

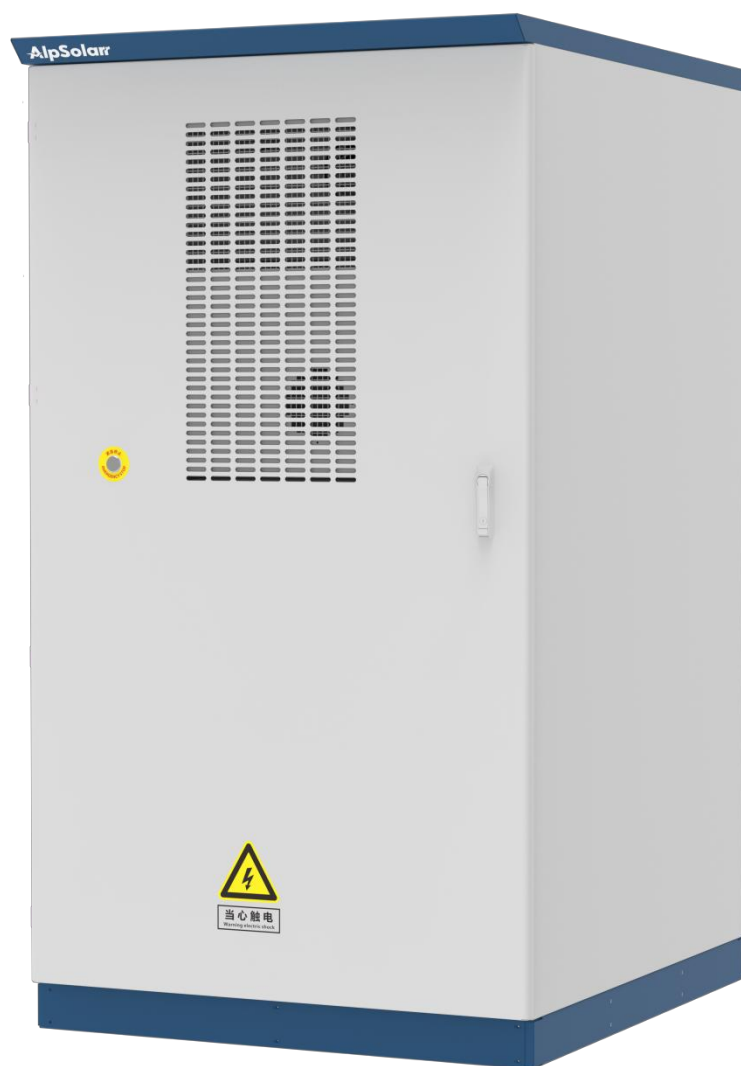


Series: AS03-50S

## ATLAS Series 03

50kW Energy Storage System

Product Specification





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## **Foreword**

Dear Customer, thank you very much for your inquiry and understanding of products researched, developed and manufactured by Shenzhen Ligoo New Energy Technology Co., Ltd (hereinafter referred to as AlpSolarr). We sincerely hope that the product and specification will meet your needs. We welcome your valuable comments and will continue to improve and enhance.

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## **I. Introduction**

### **1.1 Basic Introduction**

ATLAS 03 industrial and commercial series products are high-security, high-reliability and standardized series products developed by AlpSolarr for industrial and commercial application scenarios, which adopt modularized system configuration, flexibly match all kinds of industrial and commercial scenarios, support grid-connection and off-grid automatic switching with the switching time in millisecond level, support parallel expansion, facilitate system expansion, can realize peak and valley time shift and off-peak power consumption, and alleviate the power grid pressure. Such industrial and commercial energy storage products are suitable for application scenarios with higher requirements for power grid continuity, can be used for peak-load shifting, back-up power sources and optical storage integrated use, and are also suitable for application in micro-grid scenarios.

An industrial and commercial energy storage all-in-one machine internally includes a battery insertion box, a control box, a power control system (PCS), an air conditioning system, a battery management system (BMS), an energy management system (EMS), a fire protection system, etc.

### **1.2 Application Scenarios**

They are mainly applied in industrial parks, financial institutions, educational institutions, buildings, petrol stations, communication base stations, residential communities and other small industrial and commercial scenarios.

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## II. Product Overview

### 2.1 Specification and Model

This energy storage system is an AS03-50S series energy storage product, which adopts an outdoor cabinet type; and the internal layout of the outdoor cabinet is shown as the following figure.



Figure 2.1.1 Schematic Diagram of Effect of Product

The energy storage all-in-one machine cabinet has a nominal capacity of 40、50 kW/80、90、100 kWh, the cell connection way in a single PACK adopts 1P16S, and series connection of 11~13 PACK can be supported; and 150 Ah lithium iron phosphate cells are adopted, the capacity of one PACK is 7.68 kWh, the rated power of PCS is 40、50 kW, and the complete machine can support parallel capacity expansion.

## 2.2 Function Parameter Summary

|                                    |                                                     |                               |                               |                                                     |
|------------------------------------|-----------------------------------------------------|-------------------------------|-------------------------------|-----------------------------------------------------|
| Product Series                     | AS03-40S-080                                        | AS03-40S-090                  | AS03-40S-100                  | AS03-50S-100                                        |
| Product Model                      | AS03-40S080A<br>、AS03-40S080E                       | AS03-40S090A<br>、AS03-40S090E | AS03-40S100A<br>、AS03-40S100E | AS03-50S100A<br>、AS03-50S100E                       |
| Battery Side Parameters            |                                                     |                               |                               |                                                     |
| Cell Type                          | LFP                                                 |                               |                               |                                                     |
| Cell Specification                 | 3.2 V 150 Ah                                        |                               |                               |                                                     |
| Capacity of PACK                   | 7.68 kWh                                            |                               |                               |                                                     |
| Rated Capacity                     | 84.48kWh                                            | 92.16kWh                      | 99.84kWh                      | 99.84kWh                                            |
| Rated Voltage                      | 563.2V                                              | 614.4V                        | 665.6V                        | 665.6V                                              |
| PV Side Parameters                 |                                                     |                               |                               |                                                     |
| DC Input Voltage Range             | 150 V-1000 V                                        |                               |                               |                                                     |
| MPPT Voltage Range                 | 150 V-850 V                                         |                               |                               |                                                     |
| Number of MPPT Tracker / Strings   | 4/8                                                 |                               |                               |                                                     |
| Max. DC Input Current              | 55 A*4                                              |                               |                               |                                                     |
| Max. DC Input Power                | 52 kW                                               |                               |                               | 65 kW                                               |
| AC Side Grid Connection Parameters |                                                     |                               |                               |                                                     |
| Rated AC Output Power              | 40 kW                                               |                               |                               | 50 kW                                               |
| Max. AC Output Power               | 40kW (Australian version) / 44kW (European version) |                               |                               | 50kW (Australian version) / 55kW (European version) |
| THDi                               | <3% ( of nominal power )                            |                               |                               |                                                     |
| Rated Voltage                      | 230/400 V                                           |                               |                               |                                                     |
| Rated Frequency                    | 50/60 Hz                                            |                               |                               |                                                     |
| AC Side Off-grid Parameters        |                                                     |                               |                               |                                                     |
| Rated Output Power                 | 40 kW                                               |                               |                               | 50 kW                                               |
| Wiring Method                      | 3L+N+PE                                             |                               |                               |                                                     |
| Rated Output Voltage               | 230/400 V                                           |                               |                               |                                                     |
| Rated Output Frequency             | 50/60 Hz                                            |                               |                               |                                                     |
| THDu                               | <3% ( of nominal power )                            |                               |                               |                                                     |
| System Parameters                  |                                                     |                               |                               |                                                     |
| Communication Interface            | RS485, CAN, etc.                                    |                               |                               |                                                     |
| Communication Protocol             | Modbus                                              |                               |                               |                                                     |

