



EnerX 0.5P 530Ah Container Product Specification

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1 General Introduction

1.1 Confidentiality

This product specification is intended only for persons directly involved in this project. Distribution to other parties, especially to partners, without the consent of CATL must be coordinated by the person in charge of this project at the CATL and is governed by the confidentiality statements in the development contract.

1.2 Purpose of Document

This document is a product specification formulated by Contemporary Amperex Technology Company Limited (CATL) for the Battery Energy Storage System developed by CATL. It describes and specifies the performance index, basic functions, interface and communication, key parameters, safety features of this product, as well as matters requiring user attention and relevant legal statements.

The specifications and parameters of the products are specified in this document. If the contracting parties find any inadequacies, they shall inform CATL so as to develop better products.

CATL possesses the right to update and clarify this document.

1.3 Definitions and Abbreviations

1.3.1 Definitions

BESS: Battery Energy Storage System that uses electrochemical cells to store electrical energy.

Frequency Modulation: The grid should operate at a stable frequency, while other uncontrolled events disturb the frequency. Therefore, active power must be supplied to modulate the frequency of the grid. The BESS provides the active power to the grid.

Voltage Modulation: The grid should operate at a stable voltage, while other uncontrolled events, especially the inductive load and capacitive load, will disturb the voltage. Hence, the reactive power should be supplied to modulate the voltage of the grid. The BESS provides the reactive power to the grid.

Peak Shaving and Valley Filling: When the power plants generate more energy than the demand, the containers must absorb the excess energy which called peak shaving. When the power plants generate less energy than the demand, the containers must release the lack of energy which is called Valley filling.

PV: Photovoltaic power generation.

Wind Power: Energy obtained from the rotation of the blade driven by the wind.

Modbus TCP: The Modbus protocol includes three types of messages: ASCII, RTU, TCP. Modbus TCP is a type of communication protocol that is widely used in the industrial field.

Container: The container for the battery energy storage system.

Module: A mechanically integrated arrangement of cells connected in series and/or parallel, complete with packaging, thermal management, output DC connections, and associated cell sensing.

Cell: The smallest indivisible component of the EnerX system, assembled into a battery module in series and/or parallel array.

RTE: Round-trip efficiency, defined as discharging of the system from 100% SOC to 0% SOC immediately followed by charging the system from 0% SOC to 100% SOC. The Round-trip DC-DC energy efficiency is measured at the DC terminals of the container.

1.3.2 Abbreviations

BMS: Battery Management System.

TMS: Thermal Management System.

CAN: Controller Area Network.

FSS: Fire Suppression System.

PCS: Power Conversion System.

BOL: Beginning of Life.

EOL: End of Life.

SOC: State of Charge.

SOH: State of Health.

CSC: Cell Supervision Circuit, the basic unit of battery management.

SBMU: Slave Battery Management Unit, collects and analyzes the data from the CSC and uploads it to the MBMU.

MBMU: Main Battery Management Unit. The central control unit of the container.

EMS: Energy Management System. Monitor and manage the charging and discharging of the BESS.

Sub Control Box: Including the SBMU, fuse, isolation switch and other components.

Master Control Box: Includes IMM, MBMU, ETH and Fiber Conversion Module.

Distribution Box: Includes auxiliary power supply, UPS, and other components.

2 System Description

2.1 Application

The EnerX container is a modular, fully integrated product consisting of rechargeable lithium-ion batteries with the characteristics of high energy density, long service life, high efficiency. It can provide stable energy release for over 2h when the batteries are fully charged. The EnerX energy storage product is capable of various on-grid applications, such as frequency regulation, voltage support, arbitrage, peak shaving and valley filling, and demand response; in addition, EnerX container can also be used in black start, backup energy, congestion management, microgrid or other off-grid scenarios.

2.2 Overview

Figures 1&2 provide an illustration of the container. The detailed information can be found in the following chapters.



Figure 1 EnerX Liquid Cooling Energy Storage Container – Profile View1



Figure 2 EnerX Liquid Cooling Energy Storage Container – Profile View2

The EnerX container consists of the following parts: batteries, BMS, FSS and TMS, which are integrated together to maintain the normal operation of the container.

2.2.1 Battery

The cell capacity is 530Ah, 1P104S cells integrated in one battery pack, 4 battery packs integrated in one rack, 8 racks integrated in one container. As the core of the ESS, the battery releases and stores energy.

2.2.2 BMS

BMS adopts the distributed scheme, through the three-level (CSC--SBMU--MBMU) architecture to control the BESS, to ensure the stable operation of the ESS. It can manage energy absorption and release, the thermal management system and low voltage power supply according to the detected information: battery voltage, current and temperature. It can monitor high voltage DC/AC security, diagnose and analyze faults according information from various detectors and dry-contacts. And it can keep communication with PCS and EMS through CAN. The BMS is the most important control unit of EnerX container. The BMS possesses the UPS to keep normal function when facing the temporary out of power.

2.2.3 FSS

FSS consists of smoke detectors, heat detectors, H2 detectors, CO detectors, the fire control panel, aerosol (optional), the dry pipe (optional), the smoke exhaust ventilation system, fiber optic networking card(optional) and the UPS. FSS undertakes functions: monitor the thermal run-away risks of container through the detectors, extinguish the thermal run away, especially the flame fire, control the loss to minimum. The control panel will control and record information for the fire suppression system. The FSS is independent with any other

system and it is the security guard of EnerX container.

2.2.4 TMS

TMS consists of one powerful chiller, the PTC heater and the liquid cooling pipe distributed in each battery module. The TMS will control and keep the temperature of battery within reasonable range. The battery will work at best state and reach longest life under the thermal management system.

2.3 Advantages

EnerX container possesses the following advantages:

- 1) **Standard design for transportation.** After removing the external cooling fan, the container size reaches 20 feet, which is very convenient for transportation.
- 2) **New generation cell.** EnerX container integrates the LFP 530Ah cells from CATL, with more capacity, longer service life and higher efficiency.
- 3) **High integration.** The cell to pack and modular design will increase significantly the energy density of the same area. The system is highly integrated, with an area energy density of over 361kWh/m² or 382kWh/m² (excluding the external chiller area) .

- 4) **Extreme safety.** The system supports three levels of safety:

Firstly, the cell safety, the highly stable lithium iron phosphate is used in the EnerX container. LFP is a kind of safety material especially for the BESS.

