1.08MWh ESS Technical Solution
1036V 1050Ah

1 Project Introduction

1.1 Purpose

The purpose of this document is to explain the technical parameters of the battery management system of the 1.08M Wh container energy storage system and the related functions of the container, which mainly include the following:

- **Definition of battery system performance specifications.**
- **Battery management system function and frame structure description.**

1.2 Application

This document is only applicable to 1.08M Wh energy storage battery system.

1.3 Standard and Specification

- **The contract equipment stipulated in the relevant standards, specifications or guidelines, including all accessories and equipment purchased from other manufacturers, shall meet the requirements of these standards, specifications or guidelines.**

- **As for the clauses in the listed standards, all the dated reference standards, all subsequent amendments (excluding the content of errata) or revised versions are not applicable to this technical agreement; for undated reference documents, the latest version applies this tender document.**

Major standards to be met by equipment and accessories
NB-T 31016-2011 Technical requirements for battery energy storage power control system
Q / GDW676-2011 Test Specification for Connecting Energy Storage System to Distribution Network
Q / GDW564-2010 Technical Regulations for Connecting Energy Storage System to Distribution Network
DL / T 527-2002 Technical conditions of inverter power supply for static relay protection device
GB / T 13384-2008 General technical requirements for packaging of mechanical and electrical products
GB / T 14537-1993 Shock and collision test of measuring relays and protection devices
GB / T 14598.27-2008 Measuring relays and protection devices Part 27: Product safety

requirements
DL / T 478-2001 General technical requirements for static relay protection and safety automatic devices
GB / T 191-2008 Packaging, storage and transportation icon
GB / T 2423.1-2008 Environmental test for electric and electronic products Part 2: Test method Test A: Low temperature
GB / T 2423.2-2008 Environmental test for electric and electronic products Part 2: Test method Test B: High temperature
GB / T 2423.3-2006 Environmental test for electric and electronic products Part 2: Test method Test Cab: Constant humidity and heat test
GB / T 2423.8-1995 Environmental test for electric and electronic products Part 2: Test method Test Ed: Free fall
GB / T 2423.10-2008 Environmental test for electric and electronic products Part 2: Test method Test Fc: Vibration (sine)
GB 4208-2008 enclosure protection grade (IP code)
GB / T 17626 electromagnetic compatibility test and measurement technology
GB 14048.1-2006 Low-voltage switchgear and control equipment Part 1: General
GB 7947-2010 Basic and safety rules for human-machine interface sign identification Conductor color or digital identification
GB 8702-88 electromagnetic radiation protection regulations
DL / T 5429-2009 Technical code for power system design
DL / T 5136-2001 Technical code for secondary wiring design of thermal power plants and substations
GB 50217-2007 power engineering cable design code
GB 2900.41-2008 battery terminology
When there are discrepancies between standards and specifications, they shall be implemented in accordance with high standards.

1.4 Definition of terms

No.	Terms	Definition
1	Cell	An electrochemical device that consists of an electrode and an electrolyte and constitutes the smallest unit of a battery pack. It can store the obtained electrical energy in the form of chemical energy and convert chemical energy into electrical energy.
2	Battery Module	Two or more battery cells that are electrically connected and used as an energy source.
3	Battery Cluster	A battery system composed of several battery modules connected in series and connected to a circuit system. The circuit system generally consists of monitoring, protection circuits, electrical, communication interfaces, and thermal management devices.

4	Battery Array	A battery system that is integrated with several battery clusters connected to the same energy conversion system (PCS) to achieve power input and output as a whole, and is controlled by a background monitoring system.
5	Battery Management System,BMS	General term for the circuit system used to manage the battery charging and discharging process, improve the battery life, and provide users with relevant information. It is composed of management units such as BMU, MBMS and BAMS. Two or three layers can be selected according to the configuration of the energy storage system.
6	Battery Management Unit, BMU	It has the function of monitoring the voltage and temperature of the single battery in the battery module, and can safely manage the charging and discharging process of the battery module, and provides a communication interface for the battery. The BMU is the smallest component management unit of the battery management system (BMS). It provides the battery cluster management system (MBMS) with internal information of the battery module through the communication interface.
7	Main Battery Management System,MBMS	It is a real-time monitoring and management system composed of electronic circuit equipment, which effectively manages the battery cluster charging and discharging process, and provides alarm and emergency protection treatment for possible failures to ensure the safe, reliable and stable operation of the battery. MBMS is an intermediate level of the battery management system. It collects battery management unit (BMU) information downwards and provides information to the upper battery stack management system (BAMS).
8	Battery Array Management System, BAMS	It is a real-time monitoring and management system composed of electronic circuit equipment. It centrally manages the battery of the entire energy storage battery stack to ensure the safe, reliable and stable operation of the battery. BAMS is the highest level of the battery management system and connects to the battery cluster management system (MBMS).
9	Passive Blancing	Refers to discharging batteries through a resistor to reduce the capacity and voltage difference between batteries and maintain the consistency of power between different batteries.

