

All-in-one Liquid-cooled ESS Container ECO-B20FT5015LP User Manual



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1. Overview

1.1. Scope of Application

This product specification applies to the 5015 kWh liquid-cooled energy storage container product ECO-B20FT5015LP-2 manufactured by Sunpal Power Co., Ltd.

(hereinafter referred to as Sunpal).

It specifies the product ' s performance indicators, transportation and storage requirements, operating conditions, precautions, and risk warnings.

Model Code Explanation

- ECO — Product series: Sunpal Power Product Series
- B — Product type: Battery energy storage cabinet
- 20FT — Container size: 20-foot container
- 5015 — Rated energy: 5015 kWh
- L — Cooling method: Indirect liquid cooling
- P — Cell type: 314 Ah Lithium Iron Phosphate (LFP) cells
- 2 — Charge/discharge duration: 2-hour system

1.2. Normative References

Reference Standard:

- IEC 62619:2022 Safety requirements for secondary lithium cells and batteries for

industrial applications

- IEC 63056:2020 Safety requirements for secondary lithium cells and batteries used in electrical energy storage systems
- IEC 62477-1 Safety requirements for power electronic converter systems and equipment
- GB/T 36276-2023 Lithium-ion batteries for electric energy storage
- GB 34131-2023 Battery management system for electric energy storage
- GB 34131-2023 Technical requirements for power conversion systems in electrochemical energy storage
- GB/T 44026-2024 Technical specification for prefabricated cabin lithium-ion battery energy storage systems
- GB/T 36547-2024 Technical regulations for grid connection of electrochemical energy storage systems
- GB 4208-2008 Degrees of protection provided by enclosures (IP Code)
- GB/T 17626 Electromagnetic compatibility (EMC) – Testing and measurement techniques
- GB/T 7251.1-2023 Low-voltage switchgear and controlgear assemblies – Part 1
- GB/T 7251.2-2023 Low-voltage switchgear and controlgear assemblies – Part 2
- IEC 60068-2-6 Environmental testing – Sinusoidal vibration test standard

1.3. Definition of Terms

Item	Definition
Cell	Battery cell
PACK	Liquid-cooled battery pack
RACK	Battery cluster, a battery system composed of multiple battery PACKs and one high-voltage box
Integrated Control Cabinet	Composed of an auxiliary power supply part, a BMS management part and a DC busbar part. Its functions are to provide AC power for the inside of the energy storage container; collect internal data and communicate with the outside; and perform DC busbar connection for battery clusters.
BMS	Battery Management System
BMM	Level 1 BMS: Slave control unit of the Battery Management System
BCM	Level 2 BMS: Main control unit of the Battery Management System
CCU	Level 3 BMS: Master control unit of the Battery Management System
PCS	Power Conversion System
UPS	Uninterruptible Power Supply
EMS	Energy Management System
SOC	State of Charge of the battery

2. Product Introduction

2.1. System Overview

This product (Liquid-Cooled Energy Storage Container ECO-B20FT5015LP) is a 5015kWh (nominal energy) liquid-cooled energy storage system, which consists of main components such as a container body, a battery system, a central control and distribution cabinet, a liquid-cooled system, a battery management system and a fire protection system.

This product includes one set of 20-foot container energy storage system with 12 battery clusters. Each battery cluster is composed of 4 Lithium Iron Phosphate (LFP) battery PACKs and 1 high-voltage box connected in series, managed by 1 ESBCM (Master Battery Management Unit). Each battery PACK is composed of 104 3.2V 314Ah cells connected in series, managed by 1 ESBMM (Slave Battery Management Unit). The 12 battery clusters are connected in parallel to the central control and distribution cabinet through the DC busbar, and uniformly managed by 1 ESCCU (Master Control Battery Management Unit). The ESCCU integrates the human-machine interface of the battery management system, uploads battery data and information to the EMS at the same time, and realizes external data forwarding through the EMS. The management and monitoring system is equipped with a UPS, which can maintain the operation of the system monitoring for a certain period of time when the power grid is cut off.



Figure 2-1 Appearance

2.2. Technical Parameters

2.2.1. Container Design Scheme

This liquid-cooled energy storage container product adopts an integrated design, integrating key equipment such as the energy storage battery system, battery management system, fire protection system and liquid-cooled system into a standard 20-foot high cube container for easy stacking.

The parameters of this liquid-cooled energy storage container product are as follows:

Item	Specification	Remarks
Battery Type	LFP 314Ah	
System Configuration Mode	12*(1P104S*4)	
Nominal Energy	5015.96kWh	100%DOD, 0.5P, 25±2°C
Rated Voltage	DC1331.2V	
Voltage Range	DC1164.8 ~ 1497.6V	Cell voltage 2.8V ~ 3.6V
Rated Charging Power	2500kW	
Rated Discharging Power	2500kW	
Energy Conversion Efficiency	≥94%	Excluding the auxiliary power consumption of the energy storage

Item	Specification	Remarks
		cabinet itself
Auxiliary Power Supply (Voltage Range)	AC400V, 50Hz	
Operating Temperature	-20 ~ 55°C	
Relative Humidity	0 ~ 95%RH	
Operating Altitude	Below 4000m	Derating above 2000m
Cooling Method	Active Liquid Cooling	50% ethylene glycol solution
Fire Protection Method	PACK & Cabin-Level Aerosol + Water Sprinkler	
IP Rating	IP55	
Corrosion Resistance Grade	C5-M	
Color	RAL 7035	
Dimensions	605824382896mm	WDH
Weight	Approx. 43t	
Communication Interface	Ethernet/RS485/CAN	

2.3. Primary Electrical Drawings of the Energy Storage System

The primary electrical design drawings of the 5015kWh liquid-cooled energy storage container

product mainly include two parts: DC busbar connection and AC power distribution.

2.3.1. Primary DC System Drawing

The DC output sides of the 12 battery clusters in the system are connected into a single main DC circuit through the busbar distribution cabinet, and the main circuit is equipped with one DC isolation switch, two DC fuses and one DC surge protection device.

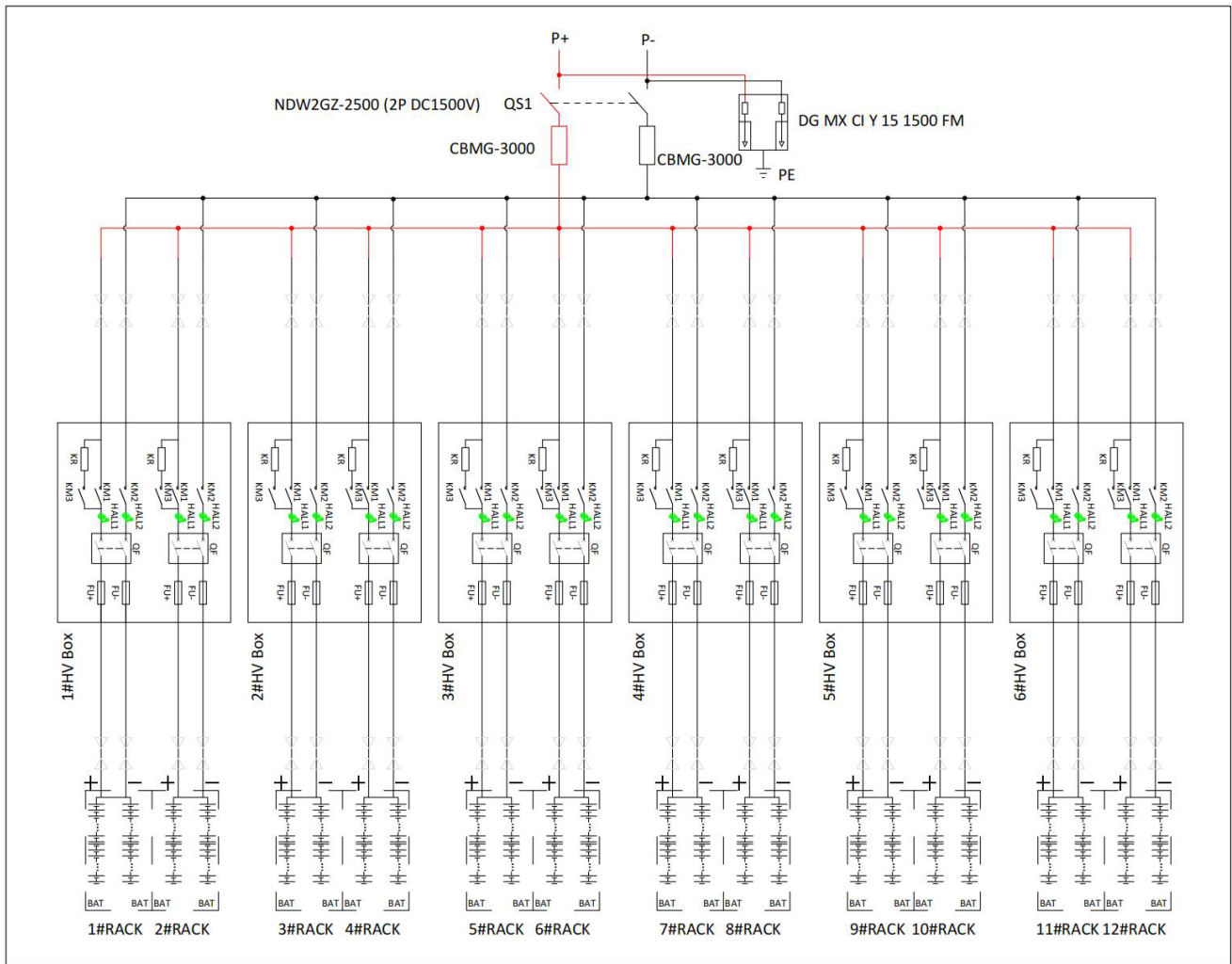


Figure 2-2 Schematic Diagram of DC Busbar Connection

2.3.2. Primary AC System Drawing

The auxiliary power supply in the system is divided into two parts: AC power supply and UPS

power supply.