Secondly, the electrical safety: a) E-Stop design; b) multiple fuse protection design; c) insulation monitor voltage monitor; d) multi-channel isolation design; e) lightning protection design.

Thirdly, the fire protection design, CATL has four-level fire control strategy. The first-level is the alarm. The second-level is ventilation and smoke exhausting to prevent deflagration. The third-level is aerosol to extinguish initial fire, and the fourth-level is the dry pipe sprinkle fire protection to prevent fire spread.

- 5) **Adaptive thermal management.** EnerX integrated single-cluster water pump, temperature control strategy automatically adjusted with battery status, prolonging battery life.
- 6) **Easy extension.** It is very convenient for the augmentation of containers or racks. Furthermore, the EnerX support one PCS connected to 2 containers; this will decrease the covered area significantly.
- 7) **High reliability.** Independent UPS design enables one UPS to support the FSS monitoring system with a 24-hour capacity, while the other draws power from the battery rack to provide standby power for approximately 7.9 hours, which significantly improves system reliability.

3 System Specifications

In this chapter, the systems specifications will be introduced in detail. For the BESS, the system specifications included the power and energy, electrical specifications, the environmental specifications, the mechanical specifications and certification standards..

3.1 Power and Energy

Table 1 Power and Energy of EnerX

DC Side Data		
P-Rate	0.5P	Remark
Cell		
Cell Type	LFP	
Cell Capacity	530Ah	
Cell Voltage Range	2.5-3.65V	The voltage should not be less than 2.5 V in any case.
Cell Rated Energy	1696Wh	
System		
Configuration	8P4S(1P104S)	
Rated Energy	5644.28kWh	
Rated Voltage	1331.2VDC	
Voltage Range	1040 ~ 1500VDC	
Rated Charging Current	1060A×2	
Maximum Charging Current	1356.8A×2	For 1 minute
Rated Charging Power	1411.07kW×2	
Rated Discharging Current	1060A×2	
Maximum Discharging Current	1356.8A×2	For 1 minute
Rated Discharging Power	1411.07×2kW	

3.2 Electrical Specifications

For the auxiliary power supply, the standard configuration is 2 auxiliary power circuit. Auxiliary 1 and auxiliary 2 is listed in Table 2. The UPS for the BMS components is include in the auxiliary power circuit. The optional configuration is 1 auxiliary power circuit and the detailed configurations can be consulted to CATL.

Table 2 Electrical specifications of EnerX

Auxiliary Power & Communication			
P-Rate		0.5P	
Auxiliary Power 1	Voltage Range	3AC+N+PE 480V(380...480V) $\pm 10\%$, 50/60HZ	
	Power	Max. 35 kW	
	Inrush Current	73A	
Auxiliary Power 2	Voltage Range	1AC (L+N+PE) 230V or 2AC+PE(380...480V)	
	Power	Max. 0.5 kW	
	Inrush Current	5A	
UPS for BMS	Backup duration	optional 1: DC24V. 7h (Draw electricity from the battery rack) optional 2: DC24V. 50min. (Draw electricity from the UPS battery)	The UPS is only used to supply power to BMS components.
UPS for FSS	Backup duration	DC24V. 24h	excluding explosion-proof
Communication Protocol		CAN, Modbus/TCP	

3.3 Mechanical Specifications

Table 3 Mechanical Data of EnerX

Mechanical Data		
Product Model	C070201	Remark
Transportation	Land or sea transportation	-
Size	6058mm(W)*2438mm(D)*2896mm(H)	-
Weight	~45t	-
Color	RAL7042/6021/9003/7035 (Optional)	-
IP Level	IP55 (Battery Room)	-
	IP55 (Electrical Room)	-
	IP67 (Electrical Control Box of Chiller)	-

3.4 Environmental Specifications

Table 4 Environmental Specifications of EnerX

Environment Condition

Specifications	Range	Remark
Charge Temperature Range	-35°C...+55 °C	It is necessary to inform CATL for professional evaluation if temperature beyond range
Discharge Temperature Range	-35°C...+55 °C	
Storage Temperature Range	-35°C...+60°C	
Application Altitude	≤4000m (no derating)	
Relative Humidity	0 ~ 95 % (non-condensing)	
Degree of Anti-corrosion of Battery Unit	C5	
Seismic Level	IEEE 693-2018 moderate design level	

3.5 Certification Standard

Table 5 Certification Standard

Standards & Certificates		
Cell	UN38.3	UN Transportation Testing for Lithium Batteries
	UL1973	Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
	IEC62619	Safety requirements for secondary lithium cells and batteries, for use in industrial applications
	UL9540A	Energy Storage Systems and Equipment
Container	UL1973	Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications
	NFPA855	Standard for the Installation of Stationary Energy Storage Systems
	NFPA69	Standard on Explosion Prevention Systems
	UL9540A	Energy Storage Systems and Equipment
	IEC 62477-1	Safety requirements for power electronic converter systems and equipment –Part 1: General
	IEC 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial

		applications
	IEC 62933-5-2	Electrical energy storage (EES) systems – Part 5-2: Safety requirements for grid-integrated EES systems – Electrochemical-based systems
	IEC61000-6-2	Part6-2:Generic standards-Immunity standard for industrial environments
	IEC61000-6-4	Part6-4:Generic standards-Emission standard for industrial environments

4 Battery Management System (BMS)

4.1 BMS Overview

BMS is used in energy storage system, which can monitor the battery voltage, current, temperature, managing energy absorption and release, thermal management, low voltage power supply, high voltage security monitoring, fault diagnosis and management, external communication with EMS and ensure the stable operation of the energy storage system.

4.2 BMS Architecture

BMS includes three-level constructure, composed of 1 unit of MBMU, 2 unit of IMM, 1 unit of ETH, 1 unit of optical fiber, 8 units of SBMUs, 32 units of CSCs. This is the architecture that one PCS connected to one container (Figure 3).