10	Active Blancing	Refers to a method of transferring energy between batteries through inductors, transformers, capacitors and other devices to reduce the capacity and voltage difference between batteries and maintain the consistency of power between different batteries.
11	State of Charge,SOC	The ratio of the current actual available battery power to the rated power.
12	State of Health,SOH	The ratio of the total charge and discharge capacity of the battery to the rated capacity.
13	Power Conversion System,PCS	The core part of the device that realizes the bidirectional energy conversion between the battery and the AC power grid is a converter composed of power electronic devices.
14	Supervisory Control And Data Acquisition, SCADA	The system platform for monitoring and coordinated control of the energy storage system, external power grid, and load is communicated by BAMS or MBMS (in the case of a two-tier architecture) to complete the information transmission and background control of the energy storage battery stack.

2 System Requirement Analysis

2.1 Technical requirements for ESS battery system

Item	**Unit**	**Battery cluster parameters**	**System parameters**	**Note**
nominal voltage	V	≈1050V	≈1050V	
voltage range	V	800-1300V	800-1300V	
battery type	/	LFP	LFP	
nominal capacity	Ah	150Ah	1350Ah	
total energy(BOL)	kWh	≥111	≥1000	
available energy	kWh	≥100	≥900	90%SOC
SOC discharge window	%	≥90	≥90	
rated power	kW	100	500	
peak power	kW	to determined	to determined	
weight	Kg	≤70		single box
storage temperature	℃	-40℃～60℃	-40℃～60℃	
discharge temperature	℃	-20℃～60℃	-20℃～60℃	
charge temperature	℃	0℃～55℃	0℃～55℃	
-20℃ discharge capacity	/	no less than 80% of the rated value	no less than 80% of the rated value	Refers to the ratio of the discharge capacity to the rated capacity of the battery system when the temperature in the battery system is at the specified value. The test conditions are 1C.

50℃ discharge capacity	/	no less than 100% of the rated value	100% no less than 100% of the rated value	
life cycles	/	200 次/SOC≥97% ≥1000 次 /SOC≥80%	200 次/SOC≥97% ≥1000 次/SOC≥80%	1C/1C、100%DOD、25℃
self-discharge rate	%/m	≤3	≤3	25℃，30 days，100%SOC
total weight of the system	kg			
IP grade	-	IP21	IP21	
fire-proof grade of the system	-	V0	V0	If it fails to meet the V0 level requirement, relevant details such as parts list and layout position must be given.