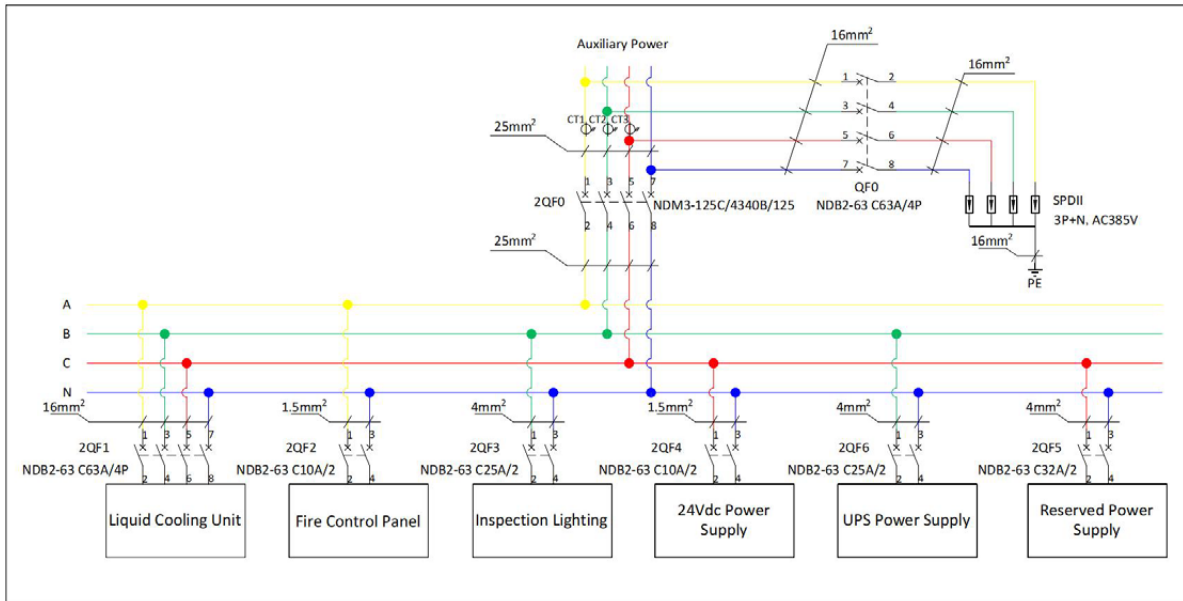


Figure 2-3 Schematic Diagram of AC Power Supply

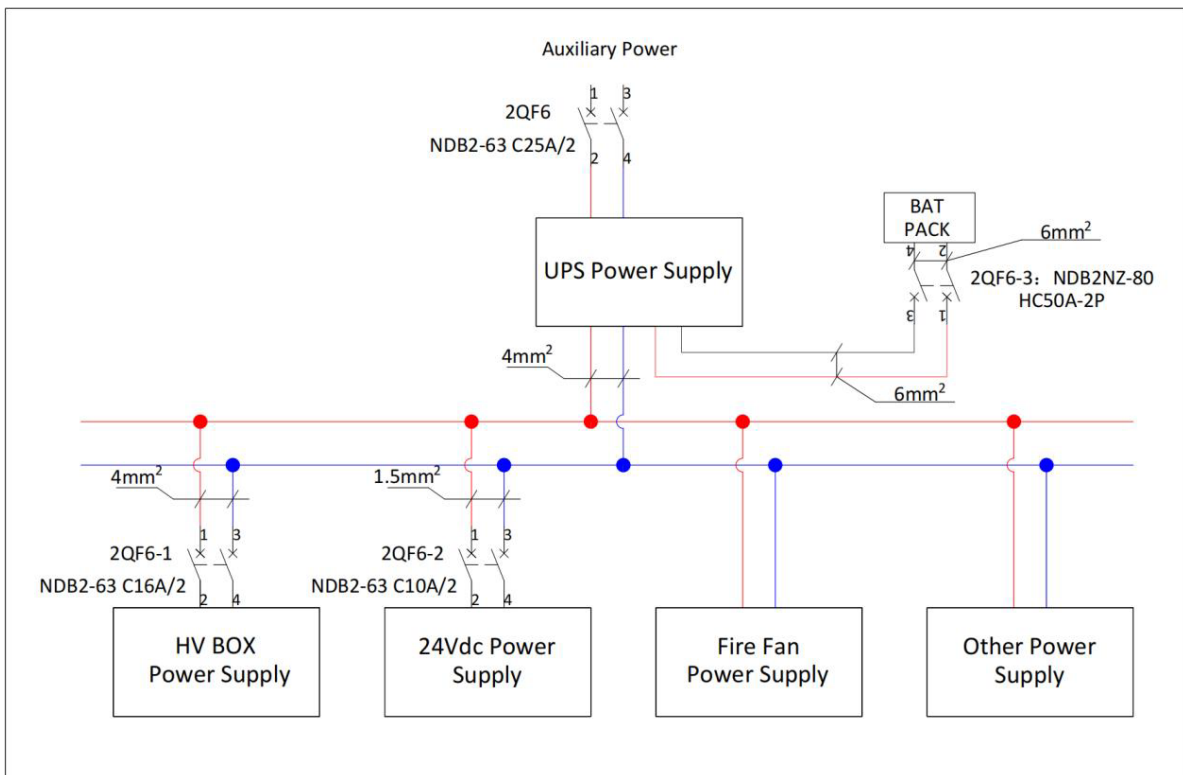


Figure 2-4 Schematic Diagram of UPS Power Supply

2.4. Exterior Design of the Energy Storage System

2.4.1. Container Design Scheme

The container structural design mainly includes the design of appearance, selection of steel structure, shell protection, container inlet and outlet lines, etc., with the specific designs as follows:

- Container overall dimensions: 20-foot standard high cube, 6058×2438×2896mm (20HQ)
- The container has good anti-corrosion, fireproof, waterproof, dustproof (sandproof), shockproof, anti-ultraviolet and anti-theft functions to ensure that the container will not fail due to corrosion, fireproof, waterproof, dustproof, ultraviolet and other factors
- The container has fireproof function: the container shell structure, thermal insulation materials, internal and external decoration materials all use flame-retardant materials
- The overall protection grade of the container is IP55; the parts where the container door panel is connected to the outside are protected by sealing strips to prevent dust or rainwater from entering the container during outdoor sand or rainfall weather. Ensure no water accumulation, water seepage or water leakage on the top of the box body, no rainwater entering the side of the box body, and no water seepage at the bottom of the box body
- The container has dustproof (sandproof) function: standard ventilation filters that can be easily replaced are installed at the air inlets and outlets of the container and the air inlets of the equipment, and can effectively prevent dust from entering the container in case of strong wind and sand weather
- The container adopts a shockproof design: ensure that the mechanical strength of the

container and its internal equipment meets the requirements under transportation and earthquake conditions, without deformation, functional abnormality, and non-operation after vibration

- The container has anti-ultraviolet function: ensure that the properties of the internal and external materials of the container will not deteriorate due to ultraviolet radiation, and will not absorb the heat of ultraviolet radiation

The appearance of this container is as follow figure shows:

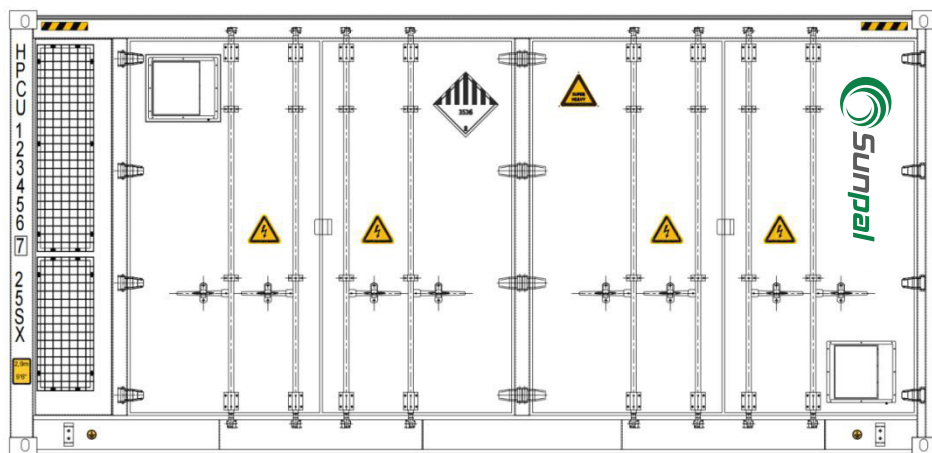


Figure 2-5 Front View

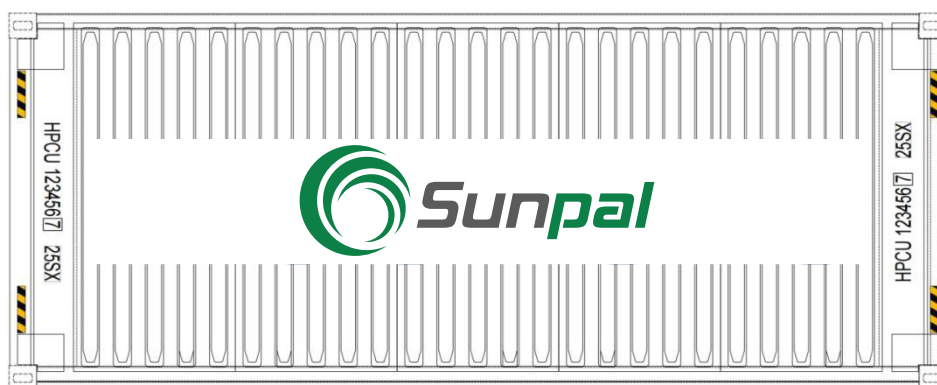


Figure 2-6 Top View

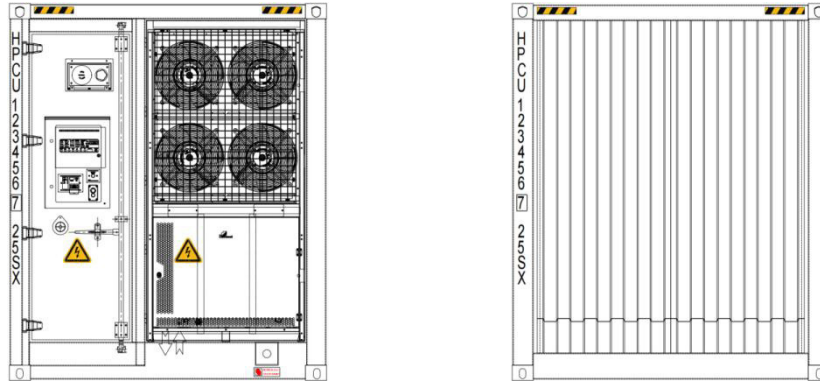


Figure 2-7 Side View

2.4.2. Ventilation Design Scheme

Adopt a layout mode of bottom air intake and top air exhaust, single intake and single exhaust, and double-side arrangement to avoid air flow short circuit and exhaust dead angles, ensure full replacement of gas in the cabin, and no accumulation of flammable gases.