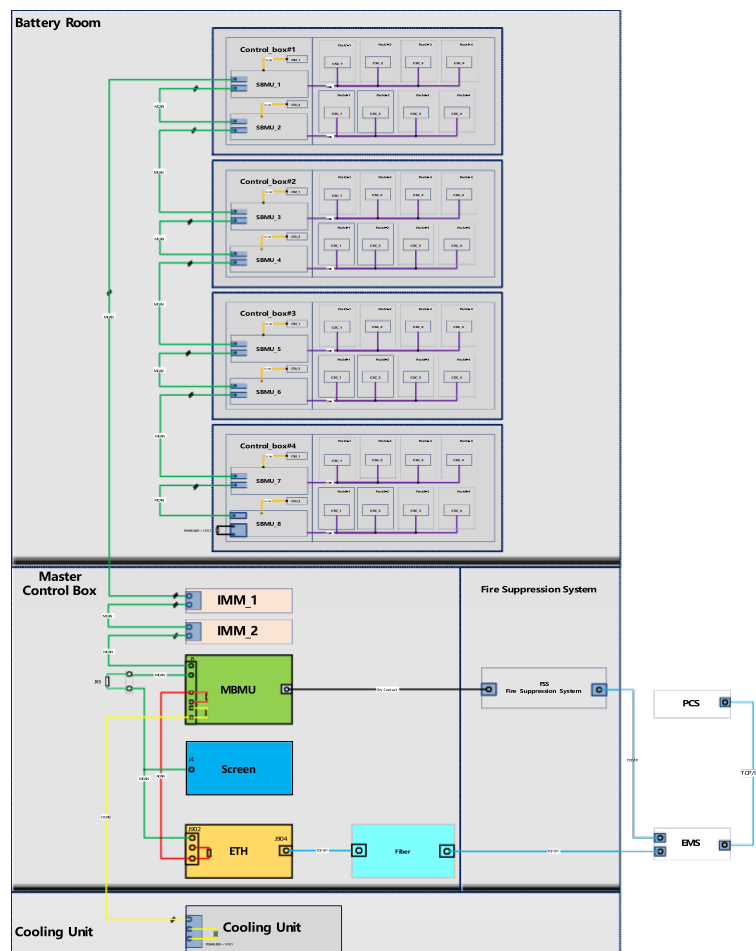


Figure 3 Three-Level BMS Architecture for One Container

4.3 BMS Function

The detailed information of BMS can be seen in Table 6. The parameters including: cell voltage sampling, cell temperature sampling, current sampling, HV sampling, ambient temperature detection, insulation detection and other important parameters.

Table 6 Detailed Performance Parameters of BMS

Item	Performance Parameters	Value	Note
Working voltage	Range	20V~26V	
Cell voltage sampling	Range	1V~4.85V	
	Accuracy	±5mV	0°C ~ +60°C
		±10mV	-40°C ~ 0°C or 60°C ~ 85°C
Cell temperature sampling	Range	-40°C ~ +125°C	
	Accuracy	±2°C	-20°C ~ +60°C
		±3°C	-40°C ~ -20°C & +60°C ~ +85°C
Current sampling	Range	±500A	
	Accuracy	<1%FSR	-40°C ~ 85°C
HV sampling	Range	0V ~ 1500V	
	Accuracy	1%FSR	
Cell balance	Current	100mA@3.2V	Opened in all channels
SOC	Accuracy	<±5%	LFP, according to specific conditions
SOH	Accuracy	<±5%	After calibration
Ambient temperature detection	Range	-40°C ~ +85°C	
	Accuracy	±3°C	
Insulation detection	Range	0 ~ 10MΩ	
	Accuracy	-30% ~ 0%	
	Detection Time	≤10s	Y capacitor<0.47μF (for single side)

4.3.1 Battery Status Monitoring

- 1) BMS monitors the battery's parameters, including cell voltage, module temperature, battery module current and total battery module voltage.
- 2) BMS detects the battery status such as State of Charge (SOC) accurate to within 5%, SOH and the SOP accurate to within 5%.

- 3) BMS functions as a safety management system in such cases as under voltage, over discharge, over voltage, over temperature, and over current of the battery. In case of failure, the system will give an alarm to the supervisory equipment, limit the charge and discharge current or power, and control the disconnection of all HV contactors. This can protect the battery while safeguarding the power systems security.
- 4) BMS shall provide battery information (including data recording and fault waveform recording) to EMS.

4.3.2 Charging/Discharging Management

- 1) BMS controls and monitors the high voltage main contactors, auxiliary relays and low voltage coils.
- 2) BMS has pre-charge control within the parallel connection among racks.
- 3) BMS works in the management of charge and discharge. It will calculate the charge and discharge power limit according to the existing status of the battery (temperature, SOC) and actual performance of electrical components and then report to EMS which has the function of controlling to these limits.
- 4) BMS has the function of balance management to extend the reliability of the battery system.

4.3.3 Thermal Management

- 1) BMS has the function of sample collecting of battery cell temperature and chiller operating status.
- 2) BMS controls the liquid cooling TMS system based on cell & coolant's temperature.

4.3.4 Program Refreshing

BMS can flash programs on site, which supports the flashing of MBMU, SBMU, IMM, CSC and ETH by using the host computer through MCAN. BMS has the function of remote software flash, which enables to update BMS from a remote client via Ethernet. Furthermore, the system supports the BMS program refreshing through EMS.

4.3.5 High Voltage Safety Monitoring

- 1) BMS has the function of system insulation detection.
- 2) BMS has the function of high voltage sampling (collecting data of the main positive voltage).

- 3) BMS supports the detection of the dry contact of fuse and combined switch, as well as the auxiliary contact of the primary loop contactor.

4.3.6 Peripheral Monitoring and Control Management

- 1) BMS has the function of ambient temperature sampling and humidity sampling, which matches according to project requirements.
- 2) BMS has multiple high-side drivers and can drive and control peripheral devices according to project requirements.
- 3) BMS has multiple dry contact interfaces and can monitor external signals according to project requirements.

4.3.7 Fault Diagnosis Management

- 1) BMS stores information such as operational parameters and historical alarms that can be viewed by ESS host computer.
- 2) BMS enables storage of latest historical alarms.

5 Fire Suppression System (FSS)

5.1 FSS Overview

As an outdoor non-walk-in battery energy storage system, EnerX provides a perfect set of fire suppression system solutions with detection, explosion control and fire extinguishing functions. The fire extinguishing control strategy is divided into four levels:

- First level, alarm warning;
- Second level, ventilation and smoke exhaust to prevent deflagration;
- Third level, aerosol is released to extinguish the initial fire;
- Fourth level, dry pipe spraying to control the spread of fire.

