calculation of Battery Rack

---Thermal Power Calculation of Single Battery Cell

Calculate the Thermal Power of 1C Battery Cell,

Quantity of Heat Production, 1C (I=40A): 3.2W

---Battery Module Thermal Power Calculation

For the 12S8P Module, the Overall Thermal Power Quantity of Heat Production, 1C (I=320A): 307.2W

---Battery Rack Thermal Power Calculation

For the 180S8P Rack, the Overall Thermal Power Quantity of Heat Production, 1C (I=320A): 4.6kW

4.12 Battery Protection Design

4.12.1 Cell Safety Design

An explosion-proof valve is used at the top of each cell. In the event that cell internal pressure is beyond the threshold under abusive situations, the explosion-proof valve will open to release the pressure and any gas generated from the internal chemical reactions. Therefore, cell explosion risk is mitigated.

Electrolyte is an important factor that affects cell cycle life and safety. In order to improve cell performance, Lishen has done research for many years on optimization of the electrolyte formula. By optimizing the composition and ratio of the solute and the solvent, the stability of the electrolyte and the battery cycle life have been improved. In the electrolyte, the overcharge resistant additive and fire-retardant additive provide improved cell thermal stability.

Iron particle removing technique is used through cell manufacturing processes to ensure that there is no iron contamination within cell components to prevent cell internal short circuit and ensure cell safety.

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4.12.2 Battery Module Safety Design

The frame and insulating cover of battery module are made from insulated materials to reduce the danger of battery burning. The cover is made from ABS/PC material to prevent short circuit during battery transportation and installation. Battery modules are secured to ensure no movement safety issue during installation and transportation.

4.12.3 Battery Rack Safety Design

The cable between modules in battery rack is high-qualified and heat-resistant to avoid fire.

The frame surface is treated with advanced static electricity spray process, and complies with relevant provisions of coating equipment's general technical requirements.

The cabinet structure has sufficient mechanical strength to ensure that all components are secure and stable, and can keep the shape. The cabinet has passed anti-seismic test and also has protective grounding.

4.12.4 BMS Safety Design

For each series of battery rack, BMS sets a temperature collection point to monitor temperature condition in real time. When the temperature rises above the preset high temperature threshold, BMS host will inform PCS to shut down, disconnect the DC relay, cut off high voltage circuit, and report temperature anomaly to the monitoring system, in order to ensure battery system safety.

The cable between modules in battery rack is high-qualified and heat-resistant to avoid fire.

High voltage DC circuit is connected with DC relay, fuse and DC switch to provide security when external short circuit happens. BCMU monitors battery rack circuit in real time.

When external short circuit occurs, the discharge current in circuit will increase to exceed the set current threshold instantly, and the relay controlled by BCMU will break to cut off discharge current. When external short circuit occurs, the discharge current in circuit will increase to reach the maximum current allowed by the fuse, which will blow to cut off discharge current. When external short circuit occurs, the discharge current in circuit will increase to reach the maximum current allowed by the DC switch, which will open to cut off discharge current.

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4.12.5 Electrical System Safety Design

(1) Bus Cabinet

A. Inside the bus cabinet, organic glass is used to cover bare copper bar, and prevent personnel from getting an electric shock when operating circuit switch;

B. The DC circuit switch is attached with shunt release. When fire broke out, DC circuit switch can trip receiving fire signal;

C. Copper bar inside the bus cabinet is wrapped with thermal shrinkable sleeve to prevent personnel from experiencing high current;

D. The bus cabinet, organic glass inside the bus cabinet and container gate should reserve isolation keyhole for inspection.

(2) Wiring

A. Cables within the container are flame-resistant. A fire-proof sealing is needed when the diameter of hole is more than 5mm;

B. The AC/DC cable has clear colored label;

C. Cable layout is crossed as few as possible.

4.13 EMS

Figure 4.13 EMS Appearance

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No.	Name	Specification	Quantity	Unit	Notes
1	EMS	2 Ethernet, 4 RS485	1	PCS	
2	Optical Ethernet Switch	KIEN1005-S-4T-240V AC	1	PCS	For Long Distance
3	Fiber Box	OTB-A08 260*140*40, 8 Core	1	PCS	For Long Distance
4	Cabinet and Fitting		1	Set	

4.14 PCS

Figure 4.14 MEGA Serial PCS Appearance

Specifications of MEGA Serial PCS

Model / Specification	MEGA0050T	MEGA0100T	MEGA0250T	MEGA0500T	MEGA0500
DC					
Max Power (kW)	55	110	275	550	550
Voltage Range (V)	300~850V			500~850V	
Max Current (A)	80	160	400	1100	920
Voltage Regulation Accuracy	＜±2%				
Current Regulation Accuracy	＜±2%				
AC					
Rated Voltage (V)	415				315