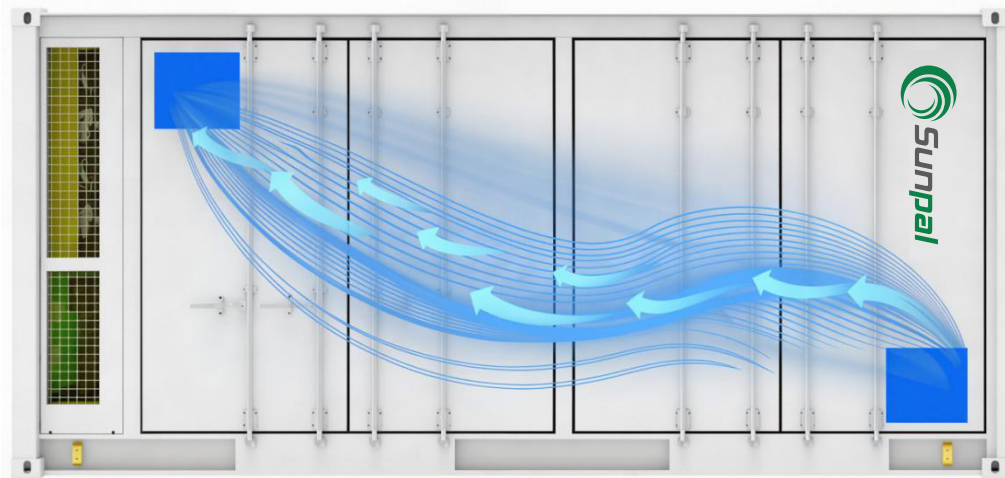


Figure 2-8 Air Duct Schematic

2.5. Internal Design of the Energy Storage System

2.5.1. Composition of Internal Equipment

The 5015kWh liquid-cooled energy storage container product is composed of 48 battery packs,

integrated and installed in one 20-foot container, including 12 battery clusters, 1 central control and distribution cabinet, 1 set of fire protection system, 1 set of liquid-cooled system, etc.

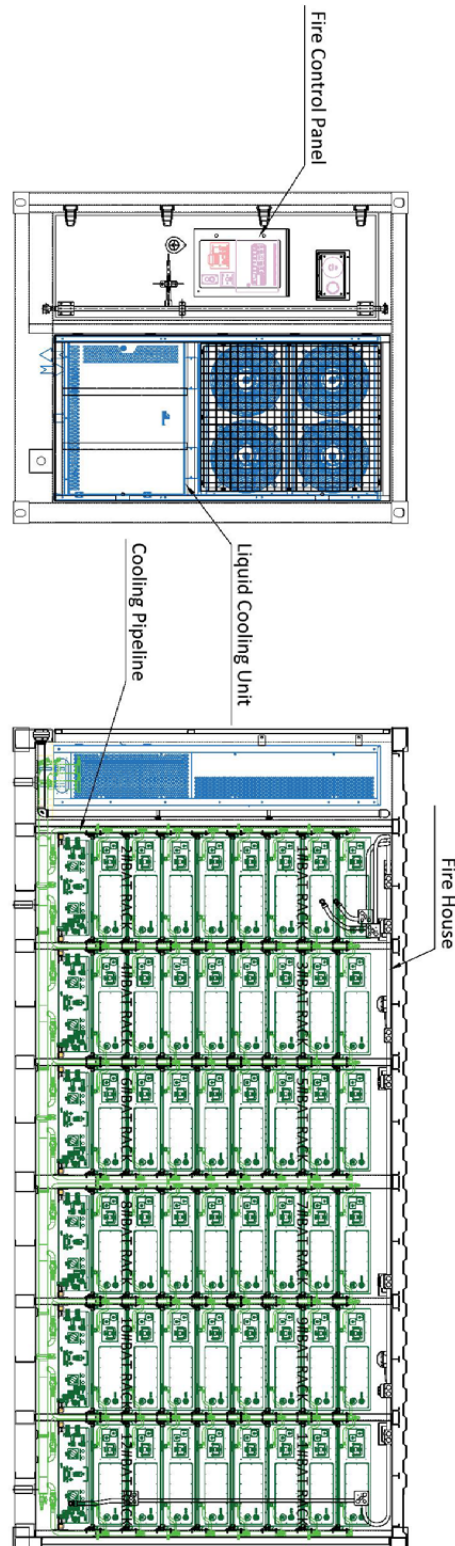


Figure 2-9 Internal Layout

The key component information is as follows:

Component	Quantity	Remarks
Battery Cells	4992	LFP 3.2V 314Ah
Battery PACKs	48	The series-parallel mode of a single battery PACK is 1P104S; in addition to cells, wire harnesses and structural parts, each battery PACK is also equipped with 1 slave control module ESBMM
High-Voltage Boxes	6	Mainly composed of master control module ESBCM, high and low voltage wire harnesses, connection terminals and structural parts
Central Control and Distribution Cabinet	1	Including key devices such as master control module ESCCU, EMS and backup power UPS, with main functions of DC busbar connection, auxiliary power distribution and local monitoring
Battery Management System	1	Including 48 slave control modules ESBMM, 12 master control modules ESBCM and 1 master control module ESCCU
Fire Protection System	1	Including 1 set of aerosol fire extinguishing system, 1 set of explosion-proof exhaust system and 1 set of emergency water fire protection system
Thermal Management System	1	Including 60kW liquid-cooled unit, three-level liquid-cooled pipeline, cooling liquid, etc.
Container Body	1	605824382896mm (WDH)

2.5.2. Battery Cells

This design scheme adopts the mainstream 314Ah Lithium Iron Phosphate (LFP) prismatic aluminum shell cells in the market. The parameter information of a single battery cell is as follows:



Figure 2-10 Battery

Item	Specification	Remarks
Nominal Capacity	314Ah	HiTHIUM/REPT*
Rated Voltage	DC3.2V	
Battery Energy	1004.8Wh	
Maximum Charging/Discharging Power	0.5P	
Operating Voltage Range	2.8V ~ 3.6V	
Charging Operating Temperature Range	0 ~ 55°C	
Discharging Operating Temperature Range	-20 ~ 55°C	
Storage Temperature	-30 ~ 60°C	

Item	Specification	Remarks
Weight	5.6±0.3kg	
Dimensions	174.7*207.11*71.70 mm	W*D*H

Note: The battery cell brand shall be subject to the actual shipment or the commercial contract.

2.5.3. Battery PACK

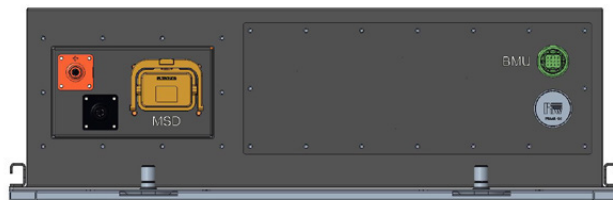


Figure 2-11 Battery Pack

According to the dimensions of the battery PACK and the selected cells, 104 cells are used for each battery PACK. Each battery PACK is composed of 4 battery modules, and each module contains 26 battery cells connected in series, i.e., 1P26S*. The battery PACK is 1P104S. The parameter information of the battery PACK is as follows:

Name	Parameter	Remarks
Nominal Energy	104.499kWh	
Rated Voltage	DC332.8V	
Voltage Range	DC291.2 ~ 374.4V	Cell voltage 2.8V ~ 3.6V
Number of Cells	104	
Cell Series-Parallel Mode	1 parallel, 104 series	

Name	Parameter	Remarks
Rated Charging Rate	0.5P	
Rated Discharging Rate	0.5P	
Product Dimensions	790*2180*249mm	W*D*H
Communication Interface	CAN	
Fire Protection Method	Aerosol	
IP Rating	IP65	
Weight	Approx. 690kg	

2.5.4. High-Voltage Box

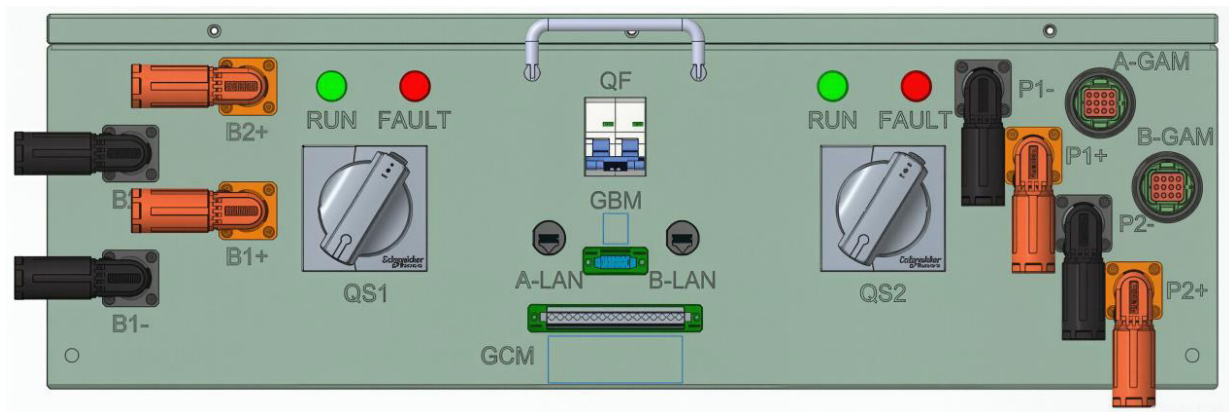


Figure 2-12 High-voltage Box

The high-voltage box is a high-voltage power circuit management unit specially designed for the energy storage system, and an intermediate unit connecting the battery cluster and the power conversion system (PCS). The high-voltage box has the functions of battery cluster voltage and current collection, battery cluster circuit contactor control and protection, summarizing the data

uploaded by the slave battery management unit ESBMM, and realizing information communication with the master battery management unit ESCCU. The high-voltage control box contains circuit breakers, contactors, fuses, circulation control circuits, current sensors, master battery management unit ESBCM, switching power supplies and other components. The high-voltage control box has fully considered the electrical characteristics, heat dissipation performance, safety performance and operability and maintainability of each component in the design, with a reasonable spatial layout and the characteristics of compact structure, flexible configuration, safety and reliability.