3 Container Technical Design

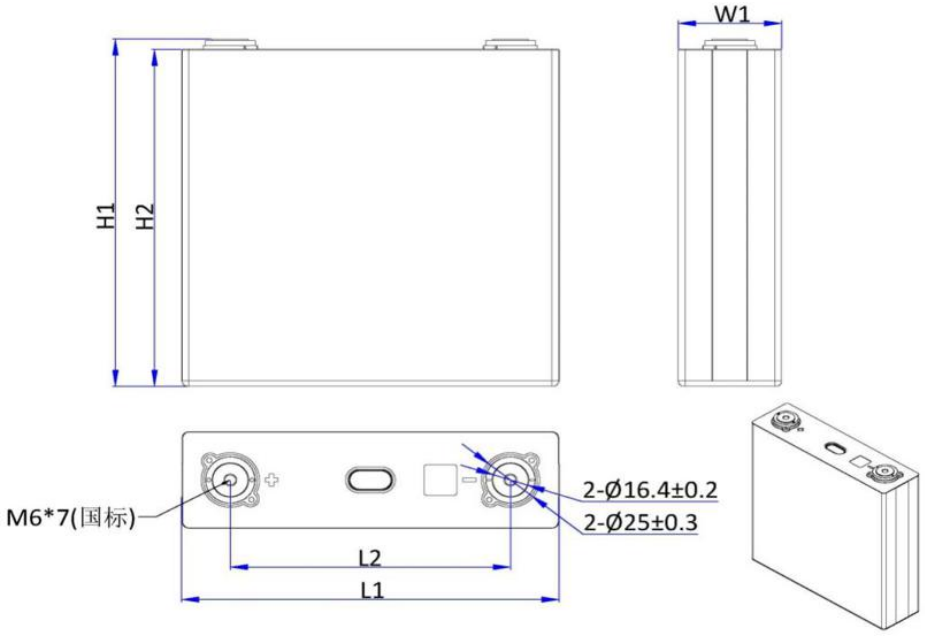
3.1 Cell design

3.1.1 Battery cell specification

Item		**Spec.**	**Remarks**
Nominal Capacity（Ah）		150	RT / 1C1C; 2.5V to 3.65V
Nominal Voltage（V）		3.2	NA
Internal Impedance（mΩ）		≤0.35	AC1kHz
Weight（Kg）		3.12±0.05	NA
Energy density（Wh/kg）		153	1C1C, RT
RT Cycle Life（Cycles）		4000/Optional）	80%SOC; RT / 1C1C; 2.5V to 3.65V
Low Temp. Discharge Cap. Retention（-20℃）		≥90%	RT,1C CC-CV to 3.65V@0.05C,-20℃ DC to 2.0V
Self-discharge Rate		≤4%	Per Month
Charge	Standard Current（A）	0.5C	CC & CV 25℃±5
	Max. Continues Current（A）	1C	Max. Pulse Current 2.6C
	Limited Voltage（V）	3.65	NA
	Cut-off Current（A）	0.05C	NA
Discharge	Standard Current（A）	1C	NA
	Max. Continuous Current（A）	2C	Max. Pulse Current 2.6C
	End Voltage（V）	2.5	
Operating Temperature（℃）	Charge （Quick mode）	0 ~ 55	< 0℃: Charging not allowed; 0 ~ 10℃: Max. Charge Current 0.5C, CC Only 10 ~ 20℃: Max. Charge Current 1C, CC Only; 20 ~ 30℃:Max. Charge Current 2C, CC&CV 30 ~ 40℃: Max. Charge Current 1C, CC&CV 40 ~ 55℃: Max. Charge Current 0.5C, CC&CV > 55℃: Charging not

			allowed;Cell Surface Temp. ≤ 60℃.
	Discharge	-20 ~ 55	Cell Surface Temp. ≤60℃
Storage Conditions	Storage Temperature （℃）	-20 ~ 40	Optimal Storage Temperature: 5 ~ 35℃ Short term：-40 ~ 50℃
	Storage Humidity （RH）	15% ~ 90%	
	State of Charge（SOC）	30% ~ 50%	
Delivery Capacity（SOC）		30%	NA

3.1.2 Dimension



No.	Code	Dimension（mm）
1	L1	174.2±0.5
2	L2	129.3±0.5
3	H1	190±0.5
4	H2	184.6±0.5
5	W1	44.7±0.5

3.2 Battery module parameters

Item	Unit	Spec.	Note
nominal voltage	V	57.6	
nominal capacity	Ah	150	
configuration	/	1P18S	
weight	Kg	≤70	
max. cont.discharge current	A	225（1.5C）	

max.cont.charge current	A	150（1C）	
peak discharge current	A	400（2.6C）	25℃，SOC50%，10s
peak charge current	A	225（1.5C）	25℃，SOC50%，10s
charge working temp.	℃	0 ~ 55	
discharge working temp.	℃	-20 ~ 55	
insulation requirement	/	more than 50MΩ	
heat method	/	no	
dimension	mm	H:210mm/W:340mm/L:596 mm	