THDI	<3% (Line Load)				
Rated Frequency (Hz)	50/60				
System					
Efficiency	>96%	>96.5%	>97.0%	>97.3%	>98.7%
Transfer Time between Charge and Discharge	<10ms				
IP Level	IP55				
Cooling Mode	Forced Air Cooling				
Humidity	<95% (No Condensation)				
Temperature	-30~50℃				
Altitude	<3000m (No Derating)				
HMI	LCD Display				
Communication	RS485, TCP/IP				
BMS Connection	Available				
Size (w*h*d)	800*2050 *800 (mm)	800*2050 *800 (mm)	1200*2050 *800 (mm)	1600*2050 *930 (mm)	1200*2050 *800 (mm)
Weight	450kg	860kg	1350kg	2770kg	1400kg

4.15 DC/DC Converter

Figure 4.15 PMDE Serial DC/DC Converter Appearance

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Specifications of PMDE Serial DC/DC Converter

Model / Specification	PMDE0050	PMDE0100	PMDE0150	PMDE0200	PMDE0250	PMDE0300
Electrical Parameters						
Rated Power (kW)	50	100	150	200	250	300
Maximum Power (kW)	55	110	165	220	275	330
PV Access	Available					
Quantity of MPPT	1 Way	2 Ways	3 Ways	4 Ways	5 Ways	6 Ways
Scope of MPPT	450~850					
Maximum Operating Current (A)	110	220	330	440	550	660
System Parameters						
Peak Efficiency	99%					
Voltage Accuracy	1%					
Current Accuracy	1%					
Supporting Batteries	Various					
IP Level	IP55					
Attitude	<3000m (No Derating)					
Humidity	<95% (No Condensation)					
User Interface	Touch Screen					
Communication	RS485, CAN					
BMS Interface	Available					
Protection Parameters						
Input Breaker	Available					
Output Breaker	Available					
Isolation Mode	Non-isolation					
Cooling Technique	Forced Air Cooling					
Wiring Method	Bottom in and Bottom out					
Weight (kg)	150	180	210	250	300	350

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4.16 Topology of Circuit Schematics

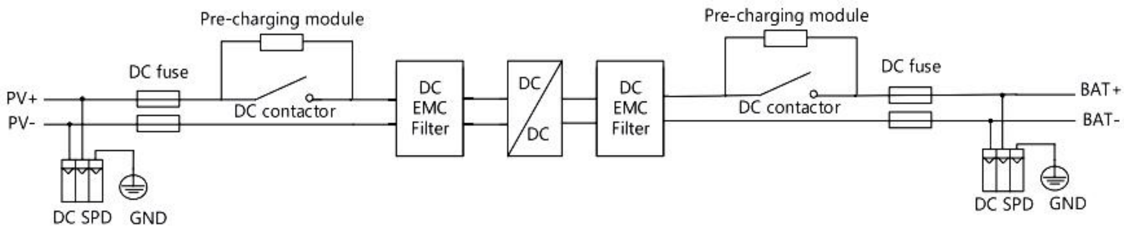

Figure 4.16.1 Topology of Battery Charging Circuit from PV System

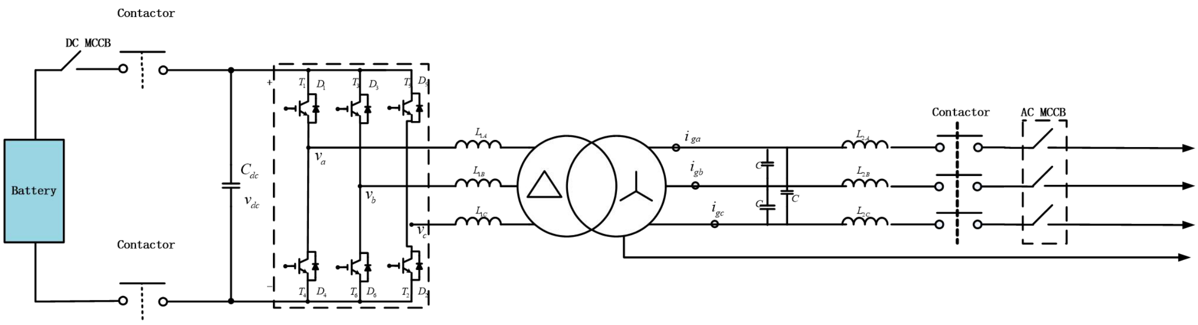

Figure 4.16.2 Topology of Power Supply from Battery Array

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