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|                          |                                                         |
|--------------------------|---------------------------------------------------------|
| Display                  | Touch screen, background terminal, APP, etc. (Optional) |
| Protection Grade         | IP55                                                    |
| Cooling Mode             | Industrial Air-conditioning                             |
| Installation Mode        | Outdoor                                                 |
| Corrosion-proofing Grade | C3 (Customizable)                                       |
| Ambient Temperature      | -30°C-55°C ( >45°C derating )                           |
| Ambient Humidity         | 0-95% (No Condensation)                                 |
| Noise                    | <70 dB                                                  |
| Altitude                 | 2000 m                                                  |
| Size (W*D*H)             | 1100*1300*2100 mm                                       |
| Weight                   | About 1500 kg                                           |

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### III. Product Specification

#### 3.1 Cell Specification

The 3.2 V 150 Ah lithium iron phosphate cell is adopted, and the cell adopts square aluminum shell design, so that the possibility of internal damage to the cell due to the fact that the surface of the cell is damaged by mechanical damage is avoided, and the safety performance of products is improved. A film-shaped explosion-proof valve is installed on each cell, which also ensures that under any extreme condition (such as internal short circuits, battery over-charging and over-discharging, etc.), a large amount of gases rapidly gathered inside the cell can be discharged through the explosion-proof valve, therefore, the selection and design of the cell have fully considered the safety of the cell and the system.



Figure 3.1.1 Schematic diagram of effect of 3.2 V 150 Ah lithium iron phosphate cell

General Parameters of Single Cell Battery

| NO. | Item           | Specification                                |
|-----|----------------|----------------------------------------------|
| 1   | Cell category  | Lithium iron phosphate ( $\text{LiFePO}_4$ ) |
| 2   | Rated capacity | 150Ah                                        |
| 3   | Rated voltage  | 3.2V                                         |
| 4   | Rated energy   | 480Wh                                        |

|    |                               |                              |
|----|-------------------------------|------------------------------|
| 5  | Working voltage range         | 2.0~3.65V                    |
| 6  | Standard charging/discharging | 0.5C                         |
| 7  | Storage temperature           | -10℃~30℃                     |
| 8  | Charging temperature          | 0℃~60℃                       |
| 9  | Discharging temperature       | -20℃~60℃                     |
| 10 | Size                          | 174 (W) *49 (D) *172 (H) mm  |
| 11 | Weight                        | 2.9±0.1kg                    |
| 12 | Energy density                | 165Wh/kg                     |
| 13 | Calendar life                 | ≥10 years (25℃, 0.5C/70%SOH) |

## 3.2 Battery PACK Specification



Figure 3.2.1 Schematic diagram of effect of battery PACK

The battery module has the following characteristics:

- (1) Modular design, quick installation and maintenance.
- (2) There are clear signs for positive and negative output terminals, and connection, inspection and maintenance are convenient.
- (3) Welding way: the laser welding technology is adopted, the impedance is low, the strength is high, and the reliability of connection is ensured.
- (4) BMS adopts the passive equalization way, the cost is low, and the market application experience is mature.
- (5) Safety design: space is reserved above the pressure relief valve of the cell to prevent explosion caused by excessive pressure in case of abnormalities.
- (6) Heat dissipation design: when the battery box is designed, its strength is fully considered,

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and the air conditioner ventilation and heat exchange mode is adopted.

Battery PACK Parameters

| NO. | Item                                 | Specifications                      |
|-----|--------------------------------------|-------------------------------------|
| 1   | Specification                        | 51.2V 150Ah                         |
| 2   | Combination way                      | 1P16S                               |
| 3   | Rated voltage                        | 51.2V                               |
| 4   | Rated energy                         | 7680Wh                              |
| 5   | Working voltage range                | 46.4 ~ 58.4V                        |
| 6   | Rated continuous discharging current | 75A                                 |
| 7   | Working temperature environment      | Charging: 0 ~ 55°C                  |
|     |                                      | Discharging: -20 ~ 60°C             |
| 8   | Storage temperature                  | -10 ~ 30°C                          |
| 9   | Weight                               | About 64kg                          |
| 10  | Size                                 | 490 (W) *566 (D) *188 (H) mm        |
| 11  | Cooling way                          | Forced air cooling                  |
| 12  | BMU installation                     | Front-mounted installation position |
| 13  | Positive and negative connection way | Cable connection                    |
| 14  | Communication way                    | CAN                                 |
| 15  | Color                                | 2C cold gray                        |
| 16  | Protection class                     | IP20                                |

### 3.3 Battery Cluster Specification

This set of energy storage system contains 1 set of battery cluster and 13 PACK, totaling 99.84 kWh. The number of PACK can be adjusted according to different capacity requirements, supporting 11~13 PACK with a capacity range of 84.48~99.84kWh.

The battery cluster has the following characteristics:

(1) The single cluster design is adopted, there are no parallel connection of cells, there are no problem of loop current, and isolation is better.

(2) The cabinet adopts a frame structure, the battery packs are connected by high-voltage (power) wiring harnesses and low-voltage wiring harnesses, and the high-voltage wiring harnesses and the low-voltage wiring harnesses meet the electrical isolation requirements.

(3) The structure is safe and reliable, and there is sufficient mechanical strength, so that it is ensured that there is no shaking or deformation of components after installation and during operation.