5.2 FSS Function

The fire suppression system is divided into three parts: detection system, explosion-proof system and fire extinguishing system. The information of the interactive interface is shown in the following Figure 4.

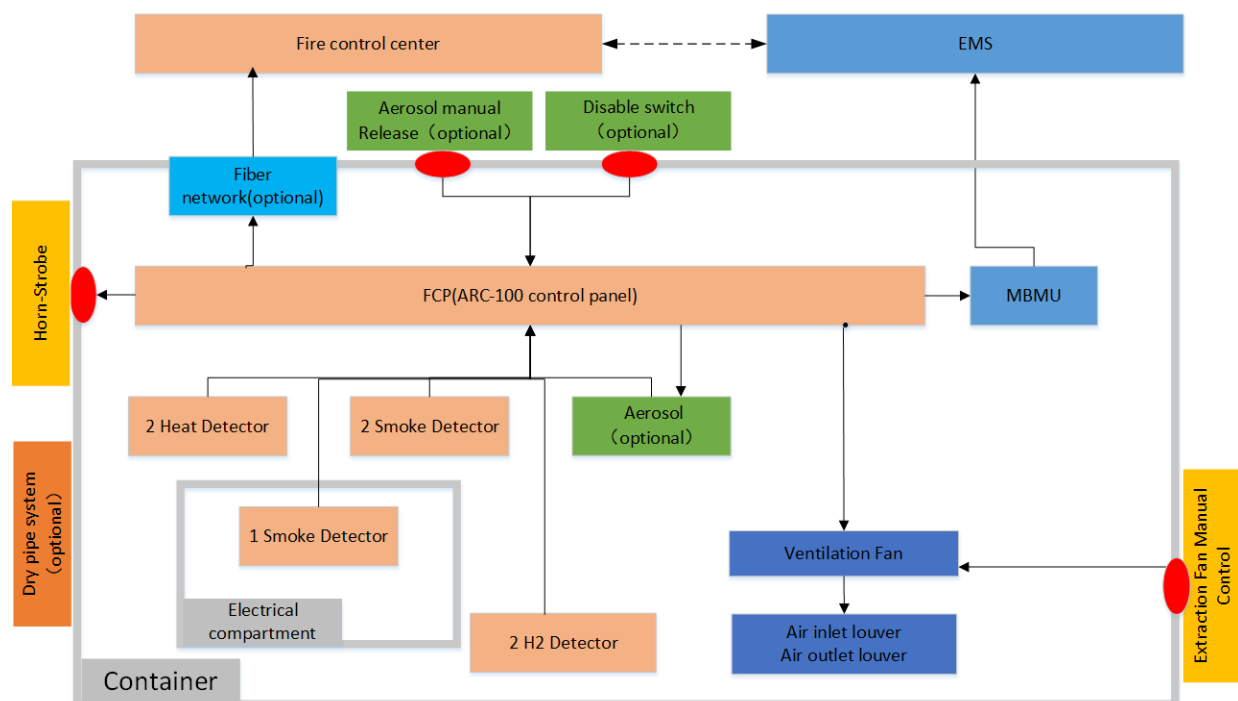


Figure 4 The Interactive Interface of FSS

5.2.1 Detection System

The detection system has three types of detectors, the number and installation position of which are shown in Table 7 and Figure 5. All detection signals are received and processed by the fire control panel, and the hydrogen(H₂) detector can be linked with the smoke exhaust ventilation system system.

Table 7 Detector Type and Position Description

No	type	quantity	Configuration	remarks
1	Heat detector	2	Standard	Detection of temperature, in the battery room
2	Smoke detector	3	Standard	Detection of smoke particles, two in the battery room, and one in the electrical room
3	H ₂ detector	2	Standard	Detection of H ₂ , in the battery room
4	Fire control panel	1	Standard	Receive detector signals and control fire extinguishing system and explosion-proof system, in the electrical room
5	Aerosol (optional)	12	Optional	When activated, aerosol power will be released rapidly to extinguish thermal runaway
6	Dry pipe system (optional)	1	Optional	When activated, dry pipe spraying to control the spread of fire.
7	Fiber network (optional)	1	Optional	Communication between fire control panle and between two network cards and eventually to the terminal host AFC-1000, in the electrical room

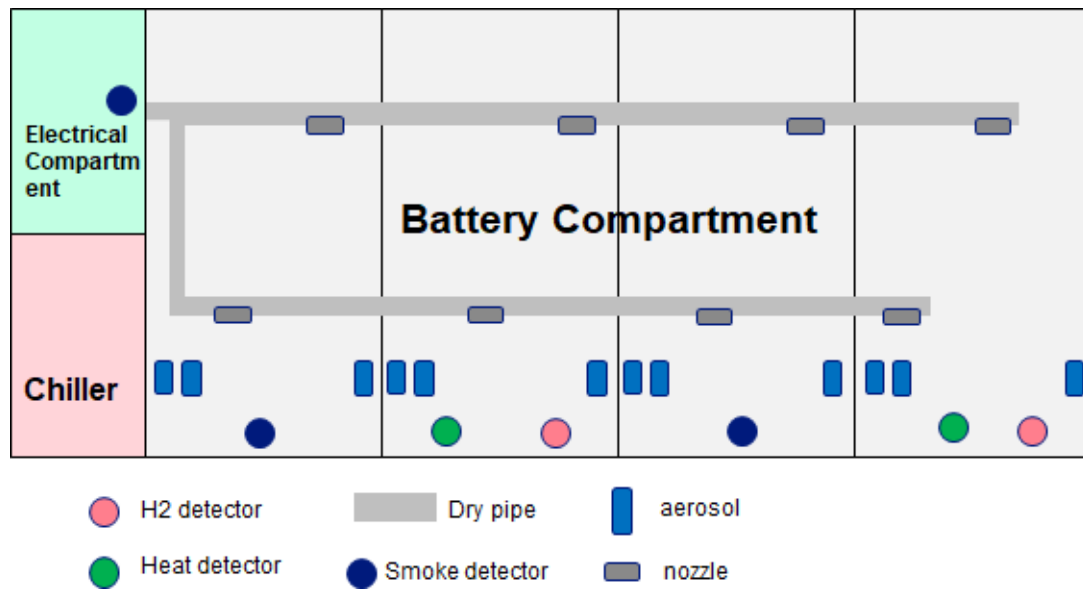


Figure 5 Type and Location of Detectors

5.2.2 Smoke exhaust ventilation System

Smoke exhaust ventilation system meets NFPA855 (NFPA 69) standard, which is shown in Figure 6.