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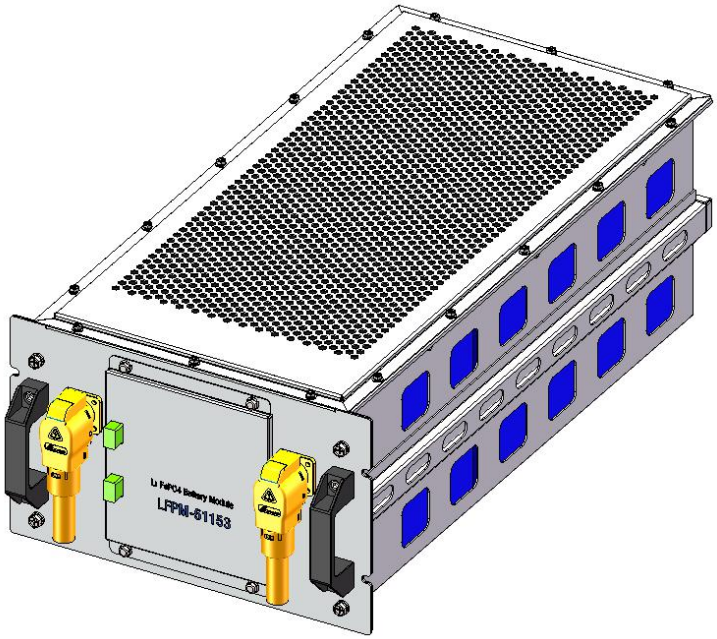
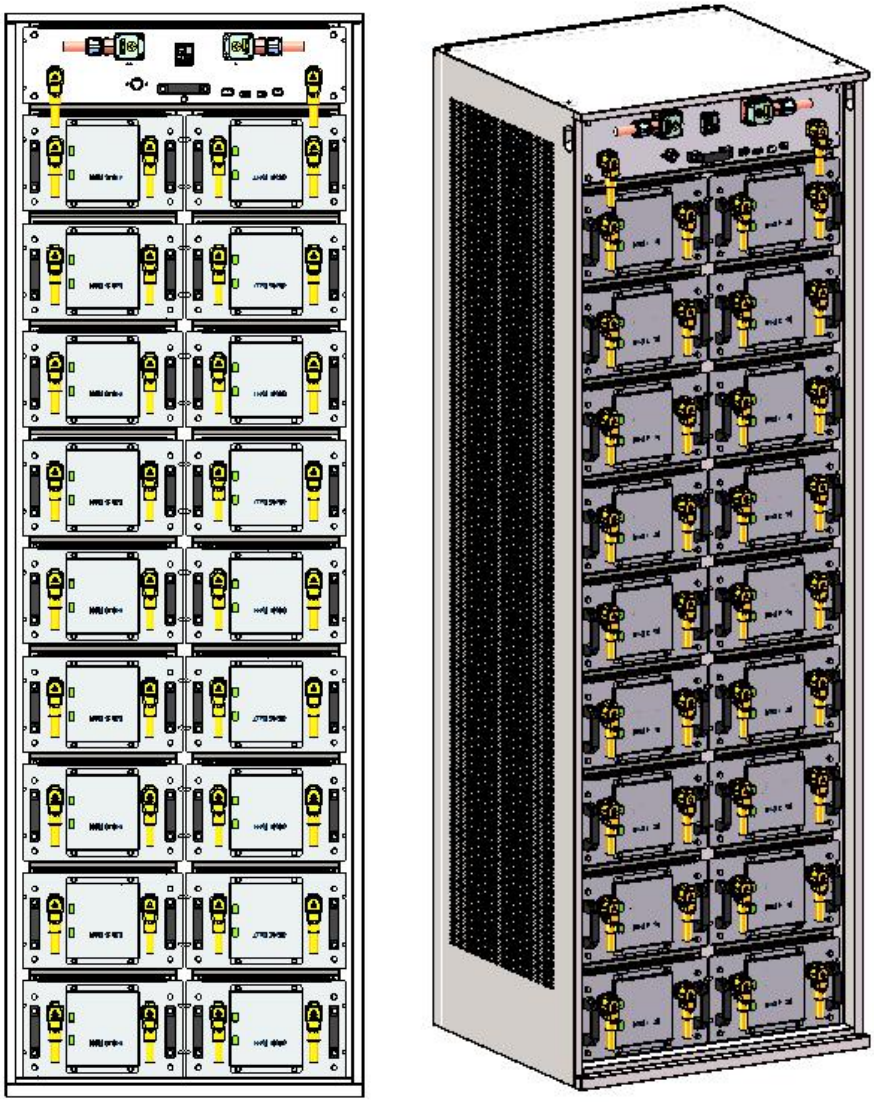


3.3 Battery cluster parameters

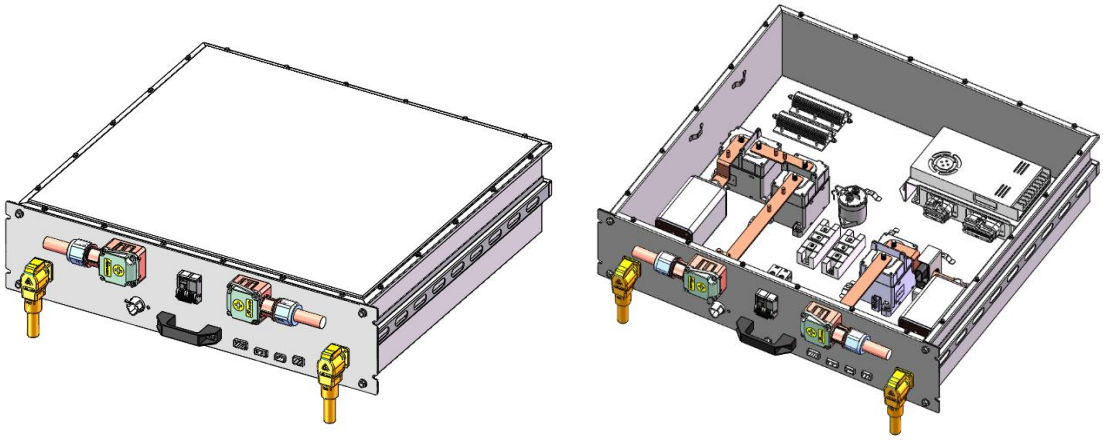
No.	Item	Spec.	Note
1	nominal voltage (50% SOC)	1036.8V	
2	nominal capacity	150Ah	
3	min. capacity	120Ah	80% of the nominal capacity
4	system configuration	324S1P	series/parallels
5	system total energy	155.5kWh	
6	system available energy	143kWh	discharge window 92%SOC
7	voltage range	810V ~ 1182.6V	available voltage range
8	(10S)max.pulse discharge current	450A	25℃，SOC50%
9		225A	55℃ > T >= 0℃