The high-voltage box adopts a highly integrated "two-in-one" design, supporting the simultaneous access of two battery clusters. The parameter information of the high-voltage box is as follows:

Item	Parameter	Remarks
Rated Operating Voltage	DC1331.2V	Meets DC1500V voltage class
Rated Operating Current	250A	
Power Supply Input	AC220V	
Dimensions	700×850×223mm	W*D*H
Operating Temperature	-20 ~ 55℃	
Operating Humidity	≤95%RH, no condensation	
Communication Interface	CAN, LAN	
IP Rating	IP20	

Item	Parameter	Remarks
Product Weight	95kg	

2.5.5. Central Control and Distribution Cabinet

The central control and distribution cabinet integrates DC busbar connection, auxiliary power distribution and local monitoring and data transmission through the master control module ESCCU and EMS, and is a key hub connecting the external PCS and ensuring the stable operation of the system.

The auxiliary power distribution system in the system is mainly divided into two parts: mains power supply and UPS power supply. The mains power supply is mainly used for power supply of conventional auxiliary equipment such as liquid-cooled units, maintenance sockets, lighting lamps, cooling fans and switching power supplies. The UPS power supply is mainly used as the backup power supply for switching power supplies, high-voltage boxes, fire protection air intake and exhaust systems and other equipment.

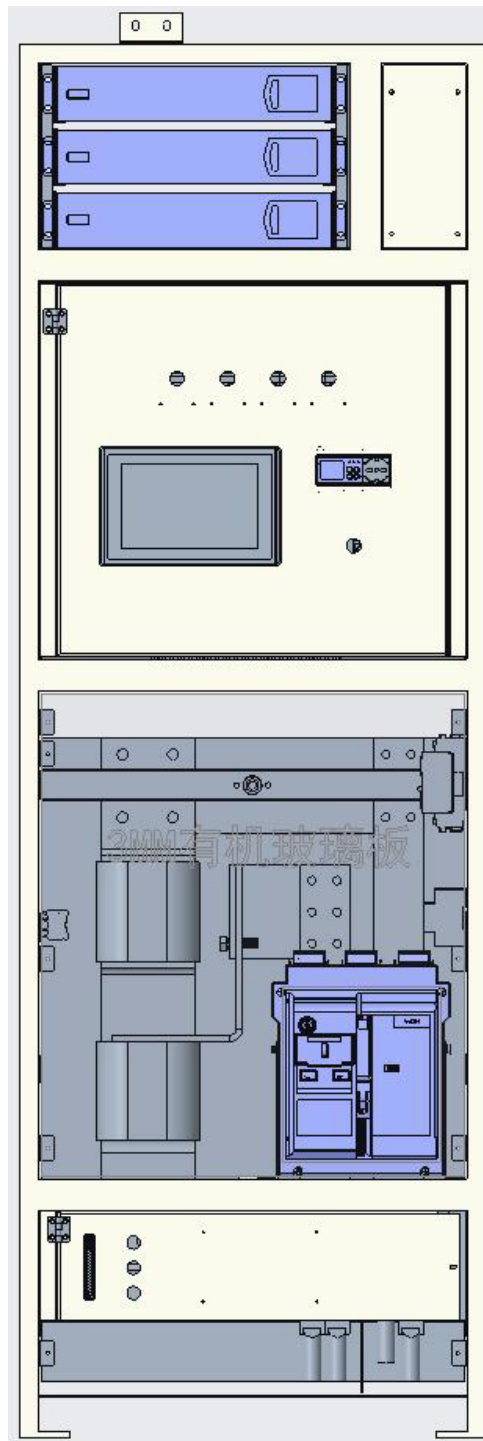


Figure 2-13 Central Control and Distribution Cabinet

Functions of the Central Control and Distribution Cabinet:

- Provide high-voltage DC busbar parallel connection for 12 418kWh battery clusters, and configure lightning protection devices

- Provide system emergency exit switches and functions for 12 battery clusters and the battery management system
- Provide CAN bus summary for 12 battery clusters, integrate into a set of battery management system, and convert the information of each battery cluster into Ethernet protocol through the master battery management unit ESCCU and send it to the EMS, and can independently complete the remote monitoring of the battery system
- Provide communication interface with external PCS
- The master battery management unit ESCCU in the central control and distribution cabinet has the function of network time synchronization

Wiring Design of the Central Control and Distribution Cabinet:

- The components in the central control and distribution cabinet are installed and wired neatly and reliably with a reasonable layout, and the insulation between electrical parts complies with relevant standards
- The DC circuit in the central control and distribution cabinet is reasonably and clearly distributed; the incoming and outgoing lines adopt well-known brand connection terminals with isolation protection between the terminals; the terminal block is reasonably designed for easy maintenance and commissioning
- A circuit breaker device is designed in the central control and distribution cabinet to ensure that the system can be disconnected step by step during maintenance
- DC positive and negative wires adopt different color codes
- High and low voltage and signal wires are separated into different trunking, and the

incoming and outgoing lines adopt the bottom-in and bottom-out lead and connection mode

- The secondary circuit wires of strong and weak electricity are laid separately, and only one wire is connected to each connection terminal. Current terminals and voltage terminals are clearly distinguished
- The component position numbers and component numbers in the cabinet are consistent with the drawings, and all operable parts are marked with their functions. The internal wiring is sleeved and numbered according to the wiring diagram, and all equipment installed on the panel is marked with plane identification marks

2.5.6. Battery Management System

The 5015kWh liquid-cooled container product includes 12 battery clusters (BAT RACKs). Each battery cluster (BAT RACK) is composed of 4 battery PACKs connected in series, and each battery is independently managed by 1 slave control module ESBMM, which is responsible for collecting and uploading all information in the battery PACK, including voltage information of 104 battery (cells), temperature information of 40 battery (cells) and temperature information of 16 pole columns. The slave control module ESBMM communicates with the upper master control module ESBCM through the standard CAN2.0 protocol.

Each battery cluster (BAT RACK) is configured with 1 master control module ESBCM. The 12 master control modules ESBCM are connected in a hand-in-hand mode through the CAN bus and summarized to one CAN communication to communicate with the upper master control

module ESCCU. The local information data is uniformly managed by the master control module ESCCU.

The master control module ESCCU adopts the standard Modbus TCP/RTU communication protocol, collects data from the liquid-cooled unit (TMS) and electric meter (Meter) in the liquid-cooled container through 485 communication, and exchanges data with the EMS industrial computer through LAN communication (Ethernet). The master control module ESCCU communicates with the external PCS through CAN, and is set with one passive DO dry contact signal.

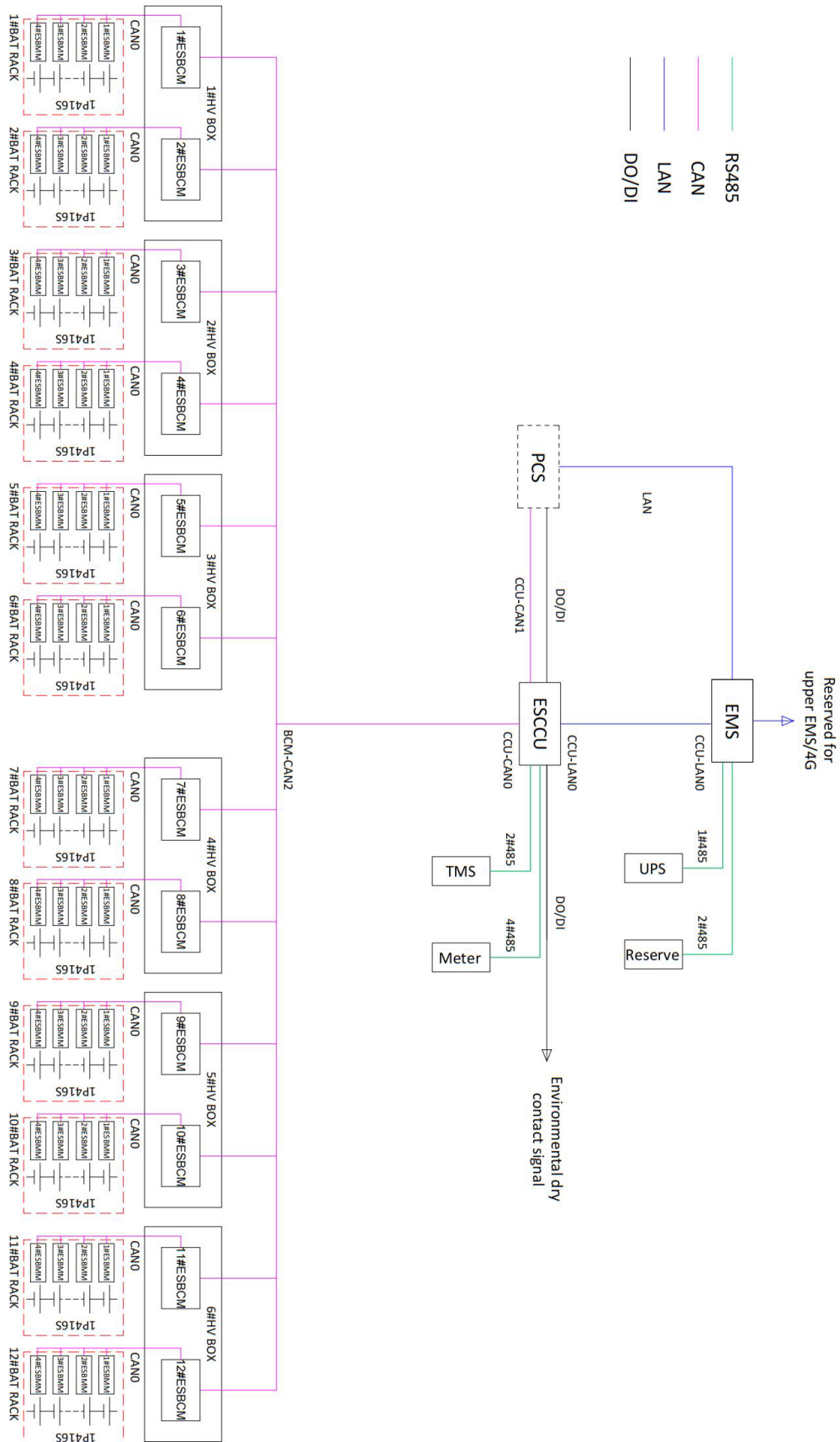


Figure 2-14 Communication Diagram

2.5.6.1 Slave Control Module - ESBMM

The ESBMM slave control module is a slave control module with integrated passive balancing function suitable for lithium battery management systems. The module provides real-time monitoring functions of single string battery (cell) voltage and temperature, and has thermal management and passive balancing capabilities at the same time. It can form a highly flexible battery management system with the master control module ESBCM through CAN communication.