(4) The design gives full consideration to electrical clearances and creepage distances. The electrical clearances and creepage distances are designed with full consideration of the system working voltage, over-voltage category, pollution class, insulation material and other factors.

Battery Cluster Parameters

| NO. | Cluster class              | Parameters                                           |
|-----|----------------------------|------------------------------------------------------|
| 1   | Composition                | 11~13 modules in series + 1 high-voltage control box |
| 2   | Series-parallel connection | 1P176S/1P192S/1P208S                                 |
| 3   | Normal charging rate       | 0.5C                                                 |
| 4   | Normal discharging rate    | 0.5C                                                 |
| 5   | Rated capacity             | 150Ah                                                |
| 6   | Rated energy               | 84.48、92.16、99.84 kWh                                |
| 7   | Rated voltage              | 563.2/614.4/665.6V                                   |
| 8   | Working voltage            | 510.4~642.4V/556.8~700.8V/603.2~759.2V               |
| 9   | Communication way          | CAN, RS485                                           |
| 10  | Equalization type          | Passive equalization                                 |
| 11  | Battery cluster dimensions | 980 (W) *580 (D) *1380 (H) mm                        |
| 12  | Battery cluster weight     | <800kg                                               |

## 3.4 Battery Management System (BMS) Specification

### 3.4.1 System Overview

The outdoor cabinet product adopts a two-level architecture, including the battery module management unit (BMU) and the battery cluster management unit (BCU) from bottom to top.

Each battery insertion box is equipped with a set of BMU, and each BMU is responsible for

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collecting monomer voltage and temperature of 16 strings of batteries in the corresponding insertion box, and equalization and other functions are realized. The BMU communicates with the BCU using the CAN bus way, and the BCU collects 11~13 BMU data (11~13 PACK) in a polling way in a time-sharing manner.

Each battery cluster is equipped with 1 set of BCU, which is installed in the high-voltage control box, and is responsible for summarizing and analyzing data uploaded by the BMU, collecting the total voltage and current of the battery cluster, and communicating with the outside via RS485 and CAN.

### 3.4.2 Functional Description

The battery management system can realize battery state monitoring, operation control, insulation monitoring, equalization management, protection alarm, communication functions, etc. Through real-time monitoring of the battery state, it can ensure normal, stable and safe operation of the system; and the consistency of the batteries is monitored, and on-line maintenance of the batteries is carried out through equalization, and the use efficiency and life of the battery group are ensured. In order to complete intelligent management and control of the whole battery stack, the battery management system includes:

First-layer management (BMU): a system that has the function of monitoring the voltage and temperature of monomer batteries in the battery module, can safely manage the charging and discharging process of the battery module, and provides a communication interface for storage batteries. BMU is the smallest constituent management unit of the battery management system (BMS) and provides internal information of the battery module to the battery cluster management system (BCU) via the communication interface.

| Function                  | Description                                                                                                            |
|---------------------------|------------------------------------------------------------------------------------------------------------------------|
| Monomer voltage detection | Conduct real-time detection of monomer battery voltage.                                                                |
| Temperature detection     | Place the temperature sensor inside the battery pack module to conduct real-time detection of the battery temperature. |
| Communication             | Upload battery information to BCU via the CAN bus.                                                                     |

|                         |                                                                                                                                                                                                                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Equalization management | The intelligent equalization control strategy is adopted to improve the consistency of single cells, equalization resistance temperature detection and equalization function failure detection are realized, and the stability and reliability of the equalization function are ensured. |
| Thermal management      | According to the temperature state of the battery module, BMU provides active thermal management of the batteries through an independently controlled fan, so as to extend the battery life and enhance the battery safety.                                                              |

Second-layer management (BCU): a real-time monitoring and management system composed of electronic circuit equipment, which effectively conducts safety management of the battery pack charging and discharging process, conducts alarming and emergency protection processing for possible failures, and ensures safe, reliable and stable operation of the batteries.

| Function                      | Description                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SOX calculation               | Overall calculation is made for clusters SOC, SOH and SOP, wherein the SOC error is <5%, and the SOH and SOP errors are <10%.                                                                                                                                                                                                                                                       |
| Current and voltage detection | The total voltage and bus voltage of battery clusters are detected, and the cluster bus current is detected in real time through the shunt.                                                                                                                                                                                                                                         |
| Display and alarm (optional)  | The information on the limit values (voltage, current, SOC, SOH, faults, etc.) of the entire battery cluster system are calculated and displayed through the touch screen (optional).                                                                                                                                                                                               |
| Communication function        | 1 CAN and 1 RS485 are arranged as external communication ports to communicate with modules such as PCS or EMS, so as to transfer system state information in real time.                                                                                                                                                                                                             |
| Protection                    | Before operation, the system conducts self-inspection, and the main loop is not closed in the event of faults such as relay sticking detection and insulation abnormalities.<br>In operation, when a serious fault of the system is detected, the main power supply loop is disconnected by controlling the circuit breaker or contactor, so as to realize the protection function. |
| System extension              | BCU supports multiple relays and switch signal interfaces itself and can also control the strong power control module through CAN communication, and the strong power control module then controls the relays to realize effective isolation of strong and weak power, which is safe and reliable, and meets diversified control needs of customers.                                |

|                        |                                                                                                                                                                                                                                                                                                                                   |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Data storage           | Information on voltage, temperature, charging/discharging capacity each time, number of charging/discharging times, charging/discharging time, etc. of the battery cluster array is stored, and the alarm state, protection information, replacement and dispatch events of the battery cluster array are recorded for reference. |
| System self-inspection | After the system is powered up, voltage, temperature and storage components and other components can be inspected to ensure that the system itself is working properly.                                                                                                                                                           |

### 3.4.3 Program of Safety Measures for Battery System

(1) The battery system adopts three-level protection: the first level is realized by the circuit breaker, and when the system current exceeds the threshold of the circuit breaker, the circuit breaker is triggered directly to trip off; the second level is realized by the DC contactor, and when the main control BCU recognizes failures of over-voltage, under-voltage, or over-current, over-temperature, etc., the failures are reported, and at the same time, the circuit breaker shunt release is enabled to disconnect the circuit breaker and disconnect the positive and negative contactor; and the third level is realized by fuse protection, and when the first level and the second level fail, the thermal disposable fuse is disconnected, thereby realizing protection of the third level, and ensuring safety of the battery system.

(2) The battery management system is arranged, the system is divided into the cell level and the battery cluster level, and the safety monitoring and protection of the whole battery system are realized according to three-level management. Over-charging, over-discharging, over-current and over-temperature (high and low temperature) protection is realized; each protection function is divided into multiple classes according to the severity class and duration, so as to realize different protection actions; and multiple fault detection functions such as connecting insulation faults, contactor sticking, fuse failures and communication faults are realized, so as to realize the fault, alarm, diagnosis and protection four-in-one safety protection mechanism of the battery system.