	max. Cont.discharge current	150A	0℃ > T > -20℃
10	Max.pulse charge current（10S）	225A	T >= 10℃
11	max.cont.charge current	150A	T >= 10℃
12	max.SOC operation window	5%SOC~97%SOC	available SOC range
13	life cycles	≥3000cycle	0.5C, SOC 95% 50 SOC 5%
14	work temp.	meet cell work temp,	
15	max. voltage	1134V	constant power/CC charge
16	max. voltage	1182.6V	pulse charge（10s）
17	min.voltage	907.2V	constant power/CC charge
18	min.voltage	810V	Pulse discharge (10s)
19	self-discharge rate	3%	1.08 Month，25℃，50%SOC
20	insulation resistance value	more than 50MΩ	
21	IP grade	IP21	
22	energy density	126.4kWh/L	volume energy density
		296.5kWh/m²	area energy density
23	dimension	760.6mm(W)*690mm(D)*2345(H)mm	
24	weight	＜1500kg	

The battery cabinet is mainly installed with a battery box and a BMS main management system, supporting wires and cables, and high and low voltage electrical protection components. The cabinet adopts a grouped and layered design, which has a beautiful appearance.The cabinet adopts the assembly structure of maintenance-free technology and modular combination to ensure that the cabinet structure has good mechanical strength, and the overall structure can meet the reliability and safety of the entire system to the greatest extent. The battery system consists of three battery racks, of which the schematic diagram of the battery rack composition is shown below:



Battery cluster structure

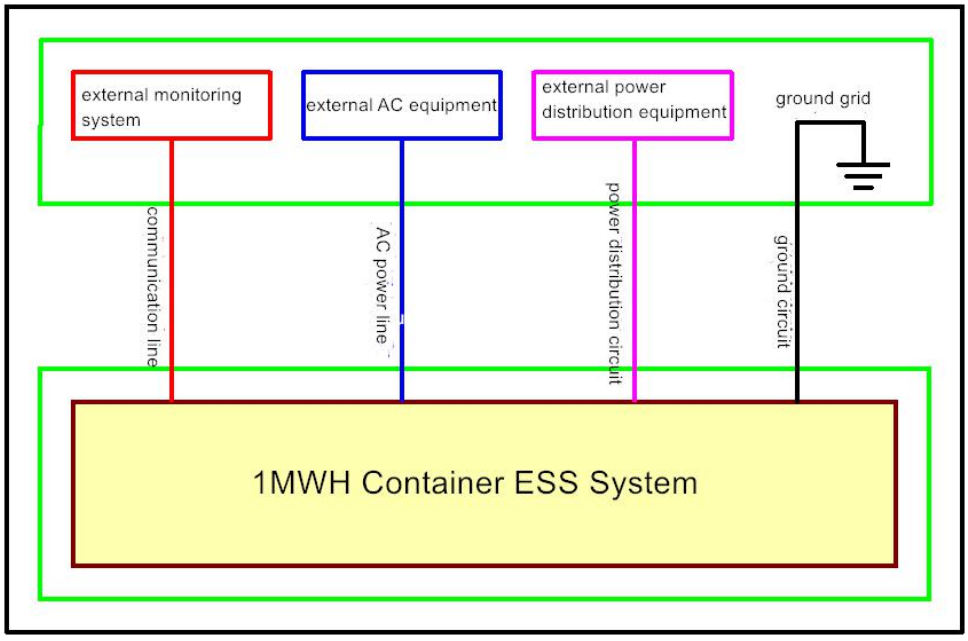


High-voltage box

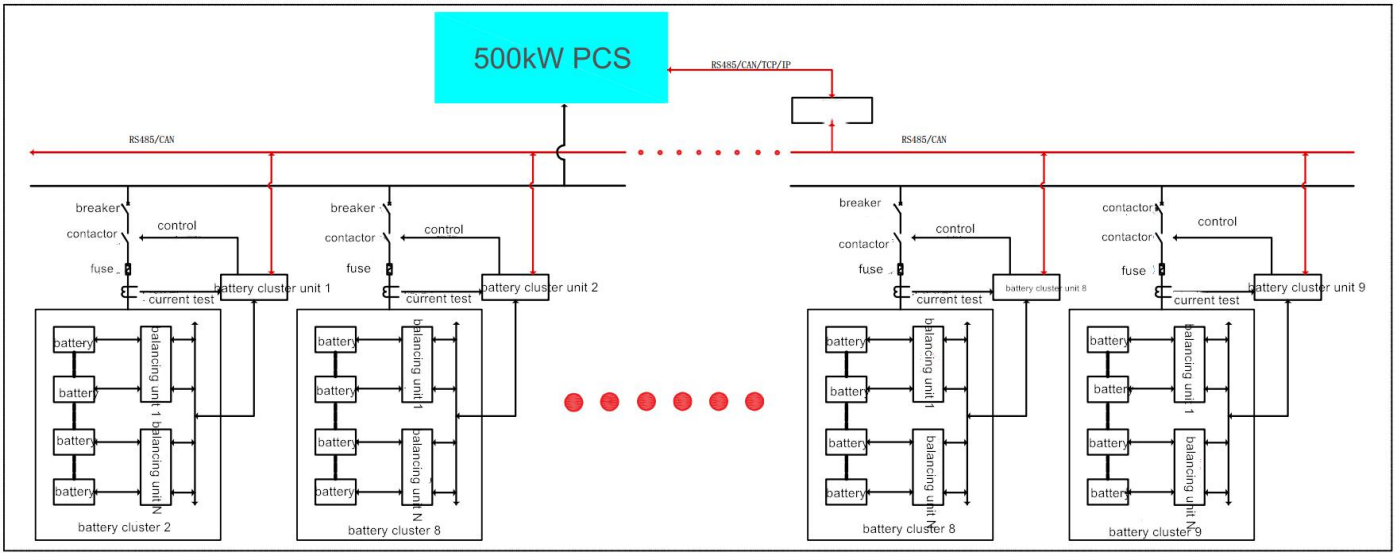
3. 4 General description of the technical solution

According to the technical requirements of 1.08M Wh of energy storage for the system configuration, a total of 500kW PCS is used in this energy storage system project. The energy storage unit consists of a PCS and 7 battery clusters, and is equipped with a battery array management unit device. Each battery cluster consists of a battery cluster management device and 18 each battery packs.

System access topology diagram:：



Container system electrical topology structure diagram:



3.4.1 Battery system specification

No.	Item	Spec.	Note

1	nominal voltage(50%SOC)	1036.8V	
2	nominal capacity	1050 Ah	
3	min.capacity	840Ah	80% of the nominal capacity
4	system configuration	324S7P	series/parallels
5	total system energy	1088.5 kWh	
6	available system energy	1001.4 kWh	discharge window 92%SOC
7	voltage range	810V ~ 1182.6V	available voltage range
8	max.pulse discharge current(10S)	1500A	25℃，SOC50%
9	max.cont.discharge current	1050A	55℃ > T >= 0℃
		1050A	0℃ > T > -20℃
10	max.pulse charge current（10S）	1050	T >= 10℃
11	max.cont.charge current	500A	T >= 10℃
12	max.SOC operation window	5%SOC~97%SOC	available battery SOC range
13	life cycles	≥3200cycle	0.5C， SOC 95% ~ SOC 5%
14	work temp.	meet cell work voltage	
15	max. voltage	1134V	constant power/CC charge
16	max.voltage	1182.6V	Pulse charge (10s)
17	min.voltage	907.2V	constant power/CC discharge
18	min.voltage	810V	Pulse discharge （10s)
19	self-discharge rate	3%	1.08 Month，25℃，50%SOC
20	insulation resistance value	more than 50MΩ	
21	IP grade	IP21	

3.5 BMS system management configuration scheme

3.5.1 BMS basic functions

BMS mainly includes battery status monitoring, operation control, event record storage function, insulation monitoring, dynamic balance management, protection alarm, communication and other functions to ensure the normal, stable and reliable operation of the system.

3.5.2 System Architecture

The BMS used in this project is designed with a three-layer architecture, namely a battery collection equalization unit, a battery cluster management unit, and a battery array manage ment unit.

Battery collection and equalization unit BMU: Responsible for managing 18 batteries in series. The main functions include monitoring the voltage, temperature and balance manage ment of the single cell, and communicating with the MBMS in the CAN bus mode. Battery cluster management unit MBMS: It is mainly responsible for managing battery voltage acquisition, current acquisition, equalization control, charge and discharge control, precharge control, power calibration, etc. in a single series circuit. The main functions include CAN communication, battery status display of each group in the series circuit, and Estimate the SOC of the battery, etc., take an alarm or protection measures when an abnormality occurs, and upload the collected battery information, abnormality information, and SOC to BAMS.

● MBMS communicates with BAMS, and uploads the collected battery voltage, temperature, current, total voltage and insulation detection level to BAMS through RS485 bus, and uploads system parameters to BAMS.

● MBMS integrates functions such as current detection, total voltage detection, insulation detection, I / O status detection, and control of external status.

● MBMS communicates with the BMU, and receives the voltage, temperature, and equilibrium status of the battery cells uploaded by the BMU through the CAN bus.