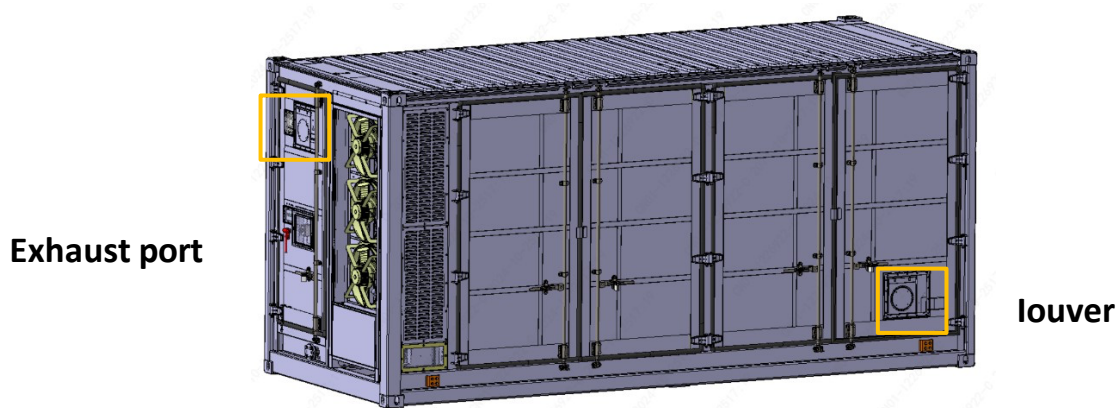


Figure 6 Smoke exhaust ventilation system

The air inlet electric louver receives the alarm signal sent by the H2 detector and opens the electric louver. The parameters of the Inlet are shown in Table 8.

Table 8 The Parameters of the the Inlet and outlet louver

Item	Specification
Supply voltage	24V DC
Rated power	60W

Position	Integrate in racks
-----------------	---------------------------

The air outlet electric louver will turn on the smoke exhaust ventilation system and releases the combustible gas in the battery room after receiving the alarm signal from the H2 detector. The smoke exhaust ventilation fan will not automatically turn off even if the concentration of combustible gas falls within the reasonable threshold. Professional fire personnel need to determine whether the thermal runaway is over and reset on the fire control panel to stop the fan.

The parameters of the exhaust port are shown in Table 9.

Table 9 The Parameters of the Exhaust Port

Item	Specification
Supply voltage	230V AC
Rated power	135W
Position	Integrate in racks
Maximum air volume	820CFM

5.2.3 Fire Extinguishing System

5.2.3.1 Aerosol

When an initial fire occurs in the battery room, a fire alarm signal will occur, and the fire extinguishing system will automatically control the release of aerosol, which can also be triggered manually. The fixed position of aerosol is shown in Figure 5.

5.2.3.2 Dry pipe

As the last line of defense, the dry pipe system can effectively control the spread of fire, which is shown in Figure 7.

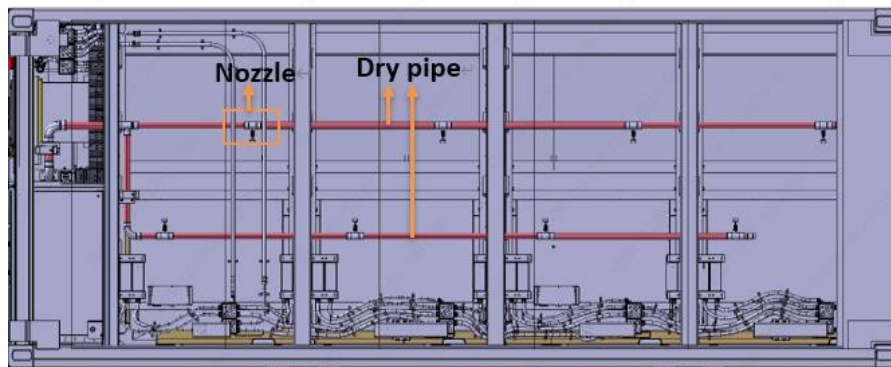


Figure 7 Dry Pipe System

The flange is installed at the entrance of the dry pipe fire protection system, for the connection between the pipes.

Table 10 The Paraments of The Flange

Item	Specification
Model	NPS 2'
Standard	ASME B16.5
Material	ASTM A105
Class	Class 150
Flange type	Threaded
Certificate	Integrate in racks

The V2709 Standard Horizontal Sidewall Nozzles are open type nozzles with rubber plug, designed for directional spray application in fixed fire protection system.

Table 11 The Parameters of the Nozzle

Item	Specification
Model	V2709
Type	Standard Horizontal Sidewall
Maximum working pressure	250 psi/1725 kPa
End connection	½ NPT

6 Thermal Management System (TMS)

6.1 TMS Overview

The TMS system of EnerX is liquid cooling, which main function is to maintain the temperature of the battery system to an allowable operating temperature range. Thus, the battery shall work at the best conditions, adsorb and release the maximum energy, slow degradation the SOH and maintain the longest life.

The Thermal management system is composed with the high-efficiency liquid cooling unit, the liquid cooling pipe under the bottom of battery and the PTC heater. The TMS works under the control of BMS. BMS sends the start up or shut down signals to the cooling unit, then the cooling unit and the PTC heater will work together to change the temperature of circulating coolant liquid for heat exchange in the cooling pipe. The

circulating liquid will exchange the heat with the battery through the pipe. Thus, the temperature of battery will increase or decrease into appropriate range.

For example, the cooling unit will be started if the BMS detect the battery temperature over the setting value. The cooling mode will be activated to decrease the temperature of circulating liquid until reaching the setting value. When the BMS detects the battery temperature less than the setting value, the heat mode will be activated to increase the temperature of circulating liquid until the setting value. Detailed information will be described below.