(3) The first-level energy storage system is equipped with an independent circuit breaker as a maintenance switch, which provides safety guarantee for overhaul and maintenance of the system.

(4) The low-voltage control system is electrically isolated from the strong power loop to ensure

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the immunity and safety of the system.

(5) The battery control system can receive fire linkage signals and scheduling.

### 3.5 High-voltage Control Box Specification

The high-voltage control box is the electrical control unit of the battery cluster, which integrates components such as BCU, the contactor, the fuse, the hall and the circuit breaker. On-off protection is carried out on the battery cluster, and it is an essential part for complete group formation and function realization of the battery cluster.



Figure. 3.5.1 Schematic diagram of effect of high-voltage control box

High-voltage control box parameters

| NO. | Item                  | Specifications               |
|-----|-----------------------|------------------------------|
| 1   | Rated working voltage | 665.6V                       |
| 2   | Rated working current | 85A                          |
| 3   | Protection class      | IP20                         |
| 4   | Product weight        | About 20kg                   |
| 5   | Boundary dimensions   | 480 (W) *547 (D) *144 (H) mm |

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## 3.6 Power Conversion System (PCS)

### 3.6.1 Basic Introduction

The PCS is a device that realizes bi-directional conversion connection of AC and DC electric energy. It is applicable to all kinds of energy storage batteries to exchange energy with the power grid in the form of charging and discharging, and is used for conducting charging and discharging control and management on energy storage components. Under control of the energy storage power station management system, “peak-load shifting” of the power grid load as well as rapid secondary frequency regulation can be realized; when cooperating with intermittent distributed energy resources (wind power and photovoltaics), the volatility of intermittent energy resources can be suppressed, so that the load characteristics of the intermittent energy resources trend to controllable “power grid-friendly loads”; and when a microgrid is formed with local loads and other distributed energy resources and isolated net running is performed, stable voltage and frequency can be provided for the loads in the microgrid.

### 3.6.2 Selection of Specification

PCS Technical Parameter Table

| Model                        |                                                     | 40kW        | 50kW |
|------------------------------|-----------------------------------------------------|-------------|------|
| Photovoltaic side parameters | Rated input voltage                                 | 600V        |      |
|                              | MPPT voltage range                                  | 150V~850V   |      |
|                              | Input maximum power                                 | 52kW        | 65kW |
|                              | Number of MPPT routes/Number of photovoltaic routes | 4/8         |      |
|                              | Maximum input current                               | 55A*4       |      |
| Battery side parameters      | Input voltage range                                 | 160V~800V   |      |
|                              | Maximum charging current                            | 85A         |      |
|                              | Maximum discharging current                         | 85A         |      |
|                              | Supported battery type                              | Lithium ion |      |
| AC side grid                 | Rated output power                                  | 40kW        | 50kW |

|                                    |                         |                                                                                                                                                                                                       |                                                       |
|------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
|                                    | Maximum input power     | 40kW (Australian version) /44kW (European version)                                                                                                                                                    | 50kW (Australian version) /55kW (European version)    |
|                                    | Rated voltage           | 230/400V                                                                                                                                                                                              |                                                       |
|                                    | Maximum output current  | 58A (Australian version) /63.8kW (European version)                                                                                                                                                   | 72.5A (Australian version) /79.7kW (European version) |
|                                    | Power factor            | 0.8 leading to 0.8 lagging                                                                                                                                                                            |                                                       |
|                                    | Rated frequency         | 50/60Hz                                                                                                                                                                                               |                                                       |
|                                    | THDi                    | <3% (of nominal power)                                                                                                                                                                                |                                                       |
| <b>AC side off-grid parameters</b> | Rated output power      | 40kW                                                                                                                                                                                                  | 50kW                                                  |
|                                    | Rated output voltage    | 230/400V                                                                                                                                                                                              |                                                       |
|                                    | Rated output frequency  | 50/60Hz                                                                                                                                                                                               |                                                       |
|                                    | Rated output current    | 58A                                                                                                                                                                                                   | 72.5A                                                 |
|                                    | THDu                    | <3% (of nominal power)                                                                                                                                                                                |                                                       |
| <b>System parameters</b>           | Communication interface | RS485, CAN                                                                                                                                                                                            |                                                       |
|                                    | Communication protocol  | Modbus                                                                                                                                                                                                |                                                       |
|                                    | Maximum efficiency      | 97.6%                                                                                                                                                                                                 |                                                       |
|                                    | Working temperature     | -40~60°C (>45°C derating)                                                                                                                                                                             |                                                       |
|                                    | Relative humidity       | 0~100%                                                                                                                                                                                                |                                                       |
|                                    | Cooling way             | Air cooling                                                                                                                                                                                           |                                                       |
|                                    | Protection function     | DC over-voltage, DC under-voltage, AC over-voltage, AC under-voltage, AC over-frequency, AC under-frequency, short-circuit protection, over-temperature protection, reverse polarity protection, etc. |                                                       |
|                                    | Dimensions (W*D*H)      | 527*294*894mm                                                                                                                                                                                         |                                                       |
|                                    | Weight                  | About 80kg                                                                                                                                                                                            |                                                       |

### 3.6.3 Functional Description

#### 3.6.3.1 Energy Bidirectional Flow Function

The power control system realizes the bidirectional charging and discharging function, can work

in an active inverter mode to realize DC to AC conversion to deliver electric energy to the power grid, as shown in Fig. 3.6.3.1.1, and can also work in an active rectifier mode to realize AC to DC conversion and absorb electric energy in the power grid to store it in the battery, as shown in Fig. 3.6.3.1.2.