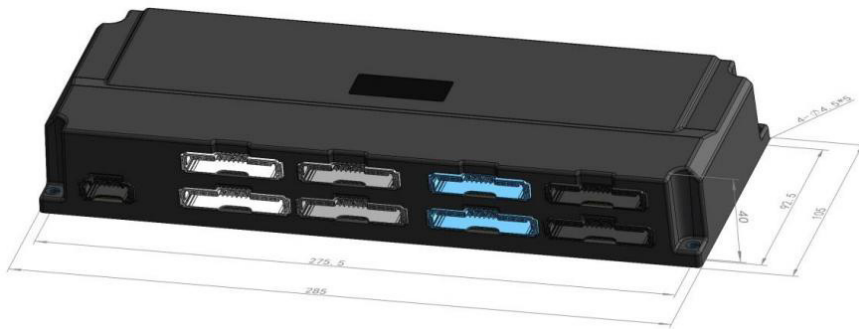


Figure 2-15 ESBMM

Function Description:

- Supports voltage monitoring of 112 series of battery cells
- Supports temperature monitoring of 112 channels of NTC (10K)
- Supports passive balancing, adopting energy consumption balancing technology, which can discharge and balance multiple single battery cells in the battery pack at the same time with a balancing current of 100mA, and the balancing energy of single battery cells can be measured
- Supports low-power acquisition mode, and the latent current in low-power mode can be

reduced to 50μA or lower

- Supports alarm functions such as power supply/cell voltage (overvoltage, undervoltage), temperature (overtemperature) and communication faults
- Supports balancing fault detection
- Supports detection function of disconnection of acquisition wire harnesses (voltage, temperature)
- Meets the application requirements of 1500V energy storage systems, complies with the functional safety and insulation voltage withstand requirements of standards such as UL 60950, IEC 60730-1:2013, GB/T 36276-2018 and IEC 62477-1:2012, and can be equipped with relevant certifications such as IEC 62619:2017 and UL 1973.

Technical Parameters:

Category	Item	Min	Typ	Max	Unit
Operating Environment	Operating Altitude	-	-	5000	m
	Relative Humidity	5	-	95	%
	Operating Temperature	-40	-	85	°C
	Storage Temperature	-40	-	85	°C
Operating Power Supply	Rated Voltage	9	24	32	Vdc
	Rated Power Consumption	-	-	0.8	W
Single String Battery (Cell) Voltage Acquisition	Acquisition Channel Number	64	-	112	Channel

	Acquisition Range	0	-	5	Vdc
	Acquisition Accuracy	-	±3	±5	mV
Single String Battery (Cell) Temperature Acquisition	Acquisition Channel Number	-	-	112	Channel
	Acquisition Range	-40	-	125	°C
	Acquisition Accuracy	-	±1	-	°C
Passive Balancing	Balancing Current	-	100	-	mA
DO	Channel Number	-	-	1	Channel
	Output Current	-	-	1	A
DI	Channel Number	-	-	2	Channel
	DIL	0	-	0.7	V
	DIH	9	-	32	Vdc
IO	Channel Number	-	-	2	Channel
	VIL	-	-	0.7	V
	VIH	3	-	5	V
CAN	Channel Number	-	-	1	Channel
	Communication Rate	125	500	1000	Kb/s

2.5.6.2 Master Control Module - ESBCM

The ESBCM master control module is a control and management module suitable for energy storage battery management systems. It is mainly responsible for battery cluster voltage and current collection, summarizing the voltage and temperature information of single cells within the cluster, calculating battery cluster states such as SOC/SOH, executing balance strategy judgment and battery fault diagnosis functions, and implementing local protection of battery clusters and relay control based on battery fault information. The ESBCM master control module is equipped with CAN communication interfaces to realize data communication with slave control modules ESBMM and the master control unit ESCCU. It has insulation collection function and state calculation functions such as single cell SOC/SOH, and is provided with redundant CAN communication interfaces, RS485 communication interfaces and Ethernet communication interfaces for communication with external devices.

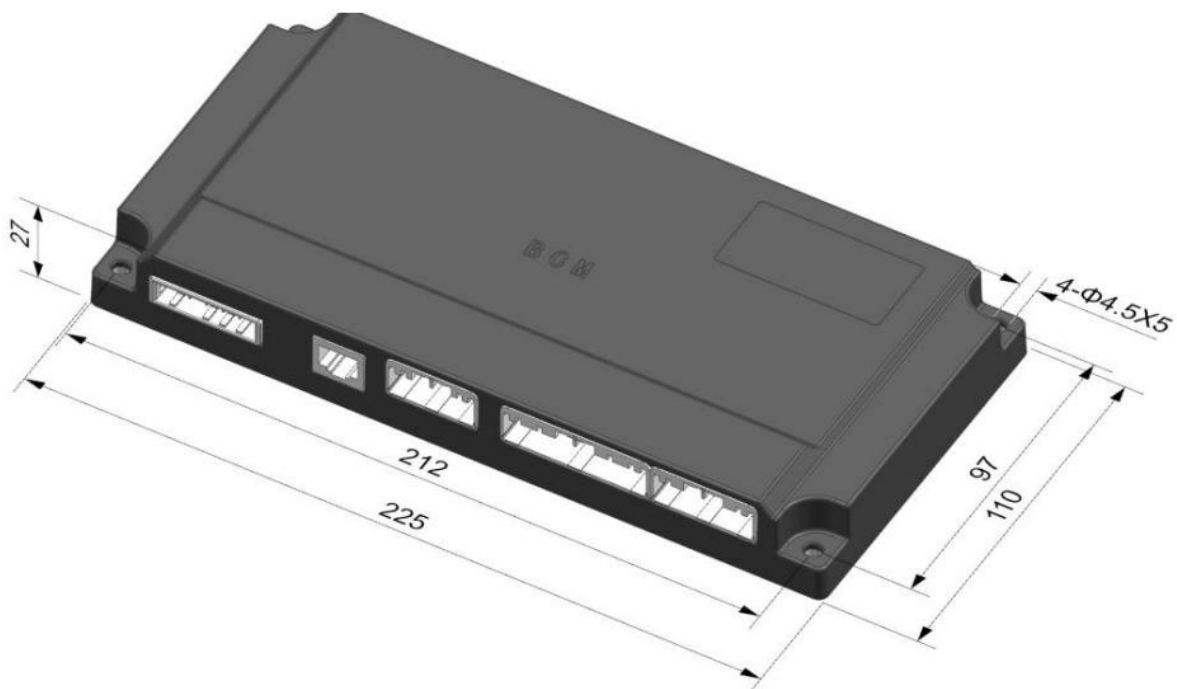


Figure 2-16 ESBCM

Functional Description

- Supports battery state data processing, summarizes real-time battery data information, and realizes the management and control of charging and discharging of battery packs/clusters after data processing.
- Supports pack terminal voltage detection, and realizes real-time detection of pack terminal voltage through isolated collection and processing of pack terminal voltage.
- Supports pack terminal current detection, and realizes real-time isolated current collection and processing via Hall sensors.
- Supports the insulation detection function of the battery system, which can be enabled or disabled according to system configuration requirements.
- Supports the estimation of SOC, SOH, SOE and SOP, and can realize the SOC and SOH estimation of single cells and battery packs.
- Supports fault detection function, including threshold alarm functions based on voltage, current, temperature, SOC, SOH, etc., and circuit cut-off protection function for extreme alarm thresholds.
- Supports system expansion functions, including multi-channel active and passive node output, relay control and management, and effective isolation of strong and weak electricity to meet diverse safety control requirements.
- Supports CAN, RS485 and Ethernet communication functions to realize information interaction.
- Meets the application requirements of 1500V energy storage systems, complies with the

functional safety and insulation withstanding voltage requirements of standards such as UL 60950, IEC 60730-1:2013, GB/T 36276-2018 and IEC 62477-1:2012, and can be equipped with relevant certifications such as IEC 62619:2017 and UL 1973.

Technical Parameters

Category	Item	Minimum	Typical	Maximum	Unit
Working Power Supply	Rated Voltage	9	24	32	Vdc
	Rated Power Consumption	-	-	3	W
5V Power Output	Rated Voltage	-	5	-	Vdc
	Output Current	-	-	300	mA
12V Power Output	Rated Voltage	-	12	-	Vdc
	Output Current	-	-	300	mA
Pack Terminal Voltage Collection	Collection Range	0	-	1500	Vdc
	Collection Accuracy	-	±0.1	±0.5	%FS
Pack Terminal Current Collection	Collection Range	0	-	±500	A
	Collection Accuracy	-	±0.1	±0.5	%

Temperature Collection	Number of Channels	-	-	4	Channel
	Collection Range	-40	-	125	°C
	Collection Accuracy	-	±1	-	°C
Insulation Resistance	Collection Range	0	-	10	MΩ
	Collection Accuracy	-	15	-	%
CAN	Number of Channels	-	-	1	Channel
	Communication Rate	125	500	1000	Kb/s
DO	Number of Channels	-	-	8	Channel
	Output Current	-	-	1	A
DI	Number of Channels	-	-	2	Channel
	DIL	0	-	0.7	V
	DIH	9	-	32	Vdc
CAN	Number of Channels	-	-	3	Channel
	Communication Rate	125	250	1000	Kb/s

LAN	Number of Channels	-	-	1	Channel
	Communication Rate	-	10/100	-	Mb/s
RS485	Number of Channels	-	-	1	Channel
	Communication Rate	1200	9600	115200	bps

2.5.6.3. Master Control Unit ESCCU

The ESCCU master control unit is the local monitoring and management unit of the liquid-cooled container energy storage system.