6.2 TMS architecture

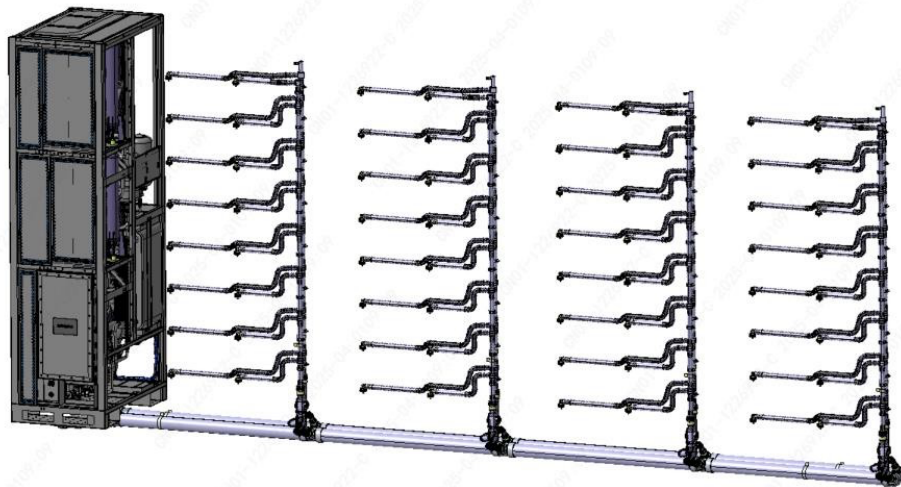


Figure 8 Overview of the cooling unit

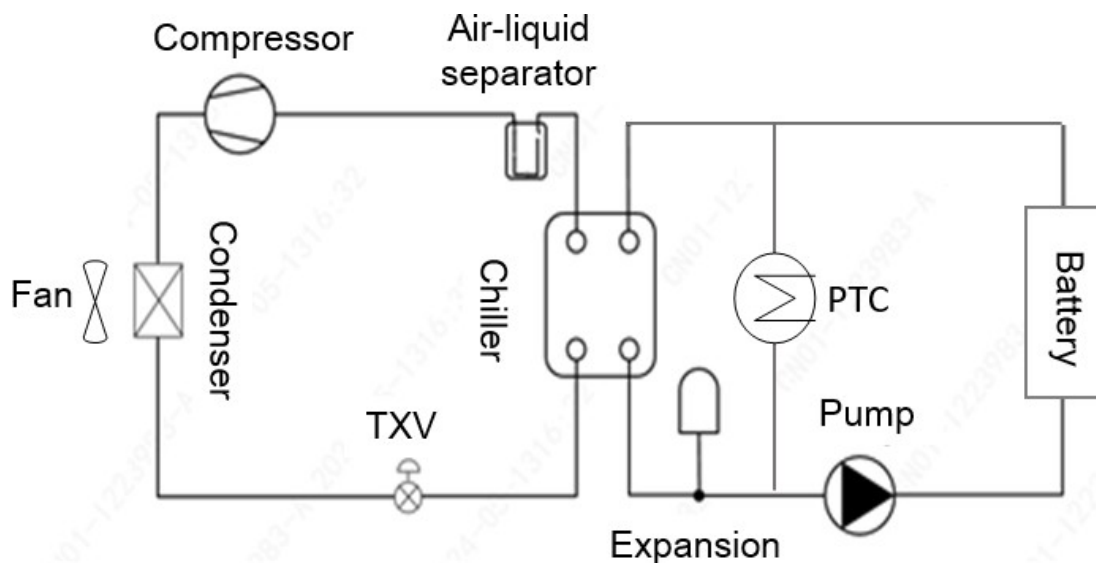


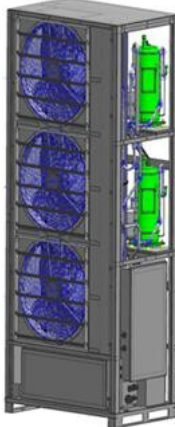
Figure 9 Architecture of Thermal Management System

The overview of cooling unit has been listed in Figure 8. EnerX own one high power cooling unit at the side of the container. TMS architecture can be described above (Figure 9). The composites parts are listed below:

- a) Compressor. The function of compressor is to compress the low temperature and low pressure refrigerant gas into high temperature and high pressure refrigerant gas. Then the gas flow to the condenser through the pipe.
- b) Condenser. The function of condenser is condensing the high temperature and high pressure refrigerant gas into ambient temperature and high pressure refrigerant liquid. Excess liquefaction heat will be taken away by the fan. Then the liquid flow to the chiller through the pipe.
- c) Chiller. The function of chiller is to exchange the heat from the refrigerant liquid with the coolant. The ambient temperature and high pressure refrigerant liquid will evaporate into low temperature and low pressure refrigerant gas. The heat will transfer from the coolant to the refrigerant liquid. The low temperature coolant will flow to the cooling plate to cool the batteries while the refrigerant gas return to the compressor. The circle process will continue and the heat of battery will be taken away.
- d) PTC Heater. The positive temperature co-efficiency resistance. The PTC will heat the coolant when the TMS get signals that the temperature of coolant is below the setting value. Then the coolant will be heated until the temperature increases to the setting value. The battery will be warmed up by the coolant.
- e) Pump. The pump will force the coolant into circulating in the pipe.

6.3 TMS Specification

Table 12 Main Feature of Thermal Management System

	Coolant: 50%Ethylene glycol,50% Deionized water
	Max. ambient temperature: 55°C
	Power supply: 3AC 380...480V
	70kW cooling capacity for 0.5P system
	Cooling capacity is auto-adjustable according to ambient temperature & discharge/charge status

The main features of TMS are listed above, which is shown in Table 12. The TMS will work under the ambient temperature range from -35°C to 55°C. The cooling power is auto-adjustable according to ambient temperature & discharge/charge status. There are four operating modes for the TMS, including shutdown mode, cooling mode, heating mode and self-circulation mode.