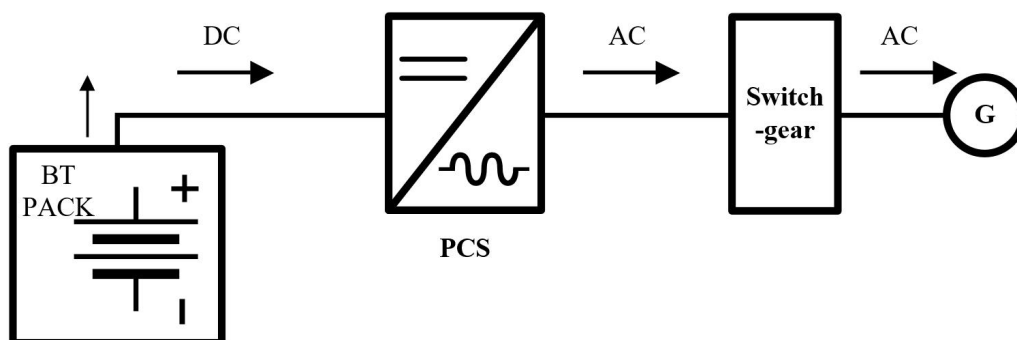


Figure 3.6.3.1.1 Active inverter mode

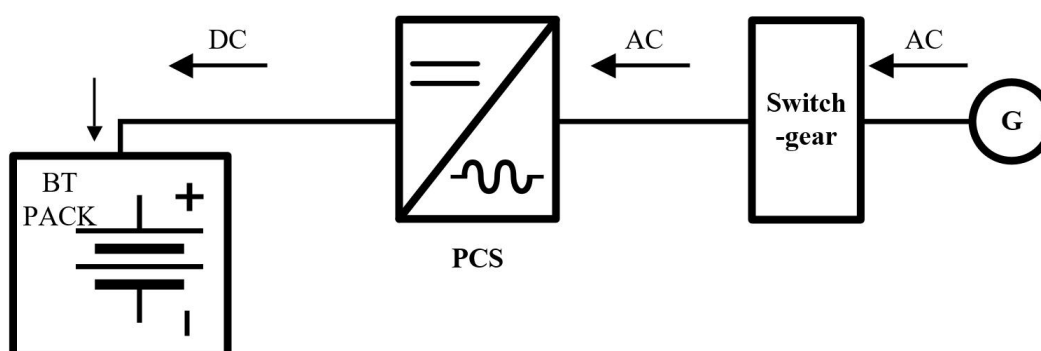


Figure 3.6.3.1.2 Active rectifier mode

### 3.6.3.2 Off-grid Operation Function

The power control system works in an V/F operation mode, a local power grid can be established, stable voltage and frequency are provided for the load, and the power balance between power generation equipment and power consumption equipment can be adjusted in real time. If this function is enabled, the mode can be set via remote communication through the inverter's local controller or upper computer. When the off-grid operation mode is selected, it must be ensured that the connection to the external power grid has been completely ended. At this time, the converter is in constant voltage and frequency output, the quality of electric energy meets the corresponding national standards, and the needs of microgrid system construction can be well met.

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### **3.6.3.3 Grid-connection and Off-grid Switching Function**

After the power control system receives commands from the background or local commands, mutual switching between the grid-connection operation state and the off-grid operating state can be carried out. The power control system can automatically monitor the state of the power grid; when the power grid is out of power, grid-connection to off-grid control is automatically carried out; and when the power grid is restored, off-grid to grid-connection control is automatically carried out, and the grid-connection and off-grid switching time can be in the millisecond level.

### **3.6.3.4 Protection Function**

The power control system has complete protection functions, mainly including:

DC over/under-voltage protection

AC over/under-voltage protection

AC over/under-frequency protection

AC over-current protection

DC short circuit protection

AC short circuit protection

Equipment over-temperature protection

Reverse polarity protection

Battery over-charging and over-discharging protection

### **3.6.3.5 Fault recording Function**

The power control system has a fault recording function and can realize power-down retention, and each copy of recorded information includes the fault time and the fault type, for facilitating accident analysis.

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### **3.6.4 Performance Description**

#### **3.6.4.1 Energy Conversion Efficiency**

The power control system can conduct bilateral energy control according to the DC bus voltage or control instructions, and the maximum energy conversion efficiency is  $>97\%$  under the charging or discharging state.

#### **3.6.4.2 Overload Capacity**

In the grid-connection mode, if the power grid side current of the power control system is at 110% of the rated current, long-term continuous operation is realized.

#### **3.6.4.3 Shock-free Grid Connection**

The synchronous grid-connection technology is adopted, the output voltage of the AC side of the power control system is adjusted to synchronize it with the power grid voltage (same in amplitude, phase and frequency), and the shock current at the moment of grid connection is suppressed better. The service life of filter capacitors of the power control system is prolonged, and the impact on the power grid at the moment of grid connection is reduced.

#### **3.6.4.4 Power Control Accuracy**

The power control accuracy is not more than 5% when the output of the power control system is greater than 20% of its rated power.

#### **3.6.4.5 Power Factor**

In the grid-connection operation mode, when not participating in system reactive adjustment, the average power factor is  $\geq 0.8$  (leading or lagging) when the output of the power control system is greater than 50% of its rated output.

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### 3.6.5 Quality of Electric Energy

#### 3.6.5.1 Quality of Electric Energy on AC Side

When delivering electric energy to the power grid or local AC loads, the power control system meets the relevant national standards in terms of harmonic distortion, voltage unbalance, DC component, voltage deviation, voltage fluctuation, flicker, etc.

##### (1) Current harmonics and waveform distortion

The PCS should not cause excessive distortion of the voltage waveform of the power grid and inject excessive harmonic currents into the power grid after being connected to the power grid, so as to ensure that it does not adversely affect other equipment connected to the power grid.

The limiting value of the current harmonic total distortion rate is 5% when the PCS operates under full loads (linear loads).

##### (2) Voltage harmonic distortion

Under no-load and rated resistive load conditions, the total harmonic distortion rate of the output voltage of the AC side of the power control system does not exceed 3%.

##### (3) Voltage unbalance

After PCS is connected to the power grid, the imbalance of the negative sequence voltage at the common connection point shall not exceed 2% and shall not exceed 4% for short time.

##### (4) DC component

During grid-connection operation, the DC current component fed by PCS to the power grid does not exceed 0.5% of its output current rated value.

##### (5) Voltage deviation

In the off-grid mode and under no-load and rated resistive load conditions, the amplitude deviation of the output voltage of the AC side of the power control system does not exceed  $\pm 5\%$  of the rated voltage, and the phase difference is less than  $3^\circ$ .

##### (6) Voltage fluctuation and flicker

The voltage fluctuation and flicker generated when the power control system is connected to the power grid for operation shall meet the regulations of the power grid.

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### **3.6.5.2 Quality of Electric Energy on DC Side**

The power control system meets the electric energy quality requirements of the battery for charging voltage and current when the battery is charged.

When charging with constant current, the precision of steady current is  $\leq 5\%$ , and the current ripple is  $\leq 5\%$ ; and when charging with constant voltage, the precision of steady voltage is  $\leq 2\%$ , and the voltage ripple is  $\leq 2\%$ .

### **3.6.6 Communication Port and Monitoring Function**

The power control system provides a variety of communication interfaces at the same time, and is equipped with communication interfaces with the battery management system and the monitoring system.