Figure 2-17 ESCCU

Functional Description

- Supports the access and control of auxiliary information such as BMS, PCS, fire protection system, air conditioner, dehumidifier, liquid-cooled unit, temperature and humidity sensor,

and IO interface.

- Supports the information collection and statistics of electric energy meter and UPS backup power supply.
- Supports the flexible configuration of communication addresses and communication point tables of auxiliary control equipment.
- Supports the fire protection strategy of the energy storage system and the fault diagnosis of energy storage system equipment.
- Supports protocols such as IEC 61850, Modbus TCP and MQTT.
- Has the function of saving and exporting real-time data, alarm information and event information.

Technical Parameters

Category	Item	Minimum	Typical	Maximum	Unit
Working Power Supply	Rated Voltage	9	24	32	Vdc
	Rated Power Consumption	-	-	10	W
CAN	Number of Channels	-	-	3	Channel
	Communication Rate	-	250	500	Kb/s
DO	Number of Channels	-	-	12	Channel

	Output Current	-	-	1	A
DI	Number of Channels	-	-	12	Channel
	DIL	0	-	0.7	V
	DIH	9	-	32	Vdc
CAN	Number of Channels	-	-	3	Channel
	Communication Rate	125	250	1000	Kb/s
LAN	Number of Channels	-	-	3	Channel
	Communication Rate	-	10/100	100/1000	Mb/s
RS485	Number of Channels	-	-	5	Channel
	Communication Rate	-	9600	19200	bps

2.5.7. Fire Protection System

The fire protection system of this product consists of one set of aerosol fire extinguishing system, one set of explosion-proof ventilation system and one set of emergency water fire protection system.

The aerosol fire extinguishing system is divided into two parts: PACK-level and cabin-level.

PACK-level:

Each battery PACK is equipped with a hot aerosol fire extinguishing device. The module adopts thermal wire detection inside; when the battery thermal runaway reaches a certain temperature, the thermal wire can detect the fire at the first time and activate the fire extinguishing device to achieve rapid fire extinguishing and prevent fire spread.

Cabin-level:

The cabin-level hot aerosol fire extinguishing system in the container uses point-type photoelectric smoke fire detectors and point-type heat fire detectors as fire detectors, and is equipped with fire sound and light alarms, manual release stations, emergency start/stop buttons, alarm bells, gas fire extinguishing controllers and cabin-level hot aerosol fire extinguishing devices to form an automatic fire protection system.

The explosion-proof ventilation system is composed of flammable gas detectors and air intake and exhaust components. When the battery cells in the prefabricated cabin experience thermal runaway and generate flammable gas, the flammable gas detector installed in the cabin will detect that the flammable gas concentration reaches the alarm threshold, and then immediately link the air intake and exhaust components for ventilation to prevent the flammable gas from reaching the explosive concentration and causing an explosion when exposed to external energy.

The emergency water fire protection system is set as a final resort to manually connect emergency water for fire extinguishing in case the automatic fire protection system fails to extinguish the fire effectively after a fire occurs in the electrochemical energy storage system. In

this scheme, the emergency water system is equipped with a water fire protection pipe network inside the cabin and an interface outside the cabin.

Working Principle of the Fire Protection System

When either the smoke detector or the heat detector in the protected area reaches the alarm threshold, a first-level fire alarm is triggered and a fire signal is output, and the alarm bell outside the protected area will be activated immediately to alert personnel to respond; when both the smoke detector and the heat detector reach the alarm threshold, or the manual release station is pressed after personnel discover smoke or open fire, a second-level fire alarm is triggered and a fire signal is output, the alarm bell and sound and light alarm outside the protected area are activated, and a 30s pre-release phase is entered. After a 30s delay, the gas fire extinguishing controller sends a signal to the fire extinguishing device, the fire extinguishing device is activated to extinguish the fire, and a feedback signal is given. During the 30s delay, if the emergency stop button is pressed, the delay will reset to 30s and the gas release will be suspended.

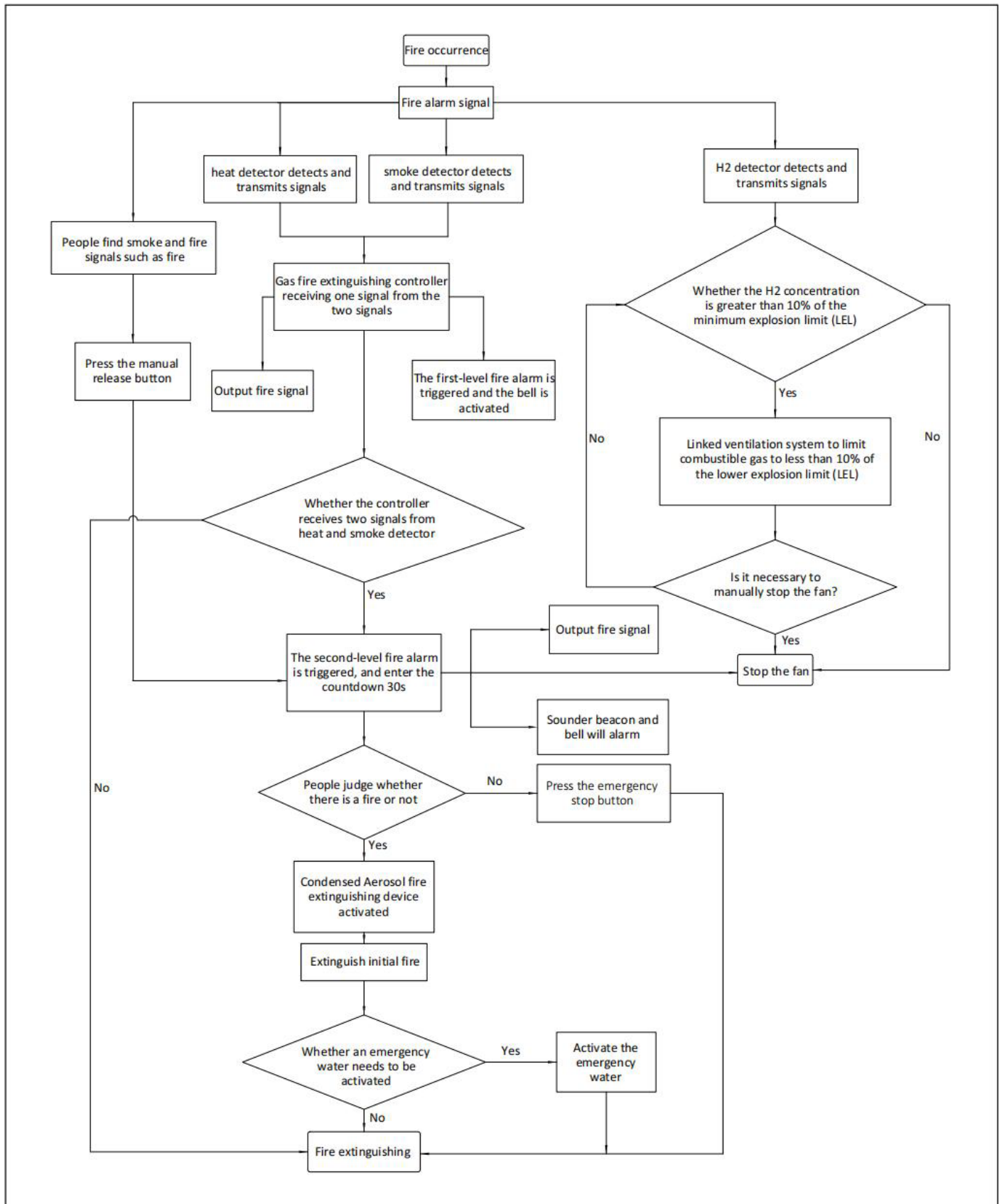


Figure 2-18 Logic Diagram of Fire Protection Diagram

Configuration of the Fire Protection System:

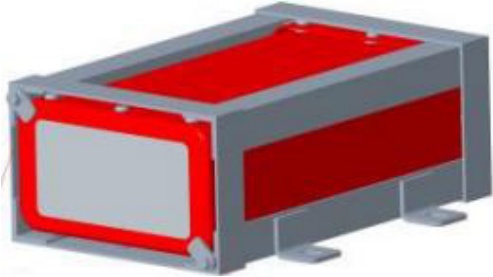
Name	Quantity	Model
Cabin-level hot aerosol fire extinguishing device	4 sets	QRR0.75G-U01
Gas fire extinguishing device	1 set	K11031M2
Smoke detector	2 sets	55000-316
Heat detector	2 sets	55000-121
Detector base	4 sets	45681-200APO
Fire sound and light alarm	1 set	958CHL1000
Alarm bell	1 set	CBE6-RS-024-EN
Emergency stop button	1 set	K91000M10
Manual release station	1 set	K91110M08
Controller battery	2 sets	SSP12-7
Air intake fan	1 set	CNBF-350A
Air exhaust fan	1 set	CNF-350A
Fan start/stop button box	1 set	CJ-B2J-A36-42
Flammable gas detector	2 sets	Xgard Bright-H2
Water fire protection system	1 set	-

Technical Parameters of the Fire Protection System:

Smoke Detector 55000-316	Item	Technical Parameter
	Working Voltage	9-33Vdc
	Quiescent Current	30-50 μ A/24Vdc
	Alarm Voltage	6-28Vdc
	Alarm Current	52mA/24Vdc
	Alarm Threshold	0.15dB/m obscuration
Temperature Detector 55000-121	Item	Technical Parameter
	Working Voltage	9-33Vdc
	Quiescent Current	55 μ A/24Vdc
	Alarm Voltage	6-28Vdc
	Alarm Current	52mA/24Vdc
	Working Temperature	AIR:-20-50°C

Fire Sound and Light Alarm 958CHL1000	Item	Technical Parameter
	Working Voltage	9-30Vdc
	IP Rating	IP45
	Working Temperature	-20-70°C
	Sound Decibel	-10dB/-20dB

Alarm Bell CBE6-RS-024-EN	Item	Technical Parameter
	IP Rating	IP33
	Working Temperature	-25-70°C
	Sound Decibel	96dB
Emergency Stop Button K91000M10	Item	Technical Parameter
	IP Rating	IP30
	Working Temperature	-5-40°C