Table 13 Power Consumption of Thermal Management System

Type of EnerX	0.5P System
Cooling Capacity	70kW
Heating Capacity	16 kW
Maximum Heating Power	22.4kW
Maximum Cooling Power	36.4kW
EER	≥ 2.8 (18°C TMS liquid , @35°C ambient)

7 User Interface

7.1 PCS Requirements

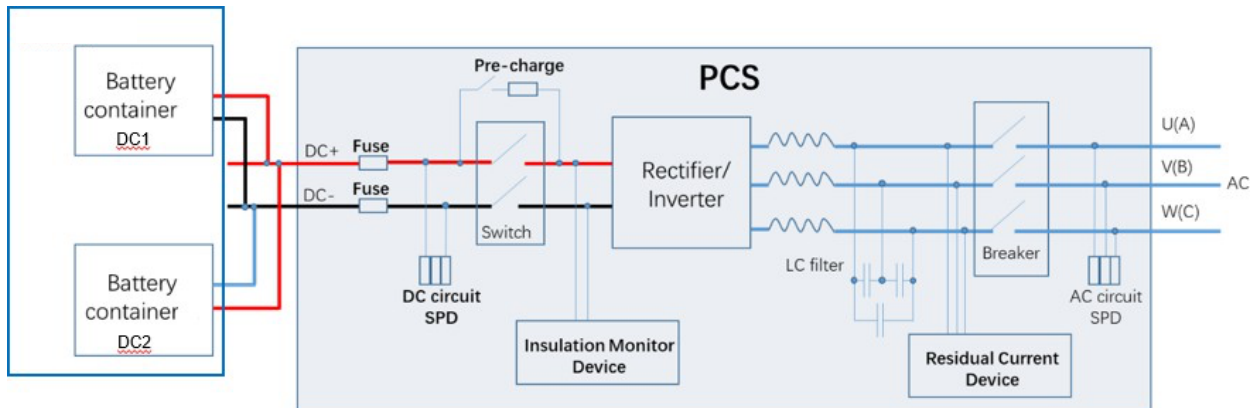


Figure 10 PCS Matching

- If DC1 and DC2 are connected to different PCS, please ensure that the two PCS run synchronously
- Please make sure to use one single copper Busbar for two parallel battery containers cable connection for positive or negative pole in PCS side.
- Please make sure to use Fuse(F) for DC circuit in PCS. The Fuse breaking time in PCS should less than the breaking time of fuse in battery container when short circuit occurs.
- Please make sure PCS have pre-charge circuit.
- Please make sure the PCS has a main circuit switch on the DC side.
- One PCS can match up to 2 battery containers.
- PCS should have SPD in DC high voltage bus.
- PCS should have SPD in AC side.
- PCS should have insulation monitor device. BMS monitor the insulation of DC bus before battery DC relay is closed. PCS monitor the insulation of DC bus after battery DC relay is closed.
- PCS should have residual current device to monitor the leakage current on AC side.
- When the battery is in a low SOC state after discharge, the grid cannot charge the battery in time and needs short-term storage. In this scenario, it is necessary to ensure that PCS is disconnected from the battery to prevent the battery from being over discharged.

7.2 Fuse Matching

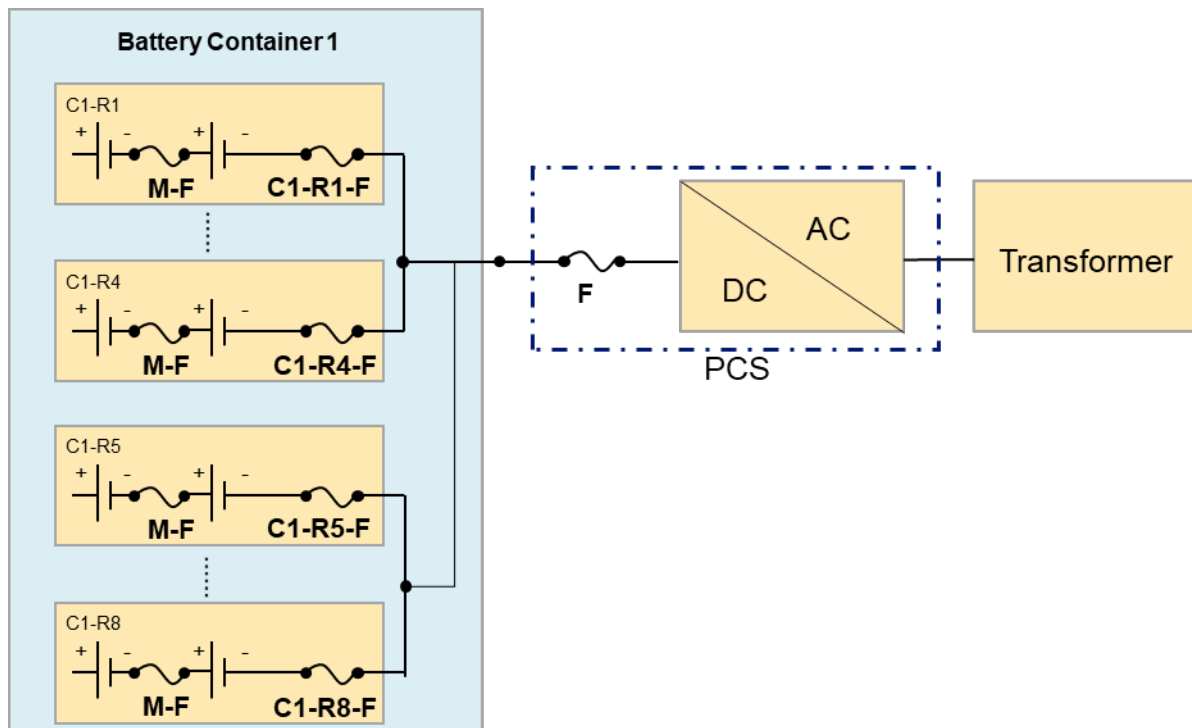


Figure 11 Fuse Matching

The principle of fuse matching:

- Fuse Breaking Time: $F < C-R-F < M-F$. the F fuse means the fuses at the DC side of PCS. The C-R-F fuses means the fuses installed in the main control boxes. The M-F fuses means the fuses installed in the packs. The breaking time of F fuse is the minimum value of these three.
 - Voltage Level: 1500V
 - One Container short circuit current is 104kA
1. One PCS connect one container, every container has 8 racks.
 2. PCS DC side fuse is Fuse F.
 3. Battery rack fuse is C-R-F.
 4. Module fuse is M-F.