#### **3.6.6.1 Communication Interface**

The power control system is equipped with CAN and RS485 communication interfaces, CAN communication interfaces are adopted with the battery management system, and RS485 communication interfaces are adopted with the monitoring system.

#### **3.6.6.2 Information Interaction**

Information interaction with the background system: the power control system uploads alarm information, switching quantity, analog quantity and other necessary information to the energy storage background system; and the background system issues operation strategy information, control information and other necessary information to the power control system.

Information interaction with BMS: BMS sends information related to battery charging and discharging control, alarm information and other necessary information to the power control system.

## **3.7 Fire Protection System**

For the fire safety protection of energy storage cabinets, our fire protection products can realize two levels of linkage protection strategies, and the second-level cabinet level fire protection can be

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selected according to the needs of customers.

First level: battery module fire protection, according to the battery module dimensions and cell capacity, the flat and fast aerosol is installed inside the PACK, a fire is quickly detected by a wire-type temperature-sensitive detector, and the battery fire is quickly extinguished within 5s. It is found through research that extinguishing the battery fire from inside to outside is the most effective way to extinguish the fire, which can minimize thermal runaway losses.

Second level (optional): cabinet fire protection, the aerosol is installed in the cabinet, smoke temperature sensors are adopted for detection, and second rekindling or electrical fires in the PACK can be effectively extinguished.

Through multi-level protection of the energy storage cabinet, it can ensure the all-round and dead-angle-free safety and security of the outdoor cabinet.

Installation and use of aerosol in battery module:

1. The best place to install the aerosol in the battery module is on the inner side of the battery cover.

2. The aerosol is activated by a thermal wire, which is automatically ignited when the temperature of any point of the thermal wire reaches the activation temperature, and the aerosol is activated to erupt from solid to gas.

3. The thermal wire is installed to surround the cell by one circle.

4. The aerosol can be retrofitted with a feedback signal line to connect to BMS or EMS, so as to provide a contact signal that is normally open (or normally closed) when normal, and the signal is opposite after eruption of the aerosol.

5. The aerosol is both a fire extinguishing device and an alarm device, which is used for achieve two purposes.

Characteristic description of aerosol program

A. Within the module:

1. aerosol is small enough to be installed inside the battery module, and it is easy and convenient to install.

2. The aerosol can be electrically or thermally activated, so there will be no malfunction.

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3. The aerosol is installed in the module, fire extinguishing is carried out from inside to outside, the fire extinguishing effect is best, and the aerosol is the most important and effective way of fire protection. It is difficult to achieve the same results with other external fire extinguishing ways.

4. It is easier to put out a small fire than a large one. If one PACK has thermal runaway, the aerosol of the PACK is erupted, the loss is only one PACK and one aerosol, a large fire cannot be caused, and the loss is also greatly reduced.

5. The aerosol can be retrofitted with a feedback signal line to provide a dry contact signal, so that BMS has one more PACK thermal runaway signal.

B. Within the cabinet (optional):

1. The wall-mounted aerosol is installed inside the cabinet to serve as second-level protection in case of battery rekindling.

2. The aerosol in the cabinet can be activated electrically with rapid response and fast action.

## **3.8 Temperature Control System**

### **3.8.1 Description of Basic Program**

The battery requires higher working environment temperature, in order to ensure that the battery works in the optimal environment temperature. One wall-mounted industrial air conditioner is arranged in the cabinet, it can ensure uniform heat dissipation of the battery insertion box, the environment temperature inside the cabinet can be ensured to be controlled within the range of suitable working temperature of the cell, and the built-in thermostat of the air conditioner can automatically start the cooling and heating function in accordance with the set highest and lowest temperature values; and in order to ensure that the air conditioner can uniformly dissipate each battery insertion box, special cooling ducts are arranged at the rears of two rows of battery modules, and temperature equalization inside the cabinet is ensured.

To solve the heat dissipation problem, we take two main ways:

(1) Heat dissipation channels are designed for battery modules, and fans of suitable power are added in front of the modules, so as to ensure that the temperature inside the modules is quickly transferred to the outside of the modules.

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(2) The outdoor cabinet is equipped with the industrial-grade cooling and heating air conditioner and heat dissipation channels, so as to ensure the environment temperature inside the cabinet.

The power supply voltage of the air conditioner is AC 220 V, which is provided by the power distribution of the control box; and the main communication way of the air conditioner is RS485, and this signal is output to the control box to communicate with the system.

### **3.8.2 Thermal Management Control Strategy**

For the heat dissipation of the device, the heat dissipation problems of the complete set have been effectively solved by installing the air conditioner on the outdoor cabinet on the one hand, and additionally installing heat dissipation fans on the PACK device on the other hand.

The air conditioner selects an industrial-grade, high-power and high-quality product special for outdoor cabinets, and the product is a cooling product developed for cabinets and other application environments. It is suitable for application scenarios where the heat generated by the equipment inside the cabinet is large, the internal equipment is sensitive to the environment temperature, and the inside and outside need to be completely isolated. This product has complete functions, high reliability and simple and convenient installation, can work after being powered on, and does not need complex debugging. The operation of the air conditioner is automatically controlled entirely according to the temperature inside the cabinet. The controller detects the temperature of return air from the cabinet through the internal circulation temperature sensor, compares it with the set point to make a judgment, and controls the compressor or fan to work.

Meanwhile, it has a dehumidification function; when the humidity in the cabinet is greater than the dehumidification starting temperature and the humidity in the cabinet is less than the dehumidification starting temperature, the electric heating dehumidification is started; and when the temperature in the cabinet rises to the dehumidification stopping temperature or humidity falls back to the dehumidification stopping temperature, heating is stopped.

The strategies used for thermal management of outdoor cabinet systems in each case are:

The temperature of the whole system is lowered by natural heat dissipation and air conditioner

forced cooling.

In other cases, such as frequent charging and discharging of the system, which cause sudden rise of temperature inside the outdoor cabinet and cannot quickly reduce temperature through an air duct natural heat dissipation manner. Heat accumulation inside the system is caused, so it is necessary to start air conditioner refrigeration for rapid cooling.