Manual Release Station K91110M08	Item	Technical Parameter
	IP Rating	IP30
	Working Voltage	21-30Vdc
	Quiescent Current	33μA/24Vdc
Aerosol Fire Extinguishing Device QRR0.75G-U01	Item	Technical Parameter
	Start Mode	Electric start
	Feedback Signal	Passive switch signal
	Protection Space	12.5m ³
	Discharge Time	15.50±5s
	Service Life	15 years

Flammable Gas Detector Xgard Bright-H2	Item	Technical Parameter
	Working Voltage	12-30Vdc
	Contact Capacity	1A@30Vdc
	Sensor Type	H2
	IP Rating	IP66
	Service Life	3-5 years
Air Intake Fan CNBF-350A	Item	Technical Parameter
	Working Voltage	220Vac
	Starting Current	1.4A±10%
	Rated Power	120W±10%
	Corrosion Resistance Grade	C5VH

Air Exhaust Fan CNF-350A	Item	Technical Parameter
	Working Voltage	220Vac
	Starting Current	1.4A±10%
	Rated Power	120W±10%
	Corrosion Resistance Grade	C5VH

2.5.8. Thermal Management System

The thermal management system of the battery cabin adopts a liquid cooling system, which consists of a liquid-cooled unit, liquid supply and return pipelines, and battery liquid cooling plates (part of the battery PACK cabinet). Meanwhile, it adopts a multi-mode and refined thermal management control logic to ensure the system temperature and temperature difference, and improve the system consistency and service life.

The liquid-cooled unit and the battery cabin adopt a completely independent structural layout to improve system safety. This design adopts a vertical liquid-cooled unit with AC power supply, which is suitable for applications where the batteries inside the energy storage container generate large heat and the internal equipment is sensitive to ambient temperature. The liquid-cooled unit adopts an integrated structure, integrating upper computer communication, alarm and other functions, with high reliability, simple and convenient installation, and no

complex debugging required. The liquid-cooled unit is equipped with a variable frequency compressor and a variable frequency water pump to realize dual variable frequency regulation of the refrigeration system and the cooling liquid circulation system, achieving high energy efficiency during operation.

The liquid cooling pipeline adopts a three-level pipeline scheme; all pipelines are made of nylon hoses with thermal insulation, anti-condensation and exhaust functions. The internal flow channel of the battery liquid cooling plate is designed with a non-uniform flow channel through thermal flow simulation analysis under all working conditions to ensure uniform flow field distribution and no fluid dead zones. The system performs refined temperature zone control based on criteria such as temperature differences at all levels and intelligently switches operation modes to reduce auxiliary power consumption and improve system efficiency on the basis of ensuring the system temperature and temperature difference.

2.5.8.1 Liquid-Cooled Unit

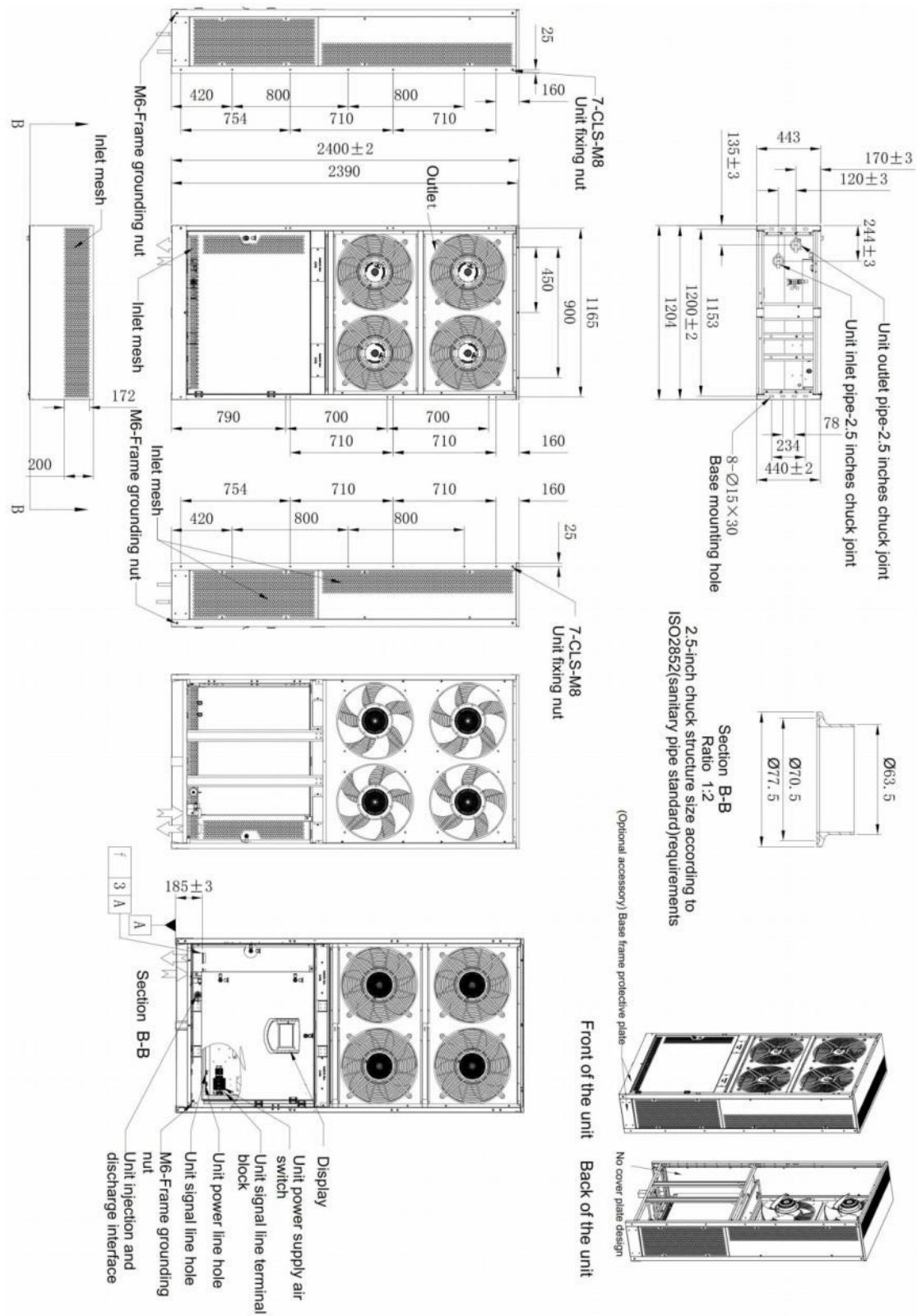


Figure 2-19 60kW Liquid-cooled Unit

The liquid-cooled unit is composed of a refrigeration cycle system and a cooling liquid circulation

system, with the working process as follows:

- 1) The compressor starts when the outlet liquid temperature reaches the refrigeration set point to compress the gaseous refrigerant. The control system of the air-cooled chiller adjusts the rotation speed of the compressor motor according to the outlet liquid temperature or the demand issued by the upper computer to control the overall power and outlet liquid temperature of the unit.
- 2) The condenser condenses the high-temperature gaseous refrigerant into liquid, and the heat is discharged to the surrounding air through the condenser surface by the fan.
- 3) The electronic expansion valve throttles and reduces the pressure of the condensed refrigerant and injects it into the plate heat exchanger, where the refrigerant evaporates and absorbs the heat of the cooling liquid.
- 4) The circulating water pump delivers the cooling liquid to the plate heat exchanger for heat exchange with the refrigerant, and then transports the cooled cooling liquid into the container to cool the battery pack.

Technical Parameters

Name	Parameter	Remarks
Working Voltage	415Vac, 50Hz	-
Refrigerating Capacity	60kW	@W18/L35
Refrigerant	R32	-
Coolant	50% ethylene glycol aqueous solution	-

Refrigeration Input Power	27.8kW	@W18/L35
Heating Capacity	24kW	$T_u=10^{\circ}\text{C}$
Heating Input Power	24kW	$T_u=10^{\circ}\text{C}$
Self-circulation Power	0.74kW	Water pump only in operation
IP Rating	IPX5	-
Corrosion Resistance Grade	C5-M	-
Dimensions	1200*440*2400mm	WDH

2.5.8.2 Liquid Cooling Pipeline

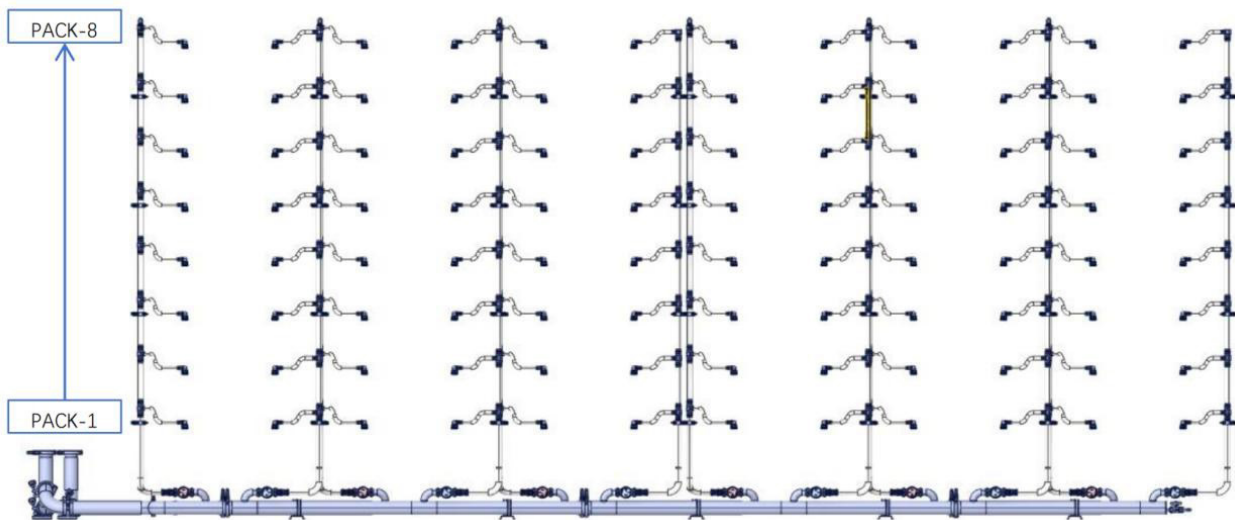


Figure 2-20 Liquid-cooled Pipeline

The liquid cooling pipeline adopts a right-in and left-out design, and is divided into three levels: the first-level pipeline is the main pipeline, the second-level pipeline is the cluster-level pipeline,

and the third-level pipeline is the PACK-level pipeline. All pipelines are made of PA12 nylon hoses, connected by quick-plug joints using crimping technology, and flexibly connected by corrugated pipes between pipelines. The connection between the third-level pipeline and the battery PACK adopts a two-way shut-off valve design to ensure no cooling liquid leakage when the battery PACK is disassembled for maintenance. The three-level pipeline system distributes the cooling liquid in the container through different pipe diameters to ensure the battery temperature in the entire container is balanced and the temperature difference between batteries is controlled.