● BAMS battery array management unit: responsible for managing a MBMS under the control of a PCS, and communicating with the PCS and background monitoring system. Its main functions include recording all battery status information, control status information, abnormal data or event information under the PCS and creating corresponding information. Files; adjust the charge and discharge power according to the SOC information of each group of batteries and the state of the battery pack; communicate with the PCS and energy storage station measurement and control system to complete the management of the entire battery array. BAMS integrated LCD display and control unit, used to display battery status information, including cell voltage, cell temperature, equilibrium status, loop current, contactor status, SOC, alarm information, parameter information, etc .; also used to set battery parameters and manual control circuit contactors.

● BAMS communicates with MBMS, receives the battery cell voltage, temperature, total voltage, current and insulation detection level sent by MBMS, calculates the maximum / minimum voltage, maximum / minimum temperature of the battery stack, displays I / O status, and sets the MBMS Parameters, control battery pack balance status and I / O

status.

● BAMS communicates with PCS, and uploads information such as the voltage, chargeable/ dischargeable capacity, battery pack status, I / O status, maximum / minimum voltage, and maximum / minimum temperature of the single battery to the PCS through the RS485 bus.

● BAMS communicates with the background, and uploads the information such as the voltage of the battery, the temperature of the battery, the status of the battery pack, the I/O status, and the chargeable / dischargeable capacity to the background monitoring system through the Internet.

3.6 Background Monitoring System (SCADA)

The monitoring background mainly implements the active and reactive power coordination control function, the charging and discharging plan curve setting function, the micro grid automatic switching function, and the communication management function. A tablet computer is placed outside the container and integrated with EMS software to achieve remote monitoring and control of the PCS. The system reserves the interface, which can be connected to the large screen for demonstration.

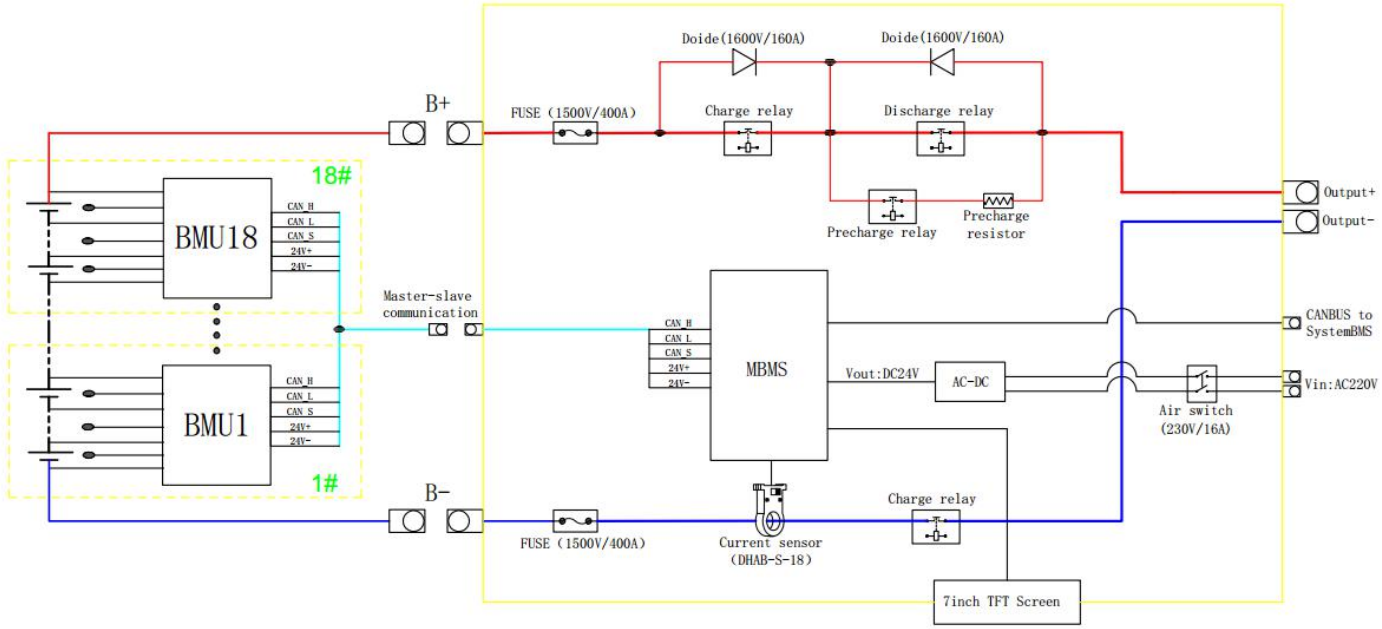
(1) Active and reactive power coordination control function When the external power grid fails, the grid-connected bus loses voltage. After the mode controller detects that the voltage of the external bus is abnormal, all inverters are automatically shut down to open the system's external grid Switch, and issue a transfer mode instruction to the bi-directional inverter (energy storage inverter), the bi-directional inverter is switched to constant voltage/ constant frequency control, and operates independently with a microgrid load. When the external power grid returns to normal, the mode controller first detects that the external power grid voltage is normal, first turns off the two-way inverter, then closes the system grid-connected switch, and the power grid runs with load. After all inverters detect that the grid voltage is normal, they are turned on and the battery enters the charging state.