The following figure shows the control strategies:

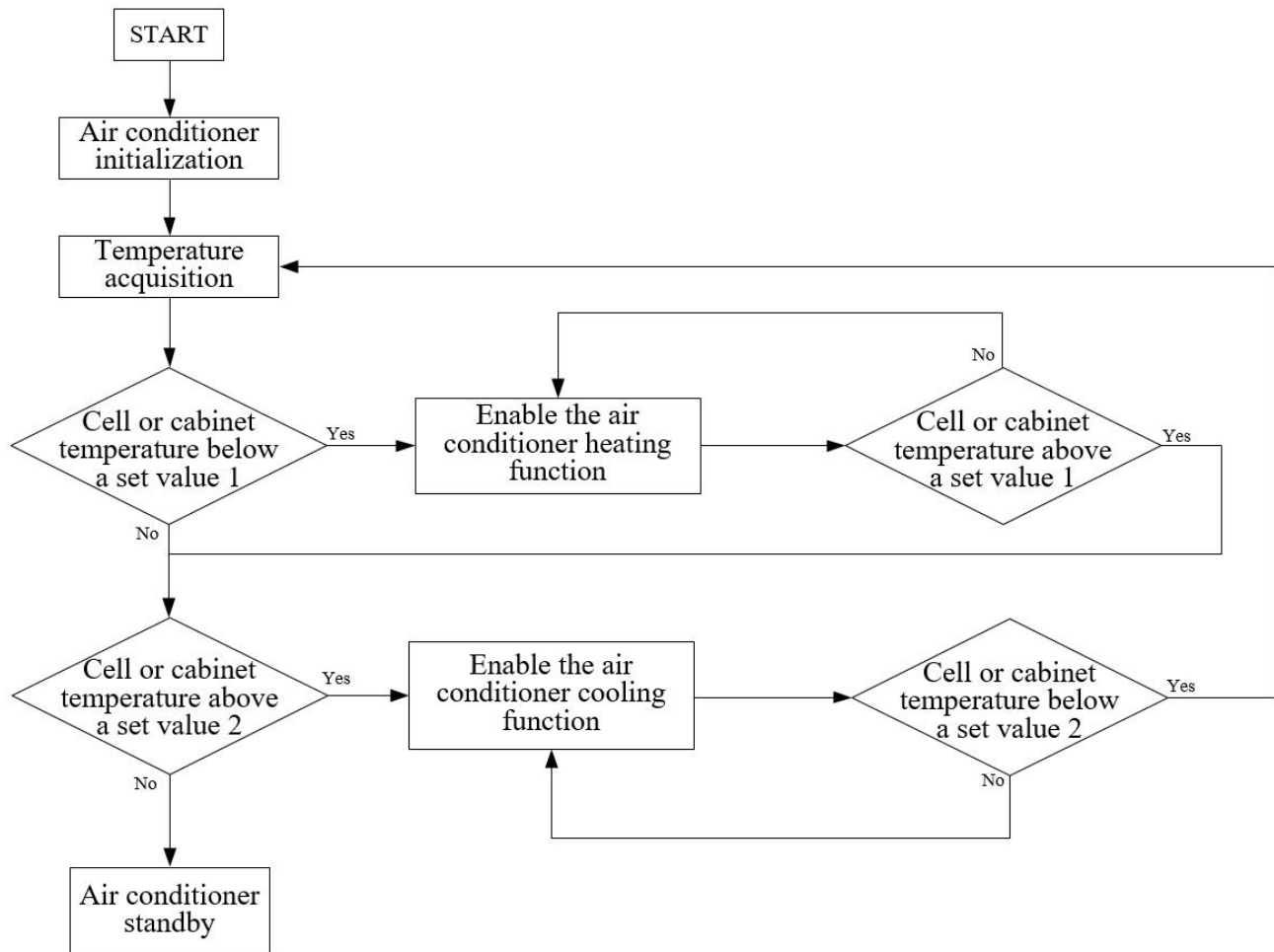


Figure 3.8.2.1 Schematic diagram of air conditioner control strategy

## 3.9 Energy Management System (EMS)

### 3.9.1 Basic Introduction

The energy storage product system is configured with a complete energy management system solution to meet multiple applications of energy storage in the power field.

The EMS technology program adopts the local single board EMS + cloud platform EMS dual

synergy program, adopts the cloud-side synergy technology route, deploys the SCADA (collecting and processing) system in the cabinet local controller, and deploys the monitoring and policy control in the cloud platform. The local controller includes the battery management system (BMS), the power conversion system (PCS), fire-fighting equipment, heat dissipation equipment, etc., in the cabinet to complete the local monitoring, information remote transmission, control execution and other functions of the equipment. The cloud platform system realizes monitoring control and energy management of the whole energy storage station. The key functions of the energy management system are huge amount of data acquisition, data storage access, system monitoring, dispatch response and safe operation protection of the energy storage system.

System Parameter Table

|     |                                      |                                                                                                               |
|-----|--------------------------------------|---------------------------------------------------------------------------------------------------------------|
| EMS | Real-time monitoring                 | Have functions of monitoring the operation state and operation data of the energy storage system in real time |
|     | Energy scheduling                    | Have functions of systematic energy scheduling control and peak-load shifting                                 |
|     | Fault alarming                       | Have functions of fault recording, analysis and the like                                                      |
|     | Statistical analysis                 | Have functions of behavioral analysis, revenue analysis and the like                                          |
|     | System management                    | Have functions of log management, rights management and the like                                              |
|     | Intelligent interaction              | Interact with cloud platforms, mobile APP, etc. for demand response, etc.; and have the VPP function          |
|     | Operation and maintenance management | Work order management, etc.                                                                                   |

### 3.9.2 Platform System Characteristic

#### (1) Cross-platform

The system has the multi-platform support and cross-platform support capability. Through the high-performance encapsulation of the access interface of the mainstream operating system, the

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differences between the underlying hardware and the operating system are shielded, and it is ensured that the upper application system obtains better flexibility, realtime performance, portability and scalability.

The system can smoothly operate on various mainstream versions of UNIX, LINUX and Windows operating systems, and also support mixed platform application of UNIX, LINUX and Windows operating systems; and the software and hardware configuration of the system is flexibly selected according to the real-time needs of the user's application system and investment situations. Typical software and hardware systems supported by the system include Solaris based on SUNSPARC, AIX based on IBMRS6000, HP-UX based on ITANIUM and various LINUX and Windows based on PC hardware platforms.

## (2) Standardization

The system adheres to the principles of standardized design and openness, which can ensure that the system keeps up with the development of the latest technology at any time, a variety of advanced application results are constantly incorporated, and standardized design makes the better openness and scalability, so that application integration and information exchange of the system are more convenient and easy. The system fully supports the IEC 61970/IEC 61850 series international standards, provides public data models, data access and interoperability implementations based on the international standard for a variety of power application systems.

## (3) Integration

Facing the trend and requirements of electric power development, various application requirements of the power grid energy management system (EMS) are fully considered, integrated design is adopted, and an open and powerful integrated platform is built.