7.3 Common Mode Voltage

- One PCS for one transformer

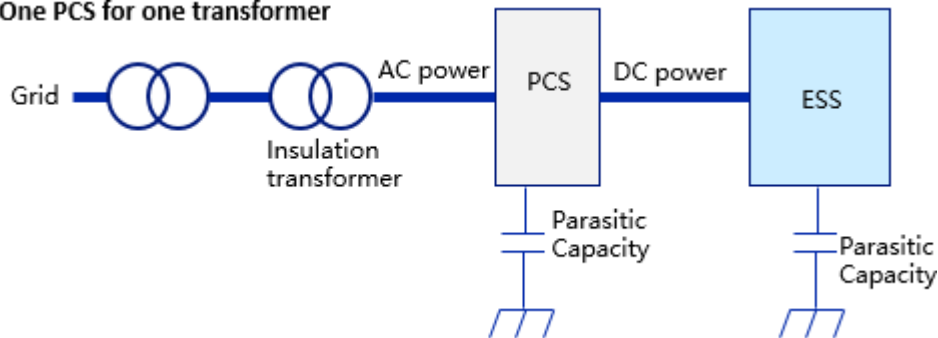


Figure 12 One PCS for One Transformer

- Multiple PCS for one transformer

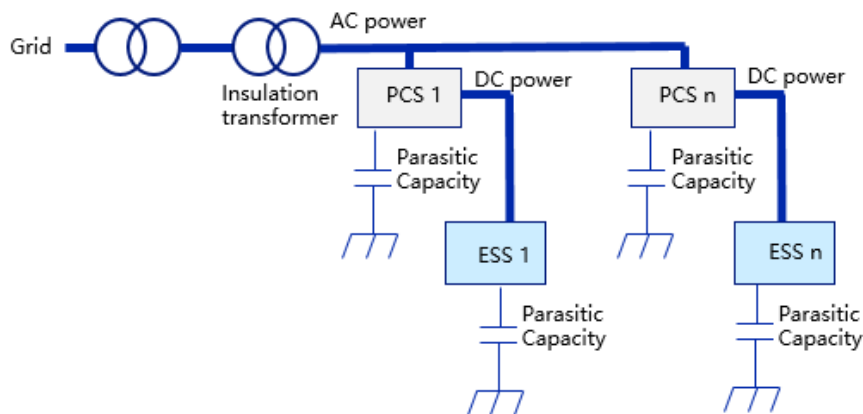


Figure 13 Multiple PCSs for One Transformer

The common mode voltage or current will affect the BESS reliability and personal safety. PCS will generate the common mode voltage and current due to the converter theory. Due to parasitic capacitance, the PCS should improve the insulation resistance isolation. And it is recommended to use insulation transformer. When multiple PCS are parallel connected, make sure that the switching of IGBT inside each PCS will not affect the other PCS to reduce the common mode voltage. The carrier synchronization should be considered in PCS control.

Make sure not to mix the AC and DC power cables, not to mix input and output cables, not to mix power cables and control cables.

7.4 Communication

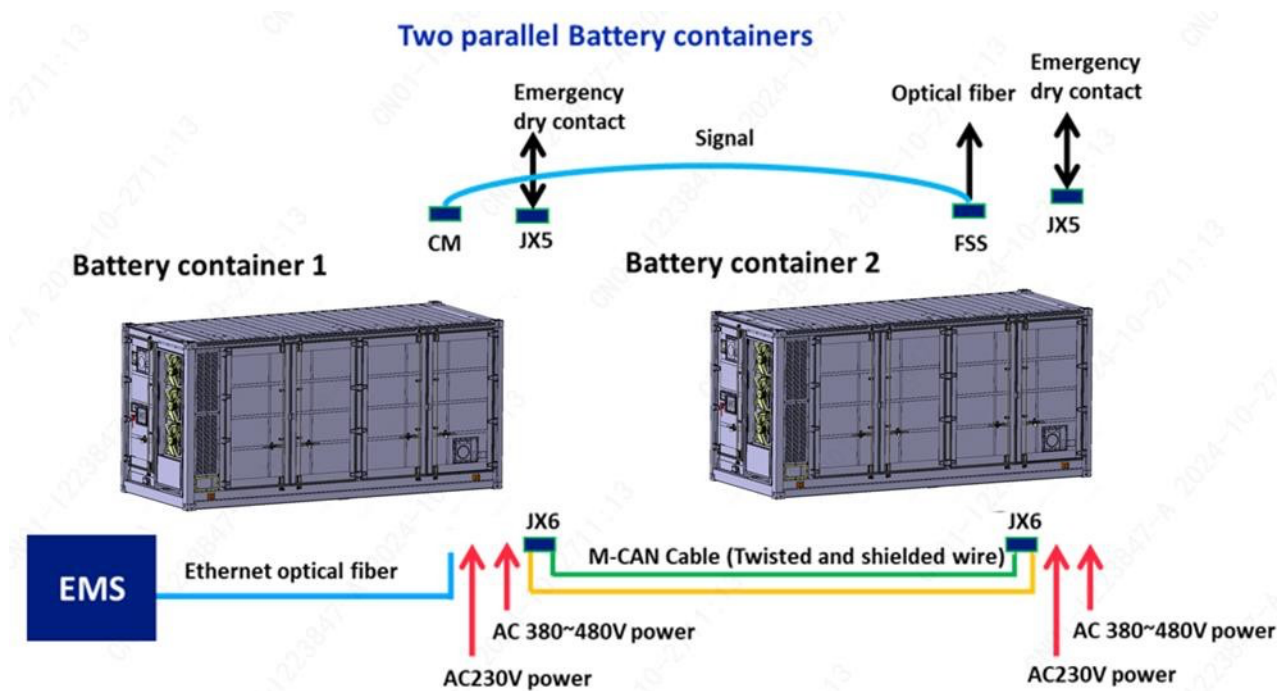


Figure 14 The Communication Architecture of the System with two containers in parallel

PCS should respond within 1s after BMS sending out the requirement.

PCS should respond within 1s after BMS sending out the emergency requirement by emergency dry contact.

PCS operation power should not exceed battery power limitation.

PCS should derating power to 0 W within 2s once receiving BMS limit to ZERO current requirement.

When the length of CAN communication loop exceeds to 30m, it is necessary to add CAN bridge to enhance communication signal.

It is recommended to use Ethernet optical fiber to communicating with EMS.

The A-CAN Bus or 485 Bus can be optional. If using the A-CAN Bus or 485 Bus, the Ethernet optical fiber will be not used.

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