The liquid cooling pipeline system has an automatic exhaust function to discharge air in the liquid cooling system in a timely manner, reducing the impact of gas on heat exchange and the stability of the cooling liquid. The liquid cooling pipeline system is equipped with easily replaceable filters to ensure the cleanliness of the cooling medium.

The external pipeline components of the liquid cooling system are required to be thermally insulated to prevent condensation.

2.5.8.3 Leakage Monitoring and Response

- **Reducing Leakage Risks**

- 1) Integrated design of the lower cabinet and the liquid cooling plate, with no joints or leakage points inside the battery PACK.
- 2) The first-level pipeline adopts nylon hoses that can effectively absorb assembly tolerances, and the sealing form is changed from stainless steel chuck to quick-plug form with lower leakage risk against vibration and impact.

- 3) The number of pipeline joints is minimized, and high-sealability pipe fittings and valves are adopted.
- 4) Pipeline joints, valves and other components are mainly arranged in the liquid-cooled unit cabin to reduce leakage risk points in the battery cabin.

- **Leakage Monitoring and Alarm**

- 1) A coupling criterion of pressure difference and liquid level is adopted to detect system leakage or blockage in advance. A flow meter can also be optionally equipped to further improve the sensitivity of leakage detection.
- 2) Alarms for liquid level changes and the number of automatic liquid replenishment times of the automatic liquid replenishment system are set to provide high early warning of system leakage.

- **Leakage Response Scheme**

- 1) After the system detects an abnormality, it estimates the leakage/blockage risk according to the leakage degree and stops the system operation in a timely manner to avoid the expansion of the abnormality.
- 2) Reliable leakage collection and discharge facilities are configured, which can not only reduce the spread of leaked cooling liquid, but also slow down the disorderly diffusion of flammable gases released by battery cell thermal runaway.

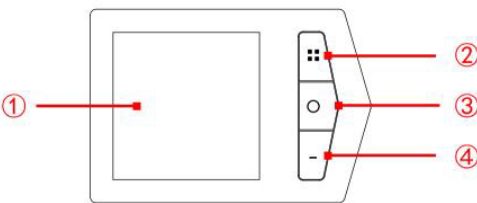
2.5.9. UPS

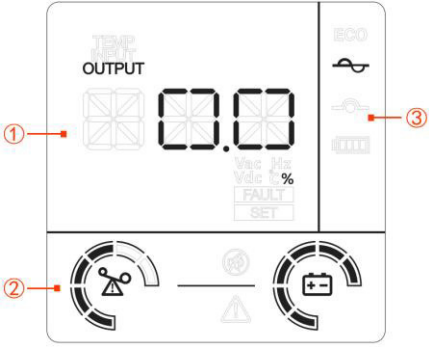
3.4.9.1 Basic Introduction to UPS

UPS (Uninterruptible Power Supply) is an uninterruptible power supply with an energy storage device, mainly used to provide uninterrupted power supply for some equipment with high requirements for power supply stability.

When the mains input is normal, the UPS stabilizes the mains voltage and supplies it to the load; at this time, the UPS acts as an AC voltage regulator and charges the internal battery at the same time. When the mains power is interrupted (accidental power failure), the UPS immediately converts the DC power of the battery into 220V AC power through the inverter and continues to supply it to the load, so that the load can maintain normal operation and the software and hardware of the load are protected from damage. UPS equipment can usually provide protection against overvoltage and undervoltage.

This product adopts KELONG YTR1103L-J, which can provide high-efficiency power protection.

Diagram	Description
	<p>① Displays UPS working status, remaining battery capacity, fault alarm, etc.</p> <p>② Short press to switch the display of output voltage, output frequency, input voltage, input frequency, battery voltage, internal temperature, output load percentage, fault information page, etc.; long press for 5s to enter the setting page, short press to select setting commands, long press to confirm command selection.</p> <p>③ In the on state, long press for 1s to shut down the</p>

	<p>unit.</p> <p>④ In the off state, long press for 1s to start the unit; in the on state and mains mode, long press for 3s to perform battery test; in battery mode, long press for 3s to mute the buzzer (cancel the mains abnormality alarm).</p>
	<p>① Displays UPS input, output, temperature, fault type, setting items, etc.</p> <p>② Displays load capacity, battery capacity, UPS fault indication, buzzer mute, etc.</p> <p>③ Displays UPS working status: mains inversion, bypass power supply, battery inversion, ECO.</p>

3. Emergency Fault Handling

3.1. Fire

- Evacuate personnel from the scene to a safe area, demarcate a safety isolation zone, and call emergency services based on the situation.
- Perform the following procedures under conditions that ensure personal safety
 1. If the wiring harness is smoking or on fire, use a carbon dioxide or dry powder fire extinguisher to put out the fire.
 2. If an energy storage battery catches fire, use a high-pressure water gun at a distance to extinguish it.
 3. In case of accidental inhalation of dense smoke, seek immediate medical attention and move to a safe location.
- Notify the manufacturer immediately to obtain further instructions

The warning content is as follows:

3.2. Flood

- Whether the system is powered on or not, evacuate personnel to a safe area and demarcate a safety isolation zone.
- Notify the system supplier to perform maintenance after the water recedes.
- The system shall not be started until the system manufacturer provides the system safety assessment result.

3.3. Battery Drop/Impact

- In the event of noticeable odors, damage, smoke, or fire, immediately evacuate personnel, report the incident to the authorities, and contact professional personnel. Under the condition of ensuring safety, the professionals shall use firefighting equipment to extinguish the fire and take other necessary measures.
- Operate under safe conditions when the appearance shows no obvious deformation or damage, and no noticeable odor, smoke, or fire occurs.

3.4. Fault Battery Recovery

- Please dispose of used batteries in accordance with local laws and regulations. Do not treat batteries as household waste. Improper disposal of batteries may cause environmental pollution or explosions.
- If the battery leaks or is damaged, contact technical support or a battery recycling company for disposal.
- When the battery is beyond its service life and unusable, contact a battery recycling company for disposal.
- Avoid exposing used batteries to high temperatures or direct sunlight.
- Avoid exposing used batteries to high humidity or corrosive environments.

- Faulty batteries must not be reused and should be promptly disposed of by contacting a battery recycling company to prevent environmental pollution.

3.5. Battery Recycling

- Before attempting to deactivate or log out of the system, contact our after-sales team. Our after-sales team can provide a list of qualified partners in your area to help ensure proper disposal of retired equipment.

4. Product Packaging, Transportation, and Storage

4.1. Product Packaging

By default, this product is delivered from the factory without external packaging.

4.2. Product Transportation

1) Transportation Condition

- The State of Charge (SOC) of the product at shipment shall be 30%–50%.
- Before shipment, all power circuit disconnecting devices shall be switched off, and the positive and negative power cables between battery packs (PACKs) as well as the power cables of the high-voltage box and control box shall be removed to ensure transportation safety.
- This containerized product is transported as a complete unit.

2) Transportation Requirements

- The transportation of the liquid-cooled energy storage container assembly shall comply with the requirements of UN 3536.
- Dedicated lifting points of the container assembly are located at the top and bottom corner fittings, and the lifting equipment shall have sufficient load capacity.
- During transportation, the container shall be protected against inversion, severe vibration, external impact, and compression.
- The container may be transported by truck, railway, or vessel.
- During transportation, the container vehicle speed shall not exceed 80 km/h on Class I and II highways, and 36 km/h on Class III roads. The container body and equipment shall not experience deformation affecting structural fit or functional damage.
- Spare parts and accessories shipped together with the container shall be properly packaged, clearly labeled with name and quantity, and meet sea transportation requirements.

4.3. Product Storage

The SOC of the 5015 kWh liquid-cooled energy storage container during storage shall be maintained between 30% and 50%.

If the customer expects the storage period to be longer than 1 month but not more than 3 months, a charge and discharge operation shall be performed in advance to adjust the SOC to

30%–50%.

If battery capacity loss or other damage occurs due to storage conditions not complying with the manufacturer's recommendations, Sunpal shall not bear any responsibility.

5. Warranty Statement

1). The warranty period of the product shall be determined according to the commercial contract.

During this period, if safety issues, performance degradation, abnormal attenuation, or other problems occur due to reasons not related to the manufacturer's design, manufacturing process, or quality control, Sunpal will only provide technical consultation support and paid replacement or repair services, and will not provide free repair or replacement services.

2). Without Sunpal's authorization, the liquid-cooled energy storage container and its accessories shall not be dismantled or modified. If the customer dismantles the product without authorization, Sunpal shall not assume any accident liability or warranty responsibility.

3). Sunpal shall not assume any responsibility for problems or accidents caused by unauthorized personnel operations or reasons unrelated to product defects, including but not limited to:

- Violations of laws, regulations, industry standards, technical agreements, safety

guidelines, or operating conditions described in this document.

- Abnormalities caused by personnel other than Sunpal during installation or operation.
- Problems caused by improper electrical equipment used together with this product.
- Issues resulting from operation beyond the battery performance limits.
- Direct electrical connection of this product with battery products of different types, models, or manufacturers.
- Unauthorized modification or alteration of the product without manufacturer approval.

6. Product Safety Guidelines

To prevent equipment damage or personal injury caused by improper use of the liquid-cooled energy storage container, please carefully read the product manual before use and strictly follow the instructions provided.

Sunpal shall not bear responsibility for any accidents or losses caused by non-professional operation or violation of the user manual.