The common platform provides unified business support for upper-level application systems through component services, including system configuration and operation management, commercial database management, real-time database management, network communication management, graphic software packages, authority management, alarm service, calculation service, reporting tools, WEB information release, etc. Through the unified and parallel real-time library integration bus, various applications such as integrated five-guard, intelligent operation ticket systems, programmed

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control, protection information management, voltage reactive power control (AGC/AVC), grounding and routing, network topology analysis and operator simulation training are integrated together in a unified way, so as to realize seamless integration and unified management of each application system.

#### (4) Intellectualization

Based on the CIM standard, cross-platform graphic, model and library integrated design is realized, the system power equipment model is constructed in full accordance with the IEC61970 public information model CIM standard, while the graphics are stored in accordance with the vector graphic standard, so that the user can automatically build the power grid model, model parameters and topology relationship at one time while drawing the graphics, and automatic generation and completeness checking of the topology structure of the equipment model are realized, thereby greatly improving work efficiency and reducing the probability of errors.

#### (5) Internationalization

Internationalization of software is a trend in today's software development, and great attention has been paid to the internationalized multilingual support of the system in the design. Multilingual processing uses the UNICODE international coding standard developed by the International Organization for Standardization. UNICODE ("Universal Multiple-Octet Coded Character Set") provides a unique code data point for each character in the world, and retains the ability to expand to more than one million code points, so it allows different languages to be stored in a single byte stream, thus fully supporting the software's multilingual data processing ability; and programs that support UNICODE can process data in any language. Based on the UNICODE standard, the layered multi-language dynamic switching function is realized, which completely separates resources of the application program from source codes, the source codes of the application programs do not need to be changed, dynamic switching of the system in different language environments can be realized through replacement of resource files in different languages, and a new technological solution is provided for meeting the internationalization market demand of the electric power monitoring software.

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## **3.10 Outdoor Cabinet**

### **3.10.1 Basic Overview**

The battery cluster, the PCS, the air conditioner, the fire protection and other equipment are integrated into the outdoor cabinet, which has the independent self-powered system, the temperature control system, the flame retardant system, the fire alarm system, the fire protection system and other automatic control and safety guarantee systems. The complete temperature control system and ventilation system ensure good heat dissipation and temperature control, and the battery is always at the best working temperature. The cabinet is internally equipped with the fire protection system to ensure the safety of the system equipment.

### **3.10.2 Cabinet Structure Design**

In order to ensure sufficient strength and meet the requirement for 10 years of life, the thickness of the outdoor cabinet shell is not less than 1.5 mm, and hot-dip galvanized steel sheet materials are adopted; Shell components made of non-conductive materials meet specific insulation requirements and meet the verification test requirements in the relevant standards.

The effective thickness of the color steel plate on the top of the outdoor cabinet is not less than 1.5 mm, the effective thickness of the color steel plate on the outer wall is not less than 1.5 mm, and the effective thickness of the color steel plate on the inner wall is not less than 1.0 mm.

Its fire protection performance meets the relevant requirements of the relevant standards, and the flame retardant materials used in the shell structure prevent internal or external fires.

Additional anti-aging coatings and surface treatment processes are used to meet the corrosion resistance specified in the relevant standards. For all bolts and screws of the cabinet door panels of disassembly design, rust-resistant materials such as stainless steel are used to facilitate future disassembly and maintenance.

The protection class of the cabinet is not less than IP55, and the cabinet has the ability to proof sand dust and water.

Vents are designed and shielded, and the same protection class and mechanical shock resistant class as the shell are maintained.

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Ventilation outlets are additionally equipped with windproof and dustproof cotton to improve waterproofing and sandproofing capabilities, and meanwhile, shutters for preventing return air are disposed inside the ducts.

Seismic capacity: 8 degrees (ground horizontal acceleration of 0.3 g, vertical acceleration of 0.15 g, with two kinds of acceleration acting at the same time. analyzed and calculated safety factor not less than 1.67).

The non-main power cables inside the cabinet select reinforced insulated cables, and the flame retardancy of the cables meets the requirements of the relevant standards.

Two fixing ways of bolt installation and welding are provided in the outdoor cabinet. The bolt fixing points and the welding points are reliably communicated with non-functional conductive conductors of the entire outdoor cabinet (under normal circumstances, not charged outdoor cabinet metal shell, etc.), at the same time, the outdoor cabinet provides grounding points meeting the power standard requirements in a form of copper bars, and the grounding points and the non-functional conductive conductors of the entire outdoor cabinet form reliable equipotential connection.

The outdoor cabinet is equipped with smoke sensors, temperature and humidity sensors and other essential safety equipment, control switches of the smoke sensor and the temperature and humidity sensor system form an electrical interlock, once the failure is detected, the outdoor cabinet can notify the user in the form of remote communication, and at the same time, the lithium battery complete equipment in operation is cut off; and when temperature and humidity sensors detect that the temperature and humidity inside the outdoor cabinet do not meet the requirements, the lithium battery complete equipment can take effective measures to make the temperature and humidity in the cabinet meet the working requirements.

### **3.10.3 Cabinet Protection Design**

1. Elbow extending design, which effectively prevents rainwater intrusion.
2. Wind-sand-proof and rain-proof four-fold structure fixed louvers are arranged to ensure that splash rain in the 180° range in any direction will not enter the interior of the cabinet.
3. Fully-sealed design of the power control system, which can prevent dust from intruding into

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the power control system and other equipment.

4. Waterproof aging high protection class, which allows it to directly work under drenching conditions.

#### 3.10.4 External Interface of Cabinet

| NO. | Equipment                         | Name of external interface             | Quantity | Specification | Remark                                                                                                           |
|-----|-----------------------------------|----------------------------------------|----------|---------------|------------------------------------------------------------------------------------------------------------------|
| 1   | Energy storage all-in-one machine | AC output interface on power grid side | 1        | AC400V        | Recommended cable model: 8AWG                                                                                    |
| 2   | Energy storage all-in-one machine | AC output interface on load side       | 1        | AC220V        | Reserved, whether to wire is selected according to the actual project conditions, recommended cable model: 8AWG  |
| 3   | Energy storage all-in-one machine | Input interface on PV side             | 4        | <DC1000V      | Reserved, whether to wire is selected according to the actual project conditions, recommended cable model: 10AWG |
| 4   | Energy storage all-in-one machine | Network interface                      | 1        | Ethernet      | Reserved, whether to wire is selected according to the actual project conditions, recommended cable model: CAT6  |

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### 3.10.5 Schematic Diagram of External Dimensions