(2) Charging and discharging plan curve setting function: the number of charging and discharging time periods, the starting time of charging and discharging, and the charging and discharging power can be set as required.

(3) Communication management function: It can communicate with PCS and BMS, display the operation information of the energy storage system, and control the startup, shutdown, and operation mode of the PCS.

4 High and low voltage electrical schematic

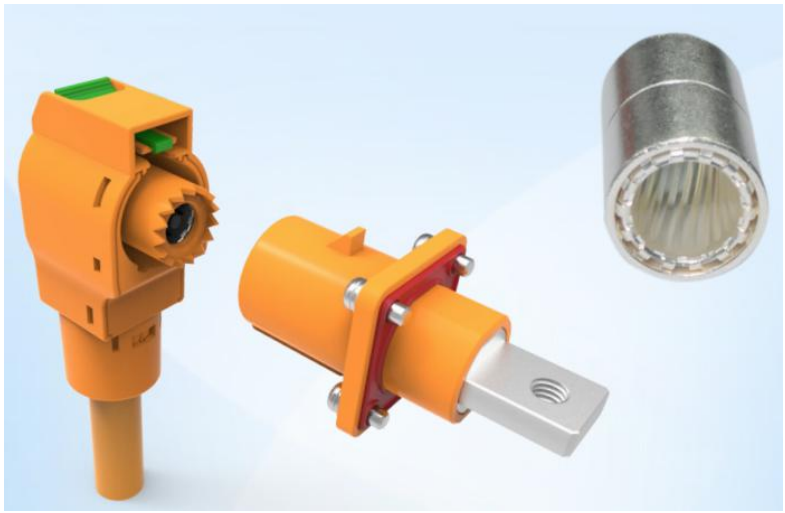
4.1 Cluster electrical schematic



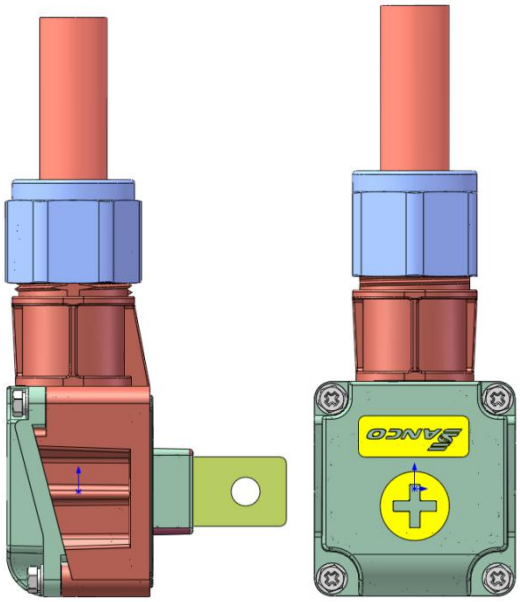
4.2 High-voltage electrical interface

4.2.1 High-voltage interface of the main circuit of the battery system

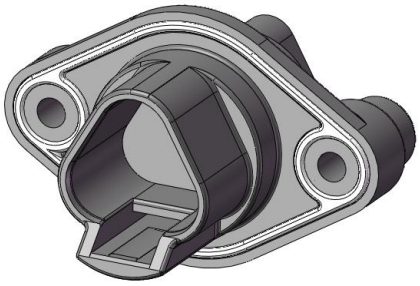
The battery module and high voltage box input power connector are shown in the figure below.



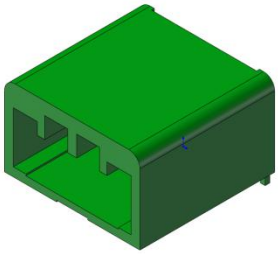
The high voltage box output power connector is shown below



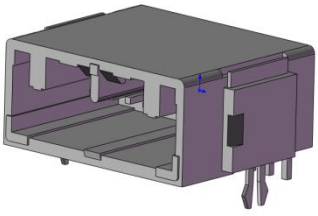
4.1.1 high-voltage input interface



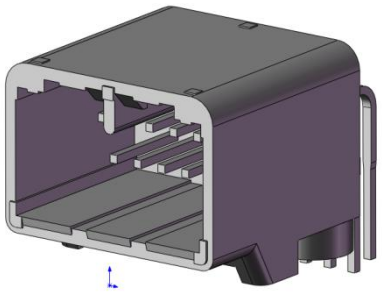
4.2 Low voltage electrical interface



4.3.2 Function expansion reserved interface



4.2.1 BAMS/MBMS communication interface



4.2.2 Maintenance interface